The American Ceramic Society

50th International Conference and Expo on Advanced Ceramics and Composites

ABSTRACT BOOK

January 25–30, 2026
Daytona Beach, Florida

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Introduction

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How to Use the Abstract Book

Refer to the Table of Contents to determine page numbers on which specific session abstracts begin. At the beginning of each session are headings that list session title, location and session chair. Starting times for presentations and paper numbers precede each paper title. The Author Index lists each author and the page number on which their abstract can be found.

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Monday, January 26, 2026

Plenary Session

Plenary and Award Talks

Room: Coquina D and E
Session Chairs: Amjad Almansour, NASA Glenn Research Center; Federico Smeacetto, Politecnico di Torino

8:50 AM

(ICACC-PLEN-001-2026) James I. Mueller Memorial Award: Li Batteries: 50 years old and the future challenges for an American based industry (Invited)

S. Whittingham*[1]

1. Binghamton University, USA

The Nobel Committee citation read: “They have laid the foundation of a wireless, fossil fuel-free society, and are of the greatest benefit to humankind.” Now the world needs to take action. Although lithium batteries celebrated their 50th anniversary in 2022, they still achieve only 25% of their theoretical energy density. Even at that level, they now dominate portable energy storage. The dominant anode and cathode today are graphitic carbon and the layered NMC oxides, LI[NiMnCoAl]O_2. Both need improving. We must push the chemistry to its limits. Ten-year lifetimes demand 99.95% reaction selectivity Alternatives to Li-NMC cells will also be discussed, including the phosphates, with also a discussion of what is very technically and/or politically challenging and maybe not viable in an attempt to correct some of the exponential hype in the battery energy storage arena. A key challenge in the Western world is to build a sustainable supply chain and manufacturing capability that leapfrogs the present 30 year old technology. We need to stop building new “old gigafactories” in North America.

9:30 AM

(ICACC-PLEN-002-2026) Mrityunjay Singh Bridge Building Award: Oxide ceramics LSI devices to mitigate global extreme weather due to computers in the AI era (Invited)

S. Yamazaki*[1]

1. Semiconductor Energy Laboratory Co., Ltd., Japan

The emerging AI era has led to a significant increase in computer power consumption, contributing to global extreme weather patterns. To address part of this issue, we will present oxide semiconductor LSI (OSLSI) devices using crystalline indium–gallium–zinc oxide (IGZO), which we named CAAC-IGZO, or crystal indium oxide (IO). Our research has revealed that OS transistors exhibit an extremely low off-current of yA (10^{-24} A)/μm, which is 10 orders of magnitude lower than that of Si FETs. We have also found that crystal IO transistors demonstrate favorable on-state characteristics and excellent frequency characteristics. We have explored various FET structures achieving a high degree of integration intended for ultra-low power consumption. With the goal of reducing the power consumption of semiconductors, the heart of data centers, to 1/100, we are currently collaborating with LSI and display companies in Taiwan and Korea. This presentation will provide details on how to accomplish ultra-low power consumption using the OSLSI technology based on crystal IO.

10:40 AM

(ICACC-PLEN-003-2026) Plenary: High performance ceramics for extreme environments: Applications for fission and fusion energy (Invited)

S. J. Zinkle*[1]

1. University of Tennessee, USA

Multiple emerging advanced technologies require high-performance materials to operate satisfactorily under extreme operating conditions such as high temperatures, high heat and particle fluxes, and corrosive environments. Due to a wide range of achievable thermal conductivities (insulating to highly conductive) combined with high upper use temperature and compatibility with corrosive environments, ceramics are attractive options for many extreme environments. A new generation of advanced high-temperature fission and fusion energy concepts are under consideration for projected worldwide energy needs and space exploration. These next generation nuclear energy systems will require advanced high-performance materials due to extreme operating environments involving high temperatures, heat fluxes and neutron displacement damage levels and intense particle bombardment. Key materials science challenges and research needs associated with reliable operation in these extreme operating environments will be summarized. The application of high-performance ceramics in these challenging operational environments will be discussed, including ultra-high temperature ceramics, MAX-phase ceramics, complex concentrated ceramics (CCCs, also known as high entropy ceramics), and a variety of ceramic-matrix composites.

11:20 AM

(ICACC-PLEN-004-2026) Plenary: Multimodal analytics and data-driven optimization of ceramic composite materials for energy and electronic applications (Invited)

S. Christiansen*[1]

1. Helmholtz-Zentrum für Materialien und Energie Berlin (HZB), Germany

Advanced ceramic composites are critical enablers of high-performance energy storage and electronic devices. To meet increasing demands for reliability, sustainability, and miniaturization, we introduce a scale-bridging, data-driven optimization pipeline that unites multimodal analytics, machine learning, and physics-based simulations. This integrative framework is broadly applicable across material systems and device platforms, with batteries and microelectronic components serving as exemplary use cases. The pipeline leverages high-resolution, correlative data from electron, ion, and X-ray microscopies (SEM, FIB-SEM, AFM, XRM), complemented by spectroscopic modalities such as Raman, IR, and μXRF. With nanoGPS-based relocalization, we achieve true multimodal correlation across instruments and scales, enabling quantitative analysis of critical features such as interfaces, degradation zones, and functional inhomogeneities. Acquisition workflows are designed to maintain chemical and structural integrity—e.g., using glovebox-integrated tools and contamination-free transfer holders—while operando methods provide dynamic insights under real device conditions. These rich datasets are integrated, analyzed, and visualized using the Correlyze platform, allowing AI-assisted segmentation, anomaly detection, and pattern recognition.

Jubilee Global Excellence Awards

Jubilee Global Excellence Awards

Room: Ballroom 3
Session Chairs: Cristina Balagna, Politecnico di Torino;
Federico Smeacetto, Politecnico di Torino

1:30 PM

(ICACC-AWARD-001-2026) The peculiar self-assembling product phases formed via in-situ reactions (Invited)

J. Wojewoda-Budka*[1]

1. Polish Academy of Sciences, Institute of Metallurgy and Materials Science, Poland

The proposed talk focuses on the reactions leading to the creation of self-assembling product phases. Initially, solid-state displacement reactions resulting in periodic layered structures will be presented for several metal/ceramic systems: Zn/Ni_3Si, Zn/Co_2Si, and Mg/SiO_2. Various opposing models involving physical and/or chemical processes that result in product periodicity have been developed. Such modulated structures can facilitate in-situ formation of multilayer (spatially ordered) inorganic materials inside the reaction zone, which may occur unintentionally in many cases, such as in joined components, composite materials, thin-film electronic devices, and metallization. The second part of the talk will address a specific group of metal-ceramic composites with a C4 structure (Co-Continuous Ceramic Composites), consisting of uninterrupted interpenetrating crystalline lattices of metallic and ceramic components. The experiment involves chemical reactions between aluminum and reactive oxides, such as Y_2O_3, SiO_2, ZnO, and NiO, to in-situ fabricate $Al\text{-}Al_2O_3$ type microstructure. This approach may open new prospects for ultra-modern, lightweight, and cost-effective metal-ceramic materials applicable in the automotive industry (pistons, bushings, control arms) and in machinery used in mining, agriculture, etc., where resistance to abrasion and thermal shocks is critical.

2:10 PM

(ICACC-AWARD-002-2026) The spark between fields: Emerging materials opportunities with electromagnetic control (Invited)

B. Jayan*[1]

1. Carnegie Mellon University, USA

This talk explores how electromagnetic fields—like microwaves—can guide chemical reactions in surprising ways, helping us create advanced materials with less heat, less waste, and more control. From coatings for batteries to 3D-printed engineering ceramics, learn how this emerging approach could transform how we power, build, and manufacture in a cleaner world.

Special Focused Session on Entrepreneurship and Commercialization

Special Focused Session on Entrepreneurship and Commercialization

Room: Ballroom 3
Session Chair: Valerie Wiesner, NASA Langley Research Center

3:20 PM

(ICACC-SPEC-001-2026) Foundation of a start-up in the field of technical ceramics (Invited)

M. M. von Witzleben*[1]

1. INMATEC Technologies GmbH, Administration, Germany

New ideas, innovative technologies often prevail just through start-ups. The example of INMATEC Technologies GmbH in Germany shows the experiences that have been made with the foundation and development of the company. The aim of the lecture is to let the audience participate in these experiences and to motivate ceramic researchers to do the same. With the support of young, brave and technology inspirated scientist, new and possibly disruptive ceramic technologies have a greater chance in a competitive world and can speed up the general technological development. First, the technological idea that forms the basis of the company to this day is presented, and then the findings from the founding of the company to the growing up of the company are reported.

3:50 PM

(ICACC-SPEC-002-2026) From materials to machines: A journey in laser innovation (Invited)

S. Jiang*[1]

1. AdValue Photonics Inc, USA

This talk will chronicle my entrepreneurial journey, from founding companies in materials like advanced glass and ceramics to developing the core technologies of optical amplifiers and lasers, and ultimately creating precision machines that integrate them all. I will detail the development and application of our laser processing systems for cutting, drilling, and machining challenging materials, including glass, ceramics, and diamond, and share key lessons learned from bridging these distinct technological domains.

4:20 PM

(ICACC-SPEC-003-2026) R&D grant funding opportunities for innovative small ceramics businesses

D. J. Gisser*[1]

1. Tillerline Associates LLC, USA

The Department of Defense, National Institutes of Health, NASA and eight other federal agencies provide grants to support innovative research and technology development at small companies. Many of these agencies seek innovations from the ceramics industry. The primary funding mechanism is Small Business Innovation Research (SBIR) grants. They are designed to prepare companies to become long-term suppliers to the US government and/or commercial industry based on the technologies developed. Most projects are initially funded for $100-300k for 6-18 months of work. Follow on support is typically $600k - $2M+. Several add-on and follow-on grants are also available. This discussion will introduce the SBIR program. We will identify methods to identify appropriate funding agencies and topics for your company, with a special emphasis on current research grant topics and opportunities relevant to the ceramics industry. In addition, we will consider strategies and tactics for developing a great proposal that meets all the compliance rules, and we will also introduce other non-dilutive R&D funding opportunities that can help small businesses grow.

15th Global Young Investigator Forum on Sustainability

15th GYIF- Sustainable Materials Development I

Room: Ballroom 5
Session Chairs: Meelad Ranaiefar, NASA Glenn Research Center; Nor Ezzaty Ahmad, UTM

1:30 PM

(ICACC-GYIF-001-2026) Next generation materials for advanced energy applications (Invited)

L. McMillon-Brown*[1]

1. NASA Glenn Research Center, Photovoltaics and Electrochemical Systems Branch, USA

Advanced materials are critical for myriad applications spanning from the incremental enhancement of human's quality life to disruptive next generation technology that enables space exploration. Here, we will review recent materials development towards advanced energy applications for terrestrial and space applications. This talk will include project overviews, systems analysis, and identifications of technological gaps which the ceramics community could aid to close.

2:00 PM

(ICACC-GYIF-002-2026) Design of interparticle photo-cross-linkable Pickering emulsion for rapid manufacturing process of 3D-printed porous ceramics (Invited)

S. Tsutaki*[1]; M. Iijima[1]; J. Tatami[2]

1. Yokohama National University, Graduate School of Environment and Information Sciences, Japan
2. Yokohama National University, Japan

3D manufacturing of porous ceramics has attracted wide attention due to its flexibility in shaping tailor-made structures. However, in current processes, large amounts of monomers are used to maintain the strength of green bodies, which requires long debinding process. To solve this issue, we developed a new photocurable Pickering emulsion which can be solidified using limited content of monomers. In our system, stabilized Pickering emulsion was fabricated by using particles surface modified with functionalized polyethyleneimine (PEI). The addition of small amount of multi-functional acrylates (MA) and photo-irradiation to this designed emulsion enabled photocuring by the formation of interparticle cross-links which occurred by radical polymerization of MA followed by Micheal addition reaction between PEI on particles and MA. Using this emulsion, a complex shaped green body was successfully obtained through DLP-3D printing. We will further demonstrate that in-line transparency of the Pickering emulsions can be increased by tuning the refractive indices of the continuous and dispersed phase in the emulsions, which played an important role in improving the printing accuracy. Finally, the obtained 3D-printed body was found to be debind-able and sinter-able under rapid heating condition (10 degree/min) owing to the reduced amount of monomers.

2:30 PM

(ICACC-GYIF-003-2026) Pyrolyzed preceramic precursors to compositionally complex ceramics (Invited)

S. Ren*[1]

1. University of Maryland, USA

Ceramics from chemically distinct preceramic polymer precursors offer unique shaping and microstructural control but face challenges such as shrinkage, uncontrolled porosity, and pyrolysis-sensitive stoichiometry. The high-temperature potential of compositionally complex ceramics is further constrained by precursor scarcity and the low-throughput nature of pyrolysis. Here, we introduce short-chain preceramic precursors crosslinked with Group IV-VI transition metals (Zr, Cr, V, Mo, Hf, W, Nb, etc.), which are compatible with extrusion-based techniques such as Direct Ink Writing. While extrusion and ultrafast pyrolysis have been explored independently, this work combines them with multi-metal precursors to enable enhanced compositional complexity, lower processing temperatures, and rapid screening of oxidation-resistant ceramics. Through ultrafast electrical pyrolysis, these crosslinked precursors convert into dense, multi-phase ceramics under a minute. The resulting materials exhibit homogeneous composition and oxidation resistance, offering a scalable route to protective coatings and bulk ceramics for extreme environments.

15th GYIF- Sustainable Materials Development II

Room: Ballroom 5
Session Chairs: Mark Du, Argonne National Laboratory; Shenqiang Ren, University of Maryland

3:20 PM

(ICACC-GYIF-004-2026) Assessment of electric field enhancement of ceramics including microdefects by using FEM analysis (Invited)

J. Araki*[1]; Y. Nakashima[2]; M. Fukushima[2]; W. Nakao[1]

1. Yokohama Kokuritsu Daigaku, Japan
2. National Institute of Advanced Industrial Science and Technology (AIST), Japan

In this study, a finite element analysis was performed to evaluate the effect of aspect ratios and dielectric constants of microdefects on the electric field enhancement using the maximum field enhancement factor. To focus on various microdefects inside ceramics sintered body such as pores, secondary phases, and grain boundary phases, the FEA model was designed to deal with aspect ratio and dielectric constants of microdefects ranging from 0.2 to 5.0 and 1 to 1000, respectively. For defect part with a lower dielectric constant than the solid part, including pores and secondary phases, as the aspect ratio of the defect part decreases (it becomes longer in the direction perpendicular to the electric field), the maximum electric field enhancement factor at the lateral surface of the defect part becomes higher. On the other hand, for defect part with a higher dielectric constant than the solid part, including grain boundary phases, the exact opposite behavior was observed. Moreover, it was also predicted that fine grain boundary phases act as a stronger source of electric field enhancement than coarse pores. These insights will provide a good indicator to identify the origin of dielectric breakdown of ceramics.

3:50 PM

(ICACC-GYIF-005-2026) Fully synthetic SEM dataset generation for machine learning based microstructure recognition in sintered alumina (Invited)

Y. Akiba*[1]; T. Mitani[1]; T. Murakami[1]; K. Aoki[1]; Y. Nakashima[2]; K. Hirao[2]; M. Fukushima[2]

1. Chukyo University, School of Engineering, Japan
2. National Institute of Advanced Industrial Science and Technology (AIST), Japan

In recent years, neural networks have made significant progress in the automatic recognition of microstructures in SEM images, which reveal the internal structure of sintered alumina. However, constructing such networks requires datasets of at least several hundred to thousands of images, making their creation highly labor-intensive. This study proposes a method to automate dataset construction by synthesizing SEM images of arbitrary alumina using deep generative models and employing them as synthetic training data. Since training the generative model itself requires a dedicated dataset, creating it manually would undermine the benefits of automation. To address this, we present a methodology for automatically constructing the generative model in addition to existing techniques for generating SEM images. Moreover, training with synthetic images can exhibit degraded recognition performance compared to training with real ones, depending on their quality. To mitigate this, we examine the requirements for synthetic images, including the geometric features and statistical properties of microstructures, as well as the texture characteristics of SEM images. This presentation is based on results obtained from a project, JPNP22005, commissioned by the New Energy and Industrial Technology Development Organization (NEDO).

4:20 PM

(ICACC-GYIF-006-2026) Accelerated discovery of oxidation-resistant ultra-high temperature ceramics via data-driven methodology (Invited)

K. Wang*[1]

1. Alfred University, USA

Machine learning (ML) methods have been successfully applied to predict phase formation and properties of novel materials, such as high entropy materials. However, the application of ML approach in high entropy ceramics (HECs) used in extreme environments, such as nuclear reactors and hypersonic vehicles etc., remains limited due to the serious data scarcity as well as data quality issues. Herein, the machine learning (ML) model is trained on data collected via high-throughput experiments (HTEs). Because the experiment was conducted under the same conditions, HTEs enable generating high-quality dataset for ML training. The experimental validation is performed to examine the performance of the ML model. In addition, the ML is also applied to inversely understand the underlying physical mechanisms. For instance, we demonstrate that a mismatch of the bonds between boron and transition metals (δB-TM) dominates the formation of HEBs. We propose an empirical rule that HEBs favor forming a single phase when δB-TM < 3.66; otherwise, multiphase. The rule has a high accuracy of 93.33% for new HEBs predictions. Additionally, we are the first attempt to apply high-throughput experiments (HTEs) assisted data-driven strategy in the prediction of oxidation recession of HEBs-SiC ceramic composites.

4:50 PM

(ICACC-GYIF-007-2026) The making and breaking of Max Phases: From processing and stability to deformation

M. Dujovic*[1]; A. Srivastava[1]; M. Radovic[1]

1. Texas A&M University, Department of Materials Science and Engineering, USA

MAX phases, a family of layered ternary carbides and nitrides, attract significant interest due to their unusual combination of properties. Beyond this, they serve as precursors to MXenes, two-dimensional nanosheets formed by selective A-layer etching. MXenes exhibit tunable surface chemistries and outstanding electronic and mechanical behavior. Despite extensive study, several aspects of MAX phases and their transformation to MXenes remain underexplored. This work focuses on three directions: (i) expanding compositional design through compositionally complex MAX phases (CCMAX), (ii) clarifying deformation and fracture mechanisms at the single-crystal level, and (iii) probing atomistic details of the MAX-to-MXene etching process. To realize CCMAX, M_2AlC systems with two to five equiatomic transition metals (Cr, Ti, Ta, V, Nb) were synthesized using single-element M_2AlC precursors instead of mixed powders, enabling precise M-site control with fixed Al and C. In-situ fracture experiments on MAX single crystals revealed how their layered hexagonal bonding governs fracture and failure. Finally, an atomistic analysis of delamination revealed the interplay between cracking and etching. Collectively, these findings advance the understanding of MAX phases and MXenes, providing strategies to design, process, and exploit this versatile materials platform for structural and functional technologies.

FS1 Bioinspiration/Green Processing & Related Technologies of Advanced Materials

FS1- Bioinspiration, Green Processing, and Related Technologies of Advanced Materials

Room: Coquina G
Session Chairs: Hang Ping, Wuhan University of Technology; Tengteng Tang, University of Virginia

1:30 PM

(ICACC-FS1-001-2026) Calcitic skeletal structures in selected organisms: Form, function, and formation (Invited)

L. Li*[1]

1. University of Pennsylvania, Materials Science and Engineering, USA

Organisms construct a variety of biological materials for different purposes, such as protection, predation, body support, and camouflage. Many of these materials are mineralized, where calcite, a polymorph of calcium carbonate, is one of the common candidate minerals. Even though pure calcite is considered to have poor intrinsic mechanical properties, such as easy cleavage and softness, calcitic biological materials are often able to achieve enhanced mechanical properties. Moreover, many of them offer additional functionalities simultaneously, such as low density, coloration, transparency, visual sensitivity, etc. Understanding the mechanisms by which organisms form these complex bioceramics offers important insights for developing process-inspired strategies in advanced ceramic fabrication. In this talk, I will present our work in elucidating the hierarchical structure, multifunctional design, and formation mechanisms of selected biogenic calcite material systems.

2:00 PM

(ICACC-FS1-002-2026) Bioinspiration from mouse epiphysis gradient: Coupling tissue porosity and mineralization to balance mechanical and biological demands (Invited)

T. Tang*[1]; J. Zhong[2]; J. Hu[3]; V. Schemenz[4]; A. Davydok[5]; R. Brunner[6]; J. Zhou[7]; W. Wagermaier[2]; A. Pitsillides[8]; W. Landis[9]; P. Fratzl[2]; J. Chen[3]

1. University of Virginia, Mechanical and Aerospace Engineering, USA
2. Max-Planck-Institut fur Kolloid und Grenzflachenforschung, Biomaterials, Germany
3. University of Exeter, Faculty of Engineering, United Kingdom
4. Charite - Universitatsmedizin Berlin, Department for Operative, Preventive and Pediatric Dentistry, Germany
5. Helmholtz Zentrum Hereon, Institute of Materials Physics, Germany
6. Materials Center Leoben Forschung GmbH, Austria
7. Showa Daigaku, Department of Biomaterials and Engineering, Japan
8. Royal Veterinary College, Comparative Biomedical Sciences, United Kingdom
9. University of California San Francisco, Department of Preventive and Restorative Dental Sciences, USA

Engineered graded materials often face trade-offs: increasing stiffness can reduce compliance for fluid movement, while lowering stiffness may undermine mechanical integrity. This balance matters in applications such as osteochondral repair scaffolds where interstitial flow is essential. We examined a biological model that manages both needs. In young mice, the femoral head surface sits on epiphyseal cartilage, creating a cartilage-only joint that must carry complex forces and keep cells alive. Using multiscale 3D imaging and quantitative morphometry, we mapped depth-resolved changes in chondrocyte lacunae (density, volume, sphericity, interconnectivity, and orientation) together with extracellular mineral content from the articular surface toward the growth plate. Deep regions contained larger, more spherical, and more clustered lacunae, whereas superficial and growth-plate-adjacent zones contained smaller, elongated lacunae with stronger alignment. Higher mineral content occurred where tissue porosity was greater in deep regions.

This correlation suggests mineralization increases where tissue porosity rises, helping maintain apparent stiffness while preserving compliance that may support fluid flow and nutrient delivery. The study provides bioinspired cues for graded ceramics and composites design to balance stiffness with permeability.

2:30 PM

(ICACC-FS1-003-2026) Understanding the strength and fracture behavior of cold sintered ceramics (Invited)

A. Jabr*[1]; P. Supancic[1]; C. Randall[2]; R. Bermejo[1]

1. Montanuniversitat Leoben, Department of Materials Science, Austria
2. The Pennsylvania State University, Department of Materials Science and Engineering, USA

The cold sintering process (CSP) enables densification at low temperatures (<350°C) by utilizing a chemically active liquid phase and applied pressure. This offers a sustainable processing route with unprecedented opportunities for materials integration and grain boundary design. Employing CSP as an alternative technique requires understanding the mechanical reliability of cold sintered ceramics, especially regarding subcritical crack growth (SCCG) under in-service (humid) conditions. This work investigates the mechanical behavior and long-term reliability of cold sintered ZnO (140°C) in comparison to conventionally sintered ZnO (1000°C), both with controlled microstructures. The mechanical response of the cold sintered samples was found to be governed by a grain size effect, promoting intergranular fracture along nanometric grains. The results show that cold sintered ceramics exhibit fracture behavior typical of nano-ceramics, showing high hardness but low fracture toughness. Lifetime testing revealed that both cold and conventionally sintered ZnO are susceptible to SCCG. Nevertheless, CSP samples show a significantly higher threshold stress intensity factor, below which no SCCG occurs. These findings highlight the potential of CSP and offer important insights into ensuring their mechanical reliability and lifetime performance.

3:20 PM

(ICACC-FS1-004-2026) Bioprocessing-inspired synthesis of prestressed artificial composites with high performance (Invited)

H. Ping*[1]; H. Xie[1]; Z. Fu[2]

1. Wuhan University of Technology, China
2. Wuhan University of Technology, State Key Lab of Advanced Technology for Materials Synthesis and Processing, China

The natural formation process of biominerals is temporally and spatially regulated by biomolecules within confined environments. These confined spaces, characterized by specific chemical compositions and precise spatial arrangements, govern the development of complex natural structures. Learning from the structure-forming process, new structures are designed and synthesized in deliberated confined systems, such as collagen fibrils. Collagen fibrils provide biological confinements for the formation of hierarchical structure with periodic arrangement. A variety of inorganic materials—such as hydroxyapatite, calcium fluoride, strontium carbonate, and calcium carbonate nanocrystals—can be deposited within collagen matrices, thereby enabling a clear understanding of the kinetics involved in the formation of new structures within confined spaces. Moreover, a newly observed phenomenon reveals that megapascal-level contractile stress is generated during intrafibrillar collagen mineralization. Leveraging this prestress effect, a laminated composite material was fabricated, exhibiting a flexural strength of 220 MPa and a fracture toughness of 6 MPa.m$^{1/2}$. With continued advancements in understanding biological processes, future innovations in structural design and functional properties can be rationally engineered.

3:50 PM

(ICACC-FS1-005-2026) Controlling freeze casting through energized fields

S. E. Naleway*[1]

1. University of Utah, Department of Mechanical Engineering, USA

Freeze casting is a bioinspired technique for the fabrication of tailored, porous ceramic materials with structuring down to the nanoscale. Mimetic of the growth of mammalian bone and other biomaterials where biopolymers template the deposit of biominerals to create complex composites, freeze casting employs a template of growing ice crystals to create a complex porous microstructure in any ceramic. We propose that this bioinspired technique can be controlled through either intrinsic (those that modify from within by altering the constituents) or extrinsic (those that apply external forces or templates) means. Through these classifications, examples of extrinsic (through energized external fields) freeze cast, bioinspired structures will be discussed with a focus mimicking the structure of natural bone. Both experimental and computational results will be discussed.

4:10 PM

(ICACC-FS1-006-2026) Toward a greener synthesis of boron carbide

B. Bonaldo*[1]; S. Dirè[1]; E. Callone[1]; R. Rovai[2]; S. Signorello[2]; G. S. Arroyo Palacios[2]; V. M. Sglavo[1]

1. Universita degli Studi di Trento, Italy
2. Industrie Bitossi SpA, Italy

Boron carbide (B4C) is a ceramic material widely used in armor, energy and electronic components thanks to its hardness, low density and high chemical resistance. It is typically produced using the Acheson process, which involves the carbothermal reduction of boron oxide using carbon derived from coal in electric arc furnaces at temperatures exceeding 2000°C. Despite its industrial relevance, this method is highly energy-intensive, generates significant emissions and requires expensive post-synthesis purification, resulting in a costly process. To address these issues, the present work explores a polyol-based approach to produce B4C in an environmentally friendly way. This route enables the formation of crystalline powders at significantly lower temperatures (<1500°C), resulting in fine particles with a diameter below 10 μm. Improved stoichiometric control and more homogeneous powders with minimal contamination can be obtained, thus reducing also the environmental impact. Coupled thermoanalytical and FTIR studies confirm clean precursor decomposition with limited by-products, while XRD, SEM and solid-state 11B NMR analyses demonstrate the formation of crystalline, high-purity B4C powders with micrometric particle sizes. The obtained results provide critical validation of the proposed approach, which is expected to reduce energy consumption and enhance sustainability.

4:30 PM

(ICACC-FS1-007-2026) Stabilization and crystallization mechanism of amorphous calcium carbonate

Q. Wang*[1]

1. Wuhan University of Technology, China

Amorphous phases hold great promise in diverse applications and are widely used by organisms as precursors to produce biominerals with complex morphologies and excellent properties. However, the stabilization and crystallization mechanisms of amorphous phases are not fully understood, especially in the presence of additives. Here, using amorphous calcium carbonate (ACC) as the model system, we systematically investigate the crystallization pathways of amorphous phases in the presence of poly(Aspartic acid) (pAsp). Results show that pure ACC transforms into a mixture of calcite and vaterite via the typical dissolution-recrystallization mechanism. Moreover, the inhibition effect of calcite growth from solution ions becomes more prominent with the increase of pAsp chain length or concentration, which significantly improves the stability of the amorphous phase and leads to crystallization of spherical or elongated calcite via the nonclassical particle attachment mechanism after pseudomorphic transformation of ACC into vaterite nanoparticles, providing guidelines for controlling the polymorph selection and morphology of crystals during the crystallization of amorphous precursors.

4:50 PM

(ICACC-FS1-008-2026) Bioprocessing-inspired mineralization technology (Invited)

Z. Zou*[1]; Z. Fu[2]

1. Wuhan University of Technology, China
2. Wuhan University of Technology, State Key Lab of Advanced Technology for Materials Synthesis and Processing, China

Revealing the crystallization mechanism of inorganic materials modulated by organic molecules has broad implications in biomineralization, crystallography, and materials science. However, directly visualizing the participation of organic molecules in the inorganic materials crystallization process remains a significant challenge. Here, we introduce carboxyl-functionalized gold nanoclusters (AuNCs) as an alternative to polymers for investigating crystallization of calcium carbonate and calcium phosphate via the transient "AuNCs-induced liquid precursor" phase. Exploiting the ultrasmall size, high density and spontaneous fluorescence properties of AuNCs, this approach enables direct in situ observation of liquid precursor formation and dynamic association/dissociation using light microscopy. The occlusion and 3D spatial distribution of AuNCs within minerals throughout the crystallization process can be visualized using confocal fluorescence microscopy and transmission electron microscopy. We also demonstrate AuNCs with specific ligands can induce collagen intrafibriallar mineralization. This study significantly advances our understanding of the roles of biomacromolecules during biomineralization and provides a promising tool for investigating crystallization mechanisms. Thus, the study provides a new bioprocessing-inspired mineralization technique for the fabrication of advanced materials.

S1 Mechanical Behavior and Performance of Ceramics & Composites

S1- Ceramics for concentrated solar-thermal power and industrial process heat

Room: Coquina E

Session Chairs: Dileep Singh, Argonne National Lab; Kamala Raghavan, Department of Energy

1:30 PM

(ICACC-S1-001-2026) Towards scale-up and testing of ceramic components for concentrating solar thermal technologies: Current status and future directions (Invited)

K. C. Raghavan*[1]

1. Department of Energy, USA

Concentrating solar-thermal (CST) plants are designed to capture the sun's energy using a collector field and convert it into thermal energy that can be stored and dispatched on-demand, making it a valuable resource for power generation and for thermally driven industrial (TDI) processes. The most current CST power technology operates at ~700°C to meet the cost target of $0.05/kWh set by the U. S. Department of Energy (DOE). Also, several TDI processes operate between 600°C and 1200°C. To meet such high temperature operation requirements DOE has continued to invest in high temperature material and manufacturing R&D for the past few years. These efforts have involved identifying ceramic materials that can survive high temperatures & in developing suitable manufacturing methods that have potential for scaling both in capacity and volume. Since, there has been tremendous progress towards scale up & on-field testing of ceramic material components, specifically of silicon carbide. Future efforts at DOE aims to expand ceramics materials portfolio to further broaden the impact of ceramics for CST applications. This presentation offers an overview of the ongoing efforts in ceramic materials for CST technologies. It highlights both the progress made to date & the future direction of ceramic materials and their crucial role in advancing CST applications.

2:00 PM

(ICACC-S1-002-2026) Performance evaluation of an additively manufactured High Operating Temperature SiC Solar-Thermal Air Receiver Test Module

R. Sarrafi-Nour[1]; J. Shiang[3]; K. Armijo[4]; K. C. Raghavan*[2]

1. GE Aerospace, Research Center, USA
2. Department of Energy, USA
3. GE Aerospace, USA
4. Sandia National Laboratories, NTSS, USA

Increasing operating temperatures of solar receivers is paramount to the efficiency of concentrated solar thermal and solar power systems. GE Aerospace Research in collaboration with Heliogen Inc and Sandia National Laboratories (SNL) is engaged in the development of ultra-High Operating Temperature SiC-matrix Solar Thermal Air Receiver (HOTSSTAR) enabled by additive manufacturing. HOTSSTAR goal is to demonstrate SiC receiver with air exit temperatures up to 1100°C. We discuss fabrication and on-sun test results of a prototype 50kW$_{th}$ test module. The receiver architecture is based on a radial airflow design and consists of a series of radial SiC receiver sectors organized around central absorber. These components were fabricated using binder-jet printed SiC followed by melt-infiltration reaction bonding process. To enhance the thermo-mechanical reliability of SiC test articles in thermal gradient/ shock environment of the application, the components were laminated with GE's MI SiC CMC. A dedicated test facility was constructed at SNL Solar Tower to evaluate the operational performance of HOTSSTAR module under solar fluxes >200 W/cm^2. We report on the test results and compare the performance of HOTSSTAR module relative to our model.

2:20 PM

(ICACC-S1-003-2026) Design and construction of a Test Bed for On-Sun Testing of an ultra- High Operating Temperature SiC Solar-Thermal Air Receiver (HOTSSTAR) Test Module

K. Armijo*[3]; J. Shiang[2]; R. Sarrafi-Nour[2]; K. C. Raghavan[1]

1. Department of Energy, USA
2. GE Aerospace, USA
3. Sandia National Laboratories, NSTTF, USA

Increasing operating temperatures of solar receivers is paramount to the efficiency of concentrated solar thermal and solar power (CST/P) systems. Supported by an award from the Solar Technology Office (SETO), US Department of Energy (DOE), GE Aerospace Research in collaboration with Heliogen Holdings Inc and Sandia National Laboratories, is engaged in development and demonstration of ultra-High Operating Temperature SiC-matrix Solar Thermal Air Receiver (HOTSSTAR) enabled by additive manufacturing. To enable thermal performance and efficiency validation experiments of a >50 kW$_{th}$ HOTSSTAR demo module, which has targeted exit air temperatures of up to 1,100°C, Sandia National Laboratories designed and constructed a dedicated air receiver test bed and the supporting test facility infrastructure. We will discuss the test facility design and approaches taken to enable prolonged reliable operations of the test bed under highly concentrated solar flux >200W/cm^2 under extreme receiver surface and air exit temperatures. We will also discuss integration and commissioning of the 50kW$_{th}$ test module with the solar tower test bed including customized temperature monitoring and thermal imaging for this test facility. We will review example test results demonstrating the operation of the test facility and the HOTSSTAR test module.

2:40 PM

(ICACC-S1-004-2026) Reliability testing of ceramic tubes for concentrating solar power applications

B. Barua*[1]; W. Yu[1]; F. Sultana[1]; M. C. Messner[1]; D. Singh[1]

1. Argonne National Laboratory, USA

Concentrating solar power (CSP) technologies are advancing to increase efficiency and meet industrial heat demands by operating at higher temperatures, which challenges the limits of metallic materials such as nickel-based superalloys. Advanced ceramics, with superior high-temperature properties, offer a promising alternative for CSP components. However, their reliability under extreme conditions must be rigorously validated to ensure long-term system performance and safety. Existing reliability models for high-temperature ceramics are typically based on 4-point bend test data and lack validation against actual component failures, limiting their accuracy in predicting real-world performance. This gap can lead to inaccurate predictions of plant economics and component lifetimes. Dedicated component testing is costly and rare, and current reliability models are seldom applied within the CSP community. This work addresses these challenges by developing a specialized facility for ceramic tube burst testing and validating reliability models using quasi-component test data. The results will inform improvements to multi-axial stress expressions and enhance the accuracy of reliability predictions for ceramic components in CSP applications, supporting safer and more cost-effective plant operations.

3:20 PM

(ICACC-S1-005-2026) SiC based heat exchanger for high temperature high pressure (HTHP) applications (Invited)

D. Singh*[1]

1. Argonne National Lab, USA

Several high-temperature and high-pressure (HTHP) applications in power generation and manufacturing require heat exchangers (HXs) to transfer heat. One such application is in concentrated solar power (CSP) where a fluid is heated up using solar radiation and the heat is transferred to another fluid to use it to run a turbine or use it as process heat. For CSP, HTHP HXs need to operate above 700°C and up to 20 MPa fluid pressures for efficient heat transfer. At these temperatures and pressures, metal heat exchangers degrade in structural performance. In this regard, heat exchangers based on advanced materials such as silicon carbide (SiC) are needed. In this presentation, design and development of a SiC-based heat exchanger will be discussed. Ceramic-to-metal approach to integrate the heat exchanger for performance testing will be presented. Efforts related to process scale-up of the SiC HX will be highlighted. Finally, results on the performance testing under realistic conditions will be presented. This work was supported by the U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) under the Solar Energy Technologies Office (SETO) Award Number 38479 at Argonne National Laboratory operated under Contract no. DE-AC02-06CH11357 by the UChicago Argonne, LLC.

3:50 PM

(ICACC-S1-006-2026) Tribological Behavior of Ti_3SiC_2-SiC MAX Phase composites (Invited)

D. Singh*[1]; S. Bajpai[2]; O. Ajayi[2]; C. Martin[2]

1. Argonne National Lab, USA
2. Argonne National Laboratory, Applied Materials Division, USA

Ti_3SiC_2 is a layered ternary MAX phase compound comprising a transition metal (M), an A-group element (A), and carbon (X), possessing low density (4.5 g/cm^3), good mechanical, and lubricating properties. For several thermal systems, the wear and erosion of MAX phase materials become an important concern, which in this study is addressed by conducting ball-on-disk tribological tests. Ti_3SiC_2 composites were produced by reactive spark plasma sintering at 1,400 °C, 40 MPa for 15 mins achieving ~99% density with ~90% Ti_3SiC_2 and ~10% TiC. Tribological tests against alumina ball sliding at 0.5N- 10N load, revealed a coefficient of friction (CoF) of ~0.85, with abrasive wear of MAX Phase as dominating mechanism including cracks, delamination, grain pull outs etc. The addition of hard SiC particles as reinforcement mitigated crack propagation and reduced wear, demonstrating improved durability and making the composite a promising candidate for high-temperature heat exchanger applications in CSP systems. This work was supported by the U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) under the Solar Energy Technologies Office (SETO) Award Number 35928 at Argonne National Laboratory operated under Contract no. DE-AC02-06CH11357 by the UChicago Argonne, LLC.

4:20 PM

(ICACC-S1-007-2026) Joining of SiC to metals by tape casting and reaction sintering method

S. Jana*[1]; J. Matyas[2]

1. Pacific Northwest National Laboratory, USA
2. PNNL, Radiological Materials & Detection, USA

This research aims at innovative joining solutions for integration of SiC ceramic to structural materials (stainless steels /Ni alloys). Primary application is focused on the use of SiC in a high-temperature concentrated solar thermal plant. Metallurgical bonding between SiC and stainless-steel blank has been achieved by using an interlayer alloy in between SiC and the metal blank. Metallurgical bonding between SiC and target metal blank is based on the formation of appropriate silicide/carbide phase in the interlayer region. Additionally, creation of a graded interlayer has been tried to accommodate thermal and physical property mismatch at the interface between SiC and the metal blank. A number of elements such as Ti, Ni, W, Mo etc. have been selected as possible interlayer alloy candidates based on available literature data. Powder metallurgy approach has been utilized to fabricate the interlayer. Specifically, tape casting method is used to create several micron-thick films of target composition, which are later stacked by lamination/warm pressing to create a mm-thick interlayer. Subsequently, joining trials in SiC blank/interlayer/metal blank have been conducted through sintering treatment. Joint interface has been characterized by SEM, and indentation method. Evidence of reaction sintering in the interlayer region has been confirmed.

S1- Functionally graded materials and multilayer ceramic systems

Room: Coquina E

Session Chair: Kamala Raghavan, Department of Energy

4:40 PM

(ICACC-S1-008-2026) Graded CMCs (Invited)

J. Binner*[1]; B. Steadman[1]; V. Venkatachalam[1]

1. University of Birmingham, Ceramic Science & Engineering, United Kingdom

Ultra-high temperature ceramic matrix composites (UHTCMCs) based on borides with continuous carbon fibres are an exciting new class of materials that have the potential to be used in extreme environments. Based on the different potential applications, the materials can be designed with the required features such as the ceramic composition and content, directionality and nature of the fibre reinforcement and (if required) level of porosity. Most composites have an homogenous matrix and are manufactured by stacking 2D fibre sheets, however the ability to take woven fibre preforms and vary the matrix composition as a function of location, and to do so in a functionally gradient manner, offers tremendous flexibility – for example, to have a UHTC ceramic at the surface and SiC in the interior, thus saving mass and cost. This has been investigated in programme designed to create high-quality UHTCMCs with a view to determining the potential for manufacturing functionally graded materials. Chemical vapour infiltration, CVI, of carbon has been used to complete the infiltration of the matrix and then the mechanical and thermo-ablative qualities of UHTCMCs formed have been determined.

5:10 PM

(ICACC-S1-009-2026) Laser cladding of Fe/WC composite coatings on ductile iron using Inconel 625 transition layer for industrial wear and corrosion applications

Y. Wang*[1]

1. Northeastern University, Mechanical Engineering, China

For the first time, Inconel 625 is introduced as a transition layer in the laser cladding of Fe/WC composite coatings on ductile iron (DI), differing from conventional approaches where Inconel is blended directly with Fe/WC powders. This transition-layer Inconel 625 strategy effectively suppresses carbon diffusion from the substrate, reduces porosity and cracking, and establishes robust metallurgical bonding—addressing key limitations of traditional Fe/WC coatings. Microstructural analysis reveals refined dendritic and equiaxed grains, uniform element diffusion, and improved WC particle retention. These features result in solid-solution strengthening, enhanced hardness, and wear resistance. Electrochemical tests show nearly 22-fold higher charge transfer resistance compared with mixed-powder coatings, confirming superior corrosion protection. This study demonstrates a reproducible and efficient methodology for fabricating durable coatings on DI, offering direct relevance to aerospace, marine, energy, and heavy machinery applications where components operate under combined wear and corrosion conditions.

S2 Advanced Ceramic Coatings for Structural/Environmental & Functional Applications

S2- CMAS-type degradation of T/EBC: Fundamentals, modeling, and mitigation strategies

Room: Coquina C
Session Chair: Douglas Wolfe, Pennsylvania State University

1:30 PM

(ICACC-S2-001-2026) Investigating the spatiotemporal effects of CMAS on thermal barrier coatings (Invited)

Z. Stein*[1]; P. Kenesei[2]; J. Park[2]; J. Almer[2]; J. Wischek[3]; M. Bartsch[3]; U. Schulz[3]; R. Naraparaju[3]; S. Raghavan[1]

1. Embry-Riddle Aeronautical University, Aerospace Engineering, USA
2. Argonne National Laboratory Advanced Photon Source, USA
3. Deutsches Zentrum fur Luft- und Raumfahrt DLR, Institute for Frontiers Materials on Earth and in Space, Germany

In sand-abundant regions, calcium-magnesium-aluminosilicates (CMAS) ingested into aircraft engines enter the turbine section, resulting in molten deposits onto thermal barrier coatings (TBC) that protect the blades. The infiltration of CMAS into the columnar structure of the 7wt% yttria-stabilized zirconia (YSZ) electron beam phase vapor deposition (EB-PVD) TBCs initiates chemical and mechanical changes linked to an interplay of complex spatial and time dependent dynamics of the coating eventually leading to spallation failure. A series of high-resolution Raman and in-situ synchrotron experiments presented here details the spatiotemporal changes to clarify the effect of these dynamics. Microstructural data from ex-situ Raman studies on samples exposed at time intervals reveal higher monoclinic phase concentration along column edges due to surface exposure and demonstrate that the majority of thermochemical changes occur within the first hour of infiltration. In-situ synchrotron studies with thermal gradients reveal rapid physical infiltration within minutes where microstructure governs the depth of infiltration. Results further quantify the temporal lag in phase change. The findings provide knowledge that will guide tailoring of coatings for CMAS mitigation ensuring that the protection of intercolumnar gap regions and interplay between thermomechanical and thermochemical effects are considered.

2:00 PM

(ICACC-S2-002-2026) Evaluation of particle degradation of a ytterbium disilicate gas turbine coating in a combustion environment ***WITHDRAWN***

J. L. Stokes*[1]; M. J. Presby[1]

1. NASA Glenn Research Center, Environmental Effects and Coatings Branch, USA

Ytterbium disilicate ($Yb_2Si_2O_7$) is a state-of-the-art topcoat material used in environmental barrier coatings (EBCs) to protect SiC-SiC composites from water vapor corrosion in gas turbine engines. However, it's degradation by thermochemical and thermomechanical particle interactions may limit its use in next generation engine systems. Several static furnace tests have been performed on $Yb_2Si_2O_7$ to elucidate methods of degradation, although dynamic testing in an engine-relevant environment has not been carried out. Ultimately, testing and evaluation of materials that incorporates all environmental damage modes will allow for an accurate assessment of long-term durability and operating lifetime. This work details the investigation of particle-induced erosion and corrosion of $Yb_2Si_2O_7$ in NASA Glenn's Erosion Burner Rig Facility. Coating durability was investigated as a function of test temperature, particle size, and deposition rate. Thermal cycling was also incorporated into testing to determine the interplay of heating/cooling cycles with particle degradation. Overall, these analyses will be used to determine coating robustness in an engine relevant environment.

2:20 PM

(ICACC-S2-003-2026) Post-corrosion analysis of CMAS attacked high-entropy rare-earth zirconates

J. J. Pflug*[1]; M. E. Schweser[1]; M. Lepple[1]

1. Justus-Liebig-Universitat Giessen, Institute of Inorganic and Analytical Chemistry, Germany

Rare-earth zirconates ($A_2Zr_2O_7$) are one of the material systems at the forefront of material research for use as future thermal barrier coatings (TBCs). The application of the high-entropy approach to these compounds via the equimolar mixing of five or more cations at the A site leads to reduced thermal conductivity and slower sintering rates. Regarding the applicability as environmental barrier coating (EBC), a high corrosion resistance against molten sands, ashes, and mineral dust, which are mainly composed of calcia, magnesia, alumina and silica (short: CMAS), is crucial. This work investigates the resistance of multicomponent rare-earth zirconates against CMAS corrosion in bulk and layered systems from ultra short (5 min) to extended (200 h) reaction times. Additionally, the composition of the corrodant was varied to represent the reactivity and viscosity of different deposits, and the reaction temperature was altered to simulate different operating conditions. Post-reaction analysis was performed using X-ray diffraction (XRD) and energy-dispersive X-ray spectroscopy (EDS) to determine the formation and composition of newly formed phases. The improvement in the materials due to the high-entropy approach was assessed through comparative studies of single-component zirconates.

2:40 PM

(ICACC-S2-004-2026) Interactions between CMAS and Nd_2O_3/Yb_2O_3: effect of the magnesia content

L. Saint-Jean*[1]; C. Petitjean[1]; P. Panteix[1]; D. Bonina[1]; S. Arnal[2]; M. Vilasi[1]

1. Universite de Lorraine, Institut Jean Lamour, France
2. Safran SA, France

Environmental and Thermal Barrier Coatings (E/TBC) are required to protect turbine blades against degradation. In both cases they are made of rare earth based compounds. They are subject to high temperature corrosion due to their interaction with molten calcium-magnesium-aluminosilicates (CMAS) wich infiltrates into the coating porosities. These infiltrations lead to the dissolution of the coating materials into the melt following an acido-basic process, and the precipitation of various phases (e.g. apatite and cyclosilicate). Both compositions of the coating and of the melt can modify the thermodynamic equilibrium and the composition of the formed phases. The scope of this work is to study the precipitation mechanism of those phases in different environments at 1300°C. C(M)AS with different contents of magnesia (0 to 20 mol.%) have been studied considering the potential influence of MgO on the extent of the liquid domain of the CMAS and on the basicity of the medium. Two rare earth oxides have been selected with rare earth cations exhibiting very different ionic radii, i.e. Nd_2O_3 and Yb_2O_3. Interactions of the different C(M)AS with both single oxides and with one equimolar mix have been characterized after 25 h at 1300°C: in all cases, a solid solution of apatite in equilibrium with the liquid is observed starting from oxides. The morphology and composition of those phases are discussed.

3:20 PM

(ICACC-S2-005-2026) Multi-phase, rare earth-based thermal barrier coatings for enhanced CMAS resistance and mechanical durability

E. Bartlett*[1]; D. L. Poerschke[1]

1. University of Minnesota, Chemical Engineering and Materials Science, USA

Rare earth zirconates have proven to be an effective thermal barrier coating (TBC) due to their low thermal conductivity and ability to withstand molten calcium magnesium aluminosilicate (CMAS) deposits that infiltrate and react with the TBC and generate stresses due to volume changes and thermal expansion mismatch. The favorable reactivity of these zirconates is offset by their low fracture toughness. Materials exhibiting increased fracture toughness and/or improved ability to resist CMAS infiltration would lead to better performance and extended lifetimes. This work investigates multiphase rare earth aluminate-zirconate composite TBC materials with selected cation substitutions intended to improve CMAS resistance and/or fracture toughness. The results, which illustrate the effect of rare earth cation size and secondary cation concentration, will be discussed in the context of next generation coating designs.

3:40 PM

(ICACC-S2-006-2026) CMAS corrosion studies with single crystals of T/EBC materials

P. Mechnich*[1]

1. DLR - German Aerospace Center, Institute of Frontier Materials on Earth and in Space, Germany

A key load during operation of turbine engines is thermal-chemical recession of hot components and protective thermal/environmental barrier coatings (T/EBC) by ingested airborne mineral dust particles, commonly referred to as CMAS corrosion. The interaction of T/EBC materials and coating microstructures with CMAS-type mineral deposits has been studied extensively in the past years. Even though the fundamental decomposition mechanisms could be deciphered for most of the state-of-the-art T/EBC materials, there are still some open questions regarding the influence of specific microstructures on recession kinetics. The presentation deals with the use of single-crystal, i.e. fully dense and grain-boundary-free materials for thermo-chemical interaction experiments with various CMAS-type mineral mixtures. Studies are performed with single crystals of YAG, Y-silicates, and YSZ with spherical CMAS particles in a heating microscope which allows a detailed analysis of melting and wetting behaviors.

S2- Processing of ceramic coatings (thermal spraying, PVD, CVD, aerosol-, polymer-, and powder-deposition and sintering)

Room: Coquina C
Session Chair: Peter Mechnich, DLR - German Aerospace Center

4:00 PM

(ICACC-S2-007-2026) Formulation and microstructural evolution of multi-component rare earth oxide thermal barrier coatings via slurry deposition

C. Massignan*[1]; P. Nape[1]; C. Whiting[1]; M. Vempuluru[1]; C. Tallon[1]

1. Virginia Polytechnic Institute and State University, Materials Science and Engineering, USA

Thermal Barrier Coatings (TBCs), composed of multi-component rare earth oxides (REOs), offer tunable properties for high-temperature applications due to their low thermal conductivity, high melting temperature, and low coefficient of thermal expansion. Slurry deposition of coatings is a cost-effective alternative to state-of- the-art air plasma spray methods. This study investigates a ternary REO system comprising yttria (Y_2O_3), erbia (Er_2O_3), and ytterbia (Yb_2O_3), in different molar ratios, to assess its suitability as a single-layer TBC material. Slip-cast and slurry-sprayed samples were fabricated at varying volume percentages and sintered under controlled conditions to explore the influence of particle packing and sintering parameters on densification behavior. Emphasis was placed on optimizing the slurry formulation to systematically investigate varying concentrations of the three REO components influencing the rheological behavior and particle packing of components consisting of slip-cast and slurry-spray coatings. Preliminary results suggest that sintering environment and temperature significantly affect final density and coating integrity, as well as the percentage of yttria, warranting further investigation into the thermophysical interactions among REO constituents during thermal treatment.

4:20 PM

(ICACC-S2-008-2026) Cold spray and micro-cold spray of ceramic films using vented nozzles

L. McAuliffe[1]; S. Bierschenk[1]; C. Roper[2]; J. Williamson[2]; S. Murray[2]; D. Kovar*[1]

1. The University of Texas at Austin Cockrell School of Engineering, USA
2. Sandia National Laboratories, USA

The micro cold spray process (MCS), also known as aerosol deposition, and low pressure colds spray, is a manufacturing process capable of depositing metal and ceramic films at room temperature. Films are produced by impacting solid sub-micron to micron-scale particles at high enough velocities that they deform, stick and form dense films. A particular challenge for MCS is the relatively narrow range of impact velocities and particle sizes that result in film formation. Particles impacting below a critical velocity bounce off the substrate without sticking and particle velocities and/or sizes above a critical value result in erosion rather than film formation. A novel vented nozzle design has been developed preferentially increases the impact velocities for finer particles. For typical powders that have a distribution in sizes, this signficantly increases the deposition efficiency by broadening the processing window for successful deposition. A similar vented nozzle design has also been demonstrated that allows deposition of ceramics using conventional high pressure cold spray. Deposition results are presented for a range of ceramic and metals.

S2- Advanced destructive and non-destructive characterization methods

Room: Coquina C
Session Chair: Peter Mechnich, DLR - German Aerospace Center

4:40 PM

(ICACC-S2-010-2026) Assessing ductility and slip behavior by micropillar compression testing – A case study for transition metal nitrides

R. Hahn*[1]; M. Lorentzon[4]; Y. Huang[5]; V. Maier-Kiener[6]; N. Ghafoor[4]; Z. Zhang[5]; C. Mitterer[6]; P. Polcik[7]; S. Kolozsvári[7]; K. Boebel[3]; H. Riedl[2]

1. Christian Doppler Laboratory for Surface Engineering of high-performance Components, TU Wien, Austria, Austria
2. TU Wien, Institute of Materials Science and Technology, Austria
3. Oerlikon Surface Solutions AG, Switzerland
4. Linkopings universitet, Thin Film Physics Division, Sweden
5. Osterreichische Akademie der Wissenschaften, Erich Schmid Institute, Austria
6. Montanuniversitat Leoben, Department of Materials Science, Austria
7. Plansee Composite Materials GmbH, Germany

Ceramics are typically limited by their intrinsic brittleness, yet recent advances suggest that controlled defect structures and negative stacking fault energies can unlock plastic deformation in transition metal nitrides. In this work, we employ in-situ micromechanical testing of single-crystal and multilayer nitride thin films to uncover their deformation mechanisms. Focused ion beam-fabricated micropillars of nitrogen-rich HfN exhibit extraordinary metal-like ductility and strain hardening above 50% compressive strain, enabled by dislocation-mediated plasticity in a defect-ordered superstructure. Similarly, TiN/TaN multilayers exploit negative stacking fault energies to promote extensive faulting and twinning, achieving unprecedented room-temperature plasticity and toughness among ceramics. Extending these studies, we compare epitaxial binary nitrides: WN shows metal-like ductility comparable to HfN and TaN, while CrN and TiN display limited slip-band dominated deformation and early strain localization. These results establish micropillar compression as a powerful probe of intrinsic deformation pathways in refractory ceramics, highlighting how defect engineering and electronic structure control can bridge the gap between metallic and ceramic mechanical responses.

5:00 PM

(ICACC-S2-011-2026) Non-destructive stress measurement in TBCs via rare-earth-doped YSZ and photoluminescence piezo spectroscopy

S. Batna[1]; S. Ramachandran*[1]; A. S. Gandhi[1]

1. Indian Institute of Technology Bombay, Department of Metallurgical Engineering and Materials Science, India

Understanding the engine lifespan through constant health monitoring is key to sustainable aviation. The engine efficiency can be maintained based on the health of the turbine blades and thermal barrier coatings (TBCs). Monitoring involves the detection of residual stresses developed in the coatings during operation. Photoluminescence piezo spectroscopy (PLPS) enables non-destructive inspection of residual stress, a key factor in condition monitoring of TBC's. Determining the piezo-spectroscopic coefficient of 8 mol% yttria ($YO_{1.5}$) stabilized zirconia (YSZ), a widely employed TBC material, can be made to demonstrate photoluminescence upon rare earth doping (REO-YSZ). This study explores the effects of ppm-level doping of RE cations such as Er^{+3}, Eu^{+3}, and Sm^{+3}. Rare earth doping exhibited no phase changes in YSZ, as observed from X-ray diffraction (XRD) and Raman spectroscopy. Analysis of thermal properties, such as thermal conductivity and coefficient of thermal expansion, aligns with pristine YSZ samples. Piezo-spectroscopic coefficient (PSC) calibration was performed on all dopant compositions by subjecting them to in-situ micro compression testing under a PL spectrometer. The PSC values are essential for residual stress measurement. The concept of ppm-level doping for stress measurement opens up new avenues for non-destructive health monitoring techniques for TBCs.

S3 23rd Intl Symp on Solid Oxide Cells Materials Science & Technology

S3-System design and demonstration

Room: Coquina H
Session Chair: Tae Ho Shin, Korea Institute of Ceramic Engineering & Technology

1:30 PM

(ICACC-S3-001-2026) The SOFC Program at the DOE's Office of Fossil Energy (FE) and National Energy Technology Laboratory (NETL) (Invited)

J. Kim*[1]; P. Burke[2]

1. U.S Department of Energy, Office of Fossil Energy, USA
2. U.S Department of Energy, National Energy Technology Laboratory, USA

The Department of Energy, through National Energy Technology Laboratory (NETL), initiated the Solid-State Energy Conversion Alliance (SECA) in 1999 to develop low-cost, environmentally friendly SOFC technology to produce electricity with an emphasis on distributed generation applications. Since its inception in 1999, the SOFC program under SECA has made progress toward commercialization of SOFC systems for electricity production; stack cost has been reduced by a factor of 10, stack size has increased by a factor of 25, and the rate at which cells degrade has fallen by a factor of 10. The U.S. Department of Energy's Office of Fossil Energy and National Energy Technology Laboratory are focusing on the development of advanced technology for low-cost, highly efficient SOFC power systems that can produce electricity from coal-derived syngas and naturals gas and low water use in both distributed generation and central power generation applications. Solid oxide fuel cell technology is the most promising technology for smaller, modular scale as well as large-scale power generation and has the potential to enable natural gas power plants to achieve efficiencies above 60% HHV.

2:00 PM

(ICACC-S3-002-2026) Advanced 100kW rSOC System for Zero Emissions Energy Networks: Development from materials to system in the 24/7 ZEN Project (Invited)

M. Torrell*[1]; L. Bernadet[2]; D. Montinaro[3]; S. Anelli[7]; F. Smeacetto[4]; D. K. Niakolas[5]; A. Tarancón[6]

1. Institut de Recerca en Energia de Catalunya, Advanced Materials for Energy, Spain
2. Catalonia Institute for Energy Research, Advanced Materials for Energy Applications, Spain
3. Solydera, Italy
4. Politecnico di Torino, Applied Science and Technology, Italy
5. FORTH/ICE-HT, Greece
6. IREC / ICREA, Spain
7. Politecnico di Torino, DISAT, Italy

The 24/7 ZEN project has reached a milestone in the development of a reversible Solid Oxide Cell (rSOC) system for grid balance, transitioning from component innovation to full system integration and containerization. This European project, led by a multidisciplinary consortium, is constructing a high efficiency rSOC system with a capacity of 33kW(SOFC)/100kW(SOEC) for its integration with both electricity and gas grids. The system is designed to enable dynamic Power-to-Gas-to-Power conversion using hydrogen or natural gas, with rapid switching capabilities (<30 minutes) and a round-trip efficiency of 45%. Recent efforts have focused on packaging the system into a containerized format to facilitate deployment, scalability, and compliance with industrial standards and safety protocols. Key technological advancements include the development of high-performance SOC components with reduced degradation rates and performances exceeding 1.4W/cm^2 and 1.75 A/cm^2. These improvements are driven by new electrode materials such as Fe–Au–Ni/GDC and $La_{0.7}Sr_{0.3}Cu_{0.15}Fe_{0.85}O_{3-\delta}$ together with optimized PLD thin film barrier layers. By advancing toward a fully operational and deployable rSOC system, the project marks a significant step toward the commercial exploitation of rSOC technology and the deployment of renewable hydrogen solutions for achieving climate neutrality.

2:30 PM

(ICACC-S3-003-2026) Modelling and simulation of lightweight solid oxide fuel cells and stacking concept for aviation (Invited)

H. Geisler*[1]; P. Nehter[1]; V. Ahilan[1]; O. Rohr[2]; C. Metzner[2]

1. Airbus Deutschland GmbH, Germany
2. Airbus Defence and Space GmbH, Germany

Airbus's ZEROe project is exploring among other options hydrogen fuel cell propulsion for a future commercial aircraft. As part of this, Airbus Central Research and Technology (CRT) is investigating Solid Oxide Fuel Cells (SOFCs) for hybrid-electric systems due to their high electrical efficiency and fuel flexibility. The overall system efficiency can be improved by using SOFC waste heat to power a gas turbine. Despite recent advances, SOFC power density needs further development for aviation. Key challenges are material choice and manufacturing of lightweight SOFCs with layered metal-ceramic structures, electrical interconnection, and integrating them thermally into stacks. Airbus CRT has achieved 2 kW/kg with a microtubular anode-supported cell (ASC) at isothermal conditions, but the performance under real world stack conditions needs to be investigated to assess the cooling requirement, which directly affects balance of plant (BoP) component sizing. To address this, a multiphysics stacking concept model was created to analyze the thermal and electrical properties of segmented in series connected SOFCs, applied on a lightweight metal-ceramic support. The model aims to optimize preheating of incoming air for high power density and low excess air, while managing temperature gradients for the metal-cermic structure. This approach could theoretically exceed 5 kW/kg in stack operation.

S3-Worldwide status of SOC Development

Room: Coquina H
Session Chair: Massimo Santarelli, Politecnico di Torino

3:20 PM

(ICACC-S3-004-2026) MiCoPower's approaches to SOC applications for sustainable distributed power (Invited)

S. Choi*[1]; J. Park[1]; J. Park[1]

1. MiCoPower Co., Republic of Korea

MiCoPower has been actively developing and investing in Solid Oxide Cell (SOC) technologies for real-world applications. We have implemented mass production of SOC cells and stacks using in-house manufacturing equipment and automated quality inspection systems. We have applied advanced data analysis techniques to classify inspection data and correlate surface and structural defects with durability outcomes. By analyzing operation maps, we identified intermediate operating conditions that improve stack resilience in fuel cell (FC) and electrolysis cell (EC) modes. For commercializing fuel cells, we have developed and refined system designs for 2 kW and 8 kW power units intended for building energy supply. These systems have been optimized for field safety and operation reliability. In the distributed power generation market — ranging from a few megawatts (MW) to several tens of MW — we are developing scalable module integration technologies. These systems are designed to maintain performance and reliability while keeping costs low as capacity increases. In this presentation, we will share our operational data and field experiences across the entire development process — from SOC cell and stack fabrication to system-level integration. We will also present our technical roadmaps for SOC based applications, including SOEC deployments and ammonia-fueled SOFCs for marine environments.

3:50 PM

(ICACC-S3-005-2026) Powering forward: The latest in solid oxide stack technology at Nexceris (Invited)

G. Slupski[1]; S. Swartz*[1]

1. Nexceris, Electochemical, USA

With over three decades of experience in solid oxide technology, Nexceris has developed multiple generations of solid oxide stack platforms. This history has allowed us to develop state-of-the-art systems in SOFC, SOEC, and ReSOC. The design challenges and progress with SOEC technology will be presented and evaluated. Research into versatile materials and systems for ReSOC will be discussed in detail. Finally ultrahigh performance SOFC stack technology has proved to be a significant challenge. Nexceris has been able to demonstrate great progress to enable new and exciting applications of SOFC technology.

4:20 PM

(ICACC-S3-006-2026) Development of solid oxide cells technology at National Atomic Research Institute, Taiwan (Invited)

C. Liu*[1]; R. Lee[2]; C. Chang[3]; Y. Cheng[1]; S. Wu[1]; W. Kao[1]

1. National Atomic Research Institute, Department of Material Research, Taiwan
2. National Atomic Research Institute, Advisory Committee, Taiwan
3. National Atomic Research Institute, Department of Physics, Taiwan

Solid oxide cells (SOCs) are all-solid-state and high-efficient energy conversion devices, including solid oxide fuel cells (SOFCs) and solid oxide electrolysis cells (SOECs). SOFC is a high efficiency device for power generation; SOEC is a high efficiency device for green hydrogen, considered by the developed countries to be the most important technologies for achieving net-zero emissions. The National Atomic Energy Research Institute (NARI) has committed to developing the SOC technology since 2003 and has established capabilities "from powder to power." Our SOFC in a size of 10 cm×10 cm reaches a power density over 500 mW/cm^2 with a degradation rate less than 1 %/kh. A prototype of 5-kW SOFC power system with more compact design and higher electrical efficiency over 45 % was tested in the end of 2018. In addition, we delivered a first home-made kW-scale SOEC stack assembled with 30 cells in 2023. The hydrogen production rate reaches 1.1 m^3/h with an efficiency over 80 %. Up to now, we have held more than 200 patents about the SOC and related technologies. NARI has the ability to develop key materials, components and systems, and we have also established close connections and technology outreach with domestic industries and researches.

4:50 PM

(ICACC-S3-007-2026) Durable high-performance metal-supported solid oxide cells fabricated by plasma spraying (Invited)

C. Chang*[2]; C. Tsai[2]; C. Yang[1]; C. Yang[1]; H. He[1]; S. Wu[3]; Y. Wu[3]; R. Lee[3]

1. Institute of Nuclear Energy Research, Physics Division, Taiwan
2. National Atomic Research Institute, Department of Physics, Taiwan
3. National Atomic Research Institute, Department of Materials, Taiwan

The development of metal-supported solid oxide cells (MS-SOCs) is critical for efficient hydrogen production and carbon-neutral energy conversion. Their superior mechanical strength, thermal cycling tolerance, and compatibility with cost-effective scalable fabrication make them attractive compared to conventional SOCs. This study demonstrates that atmospheric plasma-sprayed (APS) MS-SOCs exhibit outstanding multifunctional performance with high efficiency and stability across fuel cell, electrolysis, and CO_2/H_2O co-electrolysis modes. A single MS-SOC delivered a power density of 798 mW cm^{-2} at 700 °C under fuel cell mode. Long-term durability tests showed a low degradation rate (~1% kh^{-1}) over 500 h at 0.3 and 0.4 A cm^{-2}. In electrolysis mode, hydrogen production reached 0.6 L min^{-1} with 88 % efficiency (HHV) at 1.17 V and 80 A, while 100 h of operation at 1 A cm^{-2} showed negligible degradation. Furthermore, H_2/CO ratios of 5, 3, and 1 are obtained during CO_2/H_2O co-electrolysis at (S/C) feed ratios of 2, 1, and 1/3, respectively. Multi-cell short stacks further validate the reproducibility and scalability of the APS process. These results highlight APS as a practical and scalable route for advancing MS-SOC technology toward efficient hydrogen and syngas production.

S7 20th International Symposium on Functional Nanomaterials and Thin Films for Sustainable Energy, Environmental and Biomedical Applications

S7- Nanomaterials for thermoelectrics, photocatalysis, electrocatalysis, and solar hydrogen

Room: Flagler A
Session Chair: Muhammet Toprak, KTH Royal Institute of Technology

1:30 PM

(ICACC-S7-001-2026) Performance enhancement in n type Bi-Sb-Te and magnetic Fe_3O_4 co-doped PANI (Invited)

S. Ballikaya*[1]; M. Boroglu[2]; A. Yusuf[1]

1. Istanbul Universitesi-Cerrahpasa Muhendislik Fakultesi, Engineering Sciences, Turkey
2. Istanbul Universitesi-Cerrahpasa, Chemical engineering, Turkey

Recently organic hybrid TE materials have attracted great attention due to their lower thermal conductivity and relatively high electrical conductivity and Seebeck coefficient. In this work, we reported the structural and thermoelectric properties of n type Bi-Sb-Te and Fe_3O_4 magnetic nano particle co-incorporated PANI (Polyaniline) prepared by dip coating process. Structural analyses were performed using PXRD and particle analysis spectra, while the thermoelectric properties were measured through Seebeck coefficient and electrical conductivity measurements in the range of room temperature to 400 K. It was observed that the intense peaks seen in the PXRD analysis reflected the crystalline structure of both magnetic nano Fe_3O_4 particles (MNP) and n type Bi_2Te_3 rather than the PANI crystal structure. The Seebeck coefficient was positive for all samples, indicating that the p-type conduction mechanism was dominant. The Seebeck coefficient varied between 22-32 μV/K in the range of room temperature to 400 K, while the electrical conductivity ranged between 8-50 S/cm. Although there was no significant change in the Seebeck coefficient with the addition of magnetic nanoparticles (MNP), the electrical conductivity improved by approximately 7 times. This improvement was attributed to the alignment of magnetic nanoparticles with the magnetic field, which opened the polymer chains.

2:00 PM

(ICACC-S7-002-2026) Lead-free 0D halide $Cs_3Bi_2I_9$ as a phonon glass: Designing efficient thermoelectric materials for low grade heat recovery (Invited)

N. Mani*[1]

1. SRM Institute of Science and Technology (Deemed to be University), Nanotechnology Research Centre, India

The pursuit of sustainable energy technologies particularly thermoelectrics has accelerated the search for materials with intrinsically low lattice thermal conductivity. Our fundamental study on the thermal properties of 0D $Cs_3Bi_2I_9$ shows an exceptionally low κ_{lat} of 0.17 with a weak temperature dependence, characteristic of glass-like thermal transport. This behavior was attributed to the strong stereochemical activity of the Bi^{+3} $6s^2$ lone pair, which creates electronic antibonding states near the valence band maximum. Combined with low-frequency vibrational modes, this facilitates wave-like phonon tunnelling, establishing $Cs_3Bi_2I_9$ as promising "phonon glass" material. Based on this paradigm, we translated these insights into a composite strategy by integrating ultralow $Cs_3Bi_2I_9$ into a high-conductivity copper selenide (CuSe) matrix. The $Cs_3Bi_2I_9$ inclusions introduced dense edge dislocations and moiré fringes at interfaces, scattering a broad spectrum of phonons leading to a drastic reduction in κ_{lat} to ~0.8 at 600 K. This synergistic effect yielded a peak figure of merit (zT) of ~1 at 600 K for the 3 wt% composite which was a three-fold enhancement over pristine CuSe. Our findings underscore the potential of lead-free halide perovskites as powerful components for designing next-generation thermoelectric materials.

2:30 PM

(ICACC-S7-003-2026) Ag_2Se based TE modules with enhanced power output (Invited)

S. Ballikaya*[1]; A. Yusuf[2]; M. Toprak[3]

1. Istanbul University, Elec. Engineering Dept., Turkey
2. Istanbul Universitesi-Cerrahpasa, Engineering Sciences, Turkey
3. Kungliga Tekniska Hogskolan, Applied Physics, Sweden

In this study, the performance of a nano-structured Ag_2Se-based thermoelectric module was examined as both a power generator and a cooler, and compared with that of the commercial TEC1-12706 module. Both rigid and flexible modules containing 58 thermocouple pairs were fabricated. The Rigid-58 module exhibited over three times higher maximum power output compared to the commercial reference, highlighting the promise of Ag2Se for low-temperature TE power applications. Cooling performance tests demonstrated the critical influence of electrical configuration. Series-connected rigid modules achieved the lowest cold-side temperatures with lower input power requirements, reaching ~2 °C at 18 W, comparable to or exceeding the commercial device. In contrast, parallel-connected modules displayed stronger initial cooling but were hindered by excessive current drawing, Joule heating, and thermal instability, preventing stable saturation. Across all cases, increased input power enhanced cooling until saturation limits were reached, with the commercial and series-connected modules offering the most efficient and stable operation.

3:20 PM

(ICACC-S7-004-2026) Engineered 2D metal thiophosphates for energy conversion and storage (Invited)

M. G. Sendeku*[1]

1. Lulea tekniska universitet Institutionen for teknikvetenskap och matematik, Sweden

Two-dimensional metal thiophosphates (MPS_3) offer a tunable platform in which the chalcogen/phosphorus chemistry enables dynamic surface transformation under reaction conditions. Their structural flexibility and phosphorus and sulfur-rich environment offer a chance for surface reconstruction, promoting product selectivity. In this talk, I will show how $CdPS_3$ nanosheets undergo in-situ surface transformation to generate catalytically competent motifs, and how this transformation governs activity and selectivity in biomass upgrading under different conditions. Using operando/in-situ Raman spectroscopy and complementary post-reaction catalyst characterizations (XRD, XPS, TEM), we capture the emergence of sub-10 nm $Cd–S_x$ layers that dominate the surface, and it is correlated to the nature of the reaction and electrolyte. The critical role of electrolyte composition, applied potential, and reactant/substrate identity will also be discussed. Density functional theory (DFT) calculations rationalize how reconstructed CdS sites enhance biomass hydrogenation by providing abundant active sites, tuning electronic properties, stabilizing intermediates, and reducing energy barriers while suppressing competing hydrogen evolution. These findings establish a framework for designing dynamic catalysts, extending to broader families of layered chalcogenides and thiophosphates for sustainable chemical production.

S7- Nanomaterials for sensing, batteries and water-splitting applications

Room: Flagler A
Session Chair: Sedat Ballikaya, Istanbul University

3:50 PM

(ICACC-S7-005-2026) Hybrid Bat - Cap electrodes for high power density energy storage (Invited)

S. B. Majumder*[1]

1. Indian Institute of Technology Kharagpur, Materials Science Center, India

$Na_3V_2(PO_4)_3$ (NVP) has been qualified as one of the most promising cathode materials for Na ion rechargeable cells. To further improve its cycleability in conjunction with the rate performance; we have hybridized NVP based materials with supercapacitive component (viz. activated carbon (AC)) and synthesized NVP@C/AC and NVOPF – NVP@C/AC bi – material electrodes. These bi material electrodes yield ultra – fast charging kinetics, decent cycleability and superior rate performance characteristics. Performing electrochemical impedance spectroscopy measurements, we demonstrated that the synergic effect observed in these bi-material electrodes correlates well with the lowering of their charge transfer resistances (R_{CT}) and the increase of Li^+ diffusion coefficient (D_{Li+}). Through a detailed cyclic voltammogram analyses, we have delineated the faradaic and capacitive contribution towards the overall capacities of the bi-material electrodes at various current rates. Finally, the performance of hybrid full cell has been investigated using bi – material positive electrodes, $Li_4Ti_5O_{12}$ (LTO)-based negative electrodes in conventional organic electrolyte (1 M $LiPF_6$ in EC, DEC) used in Li ion rechargeable cells. These hybrid bat-cap electrodes are recommended for high power density applications where relatively thinner positive electrodes in rechargeable cell are flooded with organic electrolyte.

4:20 PM

(ICACC-S7-006-2026) Photoelectrochemical water splitting via an in situ formed S-scheme heterojunction of hematite and oxygen-deficient double perovskite co-catalyst (Invited)

J. Jang*[1]

1. Ulsan National Institute of Science and Technology, school of energy and chemical engineering, Republic of Korea

Hematite photoanodes integrated with oxygen evolution co-catalysts (OECs) are attractive for sustainable hydrogen production via photoelectrochemical (PEC) cells, yet they face major limitations such as poor surface charge transfer and sluggish OER kinetics. To overcome these challenges, we propose surface decoration with an oxygen-deficient double perovskite, PBSCF, serving as a highly active OEC. This architecture forms an in situ S-scheme heterojunction with hematite, as confirmed by theoretical calculations, enabling efficient electron transfer and improved reaction kinetics. As a result, the Si:Ti–hematite/PBSCF photoanode exhibits a photocurrent density of 3.70 mA cm-2 at 1.23 V_{RHE}, a lowered onset potential, and excellent stability over 120 h. These results highlight the potential of perovskite oxide layers to address intrinsic drawbacks of hematite photoanodes, offering a pathway toward efficient and durable PEC water splitting systems for clean energy applications.

4:50 PM

(ICACC-S7-007-2026) Unbiased full photoelectrochemical cell for solar-driven green hydrogen production (Invited)

F. A. Pires[1]; I. J. Silva[1]; I. Rodríguez-Gutiérrez[1]; G. H. Morais[1]; F. L. de Souza*[1]

1. Centro Nacional de Pesquisa em Energia e Materiais, Brazilian Nanotechnology National Laboratory, Brazil

Scaling photoelectrochemical (PEC) devices for efficient solar energy conversion and green hydrogen production requires low-cost, scalable, and robust fabrication methods. We present the design, fabrication, and performance of a fully operational, unbiased PEC prototype integrating hematite-based photoanodes and copper-based photocathodes, both synthesized via a versatile polymeric precursor solution (PPS) method. This enabled uniform, ultra-thin (~125 nm) films with consistent morphology and scalable deposition over areas up to 200 cm2. To assess reproducibility, 100 units of each photoelectrode were fabricated, confirming the robustness of the PPS approach. The two-photoelectrode cell was assembled using a CuO PPS photocathode in 0.5 M Na_2SO_4, an Al0.5HZr3.0 photoanode in 1 M NaOH with 0.5 mM H_2O_2, and a salt bridge conditioned in 3 M KCl. The illuminated area of each electrode was 0.28 cm2. A dark current of 3.05 μA was recorded with a hole scavenger, increasing to 0.53 mA under 1 sun illumination, confirming photoactivity of the unbiased PEC cell. Ongoing work focuses on improving performance and stability through material and interface optimization. The authors acknowledge support from CNPq, CAPES, and FAPESP via CEMol (CEPID grants 2024/00989-7 and 2023/08273-8).

5:20 PM

(ICACC-S7-008-2026) Preparation of nanomaterials for cathode catalysis

G. Zeng*[1]; Q. Sun[1]; A. Cabot[1]

1. Catalonia Institute for Energy Research, Spain

The development of advanced nanomaterials for cathode catalysis plays a crucial role in enhancing the performance of aqueous zinc-based energy storage systems. Our recent progress demonstrates that rationally engineered nanostructures can not only promote redox kinetics at the Iodine cathode but also regulate interfacial processes throughout the cell. Pre-intercalated vanadium-oxide nanobelts have shown strong capability in anchoring polyiodide species through combined physical confinement and chemical adsorption, thereby improving iodine utilization, suppressing shuttle effects, and contributing additional intercalation capacity. Meanwhile, electrolyte-induced crystal growth engineering provides further insight into how interfacial ion interactions influence zinc plating behavior. The incorporation of specific ions capable of facet-selective adsorption can redirect Zn plating pathways, suppress dendrite formation, and enhance anode stability. Integrating these two strategies, nanomaterial design for catalytic and confinement functions at the cathode, and interfacial regulation for uniform Zn plating at the anode, offers a promising route toward highly durable, high-rate aqueous zinc batteries.

S8 20th Intl Symp on APMT for Structural & Multifunctional Materials & Systems

S8- Advanced manufacturing of ceramic coatings and composites

Room: Coquina B
Session Chairs: B Venkata Manoj Kumar, Indian Institute of Technology Roorkee; Lingfeng He, North Carolina State University

1:30 PM

(ICACC-S8-001-2026) High-speed and facile vapor-phase coating of boron nitride-related materials under a localized high-temperature field (Invited)

H. Katsui*[1]; K. Shimoda[2]; M. Hotta[1]

1. National Institute of Advanced Industrial Science and Technology (AIST), Japan
2. National Institute for Materials Science (NIMS), Research Center for Structural Materials, Japan

Thin film deposition techniques of hexagonal boron nitride (BN) are applied to interphases in ceramic matrix composites (CMCs) and widely utilized in the research and development of advanced materials in optics and electronics. In SiC/SiC CMCs, the interphases are typically deposited on fibrous preforms, such as bundles and woven preforms, via CVD/CVI processes. However, the fibers in contact with each other locally prevent the growth of the interphase during synthesis because of the lack of space in the preforms. Moreover, CVD/CVI processes are time-consuming and involve hazardous gases such as haloboranes and ammonia, which impose significant constraints on experimental environments. Previous studies have reported the synthesis of thin films of a BN related phosphor material, i.e. boron carbon oxynitride (BCNO), by CVD using single-source alkylamino precursors. Inspired by the facile route, this study aims to develop a rapid coating of homogeneous BN-like interphases on SiC fibers. The deposition of boron carbonitride interphases was demonstrated on SiC monofilaments by CVD facilitated by a swept laser beam. Homogeneous BCN coatings with interfacial shear strength values suitable for CMCs applications were rapidly formed around SiC fibers through generating a localized activated field on the fiber surface by laser irradiation.

2:00 PM

(ICACC-S8-002-2026) Thermally activated crack-healing strategies toward robust environmental barrier coatings (Invited)

A. Okawa*[1]; K. Ogawa[2]; T. Hasegawa[1]; S. Yin[1]

1. Tohoku University, Institute of Multidisciplinary Research for Advanced Materials, Japan
2. Tohoku University, Fracture and Reliability Research Institute, Japan

This study investigates two crack healing strategies for environmental barrier coating material. The first investigation examines the self-healing capabilities of β-$Yb_2Si_2O_7$/SiC composites. Pre-cracked samples were annealed at 750-1400°C for up to 50 h in air and water-vapor environments. Characterization showed crack length reduction and flexural strength recovery due to volume expansion from SiC oxidation, with enhanced fracture toughness. Bayesian optimization identified optimal annealing conditions achieving a three-fold increase in fracture toughness compared to as-sintered values, while excessive treatment caused internal cracking observed by FIB-SEM. These results indicate that the observed strength recovery is predominantly attributed to compressive stress generated during SiC oxidation. The second investigation examines crack healing behavior driven by volumetric expansion during metastable α phase to stable β phase transitions in partially amorphous thermal-sprayed coatings. $33.3Yb_2O_3$-$66.6SiO_2$ glasses were synthesized via CO_2 laser irradiation, and surface cracks were introduced and annealed within the crystallization temperature range. Although new cracks formed, partial healing of initial surface cracks was observed. Overall, these findings provide insights for the development of robust environmental barrier coatings through optimization of composition and annealing protocols

2:30 PM

(ICACC-S8-003-2026) Interface enhancement and engineering in solid-state kinetic spray deposition of ceramics by utilizing a fiber laser

K. Shinoda*[1]; M. Sato[1]; T. Nagoshi[1]; T. Ghara[1]

1. National Institute of Advanced Industrial Science and Technology (AIST), Core Manufacturing Technology Research Institute, Japan

Solid-state kinetic spray deposition such as aerosol deposition and hybrid aerosol deposition is a promising deposition method that can deposit ceramic coatings at low deposition temperatures. Here, the understanding and controlling of three types of interfaces, that is, particle-particle interface, particle-substrate interface, and inner particle interfaces, are the keys. In this presentation, we would like to examine how the laser energy input can contribute to controlling these interfaces when fine particles are sprayed. Alumina and zirconia fine particles were sprayed under a fiber laser irradiation. Two modes were observed: one was a laser-cladding mode, and the other was a crystal growth mode, depending on the relative position between powder injection and the laser irradiation. Especially, peculiar crystal growth like teeth was observed at a crystal growth mode, which shows feasibility of this method as additive manufacturing of ceramics. A further possibility as a laser-assisted aerosol deposition will also be discussed.

2:50 PM

(ICACC-S8-004-2026) A new manufacturing and pyrolysis method for SiC fibers with low oxygen content

Y. Yamashita*[1]; T. Goto[1]; K. Hofuku[1]; R. Iuchi[1]

1. Kureha corporation, Japan

SiC fibers utilized in ceramics matrix composite as aircraft engine components require excellent mechanical properties and high-temperature properties. In the recent our study, the SiC fibers derived from a highly branched polycarbosilane (PCS) as precursor have been found excellent mechanical properties. Furthermore, this SiC fibers were obtained through a cost-competitive manufacturing method that does not require electron beam curing. However, further investigation of this production method, it was observed that SiC fibers pyrolyzed under conditions with even a trace amount of oxygen exhibited a significant decline in their high-temperature properties. This presentation will focus on a new pyrolysis method designed to protect fiber from oxygen. The obtained SiC fiber with low oxygen content exhibited excellent mechanical and high-temperature properties.

3:30 PM

(ICACC-S8-005-2026) Mechanical and thermal properties, corrosion resistance and self-healing ability of yttrium titanate, a candidate oxide for ODS steels (Invited)

S. T. Nguyen*[1]

1. Kokuritsu Kushiro Kogyo Koto Senmon Gakko, Department of Creative Engineering, Japan

Yttrium titanate ($Y_2Ti_2O_7$) has pyrochlore structure and its unit cell is similar to that of ZrO_2 (fluorite-structure), which have been demonstrated to be especially stable under radiation. Therefore $Y_2Ti_2O_7$ has been considered an oxide candidate for oxide-dispersion-strengthened ODS steels in nuclear reactors. The ODS steels can be manufactured by mechanical alloying yttrium oxide (Y_2O_3) powder with additional titanium powder, followed by hot extrusion and machining. Then Y_2O_3 is decomposed into yttrium (Y) and oxygen (O) during the mechanical alloying process then re-precipitate with titanium to form more stable complex oxide $Y_2Ti_2O_7$. In this study,

$Y_2Ti_2O_7$ bulk ceramic was sintered by a hot pressing method, then their mechanical properties including hardness, strength, and toughness were investigated. Thermal properties such as diffusivity, heat capacity and thermal expansion coefficient were also measured. The corrosion resistance and self-healing ability of the ceramic were investigated. The data from this study can be a good reference in the mission of finding new materials for nuclear reactors.

4:00 PM

(ICACC-S8-006-2026) Geopolymerization of Lunar and Martian regolith simulants for the production of structural shields (Invited)

L. Santo*[1]; F. Quadrini[1]; A. Proietti[1]

1. Universita degli Studi di Roma Tor Vergata, Industrial Engineering, Italy

Human settlements in Space will be possible if successful strategies for protecting astronauts and infrastructures from the related harsh environment are adopted. A solution for Lunar, Martial or Asteroidal settlements is using native powders to build blocks for construction. Depending on the physical, chemical and morphological condition of the extraterrestrial soils, different technologies can be experimented. For this aim, in this study, geopolymerization of regolith simulants of the Moon (LHS-1) and Mars (MSG-1, and JEZ-1), provided by Space Resource Technologies (FL, USA), has been carried out. Geopolymerization refers to the activation of aluminosilicate materials by an alkaline solution, forming a strong, three-dimensional network of covalently bonded Si-O-Al structures. Tests have been performed by mixing powders with a sodium hydroxide solution (15 M), compaction molding at room temperature, and subsequent high temperature drying (500°C for 3 h). Flat samples for bending tests have been manufactured, and physical and mechanical tests have shown the possibility of this technical solution to build shielding blocks with sufficient strength. Results are compared with those from other studies where different technological conditions have been applied. At the end, findings are discussed in the frame of Space sustainability.

4:30 PM

(ICACC-S8-007-2026) Synthesis of novel copper and molybdenum oxides under high oxygen partial pressures

H. Suematsu[1]; Z. Feng[1]; J. Zhao[1]; T. Do*[1]; T. Nakayama[1]

1. Nagaoka University of Technology, Extreme Energy-Density Research Institute, Japan

Novel phases can be synthesized under high pressures, which can stabilize crystals with high coordination numbers. When the oxygen partial pressure is also increased, cations with high valences can be realized. We have developed an oxygen content tuning method by introducing oxidizing agents including SrO_2, $KClO_3$, $KClO_4$, Ag_2O or AgO with the samples in high pressure synthesis capsules. By using this method, even Au could be oxidized to synthesize a novel Au-Sr-Ca-Cu-O cuprate superconductor. Powders of Au, SrO_2, $SrCuO_2$, Ca_2CuO_3 and CuO were mixed and heat treated at 5.5 GPa and 1150-1100 °C for 3 hours. Lattice images showed a layered structure similar to $CuSr_2CaCu_3O_y$. From EDS data, Au was detected and was identified as Au^{3+} by XPS. These results indicated that Au was successfully oxidized to form a novel (Au,Cu) $Sr_2CaCu_2O_y$ superconductive phase. Oxygen content tuning in the MoO_3-II phase is also shown in the presentation.

4:50 PM

(ICACC-S8-008-2026) Electroceramics from advanced photocurable silicone-based blends

A. Zilio*[1]; E. Bernardo[1]

1. Universita degli Studi di Padova, Department of Industrial Engineering, Italy

This contribution explores the fabrication of electroceramic components via additive manufacturing supported by preceramic polymers. Photocurable emulsions/suspensions were developed by blending silicones with commercial acrylates and a secondary phase of emulsified molten inorganic salts (e.g. $Ca(NO_3)_2 \bullet 4H_2O$, $Mg(NO_3)_2 \bullet 6H_2O$), optionally with glass or oxide powders. The blends exhibit photoreactive behaviour for digital light processing 3D printing, enabling precise shaping of geometries. After pyrolysis in flowing nitrogen at 700°C, a $CaO–SiO_2$ system yields an amorphous calcium silicate matrix embedded with a turbostratic carbon phase responsible for electrical conductivity. Including pharmaceutical borosilicate glass as passive filler enhances phase stability, reduces shrinkage and improves mechanical performance. This enables production of conductive glass-ceramic components for electronics. In contrast, pyrolysis in air promotes the complete removal of carbon. A precursor blend containing emulsified magnesium nitrate and dispersed alumina powders has been used to fabricate dense cordierite ($2MgO \bullet 2Al_2O_3 \bullet 5SiO_2$) monoliths and porous structures, after firing at 1350°C. Cordierite components exhibit dimensional stability and dielectric properties. This approach demonstrates the versatility and scalability of silicone-based systems in digital manufacturing of electroceramic materials with distinct functional properties.

5:10 PM

(ICACC-S8-009-2026) PUMA: A scalable framework for simulating powder post-processing in advanced manufacturing

H. D. Tran*[1]; S. Kounouho[2]; F. Sultana[1]; M. Du[1]; M. C. Messner[1]; G. Hu[1]

1. Argonne National Laboratory, USA
2. Duke University, USA

Powder-based manufacturing enables the fabrication of advanced metallic and ceramic components with tailored properties, but the performance depends critically on post-processing steps which involve the coupling of thermal, chemical, and mechanical effects, making predictive process design challenging. Existing commercial simulation tools treat these processes in isolation, lack scalability on modern high-performance computing architectures, and offer limited flexibility in constitutive modeling. In this work, we present PUMA, Powder Utilization Modeling Application, an open-source, finite-element framework for simulating powder post-processing techniques. Built on the Multiphysics Object-Oriented Simulation Environment (MOOSE) along with the GPU-accelerated New Engineering Material Library 2 (NEML2), PUMA solves coupled conservation laws for mass, momentum, and energy to predict distortion, residual stress, and (for reactive processes) degree of reaction of complex parts. The framework integrates sub-modules for sintering, curing, pyrolysis, infiltration, and solidification, allowing these sub-modules to be chained to model arbitrary post-processing pipeline.

S13 Advanced Ceramics and Composites for Nuclear Fission and Fusion Energy Systems

S13- Novel nuclear ceramics I

Room: Coquina F
Session Chair: Ian McCue, Northwestern University

1:30 PM

(ICACC-S13-001-2026) Radiation damage of ion-irradiated high entropy ceramics (Invited)

K. Wang*[1]

1. Alfred University, USA

Ultrahigh temperature ceramics, such as carbide, boride, and MAX phase, exhibited exceptional high-temperature thermomechanical properties. Also, the emerging high entropy materials have indicated superior radiation tolerance. Therefore, high entropy ceramics (HECs) are supposed to be excellent candidate materials for advanced nuclear reactors. However, the radiation response of HECs is still not well investigated. Herein, we fabricate bulk HECs by mechanical alloying and the subsequent spark plasma sintering (SPS). The HECs are irradiated by heavy ions and helium ions under various irradiation conditions. The radiation hardening is investigated by nanoindentation. The microstructural evolution, including radiation-induced dislocation loops, cavities, segregation, phase stability etc., is interrogated using analytical scanning/transmission electron microscopy (S/TEM). The radiation response of HECs is compared with binary ceramics. The results of this work will provide insights into the radiation behavior of HECs under extreme irradiation environments.

2:00 PM

(ICACC-S13-002-2026) Compositionally-complex rare earth ceramics for fusion applications

T. Davey*[1]; H. M. Gardner[2]; D. M. Nguyen[2]; J. Wade-Zhu[2]; S. Middleburgh[1]

1. Bangor University, Nuclear Futures Institute, United Kingdom
2. UKAEA, Materials Division, United Kingdom

In future fusion powerplants, hydrogen isotopes will act as the fuel, however they diffuse rapidly in steel structural materials. Liquid lithium breeder blankets have been proposed to breed tritium inside the fusion device, however lithium is corrosive to structural steels. It is essential to maintain structural integrity and tritium inventory to ensure safe and sustainable plant operation, so ceramics have been proposed for use as corrosion-resistant and permeation barrier coatings. Individual rare earth oxide coatings have shown some success as hydrogen permeation barriers, but demonstrate inadequate adhesion and property continuation across layers. To counter this, and to withstand irradiation damage, amorphous coatings have been investigated, but exhibit undesirable crystallisation and grain growth under temperature and irradiation exposure. For this work, a disordered or heavily-distorted structure is used instead: a compositionally-complex rare-earth oxide (CCREO). Compositionally-complex materials have shown improved stability, particularly at high-temperatures and under irradiation. This work presents results from an exploration of potential CCREO systems specifically targeting an application as a thermally- and irradiation-stable hydrogen permeation barrier. Density functional theory (DFT) calculations are used to model an array of compositionally-complex rare earth oxide combinations.

2:20 PM

(ICACC-S13-003-2026) Zirconium niobium carbide as promising first wall material for fusion reactors

D. Marchesi[1]; P. Cervenka[1]; A. Fazi*[1]; L. Mazzocco[1]; A. Seshadri[1]; K. Shirvan[2]

1. Massachusetts Institute of Technology, Nuclear Science and Engineering, USA
2. Massachusetts Institute of Technology, USA

Developing first-wall materials remain a critical challenge for the realization of future nuclear fusion reactors. Conventional low-Z candidates such as graphite offer operational flexibility but suffer from high erosion rates, and tritium retention, while tungsten undergoes severe embrittlement and thermal property degradation under irradiation. This work investigates zirconium niobium carbides (ZrNbC) as an alternative plasma-facing material. ZrNbC combines an exceptionally high melting point, good thermal conductivity, and promising radiation tolerance, making it a compelling candidate for high-heat-flux environments. We employed an integrated experimental–computational approach to evaluate a range of ultra-high temperature carbides under fusion-relevant conditions. Thermodynamic stability was explored via CALPHAD-based simulations, while Monte Carlo was used to estimate the impact on Tritium breeding and shielding efficiency. ZrNbC emerged among the best performing carbides. ZrNbC samples were manufactured and subjected to heavy ion irradiation. Pristine and irradiated samples were characterized using nanoindentation and electron microscopy techniques. Preliminary results show limited amorphization and defect accumulation, supporting the predicted defect saturation behavior of transition metal carbides, and indicating improved irradiation tolerance compared to current state-of-the-art solutions.

2:40 PM

(ICACC-S13-004-2026) Fabrication, plasma performance, and neutron radiation effects in ultra high temperature ceramics

D. Sprouster*[1]; K. Christian[1]; J. Li[1]; M. Cusentino[3]; J. D. Coburn[2]; L. Snead[1]; R. Kolasinski[2]

1. Stony Brook University, USA
2. Sandia National Laboratories California, USA
3. Sandia National Laboratories, USA

Ultra-high temperature ceramics (UHTCs) are promising materials for plasma-facing components in future fusion reactors due to their enhanced thermophysical and thermomechanical properties. Unlike tungsten, which suffers from radiation-induced degradation of bulk thermomechanical properties (thermal conductivity and fracture toughness), and plasma-induced surface damage (cracking, erosion/exfoliation, and fuzz formation), some UHTCs have shown resistance to irradiation-induced property degradation. However, there are some significant gaps in the manufacturing methods and fundamental understanding of the mechanisms responsible for property degradation needed for integrated plasma-facing components. This presentation will focus on our recent progress to address these two issues. We will present our results relating to (i) the fabrication of dense monolithic and doped UHTCs (ZrC, NbC, TaC, WC) using direct current sintering, and (ii) subsequent microstructure and property evolution of UHTCs following neutron irradiation and plasma exposure. The resulting UHTC compacts studied here show minimal surface degradation post plasma exposure, little-to-nil microstructure evolution, and only minor changes in thermal and mechanical properties post irradiation. Our initial results based on the fabrication and performance testing have positive implications for future PFC research.

S13- Ultra-high temperature ceramics for nuclear applications

Room: Coquina F
Session Chair: David Sprouster, Brookhaven National Laboratory

3:20 PM

(ICACC-S13-005-2026) Understanding electron and phonon transport in high temperature carbides as a means to develop high-performance nuclear ceramics (Invited)

L. Snead*[1]; K. Christian[1]; D. Sprouster[2]

1. Stony Brook University, USA
2. Brookhaven National Laboratory, Nuclear Science and Technology, USA

Nuclear ceramics and composites has been historically limited by their as-irradiated thermal conductivity. This is expecially true for the high conductivity materials SiC, BeO, and graphite. The reason for this degraded thermal transport at typical design temperatures is the scattering of phonons (primarily with) irradiation-produced vacancies and vacancy complexes. For the materials mentioned above conductivity can be reduced by as much as 90%, confounding their design use. This presentation suggests and discusses the development of UHTC's that are more resistant to thermal conductivity reduction due to an optimized electronic channel for thermal conductivity. In essence, while phonon transport decreases strongly with temperature and defect creation, electron transport is only weakly temperature and irradiation dependent. By maximizing electronic conductivity at elevated temperature such carbides can offer greater engineering design space. Specific materials describing this approach are SiC (phonon dominated, a comparitor), and VC (with both phonon and electron channels.) VC and other carbides of variable carbon sublattice stoichiometry have been fabricated via direct current sintering with elevated temperature thermal conductivity measured by laser flash and elevated temperature electrical conductivity measured by standard 4-pt probe technique.

3:50 PM

(ICACC-S13-006-2026) Tungsten fibre-reinforced tungsten - perspectives and challenges of using a brittle matrix composite as a material for fusion reactors (Invited)

J. Riesch*[1]; Y. Mao[2]; B. Böswirth[1]; D. Dickes[1]; H. Gietl[1]; T. Höschen[1]; A. Lau[2]; A. von Müller[1]; J. W. Coenen[2]; R. Neu[1]

1. Max-Planck-Institut fur Plasmaphysik, Germany
2. Forschungszentrum Julich GmbH, Germany

Similar to ceramic matrix composites, tungsten fibre-reinforced tungsten composites (W_f/W) utilize extrinsic mechanisms to enhance fracture toughness and thus overcome the intrinsic brittleness of bulk W, the primary candidate for plasma facing material in a future fusion reactor. In W_f/W composites, high strength and ductile tungsten wire is used together with an engineered fibre-matrix interface in a brittle W matrix, either produced by chemical vapour deposition or a powder metallurgical process. In this contribution we give an overview of the development of W_f/W over the past decades. Starting with proof-of-principle investigations, which demonstrated manufacturability and improved toughness in model systems, actively cooled W_f/W components finally withstood thermal loads up to 20 MW/m^2 for 500 cycles during high heat flux testing and mechanical samples retained their toughness after neutron irradiation in the BR2 fission reactor. Although showing these very promising results, the development required to finally use W_f/W in a reactor component is still huge. We will discuss possible benefits, e.g. the less pronounced irradiation embrittlement, in comparison with challenges like the need for industrialization or the qualification of design rules for composite materials.

4:20 PM

(ICACC-S13-007-2026) Design and evaluation of nanoporous ultra-high temperature ceramics (Invited)

I. McCue*[1]; C. Ott[1]

1. Northwestern University, Materials Science and Engineering, USA

Ultra-High Temperature Ceramics (UHTCs) are promising materials for use in high temperature applications, such as fusion reactors, owing to their high melting points and excellent thermo-mechanical properties. UHTCs are commercially fielded as coatings and monolithic materials, which both rely on powder-based feedstock that is difficult to densify due to its high melting point and cohesive energy, so fine feedstock particle sizes are used to help overcome this limitation. As a result, the success of fabricating a high-quality component is intimately linked to the size of the feedstock powder. Here, we will detail our advances in developing nanoscale powders of UHTC powders. We will discuss the synthesis of these materials, their overall performance at elevated temperatures, and governing kinetic equations describing their stability and decomposition. We will also provide an outlook on our processing method towards compositionally complex UHTC formulations.

4:50 PM

(ICACC-S13-008-2026) Design and development of low-activation UHTC materials for fusion first wall application

K. Christian*[2]; J. Li[2]; D. Sprouster[2]; L. Snead[2]; K. Shirvan[1]; K. Hattar[4]; B. Wirth[4]; S. J. Zinkle[4]; R. Kolasinski[3]

1. Massachusetts Institute of Technology, USA
2. Stony Brook University, USA
3. Sandia National Laboratories, USA
4. University of Tennessee, USA

First wall materials for fusion reactors face extreme environmental demands, particularly in terms of high operating temperature, high heat flux, and neutron irradiation. Current plasma-facing materials (PFMs), typified by tungsten, are limited by creep rupture, irradiation damage, degradation of thermal conductivity, embrittlement, microcracking, and erosion. Hence, a need for material advancements to combat these issues has led to an interest in ultra-high temperature ceramics (UHTCs). UHTCs and composites thereof benefit from higher operating temperatures, enabling larger thermal gradients, thicker tiles, and longer lifetimes. At the same time, limiting factors such as swelling and embrittlement are reduced, opening a potential to extend the useful lifetime of plasma-facing walls. This presentation discusses initial results for work performed under the auspices of the ARPA-E "Creating Hardened And Durable fusion first Wall Incorporating Centralized Knowledge" (CHADWICK) program. Experimentally determined processing conditions for a series of promising plasma-facing UHTC materials are shown, along with a comparison between mechanical and thermophysical properties. Criteria for advancement of candidates to secondary testing are discussed, along with next stage plans for investigation of multi-component PFMs, including solid solution carbides and extrinsically toughened composites.

5:10 PM

(ICACC-S13-009-2026) Lattice strain reversal and thermal degradation in irradiated tungsten carbide

K. Bakkar*[1]; T. Zagyva[1]; M. T. Rigby-Bell[2]; J. Wade-Zhu[2]; F. Hofmann[3]; M. Wenman[1]; S. A. Humphry-Baker[1]

1. Imperial College London, Materials, United Kingdom
2. UKAEA, Materials Division, United Kingdom
3. University of Oxford Department of Engineering Science, United Kingdom

Compact spherical fusion reactors, such as STEP, require highly efficient neutron shielding to protect their superconducting cores from radiation-induced degradation. Tungsten carbide (WC) is a prime candidate for this purpose due to its excellent neutron and gamma attenuation properties; however, its response to irradiation damage remains unclear. This study investigates the performance of binderless WC under W-ion irradiation (0.13 - 13 dpa; 100 - 400 °C), focusing on lattice swelling, defect evolution, and thermal transport degradation. Grazing Incidence X-ray Diffraction revealed moderate lattice expansion (1.3% at 0.13 dpa, 100 °C) that diminished with increasing temperature and dose, transitioning to slight contraction at high dose (-0.7% at 13 dpa, 100 °C). Transmission Electron Microscopy showed dislocation loop networks at 13 dpa but minimal defect structures at 0.13 dpa. No amorphisation or microcracking was observed. Transient Grating Spectroscopy detected an order-of-magnitude drop in thermal diffusivity after 0.13 dpa at 100 °C, with little further change at higher doses or temperatures. By understanding WC's irradiation response, this study supports its qualification for shielding in compact spherical tokamaks and guides microstructural optimisation efforts.

S14 Crystalline Materials for Electrical Optical and Medical Applications

S14- Optical material I

Room: Ballroom 4
Session Chairs: Xavier Mateos, University Rovira i Virgili; Tetsuo Tsuchiya, National Institute of Advanced Industrial Science and Technology (AIST)

1:30 PM

(ICACC-S14-001-2026) Engineered materials for micro-scale lasers operating at 2 microns (Invited)

X. Mateos*[1]

1. University Rovira i Virgili, Spain

Recent advancements in compact laser sources operating around 2 µm are driven by applications in medicine, environmental sensing, and materials processing. Microchip lasers, particularly those using thulium (Tm3+) and holmium (Ho3+) ions, benefit from diode pumping, offering high efficiency and short pulse generation due to low cavity losses and reduced roundtrip times. Monoclinic Double Tungstate (MDT) crystals like Tm:KLuW and Ho:KYW are ideal hosts due to their strong optical anisotropy, high doping tolerance, and favorable thermal lensing properties. Microchip lasers based on Tm:KLuW have achieved slope efficiencies up to 77%, attributed to efficient cross-relaxation and optimized cavity design. Codoping with Ho3+ further enhances performance, with slope efficiencies reaching 58%, suggesting potential for 2.1 µm emission. Waveguide lasers fabricated via femtosecond Direct Laser Writing (fs-DLW) in Tm:KLuW crystals show promising results. Confocal microscopy reveals structured cladding, and laser tests demonstrate linear input-output behavior. A 60 µm waveguide laser achieved 150 mW output at 1846.8 nm with 34.6% efficiency, and Q-switching conversion efficiency up to 87.6%, highlighting the viability of fs-DLW waveguides for high-performance 2 µm laser systems.

2:00 PM

(ICACC-S14-002-2026) Nd,La:CaF$_2$ transparent ceramics for high-power lasers (Invited)

Y. Tamaru*[1]; K. Fujioka[1]; Y. Matsumoto[1]; H. Yoshida[1]; J. Ogino[1]; S. Tokita[1]; K. Tsubakimoto[1]; K. Yamamoto[1]; A. Yogo[1]; J. Kawanaka[1]; N. Miyanaga[2]

1. Osaka Daigaku, Institute of Laser Engineering, Japan
2. Institute for Laser Technology, Japan

Transparent Nd,La:CaF$_2$ ceramics represent a promising gain medium for high-power, ultrashort-pulse lasers. Liquid-phase-synthesized powders were densified to produce laser-grade transparency with homogeneous Nd and La distributions. La co-doping was employed to suppress Nd^{3+}-Nd^{3+} clustering and the attendant concentration quenching. Spectroscopic properties –including emission cross sections, fluorescence lifetimes, and branching ratios– were consistent with Judd-Ofelt analysis, and the emission band centered at 1065 nm exhibited an FWHM of 28 nm, indicating suitability for broadband operation. In diode-pumped laser oscillation experiments, a slope efficiency of 20% was obtained. This talk will review processing and laser characterization. It will also discuss the potential of Nd,La:CaF$_2$ as a compelling platform for broadband, high-pulse-energy amplification, owing to the robust fluorite host (low phonon energy, low nonlinear index, comparatively high room-temperature thermal conductivity, and negative dn/dT) and scalable ceramic processing.

2:30 PM

(ICACC-S14-003-2026) Solid-state optical refrigeration of ytterbium-doped fluoride crystals

H. Tanaka*[1]

1. Leibniz-Institut fur Kristallzuchtung im Forschungsverbund Berlin eV, Germany

Solid-state optical refrigeration is an emerging technology that annihilates phonons in solids through a simple cycle of optical excitation followed by anti-Stokes fluorescence emission. This approach represents the only cryogenic cooling method without moving parts, making it intrinsically vibration-free. Such all-solid-state cooling is particularly attractive for space applications and high-precision metrology, where mechanical noise is a critical limitation. The cooling efficiency relies strongly on crystal quality, as fluorescence quantum efficiency must approach unity and parasitic absorption coefficient must be minimized for net cooling to occur. Thus, the growth of high-quality crystals is essential for advancing this field. To date, ytterbium (Yb)-doped fluoride crystals represent the state of the art. Using Yb-doped LiYF$_4$ (YLF), temperatures as low as 87 K have been achieved. Reaching even lower temperatures, such as the liquid-nitrogen boiling point (77 K), will require further improvements in crystal quality or the identification of more suitable materials. We have grown and characterized a variety of Yb-doped fluoride crystals and found that Yb-doped KY$_3$F$_{10}$ offers intrinsic advantages over Yb:YLF for cryogenic cooling. With a high-quality Yb:KYF crystal, we achieved cooling to ~180 K, even with an unoptimized pump wavelength, demonstrating its potential to reach liquid-nitrogen temperatures.

3:10 PM

(ICACC-S14-004-2026) Development of transparent hexagonal fluorapatite ceramics with c-axis orientation and fine crystal grains (Invited)

H. Furuse*[1]; S. Koizumi[1]; T. S. Suzuki[2]

1. National Institute for Materials Science (NIMS), Japan
2. National Institute for Materials Science, Optical Ceramics Group, Japan

In this study, we aimed to fabricate transparent non-cubic ceramics as novel laser materials by achieving both fine grain size and controlled crystal orientation. Hexagonal fluorapatite fine powders were synthesized via liquid-phase methods, and crystal orientation was precisely controlled using a strong magnetic field during forming process. We systematically investigated the effects of initial powder morphology and sintering conditions on the characteristics of the sintered bodies, including degree of orientation and optical properties. As a result, we successfully fabricated transparent ceramics with moderately c-axis oriented crystals and fine grains. In the presentation, we will report on the fabrication process and the detailed characteristics of the obtained ceramics.

3:40 PM

(ICACC-S14-005-2026) Influence of LiF doping on tricalcium phosphate transparency sintered by Spark Plasma Sintering

K. Prokop[2]; S. Cottrino*[1]; V. Garnier[1]; G. Fantozzi[1]; Y. Guyot[3]; M. Guzik[2]

1. MATEIS Laboratory, Material, France
2. Faculty of Chemistry, University of Wroclaw, Poland
3. ILM Laboratory, France

Among the various inorganic matrices that might be suitable for obtaining transparent polycrystalline ceramics, tricalcium phosphate (TCP) caught our attention. Indeed, TCP is an essential component of bone and teeth, it could be one of the candidate for storage phosphors in dosimeters and can also be applied to scintillators for α-ray detection. We wish to activate this material with rare earth ions, in order to obtain optical transparent ceramics, which can be used as laser sources, scintillators and phosphors under UV and blue LED pumping. We prepared transparent TCP ceramics by the Spark Plasma Sintering (SPS) technique, which is an efficient method to consolidate ceramics with a finer microstructure at low temperatures in a short time. First, undoped translucent TCP ceramics were fabricated using optimized SPS parameters. Ceramics microstructure and optical properties were investigated using X-ray diffraction and Scanning Electron Microscopy (SEM). In a second step, the influence of LiF doping content on ceramics microstructure and transparency were studied using various sintering parameters such as: temperature, time of sintering and pressure. The density of the samples measured by the Archimedes method was 99%. Optimized LiF content lead to dense ceramics having submicronic grain size (necessary to be reduce because of TCP birefringence) and promising transparency.

4:00 PM

(ICACC-S14-006-2026) Transparent ceramic channel waveguide lasers via direct-ink-write

R. Osborne*[1]; A. Brandl[1]; N. Cherepy[1]; S. A. Payne[1]; N. Ter-Gabrielyan[2]; M. Dubinskiy[2]

1. Lawrence Livermore National Laboratory, Materials Science Division, USA
2. US Army Combat Capabilities Development Command Army Research Laboratory, USA

Waveguide and fiber lasers offer several advantages over bulk laser gain media, particularly better thermal management, beam profile and mode control, and increased gain. Glass fiber lasers have dominated the market for high power, compact lasers which are useful for many applications such as manufacturing, medicine, and metrology. However, their maximum power output is limited by stimulated Brillouin scattering (SBS). Transparent ceramic laser gain media, such as rare earth-doped garnets, are not limited by SBS, and furthermore, they offer higher thermal conductivity and narrower spectral emission, and therefore could provide higher laser power output. Here, I will describe our work on the development of transparent ceramic channel waveguides, allowing for the full advantages of this geometry to be realized.

4:20 PM

(ICACC-S14-007-2026) Grain size and phase dependence on optical properties of bulk nanocrystalline hafnia and hafnia zirconia (Invited)

S. C. Mills*[1]; E. Anguish[2]; E. Patterson[2]; K. Anderson[2]; L. Kuna[2]; B. Feigelson[2]; J. Andrew[3]; J. Wollmershauser[1]

1. U.S. Naval Research Laboratory, Material Science and Technology, USA
2. US Naval Research Laboratory, USA
3. University of Florida, USA

In polycrystalline ceramics, especially those that have nanometer sized grains, it is imperative to understand the effect that intrinsic (phase) and extrinsic (grain size/morphology) properties have on material characteristics, whether mechanical, electrical, or optical properties. This work seeks to investigate bulk nanocrystalline HfO_2 (HFO) and $Hf_{0.5}Zr_{0.5}O_2$ (HZO) and the effect that phase and grain size have on the optical properties with comparison between experimental and theoretical results. Nanopowder of HFO and HZO were synthesized via reverse co-precipitation of both pure monoclinic and cubic phases, as well as a mixture of the two, for bulk ceramic fabrication via environmentally controlled-pressure assisted sintering (EC-PAS). These materials were characterized by X-ray diffraction and in-line transmission measurements, showing that phase and grain size affect the degree of transparency. Modeling was also performed, combining Raman-Viswanathan theory and finite element method numerical simulations. Using optical constant tensors specific to monoclinic HFO, the modeling showed that monoclinic HFO with grain sizes < 60 nm are expected to be transparent, verifying experimental measurements. These results provide a framework for the limits of transparency in HFO and HZO, which informs future work on optimizing this system and other nanocrystalline ceramics.

4:50 PM

(ICACC-S14-008-2026) Photoreactive ceramic coatings for advanced infrastructure materials: Enhancing durability and functionality of polymers and steels (Invited)

T. Tsuchiya*[1]; J. Nomoto[1]; Y. Uzawa[1]

1. National Institute of Advanced Industrial Science and Technology (AIST), Japan

As the urgency of climate change and CO_2 reduction grows, enhancing the safety, durability, and environmental adaptability of infrastructure has become essential. Components such as steel and plastics used in industrial and transportation infrastructure face challenges like corrosion and degradation, leading to reduced structural integrity and increased maintenance burdens. This presentation introduces the latest developments in photoreactive ceramic coating technology that significantly enhances the durability and functionality of these materials. Specifically, it reports on the reinforcement of plastic components with high transparency and weather resistance, and the long-term protection of steel structures using ceramic coatings incorporating phosphorescent materials. These technologies contribute to the realization of preventive maintenance systems while promoting the circular reuse of infrastructure materials.

S15 10th International Symposium on Additive Manufacturing and 3-D Printing Technologies

S15- Defect Functions in Additive Manufacturing

Room: Ponce de Leon
Session Chairs: Russell Maier, National Institute of Standards and Technology; Andrew Allen, NIST

1:30 PM

(ICACC-S15-001-2026) Architectural design and testing of 3D-printed alumina-based multimaterial components with enhanced damage tolerance (Invited)

R. Bermejo*[1]; J. Schlacher[1]; M. Staudacher[1]; T. Lube[1]; S. Nohut[2]; M. Schwentenwein[2]

1. Montanuniversitat Leoben, Materials Science, Austria
2. Lithoz GmbH, Austria

The potential of the LCM technology to design novel alumina-based ceramic systems is explored. The first design concept is based on a multi-material design approach, where 3D-printed alumina layers are embedded between alumina-zirconia (ZTA)-layer regions. The tailored compressive residual stresses in the embedded alumina layer regions act as an effective barrier to crack propagation, providing a minimum strength for the architecture. The retained strength after thermal shock of the multi-material ceramic is significantly higher than that of the monoliths, owed to the crack arrest capability of the embedded layers. In the second design concept, spatially tailored porosity in 3D-printing ceramic parts is introduced to enhance their damage tolerance. In such architectures, porous interlayers are printed by using a polymeric pore forming agent, which is removed after the debinding process. The specific strength of the architecture is governed by the outer-dense alumina regions, whereas the damage tolerance is enhanced through the weak porous interlayers. Based on the case studies, damage tolerant demonstrator components with tailored residual stresses (multi-ceramic blade) and porosities (ceramic nozzle) are designed, which may open new application fields in the future. In addition, a novel testing method for strength evaluation in 3D-printed ceramics is presented.

2:00 PM

(ICACC-S15-002-2026) High-loading 3D-printed open-cell zeolite catalysts with enhanced structural integrity

Y. Tang*[1]; X. Zhao[2]; Y. Li[1]

1. Dartmouth College, Thayer School of Engineering, USA
2. Oak Ridge National Laboratory, USA

3D-printed open-cell catalysts promise to overcome the mass and heat transfer limitations found in traditional pellet catalysts. However, their performance is limited by low active material loading, typically below 70 wt%, due to printing challenges such as particle aggregation and high slurry viscosity. This study presents a new Direct Ink Writing slurry formulation that surpasses these limitations, achieving over 90 wt% zeolite loading while maintaining good printability. We find that using a nonionic dispersant is more effective in preventing particle aggregation than traditional anionic dispersants. Systematic pre-processing steps, including slurry aging and printing parameters (e.g., speed, extrusion rate, nozzle size), are optimized to produce defect-free printed parts. Post-processing temperature is then fine-tuned to convert these parts into durable catalysts. 600 °C is identified as the ideal temperature for fully removing organic binders without damaging the zeolite's structure. At this temperature, the 3D-printed catalysts achieve their highest specific surface area and maintain remarkable structural integrity, withstanding a compressive stress of 1.77 MPa. This results in more than a 200% increase in mechanical strength compared to the previously reported one. This comprehensive optimization offers a promising way for developing high-performance open-cell catalysts.

2:20 PM

(ICACC-S15-003-2026) Evaluation of coherent scanning interferometry to identify defects in ceramics

P. Beanerjee*[1]; R. Maier[2]; L. O. Grant[1]

1. UNC Charlotte The William States Lee College of Engineering, Mechanical Engineering and Engineering Sciences, USA
2. National Institute of Standards and Technology, USA

Defect detection and characterization techniques are critical for ensuring reliability in ceramic components, particularly those manufactured by 3D printing, where process-induced flaws strongly affect the mechanical properties. In this work, we evaluate the use of Coherent Scanning Interferometry (CSI) as a fracture surface analysis tool and a non-destructive approach for rapid defect detection in ceramics. Alumina samples with seeded defects (varying porogen content 0.3 and 3 vol% PMMA) are studied both in polished and unpolished conditions, to determine if surface scans from CSI can be used to track the sub-surface porosity. Complementary XCT scans are planned to validate the correlation between the surface measurements and sub-surface defects. Overall, these investigations highlight the impact of CSI as a technique to examine fracture surfaces and evaluate its performance as a non-destructive testing approach to detect internal defect populations from surface topography in ceramic components.

2:40 PM

(ICACC-S15-004-2026) New characterization paths to quantify ceramic additive manufacturing feedstock slurries

A. J. Allen*[1]; R. Maier[1]; B. Dolata[1]; I. Kuzmenko[2]; J. Ilavsky[2]

1. National Institute of Standards and Technology, USA
2. Argonne National Laboratory Advanced Photon Source, USA

Ceramics additive manufacturing (AM) by direct-ink-write materials extrusion or VAT photopolymerization is widely used. For potential to be fully realized, defects must be quantified & mitigated in as-built, densified ceramics. One defect source arises from spatial deviations in feedstock slurry morphology under influence of non-uniform thermodynamic or extensional flow conditions during AM builds. Ceramic AM feedstock slurries comprise concentrated particle suspensions, with multiple components of different mean size & size distribution within a suspension medium providing acceptable stability for a build. In principle, scattering methods can quantify the particle morphology, including particle-particle interactions governing rheology. In practice, characterization of particles & their interactions is required over a wide scale range present. Recent upgrades of both the Advanced Photon Source (to APS-U) at Argonne National Laboratory, & the APS ultrasmall-angle scattering (USAXS) facility in partnership with NIST, now enable such characterization up to several micrometers in scale under in situ rheological or extensional flow conditions. Experimental data for a range of particle morphologies, concentrations & conditions will be discussed & compared with corresponding computer simulations to draw insights on slurry properties & potential for local transients to lead to component defects.

3:20 PM

(ICACC-S15-005-2026) Development of slurry-based metrologies for ceramic additive manufacturing

R. Maier*[1]

1. National Institute of Standards and Technology, USA

To enhance ceramic printed part reliability, metrologies are being developed at NIST for both direct-ink writing (DIW) and digital light processing (DLP) techniques. For slurry-based printing processes, traditional shear rheology measurements are commonly employed to characterize ceramic inks and assess printability but fail to capture the pressure-driven conditions and complex shear histories characteristic of actual printing. In addition, standard test protocols for measuring values like the yield stress of dense suspensions lack the solutions for addressing nuances specific to highly loaded ceramic systems. With this in mind, we have developed a prototype research grade test material (RGTM) produced with novel filtering and degassing methods that has good shelf life and measurement reproducibility. The goal of this RGTM is to produce a material that is highly loaded (>50 % by volume alumina powder) and nonaqueous to avoid issues with evaporation during testing that can be used as a reference to validate a yield stress testing procedure on a generic rheometer. We will present details of our development and testing of this RGTM material along with recent results of in situ X-ray scattering synchrotron experiments of the composition in both capillary extrusion and rotational shear conditions.

3:40 PM

(ICACC-S15-006-2026) Analysis on the necessity of porosity for successful thermo-oxidative stabilization of CF-PEEK

K. C. Bull*[1]; D. Gilmer[2]; G. Larsen[3]; R. Walker[2]; C. L. Cramer[3]

1. The University of Tennessee Knoxville Tickle College of Engineering, Mechanical and Aerospace Engineering, USA
2. The University of Tennessee Knoxville Tickle College of Engineering, Material Science and Engineering, USA
3. Oak Ridge National Laboratory, Manufacturing Science Division, Oak Ridge National Lab, USA

Carbon/Carbon composites (C/C) are critical structural materials in aerospace, automotive, and thermal protection system (TPS) applications due to their exceptional specific strength, stiffness, and thermal stability. Conventional C/C manufacturing methods are limited by high tooling costs and restricted geometric complexity. Additive manufacturing, particularly fused filament fabrication (FFF), enables geometric flexibility and rapid prototyping capabilities, but thermoplastics are geometrically unstable during conversion to C/C. Thermo-oxidative stabilization (TOS) is often used to induce cross-linking in thermoplastics, but it has shown to be inconsistent in stabilizing bulk preforms. This work investigates the hypothesis that open porosity within FFF-printed carbon fiber reinforced polyetheretherketone (CF-PEEK) is essential for achieving homogeneous cross-linking behavior during TOS. CF-PEEK specimens were fabricated via FFF under varied processing parameters to tailor interlayer porosity. Thermal and oxidative behavior of the as-printed polymer were characterized using thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC). A one-dimensional diffusion model was employed to evaluate oxygen transport during TOS and correlated predicted oxygen concentration profiles with experimental cross-linking data obtained from nano-indentation and Raman spectroscopy.

S15- Powder bed fusion/selective laser melting and sintering

Room: Ponce de Leon
Session Chairs: Lynnora Grant, Rice University

4:50 PM

(ICACC-S15-007-2026) Use of glass for additive manufacturing by powder bed fusion

F. O. Mear*[1]; L. Sennoun[1]

1. Universite de Lille Faculte des Sciences et Technologies, France

A constant challenge in the world of glass is the production of complex shaped items. The existing product range could be significantly expanded by the use of additive manufacturing, which is still not widely used for both traditional and technical glass parts. Among the additive manufacturing methods, there are two approaches: fusion and sintering. Powder bed fusion (PBF) is a technology that uses an electron beam or laser source to selectively bond or melt powder grains to build parts layer by layer to the desired geometry. Glass is a material that is still little used in this manufacturing technique but which seems to be a promising candidate. In the present work, we report the results obtained on borosilicate glasses containing additives such as iron oxide and other rare earths to make the glass absorbent in the laser wavelength range (1 μm). The glass must meet its ability to soften under the effect of the laser. The properties of these glasses were determined in particular by UV-Visible-NIR absorption spectroscopy, heating microscopy, DRX, Selective Laser Melting Tests, etc.

5:10 PM

(ICACC-S15-008-2026) Stereolithographic additive manufacturing of fine ceramic components with geometric modulations

S. Kirihara*[1]; F. Spirrett[1]

1. Osaka University, Joining and Welding Research Institute, Japan

In stereolithographic additive manufacturing, 2-D cross sections were created through photo polymerization by UV laser drawing on spread resin paste including nanoparticles, and 3-D models were sterically printed by layer lamination. The lithography system has been developed to obtain bulky ceramic components with functional geometries. Fine or coarse beams could realize high resolution or wide area drawings, respectively. As the row material of the 3-D printing, nanometer sized metal and ceramic particles were dispersed into acrylic liquid resins at about 60 % in volume fraction. These materials were mixed and deformed to obtain thixotropic slurry. The resin paste was spread on a glass substrate with 50 μm in layer thickness by a mechanically moved knife edge. An ultraviolet laser beam of 355 nm in wavelength was adjusted to 50 μm in variable diameter and scanned on the spread resin surface. Irradiation power was automatically changed for an adequate solidification depth for layer bonding. The composite precursors including nanoparticles were dewaxed and sintered in the air atmosphere. Through computer-aided smart manufacturing, design, and evaluation, practical material components were fabricated to modulate energy and material transfers in potential fields between human societies and natural environments as active contributions to Sustainable Development Goals.

S17 Advanced Ceramic Materials and Processing for Photonics and Energy

S17- Multi-functional materials I

Room: Flagler C
Session Chairs: Alberto Vomiero, Lulea University of Technology; Elisa Moretti, Ca' Foscari University of Venice

1:30 PM

(ICACC-S17-001-2026) Synthesis of hollow silica nanoparticles using emulsion droplet templates and their application to thermal insulating composite materials (Invited)

K. Ishii*[1]; M. Fuji[1]

1. Nagoya Institute of Technology, Japan

Hollow silica nanoparticles (HSNPs) are core–shell particles with an internal cavity and a silica shell. Their unique structure provides a high specific surface area, encapsulation ability, low thermal conductivity, and a low dielectric constant. When incorporated into different materials, HSNPs can impart new functionalities and enhance performance. In this work, we synthesized HSNPs using an emulsion-template method, where emulsion droplets serve as sacrificial cores. The droplets are coated with silica, and simple water washing removes the templates to form hollow structures. By incorporating dispersants into the droplets, the resulting HSNPs exhibit high dispersibility, which is maintained even after incorporation into composite materials. We present the functionalities of HSNPs and demonstrate their application in polymer composite films, highlighting their optical properties and heat-insulating performance. These findings indicate that HSNPs are promising fillers for advanced multifunctional coatings and energy-saving materials. Acknowledgement: This study was partly supported by JSPS KAKENHI, grant number JP 23H01801.

2:00 PM

(ICACC-S17-002-2026) Processing and properties of nano-porous sorbents and satalysts for carbon capture and conversion (Invited)

F. Akhtar*[1]

1. Lulea University of Technology, Division of Materials Science, Sweden

Production of carbon-neutral fuels is an important challenge to reduce greenhouse gas emissions from the energy sector. In this regard, the separation of carbon dioxide from power-plant flue gas and raw biogas to upgrade it to biomethane economically is a pressing challenge. Recent developments in the synthesis of novel sorbents for practical carbon capture applications, tailoring of adsorptive properties of novel porous materials, and evolution of properties required for CO_2 separation from power-plant flue gas and biogas will be described, including CO_2 uptake capacity, high CO_2 over CH_4 and CO_2 over N_2 selectivity, rapid uptake and release kinetics, and long-term durability. Furthermore, we will show the development of catalysts for CO_2 conversion to CH_4 with optimized MSI that deliver both high activity and long-term durability under demanding reaction conditions. The work highlights how tailoring metal–support interactions (MSI) by regioselectively anchoring Ni and Co onto hierarchical porous zeolite 13X strengthens the bonding between metals and the ceramic support. The resulting thin nanolayers of Ni and Co enhance electronic interactions, yielding higher catalytic stability and performance in the CO_2 methanation reaction.

2:30 PM

(ICACC-S17-003-2026) Novel materials chemistry for applications in energy storage and conversion (Invited)

N. Pinna*[1]

1. Humboldt-Universität zu Berlin, Department of Chemistry, Germany

The current trend in various energy applications, ranging from batteries to electrolizers, lays in the control of structural, physicochemical and morphological properties of materials and their interfaces. During this presentation, recent scalable strategies for nanostructured materials synthesis, targeting energy and environmental applications will be discussed. Especially, we will focus on one-pot strategies for the fabrication of hybrid and complex nanomaterials focusing on the importance of the organic-inorganic and inorganic-inorganic interfaces. Among the examples presented, we will discuss the synthesis of complex nanostructures and the stabilization of metastable phases for applications in energy, catalysis and environmental remediation. We will see that nowadays the available strategies allow a control in terms of composition, crystalline structure, morphology and nanostructuration that would have been unimaginable just few years ago. Finally, the open challenges the field is currently facing and possible further developments which are needed to meet the always growing demand for high performing materials will be also discussed.

3:20 PM

(ICACC-S17-004-2026) Engineering high-performance $TiO_2/BiVO_4$ photocatalysts for enhanced water treatment and solar hydrogen production (Invited)

A. El Hattab[1]; A. Mirzaei[2]; A. Nada[3]; Z. Shayegan[4]; S. Roualdes[5]; M. Chaker*[1]

1. Institut National de la Recherche Scientifique, Centre Energie Materlaux Telecommunications, Canada
2. Western University, Physics and Astronomy, Canada
3. Luxembourg Institute of Science and Technology, Material Research and Technology Department, Luxembourg
4. National Research Council, Clean energy innovation, Canada
5. Institut Europeen des Membranes, France

Pulsed laser deposition (PLD) was employed to fabricate $TiO_2/BiVO_4$ photocatalysts and overcome unfavorable band alignment often observed upon heterojunction formation. In the first approach, $BiVO_4$ thickness on black TiO_2 nanotube arrays was optimized for tetracycline (TC) removal under visible light, achieving a degradation rate five times higher than bare TiO_2. This improvement was attributed to enhanced light absorption, type II heterojunction formation, and an optimized mass ratio between photocatalysts. In the second approach, a thin tungsten-doped VO_2 interlayer was inserted between $BiVO_4$ and TiO_2, reversing the internal electric field, increasing photocurrent density by 145%, and accelerating TC degradation by 225%, highlighting the role of band engineering in improving charge transfer efficiency. Lastly, PLD was used to construct a dual photoanode by integrating transparent TiO_2 and $BiVO_4$ in a back-to-back configuration. This design yielded 1.72 mA cm^{-2} photocurrent and 14.2 μmol cm^{-2} h^{-1} hydrogen production, surpassing conventional heterojunctions. These findings demonstrate the versatility of PLD for fabricating high-performance photocatalysts and heterojunctions, offering valuable insights for applications in advanced water treatment, solar fuels, and energy conversion.

3:50 PM

(ICACC-S17-005-2026) Understanding organic magnetoresistance in conjugated polymers (Invited)

E. Orgiu*[1]

1. Institut national de la recherche scientifique, Energy Materials and Telecommunications, Canada

Organic conjugated polymers are especially suited for applications in (opto)electronics and thermoelectrics and represent a fantastic playground for fundamental studies on charge, heat and spin transport. While the physical phenomena associated with the application of a magnetic field are seemengly well-known for vertical devices using a non-magnetic material sandwiched between two ferromagnetic electrodes, magnetic-field effects in devices in which the organic semiconducting layer is sandwiched between non-ferromagnetic electrodes came as a great surprise. Here we present a comprehensive study wherein the organic magnetoresistance (OMAR) of different types of polymers is experimentally and theoretically unraveled. We characterized n-type, p-type and ambipolar polymers and draw general conclusions on the fundamental mechanisms underlying the observed OMAR effects in conjugated polymers. The polymers were characterized structurally and their paracrystallinity was correlated to the OMAR. Unlike most of the previous reports on OMAR, our study allows to modulate the bipolaron formation rate at the dielectric/semiconductor interface as a function of temperature and magnetic field intensity. Low and high magnetic fields characteristics are measured that strongly depend on the chemical structure of the polymer.

4:20 PM

(ICACC-S17-006-2026) Effect of selenization on the catalytic performances of Ni-hexacyanoferrate-based nanocubes (Invited)

F. Polo*[1]; E. Lushaj[2]; T. A. Shifa[1]

1. Universita Ca' Foscari, Department of Molecular Sciences and Naosystems, Italy
2. Fraunhofer-Institut fur Fertigungstechnik und Angewandte Materialforschung IFAM, Germany

For a long time Prussian-blue analogue (PBA) materials have attracted research interests owing to their intriguing stimuli-responsive electron transfer properties, spreading their use in different research field, including the energy storage, catalysis and sensing. In recent years, extensive efforts have been devoted to design and synthesize highly active, earth-abundant, and low-cost alternative catalysts for oxygen evolution reaction (OER). Moreover, the development of hierarchical nanostructures with controllable composition proved to be a new pathway to tune their physico-chemical properties. In this presentation, we describe a straightforward, two-step protocol to synthesize composite nanocubes, constituted of nickel hexacyanoferrate (Ni-HCF) and trigonal selenium, in which the characteristics of PBAs and chalcogenide-based materials are merged. The electronic, structural, and optical properties have been fully characterized, and their performances have been tested in the oxygen evolution reaction (OER) to comprehensively understand the structure–performance relationship. The new material features low charge transfer resistance and high current delivery providing enhanced kinetics toward OER.

4:50 PM

(ICACC-S17-007-2026) Light-triggered NIR theranostic nanoplatforms (Invited)

F. Vetrone*[1]

1. INRS, Université du Québec, Centre Énergie, Matériaux et Télécommunications, Canada

Luminescent nanomaterials that can be excited, as well as emit, in the near-infrared (NIR) have been investigated for use in a plethora of applications related to human health and biology. They have received considerable attention for theranostic (therapy and diagnostic) platforms where light is used as an external trigger. NIR light can penetrate tissues much better than high-energy light especially when these wavelengths lie within the three biological windows where tissues are optically transparent. At the forefront of NIR excited nanomaterials are rare earth doped nanoparticles (RENPs), which due to their 4f electronic energy states can undergo conventional (Stokes) luminescence and emit in the three NIR biological windows. However, unlike other nanoparticles, they can also undergo a multiphoton process (known as upconversion) where the NIR excitation light is converted to higher energies resulting in anti-Stokes luminescence spanning the UV-visible-NIR regions. Due to the versatility of their optical properties, it now becomes possible to generate high-energy light (UV or blue) in situ to trigger other light activated therapeutic modalities while using the NIR emission for diagnostics. Here, we present the synthesis of diverse RENPs and demonstrate how their luminescence properties can be exploited for potential use in diverse biomedical applications.

S18 Ultra-High Temperature Ceramics

S18- Compositionally complex UHTCs

Room: Coquina A

Session Chairs: William Fahrenholtz, Missouri University of Science & Technology; Frederic Monteverde, CNR-ISTEC

1:30 PM

(ICACC-S18-001-2026) Metal segregation in boride-carbide dual phase high entropy ceramics (Invited)

W. Fahrenholtz*[1]; A. Feltrin[2]; S. Divilov[3]; S. Curtarolo[3]; G. Hilmas[1]

1. Missouri University of Science & Technology, Dept. of Materials Science and Engineering, USA
2. Missouri University of Science and Technology, Materials Research Center, USA
3. Duke University, Mechanical Engineering and Materials Science, USA

Transition metal distribution was investigated in dual phase high entropy ceramics containing boride and carbide phases. Ceramics were synthesized by boro/carbothermal reduction of oxides and densified by spark plasma sintering. Metal distributions were characterized using energy dispersive spectroscopy to determine relative concentrations in the boride and carbide ceramics. Initial studies focused on dual phase ceramics containing five different transition metals. Metal distributions were generally consistent with predictions made using macroscopic thermodynamic analysis assuming ideal solution behavior. However, the distribution of vanadium varied with processing conditions and did not follow predictions. Further analysis utilizing first principles calculations and metal distributions in systems containing only two transition metals provided additional insight, revealing that vanadium distribution was affected by the overall composition of the system including carbon stoichiometry. The overall results provide a robust framework for controlling the composition and resulting hardness of dual phase high entropy ceramics.

2:00 PM

(ICACC-S18-002-2026) The thermal stability of high-entropy carbides

C. A. Butler*[1]; E. Saiz[1]; F. Giuliani[1]

1. Imperial College London, United Kingdom

High-entropy or entropy stabilised carbides are a new class of ceramic in which multiple transition metals are combined into a single-phase crystalline carbide solution. Early research has shown that high-entropy carbides provide a promising new range of materials for extreme environments, such as in thermal barrier protection. However, there are still some gaps on our knowledge of the fundamental relationship between composition, microstructure and performance in these materials. In particular, the high number of compositional degrees of freedom found in high-entropy materials means that navigating their phase stability can be complex. In this work, we explore the stability of $(HfTaZrNbTi)C_5$, which has shown excellent high temperature mechanical properties and oxidation resistance. The materials are fabricated through solid state sintering starting from carbon and oxide mixtures. The phase stability over a range of isothermal annealing temperatures is evaluated, in varying atmospheres. The resulting microstructure and chemical homogeneity are assessed through a combination of advanced characterisation techniques. To be specific, atom-probe tomography, TEM/STEM and XAS are used to analyse atomic distribution at a sub-nanometre resolution. The results provide information needed to understand how the microstructure and phases of high-entropy carbide ceramics can evolve, and how the resulting material properties will change.

2:20 PM

(ICACC-S18-003-2026) Examination of entropy-stabilized oxides by lowering the configurational entropy through the elimination of one cation

D. T. Mühmer*[1]; J. Nießen[1]; T. Tonnesen[1]

1. Rheinisch-Westfalische Technische Hochschule Aachen, Institute of Mineral Engineering, Germany

The concept of high-entropy materials is quite new and began with alloys. Since then, it has expanded to many materials, including oxide ceramics. Several assumptions have been transferred from the alloys without considering differences in chemical and thermodynamic properties. In the case of oxides, there is an oxygen sublattice that is not present in alloys. This significantly impacts the configurational entropy, which is said to be the primary energy component of high-entropy oxides. Besides the entropy-stabilized single phases, there can be solid solutions. They have a high entropy but do not depend on the entropic term to form a single phase. To examine the difference, we will analyze the impact of lowering the configurational entropy of single-phase materials consisting of five metal cations by eliminating one cation species. For a solid solution, the n-1 systems should remain single-phase, while entropy-stabilized phases are expected to form multiple phases. We chose the melting route for synthesis in an aero-acoustic levitator. Thereby, the samples experience a high cooling rate during solidification. This presentation will discuss the method of lowering the configurational entropy by degrading a single-phase five-cation system to a four-cation system.

2:40 PM

(ICACC-S18-004-2026) The role of constituent elements in thermal properties of high-entropy carbides

E. A. Pritchett*[1]; G. Hilmas[1]; W. Fahrenholtz[1]

1. Missouri University of Science and Technology, Materials Science and Engineering, USA

High-entropy carbides are a class of ultra-high temperature ceramics known for melting temperatures of over 3000°C and strength retention above 1800°C. These properties are suitable for extreme environment applications, such as structural insulators for hypersonic vehicles. A gap in knowledge exists for composition-thermal property relationships of high-entropy carbides, which this research aims to address. (MoNbTiVZr)C will be synthesized along with individual, binary, ternary, and quaternary carbides of the same constituents. Carbothermal reduction will be used to synthesize the compositions, with spark plasma sintering utilized to densify the reacted powders. Thermal diffusivity and electrical resistivity will be measured up to 2000°C to determine phonon and electron contributions to thermal conductivity for each composition. X-ray diffraction, scanning electron microscopy, and energy dispersive spectroscopy will characterize phases present, homogeneity, and metal ratios of the compositions. The thermal conductivity contributions for each composition will be compared to determine the role of constituent elements on thermal properties in high-entropy carbides.

3:20 PM

(ICACC-S18-005-2026) Transition metal diboride solid solutions for future space missions (Invited)

F. Monteverde*[1]; S. Mungiguerra[2]; S. Cassese[2]; D. De Prisco[2]; R. Savino[2]

1. Consiglio Nazionale delle Ricerche, ISSMC, Italy
2. University of Naples Federico II, Department of Industrial Engineering, Italy

AlB_2-type diboride solid solutions (DSSs) containing IV-V-VI group metals were investigated as material candidates for future space missions using a ground entry simulator. DSS dense discs were spark plasma sintered and then exposed to supersonic dissociated reacting flows. The overall degradation of the material strongly depended on the starting metal combination, and preferential oxidation took place massively. A thermal study was devised and implemented in a numerical model to validate the experimental set-up. The experimental results also showed good agreement with predictions based on a thermodynamic assessment.

3:50 PM

(ICACC-S18-006-2026) Fundamental thermal and electrical properties of a $(Cr,Mo,Ta,V,W)C_{1-x}$ high-entropy carbide ceramic

A. Sarikhani*[1]; W. Fahrenholtz[2]; G. E. Hilmas[2]; Y. Hor[1]

1. Missouri University of Science and Technology, Materials Research Center, USA
2. Missouri University of Science & Technology, Dept. of Materials Science and Engineering, USA

The development of materials capable of withstanding extreme environments is essential for enabling future technological advancements. High-entropy carbide (HEC) ceramics have gained attention for their outstanding thermal, mechanical, and chemical stability. A single-phase $(Cr,Mo,Ta,V,W)C_{1-x}$ ceramic was synthesized and densified at different temperatures for fundamental property measurements. Thermal, electrical, and magnetic properties were characterized by using a physical property measurement system at both room temperature and cryogenic temperatures. The concentrations of carbon vacancies and dissolved oxygen in the lattice were quantified using neutron diffraction and inert gas fusion analysis. The phase purity and density of the ceramic make it appropriate for fundamental property measurements, which are reported for the first time for this composition.

4:10 PM

(ICACC-S18-007-2026) Variable-temperature plasmonic high-entropy carbides (Invited)

S. Divilov*[1]

1. Duke University, Materials Science, USA

Effective thermal management at variable and extreme temperatures face limitations for the development of novel energy and aerospace applications. Plasmonic approaches, shown to be capable of tailoring black-body emission, could be effective if materials with high-temperature and tunable plasmonic resonance were available. We present a synergy between experimental and theoretical results proving that many high-entropy transition metal carbides, consisting of four or more metals at equal molar ratio, have plasmonic resonance at room, high (> 1000 °C) and variable temperatures. We also found that these high-entropy carbides can be tuned and show considerable plasmonic thermal cycling stability. This paradigm shift approach could prove quite advantageous as it facilitates the accelerated rational discovery and manufacturability of optically highly optimized high-entropy carbides with ad hoc properties.

4:40 PM

(ICACC-S18-008-2026) Processing and thermal properties of high-entropy carbides for ultrahigh temperature applications

A. Salanova Giampaoli*[1]; E. Gorzkowski[1]; J. Wollmershauser[2]

1. US Naval Research Laboratory, USA
2. U.S. Naval Research Laboratory, Materials Science & Technology Division, USA

High-entropy carbides (HECs) represent a promising class of materials for extreme environments, offering superior thermo-mechanical performance compared to conventional single-component carbides in ultrahigh temperature applications. This enhanced performance is primarily attributed to their high configurational entropy, which promotes increased stability at elevated temperatures and leads to a reduced thermal conductivity by introducing sites in the lattice where phonons scatter and reduce phonon mean free path. This work focuses on the controlled processing of single-constituent and high-entropy carbides, and the characterization of their thermal properties, with a particular emphasis on thermal expansion behavior investigated via both dilatometry and hot-stage x-ray diffraction. It is expected that the increased configurational entropy in these multi-component systems impacts the thermal expansion. A comparative analysis of these distinct measurement techniques, alongside ongoing investigations into thermal diffusivity, will provide critical insights into the thermal management and stability of HECs.

5:00 PM

(ICACC-S18-009-2026) Synthesis and characterization of complex UHTC carbide solid solutions via arc melting

A. Celik*[1]; A. Mann[1]; R. Haber[1]

1. Rutgers University, Materials Science and Engineering, USA

Ultra-High Temperature Ceramic (UHTC) transition metal carbides are of great importance due to their remarkable material properties, including high melting temperature, high hardness, good strength, and chemical stability at elevated temperatures. These properties make UHTC carbides good candidates for extreme aerospace applications, such as hypersonic vehicles and rocket nozzles. Binary, ternary and quaternary systems involving HfC, ZrC, TiC, and TaC were synthesized through arc-melting. Computational thermodynamic modeling (CALPHAD method) on equimolar and non-equimolar compositions were performed to predict phase formations and guide experimental work. Characterization with XRD, SEM, EDS and various other methods were utilized to analyze samples prior to and after arc melting. These show the potential of arc melting as a method for producing transition metal carbides with a range of compositions.

5:20 PM

(ICACC-S18-010-2026) Compositionally complex (Hf,Zr,Nb,Ti) B_2-LaB_6 ceramics

B. Cui*[1]; X. Chen[1]; L. Trinh[1]; Z. Hua[2]; K. Bawane[2]; Y. Lu[1]

1. University of Nebraska-Lincoln, USA
2. Idaho National Laboratory, USA

Novel compositionally complex borides, (Hf,Zr,Nb,Ti)B_2 and (Hf,Zr,Nb,Ti)B_2-LaB_6, were fabricated using spark plasma sintering (SPS) process. (Hf,Zr,Nb,Ti)B_2-LaB_6 exhibits a dual-phase microstructure, in which (Hf,Zr,Nb,Ti)B_2 is a primary phase with the hexagonal structure and LaB_6 is a secondary phase with a cubic structure. The mechanical properties of both (Hf,Zr,Nb,Ti)B_2 and (Hf,Zr,Nb,Ti)B_2-LaB_6 are comparable, with a combination of high hardness and moderate fracture toughness. Thermal diffusivity and conductivity of (Hf,Zr,Nb,Ti)B_2 are much lower than the individual transition metal borides but is significantly increased by the addition of LaB_6. Herein, it is implied that the thermal properties of boride ceramics can be controlled through the appropriate design of principal metal element compositions.

S19 Molecular-level Processing and Chemical Engineering of Functional Materials

S19- Precursor chemistry – Structural and thermal transformations

Room: Ballroom 1 -2
Session Chairs: Peter Kroll, University of Texas, Arlington; Samuel Bernard, CNRS; Aitana Tamayo, Institute of Ceramics and Glass, CSIC

1:30 PM

(ICACC-S19-001-2026) Polymer-derived micro/macroporous SiCON-based ceramics with integrated catalytically active metal sites to stimulate superior HER and OER activities (Invited)

S. Bernard*[1]

1. CNRS, IRCER, France

The recent development of anion exchange membrane materials has led to the emergence of the anion exchange membrane electrolysers allowing the use of non-noble transition metals in the composition of catalysts for hydrogen (HER) and oxygen (OER) evolution reactions in alkaline media. However, their nanoscale synthesis is highly challenging to limit the overpotential, particularly at the anode (OER). The PDC (Polymer Derived Ceramics) route is a non-conventional way of designing ceramics by using preceramic polymers as precursors. The coordination (or direct reaction) of these precursors with metal complexes via the functional groups and/or ligands of the polymer makes it possible to trap transition metal nanoparticles in a micro-/mesoporous PDC matrix upon pyrolysis at low temperature. By considering the fact that preceramic polymers display an intrinsic ability to in-situ form and maintain a porosity at different length scales at low temperature pyrolysis, these metal NPs become accessible while overcoming their stability issue during the catalysis process. Besides, the activity and selectivity can be simultaneously enhanced by taking advantage of the synergy between the metal NPs and the encapsulating materials. This will be the content of this presentation that will introduce our very recent works on this topic.

2:00 PM

(ICACC-S19-002-2026) Synthesis and atomic structures of Europium doped oxides (Invited)

G. Westin*[1]

1. Uppsala University, Sweden

The dopant Ln atom distribution and local coordination strongly determine the optical and magnetic properties of Ln-doped oxides. Here, Eu-doped ZnO and Al_2O_3 prepared by solution based routes are described in detail. A wide range of techniques allowing for elucidation of the overall microstructure structure to the local atomic structure of the Eu-ions was used including: TG/DSC, XRD, XPS, IR- and Raman spectroscopy, EXAFS, SEM, STEM/ED/DF/EELS/EDX/ePDF, and DFT. Here heterometallic alkoxide precursors could result in single Eu-ions evenly separated in the alumina while a complexed salt route resulted in Eu-oxide clusters distributed within the ZnO crystals without changing the ZnO unit cell dimensions more than very marginally. These two examples show how the crucial dopant structure can be tailored

2:30 PM

(ICACC-S19-003-2026) From high-entropy ceramics (HECs) to compositionally complex ceramics (CCCs) (Invited)

J. Luo*[1]

1. University of California San Diego, USA

This talk will first review a series of our studies of high-entropy ceramics (HECs), including equimolar five-component MB_2, MB, M_3B_4, MB_4 and MB_6 borides, perovskite and YSZ-like fluorite oxides, and MSi_2 and M_5Si_3 silicides, along with intermetallic compounds. In 2020, we further proposed to extend HECs to "compositionally complex ceramics (CCCs)" to include non-equimolar compositions and long/short-range ordering, which reduce configurational entropies, but offer additional opportunities to tailor/improve properties. We also reported the first dual-phase HECs/CCCs and investigated 10- to 21-component ultrahigh-entropy fluorite-based oxides. We recently investigate compositionally complex perovskite oxides for solar thermochemical hydrogen generation thru tailoring oxygen vacancies and as improved solid lithium-ion conductors via controlling interfaces. While our prior studies fabricated HECs and CCCs via solid-state reactions, we recognize that molecular precursors offer novel routes to synthesize and process HECs and CCCs with controlled compositions, phases and microstructures to achieve superior properties.

3:20 PM

(ICACC-S19-004-2026) A machine-learning Interatomic potential for predictive simulations of SiCN materials (Invited)

S. Haseen[1]; P. Kroll*[1]

1. University of Texas, Arlington, USA

We present the first machine-learning interatomic potential (MLIP) for predictive atomistic modeling of Si–C–N–H ceramic materials. The MLIP allows for the exploration of complex processes at large scales with quantum-level accuracy. We demonstrate its application to important technological problems that were previously unmanageable: self-diffusion in Si_3N_4, fracture in SiC/Si_3N_4 composites, and the polymer-to-ceramic transformation of polysilazanes. Large-scale pyrolysis simulations of polysilazanes, spanning hundreds of nanoseconds, reveal structural evolution, such as the formation of nanometer-sized graphitic segregations in SiCN ceramics and phase separation of the SiCN matrix. Our results demonstrate that this MLIP reproduces experimental observations and opens new paths for predictive atomistic modeling of ceramic materials.

3:50 PM

(ICACC-S19-005-2026) Multilayer 3D printed carbonaceous structures with hyperbranched pre-ceramic polymeric coatings and MAX phase composites. (Invited)

J. Sinclair*[1]; C. Birkel[1]; A. Das[1]; T. Long[1]; M. Madsen[1]

1. Arizona State University, School of Molecular Sciences, USA

Hyperbranched pre-ceramic poly(carbosilanes) (PCPs) represent a versatile platform for fabricating silicon carbide ceramics. Synthesized via an AB_2 monomer approach, these PCPs possess highly branched architectures with multiple terminal vinyl sites, enabling post-functionalization and tailored crosslinking. Their liquid, solvent-free nature imparts low viscosity, excellent processability, and curing at modest temperatures (200–350 °C). Controlled pyrolysis converts the polymers into amorphous SiC between 800–1200 °C and crystallization into β-SiC above 1400 °C. The ceramics also exhibit thermal stability exceeding 1600 °C. When coated onto vat photopolymerization (VPP)-derived aromatic polyimide carbon lattices, the PCPs infiltrate the porous network forming strongly adherent SiC coatings upon pyrolysis. Scanning electron microscopy confirms uniform deposition and bonding. Beyond binary SiC phases, this strategy extends to complex multi-component systems. By dispersing cationic metal species within PEGDA–LAP photoresins, complex VPP-printed geometries can be converted into layered ternary carbides, such as MAX phases. These materials uniquely combine metallic conductivity with ceramic robustness, presenting opportunities for applications demanding both structural integrity and electronic/thermal transport.

4:20 PM

(ICACC-S19-006-2026) Preceramic polymers and hybrid systems for the fabrication of high-temperature ceramics (Invited)

M. B. Dickerson*[1]; J. Ponder[1]; J. Zackasee[1]; T. Pruyn[1]; J. Delcamp[1]

1. Air Force Research Laboratory, Materials and Manufacturing Directorate, USA

Preceramic polymers (PCPs) are an attractive class of materials as they allow for the fabrication of ceramic objects using polymer processing techniques. Polymer-derived ceramics have several desirable properties, including high-temperature stability and chemical resistance. In our work, we have applied several soft-matter processing methodologies to PCPs, including block copolymer (BCP) templating and nanoparticle surface grafting, to yield high-temperature nanostructures. The ability to fabricate high-temperature ceramics and composites with features below the critical crack length improves mechanical loading responses and therefore fracture toughness as well as crack resistance. BCPs can be used to direct PCPs by selective swelling of one block leading to tailorable morphologies through control of the ratio of the polymers. BCPs can be burned out during pyrolysis, resulting in nano-featured ceramics. As PCPs suffer from substantial shrinkage between casting and pyrolysis, incorporation of nanoparticles can be used to aid in reducing contraction. Nanoparticles' propensity to flocculate makes them challenging to work with and to evenly disperse, but this can be overcome by synthesis of a polymer layer on the surface to produce polymer-grafted nanoparticles (PGNPs). PGNPs can be used alone or in conjunction with PCPs to produce ceramics with lower shrinkage and higher ceramic yields.

4:50 PM

(ICACC-S19-007-2026) Molecular precursors as building blocks for Phase-controlled synthesis of high entropy oxides

Z. Aytuna*[1]; D. Patrun[1]; T. Fischer[2]; S. Mathur[2]

1. Institute of Inorganic and Materials Chemistry, Department of Chemistry, University of Cologne, Germany
2. University of Cologne, Institute of Inorganic Chemistry, Germany

Compositionally complex oxides are attracing interest for their ability to form homogeneous crystalline phases despite their chemical complexity. In this work, we addressed a synthesis approach towards high entropy oxides by employing metal alkoxides as molecular precursors in a sol–gel approach. Partially hydrolyzed alkoxides were used to undergo controlled condensation, creating cross-linked preceramic networks where different metal centers were intimately mixed at the molecular scale. These gels served as homogeneous precursors that transformed into crystalline entropy-stabilized oxides upon calcination. By adjusting precursor choice, reaction conditions, and valency, we systematically tuned the materials and gained direct control over phase formation. This precursor-driven strategy suppressed segregation and enabled the stabilization of single-phase multi-cation oxides. Structural and spectroscopic analysis confirmed compositional homogeneity and highlighted the decisive role of precursor chemistry in phase evolution. Beyond providing structurally well-defined oxides, the approach reduced synthesis temperature and improved reproducibility compared to solid-state routes. While electrochemical water-splitting was tested as a application, the core contribution is establishing precursor-controlled sol–gel chemistry as a scalable route to entropy-stabilized oxides with tunable features.

5:10 PM

(ICACC-S19-008-2026) Polymer pyrolysis simulations of high-temperature ceramics

P. Kroll*[1]

1. University of Texas, Arlington, USA

The thermal conversion of zirconium-modified polycarbosilanes produces multi-phase ZrSiCN ceramics with improved properties for extreme environments. We develop models of polymer precursors for ZrSiCN ceramics based on allylhydrido-polycarbosilane (AHPCS; e.g., SMP-10) co-reacted with varying amounts of zirconium amine complexes. The precursor models include up to 500 atoms and are optimized using Density-Functional-Theory calculations. Calculated IR spectra reveal the influence of Zr on the vibrations of the Si-C framework. Selected models are annealed at high temperatures for pyrolysis simulations. We present atomistic details of fundamental reactions obtained from ab-initio Molecular Dynamics (aiMD) simulations. We observe intra-chain and inter-chain coupling, cross-linking, and elimination reactions. Additionally, we identify the role of hydrogen in facilitating rapid bond exchange. A comparison between SMP-10 and modified ZrSiCN precursor will be gven. By adjusting the elimination rates of gaseous species, we also simulate the effects of reactive environments, such as hydrogen atmospheres, on the products' chemical composition.

S20: Golden Jubilee- Engineered Ceramics for Achieving Net-Zero Carbon Emissions

S20- Advanced materials and manufacturing technologies for energy generation and storage systems and artificial intelligence and machine learning

Room: Coquina D
Session Chairs: Manabu Fukushima, National Institute of Advanced Industrial Science and Technology (AIST); Alexander Michaelis, Fraunhofer IKTS

1:30 PM

(ICACC-S20-001-2026) Advanced ceramics as efficient catalysts for green hydrogen and ammonia synthesis (Invited)

S. Mathur*[1]

1. University of Cologne, Institute of Inorganic and Materials Chemsitry, Germany

Thin films of functional oxides offer tunable electronic properties and high surface-area interfaces, making them ideal platforms for efficient small molecule activation in green hydrogen and ammonia production. The possibilities of engineering nanostructures in various compositions (pure, doped, composites) and forms has intensified the research on the integration of different functional material units in a single architecture to obtain new photo- and electrocatalytic materials. We report here on the influence of external magnetic fields applied parallel or perpendicular to the substrate during plasma enhanced chemical vapor deposition of transition metal oxides. Films grown from transition metal precursors showed pronounced changes in crystallographic textures depending upon whether CVD was performed with or without external magnetic field. Investigations on the water splitting properties of the hematite films in a photoelectrochemical reactor revealed superior photocurrent values of hematite photoanodes deposited in external magnetic field. This talk will demonstrate that applying magnetic fields during growth of thin films can fundamentally reconfigure lattice characteristics. This dual modulation precisely tailors their intrinsic and emergent electrochemical properties making MF-CVD a groundbreaking and versatile strategy to transform functional materials at the atomic level.

2:00 PM

(ICACC-S20-002-2026) Chemically bonded phosphate ceramics for geothermal applications (Invited)

D. Singh*[1]

1. Argonne National Lab, USA

Chemically bonded phosphate ceramics (CBPC) are a class of ceramic materials that are synthesized at low-temperatures by acid/base reactions. In general, magnesium oxide (MgO) is mixed with potassium phosphate solution to form a slurry that sets under ambient conditions in matter of few hours. Various filler materials such as fly ash, silicates, etc., can be added to control structural and mechanical properties of the set product. Recovery and use of energy from geothermal sources provides a baseload power source. In this presentation, CBPC technology is explored for geothermal well cementation applications which require the material to set at high temperatures and pressures and under corrosive environments. The talk will include discussion on the mechanism of the CBPC synthesis and characterizations on the set material. Further, the setting of the CBPC under geothermal conditions will be presented to validate the CBPC technology as a geothermal sealant material.

2:30 PM

(ICACC-S20-003-2026) Stereolithographic additive manufacturing of engineering ceramic components with functional geometries (Invited)

S. Kirihara*[1]; F. Spirrett[1]

1. Osaka University, Joining and Welding Research Institute, Japan

Stereolithographic additive manufacturing is new strategy of science and engineering to create novel functional materials with special dimensions and morphologies. In this presentation, various investigations to develop the functionally structured materials by using novel processing having minimum impacts on environments will be introduced. In stereolithographic additive manufacturing, 2-D cross sections were created through photo polymerization by UV laser drawing on spread resin paste including ceramic nanoparticles, and 3-D models were sterically printed by layer lamination. The composite precursors including nanoparticles were dewaxed and sintered in the air atmosphere. The fabrication process of engineering ceramic components fabricated though the computer aided smart manufacturing, design and evaluation (Smart MADE) will be demonstrated.

3:20 PM

(ICACC-S20-004-2026) Advanced ceramics for CCU (carbon capture and utilization) technology. (Invited)

A. Michaelis*[1]

1. Fraunhofer IKTS, Germany

Advanced ceramic materials offer enormous potential for innovations in the fields of energy conversion and storage as well as decarbonization. Especially ceramic based high temperature electrolysis (SOE: solid oxide electrolysis) can be employed as a powerful technology for highly efficient CCU applications. For this, SOE is used in the co-electrolysis mode for the simultaneous production of H_2 and CO, so called syngas. In the co-electrolysis mode, CO_2 is actively removed from the environment and fed into the SOE system. By the Fischer Tropsch processes this syngas can be transferred to e-fuels (such as SAF: sustainable aviation fuel), higher alcohols, and even waxes. We present a fully integrated co-electrolysis Fischer Tropsch System combined with ceramic gas separation membranes for the extraction of CO_2 from different sources such as exhaust gas from lime industry or biogas. We also present examples using SOE for combined CCU and CDA (carbon direct avoidance) applications in green steel production. Applying this technology, even allows to produce CO_2 "negative" steel.

3:50 PM

(ICACC-S20-005-2026) Solid-state electrolytes with fast-ion conductivity: Material structures & phase transitions (Invited)

W. Tang*[1]

1. Underwriters Laboratories Inc, Electrochemical Safety Research Institute, USA

The widespread adoption of electrification technologies has increased the demand for high energy density, long cycle life, & fast charging capabilities in electric vehicles & devices, surpassing the current lithium-ion battery (LiB) standards. By replacing the separator & liquid electrolyte in LiBs with a solid-state electrolyte (SSE) component, these properties can improve through advanced solid-state battery (SSB) technology. Typical SSEs for lithium systems include polymer-, oxide-, & sulfide-based chemistries, or composites. Recently, closo-polyborates ($B_yH_z^{n-}$) & closo-polycarborates ($C_xB_yH_x^{n-}$), initially identified as side products during borohydrides (BH_4^-) cycling for hydrogen storage, have been explored as alternative SSE materials. These lithium & sodium alkali salts exhibit fast-ion conducting properties in their high-temperature (HT) phases, due to cationic Wyckoff site vacancies & dynamic "paddlewheel" anionic rotations. This talk focuses on the development of these closoborate SSEs. Through analyzing the anionic structures within these salts & their transition temperatures (T_{trans}) to HT-phases, a link is shown between smaller anions & lower T_{trans}, enabling fast-ion conduction at device-relevant temperatures. Examining the structures of these hydroborate congeners offers insights into discovering & predicting other novel cage-polyhedrons alkali salts for SSB applications.

4:20 PM

(ICACC-S20-006-2026) Impact of vibration on the storage performance of Li-ion batteries (Invited)

P. Balaya*[1]; N. Vangapally[1]

1. National University of Singapore, Department of Mechanical Engineering, Singapore

Safety is a significant concern for all kinds of Li-ion batteries. Abuse conditions such as mechanical vibration significantly affect safety aspects and the overall electrochemical performances of Li-ion batteries. Herein, we report on the storage performance and post-mortem analyses of the pouch and cylindrical type Li-ion cells using Ni-rich cathode that are exposed to various vibration conditions, 25, 50, and 75 Hz. Vibration affects the energy efficiency of Li-ion cells upon cycling, the causes are analyzed in terms of coulombic efficiency and voltage efficiency. Promoted growth of cathode electrolyte interface (CEI) on Ni-rich NMC upon vibration and their composition affecting the coulombic efficiency are reported using HRTEM and XPS analysis. Careful analysis of impedance data using Distributed Relaxation Time method shows obvious changes in the resistances associated with diffusion and SEI affecting the voltage polarization. Possible strategies to suppress such impact by vibration through modification of Ni-rich NMC and electrolyte are proposed. Improved thermal stability and structural stability are reported by the proposed modifications.

4:50 PM

(ICACC-S20-007-2026) AI-Driven microstructure design to predict mechanical properties of alumina ceramics (Invited)

M. Fukushima*[1]; K. Aoki[2]; S. Ozaki[3]; Y. Akiba[2]; T. Maeda[3]; M. Ngo[1]; K. Hirao[1]

1. National Institute of Advanced Industrial Science and Technology (AIST), Japan
2. Chukyo Daigaku Kogakubu, Japan
3. Yokohama National University, Japan

In 2022, the Japanese government launched a national project titled “Development of a Technology Base and Applied Technologies for the Manufacturing Processes of Next-Generation Advanced Ceramics”, led by NEDO. Our team contributes by developing AI-based fracture prediction technology for alumina ceramics, whose mechanical properties are strongly influenced by microstructural features such as porosity and grain boundaries. Traditionally, converting these features into numerical data required significant manual effort. To address this, we developed a deep learning system that automatically segments and extracts key descriptors—such as grain and pore coordinates, sizes, and distributions. These data are then used in Monte Carlo simulations to estimate mechanical performance. This presentation outlines our integrated approach combining AI-driven microstructure analysis with fracture simulation, enabling automated, data-driven ceramic design. This work is based on results from project JPNP22005, commissioned by NEDO.

Tuesday, January 27, 2026

15th Global Young Investigator Forum on Sustainability

15th GYIF- Efficient Manufacturing Processes I

Room: Ballroom 5
Session Chairs: Ying Chung, Tokyo Institute of Technology; Ryota Yamamoto, Sangyo Gijutsu Sogo Kenkyujo Chubu Center

8:40 AM

(ICACC-GYIF-008-2026) Multifractal analysis of self-assembled composite microstructures: Toward applications to hollow silica nanoparticle-polymer systems (Invited)

T. Ogiya*[1]; K. Ishii[1]; Y. Sato[2]; Y. Takagi[3]; M. Ishihara[1]; F. Munakata[2]; M. Fuji[1]

1. Nagoya Institute of Technology, Japan
2. Tokyo City University, Japan
3. Tokyo University of Science, Japan

In polymer/ceramic composites, the aggregation state of the filler significantly influences material properties. Self-assembly/self-organization processes can enhance these properties by promoting controlled aggregation and the formation of interconnected aggregate networks. In examples using microscale fillers, this process improved material properties. The characteristic features of self-organized microstructures can be evaluated using multifractal analysis. This study applied multifractal analysis to composites containing hollow silica nanoparticles (HSNPs) to improve the fabrication process. HSNPs have internal voids and serve as effective fillers for enhancing thermal insulation and reducing dielectric loss of polymer composites. HSNPs are nanoscale particles, and compared to microscale fillers, they are more susceptible to excessive aggregation. Therefore, surface modification and related approaches are required to improve their dispersion in polymer matrices. Multifractal analysis was applied to polymer/HSNP composites to quantitatively evaluate particle dispersibility and aggregation behavior, and to investigate aggregation states suitable for reducing dielectric loss, along with their formation processes. Acknowledgements: This work was partially supported by JSPS KAKENHI Grant Number 23H01801 and JST SPRING, Grant Number JPMJSP2112.

9:10 AM

(ICACC-GYIF-009-2026) Development of low-temperature co-sintering process for LATP electrolyte materials toward realization of oxide-based all-solid-state batteries (Invited)

K. Ishii*[1]; A. Miura[2]; S. Miyoshi[4]; K. Takada[4]; G. Kawamura[3]; H. Muto[3]; A. Matsuda[3]; M. Fuji[4]; T. Uchikoshi[4]

1. Nagoya Institute of Technology, Japan
2. Hokkaido University, Japan
3. Toyohashi University of Technology, Japan
4. National Institute for Materials Science, Japan

Oxide-based all-solid-state batteries are composed of multiple components, including solid electrolytes and electrode active materials. To realize co-sintering in which all layers are densified and firmly bonded at the interfaces, it is essential to match the sintering behavior of each component. Among them, electrolyte materials generally require higher sintering temperatures, making low-temperature sintering a key challenge. Lowering the sintering temperature is also crucial to suppress the formation of high-resistivity phases that can arise from interfacial reactions between different materials. In this presentation, we introduce a wet-chemical route for low-temperature sintering of $Li_{1.3}Al_{0.3}Ti_{1.7}(PO_4)_3$ (LATP) electrolytes. Furthermore, we will present the co-sintering characteristics of the electrolyte with electrode materials and conductive additives, demonstrating the feasibility of integrated processing for oxide-based all-solid-state batteries.

9:40 AM

(ICACC-GYIF-010-2026) Manufacturing strategies for SiC fibers that enable reduction of energy consumption (Invited)

K. Hofuku*[1]; T. Goto[1]; Y. Yamashita[1]; R. Iuchi[1]

1. Kureha corporation, Japan

SiC fibers are utilized in the aerospace fields due to their excellent mechanical strength and thermal stability as ceramic matrix composite materials. In conventional SiC fiber manufacturing processes, electron beams are commonly used as the method for curing polycarbosilane (PCS). However, this process consumes a large amount of electricity. When power generation relies mainly on fossil fuels, this high electricity consumption leads to an increase in carbon dioxide emissions, raising environmental challenges. To address this issue, we have developed a new manufacturing strategy for SiC fibers. This method eliminates the need for electron beam irradiation by using high-softening-point polycarbosilane optimized through a molecular weight adjustment step. Our fiber shows the same high performance as conventional fibers such as Hi-Nicalon Type-S. Further investigations revealed that the PCS structure has a significant impact on the strength of the SiC fiber. Based on the relationship between properties of PCS and SiC fiber, we discuss the appropriate process conditions for PCS synthesis and subsequent pyrolysis to obtain high-quality SiC fiber. In addition, we also outline future directions for recycling low-molecular-weight PCS removed in the molecular weight adjustment step in terms of reducing environmental impact.

15th GYIF- Efficient Manufacturing Processes II/ Design and Performance of Functional Ceramics

Room: Ballroom 5
Session Chairs: Kento Ishii, Nagoya Institute of Technology; Dustin Gilmer, The University of Tennessee Knoxville Tickle College of Engineering

10:30 AM

(ICACC-GYIF-011-2026) Fabrication and evaluation of alumina paste with the addition of cellulose nano fiber for direct ink writing (Invited)

Y. Chung*[1]; A. Shimamura[1]; N. Kondo[1]; M. Hotta[1]

1. National Institute of Advanced Industrial Science and Technology (AIST), Japan

In additive manufacturing of ceramic materials, extrusion-based techniques such as direct ink writing (DIW) have received increasing attention due to their simple equipment design and broad applicability to various materials. In this method, a highly concetrated paste-like ceramic slurry is extruded through a nozzle and deposited layer by layer to form three-dimensional structures. The ability to flow during extrusion and the ability the retain shape after deposition are critical requirements for the prepared slurries and are usually evaluated by rheological properties. Carboxymethyl cellulose is one of the common used thickening agent to control the rheological properties, but its low solubility in aqueous solution decreased the flexability of adusting rheological properties of ceramic slurries. On the othe hand, cellulose nano fibers (CNFs) that are produced from fibrillating cellusoe fibers with nanoscale diameters of 10-50 nm, is found to reinfore the strength of green bodies and prevent drying cracks of ceramics made by slip casting. Based on this hypothesis, the present study investigates the thickening effect of CNFs in alumina ceramic pastes and evaluates their viscoelastic behavior under extrusion conditions.

11:00 AM

(ICACC-GYIF-012-2026) Binder jetting technology for structural ceramics: Defect formation mechanisms and improvement of mechanical properties (Invited)

K. Kamoda*[1]

1. Ricoh Company, Ltd., Advanced technology R&D Division, Japan

This presentation introduces the Particle Homogenization Modeling (PHM) method, an advanced binder jetting approach for structural ceramics. Targeting applications that demand high reliability, the method improves strength through optimized densification and defect reduction. Flexural strength tests and Weibull analysis revealed that low-strength fractures originate from poorly sintered grain boundaries, while higher strength specimens fractured from spherical defects. At strengths exceeding 330 MPa, fewer spherical defects were observed, correlating with densities above 96%. This report discusses processing optimization, defect origins, and performance benchmarking against other additive manufacturing methods.

11:30 AM

(ICACC-GYIF-013-2026) Design and evaluation of energy harvesting materials using thermal and vibration energy (Invited)

R. Yamamoto*[1]; K. Mimura[1]

1. National Institute of Advanced Industrial Science and Technology (AIST), Japan

Designs for multi-source energy harvesting materials are being developed to expand the range of environments in which energy conversion elements can operate. This can be achieved by integrating multiple power generation elements that respond to heat, vibration, and light through layering and unified wiring. However, there are inherent performance limitations due to constraints on power generation principles based on energy balances relating to heat and mechanics. Previously, we constructed an evaluation system that focused on utilizing thermal factors to improve the performance of vibration energy harvesting in perovskite-type $(Ba,Ca)(Zr,Ti)O_3$ ferroelectrics. This presentation introduces the principle of multi-source energy harvesting through pyroelectric and piezoelectric effects. Furthermore, the energy harvesting performance relating to limitations of heat transfer rates across heat sources, and designs for novel materials for next-generation devices are discussed.

S1 Mechanical Behavior and Performance of Ceramics & Composites

S1- Processing - microstructure - mechanical properties correlation

Room: Coquina E
Session Chairs: Dietmar Koch, University of Augsburg; Dong Liu, University of Oxford

8:30 AM

(ICACC-S1-010-2026) A comparative study of short fiber reinforced C/SiC with recycled and commercial carbon fibers (Invited)

R. Goller*[1]

1. University of Applied Sciences, Mechanical Engineering, Germany

Short fiber-reinforced C/SiC (sfC/SiC) materials have been widely used in ceramic brake discs over the past 20 years. The market continues to grow—driven by both regulatory requirements and the rise of electromobility, which creates new opportunities for corrosion- and wear-free friction materials. To support further expansion, more cost-effective materials and manufacturing processes are needed. One promising approach is the use of recycled materials, which can help reduce production costs while supporting sustainability goals. In this study, recycled carbon fibers were used to produce sfC/SiC via conventional liquid silicon infiltration. The resulting material was compared to sfC/SiC made with commercially available chopped carbon fibers. Thermal conductivity, thermal expansion, mechanical bending strength, and microstructural characteristics were analyzed and compared. Although the material structures differed significantly, the physical properties showed comparable values. When benchmarked against commercial sfC/SiC, the results demonstrated that recycled fibers hold strong potential for future use in low-cost ceramic matrix composite (CMC) applications, especially in automotive and industrial sectors.

9:00 AM

(ICACC-S1-011-2026) Carbon in various forms as ceramic for high end applications (Invited) *WITHDRAWN*

L. M. Manocha*[1]

1. IUAC, Materials, India

Carbon has been a leading element in material revolutions, may it be ceramics, high temperature composites or nanotechnology. Carbon is processed at high temperatures and being black in colour, can be termed as black ceramic. Innovations in composite technology revolutionised engineering materials resulting in newer reinforcements and matrix systems. Carbon in form of high-performance fibers and matrix systems spearheaded the composites products from polymer to advanced carbon-carbon and ceramic matrix composites for high end applications for space, defence and nuclear sectors. The development of carbon nanomaterials like carbon nanofibers, carbon nanotubes and carbon nanoparticles and the much talked graphene have given new dimension to interest in carbon based composites. The study of multiwall carbon nanotubes (MWCNTs) as well as hybrid reinforcing materials involving growing these on the surface of different substrates in desired directions and use these as reinforcements are significant. These variations in reinforcements affect the microstructure of the carbon matrix of the carbon/carbon composites enhancing mechanical, thermal properties and fracture toughness etc. Traditional product processing techniques as well as advanced thermal deposition techniques, all are used to make carbon products. The technique used is decided by the product properties and applications. Some of these features will be discussed.

9:30 AM

(ICACC-S1-012-2026) Reactive melt infiltration-derived C/C-SiC – "Looking for the missing link" processing – Microstructure – Properties correlations (Invited)

N. Langhof*[1]; F. Wich[1]; S. Schafföner[1]

1. University of Bayreuth, Ceramic Materials Engineering, Germany

The properties of C/C-SiC are remarkable. Besides of their light weight (density < 2.5 g/cm^3), C/C-SiC is exceptional thermal shock resistant and non-brittle. Therefore, they are applied in space crafts and in a civil application, the ceramic brake disc, as well. Nevertheless, fundamental properties are not well studied, e.g. the prediction of properties based on the composition (FVC, phase composition, etc.). Within this work we are studying relationships between the microstructure, the reinforcement style, the fiber volume and the thermomechanical properties. Therefore, 150x150x3 mm^3 CFRP-plates with phenolic resin as matrix were fabricated by warm pressing, containing 30-50 vol. % of HT-C-fibers, with 3k-plain-weave fabric or 12 mm 3k-short fiber reinforcement. After the pyrolysis (inert, > 900 °C), the obtained porous C/C plates were infiltrated with liquid Si to form C/C-SiC (vacuum, > 1420 °C). The prepared C/C-SiC samples were studied by microscopy, density and porosity, in terms of their mechanical properties (3PB, 4PB, ILSS and tensile strength) and their thermal properties. Despite of observing some obvious and expected qualitative trends, there is no consistent way to predict e.g. the tensile strength or ILSS of the materials quantitatively. Nevertheless, some approaches to overcome this drawback and to find "missing links" are introduced.

10:20 AM

(ICACC-S1-013-2026) Quantifying grain growth kinetics of RE-doped $MgAl_2O_4$ using polycrystalline diffusion couples

R. Mia*[1]; F. Shaon[1]; C. Marvel[1]

1. Louisiana State University, Mechanical and Industrial Engineering, USA

Complexion transitions are a proposed mechanism of abnormal grain growth, as certain complexion types are thought to have differing mobilities. However, mobility differences amongst various complexions are quantitatively unclear. Diffusion couple experiments with controlled concentration gradients provide a framework for studying the interfacial diffusion and complexion transitions in ceramics. In this work, Eu/Si-doped $MgAl_2O_4$ diffusion couples have been fabricated and characterized to correlate the grain boundary complexion transitions and long-range interfacial diffusivity. Well-bonded couples are synthesized using spark plasma sintering (SPS), and post-coupling annealing treatments were performed in a high-temperature furnace. Electron backscatter diffraction (EBSD) characterized diffusion zones to track grain growth and grain boundary plane changes. Abnormal grain growth was observed at elevated annealing temperatures, and growth rates were quantified as a function of distance from the diffusion line. Aberration-corrected STEM provided atomic-resolution grain boundary structures, enabling correlation between segregation states and diffusivity. This study presents a robust method for fabricating and analyzing $MgAl_2O_4$ diffusion couples, highlighting the role of annealing in activating complex phase transitions that govern grain boundary diffusivity and microstructural evolution.

10:40 AM

(ICACC-S1-014-2026) (Hf,Nb,Ta,Ti,Zr) based single phase and dual phase high entropy ceramics

R. Hassan*[1]; W. Fahrenholtz[1]; G. Hilmas[1]

1. Missouri University of Science and Technology, Materials Science and Engineering, USA

Individual single phase high entropy boride and carbide ceramics and dual phase boride-carbide ceramics containing Hf, Nb, Ta, Ti, and Zr transition metals were produced. The ceramics were synthesised by a single step boro/carbo-thermal reduction route and densified by spark plasma sintering at 1900 °C or 2000 °C for 10 minutes. To investigate any synergistic dual phase effect prevalent in the dual phase ceramic, hardness and indentation fracture toughness were measured and compared for the single phase and dual phase high entropy ceramics. The nature of indents during hardness testing and the crack propagation behaviour during indentation toughness measurements was further studied and compared among the ceramics. Overall, this work focusses on the microstructural evolution, elemental distribution and phase development in these ceramics processed via the same route, and the resulting effect on mechanical properties.

11:00 AM

(ICACC-S1-015-2026) The effect of hot forging on the thermal and mechanical properties of spark plasma sintered $SiC-TiB_2-B_4C$ composites with CeO_2 addition

A. F. Buluc*[1]; S. Turan[1]; Y. Kim[2]

1. Eskisehir Technical University, Materials Science and Engineering, Turkey
2. WORLDEX Industry & Trading Co., Ltd., Republic of Korea

Sintering of $SiC-TiB_2-B_4C$ composite was carried out by SPS at 1900°C and hot forging was applied at 2050°C to improve mechanical and thermal properties. A fully dense ceramic was obtained after SPS and the properties of the composite improved after hot forging. During SPS sintering, TiB_2 and graphite phases were in-situ formed consuming all TiC. Very strong orientation of graphite, coarsening of grain size and reduction in both liquid phase and porosities were observed after hot forging. While fracture toughness increased without compromising hardness and flexural strength, the thermal conductivity was doubled depending on the orientation of the in-situ formed graphite after hot forging. The hardness, fracture toughness, thermal conductivity, elastic modulus and density of the sintered and hot forged composites were measured as 32.2 - 32.8 GPa, 4.0 - 4.4 MPa.m$^{1/2}$, 27.8 - 58.1 W.m^{-1}.K^{-1}, 280 - 315 GPa and 3.12 - 3.08 g/cm^3 respectively. The strategy effectively overcomes the intrinsic limitations of monolithic B_4C and binary composites, opening a pathway for the development of next-generation lightweight, tough, and thermally conductive ceramics for armor and other extreme-environment applications.

11:20 AM

(ICACC-S1-016-2026) Novel processing of sub-100 nm CeO_2/Al_2O_3 composite microstructures via a eutectoid reactive sintering route

R. Maier*[1]

1. National Institute of Standards and Technology, USA

This study investigates the eutectoid decomposition of perovskite $CeAlO_3$ as a novel processing route for fabricating dense CeO_2/Al_2O_3 composite ceramics with tailored microstructures. The decomposition reaction induces simultaneous volume expansion and composite formation during sintering with processing parameters controlling the evolution from lathe-like α-Al_2O_3 and CeO_2 inclusions to coarsened, equiaxed microstructures. Two distinct processing approaches were evaluated: conventional powder mixing and sintering of CeO_2 and Al_2O_3, and reactive sintering combining oxidation of $CeAlO_3$ with simultaneous densification. A two-step heating/oxidation procedure enabled selective control of the eutectoid decomposition temperature through oxygen partial pressure manipulation, preserving fine, sub-100 nm microstructures with lamellar morphologies in the final sintered specimens. Microstructural refinement directly correlated with enhanced mechanical properties, as demonstrated by Vickers microhardness measurements. This processing strategy offers a versatile approach for controlling composite microstructure, reducing shrinkage during sintering, and optimizing ceramic properties through reactive sintering mechanisms.

11:40 AM

(ICACC-S1-017-2026) Hot forging boron carbide using spark plasma sintering

B. Yang*[1]; A. Amon[1]; M. Koelle[1]; J. Cahill[1]; K. Luo[2]; Q. An[2]; A. Bokaei[3]; M. Jafari[3]; A. Zare[3]

1. Lawrence Livermore National Laboratory, Materials Science Division, USA
2. Iowa State University, Materials Science and Engineering, USA
3. Washington State University, School of Mechanical and Materials Engineering, USA

Forging has long been the cornerstone of metal processing, celebrated for its ability to boost strength, toughness, and ductility through controlled deformation and grain refinement. This raises an intriguing question: what if forging is applied to ceramics? We investigate the feasibility and effects of hot forging boron carbide, a ceramic material known for its exceptional hardness and low density. Using spark plasma sintering, temperature and pressure can be controlled to drive the forging process. We will present and discuss the resulting microstructure, hardness, and toughness of the forged material. This work opens new possibilities for optimizing ceramics through forging, expanding their potential for use in demanding applications. This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

S2 Advanced Ceramic Coatings for Structural/Environmental & Functional Applications

S2- Thermal and environmental barrier coatings for CMC, intermetallics, and alloys I

Room: Coquina C
Session Chairs: Eric Jordan, University of Connecticut;
Kuiying Chen, National Research Council Canada

8:30 AM

(ICACC-S2-012-2026) Stability of rare earth orthophosphate EBC candidate materials in high temperature steam (Invited)

I. Hawthorne[1]; S. Ryu[1]; E. Opila*[1]

1. University of Virginia, USA

Rare earth orthophosphates ($REPO_4$) with the xenotime structure have been identified as viable materials for environmental barrier coatings (EBCs). They exhibit phase stability, reasonable thermal expansion match and chemical compatibility with SiC substrates. In addition, they have shown improved resistance to molten siliceous debris and high-temperature steam compared to state-of-the-art ytterbium disilicates. While it is known that P-O-H(g) species will form as a reaction product from $REPO_4$ - steam exposures, the exact gaseous species and solid phase reaction products are unknown. Phase diagrams for RE_2O_3-P_2O_5 systems are missing or inconsistent preventing prediction of expected solid state reaction products. In this study, $REPO_4$ specimens (where RE=Y, Yb, Er, Gd, Dy) were exposed to steam at velocities of 240 m/s for times up to 240h at 1400°C. Post-exposure cross-sections were characterized by SEM and EDS identifying a variety of porous product phases with compositions consistent with RE_2O_3, RE_3PO_7, $RE_8P_2O_{17}$ (or $RE_{14}P_4O_{31}$). Systematic variation of these $REPO_4$-steam reaction product phases in conjunction with RE_2O_3-$REPO_4$ diffusion couples across the lanthanide series provides information to map out the unknown phase diagrams for these material systems and improve understanding of $REPO_4$ stability in steam.

9:00 AM

(ICACC-S2-013-2026) High temperature isothermal and cyclic oxidation studies of sputtered and EB-PVD Si-bond coated EBC system on SiC-SiC_f substrates (Invited)

R. Naraparaju*[1]; C. Y. Guijosa Garcia[1]; A. Ebach-Stahl[1]; U. Schulz[1]

1. Institute for Frontier Materials on Earth and in Space, Germany

Rare earth disilicates ($RE_2Si_2O_7$, REDS) have been employed as environmental barrier coatings (EBCs) to enhance the durability of ceramic matrix composites (CMCs) against environmental degradation. Atmospheric plasma spray (APS) remains the prevalent technique for EBC and silicon bond coat deposition. However, physical vapor deposition (PVD) and electron beam physical vapor deposition (EB-PVD) methods are emerging as promising alternatives due to their suitability for coating complex geometries and preservation of cooling hole integrity. This study investigates the deposition of silicon bond coats on SiC-SiCf substrates using magnetron sputtering and EB-PVD techniques. Subsequently, a multilayer coating comprising yttrium disilicate (15 μm) and yttrium monosilicate (15 μm) was deposited via magnetron sputtering. The coated specimens were subjected to high-temperature isothermal oxidation and furnace cycling tests at 1250°C for durations up to 1000 hours, alongside thermal gradient cycling up to 500 cycles with surface temperatures reaching 1300°C. Oxide scale growth rates for both sputtered and EB-PVD silicon bond coats were quantified, and their implications on the lifetime performance of the EBC system are discussed.

9:30 AM

(ICACC-S2-015-2026) Porosity dependence of furnace thermal cycling lifetime and failure characteristics of multi-layer thermal barrier coatings

H. Park*[1]; N. Ayersa[1]; V. Larsen[1]; Y. Sohn[1]

1. University of Central Florida College of Engineering and Computer Science, USA

Furnace cycle testing (FCT) at 1100 °C, consisting of 10-min heating, 30-min dwell, and 20-min forced-air cooling, was performed on single- and double-layer thermal barrier coatings (TBCs) with varying densities and compositions (YSZ and YGYZ). Double-layer TBCs with a large density mismatch exhibited reduced FCT lifetimes, with spallation occurring at the interface between the ceramic layers. In contrast, double-layer TBCs with minimal density differences showed extended FCT lifetimes, comparable to single-layer YSZ TBCs, and failed at the ceramic/bond coat interface where a thermally grown oxide developed. Vickers hardness differences, used as a proxy for porosity mismatch, directly correlated with FCT lifetimes. These results highlight the critical role of engineering porosity distribution in designing durable and reliable multilayer TBC systems.

10:10 AM

(ICACC-S2-016-2026) Phase formation and thermal conductivity of rare-earth co-doped zirconia systems for TBC application

S. Kim*[1]; M. Nam[1]; J. Kim[1]; Y. Oh[1]

1. Korea Institute of Ceramic Engineering and Technology, Cross-Functional Ceramics R&D Group, Republic of Korea

Rare-earth doped zirconia materials have been high-lighted as one of the candidate materials for TBCs applicable to extreme environments including hydrogen combustion. These Rare-earth doped zirconia materials have dominant phases like cubic or tetragonal depending on the amount of addition. The low thermal conductivity and sinterability of these zirconia materials with these structures are attributed to the point defects in the crystallographic structures. In this study, phase structures are investigated with selected rare-earth(Gd, Yb, Sm, Dy) co-doped zirconia compositions. Phase formation, microstructures, and thermal conductivities are examined with the densified samples among selected compositions. The possibilities of these oxides for TBC application are also discussed.

10:30 AM

(ICACC-S2-017-2026) Cyclic steam oxidation of slurry-deposited high-temperature environmental barrier coatings on SiC

R. I. Webster*[1]; K. Lee[1]; B. J. Harder[2]; J. Stuckner[1]; B. Puleo[1]

1. NASA Glenn Research Center, USA
2. NASA Glenn Research Center, Environmental Effects and Coatings, USA

Environmental barrier coatings (EBCs) have enabled the use of silicon carbide (SiC)-based ceramic matrix composites (CMCs) in gas turbine engines by protecting the underlying CMC from corrosive combustion species. EBCs currently in service consist of a silicon bond coat and a rare earth silicate topcoat. The melting point of the silicon bond coat (~1410°C) limits the upper use temperature of these coating systems. To protect SiC-based CMCs at temperatures beyond that achievable by the current state-of-the-art, a mullite-based bond coat capable of withstanding temperatures of up to 1482°C has been developed at NASA Glenn Research Center. In this study, the mullite-based bond coat was deposited via a slurry process on CMC substrates with a chemical vapor deposition (CVD) seal coat as well as on monolithic SiC. The mullite coating was evaluated at 1427 or 1482°C in a steam cycling environment on its own and with topcoat layers consisting of $HfSiO_4$, $HfSiO_4/Yb_2Si_2O_7$, or $HfSiO_4/Yb_2Si_2O_7+Yb_2SiO_5$. Slurry processing parameters, namely the initial particle size of the coating powder, were optimized for improved coating density. Oxidation kinetics were determined for coated SiC and SiC/SiC, and phase/microstructural changes within the multilayer EBC systems were characterized.

10:50 AM

(ICACC-S2-018-2026) Understanding phase stability and sintering behavior of EB-PVD TBC systems under hydrogen combustion conditions

R. Ambekar*[1]; R. Naraparaju[1]

1. Deutsches Zentrum fur Luft- und Raumfahrt DLR, Institute for Frontier Materials on Earth and in Space, Germany

Exposure of thermal barrier coating (TBC) systems to operating temperatures is known to increase stresses, due to phase changes and morphology changes caused by sintering. The tetragonal phase structure of zirconia is prone to undergo diffusionless phase transformation at operating temperatures into monoclinic phase accompanied by volume expansion. This increase in volume combined with high residual stresses could cause early failure of the TBC system. Additionally, sintering of TBC at operating temperature is known to cause a decrease in porosity of the coating, thereby increasing the thermal conductivity of the TBC system. Phase transformation and sintering of TBC systems under aging conditions corresponding to gas turbine operation have been extensively studied. The current study aims to understand phase stability and sintering behavior of Yttria-stabilized Zirconia (YSZ) and Gadolinium Zirconate (GZO) deposited on alumina substrate using electron beam physical vapor deposition (EB-PVD), under hydrogen combustion conditions. Both TBC systems are exposed under varied water vapor contents in between 4-30 mass % at 1250°C for up to 100 hours. The corresponding changes in the phase stability and microstructure of the TBC systems are studied using X-Ray diffraction, BET measurements and scanning electron microscopy.

11:10 AM

(ICACC-S2-019-2026) Non-silicate barrier coatings for high temperature applications

B. Kowalski*[1]; R. I. Webster[1]

1. NASA Glenn Research Center, USA

Greater gas turbine engine efficiency is a major goal in aeronautics research often pursued through increased engine operating temperatures. However, it is necessary to replace the current hot-stage alloy components with more thermally robust parts, such as silicon-based ceramics and composites. Unfortunately, these materials are still susceptible to the effects of oxidation, water vapor, and (Calcium-Magnesium-Alumino-Silicate) CMAS interaction, among other issues at high temperature. To mitigate these effects, environmental barrier coating (EBC) materials are employed to help control the rate of degradation to the underlying composite, but must also survive the corrosive environment. The authors have previously presented promising results of stand-alone non-silicate EBCs. These EBCs will be applied via spin coating to different substrates. This presentation will explore coating stability and TGO growth of these EBCs in air and water vapor.

11:30 AM

(ICACC-S2-020-2026) Monazite-structured multicomponent rare earth phosphates for advanced high-temperature coating applications

T. Natarajan[1]; Z. Alam[2]; A. S. Gandhi*[1]

1. Indian Institute of Technology Bombay, Department of Metallurgical Engineering and Materials Science, India
2. DRDO Defence Metallurgical Research Laboratory, India

Ceramic coatings are widely employed in extreme thermal insulation applications in harsh environments like gas turbines and aerospace applications. Conventional coating materials like yttria-stabilized zirconia and rare- earth silicates, have limitations like phase instability, and vulnerability to environmental attack. In this study, multicomponent rare-earth phosphates (REPs) were explored as alternative candidates for high-temperature coatings. Equimolar multicomponent REPs were synthesized by a precipitation route

using phosphoric acid. The calcined powder phase analysis by X-ray diffraction confirmed the formation of single-phase monazite structure. TEM–EDS revealed homogeneous elemental distribution. Calcined powders were ball milled to obtain particle sizes below 1.5 µm. Sintering was performed at temperatures starting from 1300°C. SEM analysis of sintered compacts indicated sintered density exceeding ~94% and average grain sizes of 1.2–1.5 µm. Thermal stability was evaluated by TG–DTA up to 1500°C, showing negligible weight loss, which confirmed the absence of volatile species and the excellent high-temperature stability of the compounds. Preliminary evaluation of thermal properties and resistance to high temperature environments indicate the potential of these materials for high temperature protective coatings applications.

S3 23rd Intl Symp on Solid Oxide Cells Materials Science & Technology

S3-Manufacturing technology development

Room: Coquina H
Session Chair: Miguel Laguna-Bercero, Instituto de Nanociencia y Materiales de Aragon

8:30 AM

(ICACC-S3-008-2026) Strategies for achieving high performance in solid oxide cells using LSGM @ KICET (Invited)

T. Shin*[1]; S. Lee[1]; S. Lee[1]

1. Korea Institute of Ceramic Engineering and Technology (KICET), Republic of Korea

Solid oxide electrolysis cells (SOECs) are promising devices that can be used not only for green hydrogen production but also for electrochemical CO_2 reduction, contributing to a carbon-neutral society. As a state-of-the-art electrolyte material with superior ionic conductivity, $La(Sr)Ga(Mg)O_3$ (LSGM) has been successfully validated in various solid oxide electrochemical cells (SOCs) including SOEC. Since solid oxide electrochemical devices with LSGM can work in intermediate temperatures, it can have better durability and efficiency at lower temperature operating conditions. However, a few essential requirements must still be addresses for the widespread use of commercial LSGM based electrochemical device. Particularly, Ni-based electrodes still encounter various challenges when used with LSGM, including chemical compatibility, low durability during electrolysis, and the absence of a cost-effective manufacturing process, which hinders their commercial viability. Herein, we have pioneered the various innovative cathode comprising a Ni-based electrode decorated with nanosized doped ceria, aiming to enhance electrochemical performance. Furthermore, we applied the encapsulation technique of ultrasonic spraying to incorporate and coat ceria-based nano-dot over cathode surface, resulting in a highly uniform distribution of nano-catalysts.

9:00 AM

(ICACC-S3-009-2026) Advancing SOEC oxygen electrode fabrication through optimized ceramic processing

C. Gadea*[1]; F. Palmerini[1]; S. Pirou[1]; E. Marzia Sala[1]; A. Krishnakumar Padinjarethil[1]; J. Godet[1]; J. Hanne Kurtz[1]; A. Hauch[1]

1. Topsoe A/S, Power-to-X, Denmark

Solid oxide electrolysis cells (SOECs) hold great potential as a central component in sustainable energy solutions. The transformation of electrical into chemical energy with high efficiency and the versatility of produced hydrogen or carbon monoxide enables integration in several energy transportation and green production scenarios. The ongoing industrialization of SOEC production at Topsoe drives a series of cost related demands for efficiency improvements as well as simplifications and enhanced robustness in the steps of processing and QC. In this presentation, examples of methodology and recent progress in development related to screen printed oxygen electrodes are shared. Optimization of organic additives and solid loading in ink compositions, rheology characterization parameters (in rotational and oscillatory modes) linked to printing properties as well as examples of rheology related QC methodologies are presented. Printing features and resulting microstructure after heat treatment are discussed. Finally, the impact of improved formulation and processing will be discussed through examples of electrochemical characterization and single cell performance data.

9:20 AM

(ICACC-S3-010-2026) Manufacturing of proton conducting solid cells

A. Gondolini[1]; A. Bartoletti[1]; E. Mercadelli[1]; A. Sanson*[1]

1. ISSMC, Italy

The work examines the fabrication's steps of Proton-Conducting Cells (PCCs) based on barium cerate-zirconate (BCZY) using different methods namely conventional tape casting and a combination of screen printing/freeze casting. The study investigates critical parameters required for the development of porous- dense-porous microstructures for PCCs. For the tape casting technique, the effects of the composition and sintering conditions (T and atmosphere) on the microstructural properties of the cell were analyzed. In the combined screen printing/freeze casting route, the tailored freeze cast formulation of water-based BCZY suspensions, along with the optimization of screen-printable inks, enabled the production of robust BCZY structures with a gas-tight dense electrolyte layer supported on a highly porous backbone with unidirectional porosity. Premilinary electrochemical tests are presented.

9:40 AM

(ICACC-S3-011-2026) Laser-processed interfaces for high-pressure difference in solid oxide electrolysers: Advanced surface engineering and material design

F. D'Isanto*[1]; S. Anelli[1]; A. Baggio[1]; M. Salvo[1]; D. Menon[1]; D. Janner[1]; A. Sabato[2]; A. Tarancón[3]; F. Smeacetto[1]

1. Politecnico di Torino, Department of Applied Science and Technology, Italy
2. IREC, Nanoionics and Fuel Cells, Catalonia Institute for Energy Research, Spain
3. IREC, ICREA, Spain

This work presents the latest advancements achieved in the HyP3D EU project (GA 101101274) regarding joining and integration strategies for SOECs' high-pressure difference resistance. It emphasises surface engineering approaches, focusing on an innovative method for producing interconnect/seal/ceramic joints with improved reliability. An infrared nanosecond laser surface patterning technique was applied to Crofer22APU and yttria-stabilised zirconia substrates, enabling controlled and reproducible texturing that significantly improved the joint strength. Mechanical testing confirmed that these surface modifications lead to substantial improvements in the robustness of the interface. The shear strength results both at RT and 850°C, of the improved joined interfaces, showed the positive effects of optimal surface processing on the joining strength, with an increase of around 30%, demonstrating leak-tight sealing under pressure difference also at 850°C. These findings highlight the crucial role of surface engineering in enhancing the reliability of high-pressure difference resistant joints for SOECs.

S3-Applications

Room: Coquina H
Session Chair: Xingbo Liu, West Virginia University

10:20 AM

(ICACC-S3-012-2026) A new insight for solid oxide electrochemical technology via utilization of traditional energy resources at Idaho National Laboratory (Invited)

D. Ding*[1]

1. Idaho National Lab, Hydrogen and electrochemistry, USA

Close coupling with industrial applications is vital to unlocking the full potential of nuclear energy. High temperature electrochemistry plays an increasingly important role in this area as it helps to improve efficiency and address uncertainties of supply chains driven by industrial electrification and cheap heat resources. As one of DOE's premier multi-program energy research laboratories, Idaho National Laboratory (INL) is dedicated to ensuring the nation's energy security through the development of safe, competitive and reliable energy systems, alongside unique national and homeland security capabilities. INL's initiative, integrated energy systems (IES), provides carbon-free nuclear energy for downstream use in manufacturing and transportation. The manufacturing component of IES focuses on integrating nuclear power with excess heat. In this talk, we will provide representative examples for high temperature electrochemistry in this initiative, emphasizing recent advancement of INL's solid oxide electrochemical technologies using the traditional energy resources including natural gas/natural gas liquids, carbon, as well as CO_2 and nitrogen. These examples will span three typical material sets across different temperature ranges.

10:50 AM

(ICACC-S3-013-2026) First tests of direct conversion of H_2O/CO_2 to light olefins by means of solid oxide cells (Invited)

M. Santarelli*[1]; F. Smeacetto[2]; S. Esposito[2]; D. Ferrero[1]; S. Anelli[3]; A. Moranti[4]; M. Ferri[1]; F. Puleo[1]

1. Politecnico di Torino, Energy, Italy
2. Politecnico di Torino, Applied Science and Technology, Italy
3. Politecnico di Torino, DISAT, Italy
4. Politecnico di Torino, Italy

The research envisages the development of a solid oxide electrolytic system, which involves the co-ionic conduction of H^+ ions migrating from the anode to the cathode and available there in ionic form for the CO_2 ions resulting from the cathodic reduction of CO_2 and removed from the cathode by migration towards the anode. In this context, the cathode electrode must be designed to develop CO_2 reduction mechanisms via H^+ protons for the direct production of totally deoxygenated hydrocarbons. The activity is developed in two directions: Planar cells: co-ionic conducting electrolyte BZCY/YSZ, Ni-BZCY anode (supporting layer), cathode based on SFNM matrix with Cu nanoparticles derived by MOFs infiltration Tubular cell: same electrolyze/anode, but a hybrid approach that integrates solar-assisted thermal reduction of SFNM cathode material, enabling in-situ exsolution of Ni-Fe metallic nanoparticles (core) embedded in a perovskite matrix (shell), generating catalytically active core-shell structures. The presentation describes the two concepts, the modeling approach for the design of the two cells, and the first experimental results obtained.

11:20 AM

(ICACC-S3-015-2026) Electrochemical property of solid oxide fuel cell using fuel gas mixture containing CO and CO_2

M. Momai*[1]; H. Sumi[1]; T. Kawamura[2]; R. Yoshiie[3]

1. National Institute of Advanced Industrial Science and Technology (AIST), Japan
2. Gifu University, Graduate school of Natural Science & Technology, Japan
3. Gifu University, Chemistry and Biomolecular Science, Faculty of Engineering, Japan

Biomass gasification gas, primarily composed of H_2, CO, and CO_2, is obtained by efficiently gasifying biomass resources using O_2-enriched air. Solid oxide fuel cells (SOFCs) have attracted significant attention as a promising technology for direct conversion from biomass gasification gas to electricity. However, SOFC performance may deteriorate due to carbon deposition via the disproportionation reaction, when operated using CO-rich fuels. In this study, the electrochemical properties of the anode-supported cells were compared using a synthetic biogas and pure hydrogen. A synthetic biogas was prepared via the reverse water-gas shift reaction, using a gas mixture with an H_2/CO_2 volume ratio of 2:1. The cell performance with supplying the synthetic biogas was lower than that with supplying pure hydrogen, particularly, in term of reduced limited current densities. Increasing the anode porosity improved the fuel utilization, attributed to enhanced diffusivity of CO and CO_2 gas in the porous anode.

S6 Advanced Materials and Technologies for Rechargeable Energy Storage

S6- Ordered and Disordered Oxide-based Electrode Materials I

Room: Coquina G
Session Chairs: Naoaki Yabuuchi, Yokohama National University; Mahalingam Balasubramanian, Oak Ridge National Lab

8:30 AM

(ICACC-S6-001-2026) Tailoring chemistry, structure, and particles for disordered cathode materials (Invited)

J. Ahn*[1]

1. University of Wyoming, USA

With the use of earth-abundant raw materials, next-generation cathode materials are expected to contribute to both high energy density and stable cycle life in lithium-ion batteries. The disordered rocksalt (DRX) framework offers the potential to eliminate nickel (Ni) or cobalt (Co), while enhancing reversible redox contributions from cations and anions during cycling. In recent years, research on manganese (Mn)-based DRX compositions, particularly high-Mn DRX oxides or oxyfluorides such as $Li_{1.1}Mn_{0.8}Ti_{0.1}O_{1.9}F_{0.1}$, has demonstrated promising electrochemical performance. However, a fundamental understanding of atomic-scale structure, particle-level properties, and their impact on electrochemical behavior remains limited. This presentation will provide a detailed microscopic analysis of intrinsic atomic arrangements across short-, medium-, and long-range order as well as various physicochemical characteristics influenced by synthesis processes. A comprehensive evaluation of these interconnected parameters in relation to energy performance will offer new insights into the practical application of DRX-type cathode materials.

9:00 AM

(ICACC-S6-002-2026) High-rate Mn-based disordered rock-salt oxides enabled by rapid Joule-heating synthesis (Invited)

S. Park[1]; H. Kim[1]; K. Kim[2]; W. Jang[1]; H. Lee[1]; S. Bae[1]; H. Kim[2]; J. Lee[3]; K. Kang[4]; D. Seo*[1]

1. Korea Advanced Institute of Science and Engineering (KAIST), Republic of Korea
2. Korea Atomic Energy Research Institute, Republic of Korea
3. McGill University, Canada
4. Seoul National University, Republic of Korea

Manganese-based disordered rock-salt (Mn-DRX) oxides offer a Co- and Ni-free path to high-performance Li-ion batteries. In DRX structures, short-range order (SRO) critically influences Li-ion transport. However, conventional furnace sintering limits control over SRO due to its slow thermal ramp. Here, we demonstrate that rapid Joule heating (JH) enables effective SRO modulation via fast thermal cycling. Rapid ramping suppresses SRO formation and allows access to higher temperatures where disorder is thermodynamically favored. Rapid quenching preserves this disordered state by minimizing ordering during cooling. Using $Li_{1.2}Mn_{0.4}Ti_{0.4}O_2$ (LMTO) as a model, we show that JH at 1050 °C for 10 min (JH-10m) yields a near-phase-pure product with reduced SRO compared to conventional furnace treatment at 950 °C for 12 hr (F-12hr), resulting in enhanced rate capability (161 vs. 137 mAh/g at 1 A/g). Furthermore, the JH method successfully synthesized various DRX compositions (e.g., $Li_{1.2}Mn_{0.6}Nb_{0.2}O_2$, $Li_{1.2}Mn_{0.2}Ti_{0.4}Cr_{0.2}O_2$, and $Li_{1.2}Mn_{0.5}Ti_{0.3}O_{1.9}F_{0.1}$), all exhibiting comparable performance to furnace-derived analogs. Our findings demonstrate that rapid JH synthesis offers a robust approach to producing high-performance Mn-DRX cathodes, paving the way for high-throughput discovery across the vast DRX design space.

9:30 AM

(ICACC-S6-003-2026) Development of disordered rock-salts for Li-ion batteries (Invited)

J. Colin*[1]; M. Cogniard[1]; D. Mambert[1]; D. Louise[1]; Y. Biecher[1]; I. Profatilova[1]; D. Sotta[1]

1. Université Grenoble Alpes, CEA-LITEN, France

Li- and Mn-Rich disordered rock-salts can provide high capacities at a relatively low cost, hence they have the potential to take market share along with NMC and LFP. However, several challenges still need to be tackled from the material to the cell level before these materials could enter the market such as the stabilisation of the performances during cycling. Also the coarse granulometry of these material hinders the production of dense electrode. At CEA-LITEN, we have deployed a multifold approach to address these different challenges. During this talk, we will present some results such as the stabilisation of performances of Li_2MnO_2F obtained through an original material doping and electrolyte tuning using TMSPi additive, allowing us to prepare full cells in monolayer pouch cells with 77% capacity retention after 50 cycles. The action of the additive will be discussed in the light of OEMS and impedance data. Also the efforts carried out on controlling the morphology of these materials using post synthesis processes such as spray drying or ball-milling, paving the way to denser electrode, will be illustrated.

10:20 AM

(ICACC-S6-004-2026) Designing advanced lithium insertion materials for practical Li-ion batteries (Invited)

N. Yabuuchi*[1]; Y. Ugata[1]

1. Yokohama National University, Japan

Ni-enriched layered materials are widely used as electrode materials in Li-ion batteries for electric vehicle applications. Stoichiometric $LiNiO_2$, which utilizes the cationic Ni^{3+}/Ni^{4+} redox couple, is an ideal electrode material. However, its practical applications is hindered by gradual capacity degradation at the high voltage region, primarily due to Ni ion migration. Recently, the critical role of non-stoichiometry and anti-site defects in $LiNiO_2$ has been highlighted. Through defects engineering, highly reversible pure Ni-based layered materials without metal substitution have been successfully developed. Another important challenge is the development of practical, high-energy Co-/Ni-free Mn-based positive electrode materials, which are essential for the widespread adoption of cost-effective electric vehicles. Nanostructured Mn-based electrode materials have emerged as promising candidates for this purpose. However, these materials are generally synthesized by high-energy milling, a process unsuitable for large-scale production. More recently, nanostructured $LiMnO_2$ with high-energy density ($\sim$800 Wh kg^{-1}) has been successfully synthesized through a conventional calcination process, indicating its potential for economical electric vehicle applications.

10:50 AM

(ICACC-S6-005-2026) Cation-disordered rocksalt interphases for nickel-rich layered oxide cathodes

D. Yan[1]; J. Kim*[1]

1. Stevens Institute of Technology, Chemical Engineering & Materials Science, USA

Nickel-rich layered oxide cathodes offer high energy density for lithium-ion batteries, supporting longer EV ranges. However, they suffer from surface instability and cracking at high states of charge due to phase changes. To address this critical issues, strategies including cation doping, surface passivation, and transition metal gradient formation have been developed to reduce surface degradation. To maximize the Ni content for the layered cathodes, we introduce a method to form a thin cation-disordered rocksalt (DRX) layer at interfaces between primary particles. This approach hinges on controlling cation distribution for synthesis that drives nucleation of DRX on the surface of the layered oxide. Electron microscopy confirms uniform DRX layers on both the surface of secondary particles and internal interfaces of primary particles. This interface-engineered cathode shows better performance than the pristine one, with enhanced high-voltage stability and capacity retention. The DRX layer promotes protective passivation and denser packing of particles, reducing oxygen loss and crack formation at high charge levels.

11:10 AM

(ICACC-S6-006-2026) Development of non-flammable lithium cobalt oxide (LCO)-based lithium-ion secondary batteries

Y. Yamane*[1]; T. Ishimoto[1]; R. Narukawa[1]; T. Takahashi[1]; S. Nihongi[1]; K. Kuriki[1]; T. Nakamura[1]; K. Tomoya[1]; T. Ochiai[1]; K. Ogita[1]; K. Kajiyama[1]; H. Murakami[1]; T. Kubota[1]; T. Kakehata[1]

1. Kabushiki Kaisha Handotai Energy Kenkyujo, Japan

Lithium cobalt oxide (LCO)-based lithium-ion secondary batteries (LiBs) are installed in many mobile devices and used by people every day. While having high energy density, LCO LiBs tend to ignite easily and cause ignition accidents in various devices, which has become significant social issues. Ignition accidents in LCO LiBs are probably caused by several events: for example, when a metal piece pierces a battery cell, a short-circuit current flows through the metal piece due to an internal short circuit, which generates Joule heat and raises the temperature of components of the battery cell. As a result, the components reach their thermal runaway temperature and ignite. Ignition due to such thermal runaway can be triggered by other factors through a similar mechanism. This indicates that suppressing thermal runaway of components inside a battery cell can prevent ignition. In this presentation, we report on a configuration of LCO LiBs that suppresses the ignition.

11:30 AM

(ICACC-S6-007-2026) Improvement of $LiCoO_2$ by Mg-F treatment and occurrence of a different phase transition at high voltage

J. Saito*[1]; M. Mikami[1]; M. Takahashi[1]; T. Takahashi[1]; K. Kuriki[1]; F. Sekikawa[1]; A. Kawatsuki[1]; T. Ochiai[1]; T. Kakehata[1]

1. Kabushiki Kaisha Handotai Energy Kenkyujo, BT division, Japan

Due to its high energy density, $LiCoO_2$ is still used in many mobile applications. However, the practical capacity of $LiCoO_2$ is limited due to a harmful phase transition at high voltages. Therefore, a variety of research for improvement has been actively carried out to this day. In this study, the $LiCoO_2$ particles were subjected to treatment using a molten salt of MgF_2-LiF as a reaction accelerator. By this treatment, doping of Mg in $LiCoO_2$ bulk and formation of a stable coating layer containing Mg and F on the particle surface were achieved at the same time. When Ni and Al were added in addition to this treatment, the electrochemical stability was further improved. This modified $LiCoO_2$ exhibited excellent electrochemical performance during high-voltage operation. It was confirmed by X-ray diffraction analysis that charging the modified $LiCoO_2$ to 4.7 V inhibited a harmful phase transition and showed a different phase transition process from conventional $LiCoO_2$.

S7 20th International Symposium on Functional Nanomaterials and Thin Films for Sustainable Energy, Environmental and Biomedical Applications

S7- Synthesis, functionalization and assembly of inorganic and hybrid nanostructures

Room: Flagler A
Session Chair: Andreu Cabot, Catalonia Institute for Energy Research

8:30 AM

(ICACC-S7-009-2026) Preparation and characterization of nanocellulose crystal/zinc oxide/titanium dioxide (NCC/ZnO/TiO_2) hybrid composite (Invited)

E. d. Magdaluyo*[1]; S. Motita[1]

1. University of the Philippines, Philippines

A nanocellulose crystal/zinc oxide/titanium dioxide (NCC/ZnO/TiO_2) hybrid composite was synthesized using a simple wet-chemical method. Structural and phase analysis revealed that the hybrid composite, incorporating a ZnO/TiO_2 matrix calcined at 900°C for 12 hours, exhibited a combination of anatase and rutile phases of TiO_2, wurtzite ZnO, zinc titanate phases, and a distinct bell-shaped diffraction peak corresponding to nanocellulose. Morphological analysis showed average particle size of 0.58 ± 0.15 μm for spherical TiO_2 and 1.19 ± 0.54 μm for rod-like ZnO structures. High-resolution TEM further revealed spherical nanoparticles ranging from 27 to 46 nm, with lattice fringes corresponding to (101) plane of anatase (d-spacing = 0.375 nm), (002) plane of wurtzite ZnO (d = 0.264 nm), (220) plane of zinc titanate (d = 0.305 nm), and (002) plane of nanocellulose (d = 0.397 nm). FTIR analysis confirmed the presence of functional groups such as C–H, C=C, and C–O–C, along with shifts in –OH and C–H bands, indicating successful functionalization of the ZnO/TiO_2 matrix with NCC. The UV-vis absorbance spectrum exhibited a peak at 332 nm, corresponding to an estimated band gap of 3.21 eV, attributed to the synergistic electronic transitions of ZnO, TiO_2, and zinc titanate.

9:00 AM

(ICACC-S7-010-2026) Facet-engineered and oxygen-deficient TiO_2 nanocrystals as high-performance anodes for electrochromic devices (Invited)

C. Xing*[1]

1. Zhejiang University Institute of Wenzhou, China

The surface properties of titanium dioxide (TiO_2) nanocrystals significantly influence their electrochemical performance, particularly in applications such as electrochromic devices. In this study, shape-controlled anatase TiO_2 nanocrystals with dominant {101} facets were synthesized via a colloid method using 1-Dodecanol and 1,2-decanediol as shape-directing agents. Electron paramagnetic resonance (EPR) measurements confirmed the formation of oxygen vacancies (OVs) in these nanocrystals, which enhance electronic conductivity and regulate ionic diffusion kinetics. These properties make OVs-rich TiO_2 a promising candidate for anode materials in electrochromic smart windows. We systematically investigated the effect of electronic charge carrier concentration on the electrochemical lithium (Li^+) storage performance. Our results demonstrate that a well-balanced transport of Li^+ ions and electrons (e^-) is critical for achieving high-performance TiO_2-based electrochromic anodes. This work provides an effective strategy for facet control and performance enhancement of TiO_2 nanomaterials for advanced electrochromic applications.

9:30 AM

(ICACC-S7-011-2026) Environmental technologies applying advanced hybrid silica-based materials (Invited) *WITHDRAWN*

G. A. Seisenbaeva*[1]

1. Sveriges lantbruksuniversitet, Molecular Sciences, Sweden

Sustainability requires design of materials with tailored properties. Key strategy is combining organic, biological, and inorganic components at the nanoscale to create hybrid, biocompatible adsorbents. Materials capable of capturing or degrading persistent organic pollutants (POPs) are produced by grafting ligands onto nanostructured supports. A critical challenge in resource recycling is separating Rare Earth Elements (REEs) from Late Transition Metals (LTMs) in electronic, magnetic, and battery materials. Ligand functionalities differentiating REEs and LTMs enhance selectivity during adsorption and desorption. Ligands influencing LTM oxidation states further aid in isolating elements such as cobalt and nickel, vital in Li-ion battery cathodes. Water purification also faces urgent obstacles. POPs, particularly pharmaceuticals, accumulate in aquatic systems. A soft, biocompatible solution is their oxidative breakdown by peroxidase enzymes, though enzyme stabilization is required. Natural porous silicates offer sustainable encapsulation matrices. Per- and polyfluorinated substances (PFAS) represent another critical POP class, with rising concentration due to their extensive use in firefighting foams, cosmetics, textiles, and packaging. Our research proposes polycationic functional layers with tunable hydrophilic/hydrophobic balance to facilitate PFAS removal and accumulation.

10:20 AM

(ICACC-S7-012-2026) Nanoceramics meet microalgae toward sustainable wastewater remediation *WITHDRAWN*

M. Blosi*[1]; S. Amadori[1]; I. Zanoni[1]; A. Brigliadori[1]; S. Ortelli[1]; A. L. Costa[1]

1. Consiglio Nazionale delle Ricerche Istituto di Scienza Tecnologia e Sostenibilita per lo Sviluppo dei Materiali Ceramici, Italy

The uncontrolled release of pollutants from urbanization and industrialization poses a global challenge, as conventional wastewater treatments often fail to remove emerging contaminants. We developed hybrid materials combining microalgal biomass (Chlorella vulgaris, Neochloris oleoabundans, Phaeodactylum tricornutum) with ceramic nanophases (TiO_2, SiO_2, $CaCO_3$ from blue crab shells) to create multifunctional systems merging heavy metal biosorption with photocatalytic activity. This approach valorizes marine by-products and exploits non-living microalgae for their adsorption capacity, abundance, cost-effectiveness, and reusability. Materials were prepared through a colloidal process promoting electrostatic interactions, followed by spray freeze-drying, yielding nanostructured granules with high homogeneity. Characterization included Z-potential, BET, SEM-EDX, FT-IR, and XRD, while ICP-OES, HPLC, and UV-Vis spectroscopy assessed functional performance. Hybrid systems were tested for heavy metal biosorption, treatment of municipal wastewater, and Rhodamine B degradation under light. Results revealed a synergistic effect, with enhanced metal sorption when microalgae were supported on inorganic nanophases, highlighting the potential of these bio-nano hybrids for sustainable water treatment and suggesting their versatility for potential applications in cosmetics, agriculture, and biomedical fields.

10:40 AM

(ICACC-S7-013-2026) Natural clay based systems applying green biocatalysts for water purification ***WITHDRAWN***

A. Vardanyan[1]; G. A. Seisenbaeva[1]; T. Breijaert*[1]

1. Sveriges lantbruksuniversitet, Molecular sciences, Sweden

The development of sustainable water purification technologies is an urgent need, as conventional treatments often fail to eliminate persistent organic pollutants, generating secondary contamination. Natural clay- and silicate-based systems can act as efficient, eco-friendly alternatives. Building on natural ceramic substrates such as perlite, fly ash, and lightweight expanded clay aggregate, enzymes were immobilized using adsorption and core–shell encapsulation methods to enhance their catalytic performance and stability. Horseradish peroxidase (HRP), laccase, and xanthine oxidase (XO) were employed in both single- and tandem-enzyme systems to target pharmaceuticals, dyes, and phenolic compounds. The XO-HRP cascade efficiently removed pollutants by in situ generation and utilization of hydrogen peroxide, reaching up to complete degradation while preventing harmful byproduct accumulation. Core–shell immobilization further stabilized enzymes and enabled high degradation rates of diclofenac, carbamazepine, and paracetamol, as confirmed by NMR analysis. The ceramic-based supports provided a robust and cost-effective matrix and proved reusability and resistance to pH and temperature variations. These findings demonstrate the potential of natural clay-derived silicates as versatile hosts for biocatalysts, offering scalable, green, and circular solutions for advanced water purification technologies.

S7- Nanotoxicity, bio-imaging, drug-delivery and tissue engineering with tailored nano-bioconjugates

Room: Flagler A
Session Chair: Sedat Ballikaya, Istanbul University

11:00 AM

(ICACC-S7-014-2026) Development of inorganic contrast-agents for emerging X-ray fluorescence bioimaging (Invited)

M. S. Toprak*[1]

1. KTH Royal Institute of Technology, Dept. of Applied Physics, Sweden

Nanoparticles (NPs) are increasingly applied in areas ranging from hybrid materials and sensors to antiviral/antibacterial coatings and diverse biomedical uses, including contrast agents. Our group develops ceramic NP families for biomedical applications using bottom-up solution chemistry. Depending on the intended use, NPs are either surface-coated or assembled into larger architectures by exploiting their surface functionalities. Achieving the right surface chemistry is crucial, as it reduces processing steps and enables the targeted material properties. After initial in-vitro validation, selected NPs were optimized for in-vivo X-ray fluorescence (XRF) bioimaging studies. In this presentation, I will highlight recent activities and materials specifically designed for the unique XRF bioimaging facility in Sweden—one of only a few pioneering laboratories worldwide. The talk will cover the evolution of our work, from early-generation NPs to core–shell systems and advanced surface functionalization approaches. Examples of recent results from both in-vitro and in-vivo studies using these engineered NPs will be discussed, emphasizing their potential for next-generation biomedical imaging.

S7- Functional coatings and innovative thin film techniques

Room: Flagler A
Session Chair: Sedat Ballikaya, Istanbul University

11:30 AM

(ICACC-S7-015-2026) Flexible ceramic film fabrication and functional control via photo-assisted thin-film processes

T. Tsuchiya*[1]

1. National Institute of Advanced Industrial Science and Technology (AIST), Japan

Conventional thin-film fabrication techniques typically require high-temperature thermal processing, which limits their applicability to resin-based substrates. To address this challenge, we have developed nanomaterials and ultrathin ceramic films using fluoride, nitride, and metal oxide systems through photo-assisted reactions involving metal-organic compounds and nanoparticles. This presentation highlights recent advances in the fabrication of flexible ceramic films on polymer substrates and the control of their electrical and optical properties. In particular, we demonstrate work function modulation, epitaxial growth of metal oxide thin films, and device-level control enabled by photoreaction-based processing. These findings contribute to the development of low-temperature, substrate-adaptive ceramic technologies for advanced functional devices.

11:50 AM

(ICACC-S7-016-2026) A novel low-temperature sintering method of aerosol jet printing via particle free ink for conductive films additive manufacturing

G. Li*[1]; Y. Sun[3]; Q. Sun[1]; A. Cabot[2]

1. Institut de Recerca en Energia de Catalunya, Spain
2. Catalonia Institute for Energy Research, Spain
3. Harbin Institute of Technology, China

Aerosol jet printing (AJP) has emerged as a powerful additive manufacturing technique for fabricating precision conductive patterns and thin films due to its three-dimensional substrates compatibility and micrometer-scale resolution. However, these conductive coatings based on silver nanoparticles (AgNPs) typically require sintering above 180 °C, which is incompatible with polymer substrates and other temperature-sensitive materials, thereby limiting the broader application of AJP. Moreover, the inherent trade-off between electrical conductivity and adhesion remains a major challenge in ink formulation and post-treatment. In this work, we developed a particle-free silver ink that enables assisted sintering of printed features, achieving both excellent adhesion and high conductivity. The printed films reached a resistivity as low as 40.8 ± 0.5 μΩcm after sintering at 100 °C for 1 h, which is nearly 67 times lower than conventional thermal sintering. The microscopic evolution of nanostructures during sintering was discussed, and the mechanisms governing the enhancement of conductivity and adhesion were systematically investigated. Finally, conductive patterns were successfully integrated into flexible strain sensors, demonstrating the potential of AJP for next-generation additive manufacturing of conductive architectures.

S8 20th Intl Symp on APMT for Structural & Multifunctional Materials & Systems

S8- Field-Assisted and Extreme Processing: Mechanisms and Functional Materials

Room: Coquina B
Session Chairs: Thi Mai Dung Do, Nagaoka University of Technology; Raul Bermejo, Montanuniversitaet Leoben

8:40 AM

(ICACC-S8-010-2026) A new "phase" of matter produced by proliferation of defects (Invited)

R. Raj*[1]

1. University of Colorado, USA

We will show that the so-called flash phenomenon in fact embodies a new entity that is distinct from the classical three phases of matter. It is neither a liquid nor a solid, it consists of defects that crystallize into a crystal of their own; it is a plasma in the solid state with an evanescent presence at surfaces which can be forced to travel across "free space" under the influence of magnetic fields. Within it atoms move as fast as in metallic liquids at their melting point, although the crystal remains coherent. The discovery is likely to have a broad impact across crossdisciplinary sciences and a wide spectrum of technologies. We will describe experiments that have led to this discovery. They include (i) touch free flash sintering, (ii) in-situ calorimetry showing the generation of defects of up to 25 mol% fraction, (iii) ostensible melting in metals well below the melting point, (iii) creation of graphene infused copper where ordinary carbon is shown to diffuse within the copper matrix while simultaneously transforming into graphene in mere seconds, and (iv) chemical processing for converting zinc-sulphide into zinc-oxide quickly at low furnace temperatures. Potential revolutionary applications, hyper catalysis being one, will be discussed.

9:10 AM

(ICACC-S8-011-2026) Acceleration of high temperature processing of 8YSZ under electric field/current (Invited)

K. Morita*[1]

1. National Institute for Materials Science (NIMS), Japan

Strong electric fields have been attracted a lot of attention because it is work not only to sintering, but also to other high temperature processing such as deformation, joining and crack healing. Under the strong electric field/current, we confirmed that crack healing can be accelerated in 8Y-CSZ polycrystals as a reference material. For example, the micro-crack with an initial length of 20 mm can be healed at a specimen temperature of 1223 °C for 10 min. As compared to the healing without the electric field/current (0 V), the crack healing was apparently accelerated by about 200 times even at the same temperature of 1223 °C. The accelerated crack healing can be ascribed to accelerated grain boundary diffusivity of cations that caused additionally under the strong electric field/current. Although the room temperature bending strength decreases to about 180 MPa by forming the microcrack of 20 mm, it can be recovered to >400 MPa, which is almost the same to that of the as-sintered specimen, through the flash healing treatment at 1223 °C for 10 min. This indicates that the strong electric field/current is very effective to recover the mechanical strength through the healing of the microcrack.

9:40 AM

(ICACC-S8-012-2026) Enhanced kinetics during flash joining of TiO_2 and ZnO

R. Mundra*[1]; S. Kumar[1]; K. Kulkarni[1]; S. K. Jha[1]

1. Indian Institute of Technology Kanpur, Materials Science and Engineering, India

Flash sintering (FS) is a process where the externally applied electrical power enhances species diffusion at a lower temperature in a short duration compared to conventional methods to densify ceramics. Recently this technique has gained attention in making a single reactive compound from two or more compounds, otherwise known as reaction sintering. Different species can migrate over a few micrometers and quickly react to form new compounds. Solid-state diffusion and reaction can also help to join two different bulk ceramics and make a new multilayer functionally graded material. This technique can compete with conventional diffusion coupled methods to enhance the interdiffusion coefficient and make it energy and cost efficient. The present study uses a novel Flash joining (FJ) technique to understand the diffusion and reaction kinetics between two different ceramic oxides under atmospheric conditions. Bulk TiO_2 and ZnO were joined using Alternating Current (AC) to facilitate interdiffusion of species and formation of Zinc titanate. The experimental results showed increased kinetics in forming the diffusion layer under a predefined current limit. Based on the thickness of diffusion layer, interdiffusion coefficient has been calculated and compared against convention sintering. The results highlight the role of nonthermal effect of field in enhanced species diffusion.

10:20 AM

(ICACC-S8-013-2026) Fabrication and irradiation of non-oxide nuclear fuels and ceramics (Invited)

L. He*[1]

1. North Carolina State University, Nuclear Engineering, USA

UN and UC are promising nuclear fuel materials for advanced reactors because of their higher uranium density, superior thermal conductivity, and better compatibility with carbon-based high-temperature materials—such as SiC and graphite—compared to UO_2. ZrN and ZrC have been used or considered as surrogate materials for UN and UC, respectively, or as fuel components, owing to their similar crystal structures and comparable material properties. Various fabrication techniques, including pressureless sintering, hot pressing, spark plasma sintering, and flash sintering, have been applied or explored for these materials. To qualify them for nuclear reactor applications, irradiation testing is essential. In this study, both ex situ and in situ ion irradiations with proton, krypton, and xenon ions were performed to investigate microstructural evolution under irradiation. Electron microscopy was employed to characterize the size and density of dislocation loops and gas bubbles, providing insights into their radiation damage tolerance.

10:50 AM

(ICACC-S8-014-2026) Effect of high pressure on microstructure and properties of nano-structured transparent ceramics fabricated by high pressure spark plasma sintering

S. Cottrino*[1]; T. Douillard[1]; N. Blanchard[2]; S. Meille[1]; L. Gremillard[3]; S. Le Floch[2]

1. MATEIS Laboratory, Material, France
2. Institut Lumiere Matiere, France
3. INSA, Materials, Engineering and Science, France

In this work, high-density nanostructured nanostructured ceramics were produced by high pressure spark plasma sintering (HP-SPS) up to 5 GPa. High pressure densification produces green bodies with fine pores and improved density, which improves the sintering process. This can be explained by an important modification of the granular arrangement with first an inter-agglomerate reorganisation, then an intra-agglomerate arrangement and finally a plastic deformation of the nanoparticles. It is shown that by applying high pressure (76 MPa to 5 GPa) the densification starts at a lower temperature and is accelerated. Application of 1.5 GPa pressure reduces sintering temperatures by 500°C, resulting in dense, transparent ceramics without grain coarsening. Advanced microstructural analysis techniques have been used to monitor the evolution of the microstructure under high pressure and temperature. Real in line transmission and microhardness measurements were carried out to assess the effect of pressure on the sample properties. The ceramics obtained exhibit some optical losses at short wavelengths, but the plasticity induced in the nanograins appears to be beneficial for mechanical properties.

11:10 AM

(ICACC-S8-015-2026) Observing in-situ degradation of metallized aluminum nitride substrate under thermal cycling tests by acoustic emission and digital image correlation

M. Ngo*[1]; H. Miyazaki[1]; K. Hirao[1]; T. Ohji[1]; M. Fukushima[1]

1. National Institute of Advanced Industrial Science and Technology (AIST), Multi-material Research Institute, Japan

Metallized aluminum nitride produced by active metal brazing (AMB-AlN) substrates are commonly used in power modules for heat dissipation, but are susceptible to damage under large temperature variations. While previous studies have used thermal cycling tests ranging from -40 to 250°C, in-situ observations of degradation in AMB-AlN have not been reported. In this work, internal cracking and 3D deformation of AMB-AlN substrates were monitored by acoustic emission (AE) and digital image correlation (DIC) methods, respectively, throughout successive thermal cycles. The AMB-AlN substrates were significantly delaminated after 8 thermal cycles. In the first 5 cycles, negligible deformation and delamination were observed by 3D DIC and scanning acoustic microscopy. The cracks detected by AE produced low-amplitude signals only around -40°C. From the 6th to 8th cycles, the AE signal increased rapidly with the clear deformation of the substrate and depended on the temperature. A good correlation was found between the accumulated number of cracks detected by AE and the height of the Cu delamination from the substrate determined by DIC. In light of these findings, the delamination of the AMB-AlN substrate was attributed to the propagation of cracks in the substrate and their interconnected growth.

11:30 AM

(ICACC-S8-036-2026) Performance evaluation of new polymer additives for technical ceramic shaping processes

I. Mbarki*[1]; A. Aimable[2]; F. Rossignol[2]; A. Graham[3]; S. Crabtree[3]

1. Institute of Research for Ceramics – IRCER, The Dow Chemical Company, France
2. UMR CNRS 7315, Institute of Research for Ceramics (IRCER), France
3. Monomers and plastic additives, The Dow Chemical Company, USA

This study addresses key challenges in shaping complex ceramic components by proposing a novel approach that integrates freeze granulation and robocasting. The objective is to simplify the preparation of functionalized ceramic feedstocks using polymer additives with tailored rheological properties. A high-purity alumina powder (8.1 m_2/g) is used as a model material. Nine distinct polymeric additives are evaluated for their ability to disperse and structure ceramic suspensions with 30–50 vol% solid loading. Rheological analyses and freeze granulation experiments are conducted to assess flow behavior and granule quality under varying process conditions, including air pressure and suspension flow rate. Compaction studies up to 300 MPa examine how granule properties affect densification and microstructure. Results highlight the effectiveness of freeze granulation as a pre-processing step, enabling the incorporation of dispersants, binders, and plasticizers directly into the granules. This approach significantly enhances the printability of the resulting robocasting feedstocks, demonstrating improved powder flowability and structural integrity for additive manufacturing of advanced ceramics.

S11 Advanced Materials and Innovative Processing Ideas for Production Root Technologies

S11- Innovative manufacturing processes for recycling, sustainable energy, or the semiconductor industry

Room: Ballroom 3
Session Chair: Ayahisa Okawa, Tohoku University

9:00 AM

(ICACC-S11-001-2026) Green pathways from CO_2 to polyurethane (Invited)

J. Lee*[1]; Y. You[1]

1. Korea Research Institute of Chemical Technology, CO2 & Energy Research Center, Republic of Korea

The increasing demand for eco-friendly materials has driven the development of a sustainable process for synthesizing polyurethane monomers directly from CO_2, addressing both environmental and industrial challenges. This process incorporates CO_2 to avoid the use of toxic phosgene to produce methylene diphenyl diisocyanate (MDI), a critical precursor for polyurethane production. A dual-functional Pd/CeO_2 catalyst is employed for the oxidative carbonylation of diamines, achieving high yields of dicarbamates while effectively minimizing urea polymer formation through enhanced methoxylation reactivity. Moreover, a multi-step process utilizing methylene diphenyl diamine (MDA) as a key intermediate has been developed to synthesize CO_2-based MDI. The process includes the generation of syngas from CO_2 through dry reforming, selective catalytic hydrogenation of nitrobenzene to produce aniline, and the subsequent condensation of aniline with formaldehyde to form MDA. MDA is then converted to dicarbamates via oxidative carbonylation, followed by thermal decomposition to yield MDI. Process modeling and life cycle assessment demonstrate that this approach significantly reduces greenhouse gas emissions and environmental toxicity compared to traditional phosgene-based methods. This study establishes a scalable and eco-friendly pathway for the sustainable production of high-value polyurethane precursors.

9:30 AM

(ICACC-S11-002-2026) Halloysite nanotube decorated with Fe_3O_4@NiO_X hybrid catalyst for enhanced oxygen evolution in alkaline electrolytes

Y. Jun*[1]; S. Mhin[1]

1. Dongguk University, Energy and Materials Engineering, Republic of Korea

The oxygen evolution reaction (OER) is a kinetically sluggish, multistep process involving a four-electron transfer, which requires high overpotentials. To overcome this limitation, this study focuses on the synthesis of a heterostructure, which is a Fe_3O_4@NiO_X core-shell structure anchored on a halloysite nanotube (HNT) to enhance the oxygen evolution reaction (OER) performance. Fe_3O_4-modified HNT not only imparts conductivity but also suppresses particle agglomeration, thereby increasing the active sites. Furthermore, the synergistic effect of the core-shell structure, particularly in Fe-Ni-based materials, can contribute to reducing overpotential and improving reaction efficiency. Fe_3O_4@NiO_X nanostructure anchored on the HNT support exhibits a low overpotential of 280 mV at 10 mA cm^{-2} and long-term stability over 48 h, indicating the robust OER catalytic activity in 1.0 M KOH. Combined with experimental results, Fe_3O_4@NiO_X/HNT

makes it a promising earth-abundant transition metal-based electrocatalyst for OER in an alkaline medium.

9:50 AM

(ICACC-S11-003-2026) Na_2SO_4-modified electrolytes toward stable and high-performance aqueous zinc ion batteries

Y. Park*[1]; S. Mhin[2]

1. Dongguk University, Department of Energy and New Materials, Republic of Korea
2. Dongguk University, Energy and Materials Engineering, Republic of Korea

Aqueous zinc-ion batteries (AZIBs) are promising candidates for next-generation energy storage beyond lithium-ion batteries (LIBs) due to their high specific capacity (820 mAh g^{-1}), safety, and cost-effectiveness. The electrolyte is critical as an ion-conducting bridge between the cathode and anode, ensuring efficient electrochemical performance. Previous studies have shown that electrolyte additive engineering effectively improves AZIB performance by suppressing cathode dissolution, mitigating by-product formation, inhibiting dendrite growth, and reducing side reactions. In this work, we investigate the effects of Na_2SO_4 additives in $ZnSO_4$ electrolytes. The Na_2SO_4 additive prevents the continuous dissolution of sodium-pre-intercalated vanadium oxide ($Na_2V_6O_{16}\bullet 2H_2O$, NAVO) at the cathode and restricts Zn dendrite growth at the anode due to the lower reduction potential of Na^+ compared to Zn^{2+}. The electrostatic shielding mechanism for dendrite suppression in Zn anodes is validated through experimental and theoretical modeling. Incorporating Na_2SO_4 into $ZnSO_4$ significantly improves rate capability and cycling stability compared to pristine $ZnSO_4$. This study demonstrates a cost-effective and sustainable electrolyte engineering strategy, paving the way for dendrite-free, durable, and high-performance AZIBs.

S11- Fundamental materials: Mining, particles, bulk, and functional materials and precursors I

Room: Ballroom 3
Session Chair: Ayahisa Okawa, Tohoku University

10:30 AM

(ICACC-S11-004-2026) Beyond linear scaling: Innovations in catalyst optimization (Invited)

K. Shin*[1]

1. Hanbat National University, Republic of Korea

Recent studies in electrochemical reaction simulations have revealed the construction of Volcano plots and 2D contour plots based on a strong linear scaling relation between the adsorption energies of intermediate species. This linear scaling relation provides researchers with a straightforward descriptor to predict catalyst performance and enables the visualization of large datasets of catalyst performance on simple contour plots. However, to maximize catalyst performance, it is crucial to identify outliers that do not follow the linear scaling relation. Particularly in the oxygen reduction reaction (ORR), a strong linear scaling relation between OH and OOH adsorption energies sets clear limits on catalyst activity. Overcoming these limits requires understanding how outliers arise and how researchers can control them. In this presentation, we will explore the fundamental assumptions and theories of electrochemical catalyst simulations and examine how volcano plots and 2D contour plots are formed based on the linear scaling relation. Additionally, we will investigate the impact of ensemble, electronic, and strain effects on adsorption energies and explore various possibilities for generating outliers that deviate from the linear scaling relation.

11:00 AM

(ICACC-S11-005-2026) Scratch-induced damage evolution of SiC-Zr_2CN composites (Invited)

N. V. Dorkar[1]; Y. Kim[2]; B. Kumar*[1]

1. Indian Institute of Technology Roorkee, Metallurgical and Materials Engineering, India
2. WORLDEX Industry & Trading Co., Ltd., Republic of Korea

Scratch testing has emerged as a powerful technique for evaluating the mechanical and tribological response of advanced ceramics and composites. In the present investigation, scratch behavior of silicon carbide-in situ zirconium carbonitride composites were performed using a sphero-conical diamond indenter under varying loading conditions of 10N and 20N, respectively. The findings highlight that the presence of Zr_2CN content significantly lowered the COF and wear rate of the composites in comparison to monolithic, irrespective of test conditions. Extensive cracking, fracture and pull-out were observed as the major material removal mechanism for monolithic SiC ceramics while tribo-oxidation, along with surface deformation and ridge formation were observed for SiC-Zr_2CN composites.

11:30 AM

(ICACC-S11-006-2026) Turning mine wastes into structures: Hybrid geopolymer–Cement mortars for sustainable construction applications (Invited)

D. Quinagoran[1]; J. Narvaez[1]; A. Ventura[1]; M. Plata[1]; J. Maniaul[1]; J. Cruz[1]; D. Tungpalan[1]; K. Baladad[1]; E. d. Magdaluyo*[1]

1. University of the Philippines, Philippines

The sustainable management of mine wastes remains a critical challenge for the mining industry. This study investigated the valorization of copper mine tailings and silt in hybrid geopolymer–cement mortars for structural and construction applications. Mortars with varying tailings contents and activator concentrations were prepared and tested. Compressive strengths of 24–54 MPa met ASTM C150 requirements, while leaching tests confirmed effective immobilization of heavy metals, demonstrating environmental safety. For potential use in cement-based 3D printing, extrusion trials were conducted and analyzed using the Taguchi method to assess the effects of extrusion pressure, nozzle diameter-to-layer height ratio, and print speed. The nozzle ratio was identified as the most significant factor influencing dimensional accuracy, with optimized settings (2.5 bar pressure, 4:1 ND/LH, 20 mm/s) enabling successful block fabrication. Print defects such as edge curvature and voids underscored the need for refined path coding. In summary, hybrid geopolymer–cement mortars incorporating mine wastes showed strong potential as sustainable, 3D-printable construction materials.

S13 Advanced Ceramics and Composites for Nuclear Fission and Fusion Energy Systems

S13- Functional materials for fission and fusion

Room: Coquina F
Session Chair: Kun Wang, Alfred University

8:30 AM

(ICACC-S13-010-2026) Readiness of substoichiometric yttrium dihydride in nuclear systems: Irradiation performance perspective (Invited)

N. Cinbiz*[1]

1. Oak Ridge National Laboratory, USA

Substoichiometric yttrium dihydride is a solid moderator candidate for microreactor and fission surface power systems because of its high H retention and structural stability. While decades of research and development address the major fabrication, thermophysical properties, and limited operational questions in hydrides, readiness critical challenges on fundamental knowledge and performance are limited for a complete moderator component qualification. To address this gap, the DOE's have initiated irradiation and postirradiation examination campaigns to investigate irradiation performance. Material performance has been evaluated through a comprehensive suite of post-irradiation examinations, including neutron radiography, visual inspections, advanced x-ray diffraction, electron microscopy, and thermal property characterizations. This presentation will summarize the findings from both campaigns, with emphasis on H retention, structural and geometric stability, and the effects of irradiation on material performance. The results will be discussed in the context of technological readiness, highlighting key data gaps, outstanding challenges, and opportunities for advancing hydride moderators toward deployment. Special attention will be given to fabrication qualification requirements and pathways for ensuring technological readiness of hydride-moderated reactor systems.

9:00 AM

(ICACC-S13-011-2026) Phase stability, microstructure and hydrogen retention in entrained hydride ceramic composite moderators

L. Gurnani*[1]; M. A. Shawon[1]; D. Doyle[2]; N. Brown[2]; C. N. Taylor[3]; W. Zhong[4]; D. Sprouster[1]; L. Snead[1]; J. Trelewicz[1]

1. Stony Brook University, USA
2. The University of Tennessee Knoxville, USA
3. Idaho National Laboratory, USA
4. Oak Ridge National Laboratory, USA

Bulk monolithic hydrides, despite possessing enhanced moderating power relative to graphite, are limited in their use for small modular reactors (SMRs), due to concerns over hydrogen release and extensive cracking at high temperatures (>600 °C). To mitigate these challenges, this research presents an innovative composite moderator design comprising magnesium oxide (MgO) as the structurally stable ceramic matrix and zirconium hydride (ZrH_x) as the entrained moderating phase. Starting with the powder composition of MgO - 20 vol.% ε-ZrH_2, the final composite architecture, with ~99% of the theoretical density, is achieved by synergistically leveraging LiF as a sintering aid and field-assisted sintering at temperatures as low as 950 °C. Post sintering X-ray diffraction analysis reveals retention of ~16 wt.% of cubic zirconium hydride (δ-$ZrH_{1.66}$), indicating the role of MgO matrix in suppressing H-outgassing during sintering. Electron microscopy observations confirm the formation of dense composite microstructures, exhibiting a uniform distribution of the entrained hydride phase with crack-free MgO/hydride interfaces. The stability of the hydride phase is mapped through thermal desorption spectroscopy at temperatures within the operating limits for SMRs, thereby demonstrating the potential of entrained hydride ceramic composite moderators to enable novel microreactor designs.

9:20 AM

(ICACC-S13-012-2026) Tritium diffusion in lithium breeder blankets: A density functional theory investigation

T. Smith*[1]; C. Cockrell[1]; T. Davey[1]

1. Bangor University, Nuclear Futures Institute, United Kingdom

Nuclear fusion provides a low-carbon solution to global energy demands. A significant challenge however is sustaining the constant supply of tritium to maintain the deuterium-tritium reaction. Lithium-based ceramics are prime candidates for tritium breeding with lithium titanate (Li_2TiO_3) receiving significant attention due to its lithium density and chemical stability. Significant undertakings to understand tritium release kinetics have been made, although, the atomistic mechanisms of tritium diffusion through the pristine ceramic are not fully understood. Additionally, under operational conditions the ceramic will be irradiated with the resulting defects having an impact on diffusion. Here, we employ density functional theory (DFT) to investigate the fundamental properties and defects relevant to tritium diffusion mechanisms in lithium titanate with the eventual aim of our simulations to elucidate tritium diffusion behaviour and to further progress breeder blanket material optimisation for fusion application. Other proposed lithium ceramics, such as lithium carbide (Li_2C_2), are relatively underexplored for this application, we extend our investigations to evaluate its potential suitability for fusion breeder blanket application.

9:40 AM

(ICACC-S13-058-2026) High-throughput analysis of ultra-high temperature ceramics for first wall fusion applications

D. Marchesi[2]; L. Mazzocco*[1]; O. S. Houghton[1]; D. Pettinari[3]; A. Seshadri[1]; L. Snead[4]; K. Shirvan[1]

1. Massachusetts Institute of Technology, USA
2. Politecnico di Milano, Italy
3. Politecnico di Torino, Italy
4. Stony Brook University, USA

The development of plasma-facing materials for fusion first-wall applications remains a critical challenge, as conventional choices (such as W) suffer from irradiation-induced embrittlement, recrystallization, and precipitation of transmutation products. Ultra-High Temperature Ceramics (UHTCs), and particularly transition metal carbides (TMCs), offer a promising alternative owing to their high melting points, thermal conductivity, and radiation tolerance. In this work we employ computational thermodynamic simulations (CALPHAD) to explore the design space of ternary TMC systems. More than 170,000 compositions were screened through stringent down-selection criteria targeting high FCC phase stability and favorable homologous temperatures. Surviving compositions were further assessed for irradiation-related constraints, including post-shutdown γ-dose evolution, helium/hydrogen buildup, and the role of transmutation products in FCC stability. Finally, the impact of candidate TMCs on the neutronics of a compact, high-field tokamak was quantified using OpenMC. Overall, this study highlights the potential of tailored UHTCs as plasma-facing materials and provides a framework to guide their experimental development, helping researchers focus on promising candidates within a vast compositional landscape.

S13- Advanced processing of nuclear ceramics

Room: Coquina F

Session Chair: Jianqi Xi, University of Illinois Urbana-Champaign

10:20 AM

(ICACC-S13-014-2026) Hybrid silicon carbide-based CMCs fabricated by embedded wire CVD

J. Pegna[1]; S. Shuster[1]; S. Harrison*[1]; L. Czerniak[2]; E. J. Lahoda[2]

1. Free Form Fibers, USA
2. Westinghouse Electric Company LLC, USA

Embedded wire chemical vapor deposition (EWCVD) is a rich technology that can achieve multiple engineering targets for the nuclear power industry. EWCVD has been demonstrated to homogeneously join (weld) monolithic or CMC silicon carbide structures, fabricate low-cost, freestanding SiC/SiC CMC cladding tubes, and overcoat zirconium-based cladding with a non woven SiC/SiC layer. This presentation will focus on the fabrication of freestanding SiC/SiC tube structures and the implementation of such a CMC layer on Zircaloy tubing. Discontinuous SiC fibers were produced by Laser-Driven Chemical Vapor Deposition (LCVD) and formed into dense non-woven mattes. Mattes were subsequently wrapped on a preform and the carbon interphase coating and SiC matrix were deposited by the EWCVD process. The details of fabrication and analysis of resulting samples will be discussed.

10:40 AM

(ICACC-S13-015-2026) SiC coatings for fusion and dission applications from liquid precursors

S. Kondo*[1]; K. Okada[2]; H. Katsui[3]; H. Yu[1]; Y. Ogino[1]; M. Park[1]; K. Yabuuchi[1]; R. Kasada[1]

1. Tohoku University, Institute for Materials Research, Japan
2. Tohoku Daigaku Daigakuin Kogaku Kenkyuka Kogakubu, Department of Quantum Science and Energy Engineering, Japan
3. National Institute of Advanced Industrial Science and Technology (AIST), Multi-Material Research Institute, Japan

SiC/SiC composites are valued for their chemical stability in nuclear systems, particularly when based on high-purity constituents. In practice, however, residual additives and interphases may interact with coolants and compromise durability. Coatings with high-purity SiC are therefore a promising approach. Methyltrichlorosilane (MTS) has long served as the conventional chlorosilane precursor for crystalline SiC, but its rapid hydrolysis, corrosive HCl generation, and unreacted species raise major safety and environmental concerns. Chlorine-free liquid precursors such as hexamethyldisilazane (HMDS) and hydridopolycarbosilane offer safer handling, benign byproducts, and a stoichiometric supply of Si and C without external gases. Yet their use in structural coatings remains challenging, as decomposition often yields amorphous or porous films and precise microstructural control is elusive. To address this, we employed laser-assisted CVD to provide high energy density for densification and crystallization. The coatings were characterized by microscopy and XRD, and their hydrothermal durability was tested in an autoclave. We highlight the contrast between crystalline films formed at elevated temperatures and amorphous-like films at isothermal conditions, demonstrating how precursor chemistry and processing govern stability in high-temperature water.

11:00 AM

(ICACC-S13-016-2026) Additive manufacturing of nuclear ceramics

E. Zancan*[1]; I. Marshall[1]; G. Stephens[1]; T. Davey[1]; P. Makurunje[2]; Y. Chiu[3]; S. Middleburgh[1]

1. Bangor University, Nuclear Futures Institute, United Kingdom
2. Nuclear Futures Institute, Bangor University, United Kingdom
3. University of Birmingham, Metallurgy and Materials, United Kingdom

The growing interest in fusion energy demands the need for innovative approaches to the design and manufacture of tritium breeding structures requiring mechanical strength, thermal efficiency, and controlled permeability to reliably generate tritium. Conventional routes are constrained by tooling requirements, limited geometric flexibility, and challenges in scaling complex architectures. Likewise, granulation techniques face difficulties in achieving narrow size distributions and in meeting the demands of large-scale production. This work explores binder jetting (BJT) as a method for producing ceramic structures tailored for tritium breeding. As rapid prototyping technique, BJT enables the direct fabrication of intricate shapes offering design freedom and rapid iteration. The approach allows control of the porosity, opening pathways to designs optimized for both breeding and thermal management while offering a scalable route for the production of small, spherical ceramic kernels, where uniformity and reproducibility are paramount. Early results show that BJT can deliver accurate dimensional control, favourable sintering behaviour, and fine feature resolution. The approach has also been extended to ZrB_2 as first step towards fissile kernels. These findings suggest that BJT can provide a flexible and scalable manufacturing pathway for both fusion and fission materials for next-generation nuclear technologies.

11:20 AM

(ICACC-S13-017-2026) Designing cermet waste forms for immobilizing advanced reactor waste streams

R. Saini*[1]; A. Goel[1]

1. Rutgers University, Materials Science and Engineering, USA

The high-level waste (HLW) expected from advanced reactor (AR) fuel cycles is anticipated to contain substantial amounts of stainless steel, undissolved solids (UDS), graphite, metal oxides, and halide-based salts. Such a complex waste composition poses significant challenges for immobilization in borosilicate glass, including limited waste loading, complicated processing, reduced chemical durability of the waste form, higher costs, and longer processing times. To address these challenges and enhance vitrification, the present work focuses on developing high-density, chemically durable cermet waste forms (WFs) capable of immobilizing multiple AR waste streams. These cermets, comprising metals (stainless steel, Hastelloy), sodalite, halides, and phosphates, will be fabricated using spark plasma sintering and hot uniaxial pressing. Their phase assemblage and microstructure will be characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), energy-dispersive spectroscopy (EDS), mercury porosimetry, and helium pycnometry. The density and chemical durability of the cermets will be optimized by varying metal-to-ceramic ratios and processing parameters (temperature, pressure, time). The findings from these investigations will be presented.

11:40 AM

(ICACC-S13-018-2026) Practical CVI SiC process development: A case study in infiltration optimization

B. W. Lamm*[1]; V. I. Ramirez[1]; A. Rogers[2]; T. Koyanagi[1]

1. Oak Ridge National Laboratory, Materials Science and Technology Division, USA
2. Oak Ridge National Laboratory, Nuclear Energy and Fuel Cycle Division, USA

Chemical Vapor Infiltration (CVI) is the densification method of choice for applications requiring ultra-high purity or for materials that are difficult to sinter or machine – such as in the fabrication of SiC components for use in nuclear fission or fusion environments. Material impurities in nuclear reactor environments increase susceptibility to corrosion and irradiation-induced activation. However, CVI is by nature a chemically reactive process and thus sensitive to the selected process conditions (e.g., temperature, total pressure, precursor partial pressure, residence time). The final matrix composition is affected strongly by both thermodynamic equilibrium and kinetic reaction dynamics. As an example, additively manufactured SiC disks were CVI densified with a Si-rich SiC matrix from a hydrogen / methyltrichlorosilane (MTS) gas mixture. The relationship between several primary process parameters – gas ratio, total pressure, and temperature – and thermodynamic equilibrium and kinetic reaction dynamics will be discussed in relation to matrix composition. Based on calculated phase diagrams and kinetics process knowledge, the CVI parameters were adjusted experimentally to improve the purity of the SiC matrix.

S14 Crystalline Materials for Electrical Optical and Medical Applications

S14- Optical material II

Room: Ballroom 4
Session Chairs: Sandrine Cottrino, MATEIS Laboratory;
Hiroki Tanaka, Leibniz-Institut fur Kristallzuchtung im Forschungsverbund Berlin eV

8:30 AM

(ICACC-S14-009-2026) Transparent $MgAl_2O_4$, Y_2O_3 and MgO Ceramics for infrared sensor applications

M. Drüe*[1]; A. Frickel[1]; J. Krech[2]; A. Isserstedt-Trinke[3]; P. Sachse[3]; S. Apel[3]; L. Dittrich[2]; S. Begand[4]

1. Fraunhofer-Institut fur Keramische Technologien und Systeme IKTS - Standort Hermsdorf, Oxide Ceramics, Germany
2. 5microns GmbH, Germany
3. Micro-Hybrid Electronic GmbH, Germany
4. Fraunhofer-Gesellschaft zur Forderung der angewandten Forschung eV, Oxide Ceramics, Germany

Owing to their superior mechanical, optical and chemical properties, transparent ceramics have become a suitable alternative compared to more common transparent materials such as glasses and polymers. Their extended transmission window up to the near infrared wavelength range makes the ceramics suitable for application in optical devices such as laser components, optical lenses and sensor systems. In particular, $MgAl_2O_4$, Y_2O_3 and MgO are suitable materials for infrared sensor applications. Alongside their wide transmission window, they exhibit an excellent mechanical and chemical stability. However, to achieve the desired optical properties, a thorough processing is required, including high-purity powder materials and strictly defined annealing and hard machining procedures. In this work, the impact of the processing on microstructural and therefore optical properties of $MgAl_2O_4$, Y_2O_3 and MgO is investigated. Achieving very high spectral infrared transmission is critical for such applications, which requires the development of reliable processing methods for all materials. The main objective of this work is to produce monolithic ceramic windows with high relative density and sufficient transmission for optical sensor applications. The challenges and modifications along the processing chain are investigated with respect to their impact on the functional properties of the transparent ceramic windows.

8:50 AM

(ICACC-S14-010-2026) Implant housing with transparent spinel ceramic optical window

S. Begand*[1]; M. Drüe[1]; S. Spange[1]

1. Fraunhofer-Institut fur Keramische Technologien und Systeme IKTS - Standort Hermsdorf, Oxide Ceramics, Germany

The transparent ceramic magnesium-aluminum spinel is known for its mechanical stability, high hardness, wide transmission range and also for biocompatibility, and therefore attractive for use in medical devices. Completely new generations of actively networking micro implants were developed to provide forward-looking approaches for improved human-technology interaction. The focus here is on the application areas of tinnitus suppression and the restoration of grasping functions. Networked single implants communicate with the doctor or patient via external interfaces. The task was to develop a rigid and hermetically sealed ceramic housing with sufficient mechanical and optical properties with transparency in the IR range (λ= 1.07 μm). For this purpose, $MgAl_2O_4$ spinel was selected. Signal transmission has been provided by considering an optical window. Two shaping technologies were tested: Slip casting and manufacturing via hard machining from solid material. Various studies were carried out to produce suitable slurry and design of the mold. Sensor structure, the support plate and the power supply were developed by partners. Very first in vitro tests with assembled implants were successfully completed. Proof of concept for a network of micro active implants with transparent ceramic housing has been provided.

9:10 AM

(ICACC-S14-011-2026) Effect of ZnO and ZrO_2 content on the structural, mechanical and electrical properties of photocatalytic glasses suitable for electric melting

A. Tamayo*[1]; M. Rubio[1]; J. Rubio[1]

1. Institute of Ceramics and Glass, CSIC, Spain

Decarbonizing the glass industry is a key challenge to achieve net zero green house gas emissions by 2050. Electric heating of glass melts requires the application of high initial power and the allowance of the mobile charged species to provide enough electrical conductivity to maintain the glass melt. For this purpose, glasses with different ZnO and ZrO_2 contents have been prepared and fully characterized by means of spectroscopic, thermal, mechanical and electrical techniques. It was noted that whereas the ZnO exerts no or little effect on the network polymerization, the incorporation of ZrO_2 induces an increase on the crosslinked units. Additionally, the incorporation of increased amounts of ZnO leads to an increase of the viscosity of the glass and the relative amount of glassy phase as well. The effect of the atom mobility in the glass state is then translated to different high temperature electrical properties, which is then translated to a lower energy demand during melting. Their corrosion behavior against ZrO_2-based refractories has been determined through Raman and profile analysis. The ZnO enriched materials provoke a fast corrosion of the refractories and the formation of secondary phases at the interface glass-refractory. The ZnO content provides photocatalytic activity against drugs and emerging contaminants as well.

9:30 AM

(ICACC-S14-012-2026) Design rules for Eu^{2+} and Ce^{3+}-doped long-wavelength-emitting oxide phosphors (Invited)

K. Toda*[1]

1. Niigata University, Japan

Long wavelength-emitting (yellow and red) based on Eu^{2+} or Ce^{3+}-doped nitrides and oxynitrides have received much attention for the white LED applications. Since the synthesis of these nitride-based phosphors require special furnace (high temperature and high pressure), the research and development of new long wavelengthemitting oxide materials will be important. Many researchers claimed the redshift of 5d-4f emission in the nitride phosphors correlates with an strong covalency of the Eu(Ce)-N bond. In this study, we propose new strategy for the designing of red emitting oxide phosphors. Symmetrical octahedral sites are appropriate for the large splitting of 5d band for Eu^{2+} and Ce^{3+} ions. For example, olivine $NaMgPO_4$:Eu^{2+} phosphor with the symmetrical octahedral sites can be efficiently excited by blue light irradiation and presents red emission band centered at 628 nm. Therefore, this new strategy (octahedrally coordinated sites for the Eu^{2+} or Ce^{3+}) is a general and powerful tool for searching the red-mitting phosphors. Acknowledgements This work was supported by JSPS KAKENHI Grant Number 23K17955 (Grant-in-Aid for Challenging Research (Exploratory)).

10:20 AM

(ICACC-S14-013-2026) Photoluminescence behavior of Eu^{2+} in Ca–Y–Si–O phosphors: Role of Ca/Y ratio and crystal site occupancy

Y. Sato*[1]; A. Yamanaka[1]; M. Kobayashi[2]; K. Tomita[4]; M. Kakihana[3]

1. Okayama Rika Daigaku, Graduate School of Science and Engineering, Japan
2. Nagoya Daigaku, Institute of Materials and Systems for Sustainability, Japan
3. Osaka Daigaku, SANKEN, Japan
4. Tokai Daigaku, Department of Chemistry, Japan

Based on the concept of crystal site engineering, Ca-Y-Si-O oxide phosphors with multiple asymmetric sites were studied, focusing on the $Ca_2Y_8Si_6O_{26}$ phase. Eu^{2+} ions substituted at strong crystal field sites are expected to show red emission under blue-light excitation. Eu^{2+}-activated $Ca_2Y_8Si_6O_{26}$ samples were synthesized via the amorphous metal complex method using PGMS, followed by firing in Ar–H_2 at 1400°C. XRD confirmed single-phase formation for $Ca_{2-x}Eu_xY_8Si_6O_{26}$ (x = 0.02–0.40), though no Eu^{2+} emission was detected. In contrast, reducing Ca in $Ca_{2-x}Eu_{0.5}Y_2Si_2O_9$ led to increased formation of the $Ca_2Y_8Si_6O_{26}$ phase and red emission. PL measurements showed enhanced Eu^{2+} emission up to x = 1.0, then a decrease beyond x = 1.2. These results indicate that Ca reduction promotes $Ca_2Y_8Si_6O_{26}$ formation and Eu^{2+} activation. To probe the role of Eu valence states, Sr^{2+} (non-trivalent) was substituted, but impurity phases appeared, unlike in Eu-substituted samples. This suggests that Eu ions occupy both divalent and trivalent states, compensating Y^{3+} vacancies and stabilizing the $Ca_2Y_8Si_6O_{26}$ phase. Eu^{2+} substitution is thus crucial for red emission.

S14- Semiconductor and electronic material I

Room: Ballroom 4

Session Chairs: Matthias Bickermann, Leibniz-Institut fur Kristallzuchtung im Forschungsverbund Berlin eV; Kenji Toda, Niigata University

10:40 AM

(ICACC-S14-015-2026) Predictive evaluation of electro-optic properties of crystals

M. Ishtiyaq*[1]; S. Nakhmanson[1]

1. University of Connecticut, Materials Science and Engineering, USA

Electro-optic effects involve interactions between electromagnetic radiation and electric field in materials. These effects have remarkably diverse applications, ranging from telecommunications to next-generation photonic devices. Predictive identification of materials with large electro-optic response is highly desirable for these applications, however, associated experiments remain challenging. Ab initio simulations provide a convenient avenue for evaluating the strength of electro-optic effects in crystals, as well as other related properties (such as elasto-optic, piezo-optic, etc.). Here, we discuss an efficient workflow for predicting tensorial electro-optic coefficients (Pockels and Kerr) in non-magnetic crystals of most symmetries, including all the necessary ingredients, such as dielectric, elasto-optic and electrostrictive tensors. This approach may be modified for evaluating descriptors in high-throughput evaluations of optical properties. We benchmark our simulations on tetragonal $BaTiO_3$ and wurtzite AlN crystals, obtaining, where available, reasonably good agreement with results of prior experimental and theoretical reports. We also showcase the predictive capabilites of this approach by evaluating the strength of electro-optic effect in monoclinic chalcogenides, such as $Sn_2P_2S_6$ and $Sn_2P_2Se_6$.

11:00 AM

(ICACC-S14-016-2026) Elucidation of the mechanism of water-assisted solid-state reactions (Invited)

K. Toda*[1]

1. Niigata University, Japan

Water-assisted solid-state reaction (WASSR) has a distinctive feature: solid-phase reactions can proceed at low temperatures with the addition of trace amounts of water. In many cases, the reaction occurs below 500 K, enabling the synthesis of high-performance ceramics such as $LiCoO_2$, $BiVO_4$, and $BaTiO_3$. This reaction differs from conventional mechanochemical processes in that no mechanical stress, other than brief initial mixing, is applied. HRTEM observations demonstrate that nanocrystals react directly with one another to form products, confirming that this process is a solid-state reaction rather than a solution-mediated one. The reaction mechanism of WASSR can be described as follows. The solid acidic and basic properties of the raw materials strongly influence reactivity. It has been observed that the addition of water modifies these properties, enabling neutralization reactions to proceed. When a small amount of water is added to the raw powder, a thin film forms on the particle surface. This water layer induces acid–base reactions at the interface, accompanied by localized heat generation. This technique is gaining increasing attention as a novel soft-chemistry approach that bridges solution-based and solid-state methods. Acknowledgements This work was supported by JSPS KAKENHI (Grant-in-Aid for Scientific Research (B), Grant Number 22H01769).

S15 10th International Symposium on Additive Manufacturing and 3-D Printing Technologies

S15- Direct writing/ink jet printing technologies

Room: Ponce de Leon

Session Chairs: Paolo Colombo, University of Padova; Lisa Biasetto, University of Padova

8:50 AM

(ICACC-S15-010-2026) Additive manufacturing of continuous-fiber reinforced CMCs

A. De Marzi[1]; R. Giometti[1]; A. De Zanet[3]; A. Kumar[3]; G. Franchin[2]; P. Colombo*[2]

1. Università degli Studi di Padova, Department of Industrial Engineering, Italy
2. University of Padova, Industrial Engineering, Italy
3. Leonardo SpA, Innovation Hub - Materials Labs, Italy

Ceramic matrix composites (CMCs) have been developed for high-temperature and harsh corrosive environments, including ultra-high temperatures and extreme loading. High-strength fiber reinforcements in CMCs overcome ceramics' brittle behavior, preventing catastrophic failure under stress. Additive Manufacturing (AM) technologies enable complex geometries, such as lattice structures, lightweight components with ordered porosities, and customized parts. The combination of AM and CMCs is significant for industries needing materials with exceptional mechanical, thermal, and environmental performance to be formed into complex shapes. We fabricated continuous-reinforced ceramic matrix composite components via Direct Ink Writing, using carbon fibers and a preceramic polymer. Two different extrusion approaches have been developed, and the benefits and challenges of each will be discussed. The presence of fibers causes (in some cases) constrained matrix shrinkage and cracks formation during pyrolysis; therefore, some cycles of preceramic polymer infiltration and pyrolysis (PIP) were performed to compensate for these cracks and ensure structural integrity.

9:10 AM

(ICACC-S15-011-2026) 3D printed proton conducting ceramic membranes

A. Bartoletti*[1]; E. Mercadelli[1]; A. Gondolini[1]; A. Sanson[1]

1. ISSMC, Italy

This work introduces the key step necessary for the use of three-dimensional (3D) printing as a strategic route for the production of all-ceramic membranes for high-temperature hydrogen separation and membrane reactor applications. Dense composite membranes consisting of $BaCe_{0.65}Zr_{0.20}Y_{0.15}O_3$-δ and $Gd_{0.2}Ce_{0.8}O_2$-δ were fabricated through 3D microextrusion. A specifically engineered water-based ink was formulated and thoroughly characterized with respect to its thermal and rheological properties. Printing parameters, along with post-processing treatments, were systematically optimized to achieve planar, crack-free membranes. The as produced the 3D-printed membranes exhibited hydrogen permeabilities of 0.21 and 0.32 mL min–1 cm^{-2} at 750 °C under feed streams containing 50 % and 80 % H_2 in He, respectively. These permeation values rank among the highest reported to date for symmetric, all-ceramic membranes, underscoring the potential of additive manufacturing as a transformative technology for membrane-based hydrogen separation.

9:30 AM

(ICACC-S15-012-2026) High temperature latent heat thermal energy storage systems by direct ink writing technology

L. Biasetto*[1]; A. Stoppato[1]; E. Setten[1]; S. Shalby[1]

1. Universita degli Studi di Padova Dipartimento di Ingegneria Industriale, Italy

High-temperature (T > 500 °C) Latent Heat Thermal Energy Storage (LHTES) systems are a major challenge in the energy sector. Phase change materials (PCMs) must remain stable over many cycles, while reactions and diffusion through the encapsulation medium must be minimized to prevent degradation and leakage. A common example is hydrated salts encapsulated in steel for Concentrated Solar Power (CSP), steam generators, or waste-heat recovery. While low cost, this solution suffers from severe PCM degradation due to steel corrosion, leading to composition changes and reduced storage efficiency. Metallic alloys are now investigated as alternatives, offering a wide range of compositions and melting points. In this work, we propose a co-extrusion strategy to improve thermal energy density and capacity. A continuous PCM core is 3D-printed within a continuous ceramic shell, shaped into dense or porous structures depending on application needs. Direct Ink Writing (DIW) with highly loaded inks is employed, using a custom nozzle to co-extrude metallic core ($Al_{12}Si$) and ceramic shell (Al_2O_3) simultaneously. Heat capacity, microstructural analysis, and a preliminary Life Cycle Assessment (LCA) of the printed structures will be presented.

9:50 AM

(ICACC-S15-013-2026) Strategies for scaling aqueous ceramic material extrusion through temporal control

A. Gourley*[2]; C. Wyckoff[3]; J. Kaufman[3]; J. Hardin[1]; L. M. Rueschhoff[1]

1. Air Force Research Laboratory Materials & Manufacturing Directorate, USA
2. National Academies of Sciences Engineering and Medicine, USA
3. Aerovironment Inc, USA

While slurry-based material extrusion of high-performance ceramic and ceramic matrix composites has shown promise for high density parts relative to other additive manufacturing processes, the conflicting demands of ink flow during deposition and shape retention after extrusion hinder the fabrication of larger, more complex geometries. High solids loadings in aqueous inks exhibit complex, time-dependent flow behaviors compared to other more predictable inks. Although drying creates challenges for extrusion, the effective increase in solids loading improves part static properties, providing new strategies to address structural failure during fabrication. This work investigates the effects of temporal control during fabrication with an aqueous carbon-fiber reinforced silicon carbide (SiC) slurry to increase the scale of achievable parts. Drying tests revealed measurable slurry weight loss over time, allowing for estimations of effective solids loading. Experimental builds with varying print speeds demonstrated an increase in maximum achievable height before collapse, highlighting how material strength increased with drying time. Through the strategic control of drying behaviors and print speeds, tall and thin-walled ceramic structures exceeding 40 mm in height could be extruded, demonstrating a promising path toward fabricating larger-scale ceramic components via material extrusion.

10:30 AM

(ICACC-S15-014-2026) Analysis of mixing parameters on rheology and polymer stability in aqueous silicon carbide slurries

J. Feldbauer*[1]; C. L. Cramer[2]; D. Gilmer[3]; P. Snarr[4]; T. G. Aguirre[2]; B. L. Armstrong[5]; A. Townsend[3]

1. The University of Tennessee Knoxville Tickle College of Engineering, USA
2. Oak Ridge National Lab, Manufacturing Science Division, USA
3. The University of Tennessee Knoxville Tickle College of Engineering, Material Science and Engineering, USA
4. The University of Texas at Austin, USA
5. Oak Ridge National Lab, Material Science & Technology, USA

This work employs a Taguchi design of experiments framework to evaluate how mixing parameters influence the rheological properties and polymer stability of aqueous silicon carbide slurries. Using an L16 orthogonal array, the effects of mixing speed, mixing time, media amount, and container size were systematically studied for both planetary and roller mixing. Rheological measurements demonstrated that variations in shear intensity and media loading strongly impacted viscosity and yield strength, while container size influenced dispersion uniformity. Gel permeation chromatography (GPC) further revealed that high-shear and extended mixing promoted polymer chain scission, indicating a direct link between mixing energy and polymer particle interactions. By leveraging the Taguchi method, this study efficiently identified the dominant factors controlling slurry performance, reducing the experimental burden while providing insight into the balance between dispersion quality and polymer integrity. These findings establish a framework for optimizing slurry preparation strategies in ceramic additive manufacturing and other aqueous-based processing systems.

S15- AM of particulate and fiber reinforced composites

Room: Ponce de Leon
Session Chairs: Lisa Biasetto, University of Padova; Paolo Colombo, University of Padova

10:50 AM

(ICACC-S15-015-2026) Additive construction using concrete-Influences of composition, infill, and curing on mechanical properties

E. Faierson*[1]; B. Nelson[1]

1. Iowa State University, USA

Additive Construction (AC) technologies can provide many advantages over conventional concrete construction techniques. However, concrete mixes for use in AC applications require the mix to be pumpable, extrudable, and buildable, making the design of mixes more complex than those used in traditional concrete casting. This study explores some of the compositional limits that enable a given concrete mix to be usable in AC applications. Some mix components were utilized to mimic properties of indigenous materials that could be incorporated in concrete mixes when printing concrete in expeditionary environments. The ability to utilize materials available on-site for construction is significantly more economical than transporting them over long distances. Concrete beams were printed using various infill designs and with lengths up to seven feet using an industrial robot mounted on a linear rail. The beams were cured using several different techniques, and the flexural strength was subsequently evaluated. Compressive strength was also evaluated through removal of cores from other printed articles.

11:10 AM

(ICACC-S15-016-2026) Micro-architected lightweight Al-SiC metal matrix composite with 3D-printed SiC scaffold

M. Du*[1]; R. R. Kamath[1]; C. Zheng[1]; P. S. Chaugule[1]; N. Paulson[1]; A. C. Chuang[1]; D. Singh[1]; M. C. Messner[1]

1. Argonne National Laboratory, USA

Metal matrix composites (MMCs) reinforced with ceramic particles are promising to meet harsh-environment requirements in various applications such as aerospace and automotive. Traditional MMCs incorporate unstructured reinforcements with randomly distributed particles or fibers, leading to unstructured material properties. Therefore, there is a knowledge gap for design and manufacturing of micro-architected MMCs with tailored structures and properties. In this talk, we will present our work on design and manufacturing of micro-architected MMCs with optimized coefficient of thermal expansion (CTE) as an example. Structures of the ceramic scaffold structure and the infill metal matrix were first modeled to minimize isotropic CTE. Binder jetting additive manufacturing (AM) was then utilized to fabricate SiC unit cell parts. To improve the stability of the ceramic scaffold, various post-processing techniques were applied, including controlled heating treatment and pressureless aluminum infiltration with reinforced cooling. Upon fabrication of the Al-SiC unit cell, microstructure characterization with elemental analysis and X-ray crystallography confirmed the stability of the reinforcement phase, and CTE measurements showed enhanced stiffness properties. This work, enabled by multiphysics design and AM, will open up new opportunities for high-performance devices and products.

S17 Advanced Ceramic Materials and Processing for Photonics and Energy

S17- Multi- functional materials II

Room: Flagler C
Session Chair: Nicola Pinna, Humboldt-Universität zu Berlin

8:30 AM

(ICACC-S17-018-2026) Application of the finite difference time domain method to reveal novel photonic properties of ordered nanostructures (Invited)

O. K. Varghese*[1]; D. Waligo[1]; M. Paulose[2]

1. University of Houston, Department of Physics and Texas Center for Superconductivity, USA
2. University of Houston, Department of Physics, USA

The Finite Difference Time Domain (FDTD) method is emerging as an effective tool for modeling the optical properties of materials, especially nano and quantum structures. In this method, Maxwell's equations are discretized in time and space using the central difference approximation to find iterative solutions of electric and magnetic fields. It aids the designing of photonic devices, for example, energy conversion devices such as solar photovoltaic cells and photoelectrochemical fuel generation cells, with optimal materials characteristics for the highest device performance without implementing extensive experimentation. Nevertheless, this method has not yet been extensively applied to revealing the photonic properties of semiconductors. The mismatch between the simulated and experimental results is often a problem, especially when applied to nanostructures of semiconductors with a low absorption coefficient. We have discovered a key cause of this discrepancy and developed methodologies to minimize it. This presentation provides the details of the work.

9:00 AM

(ICACC-S17-009-2026) Surface-tailored nanomaterials for enzyme immobilization: hybrid, stable, and recyclable biocatalysts

C. Pontremoli*[1]; F. Careddu[1]; S. Rojas-Buzo[2]; N. Barbero[1]; F. C. Bonino[1]; C. Barolo[1]

1. Universita degli Studi di Torino, Department of Chemistry, Italy
2. Universitat Politecnica de Valencia, Spain

The transition toward sustainable chemical processes calls for biocatalysts capable of replacing conventional systems, which suffer from harsh conditions, leaching and limited reusability. Enzyme immobilization on nanostructured supports is a promising strategy to couple catalytic efficiency with improved stability and recyclability. Here, we reported two case studies. Lipase from Candida rugosa was immobilized onto hafnium-based metal–organic frameworks (MOFs) with tunable pore sizes. Surface functionalization with proline enhanced enzyme anchoring. The resulting bifunctional catalysts enabled a cascade conversion of 5-hydroxymethylfurfural into BHMF-diester, combining the MOF-catalyzed reduction with lipase-driven transesterification. A 57% yield was obtained, with the immobilized enzyme retaining activity over multiple cycles. In parallel, two engineered lytic polysaccharide monooxygenases (LPMOs), ScAA10C and LsAA9A, were immobilized on multi-walled carbon nanotubes and on mesoporous silica nanoparticles (MSN). Different spacers were used to modulate spatial constraints and optimize efficiency. Immobilized LPMOs preserved oxidase, peroxidase, and peroxygenase activities, showing greater resistance to oxidative stress. The use of MSN facilitated separation and recovery without compromising activity.

S17- Advanced and nanostructured materials for photo-voltaics and solar fuels I

Room: Flagler C
Session Chair: Rafik Naccache, Concordia University

9:20 AM

(ICACC-S17-010-2026) Advanced ceramic interfaces for small-molecule activation in hydrogen and ammonia photo-, electro- and piezo-catalysis (Invited)

T. Fischer[1]; S. Mathur*[1]

1. University of Cologne, Institute of Inorganic and Materials Chemistry, Germany

Moving from fossil fuel-based centralized energy supplies to intermittent renewable energy demand a diversification of how energy is converted, stored, and transported. Modular and decentralized production and utilization of energy carriers, such as hydrogen, is of key importance to address the increasing demand for renewable energies in all sectors. This presentation will highlight the synthesis and integration of nanostructured functional oxide ceramics in photo-, electro-, and piezo-catalytic activation of small molecules for hydrogen and ammonia production. By careful evaluation of interface reactions, the reduction of overpotentials in the oxygen evolution reaction (OER), polarization of small molecules during piezoelectric catalytic nitrogen reduction reaction (NRR) or an enhancement of nitrate reduction reaction (NO3RR) through magnetically ordered catalysts can be achieved. These examples highlight the need of a fundamental understanding of functional materials and their interfaces for their application in efficient energy conversion applications, to support the ongoing energy transition for a carbon-neutral future.

10:10 AM

(ICACC-S17-011-2026) Green processing of perovskite solar cells

T. Fischer*[1]; N. Heshmati[1]; S. Mathur[1]

1. University of Cologne, Institute of Inorganic and Materials Chemistry, Germany

Hybrid inorganic-organic perovskite solar cells have evolved into a competitive photovoltaic technology, recently surpassing polycrystalline silicon solar cells in laboratory settings, only after little more than a decade of R&D efforts. Due to the solution-based processing, low-cost manufacturing, and flexible device configurations are easily achievable, but their abiding limitations regarding long-term stability and formation of soluble toxic lead compounds still limit their widespread commercial application. The inks used in solution processing are a key factor in controlling the ecological footprint of device fabrication, as well as in enhancing coating efficiency and overall device performance. This presentation will summarize the application of protic ionic liquids (PILs) in perovskite solar cell fabrication and demonstrate the substitution of toxic solvent systems (DMF, NMP) with more eco-friendly alternatives to increase the ecological index of perovskite photovoltaic processing. Controlling solution dynamics also enables the fabrication of complex multi-cation hybrid perovskite compositions, which exhibit enhanced structural, compositional, and photophysical stability.

10:30 AM

(ICACC-S17-012-2026) Organic solar cells: Advanced nanoscale characterization towards biodegradable photovoltaics (Invited)

G. Fanchini*[1]

1. University of Western Ontario, Physics and Astronomy, Canada

The study of organic solar cells (OSCs) is intriguing from a fundamental point of view because of the short lifetime of excitons (strongly-correlated electron-hole pairs) in these devices. While the origin of short exciton lifetime is still open, it is now clear it is linked to strong electron-phonon coupling. The photoactive layers of OSCs is made by polymers, small organic molecules, or their combination. To date, photoconversion efficiencies approaching 20% have been reported for organic photovoltaics by modulating the exciton recombination processes, which allows for enhanced electron-hole separation. Our talk will review the photophysics of OSCs, with a focus on the contributions from our group in their characterization with advanced superresolution optical tools based on scanning probe microscopies. Finally, we will present our ongoing efforts towards biodegradable and green OSCs entirely fabricated from aqueous solutions and using poly[2-(3-thienyl)ethyloxy-4-butylsulfonate]-sodium (PTEBS, a water soluble organic polymer) as a photoactive material. These are among the best organic photovoltaics obtained to date from water-based solutions, which highlights the importance of advanced nanoscale characterization tools in designing novel organic photovoltaic architectures.

11:00 AM

(ICACC-S17-013-2026) Solution-processable coordination polymers as efficient catalysts for counter-electrodes in dye-sensitized solar cells (Invited)

S. Galliano*[1]; M. Franzini[1]; M. Raimondo[1]; K. Sasitharan[2]; G. Morritt[2]; G. Spinelli[1]; L. Cavinato[1]; M. Borri[3]; M. Zanetti[1]; B. Civalleri[1]; A. Reale[4]; M. Freitag[2]; C. Barolo[1]

1. Universita degli Studi di Torino, Department of Chemistry, Italy
2. Newcastle University, School of Natural and Environmental Science, United Kingdom
3. Martur Italy, Italy
4. Universita degli Studi di Roma Tor Vergata, Department of Electronic Engineering, Italy

Dye-sensitized solar cells (DSSCs) are an emerging photovoltaic technology that offers several advantages, including good performance under low and diffuse light, low production cost, and adaptability to flexible or transparent applications. DSSCs work through a photoelectrochemical system involving a photoanode, a dye, a redox electrolyte, and a counter-electrode (CE). Currently, the most effective CEs are based on platinum, PEDOT, or carbon materials, but they generally suffer from high costs, limited processability, and poor stability. The development of novel CEs is crucial to enhance DSSC performance and to integrate novel redox couples and dyes. In this contribution, we report the successful employment of coordination polymers (CPs) as counter electrodes in DSSCs. Both Cu- and Ni-ethenetetrathiolate-based polymers were developed and processed without additives to obtain thin film CP based CEs. When paired with various copper, cobalt, and iodine based redox electrolytes, the novel CEs achieved power conversion efficiencies exceeding 10% and comparable to benchmark platinum and PEDOT electrodes. To our knowledge, this is the first demonstration of a series of CPs, directly deposited on bare FTO, serving as efficient and stable CEs in DSSCs. This work establishes a foundation for further advancements and optimization of this promising class of materials.

11:30 AM

(ICACC-S17-020-2026) Synthesis of molecule-like metal-oxide clusters in ZnO nano-sponges (Invited)

G. Westin*[1]

1. Uppsala University, Sweden

Doped semiconductor oxides are of the highest importance for renewable energy conversion, water remediation and electronics. Crystal quality, size, connectivity, and surface structure along with the dopants electronic state, coordination and distribution are all determining the properties and are crucially dependent on the synthesis parameters. Here, synthesis and detailed characterisation Ln- and Al-doped ZnO nano-crystalline sponges is presented. The dopant atomic distribution and coordination within the h-ZnO lattice was studied with a wide range of techniques including: TG/DSC, XRD, XPS, IR- and Raman spectroscopy, EXAFS, SEM,(S)TEM/ED/DF/EELS/EDX/ePDF, and DFT. It was shown that the Ln- or Al-ions were present in the ZnO nano-crystals with much change of the hosting ZnO. The detailed structural knowledge help understanding optical and magnetic properties.

S18 Ultra-High Temperature Ceramics

S18- Response in extreme environments (irradiation, ultra-high temperature, etc.) I

Room: Coquina A

Session Chairs: Douglas Wolfe, Pennsylvania State University; Scott McCormack, University of California, Davis

8:30 AM

(ICACC-S18-011-2026) Eutectics observed in group (IV,V) psuedobinary transition metal diborides (Invited)

S. Ness[2]; A. N. Dorner[3]; W. Rosenberg[2]; P. Spencer[4]; G. Hilmas[3]; W. Fahrenholtz[3]; S. J. McCormack*[1]

1. University of California, Davis, Materials Science and Engineering, USA
2. University of California Davis, Chemical Engineering, USA
3. Missouri University of Science & Technology, Materials Science and Engineering, USA
4. The Spencer Group Inc, USA

This work presents direct experimental evidence of invariant eutectic reactions in all investigated psuedobinary (Group IV – Group V) transition metal diboride Systems [$(Ti,Nb)B_2$; $(Ti,Ta)B_2$; $(Zr,Nb)B_2$; $(Zr,Ta)B_2$; $(Hf,Nb)B_2$; $(Hf,Ta)B_2$]. Eutectic microstructures were achieved through laser heating and cooling from the melt using the environmental conical nozzle levitator (E-CNL) equipped with dual 400 W CO_2 and 500 W Yb lasers. In addition, the existence of a eutectic in the $(Zr,Ta)B_2$ psuedobinary system is further verified with oxide melt solution colorimetry (OMSC) measurements of

excess enthalpies. A preliminary updated phase diagram is presented for the (Zr,Ta)B_2 psuedobinary system. These results highlight that phase diagrams for all the group IV-V transition metal diborides need to be updated to reflect the observed eutectic reactions.

9:00 AM

(ICACC-S18-012-2026) Earth and mars hypersonic entry and ceramic thermal protection systems (Invited)

S. Mungiguerra*[1]; G. Corbi[1]; R. Costanzo[1]; D. De Prisco[1]; S. Cassese[1]; A. Cecere[1]; R. Savino[1]

1. Universita degli Studi di Napoli Federico II, Department of Industrial Engineering, Italy

Hypersonic flight and atmospheric entry into Earth or planetary atmospheres (e.g. Mars) are characterized by extremely aggressive aero-thermo-chemical environments, requiring high-performance materials for spacecraft thermal protection systems. The high energy levels also trigger non-equilibrium reactive gas conditions and exothermic recombination reactions of the atoms on the exposed surfaces. Ultra-High-Temperature Ceramics (UHTC) are considered a promising solution due to their high melting point, hardness, elastic modulus, good thermal conductivity, creep resistance and chemical stability, yet their applicability and response in different hypersonic environments has still to be completely investigated. This work presents a wide range of activities carried out at University of Naples Federico II in a supersonic plasma wind tunnel, in environments representative of Earth (N_2+O_2) and Mars (N_2+CO_2) atmospheric compositions, at total enthalpies up to 20 MJ/kg. Experimental techniques, including optical emission spectroscopy, coaxial thermocouples, non-intrusive infrared diagnostics (pyrometers and thermocameras), supported by Computational Fluid Dynamics simulations, were used for a complete characterization of the non-equilibrium aero-thermo-dynamics of the flow, of non-catalytic and fully catalytic heat loads, as well as the high-temperature response of UHTCs in representative hypersonic flight conditions.

9:30 AM

(ICACC-S18-013-2026) Loss of hardness anisotropy in tungsten carbide under irradiation (Invited)

A. Mullins[1]; K. Bakkar[1]; T. Zagyva[1]; J. Wade-Zhu[2]; M. T. Rigby-Bell[2]; S. A. Humphry-Baker*[1]

1. Imperial College London, Materials, United Kingdom
2. UKAEA, Materials Division, United Kingdom

Tungsten carbide is a candidate material for inboard shielding in future fusion reactors. These components will experience extreme neutron fluence and hence are expected to embrittle. However, no data exists on how the mechanical behaviour of different crystallographic orientations of WC respond to irradiation. We have addressed this by irradiating coarse WC grains of known orientations with 15 MeV tungsten self-ions and subjecting them to nanoindentation. The basal plane hardness in the unirradiated state was found to be 30% higher than the prismatic plane. These results agree with literature observations and theory suggesting that the prismatic planes are the preferred slip system. Our novel finding is that the hardening rate of the basal plane after irradiation was significantly less than the prismatic plane, resulting in a complete loss of hardness anisotropy at very low doses (0.13 dpa). The hardening of both orientations continued to increase significantly between 0.13 and 1.3 dpa but then saturated at higher doses. Decreased irradiation temperature also tended to enhance hardening, with indentation cracking occurring in samples irradiated at 100 °C, which was absent at 250 and 400 °C. Our findings may inform the microstructural design of WC based ceramics for extreme radiation environments.

10:20 AM

(ICACC-S18-014-2026) Plasmonic resonance of refractory high entropy carbides and carbonitrides synthesize via Field Assisted Sintering Technology (FAST) (Invited)

D. E. Wolfe*[1]; L. Wilson[1]; R. Koennecker[1]; A. Marin[1]; S. Divilov[2]; H. Eckert[2]; X. Campilongo[2]; S. Curtarolo[3]

1. Pennsylvania State University, USA
2. Duke University, USA
3. Duke University, Materials Science, Electrical Engineering and Physics, USA

Multifunctional materials with tunable and thermally stable plasmonic properties are essential for optical, telecommunication, hypersonic, and ultra high temperature applications. Plasmonic high entropy carbides (PHECs) exhibit superior thermal, chemical, and mechanical properties while demonstrating strong plasmonic resonance in the near infrared to visible wavelength range. Current research efforts have demonstrated that the strength and wavelength of this response is highly tunable by explicitly tailoring the composition of the high-entropy system. Multiple characterization techniques have been explored for measuring plasmonic resonance, including reflection electron energy loss spectroscopy (REELS) and spectroscopic ellipsometry (SE). Through these techniques, it has been observed that at least 12 different PHECs exhibit plasmonic resonance at temperatures up to 1000 °C. These PHECs show discernible plasmonic behavior at various energies and intensities based on the composition, demonstrating considerable versatility for different applications. Furthermore, these properties remain largely unchanged with increasing temperature, indicating superior high-temperature stability over traditional plasmonic systems. These discoveries pave the way for creating multifunctional and tunable optical materials for extreme environment applications.

10:50 AM

(ICACC-S18-015-2026) Unraveling the oxidation characteristics of binary, ternary, and quaternary transition metal carbides

S. Richter[2]; D. Danner[2]; A. Hirle[2]; T. Wojcik[1]; E. Ntemou[3]; D. Primetzhofer[3]; K. Boebel[5]; S. Kolozsvári[4]; P. Polcik[4]; J. Ramm[5]; H. Riedl*[1]

1. Technische Universitat Wien, Institute of Materials Science and Technology, Austria
2. TU Wien CDL-SEC, Austria
3. Uppsala Universitet, Department of Physics and Astronomy, Uppsala University, Sweden
4. Plansee Composite Materials GmbH, Germany
5. Oerlikon Surface Solutions AG, Oerlikon Balzers, Switzerland

This study explores transition metal carbides (TMCs) oxidation properties from groups IV to VI, specifically titanium, zirconium, hafnium, tantalum, and tungsten carbide. These materials are renowned for their exceptional thermal stability and mechanical strength, making them ideal for high-temperature aerospace, automotive, and machining applications. However, TMCs face significant challenges due to their poor oxidation resistance. To address this issue, we use a combinatorial physical vapor deposition (PVD) approach to investigate various alloying strategies, particularly focusing on strong oxide formers such as silicon and silicon-based materials. This research aims to create ternary and quaternary TMCs enhancing their performance in high-temperature, oxygen-rich environments. We employ Density Functional Theory (DFT) to provide a theoretical foundation for the phase formation of these novel film materials, which we will subsequently validate through structural analysis of the sputtered deposited thin film materials. These experimentally synthesized ternary and quaternary material libraries are used to assess the oxidation resistance up to 1500°C. We will analyze the scale formations using advanced characterization techniques such as HR-TEM and APT. This comprehensive material screening approach aims to improve and expand the applicability of TMCs under extreme conditions.

11:10 AM

(ICACC-S18-016-2026) Synthesis of binderless WC with brick-and-mortar structure for enhanced toughness and damage tolerance at high temperatures

B. M. Bulteel*[1]; J. Wade-Zhu[3]; F. Bouville[2]; S. A. Humphry-Baker[1]

1. Imperial College London, Materials, United Kingdom
2. ETH Zürich, Complex Materials, United Kingdom
3. UKAEA, Materials Division, United Kingdom

Tungsten carbide ceramics are used in extreme environments ranging from cutting tools to shielding in nuclear reactors which all require mechanical reliability at high temperature. To raise the fracture toughness of WC a metallic binding phase is commonly used, although this limits its operation temperature. Here we seek to develop an alternative toughening approach through the development of an anisotropic brick and mortar structure to enhance crack deflection and enable thermomechanical anisotropy. In this work, WC bricks with high aspect ratio were fabricated using molten salt synthesis. The molten salt environment, with its high diffusion and dissolution rate, promotes the formation of anisotropic particles from the crystal structure of WC and differences in crystallographic planes growth rate. We used glucose as an environmentally friendly carbon source and tungsten trioxide as a tungsten source. A detailed study of the phase formation sequence was obtained through thermogravimetric analysis coupled with ex situ X-ray diffraction. We investigated the impact of temperature, dwell time, milling methods, salt type and composition to find the conditions that favour the growth of anisotropic WC bricks. The optimum conditions resulted from a trade-off between increased diffusion from the molten salt and increased salt evaporation at high temperatures.

S19 Molecular-level Processing and Chemical Engineering of Functional Materials

S19- New processing methods, 3D printing, and knowledge-driven processing

Room: Ballroom 1 -2
Session Chair: Gurpreet Singh, Kansas State University

8:30 AM

(ICACC-S19-009-2026) Morphology study of electrospun cellulose acetate fibers using various solvents and concentrations (Invited)

W. Alkaron[1]; K. Balazsi[1]; C. Balazsi*[1]

1. HUN-REN Energiatudomanyi Kutatokozpont, Hungary

This research investigates the application of electrospinning in the production of CA fibers and examines how two critical parameters influence the morphology and dimensions of the resulting CA products during the spinning process. These factors include the solvent system employed and the concentration of the solution. By analyzing these parameters, the research aims to elucidate their effects on the characteristics of the resultant CA materials following the spinning process. The study employed acetone as a single-solvent system, while acetone–acetic acid (2:1) and N,N-dimethylformamide (DMF) (2:1) were used as mixed-solvent systems at room temperature. For the single-solvent approach, CA was dissolved in acetone at concentrations of (5, 10, 11, 13, and 15 wt%). In the co-solvent systems, CA was dissolved in acetone–DMF (2:1) at concentrations of (5, 10, 15, 16, 18, and 20 wt%), and in acetone-acetic acid (2:1) at concentrations of (5, 10, 15, and 20 wt%). Although DMF and acetic acid could dissolve CA to form clear solutions (at 5 wt%), electrospinning primarily resulted in discrete beads. In contrast, electrospinning CA in acetone produced short fibers. The optimal results, yielding continuous fibers without beading, were achieved with 10 wt% CA in acetone, 15 wt% CA in acetone/acetic acid (2:1), and 18 wt% CA in acetone/DMF (2:1).

9:00 AM

(ICACC-S19-010-2026) 3D-printed polymer-derived ceramics as platforms for catalytic processes (Invited) *WITHDRAWN*

M. Obeid[1]; C. Youssef[1]; A. Bayout[1]; C. Salameh*[1]

1. Institut Européen des Membranes, France

Polymer-derived ceramics (PDCs) have emerged as a versatile platform to design robust, architectured supports for catalytic applications under demanding conditions. By exploiting their processability at the polymer stage, advanced additive manufacturing routes—particularly 3D printing—enable the fabrication of monolithic structures with hierarchical porosity and tailored flow architectures. In this lecture, I will present recent advances where such ceramic frameworks were combined with catalytically active phases to address two pressing challenges: CO_2 valorization and water depollution. In the first case, Ni-based catalysts integrated into 3D-printed SiOC monoliths achieved efficient CO_2 methanation with remarkable activity, selectivity, and long-term stability, highlighting the synergy between promoter engineering and structural design. In the second, SiOC lattices served as durable scaffolds for immobilizing semiconductor photocatalysts, enabling continuous-flow degradation of organic pollutants with improved mass transport and reusability. Together, these studies demonstrate how the convergence of PDC chemistry and additive manufacturing opens new opportunities for sustainable catalytic technologies.

9:30 AM

(ICACC-S19-011-2026) Nanoparticle core size effects on rheology, ceramic yield, and thermal stability in preceramic polymer-grafted nanoparticle-based materials

G. Germanton*[1]; P. Gnanasekar[1]; J. Ponder[2]; P. Polisetty[1]; D. Hallinan[1]; M. Dickerson[2]; S. Ramakrishnan[1]

1. Florida State University, FAMU-FSU COLLEGE OF ENGINEERING, USA
2. Air Force Research Laboratory, USA

Preceramic polymer-grafted nanoparticles (PCPGNPs) combine the tunable chemistry of grafted polymers with the structural and thermal robustness of inorganic cores, enabling improved processability and ceramic yield in polymer-derived ceramics. By adjusting polymer chemistry and particle size, rheological and thermal properties can be tailored for specific applications. While prior studies examined polymer chemistry and core type, the influence of core size remains less understood. Here, silica PCPGNPs with identical poly(1,1-dimethylpropylsilane) coronas were synthesized and characterized by light scattering, microscopy, spectroscopy, and thermal analysis. Rheology showed that smaller cores formed stronger networks, yielding a ~100× higher storage modulus, ~250× higher yield stress, and ~300× higher viscosity with enhanced shear thinning, supporting their suitability for extrusion-based additive manufacturing. Thermogravimetric analysis revealed higher char yields (32.7 wt%) for smaller cores due to greater surface area, grafting density, and confinement effects, with ceramic yields increasing to 50.4 wt% after thermal treatment. XRD confirmed amorphous-to-β-SiC transformation across all sizes, highlighting core size as a key parameter for optimizing printability and ceramic conversion in preceramic inks.

S19- Chemically processed nanostructures and on-surface nanochemistry

Room: Ballroom 1 -2
Session Chairs: Murilo Amaral, Universidade Estadual de Campinas; Arijit Roy, Kansas State University

10:10 AM

(ICACC-S19-013-2026) Porous SiOC(H) as drug carriers in vaginal composite films (Invited)

S. Gómez-Peral[1]; F. Notario[2]; A. Tamayo*[1]

1. Institute of Ceramics and Glass, CSIC, Spain
2. Universidad Complutense de Madrid, Spain

Sustained delivery of antiretroviral agents is emerging as one of the most effective strategies to prevent the HIV virus from being sexually transmitted. Bimodal micro-mesoporous silicon oxycarbide glasses have been synthesized from preceramic hybrids and subsequently pyrolyzed to obtain amorphous materials with carbon atoms covalently bound to the silicon atoms creating an interconnected structure which give them distinctive properties, like high biocompatibility, tailorable porosity, large surface area and remarkable chemical stability, together with an easily modificable surface. The porous structure enables the incorporation of antiretroviral drugs, such as Acyclovir and Tenofovir, and their controlled release is modulated because of the surface functionalization with organosilane-type molecules and hydrogen-bond acceptors. The obtained particles are characterized by SEM, IR spectroscopy, N_2 Adsorption/Desorption, and Hg Porosimetry. In addition, the release kinetics of the antiretroviral drugs are studied in simulated vaginal fluid. The overall characterization revealed a bimodal porosity ranging from 5 nm to 50-100 nm and a high BET surface area, which enables a large drug-loading capacity. Drug release profiles adjust to Korsmeyer-Peppas model in composite polymeric gels containing the particles loaded with the drugs whereas a concentration depend mechanism takes place in the absence of the SiOC(H) particles.

S19- Molecular precursor approaches for vapor-phase synthesis (ALD, CVD) of materials

Room: Ballroom 1 -2
Session Chairs: Murilo Amaral, Universidade Estadual de Campinas; Arijit Roy, Kansas State University

10:40 AM

(ICACC-S19-014-2026) Preparation and characterization of polymer-derived HfOC/SiOC ceramic composite powders and fibermats

A. Roy*[1]; G. Singh[1]

1. Kansas State University, Mechanical and Nuclear Engineering, USA

This work outlines the synthesis of HfOC/SiOC ceramic composites in powder and fibermat forms, fabricated via a polymer-pyrolysis route that merges 1,3,5,7-tetramethyl, 1,3,5,7-tetravinyl cyclotetrasiloxane (4-TTCS) with a commercial HfC precursor in a 1:1 mass ratio. The HfC precursor was initially heated to 70°C to remove moisture, followed by blending with 4-TTCS and thermal crosslinking in the 160–400°C range. Pyrolysis was conducted at 800, 1000, and 1200°C under argon. Detailed analysis was performed using electron microscopy, X-ray diffraction, and various spectroscopies to investigate phase formation, morphology, and molecular transformation. Oxidation testing at 800°C for fibermats pyrolyzed at 1000 °C demonstrated improved structural integrity compared to the carbon-rich SiOC fibermat and the complete burnout observed for neat carbon fibermats.

S20: Golden Jubilee- Engineered Ceramics for Achieving Net-Zero Carbon Emissions

S20- New and innovative strategies and technologies for sustainable and self-sufficient solutions

Room: Coquina D
Session Chair: Palani Balaya, National University of Singapore

8:30 AM

(ICACC-S20-033-2026) Swords to plowshares: Unique nanoporous hollow glass microspheres open new opportunities in security, energy, environmental remediation and medicine (Invited)

G. Wicks*[1]

1. Applied Research Center, USA

Tiny Bubbles or Porous Wall Hollow Glass Microspheres (PWHGMs) are examples of a multiuse technology, involving tiny hollow glass micro-balloons about 1/3 the diameter of a human hair, having diameters from a few to 100 microns with outer shells about 1-2 microns thick. The most unique feature of PWHGMs is a continuous, through-wall shell nano-porosity induced via phase separation and controlled on a scale of 100 to 1,000 Angstroms. The technology was originally developed for nuclear applications at the Savannah River National Laboratory and now is being further advanced and tailored for new uses in other fields and disciplines. Among the interesting initiatives of tailored PWHGMs are in medicine (ex. drug delivery platforms, contrast agents, tissue augmentation, laryngeal use), security (ex. non-proliferation, anti-counterfeiting), energy (ex. hydrogen storage, batteries), and environmental remediation (ex. CO_2 sequestration).

9:00 AM

(ICACC-S20-009-2026) Experimental race to detect heat transfer mediated by surface phonon polaritons (Invited)

S. Shin*[1]

1. National University of Singapore, Department of Mechanical Engineering, Singapore

Controlling heat flow at the nanoscale is essential for applications ranging from energy harvesting to microelectronic thermal management. However, conventional mechanisms, conduction and radiation, offer limited tunability. Recent advances in thermo-photonic materials have opened new possibilities to manipulate heat transport using surface phonon polaritons (SPhPs), quasiparticles arising from strong coupling between mid-infrared photons and optical phonons in polar dielectrics. Here, we present experimental efforts to explore and quantify SPhP-mediated heat transfer in both radiative and conductive regimes. First, we demonstrate highly spectrally selective thermal emission from designed nano-emitters, enabled by the coherence and narrowband nature of SPhP modes. This behavior contrasts sharply with the incandescent spectrum predicted by classical theory, representing a new paradigm in far-field thermal emission control. Second, we present evidence of quasi-ballistic heat conduction along surfaces, guided by SPhPs. Unlike traditional phonons, these hybrid modes support directional energy flow that is dispersive in radiative origin yet spatially confined and surface-bound. This work represents a significant step in the experimental race to detect and SPhP-mediated heat transfer, with implications for the design of next-generation thermal management.

9:30 AM

(ICACC-S20-010-2026) Strategies for advanced cathode and anode materials in zinc-ion batteries (Invited)

S. Mhin*[1]

1. Dongguk University, Energy and Materials Engineering, Republic of Korea

Aqueous zinc-ion batteries (AZIBs) are considered promising alternatives to lithium-ion batteries due to their intrinsic safety, low cost, and environmental compatibility. However, their long-term performance is limited by cathode dissolution, Zn dendrite formation, and electrolyte instability. To address these issues, we developed a multi-component material strategy targeting the cathode, anode, and electrolyte. Na-preintercalated vanadium oxide was synthesized to stabilize the layered framework and enable reversible Zn^{2+} intercalation. In situ SAXS analysis confirmed that embedded Na ions serve as structural pillars, mitigating irreversible phase transitions. For the anode, functional coatings such as Al_2O_3 and MoS_2 were applied to suppress hydrogen evolution and dendrite growth, ensuring stable Zn plating/stripping. Additionally, the conventional liquid electrolyte and separator were replaced with a PAN-based hydrogel matrix infused with Zn^{2+}-rich aqueous electrolyte. This quasi-solid-state system enhances ion transport and interfacial contact, leading to improved cycling stability. Our results offer practical guidelines for designing durable AZIBs suitable for grid-scale energy storage.

10:20 AM

(ICACC-S20-011-2026) Defect and morphology engineering in nanomaterials for efficient photocatalysis (Invited)

E. Moretti*[1]

1. Ca' Foscari University of Venice, Department of Molecular Sciences and Nanosystems, Italy

Nowadays, one of the main technological challenges that we are facing is the ability to provide a sustainable supply of clean energy and, among all renewable sources, solar energy displays the greatest potential. Recently, the development of novel synthetic strategies has led to the preparation of nanostructured materials displaying unique properties compared to the bulk counterpart systems, with controlled and tunable morphologies able to enhance the activity and selectivity of a catalytic process. In particular, nanostructured materials synthesized via the bottom–up approach present an opportunity for future generation manufacturing of devices. Moreover, defect engineering in photocatalytic materials has proven to be a versatile approach to manipulating their behavior. This talk will focus on the importance of tuning the morphological and defective features of a catalyst as a strategy to improve the photocatalytic activity, focusing on how rationally designing inorganic materials at the nanoscale can lead to morphologies and structures suitable to enhance the catalytic performance of industrially and environmentally important processes. The talk will discuss some environmental applications that can be addressed by multi-component oxide systems, highlighting their structure-reactivity relationship. Photocatalytic drugs degradation will be presented as a successful case history.

S20- Multifunctional Ceramics for healthcare and biomedical applications

Room: Coquina D
Session Chair: Michael Halbig, NASA Glenn Research Center

10:50 AM

(ICACC-S20-013-2026) Sustainable antimicrobial composite coatings for air filters (Invited)

C. Balagna*[1]; A. Luceri[2]; F. Gattucci[2]; M. Ferraris[1]

1. Politecnico di Torino, Dept. Applied Science and Technology, Italy
2. Politecnico di Torino, DISAT, Italy

In the context of sustainable materials for health and environmental protection, we present nanostructured glass/ceramic coatings embedding silver nanoparticles, developed for air filtration systems. These coatings exhibit strong antiviral and antimicrobial properties, preventing the spread of pathogens such as bacteria, fungi, and airborne viruses, including SARS-CoV-2. Two environmentally friendly deposition techniques were explored: co-sputtering and ceramic derived polymers. The co-sputtering process enables the formation of thin, homogeneous composite coatings with silver nanoclusters embedded in SiO_2 or ZrO_2 matrices. This configuration ensures a controlled release of silver ions and long-term efficacy, even after repeated thermal sterilization. The technique is versatile, scalable and compatible with various substrates including filters and membranes. Pre-ceramic polymeric precursors offer additional advantages, such as low-temperature conversion to ceramic materials and minimal waste generation, further supporting energy-efficient manufacturing. Developed within the EU-funded NANOBLOC project, these coatings aim to improve indoor air quality, reduce secondary contamination, and promote the reuse of air filtration systems. This work highlights the potential of engineered composite as functional, sustainable solutions that contribute to global health and align with long-term goals for sustainability.

15th Global Young Investigator Forum on Sustainability

15th GYIF- Green Chemistry and Sustainable Synthesis Methods

Room: Ballroom 5
Session Chairs: Minh Chu Ngo, National Institute of Advanced Industrial Science and Technology (AIST); Yue Zhou, Missouri University of Science & Technology

1:30 PM

(ICACC-GYIF-014-2026) Next-generation metal oxide/carbon composite catalysts via sustainable mechanochemical synthesis for advanced water purification (Invited)

K. Kato*[1]

1. Gifu Daigaku, Japan

Sustainable access to clean water is among the most urgent challenges. Here, I present a simple mechanochemical process that converts common metal oxide powders and plastics into multifunctional composite catalysts—without using hazardous gases, high temperatures, or complex chemical treatments. This technology addresses critical limitations of current light-driven purification methods: its light absorption across a broad solar spectrum (UV to near-infrared) enables efficient photothermal conversion and accelerates degradation of dye pollutants by three orders of magnitude compared to conventional materials, even under visible and near-infrared light. The metal oxide/carbon structure promotes effective charge separation, while the synergy of photocatalysis and acid catalysis ensures reliable degradation of persistent pollutants, even without light. Additionally, the activated carbon byproduct

functions as both a strong acid catalyst and a heavy metal adsorbent, removing more than 90% of toxic metals (including Pb, As, and Sn). Furthermore, this approach integrates advanced materials science with sustainable manufacturing by upcycling plastic waste into high-performance catalysts for continuous water purification—offering a scalable solution aligned with the UN Sustainable Development Goals for clean water and responsible consumption.

2:00 PM

(ICACC-GYIF-015-2026) Novel fabrication process for bioactive phosphate glasses without heat treatment (Invited)

S. Lee*[1]

1. National Institute of Advanced Industrial Science and Technology (AIST), Japan

Inorganic ions can stimulate cellular activities such as adhesion, proliferation, and differentiation when present at appropriate concentrations. However, excessive amounts of inorganic ions may inhibit cell functions. Our research group has focused on bioactive phosphate glasses that control the release of inorganic ions by incorporating intermediates such as TiO_2, Nb_2O_5, and Ta_2O_5. Recently, our group successfully synthesized bioactive phosphate glasses using a liquid-phase method at room temperature. Raman spectra of the $CaO-P_2O_5-TiO_2/Nb_2O_5$ glasses (PIG-Ti/Nb) exhibited peaks corresponding to ortho- and pyro-phosphate, as well as the P–O–Ti/Nb bond. The ^{31}P MAS-NMR spectra of PIG-Ti/Nb showed peaks in the ortho- and pyro-phosphate regions, extending into the metaphosphate region. However, peaks corresponding to metaphosphate were not observed in the Raman spectra. These results indicate that the glasses contain a chain-like structure $(-O-P-O-P-O-Ti/Nb-O-)_n$, formed by pyrophosphate units bridged with TiO_x/NbO_y (denoted as Q_P^1-Ti/Nb). This Q_P^1–Ti/Nb chain structure is novel in phosphate glasses and has not been reported in conventional melt-quench-derived glasses. The liquid-phase method developed this work for preparing phosphate invert glasses offers a promising approach for biomedical applications, with the potential to regulate ion release through modifications of the glass network structure.

2:30 PM

(ICACC-GYIF-016-2026) Sustainable synthesis of compositionally complex Ultra-High Temperature Ceramics (Invited)

D. Gilmer*[1]; R. Walker[1]; J. Fischer[1]

1. The University of Tennessee Knoxville Tickle College of Engineering, Material Science and Engineering, USA

Compositionally complex ceramics (CCCs), also known as high-entropy ceramics, have emerged as a transformative class of materials engineered for use in extreme environments. These materials consist of multi-element species, making them highly tunable compared to binary ceramics, enabling precise control over their structural and functional properties. The deliberate inclusion of multiple elements introduces a high degree of chemical disorder and lattice distortion at the atomic level, enabling unique combinations of properties such as high hardness, thermal stability, corrosion resistance, and tolerance to irradiation. A unique challenge for these materials is that they can be energy intensive and difficult to synthesize and densify. The research presented here aims to address these challenges through the use of liquid precursors, such as preceramic polymers, to synthesize Ultra-High Temperature Ceramics (UHTCs) from sustainable precursors to form CCC UHTCs with tailored properties for extreme conditions.

15th GYIF- Thermo-Mechanical Behavior of Ceramics and Composites I

Room: Ballroom 5
Session Chairs: Dong Liu, University of Oxford; Kunihiko Kato, Gifu Daigaku

3:20 PM

(ICACC-GYIF-017-2026) Evolution of strength-limiting defects from heterogeneities during sintering of high-purity submicron alumina (Invited)

G. Okuma*[1]

1. Busshitsu Zairyo Kenkyu Kiko, Japan

Strength-limiting defects in ceramics have been found to originate from large-scale inhomogeneities, such as agglomerates and aggregates present in the initial powder, and evolve during the sintering process. In this study, synchrotron X-ray multiscale tomography, incorporating both micro-CT and nano-CT, was employed to investigate the development of such defects originating from transition alumina aggregates within a high-purity submicron α-alumina powder. These aggregates transformed during sintering, undergoing particle rearrangement and coarsening via surface diffusion, which led to the formation of complex pores composed of interconnected pore channels. Due to constraints imposed by the surrounding matrix, circumferential cracks partially formed along the interfaces between these complex pores and the dense matrix. Fractographic analysis of fractured bending specimens revealed that the fracture origins corresponded to these complex pores. Further fracture mechanics analysis demonstrated that the observed mechanical strength could be explained using both an elliptical crack model and a pore-crack model.

3:50 PM

(ICACC-GYIF-018-2026) Peridynamic modeling of surface degradation from lunar plume-surface interactions

A. M. Howard*[1]; U. Can[1]; B. Alicioglu[1]; K. P. Wilding[3]; K. Lorenzo[3]; A. Hatfield[2]; I. Guven[1]; V. L. Wiesner[2]; S. Prameela[3]; C. Wohl[2]

1. Virginia Commonwealth University, Mechanical and Nuclear, USA
2. NASA Langley Research Center, Advanced Materials Processing Branch, USA
3. The University of Utah John and Marcia Price College of Engineering, Materials Science and Engineering, USA

This study investigates the surface degradation of metallic and ceramic-coated materials subjected to high-velocity impacts from lunar regolith particles generated by plume-surface interactions (PSI) using the peridynamics (PD) framework. Lunar regolith is highly abrasive, angular, and electrostatically charged, causing severe erosion and potential material failure during surface operations. Apollo program observations revealed PSI effects caused structural damage to nearby hardware, including Surveyor III. In this study, spherical and irregular lunar regolith particle geometries, obtained from CT scans and 1-100 μm in diameter, are converted to PD grids and modeled as brittle materials. Metallic targets are represented with the Johnson-Cook model while ceramic protective coatings, such as alumina, are modeled using the Johnson-Holmquist 2 (JH-2) ceramic model. Low-to-moderate PSI-induced regolith particle speeds are studied. The PD framework, which calculates forces and motion from long-range interactions, simulates coating penetration and degradation patterns. Preliminary results show uncoated alloys experience greater plastic deformation at higher velocities, while coatings reduce substrate damage. Irregular particles generate higher localized stresses than spherical. Future work will present multi-particle erosion, evaluate additional coatings, and extend the dataset of irregular particles.

4:10 PM

(ICACC-GYIF-019-2026) High-throughput laser-induced particle impact testing for erosion assessment of ceramic-coated substrates in simulated plume–surface conditions

K. P. Wilding*[1]; K. Lorenzo[4]; A. M. Howard[2]; I. Guven[2]; V. L. Wiesner[3]; S. Prameela[1]

1. The University of Utah John and Marcia Price College of Engineering, Materials Science and Engineering, USA
2. Virginia Commonwealth University, Mechanical and Nuclear, USA
3. NASA Langley Research Center, Advanced Materials and Processing Branch, USA
4. The University of Utah John and Marcia Price College of Engineering, Mechanical Engineering, USA

We present a novel high-throughput laser-induced particle impact testing (LIPIT) platform designed to evaluate the erosion resistance and durability of advanced alloys and ceramic coatings under extreme particulate impact conditions. The system launches single lunar regolith simulant particles at controlled velocities and substrate temperatures—capturing impact at nanosecond timescales with ultrafast imaging—to replicate plume–surface environments encountered during lunar landings. Ceramic-coated metallic substrates are tested at velocities from tens to hundreds of meters per second across a wide thermal range representative of lunar extremes. This testing isolates coating performance thresholds where response shifts from elastic rebound to severe material removal via plastic deformation, spallation, and particle adhesion. Post-impact profilometry and scanning electron microscopy reveal microscale damage mechanisms including microcracking, interfacial failure, and erosion-induced substrate exposure. These findings directly inform coating designs that withstand extreme particulate erosion, enabling dust-tolerant, durable protection for spacecraft and planetary exploration hardware.

S1 Mechanical Behavior and Performance of Ceramics & Composites

S1- Design, reliability and life prediction modeling of materials, devices and components

Room: Coquina E
Session Chair: Monica Ferraris, Politecnico di Torino

1:30 PM

(ICACC-S1-018-2026) Lifetime of SiC filaments and tows under tensile stress and oxidation: Experiments and interpretative models (Invited)

S. Mazerat[1]; R. Pailler[2]; G. L. Vignoles*[1]

1. University Bordeaux, LCTS - Lab for ThermStructural Composites, France
2. French National Centre for Scientific Research, LCTS, France

A key feature in the performance of SiC-fiber reinforced CMCs is the resistance of the fibers to simultaneous exposure to mechanical stress and oxidation. This presentation will summarize a series of studies designed at quantifying the life time of SiC fibers. Experiments were conducted on a specific bench designed to record time to failure on filament tows, with 1st-gen fibers: Nicalon NL207 and Tyranno Grade S and 3rd-gen fibers: Hi-Nicalon S. SEM has been used to provide further useful information. Oxidation kinetics have also been determined. We have developed a model aimed at predicting the fibers lifetimes which incorporates two main phenomena: (i) slow crack growth (SCG) and (ii) fiber oxidation. The difficulty in deriving the model equations is that these phenomena interact between themselves, ie. oxidation provokes a degradation of the fibers and a reduction of the load-bearing effective section, hence accelerating SCG. We also extended the model to include the effect of fibers slack resulting from almost unavoidable initial misalignments. With it, it is possible to relate single-filament data and bundle data. The model yields very satisfactory lifetime predictions, underlining two regimes: one is SCG-dominated at high stresses and the other is oxidation-dominated at lower stresses. The temperature has an important influence on the transition between both.

2:00 PM

(ICACC-S1-019-2026) International standards for properties and performance of advanced ceramics – ASTM Commitee C28 - 40 Years of technical rigor and high quality (Invited)

M. G. Jenkins*[1]; A. Horner[5]; J. Salem[2]; G. D. Quinn[3]; T. Thornton[4]; J. Westbrook[6]

1. Bothell Engineering and Science Technologies, USA
2. NASA Glenn Research Center, Materials and Structures, USA
3. National Institute of Standards and technology, Materials Measuremenet Sciences Division, USA
4. Micromeritics Instrument Corporation, USA
5. Scalar Scientific LLC, USA
6. Corning Incorporated, USA

Mechanical and physical properties/performance of brittle bodies (e.g., advanced ceramics and glasses) can be difficult to measure correctly unless the proper techniques are used. For four decades, ASTM Committee C28 on Advanced Ceramics, has developed numerous full-consensus standards (e.g., test methods, practices, guides, terminology) to measure various properties and performance of a monolithic and composite ceramics and coatings that, in some cases, may be applicable to glasses. These standards give the "what, how, how not, why, why not, etc." for many mechanical, physical, thermal, properties and performance of advanced ceramics. Use of these standards provides accurate, reliable, repeatable and complete data. Involvement in ASTM Committee C28 has included users, producers, researchers, designers, academicians, etc. who write, continually update, and validate through round robin test programmes, more than 50 standards in the 40 years since the Committee's inception in 1986. Included in this paper is a pictogram of the ASTM Committee C28 standards and how to obtain them. A listing of other ASTM committees of interest is included. In addition, some examples of the tangible benefits of standards for advanced ceramics are employed to demonstrate their practical application.

2:30 PM

(ICACC-S1-020-2026) Numerical prediction of temperature-dependent strength scatter in alumina

T. Maeda*[1]; T. Osada[2]; S. Ozaki[3]

1. Yokohama National University, Graduate School of Engineering Science, Japan
2. National Institute for Materials Science, Research Center for Structural Materials, Japan
3. Yokohama National University, Faculty of Engineering, Japan

The strength of ceramic components exhibits significant scatter due to their brittleness and the heterogeneity of their microstructural features. Moreover, it shows a pronounced temperature dependence, generally decreasing with increasing temperature. Therefore, strength properties obtained at room temperature (RT) cannot be directly applied to the strength design of components intended for use at elevated temperatures. In this study, a numerical analysis model was proposed to predict the strength scatter at arbitrary test temperatures (RT~1,000 °C) based on microstructural observation data (pore size, pore aspect ratio, and grain size). Specifically, the prediction method previously developed by the authors for strength scatter at RT was extended by incorporating the temperature dependence of material parameters. To validate the proposed model, the scatter of three-point bending strength was predicted for alumina at 200, 400, 600, 800, and 1,000 °C using microstructural observation data. The predicted results showed good agreement with both the experimentally observed temperature dependence of strength and the strength scatter at each test temperature. This presentation is based on results obtained from a project, JPNP22005, commissioned by the New Energy and Industrial Technology Development Organization (NEDO).

3:10 PM

(ICACC-S1-021-2026) Liquid silicon infiltration in porous C/SiC: pore-scale and statistical effects on kinetics and residual stress with multiphysics modeling

H. D. Tran*[1]; F. Sultana[1]; S. Kounouho[2]; M. Du[1]; M. C. Messner[1]; G. Hu[1]

1. Argonne National Laboratory, USA
2. Duke University, USA

Liquid Silicon Infiltration (LSI) densifies porous carbon–silicon composites through chemical reactions that form silicon carbide, enhancing mechanical performance. However, LSI often produces distortion and cracking, especially in 3D-printed parts with heterogeneous porosity, and the mechanisms linking microstructure to these defects remain poorly understood. In this work, we develop a homogenized model to capture pore-size-dependent reaction kinetics, and embed it into a multiphysics finite element coupling chemical reactions, heat transfer, porous flow, and mechanics. Our simulations of LSI on graphite blocks accurately predict the spatial distribution of the final composition and capture the shortened infiltration front in fine-porosity systems caused by pore closure at the Si–graphite interface. In addition, we use two-point statistics to represent the initial porosity distribution of pre-infiltrated parts and demonstrate that heterogeneous, anisotropic porosity typical of 3D-printed components significantly broadens the residual stress distribution compared with uniform or isotropic fields of the same average porosity. Applying the model to SiC–C composites, the residual stress fields explain the experimentally observed crack initiation, with the model-informed geometry modification demonstrated experimentally to suppress cracking.

3:30 PM

(ICACC-S1-022-2026) Design of self-healing ceramics composites with Vanadium-type healing activator

T. Oshiumi*[1]; T. Hara[1]; M. Goto[1]; T. Osada[1]

1. Busshitsu Zairyo Kenkyu Kiko, Japan

Ceramics bearings have been developed and challenged in applications such as turbine engines since ceramics offer excellent heat resistance, stiffness and abrasive resistance. However, ceramics are sensitive to surface defects, and even minute cracks can reduce the overall robustness. Further, in the high temperature operating environment, especially between 350°C to 800°C where the commercial lubricants deteriorate due to oxidation, an increase in frequency of surface defects initiation due to direct contact on the sliding surfaces exacerbates undermining. Here, oxidation induced self-crack-healing ceramics is expected to be an attractive approach to solute these challenges. We focused on the addition of vanadium to the conventional Al_2O_3-SiC composites as a healing activator. Consequently, 1 vol.% vanadium doped Al_2O_3-30 vol.% SiC showed full strength recovery at 700°C for 100 hr, which is 500 times faster than the estimated healing time 5 years of Al_2O_3-30 vol.% SiC. Crack-healed part observation and thermogravimetry (TG) analysis clarified that the formed V_2O_5 not only assists the oxidation reaction of healing agent SiC as an oxidizer but also lowers the viscosity of Si-based supercooled melts as a viscosity modifier, resulting in accelerating crack gap filling and strength recovery.

S1- Novel computational approaches to enhance performance and characterization

Room: Coquina E
Session Chair: Gerard Vignoles, University Bordeaux

3:50 PM

(ICACC-S1-023-2026) "Digital CMC" - AI-enabled inverse design of non-oxide ceramic composite (Invited)

D. Koch*[1]; N. Jain[1]

1. University of Augsburg, Institute for Materials Resource Management MRM, Materials Engineering, Germany

The development of non-oxide fiber reinforced ceramics like C/C-SiC and SiC/SiC traditionally relied on experimentally driven iteration for the optimization of properties under high temperature and demanding atmosphere. We propose a virtual process built on digital twins that represent the individual process steps and intermediate material stages. Measured and simulated material properties are integrated into a material models, enabling an inverse-design process that virtually derives expected properties from necessary processing parameters like composition of raw materials or thermal treatment during ceramization. The approach begins with an electronic lab-book for data collection of all experimental and virtual processing and material data. AI methods are then implemented in order to identify processing-microstructure-property relationships. For example, the effect of various temperature-time curves during pyrolysis are automatically correlated with the resulting crack pattern in the microstructure depending on fiber orientation. Subsequently, the succeeding infiltration of the cracks with silicon, SiC matrix is created and the mechanical properties are linked to the observed microstructural features. This integrated, end-to-end framework provides a comprehensive view of the processing chain and enables accelerated, data-driven design of non-oxide CMCs, our "Digital CMC" approach.

4:20 PM

(ICACC-S1-024-2026) Machine learning assisted serial sectioning to enable rapid 3D crack network reconstruction

A. Stubbers[2]; B. Swartley[2]; E. S. Castrejon[3]; S. Durkee[2]; E. Schwind[1]; A. Ramírez-Acosta[3]; C. R. Weinberger[4]; O. A. Graeve[5]; M. García-Vázquez[3]; G. Thompson*[1]

1. University of Alabama, Metallurgical & Materials Engineering, USA
2. University of Alabama, Alabama Materials Institute, USA
3. Instituto Politécnico Nacional, Mexico
4. Colorado State University, Department of Mechanical Engineering, USA
5. University of California, San Diego, Mechanical and Aerospace Engineering, USA

Serial sectioning enables the 3D reconstruction of microstructures, providing insights into crack pathways. Nevertheless, the collection of serial section data is time-consuming because many images are required to create reliable reconstructions. We present a combination of serial sectioning and a convolutional neural network (CNN) approach to interpolate intermediate images, enabling larger cut spacings and thereby increasing the efficiency and accessibility of serial sectioning. The crack-network was trained using the zeta-Ta_4C_{3-x}, a ceramic that has a complex interwoven lath microstructure. The accuracy of CNN-assisted serial sectioning datasets was evaluated using direct image comparison and crack surface area. It was found that window size steps of up to 4μm depth cuts, from previously 0.25 μm depth cuts, only resulted in an image error of 1% but reduced the sectioning time by up to 96%. However, the error was found to be defect-dependent, with kinking having a higher error than planar fracture features.

4:40 PM

(ICACC-S1-025-2026) Prediction of pyrolysis-induced deformation and damage in LSI-produced C/C-SiC

M. Riva*[1]; L. Cavalli[2]; M. Morandini[1]; M. De Stefano Fumo[3]; A. Airoldi[1]

1. Politecnico di Milano, Department of Aerospace Science and Technology, Italy
2. Petroceramics S.p.A., Italy
3. Centro Italiano Ricerche Aerospaziali, Italy

The Liquid Silicon Infiltration (LSI) is a cost-effective method to produce C/C-SiC composites. The starting point of the process is a polymeric matrix precursor, that is then pyrolyzed and infiltrated with molten silicon. The pyrolysis process induces an internal stress state in the pieces due to the mismatch of the shrinkage of the phases. These stresses are released by the development of a crack network, which is subsequently infiltrated by silicon, thus creating the desired final microstructure. When dealing with geometrically complex elements, to obtain the desired shape the parts are constrained during pyrolysis, and this may produce additional cracks that can change the material microstructure or that are too wide to be filled by silicon, thus affecting the final characteristics of the part. For these reasons, the numerical simulation of the pyrolysis phase can be used to support the production of complex parts, aiming to reduce the technological trials and to improve the pieces quality. The work presents a homogenized biphasic approach to predict, using a thermo-elastic material model, the residual deformations due to pyrolysis and simulate the damage induced by the constraints. The model is calibrated using experimental data and its performances are verified by comparing the results of the predicted deformation with the one measured during the pyrolysis of a complex shaped specimen.

S1- Small-scale testing and in-situ characterization using electrons, photons & neutrons

Room: Coquina E
Session Chair: Gerard Vignoles, University Bordeaux

5:00 PM

(ICACC-S1-026-2026) Transmission electron microscopy study of processing-induced interphase modifications in LSI SiC/SiC

K. Bock*[1]; J. Moosburger-Will[1]; K. Postler[1]; D. Koch[1]

1. Universitat Augsburg, Institute of Materials Resource Management, Germany

SiC fiber-reinforced SiC (SiC/SiC) exhibits exceptional properties including low density, high damage tolerance, and superior high-temperature performance, making it ideal for aeroengine applications. The fiber-matrix interphase, commonly consisting of a CVD-deposited BN-SiC double-layer coating, critically determines composite performance. The BN layer provides a weak interfacial bond enabling quasi-ductile behavior, while the SiC layer protects the BN and fibers. During processing of the preceramic matrix into SiC/SiC via liquid silicon infiltration (LSI), liquid silicon and process temperature can compromise interphase integrity, potentially degrading performance. Limited high-resolution characterization data exists comparing pre- and post-processing interphase microstructures. To address this, transmission electron microscopy (TEM) is used for detailed evaluation of interphase changes of coated fibers of the same type before and after processing to SiC/SiC. Energy dispersive X-ray spectroscopy (EDS) enables elemental mapping, electron diffraction determines crystalline structure, and electron energy loss spectroscopy (EELS) investigates chemical bonding characteristics. This approach provides insights into processing-induced interphase modifications, enabling optimization of coating and LSI processing parameters to maintain interphase integrity and composite performance.

S2 Advanced Ceramic Coatings for Structural/Environmental & Functional Applications

S2- Thermal and environmental barrier coatings for CMC, intermetallics, and alloys II

Room: Coquina C
Session Chairs: Elizabeth Opila, University of Virginia; Ravisankar Naraparaju, DLR - German Aerospace Center

1:30 PM

(ICACC-S2-021-2026) Damage and failure behaviour of thermally grown oxide SiO_2 of environmental barrier coatings under extreme environment: multi-physics modelling (Invited)

K. Chen*[1]

1. NRC, Aerospace, Canada

Thermally grown oxide (TGO) SiO_2, its shape, morphology evolution and associated growth kinetics together play a critical role in environmental barrier coatings' (EBCs) durability and life span under adverse high-temperature environments. This presentation shows an investigation of crack initiation and propagation of TGO using COMSOL Multiphysics methodologies combined with a phase field damage model. The stress field and its evolution were initially simulated under a thermally cycled temperature condition. The significant tensile stress in TGO results in the vertical crack initiation distributed across the TGO scale, and then crack bifurcation and delamination along the TGO interfaces. The simulated TGO crack propagation path was validated from the experimentally observed SEM images. Furthermore, the cohesive zone method (CZM) was also used to study the TGO interface cracking behaviour. It is interesting to note that the interface crack simulated by CZM has an interaction with those from the phase field damage model. The crack tip stress from the phase field damage model facilitates the initiation of the crack by CZM. This TGO cracking behaviour is useful in studying EBC's failure mechanism and its life prediction.

2:00 PM

(ICACC-S2-022-2026) Role of deposition parameters and heat treatment on the phase stability and Nb_2O_5 loss in suspension plasma sprayed gadolinium niobate coatings

V. Hastak*[1]; K. Leng[1]; N. Curry[2]; T. Hussain[1]

1. University of Nottingham Faculty of Engineering, Centre of Excellence in Coatings and Surface Engineering, United Kingdom
2. Thermal Spray Innovations, Austria

Rare-earth based oxide ceramics viz. zirconates, niobates and cerates, owing to their excellent thermal/mechanical properties and high thermal stability has been widely considered as potential thermal barrier coating materials. The present study reports phase stability of gadolinium niobate and associated Nb_2O_5 loss deposited using suspension plasma spraying technique. 25 wt.% solid loading gadolinium niobate suspensions were prepared using powders with D_{50} particle sizes of 0.5 and 2 microns. The initial crystal structure was found to be that of cubic gadolinium niobate. On heat treatment at 800 °C and 1100 °C, significant amount of tetragonal and monoclinic $GdNbO_4$ phases were observed using XRD and Raman. The effect of particle size and deposition parameters on Nb_2O_5 loss was examined using SEM. It was evident that Nb_2O_5 loss and phase stability can be tailored using optimized process parameters and subsequent heat treatments which opens new possibilities for obtaining high performance niobate coatings.

2:20 PM

(ICACC-S2-023-2026) Thermal barrier coatings for supercritical carbon dioxide, one old and one new

E. H. Jordan*[1]; C. Jiang[1]

1. Solution Spray Technologies LLC, USA

CO_2 used as a working fluid has the potential to dramatically reduce the size of the turbine for a given power, due to the high density of supercritical CO_2 (sCO_2). In addition, sCO_2 offers improved efficiency especially at lower turbine inlet temperatures and the potential for rapid power level adjustment as needed with more intermittent renewable sources. In this work, we created a number of thermal barrier coatings (TBCs) to explore their performance in sCO_2 at 750°C at 205 bar for 500 hours. This environment presents new environmental challenges, including a high temperature acidic environment due to dissolved water vapor. In this initial testing, both atmospheric (APS) and solution precursor plasma sprayed (SPPS) yttria stabilized zirconia (YSZ) and a new SPPS coating of gadolinium apatite, the known blocking phase for CMAS, were included. The apatite phase showed adverse reaction to the sCO_2 environment and to the acidic environment used to remove the substrates for thermal conductivity testing. Both versions of yttria stablized zirconia did well in sCO_2 where the solution precursor plasma sprayed TBC had lower thermal conductivity than the APS counterpart, but at a lower deposition rate.

2:40 PM

(ICACC-S2-024-2026) Understanding interfacial stability between rare-earth oxide (REO) based T/EBC and alumina thermally grown oxide (TGO)

N. Ria*[1]; D. L. Poerschke[1]

1. University of Minnesota Twin Cities, Chemical Engineering and Material Science, USA

Rare-earth oxides (REOs) are promising candidates for next-generation thermal/environmental barrier coatings owing to their low thermal conductivity and matching coefficient of thermal expansion with Nb-based structural components. However, limited understanding of their high-temperature interfacial stability with alumina thermally grown oxides (TGO) remains a major challenge for designing multilayer coatings with long-term durability. We examined the thermochemical compatibility of alumina with five pure REOs and one mixed oxide. Diffusion couples were fabricated by spark plasma sintering and annealed at 1300 °C and 1500 °C for 1, 10, and 100 h to evaluate reaction kinetics and product evolution. Pure REOs formed rare-earth aluminates consistent with their respective binary phase equilibria, whereas the RE cations in the mixed REO partitioned into distinct aluminates. Reaction layers thickened with increasing annealing temperature and time, accompanied by porosity arising from molar volume mismatch and unequal diffusivities. We will discuss the findings in the context of guidelines for tailoring advanced multilayer architectures for Nb-based alloys, enabling improved compatibility and stability under extreme service conditions.

3:20 PM

(ICACC-S2-025-2026) Pushing the limits of compositionally complex oxides with five to ten stabilizers in zirconia for lowering thermal conductivity

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2. Indian Institute of Technology Bombay, Department of Metallurgical Engineering and Materials Science, India

Compositionally complex oxides (CCOs) represent a paradigm shift in materials design to achieve unique property combinations distinct from the individual oxides. Can CCOs provide an alternative that can replace 8 mol% YSZ (t′) as next-gen thermal barrier coatings? This work demonstrates the synthesis and characterization of stable zirconia compositions with five to ten stabilizers, pushing the boundaries of compositional complexity in thermal barrier coatings (TBCs). Advanced processing techniques enabled the formation of single-phase fluorite structures. Atom probe tomography revealed homogeneous cation distribution at the nanoscale, confirming successful stabilization. The engineered lattice distortion and enhanced phonon scattering resulted in significantly low thermal conductivity values – lower than conventional 8YSZ. Mechanical characterization demonstrated robust properties despite the complex chemistry. High-temperature stability testing confirmed single-phase retention across service-relevant temperature ranges. The systematic incorporation of multiple cations creates unprecedented opportunities for property optimization through compositional tuning. These results establish a new frontier in CCO design, demonstrating that extreme compositional complexity can be successfully harnessed to advance the materials technology for TBC applications.

3:40 PM

(ICACC-S2-026-2026) Evaluating environmental barrier coating systems in high-temperature, high-pressure steam environments

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1. Oak Ridge National Laboratory, USA

Evaluating the effects of high-temperature steam on environmental barrier coatings (EBCs) for SiC substrates is crucial for estimating coating service life for combustion turbine engine applications. However, testing of EBC/SiC systems are rarely performed in high-pressure conditions that align closely with a turbine engine environment, which can experience pressures beyond 20 atm within the combustion zone. This leads to the question of how high-pressure conditions within a high-temperature steam environment can affect the EBC, as well as other coating factors such as the effects on the thermally grown oxide (TGO) that forms from the Si-bond coat layer. To evaluate the coatings durability at higher pressures, a systematic evaluation of exposed EBC systems (i.e., $(Y/Yb)_2Si_2O_7$, $Yb_2Si_2O_7$) applied to SiC substrates were tested at 1300°C in a range of pressures above 1 atm with differing partial pressures of water vapor. Characterization was performed (e.g., SEM-BSE analysis) to evaluate the protective properties for each EBC system. Results indicate dependencies on EBC layer composition for substrate protection, as well as dependencies on pressure for TGO behavior in the varying high temperature conditions.

4:00 PM

(ICACC-S2-027-2026) Nitride-based ceramic composite coatings via atmospheric/reactive plasma spray

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1. Louisiana State University, Mechanical and Industrial Engineering, USA

Nitride coatings exhibit low hydrogen permeability in addition to promising wear and corrosion properties, so a potential application of nitride coatings is hydrogen permeation barriers. Thin nitride coatings are generally produced using methods like physical vapor deposition, which are difficult to scale for large surface-area production. The scalability of atmospheric plasma spray (APS) can be used as an alternative approach to produce large-scale nitride-based coatings. Utilization of spray environment to control in-process phase transformations and develop unique microstructures can be promising to design and synthesize higher performance coatings. Our objective is to employ reactive frameworks in APS and advanced microstructure characterization to explore mechanisms related to grain boundaries and second phases limiting long-range bulk hydrogen diffusion. This work explores APS with N_2 primary gas using TiN and Ti feedstocks with the aim to obtain desired mixed phase fractions. SEM-EDS and XRD indicated that oxides/oxynitrides/nitrides can be controlled majorly by N_2 gas flow rate. The primary focus of this work is to quantify phase transformation kinetics that produce coatings and provide mechanistic insights into nucleation and growth of nitride-based phase transitions. S/TEM is applied to characterize grain and phase boundaries in the coatings to assess potential hydrogen trapping sites.

4:20 PM

(ICACC-S2-028-2026) Advancing enviromental barrier coating testing using a high-temperature, high-velocity steam jet enviroment

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1. University of Virginia, Mechanical and Aerospace Engineering, USA
2. University of Virginia, Materials Science and Engineering, USA

Ytterbium disilicate (YbDS) has emerged as a key material for Environmental Barrier Coatings (EBCs) applied to silicon carbide (SiC) ceramic matrix composites (CMCs) for high-temperature gas-turbine engine applications. These coatings protect the underlying SiC CMCs from harsh environments, where high-temperature high-velocity steam present in the combustion environment poses significant challenge for the long-term thermochemical stability of SiC and EBCs. A horizontal tube furnace, termed a "steam jet," has been built in which high-velocity water vapor (~250 m/s) impinges on EBC coated CMCs at temperatures up to 1500°C, replicating the range of standard operating conditions seen in a gas-turbine engine. The study explores and assesses the uniformity and extent of silica depletion on model materials reaction-bonded SiC and sintered YbDS.

4:40 PM

(ICACC-S2-029-2026) Pressure effects on thermochemical stability of hot-pressed $Yb_2Si_2O_7$ EBCs in high-temperature and high-velocity steam

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Rare-earth silicate environmental barrier coatings (EBCs) react with water vapor at high temperatures, causing degradation that limits their use in turbines. To study these mechanisms under engine-relevant conditions, a high-pressure flow reactor was developed, capable of testing at 1400 °C, 5 atm, and 200 m/s. Samples are placed 1 mm from the jet exit at variable impingement angles for up to 50 h, replicating engine flow and local water vapor number density, providing insights not attainable in atmospheric tests. This study examines hot-pressed ytterbium disilicate ($Yb_2Si_2O_7$) exposed to high-velocity steam with water vapor partial pressures of 1-3 atm. Characterization using SEM, EDS, and XRD tracks microstructural evolution, phase stability, and surface morphology. Focus is on reaction depth and porosity variation, which serve as key indicators of long-term degradation. Reaction depth quantifies progression of the gas-solid interface into the bulk, linking directly to material recession and loss of protection. Porosity variation reveals steam and species transport pathways within the regressing microstructure, particularly under pressure. By correlating porosity, reaction depth, and phase transformations, this work provides new mechanistic insights into EBC degradation in high-pressure, steam-rich environments.

S3 23rd Intl Symp on Solid Oxide Cells Materials Science & Technology

S3-Upscaling of manufacturing

Room: Coquina H
Session Chair: Alessandra Sanson, CNR-ISTEC

1:30 PM

(ICACC-S3-016-2026) Upscaling protonic ceramic electrolysis cells (Invited)

Y. Kim[1]; J. Shah[2]; C. Schiller[3]; S. Ricote*[1]; S. Ricote[2]

1. Colorado School of Mines, Metallurgical and Materials Engineering, USA
2. HyET, USA
3. ATS, USA

Protonic Ceramic Electrolysis Cells (PCECs) are a promising electrolysis technology that operates in the intermediate temperature range of 500 to 600°C. In recent years, there has been a marked increase in research efforts and scientific engagement towards advancing PCEC technology. However, despite this growing momentum, several critical challenges remain—particularly in relation to the scalability and manufacturing robustness required for commercial deployment. In the present work, we report on the fabrication techniques and preliminary characterization of large-scale tubular PCECs, with a surface area exceeding 30 square cm. These tubular cells were manufactured using two different forming techniques for fuel electrode support (negatrode): injection molding and slip casting. Subsequently, the protonic ceramic electrolyte layer was applied via dip coating on the negatrode, ensuring uniform coverage and adherence. Characterization of these tubular PCECs is presented to validate the effectiveness and reproducibility of the fabrication process.

2:00 PM

(ICACC-S3-017-2026) Model-based development of industrial kilns for SOC production

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1. ONEJOON, Engineering, Germany
2. ONEJOON, Sales, Germany
3. ONEJOON Inc., CEO, USA

As a kiln manufacturer ONEJOON uses methods of numerical simulation to offer sophisticated kiln concepts to their customers. As the quality of solid oxide cells highly depends on atmospheric conditions, including its velocity and uniformity, as well as temperature distribution inside the kiln, simulation models are becoming increasingly important in the product development phase and system optimization. The presentation will show an overview of ONEJOON's upscaling process from a lab batch kiln to a full continuous production kiln for SOC with a focus on the debinding and sintering process. We included an analysis of a study conducted in the field of systems in operation where we measured temperature distribution and homogeneity in batch and roller hearth kilns. These studies are used to validate ONEJOON's CFD model parameters. These simulations provide a novel approach to derisking and accelerating the continuous kiln development. However, the simulation results are limited to the kiln system, as the product within the model is modeled as a "black box" with fixed or temperature-dependent physical values of density, heat capacity and thermal conductivity. Continued research is required to possibly include the physical process and chemical reaction models of the product itself, which would be a distinct improvement for the kiln and SOC development and optimization process.

2:20 PM

(ICACC-S3-018-2026) Scaling proton-conducting ceramic electrolysis cells: Performance and engineering challenges from button cells to 25 cm^2

S. Koomson*[1]; W. Wang[1]; Z. Zhao[1]; J. Y. Gomez[1]; W. Bian[1]; D. Ding[1]

1. Idaho National Lab, Hydrogen and electrochemistry, USA

Proton-conducting ceramic electrolysis cells (PCECs) present significant potential for hydrogen production at intermediate temperatures due to their superior ionic conductivity and thermodynamic efficiency. Although button-cell tests have shown excellent electrochemical performance, scaling up to larger formats poses several engineering challenges that could affect cell reliability, efficiency, and mechanical integrity. This study systematically investigates PCECs expanded from 1 inch to 25 cm^2 under steam electrolysis conditions. Planned characterizations include current-voltage (I–V) measurements, electrochemical impedance spectroscopy (EIS), Faradaic efficiency (FE) evaluation, and seal integrity testing. The goal is to identify performance-limiting factors related to scale-up, such as gas leakage, current non-uniformity, and contact resistance. We hypothesize that larger cells will exhibit increased area-specific resistance (ASR) and higher susceptibility to sealing failures. To address these issues, we will assess design modifications like optimized current collector distribution and enhanced mechanical sealing approaches. The findings are expected to provide engineering insights and design strategies crucial for advancing PCEC technology towards stackable, large-area electrolysis systems.

2:40 PM

(ICACC-S3-019-2026) Advanced manufacturing and characterizations enabled high performance protonic ceramic electrolysis cells at Idaho National Laboratory

F. Liu*[1]; Z. Wang[1]; W. Bian[1]; Z. Zhao[1]; M. Li[1]; D. Ding[1]

1. Idaho National Laboratory, Energy & Environmental Science and Technology, USA

High-temperature solid oxide electrolysis cells are recognized as one of the most energy-efficient technologies for hydrogen production, with the ability to integrate waste heat and steam from industrial processes, seasonal renewable electricity, or nuclear power. Their high efficiency and the use of platinum-group-metal (PGM)-free catalysts make them highly attractive compared with low-temperature electrolysis technologies. Within this family of devices, protonic ceramic electrolysis cells (PCECs) employ proton-conducting electrolytes that benefit from lower activation energy for proton transport compared with traditional oxygen-ion conduction. As a result, PCECs can operate at intermediate temperatures (350–600 °C), reducing thermal and materials constraints while maintaining high performance. In this talk, we will present our recent progress on the development of 1-inch PCECs at Idaho National Laboratory (INL). These include advances in ceramic manufacturing, mechanistic studies of hydration reactions, and performance evaluation of single devices. Importantly, our findings demonstrate how these approaches enable long-term, durable operation for hydrogen production. Together, these efforts may establish practical pathways toward stable, efficient, and scalable PCECs for future energy conversion and storage.

S3-Novel processing and design

Room: Coquina H
Session Chair: Luca Mastropasqua, University of Wisconsin-Madison

3:20 PM

(ICACC-S3-020-2026) Development of the metal-supported solid oxide fuel cell with the alumina-forming ferritic stainless-steel substrate (Invited)

K. Hara*[1]; Y. Miura[1]; Y. Cho[1]; T. Shiomi[1]; Y. Shibata[2]; S. Taniguchi[2]; K. Sasaki[2]

1. Nissan Jidosha Kabushiki Kaisha, Nissan Research Center, Japan
2. Kyushu Daigaku, Japan

Nissan Motor Corporation targets carbon neutrality across the life cycle of its products by fiscal year 2050. Solid oxide fuel cells (SOFCs), operating at 500–1000 °C with hydrogen or hydrocarbons, show high efficiencies and are key to this goal. Nissan is developing SOFCs for vehicle range extension and factory power. In 2024, a Tochigi Plant trial used ethanol-derived hydrogen in a stationary SOFC, proving renewable-fuel feasibility. Metal-supported SOFCs offer strength and manufacturability but ferritic steels suffer from Cr volatilization and oxidation. Alumina-forming alloys (AFA, AFFS) form protective Al_2O_3 scales, reducing Cr loss more effectively than chromia and enabling higher sintering. However, such firing promotes Sr–Zr–O reactions, forming insulating $SrZrO_3$. Gd-doped ceria (GDC) barriers suppress these reactions, but effectiveness depends on densification. High-temperature firing improves density but accelerates interdiffusion. This study fabricated AFFS-supported SOFCs and evaluated performance and durability, emphasizing GDC layer behavior under sintering and its impact on electrochemical properties.

3:50 PM

(ICACC-S3-021-2026) Innovative manufacturing for low-cost, high-performance SOCs

F. Gualandris*[1]

1. Hydrospark, Italy

Hydrospark aims to produce SOCs with the highest performance at the lowest cost. To this end, we have developed innovative processes that enhance both efficiency and durability. A method enables the production of a denser electrolyte than the state of the art. This ensures high ionic conduction and impermeability to gases, preventing micro-porosities that typically cause gas mixing, micro-combustions, delamination, and premature stack failure. Such improvements have a decisive impact on cell lifetime. However, performance alone is not enough: the market requires drastic cost reductions. Today, cells in Europe cost much more than the EU 2030 targets for electrolysers, that implies a cost of only €8–11.3 per cell. Traditional manufacturing, even at scale, cannot bridge this gap. Most costs derive from half-cell production, where the fuel electrode and electrolyte are sequentially tape cast. This process is slow (0.6 m/min) and CAPEX-intensive. Hydrospark has developed a new method, achieving ≥5 m/min (8.3× faster) and reducing CAPEX by 2.5×, while preserving essential microstructural properties such as porosity and percolation. The process has been validated on a small scale and is ready for industrial deployment. To accelerate this transition, we are building a new manufacturing plant fully based on these innovations, enabling production of 1 million cells/year by 2028, fully aligned with EU targets.

4:10 PM

(ICACC-S3-022-2026) Improved SOEC pocessing through Additive Manufacturing and Ultrafast Sintering (UHS) in the frame of "CleanHyPro-Open innovation Test Bench".

M. Torrell*[1]; A. Maria Asensio[1]; A. Sabato[1]; I. Babeli[1]; L. Martinho Serra[1]; A. Tarancón[2]

1. IREC, Nanoionics and Fuel Cells, Spain
2. IREC / ICREA, Spain

The CleanHyPro project is building a European Open Innovation Test Bed (OITB) to support the sustainable development and commercialization of electrolysis materials and components for clean hydrogen production. Under a unified sustainable manufacturing framework, it integrates multiple pilot lines (PLs) into a comprehensive ecosystem combining advanced technical capabilities with non-technical services to accelerate innovation. A key innovation is the pilot line for additive manufacturing of Solid Oxide Electrolysis Cells (SOECs), using stereolithography (SLA) to produce complex ceramic geometries, using SoA and innovative materials. To overcome long thermal processing times, CleanHyPro has implemented Ultrafast High-Temperature Sintering (UHS), achieving >96% densification in under 15 minutes while preserving structural integrity. A fully UHS-processed 3D-printed electrolyte-supported SOEC reached a peak power density >0.8 W/cm^2 at 900 °C, outperforming previous systems. By combining material innovation, rapid processing, and scalable manufacturing, CleanHyPro supports the full value chain and aligns with regulatory and sustainability standards, positioning itself as a key enabler of Europe's clean hydrogen transition.

4:30 PM

(ICACC-S3-023-2026) Additive manufacturing for next-generation protonic ceramic fuel cells

S. Virtanen[1]; A. Savikko[1]; B. Bilbey[1]; M. Asghar*[1]

1. Tampereen yliopisto Tekniikan ja luonnontieteiden tiedekunta, Renewable Energy Technologies Group, Finland

Protonic ceramic fuel cells (PCFCs) are a promising low-temperature (400–600°C) fuel cell technology. Compared to conventional oxygen-ion conducting ceramics, proton-conducting ceramic electrolytes offer lower activation energy (<50 eV), leading to enhanced fuel cell efficiency and power output. In this study, we utilized extrusion-based 3D printing to fabricate PCFCs using $BaZr_{0.3}Ce_{0.5}Y_{0.15}O_{3-\delta}$ and $BaZr_{0.4}Ce_{0.4}Y_{0.1}Yb_{0.1}O_{3-\delta}$ as electrolytes, NiO as the anode, and $BaCo_{0.4}Fe_{0.4}Zr_{0.1}Y_{0.1}O_{3-\delta}$ and $Ba_{0.5}Sr_{0.5}Co_{0.8}Fe_{0.2}O_{3-\delta}$ as cathodes. For comparison, we also printed oxygen-ion conducting ceramic fuel cells using gadolinium-doped ceria (GDC) as the electrolyte. To evaluate the printable pastes' rheological properties, we employed dynamic light scattering, viscometry, tensiometry, differential scanning calorimetry, and thermogravimetric analysis. The printed cells were further characterized using current-voltage measurements, electrochemical impedance spectroscopy, and advanced spectroscopic and microscopic techniques (HR-TEM-EELS, SEM-EDX) to understand the underlying mechanisms. Additionally, we systematically optimized the sintering temperature to achieve the best fuel cell performance and investigated degradation mechanisms to improve long-term stability. The highest-performing printed fuel cells achieved 926 mW/cm^2 with a three-layer structure and 426 mW/cm^2 with a single-layer structure at 550°C.

4:50 PM

(ICACC-S3-025-2026) Multifunctional (Gd,Yb,Bi)CeO_2 buffer layer enabling single-step low-temperature co-sintering of $LaGaO_3$-based SOFCs

H. Kim*[1]; Y. Lee[2]; T. Shin[1]

1. Korea Institute of Ceramic Engineering and Technology, Republic of Korea
2. Gyeongsang National University, Republic of Korea

High-temperature sintering of $LaGaO_3$-based solid oxide fuel cells often leads to interfacial reactions that degrade performance, making the manufacturing process more complex and time-intensive. Conventional approaches employ La-doped ceria (LDC) as a reaction barrier, but this typically demands additional high-temperature firing. In this study, a (Gd,Yb,Bi)CeO_2 (GYBC) buffer layer was developed to allow co-sintering of the full cell at 1000°C in a single thermal cycle. The GYBC interlayer, with its high oxygen storage capacity and good sintering behavior, enables densification of the electrolyte while integrating both anode and cathode without forming unwanted secondary phases. When fabricated via this route, the $LaGaO_3$-based cells achieved maximum power densities of 1.19 W cm^{-2} at 800°C and 1.70 W cm^{-2} at 850°C. Electrochemical evaluation suggests that the improved performance is linked to facilitated interfacial oxygen ion transport provided by the dense, chemically compatible GYBC layer. This one-step, low-temperature strategy offers a viable pathway for reducing fabrication complexity while maintaining high electrochemical output.

S6 Advanced Materials and Technologies for Rechargeable Energy Storage

S6- Na Battery Technology

Room: Coquina G
Session Chairs: Jeom-Soo Kim, Dong-A University; Wan Si Tang, Underwriters Laboratories Inc

1:30 PM

(ICACC-S6-008-2026) Sodium-ion cells and modules – Performance and safety (Invited)

J. Jeevarajan*[1]; D. RajagopalanKannan[1]; V. Premnath[1]

1. UL Resarch Institutes, Electrochemical Safety Research Institute (ESRI), USA

Advances in battery technologies have led to the introduction of sodium-ion cells in the commercial market. Some cells are commercially available while some others are more of a custom-design and available only with the original manufacturer. ESRI scientists have procured cells from both sectors and carried out tests at the cell and small module levels to characterize their performance and safety. Performance tests include rate capability at room and two other temperatures. Safety tests included overcharge, overdischarge, external short circuits and heating the cell to trigger thermal runaway. The safety tests were carried out at the single cell as well as 12 V and 48 V module configurations. Initial tests on commercially available cells indicated that under some off-nominal conditions such as the overcharge and heating tests, venting of electrolyte, fire and/or smoke were observed. The results of our test program on commercial and custom-designed cells will be presented.

2:00 PM

(ICACC-S6-010-2026) Effect of precursor co-precipitation conditions on the properties of $NaNi_{1/3}Fe_{1/3}Mn_{1/3}O_2$ as a cathode material for sodium-ion batteries (Invited)

H. Ryu[1]; M. Cho[1]; J. Kim*[1]

1. Dong-A University, Chemical Engineering, Republic of Korea

Sodium-ion batteries (SIBs) are considered promising alternatives to lithium-ion batteries (LIBs) for cost-effective energy storage applications, including entry-level electric vehicles (EVs) and energy storage systems (ESSs). Layered $NaNi_{1/3}Fe_{1/3}Mn_{1/3}O_2$ (NFM), a cathode material for SIBs, has been extensively studied and has recently become commercially available. The electrochemical properties of NFM are significantly influenced by the characteristics of its precursors, which can be tailored by controlling the parameters in the co-precipitation process. This study investigates the effect of precursor co-precipitation conditions on the physical and electrochemical properties of NFMs. In contrast to Co-containing NCM ($LiNi_xCo_yMn_zO_2$, where x+y+z=1) used in LiBs, NFM incorporates Fe, which may induce inhomogeneity during the co-precipitation of metal ions. Precursors were synthesized under various precipitation conditions by varying the chelating agent type, the chelating agent-to-metal ion molar ratio, the reaction temperature, and the pH. The physical characteristics of the precursor particles were found to be highly dependent on these parameters, which in turn significantly affect the properties of NFMs. The correlation between precursor properties and the electrochemical performance of NFM will be presented in detail at the conference.

2:30 PM

(ICACC-S6-011-2026) Charged-state Na metal batteries with high energy density and stable cyclability (Invited)

J. Hwang*[1]; F. Nozaki[1]; S. Zhang[1]; K. Matsumoto[1]

1. Kyoto Daigaku, Japan

Triphylite-$NaFePO_4$, an olivine-type positive electrode material, offers high capacity and energy density, and is composed of earth-abundant elements, making it a promising candidate for sodium-ion batteries. However, its direct synthesis is limited by thermal metastability, as heating transforms the triphylite phase into the electrochemically inactive maricite phase. This study presents a sustainable, chemical oxidation method to prepare heterosite $FePO_4$, the charged-state form of $NaFePO_4$, via delithiation of $LiFePO_4$. The process operates in a closed-loop system where oxygen serves as the oxidant, and lithium is recovered as lithium acetate for reuse. This enables cost-effective and circular production of FePO4. Building on this material innovation, we propose a lean Na metal battery configuration that utilizes a thin layer of sodium metal paired with charged-state $FePO_4$. This setup improves cyclability and maintains high energy density, addressing key challenges in anode-free battery designs.

3:20 PM

(ICACC-S6-012-2026) Design of new material used as cathode for Metal-ion batteries

A. Sagot[2]; L. Stievano[3]; V. Kovrugin[2]; T. Soudant[4]; V. Pralong*[1]

1. CNRS ENSICAEN, France
2. Ecole Nationale Superieure d'Ingenieurs de Caen, CRISMAT, France
3. Universite de Montpellier, Institut Charles Gernardt Montpellier, France
4. Laboratoire de Cristallographie et Sciences des Materiaux, France

Energy storage technologies are highly dependent on the materials used, necessitating the search for advanced, cost-effective, and environmentally friendly alternatives. However, only a limited number of elements satisfy these constraints, including abundant alkali ions (mostly Na and K), non-hazardous transition elements (Ti, Nb, Mn, Fe, Zr, Cu, or Al), or anions such as oxides or sulfides. Despite the high performance of materials based on lithium, their cost is driving the development of alternative systems based on sodium and potassium, more abundant in Earth's crust by several orders of magnitude. Moreover, Mn-based oxide materials emerge as promising cathodes for alkaline-ion batteries due to their high energy density, low cost, and low toxicity. While the exploration of these ternary diagrams has already allowed us to synthesize and study numerous phases, new compositions remain to be discovered to find an economical and non-toxic cathode material for metal-ion batteries. This presentation will discuss the relationship between structural and insertion properties in the A-Mn-O system, emphasizing our strategy for the generation of green materials for energy storage, playing with the chemist's toolkit.

3:40 PM

(ICACC-S6-013-2026) Synthesis, chemical, physical and electrochemical characterizations of $Na_{10}Mn_4O_9$

T. Soudant*[1]; V. Kovrugin[1]; G. Rousse[2]; A. Maignan[1]; L. Stievano[3]; A. Iadecola[4]; J. Tarascon[2]; M. Doublet[3]; V. Pralong[1]

1. Laboratoire de Cristallographie et Sciences des Materiaux, France
2. College de France, France
3. Universite de Montpellier, Institut Charles Gernardt Montpellier, France
4. Physicochimie des Electrolytes et Nanosystemes Interfaciaux, France

Currently, the market is largely dominated by lithium-ion (Li-ion) technology for electrochemical energy storage. The lack of real alternatives is causing strain on raw materials (lithium, cobalt, and even graphite). In response to the challenges related to resources, sodium-ion (Na-ion) batteries, which rely on a much more abundant element than lithium, represent a promising alternative. The layered oxides Na_xMO_2 (M = 3d transition metal) family offers rich solid-state chemistry with many compositions. Within the family, sodium-manganese based oxides are promising for sodium-ion batteries regarding manganese's low toxicity, and cost-effectiveness. The Na-Mn-O system includes numerous phases, with many compositions reported in the 70's primarily as single crystals for the most part. To date, the two most extensively studied phases used as cathode materials for sodium-ion batteries are Na_xMnO_2 and $Na_2Mn_3O_7$. We identified a sodium-rich phase with the composition $Na_{10}Mn_4O_9$, which exhibits its high theoretical capacity and intriguing crystal structure. We therefore reported a complete study including structural, chemical and physical and electrochemical characterizations.

4:00 PM

(ICACC-S6-014-2026) Cold-sintered $Na_{1+x}Zr_2Si_xP_{3-x}O_{12}$–$Na_{0.7}CoO_2$ composites for solid-state batteries

B. Siame*[1]; A. J. Adetona[1]; C. Grimes[1]; M. J. Myszczynski[1]; C. J. Shaw[1]; D. C. Sinclair[1]; I. M. Reaney[1]

1. The University of Sheffield, Chemical, Biological, and Materials Engineering, United Kingdom

NASICON-type $Na_{1+x}Zr_2Si_xP_{3-x}O_{12}$ ($0 \leq x \leq 3$) - NZSP is a promising solid electrolyte for solid-state batteries due to its high ionic conductivity. However, its high sintering temperature (≈1250 °C) restricts co-sintering with active materials, polymer binders, and carbon additives. This study explores a low-temperature fabrication route of cold sintering, a pressure-induced precipitation mechanism to produce dense NZSP–$Na_{0.7}CoO_2$ (NCO) composites. Optimized conditions (600 MPa, 200 °C, 5 wt% deionized water, 1 h, followed by 80 °C annealing for 48 h) yielded an NZSP–10 wt% NCO composite with a total ionic conductivity of 3.6 mS cm^{-1}, comparable to conventionally sintered NZSP. Characterization by impedance spectroscopy, SEM/XRD, TG/DSC, and Archimedes density measurements revealed that pure NZSP cold-sintered under identical conditions exhibited poor densification (≈84% relative density) and low conductivity (~10^{-5} S cm/cm). Incorporation of NCO as a flux binder improved densification (>90% relative density) and maintained high ionic conductivity. The composite's electronic conductivity

(1.4×10^{-8} S/cm) corresponds to a transference number of 0.9998, meeting solid electrolyte requirements. These findings establish cold sintering as a viable low-temperature processing method for NZSP-based electrolytes and identify NCO as an effective cold sintering densification aid.

4:20 PM

(ICACC-S6-015-2026) Influence of synthesis parameters on the conductivity of pristine and Cl/Br-doped Na_3PS_4 solid electrolytes

L. Trezecik Silvano[1]; R. Ucuncuoglu[1]; V. Knoblauch[1]; P. Kaya*[1]

1. IMFAA, Aalen University of Applied Sciences, Germany

Sustainable energy storage solutions require more abundant and less critical materials than lithium for the environment. Therefore, post-Li batteries (e.g., Na-ion batteries) are of great significance, and solid-state Na-ion batteries are a promising solution, which could increase the safety with the solid electrolytes (SEs) and the energy density with metallic sodium anode, also with its cost-effectiveness. Among various SE types, sulfide-based electrolytes meet the demand for high conductivity and excellent surface contacts in composite cathodes due to their soft nature. Na_3PS_4 (NPS) was first reported in 1992 with an ionic conductivity of $4{,}17 \times 10^{-6}$ Scm^{-1} as one of the promising ceramic SEs; however, there has been a wide variability in ionic conductivity according to the synthesis parameters. Therefore, this study investigates how synthesis parameters affect the conductivity of pristine and Cl/Br-doped NPS. Cl^- doping with moderate annealing introduces Na^+ vacancies, enhancing ionic conductivity fourfold (4.8×10^{-5} Scm^{-1}) without compromising phase stability. In contrast, Br^- doping results in NaBr precipitation and reduced conductivity. These findings highlight the impact of halogen doping and synthesis on structure–transport relationships, guiding the development of NPS-based solid electrolytes.

4:40 PM

(ICACC-S6-016-2026) Sulfide-based electrolytes for next generation solid-state potassium batteries

J. Grill*[1]; J. Popovic-Neuber[1]

1. University of Stavanger, Norway

Solid state potassium-based batteries are a promising option for post-lithium batteries as multiple inorganic solid electrolytes exhibit high room temperature ionic conductivity. These include oxide, sulfide and phosphide-based with $\sigma_{ion,RT} > 10^{-4}$ S cm^{-1} and $E_A < 0.3$ eV have been reported in the recent years. Potassium metal anodes are desired for high energy density, but due to the highly reactive nature of potassium metal, the electrolytes need to form a stable SEI layer. We have previously shown that time- and temperature dependent electrochemical impedance spectroscopy (EIS) can offer valuable insights into ion transport and growth of the SEI on planar alkali metal electrodes. Using EIS, we demonstrated that W-doped K_3SbS_4, a high-performance material, forms a stable SEI against potassium metal electrodes in symmetric cells 80 hours after assembly.

S7 20th International Symposium on Functional Nanomaterials and Thin Films for Sustainable Energy, Environmental and Biomedical Applications

S7- Nanomaterials for energy conversion, storage and catalysis I

Room: Flagler A
Session Chair: Ji-Hyun Jang, Ulsan National Institute of Science and Technology

1:30 PM

(ICACC-S7-017-2026) Rapid large-scale synthesis and performance boosting of hybrid thermoelectric generators guided by simulation (Invited)

M. S. Toprak*[1]; B. Hamawandi[2]; J. F. Serrano-Claumarchirant[1]

1. KTH Royal Institute of Technology, Dept. of Applied Physics, Sweden
2. Latvijas Universitate, Institute of Solid State Physics, Latvia

There is an increasing interest to develop thermoelectric (TE) films from pre-made nanoparticles to enable conformally deposited films for waste-heat harvesting from any surface that irradiates heat. A pre-requisite for these efforts to succeed is to have a set of well-defined, large-scale and reproducible quality n- and p-type TE materials. Fabrication methods influence materials morphology, microstructure, and surface chemistry, which in turn has a strong impact on the transport properties. We report on the synthesis of n- and p-type bismuth-antimony tellurides (Bi_2Te_3 - Sb_2Te_3) using scalable bottom-up synthesis methods. A comparison of the techniques, and the resultant materials' characteristics are performed. A hybrid ink has been developed through blending the NPs with PMMA as the polymer matrix. Dr blading technique has been used for the fabrication of thick films using these inks. Electronic transport characteristics of the hybrid films were evaluated under a temperature gradient. After the identification of promising compositions, a TE generator (TEG) has been fabricated by casting n-and p-type legs from the developed inks. Simulation guided TEG design produced a much higher power level than the classical symmetric leg TEG design. The methodologies used and characteristics of materials and TEGs at various process steps are presented.

2:00 PM

(ICACC-S7-018-2026) Band-engineering-stabilized $AgSbTe_2$ with high thermoelectric performance (Invited)

Y. Zhang*[1]

1. Zhejiang University, China

Thermoelectric (TE) generators enable the direct, reversible conversion between heat and electricity, facilitating applications in both power generation and refrigeration. In recent years, substantial advancements have been made in developing TE materials with high figures of merit (zT) for both low- and high-temperature ranges. Nevertheless, there remains a critical need for high-efficiency TE materials that operate optimally in the mid-temperature range (400–700 K). Herein, we present p-type $AgSbTe_2$ materials, engineered through compositional modification, which achieve an outstanding maximum zT value exceeding 2.0 at 673 K. This superior performance stems from multiple enhancements: an elevated carrier density due to increased silver vacancy concentration, a markedly improved Seebeck coefficient facilitated by valence band flattening, suppression of the n-type Ag_2Te phase, and enhanced thermal stability beyond 673 K. Furthermore, the optimized $AgSbTe_2$ material was successfully incorporated into a TE device, delivering an energy conversion efficiency of up to 12% at a temperature differential of 370 K. These results underscore a robust and effective strategy for engineering high-performance TE materials specifically suited for mid-temperature applications, addressing a pivotal gap in TE technology.

2:30 PM

(ICACC-S7-019-2026) Composite semiconducting nanostructures for energy harvesting (Invited)

A. Vomiero*[1]

1. Lulea University of Technology, Engineering Sciences & Mathematics, Sweden

Composite nanostructures can be applied for energy harvesting and generation of solar fuels. In most of the systems, nanomaterials can play a critical role in boosting conversion efficiency and energy use by ameliorating the processes of light management, charge photogeneration, exciton dissociation, and charge transport. A crucial role in such processes is played by the structure and quality of the interface. The structure of the interface determines the electronic configuration of the conduction and valence band in semiconducting composites, altering the electronic and optoelectronic properties of composite nanostructures. Several strategies can be pursued to modify the interface of composite systems, aiming to maximize energy harvesting and storage, including broadening light absorbance to reduce solar light losses, fastening exciton dissociation and charge injection from the photoactive medium to the charge transporting materials, reducing charge recombination during charge transport and collection at the electrodes. A few examples will be discussed, including selective solar absorbers and composites for hydrogen generation.

3:20 PM

(ICACC-S7-020-2026) Critical role of design components in flexible ZnO-based piezoelectric nanogenerators

G. Yüksel*[1]; E. Suvaci[1]

1. Eskisehir Teknik Universitesi, Materials Science and Engineering, Turkey

Piezoelectric nanogenerators (PENGs) have gained significant attention as sustainable and lead-free power sources, especially for wearable electronics, due to their ability to harvest mechanical energy from the environment. Among various candidate materials, zinc oxide (ZnO) stands out as an environmentally friendly and biocompatible semiconductor with excellent piezoelectric properties. However, the energy conversion efficiency of ZnO-based PENGs is strongly influenced by multiple factors, including morphology, orientation, dopant incorporation, and module design. The size and density of nanowall structures directly affect voltage and current output under mechanical stress, while appropriate dopants can reduce free charge carriers and enhance the piezoelectric response. Furthermore, nanogenerator design and electrode selection are critical for optimizing device performance. In this study, the effects of electrode selection and module design on the output performance of flexible ZnO-based PENGs were systematically investigated. Current-voltage measurements were used to identify the contact mechanism between ZnO nanowalls and various electrode materials. Open-circuit voltage and short-circuit current were measured, and the corresponding power output was calculated. The results highlight the crucial role of electrode material in determining the energy harvesting efficiency of ZnO-based PENGs.

3:40 PM

(ICACC-S7-021-2026) Amorphous solid-electrolyte interface formation driven by solvation regulation on zinc battery anodes

Q. Sun*[1]

1. Institut de Recerca en Energia de Catalunya, Spain

Electrolyte additives are widely recognized as an effective strategy to suppress dendrite growth and parasitic reactions in aqueous zinc-ion batteries (AZIBs). Here, we introduce a $Zn(CF_3COO)_2$ additive that reconstructs the solvation structure and promotes dual anion reduction, thereby inducing the formation of an amorphous hybrid solid-electrolyte interface (SEI) on Zn anodes. The resulting highly amorphous SEI exhibits excellent chemical stability, mechanical robustness, and high Zn_{2+} conductivity, effectively mitigating side reactions and enabling highly reversible Zn plating/stripping. Consequently, the Zn anode delivers ultra-stable cycling and remarkable reversibility, even under high current densities and deep Zn utilization.

4:00 PM

(ICACC-S7-022-2026) Active-site switching in high-entropy phosphides under electric-field regulation for enhanced bifunctional catalysts

R. He*[1]; A. Cabot[1]

1. Institut de Recerca en Energia de Catalunya, Spain

High-entropy materials (HEMs) provide a quasi-continuous spectrum of active sites but their complex compositions pose challenges for rational design. Here, FeCoNiPdWP high-entropy phosphide (HEP) nanoparticles were synthesized through a low-temperature colloidal method and evaluated as bifunctional oxygen evolution and reduction reactions (OER/ORR) catalysts. We demonstrate that their multi-element synergy enables electric-field-regulated active-site switching, which governs surface reconstruction and catalytic behavior. Under OER-relevant electric fields, the HEP surface evolves into a FeCoNiPdW high-entropy oxyhydroxide, where highly oxidized Fe, Co, and Ni dominate activity. Pd and W further modulate electronic structure and field-induced charge redistribution, enabling an OER overpotential as low as 227 mV at 10 mA cm^{-2}. For the ORR, Pd emerges as the most active component, and its electric-field-enhanced d-d coupling with Co and W optimizes electron-transfer pathways, yielding an ORR half-wave potential of 0.81 V with a four-electron process. Aqueous Zn-air batteries assembled with these HEP catalysts deliver a high specific capacity of 886 mAh g_{Zn}^{-1} and operate stably for over 700 hours. This work clarifies element-specific roles in HEMs and establishes an electric-field-modulated strategy for designing next-generation bifunctional oxygen electrocatalysts.

4:20 PM

(ICACC-S7-023-2026) Preparation and in vitro biocompatibility of hydroxyapatite hollow microspheres (Invited)

S. Chen[2]; A. Osaka*[1]

1. Okayama University, Faculty of Engineering, Japan
2. Taiyuan University of Technology, College of Artificial Intelligence, China

Hydroxyapatite is one of the most promising bioceramics because of its excellent biocompatibility and strong osteoconductivity. In this study, we fabricated hollow hydroxyapatite microspheres from gelatin and hydroxyapatite nanoparticles using a water/oil emulsion route, from which the gelatin was removed through calcination. In vitro cytotoxicity evaluation showed that the hydroxyapatite hollow microspheres were biocompatible and exhibited no recognizable cytotoxicity. These hollow microspheres support adhesion and proliferation of cells and have potential as biocompatible cell carriers.

S8 20th Intl Symp on APMT for Structural & Multifunctional Materials & Systems

S8- Advanced and Accelerated Processing of High-Performance Materials I

Room: Coquina B
Session Chair: Koji Morita, National Institute for Materials Science (NIMS)

1:30 PM

(ICACC-S8-016-2026) Towards tough and strong alumina-based ceramics through rapid sintering (Invited)

T. Prötsch[1]; J. Schlacher[1]; I. Kraleva[1]; R. Bermejo*[1]

1. Montanuniversitat Leoben, Materials Science, Austria

Layered ceramics have proved effective against contact damage and thermal shock, associated with the effect of compressive residual stresses and/or textured microstructure against surface crack propagation. In addition, the use of "rapid sintering" non-conventional techniques has made feasible tailoring the size and/or shape of grains in bulk alumina materials. In this study we explore the effect of rapid sintering on the mechanical response of layered ceramics, combining in-plane residual stresses with tailored microstructures in the different layers. Two different layered designs are investigated, sintered using a pressure-less SPS with heating rates of up to 450 °C/min. In a first design, zirconia-toughened alumina (ZTA) is embedded between alumina (EA) layers, in order to generate in-plane compressive residual stresses in the surface and fine-grained microstructure. Biaxial bending tests are performed and compared to rapid sintered and conventionally sintered bulk alumina samples. In a second design, templated alumina (TA) layers are embedded within a fine-grained (EA) alumina matrix to combine the effect of internal compressive residual stresses and crack deflection potential. Selected Herztian contact and thermal shock experiments are performed in the rapid sintered samples. Results are analysed in regard to the microstructural features and crack deflection capability of the embedded textured layers.

2:00 PM

(ICACC-S8-017-2026) Additive manufacturing of glass (Invited)

P. Colombo*[1]; G. Franchin[1]

1. University of Padova, Industrial Engineering, Italy

Glass has played an unquestionable role throughout our lives for over two millennia and remains a pivotal material for various applications including optics, electronics, architecture, jewellery and art. Despite well-established innovations in the realisation of glass components, several technical issues need to be continuously addressed. The difficulty in shaping glass is mainly related to the harsh processing conditions of conventional techniques and the significant challenges in creating transparent and crack-free parts. Moreover, given the sheer variety of applications, there is a growing interest in expanding the design space for optical properties. We worked on the additive manufacturing of pure silica and multicomponent glasses using a variety of technologies, ranging from DLP to UV-assisted DIW and Volumetric Additive Manufacturing (VAM). We employed both colloidal systems and all liquid systems based on the sol-gel approach. Complex shaped, transparent glass parts were obtained, expanding the range of refractive index values that can be achieved with pure silica glass.

2:30 PM

(ICACC-S8-018-2026) Powder-based near-net-shape forming technologies for glass ceramics (Invited)

J. Schilm*[1]; D. Wagner[1]; A. Mannschatz[1]; E. Schwarzer-Fischer[1]; R. Lenk[2]; M. Meegdes[3]; T. Moritz[4]

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2. Rauschert Heinersdorf-Pressig GmbH, Germany
3. Dentsply Sirona, Germany
4. Fraunhofer IKTS, Processes/Components, Germany

In glass-ceramic manufacturing, components are produced from ceramicised glass blocks using mechanical methods. Since no near-net-shape shaping technologies for glass ceramics have been established at a technological level, there are no options for manufacturing complex shaped components in a more resource- and energy-efficient way. powder injection molding and stereolithograpic 3D-printing as near-net-shape processes represent an alternative, through which the production of glass ceramics can be carried out more efficiently. Sintering temperatures of glass ceramics are below 1000C, which means that process heat, post-processing and material losses can be minimised. This contribution addresses the powder-based processing of glass ceramics using stereolithographic 3D printing technology and powder injection moulding, using the example of a low-expansion Zerodur glass ceramic and a high-strength lithium disilicate glass ceramic. The results shown include powder preparation of the parental glass frits, sintering and crystallisation processes, and the characterisation of relevant properties such as phase composition, microstructure formation and strength. Based on a small-format mirror carrier (Zerodur) and a thread guide (lithium disilicate), it is demonstrated that it is possible to produce dense glass-ceramic structures using powder-based processes, exploiting the potential of near-net-shape forming processes.

S8- Advanced and Accelerated Processing of High-Performance Materials II

Room: Coquina B
Session Chairs: Thi Mai Dung Do, Nagaoka University of Technology; Son Nguyen, Kokuritsu Kushiro Kogyo Koto Senmon Gakko

3:22 PM

(ICACC-S8-019-2026) Rapid high-temperature heating of silicon carbide fibers using radio frequency fields

D. Clouse*[1]; S. Panicker[1]; S. Dasari[1]; T. Goto[2]; R. Iuchi[3]; M. Radovic[4]; M. Green[1]

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2. Kureha Corporation, Japan
3. Kureha Corporation, Process Innovation Department, Japan
4. Texas A&M University, Materials Science & Engineering, USA

This presentation examines the application of radio frequency (RF) heating for the high-temperature crystallization of silicon carbide (SiC) fibers, offering a rapid and energy-efficient alternative to traditional furnace heating methods. SiC, an advanced ceramic material, is widely used in applications that require high strength, excellent temperature stability, and good conductivity. In this study, we developed a custom induction coil applicator for integration into a commercially available chamber, enabling RF heating of SiC fibers to high temperatures with minimal radiation exposure. The fibers exhibited significant orientation-dependent heating, achieving heating rates exceeding 10 °C/s when aligned parallel to the electric field. Furthermore, the presence of excess carbon in the fibers was found to significantly influence the RF heating response. This research demonstrates that optimized RF heating can rapidly heat SiC fibers to temperatures exceeding 1400 °C in seconds, reducing both processing time and energy consumption. The findings underscore the potential of RF heating as an effective, non-contact method for manufacturing high-quality SiC fibers, offering benefits in energy savings, cost reduction, and efficiency for industrial applications.

3:42 PM

(ICACC-S8-020-2026) Adopting microwave sintering for 3D-printed complex ceramic geometries

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2. Carnegie Mellon University, USA

Microwave sintering is emerging as an energy-efficient route for ceramic densification, yet its adoption for 3D-printed and intricate geometries remains limited by uneven heating and undesirable hotspots. Here, we combine microwave processing experiments with 2.45 GHz microwave–heat transfer simulations to achieve more uniform sintering of binder-jet 3D-printed Al2O3 geometries. Our process reached ~86 % relative density and ~65-66 % shrinkage with microstructure, α-alumina phases, and mechanical strength comparable to conventionally sintered parts while reducing processing time from 17 hours to only 50 minutes. To overcome hotspot formation at >1500°C and high-power inputs (250 W/min–5000 W/min), we developed a Bayesian optimization-based machine learning framework. The model predicted and mapped 258 high-certainty hotspot zones with ~90 % less computational effort and can be integrated into a reactor feedback loop to adaptively tune microwave power. Our sustainability assessment shows that replacing industrial-scale conventional sintering in North America with our microwave process could save ~372.4 million tonnes of CO2 annually, comparable to the 4-year household emissions of New York City (~368 Mt). These advances in processing, intelligence, and sustainability can accelerate the adoption of microwave sintering in ceramic manufacturing and support the decarbonization of ceramic production.

4:02 PM

(ICACC-S8-021-2026) Microwave-assisted chemical vapor infiltration of SiC-based composites – Results and perspectives of a multifrequency approach

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1. Istituto per i Processi Chimico-Fisici Consiglio Nazionale delle Ricerche Sede Secondaria di Pisa, Dipartimento di Scienze Chimiche e Tecnologie dei Materiali, Italy
2. University of Pisa, Department of Civil and Industrial Engineering, Italy

This contribution aims to describe the state-of-the-art and the developments of the Microwave-assisted Chemical Vapor Infiltration (MW-CVI) processing of SiC-based Ceramic Matrix Composites (CMCs), conducted at the Istituto per i Processi Chimico-Fisici – CNR (IPCF-CNR). First, the concepts behind the design of the MW-CVI pilot-scale reactor of IPCF-CNR will be illustrated, with particular emphasis on its multifrequency capabilities. The MW-CVI of a SiC_f/SiC tube, with a diameter of 10 cm, a height of 12.7 cm, and a wall thickness of 0.3 cm, will be discussed in detail. Starting from a density of 1.39 g/cm^3, the tube was densified up to 1.85 g/cm^3 by means of 50 h of MW-CVI, with an average deposition rate of 0.76 g/h and a reduction of about one order of magnitude of the processing time in comparison to conventional CVI. X-ray computed tomography analyses showed a controlled densification front and a homogeneous porosity reduction, without the crusting issues affecting the traditional processes. The development of techniques for the MW-CVI joining of SiC_f/SiC tubes, aiming at a localized densification of the joint region alone, will be finally illustrated. In conclusion, the MW-CVI production of SiC-based CMCs of industrial interest can provide unique advantages compared to conventional routes, in terms of time and energy savings.

4:22 PM

(ICACC-S8-022-2026) Electrical fields and grain growth of alumina

A. Kazmirsky[1]; R. Marder[1]; W. D. Kaplan*[1]

1. Technion - Israel Institute of Technology, Dept. of Materials Science and Engineering, Israel

Given the reported increase in densification rates of polycrystalline ceramics under external electrical fields, there is considerable interest in utilizing field assisted sintering processes. The question of whether external electrical fields influence grain growth is a significant issue. In this study, we conducted model experiments to explore the influence of external electrical fields (300 V/cm) on the grain growth of dense polycrystalline undoped and Ca-doped alumina at 1600°C. Our findings show a significant increase in grain boundary mobility adjacent to the negative electrode. For alumina annealed without an electrical field, Ca is known to increase grain boundary mobility in an isotropic manner. Under an electrical field, an increase in Ca concentration was observed adjacent to the positive electrode, correlated with a decreased grain boundary mobility. These experiments indicate that Ca reduces grain boundary mobility in alumina, and that oxygen vacancies, which are charge compensating defects when Ca goes into solution in alumina, are responsible for the increased grain growth kinetics. How oxygen vacancies affect the mechanism for grain boundary motion will be discussed.

S11 Advanced Materials and Innovative Processing Ideas for Production Root Technologies

S11- Fundamental materials: mining, particles, bulk, and functional materials and precursors II

Room: Ballroom 3
Session Chair: Sungwook Mhin, Dongguk University

1:30 PM

(ICACC-S11-007-2026) Medical radioacitive isotope production using hot atoms produced in neutron irradiated β-MoO_3 (Invited)

H. Suematsu*[1]; Y. Yang[2]; M. Ngo[3]; T. Kitagawa[1]; Y. Fujita[4]; Y. Takahashi[2]; T. Suzuki[5]; T. Nakayama[1]; T. Do[1]; K. Niihara[6]

1. Nagaoka University of Technology, Extreme Energy-Density Research Institute, Japan
2. Nagaoka University of Technology, Japan
3. National Institute of Advanced Industrial Science and Technology (AIST), Multi-material Research Institute, Japan
4. Nihon Genshiryoku Kenkyu Kaihatsu Kiko, Japan
5. Nagaoka University of Technology, Nuclear Technology, Japan
6. Nagaoka Sutoku Daigaku, Japan

Mo-99 is a parent nuclide of Tc-99m which has been used in medical diagnoses. Most of Mo-99 is produced as a fission product in highly enriched uranium fuel, which is not allowed to construct because of the nuclear security reasons. Instead, by irradiating neutrons on various Mo-98 compounds including MoO_3, production of Mo-99 has been tried. Among the neutron irradiation targets, β-MoO_3 draws interests of researchers because Mo-99 is selectively extracted into water after dispersion of the irradiated β-MoO_3 targets. This phenomenon was explained by the hot atoms of Mo-99 with a high kinetic energy produced by the nuclear reaction to assist the release from the β-MoO_3 target. In this study, temperature and time dependence of extraction rate of Mo-99 in water was measured. At room temperature, 75 % of the produced Mo-99 by the nuclear reaction has been extracted. From the measured activation energies, possible extraction process is discussed.

2:00 PM

(ICACC-S11-009-2026) Surface structure and gas sensing behavior of Nb_2CT_x dependent on synthesis route

A. Okawa*[1]; L. Miao[1]; T. Hasegawa[1]; Y. Xue[1]; S. Yin[1]

1. Tohoku University, Institute of Multidisciplinary Research for Advanced Materials, Japan

MXenes demonstrate significant potential for gas sensing applications, however, detailed mechanisms of sensing behavior remain unclear. This study investigates surface structure control in multilayer (ML) Nb_2CT_x and its impact on gas sensing performance. ML-Nb_2CT_x was synthesized from Nb_2AlC using 3 methods conventional HF etching, hydrothermal in-situ HF etching, and Lewis acid etching with $CuCl_2$ followed by Cu removal using ammonium persulfate solution (APS). Gas sensing tests were conducted on samples prepared by drop-casting powders onto electrodes using ammonia and toluene as target gases. Lewis acid-etched Nb_2CT_x exhibited negative gas response with decreased resistance due to amorphous Nb-O surface layers formed after APS treatment. HF-based synthesis showed positive responses with increased resistance. Lewis acid-etched samples demonstrated positive responses after subsequent HF exposure to remove Nb-O layers, confirming predictable tuning of sensing characteristics through surface modification. These findings reveal that charge carrier regulation may be governed by surface structure rather than bulk properties. The ability to switch response polarity through surface design provides a framework for developing application-specific MXene gas sensors.

2:20 PM

(ICACC-S11-010-2026) Fabrication of ZnO/MXene composites by cold sintering process and investigation their self healing ability at low temperatures

S. T. Nguyen*[1]; A. Okawa[2]; T. Do[4]; Y. Seo[3]; H. Suematsu[4]; T. Nakayama[4]

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2. Tohoku University, Institute of Multidisciplinary Research for Advanced Materials, Japan
3. Osaka University, SANKEN, Japan
4. Nagaoka University of Technology, Japan

Ceramic matrix composites (CMCs) are brittle materials, and cracks can lead to fatal damage. To address this problem, the self-healing ability of some CMCs like Al_2O_3/TiC or Al_2O_3/Ti have been developed and their healing can occurs at 400°C or lower temperatures by utilizing the volumetric expansion due to oxidation of the dispersed particles. In this study, we focus on a MXene material of Ti and C ($Ti_3C_2T_x$). MXenes are easily oxidized, therefore a significantly low self-healing temperature (lower than 300°C) can be expected. However, because MXenes are sensitive to high temperature, conventional sintering methods are not ideal for fabricating MXene composites. In this research, we focused on the cold sintering process (CSP), which allows low-temperature sintering below 300°C. Previously, we successfully fabricated ZnO/$Ti_3C_2T_x$ bulk materials using CSP, achieving a relative density of 70%. Now, we aim to further expand on this achievement by fabricating MXene bulk materials with a relative density 90% or more and realizing low-temperature self-healing composite materials.

S11- Emerging intelligent technologies and Future-oriented techniques in ceramic material engineering

Room: Ballroom 3
Session Chair: Sungwook Mhin, Dongguk University

2:40 PM

(ICACC-S11-011-2026) Application of AI in Japan's Fine Ceramics Industry and PR activities

K. Okano[1]; S. Tsuchiya*[1]

1. Japan Fine Ceramics Association, Japan

Fine ceramics industry in Japan is now expanding and developing. Many fine ceramics companies in Japan, not only producers of ceramics but also raw material suppliers, quality evaluators, market research firms, etc., get together and formulate an association, so that they promote activities to enhance the industry power. That is our "Japan Fine Ceramics Association; JFCA". JFCA activities are as follows: 1. To promote research and development of new technology such as AI and Digital technology, and to apply it to ceramics industry 2. To contribute to standardization in ISO, regarding new evaluation method for fine ceramics or new measurement technology 3. To strengthen international relationship 4. To promote human resource development 5. To promote PR activities Regarding development and application of new technologies, JFCA is developing autonomous Material Informatics driven by big data and AI implemented in new era laboratory. Regarding activities in ISO, JFCA is promoting standardization such as: - testing method for fracture toughness of fine ceramics - testing method for fine ceramics thin films and coatings - method of locating degradation of power module components Regarding enhancement of the worldwide presence of ceramics, JFCA proposed to set the International Day of Ceramics (IDOC). It was set for March 12th every year, to celebrate for current and future prosperity of ceramics society and industry.

3:20 PM

(ICACC-S11-012-2026) Method for 3D-machining of a near-net-shape manufactured ceramic matrix composite aviation turbine structure using a diamond coated milling tool

S. Kleiner*[1]; A. Rösiger[2]; R. Goller[2]

1. Technische Hochschule Augsburg, Faculty of Mechanical Engineering, Germany
2. University of Applied Sciences, Mechanical Engineering, Germany

Ceramic Matrix Composites (CMCs) offer higher heat resistance and lower density compared to nickel-based alloys, enabling increasing efficiency in aviation turbine engines. The as fired surface of carbon-fiber reinforced silicon carbide (C/SiC) lacks sufficient accuracy and surface finish, creating the need for a final machining operation. The machining of C/SiC is difficult because of their heterogenous, anisotropic and brittle properties and is usually conducted by diamond grinding. Milling is a promising new method for machining CMC-materials like C/SiC, increasing material-removal-rate. This work uniquely demonstrates precise, near-net-shape machining of a complex CMC turbine component using a diamond coated ball-nose endmill. This highlights challenges and solutions that go beyond the machining of simple test geometries. The complex, thin-walled shape in combination with an uneven raw surface of the CMC-material limits the quality of traditional tactile location methods. An in-line optical sensor is used to align the toolpaths with the fixtured structure inside the machine. The accuracy, acoustic emission (AE), surface, as well as the milling tool and its wear, are studied. The accuracy and surface finish are not only be dependent on machining parameters but local variations in material properties.

S13 Advanced Ceramics and Composites for Nuclear Fission and Fusion Energy Systems

S13- Chemical compatibility and corrosion

Room: Coquina F
Session Chair: Takaaki Koyanagi, Oak Ridge National Laboratory

1:30 PM

(ICACC-S13-019-2026) Mechanistic understanding of silicon carbide corrosion degradation in nuclear reactor environments (Invited)

J. Xi*[1]; N. Dailey[1]; Y. Xu[1]; W. Leng[1]

1. University of Illinois Urbana-Champaign, Nuclear, Plasma & Radiological Engineering, USA

The global demand for energy underscores the importance of advancing nuclear energy efficiency. Achieving this goal requires structural materials that can withstand increasingly extreme operating conditions in advanced reactors, including elevated temperatures and chemically aggressive environments. Such conditions accelerate degradation processes, threatening material reliability and long-term performance. Addressing these challenges demands both improved materials and a mechanistic understanding of their behavior under extremes. Using examples from our recent research, I present strategies to elucidate and mitigate corrosion degradation in silicon carbide (SiC), a leading candidate for nuclear structural applications. By integrating modeling with experimental techniques, we probe the relationships between microstructure, microchemistry, corrosion, and radiation response. I highlight approaches for designing SiC with enhanced corrosion resistance and examine the synergistic effects of radiation and corrosion on its performance. In addition, I discuss how coolant chemistry control can be leveraged to further improve corrosion resistance. Altogether, these examples demonstrate the critical role of combining modeling and experiments in developing mechanistic insights that inform the design of durable nuclear materials and advance the deployment of advanced nuclear technologies.

2:00 PM

(ICACC-S13-020-2026) Corrosion behavior of SiC-based ceramics in NaCl-$MgCl_2$ molten salt at 650°C

W. Kim*[1]; J. Kim[1]; C. Kim[1]; H. Lee[1]; D. Kim[1]

1. Korea Atomic Energy Research Institute, Republic of Korea

Silicon carbide (SiC) ceramics and composites possess excellent high-temperature mechanical properties, irradiation tolerance, inherent low activation and other superior physical/chemical properties. Because of these outstanding properties, they have been considered as a coating layer for graphite moderator and TRISO particle fuel and as fuel claddings in some designs in the fluoride salt-cooled high-temperature reactor (FHR). In addition, SiC ceramics are also being considered as out-of-core components such as pump bearings in the liquid-fuel chloride salt-cooled reactor. In this study, we investigated the corrosion behavior of SiC ceramics fabricated by different methods such as reaction-bonded, solid-state sintered, and chemically vapor deposited SiCs, in NaCl-$MgCl_2$ molten salt. The corrosion tests were carried out at 650°C for up to 1000 h using an alumina crucible in an Ar atmosphere. Weight changes, microstructures, phase composition, and surface chemistry after corrosion tests were compared between different SiC ceramics. By comparing the corrosion resistance of different SiC ceramics, the current research aims to provide fundamental insights into the suitability of each SiC type for high-temperature molten salt applications.

2:20 PM

(ICACC-S13-022-2026) High-temperature steam oxidation behavior of SiC-based materials for LWRs

M. K. Grosse*[1]; M. Steinbrück[1]; T. Fey[2]; K. Lambrinou[3]

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2. Friedrich-Alexander University Erlangen-Nürnberg, Department Material Science and Engineering, Germany
3. University of Huddersfield, School of Computing and Engineering, United Kingdom

This work reports on the high-temperature steam oxidation behavior of SiC-based materials tested in the HORIZON SCORPION project. Tests were conducted on SiC/SiC composites using gas flow with variable steam (H_2O) to hydrogen (H_2) ratio at 1700°C. Moreover, the steam oxidation behavior of porous SiC was compared to that of dense SiC at 1600°C. As porosity cannot be eliminated from the matrix of SiC/SiC composites produced by CVI (chemical vapor infiltration) of SiC fibers, the steam oxidation behavior of porous SiC merits further investigation as function of pore size and connectivity. Hydrogen – a byproduct of steam oxidation – cannot be rapidly transported away from reacting surfaces (cracks, pores), resulting in a local increase of its concentration. This work revealed a transition from passive to active oxidation at 1700°C using a H_2-to-H_2O molar ratio between 1 and 5 (partial H_2 pressure in the 50-83 kPa range). The effect of open porosity on the reaction rate was studied in pure H_2O and a H_2-to-H_2O molar mixture of 5:1 at 1600°C. Porous SiC reacted orders of magnitude faster than dense SiC (i.e., 300x faster in pure steam and 30x faster in the H_2/H_2O mixture). The higher reaction rate was caused by the larger surface area of porous SiC ceramics as well as by the transition from passive to active oxidation due to the higher H_2 concentration inside the open pore structure.

S13- Nuclear fuel R&D

Room: Coquina F
Session Chair: Nedim Cinbiz, Oak Ridge National Laboratory

2:40 PM

(ICACC-S13-023-2026) Innovative processes for MOX fuel fabrication (Invited)

L. Ramond*[1]; F. La Lumia[1]; F. Lebreton[1]; G. Bernard-Granger[1]; C. Pagnoux[2]; M. Roucayrol[1]; R. Caprani[1]; J. Martinez[1]; P. Martin[1]

1. CEA, DES, ISEC, DMRC, Université de Montpellier, France
2. Institut de Recherche sur les Ceramiques, France

The current industrial manufacture of UO_2-PuO_2 MOX fuel pellets is carried out by a dry route process to prepare dense samples (~95%Dth). Part of our innovative research involves proposing fuels with specific microstructures, such as MOX with controlled porosity (>10 vol%) to improve fission gas release during irradiation or MOX simulating irradiated fuels (SIMMOX) by specific incorporations of elements during milling to study the separated effect of fission products (soluble, metallics, oxides) on fuel properties. On the other hand, wet innovative processes have been investigated to limit powder dissemination, to improve the flowability of the UO_2-PuO_2 powder, or to improve the homogeneity of U/Pu. Among these processes, Freeze-Granulation has been developed and performed on a concentrated, water-based UO_2-PuO_2 powder suspension and on a nitric solution containing U and/or Pu cations. The liquid is atomized into small droplets that are instantly frozen in liquid nitrogen. After freeze-drying, a granulated powder is obtained. A calcination step is required for the solution route, to convert nitrate granules to oxides. For both suspensions and solutions, the good pressability of the granulated powder leads to the formation of dense (D_{rel}>95%) and homogenous pellets by uniaxial pressing and sintering. The freeze granulation of U/Pu nitric solutions provides a remarkably homogeneous distribution of U/Pu elements.

3:30 PM

(ICACC-S13-025-2026) Development status of candidate burnable absorbers for i-SMR in Korea

Y. Na*[1]; S. Ha[1]; C. Kim[1]; K. Lim[1]; Y. Kim[1]

1. KEPCO NF, Republic of Korea

The Innovative Small Modular Reactor (i-SMR), currently under development in Korea, has adopted boron-free operation in the primary reactor coolant and a 24-month long cycle as its Top-Tear Requirements (TTR) design. In the absence of soluble boron, the core reactivity of the i-SMR must be controlled solely by control rods and burnable absorbers. To address this challenge, a government-supported program involving industry, academia, and research institutes is developing burnable absorber for i-SMR. This study introduces candidate materials: a metal-oxide-based gadolinia absorber (Highly Intensive Gadolinia Burnable Absorber, HIGA) and UO_2 pellets with high Gd_2O_3 content. In particular, HIGA, composed of Gd_2O_3 diluted with hydration-resistant oxides such as Al_2O_3 or ZrO_2, mitigates hydration issues observed in conventional absorbers and enables effective reactivity control for long-cycle i-SMR operation. Also, UO_2 pellets with the high-content Gd_2O_3 are burnable absorber in which the Gd_2O_3 content is added up to 17 wt.%, and it has a great advantage in commercial compatibility as it can be manufactured by applying the existing commercial process and quality system as is without changing. The objective of this study is to describe the current development status of candidate burnable absorber for boron-free operation in the i-SMR, and to introduce the results of out-of-pile tests and future plans.

3:50 PM

(ICACC-S13-026-2026) The results of preliminary fabrication of high content Gd_2O_3 added UO_2 pellet by AUH mixing process

C. Min Young*[1]; Y. Na[1]; S. Ha[1]; M. Ju[1]; K. Lim[1]

1. Korea Nuclear Fuel Co Ltd, ATF development Department, Republic of Korea

More than 80 Small Modular Reactors (SMRs) are under development worldwide. In Korea, an innovative SMR (i-SMR) is being designed with 24-month operation cycles and without soluble boron, requiring advanced burnable absorber (BA) technology. High Gd_2O_3–UO_2 fuel is a promising BA candidate, but conventional fabrication is limited to ≤10 wt.% Gd_2O_3 due to poor homogeneity and low sinterability. This study applied the Ammonium Uranate Hydrate (AUH) mixing process to fabricate UO_2 pellets with higher Gd_2O_3 content. AUH mixing improves powder uniformity at the molecular level, enabling enhanced densification. Pellets containing up to 20 wt.% Gd_2O_3 were produced, and their grain size and thermal properties were evaluated. Compared with conventional dry-mixed pellets, AUH-derived fuels exhibited superior Gd distribution, improved grain growth, and higher thermal conductivity. These results demonstrate the feasibility of AUH processing for producing high-content Gd_2O_3–UO_2 fuels with improved microstructural and thermal performance, supporting advanced SMR fuel design.

S14 Crystalline Materials for Electrical Optical and Medical Applications

S14- Semiconductor and electronic material II

Room: Ballroom 4
Session Chair: Romain Gaume, University of Central Florida

1:30 PM

(ICACC-S14-017-2026) Crystals and substrates for next-generation oxide semiconductor devices (Invited)

M. Bickermann*[1]; Z. Galazka[1]; A. Popp[1]; A. Fiedler[1]; C. Guguschev[1]; R. Blukis[1]; S. Ganschow[1]; T. Schröder[1]

1. Leibniz-Institut fur Kristallzuchtung im Forschungsverbund Berlin eV, Oxides and Fluorides, Germany

The growth of oxide single crystals from the melt at high temperatures is key to enable novel wide band-gap oxide semiconductor technology. We developed 2-inch diameter gallium oxide (β-Ga_2O_3) bulk crystals grown from melt by the Czochralski method. Recently, we extended our research to develop the corresponding ternary compound β-$(Al_xGa_{1-x})_2O_3$ (AlGaO) that will allow for band-gap tuning and electron confinement. While the monoclinic structure is retained up to x = 0.4, electrical conductivity in Si doped samples deteriorates for x > 0.15, and thermal conductivity suffers even from low amounts of aluminum due to impurity scattering. Rutile GeO_2 is another novel semiconductor (bandgap 5.0–5.5 eV) with promising properties for power electronics applications. We prepared first bulk single crystals with good structural quality and high electrical conductivity when lightly doped with Sb. However, the bulk crystal growth is exceedingly difficult due to high viscosity of the melt, glass formation, and a phase transition. Thus, we utilized alkaline carbonate fluxes. Finally, $BaSnO_3$ is considered an oxide with 2DEG formation. As $BaSnO_3$ single crystals are very difficult to grow in the required size, we developed bulk growth of the lattice-matched compounds $LaInO_3$, Ba_2ScNbO_6 and (Nd,La)(Lu,Sc)O_3. However, the very high melting temperature of these compounds (about 2150°C) makes preparation challenging.

2:00 PM

(ICACC-S14-018-2026) Realization of flexible high-mobility transparent conductive films using photo-crystallization techniques and their device applications (Invited)

J. Nomoto*[1]; T. Tsuchiya[1]

1. National Institute of Advanced Industrial Science and Technology (AIST), Japan

Light irradiation techniques, which control thermal and chemical effects via wavelength and pulse width, enable device fabrication where conventional high-temperature processes are unsuitable. By optimizing precursor deposition and irradiation, we achieved functional oxide thin films on polymer substrates. This study develops flexible, high-mobility transparent conductive films through photo-induced solid-phase crystallization. Hydrogen and cerium co-doped indium oxide (ICO:H) shows carrier mobility exceeding 100 cm^2/Vs, significantly higher than ITO (<40 cm^2/Vs). Its lower carrier density enhances near-infrared transparency, making it ideal as a window electrode for solar cells. However, crystallizing amorphous precursors at ~150–200 °C is incompatible with polymer substrates, such as PET. To overcome this, we used KrF excimer laser irradiation. By tuning precursor and irradiation conditions and managing thermal transfer and expansion mismatch to suppress micro-cracks, we fabricated flexible transparent conductive films with record mobility of 133 cm^2/Vs using reactive plasma deposition. These films are expected to serve as window electrodes for next-generation solar cells, as well as electrodes and heaters for advanced sensors supporting autonomous driving.

2:30 PM

(ICACC-S14-019-2026) Advanced characterization of Gallium nitride wide-bandgap semiconductors for next-gen power electronics (Invited)

A. Clausner*[1]; C. Corley-Wiciak[2]; M. Reisinger[3]; C. Chisholm[3]; A. Tailor[4]; M. Legros[5]; A. Guitton[6]

1. Fraunhofer-Institut fur Keramische Technologien und Systeme IKTS, Germany
2. ESRF, France
3. Kompetenzzentrum Automobil- und Industrieelektronik GmbH, Austria
4. Infineon Technologies AG, Austria
5. Centre d'Elaboration de Materiaux et d'Etudes Structurales, France
6. Université de Lorraine – CNRS – Arts et Métiers Institute of Technology – LEM3, France

Gallium nitride (GaN) and Silicon carbide (SiC) gained increased importance in the field of electronics as they are used as the semiconductor materials for new wide-bandgap power electronics technologies. To that they are key innovation materials of next-generation energy, mobility, and industrial technologies. Compared to silicon as the leading semiconductor substrate, e.g. GaN has a much higher dislocation density. One key to master GaN power electronics is to characterize and understand these dislocations, their distribution, as well as their types. Most importantly in that regard is enabling of the characterization and understanding of the sub-set of electrically active dislocations, which potentially can alter the functionality of the GaN devices. In order to achieve this deeper understanding, novel characterization techniques have been developed based on Synchrotron-based techniques as well as electron probe-based techniques such as SEM and TEM. One highlight presented will be an innovative nano-second time-resolved piezoelectric strain response mapping of a GaN-based high electron mobility transistor using a stroboscopic Synchrotron-based microscopy technique. The research presented was done in the frame of the HEU project AddMorePower.eu.

3:20 PM

(ICACC-S14-020-2026) SiGe nanocrystalline thermoelectric material synthesis (Invited)

M. Zughbi*[1]; K. Anderson[2]; J. Wollmershauser[2]; B. Feigelson[2]

1. Lehigh University, Materials Science and Engineering, USA
2. US Naval Research Laboratory, USA

Thermoelectric materials offer a promising avenue for efficient heat recovery in high-temperature environments, and optimizing their performance is key for effective applications in waste heat recovery. This work aimed to develop high-efficiency, high-temperature SiGe thermoelectric materials starting with the synthesis and optimization of mechanically alloyed, SiGe doped nanopowders. The study employed environmentally-controlled, high-energy ball milling to fabricate SiGe nanopowders via simultaneous alloying, grain size reduction, and doping. Additional efforts were made to increase homogenization of the nanopowder through the use of process control agents (PCAs) and ball milling tooling optimization. Environmentally controlled -pressure assisted sintering was performed using a split sphere, high pressure apparatus to achieve a fully dense (>99%) nanocrystalline semiconductor. Nanopowders and bulk materials were characterized through X-ray diffraction (XRD) and scanning electron microscopy (SEM). Thermal properties of bulk specimens including thermal diffusivity and heat capacity were measured using laser flash analysis (LFA), while electrical conductivity and Seebeck coefficient were measured with a thermoelectric characterization instrument.

S15 10th International Symposium on Additive Manufacturing and 3-D Printing Technologies

S15- Material extrusion/fused deposition modeling

Room: Ponce de Leon
Session Chairs: Eric Faierson, Iowa State University; Andraz Kocjan, Jozef Stefan Institute

1:30 PM

(ICACC-S15-017-2026) Rapid radiation sintering of additively manufactured alumina ceramics (Invited)

A. Kocjan*[1]; M. Krizaj[2]; A. Vishwakarma[1]; A. Ivekovic[1]

1. Jozef Stefan Institute, Slovenia
2. Medical Faculty, University of Ljubljana, Slovenia

Sintering is high-temperature process essential for the final consolidation of ceramics. Typically, the densification is associated with grain growth promoted by a slow solid-state diffusion, where dense and fine-grained microstructures are targeted for superior mechanical properties. Although advanced sintering technologies, such as spark plasma sintering (SPS), flash-, ultra-high temperature- and cold-sintering processes have all succeeded in the development of refined microstructures, they are bound to complex, interrelated effects of thermal transfer phenomena, applied electric current and/or mechanical pressure, thus being limited to simple, planar-based geometries. This poses a challenge for full exploitation of ceramic additive manufacturing (AM) technologies offering geometrical complexity. Here, pressureless SPS (pSPS) was exploited for rapid radiation sintering of larger-sized complex-shaped alumina tetrahedra additively manufactured by the fused filament fabrication (FFF) process. Tetrahedra geometries with strut thickness of 5 mm, whereas the edge lengths varied from 15 mm to 40 mm, were fabricated. The objective was to study the effect of increased heating rates (33, 100 and 300 K/min) and short dwell times, without applying external pressure (and current), on the sintering outcome (homogeneity), densification, microstructural evolution and mechanical properties of as-printed tetrahedra.

2:00 PM

(ICACC-S15-018-2026) Effect of processing parameters on the mechanical behavior of 3D printed ceramic particulate reinforced polylactic acid composites

L. R. Alexander-Roy*[1]; M. C. Halbig[2]; M. Ranaiefar[2]; M. Singh[3]

1. Case Western Reserve University, USA
2. NASA Glenn Research Center, USA
3. Ohio Aerospace Institute, USA

New composite materials are emerging which expand additive manufacturing capabilities and enable new applications of traditionally processed materials. The multi-phase microstructure combined with the complex internal geometry of additively manufactured parts creates unique behavior, and potentially new capabilities. Additionally, these materials can be densified to create metal, ceramic, and glass parts with geometries typically not achievable by traditional processes. This work explores fused-filament fabrication of two types of ceramic particulate-PLA composites, a lunar basalt simulant, and borosilicate glass. To elucidate the process-parameter relationship of composite filaments, mechanical testing was conducted against a pure polylactic acid baseline material. Test specimens were created by fused-filament fabrication with minimal post-processing, and compression and tensile testing were conducted with digital image correlation (DIC). Microscopy was used to analyze the microstructure of the specimens before and after testing. The composite materials' strength is more sensitive to infill voids than the pure PLA. The elastic modulus of the composite

specimens can be tailored with certain print parameters and spherical filler material. The relationship of specimen strength and print orientation in the composite materials will be presented.

2:20 PM

(ICACC-S15-019-2026) Fused filament fabrication and characterization of silicon carbide and zirconium silicate particulates Reinforced Polylactic Acid (PLA) Composites

A. P. Gyekenyesi*[1]; M. Ranaiefar[2]; M. C. Halbig[2]; M. Singh[3]

1. Cleveland State University, USA
2. NASA Glenn Research Center, USA
3. Ohio Aerospace Institute, USA

Fused Filament Fabrication (FFF) is an additive manufacturing technique that constructs parts by extruding material layer by layer. It offers advantages such as rapid prototyping, cost effectiveness, and the ability to produce complex geometries. This study investigates the mechanical behavior of composite filaments composed of silicon carbide or zirconium silicate particulates embedded in a polylactic acid (PLA) matrix, fabricated via FFF. Pure PLA specimens were also printed and tested to serve as a baseline. A Design of Experiments (DOE) methodology was employed to evaluate the influence of key printing parameters on mechanical properties, including Young's modulus, yield strength, and ultimate strength. Microstructural analysis was performed on as printed specimens using scanning electron microscopy (SEM). For compression testing, the parameters studied were infill percentage, number of shells, and print orientation. For tensile testing, the parameters included layer height, number of shells, and infill angle. Results indicated that infill percentage had the most significant impact on compressive properties, while layer height was the dominant factor in tensile performance. These findings provide insights into optimizing FFF process parameters for ceramic particulate reinforced polymer composites.

2:40 PM

(ICACC-S15-020-2026) Effect of continuous carbon fiber architecture on mechanical properties of additively manufactured nylon composites

A. Buswell*[1]; M. Singh[2]; M. Ranaiefar[3]; M. C. Halbig[3]

1. University of Connecticut, USA
2. Ohio Aerospace Institute, USA
3. NASA Glenn Research Center, USA

Recent advancements in additive manufacturing (AM) technology have provided the means for fabricating complex material systems via fused-filament fabrication (FFF) such as polymer-matrix composites (PMCs). Advanced AM printers and print filaments are capable of embedding layers of continuous fibers into PMC specimens. The effect of print parameters, such as fiber angle, on mechanical properties is vastly underrepresented in the literature. This study investigates the effect of angle variation at which continuous carbon fiber in an Onyx matrix is deposited in fiber architectures of 0/0, 0/90, and +45/-45. As-received print filaments were characterized via TGA, DSC, and microscopy. Data from mechanical testing under compression and tension was correlated with material characterization of the print filaments as well as microscopy of printed composite test specimens. Failure behavior was also compared to microscopy and digital image correlation (DIC). It was found that the highest strength was achieved when fibers were deposited in the direction of mechanical loading under both compression and tension. However, this fiber architecture was susceptible to premature failure due to limitations imposed by the 3D printer.

3:20 PM

(ICACC-S15-021-2026) Fused filament fabrication additive manufacturing and characterization of alumina and zirconia ceramics

M. Ranaiefar*[1]; M. Singh[2]; M. C. Halbig[1]

1. NASA Glenn Research Center, USA
2. Ohio Aerospace Institute, USA

Additive manufacturing of structural ceramics offers new opportunities for lightweight, net-shape fabrication of high-performance components. In this study, alumina and zirconia ceramics were fabricated using fused filament fabrication (FFF) with varied infill percentages and infill patterns to assess the influence of processing parameters on mechanical performance. Printed green bodies underwent chemical de-binding followed by thermal treatment for sintering. Microstructural characterization of cross-sections was performed to assess differences in porosity content and distribution as a function of infill strategy. Flexural properties were evaluated using four-point bend testing. The relationship between infill architecture, infill percentage, and flexural strength is discussed, highlighting both the opportunities and challenges in processing ceramics via FFF. These findings provide guidance for optimizing print parameters to enable reliable use of additively manufactured alumina and zirconia in extreme environment applications.

S15- Applications of AM materials and components

Room: Ponce de Leon
Session Chair: Michael Halbig, NASA Glenn Research Center

3:40 PM

(ICACC-S15-022-2026) Processing of metal-ceramic composites using additive manufacturing (Invited)

A. Bandyopadhyay*[1]

1. Washington State University, Mechanical and Materials Engineering, USA

The fabrication of metal matrix composites remains a longstanding challenge due to various limitations in conventional and laser-based additive manufacturing (AM) methods. We have used laser-based powder directed energy deposition (DED), powder bed fusion (PBF), and wire-arc DED (Arc-DED) to process ceramic powder reinforced metal matrix composites. In most of our work, we have used titanium and aluminum alloys as matrices, and various nitrides, borides, phosphates, and carbides as reinforcements. We have also focused on gradient compositional variations for offering site-specific properties using AM. Using Ti-alloys, we have used B4C, NbC, boron nitride, TiB/TiB2, and calcium phosphates as reinforcements. Some of these ceramics reacted in situ and formed new compositions during processing, while others remain non-reactive. In aluminum alloys, we have used B4C and SiC as reinforcements. We have measured mechanical properties, microstructural variations, oxidation resistance, and wear-induced damage under fully immersed conditions using flat-on-disc fixtures in these compositions. The presentation will focus on processing-related challenges using different AM platforms for these multi-material structures and the influence of various ceramic reinforcements on structure-process-properties relationships.

4:10 PM

(ICACC-S15-023-2026) Additive manufacturing of large, complex ceramic components (Invited)

P. Karandikar*[1]; B. Erwin[1]; R. Albano[1]; T. Sensenig[1]

1. Coherent Corp, Additive Manufacturing, USA

Ceramic components are used in a variety of markets such as semiconductor capital equipment, armor, wear, thermal management, automotive, nuclear, and chemical process equipment. Traditionally, these are made by preforming (slip casting, injection molding, pressing, pressure casting), debinding, CNC green machining, and firing. In the case of reaction bonded ceramics (SiC, B4C, diamond, etc.), the traditional firing process is replaced with melt infiltration with silicon (also called reaction bonding). The traditional process has several limitations such as high tooling costs, inefficient use of raw materials, long prototyping times, design/shape limitations, and high machining/manufacturing costs. Additive manufacturing can overcome these limitations allowing fast, cost effective manufacturing of intricate components. In this work, we will demonstrate the use of binder jetting and stereo lithography (SLA) to make complex ceramic components with lengths as big as 0.75m (30 inches) and features as fine as 1 mm or less. First, the ability to achieve equivalent material properties by AM is shown. Next, several prototype component fabrication is demonstrated along with their validation with respect to application specific requirements. Finally, we will demonstrates the readiness of this technology for serial production.

S17 Advanced Ceramic Materials and Processing for Photonics and Energy

S17- Advanced and nanostructured materials for photo-voltaics and solar fuels II

Room: Flagler C
Session Chair: Giovanni Fanchini, University of Western Ontario

1:30 PM

(ICACC-S17-014-2026) Solution-processed perovskite photovoltaics (Invited)

M. Saidaminov*[1]

1. University of Victoria, Chemistry, Canada

Lead halide perovskite solar cells have achieved remarkably rapid efficiency gains, owing to their defect tolerance, simple fabrication, and long charge-carrier diffusion lengths. However, their development has largely relied on toxic solvents, non-scalable fabrication methods, and polycrystalline materials. In this talk, I will present our recent advancements toward overcoming these challenges, including the scalable fabrication of perovskite solar modules using green solvents, as well as the development of high-performance single-crystal perovskite solar cells.

2:00 PM

(ICACC-S17-015-2026) Controllable growth of 2D metal thiophosphates for photo- and electrochemical energy conversion (Invited)

M. G. Sendeku*[1]

1. Lulea Tekniska Universitet Institutionen fo Teknikvetenskap och Matematik, Sweden

On account of their unique crystal chemistry, tunable electronic, optical, and catalytic properties, two-dimensional (2D) metal thiophosphates have garnered tremendous attention[1]. However, the controlled growth of these materials with well-defined morphology, crystallinity, and layer thickness remains a significant challenge that limits the exploration of their full potential for energy conversion and storage applications. In this talk, I will present recent progress on the controllable synthesis of 2D metal thiophosphates, highlighting strategies to tailor crystal growth through a novel space-confined chemical vapor conversion process. Particular emphasis will be given to the role of oxide and sulfide precursors, growth parameters in shaping nanosheet formation versus bulk production. The resulting structure–property relationships will be discussed in the context of photo- and electrochemical energy conversion, including hydrogen evolution[2], organic oxidation[3, and biomass hydrogenation[4] reactions. Moreover, the most important phenomenon related to the surface reconstruction of these materials under operating conditions will be highlighted. By establishing design principles for morphology and interface control, this work paves the way for using 2D metal thiophosphates as next-generation catalysts and photoactive materials for sustainable energy technologies.

S17- Advanced and nanostructured materials for photonics, electronics and sensing

Room: Flagler C
Session Chairs: Farid Akhtar, Lulea University of Technology; Fiorenzo Vetrone, INRS, Université du Québec

2:30 PM

(ICACC-S17-017-2026) Specialty glass materials and their processing for functional surfaces, biophotonics, and sensing (Invited)

D. Menon[1]; P. Kalai[1]; M. Nagar[1]; S. Russo[1]; J. T. Pandayil[2]; N. Russo[1]; J. Lousteau[3]; N. Boetti[2]; D. Janner*[1]

1. Politecnico di Torino, DISAT, Italy
2. Fondazione LINKS, Italy
3. Politecnico di Milano, Italy

The development of specialty glasses has opened new frontiers in different fields: biophotonics, lasers, telecommunications, and functional surfaces to name a few. For instance, bioresorbable glasses are enabling the internalization of optical techniques traditionally limited to extracorporeal applications. These materials offer a viable alternative to conventional silica-based fibers, particularly for in vivo diagnostics and therapeutic interventions. In parallel, functionalization of glass fiber surfaces with coatings and nanomaterials has led to highly sensitive optical sensors, driving advances in point-of-care and bedside diagnostics. Laser processing plays a pivotal role in this context—not only for precision structuring and device fabrication, but also as a scalable tool for producing functional surfaces. Such surfaces are critical for applications including biofouling prevention and superhydrophobic performance. Additionally, laser-assisted synthesis of nanoparticles directly from bulk glasses offers a novel route to tailor properties and support scalable production. This presentation provides a comprehensive overview of bioresorbable glasses and laser processing strategies, from current research trends to future directions in material design, functionalization, and fabrication.

3:20 PM

(ICACC-S17-008-2026) Sustainable organic and inorganic materials for clean energy applications (Invited)

R. Naccache*[1]

1. Concordia University, Chemistry and Biochemistry, Canada

Sustainable carbon materials have garnered significant interest with tunable surface chemistry, simple low-cost synthesis. Reported works have focused on catalytic applications but their investigation as heterogeneous catalysts for the production of biofuels such as biodiesel remains unexplored. Biodiesel fuel production remains one of the most promising alternatives to non-renewable fossil fuels such as conventional oil and diesel. However, many challenges persist in its production related to tedious purification processes and high cost. Thus, the need for the development of novel, sustainable, and metal-free heterogeneous catalysts is required. Here, we show that these sustainable catalysts can trans/esterify the conversion of oils to biofuels with sustained catalytic efficiency for at least five reaction cycles. Our second and third-generation catalysts allow for a significant reduction of reaction temperature and operate at ambient pressure without a significant increase in the catalyst loading. Our work now tackles waste and inedible oils in order to reduce the overall cost of the process. More recently, our group has focused on the development of ternary chalcogenides for their integration in photovoltaic devices. We have focused on their synthesis using Design of Experiments in order to develop reliable synthesis methods that allow us to dial in specific physico-chemical and optical properties.

3:50 PM

(ICACC-S17-019-2026) Microprocessed piezoelectric actuators for tunable quantum photonics (Invited)

A. Rastelli*[1]

1. Johannes Kepler Universitat Linz, Insitute of Semiconductor and Solid State Physics, Austria

In the realm of quantum technologies, novel sources of quantum light—such as single photons and entangled photon pairs—play a key role. These sources find applications in secure quantum communication as well as in photonic-based quantum simulation and computing. Among the various candidates, quantum dots, which are semiconductor nanostructures, are currently regarded as the most promising due to their overall performance. A major challenge, however, arises from ensemble inhomogeneities caused by stochastic processes during fabrication. A powerful strategy to overcome this obstacle and move toward scalable devices is post-fabrication strain engineering. In this talk, I will present how this approach becomes feasible by integrating quantum dot devices with specially designed strain actuators made of laser-microprocessed ceramic or crystalline piezoelectric substrates. The resulting hybrid semiconductor–piezoelectric devices enable, e.g., the realization of wavelength-tunable sources of entangled photons, a crucial component for future quantum networks.

S18 Ultra-High Temperature Ceramics

S18- Response in extreme environments (irradiation, ultra-high temperature, etc.) II

Room: Coquina A
Session Chair: Shen Dillon, University of California, Irvine

1:30 PM

(ICACC-S18-018-2026) Ultra high temperature interfacial and bulk creep and deformation: In situ experiments and new models (Invited)

S. J. Dillon*[1]

1. University of California, Irvine, USA

Predicting high temperature creep and deformation is valuable for the design of high temperature materials. Unfortunately, developing and testing bulk materials is experimentally laborious. Small-scale experiments can be used to isolate lattice and grain boundary contributions to creep and plasticity and inform models for polycrystalline response. Laser heating and mechanical loading are combined with in situ TEM imaging to characterize creep. This work emphasizes the role of dislocation and disconnection nucleation in the creep response of high temperature ceramics, along with traditional considerations of Coble and Nabarro-Herring creep. It is demonstrated how the small-scale experiments, when combined with appropriate microstructural models, can predict the bulk response and deformation mechanism maps well.

2:00 PM

(ICACC-S18-019-2026) Building the Hypersonic Materials Workforce: A comprehensive approach to national defense training (Invited)

A. Engen*[1]

1. The American Ceramic Society, USA

The American Ceramic Society (ACerS) and the United States Advanced Ceramics Association (USACA) have been awarded a two-year Department of Defense extension for their “Professional Development for Hypersonic Materials” program, building on the January 2024 launch under DOD’s Industrial Base Analysis and Sustainment Program. This talk will outline the extension program’s three primary objectives: reaching new industry and agency audiences, increasing visibility of hypersonic materials workforce development, and introducing K-12 students to materials science career opportunities. The expanded initiative features 18 planned activities over two years. By combining professional development for current engineers with outreach initiatives, this program represents a comprehensive, long-term strategy to ensure leadership in hypersonic materials science for decades to come. Following the presentation, we invite audience participation to help expand our network of experts and training partners: 1.) Do you know subject matter experts in hypersonic materials who would be excellent instructors for our courses? 2.) Are you aware of facilities at prime contractors, DOD sites, or research institutions that could host regional training sessions?

2:30 PM

(ICACC-S18-020-2026) Advancements and implications in the development of oxidation protective coatings for ZrB_2-based UHTC materials

R. Naraparaju*[1]; J. Foerster[2]; P. Mechnich[1]

1. Institute for Frontier Materials on Earth and in Space, Germany
2. DLR - German Aerospace Center, Institute of Materials Research, Germany

The oxidation of ZrB_2 based Ultra-High Temperature Ceramics (UHTCs) leads to the formation of liquid B_2O_3 and porous ZrO_2. Above 1500°C, increased evaporation of B_2O_3 limits the long-term applicability of ZrB_2. This study explores, for the first time, the use of overlay coatings to enhance oxidation resistance. HfO_2 and Gd_2O_3 coatings were deposited via magnetron sputtering, while Al_2O_3 coatings were applied using reaction bonded aluminum oxide methods. High-temperature oxidation tests were conducted at temperatures up to 1700°C for various durations. The application of protective coatings significantly improved the oxidation resistance of ZrB_2. The underlying oxidation mechanisms were identified as: (1) formation of a liquid phase solution involving B_2O_3 that reduces its evaporation rate, and (2) densification of the ZrO_2 scale via liquid phase sintering or solid solution formation. These findings provide critical insights into coating strategies for enhancing UHTC performance under extreme conditions.

S18- Processing-microstructure-property relationships of existing or new systems

Room: Coquina A
Session Chair: Kun Wang, Alfred University

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(ICACC-S18-021-2026) MXene reinforced ultra-high temperature ceramics

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Polymer-derived ceramics (PDCs) are promising for ultra-high temperature applications but are limited by intrinsic brittleness. This study investigates the reinforcement of silicon carbide (SiC)-based PDCs using two-dimensional MXenes, including Ti_3C_2 and $TiVCrMoC_3$ MXenes, to enhance mechanical performance. Ceramic composites were synthesized using a SMP-10 matrix and various MXene concentrations via pyrolysis. Spark Plasma Sintering (SPS) was employed to fabricate dense composites. The unique layered structure and nanoplasticity of $TiVCrMoC_3$ MXene facilitate toughening mechanisms such as crack deflection, bridging, and delamination. These enhancements are attributed to effective stress transfer and strong MXene-matrix interfacial bonding. Notably, composites with 3 wt% $TiVCrMoC_3$ MXene exhibited the most significant improvements, achieving a 55.3% increase in modulus and a 49.0% rise in fracture toughness. Transmission electron microscopy (TEM) provided insights into the interfacial bonding and microstructural evolution responsible for the enhanced performance. This work highlights the potential of MXenes as high-performance reinforcements for ceramic systems in extreme environments.

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(ICACC-S18-022-2026) Thermodynamic analysis of metal segregation in two metal boride-carbide ceramics containing V with Cr, Hf, Ti, or Zr

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Dual-phase carbide-boride ceramics in different V-Me (Me = Cr, Hf, Ti, and Zr) binary systems were synthesized by boro/carbothermal reduction and densified by spark plasma sintering. Thermodynamic analysis was used to evaluate the influence of composition on the phase stability and metal segregation between phases, along with the effects on microstructure and hardness. Pairing V with Hf, Ti and Zr consistently formed a boride and a carbide phase, while the Cr-V system formed a monoboride phase and a carbon-deficient carbide. Metal segregation trends depended on composition. V preferentially segregated to the carbide phase in the Ti-V and Cr-V systems, while it was enriched in the boride phase in Hf-V and Zr-V systems. Hardness measurements showed a higher hardness for the Ti-V sub-stoichiometric system (27.7±0.9GPa at 9.8N), while Cr-V sub-stoichiometric was the lowest (18.8±0.3GPa at 9.8N). Notably, in the Zr-V system, thermodynamic predictions based solely on standard Gibbs energy deviated from experimental observations. However, when combined with first-principles calculations, the predictions aligned more closely with experimental observations. These results suggest that elemental distribution between phases results from complex interactions beyond simple Gibbs energy minimization, especially in systems with strong carbide-to-boride ratio dependence.

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(ICACC-S18-023-2026) Synthesis and densification of TaB_2-HfB_2 binary solid solution powders

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1. Rutgers The State University of New Jersey, Material Science and Engineering, USA
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Ultrahigh-temperature ceramics (UHTCs), including tantalum diboride (TaB_2) and hafnium diboride (HfB_2), are distinguished by their exceptional thermal stability and mechanical strength, making them prime candidates for applications in hypersonic aerospace systems, nuclear energy technologies, and advanced tooling. Despite considerable research efforts, the development of UHTC composites continues to face significant challenges, particularly the requirement for high-purity precursor powders with well-controlled particle size distributions. Furthermore, the absence of commercially available multicomponent boride powders represents a critical limitation that hinders the broader advancement and practical implementation of these materials In this study, guided by CALPHAD thermodynamic modeling, solid solution ($TaxHf_1$-x)B_2 powders were successfully synthesized by boro/carbothermal reduction and densified by Spark Plasma Sintering. The results of the study show that submicron solid solution powders with low oxygen content can be produced. Hence, this synthesis route offers a very effective way to create the high quality precursor powders essential for making UHTCs.

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(ICACC-S18-024-2026) Influence of Gd_2O_3 and Sm_2O_3 rare earth oxides on the densification behavior and thermal diffusivity of ZrB_2–SiC composites

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1. Rutgers The State University of New Jersey, Materials Science & Engineering, USA
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ZrB_2/SiC composites are prime candidates for structural applications under extreme conditions because of their capability to withstand ultra-high temperatures. Recent research focuses on enhancing the thermal emissivity of ZrB_2-based ceramic composites through the addition of rare earth oxides (REOs). The heat conduction mechanism in ZrB_2–SiC ceramics with added rare earth oxides (REOs) involves a complex interplay of phonon transport, electron transport, and the microstructural effects of rare earth oxide additions. REOs act as sintering aids to improve densification and REOs segregate at grain boundaries, impeding phonon transport. The microstructure was analyzed with FESEM-EDS and XRD. Moreover, the effect of REOs on the heat conduction mechanism of ZrB_2-20vol% SiC ceramics were examined by Laser Flash Analysis (LFA) technique besides microstructural examination. The results show that the influence of both porosity and ReOs addition was prominently observed in the thermal diffusivity and conductivity of spark plasma sintered monolithic ZrB_2 and ZrB_2–SiC composite.

S19 Molecular-level Processing and Chemical Engineering of Functional Materials

S19- Materials integration and device applications & Two-dimensional materials and their chemical functionalization

Room: Ballroom 1 -2
Session Chairs: Gunnar Westin, Uppsala University; Peter Kroll, University of Texas, Arlington

1:30 PM

(ICACC-S19-015-2026) Boron-modified silicon carbonitride as a sulfur host for lithium-sulfur batteries

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3. Stanford Linear Accelerator Center, USA

Lithium-sulfur batteries (LSBs) are an attractive energy storage system due to their high theoretical capacity of 2600 mAh g^{-1}. However, LSBs present a drawback known as the shuttle effect, which involves the dissolution of lithium polysulfides (LiPSs) into the electrolyte and their migration to the lithium anode, resulting in irreversible capacity fading. The use of sulfur hosts is an alternative to mitigate the shuttle effect. High porosity polymer-derived ceramics (PDCs) are effective hosts for sulfur cathodes of LSBs. PDCs present polar bonds and electrically conducting free carbon domains, which may chemically and physically adsorb soluble LiPSs, respectively, mitigating the shuttle effect. Here, boron-modified silicon carbonitride (i.e., SiBCN), derived from boron-modified polysilazanes single source precursor, was investigated as a sulfur host. The S@SiBCN composite electrode demonstrated a reversible capacity of ≈ 608.9 mAh g_s^{-1} after 100 cycles at a current density of 167.5 mA g_s^{-1}. The results for the SiBCN host were superior to those of the silicon carbonitride (SiCN) host, which provided a reversible capacity of ≈ 511.8 mAh g_s^{-1}, representing an increase of ≈ 18.9%

over SiCN after 100 cycles, highlighting the SiBCN host's contribution in suppressing the shuttle effect. Acknowledgments: FAPESP (grant numbers: 2021/09387-1; 23/11417-1; 2023/11416-5).

1:50 PM

(ICACC-S19-016-2026) Reinforced biocomposites from potato residues: A sustainable approach to thermoformable materials

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1. Universite du Quebec en Abitibi-Temiscamingue, Canada

The transition toward sustainable materials has highlighted the importance of biobased and biodegradable polymers for reducing plastic pollution. In this study, thermoplastic starch (TPS) was synthesized from downgraded potato residues combined with glycerol and water as plasticizers. Although TPS blends can be processed by conventional techniques such as thermoforming, their poor mechanical and thermal stability remains a limitation. To address this issue, a new class of TPS-based biocomposites reinforced with wood fibers is under investigation. The addition of lignocellulosic fillers is expected to enhance the structural performance of the bioplastics, especially in thermoforming applications. The base TPS blend was prepared via twin-screw extrusion and modified by incorporating varying concentrations of wood fibers. Comprehensive characterization, including DSC, TGA, DMA, rheology, and tensile testing, was performed to assess the effect of reinforcement on thermal behavior, viscoelasticity, and mechanical integrity. The thermoforming behavior of these reinforced composites is also being evaluated to establish the processing–structure–property relationships. This study demonstrates the potential of combining agri-food waste with natural fibers to develop next-generation biocomposites with improved functional properties suitable for industrial forming processes.

2:10 PM

(ICACC-S19-017-2026) Unveiling the stability of sulfur-impregnated titanium-modified silicon oxycarbide as a cathode for lithium-sulfur batteries

M. M. Amaral*[1]; O. Marques[3]; S. Bin Mujib[2]; H. G. Zanin[1]; J. Nelson Weker[3]; G. Singh[2]

1. Universidade Estadual de Campinas, Electrical and Computer Engineering, Brazil
2. Kansas State University, Mechanical and Nuclear Engineering, USA
3. Stanford Linear Accelerator Center, USA

The increasing energy demand has intensified the investigation of energy storage technologies with elevated energy density. Among the next-generation battery systems, lithium-sulfur batteries (LSBs) are an attractive technology, as LSBs have a high theoretical capacity (2600 Wh Kg^{-1}), and sulfur is an abundant element with a low cost. However, LSBs present some challenges that need to be addressed, such as the shuttle effect caused by the dissolution of lithium polysulfides and the volume expansion of sulfur during conversion reactions. The impregnation of sulfur into host materials is a strategy to mitigate the shuttle effect and suppress sulfur's volume expansion. Here, we report the use of a polymer-derived ceramic, particularly titanium-modified silicon oxycarbide (SiTiOC), as a sulfur host. The application of SiTiOC as a sulfur host promoted cycling stability, as the LSB cells showed stable performance. Furthermore, the sulfur-impregnated SiTiOC (S@SiTiOC) cathode was investigated by operando synchrotron-based transmission X-ray microscopy (TXM), which showed sulfur dissolution during the initial discharge, followed by morphological stability. These results indicate that the SiTiOC host suppressed the shuttle effect and inhibited sulfur's volume expansion, confirming its effectiveness as a sulfur host.

2:30 PM

(ICACC-S19-018-2026) Lightweight, thermally stable conductive ceramic thin-film composites for high-temperature EMI shielding applications

P. Gnanasekar*[1]; O. Ekuase[3]; G. Germanton[1]; M. Kurilich[2]; Z. Yu[3]; S. Ramakrishnan[1]

1. Florida Agricultural and Mechanical University, Department of Chemical and Biomedical Engineering, USA
2. Florida State University, Department of Materials Science and Engineering, USA
3. Florida Agricultural and Mechanical University, Department of Industrial and Engineering, USA

High-temperature EMI shielding (~1200 °C) in oxidative environments are critical for next-generation aerospace and defense systems. Traditional polymer-based EMI shielding materials degrade at high temperatures (>600 °C), while ceramics often lack sufficient electrical conductivity. MXenes reinforced preceramic matrix composites hold promise for enhanced toughness and conductivity but are hampered by the hydrophilic nature of MXenes (poor dispersibility in hydrophobic matrices) and oxidative degradation of the particles above 600 °C. To address these issues, we developed conductive ceramic thin films by covalently grafting a preceramic polymer onto MXene using allyl dimethyl silane (monomer) at different weight ratios (particle/monomer ratio - 1:3, 1:2, 1:1). The successful grafting was confirmed using FTIR, while TGA showed improved thermal stability, with 1:1 yielding the highest char (52.6 wt%) vs 42.4% (1:2) and 31.8% (1:3). Leveraging this thermal stability, we fabricated a conductive ceramic thin film using 1:1 grafted MXene with commercial SMP10 and 5 wt% BNNTs, followed by curing at 250 °C and pyrolysis at 1200 °C. XRD confirmed SiC phase, enhanced structural integrity, a stable MXene particle and the film achieved EMI shielding up to 30 dB at 10 GHz. This work provides a foundation for broader use of 2D materials in high-temperature ceramic systems.

S20: Golden Jubilee- Engineered Ceramics for Achieving Net-Zero Carbon Emissions

S20- Current trends and future directions for research and technology on advanced ceramics, composites, and multifunctional materials I

Room: Coquina D

Session Chairs: Jonathan Salem, NASA Glenn Research Center; Dong Liu, University of Oxford

1:30 PM

(ICACC-S20-014-2026) Micromechanical testing of ceramic coatings for nuclear applications up to 1000°C (Invited)

D. Liu*[1]

1. University of Oxford, Engineering Science, United Kingdom

Multi-layered ceramic coatings, such as SiC and PyC, have been used to encapsulate spherical nuclear fuel kernels for use in the next generation of nuclear fission reactors. These coatings are typically between 30 μm to 100 μm thick and will subject to harsh environments such as elevated operation temperatures and neutron radiation during service. It is important to acquire local mechanical properties of these individual coating layers as well as the interfacial strength between the coatings for better understanding of their structural integrity and to support performance modelling. In this work, micromechanical tests were carried out on SiC and PyC coatings over a range of temperatures from ambient to 1000°C with and without in-situ SEM imaging. The change of modulus and hardness as a function of temperature will be presented and the challenges associated with the high-temperature tests will be discussed.

2:00 PM

(ICACC-S20-015-2026) Unraveling experimental anomalies in the shock loaded boron carbide using a machine learned interatomic potential (Invited)

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1. University of Florida, Mechanical and Aerospace Engineering, USA
2. Illinois State University, Department of Mechanical Engineering, USA

Amorphization is a dominant deformation mechanism during high pressure loading of boron carbide (B_4C). However, few conflicting reports have emerged on the resulting microstructure and residual stress state. Molecular dynamics (MD) simulations using ReaxFF potential have revealed an increase in density of the amorphized regions and crack formation. However, microstructural observations have revealed no cracking in the amorphous islands. Also, Raman spectroscopy has detected residual compressive stress within the amorphized regions contrary to the expected stress release due to cracking reported in MD simulations. Also, no MD simulation has been able to capture amorphous band formation using the ReaxFF potential. In this research, a machine learned interatomic potential (MLIP) has been developed using neural networks and taining data at a range of strain values under different stress states. A validation procedure was developed and nonequilibrium MD simulations were conducted to investigate the shock behavior of B_4C as a function of polytype and chain orientation. Results indicate a strong dependence on both polytype and chain-orientation on shear-band formation. A rationale was developed for crack formation and residual stress state.

2:30 PM

(ICACC-S20-016-2026) Strength at the nanoscale: Hardness, toughness, and the limits of oxide nanoceramics (Invited)

R. Castro*[1]

1. Lehigh University, Material Science & Engineering, USA

This talk discusses the mechanics of oxide nanoceramics with grain sizes below ~30 nm, highlighting how grain-boundary dominated deformation and fracture replace dislocation-controlled responses typical of coarser ceramics. Indentation studies on fully dense nanocrystalline oxides show a hardness peak near ~18 to 20 nm, followed by inverse Hall–Petch softening as grains approach the single-digit nanometer regime, which is tied to high boundary and triple-junction fractions, GB sliding, and nanocrack nucleation. Across spinels and related oxides, this transition window (~20 to 30 nm) recurs, but reported trends vary depending on porosity, densification, and boundary chemistry, underscoring their first-order influence. Recent findings indicate that tuning grain-boundary energetics through controlled segregation or nonstoichiometry can increase resistance to grain-boundary sliding and suppress triple-junction cracking. However, the simultaneous optimization of hardness and toughness remains unresolved: while refinement below 30 nm boosts hardness and alters deformation mechanisms, fracture resistance does not scale in the same way, with many studies reporting brittleness and limited crack-bridging capacity. This open challenge, how to leverage nanoscale grain-boundary design to couple ultra-high hardness with improved toughness, defines the frontier for oxide nanoceramic mechanics.

3:20 PM

(ICACC-S20-017-2026) Engineered CMCs and joining strategies as enablers for net-zero energy systems (Invited)

V. Casalegno*[1]; M. Salvo[2]; C. Malinverni[1]

1. Politecnico di Torino, DISAT, Italy
2. Politecnico di Torino, Italy

Achieving net-zero carbon emissions in energy-intensive sectors requires breakthrough materials able to withstand environments where metals fail. Engineered ceramics, and particularly Ceramic Matrix Composites (CMCs), combine superior oxidation resistance with improved fracture toughness, enabling reliable operation under extreme thermo-mechanical conditions. Among them, SiC/SiC composites exhibit excellent high-temperature stability, making them strategic for decarbonized processes and advanced energy systems. Within an EU project, CMCs have been investigated as substitutes for metallic alloys in hydrogen-based steelmaking and other high-temperature industrial applications. Research focused on joining strategies—glass-ceramics, metallic brazes, and pre-ceramic polymers—capable of producing robust CMC joints, addressing a major barrier to their large-scale deployment. In parallel, another project explored SiC/SiC composites for containers in thermal energy storage for concentrated solar power, operating in direct contact with molten metallic phase change materials such as Si-based alloys. Two joining systems, a SiC-based adhesive and a glass-ceramic, were assessed for integrity, thermal compatibility, and corrosion resistance. These results confirm engineered ceramics as enabling technologies for sustainable energy production and storage, supporting the path toward net-zero carbon emissions.

3:50 PM

(ICACC-S20-018-2026) Advancing understanding of defect structure and behavior in advanced ceramics through indirect and correlative microscopy methods (Invited)

J. A. Krogstad*[1]

1. University of Illinois at Urbana-Champaign, Materials Science and Engineering, USA

Expanding the nominal design space across a wide range of next-generation ceramic applications is possible by considering open, driven systems. This design space allows for consideration of low temperature processing routes (with minimal energy outlay or improved multilayer compatibility), novel functionality (such as rapid switching between phases or configurations), and improved durability in extreme operating conditions (including radiation-prone environments, high fields, etc). Adaptive, efficient methods are necessary to document and correlate the behavior of heterogeneous defects to the evolution of microstructures and macroscopic properties of a ceramic. In this talk, I will demonstrate how we are leveraging indirect imaging of point defects to understand transport behavior, defect tolerance and microstructural evolution in irradiated ceramics and will discuss how these tools can be applied to a much broader class of materials and external drivers that harness the potential of non-equilibrium kinetic coupling for high-performance ceramics processing and performance.

4:20 PM

(ICACC-S20-019-2026) Elevated temperature fracture properties yttrium-disilicate based EBCs (Invited)

J. Salem*[1]; M. J. Presby[2]; J. L. Stokes[2]; L. C. Hoffman[2]; C. Smith[3]; R. I. Webster[3]

1. NASA Glenn Research Center, Materials and Structures, USA
2. NASA Glenn Research Center, Environmental Effects and Coatings Branch, USA
3. NASA Glenn Research Center, USA

The room and elevated temperature fracture properties of $Yb_2Si_2O_7$ environmental barrier coatings (EBC) were measured on air plasma spray (APS) and field assisted sintering technology (FAST) samples. Noteworthy is the low fracture toughness and the physical and chemical instability of the APS material even after several hours of heat treatment. Heat treatments were determined to increase hardness, elastic properties, fracture strength, and fracture toughness. The values after any heat treatment depend on the as-sprayed density. Although slow crack growth tests were attempted, material instability and increasing strength during testing limited the results. At an as-sprayed bulk density of 5.48 g/cm3, APS YbDS exhibits room temperature Young's modulus and fracture toughness of 45 GPa and 0.92 MPaÖm. With brief heat treatments (~4 hours), Young's modulus and the fracture toughness increase to 82 GPa and 1.36 MPaÖm. Subcritical crack growth is exhibited at room temperate implying water vapor induced stress corrosion. In contrast to APS material, the FAST material exhibits similar properties both as-processed and after brief heat treatment, with Young's modulus and fracture toughness of 150 GPa and 1.36 MPaÖm, respectively. The fracture toughness of the EBCs remained nominally constant up to 1316oC.

4:50 PM

(ICACC-S20-020-2026) A review of different types of Additive Manufacturing (AM) Processes (Invited)

S. Gupta*[1]

1. University of North Dakota, Mechanical Engineering, USA

In this presentation, I will review some of the developments in Additive Manufacturing Practices. More particularly, I will focus on Fused Deposition Modeling (FDM) of different polymerics systems. Their mechanical and physical will be reported. These properties will be connect with detailed microstructural analysis. Novel methods for analysing microstructure will be presented in this study. Detailed thermal analysis by Differential Scanning Calorimetry (DSC) will be presented. It is expected that these studies can add to valuable perspective for designing and optimizing additive materials.

Poster Session A

Room: Ocean Center

5:00 PM

(ICACC-PA001-2026) Evaluating the rheology of lunar regolith simulant melts and their interaction with crucible refractory materials

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1. Rutgers The State University of New Jersey, Materials Science & Engineering, USA
2. NASA Langley Research Center, Advanced Materials and Processing Branch, USA

In-situ resource utilization (ISRU) for producing metals and oxygen on the lunar surface is essential for building infrastructure, generating chemical propulsion fuel, and supporting life on the Moon. Common terrestrial extraction techniques, such as carbothermal reduction and the Bayer-Hall-Héroult process, are impractical since they require materials unavailable on the Moon. Molten regolith electrolysis (MRE) is a promising alternative that produces metals and oxygen directly from lunar regolith, the upper 10 m of granular multicomponent oxides and glasses on the surface. MRE requires temperatures of 1600°C to melt and dissociate the regolith, which can degrade containment materials through thermochemical interactions. Determining the processing ability of lunar regolith and its compatibility with crucible materials is therefore crucial for long-term MRE operation. This study evaluates the rheology (viscosity and liquidus temperature) of two molten lunar regolith simulants, i.e., lunar highlands (LHS-1) and maria (JSC-1A) simulant, and their chemical interaction with potential crucible refractory ceramics, including Al_2O_3, magnesia-stabilized zirconia, and yttria-stabilized zirconia, per the methodology described in the standard ASTM C621-84. The results will be discussed in the presentation.

(ICACC-PA002-2026) Toughening and densification of Ti-Mo-B_2 ceramics by liquid-phase reactive sintering at a reduced temperature of 1550 °C

W. Y. Alemu*[1]; J. Chen[1]

1. National Taipei University of Technology, Institute of Materials Science and Engineering, Taiwan

Titanium diboride (TiB_2) is a leading candidate for ultra-high temperature structural applications in aerospace and defense owing to its exceptional hardness, thermal stability, and electrical conductivity. However, its widespread application is restricted by inherent brittleness and poor sinterability. In contrast, molybdenum diboride (MoB_2) offers better sinterability and improved toughness but compromises hardness and high-temperature stability when used alone. To address these limitations, this study developed a novel reactive liquid-phase sintering strategy incorporating MoB2 into TiB2-based ceramics at a comparatively low sintering temperature of 1550°C. Microstructural analysis revealed refined microstructures and reduced porosity at optimal MoB_2 content. The maximum relative density of 94.2% was achieved in $Ti_{0.5}Mo_{0.5}B_2$ composite, while hardness reached 22.5 GPa in $Ti_{0.75}Mo_{0.25}B_2$, increasing with TiB_2. The combination of 323.4 MPa flexural strength and 8.9 MPa.m$^{0.5}$ fracture toughness reflects a balanced enhancement across key mechanical properties. Toughening mechanisms, including crack deflection, grain boundary pinning, and liquid-phase-assisted densification, were activated through the Ti-Mo-B_2 synergy. Furthermore, DFT results confirmed metallic bonding nature due to MoB_2 dissolving into the TiB_2 lattice, enhancing toughness and ductility.

(ICACC-PA003-2026) Laser-Assisted Joining of SiC/SiC Composite for High-Temperature Applications

K. Pandey*[1]; M. Ferraris[1]; M. De Maddis[2]

1. Politecnico di Torino, Department of Applied Science and Technology, Italy
2. Politecnico di Torino, Department of Management and Production Engineering, Italy

SiC/SiC composites are prized for their exceptional mechanical and thermal properties, making them ideal for demanding high-temperature environments across various industries. Joining these composites is challenging since Silicon Carbide does not melt, rendering welding ineffective. Glass-ceramic filler - SAY (Silica Alumina Yttria) finds compatibility with SiC/SiC composite for its thermal expansion, wettability, and thermo-mechanical stability at elevated temperatures. This study explores a pressure-less, localized joining method using an infrared diode laser with SAY as the filler. Key parameters such as laser power, exposure time, focus, and specimen positioning are optimized to achieve strong joints. Mechanical testing shows that joints can withstand forces up to 2100 N. Microstructural analysis via computed tomography and scanning electron microscopy reveals filler behavior before and after testing. A comparison between pure SAY and SAY with SiC particles as fillers is also presented, while these results are also compared with joints made in a furnace. This laser joining technique offers precise, localized heating and strong, durable joints suitable for complex SiC/SiC components in high-temperature applications.

(ICACC-PA005-2026) Impact of post-CMP stagnation time on via corrosion and reliability in TSV structures

J. Yoon*[1]

1. Sungkyunkwan University College of Engineering, Republic of Korea

Through-silicon via (TSV) technology enables vertical integration of DRAM chips and is essential for high-bandwidth memory (HBM). In the TSV process, Cu exposure after chemical mechanical polishing (CMP) makes vias vulnerable to corrosion, which can degrade mechanical reliability. This study examines the effect of post-CMP stagnation time on via defect generation and bonding strength. Wafer samples experienced post-P3 CMP stagnation at the inter-platen clean position for 5, 10, 20, and 30 minutes. SEM and FIB were used to observe surface and cross-sectional via defects. Ni-plated pads were formed, and bonding strength was measured using pad shear tests at various wafer locations. Via defect rates rose ~18% from 5 to 20 minutes and surged ~214% after 30 minutes. Shear strength declined from 15.2 gf (no delay) to 7.8 gf after 30 minutes, indicating substantial mechanical weakening. These findings highlight 20 minutes as a critical limit for stagnation time. Controlling stagnation below this threshold is essential to prevent Cu corrosion, reduce via failures, and maintain TSV reliability in advanced packaging processes.

(ICACC-PA006-2026) Influences of composition and sintering condition on microstructure and mechanical properties of Ti(C, N)-stainless steel composites

Y. Takebayashi*[1]; S. Nariki[1]

1. Tohoku Daigaku Daigakuin Kankyo Kagaku Kenkyuka, Frontier Sciences for Advanced Environment, Japan

Microstructure and mechanical properties of Ti($C_{1-x}N_x$)-stainless steel (SUS) cermets (x=0.7 and 0.5), which contains 5-20 vol.% of SUS316L, have been investigated. The samples were fabricated by the sintering at the different temperature between 1350 and 1600°C in an Ar gas atmosphere. The mechanical properties (fracture toughness measured with IF method, Vickers hardness and 3-point bending strength) were evaluated using the samples sintered. The microstructure was affected by the initial composition of the samples and the sintering temperature. The fracture toughness of the samples improved with increasing SUS content, reaching a value of about 20 MPa·$m^{1/2}$ in the samples containing 20 vol.% of SUS. The bending strength tended to be higher when the relative density of sample was higher and the Ti(C, N) grain size was finer. Uniformity in microstructure is one of important factors for improving the mechanical properties in Ti(C, N)-SUS composites. The presence of metal pools in the microstructure led to a decrease in bending strength. When a sample with x=0.5 and SUS content of 10 vol.% was sintered at 1500°C, a high bending strength of 1300 MPa was obtained.

(ICACC-PA007-2026) Porosity effects on strength of oxide-CMC coatings and joints with preceramic polymers

A. Pizzinat*[1]; M. Ferraris[1]; A. Benelli[1]

1. Politecnico di Torino, Department of Applied Science and Technology (DISAT), Italy

Oxide-based ceramic matrix composites (oxide-CMCs) are widely used in energy applications requiring high-temperature and oxidative stability. This study investigates the influence of porosity on the strength of coatings and joints formed using oxide preceramic polymers, whose adhesion and cohesion on oxide-CMC substrates were enhanced through the incorporation of functionalized fillers, including Al_2O_3 nanoparticles and fibers. Samples were processed via curing at 180 °C followed by pyrolysis at 1200 °C in air. The resulting joints were characterized in terms of morphology, microstructure, CT scan and mechanical performance.

(ICACC-PA008-2026) Study on the effect of high temperature on defects in tungsten Chemical Mechanical Planarization

J. Yu*[1]

1. Sungkyunkwan University, Department of Semiconductor and Display Engineering, Republic of Korea

With the increasing importance of Chemical Mechanical Planarization (CMP) processes, the number of tungsten steps has correspondingly risen. As a result, extensive research has been conducted on the impact of temperature in tungsten processing. Findings indicate that increased temperatures lead to an increased removal rate, thereby shortening the overall process time. However, a reduced process time cannot be considered beneficial if it results in unfavourable defect outcomes. In this study, we investigated the effects of high-temperature DIW spraying during the final stages of the CMP and polishing processes on defect variation. The results demonstrated a notable improvement in defect counts as the temperature increased. This suggests that, while various temperature evaluations are conducted to enhance the removal rate, they also contribute positively to defect reduction. Our research confirms that optimizing temperature parameters can simultaneously improve removal efficiency and defect outcomes in tungsten processing.

(ICACC-PA009-2026) Investigation of wear caused by spherical ceramic flow in CMP Head

J. Choi*[1]; T. Kim[1]

1. Sungkyunkwan University - Natural Sciences Campus, Republic of Korea

Chemical Mechanical Planarization (CMP) is a critical process in semiconductor manufacturing, ensuring planarized thin films for subsequent device fabrication. In the CMP process, the head holds the wafer and rotates it against the pad to remove excess material. To ensure wafer uniformity and quality, a gimbal structure is employed, where spherical ceramic balls are located at the center of the head to prevent tilting caused by differences in rotational inertia between the pad and the head. However, these ceramic balls undergo micro-flow motion during operation, leading to friction with surrounding components. Due to large differences in Mohs hardness among materials, progressive wear occurs, forming gaps that degrade the stability of the gimbal mechanism. This instability reduces the head's ability to maintain uniform wafer pressure and causes wafer slip, ultimately lowering process reliability and yield. This study analyzes the wear mechanisms associated with ceramic ball flow through direct component measurements and slip frequency evaluation. Visualization graphs derived from experimental data clearly confirm the progressive wear of both ceramic and polymeric materials. The results demonstrate the physical limitations of current material combinations in CMP gimbal environments and provide insights for improving the durability and stability of CMP head structures.

(ICACC-PA010-2026) Novel strategies for high-performance electrophoretically deposited coatings in reversible solid oxide cells

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This work investigates two complementary strategies to improve the manufacturing process and the performance of protective ceramic coatings for metallic interconnects in solid oxide cells (SOCs) using electrophoretic deposition (EPD). The first study focuses on the effect of particle size, reduced through ball milling, on suspension stability, green body quality, and the final microstructure of Mn–Cu–based spinel coatings. Parameters such as uniformity, porosity, and adhesion will be evaluated after deposition and sintering, with the aim of correlating particle size with coating density and performance. The second approach explores the role of doping, introducing elements such as Y and Mg into Mn–Co spinels to enhance electrical conductivity, sinterability, and chromium retention capability. Coatings By combining insights from both approaches, the project seeks to identify optimal strategies for reliable and scalable EPD coatings, advancing efficient SOC technologies.

(ICACC-PA011-2026) Electrochemical implications of preferential nitridation of Ni current collectors in ammonia-fueled SOFCs

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Ammonia is a promising carbon-free fuel for solid oxide fuel cells (SOFCs) due to its high hydrogen density and infrastructure compatibility. However, direct ammonia utilization poses a critical challenge: Ni nitridation, which degrades the performance and stability of Ni-based anodes and current collectors. This study investigates the effect of preferential nitridation of the Ni current collector on the electrochemical performance and long-term stability of Ni/YSZ anode-supported cells. Furthermore, we assessed the extent to which this preferential nitridation suppresses direct nitridation of the electrode. To this end, Ni/YSZ anode-supported cells were fabricated and operated under ammonia at 750 °C with Ag and Ni current collectors. Initial performance was assessed via I-V and electrochemical impedance spectroscopy (EIS), with ammonia decomposition rate quantified by gas chromatography (GC). Long-term tests (25, 50, and 100 h) and post-mortem analyses using X-ray diffraction (XRD) and scanning electron microscopy (SEM) were conducted to evaluate degradation. This study shows the Ni current collector enhances initial performance by promoting ammonia decomposition, which mitigates direct nitridation of the anode. It also reveals that preferential nitridation of the Ni current collector gradually degrades electrochemical performance and long-term stability.

(ICACC-PA012-2026) Sealing and steam-electrode development for the integration of protonic ceramic electrolysis cells

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Protonic ceramic electrolysis cells (PCECs) are a next-generation solid-oxide electrolysis technology whose proton-transport mechanism enables efficient operation at 400–600 °C (vs. 700–900 °C for SOECs), mitigating high-temperature corrosion and delivering high-purity H_2 at the fuel electrode side. However, scale-up and stack integration remain the principal challenges. This study investigates integration of 30-mm-diameter $BaZr_{0.44}Ce_{0.36}Y_{0.2}O_{3-\delta}$ / $SrZr_{0.5}Ce_{0.4}Y_{0.1}O_{3-\delta}$ – NiO half-cells with AISI 441 ferritic stainless-steel interconnects. Two glass-based sealants were designed and characterized, with emphasis on chemical compatibility and thermo-mechanical stability at 600 °C under steam-rich conditions. Screen-printed green tapes of the selected glasses were fabricated and used to optimize cell-to-metal joining, targeting maximum hermeticity and precise control of joint geometry. In parallel, a composite steam electrode, $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}/BaZr_{0.8}Y_{0.2}O_{3-\delta}$, was developed. Starting powders were engineered to yield screen-printable inks with controlled dispersion, stability, and rheology, enabling uniform deposition and subsequent optimization of microstructure and adhesion. Finally, electrochemical performance of the deposited electrodes was assessed by electrochemical impedance spectroscopy.

(ICACC-PA013-2026) Steam-induced Ni oxidation in direct-ammonia fuel cells: electrode-dependent degradation behavior in SOFCs

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Ammonia is a practical hydrogen carrier with a well-established infrastructure for storage and transport, motivating direct-ammonia solid oxide fuel cells (DA-SOFCs) that operate without external reforming. However, long-term use of ammonia induces degradation, especially steam-driven Ni oxidation through reactions with nitrogen species remaining after decomposition. To clarify this process, we compared DA-SOFC and protonic ceramic fuel cell (PCFC) in which steam forms at different electrodes. The SOFC used a Ni/YSZ anode and the PCFC a Ni/BCZYYb anode. Both cells operated for 100 h at the same current density, with temperatures adjusted to achieve similar ammonia conversion. Performance was evaluated by I–V curves and impedance spectroscopy, and post-test analyses assessed Ni surface oxidation. The DA-SOFC showed clear degradation over 100 h, with increased resistance and significant Ni oxidation. In contrast, the PCFC maintained stable output with negligible Ni oxidation and nearly unchanged microstructure. These results show that the electrode location of steam generation strongly governs Ni oxidation and durability under ammonia fuel. As steam in PCFCs is produced on the cathode side, the anode is less exposed to oxidizing conditions, yielding superior stability. Thus, steam management emerges as a key design principle for developing durable ammonia-fueled fuel cells.

(ICACC-PA014-2026) Formulation of novel glass sealants for protonic ceramic electrolysis cells

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This study addresses the development and comprehensive evaluation of two glass compositions as sealing materials for Proton Ceramic Electrolysis Cells (PCECs) operating in the intermediate temperature range of 500–600 °C. The thermomechanical properties of the glasses were thoroughly characterized by thermal analyses, providing detailed insights into their softening behavior, thermal expansion, and crystallization phenomena, which are crucial for ensuring reliable long-term performance. The sealants were used to evaluate their chemical and thermomechanical compatibility with $BaCe_{0.7}Zr_{0.1}Y_{0.1}Yb_{0.1}O_{3-\delta}$ (BCZYYb7111) electrolyte joined to an AISI441 interconnector. SEM-EDX analysis revealed that, after several thermal cycles (RT-=600 °C in a 50% steam–50% air atmosphere, no significant microstructural changes occurred in the sealant, confirming the excellent chemical stability, gas tightness, and interfacial compatibility under realistic operating conditions.

(ICACC-PA015-2026) Mixed ionic-electronic conductors based on high-entropy oxides synthesized via sol-gel and nebulized spray pyrolysis

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Mixed ionic-electronic conductors (MIECs) are key functional components enabling oxygen transport and electrocatalytic reactions in solid oxide cells (SOCs). High-entropy materials, including carbides, nitrides, and oxides, with their complex compositions represent a major breakthrough in the design of next-generation functional compounds. Among these, high-entropy oxides (HEOs) attract interest due to their diverse structures and unique properties. We explore HEOs synthesized via sol-gel methods, followed by uniaxial pressing and sintering in air to produce dense membranes. Nebulized spray pyrolysis is also examined to optimize morphology, phase purity, and functional performance. High configurational entropy enables stabilization of the phase-pure HEOs, as confirmed by XRD and EDXS. Scanning and transmission electron microscopy provide microstructural characterization. Multiple cations enhance oxygen flux (measured at 1023–1223 K), outperforming conventional low-entropy materials. HEOs exploit synergistic effects of multiple active metals, delivering superior activity and stability for the oxygen evolution reaction and hydrogen evolution reaction. Enhanced temperature and chemical stability, coupled with the component adjustability, positions these materials as promising candidates for oxygen transport, electrocatalysis, and, thus, advanced SOCs.

(ICACC-PA016-2026) Multiphysics model for protonic ceramic electrolysis cells and olefins electrochemical production

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In this work a comprehensive model for a protonic ceramic electrolysis cell (PCEC) and for the electrochemical production of olefins is presented. A 3D numerical model has been developed for a planar single repeating units (SRUs) and stacks. This model integrates thermal-fluid-dynamics, electrochemical processes and structural analysis, accounting for the transport of protons, electrons holes and oxygen vacancies through the membrane, typical for barium-based zirconate perovskites commonly employed in this technology and considered in this model. A key objective of this study is to quantify the impact of several parameters on hydrogen production, establishing the negative effect of the electronic leakage on the transference number. Additionally, structural effects on the SRU components resulting from operational conditions, especially temperature gradient induced thermal stresses, are examined for their impact on structural integrity and durability. The analysis explored structural parameters and operational parameters, such as interconnectors' configuration, operating temperature and streams compositions and flow rate. The parameters that most impact performance and structural integrity are identified and quantified providing insights into configurations that could improve hydrogen production and durability of the PCECs.

(ICACC-PA017-2026) Photoelectrochemically driven valence-charge control for defect inactivation and VO_2 passivation in $BiVO_4$ photoanodes

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Photoelectrochemical (PEC) water splitting is a promising solar-to-fuel technology, but $BiVO_4$ photoanodes suffer from severe surface defects and photocorrosion. Here, we report a photoelectrochemically driven valence-charge-control strategy that simultaneously deactivates defects and induces a conductive VO_2 passivation layer. By introducing V^{5+} ions and H_2O_2 into the deposition electrolyte, detrimental photocorrosion is transformed into controlled surface oxidation, reducing unstable V^{5+} to stable V_{4+}. This process produces an ultrathin VO_2 layer that suppresses charge recombination and enhances interfacial charge transfer. The resulting $BiVO_4/VO_2$ photoanodes exhibit significantly improved transport and transfer efficiencies (86% and 95%, respectively). When combined with a $CoFeO_x$ cocatalyst, the $BiVO_4/VO_2/CoFeO_x$ electrode achieves a photocurrent density of 6.2 mA cm^{-2} at 1.23 V_{RHE}, an onset potential of 0.25 V_{RHE}, and an applied bias photon-to-current efficiency of 2.4% at 0.62 V_{RHE}, while sustaining stable oxygen evolution for over 100 hours. This work demonstrates a scalable approach to overcome the intrinsic limitations of $BiVO_4$ by coupling defect inactivation with VO_2 surface passivation, offering a generalizable pathway to enhance both stability and efficiency of oxide-based PEC photoanodes.

(ICACC-PA018-2026) Local structure evolution in thin film chalcogenides explains property differences

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Advances in low power, energy-efficient information storage require controlling and understanding materials' atomic and nanoscale structure. Promising materials for memory applications include phase change memory materials, which are incorporated into devices as thin films. These phase change materials (PCMs) are used for nonvolatile and low-power memory devices, which leverage their ability to store information through reversible changes in atomic structure and associated differences in properties. For PCMs, this involves amorphous-to-crystalline phase transformations. We use pair distribution function analysis to extract direct information on the local- to mid-range structural features of thin film PCMs and their transformations, emulating the operating conditions of their devices through heating. The local structure insights reflect differences of bonding behavior and other nanoscale features, which provide understanding of key parameters, such as the mechanisms associated with crystallization or switching within the amorphous state. Upon controlled heating, these feature changes provide insight into structural transformations that enable use and optimization of memory devices, including composition-dependent atomic structure changes in the thin film chalcogenides. With this understanding of PCMs at the nanoscale, we can look towards efficient, low-power memory and computing devices.

(ICACC-PA019-2026) Rechargeable urea-assisted Zn–air battery with high energy efficiency and fast charging via Ni phase transitions and lattice distortion design

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Nickel-based catalysts are highly attractive for electrochemical energy conversion, yet their intrinsic activity is governed by phase structure and lattice dynamics. Here we demonstrate that a controllable transition from face-centered cubic (FCC) to hexagonal close-packed (HCP) Ni, accompanied by lattice distortion, provides a powerful strategy to enhance performance. Operando X-ray absorption spectroscopy reveals that the HCP phase shows a positive white-line shift at the Ni K-edge, reflecting stabilization of higher-valence Ni species, while R-space analysis indicates elongated Ni–Ni bond lengths associated with lattice strain and modified coordination. These structural fingerprints confirm that lattice distortion promotes charge delocalization and optimizes adsorption energetics of reaction intermediates. Benefiting from these features, HCP-Ni exhibits a low potential of ~1.34 V (vs. RHE) at 10 mA/cm^2. When applied in rechargeable urea-assisted Zn–air batteries, the catalyst reduces charging voltage and enables fast-charging capability, underlining its potential for practical energy storage. This work establishes Ni phase transition and lattice distortion engineering as effective strategies to regulate electronic and structural environments, offering new insights into the design of advanced electrocatalysts.

(ICACC-PA022-2026) Construction of hard carbon with oxidized-crosslinked structure for sodium-ion batteries

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Among sodium-ion battery (SIB) anode materials, hard carbon with disordered structures, large specific surface areas, low sodium storage potentials (~0.1 V), and fast reaction kinetics exhibits excellent sodium storage performance. Hence, developing hard carbon anodes for SIBs has become a major research focus. In this study, olive stone served as the hard carbon precursor, and a two-step oxidation–crosslinking strategy was applied to achieve surface functionalization and pore structure regulation, greatly enhancing sodium storage capacity. Characterization showed that oxidation–crosslinking expanded interlayer spacing and introduced oxygen-containing functional groups. Electrochemical tests revealed that the optimized olive stone–based hard carbon delivered an initial discharge capacity of 383 mAh g-1 at 0.1 C and maintained 166.7 and 81.7 mAh g-1 at 5 C and 10 C, respectively. It also exhibited excellent cycling stability, retaining 94% capacity after 300 cycles at 1 C. Mechanistic analysis indicated that oxidation–crosslinking not only tailored the carbon microstructure but also promoted stable solid electrolyte interphase (SEI) formation, enhancing structural integrity and conductivity. This work provides a simple, effective strategy for designing high-performance SIB anodes and expands the application potential of olive-derived hard carbon in energy storage systems.

(ICACC-PA023-2026) The critical role of electronic spin states in Fe-N_4 moieties on enhancing oxygen reduction activity

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The oxygen reduction reaction (ORR) is a complex process involving multiple steps with different electronic spin configurations. Understanding spin-state transitions at catalyst active sites is crucial for optimizing performance. This study investigates the ORR mechanism using atomically dispersed iron coordinated with nitrogen (Fe–N_4) on nitrogen and sulfur co-doped carbon (NCS). This system shows excellent ORR activity in both alkaline and acidic electrolytes and demonstrates practical potential in zinc-air batteries. Through operando ^{57}Fe Mössbauer spectroscopy, in situ SEIRAS, Raman spectroscopy, and DFT calculations, we reveal that the Fe spin state is key to catalytic activity. Specifically, FeN_4C_{12} active sites fully transition to the FeN_4C_{12}-Ox- state under ORR conditions, maintaining a stable spin state across a wide potential range. Oxygen adsorption increases the Fe spin magnetic moment, improving catalytic efficiency. This study highlights the critical role of electronic spin configuration in single-atom Fe catalysts during ORR.

(ICACC-PA024-2026) Study on property changes through slurry filtration

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Chemical Mechanical Polishing (CMP) is a vital process in semiconductor manufacturing, ensuring the planarization required for advanced integrated circuits. This study examines the effect of slurry filtration on removal rates during dielectric CMP. Controlled experiments revealed that longer filtration times reduce the fraction of larger particles in the slurry, which in turn leads to a significant decrease in material removal rates. While filtration is essential to prevent slurry agglomeration and surface defects, excessive filtration was found to degrade CMP performance by altering the particle size distribution (PSD). Building on these findings, additional analysis was conducted to investigate the impact of over-filtration on defectivity. The results indicate that although excessive filtration lowers the risk of particle-induced scratches, it simultaneously increases defectivity associated with non-uniform planarization and localized dishing. To address this trade-off, we propose strategies including routine monitoring of slurry filtration levels, optimizing filtration frequency, and adopting adaptive control systems. These approaches aim to balance effective filtration with the preservation of optimal removal rates and defectivity control, thereby improving process stability and overall CMP quality in high-volume manufacturing.

(ICACC-PA025-2026) Influence of sintering atmospheres on dielectric properties and redox behavior of KNN-based dielectrics for MLCCs

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Multilayer Ceramic Capacitors (MLCCs) are indispensable components in modern electronics, providing key functions such as energy storage, noise suppression, and signal filtering. With the growing electrification of automobiles, the demand for MLCCs capable of reliable operation under high-temperature and high-voltage conditions has increased significantly. Currently, MLCCs rely heavily on rare-earth elements. To reduce dependence on rare-earth elements and address environmental concerns, this study investigates lead-free $(K_{0.5}Na_{0.5})NbO_3$ (KNN)-based perovskite dielectrics. KNN-based dielectric powders were synthesized, processed into slurry form, and tape-cast to evaluate their suitability for MLCC fabrication and resistance to reduction. The dielectric properties of KNN-based thick films and bulk ceramics were characterized, and MLCC prototypes were fabricated to examine the effects of different sintering atmospheres on dielectric performance and redox stability. The results demonstrate that the reduction resistance of KNN-based dielectrics exhibit advanced reduction resistance and stable dielectric properties, confirming their potential for next-generation, environmentally friendly MLCC applications.

(ICACC-PA026-2026) Defect chemistry and dielectric property changes induced by A-site doping of Ca in bismuth sodium titanate $(Bi_{0.5}Na_{0.5}TiO_3)$

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The demand for electric vehicles has increased the need for high-performance multilayer ceramic capacitors (MLCCs) in automotive electronics. These devices must remain stable under high temperatures, vibrations, and voltages, while also meeting environmental requirements for lead-free materials. To overcome the poor thermal stability of $BaTiO_3$-based ceramics, this study examines $Bi_{0.5}Na_{0.5}TiO_3$ (BNT)-based lead-free dielectrics. BNT powders were synthesized by solid-state reaction and sintered into coin-shaped samples. Structural and microstructural properties were analyzed by X-ray diffraction and scanning electron microscopy, while ferroelectric and dielectric behaviors were evaluated through polarization–electric field loops and temperature-dependent measurements. To study defect chemistry from Ca substitution, High-Temperature Equilibrium Conductivity (HiTEC) was employed. With similar ionic radii, Ca^{2+} can occupy Bi^{2+} or Na^+ sites, acting as donor or acceptor and producing distinct charge-compensation mechanisms. Increasing Ca content reduced remanent polarization, promoted a transition from ferroelectric to relaxor-ferroelectric behavior, and enhanced energy-storage density. These findings indicate that Ca-doped BNT ceramics offer thermal stability and environmental compatibility, making them promising candidates for next-generation automotive MLCCs.

(ICACC-PA027-2026) Novel conductive glass-ceramic matrix composites from printable silicone-based emulsion

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The Na_2O-SrO-SiO_2 system offers significant potential for developing glasses that can be converted into electrically conductive glass-ceramics. Conventional routes typically require the synthesis of a parent glass, followed by complex devitrification treatments. In this study, a simplified strategy is presented, relying on preceramic polymers, specifically silicone resins combined with oxide fillers. Such systems enable the direct formation of silicate-based ceramics by heat treatment, reproducing the phase assembly of conventional glass-ceramics without the necessity of glass melting. A printable formulation was obtained by mixing a silicone resin with an acrylate-based photocurable resin, sodium nitrate, and strontium carbonate. The resulting "suspension-emulsion" was shaped into monolithic parts via digital light processing. After pyrolysis in nitrogen, ceramization yielded $SrSiO_3$ crystals embedded in a partially amorphous matrix, together with a turbostratic carbon phase derived from the silicone backbone. The coexistence of crystalline silicates and carbon provided measurable electrical conductivity. These results confirm that silicone-derived systems can act as effective precursors for conductive glass-ceramic analogues, offering single-step processing, 3D-printable shaping, and functional properties suitable for electronic and electrochemical application.

(ICACC-PA028-2026) Direct exfoliation of hexagonal boron nitride in silicone polymer: A novel feedstock for additive manufacturing of flexible micro vapor chambers

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The electronics and semiconductor industry is constantly evolving and finding its way into applications ranging from homemade appliances to advanced fields of aerospace engineering. Because of this, the research in thermal management system (TMS) is also progressing to meet the higher heat dissipation capacity of the modern circuits and chips, which led to the innovation of micro vapor chambers (VC). Although the use of VC's has already been widely commercialized, currently available feedstock for additive manufacturing (AM) of VC is still limited to solvent based metal powders. This greatly limits the use of AM based techniques in mass production of flexible VC's. Herein, we developed a novel nanocomposite material to fabricate flexible VC's via direct writing. The feedstock was prepared by in situ mechanical exfoliation of ceramic hexagonal Boron Nitride (hBN) powder within a commercial silicone polymer. The composite showed high thermal conductivity and good mechanical stability under tensile loads. This feedstock was then used to fabricate a flexible VC with porous wick structure via extruding pattern on a glass substrate. The fabricated chamber was then tested for its heat dissipation properties and showed promising performance which are comparable to commercially available thermal interfacial materials (TIM) and VC's.

(ICACC-PA029-2026) Direct Ink Writing of high zeolite catalysts for enhanced structural durability

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3D-printed open-cell catalysts promise to overcome the mass and heat transfer limitations found in traditional pellet catalysts. However, their performance is limited by low active material loading, typically below 70 wt%, due to printing challenges such as particle aggregation and high slurry viscosity. This study presents a new Direct Ink Writing slurry formulation that surpasses these limitations, achieving over 90 wt% zeolite loading while maintaining good printability. We find that using a nonionic dispersant is more effective in preventing particle aggregation than traditional anionic dispersants. Systematic pre-processing steps, including slurry aging and printing parameters (e.g., speed, extrusion rate, nozzle size), are optimized to produce defect-free printed parts. Post-processing temperature is then fine-tuned to convert these parts into durable catalysts. 600 °C is identified as the ideal temperature for fully removing organic binders without damaging the zeolite's structure. At this temperature, the 3D-printed catalysts achieve their highest specific surface area and maintain remarkable structural integrity, withstanding a compressive stress of 1.77 MPa. This results in more than a 200% increase in mechanical strength compared to the previously reported one. This comprehensive optimization offers a promising way for developing high-performance open-cell catalysts.

(ICACC-PA030-2026) Atomistic insights into PND polymer conversion to B/C solids with enhanced ReaxFF modeling

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Polynorbornenyldecaborane (PND), a boron-rich polymer, is a promising precursor for high-performance boron carbide (B_4C) ceramics. ReaxFF reactive force field molecular dynamics simulations were performed at temperatures ranging from 2000 to 3000 K for both small (5 molecules) and large (40 molecules) systems to investigate decomposition and B/C solid formation. Optimal boron clustering occurs at 2500 K in small systems and 3000 K in large systems, with clustering ratios of 3.73 and 5.76, respectively, demonstrating PND's superior thermal resilience compared to PDMS. Recognizing limitations in existing B/C/O/H ReaxFF parameters, we developed an expanded force field trained against high-temperature MD data from $C_8H_{13}B_3O_5$ isomers, B/C convex hull DFT energies, and decaborane ($B_{10}H_{14}$) dehydrogenation via an automated workflow. This refined ReaxFF enables accurate modeling of polymer-to-ceramic conversion, providing a computational framework for designing thermally stable boron-rich ceramic precursors for additive manufacturing, armor, and high-temperature applications.

(ICACC-PA031-2026) Development of the ReaxFF Reactive Force Field for titanium diboride: Thermochemical, thermophysical, and oxidation behavior

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A ReaxFF reactive force field has been developed to investigate the thermochemical and thermophysical properties and oxidation mechanisms of titanium diboride (TiB_2). The force field parameters were trained against a comprehensive set of quantum mechanical data, including heats of formation and elastic properties of various titanium boride phases. To assess the reliability of our ReaxFF force field, molecular dynamics (MD) simulations were performed to study thermal expansion and melting behavior. The simulations captured the anisotropic thermal expansion observed experimentally and showed good agreement in volumetric expansion. The predicted bulk melting point of 3120.87K falls within the experimental range (3063–3498K). We also examined the oxidation behavior of the TiB_2 surface. To accelerate surface reactions within accessible simulation timescales, Replica Exchange Molecular Dynamics (REMD) simulations were conducted. Oxidation was initiated with the formation of titanium oxides, followed by the formation of smaller gas-phase boron oxide species. These findings demonstrate that the developed ReaxFF force field reliably captures thermochemical and thermophysical behavior of TiB_2, as well as complex oxidation mechanisms, establishing it as an accurate and computationally inexpensive tool for simulating advanced ceramic materials.

(ICACC-PA032-2026) From alkoxides to thiolates: Precursor chemistry for high entropy oxides and high entropy sulfides

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Compositionally complex materials are attracting attention due to their ability to form homogeneous crystalline phases despite substantial chemical diversity. Ensuring such homogeneity requires synthetic routes that deliver precise cation mixing at the molecular level. In this work, we established a sol–gel pathway employing metal alkoxides as molecular precursors. Through controlled hydrolysis and condensation, we created chemically cross-linked preceramic networks in which different metal centers were already intimately connected before calcination. Thermal treatment of these gels yielded crystalline high-entropy oxides with uniform cation distribution. Beyond oxides, we extended this concept to high-entropy sulfides by utilizing metal thioalates as precursors. These thiolates enabled the generation of preceramic networks that transformed into crystalline sulfide phases. Altogether, our results highlight precursor-controlled sol–gel and molecular precursor chemistry as scalable and versatile approaches for synthesizing high-entropy oxides and sulfides with tunable structural and compositional features.

(ICACC-PA033-2026) Toward pore-free SiC ceramics for advanced applications

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Silicon carbide (SiC) is renowned for its superior properties such as high hardness, high thermal conductivity, excellent heat-resistance, and excellent chemical stability, which make it a promising candidate for use in various industrial applications. Pore-free SiC ceramics is very attractive because it shows enhanced mechanical properties, improved elastic modulus, superior thermal conductivity, better oxidation and corrosion resistance, and improved reliability. Full densification is relatively easy in liquid-phase sintering by filling pores by liquid flow. However, it is difficult to process fully densified SiC ceramics by solid-state sinteing because of entrapped gases in closed pores. In this presentation, a possible strategy for achieving pore-free SiC ceramics via multi-step solid-state sintering of monolithic SiC ceramics was investigated using submicron SiC powder and boron- and carbon-containing additives to achieve almost full density. A relative density of up to 99.7% and a thermal conductivity exceeding 200 W/mK were achieved using a multistep sintering strategy. Furthermore, practical applications of the SiC ceramics in semiconductor processing will also be presented.

(ICACC-PA034-2026) Fabrication of thin alumina membranes for pressure sensors by tape casting

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The demand for pressure sensors for hydrogen management will increase in coming years. Such sensors are exposed to considerable stress from hydrogen corrosion and diffusion. In addition, they must be insulating and temperature-stable to meet safety requirements. Low-pressure sensors are currently based on metallic or silicon pressure membranes. The use of ceramic membranes in hydrogen pressure sensors for low-pressure applications up to 2.5 bar represents an interesting alternative due to their tightness and inertness to hydrogen. The poster presents the development of alumina ceramic membranes of 200 μm thickness by tape casting. A casting slurry with optimized binders and plasticizer contents was developed using rheology measurements. Tape casting experiments were performed using a doctor blade casting unit. Finally, upscaling from a discontinuous to a continuous casting process was achieved by a systematic study of casting speed and drying parameters. The green tape density and microstructure were investigated by FESEM. After optimizing the sintering parameters, dense and warpage-free membranes were obtained. The density, microstructure, and hydrogen tightness of the membranes are reported. Mechanical characterization using a ring-on-ring bending tests was performed. Finally, the alumina membranes were integrated into a sensor housing and the sensor function was evaluated.

(ICACC-PA035-2026) Dielectric thin film properties of co-sputtered BZNO/TiO_2 for capacitor applications

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Bismuth Zinc Niobate Oxide (BZNO) is a promising high-permittivity dielectric, but its thin films suffer from poor crystallinity and compositional non-uniformity. To overcome these issues, we investigated composite films of BZNO and titanium dioxide (TiO_2), which is noted for its structural stability. The composite films were fabricated using RF magnetron co-sputtering. The TiO_2 target's RF power was varied while the BZNO power was fixed, allowing for precise control over the film's composition. We then analyzed the structural, compositional, and dielectric properties of the deposited films. Increasing the TiO_2 RF power raised the film's TiO_2 content, which effectively mitigated BZNO's structural limitations. Conversely, under constant thickness conditions, a higher BZNO fraction led to a significant enhancement in the dielectric constant. Our results demonstrate that co-sputtering BZNO and TiO_2 is a viable and flexible strategy for engineering high-performance composite dielectrics. This method allows for precise control of film properties, making it suitable for next-generation electronic devices.

(ICACC-PA036-2026) Stereology-based estimation of three-dimensional internal defect distribution in alumina ceramics

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Stereology is the study on obtaining characteristic values of three-dimensional (3D) distributions from two-dimensional (2D) cross-sectional information. In this study, the estimation accuracy of internal defect distribution by Schwartz-Saltykov method (SS method), a type of stereology, was verified. Specifically, a virtual microstructure model assuming ceramics was created using the discrete element method to set true values, and 3D information was estimated from the 2D cross-sectional information. We also examined how the prediction accuracy of the SS method varies with the number of particle size classes and the 2D observed area. As a result, it was confirmed that the distribution characteristics and total number of defects can be reasonably estimated by focusing on the negative values generated by the SS method. Furthermore, the SS method was applied to actual alumina ceramics and its effectiveness was confirmed. This presentation is based on results obtained from a project, JPNP22005, commissioned by the New Energy and Industrial Technology Development Organization (NEDO).

(ICACC-PA037-2026) ASTM international standards for properties/performance of advanced ceramics-Helping our world work better by Advancing Standards/Transforming Markets

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Advanced ceramics play prominent roles in global innovation trends. Properties and performance of brittle bodies such as advanced ceramics and glasses are challenging to measure accurately and precisely unless the proper techniques are used. Such techniques are embodied in the full-consensus standards (e.g., test methods, practices, guides, terminology) of ASTM Committee C28 on Advanced Ceramics which, since 1986, has developed over 50 standards to determine properties and performance of monolithic and composite ceramics as well as coatings and constituents that may apply to some glasses. These standards provide details for determining mechanical, physical, and thermal properties and performance, as well as characteristics for processing, thereby providing accurate, reliable, repeatable and complete data. Users, producers, researchers, designers, and academicians who are involved in ASTM Committee C28 write, update, and validate standards through round robin test programmes. This poster includes a pictogram of Committee C28 standards and how to obtain them. Also included is a listing of other related ASTM committees. Finally, some examples of the tangible benefits of standards for advanced ceramics demonstrate their practical application help illustrate that advancing standards can transform markets.

(ICACC-PA038-2026) In-SEM high-temperature nanoindentation of ultra-thin ceramic matrix composites

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A limitation of conventional nanoindentation test benches is the lack of possibility to observe the exact location of the indent, the deformation of the specimen during the test and the lack of applying application related high temperatures. Limitations in observation capabilities and high-temperature testing cannot easily be overcome by using different test setups subsequently due to inherent lack of crucial data in each of the tests. Interpretation of data is therefore challenging, and the real-world relevance of created data of each test may be constrained. Consequently, the presented poster shows the details of a novel in-SEM high-temperature nanoindentation test bench based on a Bruker Hysitron PI 89 SEM PicoIndenter which enables testing of materials of materials up to 1000 °C inside a scanning electron microscope. Special emphasis is put on the test setup and considerations for sample preparation needed for high-temperature testing. Ultimately, the successful determination properties of fibre reinforced composites are presented to illustrate the versatility of the used system. The presented method of in-SEM in-situ high-temperature nanoindentation offers a truly unique combination of SEM analysis and high-temperature nanomechanical characterization which pushes the boundaries of current materials research in numerous aspects.

(ICACC-PA039-2026) Methods for characterization of different electrolytes and solid oxide cells (SOCs)

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High temperature electrolysis (HTEL) has several advantages compared to other types of solid oxide cell (SOC) technologies, including a high efficiency at T = 850 °C when combined with an exothermic process. To reduce costs, increase lifetime and improve scale up production of electrolyte supported SOCs, a key is the cell thermomechanical stability. For this reason, different test methods were developed to characterize the thermomechanical properties of electrolytes and cells at room and operating temperature (T = 850 °C). To assess the room and high temperature strength of 3 mol-% yttrium stabilized zirconia (3YSZ) electrolytes, ring-on-ring and tensile tests were designed and applied. In order to study the degradation and lifetime of the electrolytes, the hydrothermal degradation was investigated, to examine possible transformations from tetragonal to monoclinic phases. To quantify the transformation, confocal Raman spectroscopy can be used even in a non-destructive analysis. Also, delamination can cause a cell failure in the stack. Therefore, an adhesion test was used to quantify the adherence of the electrodes to the electrolyte. Moreover, to quantify the local thermomechanical properties of electrolyte and cells, scanning electron microscope (SEM) in-situ nanoindentation was chosen.

(ICACC-PA041-2026) Self-supported NiO/CuO electrodes to boost urea oxidation in direct urea fuel cells

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Direct urea fuel cells (DUFCs) can be used to treat residual wastewater while generating electricity. Herein, self-supported electrodes consisting of NiO nanosheets vertically grown on CuO nanowires are synthesized to realize the urea oxidation reaction (UOR). Such electrodes show excellent UOR performance requiring 1.39 V vs. RHE to achieve 100 mA/cm2. Besides, DUFCs provide open circuit voltages and power densities up to 0.88 V and 11.35 mW/cm2. Electrochemical characterization and Raman spectroscopy prove the formation of NiOOH to enable the UOR. Mott-Schottky analysis and UV photoelectron spectroscopy show the NiO/CuO p-p heterostructure to facilitate the charge transfer from CuO nanowires to NiO nanosheets. Besides, at a local level, density functional theory calculations show that the presence of CuO modulates the electronic states of Ni at the very NiOOH/CuO interface, which results in stretched Ni-O bonds and a uniquely elongated N-H bond of urea that favors its oxidation.

(ICACC-PA042-2026) Mitigating the rock-salt phase transformation in disordered LNMO through synergetic solid-state AlF_3 and LiF modifications

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High-voltage disordered spinel $LiN_{0.5}Mn_{1.5}O_4$ (LNMO) is a promising cathode material for high power density in lithium-ion batteries (LIBs) due to its high operating voltage and three-dimensional open framework, which enables complete delithiation and lithiation during cycling. However, it suffers from poor cycle life associated with the rock-salt phase transformation. This study presents a straightforward synthesis approach to enhance the electrochemical performance of LNMO through a synergistic solid-state modification with LiF and AlF_3. This dual modification promotes rapid Li-ion diffusion, enables near-complete delithiation/lithiation, approaching the theoretical capacity of disordered LNMO, and,

more importantly, effectively mitigates the formation of the rock-salt phase, thereby enhancing structural stability, as confirmed by operando XAS and SXRD. Full cells using graphite as the anode and a high-loading cathode exhibit excellent cycling performance. They retain 80% of their capacity after 200 cycles at 0.5C within a voltage window of 3.5–4.9 V with cathode loading of 11 mg/cm^2. The findings of this study will significantly contribute to the advancement of high-power LNMO materials, offering improved battery life and thereby enhancing their potential for practical applications.

(ICACC-PA043-2026) Ca^{2+}-preintercalated V_2O_5 as a dual-function cathode additive for polyiodide anchoring in Zn-I_2 batteries

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Challenges inherent to conversion-type electrodes, including severe active material shuttling and suboptimal coulombic efficiency, continue to limit zinc-iodine (Zn-I_2) batteries. Here, we present a high-performance Zn-I_2 battery enabled by calcium-ion pre-intercalated V_2O_5 (CaVO) nanobelts as a cathode additive. By harnessing the synergistic effects of physical trapping (via activated carbon and interlayer confinement in CaVO) and chemical adsorption (through Ca^{2+} binding sites), the hybrid host framework achieves superior immobilization of iodine species while simultaneously shortening Zn^{2+} diffusion pathways, thereby facilitating efficient I^0/I^- redox kinetics. Furthermore, Ca-induced crystal structure modification enhances Zn^{2+} transport and provides additional capacity contributions. As a result, Zn-I_2 cells employing I_2-loaded CaVO (CaVO/AC@I_2) composite cathodes deliver a high specific capacity of 244 mAh g^{-1} at 0.2 A g^{-1}, outstanding rate performance with 78.5% capacity retention at 5 A g^{-1}, and an impressive energy density of 279 Wh kg^{-1}, based on the combined mass of I_2 and CaVO. This work presents a hybrid energy storage strategy for Zn-I_2 systems, providing a feasible approach for the development of next-generation high performance aqueous batteries.

(ICACC-PA044-2026) Hybrid nanomaterial-cold atmospheric Plasma approach for synergistic cancer cell inhibition

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The design of multifunctional nanocarriers offers a promising strategy for targeted cancer therapy by enhancing efficacy while reducing systemic toxicity. In this study, superparamagnetic iron oxide nanoclusters (SPIONCs) were synthesized via a solvothermal polyol method and functionalized with mesoporous silica for selective targeting. The resulting nanostructures were efficiently loaded with curcumin and salinomycin, establishing a dual-drug delivery system. Characterization (DLS, zeta potential, TEM, FTIR, BET, VSM) confirmed controlled particle size (100–300 nm), tunable surface charge, enhanced porosity, and superparamagnetic behavior, enabling efficient drug encapsulation and release. In vitro assays with breast cancer cells revealed significant time-dependent growth inhibition, further amplified by cold atmospheric plasma (CAP) exposure. The combined application of CAP and drug-loaded nanocarriers synergistically reduced cell viability via elevated ROS generation. Moreover, Ca^{2+} imaging showed intracellular calcium flux after co-treatment, correlating with oxidative stress and decreased survival. Overall, this work highlights the potential of integrating functionalized nanocarriers with plasma-induced bioeffects, magnetization features, and calcium signaling modulation as a promising multimodal strategy for effective cancer therapy.

(ICACC-PA045-2026) Preliminary investigation on non-firing ceramics from local diatomaceous earth and treated fly ash for dye and copper sulfate adsorption applications

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This study initially explores non-firing ceramic adsorbents produced from Kapatagan Diatomaceous Earth (KDE) and Treated Fly Ash (TFA) for wastewater treatment. Five formulations (TK-1 to TK-5) were prepared and tested for physical and adsorption properties. Increasing TFA content reduced water absorption and porosity while enhancing density and strength, with TK-5 (100% TFA) achieving 1.76 g•cm^{-3} bulk density and 6.27 MPa compressive strength. Adsorption tests showed a 2% (m/v) dosage and 60-minute contact time were effective. TK-2 to TK-4 removed >90% methylene blue (10–20 ppm), while all blends achieved >90% copper sulfate removal, with TK-2 and TK-3 reaching >91%. These results demonstrate an innovative, eco-friendly route for converting industrial byproducts into functional ceramic adsorbents, advancing sustainable materials and industrial root technologies.

(ICACC-PA046-2026) Experimental study on the fabrication of silicon carbide based fibers derived from silicone resins

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Silicon carbide fibers are typically manufactured from polycarbosilane. After years of manufacturing technology development, they are considered the most reliable fibers for SiC/SiC composites, the easiest to process, and possess a highly productive manufacturing process. However, the high cost of polycarbosilane itself results in extremely high prices for silicon carbide fibers, limiting their use outside of extreme environments. This research focused on the potential for manufacturing silicon carbide-based fibers from silicone resins, which have a commercial price less than one-tenth that of polysiloxane. We attempted to produce fibers mixed with polysiloxane and also to manufacture silicon carbide-based fibers without using polysiloxane at all. We investigated whether it is possible to reduce the cost of silicon carbide-based fibers.

(ICACC-PA047-2026) Structural and dielectric properties of anti-ferroelectric $AgNbO_3$ with La_2O_3 and Ta_2O_5 additions

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$AgNbO_3$, an anti-ferroelectric ceramic, is considered a promising material for high-temperature applications due to its high energy storage density and energy efficiency. Therefore, it is regarded as an alternative to ferroelectric in multilayer ceramic capacitors(MLCCs). In this study, we investigated $AgNbO_3$ focusing on the effects of La_2O_3 and Ta_2O_5 additions on its dielectric properties and microstructures. La_2O_3 addition resulted in Ag-rich phase as a secondary phase and enhanced crystal symmetry. Ta_2O_5 addition had $Ag_2Ta_8O_{21}$ as a secondary phase and reduced crystallinity. Moreover, Ta_2O_5 addition increased the grain size and improved the density, whereas La_2O_3 addition suppressed grain growth and reduced average grain size, resulting in a less dense structure. The relative permittivity enhanced approximately doubled and decrease dielectric loss at room temperature with the addition of La_2O_3. When Ta_2O_5 was added, the phase transition temperature was decreased, while the addition of La_2O_3 resulted in a more diffuse phase transition behavior. The co-addition of La_2O_3 and Ta_2O_5 exhibited properties that were intermediate between those observed when each was added independently. Further investigation of the dielectric properties was studied through P–E hysteresis measurements and grain growth behavior was investigated through EBSD(Electron Backscatter Diffraction) analysis.

(ICACC-PA048-2026) Synthesis and electrochemical characterization of Zr-Fe oxide/hydroxide nanosheets

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Transition metal oxide and hydroxide nanosheets are promising materials for electrochemical energy conversion and storage, owing to their high surface area, tunable chemistry, and efficient ion/electron transport. Zirconium-based oxides offer excellent chemical stability, while iron species exhibit strong catalytic activity in oxygen-related reactions. Combining these two elements enables the design of stable and active nanosheet catalysts. In this study, Zr–Fe oxide/hydroxide nanosheets with varying Zr-to-Fe ratios were synthesized via the ion layer epitaxy (ILE) method to explore composition-dependent effects. Morphology and thickness were analyzed by scanning electron microscopy (SEM) and atomic force microscopy (AFM), while transmission electron microscopy (TEM) provided structural insights. X-ray photoelectron spectroscopy (XPS) confirmed Fe incorporation and revealed oxidation states and elemental distribution. Electrochemical oxygen evolution reaction (OER) measurements demonstrated that Fe incorporation improves catalytic performance, suggesting a synergistic effect between Zr and Fe sites. Overall, this work establishes a clear relationship between composition and catalytic behavior in Zr–Fe nanosheets and provides useful guidelines for designing transition metal oxide/hydroxide nanostructures for high-performance energy applications.

(ICACC-PA049-2026) Development of transparent Eu^{3+}:fluorapatite ceramics for red luminescence

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Non-cubic transparent ceramics are attracting attention as new optical materials. In this study, we developed transparent Eu^{3+}-doped fluorapatite ceramics with red emission, offering wide-ranging opportunities in photonic and biomedical applications. Fine powders were synthesized by a wet-chemical route and consolidated by spark plasma sintering. The ceramics sintered at 950°C exhibited the highest transparency, achieving in-line transmittances of 81.2% and 72.9% at the red wavelength of 619 nm, and grain sizes of 98 and 153 nm, respectively. Optical characterization revealed strong excitation around 460 nm and sharp red emissions corresponding to the $^5D_0 \rightarrow {}^7F_1$ (~580 nm) and $^5D_0 \rightarrow {}^7F_2$ (~620 nm) transitions of Eu^{3+}. In this presentation, we will discuss in detail the relationship between microstructural features, transparency, and luminescence behavior.

(ICACC-PA050-2026) Fabrication and fluorescence properties of transparent Er^{3+} doped $(Y, La)_2O_3$ mixed sesquioxides ceramics

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In this study, we focus on Er^{3+} doped $(Y_{1-x}La_x)_2O_3$ mixed sesquioxide transparent ceramics. The homogeneous powders were synthesized by the co-precipitation method and sintered using spark plasma sintering (SPS) technology. As a result, the powders and ceramics have a cubic structure without any secondary phases. Due to the significant difference in ionic radius between La^{3+} and Y^{3+}, the emission bandwidth broadened with the increase of La concentration. The in-line transmittance for $Er:(YLa)_2O_3$ ceramics was reduced with La content. Appropriate hot isostatic press (HIP) treatment after SPS step allowed for the elimination of residual pores and further enhancement of optical transmittance.

(ICACC-PA051-2026) Sustainable 3D Printing of Bio-Based Ceramic Slurries Using Second-Life Glass-Derived Materials

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This study explores the reuse of waste-derived glass materials for slurry-based 3D printing via vat photopolymerization, using bio-based photocurable formulations prepared from acrylated epoxidized soybean oil (AESO) and isobornyl acrylate (IBOA). Waste sources, like mineral wool and glass from the vitrification of municipal waste incinerator bottom ash, were milled and sieved to achieve particle sizes below 25–50 µm. The powders were characterized morphologically using field emission scanning electron microscopy (FESEM) and thermally through differential scanning calorimetry (DSC), hot stage microscopy (HSM), and dilatometry, enabling the optimization of thermal treatment conditions. These powders were incorporated into AESO-based formulations to produce photocurable slurries with ceramic loadings ranging from 40 to 60 wt%. Rheological and photo-rheological analyses confirmed suitable flowability (0.2–10 Pa s) and high photo-reactivity. Porous-like structures were fabricated using masked stereolithography and subsequently heat-treated at 950 °C to remove the resin phase and consolidate the material into glass-ceramic components. The results demonstrate the feasibility of manufacturing porous glass-ceramic structures through this sustainable approach, highlighting opportunities for waste valorisation and the advancement of additive manufacturing technologies.

(ICACC-PA052-2026) Full elemental survey of aluminum scandium alloy Scalmalloy®

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Aluminum scandium alloys are proving to have great potential in the automotive, aerospace, and telecommunication industries as modern, high performance, substitutes for existing alloys and semiconductors. The constant advances in additive manufacturing (AM) enables manufacturers to produce materials of complex shapes and sizes. The combination of the high-performance requirements of these alloys as well as the challenges associated with additive manufacturing requires full chemical survey of the starting powder to be used in AM. EAG Laboratories is well positioned to conduct such analyses using multiple techniques available in-house. Inductively coupled plasma optical emission spectrometry (ICP-OES) is best suited for analyzing the major constituents of an alloy. EAG is also able to conduct NIST High Performance ICP-OES analysis. Glow discharge mass spectrometry (GDMS) is a direct-analysis technique able to survey the entire periodic table and provide ppm to sub-ppm reporting limits. Finally, instrumental gas analysis (IGA) can quantify hydrogen, carbon, nitrogen, and oxygen; the latter being an extremely important impurity for AM. Scalmalloy® is an accepted industry standard used in AM. We conducted a full elemental survey of this material at EAG Laboratories.

(ICACC-PA053-2026) Manufacturing of meta-composite thermoelectric devices with high energy generation and mechanical performance

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Solid-state thermoelectric generators (TEGs) convert heat directly to electricity with zero local emissions. However, their deployment is constrained by low conversion efficiency and the tight coupling between power factor and thermal conductivity. In this study, we report a 3D-printed meta-composite thermoelectric (TE) device that enables optimization of energy conversion and mechanical robustness. The Digital Light Processing (DLP) 3D printing approach is applied to fabricate an alumina metamaterial scaffold integrated with $Bi_{0.5}Sb_{1.5}Te_3$ (BST) TE materials. A VMM-010/PEGDA resin is formulated with 70 wt% ceramic content; incorporating CuO, TiO_2, and Nb_2O_5 additives to tailor viscosity and improve feature resolution. DLP exposure and lift parameters are optimized to yield high-fidelity green bodies, which are pyrolyzed to produce a porous alumina shell. A BST thermoelectric paste, which is modified with PEDOT:PSS to improve electrical continuity, is introduced into the scaffold by drop casting and consolidated at low temperature. The thermal–electrical finite-element (FE) model reproduces voltage evolution and heat spreading within the metastructure. The DLP-printed meta-composite TE devices deliver stable power generation under load and outstanding compressive strength, demonstrating a promising TEG design with excellent mechanical and thermoelectric performances.

(ICACC-PA054-2026) Molecular actinide precursors for chemical vapor deposition of actinide-based thin films

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Actinide based thin films are promising materials for applications ranging from nuclear technology to energy storage and conversion. Among deposition techniques, chemical vapor deposition (CVD) offers substantial advantages over physical methods, yet its success critically depends on the design of suitable precursors that combine high volatility, adequate stability, and tunable reactivity. This is particularly challenging for actinides since they exhibit high molar masses, large ionic radii and possess high coordination numbers. Driven by the quest for suitable precursors, this poster highlights reported molecular actinide systems and their resulting thin films, showcasing progress to date and outlooks for actinide CVD.

(ICACC-PA055-2026) Ultra-High Temperature (UHT) Processing of Refractory Metal Borides and Carbides at 2500°C

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Ultra-high temperature ceramics are used for the leading edge of hypersonic vehicles, engines and turbines which experience temperatures exceeding 2000°C. A liquid Hf-Nb-Ti-Ta alloy was infiltrated into a B_4C/C packed bed at 2500°C to investigate the phase equilibria and form a boride-carbide composite. A low oxygen partial pressure ($< 10^{-32}$ atm) was maintained by using a pseudo-isopiestic technique with low-temperature region (~1000°C) containing a Y-Al/Y2O3-Al2O3/carbide mixture to prevent the formation of oxides at 2500°C. Microstructural and phase formation acquired by SEM/EDS and XRD are discussed with thermodynamic calculation toward the formation of Hf-Nb-Ti-Ta diborides and monocarbides at 2500°C.

(ICACC-PA056-2026) Biaxial Radiography of Thermal Expansion and Sintering-Induced Shrinkage

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Two X-ray-sources, paired with digital-plate detectors, were combined with a custom furnace to enable real-time, non-contact extensometry measurement of the geometrical changes that occur in a sintering ceramic component. This captures component thermal expansion that occurs during heating (prior to the onset of sintering) and contraction after commencement of sintering. The two source-detector pairs, one oriented horizontally and the other vertically, defined here as a biaxially oriented radiography imaging system (BORIS), provide radiographs of a ceramic object that is positioned in the furnace's hot zone. The custom-designed furnace is comprised of relatively low-density materials (e.g., aluminum chassis and aluminosilicate insulation) and its heating elements are purposely located outside the fields of view, so the X-ray transmittance through, and radiographic imaging of, the ceramic component encounters minimized interference. The two axes enable the study of potential anisotropy of the object's changing longitudinal and transverse profiles through imaging processing. This system has advantages over sintering dilatometry and hot-stage microscopy because multiaxial dimensional changes can be tracked of actual, and relatively large, ceramic components. The sintering of various ceramic components is used to demonstrate BORIS's capabilities and attributes.

(ICACC-PA057-2026) CoorsTek advanced ceramic technologies powering tomorrow's energy landscape

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The global energy landscape is undergoing a profound transformation, driven by the need for reliable, affordable, and cleaner solutions. CoorsTek contributes to this transition through advanced ceramic technologies that enhance performance across conventional and emerging energy sectors. In nuclear energy, CoorsTek provides silicon nitride, boron carbide, tungsten carbide for seals, control rods, neutron shielding in reactors, while advancing boron carbide, silicon carbide materials as shielding and neutron absorbers for fusion systems. Hydrogen innovation is supported through solid oxide ceramic electrolyzers for green hydrogen, membranes for blue hydrogen, and catalyst support that lower methane reforming energy demands. CoorsTek also offers reliable, heat stable, corrosion resistant components for use in hydrogen, cryogenic equipment. In Oil & Gas, CoorsTek designs components to work in rugged environment that improve efficiency, extend equipment life. Renewable energy systems benefit from specialized ceramics for solar PV production, thermal storage materials for concentrated solar power, and silicon nitride bearings for wind turbines. By leveraging over 100 yeras of expertise in advanced ceramics, CoorsTek establishes itself as a vital partner in bridging conventional energy infrastructure with next generation ceramic innovations, advancing the global transition toward a sustainable energy future.

(ICACC-PA058-2026) Enhancing the thermoelectric performance of InTe through structural-distortion-induced band gap opening

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InTe has emerged as a promising thermoelectric material due to its low thermal conductivity, which is attributed to the strong anharmonic bonding of In1+, which effectively scatters phonons. However, it has a narrow band gap, which causes it to exhibit bipolar conduction and a low Seebeck coefficient. In this study, we investigate the effect of Bi and Sb doping at the In site, which introduces structural distortion that widens the band gap and suppresses bipolar conduction. The structural distortion is evidenced by lattice expansion, modified atomic interactions, and strain-driven band dispersion. A maximum zT of 0.75 and 0.82 was achieved for In0.99Bi0.01Te and In0.99Sb0.01Te, respectively. The induced distortion expands the lattice, weakens interatomic bonding, enhances phonon anharmonicity, and reduces lattice thermal conductivity. An ultralow lattice thermal conductivity of 0.27 W m-1 K-1 at 773 K is achieved. Overall, structural distortion offers an effective strategy for optimizing the thermoelectric performance of narrow-gap semiconductors.

(ICACC-PA059-2026) Coal-enhanced silicon oxycarbide composite as a stable Li-ion battery anode

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The increasing demand for affordable, high-capacity Li-ion batteries has driven research into alternative anode materials that overcome the supply constraints of conventional graphite. This study presents a coal-enhanced silicon oxycarbide (SiOC) composite as a next-generation anode material. Using domestic raw coal and polymer-derived ceramic processing, a tunable Si–O–C network is formed that delivers higher capacity than graphite while maintaining excellent cyclability due to its mechanical and electrochemical stability. Electrochemical testing demonstrated reversible capacities exceeding those of conventional graphite anodes, while enabling a pathway toward U.S.-based anode production. In situ transmission electron microscopy (TEM) and X-ray diffraction (XRD) were employed to probe the structural evolution of the SiOC composite during electrochemical cycling. These operando measurements revealed minimal volume changes (~5%) during lithiation and delithiation, indicating lithium storage through gradual rearrangement of the amorphous network rather than crystalline alloy formation. These insights clarify the lithiation mechanism in coal-enhanced SiOC and provide guidelines for designing low-cost ceramic–carbon composite anodes for lithium-ion batteries.

(ICACC-PA060-2026) He plasma treatment in ALD In2O3: Overcoming precursor screening and in-Situ annealing for high-mobility TFTs.

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Among various oxide semiconductors proposed for next-gen 3D DRAM channels, In2O3 stands out for its high electron mobility even at ultra-thin thicknesses, enabling aggressive scaling and low-T processing. Atomic layer deposition (ALD), with its self-limiting reactions and excellent step coverage, is indispensable for advanced architectures. However, the large size of indium precursors causes steric hindrance and precursor screening, limiting film quality and device performance. To address precursor screening, we integrated in-cycle He plasma treatment into ALD In2O3. The He plasma effectively alleviated precursor screening, enhanced film density, and provided in-situ annealing effects controlling oxygen vacancies, resulting in variations in mobility and carrier concentration. Finally, we utilized this approach to fabricate a dual-layer structure consisting of bottom pristine In2O3 and top He plasma-treated In2O3. The dual-layer configuration (bottom pristine In2O3/top He plasma-treated In2O3) achieved higher mobility than single-layer devices, with pristine In2O3 providing carrier percolation paths and the plasma-treated layer supplying electrons via increased oxygen vacancies and carrier concentration. This work offers a strategy for precise ALD precursor control and highlights plasma-enhanced ALD for high-mobility, low-power oxide channels in future 3D devices.

Wednesday, January 28, 2026

15th Global Young Investigator Forum on Sustainability

15th GYIF- Thermo-Mechanical Behavior of Ceramics and Composites II

Room: Ballroom 5
Session Chairs: Minh Chu Ngo, National Institute of Advanced Industrial Science and Technology (AIST); Gaku Okuma, Busshitsu Zairyo Kenkyu Kiko

9:00 AM

(ICACC-GYIF-020-2026) Anomalous crack healing in oxide ceramics induced by ion irradiation: Material dependence and critical width (Invited)

T. Miyagishi*[2]; S. Kondo[1]; Y. Ogino[1]; K. Yabuuchi[1]; H. Yu[1]; M. Park[1]; A. Hasegawa[1]; R. Kasada[1]

1. Tohoku University, Institute for Materials Research, Japan
2. Tohoku University, Grauate School of Engineering, Japan

Oxide ceramics are promising for applications in harsh environments like nuclear reactors, but their inherent brittleness is a critical drawback. We previously discovered an anomalous self-healing phenomenon in mullite ($3Al_2O_3 \cdot 2SiO_2$), where pre-existing cracks were healed by high-energy ion irradiation. This occurs at low temperatures (<300°C) where thermal diffusion is negligible, suggesting an athermal process. However, the universality of this phenomenon and the healable crack size limit are unknown. This study aims to clarify the material dependence and quantitatively evaluate the critical healable width of this ion-induced crack healing. Polycrystalline mullite, single-crystal α-alumina, and α-quartz were used. Artificial slits with various widths were fabricated by Focused Ion Beam (FIB) milling. These were irradiated with 3 MeV Si+ ions at 150-300°C, and changes in slit geometry were observed by Scanning Electron Microscopy (SEM). The most striking result is that in mullite, slits as wide as 0.81 μm were completely closed by irradiation. In contrast, α-alumina and α-quartz exhibited different behaviors. We will report quantitative results on the occurrence and critical healable width for various oxides and discuss the potential driving mechanism.

9:30 AM

(ICACC-GYIF-021-2026) Robotic automation of DUSTE Testbed for lunar/Martian Dust Tribological Experimentation

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2. NASA Langley Research Center, Advanced Materials and Processing Branch, USA
3. Analytical Mechanics Associates Inc, USA
4. Old Dominion University, College of Engineering, USA

The Dust, Ultraviolet radiation, and Space Thermal Effects (DUSTE) testbed is a vacuum chamber with modifications to facilitate evaluating material performance under simulated lunar and planetary environments. This apparatus integrates lunar or Martian dust simulant exposure, UV radiation, and cryogenic cooling to replicate harsh extraterrestrial environments. Previous DUSTE configurations for material abrasion testing required the chamber to undergo a full repressurization cycle in between exposure cycles, extending the overall duration of experiments and risking contamination. The integration of a Universal Robots UR3e collaborative robotic arm was implemented into the DUSTE testbed to improve the efficiency of experimentation, while enabling diverse testing configurations including plate abrasion, pulley-rope wear testing, and automated sample exchange to be performed in the enclosed volume under vacuum. Controls were developed using ROS2 MoveIt motion planning software, with an abstracted frontend GUI for simplified use and ease of data extraction from integrated sensors in DUSTE. Preliminary results from material and mechanism test configurations leveraging the robotic arm will be presented.

9:50 AM

(ICACC-GYIF-022-2026) Densification, mechanical and thermal properties of zirconium diboride ceramics (Invited)

Y. Zhou*[1]; W. Fahrenholtz[2]; G. Hilmas[2]

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2. Missouri University of Science & Technology, Dept. of Materials Science and Engineering, USA

Zirconium diboride (ZrB_2) ceramics were fabricated by hot-pressing. Two batches of starting powders were prepared, one with 0.5 wt% carbon and the other with 0.5 wt% carbon plus 4.7 wt% zirconium hydride (ZrH_2) additions. Phenolic resin was added as carbon source, which was used to promote densification. ZrH_2 was used to react with and remove graphite and B4C impurities from the final microstructure. Starting powders were densified at temperatures from 1750 - 2150°C under 32 MPa for 10 minutes. The cross-section morphologies were observed by scanning electron microscopy. Mechanical and thermal properties of both compositions were measured and compared. Hardness was measured at room temperature, strength was measured at elevated temperature. Thermal diffusivities were measured from room temperature to 1500°C.

<u>FS2- Ceramics to Shape the Future of Low-Carbon and Carbon-Negative Technologies</u>

FS2- Catalysts, ceramics and processes for CO_2 valorization and energy storage

Room: Flagler C
Session Chairs: Federico Smeacetto, Politecnico di Torino; Sandrine Ricote, Colorado School of Mines

8:30 AM

(ICACC-FS2-001-2026) A mechanochemical synthesis approach to Dual-Function Materials (DFMs) for the integrated capture and valorization of waste CO_2 (Invited)

M. Danielis*[1]

1. Universita degli Studi di Udine, Polytechnic Department, Italy

The integrated carbon capture and utilization approach (ICCU) represents an interesting solution to mitigate CO_2 emissions. Key elements of this approach are the Dual-Function Materials (DFMs), which are ceramic materials containing both a sorbent (an alkali phase) for the CO_2 capture and a catalytic active phase (a metal or metal oxide) for its conversion into added-value chemical feedstock. For their technological advancement, significant effort still needs to be devoted to improving both the capture capacity and the product yield. Within this context, a dry milling approach was studied with the aim of improving the DFMs performance and simultaneously reduce the environmental impact of their preparation. The DFMs obtained by milling displayed higher capture capacity and product yield compared to reference DFMs prepared by wet impregnation, both in Reverse Water Gas Shift (RWGS) and Dry Reforming of Methane (DRM), at 650°C, and methanation conditions, at 350°C. Milled samples showed higher reducibility and RWGS – DRM activity compared to wet-prepared counterparts, yet large metal particles suggested that further optimization of milling procedures could be pursued. Hence, a Design of Experiment approach was followed to enhance the performance of DFMs for the ICCU-Methanation, also achieving improved CO_2 capture capacity.

9:00 AM

(ICACC-FS2-002-2026) Polycationic oxide catalysts for CO_2 reduction: design strategies from thermo- to electrocatalysis (Invited)

P. Costa*[1]; A. Osti[1]; J. Cavazzani[1]; B. Senoner[1]; D. Chinello[1]; S. Costa[1]; A. Gilsenti[1]

1. Universita degli Studi di Padova, Italy

CO_2 activation is s key first step toward a circular carbon economy, yet its reduction to value-added products remains highly energy demanding. In the present contribution thermo-, photo-, and electrocatalytic approaches and their combinations are compared to identify strategies for catalyst and process design. Amongst the potential catalytic materials for CO_2 reduction, polycationic oxide based catalysts are attractive thanks to their compositional flexibility which facilitates CO_2 coordination, electron exchange, and ultimately hydrogenation. Surface segregation, and surface oxygen vacancies stabilization can be exploited to tune the CO_2 adsorption, while introducing redox couples favours electron exchange. Catalytic performance can also be enhanced through nanocomposition, such as decoration with metal nanoparticles (MNPs). Different catalytic performances can be obtained through the accurate selection of the polycationic support, the type of MNPs, the deposition procedure: all these aspects contribute to determine the strength of the interface and thus the activity and selectivity. Tailoring support also allows specific activation pathways, for example semiconducting supports for photocatalysis or mixed ionic–electronic conductors for electrolysis. Particular attention is given to avoiding Pt-group metals and to adopt scalable, sustainable synthesis and deposition procedures.

9:30 AM

(ICACC-FS2-003-2026) Electrochemical and chemical effects of CO_2/O_2 mixtures on state of the art SOFC cathodes for application in the novel SOS-CO_2 hybrid cycle (Invited)

M. Pagliari[1]; M. Marasi[1]; A. Cammarata[1]; D. Vandoni[4]; D. Montinaro[2]; D. McLarty[3]; E. Martelli[1]; S. Campanari[1]; A. Donazzi*[1]

1. Politecnico di Milano, Department of Energy, Italy
2. SolydEra s.p.a, Italy
3. Alternative Energy Materials, USA
4. Eni s.p.a, Technology, R&D and Digital, Italy

The SOS-CO_2 cycle is a new hybrid cycle for blue power production that integrates a SOFC stack and a gas turbine. In this configuration the SOFC stack operates at 30 bar, and is supplied with a cathodic CO_2-rich oxidizing mixture (21% O_2 79% CO_2 mol/mol), while the anode is fed with a CH_4-based reformate mixture. The consequences of feeding the 21/79 O_2/CO_2 mixture were experimentally investigated on Ni-YSZ button SOFCs (2 cm diameter, SolydEra) with LSCF-GDC and LSM-YSZ cathodes. Pressurized experiments with periodic I/V and EIS measurements were performed at Alternative Energy Materials, achieving more than 200 h of continuous operation at 30 bar and 700°C. Anodic humidified H_2 was utilized to focus on possible cathode's deactivation due to CO_2. The chemical interactions between the 21/79 O_2/CO_2 mixture and the cathodic materials was also investigated with operando XRD synchrotron experiments performed at 30 bar and 700°C for 3 hours (Alba, Barcelona). The combined results of the electrochemical and operando characterization showed that CO_2 forms Sr carbonate, but with no detrimental effects on the SOFC's performance. Numerical analyses with a physical SOFC model and appropriate kinetic correlations were also performed to predict the cell's and stack performance when the reformate mixture is supplied to the anode.

10:20 AM

(ICACC-FS2-004-2026) Analysis of perovskite redox materials in a full-cycle reactor model for solar thermochemical fuel production (Invited)

M. Santarelli*[1]; D. Ferrero[1]; F. Orsini[1]

1. Politecnico di Torino, Department of Energy, Italy

Thermochemical fuel production via two-step redox cycles driven by concentrated solar is considered a promising technology for clean energy production. The state-of-the-art process makes use of nonstoichiometric ceria as the redox oxygen carrier given its fast kinetics, crystallographic stability, cyclic durability, and abundance. However, reduction temperatures as high as 1500 °C are required to achieve a sufficient reduction extent. Currently, the most explored alternative to ceria are nonstoichiometric perovskites (ABO3-δ), allowing for a wide compositional space, doping strategies, stability at relatively high reduction extents, and more moderate reduction temperatures. Beyond the redox material itself, computational studies aimed at simulating the dynamics of the thermochemical cycle and predicting the performance of a specific reactor design are crucial, especially when novel reactor configurations and promising oxygen carriers need to be considered. In order to fully understand the full-cycle performance it is necessary to thoroughly model the entire redox cycle, i.e., oxidation as well as reduction, with finite rate chemistry modeling during both steps, especially when dealing with redox materials that are oxidation limited such as perovskites. The presentation describes therefore some activities developed around the OC materials the reactor design.

10:50 AM

(ICACC-FS2-005-2026) The effect of corrosion of silicon carbide in molten chloride salts for energy storage

C. Lewinsohn*[1]; J. Fellows[2]; M. Flinders[3]; M. Anderson[4]

1. Rational Solutions, LLC, USA, USA
2. Ceramic Theory, Inc, USA
3. Ultra Safe Nuclear Corporation, USA
4. University of Wisconsin System, USA

Molten salt-based heat transfer and storage has an important role in decarbonization of power generation and industrial processing by providing a way to store renewable energy for use when production rates are low. The temperature at which nitrate salts can be utilized is limited by decomposition or corrosion of materials in contact with salts. Higher temperatures are desired to improve the efficiency of systems incorporating molten salt thermal energy storage. Chloride salts have higher decomposition temperatures but are even more corrosive than nitrate salts. Ceramic materials are typically more corrosion resistant than metals and can resist high temperatures better than most polymers. The effects of corrosion on silicon carbide materials and components representative of microchannel heat exchangers were measured after immersion in a molten salt containing magnesium, potassium and sodium chlorides at 750°C for 500 h. Changes in weight, dimensions and surface profile were quantified and samples were investigated by scanning electron microscopy. The samples exhibited extremely low weight gain. Potential mechanisms explaining the observed results are discussed and recommendations for future research are provided.

11:10 AM

(ICACC-FS2-006-2026) Long-duration electrically charged thermal energy storage enabled by ceramic heating

S. Jeong*[1]; R. Afzal[2]; Z. Ma[3]

1. University of Central Florida, Mechanical and Aerospace Engineering, USA
2. Blasch Precision Ceramics, USA
3. National Renewable Energy Laboratory, USA

Current and emerging energy storage technologies include thermal, mechanical, chemical, and electrochemical systems, each meeting distinct operational and scalability needs. Long-duration energy storage is critical for grid stability, renewable integration, and deep decarbonization. While molten nitrate salt TES is commercially deployed in CSP, it is limited by temperature, stability, and corrosivity. Particle-based TES provides broader temperature range, stability, and low cost. Beyond solar charging, electrically charged TES (ETES) can store surplus electricity as heat in particles and release it on demand. Central to ETES is an electric particle heater, using arrays of diamond-shaped SiC elements that resistively heat flowing particles through a serpentine pathway, enabling outlet temperatures up to 1200 °C. SiC heaters must withstand extreme temperature, thermal shock, and cyclic loading while maintaining stable resistivity and corrosion resistance. Unlike commercial heaters, they require engineered, tunable resistivity for direct grid-voltage operation, eliminating inefficient step-down processes. They also face erosion and thermal fatigue, impacting flow uniformity and heat transfer. Compact, high-power heaters are essential for efficient TES, making tailored thermal, electrical, and mechanical properties of SiC elements critical for efficiency, durability, and safe grid integration.

11:30 AM

(ICACC-FS2-016-2026) Resolving conversion fluctuations in chemical looping dry reforming of methane via solid carbon management

M. Kim[1]; J. Cheon[2]; I. Jung[2]; S. Zhai*[1]

1. The Ohio State University, USA
2. Seoul National University, Republic of Korea

This study identifies and resolves conversion fluctuations in chemical looping dry reforming of methane (CLDRM) over Ni-Fe-Ce mixed oxides by linking carbon deposition dynamics to Ce-Fe phase transformation. We demonstrated that alternating high- and low-conversion cycles arise because CH_4 pyrolysis deposits the excessive amount of solid carbon that consumes a large fraction of CO_2 and thereby limits material re-oxidation; when CO_2 is pref-erentially consumed by carbon removal, bulk Ce-Fe reoxidation to $CeFeO_3$ is suppressed. When less carbon is deposited, more CO_2 is available for CeFeO3 formation, leading to a Ni-rich-Fe alloy, enhancing both CH_4 and CO_2 conversions. This feedback loop drives unstable performance whose mechanism was illustrated by our X-ray diffraction, X-ray absorption spectroscopy, X-ray photo-electron spectroscopy, and scanning electron microscopy coupled with energy dispersive spectroscopy. Two mitigation strategies were developed and validated: supplying gas-phase oxygen and increasing the solid-phase oxygen reservoir. Either approach avoids fluctua-tion, and the combined strategy maximizes syngas production while minimizing carbon accumulation over 100 CLDRM cycles. These results provide a practical route to durable high reactivity integrated catalyst and redox oxide containing Ni-Fe-Ce.

FS3 Smart Powder Processing of Multifunctional Ceramics and Catalyst Materials

FS3- Smart Powder Processing of Multifunctional Ceramics and Catalyst Materials I

Room: Ballroom 1 -2
Session Chair: Taeseup Song, Hanyang University

8:30 AM

(ICACC-FS3-001-2026) Tailoring the composition and properties of compositionally complex carbide ceramics (Invited)

W. Fahrenholtz*[1]

1. Missouri University of Science & Technology, Dept. of Materials Science and Engineering, USA

Compositionally complex carbide ceramics consist of four or more transition metals in a single phase rock salt crystal structure. Carbothermal reduction of oxides is a flexible process for synthesis of powders that provides compositional flexibility and produces powders that can be readily densified. Reactions take place in two steps with the first being reduction of oxides and the second formation of a homogeneous solid solution. Reacted powders can be densified by hot pressing or spark plasma sintering to produce fully dense ceramics. Properties such as hardness and thermal conductivity can be tailored by controlling the composition. This presentation will discuss examples of synthesis, densification, and properties of carbide ceramics.

9:00 AM

(ICACC-FS3-002-2026) Inorganic particles excellent for thermal interface material (TIM) fillers (Invited)

K. Sato*[1]; Y. Imai[1]; M. Fukushima[1]

1. National Institute of Advanced Industrial Science and Technology (AIST), Japan

To ensure proper performance of electric devices, unwanted heat generated in the devices must be effectively transferred outward. For heat dissipation, electrically insulating materials that have higher thermal conductivity should be employed as heat media. The materials are referred to as thermal interface materials (TIMs) and are often composed of thermally conductive inorganic fillers and matrix polymers. There are a variety of inorganic fillers, including alumina, aluminum nitride (AlN), hexagonal boron nitride (h-BN), and so on. From among them, adequate filler materials would be selected depending on the target applications and requirements. In the present talk, we are giving an underlying physical picture of the TIM fillers. Guided by the insights, we would like to make out inorganic fillers suitable for next-generation TIMs.

9:30 AM

(ICACC-FS3-003-2026) Atomic layer deposition on powders for precisely engineered microstructure and composition control of sintered ceramics

E. Bissell*[1]; A. Kostogiannes[2]; S. Lass[3]; A. Zachariou[1]; T. Mcnealy-James[1]; A. Mora[1]; B. Mauri-Newell[1]; N. G. Rudawski[4]; R. M. Gaume[3]; P. Banerjee[1]

1. University of Central Florida, Materials Science and Engineering, USA
2. Lawrence Livermore National Laboratory, USA
3. University of Central Florida, CREOL, USA
4. University of Florida, USA

Atomic Layer Deposition (ALD) is a thin-film deposition method that uses successive self-limiting surface reactions to coat a surface one monolayer at a time with conformal, pinhole-free films. This technique can be applied to powders to create 'core-shell' particles with precise control over the shell thickness and composition. Through this method have created diffusion barriers on the surface of ceramic particles. The barrier layer helps restrict grain growth during sintering of ceramics. A study was performed on ZnO nanoparticles with an average diameter of 60 nm. These particles were coated with 1 or 10 nm of Al_2O_3 then mixed at a 1:1 ratio with uncoated ZnO nanoparticles. The particles are compacted then hot pressed at 850 °C and 150 MPa. Our analysis of the sintered ZnO ceramics reveals that the 'Al_2O_3 layer restricts the grain size of the sintered ceramic. SEM and XRD analysis confirm that the ceramics have nanocrystalline regions, while also maintaining the original Wurtzite ZnO structure. Due to the wide variety of available ALD chemistries, this technique is broadly applicable to the field of ceramics, whether that be for microstructural control or precise doping.

9:50 AM

(ICACC-FS3-004-2026) Powder-based processing of machinable SiC composites using SiC with boride and/or nitride reinforcements

S. Chodisetti*[1]; M. Kalin[2]; B. Kumar[1]

1. Indian Institute of Technology Roorkee, Department of Metallurgical and Materials Engineering, India
2. Univerza v Ljubljani, Faculty of Mechanical Engineering, Slovenia

SiC-based ceramics are preferred for wear components in harsh environments. However, the difficulty in shaping and sintering SiC-based ceramics limits their usage. Persistent research is required to develop a quick and cost-effective machinable SiC composite with superior wear resistance. In this regard, SiC-TiB_2-ZrN-hBN composites are prepared using commercially available SiC, TiB_2 and ZrN powders. The SiC composites are sintered at a considerably lower temperature of 1800°C by spark plasma sintering. XRD and SEM results demonstrated in-situ hBN phase development in sintered composites. Furthermore, the $\beta \rightarrow \alpha$ SiC phase transition is restricted, which is attributed to the reduced sintering temperature. The electrical conductivity of composites increases with an increase in reinforcement content. All investigated composites are successfully machined by wire-EDM, and the material removal rate increased with reinforcement content. Furthermore, the reciprocating sliding wear behavior of sintered SiC-ZrN and/or TiB_2 composites is assessed at room temperature and 600°C. Results demonstrate atleast one order of lower wear at 600°C compared to room temperature. Wear mechanisms changed from severe fracture-induced wear (due to weak in-situ hBN phase) at room temperature to tribo-oxidation at high temperature.

FS3- Smart Powder Processing of Multifunctional Ceramics and Catalyst Materials II

Room: Ballroom 1 -2
Session Chair: Kunihiko Kato, Gifu Daigaku

10:30 AM

(ICACC-FS3-005-2026) Utilizing cellulose nanocrystals to develop multi-scale porous ceramics (Invited)

C. Tallon*[1]

1. Virginia Polytechnic Institute and State University, Materials Science and Engineering, USA

Cellulose nanocrystals (CNCs) have unique natural, renewable and chemical properties that could be harvested to develop new types of functional structures, like porous materials with controlled features that cannot be achieved in a cost-effective manner by other synthetic techniques. In this presentation, CNCs is established as a cost-effective manufacturing tool to create multi-scale porous titanium oxide (TIO_2) for photocatalytic and other applications. Using colloidal processing and combining selected crosslinking, shaping and in-situ synthesis, anisotropic CNC aerogels are prepared, that in turn are used as porogens for the final multi-scale porous ceramics. The tailoring of the CNC aerogel microstructure can lead to an array of anisotropic porous structure, that in turn are infiltrated with a ceramic precursor. After the subsequent calcination of the CNC aerogel, and densification of the particle network a porous ceramic framework is established. The structural integrity and the mechanisms behind morphological and microstructural features of the CNC aerogels and the final features of the ceramic samples are discussed as a function of the processing parameters. This work sets the foundations for a new platform to develop new multi-scale ceramic material microstructures using recyclable and natural materials like CNCs.

11:00 AM

(ICACC-FS3-006-2026) Production of ceramic components by ultrarapid high-temperature sintering (UHS) (Invited)

V. M. Sglavo*[1]

1. University of Trento, Italy

Ultrarapid high-temperature sintering (UHS) has been recently proposed as a technique which allows the densification of ceramic materials in very short time, thus allowing to safe a considerable amount of energy. It is based on the very rapid heating of a carbon felt inside which the sample is placed because of the Joule heating produced by an electric current running through it. The approach is very attractive also for industrial applications which can use only electrical energy and avoid carbon dioxide emissions. Nevertheless, in order to scale up the process, several aspects need to be considered and studied. In the present work, some of the fundamental processing parameters like felt configuration, sample's size, current and dwell time were analyzed during the consolidation of alumina ceramics in a prototype furnace resembling the industrial plant. The obtained materials were characterized in terms of microstructure, density and porosity and compared to the specimens produced by conventional sintering. The results point out the advantages of the UHS technique and some issues related to the surface contamination and the maximum processable dimension of the samples.

11:30 AM

(ICACC-FS3-007-2026) Heat treatment induced phase transition in nano SiC powder particles

V. Muthaiah[1]; B. Kumar*[1]

1. Indian Institute of Technology Roorkee, Metallurgical and Materials Engineering, India

The present work investigates the formation of silicon nitride nano-structures on nano silicon carbide powders via thermal exposure in nitrogen atmosphere. The high-energy milled nano powders were heat-treated with varying temperatures in Ar and N_2 atmospheres. Powder particles exposed to N_2 atmosphere exhibited significant growth of both amorphous and crystalline Si_3N_4 fibres on the nano-sized SiC particle surface. The evolution of the mixed phase nano-structures was significantly influenced by the processing conditions. Such surface-modified, mixed phase SiC-Si_3N_4 nanostructures hold significant potential in the development of emerging composite materials.

FS4 Ceramic/Carbon Reinforced Polymers

FS4- Polymer and Polymer Composites

Room: Ballroom 3
Session Chair: Shinji Ogihara, Tokyo Rika Daigaku

8:30 AM

(ICACC-FS4-001-2026) Characterization of transverse cracking in composite laminates by various experimental techniques (Invited)

S. Oshima*[1]; S. Kobayashi[2]

1. Tokyo Noko Daigaku, Division of Advanced Mechanical Systems Engineering, Japan
2. Tokyo Metropolitan University, Mechanical Engineering, Japan

Transverse cracking is recognized as an initial damage mode in polymer matrix composite laminates. Since it occurs at the microscale, experimental characterization of crack initiation and propagation is challenging. This talk presents several experimental techniques for elucidating transverse cracking mechanisms. The first topic is the identification of initial damage sites in cross-ply carbon fiber reinforced polymer laminates under cyclic loading. Crack growth behavior was sequentially captured using in-situ optical microscopy synchronized with a fatigue testing machine, and the initial damage sites were identified by image processing. The second topic is the characterization of internal crack initiation and propagation in cross-ply glass fiber reinforced polymer composites. Internal crack characterization is particularly important in practical applications, where the ratio of surface to internal cracks is smaller than in coupon specimens. A dedicated specimen was developed to evaluate internal crack initiation and propagation, and differences between internal and surface cracking behaviors were compared to clarify fundamental mechanisms.

9:00 AM

(ICACC-FS4-002-2026) Time–temperature superposition of polypropylene based on free volume and potential energy by MD simulation (Invited)

S. Yuan*[1]; T. Sakai[2]

1. Tokyo Rika Daigaku, Japan
2. Saitama University, Japan

The time–temperature superposition principle (TTSP) has been widely used to predict long-term viscoelastic behavior of polymers from short-term tests. Although TTSP has been confirmed through creep and relaxation experiments, its molecular-level mechanisms remain insufficiently understood. A deeper understanding requires direct observation of molecular motions, which is difficult to achieve experimentally. In this study, molecular dynamics (MD) simulations were employed to investigate the creep behavior of polypropylene under various temperature and pressure conditions, with particular focus on free volume and potential energy as descriptors of molecular mobility. The results demonstrated that the Arrhenius-type TTSP applies to creep compliance, free volume, and potential energy at the molecular scale. Their activation energies exhibited a consistent dependence on temperature, and constant-density models constructed under hydrostatic pressure revealed a reduction in activation energy compared with atmospheric conditions, indicating the influence of non-bonding interactions. Structural analyses further showed that changes in bond angles, torsion, kinks, and entanglements correlated linearly with creep compliance. Consequently, the validity of TTSP was confirmed to originate from the time–temperature equivalence of these molecular-scale structural parameters.

9:30 AM

(ICACC-FS4-003-2026) Comparative mechanical properties of thermoplastic and thermoset CFRPs reinforced with spun recycled carbon fibres

G. Masuda*[1]; J. Lee[1]; T. Yokozeki[1]; M. Ueda[2]; T. Koto[3]; S. Tatsuta[3]

1. Tokyo Daigaku, School of engineering, Japan
2. Nihon University, Japan
3. Tatsuta Boseki Co., Ltd., Japan

Recycled carbon fibres (rCFs) are increasingly recognized as a promising sustainable reinforcement for advanced composites. In this study, composite laminates were fabricated using slivers of spun rCF yarns as reinforcement, combined with both thermoplastic and thermoset matrices respectively. The objective was to evaluate the fundamental mechanical performance of the resulting CFRPs and to clarify the role of matrix selection in property development. Tensile and flexural tests were carried out to assess stiffness, strength, and failure strain. In addition, moulding and processing conditions were optimized for each matrix type to ensure adequate fiber impregnation and minimize void formation. The results revealed distinct differences in the property profiles between the thermoplastic- and thermoset-based composites. Thermoplastic composites exhibited higher strength and modulus due to the higher Vf. Microscopic observations further indicated that the fracture morphology depended on the fiber–matrix interfacial interactions, which are affected by both the processing conditions. These findings demonstrate that spun rCF-based CFRPs can achieve tailored mechanical performance through appropriate selection of matrix systems and process optimization, highlighting their potential as a sustainable alternative to virgin carbon fiber composites.

9:50 AM

(ICACC-FS4-004-2026) Time-temperature superposition principle of polymers and their composites and their applications

T. Sakai*[2]; S. Somiya[1]

1. Keio Gijuku Daigaku Rikogakubu Daigakuin Rikogaku Kenkyuka, Japan
2. Saitama Daigaku, Japan

The temperature dependence of the creep characteristics of thermoplastic resin and its fiber-reinforced plastics (FRP) is examined using the Time-Temperature Superposition Principle. The study also evaluates changes in creep deformation with varying fiber volume fraction, degree of physical aging, and crystallinity. Regardless of changing conditions, the results indicate that the creep curve can be calculated from the matrix resin's creep curve. Factors affecting elastic deformation through changes in modulus, as well as the acceleration or delay of viscoelastic effects, are analyzed. The findings demonstrate that changes in viscoelastic deformation are linked to activation energy.

S1 Mechanical Behavior and Performance of Ceramics & Composites

S1- Mechanical and thermal characterization of ceramics and composites, techniques & equipment

Room: Coquina E
Session Chair: Nico Langhof, University of Bayreuth

8:30 AM

(ICACC-S1-027-2026) Deformation and fracture of C/C-SiC at 1200°C using in situ X-ray micro-tomography imaging (Invited)

G. Yuan[2]; S. Flauder[3]; N. Langhof[4]; S. Schafföner[5]; D. Liu*[1]

1. University of Oxford, Engineering Science, United Kingdom
2. University of Bristol, Physics, United Kingdom
3. Universitat Bayreuth, Germany
4. University of Bayreuth, Ceramic Materials Engineering, Germany
5. University of Bayreuth, Chair of Ceramic Materials Engineering, Germany

A carbon fibre reinforced carbon-silicon carbide composite (C/C-SiC) material with a 0/90° woven fabric reinforcement and ~50% fibre volume fraction was studied in this work in terms of its deformation and fracture at both room temperature (RT) and 1200°C (inert). The crack initiation and progressive propagation processes were investigated using real-time synchrotron X-ray micro-computed tomography (XCT) imaging combined with a three-point bending configuration. The flexural strengths and failure mechanisms were determined at both temperatures. Furthermore, digital volume correlation (DVC) analysis was applied to identify and quantify the correlations between fracture phenomena and local strain concentrations. Finally, the results are discussed in terms of the correlation between microstructure and high temperature performances of the studied C/C-SiC material.

9:00 AM

(ICACC-S1-028-2026) Experimental study on tensile strength distribution of Hi-Nicalon Type S Fiber by using Dry Tow Tensile Method

S. Ramasamy[1]; E. Maillet[1]; C. Smith[1]; Y. Zhou*[1]

1. GE Aerospace, USA

Tow tensile testing were carried out on Hi-Nicalon S fiber with different gauge length. Testing system compliance were calibrated based on slope of load-displacement curves. Accurate stress strain curves were obtained after modification of system compliance and have been validated by using directly strain measurement of DIC (Digital Image Correlation). According to tow tensile model and Weibull distribution function, a one-dimension constitution equation is developed to descript stress strain response of fiber tow. Three approaches to determined Weibull shape and scale parameter from experimental data is discussed.

9:20 AM

(ICACC-S1-029-2026) Fracture toughness testing of ceramic rods in flexure

I. Reimanis*[1]; R. McGinnis[1]

1. Colorado School of Mines, USA

The V-notch razor blade technique (the SEVNB method established within ISO ISO23146:2012) was employed to create sharp, straight notches in ceramic rods. The stress intensity factors (SIF) were calculated for a crack propagating from the straight notch under flexure, as a function of crack length. It was found that the SIF increased in all cases compared to the straight notch, meaning that a simple measurement of failure load in flexure leads to a measurement of the fracture toughness. The toughness test was benchmarked with rectangular and rod geometries of aluminum oxide and then applied to bisque-fired kaolinite-based rods and tubes where it is of interest to understand the strength and fracture toughness in microchannel membrane reactors for the production of hydrogen.

9:40 AM

(ICACC-S1-030-2026) Strategies for enhancing contact damage resistance through architectural and microstructural design

A. Jabr*[1]; J. Schlacher[1]; R. Bermejo[1]

1. Technical University of Leoben, Department of Materials Science, Austria

Contact damage is a major cause of failure and rejection in ceramic components. This work presents strategies to enhance the contact damage tolerance of ceramics and ceramic composites. One bioinspired approach involves texturing the microstructure of alumina-based ceramics to deflect cracks along elongated grains. Further improvement is achieved by embedding textured layers in a multilayer architecture to induce compressive residual stresses, acting as a "protective shield" against crack propagation. Acoustic emission detection was used for monitoring the materials response. It was found that a textured microstructure can accommodate damage by shear-driven, quasi-plastic deformation instead of the classical Hertzian cone cracking. In the multilayer system, a combination of both mechanisms, namely Hertzian cone cracking on the top surface layer and quasi-plastic deformation within the embedded textured layer, was observed. Further propagation of cone cracks at higher loads was hindered owing to the combined action of the textured microstructure and compressive residual stresses. These findings demonstrate the potential of microstructure tailoring and designing with residual stresses as strategies to enhance contact damage tolerance of ceramic materials.

10:20 AM

(ICACC-S1-031-2026) Nanoindentation of B_4C-TiB_2 particulate ceramic composite doped with Cr-B compounds.

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3. AGH University of Science and Technology, Academic Centre for Materials and Nanotechnology, Poland
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The mechanical behavior of B_4C-TiB_2 doped with Cr-B compounds particulate ceramic composite sintered by Spark Plasma Sintering was studied by nanoindentation. A mixture of CrB and Cr_3B_4 phases was mixed with B_4C and TiB_2 powders before sintering to form a solid solution with TiB_2 phase. While the formation of TiB_2-Cr-B solid solution was confirmed by the microscopy and XRD, a small quantity of CrB_2 phase was also detected to be present in B_4C-TiB_2 particulate ceramic composite after sintering. The study of nanoindentation behavior of B_4C-TiB_2 ceramic composite doped with CrB and Cr_3B_4 to report the hardness and Young's modulus along with indentation stress - indentation strain behavior of B_4C and TiB_2 phases where solid solution with Cr-B compounds is formed in TiB_2 grains is shown. Load-displacement indentation plots measured during nanoindentation of B_4C matrix phase and TiB_2 strengthening phase allowed to calculate both hardness and Young's modulus of these two phases. In addition, load-displacement plots were recalculated to visualize mean contact pressure - contact depth plots, which correspond to indentation stress or hardness measurements of two phases in B_4C-TiB_2 composite. The hardness and Young's modulus of B_4C matrix phase was measured to be equal to 43±3 GPa and 526±27 GPa, respectively.

10:40 AM

(ICACC-S1-032-2026) Evaluating the fracture toughness of advanced ceramic materials using the diametral compression test method *WITHDRAWN*

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Diametral compression, while originally developed for the indirect evaluation of the tensile strength of brittle materials, can also be applied to determine the fracture toughness of advanced ceramics. Owing to its simple specimen geometry and compact testing configuration, this method offers the potential to be used also at elevated temperatures in constricted thermal environments. In this work, a methodology is developed for the evaluation of the mode I fracture toughness of advanced ceramics using diametral compression. Experimental results obtained from multiple advanced ceramics are compared with values obtained from traditional beam-based fracture toughness evaluation methods. Additionally, finite element modeling is employed to validate the experimental findings and further examine the influence of disk thickness on crack initiation and growth behavior under loading.

11:00 AM

(ICACC-S1-033-2026) Mechanical properties of zirconia-yttria-tantala (YTZ) ceramics in non-transformable tetragonal compositions

M. Galeano Camacho*[1]; C. Gutierrez Virgen[3]; H. Ageorges[2]; J. Muñoz Saldaña[1]

1. Cinvestav, Materials, Mexico
2. Universite de Limoges, IRCER, France
3. Arkansas state university, campus querérato, Engineering, Mexico

ZrO_2 stabilized with 7-8 wt.% Y_2O_3 (7YSZ) forms a non-transformable tetragonal phase (t′) widely used in thermal barrier coatings for its excellent high-temperature toughness. However, 7YSZ has reached is limited by intrinsic oxygen vacancies. As an alternative, tetragonal compositions stabilized by equimolar tetravalent and pentavalent cations in solid solution with ZrO_2 have been proposed. This study evaluates the effects of milling and solid-state reaction parameters on the phase stability of the ZrO_2-Y_2O_3-Ta_2O_5 (YTZ) system to select the best composition for plasma sprayed TBCs. Five YTZ compositions within the t′-phase zone were prepared by solid-state reaction using powder mixtures of ZrO_2-(x)$YO_{1.5}$-(x)$TaO_{2.5}$, where x=15.4%, 16%, 16.6%, 17.2%, and 17.8%. Precursors were preheated, milled, pressed, and sintered at 1500°C. Highly dense ceramics (>95% t′-phase) were obtained. SEM micrographs revealed that increasing the dopants content leads to coarse grained microstructure. Vickers microhardness test was performed and toughness was calculated for the five compositions showing values between 37-50 J/m^2, slightly higher than the obtained in a 7YSZ (~ 38 J/m^2). Nanoindentation revealed pop-ins in load–displacement curves, suggesting ferroelasticity and microcrack formation.

11:20 AM

(ICACC-S1-034-2026) Fatigue behavior of two advanced C/SiC composites at 1200°C in air (Invited)

C. Adams[1]; M. Ruggles-Wrenn*[1]

1. Air Force Institute of Technology, Aeronautics & Astronautics, USA

High-temperature tension-tension fatigue behavior of two advanced carbon/silicon carbide ceramic matrix composites was investigated. Both composites were reinforced with T300 carbon fibers. Fiber preforms consisted of 24 plies of plain weave fabric in a 0/90 layup. The first composite, C/CVI-SiC, was processed by chemical vapor infiltration of SiC into the fiber preform. Prior to CVI, the fiber preforms were coated with a duplex pyrolytic carbon and boron carbide fiber coating to create a weak fiber-matrix interphase. The second composite, C/HYPR-SiC, was also processed via CVI, but had an oxidation inhibited matrix consisting of silicon carbide and boron carbide layers. Tension-tension fatigue behavior was evaluated at 1200°C in air in tests conducted with R=0.1 at 1 Hz. Fatigue stresses were 49-200 MPa for the C/CVI-SiC and 86-260 MPa for the C/HYPR-SiC. Fatigue runout was set to 200,000 cycles. Fatigue performance of both composites was poor. Composite microstructure, as well as damage and failure mechanisms were investigated. Post-test microstructural characterization revealed extreme fiber deterioration in the C/CVI-SiC specimens, and less extreme, but still significant fiber deterioration in the C/HYPR-SiC specimens. Deterioration of the carbon fibers due to oxidation is behind the damage and failure of both composites at 1200°C in air.

S2 Advanced Ceramic Coatings for Structural/Environmental & Functional Applications

S2- Ceramic coatings for protection against oxidation, corrosion, erosion, and wear

Room: Coquina C
Session Chair: Peter Mechnich, DLR - German Aerospace Center

8:30 AM

(ICACC-S2-030-2026) Wear- and oxidation-resistant Ti-Al-C, Ti-Nb-Al-C, Ti-Cr-Al-C coatings, obtained by vacuum-arc and hybrid magnetron deposition using MAX-targets (Invited)

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5. National Science Center Kharkov Institute of Physics and Technology of the National Academy of Sciences of Ukraine, Ukraine

Due to a set of unique characteristics, MAX-phases-based coatings are good candidates for SOFC and MCF fuel cell interconnects, as well as for wear-resistant coatings operating in the fretting corrosion mode at high temperatures. The surfaces of coatings deposited on titanium substrate by vacuum-arc method (which were polycrystalline and contain high amount of MAX phases) after heating at 600 °C for 1000 h remained highly conducting: electrical conductivity σ=1,23×10^6 S/m, mass gain $\Delta m/S$=0,06 mg/cm^2, and σ=1,2×10^6 S/m, $\Delta m/S$=0,45 mg/cm^2 when Ti_2AlC or $(Ti_{0.98}Nb_{0.02})AlC$ targets were used, respectively. After heating under similar conditions of amorphous coating obtained by hybrid magnetron sputtering using Ti_2AlC target and Cr cathode (the composition of coating was similar to MAX phase stoichiometry) demonstrated σ=1,0×10^6 S/m, $\Delta m/S$=0,05 mg/cm^2 and became polycrystalline after heating. Wear-resistance of vacuum-ark deposited coating from Ti_2AlC target on steel and titanium alloy substrates occurred about two times higher at 500 °C ($W=6{,}1\times10^{-4}$ $mm^3/N\times m$) than that of steel or titanium alloy substrates, and its resistance to multi-cycle fretting fatigue occurred to be 4.8 times higher and reached N_f=324,000 cycles. The structures of coatings before and after heating were studied by X-ray, SEM EDX, Auger spectroscopy and TEM.

9:00 AM

(ICACC-S2-031-2026) Design and optimization of multi-layer ZrB_2/SiC protective coatings for carbon/carbon composites in high-temperature environments

M. Rahaman*[1]; M. Olima[2]; J. W. McCormick[1]; S. Wang[3]; M. R. Ryder[4]; M. W. Keller[2]; H. Ramsurn[1]

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2. The University of Tulsa, Mechanical Engineering, USA
3. The University of Tulsa, Physics & Engineering Physics, USA
4. Asgard Analytics, United Kingdom

Carbon/Carbon (C/C) composites are widely used in aerospace and industrial applications due to their mechanical strength, thermal stability, and erosion resistance. However, their susceptibility to oxidation above 500 °C limits long-term performance. To address this, protective coatings like silicon carbide (SiC) and zirconium diboride (ZrB2) are applied via pack cementation (PC), chemical vapor deposition (CVD), or slurry coating. Single-layer coatings often suffer from porosity, cracking, or poor sealing. This study explores a multilayer coating strategy to enhance oxidation resistance. A base SiC layer is formed using PC and modified with boron to produce B2O3 during oxidation, which seals pores and reduces oxygen diffusion. Outer layers include slurry-based ZrB2–SiC coatings with self-healing properties or dense CVD coatings. Layer configurations—PC–CVD–Slurry and PC–Slurry–Slurry—are evaluated for effectiveness. Oxidation resistance is tested at 1000 °C in air, with SEM and XRD used for microstructural and phase analysis. The goal is to develop a thin, durable SiC/ZrB2multilayer coating to protect C/C composites in extreme thermal environments.

9:20 AM

(ICACC-S2-032-2026) Design, synthesis, and characterization of a high-temperature, ultratough interpenetrating composite coating

T. A. Wexler*[1]; A. Bhattacharya[2]; T. Steyer[2]; Z. C. Cordero[1]

1. Massachusetts Institute of Technology, Aeronautics and Astronautics, USA
2. The Boeing Company, Boeing Technology Innovation, USA

Environmental and thermal barrier coatings are essential for protecting metal components in extreme environments, but their brittle nature makes them prone to delamination under thermal shock. Overcoming this failure mode remains a critical limit to the reliability and life of high-temperature turbomachinery. We recently reported a novel class of metal/oxide glass-ceramic coatings which form an interpenetrating composite when the metal content exceeds the theoretical percolation threshold for penetrable spheres. This interpenetrating structure imparts high in-plane and interfacial toughness, as metal ligaments bond directly to the metallic substrates and bridge cracks in the brittle matrix phase. This talk will describe the ICME-informed design, synthesis, and characterization of a high-temperature variant of these coatings, generalizing the previously demonstrated percolation concept.

9:40 AM

(ICACC-S2-033-2026) Rare earth phosphate–Based trilayer coatings for EBCs for SiC CMCs: Phase stability, thermal properties, and CMAS resistance

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2. Rensselaer Polytechnic Institute, Materials Science and Engineering, USA

Rare earth phosphates have gained attention as promising candidates for environmental barrier coatings (EBCs) due to their favorable properties such as chemical stability, compatible coefficients of thermal expansion (CTEs), and high resistance to calcium–magnesium–alumino–silicate (CMAS) attack. Two different phosphates were synthesized: single-component $YbPO_4$ and multicomponent $(Lu_{0.33}Dy_{0.33}Ho_{0.33})PO_4$, through a chemical route. In addition, $Yb_2Si_2O_7$ was synthesized by solid-state reaction method to form a composite phase. Using these powders, two trilayer architectures were fabricated, consisting of a top rare earth phosphate layer, a middle composite layer ($YbPO_4$ + $Yb_2Si_2O_7$), and a SiC substrate. The phase composition, thermal properties, and microstructures were systematically studied using X-ray diffraction (XRD), dilatometry, laser flash analysis, and scanning electron microscopy (SEM). $YbPO_4$ exhibited a CTE of ~6.98×10^{-6} °C^{-1}, while $(Lu_{0.33}Dy_{0.33}Ho_{0.33})PO_4$ showed ~6.30×10^{-6} °C^{-1}, both well-matched to SiC-based CMCs (~$4.5–5.5 \times 10^{-6}$ °C^{-1}). Multicomponent phosphate demonstrated lower thermal conductivity than $YbPO_4$. The CMAS corrosion at 1300 °C, formed a continuous reaction layer, mainly composed of $Ca_8MgRE(PO_4)_7$ inhibiting the CMAS penetration. At 1400 °C, however, the protective layer was absent, allowing CMAS infiltration into $REPO_4$.

S2- New coating materials - MAX phases, high-entropy phases, etc., Microstructure-property relationships and Modeling and simulation

Room: Coquina C
Session Chair: Peter Mechnich, DLR - German Aerospace Center

10:20 AM

(ICACC-S2-035-2026) Phase stability in a non-stoichiometric high-ntropy rare earth zirconate

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1. Missouri University of Science and Technology, Materials Science and Engineering, USA

High-entropy rare earth (RE) zirconates $(5RE)_2Zr_2O_7$ offer unique opportunities for tailoring thermal and structural properties. However, the phase stability of non-stoichiometric high-entropy RE zirconates whose ratio of total RE elements to zirconium deviates from unity remains underexplored. In this study, high-entropy zirconates of the form $(La_{0.2}Nd_{0.2}Sm_{0.2}Gd_{0.2}Yb_{0.2})_xZr_yO_{(1.5x+2y)}$ were synthesized via a reverse co-precipitation method with varying x/y ratios. The resulting powders were calcined at 1200 °C and 1400 °C in air. Phase identification was performed using X-ray diffraction and Raman spectroscopy to distinguish between pyrochlore and defective fluorite structures. Optical bandgaps were evaluated using UV-Vis spectroscopy. The calcined powders were densified using spark plasma sintering, and the microstructure was analyzed using scanning electron microscopy (SEM) coupled with energy-dispersive spectroscopy (EDS). Thermal diffusivity and conductivity were determined using the laser flash method. These preliminary results offer a basis for understanding the influence of composition on phase formation and thermal behavior in high-entropy zirconates, with further characterization ongoing to fully assess their functional potential.

10:40 AM

(ICACC-S2-036-2026) High-pressure- high temperature oxygenation of YBCO films deposited on STO substrates.

T. Prikhna*[1]; R. Vlad[2]; A. Kethamkuzhi[2]; R. Kluge[3]; B. Büchner[3]; M. Karpets[4]; S. Ponomryov[5]; V. Moshchil[1]; X. Obradors[2]; T. Puig[2]

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Our previous studies of superconducting layers of GdBCO and EuBCO coated conductors (CC) after high-pressure (up to 160 bar) and high-temperature (up to 800 °C) processing allowed us to conclude that signs of oxygen overdoping were observed (about what were witnessed an increase of charge carrier density n_H(100 K), reduction of c-lattice parameters of RE123 (RE=Eu, Gd) of superconducting layers, behavior of normalized resistivity before superconducting transition, and J_c variation). After treatment at 160 bar O_2 at 800 °C for 3 h J_C(77K,0T) of GdBCO_CC was increased for 21.5 % from 2.12 to 2.70 MA/cm^2, ($n_H = 7.3\times10^{21}$ cm^{-3}, p=0.174; c-parameter decreased to 1.1727(1) nm), while heating for 6 h under same pressure-temperature conditions leaded to J_C(77K,0T) increase for 18 % only. Treatment of the samples at 600 °C under 100 bar O_2 for 3, 6, and 12 h resulted in increase in J_C(77K,0T) for 8, 14 and 13 %, respectively. In the present study it has been shown that J_c as a result of oxygenation of $YBa_2Cu_3O_{7-d}$ (thickness 215 nm) deposited on $SrTiO_3$ (STO) singlecrystaline substrate by spin coating method after treatment under 100 bar oxygen pressure at 600 °C for 8h was two times increased in self field as compare to the samples oxygenated at 1 bar oxygen pressure 450 °C for 3.5 h and reached J_c (77 K, 0 T) = 4.44 MA/cm^2, J_c (5 K, 0 T) = 40.8 MA/cm^2, its T_C =91.9 K.

11:00 AM

(ICACC-S2-037-2026) Mechanics of mudflat crack patterns with partial delamination

J. Steck*[1]

1. GE Aerospace Research, USA

Coatings with residual stress often crack in patterns that resemble drying mudflats. This phenomenon is even observed in the thermal and environmental barrier coatings (TBCs and EBCs) that line modern turbine engines, where tensile stresses may arise during synthesis or operation. If the coating is modestly bonded to the substrate, then mudflat cracking is accompanied by partial delamination of the coating. In this talk, we present an analytical fracture mechanics model for a mudflat crack pattern with partial delamination. Given the mechanical properties of the coating and interface, as well as the crack spacing, the model predicts the fraction of interface that delaminates. We show that tightly spaced mudflat cracks suppress delamination. Furthermore, we show that delamination is always finite—neighboring delaminations arrest before they meet, and there is always unbroken interface beneath a mudflat crack pattern. The analytical model applies generally to coatings cracking under residual tension, including modern coatings such as TBCs and EBCs.

11:20 AM

(ICACC- S2-038-2026) Extreme Temperature Gradient and Heat Flux in the Laser Rig Testing of Porous Ceramic Coatings

L. Zhao*[1]; P. Hsu[1]

1. Florida Institute of Technology, Mechanical Engineering, USA

The performance evaluation of thermal and environmental barrier coatings (TBCs and EBCs) under high temperature gradient and high heat flux conditions is critical for their application in gas turbines. A challenge in the thermal cycling testing is achieving a sufficiently high cooling rate on the substrate side or rapid cooling on the topcoat side. A water-mist injector is introduced to augment the cooling of an airjet in a high-power CO2 laser rigs. The apparatus comprising an ultrasonic mist generator, a custom-designed mixing chamber and nozzle, and an Arduino-based control system was integrated with the laser rig. Experimental results demonstrated a significant enhancement in cooling performance. At the topcoat side temperature (T H = 1550 °C), the introduction of a 0.5-1.0% mass fraction water mist in the airjet on the substate side reduced the temperature from 1050 °C (dry air) to 850 °C (with water mist). This corresponded to an increase in laser power input from 534 W to 671 W while maintaining the same T H . The result confirms a substantial increase in the net heat flux through the coated sample thickness. Calculations of a combined convective and radiative heat transfer were performed for the dry air case. The results show that water mist injection cooling is highly effective in increasing the temperature gradients in thermal cycling tests, enabling extreme testing.

S3 23rd Intl Symp on Solid Oxide Cells Materials Science & Technology

S3-Infiltration / exsolution enhanced electrodes

Room: Coquina H

Session Chair: Tatsuya Kawada, National Institute for Materials Science

8:30 AM

(ICACC-S3-048-2026) Interfacial insights from secondary batteries toward mitigating air electrode delamination in SOECs(Invited)

H. Lim*[1]

1. Changwon National University, Republic of Korea

Solid oxide cells (SOCs) exhibit distinct degradation behaviors depending on whether they operate in fuel cell or electrolysis mode. Among the critical degradation phenomena is chemo-mechanical failure, such as electrode delamination, which results from the development of high chemical potentials within the electrolyte. Similar degradation mechanisms have also been observed in other elec-trochemical systems, notably all-solid-state batteries (ASSBs). In particular, both reversible SOCs and ASSBs share degradation pathways related to the distribution of chemical potential across electrode/ electrolyte interfaces. Accordingly, understanding the degradation mechanisms of rechargeable lithium-ion batteries can serve as an effective strategy to mitigate SOC degradation—and vice versa. In this study, we investigated the mechanism of electrode delamination in SOCs under various operating conditions and identified a key factor associated with chemo-mechanical failure. The findings offer valuable insights into the chemo-mechanical degradation of SOCs by eluci-dating parallels with failure mechanisms observed in ASSBs.

9:00 AM

(ICACC-S3-027-2026) Solution infiltration based additive manufacturing of air electrode for solid oxide cells *WITHDRAWN*

J. Liu*[2]; B. Guan[1]; Y. Picard[1]; H. W. Abernathy[2]

1. NETL Support Contractor, USA
2. National Energy Technology Laboratory, Thermal Sciences Team, USA

In solid oxide cells (SOCs), the air electrode materials, often mixed ionic electronic conductive oxides (MIECs), must exhibit high conductivity, catalytic activity for oxygen reduction, and compatibility with the electrolyte layer and/or barrier layer materials. Commonly, the fabrication of the air electrode involves powder synthesis, slurry/paste preparation, coating and sintering. During the development and application of new materials, this lengthy traditional ceramic processing procedure poses many challenges in the optimization of the air electrode, such as fine tuning the microstructure for optimal porosity and thermal/chemical compatibility under the high sintering temperature. In this study, we demonstrate an infiltration-based electrode fabrication strategy using porous Yttria-stabilized ZrO_2(YSZ) as the electrode backbone. Using state-of-the-art air electrode materials, $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ (LSCF) with Samaria-doped ceria (SDC) as a barrier layer, we fabricated air electrodes on a porous YSZ supported button cell and successfully demonstrated 1000 h reversible solid oxide cell (R-SOC) operation. The fabricated button cell shows a low total area specific resistance of 0.38 Wcm^2 after 1000-hour operation at 750°C under air and 50:50 steam to hydrogen ratio, showing superior performance and improved stability compared to a commercial cell with an identical material set.

9:20 AM

(ICACC-S3-028-2026) Anchored nanoparticles on perovskite-based anodes for enhanced direct hydrocarbon solid oxide fuel cells

L. Wu*[1]; H. Sharifi[1]; F. Chen[1]

1. University of South Carolina, Mechanical Engineering, USA

An efficient anode catalyst for hydrocarbon-fueled solid oxide fuel cells (SOFCs) should possess a stable phase structure, strong sulfur tolerance, and excellent coking resistance. However, conventional nickel-based anodes require a high steam-to-carbon ratio to mitigate coking and exhibit limited sulfur tolerance, which complicates system design and reduces overall performance. In this study, we report a nickel-free perovskite oxide as an anode material for SOFCs operating either with 50 ppm H_2S-H_2 or directly propane fuels. When heat-treated at 800 °C under reducing conditions, this anode undergoes a phase transformation into a Ruddlesden–Popper structured oxide, accompanied by the in-situ exsolution of respective metallic nanoparticles that are uniformly anchored on the perovskite surface. When employed as the anode of an $La_{0.8}Sr_{0.2}Ga_{0.83}Mg_{0.17}O_{3-\delta}$ (LSGM) electrolyte-supported SOFC, this novel anode exhibits excellent electrochemical performance, achieving peak power densities (PPDs) of 1.12 and 1.01 W cm^{-2} at 800 C using hydrogen and 50 ppm H_2S-H_2 (3% H_2O) as fuels, respectively. Furthermore, a PPD of 0.280 W cm^{-2} is obtained at 750 C when operating directly on propane. In addition, the cell demonstrates remarkable durability, maintaining stable operation for over 500 h when directly operating on propane fuel.

9:40 AM

(ICACC-S3-029-2026) Electrochemical characterization of metal-doped ceria electrodes for high-temperature CO_2 electrolysis

J. Lee[1]; S. Lee*[1]

1. Korea Institute of Ceramic Engineering and Technology (KICET), Republic of Korea

Ceramic-based electrodes offer high durability, making them promising alternative fuel electrodes for high-temperature CO2 electrolysis. However, their limited catalytic activity poses a significant challenge to achieving high electrolysis performance. This study investigates ceria-based electrodes doped with metals to enhance CO2 electrolysis performance. We employed electrochemical impedance spectroscopy (EIS) to determine the catalytic activity and reaction kinetics of CO2 reduction on these electrodes. Furthermore, distribution of relaxation times (DRT) analysis was used to examine the adsorption and dissociation processes of CO2 molecules under varying conditions, including different gas atmospheres, catalyst types, and temperatures. The results demonstrate that metal co-doping significantly enhances catalytic activity, leading to a high electrolysis performance of 1.584 A cm-2 at 1.5 V under CO2 electrolysis conditions. This suggests that the appropriate addition of metal elements is an effective strategy for improving the performance of high-temperature CO2 electrolysis.

S3-Electrode design

Room: Coquina H

Session Chair: Josef Schefold, European Institute for Energy Research

10:20 AM

(ICACC-S3-030-2026) Scaling of high temperature electrolysis cells for hydrogen production using advanced electrodes (Invited)

M. Laguna-Bercero*[1]; J. Zueco-Vincelle[1]; A. Campos-Galera[1]; A. Alconchel-Allue[1]; C. De La Torre-Gamarra[1]; A. Orera[1]

1. Instituto de Nanociencia y Materiales de Aragon, Spain

Our current efforts focus on key stages of advanced device development, including cell fabrication, scaling up manufacturing processes, designing and assembling stacks, and integrating novel materials to improve SOC efficiency. Regarding cell manufacturing, we fabricated planar anode-supported SOE cells (5 x 5 cm^2) using state-of-the-art materials such as YSZ for the electrolyte, Ni-YSZ for the hydrogen electrode, and LSM-YSZ for the air electrode. These cell layers are produced through cost-effective, industrially scalable deposition techniques, including tape casting and screen printing. We've reached a pre-industrial fabrication scale, capable of processing large quantities of inks and producing cells in batches. The electrochemical performance of these standard cells is comparable to commercial cells, achieving aproximately -1 Acm^{-2} at 1.3V and 800 °C. Additionally, different perovskite-structured metal oxides and Ruddlesden-Popper materials have demonstrated high electrocatalytic activity for the oxygen reduction. Scalable synthesis methods, such as the combustion technique, were used, resulting in promising electrochemical performance, surpassing standard compositions. This research lays the groundwork for advancing SOC technology with a focus on enhancing efficiency, scalability, and lifespan—critical factors for meeting the EU's green hydrogen targets.

10:50 AM

(ICACC-S3-031-2026) Development of proton conducting solid oxide cells for fuel cell and electrolysis applications (Invited)

T. Suzuki*[1]; M. Dewa[1]; N. Cameron[1]; C. Junaedi[1]; S. Roychoudhury[1]

1. Precision Combustion, Inc., USA

Precision Combustion, Inc. (PCI) has been developing a solid oxide cell technology based on proton conducting materials that allows reversible or regenerative operation as both power generator (i.e., fuel cell mode) and H_2 generator/compressor (i.e., electrolysis mode). It is based on a novel cell architecture, materials, and processing techniques. Initial testing of the cell architecture indicated potential to be lightweight and presents several advantages over state of the art, including high gravimetric and volumetric power density at <700°C, rapid thermal cycle tolerance for fast start-up and shut-down, and more redox tolerance. The goal of cell development is to generate high power density at fuel cell operating conditions for high cell efficiency (>70%) and to produce high-purity H_2 under electrolysis mode. The structure of our cell also allows for simultaneous compression of the H_2 produced to an intermediate pressure. In this presentation, the results from the cell evaluation under fuel cell mode will be highlighted, including the power density, efficiency, thermal cycle stability, and durability at steady state conditions. The cell performance under electrolysis mode will also be summarized. An improvement in the cell performance as a result of the design advancement, which could improve the overall stack lifetime, will also be described.

11:20 AM

(ICACC-S3-032-2026) Optimizing oxygen transport in Ruddlesden-Popper oxides through crystal facet engineering and magnetic grain alignment

A. Feldhoff*[1]; M. Wellmann[1]; Z. Zhao[2]; G. Escobar Cano[1]; F. Steinbach[1]; B. Breidenstein[3]; H. Petersen[3]; A. Graff[4]; M. Thiem[5]; W. Xie[5]; M. Widenmeyer[5]; A. Weidenkaff[5]; M. Matsuda[6]

1. Leibniz University Hannover, Institute of Physical Chemistry and Electrochemistry, Germany
2. Freie Universitat Berlin, Institute of Chemistry and Biochemistry, Germany
3. Leibniz Universitat Hannover, IFW – Institute of Production Engineering and Machine Tools, Germany
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5. Technische Universitat Darmstadt, Institute of Materials Science, Germany
6. Kumamoto University, Department of Materials and Engineering, Japan

Mixed ionic-electronic conductors (MIECs) are a vital component of air electrodes in solid oxide cells (SOC). The layered crystal structure of Ruddlesden-Popper-type MIECs lend them highly anisotropic transport properties, which are underutilized in ceramics with random grain orientations. We show that using crystal facet engineering or a magnetic field, to align grains through magnetic susceptibility differences between the a,b-plane and c-axis, improves ceramic texturing and oxygen transport. $La_2NiO_{4+\delta}$ (LNO) nanorods, synthesized via reverse microemulsion - a crystal facet engineering method - served as building blocks for developing ceramics with improved oxygen permeation due to favorable crystal facets present. Improvement in functional properties was most pronounced at the lower end of the explored temperature range. Asymmetric or bulk $Nd_2NiO_{4+\delta}$ (NNO) ceramic membranes were prepared by drop casting or slip casting in a 0.8 to 0.9 T magnetic field, followed by sintering. The field direction during casting dictates grain orientation, aligning either the c-axis or a,b-plane parallel to the ceramics's normal. The a,b-plane textured NNO ceramics showed significantly increased oxygen permeation between 1023-1223 K, maintaining CO_2 stability. These methods boost oxygen transport and enhance LNO and NNO's potential for future SOC applications.

S6 Advanced Materials and Technologies for Rechargeable Energy Storage

S6- Solid State Batteries

Room: Coquina G
Session Chairs: Guoying Chen, E O Lawrence Berkeley National Laboratory; Hirotoshi Yamada, Nagasaki Daigaku

8:30 AM

(ICACC-S6-017-2026) Advanced high-energy all-solid-state batteries (Invited)

G. Chen*[1]

1. E O Lawrence Berkeley National Laboratory, USA

All-solid-state batteries (ASSBs) are hindered by critical material and interfacial challenges, including electrolyte instability, lithium dendrite formation at the anode, and chemo-mechanical degradation at the cathode. We introduce an integrated approach to overcome these barriers by co-designing all cell components. Our work features novel halide-based solid electrolytes (SEs) with superior ionic conductivity and stability, composite cathodes that integrate uncoated high-voltage materials, and a stable lithium-metal anode that enables dendrite-free cycling. This holistic design results in full cells with excellent long-term performance. Using advanced characterization, we explain the mechanisms driving this stability and discuss key strategies for developing next-generation ASSBs.

9:00 AM

(ICACC-S6-018-2026) Low-temperature sintering of NASICON-type $Li_{1.5}Al_{0.5}Ge_{1.5}(PO_4)_3$ and its application to all-solid-state batteries (Invited)

H. Yamada*[1]

1. Nagasaki Daigaku, Japan

Among various types of all-solid-state batteries (ASSBs), sulfide-based ASSBs are at the stage of practical application, while oxide-based ones are still undergoing feasibility studies. This is mainly due to their interfacial issues, including interphases and/or contact areas that limit the energy and power of the ASSBs. Here, we developed materials and processes of NASICON-type solid electrolytes, enabling electrochemically active interfaces between the solid electrolytes and the active materials. For the NASICON-based ASSBs, a precursor of $Li_{1.5}Al_{0.5}Ge_{1.5}(PO_4)_3$ (LAGP) was prepared using a solution method with oxalic acid as a chelating agent, which was then sintered and crystallized at 600°C. LAGP obtained by sintering the precursor at 600°C exhibited rather high total conductivity of 2×10^{-5} S/cm. The hot press facilitated ionic conductivity to 1×10^{-4} S/cm, which is comparable with LAGP prepared by solid-state sintering at 800°C or a higher temperature. A 3 V-class ASSB without any organic components was fabricated with TiO_2 anode and $LiCoPO_4$ cathode, which exhibited an initial discharge capacity of 66 mAh/g (0.17 mAh/cm^2) at 25°C. The performance could be further improved by optimizing materials, processes, and architecture, some of which will be shown and discussed in the talk.

9:30 AM

(ICACC-S6-019-2026) Structure and superionic transition of Li_3YCl_6 and Li_3YBr_6 (Invited)

J. Liu*[1]; Y. Zhang[1]; P. Cuillier[1]; Z. Liu[2]; H. Chen[2]

1. Oak Ridge National Laboratory, USA
2. Georgia Institute of Technology, Mechanical Engineering, USA

Halide-based Li^+ solid-state electrolytes have garnered renewed interest in recent years, primarily due to their significantly enhanced Li^+ ionic conductivity and excellent stability with high-voltage cathodes. It is well established that synthetic conditions and protocols can drastically influence cation defect chemistry, thereby impacting Li^+ mobility in these materials. Despite extensive research, considerable debate remains regarding the fundamental mechanisms governing Li^+ transport, particularly about the Li^+ superionic transitions in these compounds, which continue to impede performance optimization. In this talk, I will present a comprehensive structural picture of Li_3YCl_6 and Li_3YBr_6 synthesized under varying conditions. Additionally, I will discuss the different structural origins of the superionic transitions observed in these two compounds.

10:20 AM

(ICACC-S6-020-2026) Measurement of ion transportation in solid-state battery electrodes with $Li_{10}GeP_2S_{12}$-type solid electrolytes (Invited)

S. Hori*[1]

1. Institute of Science Tokyo, Japan

Understanding ion transportation in battery electrodes is important for developing all-solid-state batteries. This study reports all-solid-state cells that are suitable for highlighting lithium transportation. The cathode composite for cells was fabricated by mixing $LiNbO_3$-coated $Li_xCoO_2(0.5 \le x \le 1-\delta)$ and $Li_{10+y}Ge_{1+y}P_{2-y}S_{12}$ (LGPS) as a solid electrolyte, which shows high ionic conductivity exceeding 10 mS cm^{-1} at room temperature. For a separator another kind of LGPS-type solid electrolyte was pelletized. In the cell preparation, firstly states of charge for the cathode composite were controlled by charging or discharging the composite in In-Li half cells. Then, cells were fabricated with charged ($x = 0.5$) and discharged ($x = 1-\delta$) cathode composites for working and counter electrodes, respectively. Such "asymmetric" cells are expected to highlight ionic transportation during charge–discharge, because they have a simple configuration, their electrode thickness can be varied, and a large current can be applied due to the inherently high-rate capability of Li_xCoO_2. In the presentation, the "asymmetric-" cell performance with varying current density up to 40 C will be reported and discussed by a comparison with simulated results calculated using an impedance-based modeling. This work was supported by JSPS KAKENHI Grant Number JP25H01962.

10:50 AM

(ICACC-S6-021-2026) Designing catholytes for argyrodite solid-state batteries (Invited)

C. Ban*[1]

1. University of Colorado, Boulder, Mechanical Engineering, USA

All-solid-state lithium-metal batteries that utilize Li_6PS_5Cl (argyrodite) solid electrolytes in combination with high-voltage $LiNi_{0.8}Mn_{0.1}Co_{0/1}O_2$ (NMC811) cathodes promise high energy density; however, they often face rapid capacity fade. This presentation will discuss the degradation linked to structural and morphological changes in NMC811, as well as the electrochemical oxidation of argyrodite. We will explore known stabilization strategies and present our approach to enhancing the cathode-electrolyte interface through catholyte engineering using scavenging additives. Mechanistic insights will be provided by correlating microscopic and spectroscopic analyses with electrochemical measurements, aiming to connect interfacial chemistry to battery performance. Our stabilization strategy has significantly improved long-term cycling stability, demonstrating that suppressing parasitic interfacial reactions can effectively mitigate argyrodite oxidation while preserving the layered structure of NMC811. Overall, this work clarifies the interfacial degradation pathways in NMC811/argyrodite systems and introduces a low-cost, scalable method for stabilizing nickel-rich oxide cathodes in sulfide-electrolyte solid-state batteries, ultimately enhancing their practical application.

11:20 AM

(ICACC-S6-022-2026) Tuning ionic and thermal conductivity in LLZO via mechanical strain: An atomistic approach

S. Khan*[1]; X. S. Chen[1]

1. UNC Charlotte, Mechanical Engineering, USA

LLZO is a garnet-type ceramic material which is one of the most promising solid electrolytes in next generation all-solid-state lithium batteries. During the battery operation, mechanical stress is an issue that can significantly influence their electrochemical performance. In the present work, molecular dynamics simulations have been performed to investigate the effects of mechanical strain on ionic and thermal transport properties of LLZO. It is found that the computed ionic and thermal conductivities for unstrained LLZO closely match the experimental values. Ionic conductivity has been analyzed by systematically applying tensile strain across the pivotal deformation stages: elastic region, structural phase transition, and pre-fracture. Results revealed that ionic conductivity increases with elastic strain due to enhanced lithium diffusivity, but returns to its initial state following the phase transformation. The ionic conductivity found to be highest at the higher strain showing a complex-nonlinear response, suggesting the potential of strain engineering to optimize the lithium-ion mobility. Thermal conductivity has been computed using the Green-Kubo formalism, which shows a decreasing trend with increasing strain. The combined analysis facilitates the opportunities for strategic framework, emphasizing the importance of balancing electrochemical performance with thermal stability.

11:40 AM

(ICACC-S6-023-2026) Solution-based synthesis and ultrafast high-temperature sintering of LLZO for scalable solid electrolytes

Y. Feng*[1]; J. Libera[1]; S. Liu[2]; Y. Wen[2]; L. Hu[2]; J. Li[1]

1. Argonne National Laboratory, Applied Materials Division, USA
2. Yale University, USA

All-solid-state batteries (ASSBs) promise enhanced safety and higher energy density than conventional Li-ion systems. Among solid-state electrolyte candidates, the garnet $Li_7La_3Zr_2O_{12}$ (LLZO) is intrinsically nonflammable, electrochemically stable with NMC cathodes, and effective in suppressing lithium penetration. However, scaling oxide electrolytes from lab to production remains challenging, requiring thin, large-format, phase-stable layers with robust, low-impedance interfaces and strict control of lithium stoichiometry. To meet this challenge, we present a manufacturing-oriented approach that integrates scalable LLZO synthesis with ultrafast high-temperature sintering (UHS). Solution-based ultrasonic spray pyrolysis and flame spray pyrolysis produce micro-sized LLZO with controlled composition and uniformly distributed dopants. We investigate how precursor chemistry and processing protocols affect particle size distribution, morphology, and phase evolution. UHS then rapidly densifies thin, cubic-phase LLZO using sub-minute cycles that achieve $\sim 10^3$–10^4 °C/min heating/cooling, curbing lithium loss and limiting grain coarsening. The process is compatible with continuous handling, high-throughput manufacturing. Collectively, scalable solution-based synthesis and ultrafast electrolyte sintering provide a pathway to cost-effective, scalable oxide-electrolyte ASSB manufacturing.

S7 20th International Symposium on Functional Nanomaterials and Thin Films for Sustainable Energy, Environmental and Biomedical Applications

S7- Nanomaterials for energy conversion, storage and catalysis II

Room: Flagler A
Session Chair: Muhammet Toprak, KTH Royal Institute of Technology

8:30 AM

(ICACC-S7-024-2026) High entropy alloy nanoparticle catalysts (Invited)

A. Cabot*[1]

1. Catalonia Institute for Energy Research, Spain

High-entropy alloys (HEAs) have emerged as a transformative platform for electrocatalysis. Their appeal lies in the vast compositional versatility enabled by the combination of five or more elements, which generates a rich diversity of atomic configurations and surface sites ideally suited for complex multistep reactions. Recent years have witnessed explosive growth in the development of HEMs across diverse material classes and their application to a wide range of electrochemical reactions. Yet significant challenges remain to fully harness their capabilities while managing their intrinsic structural and chemical complexity. Advancing the field requires exploring compositional space, pinpointing reaction sites, and achieving atomic-level control of surface composition and organization. I will present our recent work on the colloidal synthesis of HEA nanoparticles, discuss their electrocatalytic properties, and demonstrate their potential as oxygen catalysts.

9:00 AM

(ICACC-S7-025-2026) Development of boron-alumina/silica nanofiber catalytic membranes structures for plasma catalysis in space applications

R. A. Yager*[1]; K. Kajal[1]; A. Stanishevsky[1]

1. University of Alabama at Birmingham, Physics, USA

Boron–alumina/silica nanofibrous membranes were fabricated and optimized as high-surface-area, thermally stable materials with potential use in plasma environments. Precursor chemistry was tailored to control the B:Al:Si ratio and enable incorporation of transition-metal dopants (Ni, Fe, Cu) to adjust structural and functional properties. Nanofibers were produced using alternating-current electrospinning, collected as sheet or bulk materials and assembled as various 3-D structures. These assemblies were subsequently annealed under controlled thermal cycles to achieve phase purity, flexibility, and rigidity. Structural characterization by SEM and XRD confirmed uniform fiber morphology, shrinkage behavior, and crystalline phase evolution with increasing annealing temperature. Mechanical testing demonstrated good stability and robustness, supporting their suitability for integration into harsh operational environments as required in space missions. These results highlight the tunability of boron-alumina/silica nanofiber membranes through precursor design and processing, providing a versatile platform for advanced applications such as CO_2 and CH_4 conversion and catalytic plasma systems.

9:20 AM

(ICACC-S7-026-2026) Defective oxide engineering: Electrostrictive Ceria–Zirconia layers from spray pyrolysis

M. Mehdizade[1]; A. Kabir[2]; V. Esposito[2]; S. Molin*[1]

1. Politechnika Gdanska Wydzial Elektroniki Telekomunikacji i Informatyki, Department of Functional Materials Engineering, Poland
2. Technical University of Denmark, Denmark

Ceria–zirconia ($Ce_xZ_{1-x}O_2$) thin films were deposited on quartz and sapphire substrates using spray pyrolysis as a scalable, solution-based method. The effects of precursor volume, spraying speed, and composition ($x = 0.25–0.75$) on film morphology and properties were investigated. XRD confirmed the formation of single-phase solid solutions without phase segregation, while AFM showed increased surface roughness with higher precursor volumes. Electrostriction measurements revealed a characteristic second-order response typical of ceria-based defective oxides, with strain dependent on Zr content and processing conditions. These results highlight the potential of spray-pyrolyzed ceria–zirconia layers as lead-free electrostrictive materials for future actuator and sensing applications.

9:40 AM

(ICACC-S7-027-2026) Beyond nuclear: Rethinking actinide (Th, U) oxides for alternative energy applications

A. Lichtenberg*[1]; S. Mathur[2]

1. University of Cologne, Inorganic and Material Chemistry, Germany
2. University of Cologne, Institute of Inorganic Chemistry, Germany

Actinide oxides, particularly those containing uranium, thorium and plutonium, are primarily recognized for their applications in nuclear energy. With the rising global energy demand and the urgent need to replace fossil fuels, there is growing emphasis on expanding nuclear power. Yet, actinide oxide systems also offer promising avenues for research and application beyond the nuclear realm. The integration of actinide oxides into energy transformation and storage technologies enables new perspectives in material development. In this context, thorium- and uranium-based oxides exhibit distinct properties that render them attractive for advanced applications. Thorium dioxide combines outstanding insulating behavior with exceptional thermal stability, while uranium oxides are efficient (photo-)electrocatalysts due to their favorable bandgaps and easy valence switching uranium centers. Furthermore, uranium's rich redox chemistry, with accessible oxidation states ranging from +I to +VI, facilitates diverse reactivity and coordination environments. This presentation highlights syntheses of thorium and uranium oxide materials derived from molecular precursors and their emerging applications in photocatalysis, electrocatalysis, and lithium-ion battery technology, underscoring the untapped potential of actinide oxides beyond nuclear energy.

10:20 AM

(ICACC-S7-028-2026) Influence of microstructural engineering in PVC polymers films on the electrical output performance of triboelectric nanogenerators

S. Dadashov*[1]; G. Güdücü[3]; B. Göl[3]; E. Suvaci[2]

1. Eskisehir Teknik Universitesi, Chemical Engineering, Turkey
2. Eskisehir Teknik Universitesi, Material Science and Engineering, Turkey
3. Eskisehir Teknik Universitesi, Material Science, Turkey

During the last decade, triboelectric nanogenerators (TENGs) have attracted significant interest due to their ability to convert mechanical energy into electricity, making them promising power source candidates for next-generation wearable microelectronics. However, TENGs still remain insufficient for many practical applications, creating a strong demand for innovative manufacturing approaches.In this study, polyvinyl chloride (PVC) based films with porous microstructure were produced using phase inversion method.The microstructure of the films was systematically tailored by varying synthesis parameters, including polymer molecular weight, polymer concentration, and piezoelectric filler loading. Subsequently, contact-separation mode TENGs were fabricated and electrically characterized.The results showed that the tailoring of the microstructure led to a significant increase in electrical performance. In this regard, the open circuit voltage increased from 10 V to 50 V, the short circuit current increased from 10 μA to 20 μA, and the power density reached 3.3 W/m2.These findings confirm that understanding the relationship between processing conditions and microstructure plays a critical role in improving the electrical output of TENG devices.

S8 20th Intl Symp on APMT for Structural & Multifunctional Materials & Systems

S8- Design, Synthesis, and Advanced Manufacturing of Functional Ceramics I

Room: Coquina B
Session Chair: Ayahisa Okawa, Tohoku University

8:40 AM

(ICACC-S8-023-2026) Silicone-based emulsions for advanced additive manufacturing of highly porous biosilicate glass-ceramics (Invited)

H. Elsayed[1]; V. Diamanti[1]; B. Holubova[3]; M. Schwentenwein[2]; E. Bernardo*[1]

1. University of Padova, Department of Industrial Engineering, Italy
2. Lithoz GmbH, Austria
3. Technicka univerzita v Liberci, Czechia

Silicone polymers, added with oxide fillers and fired in air, yield a variety of silicate ceramics. Some fillers are not introduced for the reaction with polymer-derived amorphous silica, but as providers of liquid phase, catalyzing the ionic interdiffusion upon high heating and turning into intergranular glass phase upon cooling. In this context, the Biosilicate® glass-ceramic ($CaO-Na_2O-SiO_2-P_2O_5$ system) can be reproduced from commercial silicones with $CaCO_3$, Na_2CO_3, and sodium phosphate powders, by firing at 1100 °C. This study presents recent developments in additive manufacturing of silicone blends, later transformed into highly porous Biosilicate scaffolds (porosity >85%), with a significant revision of fillers. CaO and Na_2O are supplied as liquids (molten hydrated nitrates and acetates or their aqueous solutions), dispersed as nano-emulsions in a photocurable mixture of silicones and acrylates, improving homogeneity. Solution-based emulsions form pseudoplastic pastes for direct ink writing, allowing P_2O_5 precursor dissolution and water evolution upon firing, leading to reticulated scaffolds with 'spongy' struts. Emulsions from molten salts, used in vat stereolithography, enable precise control of complex scaffold topology. P_2O_5 is supplied through suspended phosphoric acid, supported by continuous vat mixing, as phosphates lack near room-temperature melting salts.

9:10 AM

(ICACC-S8-024-2026) 3D-Printing of highly transparent alumina ceramics (Invited)

A. Erlacher[3]; M. Jiang[2]; P. Bowen[1]; Z. Zhao[2]; M. Stuer*[3]

1. Ecole polytechnique federale de Lausanne, Laboratory of Construction Materials, Switzerland
2. Shanghai Institute of Technology, School of Material Science and Engineering, China
3. Swiss Federal Laboratories for Materials Science and Technology (Empa), Nanopowders and Ceramics Group, Switzerland

Additive manufacturing (AM) of ceramics promises unprecedented design freedom, yet practical process constraints such as support structures and post-processing requirements challenge its "free complexity" potential. Beyond shaping capabilities, AM also enables novel material property optimizations through its layer-by-layer design approach - offering a level of control over microstructural evolution that conventional techniques cannot achieve. This unique advantage positions AM as a promising tool for tailoring ceramic materials, though its full potential for material optimization remains largely unexplored. In this study, the DLP-based 3D printing of complex-shaped, highly transparent alumina is presented. Experimental results indicate that exceptional optical properties correlate with the degree of single crystal conversion during sintering. Specifically, above a critical threshold of 1.0 wt% triphenylphosphine oxide (TPO) and appropriate sintering temperatures, no more grain boundaries can be observed in SEM image analysis. This observation is further corroborated by optical performance data in the visible light spectrum, confirming the significant microstructural changes. The material composition alone is insufficient to achieve this without the AM step. These findings highlight the potential of AM to achieve single-crystal-like ceramics, unlocking new applications in optics, electronics, and high-performance materials.

9:40 AM

(ICACC-S8-026-2026) Fundamental questions on advanced ceramics fabricated via selective laser sintering (Invited)

B. Cui*[1]; L. Trinh[1]; L. Wadle[1]; X. Zhang[1]; F. Wang[1]; H. Dong[1]; Y. Lu[1]

1. University of Nebraska-Lincoln, USA

Direct selective laser sintering (SLS) process is a novel and promising approach for additive manufacturing of structural and functional ceramics. Without polymer binders or resins, dense and three-dimensional ceramic parts can be fabricated with a layer thickness of several hundred micrometers, in which pores or microcracks are absent. The SLS process may also induce new physical phenomena such as ultrafast sintering, metastable phase transformation, and extraordinary defects. For example, cellular structures with element segregation and dislocations on cell boundaries were observed in (Zr,Nb,Ta,Ti,W)C compositionally complex carbide, while a Ti-rich secondary phase was distributed at grain boundaries of the hexagonal $BaTiO_3$. This talk will discuss these new physical phenomena and fundamental questions related to the defect formation during SLS of advanced ceramics.

S8- Design, Synthesis, and Advanced Manufacturing of Functional Ceramics II

Room: Coquina B
Session Chair: Minh Chu Ngo, National Institute of Advanced Industrial Science and Technology (AIST)

10:30 AM

(ICACC-S8-027-2026) Effect of sintering aid on texture and transparency of YVO_4 ceramics

T. S. Suzuki*[1]; L. Liu[2]; J. Li[2]; K. Morita[2]

1. National Institute for Materials Science, Optical Ceramics Group, Japan
2. National Institute for Materials Science (NIMS), Japan

YVO_4 transparent ceramics are key materials for advanced optical applications, including scintillators and lasers, due to their excellent optical nonlinearity, high thermal resistance, and remarkable chemical stability. Achieving high transparency in polycrystalline YVO_4 requires effective control of crystal orientation, owing to its hexagonal structure. In this study, strong magnetic fields were used during the forming process to successfully align the crystallites in YVO_4 ceramics. Additionally, $LiVO_3$ was introduced as a sintering aid to further enhance densification and optical properties. The addition of $LiVO_3$ lowered the onset temperature of shrinkage during SPS by over 100°C, enabling better densification at reduced temperatures. With the addition of 0.5 or 1 wt% $LiVO_3$, the ceramics demonstrated improved sinterability and higher optical transmittance, while maintaining the preferred orientation induced by magnetic field. However, using 2 wt% $LiVO_3$ led to a decrease in both crystallographic orientation and transparency, indicating that excess sintering aid can negatively impact the microstructure. These results underscore the importance of optimizing both the sintering aid content and the magnetic alignment method to fabricate highly oriented and transparent YVO_4 ceramics suitable for innovative optical devices.

10:50 AM

(ICACC-S8-028-2026) Rapid pressureless sintering of ceramics with graphene-like networks

N. Bhootpur*[1]; S. Drev[4]; B. Wicklein[3]; T. Rojac[2]; C. Manière[5]; A. Kocjan[1]

1. Institut Jozef Stefan, Department for Nanostructured Materials, Slovenia
2. Institut Jozef Stefan, Electronic Ceramics Department, Slovenia
3. Instituto de Ciencia de Materiales de Madrid, Spain
4. Institut Jozef Stefan, Center for Electron Microscopy and Microanalysis (CEMM), Slovenia
5. Laboratoire de Cristallographie et Sciences des Materiaux, France

Ceramic matrix composites with carbon-nanofillers improve mechanical and electrical properties. Homogeneous incorporation of nanofillers is challenging. Pressure-assisted Spark Plasma Sintering (SPS) is favoured, but imparts undesired anisotropy in properties due to filler alignment (⊥ to pressure). SPS is geometrically limited, not suitable for additively manufactured (AM), complex-shaped, multi-material ceramics. We could benefit in exploiting the functionalisation of nanofillers via a pressure-less sintering approach such as ultra-high temperature sintering (UHS) and pressureless SPS (pSPS). They deliver high heating rates and are successful in the consolidation of AM ceramics. We studied the rapid sintering (pSPS and UHS) of oxide ceramic matrices with homogeneously dispersed cellulose nanofibres (CNF), which are plant-based, hydrophilic, and easy to incorporate. Conventional SPS in situ transformed CNF into few-layer graphene-like (FLG) networks not prone to anisotropic alignment. Similar powders were prepared for pressureless sintering, where the effect of heating rates (10^0–10^5 °C/min) on densification and microstructure-related properties was studied. Graphitisation (D,G,2D Raman bands) was correlated with transmission electron microscopy (TEM) imaging of the graphitised layers and their electrical properties. The study highlights high heating rates as a route to functionalise multi-material ceramics.

11:10 AM

(ICACC-S8-029-2026) Additive manufacturing of cold isostatic press molds for low-cost rapid prototyping of near-net shape ceramics

T. W. Moore*[1]; D. H. Burk[2]; S. M. Kilczewski[1]; S. M. Smith[1]

1. US Army Combat Capabilities Development Command Army Research Laboratory Aberdeen Proving Ground, USA
2. University of North Texas, USA

Cold isostatic pressing (CIP) is a well-established method for producing ceramic green bodies with high densities and strength. A wide variety of geometries can be produced using this method by filling soft elastic molds with the appropriate shape. While the cost per component using this process is relatively low, the cost per design iteration can be quite high due to the need to produce custom tooling for each iteration. This also causes prototyping cycles to be slow, dependent on the manufacturing speed of first the tooling, then the mold, then the green body. In this work, a method for additive manufacturing CIP molds using stereolithography is discussed which drastically reduces cost and cycle time for prototyping ceramic parts by eliminating the need for tooling. Geometric factors such as aspect ratio, size effects, and surface patterning are also explored to determine design constraints on the CIP process that have previously not been studied, likely due to prohibitive cost. Finally, a simple empirical approach to designing molds is tested to determine the feasibility of using this process for producing near net shape components.

S13 Advanced Ceramics and Composites for Nuclear Fission and Fusion Energy Systems

S13- Material technologies for core structures of light water reactors I

Room: Coquina F
Session Chair: L Snead, Stony Brook University

8:30 AM

(ICACC-S13-027-2026) Irradiation performance and length scaling of SiGA® nuclear fuel cladding (Invited)

S. Gonderman[1]; A. Sathrum*[1]; D. Frazer[1]; L. Borowski[1]; R. Haefelfinger[1]; M. Alavi[1]; J. Kosmatka[1]; R. Hon[1]; S. Oswald[1]; A. Giles[1]; W. Campbell[1]; J. Unangst[1]; W. McMahon[1]; D. Kuebler[1]; C. Jones[1]; J. Quan[1]; A. Moore[1]; G. Jacobsen[1]; C. Deck[1]; J. Gazza[1]; T. Koyanagi[2]; D. Kamerman[3]; J. Stockwell[3]; P. Xu[3]

1. General Atomics Electromagnetic Systems Group, Nuclear Technologies and Materials, USA
2. Oak Ridge National Laboratory, USA
3. Idaho National Laboratory, USA

General Atomics Electromagnetics (GA-EMS) is developing SiGA® composite cladding technology for LWR applications to deliver improved operational performance and enhanced safety. Progress updates will be reported on recent irradiations of SiGA® rods conducted in the Advanced Test Reactor (ATR) at INL and in MIT-R at MIT. Rods from both of these tests maintained gas-tightness and mechanical integrity following irradiation, demonstrating success of the SiGA® design to withstand the high-pressure coolant environment. The successful unfueled testing has positioned SiGA® rods for fueled testing in ATR, planned for the spring of 2026. In addition, progress made towards demonstrating commercial length cladding fabrication will be presented. To support SiGA® cladding adoption GA-EMS has been developing a nuclear grade prepreg approach that will reduce the time & energy needed to densify SiGA® composite cladding by over 50% and is compatible with the established SiGA® fabrication process. The use of a preceramic polymer to assist in composite densification reduces the need for capital and energy intensive CVD systems, shortens the densification time, and results in a near net shape product which requires less machining. Initial out-of-pile and in-pile performance data on the SiGA® prepreg approach will be presented in the context of how this path is being developed to meet nuclear fuel rod requirements.

9:00 AM

(ICACC-S13-028-2026) Research update on SiC ceramic matrix composites at Idaho National Laboratory for ATF Development (Invited)

P. Xu*[1]; G. K. Singh[1]; S. Gonderman[2]; J. Gazza[2]

1. Idaho National Lab, USA
2. General Atomics, USA

Silicon Carbide (SiC) ceramic matrix composite cladding is being investigated as a candidate for accident-tolerant fuel in light water reactors due to its high-temperature oxidation properties, superior irradiation resistance, and accident scenario margins. Modeling and simulation efforts indicate SiC ATF fuel remains intact during Reactivity Insertion Accident (RIA) and Loss of Coolant Accident (LOCA), without cladding breach or fission product release. SiC cladding also shows optimal safety potential in severe accident conditions by providing extended coping time, enhanced temperature resistance, and greater margins at elevated temperatures. The Idaho National Laboratory (INL), in collaboration with General Atomics, is developing SiC ATF using advanced testing and characterization techniques to understand SiC CMC behaviors under normal and accident conditions. Two batches of SiC rods have undergone irradiation at INL's Advanced Test Reactor, reaching 4 displacements per atom (dpa). Post-irradiation examination (PIE) is in progress, with major findings to be discussed. These data are essential for understanding SiC's in-core performance prior to deploying Lead Test Rods (LTR) and for enhancing the database that supports advanced simulation, predictive model development, and integration with artificial intelligence.

9:30 AM

(ICACC-S13-029-2026) Micromechanical modelling of thermo-mechanical behaviour in nuclear grade SiC-SiC composites (Invited)

Y. Chen*[1]

1. University of Bath, Mechanical Engineering, United Kingdom

The application of SiC/SiC composites in nuclear systems demands a thorough understanding of irradiation-induced dimensional changes and their impact on mechanical property degradation. Neutron irradiation can cause swelling mismatches between fibres and matrix, leading to residual stresses and damage mechanisms such as matrix cracking and interface debonding. To investigate these effects, microscale models can be used. However, simulating the thermo-mechanical behaviour of SiC/SiC composites at the microscale presents a significant computational challenge. Off-the-shelf finite element software often lacks the efficiency required for such simulations, as realistic models must include thousands of fibres and resolve sub-micron interphase layers. This necessitates large representative volume elements (RVEs) with extremely fine meshes, resulting in prohibitive computational costs. To address this, we present a novel numerical solver based on the Fast Fourier Transform (FFT) technique, designed to accelerate computation through parallel processing and high-performance computing (HPC) resources. This approach enables efficient and scalable simulation of complex microscale phenomena, offering new insights into the damage evolution and mechanical performance of irradiated SiC/SiC composites.

S13- Material technologies for core structures of light water reactors II

Room: Coquina F
Session Chair: Aaron Sathrum, General Atomics Electromagnetic Systems Group

10:20 AM

(ICACC-S13-030-2026) Development of CVI/CVD-SiC/SiC composite for advanced technology fuel for LWR applications

S. Suyama*[1]; M. Ukai[1]; T. Nishimura[1]; S. Kuboya[1]; R. Kojima[1]; F. Sawa[1]; F. Kawahara[1]; M. Akimoto[1]; T. Takada[1]

1. Toshiba Energy Systems & Solutions Corporation, Japan

CVI-SiC/SiC composites have been considered for use as core materials in nuclear reactors due to their low activation, low neutron absorption cross-section, and irradiation stability, which stem from their high purity, stoichiometric and crystalline SiC matrix. Since the Fukushima Daiichi Nuclear Power Plant accident in March 2011, these materials have been developed worldwide as components of accident-tolerant fuels (ATFs). In Japan, as of 2025, more than a decade has passed since the accident, yet only 14 out of 33 nuclear reactors have been restarted. Consequently, there is a growing demand in Japan for the development of accident-tolerant fuels, which are now referred to as advanced technology fuels, to enhance nuclear safety. Toshiba Energy Systems Corporation has been developing process technologies for thin-walled and elongated tubes and boxes made of CVI/CVD-SiC/SiC since 2012. These composites are designed to withstand steam environments exceeding 1200°C under accident conditions. Additionally, hydrothermal corrosion resistance during normal LWR operation is required. To improve surface corrosion resistance, CVD-SiC coatings are applied to

CVI-SiC/SiC layers. Promising irradiation data have been obtained under PWR conditions. To enhance performance under BWR conditions, testing is being conducted as part of a Japanese national project utilizing overseas reactors.

10:40 AM

(ICACC-S13-031-2026) Mechanical characterization and damage propagation of SiC composite cladding

W. McMahon*[1]; S. Gonderman[1]; G. Jacobsen[1]; D. Frazer[1]; J. Kosmatka[1]; J. Gazza[1]; X. Huang[2]; J. Bao[2]; I. Hopkins[2]; T. Chen[3]; S. Doran[3]

1. General Atomics Electromagnetic Systems Group, Nuclear Technologies and Materials, USA
2. University of South Carolina, Mechanical Engineering, USA
3. Oregon State University College of Engineering, USA

General Atomics Electromagnetic Systems (GA-EMS) is developing SiGA® cladding, a silicon carbide (SiC) fiber reinforced ceramic matrix composite (CMC) nuclear fuel cladding, to provide enhanced safety and operation benefits to the nuclear industry through high-temperature stability and irradiation resilience. To address the impact of complex microstructure and non-linear damage evolution that make accurate mechanical characterization of SiC–SiC CMCs challenging, GA-EMS has developed three complementary testing techniques, reverse C-ring, in-situ expansion due to compression, and hydraulic burst to evaluate tubular SiC–SiC CMC architectures under representative in-core loading conditions. These methods provide a clearer view of progressive damage, from initial matrix cracking to leak onset providing critical information needed to optimize SiC-SiC CMCs for extreme environments. Data from this testing show SiGA® cladding can maintain gas-tightness and structural integrity under representative in-core stress states. Details on the experimental techniques and performance data will be presented in the context on how this testing fits in a comprehensive framework for evaluating fracture mechanisms, correlating microstructural features with macroscopic performance, and guiding the qualification of next-generation CMC cladding systems.

11:00 AM

(ICACC-S13-032-2026) Multiscale modeling of silicon carbide cladding

G. Singh*[1]; J. Yu[1]; P. Xu[1]; F. Xu[1]

1. Idaho National Laboratory, USA

Silicon carbide (SiC) composites are being considered for nuclear reactor applications due to their favorable properties. However, these materials are complex, making their modeling and analysis difficult. In this study, multiscale modeling of SiC composites is performed accounting for the discrete properties of the composite constituents (fibers, interphase and matrix) and microstructural features. The modeling process uses a modular approach, developing models at various length scales, where properties assessed at lower scales serve as inputs for higher scale models. This talk will present the specifics of this modeling approach, along with verification, validation, and demonstration cases.

11:20 AM

(ICACC-S13-033-2026) Advancements in SiC material technologies for accident-tolerant fuel cladding applications

T. Koyanagi*[1]; Y. Katoh[1]

1. Oak Ridge National Laboratory, USA

The SiC fiber-reinforced SiC matrix (SiC/SiC) composite is a promising material system for enhancing the accident tolerance of light-water reactor (LWR) cladding due to the material's excellent high-temperature strength and oxidation resistance. Additionally, SiC/SiC composites possess the properties required for the normal operation of LWRs, such as low neutron absorption. Through systematic characterizations of SiC/SiC composite tubular materials, the promises and challenges of the current generation of nuclear-grade SiC/SiC composites are becoming increasingly clear. Current R&D activities aim to advance SiC cladding concepts to a maturity level suitable for supporting lead test rod insertion into commercial LWRs. Key issues to address through successful demonstrations include (1) hermetic cladding and end-plug, (2) resistance to steady state corrosion and micro-cracking, and (3) the capability to effectively model SiC cladding behavior and predict failure probability. This paper will present pathways to advance SiC composite material technologies to overcome the current limitations by updating our understanding of the material behavior under LWR-relevant environments through unique experiments involving the interplay of multiphysics phenomena. The engineering design of SiC-based composites to meet specific property requirements for LWR cladding applications will also be covered.

11:40 AM

(ICACC-S13-034-2026) Grain boundary engineered SiC with improved coolant compatibility for LWRs

K. Lambrinou*[1]; C. Sauder[2]; F. Bourlet[2]; M. K. Grosse[3]; M. Steinbrück[3]; J. A. Hinks[1]; P. Wang[4]; S. Huang[5]; J. Vleugels[5]

1. University of Huddersfield, School of Computing and Engineering, United Kingdom
2. CEA, DRMP, France
3. Karlsruhe Institute of Technology, Institute for Applied Materials, Germany
4. University of Michigan, Nuclear Engineering & Radiological Sciences, USA
5. KU Leuven, Materials engineering, Belgium

SiC/SiC composites are a promising accident-tolerant fuel (ATF) cladding material concept considered for use in Gen-II/III light water reactors (LWRs) due to the attractive properties of SiC (e.g., refractoriness, pseudo-ductility). Unfortunately, the coolant (water/steam) compatibility of all state-of-the-art SiC/SiC composite ATF claddings designed for LWRs is still inadequate, challenging their imminent deployment to market. This work explores the viability of grain boundary (GB) engineering as an approach to improve the coolant compatibility of SiC-based ATF claddings for Gen-II/III LWRs. More specifically, bulk SiC ceramics were GB engineered with compounds (i.e., $Y_3Al_5O_{12}$ & Y_2SiO_5) that had exhibited excellent compatibility with both water under irradiation and high-temperature steam. All ceramics (i.e., bulk $Y_3Al_5O_{12}$ & Y_2SiO_5; SiC GB engineered with $Y_3Al_5O_{12}$ & Y_2SiO_5) were subjected to autoclave (360°C, 28 days, PWR water), steam oxidation (1600°C, 1 h), and synergistic proton irradiation/aqueous corrosion (5.4 MeV p^+, 320°C, 48 h, PWR water with 3 ppm H_2) tests. The performance of GB engineered SiC ceramics under proton irradiation in contact with slowly flowing PWR water was benchmarked against that of CVD SiC tested under identical conditions. CVD (chemically vapor deposited) SiC coatings are deposited on SiC/SiC composites to minimize material losses under nominal LWR operation conditions.

S14 Crystalline Materials for Electrical Optical and Medical Applications

S14- Scintillator

Room: Ballroom 4
Session Chairs: Thomas Rudzik, Lawrence Livermore National Laboratory; Ross Osborne, Lawrence Livermore National Laboratory

8:30 AM

(ICACC-S14-021-2026) Fabrication of $Li_{6.388}La_3Al_{0.204}Hf_2O_{12}$:$Ti^{4+}$ dual-mode scintillator

J. Glodo[2]; T. Rudzik[1]; A. Kostogiannes[1]; N. Cherepy[1]; S. A. Payne[1]; Y. Wang[2]; M. Müller*[2]

1. Lawrence Livermore National Laboratory, USA
2. Radiation Monitoring Devices Inc, USA

Detection of nuclear materials at borders requires the development of low cost, stable, and robust detection systems, which can identify both gamma and neutron radiation. Multi-modal detectors provide a variety of advantages, such as saving space as well as lowering weight and cost. In this study, we investigated a new dual mode garnet-based scintillator. $Li_{6.388}La_3Al_{0.204}(Hf)O_{12}$:$Ti^{4+}$ was prepared by a solid-state method in combination with uniaxial hot-pressing. Al^{3+} doping was used to stabilize the cubic structure of $Li_7La_3Hf_2O_{12}$. Ti^{4+} was used as an activator for emission in the blue spectral region. Phase purity and microstructure were investigated through X-ray diffraction and scanning electron microscopy. Furthermore, scintillation measurements were performed, including X-ray excited emission, gamma-ray spectroscopy, and thermal neutron detection. The fabricated scintillators were found to have a light yield of approximately 3000 photons×MeV^{-1} at 662 keV (^{137}Cs) and 1700 photons×$neutron^{-1}$. The composition is a promising material for dual mode detection for homeland security and other applications. This work has been supported by the U.S. Department of Homeland Security, Countering Weapons of Mass Destruction, under competitively awarded contract 70RWMD23C00000018. This support does not constitute an express or implied endorsement on the part of the Government.

8:50 AM

(ICACC-S14-022-2026) Fabrication of Cs_2HfCl_6 transparent ceramics via hot forging *WITHDRAWN*

A. Zachariou*[1]; S. Lass[1]; E. Karacaoglu[1]; S. Motakef[3]; F. Moretti[4]; R. M. Gaume[2]

1. University of Central Florida, CREOL, College of Optics and Photonics, USA
2. University of Central Florida, CREOL, USA
3. CapeSym Inc, USA
4. E O Lawrence Berkeley National Laboratory, USA

Cs_2HfCl_6 (CHC) is a crystalline scintillator material researched for a variety of applications in nuclear spectroscopy, such as gamma-ray detectors, with potential for future commercialization. However, fabrication of large-scale stoichiometric CHC when grown from the melt can be challenging. Here, we present an alternative solution for size-scale up where the need for perfectly grown single crystals is eliminated, and instead, polycrystalline CHC boules, rapidly cooled from melt, are hot forged into polycrystalline ceramics with decreased grain sizes. Grain size refinement from a few millimeters down to tens of microns is demonstrated, resulting in highly transparent CHC ceramics. Various aspects of the hot forging process, including the temperature range, strain rate, and dislocation formation are discussed.

9:10 AM

(ICACC-S14-023-2026) Effects of cerium doping concentration on the microstructural, optical, and scintillation properties of GAGG ceramic scintillators

W. M. Bowman*[1]; S. Lass[1]; W. Wolszczak[2]; F. Moretti[2]; R. M. Gaume[1]

1. University of Central Florida, CREOL, USA
2. E O Lawrence Berkeley National Laboratory, USA

This study systematically investigates how cerium (Ce) concentration influences fast scintillation kinetics and optical quality in Ce:GAGG ceramics—key attributes for scintillator applications such as computed tomography (CT) and x-ray radiography of rapidly moving subjects. To this end, a series of Ce:GAGG ceramics with Ce doping levels ranging from 0.1 to 10 at% was synthesized via solid-state powder processing and reactive sintering. The materials were characterized using UV-Vis spectroscopy and radioluminescence (RL). Transparent Ce:GAGG ceramics with optical transmission exceeding 80% were successfully fabricated without the use of co-dopant sintering aids, demonstrating that Ce itself facilitates densification during sintering. This intrinsic sintering aid effect of Ce enhances material transparency. However, Ce concentrations above 2.0 at% led to the precipitation of secondary phases, which adversely affected optical transmission. Both RL intensity and decay time decreased monotonically with increasing Ce content. At higher Ce concentrations, the decay profiles required fewer time constants, indicating a simplification of the scintillation response. Thermally stimulated luminescence (TSL) measurements further revealed a reduction in trap filling with increasing Ce concentration.

9:30 AM

(ICACC-S14-024-2026) Pixelated transparent ceramic x-ray imaging screens fabricated via direct-ink-write

A. Kostogiannes*[1]; T. Rudzik[1]; N. Cherepy[1]; S. A. Payne[1]

1. Lawrence Livermore National Laboratory, Materials Science Division, USA

Direct-ink-write has been shown to be a viable route to fabricate near-net shape transparent ceramic scintillators with a pixelated structure for x-ray imaging. This form factor has been implemented with GLO, $(GdLu)_2O_3$: Eu, ceramics to improve imaging efficiency and spatial resolution. Here, we describe our work with this additive manufacturing technique, extended to a variety of scintillator compositions. Pixel size, length, fill factor and material composition can all be engineered to improve scintillator imaging screen properties, while offering potential for scalable manufacturability.

9:50 AM

(ICACC-S14-025-2026) Yb^{3+}:Lu_2O_3 thick film phosphors rapidly grown via chemical vapor deposition process for fast-response scintillators

A. Ito*[1]; T. Nakayama[1]

1. Yokohama National University, Graduate School of Environment and Information Sciences, Japan

Fast-response inorganic phosphors are expected to find applications in X-ray imaging and high-energy physics applications. In addition, the spatial resolution of nondestructive X-ray testing can be improved by thick-film scintillators. In the present work, we focus on high-speed deposition and fast response of the thick-film phosphors of Yb^{3+}-doped Lu_2O_3 (Yb^{3+}:Lu_2O_3). Using chemical vapor deposition, we successfully prepared Yb^{3+}:Lu_2O_3 thick films at high deposition rates of severan tens μm per hour. Increasing the Yb vaporization temperature led to an increase in the lattice constant of the Yb^{3+}:Lu_2O_3 films, implying a higher Yb concentration. These films displayed Yb^{3+} charge-transfer luminescence (300–600 nm) together with f–f transition emission (900–1100 nm). For scintillation excited by 5.5 MeV α-particles from ^{241}Am source, Yb^{3+}:Lu_2O_3 thick films with 0.6–9.4 mol%Yb_2O_3 yielded 880–1290 photons per 5.5 MeV and showed a fast decay constant of 1.9–2.2 ns.

10:30 AM

(ICACC-S14-026-2026) Development of large and transparent Lu_2O_3:Yb^{3+} ceramic scintillators

M. Müller*[1]; A. Kim[1]; S. Kim[1]; G. Adhikari[1]; L. Zhang[3]; H. Newman[3]; P. E. Albert[2]; J. A. Reiss[2]; Y. Wang[1]; J. Glodo[1]; L. Pandian[1]

1. Radiation Monitoring Devices Inc, Ceramics, USA
2. The Pennsylvania State University - University Park Campus, USA
3. California Institute of Technology, USA

Calorimeters made of inorganic scintillators play a crucial role in high-energy physics experiments due to their excellent energy resolution and detection efficiency. Scintillators with a fast decay time (< 10 ns) and outstanding radiation hardness will be essential to cope with the high event rates expected in future experiments. Lu_2O_3:Yb^{3+} has a fast decay time and combines a high density (9.4 g×cm^{-3}) with a high effective atomic number (Z_{eff} = 68). Moreover, Lu_2O_3:Yb^{3+} crystallizes in a cubic structure making it suitable for the fabrication of transparent ceramics. Two approaches were pursued to produce large Lu_2O_3:Yb^{3+} ceramic scintillators, hot isostatic pressing and field assisted sintering. The work focused on the development of ceramics with a volume of 5 – 60 cm^3. The microstructure and scintillation properties of the ceramics were analyzed. The microstructure was investigated using scanning electron microscopy and energy-dispersive X-ray spectroscopy. The scintillation properties were assessed through radioluminescence spectroscopy as well as pulse-height analysis. The fabricated scintillators were transparent and showed an emission maximum between 350 – 370 nm. The decay time was found to be approximately 2 ns. This work was supported by the US Department of Energy under Grant Award Number DE-SC0021686. This support does not constitute an express or implied endorsement on the part of the government.

10:50 AM

(ICACC-S14-027-2026) Improved transparency in Gadolinium-doped lutetium oxide ceramics

T. Rudzik*[2]; A. Kostogiannes[3]; N. Cherepy[1]

1. Lawrence Livermore National Lab, Chemistry and Materials Science, USA
2. Lawrence Livermore National Laboratory, USA
3. University of Central Florida, Materials Science and Engineering, USA

Gadolinium-doped lutetium oxide (GLO) ceramic is a transparent material with demonstrated high performance as a scintillator when additionally doped with Eu, exhibiting high stopping power and radiation hardness as well as superior light yield and resolution compared to the best current commercially available scintillators. Over the past decade, the LLNL optical ceramics group has refined fabrication methodology to enhance its performance and has demonstrated a wide range of form factors and processing routes which can be employed to optimize for specific applications, including large plates and pixelated arrays. In this work, we carefully analyze the effect of increasing the Gd/Lu atomic ratio relative to our standard composition. Results show a decrease in optical scatter is possible when switching to a higher Gd concentration composition. Work is underway to successfully fabricate it in the range of form factors demonstrated for our standard composition, and the associated challenges will be discussed.

11:10 AM

(ICACC-S14-028-2026) Transparent ceramic garnet for gamma spectroscopy and imaging

R. Osborne*[1]; N. Cherepy[1]; S. O'Neal[1]; Z. M. Seeley[1]; S. A. Payne[1]

1. Lawrence Livermore National Laboratory, USA

Transparent ceramic oxides offer the excellent ruggedness and environmental stability required for long service life even when deployed in harsh environments. Detector materials for gamma spectroscopy and imaging are needed that are not fragile and do not degrade in humid air or typical ambient temperatures. The Cerium-doped Gadolinium Yttrium Gallium Aluminum Garnet, or GYGAG(Ce), transparent ceramic scintillator offers a density of 5.9 g/cm^3 and Z_{eff} of 48, along with a light yield of 50,000 Photons/MeV, a principal decay time of 100 ns, and outstanding radiation hardness. High phase stability results in excellent fabrication yield and low optical scatter of <1%/cm. The fabrication, scintillation properties, and detection performance of GYGAG(Ce) transparent ceramics in sizes up to 8 in^3 will be described.

11:30 AM

(ICACC-S14-029-2026) Effect of porosity on the performance of Ce:GAGG ceramic scintillators

W. M. Bowman*[1]; S. Lass[1]; W. Wolszczak[2]; F. Moretti[2]; R. M. Gaume[1]

1. University of Central Florida, CREOL, USA
2. E O Lawrence Berkeley National Laboratory, USA

While porosity and secondary phases have historically hindered the fabrication of high-performance ceramic scintillators, recent advances have enabled their effective mitigation. To evaluate the residual impact of porosity-induced scattering on scintillator performance, Ce:GAGG ceramics were processed under varied heat treatment conditions to induce controlled levels of optical scattering. Remarkably, ceramics with transmission exceeding 80%—comparable to single crystals—were successfully fabricated at thicknesses greater than 5 mm using solid-state reactive sintering, without the need for co-dopant sintering aids. Absorption and scattering properties of the samples were quantified and incorporated into GEANT4 Monte Carlo simulations, which revealed that scintillation optical transport efficiency decreases by only 10% even in nearly opaque materials. These findings underscore the potential for significant cost reductions in scintillator ceramic fabrication for radiographic applications, with manageable trade-offs in optical clarity and transport performance.

S15 10th International Symposium on Additive Manufacturing and 3-D Printing Technologies

S15- Vat photopolymerization/stereolithography

Room: Ponce de Leon
Session Chairs: Majid Minary, University of Texas at Dallas;
Aljaz Ivekovic, Institut Jozef Stefan

8:30 AM

(ICACC-S15-025-2026) Additive manufacturing of ceramic catalytic frameworks with magnetic heating functionality (Invited)

A. Ivekovic*[3]; M. Vuksic[3]; T. Konegger[1]; M. Schwentenwein[2]; S. Gyergyek[3]; A. Kocjan[3]

1. TU Wien, Institute of Chemical Technologies and Analytics, Austria
2. Lithoz GmbH, Austria
3. Jozef Stefan Institute, Slovenia

A catalytic converter's performance depends mainly on the trade-off between the total surface area and the pressure drop through the system. Additive manufacturing offers the ability to design and manufacture intricate channel structures, thus overcoming the structural limitations of conventional catalytic converters. Effective heat transfer management is essential to maintaining the reaction kinetics and the thermodynamic driving force. Typically, catalytic converters depend on external heating or preheating mixtures, which demand considerable energy and time. Alternatively, magnetic nanoparticles embedded in the ceramic framework enable (electrified) on-demand heating directly to the catalyst zone, significantly reducing energy consumption while improving reaction kinetics. Combining the geometrical advantages of AM with the incorporation of magnetic nanoparticles within a ceramic structure, modular,

on-demand magnetic heatable catalytic substrates can be realised. Metal-modified preceramic polymer was used to fabricate SiOC(Me) (Me= Fe, Ni, Co) structures using Digital Light Processing. During the polymer-to-ceramic conversion in the range 600 °C-1500°C, amorphous SiOC ceramic is formed with in-situ generated functional magnetic nanoparticles (MNs). The heating ability of the formed ceramic framework was correlated to the pyrolysis temperature, phase composition and size of the MNPs.

9:00 AM

(ICACC-S15-026-2026) Resolving slurry instabilities in ceramic 3D printing with strategic mixing and computer vision tracking

A. Gupta*[1]; R. Ghosh[2]; A. Kumar[2]; K. Balani[1]; S. K. Jha[1]

1. Indian Institute of Technology Kanpur, Department of Materials Science and Engineering, India
2. Indian Institute of Technology Kanpur, Department of Biological sciences and Bioengineering, India

Persistent inhomogeneity and phase separation in ceramic slurries limit the precision and reliability of vat photopolymerization-based 3D printing. Conventional stirring/ ultrasonication takes >24 hours and fails to ensure uniform dispersion up to printing resolution (<200 μm), causing unstable formulations and defects. To overcome these limitations, we developed a rapid, integrated approach combining multistep mixing and real-time slurry stability tracking. Our sequential —magnetic stirring (S), ultrasonication (U), gas purging (N)—S_{MUN} protocol produced homogenous slurries in <40 min at high solid loadings (<50 wt.%), while preserving sub-resolution uniformity. We implemented a computer vision algorithm that tracks pixel intensities across the dynamic interface between supernatant and sediment layers in unstable slurries. This method detects early-stage phase separation within 20 min, outperforming visual inspection or light scattering methods that take over 48 hours. These strategies enabled control over composition and geometry during printing scaffolds (0.5 mm struts, 2 mm pores) using DLP with 58S bioglass-loaded slurries, demonstrating reliable print fidelity. By accelerating both formulation and evaluation, this platform reduces trial-and-error, supports rapid design iteration, and addresses key bottlenecks in ceramic 3D printing for clinical and industrial use.

9:20 AM

(ICACC-S15-027-2026) Ultra-fast thermal debinding (UfTD) for 3D-Printed ceramics

M. Minary*[1]

1. The University of Texas at Dallas, Mechanical Engineering, USA

Thermal debinding is a critical bottleneck in the production of ceramics fabricated by vat photopolymerization (VPP), often requiring several tens of hours of slow heating to prevent deformation or cracking. We present an ultra-fast thermal debinding (UFTD) method that achieves heating rates exceeding 100 °C/min. UFTD leverages the advantages of vacuum processing and rapid heating from porous resistive elements to accelerate binder removal while preserving the structural integrity of printed parts. Green bodies produced via VPP were successfully debound and sintered in under 30 minutes without structural compromise. Key parameters, including thermal profiles, mass loss behavior, and defect formation, were systematically evaluated. This approach significantly reduces processing time while maintaining geometric fidelity and opens new possibilities for rapid ceramic manufacturing. A notable application of this method is in enabling same-day production of 3D-printed all-ceramic zirconia crowns for chairside dental restorations.

9:40 AM

(ICACC-S15-028-2026) Ceria-stabilized zirconia-based ceramics: overcoming challenges in Digital Light Processing

B. Coppola[1]; E. Rossi[2]; M. Sebastiani[2]; F. Mussano[3]; L. Montanaro[1]; P. Palmero*[1]

1. Politecnico di Torino, Applied Science and Technology, Italy
2. Universita degli Studi Roma Tre Dipartimento di Ingegneria Civile Informatica e delle Tecnologie Aeronautiche, Italy
3. Universita degli Studi di Torino, Scienze Chirurgiche, Italy

Ceria-stabilized tetragonal zirconia (Ce-TZP) ceramics show great potential in structural and biomedical fields. This study investigates the fabrication of Ce-TZP and composite by Digital Light Processing, facing the challenge of strong UV absorption by cerium oxide at the operative wavelength. Mechanical and thermal pre-treatments were applied to commercial Ce-TZP powder, to assess their effects on surface/structural changes, printability, and properties of sintered ceramics. Milling was effective in producing a loosely dispersed fine powder, but induced the appearance of oxygen vacancies, likely due to the partial reduction of cerium from tetravalent to trivalent state. Oxygen vacancies, along with ceria segregation at zirconia surfaces, increased UV absorbance, hindering slurry photopolymerization. Calcination restored the tetravalent oxidation state enabling the production of nearly defect-free samples. Know-how from monophasic Ce-TZP ceramics was transferred to triphasic composites (comprising 8 vol% a-Al_2O_3 and 8 vol% $SrAl_{12}O_{19}$), yielding 98% dense ceramics with ~470 MPa flexural strength and fine, homogeneous microstructure. Finally, a dental implant prototype of the triphasic composite was fabricated, demonstrated high printing accuracy and resolution of the technology. Project “CONCERTO”, funded by the MIUR Progetti di Ricerca di Rilevante Interesse Nazionale (PRIN) Bando 2020.

10:20 AM

(ICACC-S15-029-2026) Vat photopolymerization of dielectric and piezoelectric ceramics

M. Schwentenwein*[1]; L. Mikiss[1]; D. Brouczek[1]; S. Gebhardt[2]; C. Molin[2]; H. Neubert[2]; C. Bae[3]

1. Lithoz GmbH, Austria
2. Fraunhofer-Institut fur Keramische Technologien und Systeme IKTS, Germany
3. Korea Institute of Materials Science, Department of 3D printing materials, Republic of Korea

The objective of this study is to evaluate the feasibility of using VPP technology for the fabrication of dielectric and piezoceramic components. Given the growing demand for advanced ceramic materials in electronic and electromechanical applications, this research aims to determine whether VPP-produced components exhibit comparable electrical and piezoelectric properties to conventionally manufactured counterparts. This study presents a comprehensive investigation into the use of VPP for the additive manufacturing of both dielectric and piezoceramic materials. Specifically, dielectric ceramic components with a broad range of dielectric constants (10 to 60) were examined to determine their permittivity and quality (Q) factor along with different types of lead-free piezoceramics. Experimental results demonstrate that VPP technology successfully produced dielectric components with basic electrical properties comparable to conventionally fabricated tape-cast parts. For piezoceramic materials, the performance of VPP-fabricated components proved equally promising. The d33 values for soft-doped PZT reached approximately 650 pC/N, while the lead-free piezoceramic components achieved values around 100 pC/N. These metrics align closely with those reported for traditionally manufactured analogues, showcasing the capability of VPP to produce piezoelectric materials with high functional performance.

10:40 AM

(ICACC-S15-030-2026) Manufacturing of meta-composite thermoelectric devices with high energy generation and mechanical performance

Y. Tang[1]; M. Li*[1]; Y. Li[1]

1. Dartmouth College, Thayer School of Engineering, USA

Solid-state thermoelectric generators (TEGs) convert heat directly to electricity with zero local emissions. However, their deployment is constrained by low conversion efficiency and the tight coupling between power factor and thermal conductivity. In this study, we report a 3D-printed meta-composite thermoelectric (TE) device that enables optimization of energy conversion and mechanical robustness. The Digital Light Processing (DLP) 3D printing approach is applied to fabricate an alumina metamaterial scaffold integrated with Bi0.5Sb1.5Te3 (BST) TE materials. A VMM-010/PEGDA resin is formulated with 70 wt% ceramic content; incorporating CuO, TiO2, and Nb2O5 additives to tailor viscosity and improve feature resolution. DLP exposure and lift parameters are optimized to yield high-fidelity green bodies, which are pyrolyzed to produce a porous alumina shell. A BST thermoelectric paste, which is modified with PEDOT:PSS to improve electrical continuity, is introduced into the scaffold by drop casting and consolidated at low temperature. The thermal–electrical finite-element (FE) model reproduces voltage evolution and heat spreading within the metastructure. The DLP-printed meta-composite TE devices deliver stable power generation under load and outstanding compressive strength, demonstrating a promising TEG design with excellent mechanical and thermoelectric performance

S18 Ultra-High Temperature Ceramics

S18-Super-hard UHTCs

Room: Coquina A
Session Chair: Christopher Weinberger, Colorado State University

8:30 AM

(ICACC-S18-025-2026) Electronic origins of structural energies and hardness trends in the transition metal carbides and nitrides (Invited)

B. Watkins[1]; C. R. Weinberger*[1]

1. Colorado State University, Department of Mechanical Engineering, USA

It is well known that the hardness of the cubic transition metal carbides and nitrides vary with carbon content and transition metal content. However, the exact origins of these changes in hardness are not completely understood. This need for understanding is further motivated by the development of high entropy carbides and nitrides, where the interplay between chemistry processing and properties are quite complex. In this talk, we examine how chemistry alters the structural energy differences and stacking fault energies in the B1 structured transition metal carbides & nitrides. We utilize DFT to compute structural energy differences and stacking fault energies and utilized multiscale modeling to predict the resulting hardness trends. We then analyze how the bonding and antibonding states that arise during bonding in the different compounds affect the preference of crystal structure and how this alters hardness. This work demonstrates that the competition between the B1 and Bh structural energy differences largely correlates to the predicted hardness trends. Further, softer materials generally have bonding states in the competing Bh structure while harder materials do lack these bonding states, demonstrating that the hardness in the B1 structure is actually controlled by bonding that occurs in this competing structure.

9:00 AM

(ICACC-S18-026-2026) High entropy carbide superlattice deposition by modulated reactive sputtering

N. O. Marquez Rios*[1]; N. S. McIlwaine[1]; S. Udovenko[1]; J. Maria[1]

1. The Pennsylvania State University, Materials Science and Engineering, USA

Transition metal high entropy carbide multilayer thin films were synthesized by reactive sputtering in bipolar HiPIMS using methane as carbon source. Time-modulated plasmas asynchronously pulse two cathodes with different target formulations, enabling superlattice stacks of either two unique 5-component carbides or a 5-component carbide and a binary carbide. These combinations allow hardness trends from chemical disorder and nanoscale layering to be isolated. Superlattices were produced with layer thicknesses between 3–50 nm, and total film thicknesses above 1 μm. Microcomputer control enables tuning of periodicities, volume fractions, and interface densities. Crystallinity was examined by XRD, surface topography by AFM, and morphology by SEM. Mechanical response was evaluated by Berkovich nanoindentation to assess layer-scale effects. In general, multilayers show hardening where hardness exceeds that of endmember films, though values depend strongly on the metal-to-carbon ratio and film density. In optimized carbide systems, hardness values up to 40 GPa are observed and will be reported.

9:20 AM

(ICACC-S18-027-2026) Development of superhard high-entropy carbide and carbonitrides for extreme environments via FAST sintering

D. E. Wolfe*[1]; L. Wilson[1]; R. Koennecker[1]; A. Marin[1]; S. Curtarolo[2]; W. Fahrenholtz[3]; J. Maria[1]; D. Brenner[4]; E. Zurek[5]

1. Pennsylvania State University, USA
2. Duke University, Materials Science, Electrical Engineering and Physics, USA
3. Missouri University of Science & Technology, Dept. of Materials Science and Engineering, USA
4. NC State University, USA
5. University of Buffalo, USA

High-entropy ceramics (HECs), including high-entropy carbides and carbonitrides (HEC/HECNs), are promising candidates for structural applications in extreme environments due to their remarkable thermal stability, chemical inertness, and mechanical robustness. Traditional materials often degrade at higher temperatures (>1200°C) through phase instability or mechanical softening. Several compositions of HECs and HECNs offer favorable alternatives due to entropy stabilized structures retaining their hardness under extreme conditions. Ideal HEC/HECN systems form single-phase solid solutions which can undergo spinodal decomposition when under thermal treatment. This decomposition can result in nanoscale compositional barriers hindering dislocation motion and enhancing hardness. The inherent compositional flexibility of HEC/HECNs enables the fine-tuning of physical and chemical properties to meet specific performance criteria. By systematically varying elemental constituents, it is possible to design materials with targeted thermal, chemical, and mechanical behaviors, surpassing the performance of conventional ceramics and metals in similar conditions.

9:40 AM

(ICACC-S18-028-2026) Mechanical properties and stability against ablation of hot pressed HfB_2 – based ceramics depending on amount and quality of SiC addition

T. Prikhna*[1]; P. Barvitskyi[1]; H. Ünsal[2]; A. Lokatkina[1]

1. Institute for Superhard Materials of the National Academy of Sciences of Ukraine, Ukraine
2. Institute of Inorganic Chemistry, Slovak Academy of Sciences, Dubravska cesta 9, SK-845 36, Slovakia

UHT HfB_2 - based ceramic has high thermal conductivity, mechanical properties, corrosion resistance due to formation of protective oxidation-resistant scale at high temperatures. Addition of SiC to HfB_2 improves mechanical characteristics and stability against oxidation. We analyzed influence of amount of SiC addition and its quality (morphology and sizes of grains, admixtures) on hot pressing densification under 30 MPa, ceramics mechanical properties and stability against ablation in air. The highest microhardness H_V =38.6 ±2.5 GPa and fracture toughness K_{1C} =7.7 ±0.9 MPa $m^{0.5}$ (under 9.8 N load) demonstrated composite prepared from HfB_2-30 wt.% SiC (5-10 μm). Air ablation tests with a gas burner showed that HfB_2 ceramics with 30 wt. % SiC of 30-100 μm (fragmentary grains with sharp edges, with 0.5 wt. % Fe and 2.9 wt. % O admixtures) and 5-10 μm (single-crystal grains with a hypercubic shape close to spherical, without admixtures) turned out to be significantly more heat-resistant - up to 2066 and 2080 °C, respectively (the mass loss was 0.25 mg/s), than HfB_2 ceramics without additives (cracked at 1870 °C). The addition of 30 wt. % of SiC powders with sharp fragment grains of 1 μm in size (with 9 wt. % O admixture) or 3-10 μm (with 4.1 wt. % O) led to cracking at 1787 °C and 1455 °C, respectively.

S18- Simulation and theory for predicting stability or behavior under extreme environments

Room: Coquina A
Session Chair: Stefano Curtarolo, Duke University

10:20 AM

(ICACC-S18-029-2026) Tuning functional synthesizability of high-entropy ceramics with a variational approach to DEED. (Invited)

S. Curtarolo*[1]

1. Duke University, Materials Science, Electrical Engineering and Physics, USA

In this presentation we will introduce delta-DEED, a variational approach to tune functional synthesizability of high-entropy ceramics. We will see how to make multi-phase ceramics out single-phase ones and vice versa. Research sponsored by DoD- ONR.

10:50 AM

(ICACC-S18-030-2026) Development of a reaction model for silicon-doped boron nitride formation with experimental validation *WITHDRAWN*

A. M. Daniels[1]; C. Cha[2]; H. Koo[2]; H. Chelliah*[1]

1. University of Virginia, Mechanical and Aerospace, USA
2. Rolls-Royce Corporation, USA

Optimization of CVD reactors designed for various coatings and densification processes require well validated thermo-chemical models. One good example is the coating of Si-doped boron nitride (Si-BN) on silicon carbide fibers or tows. Specifically, controlling the level of Si doping of BN coatings require accurate thermo-chemical models that include the details of decomposition and mixing of key reagents and having sensitivities with respect to temperature, pressure, composition, and residence time. Unfortunately, the existing kinetic models are incomplete in details and the associated rate parameters are known to have large uncertainties. In this work, an open-source software package Reaction Mechanism Generator (RMG) is used with the semi-global BN model proposed by Allendorf et al. (1996) as the starting point. A custom micro-CVD reactor was developed, enabling independent mixing of multiple precursors with precise control of operating conditions. The resulting thermo-chemical and kinetic models were then applied in simplified flow reactor simulations to demonstrate the effects of temperature, pressure, residence time, and feed composition on BN coating chemistry. While these models reveal key process sensitivities and highlight important reactor flow-chemistry interactions, experimental validation of doped coatings on surrogate substrates is still ongoing.

S18- Novel processing methods for bulk, coatings, thin films, fibers, and/or composites

Room: Coquina A
Session Chair: Carolina Tallon, Virginia Tech

11:10 AM

(ICACC-S18-031-2026) Liquid phase sintering of Cf – ZrB_2 UHTCMCs *WITHDRAWN*

D. Sciti*[1]; S. Failla[1]; A. Vinci[1]; M. Mor[1]; L. Zoli[1]

1. CNR - ISSMC, Italy

Zirconium diboride-based UHTCMCs are currently considered a promising class of materials for aerospace applications. One of the challenges in the production of these composites is the densification stage, carried out at very high temperatures. In this study, the liquid-phase sintering of ZrB_2-Cf UHTCMCs was investigated to decrease the densification temperature, using liquid-forming sintering aids such as $ZrSi_2$ and $Si3N_4$. Both fiber-reinforced and non-reinforced systems were prepared and sintered by hot pressing and spark plasma sintering. Thermodynamic analyses and ad hoc interface experiments were conducted to reconstruct reactions at the matrix/fibre interface during matrix densification. The formation of a liquid phase lowered the sintering temperature; however, the accumulation of liquid at the matrix/fiber interface increased fiber corrosion. Compared to bulk systems, the addition of fibers slowed down densification. Microstructural analyses and mechanical tests were conducted to assess the effect of sintering aids on strength and oxidation resistance.

11:30 AM

(ICACC-S18-032-2026) Novel additive manufacturing method of ultra-high temperature ceramics: Electron beam melt assisted in-situ synthesis of TiB_2 – ZrB_2 – TiC

A. Dobosz*[1]; R. Crookes[1]; G. Jones[1]; K. Hadley[1]

1. Lucideon Ltd, Advanced Materials, United Kingdom

Ultra-high temperature ceramics (UHTCs) have gained increased interest in recent years as they have the potential to resolve challenges with operating temperature and extreme environments in applications such as advanced rocket propulsion, hypersonic aircraft, and nuclear power. UHTCs are notoriously difficult to manufacture, especially in complex forms. In this work we focused on a new approach to synthesize near net shape UHTCs by utilizing an in-situ reactive self heating synthesis (SHS) within an electron beam powder bed printing system, producing a part directly out of an additive manufacturing process. Various formulations have been developed to result in a locally reacting, non-propagating synthesis initiated by the electron beam. Electron Beam Melting (EBM) trials were performed on pressed pellets and granulated feedstock. The SHS reaction was successfully selectively initiated, forming reaction melt lines and areas. The resulting reacted material has been characterised through SEM with EDS, as well as XRD analysis. EBM parameters were explored, including preheating, beam focus, and beam currents, to produce reaction melts. This work is the first example of combined SHS and additive processing to produce UHTCs.

11:50 AM

(ICACC-S18-033-2026) Achieving microstructural anisotropy in UHTCs (Invited)

C. Tallon*[1]

1. Virginia Polytechnic Institute and State University, Materials Science and Engineering, USA

The design of thermal protective systems (TPS) for hypersonic vehicles is exceptionally challenging due to the ruthless conditions of atmospheric reentry, like extreme heat fluxes, temperatures and stagnation pressures in highly oxidative environments. TPS must survive those conditions while exhibiting minimal material ablation, low weight and ability to be shaped in multiple, complex geometries. Ultra-High Temperature Ceramics (UHTCs) are part of the equation to solve the problem of material selection to guarantee these components survivability. There has been a remarkable development over the past 20 years for UHTCs in their state-of-art manufacturing and microstructural design, although most of the solutions still revolve around isotropic microstructures. Recent advances in manufacturing have paved the way for exploring new UHTC microstructures that could lead to other heat management strategies. In this talk, innovative colloidal processing approaches to develop anisotropic microstructures in UHTCs will be discussed, for small and large, complex geometries, including aligned porosity, textured microstructures and high aspect ratio building blocks. This anisotropy could allow the tailoring of the thermomechanical response in different directions within the same component and enable innovative active and passive cooling strategies. This also opens the door to other types of applications beyond hypersonics for these materials.

S20: Golden Jubilee- Engineered Ceramics for Achieving Net-Zero Carbon Emissions

S20- Challenges and prospects for various ceramic technologies

Room: Coquina D
Session Chairs: Csaba Balazsi, ELKH Centre for Energy Research; Valerie Wiesner, NASA Langley Research Center

8:30 AM

(ICACC-S20-021-2026) From lab to lunar surface: Validating dust-mitigation materials for extreme environments (Invited)

V. L. Wiesner*[1]

1. NASA Langley Research Center, Advanced Materials and Processing Branch, USA

As humanity expands its ventures into lunar exploration, the demand intensifies for materials capable of enduring extreme environmental and service conditions. The Moon's surface presents numerous challenges, including ultra-high vacuum exposure, temperature extremes and intense radiation. Additionally, lunar regolith threatens component durability and reusability due to its abrasive nature. Lunar dust particles scoring, adhering or embedding into surfaces and within device-confined geometries, such as bearings, drive mechanisms and connectors, can cause premature component wear or failure. Furthermore, the interaction between the rocket plume and surface during vehicle landings and ascents creates severe erosive conditions near critical vehicle components and adjacent infrastructure. A key barrier hindering materials discovery for lunar dust tolerant applications is a lack of standard laboratory methods to evaluate material properties and performance under representative operating conditions. A case will be presented for research activities supporting identification, processing and characterization of candidate materials in conjunction with innovations in standardized testing and qualification. Results will highlight current and emerging test methods for simulating lunar dust exposure and component degradation along with flight experiments.

9:00 AM

(ICACC-S20-022-2026) Microscale mechanical properties of silicon nitride ceramics (Invited)

T. Ohji*[1]; J. Tatami[1]

1. Yokohama National University, Japan

This paper presents recent work on the microscale mechanical properties of silicon nitride (Si_3N_4), as determined by microcantilever bending tests. We first focus on the deformation behavior and fracture strength of Si_3N_4 single crystals. β- Si_3N_4 single crystals exhibit plastic deformation at room temperature under high bending stress, and the yield stress depends on crystal orientation. The critical resolved shear stress of the primary slip system is estimated to be below 1.5 GPa based on the yield stress. Next, we address the microscale mechanical properties of Si_3N_4 polycrystalline ceramics, with emphasis on grain-boundary strength and toughness in relation to the intergranular glassy film (IGF), which is influenced by processing parameters such as sintering additives. We assess two fracture modes: one at the IGF–grain interface and the other within the IGF itself. In both cases, the effects of rare-earth oxide additives are discussed. Finally, we shed light on the microscale rising R-curve behavior of Si_3N_4 polycrystalline ceramics. The obtained crack-tip toughness, as well as the toughness at a 10 μm crack extension extrapolated from the R-curve, agrees well with previous results obtained from macroscale bending tests. This work was supported by JST, CREST Grant Number JPMJCR2192, Japan.

9:30 AM

(ICACC-S20-023-2026) $Y_{1-x}Tb_xTaO_4$ single crystals as scintillators for X-ray detection (Invited)

K. Shimamura*[1]; E. G. Víllora[1]; Y. Zhou[1]; D. Nakauchi[2]; T. Kato[2]; N. Kawaguchi[2]; T. Yanagida[2]

1. National Institute for Materials Science (NIMS), Japan
2. Nara Institute of Science and Technology, Japan

Single-crystal scintillator that is free from toxic elements and has scintillation properties comparable to commercial $CdWO_4$ (CWO) in terms of light yield, afterglow, and stopping power, has been demanded since long. In this work, transparent and colorless $Y_{1-x}Tb_xTaO_4$ (YTTO) mixed single crystals have been grown by the floating-zone (FZ) technique and investigated as scintillators. The optimum scintillation performance was found for 15% Tb concentration: the light yield was about 1.5 times that of CWO, while the density, the stopping power, and the afterglow were comparable. These results demonstrate the potential of $Y_{0.85}Tb_{0.15}TaO_4$ single crystals as an environmentally friendly alternative to CWO ones for high-energy X-ray radiography.

10:20 AM

(ICACC-S20-024-2026) The role of interfaces in nanocarbon added ceramics (Invited)

C. Balazsi*[1]; K. Balazsi[1]

1. HUN-REN Energiatudomanyi Kutatokozpont, Hungary

The lecture will give a comprehensive view on innovative developments made in the field of nanocarbons e.g. carbon black, carbon nanotubes, graphene added ceramics highlighting the key issues related to integration technology and improvements in the mechanical, tribological or functional properties as a result. Among non-oxide ceramics the silicon nitride based ceramics are well-known as low density materials with high strength and toughness. Silicon nitride, known as a typical dielectric material, is an ideal candidate for several structural applications, even at high temperatures. The addition of graphene or carbon nanotubes to silicon nitride to create ceramic nanocomposites gives rise to promising applications in a wide range of fields such as electronics, biomedical aids, membranes, flexible wearable sensors and actuators, energy systems. The presentation will show how the use of different reinforcing phases are distributed to ceramic interfaces in the microstructure and as a result, mechanical properties, electrical, thermal conductivity and tribological properties of the final silicon nitride nanocomposites. The prospective future applications will be also discussed.

10:50 AM

(ICACC-S20-025-2026) Thin-film processing of functional ceramics: Current challenges and future directions (Invited)

T. Fischer*[1]; S. Mathur[1]

1. University of Cologne, Institute of Inorganic and Materials Chemistry, Germany

The need for faster and more powerful electronic circuits demands a materials transition enabling high frequency and high-power operation, which can currently only be fulfilled by functional oxide and nitride ceramics. Also, the increasing demand for critical raw materials in energy conversion (e.g, electrolysis), transport, and storage (e.g., batteries) cannot be met by sourcing more raw materials but requires concentrating their use at the functional interface. Therefore, thin film deposition techniques have evolved into key processing capabilities for realizing the needed interface functions in microelectronics, energy conversion, catalysis, medicine, transportation, etc. The chemical vapor deposition processes (CVD), including atomic layer deposition (ALD), enable a beyond line-of-sight fabrication of highly controllable thin-films of complex compositions and geometries. One bottleneck of these precursor-based processes remains the availability of tailored precursors for clean and efficient thin film growth. This lecture will also highlight how external magnetic fields open, in combination with tailored molecular precursors, a new process dimension to controll morphology, phase, and composition of functional thin fims and their application in photo- and electrocatalytic applications for hydrogen and ammonia prodcution.

11:20 AM

(ICACC-S20-026-2026) Prepreg-based oxide fiber composites (OFC): Materials for lightweight and thermostable structures (Invited) *WITHDRAWN*

W. Krenkel*[1]; G. Puchas[1]; J. Winkelbauer[1]

1. University of Bayreuth, Ceramic Materials Engineering, Germany

Slurry-based prepreg processes for fabric-reinforced composites as well as a fiber spraying process for short fiber prepregs were developed with the material system Nextel 610/Al2O3-ZrO2. OFC materials combine high thermo-mechanical properties with a superior oxidation and corrosion resistance in combustion environment. Due to their porous and therefore “weak” matrix, they show a damage-tolerant fracture behavior as well as a low thermal conductivity predestining them, in combination with a moderate density of less than 3 g/cm3, for lightweight applications. 2D-fabric reinforcements show a restricted drapability, therefore the complexity in shaping OFC components is limited and their behavior is generally anisotropic. Short fiber reinforcements offer a high degree of freedom in the prepreg’s drapability and allow a manufacture with less waste. The two prepreg processes which are patented and transferred to industrial partners will be described and compared with respect to materials properties, costs and design aspects.

FS2- Ceramics to Shape the Future of Low-Carbon and Carbon-Negative Technologies

FS2- Technologies and ceramics for emerging low-carbon processes and hydrogen production

Room: Flagler C

Session Chairs: Maila Danielis, Universita degli Studi di Udine; Massimo Santarelli, Politecnico di Torino; Charles Lewinsohn, Colorado State University System

1:30 PM

(ICACC-FS2-008-2026) Protonic ceramics: overview, transport mechanism, and applications (Invited)

S. Ricote*[1]

1. Colorado School of Mines, Mechanical Engineering, USA

Protonic ceramics are a class of materials capable of conducting protons at intermediate temperatures, typically in the range of 400–600 °C. In addition to proton conduction, these materials can also facilitate the transport of other charge carriers, such as oxide ion vacancies and electronic defects like polarons. This presentation will begin with an overview of the hydration behavior of protonic ceramics. Following this, we will explore in greater depth the temperature- and oxygen partial pressure-dependent conductivity, examining how these parameters influence the transport properties of various charge species. Finally, the talk will highlight several promising applications of protonic ceramics, including their use in protonic ceramic fuel cells (PCFCs), protonic ceramic electrolysis cells (PCECs), and membrane reactors for energy and chemical conversion technologies.

2:00 PM

(ICACC-FS2-009-2026) Solid-state electrochemical reduction of iron oxide: A comparative analysis of protonic and oxygen-ion pathways

V. Dhongde[1]; S. Singh[1]; L. Mastropasqua*[1]

1. University of Wisconsin-Madison, Mechanical Engineering, USA

The electrochemical reduction of iron oxides presents a promising approach to electrify the production of iron and the refinement of ores, reduce emissions, and potentially increasing product yield per unit energy (kg_{Fe}/MJ). This research for the first time presents a comparative analysis of a batch solid-state electrochemical cell in two configurations utilising an iron oxide negatrode. In a proton-conducting cell (Iron oxide|BCZY|BCZY-NiO), electroreduction is accomplished through hydrogenation as protons are transported through the electrolyte supplied via steam electro-oxidation at the positrode. In an oxygen-ion conducting cell (Iron oxide|YSZ|YSZ-NiO), where electroreduction takes place by electrochemically extracting oxygen anions through the electrolyte. Both systems show a significant rise in electrochemical impedance after reduction. This transformation is attributed to the cathodic reaction from iron oxide, a mixed ionic-electronic conductor (MIEC), into metallic iron, a pure electronic conductor. The transition removes the distributed ionic pathways in the oxide, limiting electrochemical activity to the planar cathode-electrolyte interface. The collapse of the active interfacial area fundamentally changes charge-transfer kinetics, providing insights into the evolution of electrode performance during reduction.

2:20 PM

(ICACC-FS2-010-2026) Development of impurity-tolerant FAU zeolite membranes for CO_2 separation from industrial flue gases

S. B. Lundin*[1]; A. Ikeda[1]; Y. Kohno[1]; Y. Hasegawa[1]

1. Sangyo Gijutsu Sogo Kenkyujo Tohoku Center, Japan

The tunable properties of zeolites have allowed for the development of high permeance and selectivity CO_2 separation membranes, with ideal properties for CO_2 separations from industrial flue gases. Unfortunately, industrial CO_2 often contains NO_x and SO_x impurities up to several hundred ppm, which can potentially inhibit CO_2 permeation or damage the zeolite structure. This work focuses on increasing the long-term stability of FAU-type zeolite membranes by understanding the effects of NO_2 and SO_2 on membrane performance and zeolite structure. Failure testing was accelerated by using concentrations of NO_2 and SO_2 up to 5% to understand the effects on the zeolite structure, and the Si/Al ratio was varied to determine its effect on stability. Powder samples exposed for two weeks at 150 °C showed evidence of structural degradation, likely due to the formation of acidic surface species on the zeolite structure. Notably, increasing the Si/Al ratio significantly improved the structure stability and decreased impurity adsorption amounts. Continuous monitoring of gas permeance through the membranes similarly showed improved performance at higher Si/Al ratio, with lower CO_2 permeance declines and higher long-term stability. These results suggest that developing practical zeolite membranes for long-term CO_2 separations should focus on higher Si/Al ratio zeolite types and synthesis methods.

2:40 PM

(ICACC-FS2-011-2026) $Pr_{0.2}Ce_{0.8}O_{2-\delta}$-$BaCe_{0.5}Hf_{0.3}Y_{0.1}Yb_{0.1}O_{3-\delta}$ solid composite ceramic membrane for efficient hydrogen separation

E. Hintz*[1]; V. Dhongde[1]; L. Mastropasqua[1]

1. University of Wisconsin-Madison, Mechanical Engineering, USA

Membrane-based technologies offer an effective means of separating hydrogen from mixed-gas streams. Specifically, dense ceramic membranes exhibit exceptionally high hydrogen purity and material stability under common industrial gases, such as CO, CO_2, and H_2S. This study presents the fabrication and evaluation of a novel dense ceramic-ceramic composite membrane designed for hydrogen separation. The membrane combines an electron-conducting fluorite phase, $Pr_{0.2}Ce_{0.8}O_{2-\delta}$ (PCO), with a proton-conducting perovskite phase, $BaCe_{0.5}Hf_{0.3}Y_{0.1}Yb_{0.1}O_{3-\delta}$ (BCHYYb). The two ceramic powders were prepared using a Nitrate-Citric Acid combustion method, then ball-milled together. A planar two-layer cell consisting of a porous support layer and a dense functional layer was pressed from the powder and sintered. The investigation of hydrogen permeation was conducted at 500°C-900°C, with an Ar–H_2 gas mixture provided to the feed side. Gas chromatography of the permeate was used to analyse the H_2 permeation through the membrane. The membrane exhibited high hydrogen flux exceeding 1 with a 50:50 molar ratio of Ar-H_2 at just 600°C. This indicates that PCO–BCHYYb demonstrates significant promise as a performant, durable material for hydrogen separation applications.

3:20 PM

(ICACC-FS2-013-2026) Clay-based ceramics for hydrogen production and gas separation

I. Reimanis*[1]; R. McGinnis[1]; S. Ricote[2]; G. Coors[3]; R. Marder[4]; W. D. Kaplan[4]

1. Colorado School of Mines, USA
2. Colorado School of Mines, Mechanical Engineering, USA
3. Hydrogen Helix, USA
4. Technion - Israel Institute of Technology, Dept. of Materials Science and Engineering, Israel

Kaolinite-based clay exhibits a very porous microstructure with high surface area. When bisque fired it retains the desirable morphology and is ideal for use as a catalyst support as well as for gas separation due to naturally forming porous microchannels. Recent experiments with Ni-infiltrated bisque-fired kaolinite have demonstrated that hydrogen can be produced from ethanol (ethanol steam reforming, ESR) at rates that are of high commercial interest. Additionally, the high surface area and fine pore channels lead to excellent gas separation performance. The talk will describe the processing, microstructure evolution, and mechanical integrity of kaolinite-based ceramics in the context of ESR and gas separation.

3:40 PM

(ICACC-FS2-014-2026) Looping-accelerated CO_2 mineralization for cost-competitive cementitious materials and hydrogen

K. Shank[1]; H. Xu[1]; Y. Yunming[1]; A. Arjomand[1]; J. Qin[1]; S. Zhai*[1]

1. The Ohio State University, USA

We introduce a novel sodium carbonate (Na2CO3) looping process that accelerates CO2 capture and mineralization by silicate feedstocks such as steel slags, producing a carbonate-rich product and amorphous silica as cementitious materials. Demonstrated on steel slags, the process achieved 59% and 35% capture for point-source and air CO2, respectively, mineralizing to up to 2.79 mmol CO2 per gram of slag. Compared to traditional slag-water CO2 mineralization, Na2CO3 looping captured and mineralized an order of magnitude more CO2. The process offers several key advantages and novelties: (1) no net chemical consumption; (2) CO2 capture and mineralization occur at room temperature and 1 atm; (3) the CO2 source can be either point source or ambient air; (4) both reaction steps in looping are exothermic, lowering system energy demand; and (5) two cementitious products—carbonate-rich solids and amorphous silica—are generated separately, enabling flexible blending in downstream applications. Additionally, utilization of slag waste heat enables reaction with steam to produce up to 1.01 mmol H2 per gram of slag. Without product revenues, levelized costs are only $252 and $50 per ton of CO2 for air and point-source capture, respectively; considering product revenues, the payback periods are only 1.9 and 0.8 year for air and point-source CO2.

4:00 PM

(ICACC-FS2-015-2026) Impact of Hydrogen-Rich Metals on Refractory Ceramics

K. Naresh[1]; E. Agyekum[1]; C. Hulme[1]; N. Wagri*[1]

1. Kungliga Tekniska Hogskolan, Department of Materials Science and Engineering, Sweden

Iron and steel account for over 90% of the world's metals production and around 7% of the world's CO2 emissions. Current trends to reduce this figure include a shift to scrap-based production but this can only satisfy around one third of demand: reduction of virgin ore is still required. Strategies to reduce greenhouse gas emissions from ore-based production include a shift from fossil carbon to biocarbon and, increasingly, a shift to reduction of ore using hydrogen. This is a fundamental change from carbon-based reduction and leads to many new challenges, including the chemical reaction of hydrogen-enriched liquid metals inside furnaces with the refractory linings of the furnaces. Refractory linings include materials such as Al2O3 (alumina), MgO (magnesia) and CaO (lime) and are needed to withstand the high temperatures and wear from the liquid iron and steel as it is processed and poured. These materials are susceptible to attack by hydrogen, which can remove the oxygen from their structures and lead to failure of the bricks. This would then lead to contamination of the liquid metal and, in the extreme case, leaks from the vessels containing the liquid metal. This research aims to assess the susceptibility of different refractory materials to hydrogen that is dissolved in the metals that are used in steelmaking and have been made by reduction using hydrogen gas or other hydrogen-rich atmospheres.

FS3 Smart Powder Processing of Multifunctional Ceramics and Catalyst Materials

FS3- Smart Powder Processing of Multifunctional Ceramics and Catalyst Materials III

Room: Ballroom 1 -2
Session Chairs: Masako Uematsu, Ippan Zaidan Hojin Fine Ceramics Center; Junichi Tatami, Yokohama National University

1:30 PM

(ICACC-FS3-008-2026) High-entropy carbides with up to nine metals and their order–disorder transition (Invited)

B. Anasori*[1]

1. Purdue University, USA

Alloys and ceramics with five principal elements are usually considered high-entropy materials. A key question is how enthalpic preferences for ordering or segregation appear at grain boundaries in multi-principal materials, especially when grains are thinned to only a few atoms, making the boundary the dominant feature. Studying such structures is challenging due to the difficulty of growing and designing sub-nanometer thin films. By using layered carbides, MAX phases, and 2D MXenes, we are now able to study the effect of interfaces and phase boundaries on entropy stabilization. To explore this behavior, we designed and synthesized about 40 novel carbides with two to nine metals and found that seven or more metals are needed to overcome the enthalpic preference for ordering in these carbides. In this talk, I will discuss the transition from order to disorder in these layered and 2D carbides and present some of their functional and catalytic properties.

2:00 PM

(ICACC-FS3-009-2026) Advances on mechanochemistry and what's missing (Invited)

M. Boaro*[1]

1. Universita degli Studi di Udine, Polytechnic Department of Engineering and Architecture, Italy

Mechanochemical routes are reshaping catalyst and electrode synthesis by enabling solvent-lean, energy-efficient fabrication of nanostructured oxides, carbons, and dispersed (single-atom) metals. Beyond simplifying workflows, ball milling and related methods imprint strain, defects, and partial amorphization that translate into activity and durability gains across thermo-, photo- and electrocatalysis. In situ probes clarify mixing, bonding, and phase evolution during milling, informing design. We also outline limitations: sensitivity to jar/media contamination, atmosphere control, and protocol transferability; and, above all, scale-up. Despite kilogram-scale demonstrations (including single-atom catalysts), robust, quality-assured production remains challenging due to heat management, wear, and reproducibility. This overview summarizes the state of the art and integrates University of Udine results on solvent-free preparation of supported metals catalysts, where defects and specific metal–support contact deliver catalytic improved performance. Overall, mechanochemistry offers a greener toolbox, but a clear understanding and forecasting of mechanisms and parameters involved during the synthesis, and practical scale-up methods are urgently needed.

2:30 PM

(ICACC-FS3-010-2026) Hollow ceramic particles via chemical vapor deposition on template particles

H. Katsui*[2]; Y. Nakashima[2]; N. Kishikawa[1]; S. Kawase[1]; M. Hotta[2]

1. Nagoya Municipal Industrial Research Institute, Japan
2. National Institute of Advanced Industrial Science and Technology (AIST), Japan

Hollow silica particles (HSPs) have attracted considerable attention due to their unique internal voids and large surface areas. The template method is one of the major techniques for producing hollow particles with excellent structural controllability, where coating on the template is usually achieved by liquid-phase processes such as the sol–gel method. In contrast, chemical vapor deposition (CVD) also enables coating on particles, and its application is expected to allow the synthesis of various ceramic hollow particles, including both oxides and non-oxides. This study aims to investigate the feasibility of applying CVD as a template method for fabricating hollow ceramic particles. HSPs were prepared using calcium carbonate templates coated with silica layers via rotary CVD at 540°C for deposition times ranging from 60 to 240 min. The silica layer thickness varied from 17.4 to 22.9 nm depending on the deposition duration. After removal of the template, the HSPs prepared with 60 min of deposition exhibited numerous micropores, with a specific surface area of 223 m^2/g. In contrast, when the deposition time was extended to 120–240 min, the resultant HSPs exhibited no detectable micropores.

FS3- Smart Powder Processing of Multifunctional Ceramics and Catalyst Materials IV

Room: Ballroom 1 -2
Session Chair: William Fahrenholtz, Missouri University of Science & Technology

3:10 PM

(ICACC-FS3-011-2026) Direct observation of particle deposition dynamics on plaster mold surfaces during slip casting using high-concentration slurry (Invited)

M. Uematsu*[1]; T. Kimura[1]

1. Japan Fine Ceramics Center, Japan

Slip casting using high-concentration slurries and plaster molds is widely applied in ceramic production. Slurry properties such as particle size distribution, viscosity, and dispersion state strongly influence the microstructure of the green body and the performance of the final product. Clarifying the relationship between slurry properties and ceramic microstructure is crucial. However, suspensions of fine particles at high concentrations often exhibit nonlinear flow behaviors such as thixotropy, and particle motion in such slurries has not been fully elucidated. Moreover, the internal structure of the slurry changes during molding, making local variations difficult to predict. To better understand particle behavior in concentrated slurries, a transparent slurry was developed to directly visualize the internal structure. The slurry was prepared using a transparent raw powder and a liquid with a matched refractive index, reducing light scattering at the particle-liquid interface and allowing visible light transmission. A fluorescent agent was added, and observation with a confocal fluorescence microscope enabled in-situ cross-sectional imaging. This presentation reports the particle deposition behavior of slurries with different particle size distributions and dispersion states as they deposit on the surface of a plaster mold.

3:40 PM

(ICACC-FS3-012-2026) Spray freeze granulation drying of silicon nitride slurries prepared from tert-butyl alcohol and cyclohexane solvent mixtures

J. Tatami*[1]; R. Yamazaki[1]; M. Iijima[1]; S. Kawaguchi[2]; N. Kondo[3]

1. Yokohama National University, Japan
2. Preci, Japan
3. Sangyo Gijutsu Sogo Kenkyujo Chubu Center, Japan

Silicon nitride (Si3N4) ceramics are typical engineering ceramics, which have been applied to bearings, substrates, and so on. Because of expansion of the applications, the improvement of the mechanical reliabililty is desired based on the advanced powder processing. A spray freeze granulation drying technique is suitable for obtaining soft and homogeneous granules, but the use of an aqueous slurry could degrade raw materials such as nitride. In this study, the Si3N4 granules were obtained from the slurries prepared from tert-butyl alcohol and cyclohexane solvent mixtures by the spray freeze granulation drying technique. As a result of an in situ optical coherence tomography observation of the freezing behaviour, it was shown that the slurry from a solvent mixture of the eutectic composition froze in a single step in a shorter time than the other solvent mixtures. The granules of that composition prepared by spray freeze granulation drying had a smaller size and a narrower size distribution, which resulted in a homogeneous internal structure of silicon nitride ceramics. Furthremore, it was also found that highly dense, homogeneous and high strength β-Si3N4 ceramics were obtained using granules prepared using 50 mol% OA by spray freeze granulation drying.

4:00 PM

(ICACC-FS3-013-2026) Templated growth of metal oxides in montmorillonite-modified SiOC ceramics

A. Rau*[1]; K. Bawane[3]; K. Lu[2]

1. Virginia Polytechnic Institute and State University, USA
2. University of Alabama at Birmingham, USA
3. Idaho National Lab, Characterization, USA

This study investigates the templated in-situ growth of transition metal oxide nanoparticles in silicon oxycarbide (SiOC) matrices modified with amino-silane-functionalized montmorillonite (MMT) nanoclays. Iron(III) acetylacetonate was used as an active filler to catalyze phase evolution during pyrolysis at 1200°C and 1400°C. MMT domains act as nucleation sites that localize Fe species, forming core-shell $FeO_x@Fe_3Si$ particles embedded within the SiOC matrix. These regions support varied β-SiC nanowire growth through vapor-liquid-solid (VLS) and carbothermal mechanisms, modulated by temperature and filler distribution. Comparisons with Co, Ni, and Fe-based bimetallic systems ($FeCo_{0.5}$, $FeNi_{0.8}$) reveal that metal clustering on MMT enhances oxide formation and novel bimetallic oxides not obtainable solely through metal-modified active filler pyrolysis methods. These hybrid nanocomposites are promising candidates for porous ceramics, catalysis, and magnetic applications. The findings highlight the unique role of MMT as both structural template and chemical mediator in advanced ceramic design.

4:20 PM

(ICACC-FS3-014-2026) Exploring in-situ hBN interphase synthesis via dip coating: Engineering the carbon fiber/ SiC matrix interface

B. Kumar*[1]; S. E[1]

1. Indian Institute of Technology Roorkee, Metallurgical and Materials Engineering, India

Interfacial engineering is crucial for the mechanical and thermal properties and performance of carbon fiber reinforced SiC (C_f/SiC) composites for high-temperature structural applications. Dip coating is an effective yet undervalued process to introduce an interphase that diminishes the limitations of conventional methods like CVD while targeting economic and sustainable development. A systematic investigation was carried out to optimize the key process parameters in dip coating to obtain in-situ synthesized hBN interphase. Optimum conditions of boric acid to urea precursor ratio, polyvinyl alcohol binder content, dip-drying cycles and nitriding temperature resulted in uniform, crystalline hBN layer that effectively improved the composite's fracture toughness mechanisms by promoting extensive fiber debonding and pullout, as well as prevent fibers from thermal degradation via protective hBN and boron oxides - oxynitrides. The composite is fabricated by successful slurry impregnation of nano β-SiC matrix into fiber preforms and consolidation by spark plasma sintering, reducing overall development procedure's complexities along with cost effectiveness and controlled energy consumption. This streamlined approach provides a scalable alternative to traditional methods to indigenously develop high performance C_f/SiC composites with controlled interphases.

FS5 High Voltage Materials for Advanced High Power Electrical Applications

FS5- High Voltage Materials for Advanced High Power Electrical Applications

Room: Coquina C
Session Chair: Dong Liu, University of Oxford

1:30 PM

(ICACC-FS5-001-2026) Enhancing high-temperature performance of copper-graphene composites for advanced electrical applications (Invited)

M. Cullinan*[1]

1. The University of Texas at Austin, USA

Copper is the standard for electrical applications across many industries due to its unique properties. However, there are challenges related to its weight and performance in extreme environments that limit copper's usage particularly in aerospace applications. Alternative materials, such as graphene, are lightweight with excellent electrical properties that combined with copper positively improve and protect the copper from deteriorating in high temperature applications. This research explores two approaches to making a copper-graphene composite (CGC) to improve thermal stability and electrical conductivity at elevated temperatures. The first approach focuses on a direct graphene growth through chemical vapor deposition (CVD) on a copper substrate that is further formed into wires using repeated heat treatments combined with wire drawing steps. The second approach focuses on graphene transfer on thin copper films to create alternating layers of copper-graphene stack. These approaches are accompanied by simulations that predict how to improve electrical conductivity of copper/graphene conductors by testing the material under various conditions. Based on the composite fabrication method, data collected and simulations, a description of the overall effects of graphene on copper is given along with recommendations for improving future graphene/copper composite materials.

2:00 PM

(ICACC-FS5-002-2026) Lightweight silver-carbon nanotube composite fibers for high conductivity power transmission (Invited)

V. Shanov*[1]; Q. Fang[1]; H. Tran[1]; A. Raut[3]; M. Khosravifar[3]; D. Mast[2]

1. University of Cincinnati, Department of Chemical and Environmental Engineering, USA
2. University of Cincinnati, Department of Physics, USA
3. University of Cincinnati, Department of Mechanical and Materials Engineering, USA

Conventional copper power cables for power transmission add substantial mass, limit routing flexibility, and contribute to energy losses across mobile and grid systems. In this work, we present a scalable route to silver–carbon nanotube composite fibers, integrating Ag nanoparticle infiltration by ultrasonic atomization during array-to-fiber spinning with oxygen-plasma functionalization and continuous silver electroplating. The roll-to-roll process yielded fibers with a uniform Ag shell and Ag nanoparticles embedded within the CNT network, confirmed by SEM/FIB-EDS and Raman spectroscopy. This hybrid architecture substantially enhanced charge transport, elevating electrical conductivity by nearly two orders of magnitude compared with pristine CNT fiber, thus achieving a 17-fold improvement over previous Cu-CNT fiber work, reaching $8.68 \times 10^{\wedge 6}$ S/m, while also increasing the maximum current density. Mechanical performance remained robust, where Ag-nanoparticle infiltration strengthened the fiber, and the Ag coating traded some strength for improved conductivity. Nevertheless, the fibers preserved flexibility, with small radius bending causing only local shell cracking. This continuous, scalable processing enabled arbitrary length fabrication of lightweight, flexible conductors, and offered a promising alternative to copper conductors for power transmission and electrified vehicles.

2:30 PM

(ICACC-FS5-003-2026) Partial discharge test rig considerations for aerospace materials research (Invited)

M. Lizcano*[1]

1. NASA Glenn Research Center, USA

Safe and reliable electrical insulation is critical for future aerospace power systems, particularly as designs push toward higher voltages (>300 V) and elevated switching frequencies. Under such conditions, insulation systems face accelerated aging mechanisms that can compromise long-term reliability and safety. This work presents the design considerations for a partial discharge (PD) test rig tailored for aerospace materials research, with emphasis on mitigating environmental noise prior to testing to ensure data integrity. The rig enables high-frequency testing under controlled conditions, allowing evaluation of candidate insulation materials relevant to advanced aerospace platforms. Recent experimental results are discussed for polyether ether ketone (PEEK) composites containing hexagonal boron nitride fillers, highlighting the influence of filler content on PD resistance and overall dielectric performance.

S1 Mechanical Behavior and Performance of Ceramics & Composites

S1- Mechanical characterization of ceramics and composites, techniques & equipment

Room: Coquina E
Session Chairs: Nico Langhof, University of Bayreuth; Ralf Goller, University of Applied Sciences

1:30 PM

(ICACC-S1-035-2026) Synergistic effects of stress, temperature, and erosion on damage evolution and strength degradation in oxide/oxide ceramic matrix composites

F. Mirza*[1]; G. N. Morscher[1]

1. University of Akron College of Engineering and Polymer Science, USA

Oxide/Oxide ceramic matrix composites (Ox/Ox CMCs) are promising candidates for structural use in high-temperature environments owing to their oxidation resistance and damage tolerance. This study presents a comprehensive investigation of their degrada-tion under combined thermo-mechanical and erosive conditions. Experiments were conducted at temperatures up to 1200 °C and particle velocities of 200 m/s, using both single- and double-sided erosion impacts to examine the role of damage distribution. Surface damage morphology were characterized by optical microscopy, while post-exposure tensile testing quantified remaining strength of composites. Results revealed a linear increase in cumulative mass loss, with higher erosion rates observed under applied stress compared to erosion-only impacts. However, applied stress exerted minimal influence on remaining strength, showing erosion as the dominant degradation mechanism. Double-sided impacts produced more uniform damage morphologies, mitigating eccentricity effects and slightly enhancing net-section stress. Overall, the results high-light the combined influence of stress, temperature, and erosion in Ox/Ox CMCs, with erosion impact alone dictating long-term dura-bility under demanding service conditions.

1:50 PM

(ICACC-S1-036-2026) Sintering-induced defect control and mechanical performance in additively manufactured silica and porcelain lattices

J. Kim*[1]; K. Trinh[1]; S. Chen[1]; A. Charrue[2]; P. Belleville[2]; K. Lee[1]

1. Los Alamos National Laboratory, USA
2. CEA, France

Additive manufacturing (AM) enables precise control of complex ceramic architectures; however, sintering-induced defects such as cracking and delamination remain a challenge, especially in silica-based ceramics due to their high shrinkage rate. First, we focus on optimizing debinding and sintering strategies to reduce such defects and improve dimensional stability in silica system. Various lattice geometries, including simple cubic (SC), body-centered cubic (BCC), and gyroid (G), were fabricated via direct light processing. Processing parameters such as ramp rate, hold time, and atmosphere were varied to assess their effects on densification and microstructure. Optimized profiles enhanced density uniformity and reduced defect formation for silica lattices. The second part extends this framework to porcelain lattices to examine how geometry influences mechanical performance and establish qualification processes. Porcelain lattices produced using the same AM approach were tested at different volume fractions and unit cell sizes to evaluate their mechanical performance. Gyroid and SC structures at 20–25 vol% achieved the best balance of stiffness, strength, and weight. Process optimization improved both compressive strength and damage tolerance, while porcelain's fracture resistance provided superior mechanical reliability compared to silica lattices.

S1- Role of fibers, matrices, coatings, and interfaces in mechanical behavior

Room: Coquina E
Session Chairs: Nico Langhof, University of Bayreuth; Ralf Goller, University of Applied Sciences

2:10 PM

(ICACC-S1-037-2026) Defining weakness: How to determine the suitability of weak matrix systems for ceramic matrix composites without using fibers (Invited)

G. Puchas*[1]; L. Wagner[1]; F. Lindner[1]; S. Schafföner[2]

1. University of Bayreuth, Ceramic Materials Engineering, Germany
2. University of Bayreuth, Chair of Ceramic Materials Engineering, Germany

Oxide fiber composites (OFCs) predominately use a weak, i.e. highly porous, matrix to ensure a damage tolerant fracture behavior. They exhibit an excellent thermomechanical behavior at high temperatures as well as a lightweight construction potential. In most cases, new matrices are not developed separately, but directly during the OFC development. While this allows the OFC properties to be assessed directly, it most likely leads to several iteration loops with cost-intensive fibers. Additionally, the number of influencing parameters multiplies, which in turn increases the number of necessary iteration loops. We've investigated the possibility of assessing the suitability of matrices prior to the OFC development on monolithics by determining the Young's modulus as well as the fracture energy of the matrix and classifying them in the He-Hutchinson-diagram. For our initial studies, we used a 75 wt% Al_2O_3, 25 wt%ZrO_2 matrix, which has already shown to lead to excellent OFC properties. By varying its porosity and comparing its classification in the He-Hutchinson diagram with the behavior of short fiber- as well as fabric-reinforced Nextel^{TM} 610/Al_2O_3-ZrO_2 with varying porosity, the validity of the method was evaluated. Subsequently, the method was used to investigate the suitability of several new mullite matrices.

2:40 PM

(ICACC-S1-038-2026) Development of ceramic fibres and CMCs at Fraunhofer ISC Centre HTL (Invited)

A. Rüdinger*[1]

1. Fraunhofer HTL, Ceramicfibre, Germany

The Fraunhofer ISC Center HTL develops innovative ceramic fibers and Ceramic Matrix Composites (CMCs), focusing on oxide (OCMC) and non-oxide (NoCMC) systems for industrial applications. Key highlights are the development of next-generation oxide fibers (NGO fibers) within the EU project InVECOF, cutting-edge SiBNC fibers designed for demanding industrial applications as well as their small scale production in HTL's state-of-the-art fiber pilot plant. The Fraunhofer Center HTL offers a fully integrated process chain for CMC innovations. This encompasses application oriented ceramic fiber selection and production, high-performance fiber coatings, CMC design, development and manufacturing, as well as Environmental Barrier Coatings (EBC), Thermal Barrier Coatings (TBC), final machining, and comprehensive material and component characterization. These technologies support demanding applications in oxide (Combustion aids, production aids, flame tubes, exhaust systems, nose caps, burner nozzles, thermal protection systems) and non-oxide (SiC/SiC and C/SiC) composite systems, targeting exceptional performance in high-temperature and chemically aggressive environments. This talk will showcase the Fraunhofer Center HTL's end-to-end approach to fiber and CMC innovation, demonstrating how its unique capabilities drive advancements from material design to fully functional composite components.

3:30 PM

(ICACC-S1-039-2026) Rare-earth oxide interphases for SiC/SiC ceramic matrix composites (Invited)

T. Nelson*[1]; C. Prentice[1]; O. Gavalda-Diaz[2]; A. J. Leide[3]; D. Andrews[3]; J. Ball[5]; F. W. Zok[4]

1. Archer Technicoat Ltd, United Kingdom
2. Imperial College London, United Kingdom
3. UKAEA, United Kingdom
4. University of California, USA
5. The Henry Royce Institute, United Kingdom

From initial use as environmental barrier coatings for SiC/SiC CMCs, rare-earth oxides, such as ytterbium disilicate, present an interest as interphase materials in similar ceramic composites. This work focuses on the deposition of these interphases through use of an aerosol-assisted chemical vapour infiltration technique (CVI) and subsequent testing. Of particular interest is the assessment of the materials' suitability for use in both the aerospace and nuclear industries – through steam-oxidation, irradiation, fibre push-out and tensile testing of mini-composite samples. Characterisation of the interphases, and parameters that affect the interfacial properties will be discussed in the context of specific use-cases. Future work regarding development of these interphases will also be covered, along with other applications for the technology.

4:00 PM

(ICACC-S1-040-2026) Mechanical performance of silicon carbide CMCs reinforced with laser-driven chemical vapor deposition fibers

S. Harrison*[1]; K. L. Williams[1]; G. Thompson[2]; M. Pavel[2]; S. Winckler[3]

1. Free Form Fibers, USA
2. University of Alabama, Metallurgical & Materials Engineering, USA
3. Global Composites, Inc, USA

Free Form Fibers and the University of Alabama at Tuscaloosa collaborated to examine the room temperature and elevated temperature behavior of silicon carbide (SiC)-based composites and fibers produced by laser-driven chemical vapor deposition (LCVD). 3-point and 4-point bend modulus of rupture testing was performed over a range of temperatures from 20°C to 1800°C on ceramic matrix composite coupons made with a non woven SiC veil reinforcement phase. Fracture strength and fractography data will be presented. Additional studies were performed to evaluate the oxidation behavior of the LCVD SiC fibers up to 1500°C and compared to that of Hi Nicalon-Type S.

S1- Manufacturing and testing of joined and integrated components and structures

Room: Coquina E
Session Chairs: Nico Langhof, University of Bareuth; Ralf Goller, University of Applied Sciences

4:20 PM

(ICACC-S1-041-2026) Torsion-based Identification of shear properties in bonded joints

A. Benelli*[1]; D. Paolino[2]; L. Goglio[2]

1. Politecnico di Torino, DISAT, Italy
2. Politecnico di Torino, Mechanical and Aerospace Engineering, Italy

In the study, we present a torsion based experimental-analytical framework to identify the shear response of bonded joints. The aim is a single model that represents fully elastic responses typical of ceramic joints as well as the wide plastic region exhibited by polymer-based adhesives and in glass-ceramic joints at elevated temperature. Specimens are loaded in torsion, which produces an almost pure shear state, unlike single lap tests with complex, non-uniform stresses. Piecewise linear shear laws are fitted to torque – rotation curves through an efficient parameter estimation routine to recover shear modulus, yield onset, hardening/softening moduli, and ultimate shear strength. A MATLAB script fits the model to the measured torque rotation curve by minimizing the model – data discrepancy; the number of segments (up to six) can be selected by the user to capture the shear response. For an n-segment law, 2n–1 parameters are identified. We validate the approach on a polymeric adhesive to prove its ability to capture extensive plasticity. The resulting torsion-based workflow represents a practical alternative to standard shear tests and a basis for a unified characterization of bonded joints in shear.

4:40 PM

(ICACC-S1-042-2026) Joining techniques for advanced ceramics and composites

J. Alexander*[1]; J. Binner[2]

1. University of Birmingham, United Kingdom
2. University of Birmingham, Ceramic Science & Engineering, United Kingdom

Large / complex ceramic component fabrication is challenging, hence joining multiple smaller parts provides a cost-effective approach for creating these. Joining of ceramics is also a stepping stone in the repair process. This is of high interest since the fabrication of advanced ceramic materials is costly both financially and energetically, and therefore would enable the repair of monolithic and composite parts that fall out of specification during manufacture, and the extension of service life of damaged components. However, challenges exist when trying to produce joints which yield mechanical properties sufficient for use in challenging environments, such as high temperatures. The current work explores some joining methods and assesses their physical and mechanical properties.

S3 23rd Intl Symp on Solid Oxide Cells Materials Science & Technology

S3-Operation and electrochemical characterization

Room: Coquina H
Session Chair: Harry Abernathy, National Energy Technology Laboratory

1:30 PM

(ICACC-S3-033-2026) Modeling and validation of high-temperature oxygen electrode reactions in SOCs (Invited)

T. Kawada*[1]; M. Sakai[1]; S. Endo[1]; M. Yamaguchi[1]; K. Yashiro[1]

1. Tohoku University, Graduate School of Environmental Studies, Japan

The oxygen electrode reactions in mixed conducting electrodes, $La_{0.6}Sr_{0.4}CoO_{3-\delta}$ and $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$, were modeled using nonlinear tranmission line circuits. The model consists of two tranportation lines for oxide ions and electrons. They are interconnected throughout the electrode thickness by a local chemical capacitance and a local surface exchange resistance. The valules of each resistor and capacitor depend nonlinearly on the local oxygen potential. Gas diffusion resistance in the porous electrode is integrated when necessary. The dc and ac responses of the model was calculated by using a general-purpose circuit simulator, SPICE, to handle the nonlinear circuit elements. The local surface exchange current through the surface exchange resistance was expressed as $j_s=j_{s,0}\delta\ (a_{O,s}{}^2-p_{O2,g})$, considering the experimental evidence for dense film and micro/nano-porous electrodes. Validation of the model calculation was made by measuring dc current vs. voltage relationships, linear impedances, and nonlinear higher harmonic responses. A reasonable, though not perfect, agreement was obtained between the model calculations and the experimental results. The model was applied to an anode-supported single cell to explore measures for imporoving its capability of reduced/variable temperature operation in a project conducted by F-REI.

2:00 PM

(ICACC-S3-034-2026) Pattern recognition in electrochemical impedance spectroscopy measurements for facilitated characterization (Invited)

C. F. Mänken*[1]; D. Schäfer[1]; R. C. Samsun[1]; R. A. Eichel[1]

1. Forschungszentrum Julich GmbH, Institute of Energy Technologies, Fundamental Electrochemistry (IET-1), Germany

Over 2600 electrochemical impedance spectroscopy (EIS) measurements, conducted on 15 solid oxide cell (SOC) stacks, subjected to varying operational modes and conditions, were consolidated. A specifically developed curation procedure was applied to compensate for recurrent instabilities and parasitic inductive impedances. Dominant patterns, referred to as eigenspectra, providing a low-dimensional representation of every EIS measurement could be identified by singular value decomposition of the EIS dataset. These are shown to be particularly suitable for the training of data-driven models and for the identification of deviations from expected behavior. For instance, an emerging leakage on one specific stack layer. Furthermore, the eigenspectra can be used as a reconstruction basis U_r in which every EIS measurement in the data set corresponds to a unique r-dimensional representation. One application is the usage as a filter to compensate for process-related noise during EIS by calculating the corresponding reconstruction of such an EIS measurement. The most significant advantage is that identifying tailored frequencies f^* from the eigenspectra enables the reconstruction of complete EIS spectra from sparse measurements. As exemplified with experimental data, the measurement of $|f^*|=3...6$ is sufficient for accurate reconstructions, thus facilitating the characterization.

2:30 PM

(ICACC-S3-035-2026) Effect of operating mode on patterned Ni–GDC electrodes in solid oxide cells

G. Yao*[1]; A. Sciazko[1]; Y. Komatsu[1]; T. Okabe[1]; K. Nishimura[1]; Z. Lyu[1]; J. Tao[1]; N. Shikazono[1]

1. The University of Tokyo, Institute of Industrial Science, Japan

The large-scale application of solid oxide cells (SOCs) is limited by electrode degradation. In the fuel electrode, Ni migration and agglomeration have been recognized as key degradation mechanisms. In addition, gadolinium doped ceria (GDC), which is widely used as a mixed ionic electronic conductor (MIEC) in fuel electrodes, is known to migrate and redistribute under both fuel cell (FC) and electrolysis (EC) modes. The interaction between Ni and GDC further complicates the degradation phenomenon, and the underlying mechanisms remain insufficiently understood. In this study, two-dimensional patterned Ni–GDC electrode cells were fabricated. Operando and ex-situ observations were conducted under different operating modes. Specifically, compared with EC-only cells (operated solely in EC mode), FC–EC cells (pretreated under FC before EC operation) maintained stable current density with enhanced Ni–GDC interfacial adhesion. Scanning electron microscopy (SEM) analysis further revealed surface modification of GDC after FC pretreatment, which was not observed in EC-only cells. These findings demonstrate the effect of operating mode on Ni–GDC interaction. By suppressing interfacial degradation, FC pretreatment provides an effective strategy to enhance the long-term durability of Ni-GDC electrodes.

2:50 PM

(ICACC-S3-036-2026) Thickness dependence of area specific resistance of composite air electrode

M. Kusnezoff*[1]; N. Trofimenko[1]; S. Mosch[1]

1. Fraunhofer IKTS, Germany

Systematic study on influence of thickness of area specific of composite LSM82/8YSZ air electrode shows considerable increase of polarization resistance decreasing the electrode thickness ≤10 µm. The observed effect can be explained using Transmission Line Model (TLM) applied to the composite electrode and considering the 8YSZ network as ionic conducting matrix and LSM82 surface as electrochemically active area for oxygen surface exchange. The estimated values of oxygen exchange coefficient and oxygen vacancies concentration in LSM82 from fitting the impedance spectra are higher than it can be expected from LSM82 material data showing activation of LSM82 by interaction with 8YSZ during the sintering.

S3-Simulation & Modeling

Room: Coquina H
Session Chair: Sandrine Ricote, Colorado School of Mines

3:30 PM

(ICACC-S3-037-2026) Characterization and modelling of solid oxide cells: An overview of ongoing activities at CEA-Grenoble (Invited)

M. Hubert[1]; D. Cademartori[1]; S. Fournier[1]; G. Tambade[1]; K. Saravanabavan[1]; C. Hartmann[1]; J. Laurencin*[1]

1. CEA, DTCH, France

Solid Oxide Cells (SOCs) have attracted increasing attention as they can offer high electrical efficiency due to their high operating temperature. Their porous electrodes have an intricate and fine microstructure that plays a key role in performance. However, due to various degradation phenomena activated at high temperatures under polarization, the SOCs are still subjected to various material and mechanical instabilities limiting their durability. To date, the basic degradation mechanisms associated with complex electrode reaction pathways remain unclear. To unravel these intertwined phenomena, an integrated approach has been developed coupling post-test characterizations with a modelling framework. The model starts from the atomic scale and takes into account electrochemical and mechanical cell behavior. The current status of the characterization and modelling of SOC activities at CEA-Grenoble will be presented. Regarding the H_2 electrode, the methodology will be illustrated using the example of Ni migration and reoxidation in conventional nickel-yttria-stabilised zirconia cermets. For the O_2 electrode, the decomposition of classical lanthanum strontium cobalt ferrite will also be addressed under different operating conditions. Finally, investigations into infiltrated electrodes made of alternative materials (praseodymium oxide and lanthanum nickelate) will be presented.

4:00 PM

(ICACC-S3-038-2026) Using simulation to analyze solid oxide cell degradation and improve durability (Invited)

H. W. Abernathy*[1]; Y. Lei[2]; F. Xue[3]; W. K. Epting[3]; Y. Picard[2]

1. National Energy Technology Laboratory, Thermal Sciences, USA
2. US DOE National Energy Technology, USA
3. National Energy Technology Laboratory, USA

Through the US Department of Energy's Solid Oxide Fuel Cell (SOFC) and H2NEW programs, the National Energy Technology Laboratory (NETL) has developed a comprehensive solid oxide cell (SOC) multiphysics performance degradation modeling framework. The framework uses microstructurally resolved information about an SOC to simulate lifetime performance under different operating conditions (i.e., fuel cell, electrolysis, reversible operation) while subjected to selected degradation modes (e.g., coarsening, secondary phase formation, cation interdiffusion, cracking/delamination). Having exact control of the microstructural and kinetic parameters of a cell provides insight about the relative importance of different electrode features and different degradation modes. Knowing which features and degradation modes to focus on provides practical research guidance for developing fuel cells and electrolyzers that can meet commercialization metrics such as cost of electricity and levelized cost of hydrogen. The talk will review the current capabilities of NETL's modeling framework and will present case studies to improve SOC electrode design and operation.

4:30 PM

(ICACC-S3-039-2026) Machine learning–Guided design of oxygen electrodes for solid oxide electrolysis cells: Doping, interface engineering, and high-entropy strategies

G. Liu[1]; S. Yang[1]; Y. Zhong*[1]

1. Worcester Polytechnic Institute, Mechanical and Materials Engineering, USA

The performance and durability of oxygen electrodes remain key challenges in advancing SOECs. We present a machine learning–accelerated framework to systematically design and evaluate perovskite-based oxygen electrode materials through three integrated approaches. First, we investigate $LaCoO_3$-based perovskites doped with 20 elements on the A and B sites to evaluate their effects on phase stability and oxygen-ion/electronic conductivity. Machine learning models trained on high-throughput DFT and thermodynamic data identify dopants that balance stability and transport properties. Second, we develop an automated interface construction pipeline for perovskite/R-P phase heterostructures. By minimizing interfacial energy and strain using structural descriptors and thermodynamic constraints, we construct stable, coherent interfaces that enhance durability and oxygen exchange kinetics. Third, we explore high-entropy strategies by introducing multi-elemental disorder on both A and B sites of the perovskite lattice. ML-guided sampling enables efficient screening of configurationally complex compositions to predict phase stability and transport behavior under SOEC conditions. Together, these efforts demonstrate the potential of machine learning to accelerate the discovery and optimization of next-generation oxygen electrodes for SOECs.

4:50 PM

(ICACC-S3-040-2026) Modeling of void formation driven by inner oxygen pressure in solid oxide electrolysis cells

F. Xue*[2]; Y. Lei[1]; T. Cheng[2]; W. K. Epting[2]; H. W. Abernathy[3]; Y. Wen[2]

1. US DOE National Energy Technology, USA
2. National Energy Technology Laboratory, USA
3. National Energy Technology Laboratory, Thermal Sciences, USA

WITHDRAWN

Solid oxide electrolysis cells (SOECs) show void and crack formation within the yttria stabilized zirconia (YSZ) electrolyte close to the oxygen electrode, which is attributed to the inner oxygen pressure generated at high current densities. This work develops a modeling framework for void nucleation, growth, and coalescence in SOECs, in which the kinetics is controlled by cation diffusion within YSZ. The inner oxygen pressure is calculated by a microstructure-based electrochemical model incorporating electron and oxygen ion conduction, along with Butler-Volmer-type chemical reactions at triple-phase boundaries and two-phase-boundaries. The model is employed to simulate void formation and coalescence in lanthanum strontium cobalt ferrite (LSCF)-based SOECs under various cell voltages and operating temperatures. Distinct void distributions are observed at moderate and high cell voltages. Parametric simulations are performed to study the effect of the ionic conductivity of the interdiffusion layer (IDL) between YSZ and the gadolinium-doped ceria (GDC) barrier layer. The IDL forms during the thermal processing of the SOECs and can contain a blend of compositions and grain structures with the ionic conductivity different from the neighboring layers. It is demonstrated that reduced ionic conductivity of the IDL results in void formation with a distance to the GDC barrier layer.

5:10 PM

(ICACC-S3-041-2026) A phase-field model on Ni redistribution in the hydrogen electrode of solid oxide cells through surface diffusion of Ni(OH) and NiH *WITHDRAWN*

Y. Lei*[1]; Y. Mantz[2]; W. Saidi[1]; W. K. Epting[1]; H. W. Abernathy[3]; Y. Wen[1]

1. National Energy Technology Laboratory, USA
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3. National Energy Technology Laboratory, Thermal Sciences, USA

Ni redistribution is an important degradation mode in the hydrogen/steam electrode of solid oxide cells. With multiple pathways being proposed in the literature, there is still no consensus on the underlying mechanism. NETL has developed a phase-field model to simulate the Ni redistribution driven by surface diffusion of Ni(OH) and NiH. Using the surface coverage and diffusivity of each species calculated from density functional theory and kinetic Monte Carlo simulations on the Ni (111) surface, we simulated the Ni redistribution under different operating conditions in both fuel cell and electrolysis modes. Despite that the diffusivities of Ni(OH) and NiH are smaller than the self-diffusivity of Ni on the Ni surface, these species can still cause directional Ni redistribution during operations, with Ni(OH) driving Ni down steam partial pressure gradients and NiH driving Ni up steam partial pressure gradients. The simulated degree of Ni redistribution was compared to existing literature reports to understand the kinetics of Ni redistribution.

5:30 PM

(ICACC-S3-042-2026) d-Buffer unleashed: Orbital-level electronic modulation decoupling Ce 4f and O 2p states in protonic ceramics

S. Chen*[1]; Q. Li[1]; Y. Mei[2]; H. Tian[1]; X. Li[3]; K. An[4]; Y. Chen[4]; D. Yu[4]; F. Li[2]; W. Li[3]; X. Liu[5]

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4. Oak Ridge National Laboratory, USA
5. West Virginia University, Mechanical & Aerospace Engineering, USA

Protonic ceramic membranes (PCMs) are critical to hydrogen separation and energy conversion, yet their performance is hindered by rapid degradation under CO_2- and H_2O-rich atmospheres. Here, we propose and validate the d-Orbital Buffering Mechanism, in which Nb and Hf co-doping modulates the local electronic structure to suppress detrimental gas interactions. Guided by this principle, we successfully synthesized pure-phase $BaNb_{0.05}Hf_xCe_{0.7-x}Yb_{0.25}O_{3-\delta}$ (BNHCYbx, x=0.1, 0.2, 0.3), achieving orthorhombic–cubic phase transition control and favorable sintering dynamics. Structural and electronic analyses reveal that the enhanced stability arises from optimized atomic packing and electron delocalization, which mitigate lattice distortion and CO_2/H_2O-induced destabilization. Electrochemical characterization demonstrates that BNHCYb0.1 and BNHCYb0.2 deliver superior conductivity (1.28×10^{-2} and 1.39×10^{-2} S cm^{-1} at 600 °C) and long-term durability compared to conventional $BaZr_{0.8}Y_{0.2}O_{3-\delta}$ (BZY20) under harsh conditions. Beyond a material design strategy, the d-Orbital Buffering Mechanism establishes a robust theoretical paradigm that elucidates previously unexplained intrinsic phenomena in protonic ceramics, providing a deeper mechanistic understanding of their stability and performance.

S5 Next-Generation Bioceramics and Biocomposites

S5- Bioactive, resorbable and porous bioceramics and composites

Room: Flagler A
Session Chairs: Cristina Balagna, Politecnico di Torino; Hui-Suk Yun, Korea Institute of Materials Science

1:30 PM

(ICACC-S5-001-2026) Exploring the potential of bioactive glasses in hard and soft tissue regeneration (Invited)

V. Cannillo*[1]

1. Universita degli Studi di Modena e Reggio Emilia, Italy

Bioactive glasses (BGs) have seen growing use in biomedical applications, demonstrating remarkable potential for the regeneration of both hard and soft tissues. While their use in hard tissue repair is well established, recent studies have highlighted their promising role in soft tissues, including the healing of chronic wounds. The first BG, 45S5, was developed by Hench. Since then, research efforts have focused on creating new formulations aimed at two main goals: (i) enhancing bioactivity beyond that of 45S5 and (ii) reducing its tendency to crystallize during processing, which can compromise material performance. Incorporating specific ions—such as silver, copper, magnesium, strontium, and zinc—has been shown to improve biological responses, earning these elements the designation of "therapeutic ions". This presentation will introduce several recently developed BGs that incorporate therapeutic ions. These novel glasses not only outperform 45S5 in terms of biological response but also feature significantly higher crystallization temperatures and broader processing windows. Thus, fully amorphous materials can be achieved even after thermal treatments. This makes the new BGs suitable for a wide range of applications, including granules, 3D scaffolds, composite systems, wound dressings, dental putties, and coatings.

2:00 PM

(ICACC-S5-002-2026) Development of bioactive apatite nuclei-incorporated polyetheretherketone with high apatite-forming ability and bone-bonding ability (Invited)

T. Yabutsuka*[1]

1. Kyoto University, Graduate School of Energy Science, Japan

When the pH of a simulated body fluid (SBF) with an inorganic ion concentration similar to that of human plasma increases, the SBF becomes more supersaturated with calcium phosphate and calcium phosphate particles (apatite nuclei) are deposited in the SBF. The author applied this phenomenon and found that apatite nuclei can be precipitated in the pores of a substrate material that has previously formed pores on its surface, thereby imparting a high apatite formation ability to a wide variety of materials such as metallic, ceramic, and polymeric biomedical materials. For example, the author applied the above treatment to polyetheretherketone (PEEK), which is used as an intervertebral body spacer, and carbon fiber-reinforced PEEK (CFR-PEEK), achieving high apatite-forming ability in initially bioinert biomedical polymers. In the above material group, apatite formation was induced in the pores and on the surfaces of the SBF within one day. Furthermore, bioactive PEEK and bioactive CFR-PEEK obtained by this method exhibited significantly higher bone-bonding ability than untreated PEEK and untreated CFR-PEEK when implanted in rabbit tibia. These findings suggest that bioactive treatments using this method can be applied to bioinert biomedical materials, for which achieving bioactivity is challenging.

2:30 PM

(ICACC-S5-003-2026) Machine learning guided biomimetic, biohybrid and bioactive biomaterials (Invited)

C. Tamerler*[1]

1. University of Kansas, Mechanical Eng & BioEngineering, USA

Molecular recognition by proteins plays a critical role in biological processes including biomineralization. Inspired by biological processes, our group has been exploring peptides as key molecular building blocks mimicking molecular recognition to guide interfacial interactions in biomaterials design. We incorporated machine learning (ML) methods to capture distinct peptide functionalities as elements of critical modular building blocks. As a heuristic method, we discover the rules distinguishing different functional outcomes and enrich the search domains. Resulting functional domains are utilized as modular systems intrinsically demonstrating different properties ranging from mineralization to desired bioactive functions. Identifying materials selective peptides, their characterization, and iterative design with enhanced properties will be discussed by providing specific examples on biohybrid biomaterials designed by our group incorporating antimicrobial and remineralization among other functions. The combined complexity and prevalence of diseases relates to oral and overall health requires well engineered and effective interventions to optimize patient outcomes. Our particular focus will be provided towards exploring biomimetic approaches that can impart the key biological activity toward prevention of diseases to restoring oral and overall health.

3:20 PM

(ICACC-S5-004-2026) Modelling bone regeneration by ceramic design (Invited)

K. Balazsi[1]; B. Almássy[1]; C. Balazsi*[1]

1. HUN-REN Energiatudomanyi Kutatokozpont, Hungary

Several types of biomaterials have been used for total hip replacements (THRs) in orthopaedic surgery since the 20th century. Metallic materials, such as stainless steel, cobalt-chromium, titanium and titanium alloys have been widely used due to their excellent mechanical strength. Stainless steel was replaced soon by the reason of poor biocompatibility and corrosion in the body. Nowadays, Si_3N_4 is a new bioceramic for total hip replacements with extremely good mechanical properties. Hydroxyapatite (HA) is a widely used bioceramic in implantology considering its high bioactivity. A biodegradable and bioactive coating (e. g. HA) on the bioinert ceramic implant's surface (e. g. Si_3N_4) could induce tissue reactions and help avoid the rejection from the body in the critical early few days after the operation. In this presentation, different preparation of ceramic biomaterials will be showed from traditional technologies to novel applications. The main trends of the modern biomaterial science and technology, as well as the fundamental scientific problems will be discussed.

3:50 PM

(ICACC-S5-005-2026) 3D printing of borosilicate bioactive glass: From glass preparation to porous scaffolds for bone tissue engineering

M. E. Pianou*[1]; G. Goretti[2]; N. Olivera Jurjo[3]; A. Schiavi[1]; E. Vernè[1]; M. Schwentenwein[2]; P. Vena[3]; F. Baino[1]

1. Politecnico di Torino, Italy
2. Lithoz GmbH, Austria
3. Politecnico di Milano, Italy

Because of their biocompatibility, good thermal properties, and bioactivity, borosilicate glasses are good options for bone tissue engineering (BTE). In this work, we examine the connection between the mechanical and structural performance of 3D-printed porous scaffolds and the properties of the parent borosilicate glass 1393B20 ($SiO2-B_2O_3-P_2O_5-Na_2O-K_2O-CaO-MgO$ system). Differential scanning calorimetry (DSC) and hot-stage microscopy (HSM) were used to identify characteristic temperatures and see the thermal behavior. To optimize scaffold fabrication, avoid crystallization, and ensure densification, it is important to comprehend these factors. After Vat photopolymerization, scaffolds were thermally processed at specific sintering temperatures. Compressive tests were done to evaluate the mechanical properties, and permeability was evaluated to determine suitability for tissue ingrowth. A detailed analysis examined the relationship between scaffold performance/porosity and the sintering/thermal behavior of the glass. These findings provide information for creating borosilicate glass scaffolds with optimal qualities for BTE applications by showing how adjusting the thermal profile affects scaffold architecture, permeability, and load-bearing capacity. Our work helps bridge the gap between regenerative medicine performance and material processing parameters.

4:10 PM

(ICACC-S5-006-2026) Enhancing 45S5 bioactive glass scaffolds with silicon nitride and graphene oxide coatings for mechanical and biological performance

C. Bagci*[1]; F. E. Bastan[2]; A. R. Boccaccini[3]

1. Hitit University, Department of Metallurgical and Materials Engineering, Turkey
2. Sakarya Universitesi, Metallurgical and Materials Engineering, Turkey
3. University of Erlangen-Nuremberg, Institute of Biomaterials, Germany

Since the use of bioactive glasses as biomaterials offers advantages over metals and oxides, ongoing studies aim to further improve their biocompatibility and mechanical properties. Silicon nitride exhibits excellent mechanical and bioactive performance, including antibacterial effects and osseointegration. Silicon nitride (SN) was used both as a reinforcement and a coating material for bioactive glass scaffolds. Initially, pure 45S5 bioactive glass (BG), and BG substituted with SN, were fabricated into scaffolds. These scaffolds were then coated with graphene oxide (GO). Additionally, pure BG scaffolds were coated with nano-SN powders and chitosan (Cht) via electrophoretic deposition (EPD). Four different coated sample types were subjected to in vivo testing and MG-63 cell culture assays. The samples were further characterized in terms of morphology, mechanical properties, degradation, and dissolution behavior using FTIR, XRD, and SEM analyses. Mechanical test results showed a slight increase in compressive strength for the BG+GO, BG+Cht, and BG+SN scaffolds. However, in the case of the BG composite coated with GO, the compressive strength decreased. Cell viability results indicated that the number of cells on the surface of BG-SN scaffolds was comparable to the control, while all other samples exhibited higher cell counts than the control.

4:30 PM

(ICACC-S5-007-2026) Advanced direct ink writing of polymer-derived hardystonite-based bioceramics

V. Diamanti*[1]; H. Elsayed[1]; E. Bernardo[1]

1. Universita degli Studi di Padova, Industrial Engineering, Italy

Solid solution of hardystonite ($Ca_2ZnSi_2O_7$) bioceramics are very attractive for the excellent trade-off between biological response and mechanical properties. The additive manufacturing of these systems is supported by novel formulations, enabling a highly homogeneous distribution of oxide additives within a silica-yielding matrix, in turn favouring the phase purity after firing at 1000-1200°C, in air. Blends of silicone polymer and photocurable acrylates are added with aqueous suspensions of ZnO nanoparticles and/or solutions of Ca,Mg and B compounds, in emulsion (with the help of surfactants). These mixtures configure pseudoplastic pastes, extruded to form highly porous lattices and stabilized by UV curing. The Zn/Mg ratio, in formulations yielding $Ca_2Zn_xMg_{1-x}Si_2O_7$ bioceramics, has a complex impact on the UV absorption and microstructural development, stimulated by the water vapour evolution upon heating. Lattices, in fact, combine both porosity from printing and porosity within the struts, which may change from 'spongy' to 'tubular'.

Boron inclusion (from the dissolution of boric acid in the aqueous phase), on the other side, has a dramatic impact on the firing temperature, enabling the achivement of $Ca_2Zn_{1-y}B_{2y}Si_{2-y}O_7$ ceramics at only 1000°C. Overall, the results achieved support the suitability of polymer-derived hardystonite-based bioceramics as advanced biomaterials for regenerative applications.

4:50 PM

(ICACC-S5-008-2026) Advancing bone regeneration: Biodegradable and biocompatible geopolymer scaffolds

G. Dal Poggetto*[1]

1. NC State University, USA

Bone Tissue Engineering (TE) combines biology, materials science, and engineering to overcome limits of conventional bone repair. Its aim is to create biomimetic solutions that restore function and promote regeneration. Central to TE are scaffolds, 3D frameworks mimicking the extracellular matrix to support cell adhesion, proliferation, differentiation, vascularization, and integration. Current scaffolds face drawbacks: metals provide strength but lack bioactivity; polymers aid regeneration but are weak; ceramics are bioactive yet brittle. These issues restrict clinical use. Research thus seeks materials replicating bone's structure and mechanics while enhancing regeneration. Knowledge gaps remain in scaffold–microenvironment interactions and in designing patient-specific scaffolds for complex defects. Geopolymers, alkali-bonded aluminosilicate materials, emerge as promising alternatives. Their silicate-rich chemistry and tunable porosity support vascularization and integration. Our results show biodegradability, fibroblast compatibility, and mechanical strength comparable to cortical bone, positioning geopolymers as strong candidates. Challenges remain, ptimizing degradation, improving bioactivity, and scaling production, but addressing these can establish geopolymer scaffolds as next-generation solutions for musculoskeletal repair.

5:10 PM

(ICACC-S5-009-2026) 3D printed functionalized Calcium Phosphate ceramics and composites with natural medicine for bone healing (Invited)

S. Bose*[1]

1. Washington State University, School of Mechanical and Materials Engineering, USA

Additively manufactured (AM) or 3D printed (3DP) biomedical devices are revolutionizing treatment options by enabling patient-specific geometries and chemistry with optimized mechanical performance. Calcium Phosphate (CaP) scaffolds for bone grafts and coatings are used in orthopedic and dental devices. Establishing process property relationships for different AM or 3DP techniques is vital to successfully implementing these manufacturing practices in biomedical devices based on clinical needs. Not only the dopant chemistry of different oxide ceramics, such as MgO, ZnO, SiO_2, in CaP but also the use of natural medicinal compounds (NMCs), e.g., Turmeric (Curcumin), Ginger (Gingerol), Garlic (Allicin), Oregano (Carvacrol/thymol), have shown better osseointegration using both CaP-coated Ti and 3DP CaP scaffolds with improved interfacial mechanical properties both in vitro and in vivo studies in rat and rabbit distal femoral defect models. This integrated strategy enables the design of next-generation orthopedic and dental implants with improved biological performance, structural integrity, and long-term reliability. The presentation will discuss the design of next-generation implants tailored to meet clinical needs in treating bone disorders.

S6 Advanced Materials and Technologies for Rechargeable Energy Storage

S6- Negative Electrode Materials and Ordered and Disordered Oxide-based Electrode Materials II

Room: Coquina G
Session Chairs: Nicola Pinna, Humboldt-Universität zu Berlin; Seongjae Ko, Tokyo Daigaku

1:30 PM

(ICACC-S6-024-2026) Disordered versus ordered niobates as electrode materials for rechargeable batteries (Invited)

N. Pinna*[1]

1. Humboldt-Universität zu Berlin, Department of Chemistry, Germany

A well-ordered structure with high crystallinity is crucial in various applications, particularly in electrode materials for batteries. The dimensionality and connectivity of the interstitial sites, determined by the crystal structure, inherently influence alkali ions diffusion kinetics. Niobium-based oxides structures are built by the assembly of ReO_3-type blocks of specific sizes with metal sites having well defined positions within the crystalline structure. Structural disorder generally disrupts the regular pathways for ion and electron transport, leading to a lower overall conductivity. Here, we report a new anomalous disordered niobium tungsten oxide structure that significantly enhances the Li-ion storage performance compared to the ordered phase. The disordered tetragonal phase consists of corner-shared NbO_6 octahedra blocks of varied sizes, including [5x4], [4x4], and [4x3], with a disordered arrangement of the tungsten tetrahedra at the corners of the blocks, together with strong distortion of the WO_4 tetrahedra. This structural arrangement is found to be extremely robust during lithiation/delithiation, with a homeostatic local structure evolution during cycling, as determined by operando X-ray diffraction and X-ray absorption spectroscopy. This study highlights the benefits of introducing disorder into niobium tungsten oxide shear structures.

2:00 PM

(ICACC-S6-025-2026) Stable Li plating/stripping in $LiPF_6$ ether-based electrolytes (Invited)

P. R. Harks[1]; S. Ko*[1]; W. Zhao[1]; N. Takenaka[1]; Z. Fang[1]; Y. Hao[1]; A. Yamada[1]

1. Tokyo Daigaku, Chemical System Engineering, Japan

The commercialization of Li-metal batteries has been severely limited by unstable Li plating/stripping and persistent electrolyte decomposition at the Li-metal surface. To address these challenges, electrolytes combining ether solvents and imide salts have been extensively investigated, as they promote the formation of a stable solid electrolyte interphase (SEI). Nevertheless, the intrinsic drawbacks of imide salts, high cost, corrosive behavior, and low oxidative stability, hinder their practical use in Li-metal batteries. Here, we revisit $LiPF_6$, the conventional salt used in modern Li-ion batteries, as an alternative approach to overcome the long-standing challenges of Li-metal anodes. (1) Computational analyses reveal that molecular modifications, including methyl substitution and large cyclic ether frameworks, suppress the intrinsic chemical instability (polymerization) of $LiPF_6$/ether electrolytes. (2) The optimized electrolytes enable the formation of a robust (LiF-rich inner/organic-rich outer) bilayer SEI. (3) Incorporating acid-scavenging separators further stabilizes the interphase. Collectively, these advances enable extremely high Coulombic efficiencies above 99.5% for Li plating/stripping, comparable to or even surpassing the performance of advanced imide-salt-based electrolytes, without relying on fluorinated solvents/diluents, high salt concentrations, or specialized additives.

2:30 PM

(ICACC-S6-026-2026) Anode-Free vs. Anode-Less: Assessing the realistic limits of anode elimination in alkali metal batteries

D. Patrun*[1]; Z. Aytuna[1]; T. Fischer[1]; S. Mathur[1]

1. Universitat zu Koln, Institute of Inorganic and Materials Chemistry, Germany

Dendrite growth and the formation of an unstable solid electrolyte interphase (SEI) remain key challenges for anode-free alkali metal batteries. A promising strategy to mitigate these issues represents the targeted surface modification of current collectors. Plasma-enhanced chemical vapor deposition (PE-CVD) offers an industrial scalable surface modification technique due to its low-temperature operation making it affordable, beside costly gas phase deposition methods, like ALD. This study leveraged the advantages of PE-CVD, namely precise thickness control and high coating homogeneity, to determine the minimal coating thickness required in anode-less desing, while competing with benchmark performances. SnO_{2-x} and carbon, serving as alkaliophilic coatings, were applied to aluminum and copper substrates and comparatively assessed for their performance in sodium and lithium metal batteries. The plating stripping behaviour was investigated using electrochemical techniques and post-cycling SEM studies. The altering of the cells was monitored by combining electrochemical impedance spectroscopy (EIS) and X-ray photoelectron spectroscopy (XPS). Our anode-free alkali metal battery designs enable the reduction of SEI growth and suppress the dendritic growth of alkali metal, a typical risk responsible for battery explosions and fires.

3:10 PM

(ICACC-S6-027-2026) Towards sustainable tribological solutions: Recycled graphite from Li-Ion batteries as low-CoF coatings

S. K. Ghosh*[1]; Z. Frank[1]; S. K. Ghosh[2]

1. University of Arkansas at Little Rock, Mechanical Engineering, USA
2. University of Arkansas at Little Rock, Chemistry, USA

The recycling of graphite from spent lithium-ion batteries represents a sustainable pathway to reduce environmental impact while enabling the development of advanced functional coatings. In this study, graphite was successfully recovered from end-of-life Li-ion battery anodes through a controlled extraction and purification process. Comprehensive characterization was performed using scanning electron microscopy (SEM), transmission electron microscopy (TEM), X-ray diffraction (XRD), and Raman spectroscopy to assess the structural integrity, crystallinity, and defect evolution of the recycled graphite. SEM and TEM analyses confirmed the preservation of layered morphology with minimal structural degradation, while XRD results demonstrated high crystallinity comparable to commercial graphite. Raman spectroscopy further revealed a balanced D-to-G band ratio, indicating the presence of minor defects without compromising graphitic order. The recovered graphite was subsequently utilized for the development of low-coefficient-of-friction (CoF) coatings, demonstrating favorable tribological performance. These results validate the feasibility of recycling Li-ion battery graphite as a cost-effective and environmentally sustainable feedstock for advanced coating applications.

3:30 PM

(ICACC-S6-028-2026) Dual carbon layered silicon composite anode materials for high energy density batteries by optimizing experimental and rational electrode design

J. Lee*[3]; S. Hwang[1]; H. Cho[1]; S. Bae[1]; H. Kim[1]; S. Lee[1]; Y. Woo[2]; H. Lee[2]; Y. Kim[3]

1. LEMON ENERGY Inc., Republic of Korea
2. National Institute for Mathematical Sciences, Republic of Korea
3. Inha University, Materials Science and Engineering, Republic of Korea

Silicon (Si) is an anticipated battery material thanks to its amazing capacity potential compared to the current graphite anode. However, the explosive volume changes during the lithiation and delithiation process results in structural collapse of composites, loss of conductive contacts, growth of solid-electrolyte interface, which cause a severely decreased capacity over cycles. We introduced robust carbon framework, called double carbon coating layers, to encapsulate the Si and the pores that provide a buffer for its expansion and reduce the stress to maintain integrity. Double layer shows less electrode expansion and electrical impedance changes, higher columbic efficiency and capacity retention, however, single carbon coating layer has the advantage of high initial capacity and initial columbic efficiency. Incorporating graphite as a buffer can also alleviate stress on dual carbon layer composite and improves electrode density. This study has achieved high energy density anode electrode demonstrating an ICE of 95% and initial capacity 2000mAh g^{-1} according to silicon crystallinity and silicon carbon composite composition from 10% to 30%. Furthermore, it provides valuable insights into the electrode design of dual layer of Si/C composites anode materials and graphite by analyzing experimental data and computational analysis.

3:50 PM

(ICACC-S6-029-2026) Advancing the performance of Mn-rich cathodes: A novel synthesis process for improving volumetric energy densities (Invited)

A. D. Vu*[1]; J. Carter[1]; J. Kim[1]; S. Mallick[1]; M. Sultanov[2]; A. Gutierrez[2]; J. Wen[2]; Y. Ito[3]; J. R. Croy[1]

1. Argonne National Laboratory, Chemical Sciences and Engineering, USA
2. Argonne National Laboratory, USA
3. Northern Illinois University, Department of Physics, USA

Lithium- and manganese-rich (LMR) cathodes offer promising alternatives to conventional Ni- and Co-based $LiNi_xMn_yCo_{1-x-y}O_2$ (NMC) cathodes due to their high gravimetric energy density, low cost, enhanced safety, and reliance on earth-abundant manganese. While recent work has shown advances toward meeting the established challenges of LMRs (e.g., voltage fade, Mn dissolution, impedance rise), a more overlooked but highly critical barrier to practical implementation is their low electrode-level energy densities. This talk presents a comprehensive study on the performance of LMR cathodes as it relates to synthesis and optimization of Mn-rich cathode precursors and final cathode products. Various methods of precursor synthesis will be discussed in terms of the advantages and disadvantages of each in the production of LMR cathodes. In light of these results, we will introduce a novel synthesis process that provides a path for low-porosity LMR particles to achieve high electrode-level packing/energy densities. These particles are shown to enable electrode-level porosities as low as ~30% with high mechanical stability and excellent electrochemical performance. Technoeconomic modeling reveals that cells utilizing these advanced LMR cathode-electrodes can achieve ~280 Wh/kg (>500 Wh/L) in large pouch cells at cost of <$80/kWh.

4:20 PM

(ICACC-S6-030-2026) Rapid formation of cation-disordered rocksalt type lithium-rich cathodes from layered type cathodes by laser irradiation process

F. Sato*[1]; K. Maki[1]; T. Honma[1]

1. Nagaoka Univeristy of Technology, Department of Materials Science and Bioengineering, Japan

Cation-disordered rocksalt type (DRX) lithium-rich cathodes are expected for lithium-ion batteries that have a high energy density and a high operating voltage. Conventionally, DRX structures are formed by applying prolonged mechanical energy, such as ball milling for a long time, to layered type oxides to induce disorder in the cation distribution. However, alternative rapid formation processes are required to accelerate the research progress of DRX cathodes. In this study, we focused on a laser irradiation process that can instantaneously supply thermal energy. Laser irradiation of samples containing transition metals that absorb light in the near-infrared region generates super thermal field at the irradiation

site, leading to melting and structural transformations. Layered type $Li_{1.2}Ni_{0.13}Co_{0.13}Mn_{0.54}O_2$ (LNCMO) cathodes were laser irradiated with a wavelength of 1064 nm, laser power above 3 W, and a scanning speed of 100 mm/s. From the XRD pattern, the laser-irradiated samples showed suppressed layered oxide peaks and the emergence of DRX-related peaks. These results demonstrate that DRX structures derived from LNCMO can be formed within microseconds by laser irradiation. This study demonstrates that laser-induced rapid phase transformation enables high-throughput exploration and screening of advanced cathode materials.

4:40 PM

(ICACC-S6-031-2026) Next generation batteries for aerospace

D. Dornbusch*[1]; W. H. Huddleston[3]; V. Yamakov[4]; R. P. Viggiano[1]; Y. Lin[2]

1. NASA Glenn Research Center, Materials, Chemistry, and Physics Branch, USA
2. NASA Langley Research Center, Advanced Materials and Processing Branch, USA
3. HX5, LLC, USA
4. Analytical Mechanics Associates Inc, USA

Energy storage plays a critical part in the success of future NASA missions that desire batteries with higher energy density, higher power, and most critically improved safety. These performance requirements stretch beyond that of electric automobile markets as operation occurs across a range of extreme environments. One approach to improve the safety and energy may be to transition to non-volatile solid-state electrolytes (SSE) which promise many advantages over traditional flammable liquid electrolytes and may also be an enabling technology for next generation chemistries such as lithium-sulfur (Li-S). However, significant manufacturing challenges must be overcome before the adoption of such technology. Furthermore, design and development of novel cathode composites through integration of experiment and a particle dynamics model will be discussed. Optimization and development of novel systems driven by performance in extreme environments will also be discussed.

S8 20th Intl Symp on APMT for Structural & Multifunctional Materials & Systems

S8- Design, Synthesis, and Advanced Manufacturing of Functional Ceramics III

Room: Coquina B
Session Chair: Bai Cui, University of Nebraska–Lincoln

1:30 PM

(ICACC-S8-030-2026) Fabrication of dense yttrium oxyfluoride ceramics and their corrosion behavior of under plasma exposure (Invited)

K. Yoshida*[1]; S. Yamamoto[1]; Y. Tazaki[2]; Y. Shigeyoshi[2]; K. Matsukura[2]

1. Tokyo Kagaku Daigaku, Japan
2. Mitsui Mining & Smelting Co.,Ltd., Japan

Structural and coating materials with excellent plasma resistance have been strongly required for semiconductor manufacturing equipment because halogen-based plasma, which has been commonly employed in etching of silicon wafers, corrodes the inner ceramic components of the plasma etching equipment, such as the inner wall, showerhead, focus ring, and susceptor. Alumina (Al_2O_3) and yttria (Y_2O_3) have been conventionally used as parts inside the chamber of the plasma etching equipment. Present authors have paid attention to yttrium oxyfluoride (YOF, $Y_5O_4F_7$) as promising plasma-resistant ceramics applied for the ceramic components of the plasma etching equipment. Although yttrium oxyfluoride ceramics were considered to be difficult to be densified by sintering due to the decomposition and phase transition at high temperature, we have reported that dense yttrium oxyfluoride ceramics were successfully achieved by pressureless-sintering and hot-pressing, and they showed higher plasma resistance than Y_2O_3 and yttrium fluoride (YF_3). In this symposium, fabrication of dense yttrium oxyfluoride (YOF, $Y_5O_4F_7$) ceramics by pressureless-sintering and hot-pressing, and their corrosion behavior under plasma exposure will be introduced and discussed.

2:00 PM

(ICACC-S8-031-2026) Boron nitride nanomaterials: From mechanochemical synthesis to cutting edge applicaitons (Invited)

S. Mateti*[1]

1. Deakin University Faculty of Science Engineering and Built Environment, Australia

Since 2013, our group has pioneered the mechanochemical synthesis and application of boron nitride (BN) nanostructures, including nanosheets and nanotubes, establishing a foundation that has influenced both academic research and industrial adoption. Through controlled ball-milling strategies, we have achieved scalable production of high-quality BN nanosheets and tubes with tunable surface chemistry, defect density, and electronic functionality. This decade-long effort is consolidated in a monograph on BN nanomaterials and more than 60 publications, highlighting breakthroughs in gas storage, separation, and multifunctional device integration. Recent advances demonstrate how BN nanostructures can be engineered for solid-state hydrogen storage [1,2], achieving uptake capacities >10 wt% with controlled release at moderate temperatures. Beyond energy, BN's thermal stability, oxidation resistance, and neutron shielding capacity make it promising for aerospace applications, including lightweight protection and thermal management. This presentation reflects on our BN journey [3] while outlining future directions at the interface of nanomaterials, energy, and space technology.

2:30 PM

(ICACC-S8-032-2026) Sintering and dissolution properties of the MgO-BaO system

T. Do*[1]; Y. Su[1]; R. Andri[1]; N. Osawa[1]; T. Suzuki[1]; H. Suematsu[1]

1. Nagaoka University of Technology, Nuclear System Safety Engineering, Japan

Targeted alpha therapy (TAT) delivers highly energetic alpha particles directly to cancer cells, minimizing damage to surrounding healthy tissue. Actinium-225 (^{225}Ac) is a promising radioisotope for TAT due to its10-day half-life and a decay chain that releases four alpha particles. Current production relies on specialized methods, such as the alpha decay of Thorium-229, or proton irradiation of Radium–226 (^{226}Ra). These methods are limited by high cost and low supply of ^{225}Ac. This proposal explores a novel method for ^{225}Ac production by optimizing the target design for neutron irradiation of a ^{226}Ra target. A significant challenge lies in maximizing the production yield while ensuring high radiochemical purity. Due to strict regulations on handling highly radioactive materials in Japan academic settings, barium oxide (BaO) will be used as a non-radioactive surrogate for radium oxide in initial studies. This study will focus on optimizing the physical properties of the target pellet. MgO mixed with 0.36 mass% BaO will be compacted at different pressures and sintered at 1400°C under an argon atmosphere for various durations. The porosity and morphology of the MgO-BaO pellets will be analyzed to determine the optimal conditions for the target. The dissolution of BaO in an HNO_3 solution will be measured over time. The findings will provide a foundation for designing an efficient ^{226}Ra target for the production of ^{225}Ac.

2:50 PM

(ICACC-S8-033-2026) Fabrication of SiC and SiC/Ti_3SiC_2 composites by novel two-step reaction sintering

J. Yang*[1]; N. Zhang[1]

1. Xi'na Jiaotong University, China

A typical process for producing reaction bonded silicon carbide (RB-SiC) is to infiltrate liquid silicon into a porous SiC/C compact, to obtain a composite comprised of the original SiC, newly formed SiC and residual Si. There are some studies available on the reduction of the fatal influence of the residual Si, such as by using Si–Ti–$MoSi_2$ mixed powder as the infiltration liquid, or using an alternative carbon source such as boron carbide, however, none of these methods could not produce RB-SiC free from residual Si. Thus, more effort should be focused on the understanding of reaction process respect to the reaction occurrence. Recently two step reaction sintering is proposed for the MRI technique to obtain high purity ceramic, such as SiC, SiC/Ti_3SiC_2, etc.. The method is interesting both in basic phenomena and industrial application. Here, the present situation of the two step reaction sintering using Si and SiTi2 alloy will be shown and will be discussed on future direction of the RMI.

S8- Design, Synthesis, and Advanced Manufacturing of Functional Ceramics IV

Room: Coquina B

Session Chair: Thi Mai Dung Do, Nagaoka University of Technology

3:30 PM

(ICACC-S8-034-2026) Additively manufactured black-zirconia TPMS structures for high-performance solar absorption applications *WITHDRAWN*

M. Azam*[1]; A. Hamza[1]; A. Raza[1]; K. Askar[1]; T. Zhang[1]

1. Khalifa University, Department of Mechanical and Nuclear Engineering, United Arab Emirates

Additive manufacturing (AM) of ceramics allows the fabrication of high-performance components for diverse applications, including healthcare, aerospace, and energy. This work aims to investigate the microstructural, optical, and mechanical properties of an additively manufactured engineering ceramic. By utilizing cost-effective fused filament fabrication (FFF), black-colored zirconia (ZrO_2) triply periodic minimal surfaces (TPMS)-based various ceramic structures are fabricated in this study. The microstructural analysis of ZrO_2 revealed finer grains and better densification (98%), which contributed to its superior mechanical properties. Among the gyroid, diamond, and primitive topologies, the primitive demonstrated the best mechanical performance. For instance, the ZrO_2 primitive structure exhibited a compressive strength of ~89 MPa, which is 456% more than its diamond counterpart. Overall, ZrO_2 showed the average solar absorptance of ~90% in UV–vis–NIR range, independent of the topology. Our findings suggest the potential applications of complex-shaped ZrO_2 structures in high-performance components such as solar receivers.

3:50 PM

(ICACC-S8-035-2026) Process-derived fracture networks in vat photopolymerised zirconia ceramics

P. Makurunje*[1]; S. Middleburgh[1]

1. Nuclear Futures Institute, Bangor University, United Kingdom

Zirconia ceramics were fabricated using liquid resin vat photopolymerisation with digital light processing (DLP) and examined for process-induced crack profiles. Fracture networks in both dried (pre-sintered) and post-sintered ceramics were characterised by scanning electron microscopy and X-ray computed tomography to understand crack formation during drying and sintering. The analyses focused on the effects of fluid pressures and evaporation during these stages. Fracture behaviour was assessed and compared to identify the mechanisms of crack initiation and propagation in zirconia. Flexural tests further contributed to understanding crack propagation pathways. The observed crack orientations across printing layers, together with the quasi-composite fracture response, provided insights for optimising drying and sintering parameters in vat-photopolymerised, DLP-processed zirconia ceramics.

S9 Porous Ceramics Novel Developments and Applications

S9- Future approach for porous ceramics

Room: Ballroom 3

Session Chair: Farid Akhtar, Lulea University of Technology

1:30 PM

(ICACC-S9-001-2026) ALD-functionalized 3D-printed isoporous ceramic guides for microfluidics (Invited)

A. Jimenez[1]; D. Ribas Gomes[1]; C. Hedrich[2]; K. P. Furlan*[1]

1. Karlsruher Institut fur Technologie, Institute for Applied Materials - Ceramic Materials and Technologies, Germany
2. Technische Universitat Hamburg, Electron Microscopy Unit (BEEM), Germany

Nature-inspired fluid transport mechanisms is increasingly studied for applications in diverse field such as tissue engineering, microfluidics and energy conversion. In particular, surface-tension-driven flow in porous structures enables efficient liquid transport over long distances without the need for external energy input. Harnessing this concept, a novel processing route to produce functional isoporous ceramic guides is presented. This approach integrates an additive manufacturing principle - direct writing - with colloidal assembly and Atomic Layer Deposition (ALD). The printing method, referred to as Additive Manufacturing combined with Colloidal Assembly (AMCA), enables rapid printing of water-based, additive-free dispersions in various patterns onto diverse substrates. After printing, the polymeric templates undergo ALD coating with aluminium oxide or titanium dioxide followed by thermal burn-out for template removal, resulting in highly-porous ceramics. The functional structures show tunable wetting properties and fluid transport characteristics, influenced by material composition and porosity. The adaptability of the AMCA+ALD process to engineer tailored porous guides holds promise for applications in lab-on-a-chip technologies or passive cooling systems.

2:00 PM

(ICACC-S9-002-2026) Toward auxetic ceramics: 3D printing and characterization of Al_2O_3 and ZrO_2 hexachiral structures (Invited)

L. Biasetto*[1]; J. Guther[2]; A. Corsini[1]; P. Colombo[1]; T. Fey[2]

1. University of Padova, Department of Industrial Engineering, Italy
2. Friedrich-Alexander University Erlangen-Nürnberg, Department Material Science and Engineering, Germany

Auxeticity is a property observed at both the molecular and macrostructural levels and can be broadly defined as the behavior of materials and structures exhibiting a negative Poisson's ratio (i.e., they expand laterally when subjected to axial tensile loading). Auxetic behavior has, for instance, been reported in certain perovskites (e.g., titanates) at the molecular scale, where it has been exploited to enhance the piezoelectric effect. At the macrostructural level, re-entrant and chiral metallic architectures are studied to improve the impact resistance of metallic components for energy absorption applications. Their ceramic counterparts may provide valuable opportunities for sensor and actuator technologies, so as for components with tailored Coefficient of Thermal Expansion. In this work, we present our first results on extrusion-based 3D printing of Al_2O_3 and ZrO_2 commercial pellets to fabricate hexachiral auxetic structures. Using a customized G-code, we successfully 3D printed, debinded, and sintered auxetic samples, which were subsequently subjected to mechanical and microstructural characterization (μCT measurements of green and sintered samples). This study represents an initial step toward the production of ceramic auxetic materials, with potential for extension to tailored pellet compositions and the possibility of leveraging the intrinsic auxeticity of perovskites.

2:30 PM

(ICACC-S9-003-2026) Automating the future: High-throughput production of porous alumina ceramics

E. Wolf[1]; K. G. Webber[1]; T. Fey*[1]

1. Friedrich-Alexander-Universität Erlangen-Nürnberg, Materials Science and Engineering, Germany

The high-throughput (HT) method is characterized by an automated sample preparation and analysis coupled with AI-driven data evaluation. While it is already well established in the pharmaceutical and chemical fields, its application in materials science, especially in ceramics research, remains limited. Key areas in ceramics research that would greatly benefit from the use of HT processing are the analysis of phase diagrams or the evaluation of the complicated relationship between microstructure and properties in porous ceramics. We present the first step toward automated processing of porous ceramics by the sacrificial templating method, using an automatic powder dispensing robot to improve accuracy and reduce manual work. Porous alumina ceramics with varying porosities (0 - 50 vol%), pore geometries (spherical and fibrous) and pore sizes (10 – 150 μm) were successfully fabricated using different organic pore formers. Precise dosing enabled fine tuning of porosities, resulting in highly tunable mechanical properties. The microstructure was analyzed using μ-CT technique, characterizing the shape, connectivity and size of the pores. Our results highlight the significant potential of high-throughput methods in advancing porous ceramic research, offering opportunities for increased efficiency and precision in material characterization and development.

S9- Engineering Porous Architectures

Room: Ballroom 3
Session Chair: Kaline Furlan, Hamburg University of Technology

3:10 PM

(ICACC-S9-004-2026) Design and structuring of porous materials with expanded ultralow-density microspheres

F. Akhtar*[1]

1. Lulea University of Technology, Division of Materials Science, Sweden

Expanded ultralightweight hollow microspheres are gaining attention as advanced pore formers for ceramics, insulation, and construction materials, enabling the design of porous structures with tailored properties. Unlike conventional pore formers, they simplify processing, lower energy demand, reduce carbon footprint, and yield superior mechanical performance. Their integration into emerging manufacturing techniques, such as 3D printing and multimaterial granulation, demonstrates their versatility in shaping next-generation porous materials. In insulation, ultralow-density microspheres incorporated into granules and panels provide low weight, controlled heat transfer, and improved mechanical strength, making them attractive for low-carbon building solutions. In construction, microspheres offer a sustainable alternative to traditional air-entrainment technologies by enabling frost-resistant concrete with higher strength and more reliable control of frost resistance properties. This work highlights the technical advantages of processing porous ceramics to accelerate the development of sustainable, high-performance materials.

3:30 PM

(ICACC-S9-007-2026) Combination of freeze casting and gelcasting to obtain porous ceramics

I. Klösel[1]; T. Fey*[1]

1. Friedrich-Alexander University Erlangen-Nürnberg, Department Material Science and Engineering, Germany

Well-established techniques for tailoring the microstructure and enhancing the mechanical and thermal properties of porous ceramics are freeze casting and gelcasting, which offer a wide range of technological applications requiring lightweight materials with high permeability such as thermal insulation, filtration, catalysis or biomedical implants. By combining these conventional techniques, it is possible to utilise the advantages of both methods. While the freeze casting approach enables the formation of highly directional and interconnected pore structures by freezing a ceramic slurry and subsequent sublimation of the solvent, the gelcasting approach ensures mechanical strength by using a polymer gel to solidify the ceramic network prior to sintering. In this study, alumina (Al_2O_3) foams with different ceramic contents of the suspensions are prepared using the gelcasting process and agarose as gelling agent, which are then frozen and freeze-dried. The influence of the drying time of the gelled foam before freezing and the residual water content of the suspension on the porosity development is investigated. The mechanical and thermal properties as well as the microstructure are also analysed.

3:50 PM

(ICACC-S9-006-2026) Fabrication of porous ceramics via DLP-3D printing using nanoparticle suspensions and subsequent rapid thermal processing (Invited)

M. Iijima*[1]; Y. Yamanoi[1]; F. Yokomori[1]; J. Tatami[1]

1. Yokohama National University, Japan

Additive manufacturing using photocurable suspensions has gained attention as an effective strategy for fabricating porous ceramics with tailored architectures. Although numerous effective processing routes have been developed, conventional approaches often involve time-consuming post-printing steps, including drying and debinding. To address this issue, we propose applying the concept of interparticle photo-cross-linkable suspensions to nanoparticle-based formulation design. The interparticle photo-cross-linkable suspension represents a unique system wherein ceramic powders are stabilized by reactive dispersants and become photocurable via direct interparticle crosslinking facilitated by a minimal amount of acrylate monomers. Since nanoparticles can provide short interparticle distances even at low particle volume fractions, loosely packed photocured bodies can be printed utilizing interparticle photo-cross-linkable nanoparticle suspensions, and subsequently processed into highly porous structures through rapid drying and debinding without occurring structural collapse. We will demonstrate the proposed process with SiO_2 nanoparticles, and then extend its application to Al_2O_3-based system for catalyst support purposes.

S10 Integrated computational -Experimental modeling ad design of ceramics and composites

S10- Multi-scale modeling of processing, microstructure, and performance

Room: Ballroom 4
Session Chairs: Gustavo Costa, NASA Glenn Research Center; Benoit Rousseau, LTN UMR CNRS 6607

1:30 PM

(ICACC-S10-001-2026) Architecture design for thermal and environmental barrier coatings for next-generation refractory alloys (Invited)

D. L. Poerschke*[1]

1. University of Minnesota, Chemical Engineering and Materials Science, USA

Thermal and environmental barrier coatings (T/EBCs) are used to protect metal and ceramic composite structural components used in the hot section of turbine engines. Recent advances in the design of refractory alloys and composites with higher temperature capability necessitate new T/EBC materials and architectures to meet inter-related (and often competing) performance criteria. We will first discuss the application of thermo-mechanical analysis to screen candidate architecture and property space to identify viable architectures and priorities for new material development. We will then discuss progress in identifying new composite coating materials based on combinations of rare earth zirconates and aluminates that could fill property gaps. We will conclude by discussing consideration for the durability of coatings based on these materials in complex service environments, and the application of these insights to guide next-generation T/EBC design.

2:00 PM

(ICACC-S10-002-2026) Development of next-generation simulation technologies for advanced ceramic manufacturing processes (Invited)

M. Sakai*[1]

1. Tokyo Daigaku, Department of Nuclear Engineering & Management, Japan

Fine ceramics are widely used in fields such as semiconductor manufacturing equipment, vacuum devices, medical instruments, cutting tools, and electronic components. Their production relies on powder processes including grinding, mixing, and packing. In these processes, numerical simulations are expected to play a crucial role in elucidating underlying mechanisms and optimizing manufacturing conditions. However, actual ceramic manufacturing involves a vast number of solid particles, moving boundaries, and complex solid–fluid interactions, which require highly advanced computational models. To address these challenges, our group has developed advanced numerical models. Particle behavior is represented by the Discrete Element Method (DEM). In particular, we have proposed a coarse-grained DEM suitable for industrial-scale systems, a scalar-field-based boundary model for moving walls, and an implicit drag scheme that enables robust solid–fluid coupling. This presentation introduces applications of these models to fine ceramic manufacturing processes, highlighting their potential to advance both fundamental understanding and practical process optimization. This study is finanicially supported by the JSPS KAKENHI (Grant No. 24K22289) and the Social Cooperation Program for Fundamental Technologies on Powder Process Digital Twin in The University of Tokyo.

2:30 PM

(ICACC-S10-003-2026) Fronts in multiphysics modeling of fiber-reinforced ceramics preparation or degradation :An overview (Invited)

G. L. Vignoles*[1]

1. University Bordeaux, LCTS - Lab for ThermStructural Composites, France

Fiber-reinforced CMCs pose numerous physico-chemical modeling challenges, either related to their processing or to their degradation in use. The models all feature phenomena such as chemical reactions as well as transport of fluids and heat in porous media. Remarkably, in several instances, the notion of front appears. We will present and compare in this presentation the fronts occurring during (i) combustion synthesis, (ii) thermal-gradient CVI, (iii) oxidation of C/C composites and (iv) melt-infiltration of SiC/SiC composites. Numerical and analytical methods will be shown and the existence, behavior and parameter sensitivity of the fronts will be compared from one situation to another and discussed.

3:20 PM

(ICACC-S10-004-2026) Development of an advanced heat transfer model for DEM-CFD simulations

T. Imatani*[1]; M. Sakai[1]

1. Tokyo Daigaku, Department of Nuclear Engineering & Management, Japan

Gas-solid flow systems are ubiquitous in various engineering fields, including ceramics processing. The discrete element method (DEM) coupled with computational fluid dynamics (CFD) is widely used in numerical simulations to better understand the behavior of these systems. However, the DEM faces significant challenges in modeling the heat transfer. While heat conduction in the solid phase is affected by the spring constant, small spring constant value is often employed in the DEM. Therefore, complex models considering actual contact duration and area are necessary. Furthermore, existing heat transfer models show low compatibility with scaling law models such as the coarse-grained DEM. Setting a high coarse grain ratio reduces the accuracy of the heat transfer predictions. To overcome these challenges, we develop an advanced heat transfer model based on an Eulerian framework for the DEM. Namely, in the proposed model, particle motion is described by the DEM, while heat transfer is represented by an Eulerian description. Notably, the new heat transfer model depends only on the solid volume fraction and is not influenced by the contact states in the DEM. The validity of the model is demonstrated by comparing the simulation results with the experiments. In addition, the proposed model is shown to be independent of the spring constant and highly compatible with the coarse-grained DEM.

S10 - Material Informatics and machine learning

Room: Ballroom 4
Session Chair: Yu (Michael) Zhong, Worcester Polytechnic Institute

3:40 PM

(ICACC-S10-005-2026) Diffusion–model–driven discovery of ferroelectrics for photocurrent applications (Invited)

B. Yeo[2]; S. Kang[1]; J. Lee*[1]

1. Korea Institute of Science and Technology, Republic of Korea
2. Pukyong National University, Department of Energy Resources Engineering, Republic of Korea

Ferroelectric materials are vital for next-generation memory and photovoltaic technologies, yet their discovery is limited to the few known prototypes. Here, we present a design framework that integrates diffusion-model-based crystal generation with multi-fidelity screening to the discovery of ferroelectrics. Using MatterGen, we generated 12,800 candidate structures and applied a pipeline combining diverse machine-learning tools and density functional theory calculations. This process revealed two promising candidates both insulating and switchable. The calculated polarization values of two candidates are 8.9 μC/cm^2 and 144.1 μC/cm^2, respectively. The calculated polarization of 144.1 μC/cm^2 is comparable to that of Sc-doped AlN, one of the highest-polarization ferroelectrics reported to date. In addition, HSE06 calculations yield band gaps of 1.58 eV and 1.13 eV, respectively, suggesting strong potential for photocurrent applications. These findings establish new promising candidates for the ferroelectric family and demonstrate the power of generative models to uncover novel functional materials

4:10 PM

(ICACC-S10-006-2026) Data driven and physics informed machine learning for composite modelling (Invited)

Y. Chen*[1]

1. University of Bath, Mechanical Engineering, United Kingdom

Numerical modelling of composite materials is often computationally intensive, especially when microstructural complexity and multiphysics interactions are involved. In recent years, machine learning (ML) techniques have emerged as promising tools to alleviate some of these computational challenges. In this talk, I will present our recent efforts in applying ML to predict mechanical and transport behaviours in composite systems. The first part of the talk focuses on the use of the Fourier Neural Operator (FNO) to predict stress fields and microcrack patterns within composite microstructures. Training data is generated using a Fast Fourier Transform (FFT)-based solver, which efficiently captures the mechanical response across heterogeneous domains. The FNO model demonstrates strong predictive capabilities and generalisation potential, although caveats and limitations will be discussed. The second part introduces a physics-informed neural network (PINN) developed to model fluid flow in bi-porous media, which is relevant to composite manufacturing processes such as polymer infiltration and pyrolysis. By embedding governing equations directly into the learning framework, the PINN offers a data-efficient approach to simulate flow behaviour in complex porous architectures.

S13 Advanced Ceramics and Composites for Nuclear Fission and Fusion Energy Systems

S13- Overview of nuclear ceramics development

Room: Coquina F
Session Chair: Gyanender Singh, Idaho National Laboratory

1:30 PM

(ICACC-S13-035-2026) Historical and future roles of brittle matrix composites for fusion and fission energy (Invited)

Y. Katoh*[1]

1. Oak Ridge National Laboratory, USA

Coincidently, it was fifty years ago when the original development of silicon carbide (SiC) fiber via a polycarbosilane polymer precursor route was reported. Today, SiC fiber reinforced, SiC matrix (SiC/SiC) composites enabled by that invention are broadly considered for nuclear applications, including the accident-tolerant fuels for light water reactors, internal components for advanced high temperature reactors, and structural and functional components of fusion reactors. While attractiveness of these materials to those applications are based heavily upon the inherent radiation tolerance and nuclear properties of SiC, the underrecognized value of SiC/SiC composites is the fact that they opened the way, or perception, of using brittle materials to constitute nuclear components of structural functions. In this presentation, we provide a brief historical overview of SiC/SiC composites for fusion and fission applications, followed by discussion on the future roles of and opportunities for brittle matrix composites in the evolving energy landscape. This work was supported by the US Department Energy (DOE) under contact DEAC05-00OR22725 with ORNL, managed by UT Battelle, LLC.

2:00 PM

(ICACC-S13-036-2026) TRISO development at ORNL: Near-term deployment and long-term development (Invited)

G. W. Helmreich*[1]; T. J. Gerczak[1]; E. Lopez Honorato[1]; W. Cureton[1]

1. Oak Ridge National Laboratory, USA

Tristructural isotropic (TRISO) particle fuels are a mature technology with a long history of support in the United States through the Advanced Gas Reactor Fuel Development and Qualification (AGR) Program. As the AGR Program nears its conclusion, the qualification basis data which it has generated is being used to support near-term reactor deployment plans for many domestic companies. Within this exciting environment, Oak Ridge National Laboratory continues to apply decades of expertise in support of the technology. Current research thrusts include concluding the AGR program with post-irradiation examination of the industry-scale AGR-5/6/7 experiment, supporting the economics of near-term TRISO reactor deployment through innovations in particle fuels characterization and fabrication, and exploration of novel particle fuel architectures to further improve performance and expand the envelope of particle fuel reactor designs.

2:30 PM

(ICACC-S13-037-2026) Overview of UKAEA shielding material development for fusion applications (Invited)

M. T. Rigby-Bell*[3]; M. Emmanuel[3]; J. Sharp[1]; M. Hasegawa[2]; J. Wade-Zhu[3]; R. Mellor[4]; D. Jarvis[4]; D. Sandoval Ravotti[5]; E. Tarrés i Puit[5]

1. University of Birmingham, United Kingdom
2. Imperial College London, United Kingdom
3. UKAEA, Materials Division, United Kingdom
4. VSCA AS, Norway
5. Hyperion Materials & Technologies Spain SL, Spain

Compact spherical tokamaks have severely limited space for central column shielding, which is required to protect the magnets from high energy neutron radiation. Materials are required which can both moderate and capture fusion spectrum neutrons efficiently. They must be tolerant to radiation damage; compatible with high pressure coolants; have good thermal transport properties; and avoid the creation of long-lived radioisotopes. Conventional nuclear shielding materials such as B_4C, concrete and water are likely inadequate for compact spherical tokamaks. High density refractory ceramics such as tungsten carbides and borides, as well as transition metal hydrides, are potential candidates. However, their behaviour under fusion relevant conditions is poorly understood. UKAEA is collaborating with commercial fusion programmes, universities and industry partners across the world to design, develop and test novel materials to meet nuclear fusion shielding challenges. We use a combination of neutronics and nuclear inventory modelling; material and manufacturing development; and advanced characterisation techniques to predict material performance under intense neutron and gamma irradiation, exposure to corrosive interfaces and high thermal loading. We present an overview of current activities across UKAEA in neutron shielding material development for nuclear fusion applications and the key role of ceramics.

S13- Function materials for nuclear applications

Room: Coquina F
Session Chair: Max Rigby-Bell, UKAEA

3:20 PM

(ICACC-S13-038-2026) Quantifying defect-stored energy in YBCO-based fusion magnets (Invited)

A. R. Devitre*[1]; L. D. Kortman[2]; C. A. Hirst[3]

1. Massachusetts Institute of Technology, University of Tennessee Knoxville, USA
2. University of Michigan, Nuclear Engineering and Radiological Sciences, USA
3. University of Wisconsin-Madison, Department of Nuclear Engineering and Engineering Physics, USA

Over the lifetime of a fusion power plant, irradiation-induced defects will accumulate in the superconducting magnets compromising their ability to maintain plasma confinement. These defects also store potential energy within the crystalline lattice of materials, which can be released upon annealing. This phenomenon raises the question of whether the energy stored in defects may be sufficient to accelerate, or even trigger, a magnet quench? To provide an order of magnitude estimate, we used molecular dynamics simulations to generate defected YBCO supercells and conduct isothermal annealing simulations. Our results reveal that the maximum volumetric stored energy in a 4 mDPA defected single crystal of YBCO (240 J/cm^3) is 30 times greater than the experimental minimum quench energy values for YBCO tapes (8.1 J/cm^3). Our simulations also show that the amount of energy released increases as a function of annealing temperature or irradiation dose. This trend demonstrates that localized heating events in an irradiated fusion magnet have the potential to release significant amounts of defect energy. These findings underscore the critical need for experimental validation of the accumulation and release of defect stored energy, and highlight the importance of incorporating this contribution into quench detection systems, to enhance the operational safety of large-scale YBCO fusion magnets.

3:50 PM

(ICACC-S13-039-2026) Processing and properties of $Be_{12}Ti$ for advanced fusion blanket multipliers

J. Li*[1]; K. Christian[1]; D. Bhardwaj[1]; D. Sprouster[1]; L. Snead[1]; N. R. Brown[2]

1. Stony Brook University, USA
2. The University of Tennessee System, Department of Nuclear Engineering, USA

Beryllides are promising for advanced neutron multipliers due to low chemical reactivity, decreased helium swelling, good compatibility with structure materials, and reduced tritium retention. Among various beryllide systems, $Be_{12}Ti$ has been the most extensively studied, owing to its high theoretical Be number density, which enables superior neutron multiplication in fusion blanket applications. Previous studies have explored the processing-properties of the $Be_{12}Ti$ system, revealing the complex phase behavior. Despite claims of achieving “phase-pure” $Be_{12}Ti$ in some reports, multiple phases are clearly present. In this work, we systematically investigate the Be-Ti powder processing across a range of stoichiometry to optimize density and microstructures of monolithic $Be_{12}Ti$-based compacts. Dense monoliths (>98% relative density) with high thermal conductivity and microhardness were successfully fabricated. We also investigated two-phase Be12Ti-Be composites, with 5-20 % additional Be. This work presented microstructure, thermophysical, mechanical properties, and tritium breeding ratio (TBR) properties of these samples. The results demonstrate that the presence of excess Be at grain boundaries provides a fine channel microstructure, leading to enhanced thermal and mechanical properties and negligible impact on neuron multiplication.

4:20 PM

(ICACC-S13-040-2026) Investigation of cemented tungsten carbide as a shielding material for spherical tokomaks

M. Emmanuel*[1]; M. T. Rigby-Bell[1]; J. Wade-Zhu[1]

1. UKAEA, Materials, United Kingdom

Compact spherical tokamaks (c-STs) share key features with conventional high aspect ratio tokamaks, but offer operational advantages such as superior confinement, higher power densities, and increased temperatures. Their compact design also allows for shorter build times and lower manufacturing costs. However, a major challenge for c-STs is the limited space for inboard shielding due to the slender central column requiring materials with high shielding efficiency. Inboard shield protects high-temperature superconducting (HTS) tapes from neutron damage. Cemented tungsten carbide is a promising candidate due to its excellent neutron attenuation, high melting point, and thermal conductivity. While Co-binder carbides are common in cutting and drilling tool industry, cobalt is unsuitable for fusion environments due to its radioactivity after neutron exposure. This study uses a FeCr binder system to circumvent this issue. To evaluate irradiation response, WC-FeCr samples were subjected to 15 MeV W self-ion irradiation over a range of doses (0.13–13 dpa) and temperatures (100–400 °C). Nanoindentation and microcantilever testing assessed mechanical property changes post-irradiation. Transmission electron microscopy (TEM) was then used to characterise irradiation-induced defects and correlate them with observed changes in material behaviour.

4:40 PM

(ICACC-S13-041-2026) Pyrolysis of SiOC/MXene: Chemical and structural evolution under microgravity and controlled atmospheres

M. Shaik*[1]; K. Lu[1]

1. The University of Alabama at Birmingham School of Engineering, Mechanical and Materials Engineering, USA

This study will investigate the chemical and structural evolution of SiOC/1 wt% MXene composites during pyrolysis under microgravity and controlled atmospheres. Pre-pyrolysis will be performed in Ar and Ar + H_2O to modify Si–O–C and Si–CH_x networks, followed by pyrolysis at 800 °C and 1000 °C under space vacuum and Earth conditions. The research aims to examine how microgravity preserves uniform distributions of SiC nuclei and free carbon, limits phase segregation, and affects the thermal behavior of MXene additives, promoting the formation of conductive Ti–O–C networks. Structural characterization using XPS, TEM/EELS, and TGA/DTA will provide insight into Ti_3C_2 phase evolution, carbon distribution, oxidation resistance, and microstructural development. By comparing space- and Earth-processed samples, this study will explain the role of microgravity and precursor atmosphere in controlling material uniformity, oxidation resistance, and the stability of MXene-derived phases in SiOC composites.

S15 10th International Symposium on Additive Manufacturing and 3-D Printing Technologies

S15- Vat photopolymerization/stereolithography II

Room: Ponce de Leon
Session Chairs: Martin Schwentenwein, Lithoz GmbH;
Meelad Ranaiefar, NASA Glenn Research Center

1:30 PM

(ICACC-S15-031-2026) Sustainable and reprocessable bio-based binder systems for ceramic vat-photopolymerisation with tunable properties

B. Ozkan*[1]; A. Goulas[1]; A. Ketharam[1]; S. S. Yarahmadi[1]; B. Vaidhyanathan[1]

1. Loughborough University, Department of Materials, United Kingdom

Ceramic vat-photopolymerisation (VP) has traditionally relied on petrochemical acrylates that provide good printability but depend on fossil resources and lack circularity. UV-curable systems offer a greener alternative, and their sustainability can be advanced through bio-based acrylates. Bio-based materials, derived wholly or partly from biomass, reduce reliance on fossil feedstocks and support low-carbon manufacturing. In this work, we developed sustainable binder systems by formulating bio-based acrylate monomers and oligomers with petrochemical components to balance printability and eco-performance. Fully bio-based systems (~70% content) showed low viscosities but reduced strength, while 20–30% bio-content gave the best compromise with tensile strengths ~22 MPa and viscosities compatible with ceramic VP. Thermal analysis confirmed stability comparable to conventional systems with altered degradation pathways. Recycling was demonstrated at 70% bio-content with minimal property loss. Despite higher strength from petrochemical additives, printable 70% bio-content systems were achieved, showing that tuning bio-content can meet application demands whilst ensuring sustainability. Alumina ceramics fabricated with these binders achieved flexural strengths up to 350 MPa and hardness of ~1900 HV, confirming structural integrity comparable to conventional formulations.

1:50 PM

(ICACC-S15-032-2026) Aqueous-based photocurable ZrO_2 suspensions for sustainable DLP-3D printing: Design and influence of photo-initiators

M. Iijima*[1]; R. Tomiyama[1]; J. Tatami[1]

1. Yokohama National University, Japan

Additive manufacturing of ceramics using photocurable suspensions has become an essential method for fabricating components with customized geometries. While substantial advances have been made in printable formulations, the implementation of sustainable printing through aqueous media, biomass-derived substances, and short debinding processes remains an open frontier that warrants further investigation. Herein, using ZrO_2 as model substances, we propose an aqueous-based suspension in which raw powders are stabilized in water with the aid of amino acids and rendered photocurable via an interparticle photo-crosslinking reaction induced by a small amount of water-soluble acrylates. While the suspension with azo-type photo-initiators found to result in the formation of continuous pores in the DLP-printed green parts along the layer stacking direction due to the coalescence of nitrogen gas bubbles generated by the photolysis reaction, the usage of acylphosphine oxide type photo-initiator resulted in successful 3D printing of green parts having complex geometries. Further, due to the limited content of combustible organic compounds remaining in the photocured green bodies, densified parts were successfully obtained without structural collapse even through rapid (10 K/min) heating for debinding and sintering.

2:10 PM

(ICACC-S15-033-2026) 3D printing of ceramic combustion chamber for hydrogen combustion

F. Faysal[1]; L. Longas[1]; K. Ahmed[1]; J. Gou*[1]

1. University of Central Florida, Mechanical and Aerospace Engineering, USA

Alumina ceramics exhibit remarkable thermal stability, hardness, and chemical resistance, making them suitable for extreme environment applications. In this study, a high-purity alumina cylinder was 3D printed using a slurry-based photopolymerization technique combined with masked stereolithography (mSLA). The green body was processed through controlled debinding and sintering at elevated temperatures to obtain a dense ceramic structure. Microstructural and thermal characterizations, including SEM, XRD, and TGA, confirmed high consolidation, stable phase composition, and strong thermal resistance. The manufactured alumina cylinder is designed to function as a thermal protective layer within a hydrogen engine, where it will be exposed to high heat flux. The fabrication approach offers precise geometric control, reduced defects, and high relative density compared with conventional forming methods. This study demonstrates the feasibility of additive manufacturing for producing robust alumina ceramics and highlights their potential as reliable thermal management materials in propulsion and energy systems.

S15- Materials and process characterization tools and Multi-material and hybrid printing techniques

Room: Ponce de Leon
Session Chair: Motoyuki Iijima, Yokohama National University

2:30 PM

(ICACC-S15-035-2026) Alumina green body feedstock for microwave volumetric additive manufacturing

J. Carmichael*[2]; K. T. Strong[2]; T. Diebold[1]

1. Sandia National Laboratories, USA
2. Sandia National Laboratories, Material Mechanics and Tribology, USA

Volumetric additive manufacturing (VAM) is an evolving technology for the rapid printing of 3D structures. Microwave energy is of great interest for VAM technology as its improved penetration depth and useability with opaque resins make it more versatile than using light as an energy source for printing. Microwave's advantages over optical light enables ceramic materials to be rapidly printed with VAM techniques. In this work, alumina particles are surface functionalized and mixed with a microwave-reactive organic binder to form a slurry, which is then slip cast. Samples are irradiated with a single antenna microwave at various power levels and times to determine optimal settings for VAM. The resulting green body is compared to conventional slip casting methods. Scanning electron microscopy (SEM), thermogravimetric analysis (TGA), and density measurements of the sintered material compare the microwave-formulated ceramic to traditional slip cast alumina. SNL is managed and operated by NTESS under DOE NNSA contract DE-NA0003525. SAND#SAND2025-12574A.

2:50 PM

(ICACC-S15-036-2026) High interconnection density HTCC: Towards space-grade electronics miniaturization via hybrid additive manufacturing

A. Junger*[1]; P. Michaud[1]; V. Pateloup[1]

1. Universite de Limoges, France

High Temperature Co-fired Ceramics (HTCC) are widely used for electronic packaging, where conductive networks embedded in ceramic layers ensure robustness and hermeticity. To address the stringent requirements of space applications – high thermal

conductivity, low dielectric constant, complex metallization - this work explores a hybrid additive manufacturing approach for high interconnection density HTCC. A custom SLA/robocasting system is developed to fabricate AlN substrates and deposit Mo tracks, with a target resolution of 50 µm in line width and spacing. Printing formulations and strategies are defined to achieve precise, defect-free circuits set in ceramics. Tracks of 100 µm width × 10 µm thickness × 60 µm gap are achieved. Co-firing at 1800 °C in a reducing atmosphere yields dense, conductive Mo networks within AlN, enabling reliable HTCC packages. Hyper-frequency devices are fabricated and characterized, confirming the potential of this hybrid process as an alternative to conventional HTCC routes. These results highlight the prospects of a hybrid SLA/robocasting process for miniaturized, space-grade electronics, paving the way for future optimization in performance, and functionality. This work is carried out at IRCER in collaboration with Thales Alenia Space, with support from the French Defence Innovation Agency (AID).

S15- Binder jetting processes

Room: Ponce de Leon
Session Chair: Jihua Gou, University of Central Florida

3:30 PM

(ICACC-S15-037-2026) Improved packing density of powder compacts via binder jetting with binary powder mixing

A. Shimamura*[1]; Y. Chung[1]; C. Matsunaga[1]; M. Hotta[1]; N. Kondo[1]

1. National Institute of Advanced Industrial Science and Technology (AIST), Japan

Binder jetting (BJ) is an additive manufacturing technology in which a part is fabricated layer by layer by depositing a liquid binder in the designated regions of each layer until the feature is complete. This process allows the production of ceramic products with complex shapes. Although complex shapes can be formed in ceramic compacts via binder jetting, one important consideration is that the density of ceramic products fabricated by this method is relatively low compared to those produced by other ceramic processes, such as cast molding or press molding. Powder preparation for the densification of products fabricated via binder jetting is a key step affecting the performance of the final product. Bimodal powder mixing with different particle sizes is an effective approach to improve powder packing density. In this study, the optimization of powder mixing was investigated. Alumina powder was used as a representative material. Three types of alumina particles of different sizes were used as binary particles and mixed in various proportions with coarse alumina powder. Green bodies were produced from the powder mixtures with varying amounts and sizes of the binary powder. The bulk densities, microstructures, and pore size distributions of the green bodies were then characterized.

S16 Geopolymers Inorganic Polymers and Sustainable Construction Materials

S16- Alkali-based geopolymers and Acid-based phosphate geopolymers

Room: Ballroom 5
Session Chair: Waltraud Kriven, University of Illinois at Urbana-Champaign

1:30 PM

(ICACC-S16-001-2026) Processing and characterization of silico-aluminum phosphate geopolymer hybridized with a high-temperature polymer (Invited)

D. Samuel*[1]; M. Lee[1]; C. Peruzzi[1]; P. Hewitt[1]; W. Hartt[1]; W. J. Monzel[2]; D. Simone[2]

1. Aerovironment Inc, USA
2. Air Force Research Lab Materials and Manufacturing Directorate, Structural Materials, Composites Branch, USA

Polymer additives may help mitigate some disadvantages of geopolymers, such as low toughness and high porosity. However, most polymers that are soluble and stable in geopolymer precursor solutions decompose at low temperatures and cannot provide any benefits at moderate or elevated temperatures. We have been investigating polymer additives that are stable to relatively high temperatures (>300 °C) and are soluble in phosphoric acid solutions to make hybrid organic/inorganic metakaolin-based phosphate geopolymers. The aim is to improve the geopolymer matrix's mechanical properties such as hardness, flexural strength, and fracture toughness at service temperatures of about 300-700 °C and maintain processability to incorporate conventional fiber or particulate reinforcements later. This also requires improving our understanding of processing silico-aluminum phosphate geopolymers so that elevated temperatures can be reached without causing cracking and retaining strength. We will describe our progress thus far, including findings on heat treatment/crystallization of the geopolymer, microhardness, and microstructure.

2:00 PM

(ICACC-S16-002-2026) Phosphate ceramics made with steel slag waste from the steel making industry

H. A. Colorado L.*[1]

1. Universidad de Antioquia, Colombia

Phosphates offer a promising alternative to conventional cements and ceramics, particularly due to their ability to be synthesized without high-temperature thermal processing. Unlike traditional materials that often require energy-intensive manufacturing, phosphates can be produced through chemical reactions at ambient temperatures. This key advantage significantly reduces the carbon footprint associated with material processing, addressing a critical environmental concern. This research explores the application of solidification/stabilization technology to create novel phosphate formulations incorporating hazardous metallurgical waste. Our comprehensive chemical and mechanical characterizations demonstrate that these innovative materials not only effectively stabilize hazardous waste, but also show great potential as replacements for traditional construction and industrial materials.

2:20 PM

(ICACC-S16-003-2026) Mechanical and thermo-physical characterization of Na-based geopolymer foams reinforced with phosphate mine waste particulates and fibers. (Invited)

S. Sbi*[1]; A. Stumpf[2]; A. Aboulayt[3]; N. Semlal[4]; J. Alami[1]; Y. Tamraoui[1]; W. M. Kriven[2]

1. Universite Mohammed VI Polytechnique, Morocco
2. University of Illinois Urbana-Champaign, USA
3. Ecole Nationale d'Architecture - Tetouan, Morocco
4. Groupe OCP, Morocco

This study investigates the development of sodium-based geopolymer foams (GPFs) reinforced with phosphate mine waste rock (PMWR) particulates and natural (hemp) or synthetic (basalt) fibers for sustainable construction applications. Mechanical and thermal characterization demonstrated that dual reinforcement enhances both flexural strength (up to 13.5 MPa) and thermal insulation performance, suggesting a good synergistic effect between the particulate and fiber phases. Microstructural observations revealed an improved fiber–matrix interaction, which limited crack propagation and improved load transfer. Basalt fibers were more effective in increasing strength and toughness, while hemp fibers improved ductility and deformability of the tested composites. Increasing the filler content significantly altered the pore structure of the GPF matrix, with noticeable changes in pore size, morphology, and connectivity influencing the composites' mechanical and thermal behavior. The results are promising and demonstrate the potential of integrating phosphate mine waste rock and fibers to develop cost-effective and energy-efficient materials aligned with circular economy principles.

3:10 PM

(ICACC-S16-004-2026) Geopolymer application for radioactive wastes resulting from the Fukushima Daiichi Nuclear Power Plant accident (Invited)

K. Toda*[1]; A. Yildirim[2]; L. Lang[2]; M. Viaud[2]; P. Prihutami[1]; Y. Doi[2]; T. Saito[1]

1. The University of Tokyo, Nuclear Professional School, Japan
2. The University of Tokyo, Graduate School of Engineering, Japan

The Fukushima Daiichi Nuclear Power Plant (FDNPP) accident in 2011 resulted in severe reactor-core damage, hydrogen explosions, and large-scale radionuclide release. Fuel debris remains inside the damaged reactors will be retrieved, while large volumes of secondary wastes from contaminated water treatment and off-site decontamination activities are temporarily stored. In decommissioning and final radioactive waste disposal scenarios, geopolymers are being considered as binders or barriers for their high-temperature stability, mechanical strength, low hydrogen generation, and strong radionuclide immobilization capacity. This presentation will discuss recent advances and future prospects for geopolymer applications in Fukushima-related waste management. Examples of the application fields are the potential in situ solidification of fuel debris before retrieval, immobilization of spent sorbents from water treatment systems, and stabilization of Cs-bearing fly ash generated during disaster waste volume reduction. These applications illustrate the importance of the versatility of geopolymers in addressing both immediate decommissioning challenges and long-term waste stabilization, underscoring their potential as a promising material candidate in nuclear waste management.

3:40 PM

(ICACC-S16-005-2026) Formulation and properties of porous geopolymers for transportation applications

É. Prud'homme*[1]; M. Mouafon[2]; D. Habans[1]; G. Dusserre[2]; T. Cutard[2]; P. Reynaud[1]

1. Institut National des Sciences Appliquees de Lyon, MATEIS, France
2. Ecole Nationale Superieure des Mines d'Albi-Carmaux, ICA, France

Developing lightweight, insulating materials that have improved mechanical properties and a low environmental impact is now a key challenge for the transport industries. The aim is to replace dense, environmentally impactful metal materials. Geopolymer materials are promising candidates due to their properties, the availability of their resources, and their low-temperature synthesis. Controlling porosity in relation to usage properties is therefore fundamental to developing an optimised material. This study investigates the development of porosity in geopolymers based on metakaolin, sodium hydroxide and silicate. To create porosity, aluminium and cetyl trimethyl ammonium bromide (CTAB) were added in various proportions. The resulting materials were characterised in terms of porosity (X-ray tomography, SEM), microstructure (XRD, ATD-ATG, FTIR), density and thermal and mechanical properties. The various microstructural analyses revealed no differences in the geopolymer network among the samples. CTAB is essential for maintaining porosity and can double it at a constant aluminum content. The ratio between CTAB and Al powder allows pore distribution to be controlled. The most effective material has a porosity of up to 80%, a density of 0.350 g/cm^3, a compressive strength of 2.3 MPa and a thermal conductivity of approximately 0.1 W/(m.K), making it highly promising for use in transport applications.

4:00 PM

(ICACC-S16-006-2026) Geopolymer-derived crystallization under hydrothermal conditions

P. H. Sin*[1]; W. M. Kriven[1]

1. University of Illinois Urbana-Champaign, Materials Science and Engineering, USA

The study aims to determine the impact of hydrothermal environments on geopolymers of varying cation and silica compositions by preparing geopolymer slurries and subjecting them to conditions composed of an aqueous, high-temperature and high-pressure environment. Prior work has shown that gels produced by mixing an alkali metal oxide, an aluminum source, and a silicon source subjected to hydrothermal conditions can form various crystalline products. In this work, geopolymer slurries were produced by the addition of metakaolin to alkali solutions containing lithium, sodium, potassium, or cesium cations. Fumed silica and silicic acid were used to control the silica ratio of the slurry. XRD, SEM, TGA and other techniques were used to characterize and classify the products before and after treatment. Results showed that an amorphous geopolymer product that was first treated at 50 degrees Celsius would often undergo transformations into crystalline structures, generally related to zeolites and tectosilicates, after being subjected to temperatures of 300 degrees Celsius and 8.59 MPa for 10 hours in an aqueous environment. The results also appear to suggest products made from smaller cations may crystallize more easily than products made from larger cations. These results introduce an additional method for the production of various aluminosilicate crystals via geopolymers as starting materials.

4:20 PM

(ICACC-S16-024-2026) Effect of thermal exposure on the mechanical properties of textile reinforced composites with K-metakaolinite geopolymer matrix (Invited)

H. Rahier*[1]; G. Meza-Hernandez[1]; S. Onisei[1]

1. Vrije Universiteit Brussel, Materials and Chemistry, Belgium

Textile reinforced composites (TRC) are commonly prepared with organic polymer matrices. They can however also be produced with a cementitious matrix. A distinction can be made between low volume fraction composite (max about 5 vol % of textile) and high volume fraction composites (above 20 vol% of textile). High volume fraction composites can have many applications in constructions, not limited to buildings. Compared with thermoset or thermoplast based composites, their cost and environmental impact is much smaller. They cannot burn and can even be used at temperatures exceeding the temperatures where organic materials are stable (above 300 °C). As such they fill the gap between thermoset based composites and ceramic matrix composites. The composites were fabricated by impregnating woven basalt fibers with a defined amount of the fresh matrix. The matrix was characterized by isothermal calorimetry, Differential Scanning Calorimetry (DSC), flexural strength, and elastic modulus measurements. The composites specimens were characterized by scanning electron microscopy, flexural strength, and elastic modulus after curing at 80 °C and following post-heating at 300 °C and 500 °C. Basalt fiber-based composites achieved flexural strength up to 100 MPa and elastic moduli of 16 GPa. The strength reduces to about 40 MPa after heating to 500 °C.

4:50 PM

(ICACC-S16-025-2026) Sustainable carbon capture with geopolymer-based zeolite 4A: Low-cost design, high-value performance (Invited)

P. Mokhtari*[1]; P. Sin[1]; M. Wlodarczyk[1]; P. Numkiatsakul[1]; W. Kriven[2]

1. University of Illinois at Urbana-Champaign, Materials Science and Engineering, USA
2. University of Illinois at Urbana-Champaign, USA

The development of cost-effective and durable sorbents is critical for advancing carbon capture technologies. In this study, hierarchically porous, geopolymer-based Zeolite 4A composites were synthesized via a one-pot, low-temperature route that eliminates energy-intensive hydrothermal processing. Environmentally benign porogens, canola oil and hydrogen peroxide, were used to tailor interconnected pore networks, facilitating rapid gas diffusion and high surface accessibility. Structural analyses confirmed in situ crystallization of LTA-type Zeolite 4A within the geopolymer framework. Dynamic vapor sorption measurements demonstrated a CO2 uptake of 2.43 mmol/g, comparable to benchmark activated carbon (2.59 mmol/g) and SAPO-34–geopolymer composites (2.41 mmol/g). Importantly, the composite retained crystallinity, mechanical integrity, and adsorption capacity after thermal cycling, indicating strong potential for use in pressure- and temperature-swing adsorption processes. By combining low-cost feedstocks, sustainable synthesis, and competitive performance, geopolymer-based Zeolite 4A emerges as a promising candidate for scalable, next-generation CO2 capture and storage solutions

S18 Ultra-High Temperature Ceramics

S18- Precursors for powders, coatings, and matrix or fibers of composites

Room: Coquina A
Session Chair: Yoonjoo Lee, Korea Institute of Ceramic Engineering and Technology

1:30 PM

(ICACC-S18-034-2026) Precursor-derived synthesis and crystallization of $HfC_{1-x}N_x$ ceramics: Insights into composition and microstructural evolution (Invited)

Y. Lee*[1]; D. Shin[1]

1. Korea Institute of Ceramic Engineering and Technology, Republic of Korea

The polymer-derived ceramics (PDC) route allows for low-temperature synthesis, ensuring compositional homogeneity and tunable microstructures through molecular-level precursor design. This method is particularly well-suited for producing nanopowders and composites. Additionally, polymeric precursors offer advantageous rheological properties, making them appealing for coatings and composite fabrication. However, it remains challenging to achieve stoichiometric HfC due to complications with oxygen incorporation and the control of free carbon. In this study, we investigate the crystallization behavior of $HfC_{1-x}N_x$ ceramics derived from amine-coordinated preceramic polymers. The Hf–C–N system forms a continuous solid solution, allowing for compositional changes during heat treatment. At elevated temperatures, nitrogen loss occurs, and oxygen ingress further depletes the nitrogen content. The crystallization of $HfC_{1-x}N_x$ is also influenced by pressure conditions. Compositional variations were analyzed using Vegard's law, while the evolution of crystallite size was estimated using the Scherrer equation.

2:00 PM

(ICACC-S18-035-2026) Morphology determination and control of transition metal carbides (TMCs) powders

Y. Huang*[1]; C. R. Weinberger[1]

1. Colorado State University, Department of Mechanical Engineering, USA

Ceramic precursor powders, along with processing, influence the microstructure and hence properties of ceramics made through powder metallurgy. The determination and control of powder microstructure is thus critical for engineering properties such as fracture toughness and creep resistance. In this talk, we examine the thermodynamics and kinetics behind powder morphology determination and control, with a specific focus on the group IVB and VB transition metal carbides (TMCs), which belong to the class of ultra-high temperature ceramics. We show that local carbon source can significantly alter the morphology of the TMCs. The depletion of carbon source in the processing environment favors growth of truncated octahedral powders, while a high carbon concentration leads to truncated cubic crystal growth.

2:20 PM

(ICACC-S18-036-2026) Reaction synthesis and stability kinetics of nanoporous TaC derived from Ta precursors

C. Ott*[1]; A. Peters[2]; I. McCue[1]

1. Northwestern University, Materials Science and Engineering, USA
2. Stratolaunch LLC, USA

Ultra-high temperature ceramics (UHTCs) have drawn interest for use in hypersonic structures due to their high melting points, excellent thermo-physical properties, and reasonably low densities; however, due to processing limitations, they have primarily been used as monolithic materials or coatings. Here, we are interested in adding additional functionality (e.g., ablation resistance, transpiration cooling) by developing a porous UHTC. This work determines the kinetic parameters of the conversion of nanoporous metals to ultra-high-temperature ceramics via gas-phase conversion at elevated temperature for powder with a single feature size. Additionally, the microstructural evolution of the carbide phases in carburized powder are examined with transmission Kikuchi diffraction (TKD) and electron backscatter diffraction (EBSD). Finally, the present work aims to explore the interplay between the conversion process and ligament coarsening as a function of carbide phase fractions and feature size, by gas carburizing dealloyed metal powder with tunable feature sizes to quantify the process for creation of nanoporous ultra-high-temperature ceramics with stable feature sizes appropriate for a given application.

S18- Characterization methods and lifetime assessment

Room: Coquina A

Session Chair: Yue Zhou, Missouri University of Science & Technology

3:20 PM

(ICACC-S18-037-2026) 4DSTEM characterization of local structure in high-entropy borides

A. Mirzaei*[1]; S. J. Dillon[1]

1. University of California Irvine Henry Samueli School of Engineering, Department of Materials Science and Engineering, USA

High-entropy ceramics, such as transition metal borides, are promising candidates for extreme-environment applications due to their exceptional thermal stability, mechanical hardness, and high temperature oxidation resistance. Their high configurational entropy promotes phase stability at elevated temperatures by reducing Gibbs free energy, making them promising candidates for applications such as aerospace, defense and microelectronics. However, the chemical complexity that stabilizes their crystal structure drives intricate local structural variations. Therefore, understanding atomic-scale structure–property relationships remains a key challenge, given the high chemical disorder inherent to their multi-principal-element composition. In this work, nanobeam 4DSTEM is employed to map local crystallography, strain distributions in high-entropy borides. Spatially resolved reciprocal space maps are reconstructed by acquiring nanobeam diffraction patterns at each probe position, revealing nanoscale lattice distortions and chemical disorder signatures. The correlation of 4DSTEM-derived strain maps with complementary spectroscopy provides insight into the coupling between compositional fluctuations and local lattice distortions. This study demonstrates 4DSTEM as a quantitative tool for unraveling the structural complexity of high-entropy ceramics, enabling microstructure design for extreme-performance applications.

3:40 PM

(ICACC-S18-038-2026) The processing space of titanium carbide fibers grown by laser chemical vapor deposition

K. J. Mitchell*[1]; G. Thompson[2]

1. University of Alabama, Interdisciplinary Materials Science PhD Program, USA
2. University of Alabama, Metallurgical & Materials Engineering, USA

Laser chemical vapor deposition (LCVD) is a novel processing technique that utilizes the heat from a focused laser to nucleate a solid deposit from a gaseous vapor pyrolytically. The retraction of the laser from a substrate then enables the growth of fibers. Here, we report a processing space map based on the ratio of hydrogen, ethylene, and titanium tetrachloride gaseous precursors in the growth of TiC fibers as a function of deposition temperature. X-ray diffraction, energy dispersive spectroscopy, and electron microscopy are implemented to characterize fiber growth morphology. Dependent upon processing conditions, the fibers can exhibit a radial change in composition resulting from a core-shell structure to a hollow tube formation. The diminished partial pressures of hydrogen and titanium tetrachloride ratio is shown to be a key variable in this control that is captured in the proposed map. Using single fiber tensile tests, the strength of these different fibers is linked to the processing space found on the map.

S20: Golden Jubilee- Engineered Ceramics for Achieving Net-Zero Carbon Emissions

S20- Innovative manufacturing processes for greening of ceramics manufacturing industrial processes

Room: Coquina D

Session Chairs: Hua-Tay Lin, Guangdong University of Technology; Monica Ferraris, Politecnico di Torino

1:30 PM

(ICACC-S20-027-2026) Additive manufacturing of geopolymers (Invited)

P. Colombo*[1]

1. University of Padova, Industrial Engineering, Italy

Geopolymers possess a chemical composition similar to zeolites, intrinsic micro- and mesoporosity and have ion-exchange capabilities; these features make them highly interesting for environmental applications as sorbents and catalysts for multiple reactions. Moreover, the possibility of room to low temperature consolidation, low CO_2 emissions and the fact that they can be obtained from waste make geopolymers attractive from the processing point of view. We explored Direct Ink Writing for additive manufacturing of hierarchically porous components comprising geopolymers as active material and/or as a matrix for active fillers, such as zeolites and activated carbons. Structures with designed macroporosity >50%vol were fabricated and characterized in terms of microstructure, mechanical properties, specific surface area and permeability. Specific compositions and functionalization protocols were developed for selected applications, including biodiesel production catalysis, CO_2 adsorption, water purification from cationic and anionic pollutants as well as pharmaceuticals. Large scale binder jetting of geopolymer-based components has also been carried out, for fire protection applications in tunnels, adding either metakaolin or a reactive slag to the powder bed and generating parts by selective jetting of an alkaline solution. In addition, temperature-resistant molds for the production of blown art glass parts have been successfully manufactured.

2:00 PM

(ICACC-S20-028-2026) Joining of ceramic matrix composites: A contribution to net-zero carbon emission (Invited)

M. Ferraris*[1]

1. Politecnico di Torino, Department of Applied Science and Technology, Italy

Ceramic matrix composites (CMCs) are advanced materials with significant potential for industrial and energy applications, particularly in achieving Net-Zero emissions. However, their reliable and energy-efficient joining methods remain a critical challenge. This talk explores several strategies for joining CMCs using glasses, brazing alloys and polymer-derived ceramics. Innovation in processing and characterization of CMC-based joined components developed at GLANCE-Glasses, Ceramics and Composites research group at Politecnico di Torino, Italy, will be presented and discussed. The combination of advanced design of interfaces and joining materials/technologies, selective matrix removal from the composite surface, laser structuring and mechanical machining of the composite/metal surfaces will be discussed and compared to existing solutions. The work done with the aim of developing reliable and user-friendly international standard test to measure the shear strength of joined components will also be reviewed.

2:30 PM

(ICACC-S20-029-2026) Ceramic additive manufacturing: Innovations driving net-zero carbon solutions (Invited)

H. Yun*[1]

1. Korea Institute of Materials Science, Republic of Korea

Attaining net-zero carbon emissions necessitates advancements in materials and manufacturing technologies that diminish resource utilization and environmental repercussions. Ceramic additive manufacturing (AM) provides significant benefits compared to traditional methods by facilitating accurate manipulation of intricate geometries, reducing waste, and consolidating many capabilities into a singular process. This review will examine key breakthroughs in ceramic AM that promote carbon neutrality, such as multi-material printing, sintering-free processing methods, support-less fabrication processes, and design optimization via computational tools. Applications are examined in energy conversion and storage, hydrogen production, environmental cleanup, and carbon capture, where AM improves efficiency, durability, and sustainability. These advancements highlight the capability of ceramic AM to enhance performance in challenging conditions while also facilitating decarbonization and the creation of circular manufacturing systems.

3:20 PM

(ICACC-S20-030-2026) A design-to-manufacturing framework for multifunctional piezocomposites in energy harvesting, sensing, and actuation (Invited)

Y. Li*[1]

1. Dartmouth College, Thayer School of Engineering, USA

Piezocomposite materials, which integrate piezoelectric ceramics with polymer matrices, provide a versatile platform for multifunctional devices in energy harvesting, sensing, and actuation. In this presentation, I will discuss our recent advances in the design and manufacturing of piezocomposites, with a focus on tunable architectures and multifunctional performance. A design-to-manufacturing framework is established to optimize composite geometries for specific functionalities, with artificial intelligence integrated to enhance design efficiency and accuracy. Digital Light Processing (DLP) 3D printing is employed to fabricate piezocomposites with customized geometries and tailored properties. Several case studies will be provided to demonstrate the capability of these engineered materials to achieve both energy harvesting from ambient vibrations and dual-mode sensing of acceleration and dynamic force within a single device. The findings illustrate the potential of rationally designed piezocomposites to bridge the gap between structural materials and active devices, opening pathways toward next-generation multifunctional systems in healthcare, robotics, and sustainable energy technologies.

S20- Advanced technologies to increase energy efficiency and reduce the carbon footprint of energy production and consumption

Room: Coquina D
Session Chair: Michael Halbig, NASA Glenn Research Center

3:50 PM

(ICACC-S20-031-2026) Ultrafast high-temperature sintering technology in manufacturing of advanced ceramics for a NET-zero future (Invited)

H. Lin*[2]; F. Zhu[2]; S. Grasso[1]

1. Queen Mary University of London, United Kingdom
2. Guangdong University of Technology, China

The ultrafast high-temperature sintering (UHS) is a disruptive and innovative technology for processing ceramics, and has drawn a great scientific interest as a part of the global efforts to achieve NET-zero emission. The UHS processing can offer great potentials to revolutionize the ceramics industrial sectors by: i) substantially reducing the time and energy consumption of ceramic processing, and ii) consolidating ceramics prone to thermal decomposition during high temperature exposure. In particular, UHS has shown enormous potentials and unique advantages in manufacturing ceramics with fine tuning over the grain shape and size, interfacial structure, and phase composition/stoichiometry, which brings great opportunities to surpass the constrains imposed by conventional sintering processes. However, several technical challenges remain unaddressed. Scaling up to larger sample with a complex shape also remains an open challenge, requiring additional research activities to explore the possibilities. Combining the latest research progress and achievements of our research team in this UHS field, this presentation will rigorously elaborate and explore the application values and potential challenges of UHS technology in the processing of advanced ceramics. It would provide a clearer pathway for the novel sintering approach from both fundamental and applied perspectives.

4:20 PM

(ICACC-S20-032-2026) High thermoelectric performance and long-term stability in Indium single-filled $CoSb_3$ Skutterudites via kinetically engineered InSb nanolayers (Invited)

H. Kim*[1]

1. University of Seoul, Republic of Korea

Achieving high performance and reliability in thermoelectric skutterudites has conventionally relied on complex multi-filling strategies and prolonged annealing, which often increase synthesis cost and reduce reproducibility. Here, we demonstrate that comparable or superior performance can be achieved in a simple indium single-filled $CoSb_3$ through kinetic control of the melt-spinning process. By tuning the quenching rate, we promote the in-situ crystallization of ~5 nm-thick InSb nanolayers that uniformly decorate $CoSb_3$ grain boundaries during sintering. These nanolayers enhance the weighted mobility ratio by selectively scattering minority carriers, suppress bipolar conduction, and introduce additional phonon scattering pathways while preserving carrier mobility. The optimized $In_{0.4}Co_4Sb_{12}$ achieves a peak zT of 1.35 at 773 K and an average zT of ~0.95 across 300 - 873 K. Thermoelectric modules deliver a high power density of 3.5 W cm^{-2} and retain over 95 % of their output after 2000 h at 623 K. This kinetically driven single-filling approach provides a scalable and more accessible alternative to compositional complexity, establishing a broadly applicable route to high-efficiency and durable thermoelectric devices.

Poster Session B

Room: Ocean Center

5:00 PM

(ICACC-PB-001-2026) Tailoring magnesium phosphate cements with chitosan-based hydrogels for injectable bone repair

K. Stanislawska*[1]; D. Kozien[2]; A. Ronowska[3]; J. Kozlowska[4]; M. Wekwejt[5]

1. Politechnika Gdanska, Scientific Group ‘Materials in Medicine’, Advanced Materials Center, Poland
2. Akademia Gorniczo-Hutnicza im Stanislawa Staszica w Krakowie, Department of Ceramics and Refractories, Poland
3. Gdanski Uniwersytet Medyczny, Department of Laboratory Medicine, Poland
4. Uniwersytet Mikolaja Kopernika w Toruniu, Department of Biomaterials Technology and Cosmetic Chemistry, Poland
5. Politechnika Gdanska, Department of Biomaterials Technology, Poland

Magnesium phosphate cements (MPC) are bioactive and rapidly setting materials suitable for bone repair, yet their uncontrolled setting and limited injectability remain challenges. This study investigates MPC, obtained from calcined MgO and KH_2PO_4, modified with chitosan-based (CS) hydrogels to improve functional performance. Both CS and carboxymethyl CS were evaluated as polymeric additives, cross-linked with glycerophosphate and/or divalent cations. The composites were characterized physicochemically, mechanically, and biologically to establish links between composition and performance. The formulations exhibited dual-setting reactions, tunable setting kinetics, and improved cohesion during handling. The phase composition remained largely unchanged, with k-struvite confirmed as the principal phase, while the microstructure was comparable to that of pure MPC. Differences in degradation, mechanical strength, and cytocompatibility reflected the influence of composite chemistry and setting parameters. The optimized cements maintained structural integrity and were compatible with human osteoblasts without adverse effects on cell viability. Overall, the results confirm that MPC modified with CS/CMCS represents a promising system for injectable bone substitutes dedicated to minimally invasive orthopedic applications.

(ICACC-PB-002-2026) Processing development of NASICON-based multilayer ceramic batteries via MLCC-inspired processing

J. Seong*[1]; J. Lee[1]; J. Heo[1]; Y. Son[1]; S. Lee[1]

1. Changwon National University College of Mechatronics, School of Materials Science and Engineering / Department of Materials Convergence and System Engineering, Republic of Korea

Adapting multilayer ceramic capacitor (MLCC) processing to solid-state batteries provides a scalable route to all-ceramic energy-storage devices. In this work, NASICON-type solid electrolytes were selected as the sodium-ion-conducting electrolyte platform. For cathode preparation, $Na_3V_2(PO_4)_3$ powder was blended with conductive carbon and a small amount of polyvinylidene fluoride binder to create a slurry that was tape-cast into freestanding electrode sheets. Anode sheets were fabricated in a similar manner using a $NaTi_2(PO_4)_3$-based slurry. These electrode sheets were alternately stacked with NASICON electrolyte layers and co-fired, producing a multilayer ceramic battery architecture analogous to MLCC. Characterization prioritized feasibility and reproducibility rather than performance optimization. Thickness uniformity, shrinkage behavior, and interfacial bonding were examined. Scanning electron microscopy confirmed well-bonded multilayers, while impedance spectroscopy verified ionic conduction through the NASICON laminate. Preliminary electrochemical tests demonstrated stable battery operation using the $Na_3V_2(PO_4)_3$ /$NaTi_2(PO_4)_3$ electrode configuration. This work establishes a proof of concept for NASICON- based multilayer ceramic battery fabrication and provides a foundation for future performance -oriented investigations.

(ICACC-PB-003-2026) Development of machine-learned interatomic potentials for modeling amorphization of SiO_2 surfaces via argon bombardment

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Advance semiconductor applications require wafer-to-wafer bonding to be highly predictable, efficient, and compatible with diverse material compositions. Fusion bonding faces challenges due to high temperature annealing between interfaces. Low-temperature surface activated bonding (SAB) using ion irradiation offers a promising alternative, though SAB outcomes are less predictable due to limited understanding of bonding theory and modeling approaches. Accurate modeling of ion-induced surface modification is critical for predicting bonding outcomes. We present the results of training a machine-learned interatomic potential (MLIP) that is tailored to Ar ion beam interactions with idealize crystalline SiO_2 surfaces. We used ab initio methods to compute energy, force, and stress data across a range of ion energies, angles, and defect configurations. The data was used to train a spectral neighbor analysis potential (SNAP) capable of capturing short- and long-range interactions critical to plasma-surface activation. We then applied the potential within LAMMPS to model Ar+ ion bombardment of idealized SiO_2 surfaces to induce amorphization of the surface. We present our quality characterization of the amorphized surface in terms of atomistic geometry and electronic structure. The usefulness of this technique for preparing simulated SAB models will be discussed.

(ICACC-PB-004-2026) Comparative study on oxidation tests for antioxidative carbon/carbon composite coatings: Thermogravimetric analysis versus muffle furnace

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Carbon/Carbon (C/C) composites have applications in the aerospace industry, but experience mass loss above 500 °C in oxygen environments. High-temperature ceramic (HTC) coatings protect C/C composites from oxygen exposure. Silicon carbide has been widely used as an HTC coating for C/C composites due to its high melting point, a CTE close to carbon, and ability to form SiO2. The main techniques used to obtain SiC coatings on C/C composites are pack cementation and chemical vapor deposition. Slurry is another common coating method that can produce a ZrB2 HTC coating. Thermogravimetric analysis (TGA) and muffle furnace testing are two common methods for testing the performance of HTC coatings. TGA provides continuous mass loss data, allowing kinetic analysis of oxidation processes, while muffle furnace testing simulates conditions closer to service environments. In this work, a comparative evaluation of these oxidation tests was performed. Preliminary results reveal that although both methods capture the overall oxidation resistance trends, significant differences arise in the rate of mass loss, coating degradation behavior, and coating endurance. This study also explores whether a correlation exists between the two methods so that TGA can provide predictive indicators for the long-term oxidation performance observed in furnace exposures.

(ICACC-PB-005-2026) MAXCarbon hybrid fibres for durable electrochemical components in hydrogen technologies towards net-zero carbon emissions

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Achieving net-zero carbon emissions requires disruptive materials for energy conversion systems, particularly in hydrogen technologies. Electrolysers and fuel cells rely on carbon-based components such as bipolar plates, gas diffusion layers (GDLs) and porous transport layers (PTLs). However, conventional carbons are prone to corrosion, oxidation, and degradation under electrochemical operating conditions, which limits efficiency and shortens service lifetimes. These challenges hinder large-scale deployment and economic competitiveness of hydrogen technologies. MAXCarbon fibres, produced by transforming carbon textiles into Ti_3SiC_2 (MAX-phase) and carbon fibre hybrids, offer a promising solution. The resulting material combines high electrical conductivity with excellent corrosion and oxidation resistance, as well as long-term mechanical stability. Current research efforts focus on fabricating demonstrators where conventional carbon components are replaced by MAXCarbon-based counterparts in bipolar plates, GDLs and PTLs. This substitution is expected to reduce performance losses due to degradation, improve energy efficiency and increase the durability of components. By enabling more reliable and longer-lasting electrochemical devices, MAXCarbon contributes to the realisation of hydrogen-based systems as a cornerstone of net-zero carbon energy technologies.

(ICACC-PB-007-2026) Reinterpretation of the dielectric breakdown behavior of ceramics based on electric field enhancement by inherent microdefects

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Dielectric breakdown is a fatal phenomenon for insulative ceramics, but the mechanism is still unclarified. Similarly to mechanical properties, the dielectric breakdown strength is possibly sensitive to the characteristics of microdefects. The present authors reported the magnitude of electric field enhancement around microdefects strongly depends on those aspect ratio and dielectric constant. Here, we reassessed the past experimental reports regarding microdefects and dielectric breakdown behavior of ceramics, based on electric field enhancement. The focus was especially put on the dependency of dielectric breakdown strength on the macroscopic parameters related to microdefects such as average grain size. As a result, such macroscopic correlations were found to be explained well by electric field enhancement. This means it is extremely important to consider the electric field enhancement in the vicinity of microdefects, especially grain boundary phases with high aspect ratios. At last, we quantitatively evaluated electric field enhancement around some defects in Al_2O_3. Molecular dynamics simulation and ab initio calculation were employed to obtain atomic structure and dielectric constant of some microdefects. Consequently, thin intergranular phase of segregated Y^{3+} was figured out to enhance the electric field about 7.8 times as high as the average.

(ICACC-PB-008-2026) Determination of P-O-H(g) species stability in high temperature oxdiation environment

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$REPO_4$ are under investigation as candidate materials for environmental barrier coatings in high temperature steam environments due to their high thermochemical stability and chemical resistance. Under these conditions, depletion of an unknown phosphorus hydroxide (P-O-H(g)) species is expected. Use of the transpiration technique is planned to identify and characterize thermodynamic properties of the unknown P-O-H(g) species. Equilibrium two phase mixtures of RE oxyphosphates are needed to maintain a constant phosphorous chemical potential of reactants for these studies, however, phase equilibria in RE_2O_3-P_2O_5 systems are largely unknown. For example, yttrium oxyphosphate phases intermediate to YPO_4 and Y_2O_3, such as $Y_8P_2O_{17}$, $Y6P_4O_{19}$, and Y_3PO_7 are suggested from available Y_2O_3-P_2O_5 phase diagrams. However, their stability and formation at high temperatures remain experimentally unverified. This study investigates the formation and stability of intermediate RE oxyphosphate phases in the $REPO_4$-RE_2O_3 system using diffusion couple experiments.

(ICACC-PB-009-2026) Structural optimization of transport properties in artificial interfacial solids for high-ZT thermoelectrics

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Artificial Interfacial Solids (AIS), bulk-solid monolithic materials fabricated from purposefully engineered nanoparticle blocks are expected to possess decoupled thermal and electronic transport properties, thus alleviating some shortcomings of 'traditional' thermoelectric compounds, as reflected in improved efficiency for interconversion of thermal and electric energy. Here we present the results of mesoscale- and atomistic-level modeling of AIS thermoelectric properties, including their variation at grain boundaries and interfaces, with input from microstructure evaluation by electron microscopy. We aim to develop a predictive multiscale computational framework for the design of novel AIS-based thermoelectrics – by establishing connections between thermoelectric performance and geometrical descriptors, such as size, shape and orientation of the AIS nanoconstituents, characteristics and morphology of the interfacial regions connecting them, and other relevant materials-dependent parameters. Such materials could be employed for thermal energy recovery in a variety of applications, as well as improve the efficiency of solid-state thermoelectric generators (which are inherently quiet and vibration free power sources).

(ICACC-PB-010-2026) Synergistic approaches for improving antimicrobial activity of electrospun fibers

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Bacterial contamination represents a critical global concern, contributing significantly to the growing challenge of antimicrobial resistance (AMR). Silver nanoparticles (AgNPs) are well known for their strong antibacterial activity; however, their extensive use over the years has raised issues of reduced efficacy and potential resistance. To enhance their antibacterial performance, combining silver with other antibacterial agents has emerged as a promising strategy. Zinc oxide (ZnO), a semiconductor with both catalytic and antibacterial properties, can act synergistically with silver to amplify antimicrobial effects. In this work, poly(lactic-co-glycolic acid) (PLGA), a biodegradable and FDA-approved polymeric matrix, is employed to enable broader applicability and biocompatibility of these advanced nanocomposites. Three functionalization approaches are explored: (i) nanoparticle encapsulation, (ii) nanoparticle encapsulation combined with surface reduction, and (iii) nanoparticle encapsulation followed by plasma-enhanced chemical vapor deposition (PE-CVD) coating. These strategies aim to develop multifunctional antibacterial systems with enhanced stability, efficacy, and potential for application in biomedical and environmental fields.

(ICACC-PB-011-2026) Exploring fully flexible batteries: Material and morphology design of bendable electrodes

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Portable electronics, such as smartwatches, smart textiles, and implantable devices, pose increasing demands on mobility and miniaturization, two combined requirements that conventional batteries are limited to meet. Traditional battery technologies are rigid and can pose safety risks under mechanical deformation. This creates a clear need for novel battery concepts that are not only efficient and lightweight but also flexible and adaptable. Our work focuses on the development of flexible batteries by individually investigating bendable anode and cathode components. Fabrication techniques such as electrospinning and high-pressure filtration are employed to produce mechanically compliant and free-standing carbon-based electrodes. These are further modified at nanoscale using conductive coatings or active material layers, applied via gas-phase deposition methods, like plasma-enhanced chemical vapor deposition (PE-CVD) and autoclave reactions. The study seeks to improve the mechanical flexibility of intrinsically brittle materials while maintaining their electrochemical performance in battery applications.

(ICACC-PB-012-2026) Conjugated bronze/anatase/rutile TiO_2-carbon anodes engineered from titanium-based metal-organic frameworks for enhanced lithium-ion storage

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The growing demand for high-rate and durable lithium-ion batteries (LIBs) requires anodes with fast kinetics, high capacity, and stability. Titanium dioxide (TiO_2) is attractive due to its safe and stable structure but suffers from low conductivity and sluggish ion diffusion. Here, we report a multiphase TiO_2-carbon nanocomposite (BAR TiO_2) that integrates bronze (B), anatase (A), and rutile (R) phases, synthesized via a two-step pyrolysis of titanium-based metal-organic frameworks (Ti-MOFs). For Ti-MOFs synthesis, the surface potential and Ti-OH interactions were precisely tuned, and subsequent pyrolysis produced densely packed BAR interfaces embedded within a conductive carbon matrix. Benefiting from this architecture, the BAR anode delivers a reversible capacity of 391 mAh g^{-1} at 0.3 A g^{-1} and maintains 163 mAh g^{-1} after 9000 cycles at 10 A g^{-1}. The enhanced performance originates from the synergistic roles of each phase: TiO_2-R accelerates ion transport, nanoscale TiO_2-B contributes pseudocapacitive behavior, and TiO_2-A ensures structural stability. In addition, the MOF-derived carbon framework enhances conductivity and interfacial stability. These results demonstrate a rational design strategy that leverages MOF chemistry and multiphase TiO_2 integration, providing a viable route to high-performance anodes for next-generation LIBs.

(ICACC-PB-013-2026) Incorporation of partially pre-lithiated silicon anodes into Li-S all-solid-state batteries for dendrite suppression

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High-energy-density Li metal all-solid-state batteries suffer from dendrite formation, whereas pre-lithiated alloy-based anodes are promising alternatives owing to their high capacity and lithiophilic properties. Our previous work demonstrated that low-lithium-concentration Li_1Si forms a Li-depletion zone during initial dealloying, where alloying preferentially proceeds in Li-rich regions, as evidenced by increased capacity and reduced Li-ion diffusion resistance. Building on this observation, we prepared two-phase anodes composed of Li_xSi and unalloyed Si_y ($x = 2$ or 3.75; $y = 1$ or 0.62) to elucidate the alloying mechanism of residual silicon. Full cells were assembled using argyrodite electrolytes and sulfur composite cathodes. Specifically, in the $Li_{3.75}Si + Si_{0.62}$ system, residual silicon alloying suppressed volume expansion and voltage noise, leading to improved capacity retention. Voltage profiles and EIS were measured using both two-electrode and three-electrode systems. The phase transformation of residual silicon and Li-ion distribution at the anode surface were analyzed using XRD, XPS and TOF-SIMS. This work highlights that incorporating residual silicon into a two-phase anode offers an effective strategy to suppress degradation while enhancing the stability and electrochemical performance of high-lithium-concentration all-solid-state Li–S batteries.

(ICACC-PB-014-2026) Synthesis of metastable triphylite-type $NaMPO_4$ via laser-induced processing for cathodes in sodium-ion batteries

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Oxide-based all-solid-state sodium-ion batteries (Na-ASSBs) are promising next-generation energy storage systems owing to intrinsic safety and lower costs compared to lithium-ion batteries. Among candidate cathodes, $NaMPO_4$ offers high theoretical capacity (>150 mAh/g). However, its stable maricite-type structure lacks Na^+ diffusion pathways, resulting in poor electrochemical activity. In contrast, the triphylite-type structure, isostructural to $LiFePO_4$, provides a three-dimensional Na^+ conduction network but exists only as a metastable phase in $NaMPO_4$, usually obtained from undercooled melts or amorphous precursors. Here, we investigate crystallization in $NaNi_xMn_{1-x}PO_4$ solid solutions using localized melting and quenching by laser irradiation. Powders were synthesized by solid-state reaction, pelletized, and irradiated with a 1064 nm laser (3 W, 50 mm/s). X-ray diffraction revealed that $x=0–0.3$ retained maricite, whereas at $x=0.1$, which failed to form a single phase via conventional synthesis, laser heating (~1700°C) enabled homogeneous solid solution formation. For $x \geq 0.4$, partial conversion from maricite to metastable triphylite $NaMPO_4$ was observed. These results demonstrate that laser irradiation provides a versatile route to access metastable phases with enhanced Na^+ conductivity, offering opportunities for materials design beyond equilibrium synthesis.

(ICACC-PB-015-2026) Preparation and characterisation of $Na_{0.5}Bi_{0.5}Cu_3Ti_4O_{12}$ (NBCTO) for electrical applications

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Complex perovskite-related oxides in the $ACu_3Ti_4O_{12}$ family exhibit colossal low-frequency permittivity arising from internal barrier layer capacitance (IBLC). $Na_{0.5}Bi_{0.5}Cu_3Ti_4O_{12}$ (NBCTO), a lead-free member of this family with a body-centered cubic perovskite-related structure (Im-3), has been reported to combine giant dielectric constants with relatively stable temperature/frequency response, attributed to semiconducting grains separated by insulating grain boundaries (Maxwell–Wagner polarization). This thesis investigates the processing–structure–property relationships in NBCTO ceramics produced from ball-milled oxide powders and densified by rapid sintering, targeting controlled grain/GB architectures. Phase purity and lattice symmetry will be verified by powder X-ray diffraction (XRD), while microstructure (grain size, grain-boundary features) will be quantified via scanning electron microscopy (SEM). The dielectric permittivity (ε') and loss ($\tan \delta$) will be measured versus frequency and temperature; the Seebeck coefficient (S) will be profiled versus temperature to probe charge-transport mechanisms. For milled powders, particle-size distributions will be determined and related to sintering behavior and final dielectric performance.

(ICACC-PB-017-2026) Thin ceramic-coated polyolefin separators via water-based processing for enhanced battery energy density

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Enhancing battery energy density requires not only high-loading electrodes but also thinner and lighter components such as separators. However, reducing separator thickness often compromises mechanical strength and safety. In this work, a thin boehmite coated polyolefin (B/PO) separator was developed to address these challenges. By utilizing low-density boehmite ceramics in combination with water-based binders (PVA and PAA), a uniform coating layer of only ~4 μm on each side was achieved without significant weight penalty. This architecture not only reduces the separator thickness but also enhances its mechanical robustness. The B/PO separator exhibited excellent thermal resistance, showing less than 2% shrinkage at 150 °C, while maintaining comparable electrochemical performance to the uncoated polyolefin separator. When evaluated in NCM622//Graphite full cells under high-temperature cycling (60 °C), the B/PO separator delivered stable performance over 100 cycles, whereas the bare separator suffered from early failure within 50 cycles. These results highlight that thin, lightweight, and thermally stable ceramic-coated separators can simultaneously improve energy density and safety, making them highly attractive for practical high-energy battery applications.

(ICACC-PB-018-2026) Construction of a materials map using an autoencoder and development of a search method for ion conductive materials

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Introduction All-solid-state Li-ion batteries promise safety and high energy density, and thus fast Li ion conductive solid electrolytes are required urgently. However, it is challenging to identify materials with high ionic conductivity from the vast number of potential candidates. In this study, we employed an autoencoder to map the relationship between composition, structure, and ionic conductivity of known materials onto a two-dimensional space, thereby enabling an overview-based design of high ionic conductivity materials from various candidates. Methods We used 711 Li–O entries from the Materials Project and estimated ME using the Bond Valence Force Field (BVFF) method. Compositional and structural features were converted into histograms and compressed to one dimension with an autoencoder, producing a two-dimensional materials map. A neural network was then trained to predict ME across the map, highlighting low-ME regions. Finally, a diffusion-model-based generative AI, conditioned on these regions, was applied to generate new materials. Results and Discussion Both descriptor sets were accurately reconstructed by the autoencoder. The 2D predicted-ME map showed strong structural dependence, highlighted low-ME regions as discovery targets, and enabled strategic materials development through descriptor reconstruction and virtual material generation.

(ICACC-PB-019-2026) Geometry optimization of Al_2O_3 lift pins with weighted structures for mitigating carbon fouling in CVD reactors

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Al_2O_3 ceramic lift pins are widely used in semiconductor CVD reactors to support wafer loading and unloading operations. However, persistent carbon deposition on the pin surface, particularly at the weighted lower section, has been identified as a critical reliability issue. Due to insufficient purge gas penetration into the weight region, carbon fouling accumulates, leading to increased cleaning frequency, shortened component lifetime, and potential contamination risks. In this study, we propose a dual approach combining geometry optimization of the weighted structure and surface roughness control. First, vent holes were introduced into the weight to allow clean gas to flow directly through the lower region, thereby improving purge efficiency and reducing fouling hotspots. Second, the pin surface was engineered to minimize surface energy and further suppress carbon adhesion. Both experimental evaluation and computational fluid dynamics (CFD) simulations confirmed enhanced gas flow uniformity and a significant reduction in carbon buildup. The results demonstrate that the integration of vented weight design and surface finishing provides a practical pathway to extend component lifetime and ensure stable reactor performance. This study highlights the importance of geometry-driven gas distribution control in advanced ceramic components for semiconductor manufacturing.

(ICACC-PB-020-2026) Development of aluminum nitride (AlN) dispersion strengthened austenitic stainelss steel through powder metallurgy route

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This study demonstrates the development of a dispersion-strengthened austenitic stainless steel by incorporating ceramic dispersoids (AlN) into an austenitic steel matrix through the powder metallurgy route. Initially, Fe–2.3 wt.% Al powder was gas nitrided and subsequently mechanically alloyed by ball milling with 18 wt.% Cr and 8 wt.% Ni powders. The ball-milled powder batch was then consolidated by spark plasma sintering (SPS) at 950°C for 15 min under a holding pressure of 60 MPa. A homogeneous ferritic solid solution developed after 40 h of ball milling, which transformed into a metastable austenitic matrix after SPS. Interestingly, chromium nitride (Cr_2N) precipitation was also observed, suggesting partial dissociation of AlN. The resulting microstructure was characterized by ultrafine grains (~0.5 μm) with uniform nitride dispersion. This led to a remarkable increase in hardness (~650 HV). The study highlights the potential of SPS-assisted ceramic dispersion strengthening of austenitic stainless steels as a pathway for tailoring mechanical and functional properties in metallic matrices.

(ICACC-PB-022-2026) Effects of Al_2O_3 and MgO precursors on the development of 3D printed cordierite lattice structures by hybrid direct ink writing of silicone emulsions

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Cordierite-based porous ceramics are highly valued in many fields, including catalytic converters and particulate filters. The present work introduces a novel water-in-oil emulsion approach for the easy fabrication of highly porous cordierite lattice structures via 3D printing. Droplets of an aqueous solution, consisting of Al_2O_3 and MgO precursors in water, are homogeneously dispersed as an emulsion within an oily phase, consisting of a silicone/acrylate blend, with the help of a surfactant. The resulting pseudoplastic ink is successfully employed to fabricate reticulated structures, by direct ink writing, later stabilized by UV-curing. The choice of Al_2O_3 and MgO of precursors, in the form of hydrated salts or oxides nanoparticles, proved to directly affect the temperature required for cordierite formation and the mechanical integrity of the final ceramics. Therefore, the proposed study highlights the exceptional flexibility of the proposed emulsion-based approach in the production of cordierite ceramics with tailored phase purity and porosity. Furthermore, the possibility to adjust additional parameters (e.g. printing setup, curing conditions, geometry) allows for precise control over material properties, paving the way for further optimization and advanced developments

(ICACC-PB-023-2026) Integrated multiscale modeling and field validation of 193 nm UV induced compaction in amorphous silica optics for predictive wavefront error control *WITHDRAWN*

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This work develops an integrated computational–experimental framework that, within the 193 nm deep UV photolithography step of advanced semiconductor chip manufacturing, quantitatively links atomistic defect evolution and densification (compaction) in amorphous silica optics to fleet-level drift in a direction-specific degree of wavefront error (WFE). Machine learning-accelerated molecular dynamics (LAMMPS + MACE) runs over 10 million irradiation–recovery cycles to capture defect formation, ring reorganization, and volume contraction, defining an operational compaction index. The resulting compacted states are re-equilibrated and analysed with VASP DFT to obtain dielectric tensors and optical constants. A linear surrogate links compaction to the refractive index shift Δn, showing a monotonic drop from ~1.2× to 0.9× versus pristine silica. Field monitoring over 10 ArF immersion scanners shows direction-specific WFE increasing with runtime and dose, steepening beyond the elastic regime. Closing the loop (MD defect/density → DFT optical response → scanner-level WFE) provides thresholds for anomaly detection, predictive maintenance, and calibration. The framework extends to UV-exposed optical ceramics and composites for reliability-aware design under coupled loads.

(ICACC-PB-024-2026) A style transfer DNN and algorithmic simulation approach for generating SEM images of polycrystals to train segmentation networks

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In recent years, deep learning has been effective at recognizing microstructures in SEM images of polycrystals. However, such images vary greatly in microstructure and texture due to differences in raw materials, manufacturing methods, and imaging conditions. Models trained on a single or limited dataset often show reduced accuracy when applied to specimens from different conditions. Addressing this usually requires retraining on a dataset tailored to the target specimen, but creating such datasets demands extensive manual annotation. Here, we propose a system combining simulation and deep learning to automatically generate SEM image datasets with customizable characteristics. Specifically, we present an algorithmic method that produces simulated microstructures from statistical distributions, avoiding governing equation–based grain growth simulations and enabling SEM images with arbitrary microstructures. To add arbitrary textures, an image generation model converts simulated microstructures into synthetic SEM images. By leveraging these paired images as training data, deep learning models for automatic microstructure recognition can be developed without annotation. This presentation is based on results obtained from a project, JPNP22005, commissioned by the New Energy and Industrial Technology Development Organization (NEDO).

(ICACC-PB-025-2026) Innovative synthesis of solid solution MAX phase $(Nb_xTi_{1-x})_3AlC_2$

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The rapid expansion of MAX phase compositions over the past 15 years has been driven by the need to broaden the chemical space and functionality of their MXene derivatives. Despite this progress, 312 MAX phases remain comparatively limited in compositional diversity compared to their 211 counterparts. For example, while Nb_2AlC (211) and Nb_4AlC_3 (413) are stable, the intermediate Nb_3AlC_2 (312) phase is unstable under ambient conditions. Solid solutions provide a pathway to stabilize otherwise inaccessible 312 MAX phases, yet conventional synthesis methods using elemental powders remain challenging due to the formation of competing phases and the need for extensive optimization. In this work, we introduce an alternative approach that employs end-member MAX phases as precursors. By combining Ti_3AlC_2 with Nb_2AlC and Nb_4AlC_3, we synthesized $(Nb_xTi_{1-x})_3AlC_2$ solid solutions, established the Nb solubility limit, and produced the corresponding MXenes. This strategy offers a more efficient route for solid-solution MAX phases and MXenes, enabling accelerated recipe discovery.

(ICACC-PB-026-2026) Sintering optimization and grain size evaluation of additively manufactured SiC for nuclear applications

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Silicon carbide (SiC) is a promising structural material for advanced nuclear reactors owing to its thermal conductivity, high-temperature strength, and neutron-irradiation resistance. Additive manufacturing (AM) offers design flexibility and cost benefits. However, impurities or sintering aids in commercial SiC can cause irradiation-induced instability and degrade neutron economy. Realizing complex, high-purity SiC by AM requires (1) complete debinding to avoid contamination and (2) densification by pressureless sintering under a controlled atmosphere. Accordingly, debinding and sintering parameters were systematically optimized to establish conditions for dense, high-purity SiC. Combination of chemical and thermal debinding processes, with an upper temperature of 650 °C under flowing nitrogen, was identified, enabling complete binder removal and providing high-purity green bodies for subsequent processing. Then, the present work focuses on sintering, which controls densification, grain growth, and microstructural stability, using pressureless sintering up to 2200 °C in argon. This study examines the effects of sintering parameters on grain size, porosity, and overall integrity. Microscopic characterization and etched surface analyses were used to quantify grain size distributions. The results demonstrate how sintering conditions refine the microstructure of AM SiC.

(ICACC-PB-028-2026) In situ transmission electron microscope mechanical testing for ultrahigh temperature ceramics

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Reliable mechanical testing at ultrahigh temperatures (>2000 °C) remains a major challenge in materials science, despite decades of focused research. Recent work by Dillon and collaborators introduced a novel platform that integrates in situ transmission electron microscopy (TEM) with localized laser heating and nanomechanical loading, enabling high-precision testing of materials at extreme temperatures. Building on this approach, the present study demonstrates in situ microscale fracture toughness measurements of high entropy ceramics using TEM-based mechanical testing. The results highlight the technique's potential for probing deformation and failure mechanisms at small scales, offering a new pathway for evaluating the mechanical reliability of advanced structural ceramics.

(ICACC-PB-029-2026) Development of superhard high-entropy carbide and carbonitrides for extreme environments via FAST sintering

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High-entropy ceramics (HECs), including high-entropy carbides and carbonitrides (HEC/HECNs), are promising candidates for structural applications in extreme environments due to their remarkable thermal stability, chemical inertness, and mechanical robustness. Traditional materials often degrade at higher temperatures (>1200°C) through phase instability or mechanical softening. Several compositions of HECs and HECNs offer favorable alternatives due to entropy stabilized structures retaining their hardness under extreme conditions. Ideal HEC/HECN systems form single-phase solid solutions which can undergo spinodal decomposition when under thermal treatment. This decomposition can result in nanoscale compositional barriers hindering dislocation motion and enhancing hardness. The inherent compositional flexibility of HEC/HECNs enables the fine-tuning of physical and chemical properties to meet specific performance criteria. By systematically varying elemental constituents, it is possible to design materials with targeted thermal, chemical, and mechanical behaviors, surpassing the performance of conventional ceramics and metals in similar conditions.

(ICACC-PB-030-2026) Development and performance of Nb–Ni bonded polycrystalline CBN composites sintered under high pressure and temperature

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Cubic boron nitride (CBN) is the second hardest known material after synthetic diamond and is classified as an advanced ceramic. In this study, polycrystalline CBN (PCBN) composites were developed using a novel Nb–Ni metallic binder to enhance densification and mechanical performance under high-pressure, high-temperature (HPHT) sintering conditions. Samples were processed at 7.7 GPa and 1500–1900 °C for 3 min to prevent the transformation of CBN into its hexagonal phase (hBN). Microstructural observations using scanning electron and confocal laser microscopy revealed dense and well-bonded structures with minimal porosity. X-ray diffraction confirmed phase purity and stability of CBN after sintering. Machining tests conducted according to ISO 3685 using SAE 4140 steel demonstrated improved flank wear resistance and surface finish compared with conventional metallic binders. The Nb–Ni system promoted strong diffusion bonding and thermal stability due to its high melting point, low thermal expansion coefficient, and good compatibility with CBN. These results indicate that niobium is a promising binder for the production of PCBN cutting tools, enabling enhanced wear resistance and performance under severe conditions.

(ICACC-PB-031-2026) Gas adsorption performance of CO_2 adsorbents after accelerated durability tests with flue gas impurities

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To achieve carbon neutrality, it is essential to capture CO_2 from diverse emission sources and the atmosphere. Toward 2050, the proportion of CO_2 separation and recovery from post-combustion flue gases containing low CO_2 concentrations is expected to increase. In addition to CO_2 and N_2, such flue gases contain impurities including O_2, water vapor, and acidic gases such as NOx and SOx. These impurities are known to degrade CO_2 adsorbents, making durability evaluation critical for their practical application. In this study, we performed accelerated durability tests by exposing two representative adsorbents—zeolite 13X (a physical adsorbent) and polyethyleneimine-impregnated silica gel (a chemical adsorbent)—to simulated flue gas impurities. We then evaluated their gas adsorption performance and report the results obtained under these conditions.

(ICACC-PB-032-2026) Interparticle forces behind plasticity of ceramic pastes

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Plastic forming methods of ceramic pastes, such as extrusion, have been significant in the ceramics industry for many years. Despite its significance, the plasticity of ceramic pastes is poorly understood. It is essential to understand the fundamentals of ceramic paste plasticity to develop a forming technology with superior performance. The ceramic pastes' plasticity can be characterized by the co-existence of apparently opposing properties, i.e., "flowability" and "rigidity". It has been claimed that the apparently opposing properties can be achieved by controlling the interparticle interaction that is attractive at long-range and repulsive at short-range. In the present study, we aimed to verify the model based on experimental results from interaction force measurements. The interaction forces are gathered by the atomic force microscope (AFM) colloid probe technique. Based on the discussion, it is concluded that the above microscopic model avails to interpret ceramic pastes' macroscopic behaviors.

(ICACC-PB-033-2026) Electric field-assisted joining of TaC -SiC ceramics without fillers using spark plasma sintering: Influence of SiC content

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The use of ultra-high-temperature ceramics needs effective joining techniques in order to handle the constraints of producing complex shaped components. This study investigates a unique technique for effectively bonding identical pre-sintered highly dense TaC-SiC ceramics composites with (0 and 35 vol% SiC) without filler material using spark plasma sintering. Strongly bonded interface produced with no visible cracks or porosity at the junction. The composite containing 35vol% SiC has higher shear-strength of joints of 120 MPa due to the development of the in-situ intermetallic compound tantalum silicide (Ta_3Si). Furthermore, heating the joints at 800°C demonstrated that monolithic TaC has a larger mass gain, but a protective passive oxide layer of SiO_2 on the composite limits further oxidation, resulting in a reduced mass gain and less cracking/spalling. This study demonstrates the potential of spark plasma sintering to join TaC-SiC composites without filler, and the beneficial effect of SiC addition to obtain strong and oxidation-resistant joints for thermal protection system applications.

(ICACC-PB-034-2026) Classification of fatigue damage in carbon fiber reinforced plastics laminates using acoustic emission technique

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Fatigue damage in carbon fiber reinforced plastics (CFRP) is very complicated. The acoustic emission (AE) technique utilizes the phenomenon called AE, in which elastic energy is released and ultrasonic waves are generated when the structural member is deformed or cracked. It enables real-time damage monitoring. However, the relationship between AE and damage has not yet been clarified, and further research is needed. In this study, CFRP specimens with a lamination configuration of $[0/90]_s$ were subjected to tensile and fatigue tests. AE waves were measured and damage observations were conducted to investigate the correspondence between damage mechanisms and AE waves after cyclic loading. The results showed that AE waves around 90, 300-530, and 700-860 kHz might correspond to transverse cracking, delamination, and fiber fracture, respectively. It was also found that the residual strength and stiffness of fatigue-damaged specimens decreased, and that damage

progressed intermittently from low stress loading, leading to eventual fracture.

(ICACC-PB-035-2026) Predicting stiffness reduction in fiber-reinforced composites with matrix cracks: A data-driven approach integrating experiments and modeling

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Fiber-reinforced plastics are extensively applied in aerospace, automotive, and marine structures owing to their superior strength-to-weight ratio and durability. Matrix cracking is a dominant damage mechanism that leads to stiffness reduction and residual strain, particularly in laminates with off-axis plies. Traditional analytical, numerical, and experimental methods for quantifying such degradation are constrained by simplifying assumptions, high computational costs, or time-intensive procedures. In this study, a data-driven framework is developed that integrates experimental and analytical datasets to predict stiffness reduction in fiber-reinforced composites. The experimental dataset incorporates image-based analysis of crack density, providing quantitative measures of damage evolution, while finite element–based analytical results complement these observations with theoretical predictions. Random Forest and LightGBM regression models are trained and evaluated to capture the nonlinear relationships governing stiffness loss and residual strain accumulation. The results demonstrate the potential of machine learning to effectively combine image-derived crack density and analytical modeling, enabling accurate and efficient prediction of mechanical degradation in fiber-reinforced composite laminates.

(ICACC-PB-036-2026) Effect of stacking sequences on the low-velocity impact response of composite overwrapped pressure vessels

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One of the major challenges in maintaining the structural integrity of composite overwrapped pressure vessels (COPVs) is their susceptibility to low-velocity impact damage. This study investigates the effect of stacking sequences on the low-velocity impact response of COPVs through both numerical simulations and experimental tests. A multi-stacked shell finite element model with cohesive zone elements was developed and validated against drop-weight impact experiments, showing good agreement in force–time histories and damage patterns. The results reveal that stacking sequences combining hoop and helical layers tend to experience more severe delamination due to high interlaminar shear stresses, while certain layups provide superior impact resistance. Furthermore, the energy absorbed during impact was found to correlate well with the extent of material damage, offering a reliable indicator for residual strength evaluation. Overall, the findings highlight the critical role of stacking sequence design in enhancing the impact resistance and structural reliability of COPVs.

(ICACC-PB-037-2026) Evaluation of vibrational properties of polymer materials by molecular dynamics simulation

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The viscoelastic properties of polymeric materials are strongly dependent on both temperature and frequency. While the frequency–temperature superposition principle (TTSP) has been widely confirmed in experimental rheology, its molecular-scale validity has not yet been clarified. In this study, molecular dynamics (MD) simulations were performed to investigate the frequency and temperature dependence of isotactic polypropylene. Cyclic tensile deformation was applied in the GHz frequency range under different thermal conditions, and the corresponding stress–strain responses were analyzed. The results revealed a distinct phase lag between strain and stress, leading to the identification of hysteresis behavior. From these responses, the storage modulus (E') and loss tangent ($\tan\delta$) were evaluated. The values of $\tan\delta$ were found to increase with both frequency and temperature, and their magnitude was consistent with typical experimental ranges, confirming the reliability of the method. Although the E' showed slightly higher values compared with macroscopic experiments, the frequency dependence supported its physical validity. Consequently, the simulations reproduced the vibrational behavior of polypropylene and allowed the evaluation of viscoelastic parameters such as storage modulus and loss tangent.

(ICACC-PB-038-2026) Evaluation of the effect of cellulose fiber on the mechanical properties of wood plastic composites

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Wood plastic composites have gained considerable attention as environmentally friendly reinforcement materials. These composites are classified into two types based on the thickness of the wood fibers: cellulose nanofiber (CNF) composites and microfibrillated cellulose (MFC) composites. In this study, the mechanical properties of these composites, with polypropylene (PP) as the matrix resin, were evaluated. The results of tensile testing indicated that tensile strength increased with a higher fiber volume fraction. Fracture surface analysis revealed that CNF composites exhibited brittle fracture characteristics, whereas MFC composites demonstrated ductile fracture behavior. These findings suggest that the fiber network structure in CNF composites has a significant impact on their mechanical properties, while the fiber network structure appears to have minimal effect on the mechanical characteristics of MFC composites.

(ICACC-PB-039-2026) Effects of molding conditions on mechanical properties of unidirectional CFRP preforms

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Carbon fiber reinforced thermoplastics (CFRTPs) have attracted significant attention due to their recyclability and short molding time. Despite these advantages, their applications remain limited because maintaining consistent quality is challenging. In particular, molding conditions strongly influence the mechanical properties of CFRTPs, as the crystallization behavior of semicrystalline thermoplastics used as matrices varies with processing conditions. This study aimed to characterize the mechanical properties of CFRTP laminates fabricated from unidirectional preforms under different molding conditions. The preforms consisted of commingled yarns of carbon and polyamide fibers, produced using fiber tow spreading–commingling technology. These yarns facilitated resin impregnation while retaining formability for complex shapes. Unidirectional CFRTP laminates were molded at different maximum temperatures, and their mechanical properties, such as bending modulus and strength, were evaluated. Finally, the mechanisms governing bending behavior under different manufacturing conditions were discussed based on the experimental results.

(ICACC-PB-040-2026) Molecular dynamics of weak bonds in CFRP adhesive joints

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In adhesive joints utilizing carbon fiber reinforced plastics, inadequate adhesion may arise due to contamination at the bond line that leads to weak bonding. The mechanisms underlying weak bonds were examined through molecular dynamics simulations. Models representing weak bonds were developed by introducing contaminants, specifically water, xylene, and silicone molecules, into two types of epoxy systems. Mechanical properties of these weak bond models were assessed using tensile and shear analyses. The findings demonstrated that contaminant addition diminished model strength, with stress concentrations appearing at the bond line due to the presence of these molecules. To further interpret these results, evaluations of density and free-volume distributions were conducted. It was observed that the molecular size of each contaminant influenced its distribution within the epoxy matrix, thereby impacting the mechanical characteristics of the material.

(ICACC-PB-042-2026) Dual-channel phonon transport in two-dimensional materials with low thermal conductivity

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The approach of solving the Boltzmann transport equation (BTE) is widely used to evaluate the thermal conductivity and screen low thermal conductivity materials for thermoelectric applications, where phonon transport is approximated as particlelike propagation. Phonon transport through a wavelike tunneling channel, as described by the Wigner transport equation (WTE), will have a notable effect in some two-dimensional (2D) materials due to the parabolic out-of-plane acoustic modes and lower phonon energy, which is usually neglected, inducing an underestimation of thermal conductivity. Here, we investigate the phonon transport of four representative 2D structures by the WTE approach. Both the low-symmetry unit cell with heavy atoms and the strong anharmonicity will lead to a higher contribution from the tunneling channel. The total lattice thermal conductivity of low-symmetry KAgSe is only 0.34 $Wm^{-1}K^{-1}$ at 800 K, of which 26% is contributed by the wavelike tunneling. The strong lattice anharmonicity of 2D InSe with lone-pair electrons induces wide phonon linewidths for both acoustic and optical phonon modes, suppressing the conductivity through particlelike propagation channel. The coherence conductivity through wavelike tunneling accounts for 58% of the total one at 800 K. Our work helps to gain a better understanding of the dual-channel phonon transport in complex 2D structures.

(ICACC-PB-043-2026) Spectroscopic analysis of hydroxyapatite and its application to diagnostic techniques in hereditary tooth/skeletal dysplasia

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Hydroxyapatite, the main component of hard tissues such as bones and teeth, is known to change the apatite crystal structure and collagen orientation in hard tissue diseases such as dental caries and osteoporosis. If this process could be measured and artificially controlled, it would contribute greatly to the diagnosis of hard tissue diseases and the regeneration of bones and teeth. Furthermore, spectroscopic analysis of deciduous teeth from hypophosphatasia (HPP) patients and femora from a HPP model revealed that the crystallinity of biological apatite is reduced in HPP. It has been suggested that hydroxyapatite crystallinity could be a biomarker for HPP, and monitoring apatite crystallinity using spectroscopic analysis is expected to contribute to the development of diagnostic techniques and therapeutic drugs for HPP.

(ICACC-PB-044-2026) Composite of cross-linked nanogel and directly converted osteoblasts enhance bone regeneration

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Bone resorptive disease decrease patient's QOL. The osteoblasts play central roles in bone formation. Providing osteoblasts with a desirable scaffold leads effective bone regeneration therapy. Direct conversion into osteoblasts from somatic cells is promising strategy to supply functional cells. Therefore, we newly developed Fibronectin coated Cross-linked-Porous Freeze-Dried Nanogel (Fib-Clip-FD nanogel) as a scaffold, induced osteoblasts from fibroblasts by direct conversion on it, and evaluated the osteogenic-response. Acryloyl group modified cholesterol-bearing pullulan was cross-linked by PEGSH. Followed by freeze-drying, converted it into porous cross-linked nanogel, which was then coated with fibronectin. At first, we checked cell adhesion on the Fib-Clip-FD nanogel. Next, we attempted 3D direct conversion of human fibroblasts into osteoblasts (dOBs) on it. We investigated the ontogenetic characters of the complex of Fib-Clip-FD nanogel and dOBs (Fib-Clip-FD nanogel/dOBs composite) in vitro and in vivo. The cells attached and proliferated on the Fib-Clip-FD nanogel. Osteoblast-specific genes were highly expressed, and calcified bone matrix was produced in the composite. Furthermore, the mice transplanted the composite showed significant bone regeneration. Taken together, Fib-Clip-FD nanogel/dOBs composite could be an effective bone regeneration therapy.

(ICACC-PB-045-2026) Sustainable composite nanocoatings for antimicrobial/antiviral protection for several applications

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The COVID-19 pandemic has highlighted the urgent need for innovative materials to reduce the spread of airborne pathogens in public, clinical, and industrial environments. The European NANOBLOC project addresses this challenge by exploring multiple sustainable synthesis methods for antimicrobial coatings, evaluating their efficacy across different substrates and application contexts. These coatings are designed to ensure long-term durability and environmental safety. Within this framework, the Politecnico di Torino, leading the project, has focused its research on the co-sputtering technique to develop nanostructured composite coatings with embedded silver nanoclusters in glass or ceramic matrices, to inhibit bacterial growth and reduce viral vitality, including influenza and coronavirus strains. The coatings are tested through inhibition halo assays, CFU counts, and ion release monitoring on several materials. The co-sputtering process is scalable and energy-efficient, validated through industrial collaborations for large-scale implementation. This approach combines biocidal efficacy, material resilience, and sustainable production, offering a promising solution for health protection in diverse environments.

(ICACC-PB-046-2026) A green wall concept: Micro- and nanoparticles for enabling algae growth on concretes

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As urbanization reduces green spaces, vertical gardens offer thermal insulation, noise reduction, pollutant absorption, and wildlife support. A key challenge is maintaining a consistent nutrient supply without environmental harm such as groundwater contamination. Nanofertilizers, using nanomaterials as nutrient carriers, provide a sustainable alternative by enhancing absorption and reducing runoff, crucial in urban areas with low soil capacity and high surface runoff. Our reserch presents a novel approach of integrating plant material directly into the structure without soil. We investigated nanofertilizers containing calcium, phosphorus, silicon, and zinc on the growth of Zygnema circumcarinatum, a model plant, as well as higher plants on concrete blocks. Results show nanofertilizers ensured better retention, extended release, and reduced loss compared to water-soluble fertilizers, which caused early dilution and nutrient imbalance. Material choice remains critical to avoid compromising structural stability and safety.

(ICACC-PB-048-2026) Electrostatics and chemistry combination divalent cobalt ions and alkali treated MXene for high performance lithium ion batteries

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In order to break through the drawback of low capacity of graphite as anode material for lithium-ion batteries (LIBs), the development of novel electrode materials is crucial for high-performance LIBs. Recently, MXene with two-dimensional nanosheets structure has attracted extensive attention due to its numerous exposed lithium storage sites and shortened transport paths as well as superior conductivity. Here, the Co doped MXene (Co@MXene) composites-based anode for LIBs were prepared using alkali treated MXene matrix and Co ions through electrostatic adsorption under relatively mild conditions, delivering excellent reversible capacity (1283.2 mA h g^{-1} at 0.1 A g^{-1} after 120 cycles) and long-term stability (349.4 mA h g^{-1} at 1 A g^{-1} after 1000 cycles). Impressively, the preparation of anodes in simple method and under moderate operating conditions is superior to the conventional preparation approach, which facilitates practical applications. This work provides ideas for the design of advanced LIBs anode materials with quick reaction kinetics, presenting tremendous potentials in electrochemical energy storage applications.

(ICACC-PB-049-2026) High-temperature dielectric properties characterization: A cornerstone for microwave-assisted process design and modelling

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The efficiency of the microwave (MW) processing is strictly related to the dielectric properties of the involved materials. This is particularly true for those processes involving ceramic materials and high temperatures. This contribution describes the technique developed at the Istituto per i Processi Chimico-Fisici-CNR (IPCF-CNR) to determine the dielectric permittivity of samples at 2.45 GHz and temperatures up to 1200 °C. It also provides a demonstration of the optimization of the MW irradiation in a typical MW-CVI of SiCf/SiC composites. Typical dielectric values obtained for SiCf/SiC ceramic matrix composites with a different densification degree will be shown, evidencing a strong dependence - up to a factor 4 - of the dielectric permittivity components on both temperature and density. On the basis of the dielectric data, a comprehensive multiphysics numerical modelling was developed. The main results of the modeling in terms of energy efficiency and temperature distribution will be discussed, demonstrating how this information can be employed to improve the MW heating of the sample and the efficiency of the process. In conclusion, the knowledge of the dielectric properties of the material to process represents, together with rigorous numerical modeling, a key factor in the design, setup, and optimization of the MW-assisted processes.

(ICACC-PB-051-2026) Comparative study of porous ceramics shaped by freeze tape casting

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The present work is focused on the microstructural characterization of clay-based ceramics manufactured by freeze tape casting. To achieve this, two raw clays were selected; H (halloysite) and K (kaolinite). These clays were chosen because of their abundance and their beneficial properties. They exhibited a monomodal and bimodal distribution respectively and were used to prepare two slurries. The slurries were shaped by freeze tape casting (FTC) and sintered at 1100 °C and 1200 °C. SEM observations revealed a difference in microstructure and texture. We observed that the microstructure and pore morphology partly depend on the type of clay minerals present in the material. In fact, all ceramic disks displayed distinct microstructural differences in their raw state. After sintering, however, only minor differences were found between ceramic disks sintered at 1100 °C and those sintered at 1200 °C. In FTC-K ceramic disks (sintered at both 1100 °C and 1200 °C), the flattened pores appeared more textured in cross-section, and these ceramics contained a larger number of pores compared to the FTC-H disks. This behavior suggests that the stacking of kaolinite platelets does not produce the same interactions as spheroidal or tubular halloysite particles, leading to different microstructural features.

(ICACC-PB-052-2026) SiC-SiC CMCs & graphite in nuclear reactors: Rules in ASME BPV Code Sec. III, Div. 5 for Nonmetallics - 2027 Edition Proposed Revisions

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US DOE is supporting use SiC-SiC CMCs and graphite to enhance fuel performance and improve accident tolerance in high-temperature reactors (HTRs) because these materials are tolerant to the relevant irradiation and chemical environments. Because SiC-SiC CMCs and graphite are nonconventional materials, they are of special concern because the mission of the US Nuclear Regulatory Commission (NRC) is to license and regulate the nation's civilian nuclear reactors, reactor designs and reactor materials. NRC is legally required to use consensus codes and standards as integral parts of the regulatory process. Therefore, the ASME Boiler and Pressure Vessel (BPV) Code Section III "Rules for Construction of Nuclear Components" (including accepted materials) is included in the NRC regulations. Division 5 on HTRs of Section III has supported a working group on graphite and ceramic composites since 2008. For SiC-SiC CMCs to be incorporated into future HTRs, they must be included in ASME BPV Code as acceptable materials. A progress update is provided on proposed revisions for the 2027 edition of Design and Construction Rules in ASME BPV Code that specifically address use of graphite and SiC-SiC CMCs in core and core components.

(ICACC-PB-053-2026) Evaluating mechanical performance and optimizing ratios for rice hull ash and cement in shotcrete

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Rice hull ash (RHA), a renewable agricultural by-product obtained from rice hulls—which constitute approximately 20% of the weight of harvested rice grains—is rich in amorphous silica and exhibits strong pozzolanic properties. Due to its chemical composition, RHA presents significant potential as a partial replacement for cement in shotcrete applications for the mining industry. This study investigates the mechanical performance of shotcrete incorporating RHA at replacement levels of 0%, 5%, 10%, 15%, and 20% by weight of Type-1T ternary blended cement. The results indicate that a 10% RHA replacement yields the highest compressive strength at 39.54 MPa, while a 5% replacement provides the highest flexural strength at 5.90 MPa. However, workability was observed to decline substantially at replacement levels exceeding 20%. A desirability analysis using Response Surface Methodology (RSM) determined the most optimal RHA replacement level at 5.33%, balancing compressive strength, flexural strength, and workability in accordance with industry standards. These findings highlight the viability of RHA as a sustainable and effective alternative for partial cement replacement in shotcrete, contributing to both performance enhancement and environmental sustainability.

(ICACC-PB-054-2026) A simulation-based 4D-STEM workflow for ptychographic analysis of high entropy ceramics

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High Entropy Ceramics (HECs) exhibit remarkable properties, but understanding their atomic-scale structure-property relationships remains a significant challenge. Four-dimensional scanning transmission electron microscopy (4D-STEM) combined with ptychography offers a pathway to map local strain and chemical disorder with high precision. However, the accuracy of these reconstructions is highly sensitive to experimental parameters and sample conditions. This work presents a complete simulation-to-reconstruction workflow to investigate and optimize 4D-STEM ptychography for HECs. Using the abTEM simulation package, we generated realistic 4D-STEM datasets for a model high entropy boride, $(Hf,Na,Ta,Ti,V)B_2$. The simulations systematically explore the influence of key experimental variables, including probe convergence angle, electron dose, and the effect of thermal vibrations via the frozen phonon model. The simulated datasets were then processed using the py4DSTEM library to perform ptychographic phase reconstruction. By comparing the reconstructions against the known ground-truth potentials, we quantify the impact of thermal diffuse scattering and noise on image fidelity. This workflow provides a critical framework for optimizing experimental design and validating reconstruction algorithms, ultimately enabling more accurate quantitative analysis of complex ceramic materials.

(ICACC-PB-055-2026) Microwave-Absorbing Metal Oxides and Their Application to CO_2 Conversion Catalysis

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With the increasing importance of electrification-based process technologies, the industrial demand for microwave (MW) heating applications—such as catalyst synthesis, reaction processes, and drying—continues to rise. While carbon-based materials and SiC exhibit excellent microwave absorption and heating capabilities, conventional metal oxide materials demonstrate inherently low MW absorption, limiting their applicability in MW-driven catalytic processes. In this study, we propose a synthesis strategy for metal oxides with significantly enhanced MW heating performance. By introducing specific metal dopants into reducible supports (CeO_2, TiO_2 and ZrO_2) followed by reduction treatment, a mixed oxide phase was formed between the dopant and the host oxide lattice. This newly generated mixed oxide induces pronounced lattice distortion and interfacial polarization, thereby markedly improving MW absorption capability. The developed MW-absorbing metal oxide supports were subsequently impregnated with Ni and evaluated for the dry reforming of methane (DRM). The catalysts exhibited stable MW-induced heating behavior and excellent catalytic activity even under harsh high temperature and redox reaction conditions.

(ICACC-PB-056-2026) Influence of pFIB delayering conditions on surface contamination and PVC sensitivity in SEM for semiconductor pFA

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Plasma Focused Ion Beam (pFIB) delayering is widely used for large-area physical failure analysis (pFA) in semiconductor devices, but the process can introduce surface contamination that degrades passive voltage contrast (PVC) imaging in scanning electron microscopy (SEM). Surface carbon-rich deposits are known to reduce PVC contrast, while oxygen plasma cleaning can restore imaging performance. In this work, pFIB operating parameters were systematically varied to investigate their effect on contamination and subsequent SEM imaging quality. Low-voltage pFIB delayering produced significantly higher surface contamination compared to high-voltage conditions. SEM observations further revealed that contamination behavior depends critically on the beam interaction mode. Continuous scanning led to accumulation of contamination and reduced image sharpness, whereas static beam irradiation resulted in localized brightening resembling charging effects. These findings elucidate the contamination mechanisms during pFIB delayering and underscore the importance of optimizing both milling and imaging conditions to preserve PVC sensitivity and enable reliable surface characterization for failure analysis.

(ICACC-PB-057-2026) Growth of vertically aligned BaTiO3 nanowire arrays on flexible substrates for piezoelectric energy harvesting

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One of the main challenges in the development of microelectronic systems used in technologies such as Internet of Things and 5G is providing them with a reliable and sustainable power source. Traditional batteries are heavy and require frequent charging, which limits their use in small and portable devices. Piezoelectric nanogenerators (PENGs), which can convert body movements into electricity, offer a promising alternative for powering these systems. In this study, lead-free BaTiO3 nanowires with high piezoelectric properties were vertically grown on flexible and conductive titanium foil using two step hydrothermal synthesis method. Each step of the process was optimized, and a uniform layer of nanowires with high aspect ratio over 100 was obtained. Afterwards, sandwich-like PENG modules were produced using vertically aligned BaTiO3 nanowires on flexible and conductive substrates, and electrical analyses were performed. Atomic Force Microscopy analysis results showed that a single nanowire could produce about 0.50 mV of voltage. The 1×1 cm2 BaTiO3 based PENGs generated up to 7.4 V open-circuit voltage and 9.2 µA short-circuit current, demonstrating their potential for powering small electronic devices.

(ICACC-PB-058-2026) Effect of the mixing fraction of dispersants with different molecular weights on the flow characteristics of non-aqueous silica slurries

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The particle concentration of slurries increases over time during ceramic shaping and drying operations. Therefore, understanding the flow characteristics of slurries as a function of particle concentration, is vital for achieving high-performance ceramic fabrication. We have previously investigated the effect of comb-type polymer dispersants, systematically designed with controlled repeating unit numbers and side chain length, on the flow properties of titania/aqueous slurries across a range of particle concentrations. Our findings demonstrated that the dispersion behavior of the slurries can be rationalized in terms of the apparent adsorption layer thickness of the polymer dispersant and the average particle-to-particle distance. However, it remains unclear whether similar systematization and analysis can be applied to other slurry systems that employ general-purpose polymer dispersants with different molecular weights. Herein, we focus on the flowing behavior of silica/butyl carbitol slurries stabilized by mixed polyethyleneimine (PEI) having different average molecular weights. We will clarify how the mixing ratio of PEI having different molecular weights affects the apparent adsorption layer thickness and the particle concentration dependent flowing behaviors.

(ICACC-PB-059-2026) Correlation of apparent thermal conductivity with specific surface area and relative density of a sintering alumina

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The observed changes in apparent thermal conductivity (κapp) of an alumina powder undergoing sintering during heating are explored in parallel with measured reductions in the specific surface area (SSA) and increases in relative density (ρRD) as a function of temperature. The κapp was measured at room temperature after exposure to numerous temperatures with the onset of sintering causing reductions in the SSA, indicative of mass transport activity (e.g., neck formation and its growth), and increasing ρRD. Different forming methods (vibration, pressing, and dispersion) were used to explore if and how the initial compact density (i.e., ρ0 and the initial pore size distribution) affected responses of κapp, SSA, and ρRD. As the forming methods dictate the initial pore size distribution and subsequently initial compact density (ρ0) the trajectory of the SSA reduction represents a pseudo connectivity change with respect to heat treatment and is independent of the forming method, but dependent on the initial powder characteristics. A model was developed that portrays the trajectory that binds SSA, ρRD, and κapp as a function of temperature and time for an alumina but that is extendable to other ceramics too that begin to sinter during their heating.

(ICACC-PB-060-2026) Empowering the next generation of ceramic leaders: The mission and impact of the PCSA

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1. Texas A&M University, Materials Science and Engineering (MSEN), USA
2. Pennsylvania State University, Material Science and Engineering, USA
3. Texas A&M University, Materials Science and Engineering, USA
4. University of California Davis, Materials Science and Engineering, USA
5. Ceramic and Glass Industry Foundation, USA

The mission of the PCSA is to engage students as active, long-term leaders in the ceramics community and to strengthen their continued participation in the American Ceramic Society at local, national, and international levels. PCSA provides valuable access to professional opportunities, including travel, internships, and fellowships, for undergraduate and graduate students, which are essential for their academic and personal development. Organized into five committees, the PCSA offers students the opportunity to contribute to initiatives focused on delegate recruitment, professional development, educational outreach, communications, conference programming, and student competitions. A core part of PCSA is ensuring that students are engaged within the materials science fields across the university system, both domestically and worldwide, spanning ACerS divisions, sections, and chapters. By bridging students with ACerS leadership, industry partners, and prominent researchers, we help build a strong pipeline of future leaders prepared to contribute to the advancement of ceramics and materials science and to fill an age gap in the ceramic and glass workforce. Internationally, the PCSA is committed to broadening and strengthening the global ceramics community by welcoming numerous international delegates each year, fostering cross-cultural collaboration, and expanding the Society's global reach.

(ICACC-PB-061-2026) Modifying pore structure in bisque-fired kaolin membranes for hydrogen production and gas separation

O. Olaleye*[1]; S. Ricote[2]; G. Coors[5]; A. Staerz[3]; I. Reimanis[4]

1. Colorado School of Mines, Metallurgical and Materials Engineering, USA
2. Colorado School of Mines, Mechanical Engineering, USA
3. Colorado School of Mines, MME, USA
4. Colorado School of Mines, USA
5. Hydrogen Helix, USA

Kaolin-based membranes offer a low-cost alternative for hydrogen production via Ethanol Steam Reforming (ESR) due to their natural abundance and optimal thermomechanical properties. However, achieving adequate surface area while maintaining appropriate pore size for gas separation and catalyst support remains challenging. This study investigates post-firing chemical activation to enhance the pore structure of bisque-fired kaolin membranes. Samples were initially bisque-fired at 850°C and 1000°C, then subjected to acid activation under reflux conditions (6M HCl, 90°C, 6 hours). N2 gas adsorption analysis revealed microstructural changes. Acid-activated samples fired at 850°C exhibited a 13-fold increase in surface area (from 24.8 to 326.3 m/g) and a 157% increase in pore volume, with 29% of total pore volume now comprising micropores (<2nm). The average pore diameter decreased by 14% to 36.3 nm (mesoporous), remaining within the Knudsen diffusion regime. Samples fired at 1000°C showed greater resistance to chemical attack, with only a 19% surface area increase. Pre-firing chemical treatments (acid/alkaline slip modifications) showed negligible effects on final pore structure, confirming that post-firing activation is critical. These results demonstrate that post-firing acid activation of bisque-fired kaolin can produce high-surface-area membranes suitable for ESR.

(ICACC-PB-062-2026) Investigation of Cd and Ga dopants in ultrafast scintillators Cs_2ZnCl_4 and Cs_3ZnCl_5

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1. The University of Tennessee Knoxville Tickle College of Engineering, Materials Science and Engineering, USA
2. University of Tennessee, Scintillation Materials Research Center, USA

Scintillators exhibiting core-valence luminescence (CVL) are generating significant interest for radiation detection applications where ultrafast timing is required, i.e time-of-flight positron emission tomography (TOF-PET) and calorimetry in high-energy physics. This ultrafast emission arises when a valence band electron radiatively recombines with a core hole. This process occurs only when the energy gap between the upper core and valence band (ECV) and the width of the valence band (ΔEV) is less than the crystal's band gap (Eg). In this work, we focus on enhancing the CVL process in Cs2ZnCl4 and Cs3ZnCl5 by tuning the energy gap between the valence and core bands, via cadmium (Cd) and gallium (Ga) doping. High-quality Ø7 mm single crystals of both compounds, doped with various concentrations of Cd and Ga, were grown via the vertical Bridgman technique. Scintillation characterization indicated that both dopants successfully improved the light yield and accelerated scintillation decay compared to the undoped samples. Notably, Cd doping resulted in faster decay kinetics than Ga doping, suggesting distinct influences of their respective core levels on the host band structure. These results demonstrate the viability of doping as a route for optimizing halide scintillators for next-generation fast-timing detectors.

Thursday, January 29, 2026

S1 Mechanical Behavior and Performance of Ceramics & Composites

S1- Ceramics for aerospace and other transport applications

Room: Coquina E
Session Chair: B Venkata Manoj Kumar, Indian Institute of Technology Roorkee

8:30 AM

(ICACC-S1-043-2026) Ultrahigh temperature measurements of emissivity, thermal conductivity, solidus and liquidus temperatures, and cohesive energy of ceramics (Invited)

P. E. Hopkins*[1]

1. University of Virginia, USA

Here we present the development of techniques to determine the spectral emissivity/absorptivity, melting temperature, thermal conductivity and cohesive energy of a range of oxide and metal carbide refractory ceramics. We demonstrate measurements of the spectral absorptivity/emissivity and emittance of a series of rare-earth doped oxides, zirconates and metal carbides at temperatures up to their melting point. We observe a nearly universal increase in graybody like emittance of the rare earth oxides up to their melting points. In the metal carbides, we show that the temperature dependent emissivity of metal carbides either increases or decreases up to their melting point depending on the electronic configuration and surface roughness. We then determine the solidus and liquidus temperatures of various ceramics to understand the thermomechanical response of different stoichiometries on melting and material failure. In tandem with laser heating and probing, we demonstrate the ability to measure the thermal conductivity of materials through these phase transitions. Finally, using short-pulsed laser ablation techniques, we show the ability to measure the cohesive energies of materials, providing a direct link between measured atomic bond strength and the thermomechanical response of ceramics.

9:00 AM

(ICACC-S1-044-2026) Microstructural characterization and structural property determination of oxide/oxide ceramic matrix composites upon thermal plasma exposure (Invited) ***WITHDRAWN***

H. James[1]; A. K. Singh*[1]

1. Baylor University, Mechanical Engineering, USA

In this study, Oxide/Oxide ceramic matrix composites (CMCs) were exposed to thermal plasma conditions intended to mimic harsh environments encountered in hypersonic flights. The exposures were done under near-vacuum conditions as well as under full atmospheric conditions for a range of heat fluxes. In all the investigations, in-situ behavior was monitored using video, pyrometry and emission spectroscopy techniques. The resulting microstructure was evaluated using optical and scanning electron microscopy and X-Ray Diffraction. Post-exposure structural tests were also performed on select specimens. Samples exposed to plasma in near-vacuum environments showed exceptional resilience with minimal mass and thickness loss. The impinged surfaces texture and nearby fibers exhibited grain coarsening. Atmospheric pressure conditions were significantly more aggressive. Melting was observed in all cases. Grain coarsening and fiber and matrix fusion were observed throughout the full thickness of the laminates. For the heat flux and test durations considered, the effects on the structural properties, namely short beam and compressive strengths, were minimum.

9:30 AM

(ICACC-S1-045-2026) Innovative CMC materials tailored for aerospace applications

L. Cavalli*[1]; F. Giacometti[1]; C. Gigante[1]; M. Arnoldi[1]; M. Cantù[1]; Y. Akram[1]; M. Boiocchi[1]; M. Valle[1]

1. Petroceramics S.p.A., Italy

Petroceramics has developed advanced materials designed to meet the demanding requirements of various aerospace applications, offering properties such as light-weight, high thermal stability, resistance to extreme thermal shocks, and stability in harsh environments. Two materials currently marketed by Petroceramics — ISiComp® and OxyComp® — are based on Carbon Fiber Reinforced SiC (C/C–SiC), produced through the Liquid Silicon Infiltration (LSI) process. The link between microstructure, mechanical properties, and thermal stability has been studied in depth. ISiComp® exhibits excellent mechanical properties and is used in the Thermal Protection System (TPS) of Space Rider, the European reusable re-entry vehicle. OxyComp®, with a high SiC content, is employed in components that operate at high temperatures in oxidizing atmospheres for extended durations. It is currently being used for the production of nozzle extensions and TPS for combustion environments. Petroceramics has also developed specialized equipment for mechanical characterization of materials in inert atmospheres at ultra-high temperatures, up to 2700°C. An extended focus was dedicated to the interaction between C/C–SiC materials and different environments, such as O_2, H_2O, CO and CO_2. These tests have revealed both the strengths and limitations of these materials, confirming their highly promising performance for the production of fully reusable TPS components.

10:10 AM

(ICACC-S1-046-2026) Design of energy absorbing and tough ceramics for rotating detonation engines (RDEs)

B. Pajo*[1]; B. Lam[1]; R. Trice[1]; C. Martinez[1]

1. Purdue University, School of Materials Engineering, USA

Rotating detonation engines (RDEs) represent an extreme propulsion environment, combining high-frequency dynamic loads with sustained temperatures near 1600 °C. While they highlight the need for resilient high-temperature materials, conventional ceramics remain limited by their inherent brittleness. One promising approach is the introduction of glassy phases that can dissipate mechanical energy through structural relaxation near the glass transition temperature (Tg). To explore this concept, we employ a silica (SiO_2)/mullite ($3SiO_2 \cdot 2Al_2O_3$) model system as a platform to study energy absorption and toughness enhancement in glass–ceramic composites. In this architecture, silica acts as a discrete viscous phase, while mullite provides a stable elastic matrix. By compositionally tuning the Tg of the silica, the relaxation response can be aligned with relevant loading frequencies and operational conditions. We present results on the fabrication of tailored SiO_2 and SiO_2/mullite composites and examine the role of glass chemistry, volume fraction, and particle size on high-temperature damping and fracture resistance. These findings demonstrate a materials design strategy where discrete viscous inclusions are engineered within elastic matrices to enable energy dissipation, offering insights into the development of next-generation structural ceramics for dynamic high-temperature environments.

10:30 AM

(ICACC-S1-047-2026) TiC-based UHTCMCs synthesized via polytitanoxane-derived polymer infiltration and pyrolysis

K. Y. Wickramathilaka*[1]; I. Perera[1]; J. Valus[1]; R. Purgay[1]; S. Salamanca[1]; T. Bliznakov[1]; S. Suib[1]

1. University of Connecticut, USA

Hypersonic vehicles, capable of traveling beyond Mach 5, are a focal point of next-generation aerospace defense, supporting high-speed reconnaissance and precision strike systems. These platforms face severe thermal and mechanical stresses from aerodynamic heating, creating a demand for structural materials that combine heat resistance, mechanical strength, and low weight. Conventional alloys provide high-temperature performance but suffer from excessive density (8–9 g/cm^3), limiting their use in fully operational hypersonic aircraft with independent takeoff capability. UHTCs, offer exceptional thermal stability with melting points above 3000 °C, making them suitable for nose cones and leading edges. However, their extreme densities (10–15 g/cm^3) remain a major constraint for mass-sensitive aerospace applications. To overcome this challenge, this work explores a titanium-based ceramic matrix composite system centered on TiC, which has a much lower density of 4.9 g/cm^3. Titanium is already well established in aerospace for its superior strength-to-weight ratio, and its ceramic derivative provides a promising balance between thermal performance and reduced mass. Using polymer infiltration and pyrolysis, this study develops a TiC-based matrix reinforced with carbon fibers, demonstrating improved infiltration efficiency and enhanced mechanical properties for hypersonic vehicle structures.

S1- Ceramics for energy generation, turbines, and environmental applications

Room: Coquina E
Session Chair: B Venkata Manoj Kumar, Indian Institute of Technology Roorkee

10:50 AM

(ICACC-S1-049-2026) Bioinspired design of self-healing ceramics with 3D network of healing activator

T. Osada*[1]; M. Mitome[1]; T. Hara[1]; T. Abe[1]; W. Nakao[2]; T. Ohmura[1]

1. National Institute for Material Science, Japan
2. Yokohama National University, Japan

Self-healing of surface cracks through the oxidation of pre-incorporated healing agents is an attractive function for high-temperature structural ceramics components with stringent safety requirements, such as turbine parts in aircraft engine. Based on insights gained from elucidating the healing mechanism, this paper reports a novel approach for self-healing design with a 3D network of healing activators. We demonstrate that the addition of small amounts of activators, typically doped MnO, selected through appropriate thermodynamic calculations and localized at the fracture path, significantly accelerates healing by more than 6,000 times and reduces the required reaction temperature. The activators on the fracture path rapidly fill the fracture gap by generating a mobile, supercooled melt, enabling efficient oxygen supply to the healing agent. Furthermore, the activators promote the crystallization of the melt, forming a mechanically strong healing oxide. We also reveal that the healing mechanism can be divided into an initial oxidation phase and two additional phases. Based on bone healing, we name these phases the inflammatory phase, the repair phase, and the remodeling phase, respectively.

11:10 AM

(ICACC-S1-050-2026) YSZ/Si(B)CN ceramic matrix composites coated with BNNT/Si(B)CN nanocomposites for hydrogen combustion conditions

Y. Wang[1]; C. Maitti[1]; Z. Yu[2]; J. Gou*[1]

1. University of Central Florida, Mechanical and Aerospace Engineering, USA
2. FAMU-FSU College of Engineering, Industrial and Manufacturing Engineering, USA

Gas turbine engines for power generation are increasingly transitioning to hydrogen-based combustion systems to achieve net-zero carbon emissions. However, hydrogen combustion generates high temperatures and significant water vapor, posing severe challenges for structural materials. To address these demands, we have developed ceramic matrix composites (CMCs) consisting of yttria-stabilized zirconia (YSZ) fibers reinforced with a Si(B)CN matrix, combined with boron nitride nanotube (BNNT)/Si(B)CN nanocomposites as a surface coating. Incorporating 15 wt% BNNTs increased the Si(B)CN density to 2.77 g/cm^3, a 78.7% improvement, while maintaining structural integrity and showing no mechanical degradation after ten thermal shock cycles. Thermogravimetric analysis revealed only a 0.4% mass gain after oxidation at 1350 °C for 30 min, attributed to the formation of a protective oxide layer. Microstructural and phase analyses were conducted via SEM and XRD, while thermal stability, oxidation resistance, and ablation performance were assessed using hydrogen torch testing. The YSZ/Si(B)CN CMC with BNNT/Si(B)CN coating demonstrated excellent thermal and environmental durability, highlighting its promise for next-generation hydrogen combustion components and advanced thermal management applications.

11:30 AM

(ICACC-S1-051-2026) Synthesis and characterization of YSZ fiber reinforced high-entropy carbide composites

C. Maitti[1]; Y. Wang[1]; J. Gou*[1]

1. University of Central Florida, Mechanical and Aerospace Engineering, USA

High-entropy carbides (HECs), composed of multiple refractory metal elements (Hf, Ta, Zr, Ti, Nb, V, and W), offer superior chemical and thermo-mechanical stability compared to conventional binary carbides such as SiC and ZrC, but monolithic HECs often suffer from severe shrinkage, cracking, or fracture during densification. In this study, HECs were synthesized through a polymer precursor-based modified Pechini process, where citric acid functioned as both a chelating agent and carbon source. To overcome the brittleness of bulk HECs, yttria-stabilized zirconia (YSZ) fiber-reinforced HEC ceramic matrix composites (CMCs) were fabricated via polymer infiltration and pyrolysis (PIP). YSZ fibers were selected for their high thermal stability up to ~2200 °C, excellent oxidation resistance, and long-standing application in thermal barrier coatings. The ablation resistance of the composites was evaluated using hydrogen torch testing at 185 W/cm^2 for 30 min, maintaining a front-surface temperature of ~1400°C. Thermal stability, oxidation resistance, and ablation behavior were further assessed by TGA and microstructural analysis, demonstrating the promise of YSZ/HEC composites as candidates for next-generation propulsion and power-generation systems.

S3 23rd Intl Symp on Solid Oxide Cells Materials Science & Technology

S3-Electrolyte: performance and mechanical properties

Room: Coquina H
Session Chair: Sebastian Molin, Gdansk University of Technology

8:30 AM

(ICACC-S3-043-2026) Development and production of SOFC/EC cells based on multipotent zirconia (Invited) *WITHDRAWN*

B. Yoon*[1]

1. Dentium Co Ltd, Republic of Korea

Zirconia (ZrO_2) is a high-performance ceramic material recognized for its unique combination of mechanical strength, chemical stability, and functional versatility. In the field of structural materials, zirconia is widely utilized as a load-bearing and grinding medium, due to its high hardness, wear resistance, and fracture toughness. In biomedical applications, zirconia has gained significant attention in dentistry and orthopedics. Especially, 3 ~ 5 mol% yttria stabilized zirconia has been extensively used in dental crowns, bridges, and implant owing to its excellent biocompatibility, aesthetics, and durability. In the energy sector, zirconia plays a pivotal role in gas sensors, thermal barrier coating and SOFC/ECs. By adjusting the yttria content in zirconia mainly from 8YSZ, we optimized its functional properties for energy applications, and a scalable manufacturing process was developed to enable cost-effective mass production of SOFC/EC cells with anode supporting layer (ASC) which is open to customers for the collaboration to utilize their own composition and structure for scale-up. Furthermore, based on the raw materials techniques with dopants, the Dentium Consortium is developing the electrolyte supported cells (ESC) by collaborating with leading domestic institutes/companies and renowned oversea research organizations (Fraunhofer IKTS and DTU).

9:00 AM

(ICACC-S3-044-2026) Multi-material design to optimize mechanical strength and ionic conductivity in 8YSZ ceramic SOFCs

A. Jana[1]; J. Schlacher[1]; I. Kraleva[1]; A. Egger[2]; E. Bucher[2]; R. Bermejo*[1]

1. Montanuniversitat Leoben, Materials Science, Austria
2. Montanuniversitat Leoben, General Analytical and Physical Chemistry, Austria

The use of thick electrolytes (~250 µm) yields higher ohmic resistances and lower cell performances compared to anode-supported cells. However, minimizing ohmic losses by using thin (<100 µm) electrolytes is challenging and assessing their mechanical reliability requires novel testing protocols. In this work, a multi-material approach is explored for tailoring the mechanical and functional properties of zirconia-based electrolytes. The combination of alumina-toughened zirconia (ATZ) surface layers with an embedded 8 mol% yttria-stabilized zirconia (8YSZ) layer introduces compressive residual stress in the electrolyte surface after sintering. Biaxial strength is measured in multi-material and monolith samples using an adapted B3B test. The ionic conductivity is measured by electrochemical impedance spectroscopy between 600°C and 1000°C. The effect of alumina addition is investigated in samples containing surface ATZ layers with 10 vol% or 20 vol% alumina. Experimental results show that the strength of multi-material electrolytes can be increased by up to ~30% compared to the monolithic 8YSZ, while maintaining the ionic conductivity of the 8YSZ base material. The effect of compressive and tensile residual stresses on the strength and ionic conductivity in the multi-material electrolyte is discussed, offering new paths to enhance both structural and functional properties in SOFCs.

9:20 AM

(ICACC-S3-045-2026) Comparing high temperature tensile properties of 3YSZ-elektrolyte with complete SO-cells

N. Langhof*[1]; I. Bombarda[1]; S. Schafföner[2]

1. University of Bayreuth, Ceramic Materials Engineering, Germany
2. University of Bayreuth, Chair of Ceramic Materials Engineering, Germany

High temperature electrolysis (HTEL) has several advantages compared to other types of solid oxide cell (SOC) technologies, including a high efficiency at T = 850 °C when combined with an exothermic process. To reduce costs, increase lifetime and improve scale up production of electrolyte supported SOCs, a key property is the cell mechanical stability, which for electrolyte supported cells is mainly provided by the ceramic electrolyte. In this study, the authors investigated the mechanical properties of solid electrolyzer cells (SOECs) at room and operating temperature. Therefore, tensile tests were performed for the evaluation of the SOC-strengths up to 850 °C. The authors previously developed this test setup for the evaluation of tensile properties of ultrathin ceramic tapes, especially to perform a room and high temperature mechanical properties characterization of 90 µm thin 3%mol yttrium-stabilized zirconia (3YSZ) ceramic tapes for SOECs. The test setup was then transferred to characterize different solid oxide electrolyzer cells in terms of room and high temperature tensile strength. The cells show a lower strength compared to the electrolytes both at room and high temperature. The lower strength was attributed to different failure mechanisms compared to the test of the 3YSZ electrolyte. The fractured surfaces were studied and correlated with the strength values.

9:40 AM

(ICACC-S3-046-2026) Mechanical characterization of protonic ceramic electrolyte materials: Pristine and post-humidification

A. Moranti*[1]; S. Ricote[2]; F. Smeacetto[3]; M. Santarelli[4]

1. Politecnico di Torino, Italy
2. Colorado School of Mines, Mechanical Engineering, USA
3. Politecnico di Torino, Applied Science and Technology, Italy
4. Politecnico di Torino, Energy, Italy

Protonic ceramic materials are expected to enable high efficiency and clean energy conversion. This study investigates the mechanical properties of (BZY20) and (BCZYYb7111), focusing on parameters such as elastic modulus and fracture stress. Elastic modulus is measured using nanoindentation techniques, while fracture stress, determined through four-point bend tests, with the results represented using a Weibull distribution, which statistically models the variability in fracture stress data, offering a comprehensive view of the materials' reliability and durability from the manufacturing process. Also, fracture toughness, useful to assess the material's resistance to crack propagation, is determined by prenotching of the bars. By analyzing both pristine samples and those subjected to humidification, the study provides an evaluation of the materials' performance under varying environmental conditions, also to simulate real-world operating environments and evaluating their impact on mechanical properties, with their effect on long-term use in energy applications, ensuring their performance and durability over time. This research aims to contribute to the broader goal of developing robust and durable protonic ceramic materials for energy applications, as well as towards scale-up and commercialization.

S3-Durability & Degradation

Room: Coquina H
Session Chair: Jérôme Laurencin, CEA

10:20 AM

(ICACC-S3-047-2026) Steam electrolysis with solid oxide cells with thin supporting electrolyte: Advances within the German H2Giga R&D project (Invited)

J. Schefold*[1]; A. Leon[1]

1. European Institute for Energy Research, Germany

Industrialization of the manufacturing process of water/steam electrolyzers is currently done by number of companies. In that context, the German lead project H2Giga (2021-2025) provides the background to increase the volume of electrolytic hydrogen, using different low and high temperature technologies. Steam electrolysis with solid oxide cells at high temperature benefits from fast electro-chemical kinetics at the electrodes, and high current densities appear feasible with electrolyte supported cells (ESC), provided that the ionic conduction losses in the electrolyte can be reduced. For that purpose, ESC with 3YSZ-electrolytes with 30-40 μm thickness (vs. the standard 90 μm) were developed by the company Sunfire and were extensively tested on cell and stack level within the H2Giga project. Ni/GDC served as fuel electrode and LSCF as oxygen elec-trode. This contribution covers cell testing activities with current densities of up to 1.2 A cm^{-2} and a duration of 10,000 h, achieving a low degradation in the 2 - 3 mV/1000 h range at a cell voltage close to the thermal neutral value. Durability testing was accompanied in-situ by impedance spectroscopy (IS), followed by post-test anal-ysis. IS confirmed a small and mainly ohmic degradation during the experimental runs. Ohmic degradation might notably be induced by a decay of ionic conduction in the electrolyte.

10:50 AM

(ICACC-S3-026-2026) Metal catalyst infiltration into perovskite oxides for enhanced CO_2 reduction (Invited)

S. Lee*[1]; T. Shin[2]

1. Korea Institute of Ceramic Engineering and Technology, Climate&Energy R&D Group, Republic of Korea
2. Korea Institute of Ceramic Engineering & Technology, Energy Materials Center, Republic of Korea

Solid oxide electrolysis cells (SOECs) are emerging as a key tech-nology for high-temperature CO_2electrolysis, offering a viable pathway toward carbon neutrality and renewable energy storage. A critical challenge, however, lies in designing fuel electrodes with high activity and stability across operating conditions. In this work, we systematically explored the effect of transition metal catalysts (Ru, Co, Fe, and Ni) incorporated into LSCM electrodes. Distinct catalytic trends were observed: Fe enhanced performance at high temperature, while Ru was particularly effective at lower temperature (700 ° C) and under pure CO_2. Notably, Ru incorporation doubled the current density compared with bare LSCM, highlighting its strong ability to activate CO_2 molecules. Mechanistic insights from CO_2-TPD, in situ XPS, and DFT calculations revealed that Ru provides favorable elec-tronic interactions that stabilize reaction intermediates and facilitate bond cleavage. Building on this understanding, we applied a simple and scalable ultrasonic spraying method to introduce Ru catalysts, achieving both high current densities and faradaic efficiencies near 95%. These findings not only elucidate catalyst-specific roles in CO_2 electrolysis but also establish a practical framework for engi-neering efficient SOEC electrodes that can accelerate the transition to sustainable energy systems.

11:20 AM

(ICACC-S3-049-2026) Towards increased stability, performance and robustness of SOEC: The CELCER-EHT project

E. Grindler*[1]; F. Lefebvre-Joud[1]

1. Univ Grenoble Alpes – CEA/LITEN, France

The CELCER-EHT project aims to develop Solid Oxide Electrolysis Cells (SOEC) offering levels of performance and durability beyond the current state of the art. The project gathers 11 French academic laboratories and 2 CEA departments, and is structured around two main milestones: - By 2024, by improving current cell materials and microstructures, the degradation rate is deceased down to 1%/1000h when operating at -0.85 A.cm^{-2} and 1.3V per cell between 750 and 850°C. - By 2027, the integration of breakthrough materials allows a degradation rate as low as 0.7%/1000h at -1 A.cm^{-2} and 1.3V between 750 and 850°C. Over 3 years, efforts have focused on improving current cell materials by optimizing compositions, microstructures and interfaces. An improved cell has demonstrated promising durability with a degradation rate <1%/1000h during 5,000 h at -1 A.cm^{-2}. The fabrication process has been scaled-up to a pilot line, and 200 cm^2 cells will be tested at stack level. A validated multi-scale modelling tool for this new cell has identified new ways to enhance the H_2 electrode microstructure. Work has also been conducted on the development and implementation of breakthrough materials such as nickelates or oxyfluorinated materials. To analyse the chemical stability of these new microstructures or compositions, in-depth characterization campaigns have been performed, using in particular large instruments.

11:40 AM

(ICACC-S3-050-2026) Insights into degradation and oxygen vacancy dynamics in SOECs

J. Lee*[1]; T. Kim[2]; J. Joo[2]; T. Shin[1]

1. Korea Institute of Ceramic Engineering and Technology, Republic of Korea
2. Gwangju Institute of Science and Technology, Republic of Korea

The production of clean hydrogen via high-temperature electrolysis using Solid Oxide Electrolysis Cells (SOECs) has garnered considerable attention. A primary challenge for SOEC longevity, however, is rapid degradation, often manifested as delamination at the electrode-electrolyte interface due to mechanical stress from oxygen accumulation. While this failure is fundamentally linked to a disparity in oxygen ion transport properties, conventional strategies focusing on this mismatch overlook the dynamic evolution of ionic conductivity under operational conditions. Specifically, the concentration of oxygen vacancies—the primary charge carriers for ion transport—is highly sensitive to the severe oxygen partial pressures of the SOEC operating environment. Consequently, a comprehensive understanding of oxygen vacancy dynamics is paramount for designing more durable SOECs. Here in, we utilize a dense model electrode to systematically investigate the electrochemical phenomena occurring at the electrode and its interface. Our primary objective is to establish a clear correlation between degradation, oxygen vacancy dynamics, potentials and degradation. The findings are expected to offer insight for electrode design to improve the stability of SOECs through material optimization under operating conditions.

S4 Advanced Materials for Thermoelectric and Thermionic Energy Conversion

S4- Nanomaterials and nanocomposites

Room: Ballroom 1 -2
Session Chairs: Holger Kleinke, University of Waterloo;
Serge Nakhmanson, University of Connecticut

9:00 AM

(ICACC-S4-001-2026) Native defects engineering in Cu_2Se-based hierarchical composites (Invited)

F. Poudeu*[1]; Z. Yin[1]; R. Lu[1]; T. Bailey[1]; C. Uher[1]

1. University of Michigan, USA

The mutual hierarchical integration of heavily doped p-Cu_2Se with semiconductors such as p-$CuMSe_2$ (M = In, Ga) and p-Cu_4TiSe_4 enables the engineering of electronic defects distribution within the resulting composites. By leveraging native defects in Cu_2Se, $CuMSe_2$, and Cu_4TiSe_4 phases, we demonstrate careful tunability of the concentration and energy distribution of active electronic defects in bulk hierarchical (1-x)Cu_2Se-(x)$CuMSe_2$(CMS) and (1-x)

Cu_2Se-(x)Cu_4TiSe_4 (CTS) composites. We found that the carrier density in CMS composites decreases with increasing $CuMSe_2$ content, reaching a minimum at x = 0.45 before suddenly increasing near equimolar composition, which is attributed to shallow defects hybridization within the bandgap of the composites. Conversely, the carrier density in CTS composites increases upon incorporation of the Cu_4TiSe_4 phase, which is attributed to type-I band alignment at the Cu_2Se/Cu_4TiSe_4 interface. These findings indicate that coexisting "active" electronic defects are distributed over a broad energy range in bulk hierarchical CMS and CTS composites, consistently with nondegenerate behavior. This finding is not consistent with the degenerate semiconducting behavior from the temperature dependent electrical conductivity. In this paper, I will discuss these results, emphasizing the correlations between microstructure, electronic band alignment, and electronic transport properties.

9:30 AM

(ICACC-S4-002-2026) Investigating microstructure via thermal conductivity imaging: from grain boundaries, to phase segregations and material anisotropy (Invited)

E. Isotta*[1]; O. Balogun[3]; J. Snyder[2]; C. Scheu[1]

1. Max-Planck-Institut fur Nachhaltige Materialien GmbH, Germany
2. Northwestern University, Department of Materials Science and Engineering, USA
3. Northwestern University, Mechanical Engineering, USA

Maximizing thermoelectric performance requires a comprehensive understanding of how distinct microstructures influence phonon and electron transport, but this remains elusive due to the scarcity of spatially-resolved investigations. In this talk, I will illustrate how thermal conductivity (κ) imaging can shed light on the local behavior of key microstructures, including grain boundaries, phase segregations, and local variations in crystal orientation. Grain boundaries reveal a κ suppression localized in their vicinity, which can be quantified in terms of a thermal boundary resistance. Boundaries show marked variations in behavior: misorientation angle and interface morphology strongly affect the resistance. In Mg_2Si-Mg_2Sn alloys, κ together with Seebeck coefficent imaging offer insights into the chemical heterogeneity within the sample, guiding further material optimization. In Sb_2S_3 rotating crystals, κ imaging enables to identify a pronounced κ anisotropy, which is linked with the expression of Sb lone pairs. Extracting transport properties from microscale imaging experiments offers a powerful route to establish local structure-chemistry-property correlations. This can advance our understanding of phonon-defect interactions, enabling the rational engineering of microstructures for enhanced thermoelectric performance.

10:20 AM

(ICACC-S4-003-2026) Dual spark-plasma texturing and electrospun nanoribbons for superior thermoelectric performance of misfit-layered calcium cobaltite ceramics (Invited)

A. Feldhoff*[1]; K. Kruppa[1]; I. Maor[5]; A. Karlin[5]; K. Kebel[1]; F. Steinbach[1]; H. Petersen[2]; D. Stobitzer[3]; W. Xie[4]; A. Weidenkaff[4]; G. E. Shter[5]; M. Mann-Lahav[5]; G. Grader[5]

1. Leibniz University Hannover, Institute of Physical Chemistry and Electrochemistry, Germany
2. Leibniz Universitat Hannover, IFW – Institute of Production Engineering and Machine Tools, Germany
3. NETZSCH-Geratebau GmbH, Germany
4. Technische Universitat Darmstadt, Institute of Materials Science, Germany
5. Technion - Israel Institute of Technology, Chemical Engineering, Israel

The misfit-layered cobaltite $[Ca_2CoO_{3-\delta}]_{0.62}[CoO_2]$ (CCO) is a promising high-temperature thermoelectric p-type material for converting waste heat to electricity. Its anisotropic properties favor texturing and nanostructuring to boost performance. We explore electrospinning and dual sintering processes to assess their impact on CCO's texturization and thermoelectric properties. Electrospun CCO forms flat nanoribbons processed into textured ceramics, enhancing alignment and densification. X-ray diffraction pole figures verify improved texture. While pressureless sintering initiates texture, spark plasma sintering (SPS) followed by edge-less spark plasma texturing (SPT) further optimizes grain alignment and density, reducing porosity. Microstructures are characterized via X-ray diffraction, TEM, SEM, and EDXS. Thermoelectric measurements show the power factor reaching $16.3\ \mu W\ cm^{-1}\ K^{-1}$ with SPS-SPT-treated nanoribbons. The zT value for undoped CCO reaches 0.53 at 1073 K, rivaling doped alternatives. This synergy between electrospinning and SPS-SPT establishes a new standard for undoped, dense, textured ceramics with enhanced in-plane thermoelectric properties.

10:50 AM

(ICACC-S4-004-2026) Investigating the role of Ag and Ni phases in the thermoelectric properties of Multicomponent Oxides Composites

M. M. Czudec*[1]; M. Gazda[1]; T. Miruszewski[1]

1. Politechnika Gdanska, Poland

Strong possibilities for thermoelectric applications at high temperatures, multicomponent oxides (MCOs) are distinguished by their exceptional thermal stability, tunable electrical behavior, and compositional diversity. Many cations result in structurally complicated and disordered lattices, which offer various ways to modify composition and manage defect chemistry to tailor thermoelectric properties. The goal of the research is to create composite thermoelectric materials based on perovskite-type MCOs (ABO3 structure), in which the B-site is substituted with a mixture of Fe, Zr, Hf, Sn, Ti, Ce, Co, In, Sm, Y, and/or Yb, and the A-site is occupied by barium. The creation and analysis of MCO-based composites, including metallic silver (Ag) and nickel (Ni) in various wt% configurations, are the main focus of this work. In order to create conductive phases inside the ceramic matrix, these metals are incorporated using solid-state synthesis. The impact of metallic additions on the thermopower response is specifically examined, and the overall Seebeck coefficient is evaluated throughout a broad temperature range. Additionally, because protonic defects have the potential to improve effective thermoelectric performance, their involvement in transport pathways is taken into consideration.

11:10 AM

(ICACC-S4-005-2026) Enhanced thermoelectric performance of porous $SrTiO_3$ ceramics with exsolved Ni nanoparticles

M. Ohtaki*[1]; S. Hirata[1]; L. Aoki[1]; K. Suekuni[1]

1. Kyushu Daigaku, Interdisciplinary Graduate School of Engineering Sciences, Japan

Here we report an enhanced thermoelectric performance of sintered $SrTiO_3$ (STO) ceramics doped with Nb and Ni, which subsequently contained highly dispersed Ni nanoparticles formed via an exsolution reaction caused by a reducing post-treatment. Samples with a representative composition of $Sr_{0.95}(Ti_{0.8}Nb_{0.2})_{0.95}Ni_{0.05}O_3$ (STNNO) were prepared by calcining mixed raw oxide powders at 1273 K twice to form the STO phase. The resulting powder was mixed with a graphite powder and heated at 1693 K in air, and subsequently reduced at 1623 K under 5% or 20% H_2/N_2. An XRD study confirmed that all the samples have the STO structure even after the reducing post-treatment. SEM/EDS observation of the cross section of the samples revealed discretely dispersed Ni nanoparticles of ca. 50 nm in diameter. While the electrical conductivity of the sample reduced in 20% H_2 was significantly higher than that reduced in 5% H_2, the Seebeck coefficient was very insensitive to the sintering temperature and reducing atmosphere. However, the lattice thermal conductivity was the lowest for the sample reduced in 20% H_2, resulting in ZT = 0.6 at 1073 K as the highest value among the STO-based oxides so far reported.

S5 Next-Generation Bioceramics and Biocomposites

S5-Additive manufacturing and hybrid bioceramic-polymer systems

Room: Flagler A
Session Chair: Enrica Vernè, Politecnico di Torino

8:30 AM

(ICACC-S5-010-2026) Fabrication of sphene-based core-shell structures via co-axial Direct Ink Writing'

V. Gastaldi*[1]; L. Biasetto[1]; D. Bellucci[2]; V. Cannillo[2]

1. Universita degli Studi di Padova, Industrial Engineering, Italy
2. Universita degli Studi di Modena e Reggio Emilia, Department of Engineering "Enzo Ferrari", Italy

Co-axial extrusion 3D printing is a multi-material additive manufacturing (MMAM) technology that allows the fabrication of a new generation of components with tunable final characteristics. The high potential of the process lies in the possibility of combining different materials (i.e., dense and porous, or ductile and brittle) to obtain hybrid and tailored properties. In this work, we explore the fabrication of sphene ($CaTiSiO_5$)-based core-shell structures by a one-step co-extrusion nozzle via Direct Ink Writing. These components, specifically conceived for bone substitution, are produced using two design strategies: a dense sphene core surrounded by a porous sphene shell, and a metallic inner core coupled with a porous sphene shell. Sphene is a bioceramic that, thanks to its verified bioactivity, was chosen to fabricate components suitable for bone substitution. This study highlights the main challenges of the process, including inks' formulation, debinding and sintering, and the control of volumetric shrinkage of the coupled materials. Finally, the resulting core–shell structures are assessed in terms of mechanical performance, morphology (SEM-EDS), and functional properties, including in vitro tests to demonstrate the biological performance and their potential as next-generation biomedical implants.

8:50 AM

(ICACC-S5-011-2026) Vat photopolymerization of BG1d bioactive glass for the fabrication of bone scaffolds

V. Rigano*[1]; R. Gabrieli[1]; L. D'Andrea[3]; P. Vena[3]; S. Anelli[1]; A. Schiavi[5]; M. Schwentenwein[2]; D. U. Tulyaganov[4]; E. Vernè[1]; F. Baino[1]

1. Politecnico di Torino, DISAT, Italy
2. Lithoz GmbH, Austria
3. Politecnico di Milano, Department of Chemistry, Materials & Chemical Engineering, Italy
4. Turin Polytechnic University in Tashkent, Uzbekistan
5. Istituto Nazionale di Ricerca Metrologica, Italy

Bioactive glasses (BGs) are attractive for bone regeneration due to their ability to bond with tissues and stimulate new bone growth, yet conventional compositions such as 45S5 remain limited by poor processability. This study presents BG1d, a new silicate glass engineered for superior bioactivity and mechanical reliability, and its application in 3D printing by vat photopolymerization (VPP). BG1d powders were synthetized, sieved below 25 μm, and characterized by XRD, FESEM, particle size analysis, and thermal methods (DSC, HSM). Photocurable inks were prepared by dispersing BG1d in acrylate-based monomers with optimized photoinitiators and dispersants, while rheology and curing depth were tuned for reliable VPP printing. Using VPP, bulk and porous scaffolds with precise, reproducible architectures were fabricated, and optimized sintering strategies are being developed to overcome cracking and densification. Mechanical and permeability assessments are underway to establish performance relevant to osteointegration. These findings demonstrate the feasibility of translating BG1d into printable inks and shaping it into complex 3D scaffolds with tailored architecture. The integration of this novel bioactive glass with additive manufacturing offers a promising route toward next-generation scaffolds that unite structural integrity with biological functionality for bone tissue engineering.

9:10 AM

(ICACC-S5-012-2026) Synergistic design of magnesium potassium phosphate with natural hydrogels: An approach to injectable and biofunctional bone cements

M. Wekwejt*[1]; A. Melnyk[2]; R. Jesiolkiewicz[2]; M. Wojtala[2]; A. Mielewczyk-Gryn[3]; D. Kozien[4]; A. Ronowska[5]; J. Kozlowska[6]; U. Gbureck[7]

1. Politechnika Gdanska, Department of Biomaterials Technology, Poland
2. Politechnika Gdanska, Scientific Group 'Materials in Medicine', Poland
3. Politechnika Gdanska, Department of Ceramics, Poland
4. Akademia Gorniczo-Hutnicza im Stanislawa Staszica w Krakowie, Department of Ceramics and Refractories, Poland
5. Gdanski Uniwersytet Medyczny, Department of Laboratory Medicin, Poland
6. Uniwersytet Mikolaja Kopernika w Toruniu, Department of Biomaterials Technology and Cosmetic Chemistry, Poland
7. University of Wurzburg, Department for Functional Materials in Medicine and Dentistry, Germany

The work explores the integration of magnesium potassium phosphate cements (MPC) with natural hydrogels to improve injectability and control setting behavior. The approach combines calcined MgO and KH_2PO_4 with aqueous solutions of sodium alginate, κ-carrageenan, and guar gum, followed by a dual-setting mechanism in which ionic and/or physical crosslinking occurs in parallel with the hydraulic reaction of the ceramic phase. The composites are being evaluated through physicochemical, mechanical, and biological analyses. Hydrogel incorporation provided tunable setting times, reduced exothermic curing, and improved paste cohesion. These modifications did not disturb k-struvite formation, the principal binding phase of MPC, although in some systems additional phases appeared. The optimized formulations showed reliable injectability, preserved mechanical performance, and consistent handling. Biological tests confirmed osteoblast adhesion and viability, demonstrating biocompatibility. Altogether, this work develops dual-setting MPC–hydrogel composites as injectable, biofunctional bone substitutes with strong potential for minimally invasive clinical use. // This research is supported by the Gdansk University of Technology (PLUTONIUM, DEC-3/2022/IDUB/III.4.3/Pu) and by the Polish Ministry of Education and Science (FERS.01.05-IP.08-004/23).

S5- In vitro & in vivo biocompatibility & Bioceramics for implantable devices, biosensor and cosmetic application

Room: Flagler A
Session Chair: Katalin Balazsi, Centre for Energy Research HAS

9:30 AM

(ICACC-S5-013-2026) Ceramic pressure slip casting of complex geometries like knee implant (Invited)

S. Begand*[1]; S. Spange[1]; K. Hans[2]; C. Ortmann[2]; M. Liebelt[2]; T. Oberbach[2]

1. Fraunhofer-Institut fur Keramische Technologien und Systeme IKTS - Standort Hermsdorf, Oxide Ceramics, Germany
2. Mathys Orthopaedie GmbH, Germany

Currently, knee implants are predominantly made of metal. Failure of such implants are mainly caused by metal ion release, corrosion and particle abrasion. The use of ceramic knees could be the solution. Knee implants have a complex geometry and are therefore especially for ceramics challenging to manufacture. This study focuses on near net shape method called pressure slip casting to produce such complex geometries, using unicondylar knee implants. Compared to conventional slip casting, which relies on capillary action, pressure slip casting applies external pressure to improve mold filling, reduce defects, and shorten processing time. This technique enables both near-net-shape manufacturing and efficient material use. Well established alumina toughened zirconia ATZ ceramic was used. Primary particle size in the slurry of below 100 nm needs appropriate designed mold material. Unlike conventional slip casting inorganic molds with defined porosity and adapted construction were used. Mold and slurry formulations are key factors to enable pressure slip casting for complex, fine-grained ceramic geometries. This work shows that a complex-shaped component such as a unicondylar knee can be manufactured using pressure casting. Near net shape technology enables sustainable and resource-efficient manufacturing of ceramic implants.

10:20 AM

(ICACC-S5-014-2026) Is In vivo ageing of dental zirconia ceramics clinically relevant? (Invited)

A. Kocjan*[1]; P. Jevnikar[2]; T. Douillard[3]; C. Sanon[3]; J. Chevalier[4]; R. Kohal[5]

1. Jozef Stefan Institute, Slovenia
2. Medical Faculty, University of Ljubljana, Slovenia
3. Materiaux Ingenierie et Science, France
4. INSA Lyon, Materials Science, France
5. Albert-Ludwigs-Universitat Freiburg Medizinische Fakultat, Germany

The present study assessed the clinical relevancy of in vivo aging of 3Y-TZP ceramics in the oral environment with the emphasis on the roles of the comparison to in vitro aging extrapolations and the zirconia's surface state. 3Y-TZP disk specimens, varying sintering protocols, grain sizes, and surface states (as-sintered, polished and airborne-particle-abrasion) were incorporated in lingual flanges of complete dentures of 12 edentulous volunteers for up to 48 months. In vitro hydrothermal aging at 134 °C was also performed. In addition, the extent of ageing was assessed from five 3Y-TZP implants (ZiUnite with a porous coating) explanted from prospective clinical investigations due to periimplant bone-breakdown after 37, 40, 52, 64 and 181 months. XRD, conventional SEM and FIB-SEM tomography were employed for evaluation. Biomedical grade 3Y-TZP is susceptible to in vivo ageing, depending on the composition and surface state. The ageing kinetics of 3Y-TZP disks were almost 3-times faster than the in vivo predictions, but the extent of degradation did not yet constitute grounds for clinical concern. In the case of implants with porous surface coating, all explanted specimens exhibited extensive surface t-m transformation, pronounced microcracking and subsequent coating degradation, which all possibly contributed to bone loss, loss of osseointegration and subsequent implant failure.

10:50 AM

(ICACC-S5-015-2026) Ceramic finger joint implants: AI designed and manufactured by direct shaping

S. Begand*[1]; T. Moritz[2]; S. Spange[1]

1. Fraunhofer-Institut fur Keramische Technologien und Systeme IKTS - Standort Hermsdorf, Oxide Ceramics, Germany
2. Fraunhofer-Institut fur Keramische Technologien und Systeme IKTS, Processes and Components, Germany

Inspired by individual restorations in dental applications and by the possibilities of fully digital process chains, AI-designed ceramic finger joint implants were manufactured using direct shaping methods. Small finger joints in particular suffer from stiffening, which reduces mobility. Patient-specific ceramic implants promise high fit accuracy, improved functionality, and long-term durability. This project demonstrates a fully digital workflow, starting from patient CT data and extending to AI-assisted automated design and near-net-shape manufacturing of patient-specific ceramic finger joint implants, followed by application-oriented testing. Two direct shaping methods were applied: slip casting and CerAM VPP (Vat Photopolymerization). Both enable near-net-shape production of complex geometries. While slip casting is particularly suitable for simpler TPMS-type structures, vat photopolymerization allows the realization of more complex 3D architectures, which provide advantages in terms of mechanical properties and, in particular, improved osseointegration. The work was focused on alumina-toughened zirconia (ATZ) ceramics. Slip casting further enabled simultaneous micro- and macro-structuring in a single process step. Using both methods, ATZ implants demonstrated superior mechanical performance combined with osseointegration-stimulating stem surface structures and well-conditioned articulation planes.

11:10 AM

(ICACC-S5-023-2026) CoorsTek Permallon®: Alumina matrix composite advancing ceramic bearing surfaces in total hip arthroplasty

H. Yegingil*[1]; J. Haftel[2]; A. Cafiero[1]; L. Strong[1]

1. CoorsTek Inc, Medical & Clean Technologies (MCT), USA
2. CoorsTek Inc, Bioceramics, USA

Permallon®, developed by CoorsTek Bioceramics, represents a significant advancement in ceramic bearing surfaces for total hip arthroplasty. Engineered as an alumina matrix composite, the material incorporates advanced toughening mechanisms to enhance mechanical integrity while maintaining biocompatibility and hydrothermal stability. Unlike metallic alternatives, Permallon® eliminates the risk of ion generation at the bearing surface, ensuring long term biological safety. Permallon® performs favorably against leading ceramic femoral head materials, offering improved durability and reliability. Rigorous testing demonstrates superior wear resistance and axial burst strength, exceeding FDA guidance and industry standards under conditions surpassing physiological loads. With over 100 years of expertise in technical ceramics, more than six million implant grade products manufactured since 2005, CoorsTek Bioceramics has established itself as a global leader in orthopaedic ceramics. Beyond hip arthroplasty, its bioceramic components are utilized in neurological, cardiological, spinal, and radiological applications. Permallon® exemplifies the company's commitment to innovation, patient safety, and collaborative partnerships with medical implant manufacturers, positioning it as a next generation solution for joint replacement technologies.

S6 Advanced Materials and Technologies for Rechargeable Energy Storage

S6- Ionics, Interface, characterization and modeling I

Room: Coquina G
Session Chairs: Chunmei Ban, University of Colorado, Boulder; Dominic Bresser, Karlsruher Institut fur Technologie

8:30 AM

(ICACC-S6-032-2026) Charge transport at and across lithium|Electrolyte interfaces and interphases (Invited)

D. Bresser*[1]

1. Karlsruher Institut fur Technologie, Helmholtz Institute Ulm (HIU), Germany

Li-metal electrodes are considered the next great leap forward towards achieving higher energy density batteries. However, their high reactivity with essentially all liquid and solid electrolytes remains a formidable challenge – concerning both the cycle life of the cell and its safety owing to the commonly inhomogeneous, potentially dendritic lithium deposition upon continuous stripping and plating. Herein, we will report on our most recent efforts to deepen our understanding of the reactions and processes occurring at the lithium|electrolyte interface using liquid and/or solid electrolyte systems. These efforts include the determination of the exchange current density as a measure for the reactivity and Coulombic efficiency, the use of X-ray tomography to study the impact of the electrolyte composition on the morphology of the plated lithium, and the development of an unsupervised data-clustering approach to identify characteristic cycle life stages of lithium-metal electrodes. The newly gained insights are anticipated to help guiding the development of further advanced electrolyte systems to eventually enable the widespread use of lithium-metal electrodes in next-generation batteries.

9:00 AM

(ICACC-S6-033-2026) Battery ionics and electrodics: A tour thorough relevant materials and their interphases (Invited)

J. Popovic-Neuber[1]; J. Grill*[1]

1. University of Stavanger, Norway

Ion motion is ubiquitous in battery technology, and the thermodynamics and kinetics of cation transport determine the suitability of specific materials for application as battery electrode or electrolyte. In this talk, I will touch upon how concepts from solid state ionics and electrochemistry allow for development and understanding of different battery materials and the interphases they form in electrochemical cells. These include sodium, potassium, magnesium and aluminium metal anodes, Si electrodes, liquid, liquid/solid, polymer, and semi-solid electrolytes, and potassium solid-state electrolytes. The focus will also lie on the development of measurement methodology based on electrochemical techniques such as electrochemical impedance spectroscopy and galvanostatic polarization which allow for elucidation of both transport properties and time and/or current battery ageing mechanisms, both on materials and cell level.

9:30 AM

(ICACC-S6-034-2026) Theoretical study on the ionic flow in materials via non-equilibrium stochastic process and molecular dynamics simulations (Invited)

Y. Ando*[1]

1. Tokyo Kagaku Daigaku, Japan

In recent years, much research has focused on the interactions between ions and their surroundings to improve the properties of battery materials. It has been observed in the materials that rapid and flexible changes in the crystal lattice and atomic and molecular clusters facilitate ion flow and enhance functionality. However, no theory has yet been established that can accurately capture, understand and control the collective motion of ions (ion flow) and the various interactions that induce it. In this talk, we will report on the progress of research on non-equilibrium stochastic process and materials simulation aimed at understanding ion flow. First, the ion-conductor-inspired model using asymmetric simple exclusion process (ASEP), which is a typical research tool for jamology, is demonstrated. Although they do not take into account all physical effects, they lead to interesting considerations, such as nontrivial results for particle density separation in polycrystalline structure. In addition, we have extended the conventional molecular dynamics (MD) calculation to non-equilibrium condition to achieve efficient ionic conductivity calculations. As a result, we observed non-Arrhenius behavior, in which the temperature dependence of ion conductivity is non-linear. Based on the above results, we finally discuss the prospects of our research.

10:20 AM

(ICACC-S6-035-2026) Characterization of interfacial processes in liquid and solid-state batteries by surface spectroscopic methods (Invited)

J. Swiatowska*[1]; Y. Zhou[1]; S. Zanna[1]; A. Seyeux[1]; B. Tian[2]

1. Centre National de la Recherche Scientifique, Chimie ParisTech, France
2. Shenzhen University, International Collaborative Laboratory of 2D Materials for Optoelectronics Science and Technology of Ministry of Education, Institute of Microscale Optoelectronics, China

The analysis and understanding of electrode processes at the electrode/electrolyte interface is crucial for the development of high-energy-density liquid and solid-state batteries. Not only charge transfer, but also performance and lifetime, are strongly influenced by interfacial reactions, including electrolyte decomposition. Charge-transfer barriers can be tuned by electrolyte engineering or electrode surface modifications. In Li-ion batteries, the reduction of liquid organic electrolytes leading to the solid electrolyte interphase (SEI) is particularly complex on materials undergoing volume changes, such as Si-based alloying electrodes. Electrolyte composition (solvent, salt, additive) and electrode chemistry, including the binder, have a major impact on SEI properties. Interfacial instability and parasitic side reactions significantly hinder the practical deployment of halide-based all-solid-state lithium batteries. Employing LiPON as an interfacial, functional layer on lithium metal has been shown to mitigate degradation and stabilize the interface. These studies demonstrate the effectiveness of combining surface analysis techniques, such as X-ray photoelectron spectroscopy and time-of-flight secondary ion mass spectrometry, for detailed chemical and structural characterization of surfaces and interfaces in liquid and solid-state batteries.

10:50 AM

(ICACC-S6-036-2026) Insights from atomistic modeling of battery materials (Invited)

H. Iddir*[1]

1. Argonne National Laboratory, Chemical Sciences and Engineering, USA

Cathode materials with improved energy densities, longer cycle-life, and improved safety characteristics are needed for portable electronic devices, smart grid systems, and transportation technologies. The highest energy-density cathode materials are based on transition metal oxides, such as layered $LiMO_2$ (M = Co, Ni, Mn), and lithium and manganese-rich composite layered transition metal oxide (LMR-NMC, LxS) materials. These cathode materials can address some of the challenges associated with next-generation energy storage devices. However, sufficient knowledge on the atomic scale structure, local environment, and processes governing these metrics in working cells is still lacking. Herein, I will present few examples of current interest to the Li-ion battery research community using density functional theory and molecular dynamics to provide few insights on select structure-property relationships, elemental segregation, surface reconstruction, cathode-electrolyte interaction, bulk stability, and Li transport.

11:20 AM

(ICACC-S6-037-2026) Engineering microstructure in dry-processed cathodes via calendering

H. Park*[2]; S. Trask[1]; A. Jansen[1]; J. Li[2]

1. Argonne National Laboratory, USA
2. Argonne National Laboratory, Applied Materials Division, USA

Dry-electrode manufacturing is emerging as a promising pathway toward next-generation lithium-ion batteries, offering lower production costs, environmentally friendly processing, compatibility with thick electrodes, and improved rate capability. Unlike slurry-based methods, calendering in dry processing is a multifunctional step that not only densifies the electrode but also promotes shear-induced PTFE fibrillation, reorganizes the microstructure, sets the thickness, and enhances lamination. While these roles are essential, they also introduce challenges such as an increased risk of active material fracture and pore collapse. In this study, considering microstructure, particle fracture, electrochemical properties, and mechanical properties, we systematically mapped the thermomechanical process window defined by roll gap, roll temperature, line speed, and the number of passes. Our results further emphasize the importance of avoiding over-densification and preventing damage to active particles. This integrated framework provides actionable guidance for scaling dry electrodes at industrially relevant throughputs, enabling concurrent optimization of mechanical integrity and electrochemical performance.

11:40 AM

(ICACC-S6-038-2026) Pilot-scale manufacturing and surface modification strategies of NaSICON membranes

A. Gibson*[1]; K. Lemley[1]; T. Dysert[1]; N. Kidner[1]

1. Nexceris, USA

Nexceris has a strong background in ceramic membrane production, primarily in the SOFC/SOEC industry. Over the past few years, we have branched into powder production and membrane fabrication of solid electrolyte materials for next generation batteries. In particular, we have produced high purity NaSICON powder and membranes with excellent flatness and low defect occurrence in pilot-scale quantities. These membranes have been utilized within the Adena cell technology, which is based on a sodium metal halide cell chemistry. For use in this particular type of cell, surface modifications of the membrane are imperative to decrease interfacial resistance and improve wettability of the molten sodium anode. Herein, we will discuss the manufacturing of the NaSICON membrane, its electrochemical performance, and two surface modification strategies, including a spin coated layer and a nanoparticle exsolution strategy.

S9 Porous Ceramics Novel Developments and Applications

S9- Additive Manufacturing and Functional Design

Room: Ballroom 3
Session Chair: Gisele Laure Lecomte-Nana, Universite de Limoges

8:30 AM

(ICACC-S9-008-2026) Novel processing method of porous ceramics using polysaccharide networks grown in green bodies as sacrificial templates (Invited)

M. Uematsu*[2]; K. Ishii[1]; T. Kimura[2]; T. Uchikoshi[3]

1. Nagoya Institute of Technology, Advanced Ceramics Research Center, Japan
2. Japan Fine Ceramics Center, Japan
3. National Institute for Materials Science, Japan

Starch, a plant-derived polysaccharide, swells when heated in water, forming a network structure. After cooling, it hardens while maintaining the network structure. In this study, we focused on this property and applied starch as a sacrificial template to create interconnected porous ceramics. While starch powder has been used in conventional processes, it typically results in isolated pores resembling the original particle shape. However, in some applications, an interconnected pore structure is desirable. Therefore, we heated starch-containing ceramic slurry prior to mold casting to induce gelatinization and form a fine network structure within the green body. The porous structure was characterized using the liquid immersion method and confocal fluorescence microscopy. This method reduces light scattering by immersing the sample in a liquid with a matching refractive index, enabling high-resolution internal observation. Our results demonstrate that this process enables the formation of micron-scale interconnected pore networks. This novel, sustainable method offers improved control of pore connectivity in porous ceramics using biopolymer-based templates.

9:00 AM

(ICACC-S9-009-2026) Electrically conductive glass matrix composite scaffolds via digital light processing of silicone-based blends

A. Zilio*[1]; K. Vezzù[1]; V. Di Noto[1]; E. Bernardo[1]

1. Universita degli Studi di Padova, Department of Industrial Engineering, Italy

The present study addresses the fabrication of porous gyroid architectures through additive manufacturing based on preceramic polymers. Photocurable emulsions were engineered by combining silicone with acrylate monomers and by dispersing a secondary phase of emulsified inorganic salts ($Ca(NO_3)_2 \bullet 4H_2O$). These formulations exhibit light-curing behaviour that is compatible with digital light processing, thereby facilitating the precise reproduction of triply periodic minimal surface (TPMS) geometries. Subsequent pyrolysis under nitrogen at 700 °C results in CaO-SiO_2 derived matrices which embed a turbostratic carbon fraction, the latter being responsible for the emergence of electrical conductivity. The utilization of pharmaceutical borosilicate glass as an inert additive, introduced at varying loadings, was found to stabilize phase assemblages, mitigate sintering-induced shrinkage, and mechanicelly reinforce the lattices. The obtained structures exhibit a high surface-to-volume ratio, controlled porosity, and a combination of structural robustness with electrical functionality. These characteristics underscore their potential as multifunctional scaffolds for electrocatalytic systems, where the simultaneous requirements of efficient charge transfer, durable architecture, and maximized accessible surface area are paramount.

9:20 AM

(ICACC-S9-010-2026) Spatially tailored porosity in alumina by multi-material additive manufacturing

M. Schwentenwein*[1]; S. Nohut[1]; J. Schlacher[2]; R. Bermejo[2]

1. Lithoz GmbH, Austria
2. Montanuniversitaet Leoben, Institut fuer Struktur- und Funktionskeramik, Austria

This study focuses on the fabrication of porous alumina ceramics via vat photopolymerization (VPP)-based additive manufacturing, employing photocurable alumina suspensions containing different concentrations of poly(methyl methacrylate) (PMMA) microbeads as pore-forming agents (PFAs). The influence of PFA concentration, printed layer thickness, PFA particle size, and sintering temperature on the resulting microstructure and mechanical performance was systematically investigated. Findings show that careful adjustment of material composition and processing parameters enables a controlled balance between porosity and mechanical strength. In addition, the study explores multi-material VPP to produce advanced ceramic architectures, including laminate structures with porous interlayers and functionally graded ceramics featuring porosity gradients. By tailoring suspension formulations and optimizing debinding and sintering conditions, multi-material designs with customized mechanical and thermo-mechanical properties were successfully realized. Mechanical behavior was assessed through biaxial bending tests, while structural characteristics were analyzed using scanning electron microscopy. Results demonstrate that introducing porous interlayers improves damage tolerance in layered ceramics by promoting crack deflection, thereby mitigating catastrophic failure.

9:40 AM

(ICACC-S9-011-2026) Shaping the future: Additive manufacturing of porous ceramics

L. Wahl[1]; S. Funk[1]; M. Weichelt[1]; T. Fey*[1]

1. Friedrich-Alexander University Erlangen-Nürnberg, Department Material Science and Engineering, Germany

Additive manufacturing (AM) offers unprecedented design freedom for the production of complex and porous and cellular lightweight ceramic structures. When combined with energy-efficient synthesis routes such as sol–gel processing, AM enables the fabrication of highly porous components with reduced sintering temperatures and material consumption. Techniques like stereolithography, robocasting (direct ink wiriting), and replica methods using 3D-printed templates allow precise control over architecture, porosity, and strut morphology—key parameters for optimizing mechanical and functional properties. Cellular and honeycomb structures based on alumina, BaTiO3 and BCZT demonstrate that high structural complexity and ultrahigh porosity (up to 97%) are achievable with AM, while maintaining sufficient strength and excellent piezoelectric performance (up to 359 pC/N) using piezo-ceramics. By tailoring the powder properties through sol–gel synthesis and surface modification, sintering temperatures can be significantly lowered without compromising functionality. This integrated approach highlights the potential of additive manufacturing not only to reduce energy input and material usage but also to unlock new design paradigms in ceramic engineering—paving the way for sustainable, high-performance applications in sensing, actuation, and structural components.

S9- Innovative Processing and Characterization Techniques

Room: Ballroom 3
Session Chair: Tobias Fey, Friedrich-Alexander University Erlangen-Nürnberg

10:20 AM

(ICACC-S9-012-2026) Shaping geopolymers into plasma-compatible catalysts for methane decomposition

S. Mehdi*[1]; A. Gharzouni[1]

1. Institut de Recherche sur les Ceramiques, France

Non-thermal plasma (NTP) provides an efficient route for CO_2 -free hydrogen production via methane cracking ($CH_4 \rightarrow C + 2H_2$). The catalytic performance of this process relies on the dielectric and structural stability of the support under strong electric fields. Geopolymers, synthesized by alkali activation of aluminosilicates, emerge as promising candidates owing to their tunable porosity, thermal resistance, and ease of shaping. In this work, metakaolin-based geopolymer foams were developed using potassium silicate as the activator. The pore network was tailored by varying surfactant concentration and chemical foaming agents. Structural (XRD, FTIR, SEM) and dielectric analyses revealed that increasing surfactant and foaming agent contents improved pore interconnectivity, total porosity, and plasma discharge uniformity. Preliminary dielectric barrier discharge experiments showed that geopolymer foams enhanced methane conversion and hydrogen selectivity (from 3–4% to 6–15%), confirming their potential as stable, low-cost, and plasma-active catalyst supports for methane decomposition. Keywords: Geopolymers; porous ceramics; plasma catalysis; methane decomposition; hydrogen.

10:40 AM

(ICACC-S9-013-2026) Hot Disk method–Fast, easy, and non-destructive thermal conductivity characterization of porous ceramics

A. A. Trofimov*[1]

1. Orton Ceramic Foundation, Instruments, USA

Porous ceramics are widely utilized in thermal insulation, energy systems, environmental technologies, and structural applications where control of heat transfer is critical. Accurate determination of their thermal conductivity, diffusivity, and heat capacity is essential for understanding performance, optimizing design, and predicting service life. However, the heterogeneous nature of porous ceramics (including refractories, foams, powders) often presents challenges for conventional thermal measurement techniques. Hot Disk Transient Plane Source (TPS) method offers a unique, non-destructive approach for comprehensive thermal characterization of ceramics. With a single measurement, TPS method determines both thermal conductivity and diffusivity, thereby enabling calculation of heat capacity. Its flexibility in accommodating diverse specimen sizes and shapes makes it particularly suitable for challenging porous materials where traditional methods such as Hot Wire or Laser Flash may be less effective. This work will introduce the fundamentals of the Hot Disk technique and demonstrate its advantages for studying porous ceramics. Performance relative to Hot Wire and Laser Flash will be discussed. Selected case studies will highlight correlations between microstructure and thermal properties, including degradation of refractory ceramics and evaluation of ceramic foams and powders.

11:00 AM

(ICACC-S9-014-2026) Mercury-free liquid metal intrusion porosimetry for ceramic pore size characterization

C. Baldizar[1]; D. Schuetz*[2]; M. Noisternig[2]; S. Stauder[2]; R. Ahmad[1]

1. Anton Paar Quanta Tec, USA
2. Anton Paar GmbH, Austria

Mercury intrusion porosimetry (MIP) is a cornerstone technique for characterizing porous materials, yielding pore size distributions, porosity, and pore volume over an exceptionally broad range of pore sizes. Although often attributed to mercury's non-wetting properties, its mercury's irreplaceability in porosimetry actually arises from its exceptional inertness: unlike most low-melting metals or alloys, mercury resists oxidation due to relativistic stabilization of its 6s electrons. This common misconception has long complicated efforts to identify alternatives. At the same time, mercury's toxicity and growing regulatory restrictions, most notably through the Minamata Convention, demand safer solutions. Here, we demonstrate that eutectic gallium–indium (eGaIn) offers a practical pathway to replacing mercury in liquid metal intrusion porosimetry. By carefully mitigating oxidation effects that otherwise induce wetting, eGaIn can replicate the critical functional role of mercury. We validate this approach on standard reference materials and technologically relevant ceramic systems, showing close agreement with conventional MIP data. We present both the data as well as the technological principles that enabled us to achieve this replacement. Our results establish a safer, sustainable, and accurate route for pore structure analysis of ceramics, advancing beyond the constraints of mercury.

11:20 AM

(ICACC-S9-015-2026) Impact of starch and bone ash on the final properties of kaolin and metakaolin-based porous ceramics.

M. Mouafon[3]; G. Lecomte-Nana*[1]; N. Tessier-Doyen[1]; D. Njoya[3];
M. Lacroix[1]; Y. Launay[1]; A. Njoya[2]

1. Universite de Limoges, France
2. Universite de Dschang, Cameroon
3. Universite de Yaounde I, Cameroon

A kaolinic clay was used as principal component to the elaboration of novel porous ceramics with cassava starch and bovine bone ash added up to 15%. Metakaolitic clay was prepared by sintering this kaolinic clay at 700°C for 4h. Porous ceramics were manufactured by uni-axial pressing, dried at 40°C for 48h and 100°C for 24h, and sintered respectively at 1000°C and 1150°C for 2 hours. The effect of additives type and sintering temperature on microstructure, flexural strength, thermal behavior and porosity of different ceramics were investigated to characterize the elaborated products. SEM micrographs of samples sintered at 1000°C reveals low cohesion between particles and higher porous cavities than those of samples sintered at 1150°C. Ceramics open porosity varies between 48% and 61% at 1000°C, and 42% et 57% at 1150°C. regarding the porogenic agent type, flexural strength moved from 0.2 to 5.5 MPa. BET specific surface area of different samples varies between 0.72 m^2/g and 8.32 m^2/g, and decrease while temperature increases. Corrosion rate are less than 6% for different porous ceramics at different temperatures except KM15 elaborated at 1000°C for which corrosion rate is 10.3%. Ceramics conductivities are between [0.12 - 0.24] $W.m^{-1}.K^{-1}$ for those obtained at 1000°C; and [0.15 - 0.32] $W.m^{-1}.K^{-1}$ for those obtained at 1150°C.

11:40 AM

(ICACC-S9-016-2026) Highly porous 3D-printed 70S30C bioglass scaffolds from engineered silicone-based emulsions

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1. Universita degli Studi di Padova, Industrial Engineering, Italy

70S30C (70 mol% SiO_2, 30 % CaO) bioglass is recognized as one of the most promising bioceramics for bone tissue engineering. It is often considered as a reference composition for sol-gel derived bioglasses, due to its simplicity; however, the controlled fabrication of amorphous structures, free from undesirable crystalline phases in oxidizing atmosphere, remains a critical challenge. In this work, a 'third way' between conventional glass melting and sol-gel processing is explored, enabling the coupling of synthesis and shaping, also through additive manufacturing. Specifically, commercial silicone resins mixed with photocurable acrylates form the basis for pastes processed by direct ink writing to obtain reticulated scaffolds, later stabilized by UV curing. Upon firing in air at 800°C, the silicone component provides amorphous silica, while Ca ions are introduced from calcium nitrate tetrahydrate. A key aspect is the quasi-molecular distribution of the CaO precursor, enabled by dissolving the salt in water and dispersing the solution as an emulsion within the silicone/acrylate blend. The resulting scaffolds are fully amorphous, nearly crack-free, and exhibit a unique hierarchical architecture: macropores from printing are combined with pores in the struts, arising from salt decomposition, water release, and the polymer-to-ceramic transformation of the silicone.

S10 Integrated computational -Experimental modeling ad design of ceramics and composites

S10- Modeling of structure and property of ceramics and composites I

Room: Ballroom 4
Session Chairs: Paul Rulis, University of Missouri - Kansas City;
Jung-Hoon Lee, Korea Institute of Science and Technology

8:30 AM

(ICACC-S10-008-2026) An ab initio defect chemistry analysis of $Ln_2NiO_4+\delta$ (Ln = La, Nd, Pr) (Invited)

Y. Zhong*[1]

1. Worcester Polytechnic Institute, Mechanical and Materials Engineering, USA

Layered Ruddlesden–Popper nickelates have emerged as promising alternatives to conventional perovskite materials for intermediate-temperature solid oxide fuel cells (IT-SOFCs), owing to their favorable oxygen transport properties. This work presents a first-principles defect chemistry study of $Ln_2NiO_4+\delta$ (Ln = La, Nd, Pr), aiming to understand the role of intrinsic oxygen-related defects in enabling high ionic conductivity. The approach integrates density functional theory (DFT) calculations, chemical potential analysis, and Zentropy-based statistical mechanics to systematically evaluate defect formation energies, carrier concentrations, and thermodynamic stability across varying temperatures and oxygen partial pressures. A rigorous computational workflow was developed, including structural relaxation, dielectric tensor corrections, and multi-charge-state defect modeling. This framework enables a deeper understanding of oxygen defect behavior in complex oxides and provides a foundation for guiding future materials optimization. Ongoing efforts include migration barrier calculations, high-temperature effects, and validation through AIMD and experimental data.

9:00 AM

(ICACC-S10-009-2026) Electronic structure and surface properties of nitrides from first-principles calculations (Invited)

M. Magnuson*[1]

1. Linköping University, Department of Physics, Chemistry and Biology (IFM), Sweden

A comprehensive density functional theory (DFT) study of a wide range of nitride materials is presented, including transition-metal nitrides, group III–V semiconducting nitrides, and complex systems. Using both standard and hybrid exchange-correlation functionals, structural, electronic, strain and surface properties that underpin their behavior in electronic and energy-related applications are explored. The calculations reveal that wide band gap nitrides are sensitive to doping and defect chemistry, which can introduce shallow donor or mid-gap states that significantly alter electronic transport. Surface slab models show that vacancy formation energies and terminations strongly affect surface stability and work functions, while nitrogen-rich conditions promote the formation of metastable spinel-like phases. The interplay between composition, surface termination, and defect states is found to be critical in tuning the properties of these materials. The results offer fundamental insights into how electronic structure engineering in nitrides can be harnessed for applications ranging from protective coatings and transparent conductors to optoelectronic devices and heterogeneous catalysis.

9:30 AM

(ICACC-S10-011-2026) Design of 3D SiC-based architectures using topology optimisation for improving the global performances of volumetric solar absorbers (Invited)

A. de la Vauvre[1]; Y. Favennec[1]; L. Cangemi[2]; B. Rousseau*[1]

1. LTeN, France
2. IFP Energies nouvelles, France

Volumetric solar absorbers are radiative-convective heat exchangers whose design is subject to coupled thermal and material constraints. These challenges must be addressed in a systemic manner to make them industrially viable. The inhomogeneity of the heating inevitably leads to significant spatial thermal gradients within their volumes, causing damaging fractures. Various empirical solutions have been proposed to better transfer the incident solar radiation into the heat exchanger volume while minimising thermal losses, but the results have not been conclusive in terms of energy conversion. To achieve this, it is essential to treat the physics involved in heat exchanges as accurately as possible and then to automatically adapt the local distribution of the solid matter in the heat exchanger. Topological optimisation meets this requirement insofar as it can handle both radiative transfers and pseudo-Darcy flows. This presentation will outline a continuous-scale topological optimisation approach combined with a gradient descent method calculated from the adjoint states, followed by an associated deshomogenisation process used to create volumetric solar absorbers based on 3D SiC-based architectures. Depending on the desired function objective, architectures designed to maximise solar heat conversion or minimise thermal gradients will be proposed.

10:20 AM

(ICACC-S10-012-2026) Simulated characterization to aid processing of calcium lanthanum sulfide

C. Atkinson*[1]; M. C. Guziewski[1]; A. L. Fry[1]

1. US Army Combat Capabilities Development Command Army Research Laboratory Aberdeen Proving Ground, USA

Calcium lanthanum sulfide ($CaLa_2S_4$) and other stoichiometries in the Ca-La-S (CLS) system are candidate materials for applications in the long-wave infrared (LWIR) due to their transmittance range and thermomechanical properties. Experimental findings have shown defects arise during processing, such as sulfur vacancies and oxygen impurities, influencing the optical properties that make them desirable for such applications. Understanding the relationship between processing routes and defect content is vital for optimizing material processing. In this study, these relationships are understood by utilizing density functional theory to create predictive models of defects within the crystal structure and then create simulated characterization profiles for various stoichiometries and defect content. These profiles are compared to results of fabricated samples, allowing for a more rapid interpretation and understanding of the effect of different processing routes on the performance of the material.

10:40 AM

(ICACC-S10-013-2026) Analysis of catalyst layer structures in polymer electrolyte fuel cell cathodes using neural network molecular dynamics simulation

K. Kamata*[1]; K. Suzuki[1]; S. Fukushima[1]; Y. Ootani[1]; N. Ozawa[2]; M. Kubo[1]

1. Institute for Materials Research, Tohoku University, Japan
2. Tohoku University, New Industry Creation Hatchery Center, Japan

Polymer electrolyte fuel cells (PEFC) are increasingly expected to power heavy-duty vehicles such as buses and trucks, which require high output. Achieving such performance depends on the catalyst layer (CL) structure. The CL is composed of Pt catalyst nanoparticles, ceramics co-catalysts, carbon supports, ionomers, and water molecules. On the Pt catalyst nanoparticles of the CL at the cathode, the oxygen reduction reaction (ORR), in which O_2 chemically reacts with protons and H_2O is formed, plays a decisive role in determining the output of the fuel cell. To clarify highly active CL structures, the effects of the CL structure on ORR activity should be understood at the atomic scale. For such an atomic-scale understanding, ab initio molecular dynamics (AIMD) has conventionally been the exclusive methodology. However, due to the enormous computational cost, AIMD can only simulate ORR on Pt catalyst nanoparticles, making full-CL modeling impractical. To overcome this limitation, we constructed a neural network potential (NNP) trained on AIMD data. Using this NNP, we successfully reproduced the complicated CL structures in PEFC. This approach will examine how the CL structure influences the ORR activity, providing theoretical principles for the rational design of the highly active CL at the cathodes in the future.

S12 Atomically Layered Carbides, Nitrides, Borides, and Related Materials- From Bulk to Low Dimensional Derivates

S12-Atomically Layered Carbides, Nitrides, Borides, and Related Materials- From Bulk to Low Dimensional Derivates I

Room: Flagler C
Session Chairs: Miladin Radovic, Texas A&M University;
Konstantina Lambrinou, University of Huddersfield

8:30 AM

(ICACC-S12-001-2026) The MAX phases: A historical perspective and future divinations (Invited)

M. Barsoum*[1]

1. Drexel University, Materials Science and Engineering, USA

In this talk I will review the history of these layered, hexagonal, machinable carbides and nitrides starting with their discovery in the sixties by Nowotny and coworkers, to our rediscovery in the mid-nineties to today. I will summarize the properties that render them unique like their mechanical properties and their in-plane electrical conductivities, arguably the one property that renders MXenes - their 2D derivative we discovered in 2011 - unique. What the future holds is more difficult to envision. In 1996, there were about 50 MAX phases; today their number has exploded to roughly 10 times that number. The world seems to discover new MAX phases faster than we can characterize them. It follows that even if no new MAX phases were ever discovered, it will take a long time to digest what we have. There is thus little doubt that their future is quite bright and truly exciting.

9:00 AM

(ICACC-S12-002-2026) Let's talk A: Synthesis and properties of MAX phases with exotic A-elements (Invited)

C. Birkel*[1]; A. Loloee[1]; S. Kale[1]

1. Arizona State University, USA

The number of MAX phases has increased tremendously over the last decade which has been driven by reports on interesting magnetic behavior of Cr- and Mn-based MAX phase thin films as well as using MAX phases as precursors for 2D MXenes. More than 350 members are known, which include ternary compounds and (single-, double-site) solid solutions. The vast majority of MAX phase works are on compounds with group 13 and 14 A-elements, e.g. Al, Ga, Si, however, the chemical diversity is much greater and goes far beyond these elements. In this talk, I will discuss our work on MAX phases with "exotic", meaning less common, A-elements. This includes P- and As-containing MAX phases, such as V2PC and V2AsC, as well as new A-site solid solution MAX phases, e.g. M2(Ga/Ge)C (M = Cr, V). I will also show a new MAX phase that contains an entirely unexpected element on its A-site. Aside from their synthesis and structural science, I will discuss the oxidation behavior of some of these phases. We synthesize our materials by classical and non-conventional (microwave heating) solid-state reactions and sol gel-based approaches. All products are carefully characterized by numerous diffraction (lab and synchrotron X-rays), microscopy, spectroscopy (lab and hard-X-ray photoelectron spectroscopy) and thermal analysis techniques.

9:30 AM

(ICACC-S12-003-2026) Defect engineering of 2D MXenes to control stability and phase transformation (Invited)

B. Anasori*[1]

1. Purdue University, USA

MXenes are a large family of 2D materials with about 100 compositions synthesized to date. In addition to the compositional and structural tunability of MXenes, defects, specifically basal plane point defects, provide us with opportunities (and challenges) in controlling MXene stability and properties. In this talk, I will present how MXene synthesis conditions control the basal plane metal vacancy concentrations, ranging from less than 1 at.% vacancy to ~ 20 at.%. The optimized $Ti_3C_2T_x$ single flakes with < 1 at.% vacancies remain stable in air up to 600 °C before oxidation and in an inert environment up to 1000 °C before transformation to 3D bulk carbide. Atomic-layer resolution secondary ion mass spectrometry (SIMS) results indicate cations can either decorate the surface or occupy the metal vacancy sites, depending on the vacancy concentration of the basal planes. When defect sites are occupied by cations, defective MXene flakes can be stabilized and approach the stability of pristine MXene flakes. A similar trend of stability by defect engineering is observed in other MXenes, such as Ti_2CT_x, $Nb_4C_3T_{x,}$ and $Ta_4C_3T_x$. Understanding and controlling defects demonstrates an important way to tune MXenes' behavior and properties and represents a potential new atomic-scale tool for designing and achieving ideal phase-property relationships of carbides and their composites for extreme applications.

10:20 AM

(ICACC-S12-004-2026) Synthesis and characterisation of Al_5C_3N thin films and bullk– revisiting a layered carbonitride (Invited)

E. Lewin*[1]

1. Uppsala Universitet, Dept. of Chemistry - Ångström, Sweden

Al_5C_3N is an atomically layered carbonitride phase, which first was reported in 1935, with the structure determined in the 1960:s. The structure consists of AlN, Al_2C and Al_2C_2 layers with shared Al atoms. The compound has however not been widely studied, and the physical and chemical properties of Al_5C_3N are more or less unknown. This paper presents recent results on Al_5C_3N thin films and bulk samples. Coatings were grown using reactive sputter-deposition with nitrogen, at temperatures of 650 and 800°C. The bulk samples were synthesised by a solid-state reaction of AlN and Al_4C_3 in a nitrogen-containing atmosphere at 1950°C. Samples were characterised using X-ray and neutron diffraction, X-ray photoelectron spectroscopy, as well as high-resolution transmission electron microscopy. Mechanical and optical properties were determined using nanoindentation and absorption and reflection measurements. Using AlN(00l)/α-Al_2O_3(00l) substrates at 800°C an epitaxial growth of thin films was achieved, but with a large number of defects - mainly identified as extra stacking planes locally inserted into the structure. The coatings exhibited a ceramic hardness of 18-19 GPa, and optical measurements determined band gaps of 1.8 and 2.5 eV for films deposited at 800°C. In-depth analysis of the bulk samples leads to a revised structure determination, with mixed occupancy and $P6_3$/mmc (194) symmetry.

10:50 AM

(ICACC-S12-005-2026) Achieving phase-pure MAX phase ceramics via the steric stabilization of complex solid solutions (Invited)

N. Goossens*[1]

1. Empa, High Performance Ceramics, Switzerland

The nanolaminated MAX phases are described by the $M_{n+1}AX_n$ stoichiometry, where M is an early transition metal, A is an A-group element, X is C and/or N, and n =1-4. Their tunable structure and composition endow them with tailorable properties that are exploited in application-oriented materials design. However, producing phase-pure bulk MAX phase ceramics relies on the complex interplay between structural stability, competing phase formation, diffusion kinetics, and process-specific factors. Controlling the internal lattice distortions whilst exploiting configurational entropy enhancement via the rational design of chemically complex MAX solid solutions is the key to produce highly pure ceramics with engineered microstructure and grain morphology. This talk discusses steric stabilization in chemically complex solid solutions on the M- & A-site to stabilize challenging MAX phase chemistries and addresses the (adverse) implications of (in)adequate processing conditions on the formation mechanism, microstructure, and final properties of complex MAX phases. Rational solid solution design embracing chemical complexity holds immense potential for producing high-purity MAX phase ceramics with engineered microstructures and tailored properties, even under stringent application-driven compositional design constraints.

11:20 AM

(ICACC-S12-006-2026) Dissecting the chemistry of MAX phase delamination: Pathways, intermediates, and morphological evolution

M. Dujovic*[3]; S. Celik[3]; V. Deshpande[1]; J. L. Lutkenhaus[2]; M. Green[2]; A. Srivastava[3]; M. Radovic[3]

1. University of Cambridge, Department of Engineering, United Kingdom
2. Texas A&M University, The Artie McFerrin Department of Chemical Engineering, USA
3. Texas A&M University, Department of Materials Science and Engineering, USA

MXenes are a rapidly expanding family of two-dimensional transition metal carbides, nitrides, and carbonitrides, derived from MAX phase precursors by selective etching of A-group elements. They are valued for their exceptional conductivity, chemical tunability, and structural stability in diverse applications. Although over 340 MAX phases have been reported, only ~50 MXenes have been experimentally realized, underscoring the limited understanding of the transformation mechanisms during etching. In this study, we examine the etching behavior of Ti_3AlC_2, using microwall structures FIBed from grains with different crystallographic orientations, where the longer edges are aligned parallel to the basal planes and exposed to hydrofluoric acid (HF). By tracking the interface between etched and unetched regions and atomic-level changes at the etching front using a Transmission electron microscope (TEM), we provide the first direct experimental evidence of lattice parameter expansion in delaminated domains, consistent with first-principles predictions. These findings clarify structural evolution and etching dynamics underlying MXenes' accordion-like morphology.

11:40 AM

(ICACC-S12-007-2026) Role of precursor chemistry in reaction pathways and oxygen incorporation in Ti_3AlC_2

K. Lee*[2]; V. R. Sanchez[1]; C. Wang[2]; M. Dujovic[2]; C. Novosad[2]; S. A. Tsipas[1]; J. Lutkenhaus[3]; M. Green[3]; A. Djire[3]; M. Radovic[2]

1. Universidad Carlos III de Madrid, Department of Materials Science and Engineering and Chemical Engineering, Spain
2. Texas A&M University, Department of Materials Science and Engineering, USA
3. Texas A&M University, Department of Chemical Engineering, USA

Ti_3AlC_2, the most extensively studied MAX phase, can be synthesized under diverse conditions, yet the role of precursor type in its formation pathways and oxygen incorporation remains insufficiently understood. This study examines the effects of precursor composition, molar ratio, and synthesis atmosphere on Ti_3AlC_2 synthesis. X-ray diffraction confirmed Ti_3AlC_2 as the primary phase under all conditions, although excess aluminum promoted competing intermetallic phases. Rietveld refinement identified two distinct pathways depending on initial Al content, along with a unique route for graphite-derived samples. Oxygen levels, quantified using ONH analysis, WDS, and SIMS, averaged ~3.2 at.% across all syntheses, corresponding to ~8.8 at.% oxygen substitution on the carbon sublattice, with no statistically significant dependence on Al content. These findings demonstrate that while Ti_3AlC_2 forms through multiple precursor-dependent pathways, its structural, morphological, and chemical characteristics—particularly oxygen incorporation—remain consistent. This provides a robust framework for rational precursor selection in synthesizing high-quality Ti_3AlC_2.

S13 Advanced Ceramics and Composites for Nuclear Fission and Fusion Energy Systems

S13- Advanced characterization techniques and methods

Room: Coquina F
Session Chair: Dong Liu, University of Oxford

8:30 AM

(ICACC-S13-042-2026) In-situ transmision electron microscopy testing of nuclear relevant ceramics (Invited)

K. Hattar*[1]

1. The University of Tennessee Knoxville Tickle College of Engineering, Nuclear Engineering, USA

The increasing demand for clean energy has resulted in the emergence of many new reactor concepts for future nuclear fission and fusion energy systems. Many of these concepts in development are largely limited by the thermal, radiation, and mechanical stability of the materials that can survive. Nuclear systems also need to have well validated modeling in order to maintain the outstanding safety record. In order to provide the necessary predictive modeling, experiments with the ability to provide fundamental observations of the governing mechanisms are essential. This presentation will highlight the potential for advanced in-situ transmission electron microscopy (TEM) to explore the impact of temperature, radiation damage, trapped gas bubbles, mechanical loading, and combinations thereof. This is possible due to recent advancements made in coupling TEM with laser heating, quantitative nanomechanical testing, and ion bombardment. Examples of such mechanisms will be demonstrated in several advanced ceramics including but not limited to lithium aluminate, silicon nitride, transition metal dichalcogenides, and depleted uranium oxide. The recent development of such an instruemnt at the Tennessee Ion Beam Materials Laboratory will be demonstrated. Finally, this presentation will conclude with the future potential of the field to progress our understanding of mechanisms active in advanced ceramics.

9:00 AM

(ICACC-S13-043-2026) Non-destructive evaluation of SiC/SiC composites using guided waves and physics informed machine learning

G. Subhash*[1]; M. P. MacIsaac[1]; C. Tran[2]; A. Beck[3]; W. Eum[2]; J. Harley[2]

1. University of Florida, Mechanical and Aerospace Engineering, USA
2. University of Florida, Department of Electrical and Computer Engineering, USA
3. University of Florida, Department of Physics, USA

Silicon carbide fiber-reinforced, silicon carbide matrix (SiC_f-SiC_m) composites have been identified as viable candidates for nuclear fuel cladding. Inspection of these materials remains a challenge due to their complex woven composite structure consisting fibers, matric, weave architecture, defects, hierarchical length scales etc. This complexity is further exacerbated by the high curvature of the tube. Current diagnostic techniques such as X-ray computer tomography (XCT) requires specimens to be sectioned, and is not amenable to online monitoring. To address this challenge, we have developed a physics-informed machine learning (PIML) framework based on a generalized superelliptical form of the 2D scalar wave (Helmholtz) equation to predict structural features in anisotropic materials and experimentally validated this approach by capturing the wave propagation characteristics in metals and variety of planar composites using a laser Doppler vibrometer system. Our PIML framework extracts knowledge directly from experimental data without an underlying analytical basis. The proposed framework learns material characteristics from only the wave equation, allowing the framework to adapt to many scenarios. We have now extended this approach on planar SiC_f-SiC_m composites and demonstrate how material properties are extracted.

9:20 AM

(ICACC-S13-044-2026) Super-resolution enhancement of XCT for SiC/SiC composite tube inspection

J. D. Arregui-Mena*[1]; A. Ziabari[2]; O. Rahman[2]; T. Koyanagi[2]

1. Oak Ridge National Lab, Nuclear Materials Science & Technology Group, USA
2. Oak Ridge National Laboratory, USA

X-ray computed tomography (XCT) is an indispensable tool for the non-destructive evaluation of silicon carbide–silicon carbide (SiC/SiC) composite fuel cladding, where internal pores and microstructural features are otherwise inaccessible. Accurate detection and quantification of these defects are critical for assessing cladding performance and reliability under reactor conditions. However, acquiring high-resolution XCT scans of cladding sections is time intensive, limiting throughput and making large-scale inspection impractical. While reducing scan resolution improves efficiency, it comes at the cost of spatial detail, undermining the reliability of pore characterization and defect detection. Super-resolution algorithms offer a promising pathway to overcome these limitations by enhancing the fidelity of lower-resolution XCT reconstructions. In this study, we compare high- and low-resolution scans to evaluate how high-resolution data can be used to improve the quality of lower-resolution reconstructions. Pore characterization and internal surface analyses of the cladding tubes are presented to assess the viability of this approach for SiC/SiC composite materials.

9:40 AM

(ICACC-S13-045-2026) CMC tubular components in High-Temperature Reactor (HTR) nuclear applications: Review of current and draft ASTM standards for CMC tubes

M. G. Jenkins*[1]; J. E. Gallego[1]; G. Singh[2]

1. Bothell Engineering and Science Technologies, USA
2. Idaho National Laboratory, USA

US DOE is supporting the use of advanced materials for core and reactor unit components in advanced, high-temperature reactors. SiC-SiC ceramic matrix composites (CMCs) greatly expand the design window for various components in terms of operating temperatures, applicable stresses, and service lives while significantly improving accident tolerance and safety margins. For example, CMC tubular components include fuel rods, control rod sleeves, and control rod joints. Possible failure modes include axial and hoop tension, axial flexure, axial and diametral compression, and axial shear. Because fibre-architecture and matrix formation are unique to CMC tubes, material properties cannot be determined from coupons extracted from the tubes. Therefore, test methods are required that use CMCs tubes as test specimens. A review is provided for current ASTM test methods for CMC tubes (e.g., C1773 for axial tensile strength; C1819 and C1863 for hoop tensile strength; and C1899 for flexural strength). In addition, a draft ASTM test method has been developed to determine the axial compressive strength of CMC tubes. The draft standard addresses such experimental issues as test specimen geometries/preparation, test fixtures, test equipment, interferences, testing modes/procedures, data collection, calculations, reporting requirements, precision/bias.

S13- SiC-based material development for nuclear fission ad fusion

Room: Coquina F
Session Chair: Khalid Hattar, The University of Tennessee Knoxville Tickle College of Engineering

10:20 AM

(ICACC-S13-046-2026) Damage progression and failure of SiC/SiC composites subjected to in-situ 4-point bending

E. Cakmak*[1]; N. Cinbiz[2]; J. D. Arregui-Mena[3]; T. Koyanagi[2]

1. Oak Ridge National Laboratory, Materials Science and Technology Division, USA
2. Oak Ridge National Laboratory, USA
3. Oak Ridge National Lab, Nuclear Materials Science & Technology Group, USA

Silicon carbide matrix silicon carbide fiber (SiC/SiC) ceramic composites are promising candidates for both fission and fusion applications in the nuclear field. Various combinations are engineered to obtain optimal mechanical properties such as the weave structure, fiber volume, fiber type and diameter, interface coating and matrix deposition no name a few. This many variables is enough to make their deformation behavior extremely complicated and 4-point bend testing is used as a relatively simple test method to screen through candidate materials. Historically, the proportional limit strain (PLS) is used as an indicator of micro-cracking however, is often not supported by microstructural data. We have previously shown that high-resolution in-situ x-ray computed tomography is a powerful technique to track and follow deformation along the load curve with volumetric microstructural data. In this study we apply in-situ mechanical deformation to bend bars extracted from miniature SiC/SiC composite specimens with high-resolution XCT. Deep learning aided segmentation and systematic data analysis combined with strain maps revealed by Digital Volume Correlation are used to detect critical defects that lead to ultimate failure as well as correlate defect evolution to mechanical indicators such as PLS. The work was supported by DOE Office of Nuclear Energy, Advanced Fuels Campaign.

10:40 AM

(ICACC-S13-047-2026) Joining of SiC/SiC by preceramic polymers for safe nuclear energy applications.

A. Pizzinat*[1]; M. Ferraris[1]; D. Alidoost[1]; A. Benelli[1]

1. Politecnico di Torino, Department of Applied Science and Technology (DISAT), Italy

Silicon carbide fiber–reinforced silicon carbide (SiC/SiC) composites have attracted significant attention as candidate materials for safer and more efficient nuclear fuel cladding, as well as for advanced fusion and fission reactor systems. Their excellent thermal stability, high strength, and radiation resistance make them particularly suitable for such demanding environments. However, the development of reliable joining techniques and compatible materials remains a key challenge for their practical implementation. One promising strategy is the use of SiC-based preceramic polymers for both joining and coating SiC/SiC composites. In this approach, a polycarbosilane precursor is combined with SiC microparticles and fibers, followed by controlled thermal treatments under vacuum: curing at 200 °C and pyrolysis at 1450 °C. This method provides potential advantages in tailoring joint integrity and coating performance while maintaining chemical compatibility with the composite. This report examines the morphology, microstructure, and mechanical behavior of the resulting joints and coatings, with particular emphasis on the role of porosity in determining joint strength. Acknowledgements: This research was funded by the EU's Horizon 2020 programme under grant No. 101059511 - Project SCORPION (SiC Composite Claddings: LWR Performance Optimisation for Nominal and Accident Conditions).

11:00 AM

(ICACC-S13-048-2026) Evaluation of SiC and SiC-based ceramics for use in advanced fusion vacuum vessels

K. Vasudeva*[1]; M. Rae[2]; A. Wylie[1]; J. Demiane[1]; W. Cairang[1]; W. Zhou[1]; S. Huberman[3]; K. Woller[4]; M. P. Short[1]; S. E. Ferry[4]

1. Massachusetts Institute of Technology Department of Nuclear Science and Engineering, USA
2. Massachusetts Institute of Technology Department of Materials Science and Engineering, USA
3. McGill University, Chemical Engineering, Canada
4. Massachusetts Institute of Technology Plasma Science and Fusion Center, USA

The Liquid Sandwich Vacuum Vessel is a disruption-proof VV design which features a non-conductive structural material shell enclosing a conductive liquid. The leading structural material candidate is NITE-SiC/SiC. This assembly is contained within the liquid immersion blanket of the ARC Tokamak. Results from two workstreams within the LSVV project will be presented. The first workstream aims to uncover the effect of transmutants on the thermal diffusivity of SiC using in-situ transient grating spectroscopy (TGS) and dual-ion irradiation. Experimental results will be presented to show in-operando measurement of thermal diffusivity of 3C-SiC using TGS during exposure to Si^{4+} ions at multiple temperatures. Preliminary results will be presented showing the effect of He pre-implantation followed by Si^{4+} irradiation on thermal diffusivity. Complementary computational work has been carried out to assess the reliability of TGS across different defect regimes. This is done using the variational solution to the BTE. The second workstream aims to understand the corrosion response of NITE-SiC/SiC to fluoride-bearing molten salts. Cross-sections of the corroded samples are analyzed using SEM/EDS, while XPS is used to probe corrosion products. Cracks were seen in the microstructure after exposure to both salts, the cause of which has been explored using Raman Spectroscopy and EBSD.

11:20 AM

(ICACC-S13-049-2026) Updates on dry irradiation of SiC/SiC cladding at MITR

L. Mazzocco*[1]; N. Cetiner[2]; A. Seshadri[1]; D. Carpenter[2]; K. Shirvan[1]

1. Massachusetts Institute of Technology, USA
2. Massachusetts Institute of Technology, Nuclear Reactor Laboratory, USA

Silicon carbide composites (SiC_m/SiC_f) are leading candidates for accident-tolerant fuel cladding due to their high-temperature strength, slow oxidation kinetics, and low neutron absorption. While there is an extensive history of irradiations of SiC/SiC composites, comprehensive testing and qualification are needed for the adoption of novel cladding materials and architectures, especially on prototypical tubular specimens. A dry irradiation capsule, to be inserted in the MIT research reactor (MITR), is devised with the integration of electrical heaters to reproduce a radial heat flux (~0.5 MW/m^2) and fast neutron fluxes (~10^{14} $n/cm^2/s$) comparable to prototypical LWR conditions. The experimental set up is designed to accommodate both end plugged and open-ended SiC/SiC tubes with accurate online temperature monitoring and control. The environment is chosen to reproduce an evolution of temperature, thermal conductivity, and thermomechanical stresses in the specimens comparable to those found in a LWR cladding tube. This presentation will cover the design, fabrication and numerical modeling of the irradiation capsule as well as post-irradiation examination (PIE) plans for the irradiated cladding specimens.

11:40 AM

(ICACC-S13-050-2026) Effects of high dose neutron irradiation at LWR-relevant temperatures on the mechanical properties of SiC/SiC composites

Y. Jimba*[1]; T. Koyanagi[1]; Y. Katoh[1]

1. Oak Ridge National Laboratory, USA

Neutron irradiation effects on thermo-mechanical properties SiC/SiC composites are critical for assessing their feasibility and lifetime in accident-tolerant core structures of light water reactors (LWRs). While certain chemical vapor infiltrated SiC/SiC composites retain mechanical properties after neutron irradiation at LWR-relevant temperatures and doses, the degradation processes remain unclear. This study extends prior work by increasing neutron damage to 30 dpa to identify a potential threshold dose for degradation in mechanical and thermal properties. Irradiation was conducted at the High Flux Isotope Reactor at Oak Ridge National Laboratory. Flexural testing at ambient temperature, dimensional inspection, and thermal diffusivity measurements found irradiation-induced changes appeared saturated between 2 and 30 dpa. Despite stable bulk properties, electron microscopy revealed the carbon interphase became porous after irradiation to 30 dpa. This behavior is discussed using numerical analysis of irradiation-induced internal stress from differential swelling among matrix, fiber, and interphase, based on Raman-derived microstructural insights. This study reveals a specific SiC/SiC composite microstructure—particularly the carbon interphase—stable up to 30 dpa at ~300 °C. This work was supported by US DOE Office of Nuclear Energy, Advanced Fuels Campaign.

S16 Geopolymers Inorganic Polymers and Sustainable Construction Materials

S16- Sustainable construction materials I

Room: Ballroom 5
Session Chair: Pozhhan Mokhtari, University of Illinois at Urbana-Champaign

8:30 AM

(ICACC-S16-007-2026) Challenges and opportunities of weak alkali activation of waste glass (Invited)

E. Bernardo*[1]; I. Lancellotti[2]; M. Catauro[3]

1. Universita degli Studi di Padova Dipartimento di Ingegneria Industriale, Italy
2. University of Modena and Reggio Emilia, Engineering Enzo Ferrari, Italy
3. Universita degli Studi della Campania Luigi Vanvitelli, Italy

In the general domain of alkali activated materials glass has been variously proposed. Alkali alumino-silicate glasses may configure precursors for zeolite-like gels by direct attack of alkaline solutions; industrial residues (waste glasses), corresponding to discarded fractions of glass cullet, normally alumina-poor, may be considered as supplier of silica and alkali. In most cases, the use of glass is conditioned by the extensive dissollution of components in the activating solution. This contribution summarizes a variety of experiences concerning waste glasses in fine powders suspended in relatively diluted alkaline solutions (not exceeding 3M NaOH or KOH). Suspensions harden, upon drying at 40-80 °C, by the welding of adjacent particles, due to the condensation of hydrated surface layers, while dissolved components form a gel which is not essential for the stability of the final product. Challenges concern the distribution of alkali ions (from both solution and glass), which should not interfer with the condensation, and the segregation of metalloid ions (Sb, As) in the gel. Opportunities concern the stabilization of the gel phase, by addition of alumina-rich waste (e.g. of volcanic origin), and the application of microwave heating, upon drying, promoting the formation of alkali carbonates, and the application of 'washing' steps (implying the removal of gels and recovery of alkali).

9:00 AM

(ICACC-S16-008-2026) Effect of mineral binder and vegetal particles on ITZ formation in bio-based concrete

É. Prud'homme*[1]; F. Delhomme[2]; S. Amziane[3]; E. Toussaint[3]; S. Marceau[4]

1. Institut National des Sciences Appliquees de Lyon, MATEIS, France
2. Institut National des Sciences Appliquees de Lyon, GEOMAS, France
3. Institut Pascal, France
4. Universite Gustave Eiffel, France

Hempcrete is a low-carbon-footprint building material consisting of a mixture of cement and/or lime and vegetable particles (shiv). Its high porosity and low density provide good insulation and hygrothermal and acoustic properties. However, its mechanical strength is poor due to an interfacial transition zone (ITZ) around the shiv that does not fully hydrate like the rest of the matrix. The ITZ forms primarily due to the diffusion of sugars from the hemp to the cement paste. To improve its mechanical properties, it is essential to understand the interactions in binder-fiber bonding pairs. To this end, four types of cement (Portland, Prompt, LC3, and CEM IV) and two types of vegetal (hemp and bamboo) were studied. To visualize the ITZ, its formation was monitored over time using image analysis with pellets of crushed vegetal immersed in the binder. Additionally, indentation tests were performed on various areas of the ITZ. Hemp pellets produced smaller halos than bamboo, suggesting that hemp has a lesser impact on binder hydration and may perform better. For the various binders, setting time appears to be a key factor in ITZ formation. Finally, X-ray tomography tests revealed a difference in porosity between the ITZ and the rest of the matrix. The long-term objective is to expand these tests to identify the most effective binder/vegetal combinations for producing efficient plant-based concrete.

9:20 AM

(ICACC-S16-009-2026) Sustainable solutions of ceramic composites using additive manufacturing

H. A. Colorado L.*[1]

1. Universidad de Antioquia, Colombia

Additive manufacturing, also known as 3D printing, is a highly adaptable technology that can create almost any shape from a diverse array of materials. This includes everyday substances like food, cement, metals, and polymers, as well as less conventional ones such as soil and even waste. With global pollution posing a severe threat to life on Earth due to rising populations, increasing energy demands, and escalating greenhouse gas emissions, 3D printing offers a potent solution. It has the potential to significantly improve material circularity, thereby lessening the negative environmental impact of both engineered and natural materials once they reach the end of their lifespan. This research investigates several methods for creating structural materials from solid waste, specifically focusing on organic and inorganic wastes in applications including bricks, alternative cements, and additive manufacturing. Our work involved producing and characterizing composites using various additive manufacturing technologies, which yielded very promising results.

9:40 AM

(ICACC-S16-010-2026) Development of materials based on raw earth and mycelium

É. Prud'homme*[1]; F. Delhomme[2]; D. Perret[3]

1. Institut National des Sciences Appliquees de Lyon, MATEIS, France
2. Institut National des Sciences Appliquees de Lyon, GEOMAS, France
3. FungiMaker, France

Earth-based building materials are an environmentally friendly alternative to traditional materials like concrete. However, their poor water resistance limits their widespread use. One solution is to stabilize the earth by adding mineral binders; however this often results in a significant increase in environmental impact. Another solution is to use an organic binder, such as alginate or tannin. Using mycelium - the vegetative part of fungi consisting of a network of filaments called hyphae - is also an interesting possibility. This study investigates thow adding mycelium to soil and organic particle mixtures improves their water retention and mechanical performance. First, the behavior of the mycelium is studied in the presence of different organic particles and under different curing conditions (time and temperature)—an essential step for the mycelium's proper development. The development of the mycelium network was studied using macroscopic observation and scanning electron microscopy. Then, different soil contents were added. These tests achieved mechanical compressive strengths of around 1 to 2 MPa, as well as good water durability under the drop test. This makes it possible to consider filling or structural applications in new construction or the renovation of old buildings. Developing this organo-mineral material will result in a product with a low carbon footprint and performance suited to structural needs.

10:20 AM

(ICACC-S16-011-2026) Assessing the mechanical performance of rice hull ash (RHA) as cement replacement for enhanced grouting applications (Invited)

T. Borongon[1]; R. Esmael[1]; N. Hadji Rakim[1]; K. Martir[1]; J. Paez[1]; R. Hilot[1]; A. Secula[1]; S. D. Kempis[1]; A. Caamino*[1]

1. MSU-Iligan Institute of Technology, Department of Materials and Resources Engineering & Technlology, Philippines

Rice hull ash (RHA), a renewable by-product derived from rice hulls, is rich in amorphous silica and exhibits significant pozzolanic reactivity. Through its reaction with calcium hydroxide, RHA contributes to the formation of additional calcium silicate hydrate (C-S-H), thereby improving both mechanical performance and environmental sustainability. In this study, grout mixtures incorporating 0%, 5%, 10%, 15%, and 20% RHA were evaluated at a constant water-to-cement ratio of 0.55 and a sand-to-cement ratio of 1.5. Key performance parameters assessed included fluidity, setting time, shrinkage, and compressive strength at 7 and 28 days. Fluidity was optimized in mixtures containing between 6.2% and 9.52% RHA, while maximum compressive strengths were achieved at 8.4% RHA (7 days) and 5.5% RHA (28 days), as determined using Response Surface Methodology (RSM). All mixes exhibited initial and final setting times within 16 and 20 hours, respectively. Using Euclidean Compromise Programming, the optimal formulation was identified at approximately 7% RHA, achieving a fluidity of 14 seconds, setting times between 6 and 7 hours, and compressive strengths of 10.53 MPa (7 days) and 15.16 MPa (28 days). These results demonstrate the potential of RHA as a sustainable partial cement replacement in grout formulations, specifically underground mining applications.

10:50 AM

(ICACC-S16-012-2026) Nondestructive evaluation of sand–bamboo fiber reinforced geopolymer composites for structural applications (Invited)

R. A. Sa Ribeiro*[1]; M. G. Sá Ribeiro[1]; P. Mokhtari[2]; W. M. Kriven[3]

1. INPA-National Institute for Amazonian Research, Green Building and Engineering Laboratory, Brazil
2. University of Illinois at Urbana-Champaign, Materials Science and Engineering, USA
3. University of Illinois at Urbana-Champaign, USA

This study presents the synthesis, optimization, and performance evaluation of hybrid geopolymer composites reinforced with fine sand particulates and alkali-treated bamboo fibers, targeting sustainable alternatives for structural applications. A metakaolin-based geopolymer matrix activated with sodium silicate and NaOH was formulated with varying contents of ball-milled sand, regular fine sand, and bamboo fibers. Mechanical performance was characterized via four-point bending, while nondestructive evaluation (NDE) using resonant frequency methods provided estimates of dynamic Young's modulus. Complementary microstructural and compositional analyses (SEM, EDS, XRD, EDXRF) elucidated phase assemblage, filler dispersion, and fiber–matrix interfacial bonding. The Taguchi method was employed for multi-factorial optimization, identifying an optimal mix comprising 20 wt.% ball-milled sand, 40 wt.% regular sand, and 5 wt.% bamboo fibers. This composition exhibited superior flexural strength and dynamic modulus. A strong linear correlation between flexural strength and dynamic modulus validates the predictive utility of resonant NDE techniques. Results confirm the potential of hybrid natural–mineral reinforcements in developing eco-efficient geopolymer composites for load-bearing applications.

S16- Use of waste materials to make geopolymers

Room: Ballroom 5
Session Chair: Henry Colorado L., Universidad de Antioquia

11:20 AM

(ICACC-S16-013-2026) Geopolymer-mullite composites derived from alumina based bricks using rice ash as silica modifier (Invited)

C. Bagci*[1]; E. Dolu[1]; W. M. Kriven[2]

1. Hitit University, Department of Metallurgical and Materials Engineering, Turkey
2. University of Illinois at Urbana-Champaign, USA

This study investigates the development of porous geopolymer–mullite composites made from alumina-based refractory brick waste, utilizing rice husk ash (RHA). The geopolymerization process was initiated using a strong alkaline activating solution, combining alumina-rich brick powder with the required amount of RHA to achieve molar ratios of 1:1:4:11. The geopolymer pastes were subsequently cured in a humidity-controlled, constant-temperature oven at 80 °C for 48 hours. XRD and corresponding FTIR results illustrated that mullite in the brick waste powder was partially dissolved into alumina and silica species, with remained mullite crystalline peaks. Microstructural analysis revealed that alkali activation partially developed a 3D network structure, with RHA contributing to finer porosity due to its high surface area and amorphous silica content. Weibull modulus analysis from compressive and three-point bending tests revealed that the final composite materials exhibited remarkable compressive and flexural strength, attributed to the reinforcing effect of the mullite phase. The composites demonstrated reasonable compressive strength, making them suitable for lightweight thermal insulation and refractory applications. The combined use of alumina waste and bio-silica modifiers highlights the potential for circular economy strategies in advanced material design.

11:50 AM

(ICACC-S16-014-2026) Using waste materials and geopolymer as a binder for reinforced construction material

J. Lin*[1]; W. M. Kriven[1]

1. University of Illinois Urbana-Champaign, Material Science and Engineering, USA

The goal of this project is to revalorize waste materials such as 20 mm long metal wires from tires by using them as chemical and physical reinforcements in geopolymer to strengthen its properties, the waste materials that could be potentially harmful to the environment could be used for both environmental and industrial advantages. The metallic wires were previously reinforcements in rubber tires, and were disposed after the tires were worn out and chemically decomposed. With geopolymer as binder, a composite made from largely waste materials but having good properties could be fabricated. The manufacture of geopolymer produces only 25% of CO_2 emission compared to the manufacture of popular construction materials such as Portland cement. This project aims to find an optimal ratio of steel wires to incorporate into geopolymer composites to maximize their mechanical properties through multiple rounds of four-point flexural strength and uniaxial compression tests, along with X-ray diffraction (XRD), X-ray fluorescence (XRF), scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDX), thermogravimetric analysis (TGA), and differential scanning calorimetry (DSC) for the characterization of the geopolymer composites.

S20: Golden Jubilee- Engineered Ceramics for Achieving Net-Zero Carbon Emissions

S20- Current trends and future directions for research and technology on advanced ceramics, composites, and multifunctional materials II

Room: Coquina D
Session Chairs: Young-Wook Kim, WORLDEX Industry & Trading Co., Ltd.; Stuart Hampshire, University of Limerick

8:30 AM

(ICACC-S20-034-2026) Silicon Carbide: A multifunctional ceramic material (Invited)

Y. Kim*[1]; D. Kim[1]; H. Kim[2]

1. WORLDEX Industry & Trading Co., Ltd., Republic of Korea
2. University of Seoul, Republic of Korea

Silicon carbide-based ceramics demonstrate exceptional versatility, with properties that can shift like a chameleon – from electrical insulation and conductivity, from extreme heat resistance to notable deformability, and from strong thermal conduction to effective thermal insulation. This presentation will discuss approaches to engineering SiC ceramics with customized characteristics, emphasizing variants that are electrically conductive, heat tolerant, and thermally conductive. These advancements are realized through precise microstructure control and the judicious selection of sintering additives. The presentation will also introduce two innovative processing strategies: one employing thermodynamic instability principle to achieve homogeneous porous structures, and another demonstrating successful densification of fully ceramic microencapsulated nuclear fuels without applied pressure. Applications of SiC-based ceramics in both semiconductor processing parts and ballistic armor will also be addressed. This work was supported by a grant from the Korea Research Institute for Defense Technology Planning and Advancement (Project No. 24FS02, "Development of ultra-light ceramic personal bulletproof plate fabrication technology") under the Defense Science and Technology Innovation Promotion Act.

9:00 AM

(ICACC-S20-035-2026) Joining, integration, and repair of ceramic matrix composites for aerospace applications: Technical challenges and opportunities (Invited)

M. C. Halbig*[1]; M. Singh[2]; A. S. Almansour[1]

1. NASA Glenn Research Center, USA
2. Ohio Aerospace Institute, USA

Ceramic matrix composite (CMC) materials are enabling for high temperature aerospace applications such as turbine engine components, thermal management, and thermal protection systems due to their high temperature capability, relatively low density, damage tolerance, and environmental durability. Joining and integration solutions are necessary for the wider utilization and fabrication of complex CMC shapes and the integration of CMC components with metal-based systems. Each joining and integration approach must be tailored for its specific application. This tailored approach should consider component geometries, application temperature, environment and stress states, life and reuse requirements, material compatibility, joining method or braze selection, and tailoring of the interlayers. This presentation highlights NASA GRC developed joining and integration technologies with a focus on processing and optimization, thermomechanical testing, and processing-microstructure-property correlations. In addition, the complimentary technology of CMC repair to extend service life will be introduced. A damage repair approach was assessed by comparing the performance of undamaged, damaged and unrepaired, and damaged and repaired CMC coupons tested under relevant conditions of oxidizing environment, stress, and elevated temperature.

9:30 AM

(ICACC-S20-036-2026) Glass and ceramics for hydrogen technologies: Current solutions and perspectives (Invited)

F. Smeacetto*[1]

1. Politecnico di Torino, Applied Science and Technology, Italy

Hydrogen-related technologies are crucial for enabling the deep decarbonization of the energy system. Advanced glass and ceramic materials are essential in achieving enhanced efficiency and durable electrochemical energy conversion systems, including reversible solid oxide cells, electrolysers, and proton-conducting membranes. These technologies enable efficient and high-purity production of green hydrogen. As the EU targets 10 million tonnes of renewable hydrogen production by 2030, advanced electrolysis technologies are crucial for diversifying the technological landscape, reducing reliance on critical raw materials, and meeting decarbonization goals in hard-to-abate sectors. Current solutions and challenges related to the design, processing, microstructure-property-performance relationships of different glass and ceramic-based systems, as well as their integration process, are presented. Promising recycling strategies for recovering valuable ceramic materials to remanufacture SOCs components, thereby promoting a circular economy approach in the field of fuel cells and hydrogen (FCH) technologies, will also be presented and discussed.

10:20 AM

(ICACC-S20-037-2026) Review of developments in silicon nitride ceramics: Current trends in power electronics and biomedical applications (Invited)

S. Hampshire*[1]

1. University of Limerick, The Bernal Institute, Ireland

Silicon nitride-based ceramics are leading materials for emerging applications with their unique combination of high strength, fracture toughness and hardness. These properties arise during liquid phase sintering with oxide additives to develop bi-modal microstructures with high aspect ratio β-Si_3N_4 grains and intergranular glass phase. Silicon nitride also forms solid solutions with Al_2O_3

to form β- and α-SiAlONs allowing tailoring of compositions for applications such as cutting tools, bearings, pump components and turbocharger rotors. Emerging applications for Si_3N_4 include heat dissipation substrates in power electronics modules and potential use as biomedical devices. High thermal conductivity silicon nitrides have been developed by varying processing and sintering additives to produce microstructures with large β-Si_3N_4 grains and low lattice oxygen. The combination of high thermal conductivity and exceptional strength and fracture resistance allows their use in thermal management of high voltage power systems. The unique surface chemistry of silicon nitride allows it to interact favorably with the human body. Its reaction with biological fluids provides it with significant antipathogenic, osteogenic, and other therapeutic properties. Si_3N_4 is osteoconductive with antibacterial and antiviral properties, making it a leading candidate for biomedical applications.

10:50 AM

(ICACC-S20-038-2026) Cost-effective ceramic manufacturing and processing strategies for extreme conditions (Invited)

C. Tallon*[1]

1. Virginia Polytechnic Institute and State University, Materials Science and Engineering, USA

Ceramic processing is responsible for a significant contribution to carbon emissions worldwide. Although efforts to decarbonize the ceramic industry can be tied to efforts to achieve cost-effectiveness in manufacturing, it is difficult to attain, especially for structural ceramics for extreme conditions. These have stringent requirements for high purity raw materials, controlled particle size, multi-stage processing with high temperature sintering to produce a reliable, well controlled microstructure to ensure the desired performance. Near-Net-Shaping Colloidal Routes can help by reducing amount of material needed, need for machining, overall temperature and need for pressure for densification (by improving particle packing in green), while providing avenues to achieve desirable microstructural complexity required to tackle some of the most demanding applications, like thermal protective systems for hypersonics. This talk will summarize strategies to develop new generation of thermal protective systems (including ultra-High Temperature Ceramics (UHTCs)) using colloidal processing approaches that rely on extremely low amount of organic additives and very simple processing to produce complex microstructures. This talk will also describe approaches to integrate polymeric structures into the ceramic final structure to reduce the amount of organic residue of the overall manufacturing approach.

11:20 AM

(ICACC-S20-008-2026) Diversified external separation forces enabling disassembly-Oriented design for creating new resource circulation loops toward carbon neutrality (Invited)

C. Tokoro*[1]

1. Waseda University, Japan

Achieving carbon neutrality requires not only low-emission technologies but also restructured material circulation within a circular economy framework. Currently, external forces for disassembly in resource circulation are limited to mechanical crushing or manual dismantling. We propose a resource circulation approach that integrates various separation forces beyond conventional grinding, such as electrical pulsed discharge, microwave irradiation, and induction heating. These forces induce localized energy input at material interfaces, enabling the selective separation of complex multi-material components through selective heating, localized chemical reactions, and physical detachment. When combined with structural design strategies that facilitate force-driven disassembly, this approach establishes new energy-efficient recycling pathways. It also promotes high-purity, low-carbon recycling by encouraging separation-conscious design from the outset rather than relying on end-of-life treatment. This presentation introduces case studies in which these techniques have been applied to complex multi-material products, including LiBs, PV panels, and CFRP laminates.

11:50 AM

(ICACC-S20-039-2026) Functional design of rare-earth silicate EBCs (Invited)

J. Zhang*[1]

1. Institute of Metal Research, Chinese Academy of Sciences, High-performance Ceramics, China

Environmental barrier coatings (EBCs) are needed to protect SiCf/SiC ceramics from degradation advanced modern gas turbines. Multifunctional requirements were established for EBC, including matched coefficient of thermal expansion (CTE), low thermal conductivity as well as corrosion resistance to both steam and calcium-magnesium-aluminum-silicate (CMAS) deposits. In the current talk, tailoring thermal expansion behavior of rare earth silicates by means of local disordered structure was illustrated. Coordinative local disturbances introduced by strategic high-entropy design have been proposed as the key method for CTE regulation. To achieve thermomechanical robustness against CMAS deposits, thermochemical equilibrium between rare-earth oxides and calcium-magnesium aluminum-silicate deposit was investigated. The variation of rare earth constituents results in the transformation of crystalline products from apatite/silicocarnotite to garnet/diopside, which accelerates the consumption of CMAS melt and facilitates corrosion mitigation. A pseudo-ternary phase diagram was established, which had a great potential to describe phase equilibrium in coating-deposit systems and could provide guidance for compositional design of corrosion-resistant coatings.

FS6 Innovative material processing for diverse resource circulation loops

FS 6- Innovative material processing for diverse resource circulation loops I

Room: Ballroom 3
Session Chairs: Beihai Ma, Argonne National Laboratory;
Kaka Ma, Texas A&M University

1:30 PM

(ICACC-FS6-001-2026) Electric pulse disassembly of epoxy adhesives through conductive nanoparticle dispersion control (Invited)

C. Tokoro*[1]; Y. Okada[2]; S. Yamashita[2]; M. Kubo[3]; T. Saito[3]; K. Sato[1]; K. Matsuo[4]; M. Inutsuka[1]; A. Narita[5]; H. Kamiya[6]

1. Waseda University, Japan
2. Tokyo Noko Daigaku, Japan
3. Tohoku Daigaku, Japan
4. Waseda Daigaku Riko Gakujutsuin, Japan
5. Waseda University, Sustainable Energy & Environmental Society Open Innovation Research Organization (SEES), Japan
6. Tokyo University of Agriculture and Technology, Institute of Engineering, Japan

This study explores a material design strategy for easily degradable adhesion using conductive nanoparticles under electric pulse stimulation. Both silver and carbon black nanoparticles act as conductive fillers to intensify the internal electric fields and induce discharge within the epoxy adhesive layers. The discharge promotes localized vaporization and interfacial gas expansion, causing rapid separation without the use of heat or solvents. To enhance dispersion stability, silver nanoparticles were synthesized through ligand-assisted reduction. Oleylamine-based surface modification effectively suppressed aggregation during curing and enabled uniform nanoparticle dispersion in the resin. Simulations and experiments showed that dispersion uniformity and aggregate distance critically determine the discharge probability. The combination of the discrete element method and molecular dynamics simulations provides quantitative guidance for nanoparticle surface modification and optimal concentration control. These results contribute to the development of multi-material recycling processes that utilize electric pulses as clean and selective disassembly stimuli.

2:00 PM

(ICACC-FS6-002-2026) Integrating innovation, safety, and sustainability in the recovery of strategic elements from Li-Ion battery black mass (Invited)

A. Mannu*[2]; M. Di pietro[1]; V. Anania[1]; A. Zanoletti[2]; A. Cornelio[2]; A. Mele[1]; L. Depero[2]; E. Bontempi[2]

1. Politecnico di Milano, Italy
2. Universita degli Studi di Brescia, DIMI, Italy

The rapid growth of Li-ion battery demand needs sustainable recycling strategies to ensure resource circulation and reduced environmental impacts. An innovative two-step method for recovering critical metals from spent Li-ion battery black mass (BM) is presented. A tailored microwave-assisted process was applied to the BM, enhancing the water-based Li leaching efficiency under mild conditions. Residual BM was then treated with a deep eutectic solvent (DES), enabling selective Co recovery at moderate temperatures. The study of the DES leaching stage revealed an unprecedented effect intrinsic to the DES nature, offering new insights into solvent–solid interactions and expanding the conceptual scope of DES-based solvometallurgical processes. In parallel, a customized sustainability assessment tool to evaluate laboratory-scale solvometallurgical practices involving BM was developed. Importantly, and for the first time, this assessment identified health and safety at work as a pivotal element of sustainability, complementing the evaluation of process performance and environmental considerations. Altogether, this combined approach demonstrates a highly promising pathway for advancing circular resource use in Li-ion battery recycling, while contributing to the design of greener, safer, and more innovative material processing technologies.

2:30 PM

(ICACC-FS6-003-2026) Advancing the recovery of LIBs: Microwave-assisted direct recycling of end-of-life electric vehicle LIBs with LFP (Invited)

M. Ng*[1]; X. Chen[2]; R. Panchal[2]; S. Bhattacharyya[2]; J. Jeevarajan[1]; P. Ajayan[2]

1. Underwriters Laboratories Inc, UL Research Institutes | Electrochemical Safety, USA
2. Rice University, Department of Materials Science & NanoEngineering, USA

This research introduces a novel approach to the direct recycling of end-of-life lithium-ion batteries (LIBs) from electric vehicles (EVs), specifically those using lithium iron phosphate (LFP) chemistry. The focus is on efficiently recovering battery-grade cathode materials while maintaining the original chemical integrity for immediate reuse. Building on previous studies, this method aims to reduce the extensive chemical treatments and mechanical separation steps typical of traditional hydrometallurgical techniques. By using salt solutions for discharge, the process simplifies material handling, avoids unnecessary complexity, and minimizes environmental impact. Cathode materials from harvested electrodes of retired EVs are used to characterize and analyze the preserved structure of regenerated LFP materials, comparing them with pristine materials. Additionally, the project examines regeneration processes powered by microwave energy, offering a sustainable and scalable alternative to conventional heating methods. While the scope of the regeneration process is still under evaluation, preliminary results suggest promising pathways for future development. Together, these advancements position microwave-assisted direct recycling as a viable strategy for enhancing resource efficiency, reducing carbon footprints, and supporting the sustainable growth of EV technologies.

FS 6- Innovative material processing for diverse resource circulation loops II

Room: Ballroom 3
Session Chairs: Chiharu Tokoro, Waseda University;
Migo Szeman Ng, Underwriters Laboratories Inc

3:20 PM

(ICACC-FS6-004-2026) High frequency induction heating delamination for Li-ion battery electrode materials recycling operations (Invited)

B. Ma*[1]; O. Kahvecioglu[1]; B. Polzin[1]; J. S. Spangenberger[1]

1. Argonne National Laboratory, USA

An ultra-fast delamination process utilizing high-frequency induction heating was developed at Argonne National Laboratory to enable efficient recycling of active electrode materials from spent Li-ion batteries. This energy-efficient technology eliminates the need for expensive, high-temperature, or mechanically intensive separation processes, offering a transformative solution for Li-ion battery recycling operations. The process facilitates the recovery of critical materials - including graphite and active cathode - from manufacturing scraps and end-of-life Li-ion battery electrodes. We demonstrated active material recovery rate of ~97%. The recovered materials are of high quality and purity, making them suitable for direct reuse in production of new Li-ion batteries. Electrochemical testing of cells fabricated with the recovered anode materials revealed performance comparable to cells made with pristine materials, underscoring the viability of this approach for cost effective battery manufacturing. By leveraging induction heating, this recycling technology reduces costs, and minimizes energy consumption. Its implementation has the potential to significantly improve energy efficiency in the recovery and reuse of critical materials, addressing key challenges in the Li-ion battery supply chain vulnerability and advancing the circular economy for battery materials.

3:50 PM

(ICACC-FS6-005-2026) Towards circular approaches and revenue diversification in wPCB recyling (Invited)

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Waste printed circuit boards (wPCBs) are layered metal-polymer composites, with polymer laminates made of epoxy resin reinforced by fiberglass and modified with additives like flame retardants, curing agents, and fillers. Copper, making up to 34% of the board's mass, is the most abundant metal, but it is the minor amounts of high-value metals like gold and palladium that chiefly drive recycling economics. The most common industrial-scale pathway to recycling wPCBs is through pyrometallurgical processes where combustion and reduction separate and concentrate metals. Research shows pyrometallurgy causes significant emissions and considerable metal losses, while hydrometallurgy struggles with metal liberation efficiency and toxic effluent control. Advances in wPCB recycling show promise, but economic viability is still unclear, and growing waste volumes amplify the environmental and health hazards of poor disposal. This paper presents flowsheet configuration strategies for closed-loop recycling of waste PCBs, encompassing fully hydrometallurgical routes and hybrid pyrolysis-hydrometallurgy schemes. It further examines process integration opportunities through effluent stream coupling between PCB manufacturing and recycling operations. The recovery of value-added organic compounds is explored as a strategy to enhance process sustainability and reinforce economic viability within the recycling framework.

4:20 PM

(ICACC-FS6-006-2026) Selective delamination of aluminum-polymer multilayer films by the electric pulsed discharge for the advanced recycling

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2. Dai Nippon Printing Company, Japan

Aluminum demand is rising, resulting in a steady increase in production. In 2024, the global output is expected to reach approximately 73 Mt, nearly three times that of 2000. However, producing aluminum from bauxite is highly energy intensive and a significant source of greenhouse gas emissions. Therefore, recovering and recycling aluminum from end-of-life products is essential. Aluminum is extensively employed in multilayer packaging owing to its superior barrier properties against oxygen and moisture. However, a major challenge lies in the delamination of thin aluminum from the plastic covering layers in these composite structures. Consequently, these materials are predominantly disposed of through landfilling or incineration, presenting a substantial obstacle to effective aluminum recycling. The electric pulse method, which applies a high voltage instantaneously, is well-suited for selectively separating the interface between conductors and insulators. This method requires no chemical reagents and relies on localized, instantaneous heating, thereby reducing environmental impact and energy consumption. In this study, this method was employed to separate the aluminum and plastic layers with a single discharge. Moreover, the optimal delamination conditions were determined, and the underlying separation mechanism was investigated.

4:40 PM

(ICACC-FS6-007-2026) Gravity separation experiment of a low-grade iron ore for securing direct reduced iron production process

G. Numao*[1]; Y. Yamamoto[2]; K. Yoshiya[2]; Y. Takaya[2]; C. Tokoro[3]

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3. Waseda Daigaku, Japan

Achieving carbon neutrality requires a reduction in carbon dioxide emissions in the steel industry. In recent years, research on the direct hydrogen reduction method, which uses hydrogen as a reducing agent in the iron ore reduction process, has progressed. However, this steelmaking process has a low impurity removal capability and can only use high proportion of high-grade iron minerals such as hematite. This study focused on the difference in the specific gravity of liberated mineral particles and used gravity separation to separate impurities (quartz) and low-grade iron minerals (goethite) from high-grade iron minerals (hematite). The iron ore sample used in this study was collected from an Australian iron ore deposit and had an iron grade of 59.4%. The main constituent minerals were hematite, goethite, and quartz. After crushing, the samples were classified into particle size fractions by wet sieving, and hydraulic classification tests based on Stokes' law were conducted for each fraction. The samples were then evaluated using wavelength-dispersive X-ray fluorescence (XRF) and X-ray diffraction (XRD). The results demonstrated that high-grade iron minerals can be efficiently recovered by utilizing the density characteristics of each mineral. This study is based on results obtained from a project, JPNP21019 (GREINS), commissioned by NEDO.

5:00 PM

(ICACC-FS6-008-2026) Upcycling of industrial by-products through mineral carbonation and their potential as supplementary cementitious material (Invited)

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To address the need for CO_2 reduction in the cement industry, strategies involve use of clean energy sources, supplementary cementitious materials (SCMs) and carbon capture and utilization (CCU) technologies. The present research proposes an integrated approach, combining the mineral carbonation of industrial waste with their use as partial clinker substitutes in cement production. The investigated wastes, Electric Arc Furnace (EAF) slag and Cement By-Pass Dust (CBPD) were selected for their composition and availability. Carbonation was carried out by a low-energy aqueous route, which consumed reactive phases such as larnite and merwinite in EAF slag, and free lime and calcium hydroxide in CBPD, resulting in significant CO_2 uptakes of 7.7% and 24.1%, respectively. The treated powders replaced up to 30% of cement in mortar formulations. Mechanical tests at 28 days, supported by isothermal calorimetry, bound water measurements, and portlandite consumption tests, confirmed that carbonation enhanced their properties as SCMs. Specifically, EAF slag showed increased pozzolanic reactivity, while CBPD shifted from chloride-rich, non-reactive waste to a high-calcium carbonate content, commonly used as cement filler. These results highlight both materials as promising low-carbon alternatives, contributing to the reduction of the sector's environmental footprint.

S1 Mechanical Behavior and Performance of Ceramics & Composites

S1- Ceramics for energy generation, turbines, and environmental applications

Room: Coquina E
Session Chairs: Michael Jenkins, Bothell Engineering and Science Technologies; Jonathan Salem, NASA Glenn Research Center

1:30 PM

(ICACC-S1-052-2026) Development of SiC encapsulation for thulium oxide targets as potential nuclear batteries

C. Ang[1]; B. Shaver[1]; K. Wheeler*[2]

1. University of Tennessee, Knoxville, USA
2. The University of Tennessee Knoxville Tickle College of Engineering, Nuclear Engineering, USA

As the commercial space market expands, the accessibility of radioisotopes for nuclear batteries has become an increasing demand. Here, we discuss the concept, principles, fabrication, and testing of nuclear-grade silicon carbide (SiC) cladding for potential isotopic fuels. We start with confirming the elemental analysis and phase identification by X-ray Fluorescence and X-ray Diffraction. The SiC materials were joined through a nuclear-grade SiC method discussed in another paper. After sealing, the fabrication process of the targets were assessed through micro-hardness, tolerances, and an exercise of the heat transfer gap. A key concern was the effect of Tm_2O_3-SiC reaction, which prevented the sealing process from exceeding key temperatures. Above certain temperatures, Tm_2O_3 will migrate, behaving similarly to its sintering additive Y_2O_3. This technology offers demonstrates a pathway for refractory materials encapsulation needed for sealed source and isotopic fuel production.

1:50 PM

(ICACC-S1-053-2026) Oxidation and testing of SiC joins: Development and evaluation for nuclear and aerospace applications

C. Ang[1]; K. Wheeler*[2]; M. Crespillo[2]; K. Hattar[2]; T. Koyanagi[3]

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The joining of SiC components is critical to refractory and nuclear components such as advanced gas reactor cladding and aerospace applications. We discuss the concept, predictions, fabrication, thermal shock, and oxidation of nuclear-grade silicon carbide (SiC) based on nano-infiltration transient eutectic (NITE). The strengthening of SiC under irradiation is caused by the unusual phenomenon of increased swelling at low temperature, making it ideal for heat transfer surfaces. Since joins are usually the weak link, we propose a join that can strengthen as a result of ballistic mixing during irradiation. SEM/EDS shows Al_2O_3-Y_2O_3 in predicted amounts as a thin grain boundary phase. The thermal shock testing of SiC was conducted above 1273K to isolate and determine the point of failure and subsequent Griffith flaw location as a function of process conditions. The oxidation of joins was investigated with both reference CVD materials and baseline substrates, to quantify both the parabolic oxidation kinetics and the expected limitations in oxidation resistance of NITE SiC. These characteristics are crucial for applications of NITE SiC in nuclear and aerospace applications.

S1- Fracture mechanics, failure analysis and fractography

Room: Coquina E

Session Chairs: Michael Jenkins, Bothell Engineering and Science Technologies; Jonathan Salem, NASA Glenn Research Center

2:10 PM

(ICACC-S1-054-2026) On the terminal velocity of cracks in glasses and ceramics: A new modified Mott-Robert-Wells model (Invited) *Moved to Tuesday, January 27 at 9:00 AM*

G. D. Quinn*[1]

1. National Institute of Standards and technology, Materials Measuremenet Sciences Division, USA

The terminal crack velocity, v_{ct}, of cracks in ceramics and glasses is important for some dynamic loading conditions such as ballistic impact. Terminal velocity is limited by several factors including elastic wave velocities that control how the strain energy moves with and ahead of the fast crack tip. The literature varies as to whether longitudinal, transverse, or Rayleigh waves are controlling. Test data often do not agree with any of the models. The reason for this is that the models are based on 2-dimensional continuum mechanics. Cracks moving at very high velocities in real brittle materials are 3-dimensional. The Mott-Roberts-Wells model of the 1940s matches experimental measurements for some key glasses, including fused silica and low-density borosilicates. Their model is essentially the Griffith equation modified with an additional term for the kinetic energy of the crack. It concludes that $v_{ct} = 0.38\ v_L$. where v_L is the longitudinal wave velocity. Deviations of data from their model may now be explained by a modification to the model that considers the 3-dimensionality of a fast crack. Fracture mirror data supports this new conclusion. Alternative notions of voids opening up in front of fast-cracks, that may be suitable for polymers and metals, are not relevant to ceramics and glasses.

2:40 PM

(ICACC-S1-055-2026) Understanding microstructure-controlled fracture and toughening through a probabilistic framework

S. Hossain[2]; H. Brumblay[2]; D. P. Dupre[1]; A. Stubbers[1]; X. Tang[2]; G. Thompson*[1]; O. A. Graeve[3]; C. R. Weinberger[4]

1. The University of Alabama, USA
2. Colorado State University, USA
3. University of California, San Diego, Mechanical and Aerospace Engineering, USA
4. Colorado State University, Department of Mechanical Engineering, USA

Fracture in polycrystalline brittle materials is governed by the stochastic competition of inherent flaws and potential fracture paths, which are controlled by the material's intrinsic cleavage planes and their interplay with its microstructure. Toughening such materials demand a quantitative link between fracture mechanisms and microstructural attributes such as grain orientation, cleavage-plane availability, and grain-boundary resistance. Yet, no model exists that can account for this link. To fill this gap, we have developed a probabilistic framework using Markov chain process to model the statistical nature of microstructural features in crack propagation. Our method quantifies, for the first time, the separate contributions of key microstructural features and delivers predictive distributions of fracture toughness while accounting for variations in grain size and number, boundaries, and orientation distributions. We demonstrate the utility of our approach by analyzing fracture-path distributions from micro-indentation experiments in a model ceramic, enabling direct estimation of the relative resistances of intergranular versus transgranular fracture.

3:20 PM

(ICACC-S1-056-2026) Correlation between structural geometry and damage localization of triply periodic minimal surface-based ceramic unit cells

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Inspired by porous structures in nature, artificial porous materials are manufactured for a wide range of applications. Compared with other porous structures, Triply periodic minimal surfaces (TPMS) have the following significant features: the geometries can be fully expressed by mathematical functions; they are periodic in three directions and have zero mean curvature, providing highly interconnected architectures. TPMS can be easily printed as construction elements after microstructure optimization for prescribed loading. In this study, the compressive failure of four alumina-based TPMS types (Primitive, Gyroid, Neovius, and IWP) with the same volume fraction was investigated using finite element analysis. To capture the critical influence of geometry on failure behavior, a computational framework was developed to evaluate surface inclination angles and estimate cross-sectional areas within each structure. An analytical study of geodesics on the structural surface and potential crack paths was also conducted. After that, the distributions of cross-sectional area, inclination angle, and damage localization were compared to assess their interrelated effects within each TPMS. Stress concentrations along the cross-sections and inclined surfaces were also analyzed to clarify the influence of local geometry on crack development.

3:40 PM

(ICACC-S1-057-2026) Impact of mechanical recycling on material and process characteristics in powder injection molding

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2. Katholieke Universiteit Leuven, Surface and Interface Engineered Materials (SIEM), Belgium

Ceramic injection molding (CIM) enables the production of complex, high-precision ceramic components using feedstock composed of ceramic powder dispersed in a polymer binder system. The functional product often represents only a small fraction of the molded part, while runners, sprues, and defective green parts account for a substantial amount of excess material. Since ceramic feedstock is much more expensive than thermoplastics, recycling can improve the economic viability of CIM. In this study, bar-shaped alumina green parts were injection molded, mechanically shredded, and reused as feedstock for up to ten recycling cycles. Dimensional accuracy and mass density of the green parts were evaluated, followed by debinding and sintering. No differences in sintered density or shrinkage were observed between virgin feedstock and material recycled up to ten times, indicating that the binder content remains stable during processing. However, the required injection pressure decreased with each recycling step, suggesting polymer chain scission from thermal degradation in the heated screw and mechanical stresses during shredding. With the ceramic powder fraction remaining constant, the stability of Young's modulus and flexural strength suggests recycling preserved sintered parts' structural performance. Weibull analysis confirmed consistent mechanical performance across recycling cycles.

4:00 PM

(ICACC-S1-058-2026) Micromechanical model for ceramic matrix composites under static tensile loading

D. Haruyama*[1]

1. IHI Corporation, Japan

To enhance fuel efficiency in aircraft, the application of ceramic matrix composites (CMCs) to engine components has been increasing in recent years. Accurate prediction of the structural strength and a thorough understanding of the failure mechanisms of engine parts require precise modeling of the microscopic structure and micro-damage in CMCs, as well as reliable prediction of their mechanical behavior. In this study, we focus on unidirectional and cross-ply laminated CMCs, with the objective of accurately representing material behavior such as stress-strain relationships and crack growth processes. For matrix cracking accompanied by fiber-matrix interfacial debonding and transverse cracking, we developed a random crack growth model utilizing the Monte Carlo method. Application of this model enabled a close representation of the crack density observed in experimental tests. Furthermore, a micromechanics model was constructed by integrating a periodic crack growth model, which is equivalent to the random crack growth model, with a fiber fracture model. The stress-strain relationships calculated using this micromechanical model showed good agreement with experimental results, thereby demonstrating the validity and applicability of the proposed modeling approach.

4:20 PM

(ICACC-S1-059-2026) Correlating acoustic emissions to cracking in silicon carbide micro-indentations

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4. University of California, San Diego, Mechanical and Aerospace Engineering, USA
5. University of Alabama, Metallurgical & Materials Engineering, USA

Acoustic emission (AE) is a technique that uses high-frequency elastic waves generated by the rapid release of energy to detect cracking. In this study, we have aimed to link the emission signal to the number and extent of cracking using single-crystal SiC. Two hundred fifty indents up to 8N loads were applied, creating more than 1500 individual emission peaks. While the average AE signal from successive peaks was well defined in load, the data point spread was vast. Consequently, one is unable to directly contribute a specific load or sequential AE event to a particular AE intensity. However, one can correlate crack length to the AE. Several loads were used to generate differing crack lengths which were correlated successfully to total AE. Besides surface crack identification, a subset of indents was serial sectioned to reconstruct a 3D representation of the cracking network. While differences in emission peaks were noted between each of these indents, the extent of the network did not correlate to the measured signal, i.e., a larger network had a smaller overall emission signal. Collectively, these results give statistical insights into the extent AE can be used to correlate to the type of cracking events in materials directly.

S3 23rd Intl Symp on Solid Oxide Cells Materials Science & Technology

S3-Protective coatings and sealants

Room: Coquina H
Session Chair: Muhammad Imran Asghar, Tampereen yliopisto Tekniikan ja luonnontieteiden tiedekunta

1:30 PM

(ICACC-S3-051-2026) Self-healing glass seal with mixed composition for electrochemical cell

F. O. Mear*[1]; R. Voivenel[1]; R. Podor[2]

1. Universite de Lille Faculte des Sciences et Technologies, France
2. Institut de Chimie Separative de Marcoule, France

Sealing is an ongoing concern for the development of pSOFC and pSOEC systems, mainly because gas tightness largely drives performance and is a critical key to develop these technologies. The main difficulties are due to the fact that gas tightness must be achieved at high temperature (» 800°C). Among the different technologies, we find glass seals: rigid ($T_{soft} > T_{pSOC}$) and compliant ($T_{soft} < T_{pSOC}$). Rigid glass seals have good durability and resistance to crystallization, and therefore good stability at high temperatures. However, it's required high forming temperatures. In contrast, compliant glass seals, which are generally less stable with respect to thermal and chemical aging, have the advantage of being able to be formed at a temperature lower than the stack's operating temperature (800°C). To tackle this question, we report on self-healing hybrid glassy seals, which represent an interesting alternative to compliant or rigid seals. In this lecture, we present our work on mixed rigid and compliant glass seal, particularly with the influence of the compliant glass content in the rigid matrix on the physicochemical properties, forming, resistance to crystallization and the ability of the seal to self-repair at 800°C.

1:50 PM

(ICACC-S3-052-2026) Innovative glass sealants for the integration of protonic ceramic electrolysis cells

F. Da Prato*[1]; S. Gross-Barsnick[2]; W. Deibert[3]; S. Ricote[4]; W. Meulenberg[3]; M. Santarelli[1]; F. Smeacetto[5]

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2. Forschungszentrum Jülich GmbH, Institute of Technology and Engineering (ITE), Germany
3. Forschungszentrum Jülich GmbH, Institute of Energy Materials and Devices (IMD), Germany
4. Colorado School of Mines, Mechanical Engineering, USA
5. Politecnico di Torino, Applied Science and Technology, Italy

Scaling up protonic ceramic electrolysis cells (PCECs) to single repeating units and short stacks remains a significant challenge. A key requirement is the development of reliable sealants capable of operating at 600 °C in steam- and hydrogen-rich environments. In this study, two tailored glass compositions were designed for joining $BaZr_{0.44}Ce_{0.36}Y_{0.2}O_{3-\delta}$ /$SrZr_{0.5}Ce_{0.4}Y_{0.1}O_{3-\delta}$ – NiO half-cells to AISI 441 stainless steel. Powders were engineered with controlled particle size and surface area to enable precise screen printing, ensuring dimensional accuracy, material efficiency, and scalability. Comprehensive thermal characterization was conducted to assess crystallization behavior and viscous flow, providing the basis for optimizing the joining temperature profile. Sandwich-like joined samples (half-cell/glass/metal), were fabricated and processed to evaluate chemical and thermo-mechanical compatibility. The joining pressure, temperature profile, and dwell time were optimized on 30 mm-diameter half-cells, with leak testing and the final geometric parameters of the sealant used as evaluation criteria. Finally, the chemical stability of the glass joints was assessed after thermal cycling and long-term exposure to humid air and hydrogen-rich atmospheres.

2:10 PM

(ICACC-S3-053-2026) Processing–Structure–Property Relationships in Mn–Cu–Fe Spinel Oxide Coatings for SOC Interconnect Protection

M. Mehdizade[1]; S. Molin*[1]

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The long-term stability of solid oxide cell (SOC) stacks is strongly limited by oxidation and chromium volatilization of ferritic stainless-steel interconnects. Protective spinel oxide coatings can mitigate these effects while maintaining electrical conductivity. In this work, Mn–Cu–Fe spinel coatings ($Mn_{2-x}CuFe_xO_4$) were prepared by spray pyrolysis on Crofer 22 APU and alumina substrates. The impact of Fe substitution and processing parameters on coating microstructure, phase stability, and conductivity was systematically investigated. Optimized deposition conditions yielded dense, crack-free coatings with controlled thickness and porosity. Moderate Fe content ($x \approx 0.5$) reduced porosity below 12% and stabilized the cubic spinel phase, while higher Fe levels promoted CuO precipitation. Electrical conductivity remained above the interconnect requirement of 50 S cm^{-1} in the 400–850 °C range, with activation energy sensitive to Fe content and deposition parameters. These results highlight that careful compositional tuning and processing optimization enable Mn–Cu–Fe spinel oxide coatings to combine oxidation resistance with high conductivity, offering a scalable solution for SOC interconnect protection.

2:30 PM

(ICACC-S3-054-2026) Minimizing Cr-evaporation from balance of plant components by utilizing cost-effective alumina-forming austenitic steels

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2. Oak Ridge National Laboratory, USA
3. West Virginia University, Chemical & Biomedical Engineering, USA

In order to alleviate the Cr poisoning of oxygen electrode and achieve long-term high performance of SOC stacks, various Al_2O_3-forming austenitic (AFA) stainless steels were developed and evaluated in this work. It is shown that on the AFAs, an alumina-based protective layer forms under high temperature that is invulnerable to water vapor effects and suppresses the diffusion of chromium and manganese which can prevent the generation of spinels on the alloy surface. The chromium (Cr) evaporation behavior of several different types of iron (Fe)-based AFA alloys and benchmark Cr_2O_3-forming Fe-based 310 and Ni-based 625 alloys was investigated for 500 h exposures at 800 °C to 900 °C in air with 10% H2O. The Cr evaporation rates from alumina-forming austenitic (AFA) alloys were ~5 to 35 times lower than that of the Cr_2O_3-forming alloys depending on alloy and temperature. The Cr evaporation behavior was correlated with extensive characterization of the chemistry and microstructure of the oxide scales, which also revealed a degree of quartz tube Si contamination during the test. Long-term oxidation kinetics were also assessed at 800 to 1000 °C for up to 10,000 h in air with 10% H_2O to provide further guidance for SOFC BOP component alloy selection.

2:50 PM

(ICACC-S3-055-2026) Advanced sintering strategies for Mn–Cu spinel coatings deposited by EPD on metallic interconnects

F. Gallo*[1]; F. D'Isanto[2]; S. Anelli[3]; M. Torrell[4]; L. Bernadet[4]; D. Montinaro[5]; F. Smeacetto[2]

1. Politecnico di Torino, Italy
2. Politecnico di Torino, Department of Applied Science and Technology, Italy
3. Politecnico di Torino, DISAT, Italy
4. Catalonia Institute for Energy Research, Advanced Materials for Energy Applications, Spain
5. SolydEra, Italy

In this work, a manganese–copper spinel was selected as a protective coating for 441 stainless steel, widely used for interconnect applications due to its corrosion resistance and mechanical stability. A design of experiments (DoE) approach was applied to optimize key parameters, such as applied voltage and deposition time, to ensure uniform coatings. After deposition, both conventional sintering and innovative rapid thermal processing (RTP) were investigated to improve coating adhesion and structural integrity while reducing energy consumption. Microstructural and thermomechanical analyses were carried out to evaluate adhesion, porosity, and compatibility with the substrate. At the same time, electrical characterization confirmed the ability of the most promising coatings to combine conductivity with protection against chromium evaporation. The coated interconnects were subsequently tested in a stack under both fuel cell and electrolysis modes, demonstrating the effectiveness of the coating and the feasibility of operation in reversible SOCs. The results, obtained within the EU co-funded 24/7 ZEN project (GA 101101418), highlight EPD combined with advanced sintering as a promising strategy to achieve scalable, reliable, and high-quality multi-layered coatings for reversible solid oxide systems.

S3-Proton conducting cells

Room: Coquina H
Session Chair: Mihails Kusnezoff, Fraunhofer IKTS

3:30 PM

(ICACC-S3-056-2026) Development of high-performance and high-durability protonic ceramic cells with nanocomposite electrode technology (Invited)

H. Shimada*[1]

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Protonic ceramic cells (PCCs) are electrochemical devices capable of highly efficient energy conversion. Furthermore, their operating temperature (400–600°C) is lower than that of conventional oxide-ion-conducting solid oxide cells (SOCs), enabling cost reduction and compact systems. PCCs can perform power generation fuel cells and hydrogen production electrolizers, hydrogen separators, and hydrogen compressors, making them promising devices for realizing a hydrogen society. Improvement in the current density and durability of PCCs contributes to cost reduction, acerating widespread commercialization. Thus, to improve the PCC performances, an oxygen electrode utilizing nanocomposite technology was developed, and the materials and structure of PCCs were optimized to accommodate this electrode. The nanocomposite oxygen electrode aims to achieve effects such as expanding the reaction area and suppressing sintering degradation by combining multiple nano-scale oxide materials. In this work, on the basic composition of an electronic conductor $(La,Ba)CoO_{3-\delta}$ and a protonic conductor $Ba(Zr,Yb)O_{3-\delta}$ was fabricated using spray pyrolysis technique. We report on the characterization results of the nanocomposite electrode and its electrochemical performance in both fuel cell and electrolyte modes when integrated into the optimized PCCs.

4:00 PM

(ICACC-S3-057-2026) Advancing PCEC fabrication through additive manufacturing and interface optimization

S. Anelli*[2]; D. Ferrero[1]; M. Santarelli[1]; F. Smeacetto[2]

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2. Politecnico di Torino, Applied Science and Technology, Italy

Protonic ceramic electrolysis cells (PCECs) offer efficient hydrogen production at intermediate temperatures (400–650 °C), enabling the generation of pure, dry H_2 with lower energy input than traditional high-temperature electrolyzers. Their implementation, however, is hindered by the integration complexity of $Ba(Ce,Zr)_{1-y}Y_yO_{3-\delta}$ (BZCY) perovskite-based electrolytes and the limited availability of critical raw materials. This work explores the fabrication of PCECs using additive manufacturing (AM) techniques, particularly robocasting, to streamline production and reduce material waste (Anelli et al., 2022). The improved design freedom of AM enables enhanced interface tightness through controlled roughness and interlocking between the electrolyte and glass sealant. Thermocurable ceramic pastes are formulated and optimized for 3D printing. BZCY membranes are characterized by electrochemical impedance spectroscopy (EIS) to assess their conductivity. Interfacial compatibility and long-term performance are evaluated via SEM and XRD after thermal cycling and ageing in humid environments. The study demonstrates how AM facilitates integration and reliability of PCECs, establishing the basis for scalable, efficient hydrogen systems.

4:20 PM

(ICACC-S3-058-2026) BZCYYb4411 based protonic ceramic electrolysis cell (PCEC)

Z. Zhuang[1]; V. Dhongde[1]; L. Mastropasqua*[1]

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Protonic ceramic electrochemical cells can produce hydrogen at intermediate temperature (300-600°C) with single cell electric-to-hydrogen efficiency <40 kWh kg^{-1}, and without the use of noble metal catalysts. The proton conduction through dense ceramic electrolytes occurs via a low-activation energy polaron hopping transport mechanism (0.3-0.6 eV). Triple-conducting oxides, which can conduct H^+, O^{2-}, and e^-, could act as a promising positrode material to offer large three-phase boundaries and enable fast reaction kinetics. In this study, we synthesized $BaZr_{0.4}Ce_{0.4}Y_{0.1}Yb_{0.1}O_{3-\delta}$ (BZCYYb4411) electrolyte and $PrBa_{0.5}Sr_{0.5}Co_{1.5}Fe_{0.5}O_{5+\delta}$ (PBSCF) anode powder via the sol-gel method, tested the electrolyte conductivity and made a full cell. The conductivity of BZCYYb4411 is tested at 350-650°C via electrochemical impedance spectroscopy (EIS) with varying steam concentrations (5–40%). The impedance variation with various temperatures and steam concentrations is analyzed via distribution of relaxation times (DRT), the result shows the ohmic resistance is the dominant resistance. PBSCF|BZCYYb4411|BZCYYb4411-NiO (Ni) cathode-supported full cell (~20 mm diameter) is fabricated by tape casting and screen printing. EIS, polarization curves, and 100 h stability tests are conducted to evaluate the influence of temperature and steam concentration of PCEC, and optimizing cell performance.

4:40 PM

(ICACC-S3-059-2026) Proton conductive electrolyte production by water-based tape casting

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2. Fondazione Bruno Kessler, Center for Sustainable Energy - SE, Italy

Proton conductive solid oxide cells (PCC) are considered a promising technology for green hydrogen production because of their lower temperature working range which depends on the electrolyte membrane conduction mechanism, with PCC moving protons instead of oxygen ions. Despite the efforts put in this technology, few examples of its scale up have been proposed until now, mostly depending on some challenges showed by the electrolyte materials commonly used, $BaZr_{0.8}Y_{0.2}O_{3-\delta}$ (BZY20) and $BaCe_{0.8}Y_{0.2}O_{3-\delta}$ (BCY20), like sintering and chemical stability. In this work water-based tape casting is proposed as production routh for the electrolyte layer, specifically BZY20 composition. The colloidal system was studied in details and specific additives were selected, to be efficacious as dispersant, binder and plasticizer. The green tape was characterized through thermal analysis and electron microscopy. The green was densified through conventional sintering. I-V curve and EIS analyses were performed to assess the quality of the electrolyte. The identified process, based on water-based tape casting, allows the production of stable and reproducible green tape. An optimized heating program for its sintering was designed to obtain samples with near 90% relative density.

S4 Advanced Materials for Thermoelectric and Thermionic Energy Conversion

S4- Selenides and tellurides

Room: Ballroom 1 -2
Session Chairs: Michitaka Ohtaki, Kyushu Daigaku; Armin Feldhoff, Leibniz University Hannover

1:30 PM

(ICACC-S4-006-2026) Thermal transport in supported 2D indium selenide flakes (Invited)

M. Zebarjadi*[1]

1. University of Virginia, Electrical and Computer Eng., USA

Two-dimensional (2D) layered materials are promising for nanoscale and flexible electronics due to their unique mechanical, thermal, and electronic properties. Many proposed devices place thin flakes on substrates, where strain is usually assumed to be negligible because of weak van der Waals coupling. In this talk, I will focus on indium selenide (InSe) and the discrepancies reported in the thermal conductivity of thin flakes. Bulk InSe crystals show consistent behavior despite the influence of roughness and impurities, but supported flakes display a wide spread in thermal conductivity that we trace to substrate-induced strain and surface nonuniformity. I will present measurements on both doped and intrinsic flakes, showing that intrinsic flakes exhibit higher thermal conductivity than doped ones, despite being thinner—consistent with reduced impurity scattering and greater uniformity. I will argue that explicitly accounting for substrate-induced strain is essential to explain and model thermal transport in 2D InSe flakes.

2:00 PM

(ICACC-S4-007-2026) Spectator ions determine surface chemistry, dopant Incorporation, and microstructure that govern transport

C. S. Fiedler*[1]; M. Ibáñez[1]

1. Institute of Science and Technology Austria, Austria

Alkali metal salts are commonly used in solution-based synthesis, often chosen for their solubility, availability, and ease of use. They are frequently treated as bystanders, but it turns out they are far from passive. Here, we show that alkali ions such as Li+, Na+, and K+ remain active beyond the reaction stage, influencing surface chemistry, crystalline domain, and defect formation, ultimately affecting material performance. This is particularly relevant for thermoelectrics, where solution processing offers a scalable, low-cost route to high-performance materials. In the aqueous synthesis of SnSe, a thermoelectric relevant material, we find that simply changing the alkali salt dramatically alters nucleation, grain size, phase purity, and dopant distribution, factors that govern electrical conductivity, carrier mobility, and phonon scattering. We emphasize that strategic selection and control of alkali precursors must be guided by a nuanced understanding of how these ions influence structure-property relationships across multiple length scales. Ultimately, clarifying the role of alkali ions provides the foundation for designing synthesis strategies that couple structural control with defect engineering to optimize thermoelectric performance.

2:20 PM

(ICACC-S4-008-2026) Engineering weighted mobility ratio through magnetic nanoparticle inclusion for reduced bipolar effects in Bi–Sb–Te thermoelectrics

M. Heo*[1]; S. Ye[2]; H. Kim[3]; J. Roh[2]

1. Northwestern University, Department of Materials Science and Engineering, USA
2. Kyungpook National University, Department of Hydrogen and Renewable Energy, Republic of Korea
3. University of Seoul, Republic of Korea

Traditionally, enhancing the weighted mobility ratio (A) in narrow-band-gap thermoelectrics to counter detrimental bipolar effects at high temperatures has relied almost exclusively on grain size reduction to the nanoscale. This work introduces a novel strategy that utilizes the incorporation of ferromagnetic nanoparticles (NPs), such as Fe or Co, into a p-type $Bi_{0.4}Sb_{1.6}Te_{3.0}$ (BST) matrix to effectively suppress this bipolar transport. Deployed via a solvent-free metal-decoration technique, these NPs are distributed uniformly, generating localized magnetic fields and creating interfacial energy barriers that function as filters against low-energy charge carriers. Analysis based on a two-band model confirms that the inclusion of Fe NPs significantly improves the A by increasing the asymmetry between hole and electron mobility. Furthermore, this method lowers the minority carrier concentration through Lorentz-force-induced scattering. Consequently, BST with Fe NPs exhibits a remarkable peak zT of ~1.24 at 363 K, sustains a zT greater than 1 up to 420 K, and shows a value of ~0.87 at 483 K, marking a nearly 50% enhancement over the pristine BST. This research establishes that the integration of magnetic NPs is a powerful and broadly applicable method for engineering the A and bipolar conduction in narrow-gap thermoelectric systems.

2:40 PM

(ICACC-S4-009-2026) Band convergence correlated electronic transport properties of n-type Bi-Te-Se alloys

M. Heo[2]; K. Lee[4]; S. Kim[3]; H. Kim*[1]

1. University of Seoul, Republic of Korea
2. Northwestern University, USA
3. University of Seoul, Department of Materials Science and Engineering, Republic of Korea
4. Yonsei University, Republic of Korea

n-type Bi-Te-Se thermoelectric alloys show a limited conversion efficiency compared to their p-type counterpart of Bi-Sb-Te alloys, which hinders further widespread of applications. For p-type Bi-Sb-Te alloys, band convergence has become a prerequisite to maximize their thermoelectric figure-of-merit and is achieved by converging valence bands of Bi_2Te_3 and Sb_2Te_3, both with sixfold-degenerate Fermi surfaces. However, despite the high valley degeneracy and small band gaps also present in n-type Bi-Te-Se alloys, theoretical and experimental routes to initiate and maximize the band convergence effect in n-type Bi-Te-Se alloys have been missing due to escalated difficulties to decouple electronic contribution of each participating band from observed electronic transport properties. Here, we show the interaction between Fermi surfaces of Bi_2Te_3 and those of Bi_2Se_3 by experimental data-driven band modelling, and the band convergence is found to be present in n-type $Bi_2(Te_{1-x}Se_x)_3$ near x = 0.1.

S4- Devices and applications

Room: Ballroom 1 -2
Session Chairs: Hyun-Sik Kim, University of Seoul; Mona Zebarjadi, University of Virginia

3:20 PM

(ICACC-S4-010-2026) Transverse thermoelectric generators using thermoelectric oxides (Invited)

J. Topfer*[1]; R. Löhnert[1]; A. Bochmann[1]; A. Ibrahim[2]; B. Capraro[3]

1. Ernst-Abbe-Hochschule Jena, Germany
2. Friedrich-Schiller-Universitat Jena, Germany
3. Fraunhofer IKTS, Ceramic Tapes, Germany

Thermoelectric generators are typically fabricated using the standard dual-leg design including manufacturing, arranging and contacting many individual sintered p- and n-type ceramic blocks. Alternatively, application of the transverse thermoelectric effect is based on a combination of ceramic oxides pellets and metal layers in transverse thermoelectric generators (TTEGs). This layer stack is tilted at a certain angle with respect to the thermal gradient to give an artificial anisotropic material. Moreover, transverse multilayer thermoelectric generators (TMLTEG) with charge transport perpendicular to the heat flow direction were prepared using cofiring of stacks of layers of tape-cast p- or n-type thermoelectric oxides in combination with printed AgPd metal layers. We report on sintering behavior and thermoelectric properties of the individual thermoelectric oxides, as well as on co-firing behavior of metal and oxides. Based on analytical calculations, we have developed the concept of Babin-plots, describing the power output and conversion efficiency for a given material combination as function of the internal and external device geometry. We demonstrate this approach in combination with device simulations and measurements for pellet-based and multilayer transverse generators using the thermoelectric oxides $Ca_3Co_4O_9$ and $La_2CuO_{4.}$

3:50 PM

(ICACC-S4-011-2026) Various device structures of thermoelectric systems (Invited)

W. Kim*[1]

1. Yonsei University, School of Mechanical Engineering, Republic of Korea

We present various device architecture of thermoelectric devices and systems. First, I am going to talk about architecture for body heat harvesting application aiming to operate sensors and actuators for healthcare application. Continuous monitoring of vital signs and timely treatment are the future trends for wearable and implantable healthcare systems. Here, we demonstrate a feasible true continuous healthcare system for type 1 diabetes by combining a low-energy micropump, self-powered glucose sensor, and ceaseless power supply based on thermoelectrics. In addition, we are going to present our recent efforts to build a compact vital band containing wearable sensors, unintermittent power supply, and flexible circuits at single location. The vital band is specially designed for continuous monitoring of core body temperature (CBT) with novel CBT sensors and a pulse rate sensor operated by intermittent power. Secondly, we present a new device architecture for waste heat recovering for low $/W system and refrigeration. The unique structure reduced material consumption by 60% (low $), and at the same time increased power output by 230%. For refrigeration, this unique structure reduces power consumption by 68% while being 33% lighter in weight than a conventional thermoelectric refrigerator. Overall, this talk can provide emphasis on device architecture without increasing thermoelectric properties of materials.

4:20 PM

(ICACC-S4-012-2026) Advances in flexible thermoelectric devices for personal cooling under extreme heat conditions (Invited)

R. Chen*[1]

1. University of California, San Diego, Mechanical and Aerospace Engineering, USA

Global warming is causing increasingly frequent and intense extreme heat events, impacting a growing share of the global population. These events disproportionately harm vulnerable groups, including outdoor workers, people with pre-existing health conditions, and those without adequate housing or cooling. Despite public health efforts, heat-related emergency visits, hospitalizations, and fatalities continue to rise worldwide. Personal active cooling offers a promising way to mitigate heat stress by maintaining skin temperature within the thermal comfort zone. Thermoelectric cooling is appealing for its solid-state design, light weight, and precise temperature control. Recent research has advanced flexible, wearable thermoelectric devices through innovations in materials, device architecture, and fabrication, improving performance and comfort. A complete personal cooling solution must also incorporate other thermal management elements, such as thermally conductive fabrics and efficient wearable heat sinks—areas still underexplored. Hybrid approaches that combine thermoelectric and evaporative cooling can further enhance efficiency and wearability. This presentation will review our recent progress, key challenges, and future directions toward practical, scalable thermoelectric personal cooling systems to protect vulnerable populations during extreme heat events.

4:50 PM

(ICACC-S4-013-2026) Solid-state suspended micro-thermoelectric bridges for on-chip cooling

J. Kim*[1]; Y. Yoon[1]; S. Shin[2]

1. Korea Advanced Institute of Science and Technology, Department of Mechanical Engineering, Republic of Korea
2. National University of Singapore, Department of Mechanical Engineering, Singapore

Modern processors develop intense, non-uniform hot spots that throttle operating frequency and shorten device lifetime. Package-level air or liquid cooling cannot overcome the thermal resistance bottleneck across the junction, package, and thermal interface material. Although thermal interface materials mitigate interfacial gaps, at high heat fluxes heat cannot be conducted rapidly enough from inside the chip to the surface. Thermoelectric coolers, which transport heat via charge carriers rather than fluids, are compact, vibration-free, and well suited for localized thermal management. However, conventional vertical pillar thermoelectric coolers suffer from significant contact resistance due to fixed cross-sections and challenges in fabricating stable high-aspect-ratio structures, thereby limiting the achievable temperature drop. To address these limitations, a suspended bridge structure is proposed. Metallization of the thermoelectric leg sidewalls enlarges the effective contact area and reduces contact resistance, while suspension suppresses thermal leakage into the substrate. Furthermore, the lateral layout permits adjustment of leg length for operating optimization. Three-dimensional multiphysics simulations map the thermoelectric response and identify operating regimes. The proposed devices were microfabricated, and their thermal performance was experimentally characterized.

S5 Next-Generation Bioceramics and Biocomposites

S5- Ceramics and composites with antimicrobial, antiviral and drug delivery properties

Room: Flagler A
Session Chairs: Andraz Kocjan, Jozef Stefan Institute;
Sabine Begand, Fraunhofer-Gesellschaft zur Forderung der angewandten Forschung eV

1:30 PM

(ICACC-S5-016-2026) Stimuli-responsive bioconjugated nanocarriers for tumor-specific drug delivery (Invited)

S. Ilyas[1]; S. Mathur*[1]

1. Institute of Inorganic and Materials Chemistry, University of Cologne, Germany

Drug accumulation to tumors remains hindered by rapid clearance, poor targeting, and off-target toxicity. To address these barriers, we engineered hollow mesoporous silica nanocarriers with stimuli-responsive thin coatings and surface conjugation chemistries for controlled release and ligand-driven targeting. Electrokinetic analysis confirmed precise ligand quantification, correlating with selective tumor accumulation and minimal effects on healthy organs. Beyond systemic therapy, embedding these drug carriers in defect free PLGA patches enabled sustained release for localized skin remodeling applications. Furthermore, nanocarriers co-conjugated with more than one therapeutic molecule enabled synergistic therapeutic effects to different diseased cells. This strategy addresses key challenges in particle conjugation and drug delivery, offering a safer and more effective approach for future medical applications.

2:00 PM

(ICACC-S5-017-2026) Fabrication and biomedical applications of calcium phosphate nanoparticles immobilizing functional substances (Invited)

M. Nakamura*[1]

1. National Institute of Advanced Industrial Science and Technology (AIST), Japan

Calcium phosphates (CaPs) are biocompatible and safe materials. CaP nanoparticles are expected to be useful as carriers for delivering and releasing functional substances, such as bioactive proteins, antibacterial agents, drugs, and imaging agents, to cells and tissues. CaP nanoparticles immobilizing these functional substances can be fabricated under mild conditions from a supersaturated CaP solution. However, this technique is associated with the following challenges: difficulty in controlling the structure and dispersibility of nanoparticles and low immobilization efficiency of functional substances. We addressed these issues by combining conventional methods with molecular techniques utilizing biomolecules and pharmaceutical agents that possess ionic properties. The resulting nanoparticles can exhibit a variety of biomedical functions depending on the characteristics of the immobilized functional substances, such as promotion of cell proliferation, antibacterial activity, and MRI contrast enhancing activity.

2:30 PM

(ICACC-S5-018-2026) Te-doped bioactive glass powders as filler for electrospun polymeric composite fibers with antibacterial properties (Invited)

M. Miola[1]; E. Piatti[1]; F. Iorio[2]; L. Liverani[2]; A. R. Boccaccini[2]; E. Vernè*[1]

1. Politecnico di Torino, Applied Science and Technology, Italy
2. University of Erlangen-Nuremberg, Germany

This work presents the development of novel polymeric composite fibers via electrospinning, incorporating Te-doped bioactive glass powders (STe5) as functional fillers. The STe5 glass was selected for its bioactive, antibacterial, and antioxidant properties. Poly(e-caprolactone) (PCL) served as the biopolymeric matrix, with acetic acid (AA) used as the solvent. Field Emission Scanning Electron Microscopy (FESEM) confirmed successful integration of glass powders into the fibers at concentrations up to 20 wt%. Characterization included wettability, mechanical testing, in vitro stability, and preliminary antibacterial assays. Results demonstrated that AA treatment did not compromise the bioactivity of the glass powders. The inclusion of STe5 enhanced fiber wettability, improved mechanical performance with increasing filler content, and contributed to antibacterial efficacy. These findings highlight the potential of these composite materials for multifunctional applications in tissue engineering.

3:20 PM

(ICACC-S5-019-2026) Antimicrobial bioactive glass-loaded nonwoven fabrics: Tailoring BGs to the specific application (Invited)

F. Basoli*[1]; M. Trombetta[1]; D. Bellucci[2]; V. Cannillo[2]

1. Universita Campus Bio-Medico di Roma, Italy
2. Universita degli Studi di Modena e Reggio Emilia, Italy

The recent pandemic and the antimicrobial resistance represent a major challenge to global health making the development of personal protective equipment, in particular respirators, with effective antimicrobial properties and minimal impact on the environment an urgent priority. In the framework of the GAiA project, founded by NextGenerationEU M4C2 Investment 1.1 CUP C53D23008340001, Zn- and Mg- containing BG formulations, synthesized by melt-quenching route, were analyzed focusing on the relationship between quantity of dopants, antimicrobial properties and reactivity. Antimicrobial tests showed that the as made BGs posses a strong activity against both Gram± bacteria. Nonwoven fabric made from water-soluble polymers, thus avoiding toxic solvents and minimizing the use of polluting agents, was realized. The porosity of the said fabric was as such that it can be hypothesized its use for airway protection systems. Furthermore, following an esterification process, the total insolubility of the electrospun yarn was demonstrated. BGs were eventually incorporated within the network of the fabric guaranteeing their immobilization and the impossibility of their release. To further tailor antimicrobial properties BGs by sol-gel route were synthesized leading to nano-sized particles. Also, to overcome the batch to batch reproducibility, in-flow synthesis by microfluidic devices was tested.

3:50 PM

(ICACC-S5-020-2026) Tailored nanostructured composite coatings for antiviral and antibacterial air filters via co-sputtering

A. Luceri*[1]; S. Perero[1]; M. Donalisio[2]; D. Lembo[2]; M. Ferraris[1]; C. Balagna[1]

1. Politecnico di Torino, Dept. Applied Science and Technology, Italy
2. San Luigi Gonzaga University Hospital, Department of Clinical and Biological Sciences, Italy

Functional nanomaterials with tailored properties are essential for sustainable solutions in health and environmental protection. This work presents nanostructured composite coatings for air filtration systems, developed within the European NANOBLOC project. The coatings aim to reduce viral and bacterial transmission through environmentally friendly methods. Silver nanoclusters are embedded in glass or ceramic matrices via a co-sputtering technique, forming thin coatings that gradually release silver ions. These ions inhibit bacterial growth and reduce viral vitality, including influenza and coronavirus strains. The coatings retain their antimicrobial efficacy after thermal regeneration and sterilization, demonstrating excellent thermal stability. Co-sputtering enables scalable and energy-efficient production, making the technology suitable for industrial implementation. The composition and structure of these coatings can be tailored to meet the specific requirements of diverse applications. The combination of biocidal activity, material durability, and eco-friendly fabrication positions these coatings as a promising solution not only for air filtration systems but also for high-touch surfaces in clinical, industrial, and public settings. This approach aligns with current demands for novel synthesis strategies and multifunctional materials in health-related applications.

4:10 PM

(ICACC-S5-021-2026) Enhancing antibacterial properties of bioactive glasses through plasma surface modification

K. Pontillo*[1]; M. Miola[1]; K. Costabello[3]; M. Lai[3]; S. Ferraris[1]; Z. Najmi[2]; A. Cochis[2]; L. Rimondini[2]; E. Vernè[1]

1. Politecnico di Torino, Department of Applied Science and Technology, Italy
2. Universita degli Studi del Piemonte Orientale Amedeo Avogadro, Italy
3. IRIS Srl, Italy

Bioactive glasses are widely used in bone tissue regeneration but are prone to bacterial colonization, leading to implant-associated infections. This study investigates the surface modification of two bioactive glass compositions (SBA2 and S53P4) via non-thermal atmospheric plasma (He/O_2 or He/N_2) to impart antibacterial properties without antibiotics. Bioactive glasses were activated and coated with organic layers via plasma to reduce bacterial colonization or enhance antiadhesive properties. Surfaces were characterized using FE-SEM, EDS, FTIR, confocal microscopy, water contact angle, and zeta potential. Bioactivity was assessed in simulated body fluid (SBF), and antibacterial efficacy against Staphylococcus aureus followed ISO 22196. Results confirmed successful coating deposition with altered topography, chemistry, and wettability. Contact angle analysis showed increased hydrophobicity depending on the coating. Despite modifications, hydroxyapatite formation occurred, indicating preserved bioactivity. Notably, bacterial adhesion was reduced—up to two orders of magnitude—on coated samples compared to controls. These findings show that plasma-assisted surface engineering reduces microbial colonization while maintaining the regenerative potential of bioactive glasses, offering a promising strategy to enhance implant performance.

4:30 PM

(ICACC-S5-022-2026) Advanced functionalization strategies for antibacterial filtration materials

F. Gattucci*[1]; M. Miola[1]; C. Balagna[1]

1. Politecnico di Torino, DISAT, Italy

The development of antimicrobial filtration materials is vital for improving air and water quality, particularly in response to the growing threat of multidrug-resistant pathogens. This work focuses on designing functionalization strategies that impart strong antibacterial properties to various materials. These strategies include coating techniques compatible with heat-sensitive substrates, eco-friendly surface functionalization methods that exploit surface chemistry to decorate zeolites and polymers with antimicrobial nanoparticles, and the incorporation of antibacterial agents directly during membrane fabrication. Composite coatings containing silver nanoclusters are produced through co-sputtering and polymer-derived ceramic techniques. Additionally, in situ reduction and precipitation of silver, silver oxide, and copper oxide nanoparticles are achieved using green functionalizing agents such as tannic acid and curcumin on natural zeolite and polymer surfaces. Silver nanoparticles are also reduced in DMF and ethanol and then integrated into polymeric matrices during the electrospinning process. These complementary strategies establish versatile, scalable, and sustainable pathways for engineering advanced antimicrobial filtration materials, paving the way for improved performance, extended durability, and broader applicability in next-generation air and water purification systems.

S6 Advanced Materials and Technologies for Rechargeable Energy Storage

S6- Ionics, Interface, characterization and modeling 2 and Advances in Beyond-Lithium Battery Technologies

Room: Coquina G
Session Chairs: Valerie Pralong, CNRS ENSICAEN; Frederick Gray, Underwriters Laboratories Inc

1:30 PM

(ICACC-S6-039-2026) Fabrication of oxide-based all-solid-state batteries via laser-induced local melting process (Invited)

T. Honma*[1]; F. Sato[2]

1. Nagaoka Univeristy of Technology, Department of Materials Science and Bioengineering, Japan
2. Nagaoka University of Technology, Japan

All-solid-state batteries (ASSBs) are considered promising next-generation energy storage devices due to their potential for higher energy density and enhanced safety compared to conventional lithium-ion batteries. Oxide-based ASSBs, in particular, offer excellent thermal stability and electrochemical potential stability, and are advantageous in terms of processability, as they can be handled under ambient dry air. However, densification of oxide materials generally requires high-temperature sintering, and the formation of heterogeneous interfaces among cathodes, solid electrolytes, and anodes remains a critical challenge. Localized heating induced by nonradiative relaxation of d–d and f–f transitions in transition-metal ions enables local crystallization or melting. By irradiating a near-infrared laser, temperatures above the liquidus can be achieved within milliseconds. The resulting melt pools undergo crystallization or amorphization upon super cooling. We discuss laser-induced structural transformations in transition-metal phosphates, $Na_3Zr_2Si_2PO_{12}$ solid electrolytes, and tin-silicate anodes. The relationship between melt-solidification processes, microstructural evolution, and electrochemical performance is highlighted, with particular emphasis on the formation of heterogeneous solid–solid interfaces, which are crucial for realizing practical oxide-based all-solid-state batteries.

2:00 PM

(ICACC-S6-040-2026) Operando optical microscopy to image Li diffusion and chemical reactions in the solid state battery (Invited)

X. Shan*[1]; G. Thomas[1]; W. Tang[2]; B. Kottathodi[2]; J. Jeevarajan[3]

1. University of Houston, Electrical and Computer Engineering, USA
2. Underwriters Laboratories Inc, Electrochemical Safety Research Institute, USA
3. UL Resarch Institutes, Electrochemical Safety Research Institute (ESRI), USA

Increasingly complex and heterogeneous chemical reactions on the battery electrode surfaces require the characterization methods to provide a complete picture of localized and dynamic molecular interactions and Li diffusion information. In this presentation, we will introduce our efforts in developing and utilizing operando optical microscopy to study the dynamic processes in solid-state battery reactions. First, a reflection-mode optical microscope was developed. Using this setup, we successfully imaged localized Li ion diffusion within NMC particles, revealing significant particle size-dependent Li diffusion phenomena. Larger NMC particles exhibited pronounced diffusion delays at different locations, whereas smaller particles demonstrated a much faster diffusion process. Additionally, we extracted the lithium diffusion coefficients of individual NMC particles. The study further explores lithium diffusion under varying charging rates and temperatures. Second, we have developed a sample holder that allows us to apply pressure and temperature and keep the environment sealed for a long time. Using this sample holder, we have obtained Raman imaging of SSB's cross-section during the charging and discharging process. In the end, we used both techniques to study SSB reactions in the high-temperature conditions, which could provide critical insight into battery safety.

2:30 PM

(ICACC-S6-041-2026) Geo-inspired crystal chemistries for designing electrode materials (Invited)

V. Kovrugin*[1]

1. Ecole Nationale Superieure d'Ingenieurs de Caen, CRISMAT, France

Minerals provide a rich source of inspiration for designing sustainable and high-performance electrode materials. Many naturally occurring compounds display robust frameworks and redox-active centers that can host alkali cations, offering structural motifs directly translatable into battery electrodes. Polyanionic systems such as phosphates, sulfates, and silicates exemplify how strong inductive effects and diverse architectures enable high operating voltages, efficient ion transport, and cycling stability. Striking parallels exist between synthetic phases and mineral prototypes, including classic phosphate triphylite-, or more original sulfate alluaudite- and eldfellite-related structures, which have already demonstrated promising energy storage properties. Beyond structural analogies, mineralogical formation pathways reveal how complex frameworks can emerge under natural conditions, guiding new synthetic strategies in the laboratory. With thousands of mineral species identified but only a few explored electrochemically, the geosphere remains an underused materials library. Bridging mineralogy and battery science thus opens a vast and sustainable design space for future rechargeable energy storage technologies, enabling electrodes that combine Earth-abundant chemistry with the resilience and versatility of natural crystal architectures.

3:20 PM

(ICACC-S6-042-2026) The impacts of dry mixing on electrode microstructure and performance in lithium-ion batteries (Invited)

F. S. Gray*[1]; W. Tang[1]; J. Jeevarajan[1]

1. Underwriters Laboratories Inc, Electrochemical Safety Research Institute, USA

The lithium-ion electrode fabrication process has not changed significantly since the 1980s, and most of the industrial scale processes follow a wet-mix procedure. Dry mixing has been investigated as a potential alternative for cathodes, but studies have reported mixed results, potentially due to compressing all coatings to a fixed density despite demonstrations that dry mixing shifts to the pore size distribution towards electrolyte accessible mesopores and improves compressibility. This work investigates the effects of wet and dry mix methods on the performance and physical characteristics of both NMC811 cathodes and graphite anodes and the interplay with porosity. Preliminary results showed that dry mixing processes improved the yield-strength of the anode slurry without altering the viscosity behavior, allowing for thicker coatings; while in the cathode dry mixing reduced the slurry viscosity, allowing for potentially higher solid loadings and faster drying. SEM analysis of the fabricated coatings showed that dry mixing had produced a uniform coating of carbon on the active particles, resulting in less localized polarization in the electrode. This may inhibit the lithium-plating on the anode, improving both safety and cycle life. Overall, dry mixing offers a more effective and scalable approach for enhancing Li-ion battery performance through a fully optimized mixing process.

3:50 PM

(ICACC-S6-043-2026) The development of a robust PTFE fiber network for homogeneous dry thick electrodes (Invited)

U. Paik*[1]; T. Song[1]; J. Kim[1]; M. Kim[1]; S. Han[1]; J. Sun[1]; I. Hwang[1]

1. Hanyang University, Department of Energy Engineering, Republic of Korea

The transition to electric vehicles and energy storage, driven by carbon neutrality goals, is increasing demand for sustainable, high-energy lithium-ion batteries (LIBs). Advances in electrode materials and cell design have improved energy density, but further progress is needed, particularly in thick electrode fabrication. The roll-to-roll dry coating has emerged as a scalable, solvent-free route to thick electrodes with homogeneous microstructure. Such homogeneity ensures uniform pore/conductive agent distribution, lowering Li-ion/electron resistances and enhancing electrochemical performance. The microstructure is governed by a robust PTFE fiber network through four steps: (i) establishment of interfacial interactions between PTFE and other electrode components, (ii) transmission of shear force to PTFE through these interactions, (iii) shear-induced PTFE fibrillization, and (iv) construction of a robust fiber network. Dry electrodes with high areal capacity (10 mAh cm-2) are achieved by modulating PTFE fibrillization through interfacial engineering with electrode components, namely (i) introducing crystalline conductive agents and (ii) applying conductive coatings on cathode materials. The prepared dry electrode with homogeneous microstructure shows reduced ionic resistances due to the short Li^+/e^- diffusion lengths, thereby significantly enhancing the electrochemical performance of LIBs.

4:20 PM

(ICACC-S6-044-2026) Local organization in high-voltage spinel $LiNi_{0.5-x}Mn_{1.5+x}O_4$ revealed by 4d-STEM: Influence on electrochemical properties (Invited)

F. Weill*[1]; G. Oney[1]; I. Tertov[1]; F. Adrar[2]; E. Suard[3]; m. Hendrickx[4]; A. Demortiere[2]; P. Calbelguen[4]; C. Masquelier[2]; L. Croguennec[1]

1. Institut de Chimie de la Matiere Condensee de Bordeaux, France
2. Laboratoire Reactivite et Chimie des Solides, France
3. Institut Laue Langevin, France
4. Umicore, Belgium

Knowledge of local order is essential for understanding the electrochemical properties of materials for the positive electrodes of Li-ion batteries. While spectroscopic techniques such as NMR or Raman can be used to explore local order, transmission electron microscopy has the advantage of being able to locate cationic displacement or heterogeneities at the particle level. The LiNi0.5Mn1.5O4 (LNMO) spinel appears very promising as positive electrode materiel for Li-ion batteries because of its high operating voltage (4.8 V vs Li^+/Li, associated with the $Ni^{4+}/Ni^{3+}/Ni^{2+}$ redox couples) responsible for its high energy density. It has been shown that the crystallographic form of this compound, which can be either ordered, with Ni and Mn occupying two distinct crystallographic sites respectively, or disordered, with the transition metals sharing the same site, has a major influence on the electrochemical properties. But examination of the width of the diffraction lines indicates that a finer description of the compound's organization is needed. We will show that 4D-STEM has enabled us to understand the local organization of LNMO and in particular the arrangement of ordered and disordered domains within a particle. We will then show how this organization influences the electrochemical properties.

4:50 PM

(ICACC-S6-045-2026) Investigations into the electrochemical cycling of zinc in mildly acidic electrolytes (Invited)

T. N. Lambert*[1]; C. Quilty[1]; I. Bezsonov[1]

1. Sandia National Laboratories, Photovoltaics and Materials Technology, USA

Zn is a nearly ideal anode for grid energy storage owing to its high capacity, low cost, existing supply chain, environmental benignity, relative safety, high stability in water. Despite many recent advances, the high-capacity utilization of Zn for thousands of cycles remains a challenge, with cycle life typically obtained at the expense of energy density. The prevailing mechanistic viewpoint obtained from recent literature is that the cycling mechanism of Zn in mildly acidic electrolytes is unknown, the formation of zinc hydroxy anion (X) (ZHX) phases that occurs are largely irreversible and that such ZHX is derived primarily from the HER reaction. This mechanism, if correct, clearly poses challenges as it involves the consumption of both electrolyte and active material, which would preclude any long-term cycling, especially at high Zn utilization. We will present cycling data and our results from specific inquiries into evaluating proposed mechanisms for the electrochemical cycling mechanism of zinc in mildly acidic electrolytes. Additionally, the effect of the electrolyte anion on cycling, the structure, morphology, and functionality of the as-formed interphase will be discussed.

5:00 PM

(ICACC-S6-046-2026) Ultrahigh energy storage efficiency in high-entropy $BiFeO_3$-$BaTiO_3$-$NaNbO_3$-$NaTaO_3$ relaxor ceramics

J. Anthoniappen*[1]; C. Tu[2]; K. Feng[3]; R. Chien[4]

1. University of San Carlos, Physics, Philippines
2. Fu Jen Catholic University, Physics, Taiwan
3. Ming Chi University of Technology, Department of Mechanical Engineering, Taiwan
4. Ming Chi University of Technology, International Ph.D. Program in Innovative Technology of Biomedical Engineering and Medical Devices, Taiwan

Dielectric ceramics are well recognized for their potential in high-field and energy-density capacitor applications. However, achieving both high energy density and efficiency remains a significant challenge. Among various strategies, the high-entropy approach has proven effective in improving the energy storage performance of ferroelectric relaxors. In this study, a high-entropy 0.8(0.7$BiFeO_3$-0.3$BaTiO_3$)-0.1$NaNbO_3$-0.1$NaTaO_3$ (BF-BT-NN-NT) bulk ceramic was fabricated using a two-step calcination process, with an addition of 0.1 wt % MnO_2. The unipolar polarization-electric field (P-E) hysteresis loop revealed an impressive energy efficiency (η) of 90% and a recoverable energy density (W_{rec}) of 6.0 J cm^{-3} at 375 kV cm^{-1}. Temperature dependent P-E hysteresis loop demonstrated its thermal stability up to 150°C. These excellent results are attributed to enhanced multiple lattice distortions, grain boundary stability, and the formation of nanoclusters induced by the high-entropy configuration. The inclusion of paraelectric $NaTaO_3$ in the $BiFeO_3$–$BaTiO_3$ matrix plays a key role in generating lattice distortions and nanoclusters. Additionally, MnO_2 improves electric resistivity at the grain boundaries, enhancing the electric breakdown strength. This study highlights the potential of high-entropy BF-BT-NN-NT ceramics to advance energy storage performance in ferroelectric relaxor systems.

S10 Integrated computational -Experimental modeling ad design of ceramics and composites

S10- Modeling of structure and property of ceramics and composites II

Room: Ballroom 4
Session Chairs: Mikio Sakai, Tokyo Daigaku; Eva Zarkadoula, Oak Ridge National Lab

1:30 PM

(ICACC-S10-014-2026) Phase-field modeling of crack growth and interface sliding in ceramic matrix composites *WITHDRAWN*

F. Xue*[1]; T. Cheng[1]; Y. Lei[2]; R. Oleksak[1]; Y. Wen[1]

1. National Energy Technology Laboratory, USA
2. US DOE National Energy Technology, USA

Fiber-reinforced ceramic matrix composites (CMCs) are used in structural components of gas turbines and fusion reactors due to their enhanced toughness compared to monolithic ceramics. The enhanced toughness is due to the interaction between the CMC microstructure and mechanical damage that involves fiber bridging, fiber pull-out, crack deflection, and sliding at the fiber-matrix interfaces. This study develops a phase-field framework that explicitly accounts for microstructure-level cracking and interface sliding in CMCs. Fiber bridging and fiber pull-out are successfully reproduced, and the critical role of interface sliding in fiber bridging is demonstrated. Simulations are performed to investigate the effects of fiber layout, interface sliding resistance, and operating conditions on crack growth under monotonic load and in the situation of thermal/mechanical fatigue. Simulation results highlight both microstructural features and operating conditions that can strongly impact damage evolution. This model provides quantitative understanding of the CMC damage processes and could serve as a valuable tool for guiding design of the CMC microstructure.

1:50 PM

(ICACC-S10-015-2026) Oxygen reduction reaction simulation at a polymer electrolyte fuel cell cathode by neural network molecular dynamics method

K. Suzuki*[1]; K. Kamata[1]; S. Fukushima[1]; Y. Ootani[1]; N. Ozawa[2]; M. Kubo[1]

1. Institute for Materials Research, Tohoku University, Japan
2. Tohoku University, New Industry Creation Hatchery Center, Japan

To reveal a hydrogen society, high-power and durable polymer electrolyte fuel cells (PEFCs) are required. The PEFC performance is attributed to the oxygen reduction reaction (ORR) activity at the cathode catalyst layer (CL), consisting of carbon supports, Pt catalyst nanoparticles (NPs), ceramics co-catalysts, ionomers, and water. During ORR, protons conduct from the anode through the ionomers and chemically react with oxygen molecules from the gas phase on the Pt NPs. Here, water is mainly generated, but hydrogen peroxide (H_2O_2) is also generated as a by-product. H_2O_2 changes to OH radicals, which decompose ionomers, degrading proton conductivity and ORR activity. For highly durable PEFC, we should design a CL structure that suppresses H_2O_2 formation by revealing the influence of the CL structure on the ORR. The neural network molecular dynamics (NNMD) method is effective for elucidating the chemical reaction dynamics during ORR, because the NNMD method with a neural network potential trained on data from ab initio MD calculation can accurately simulate chemical reaction dynamics. In this study, to investigate the influence of the CL structure on ORR activity, we examined the ORR on a Pt NP in the CL by the NNMD method and represented the adsorbed intermediate structures. In the presentation, we will discuss the influence of the CL structure on the ORR.

2:10 PM

(ICACC-S10-016-2026) Molecular dynamics simulation analysis of anti-icing properties of hydrophilic concentrated polymer brush

K. Furudate*[1]; Y. Hara[1]; S. Fukushima[1]; Y. Ootani[1]; N. Ozawa[2]; M. Kubo[1]

1. Institute for Materials Research, Tohoku University, Japan
2. Tohoku University, New Industry Creation Hatchery Center, Japan

Adhesion of ice and snow on the infrastructural equipment, such as aircraft wings and wind turbine blades, can lead to substantial energy losses and serious safety hazards. Consequently, the development of passive, energy-free anti-icing surfaces is considered a crucial enabling technology. Among various strategies, coatings based on concentrated polymer brushes (CPBs) are exceptionally promising. A CPB composed of polymer chains densely grafted onto a ceramic substrate, exhibits remarkably low ice adhesion forces, even when the polymer chains are hydrophilic. However, the fundamental molecular-level mechanism behind this phenomenon, especially how water behaves and freezes within the CPB layer, remains poorly understood, thereby limiting rational design for further improvement. Therefore, we employed large-scale, all-atom molecular dynamics (MD) simulations to elucidate the anti-icing mechanism of hydrophilic polyethylene glycol-based CPBs in detail. In this talk, we will specifically present the structural and dynamic properties of water molecules confined within the PEG brush at sub-zero temperatures and discuss their implications for the design of anti-icing CPB coatings.

2:30 PM

(ICACC-S10-017-2026) Investigating the role of nano-Si in Polycarbosilane pyrolysis using ReaxFF simulations

M. Shaik*[1]; K. Lu[1]

1. The University of Alabama at Birmingham School of Engineering, Mechanical and Materials Engineering, USA

This study investigates the effect of incorporating nano-Si particles into the Polycarbosilane (PCS, SMP-10) system on SiC yield during pyrolysis, using reactive molecular dynamics (ReaxFF) simulations. Simulations were conducted at 1500 K, 3000 K, and 4500 K to analyze bond formation, gas release profiles, and radial distribution functions (RDFs), thereby providing atomistic insight into the mechanisms of SiC evolution. The simulations suggest that nano-Si particles can enhance SiC yield by reacting with free carbon, thereby reducing non-stoichiometric phases and improving structural integrity. Their high surface energy and large surface area are expected to accelerate Si–C reactions and facilitate nucleation at lower temperatures (<2000 K), potentially leading to uniform, nano-sized SiC grains. At room temperature, nano-Si particles are predicted to remain stable as small clusters with intact Si–Si bonding, while above 1500 K they may actively participate in diffusion and bonding processes that promote SiC formation. Furthermore, introducing 5 wt% nano-Si into SMP-10 with ~5 wt% free carbon is anticipated to compensate for carbon excess during pyrolysis, enhancing SiC yield, reducing porosity, and improving ceramic density.

S10- Modeling of surfaces, interfaces, and grain boundaries at multiple scales

Room: Ballroom 4
Session Chair: David Poerschke, University of Minnesota

2:50 PM

(ICACC-S10-018-2026) Deciphering 2D interfacial phases: From computing grain boundary phase diagrams to controlling microstructural evolution with electric fields (Invited)

J. Luo*[1]

1. University of California San Diego, USA

Grain boundaries (GBs) can undergo structural transitions to form crystal-like, amorphous-like, and quasicrystal-like interfacial phases that are thermodynamically two-dimensional (also known as "complexions"); see, e.g., a recent perspective article: Science 368:381 (2024) and references therein. As bulk phase diagrams are arguably the most useful materials design tool, it is envisioned that their GB counterparts can be equally useful for materials science. In this talk, I will review a series of our studies to compute GB phase diagrams. In addition to temperature and chemical potentials, an applied electric field can induce a GB transition via electrochemical coupling. Here, electrically induced GB transitions can be used to tailor microstructural evolution.

3:20 PM

(ICACC-S10-019-2026) Elucidating abnormal grain growth kinetics of Eu-doped $MgAl_2O_4$ using complexion-governed Monte Carlo grain growth simulations

B. Zalatan[2]; S. Huang[2]; S. Esslestyn[1]; M. Harmer[3]; B. Chen[2]; C. Marvel*[1]

1. Louisiana State University, Mechanical and Industrial Engineering, USA
2. Lehigh University, Department of Computer Science and Engineering, USA
3. Lehigh University, Materials Science and Engineering, USA

Grain boundary complexion transitions are theorized to drive abnormal grain growth as complexion-induced abnormal grain growth has been extensively observed in Eu-doped $MgAl_2O_4$. Nucleation and propagation of high mobility complexions provide certain grains a growth advantage if it is surrounded by such interconnected high mobility complexions. However, it is unclear how complexions most realistically propagate through a coarsening microstructure. In this work, a 3D Monte Carlo Potts grain growth model was used to assess abnormal grain growth by varying permissible complexion propagation mechanisms as a means to replicate abnormal grain growth behaviors observed experimentally. The key result was that a newly integrated sweeping mechanism was most effective in increasing abnormal grain nucleation and growth, while also promoting stronger clustering of abnormal grains. An unexpected observation was that, on average, transitioned grain boundaries exhibited a short lifetime in a coarsening microstructure, which indicates that complexion transitions must collectively move through a microstructure to sustain abnormal grain growth. This experimentally-motivated work provides an improved understanding of complexion propagation which will aid future experimental studies of complexion-dependent microstructure evolution.

3:40 PM

(ICACC-S10-020-2026) Strategies for designing shape-memory ceramics via lattice distortions from applied stresses

E. M. Feygin*[1]; C. A. Schuh[2]

1. Massachusetts Institute of Technology, Department of Materials Science and Engineering, USA
2. Northwestern University, Department of Materials Science and Engineering, USA

Compositional tuning is the classical route to lowering thermal hysteresis in shape memory alloys (SMAs) and, more recently, in shape memory ceramics (SMCs). However kinetic and thermodynamic limitations arise in SMCs creating a need for other methods of altering the crystallography of the transformation. In this study, we include applied elastic stresses in the current crystallographic theories of martensitic transformations and analyze how the resulting lattice distortions affect interface compatibility in model shape-memory systems. We first validate our theoretical results on experimental data collected from the literature on SMAs and find our theory predicts that the strain resulting from realistic applied stresses improves interface compatibility and modulates thermal hysteresis as much as changes in composition do. Furthermore, we find that the relationship between interface compatibility and stress has a strong orientation dependence. We then extend this empirically validated theoretical analysis to zirconia-based SMCs, where the additional crystallographic complexity and the ability to withstand larger stresses potentially offer a richer design space. Our work implies that strain engineering may be an effective strategy for designing shape-memory ceramics with improved functional properties.

S10- Multifunctional ceramics and composites-multiphysics modeling, characterization and design

Room: Ballroom 4
Session Chair: Gerard Vignoles, University Bordeaux

4:00 PM

(ICACC-S10-021-2026) Computational and experimental chemical thermodynamics for predicting the stability of aerospace materials in extreme environments (Invited)

G. Costa*[1]; B. Kowalski[1]; R. I. Webster[1]; J. L. Stokes[2]; C. Bodenschatz[1]; J. Reynolds[3]

1. NASA Glenn Research Center, USA
2. NASA Glenn Research Center, Environmental Effects and Coatings Branch, USA
3. NASA Marshall Space Flight Center, USA

Computational and experimental chemical thermodynamics research are essential to predict the behavior of aerospace ceramic materials for use in several critical research areas at NASA Glenn Research Center (GRC). These materials are of interest for applications in extreme environments, including nuclear, hypersonic, and other high temperature, corrosive conditions. In this work, we summarize and discuss our previous and current studies at NASA GRC using high temperature reaction calorimetry and computational tools to evaluate the thermodynamic stability of ceramic coating material phases and chemical compositions as well as their resistance against corrosion. The first study involves the computational and experimental research on the chemical and thermodynamic properties of rare-earth mono and disilicates for environmental barrier coating applications on hot section components of military and commercial aircraft turbine engines. The second study discusses the results from calorimetric measurements on the energetics of ultra-high temperature bi- and tri-carbides for protective coating applications in extreme nuclear and hypersonic environments. Implications of the results on predicting the ceramic coatings energetic stability regarding their field of applications are discussed.

S10- Modeling defects and amorphous matter and their evolution

Room: Ballroom 4
Session Chair: Martin Magnuson, Linkoping University

4:30 PM

(ICACC-S10-022-2026) Modeling ion-induced defects and recovery in semiconductors at the atomic scale (Invited)

E. Zarkadoula*[1]; I. Decebal[2]; A. Hotnog[2]; Y. Zhang[3]; W. J. Weber[4]; G. Velisa[2]

1. Oak Ridge National Laboratory, Center for Nanophase Materials Sciences, USA
2. Horia Hulubei National Institute for Physics and Nuclear Engineering, Romania
3. Queen's University, Smith Engineering, Canada
4. University of Tennessee, Materials Science & Engineering, USA

Defects are central to the behavior of semiconductors and oxides, and understanding their formation and recovery is essential for electronic and sensing applications. In this presentation, I will use molecular dynamics simulations compared to experiment to examine how energetic ions can induce defect recovery in semiconductors and oxides. The focus will be on the atomistic processes that govern the creation of defects, their short-timescale evolution, and the mechanisms that enable recovery across different materials. Comparisons with experimental observations will be used to connect atomic-scale insights with measurable radiation response. Together, these results provide a deeper understanding of defect dynamics in semiconductors and oxides and contribute to broader efforts in modeling defects, amorphous matter, and microstructural evolution under irradiation. Work was supported by the Center for Nanophase Materials Sciences, a US Department of Energy, Office of Science User Facility at Oak Ridge National Laboratory.

5:00 PM

(ICACC-S10-023-2026) Structural and electronic modeling of amorphous molecular solids (Invited)

P. Rulis*[1]

1. University of Missouri - Kansas City, Physics and Astronomy, USA

Amorphous molecular solids, grown via plasma enhanced chemical vapor deposition (PECVD) from molecular precursors, have particular suitability for controlled variation in resultant properties. Under the low-temperature and non-thermodynamic PECVD conditions the substructure of the molecular precursor source ingredients is retained in the resultant amorphous thin film to a degree that is a function of the growth parameters. The detailed structure of the thin-film is subject to variation of the growth parameters including substrate temperature, gas pressure, plasma energy, precursor flow rate, etc. Ideally, the optimization and search process could be dramatically sped up with the use of computational methods that can realistically model the possible resultant structures, correlate those structures to growth parameters, and enable a search for models with the desired properties. In this presentation, progress on the development of such an approach will be presented. The application of atomic scale model generation to hexamethyldisilazane (HMDS) will be shown using template-driven explicit bond formation methods, showcasing their capabilities and limitations. Comparison of the resultant models with variance data from fluctuation electron microscopy analysis of comparable growth samples and radial distribution function data will be used to help judge the product quality.

S12 Atomically Layered Carbides, Nitrides, Borides, and Related Materials- From Bulk to Low Dimensional Derivates

S12-Atomically Layered Carbides, Nitrides, Borides, and Related Materials: From Bulk to Low Dimensional Derivates II

Room: Flagler C
Session Chairs: Babak Anasori, Purdue University; Ankit Srivastava, Texas A&M University; Garritt Tucker, Baylor University

1:30 PM

(ICACC-S12-008-2026) Exchange Hamiltonian and complex high magnetic field phase diagram in RE-i-MAX phases (Invited)

O. Dieguez*[1]

1. Tel Aviv University, Israel

Rare-earth-based-in-plane-ordered MAX phases (RE-i-MAX) are a family of nano-laminated compounds with chemical formula $(Mo_{2/3}RE_{1/3})_2Al_C$ that have attracted interest as potential precursors for magnetic two-dimensional (2D) derivatives (MXene). Investigation of the magnetic properties of these materials is a work in progress both experimentally and theoretically. I will focus on recent findings in the magnetic study of these fascinating phases. High magnetic field, frequency dependent ac susceptibility measurements have revealed hidden high magnetic field that grows from RE=Gd, to Er. In RE=Tb, these measurements show the emergence of frequency dependent phase attributed to a dynamic spin component in this compound observed previously in μSR measurements. The exact nature of these high magnetic and frequency dependent phases needs to be further studied. To that end and more the magnetic exchange interactions, with RE = Nd, Sm, Gd, Tb, Dy, Ho, and Er are calculated using density functional theory and are measured using magnetic diffuse neutron scattering on powder samples with RE =Tb and Er. Good quantitative agreement is found between calculated and observed magnetic parameters. An important finding from these calculations is the significance of the exchange interaction between RE atoms across the Al layer which may have strong implications on the existence of magnetism in RE-i-MAX based MXenes.

2:00 PM

(ICACC-S12-009-2026) Atomistic-origins of deformation and damage in MAX Phases: Basal dislocations and kinking (Invited)

G. Tucker*[1]; G. Plummer[2]; A. Gupta[3]

1. Baylor University, USA
2. NASA Ames Research Center, USA
3. Freudenberg Performance Materials Holding SE & Co. KG, Germany

MAX phases, a large family of ternary carbides and nitrides with an atomically layered crystalline structure, exhibit many favorable properties, including high temperature stability and elastic stiffness, while also being easily machinable and damage tolerant. While these properties are advantageous for various engineering applications, the atomic-scale origins of key defects and mechanisms are still being pursued. The complexity in their mechanical behavior results from the interplay between several deformation mechanisms – basal dislocations, elastic buckling, kinking, and delamination. Recent advances in atomistic modeling have enabled new insights into these processes. Utilizing atomistic simulations, basal dislocation core structures are studied, elucidating the key role of intralayer bonding, with weak bonds that result in non-planar cores and less mobile dislocations. Furthermore, the formation and incipient formation of kink bands are now linked with the delamination of the basal planes. Finally, the variations in mechanical properties and underlying deformation mechanisms in the presence of irradiated vacancy clusters and at high temperature are probed.

2:30 PM

(ICACC-S12-010-2026) On crystallographic slip in Al-based MAX phases (Invited)

M. Radovic[1]; A. Srivastava*[1]

1. Texas A&M University, USA

The single-crystal-level mechanical response of MAX phases is characterized using small-scale mechanical testing of specimens machined from individual grains via focused ion beam milling. The focus is on understanding crystallographic slip in these materials, with emphasis on the effect of M elements and MX layer stacking sequences in Al-based MAX phases. Our findings show that crystallographic slip in all these materials deviates strongly from classical Schmid's law, with the critical resolved shear stress exhibiting an approximately linear dependence on the normal stress acting on the slip plane. More importantly, the material-specific coefficients in this linear relation, obtained from experimental trends, can be explained in terms of theoretical M-A bond (or cleavage) strengths and shear strengths for basal slip, as estimated from atomistic simulation data on cleavage and shear energies. These results provide new insights into the fundamental deformation mechanisms of MAX phases.

3:20 PM

(ICACC-S12-011-2026) Low-temperature synthesis of Ti_2AC (A = Si or Ge) MAX-based coatings via reactive cathodic arc evaporation

A. Gitschthaler*[1]; P. Doerflinger[1]; R. Hahn[1]; J. Ramm[2]; K. Boebel[2];
S. Kolozsvári[3]; P. Polcik[3]; E. Ntemou[4]; D. Primetzhofer[4]; D. Fuchs[5];
A. Limbeck[5]; A. Davydok[6]; C. Krywka[6]; H. Riedl[7]

1. Christian Doppler Laboratory for Surface Engineering of high-performance Components, TU Wien, Austria, Austria
2. OC Oerlikon Balzers AG, Liechtenstein
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4. Uppsala Universitet, Sweden
5. Technische Universitat Wien Institut fur Chemische Technologien und Analytik, Austria
6. Helmholtz Center Hereon, Institute of Materials Physics, Germany
7. TU Wien, Institute of Materials Science and Technology, Austria

MAX phases are a unique class of nanolaminated compounds that combine metallic and ceramic properties, offering excellent electrical and thermal conductivity together with remarkable resistance to creep, oxidation, and corrosion. These characteristics make them highly attractive as protective and functional coatings for next-generation technologies. However, conventional sputtering techniques struggle to provide suitable growth conditions at reduced synthesis temperatures, often leading to phase instability and the formation of competing phases. Despite more than two decades of research on Ti–A–C (A = Si or Ge) MAX coatings [1,2], it has yet to be achieved to deposit them under less harsh, more practical conditions. To address this issue, Ti_2–A–C (A = Si or Ge) thin films were deposited by cathodic arc evaporation of metallic TiA (A = Si or Ge) targets in reactive Ar/C_2H_2 plasma atmospheres using an industrial-scale coating plant. To understand the relationship between deposition parameters, chemical composition, and phase formation, the resulting films were comprehensively characterized using high-resolution techniques, including ToF-ERDA-calibrated GD-OES, 2D-BBXRD, and t-CSXRD measurements. Overall, these analyses demonstrate, for the first time, that Ti_2–A–C MAX-based coatings can be successfully synthesized by reactive CAE at temperatures as low as 550 °C.

3:40 PM

(ICACC-S12-012-2026) Low temperature synthesis of Ti_3SiC_2 thin films by high power impulse magnetron sputtering

P. Doerflinger*[2]; A. Gitschthaler[2]; R. Hahn[2]; J. Ramm[4]; K. Boebel[4];
S. Kolozsvári[5]; P. Polcik[5]; E. Ntemou[6]; D. Primetzhofer[6]; D. Fuchs[1];
A. Limbeck[1]; A. Davydok[3]; C. Krywka[3]; H. Riedl[2]

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5. Plansee Composite Materials GmbH, Germany
6. Department of Physics and Astronomy, Uppsala University, Sweden

Nanolaminated ternary nitrides and carbides blur the line between metallic and ceramic material properties. But still the applications of MAX phase thin films, combining electrical and thermal conductivity with oxidation resistance, are constrained by the high temperatures required to form the layered $M_{n+1}AX_n$ structure. In this case study, high power impulse magnetron sputtering has been employed to expand Ti_3SiC_2 thin film synthesis to the low-temperature region by heavy ion bombardment. Aiming for a production-compatible deposition process, a single-step-single-target reactive deposition approach at a substrate temperature below 600 °C was implemented. Hence, no post annealing or intentional seed layer deposition was applied. ToF-ERDA and ToF-ERDA-calibrated GD-OES show Ti_3SiC_2 near stoichiometry for the thin films deposited at $C_2H_2/(Ar+ C_2H_2)$ gas fractions below 5 % and peak power densities above 1 kW/cm^2 on the TiSi 75/25 at. % target. Synchrotron diffraction experiments unravel the effects of the high energy ion flux resulting in isolated [110] growth of Ti_3SiC_2 which could be cross-validated by SAED. The tuned MAX phase orientation of the sputter deposited Ti_3SiC_2 marks a key step toward unlocking the full potential of the anisotropic metallic-ceramic properties in protective coating technology.

4:00 PM

(ICACC-S12-013-2026) Development of a MAX phase CMC using wet winding for high-temperature applications in aggressive environments

L. R. Aretz*[2]; F. Curvers[2]; F. Jung[1]; T. Tonnesen[2]; T. Gries[1]

1. RWTH Aachen University, Institut für Textiltechnik, Germany
2. Institute of Mineral Engineering, RWTH Aachen University, Chair of Ceramics, Germany

The development of high-temperature structural materials is of central importance for improving efficiency in energy-intensive sectors such as power generation, aerospace, and space exploration. Fiberreinforced composites with ceramic matrices offer significant potential in this regard. In particular, MAX phases represent a highly promising matrix material, as they uniquely combine ceramic attributes such as high stiffness, oxidation resistance, and thermal stability with metallic characteristics including good machinability, fracture toughness, and damage tolerance. In this contribution, we present wet winding as a scalable processing route for the fabrication of fibrereinforced CMCs with a Ti_2AlC MAX-phase matrix. Due to the incongruent melting behaviour of MAX phases, melt-based processing is not possible. Therefore slurry-based approaches are needed. We report on the development of an $Al_2O_{3(f)}/Ti_2AlC$ composite system, focusing on the design of a suitable slurry formulation for wet winding. The requirements for MAX-phase slurries are defined, and suitable additives are identified to achieve the desired rheological properties. The manufactured composite samples are characterized with respect to their mechanical and thermal performance. On this basis, the potential of $Al_2O_{3(f)}/T_{i2}AlC$ CMC for structural applications under aggressive high-temperature environments is evaluated.

4:20 PM

(ICACC-S12-014-2026) In-situ TEM observation of nanoplasticity of high entropy MXenes

Y. Gan*[1]; R. Namakian[1]; C. Wei[1]; S. Xiang[1]; K. Y. Xie[1]; B. C. Wyatt[2]; B. Anasori[2]; C. Wu[1]

1. Texas A&M University, USA
2. Purdue University, USA

Material fracture is often an irreversible, catastrophic event, especially in low-dimensional materials where atomic-scale thickness leads to enhanced brittleness despite high strength. In this work, we discovered that the mechanical resilience of MXenes particularly high-entropy compositions can be significantly enhanced via intrinsic nanoplasticity. Using in-situ high-resolution transmission electron microscopy (HR-TEM), we directly observe dislocation nucleation, and evolution in real time under electron beam-induced residual stress. Unlike traditional brittle fracture, cracks in $TiVCrMoC_3$ MXenes emit dislocations that relieve stress and delay propagation. This sequential sliding and fracture process absorb energy through lattice reconstrcution and slip without compromising structural integrity. In contrast, low-entropy $Mo_2Ti_2C_3$, $Mo_2Nb_2C_3$ MXenes exhibit amorphization under stress, lacking such plastic accommodation. Our findings are further supported by atomic modeling and crystallographic slip system analysis, confirming that high-entropy induced disorder promotes active dislocation mechanisms and structural adaptability. This discovery provides a new pathway for enhancing toughness in 2D layered materials, by controlling fracture behavior at the atomic level through entropy engineering.

S13 Advanced Ceramics and Composites for Nuclear Fission and Fusion Energy Systems

S13- Novel nuclear ceramics II

Room: Coquina F
Session Chair: Takaaki Koyanagi, Oak Ridge National Laboratory

1:30 PM

(ICACC-S13-051-2026) Microstructural optimisation of WC-FeCr low activation neutron shielding material for fusion energy

S. Uthayasekaran*[1]; E. Saiz[1]; T. Sauberlich[2]; S. Humphry-Baker[1]

1. Imperial College London, Materials, United Kingdom
2. H.C. Starck, Germany

WC-FeCr is a candidate fusion neutron shielding material due to its good radiation attenuation properties and low-activation characteristics. For optimal neutronics performance, a low (<3wt.%) binder content is essential, which may require pressure-assisted densification. A systematic study has been conducted varying the sintering conditions. Near full density (>98 %) was achieved when the binder liquid formation temperature (~1180 °C) was exceeded. The effect of starting WC powder particle size was investigated ranging 0.5 to 4 microns, with the smaller particle sizes improving densification. The resulting microstructures were studied using X-ray diffraction, SEM and EBSD to assess grain growth. Average grain size increased very little during sintering - e.g., from 1.8 to 2.0 μm over a 10-minute dwell period at 1350 °C, suggesting that diffusion in the binder is very sluggish, and that densification may be driven by pressure induced pore infiltration. The impact of starting particle size on fracture toughness was assessed, which ranged from 7.5-8.5 MPa $m^{-1/2}$. Thermal conductivity was strongly grain size dependent, peaking at 2.5 μm due to a competition between porosity scattering and boundary scattering. The results suggest that a low binder content of 3 wt.% can enable a significant reduction (550-700 °C) in sintering temperature and enhanced mechanical performance.

1:50 PM

(ICACC-S13-052-2026) Toward zero-rupture TRISO fuel encapsulation in MgO via pressureless sintering

I. Kumar*[1]; A. Pophali[1]; T. J. Kim[1]; D. Sprouster[1]; L. Snead[1]; J. Trelewicz[1]

1. Stony Brook University, Material Science and Chemical Engineering, USA

TRistructural-ISOtropic (TRISO) particle fuel is a leading accident-tolerant fuel (ATF) design for advanced high-temperature reactors. However, its use in fully ceramic microencapsulated (FCM) form has been limited by limitations of conventional graphite matrices, including chemical instability, oxidation and cracking at high temperatures, and long-term waste management challenges. To address these issues, ceramic composites (MgO-X, where X can be BeO or ZrH 1.6) have been proposed as replacements due to their superior irradiation tolerance, cost, chemical stability, and better waste management. This study demonstrates the synthesis of dense MgO compacts and the encapsulation of ZrO2 and TRISO particles using LiF as a sintering aid. Processing parameters, including LiF content, temperature, pressure, and sintering cycles, were optimized to produce these compacts. TRISO encapsulation was achieved by first establishing monolithic MgO, followed by the incorporation of ZrO2 and surrogate TRISO particles using the templating method. The results provide an optimized route to create these compacts with low temperature and no pressure. This lays the foundation for MgO-X composites as a matrix with enhanced neutronic and thermal performance for next-generation reactors.

2:10 PM

(ICACC-S13-053-2026) Low temperature sintering of WB composites for fusion

O. T. Oladosu*[1]; I. T. Elizarova[1]; E. Saiz[1]; L. Evitts[2]; J. Wade-Zhu[3]; D. Bowden[3]

1. Imperial College London, Materials, United Kingdom
2. Bangor University, United Kingdom
3. Culham Centre for Fusion Energy, United Kingdom

Spherical tokamaks offer advantages in the development of fusion reactors, but the limited space in the central column presents challenges for neutron shielding. Tungsten boride (WB) is a promising shielding material due to its high neutron scattering and absorption. However, its high sintering temperature complicates the fabrication of dense parts. This presentation discusses the low temperature sintering of WB composites using an "inorganic polymer" binder (BOMAG). Binder formation and sintering occur through the reaction of MgO and H_3BO_3 at ~300 °C under pressure (up to 370 MPa). This approach can be used to sinter composites with WB contents up to 98 wt% and densities reaching 12 g/cm^3. The effect of binder composition, boride granulometry and processing conditions on the density and microstructure of the materials will be discussed and related to their thermomechanical properties and stability. This work highlights a viable route for producing compact WB-based shielding components via low-temperature processing.

2:30 PM

(ICACC-S13-054-2026) Processing and properties of a high recycle content bentonite-graphite composite for nuclear waste repository application

A. Kolanti*[1]; K. Christian[1]; Y. Huang[2]; S. Fayfar[2]; C. Tan[3]; D. Sprouster[1]; L. Snead[1]

1. Stony Brook University, Materials Science, USA
2. Massachusetts Institute of Technology, Nuclear Reactor Laboratory, USA
3. Idaho National Laboratory, USA

Bentonite clay has long been considered and utilized as a backfill material, especially for high-level waste repositories, due to its numerous attributes, including swelling in the presence of moisture, the ability to combine low permeability with high retention, and chemical stability. However, it has low thermal properties due to the poor conductivity of bentonite. The aim of this work is to develop a composite material with improved thermo-physical properties. As part of this work, graphite was crushed and mixed with bentonite clay at varying graphite weight percentages (0 wt%, 5 wt%, 10 wt%, 20 wt%, and 50 wt%). These composites underwent hydraulic conductivity tests, and the results showed that hydraulic conductivity decreased with increasing graphite content. X-ray Computed Tomography (XCT) revealed that the reduction in hydraulic conductivity is mainly due to the tortuous pore path. Laser Flash Analysis (LFA) measured at 200 °C showed improved thermal diffusivity with increasing graphite content. Differential Scanning Calorimetry (DSC) showed that the Cp values improved with increasing graphite content. In conclusion, we have designed and developed a composite material with enhanced properties that is suitable for deep geological repositories.

2:50 PM

(ICACC-S13-055-2026) Evolution of amorphization and nanohardness in Si-RS-SiC under Fe ion irradiation

Y. Nishimura*[1]; Z. Yang[1]; C. Yang[1]; Z. Zhu[1]; B. Li[1]; H. Abe[1]

1. Tokyo Daigaku, School of Engineering, Japan

The SiC fuel matrices for innovative high-temperature gas-cooled reactors design as part of the demonstration program serve as the fuel particle bed structure, barrier to severe oxidation during accidental scenarios, and heat transfer medium in the block-type cores. Of particular importance in technology are mechanical/thermal stabilities of the SiC matrix that is being irradiated during the service. Reaction sintering (RS) process has been developing for the highly densified SiC matrix production. Since some residual Si remain in the matrix after the sintering, irradiation behaviors of the Si-RS-SiC are critical issues for its potential application. In this study, amorphization and nanohardness changes of Si-RS-SiC irradiated with 2.5 MeV Fe 2+ ions from room temperature to 500 degrees celcius at doses from 0.5 to 2.5 dpa are investigated. At the dose of 1 dpa, the results of Raman spectrum reveal obvious amorphization; crystalline Si and crystalline SiC (LO + TO) peaks are not distinct and a new broaden scattering band appears. At this dose, the mechanical properties of irradiated RS-SiC are measured correspondingly. The hardness and elastic modulus after irradiation decrease by 16% and 35%, respectively. The amorphous swelling is estimated as 8.3%, which is larger than CVD-SiC references. Nanoscale characterization and thermal conductivity changes need to be addressed in the future work.

S13- Novel nuclear ceramics III

Room: Coquina F

Session Chair: Takaaki Koyanagi, Oak Ridge National Laboratory

3:30 PM

(ICACC-S13-056-2026) Oxidation resistance of LPS-SiC containing dual rare-earth additives

H. Sakai*[1]; T. Hinoki[1]

1. Kyoto University, Japan

SiC/SiC composites are promising candidates for next-generation fuel cladding because of their excellent chemical and thermal stability. Oxidation of SiC is generally suppressed by the formation of a silica layer; however, this protection becomes ineffective in a steam environment, particularly at temperatures above 1400 °C. When RE-oxide containing SiC was oxidized in steam, the RE oxides diffused to the surface, where they reacted with the SiO_2 scale to form a RE-silicate layer. This RE-silicate layer is expected to provide resistance to steam oxidation. Lu-oxide diffused rapidly to the surface and formed a uniform coverage, but the resulting layer was not sufficiently thick to offer effective oxidation protection. In contrast, Yb diffused more slowly, producing a Yb-silicate layer that was less uniform but thicker than the Lu-silicate layer. In this study, Yb-oxide, Lu-oxide, and alumina were used as sintering additives, and dense monolithic SiC with a porosity of less than 2% was fabricated by liquid-phase sintering (LPS). The samples were exposed to steam at 1400 °C for 10–100 hours. Mass and volume changes were measured before and after oxidation, and the surfaces and cross-sections were examined by SEM. A dense and uniform silicate layer was formed, and the weight change was reduced to one-fifth of that observed in SiC sintered with Yb-oxide and alumina.

3:50 PM

(ICACC-S13-057-2026) Polymeric Flocculants in Nuclear Sludge Treatment: Architecture and Performance *WITHDRAWN*

J. Ojur*[1]

1. Cranfield University, United Kingdom

Effective management of spent ion exchange (IEX) media is a critical challenge for nuclear wastewater remediation at facilities like Sellafield's Site Ion Exchange Effluent Plant (SIXEP). Hydraulic transfer of clinoptilolite IEX produces fine suspensions with poor settleability and high-water content, complicating interim storage and downstream treatment. This work explores polymeric flocculants as a low-cost, scalable option to improve sludge consolidation. Two cationic polymers were tested across 0.1–10% (v/v) solids: a high-molecular-weight linear polyacrylamide and a branched polyamine-epichlorohydrin resin. Flocculation was evaluated via turbidity reduction, zeta potential, polymer adsorption, bed volume, floc size, fractal dimension, and shear response. The linear polyacrylamide promoted bridging, forming compact flocs with strong resilience and regrowth, while the branched resin acted via patch flocculation, yielding larger but fragile aggregates. By linking polymer architecture to settling efficiency and stability, this study defines dosage windows (5–100 ppm) for effective sludge conditioning and stresses the importance of tailoring flocculant choice to material microstructure. The results offer practical guidance for integrating polymer-assisted consolidation into nuclear effluent treatment and advancing safer, more sustainable waste management strategies.

S16 Geopolymers Inorganic Polymers and Sustainable Construction Materials

S16- Sustainable construction materials II

Room: Ballroom 5

Session Chair: Enrico Bernardo, University of Padova

1:30 PM

(ICACC-S16-015-2026) Alkali-activated aggregates as a sustainable solution within a circular economy (Invited)

V. Ducman[1]; A. Tesovnik*[1]; P. Perumal[2]

1. Slovenian National Building and Civil Engineering Institute, Slovenia
2. University of Oulu, Fibre and Particle Engineering Research Unit, Finland

In line with sustainable development and the circular economy, solutions are being sought to convert waste into new products. The construction industry uses a lot of virgin materials, but can also utilise large quantities of waste materials. One example is the use of ash for the production of artificial aggregates. The annual production and consumption of aggregates on global level is estimated to be 50 billion tonnes, and a large part of this can be replaced by processing waste materials into recycled and artificial aggregates. Through alkali activation construction aggregates with good performance can be obtained. This contribution presents the process of various waste granulation and alkali-activation into artificial aggregates, their characterisation and possible improvements (e.g. by pre-treatment or carbonation of the aggregates). Additionally, focus is put also on environmental aspects, such as leaching and global warming potential (CO_2 footprint).

2:00 PM

(ICACC-S16-016-2026) Sintered alkali-activated aggregates from co-combustion biomass ash

A. Tesovnik*[1]; V. Ducman[1]

1. Slovenian National Building and Civil Engineering Institute, Slovenia

The growing demand for sustainable construction materials calls for innovative strategies to valorize underutilized industrial byproducts. Biomass ashes, produced as residues from energy generation, remain underutilized despite their suitability as precursors for alkali activation. Since aggregates account for the largest volumetric fraction of concrete and mortar, converting ashes into alkali-activated aggregates offers an effective pathway for waste stabilization and circular resource use. In this study, co-combustion biomass fly ash was processed into lightweight aggregates via disc pelletization using sodium silicate solutions. The aggregates were subjected to different curing regimes, including ambient conditions and low-temperature curing, followed by heat treatment up to 1200 °C. Their performance was evaluated through mechanical strength testing and microstructural characterization. The results show that alkali activation combined with sintering significantly enhances aggregate strength. Microporosity was found to be influenced by the residual cellulose content in co-combustion ash as well as the applied sintering temperature. The study demonstrates that sintered alkali-activated aggregates can achieve comparable performance to natural ones. The short sintering time is emphasized as both beneficial for strength development and acceptable from an environmental perspective.

2:20 PM

(ICACC-S16-017-2026) Geopolymer plates reinforced with Guadua bamboo fibers (Invited)

M. G. Sá Ribeiro*[1]; I. P. Miranda[2]; W. M. Kriven[3]; R. A. Sa Ribeiro[4]

1. National Institute for Amazonian Research (INPA), Green Building and Engineering Laboratory (LECVerde), Brazil
2. Instituto Nacional de Pesquisas da Amazonia, Brazil
3. University of Illinois at Urbana-Champaign, USA
4. INPA-National Institute for Amazonian Research, Green Building and Engineering Laboratory, Brazil

The increasing demand for more sustainable construction materials highlights the need for lower-carbon alternatives to conventional cement-based products. This study explores the development of a geopolymer composite reinforced with fibers from Guadua angustifolia, a bamboo species native to Central and South America. Bamboo culms were processed into alkali-treated fibers, while kaolinite-rich clay from the Amazon region was used to produce metakaolin, forming the base of the geopolymer matrix. The composite plates were fabricated in a three-layer configuration: an outer layer of pure geopolymer and two other layers reinforced with bamboo fibers oriented transversely and longitudinally. The study evaluated mechanical performance through four-point flexural strength testing, supported by statistical (Weibull) analysis and microstructural characterization using SEM, EDS, and XRD. The optimal formulation, combining sodium-based metakaolin geopolymer with 20 wt.% fine sand and 5 wt.% bamboo fibers, achieved a flexural strength of 19.0 MPa. Final plate prototypes reached 10.3 MPa flexural strength under equilibrium conditions and maintained ASTM/ABNT A-II/3 classification even after water saturation. The findings demonstrate the potential of bamboo-reinforced geopolymers as a viable alternative for building applications, primarily using locally available materials.

3:10 PM

(ICACC-S16-018-2026) Discovering Novel Geopolymer Nanocomposites: Synthesis and Mechanical Properties (Invited)

A. Akono*[1]

1. North Carolina State University, USA

Geopolymers are a class of inorganic polymeric, X-ray amorphous materials consisting of alumina, silica, and alkali metal oxides. I will present results from my research group, where in the last three years, we have investigated the incorporation of nanofiller phases in metakaolin potassium-based geopolymer. The motivation is to yield enhanced-performance multifunctional materials. For instance, one motivation is to increase the electrical conductivity and the dielectric constant through the use of carbon-based nanofillers. Another motivation is to increase the strength-to-weight ratio and the stiffness-to-weight. Finally, a third motivation is to yield fracture tolerant materials. In my laboratory, we have studied several types of nanofillers: silica nanoparticles, titanium dioxide nanoparticles, carbon nanofibers, multiwalled carbon nanotubes, and graphene oxide nanoplatelets. The first lesson learned is that nanomaterial dispersion is very important and the optimal dispersion route varies from one kind of nanofiller to the next. Second, we have seen a reduction in porosity with the addition of nanofillers. Third, we have observed that nanofillers influence the geopolymerization reaction. Finally, we noted an increase in mechanical properties for geopolymer nanocomposites. These findings are important to guide the discovery of novel multifunctional nanostructured materials.

S16- Synthesis, processing microstructure

Room: Ballroom 5
Session Chair: Hubert Rahier, Vrije Universiteit Brussel

3:40 PM

(ICACC-S16-019-2026) 3D-Printed macroporous geopolymers for sustainable environmental applications (Invited)

Y. Ettahiri*[1]; C. Pelegris[1]; R. Davidovits[1]; M. Guessasma[1]

1. Universite de Picardie Jules Verne IUT de l'Aisne, France

This study aims to develop innovative macroporous 3D geopolymer for sustainable environmental applications. A novel geopolymer ink was formulated and optimized to ensure continuous extrusion, good shape stability, and controlled setting. The ink's rheological properties were carefully adjusted to achieve precise layer stacking and maintain the designed pore architecture. The printed samples exhibited a well-connected macroporous network with pores clearly visible to the naked eye, unlike conventional micro- or mesoporous geopolymers. Mechanical testing confirmed sufficient compressive strength despite the high porosity, while preliminary adsorption experiments showed effective contaminant removal from water. Additional tests in aggressive acidic environments demonstrated excellent acid resistance, highlighting durability for harsh conditions. This first demonstration of visibly macroporous 3D-printed geopolymers proves that additive manufacturing can create stable, large-pore structures suitable for advanced filtration, adsorption, thermal insulation, and sustainable infrastructure solutions.

4:10 PM

(ICACC-S16-020-2026) Development of sustainable 3D printing geopolymers for acidic environments

Y. Ettahiri*[1]; C. Pelegris[1]; R. Davidovits[1]; M. Guessasma[1]

1. Universite de Picardie Jules Verne IUT de l'Aisne, France

This study focuses on developing innovative geopolymer formulations engineered for enhanced acid resistance and compatibility with 3D printing technologies. The primary challenge lies in designing chemically stable matrices that retain their mechanical integrity under acidic conditions, achieved through the selection of appropriate precursors and additives. A secondary objective is the

optimization of rheological properties to ensure smooth extrusion and strong interlayer adhesion during 3D printing. Geopolymer specimens were 3D printed with dimensions of 15 × 15 × 5 mm, a 30% infill, and a 1 mm nozzle diameter. Acid resistance was evaluated using hydrochloric acid (HCl) and sulfuric acid. Chemical durability was assessed through various physico-chemical tests, Advanced characterization techniques were employed to investigate degradation mechanisms in detail, including XRD, ^{29}Si and ^{27}Al MAS NMR, FTIR, SEM. The results demonstrate enhanced acid resistance and structural stability, highlighting the potential of optimized 3D-printed geopolymers as durable and sustainable materials for infrastructure applications in aggressive acidic environments.

4:30 PM

(ICACC-S16-021-2026) Extended Si:Al:Na:Ca ratio effects on the composition–properties–performance relationships of alkali-activated materials and geopolymers in adsorption (Invited)

M. Hossain*[1]; T. Luukkonen[1]; J. Vepsäläinen[2]

1. Oulun Yliopisto Teknillinen Tiedekunta, Fibre and Particle Engineering Research Unit, Finland
2. Ita-Suomen yliopisto, School of Pharmacy, Finland

Compositional tuning of alkali-activated materials (AAMs) and geopolymers reshapes their microstructure and adsorption properties, yet the correlation between material properties and adsorption performance across wide compositional ranges remains unclear. Three sets of AAMs/geopolymers were synthesized with varying atomic ratios: Ca-free geopolymers ($Si_1Al_1Na_1$–$Si_{20}Al_1Na_1$) and Ca-containing AAMs ($Si_1Al_1Na_1Ca_2$–$Si_{20}Al_1Na_1Ca_{21}$ and $Si_4Al_1Na_1Ca_1$–$Si_4Al_1Na_1Ca_5$). The microstructural properties of AAMs/geopolymers were correlated with adsorption performances toward cations of different aqueous radii. The adsorption of methylene blue (MB) and rhodamine 6G (R6G) increased with increasing Si/Al ratios in Ca-free geopolymers, positively correlating with specific surface area (r = 0.99 and 0.80, respectively), while ammonium (NH_4^+) showed the reverse trend. MB accessed aluminosilicate rings at Si/Al >1 due to its smaller hydrated radius, whereas R6G could only enter at Si/Al > 5, highlighting that ring size governs guest access in AAM/geopolymer. Introducing Ca into the system substantially altered the main gel phases, reducing the adsorption amount of MB, R6G, and NH_4^+ by 64.4%, 32.3%, and 19.9%, respectively. These findings could be a valuable reference for the design of next-generation AAM/geopolymer adsorbents and other high-end materials.

5:00 PM

(ICACC-S16-022-2026) Acidification of low-grade phosphate rock by bioleaching with Acidithiobacillus thiooxidans and its mineralogical effects

S. M. Restrepo Arcila*[1]; H. A. Colorado L.[2]; M. Márquez[1]

1. Universidad Nacional de Colombia, Materials and nanotecnology, Colombia
2. Universidad de Antioquia, Colombia

This study describes the leaching process of a Colombian phosphate rock using sulfuric acid of biological origin to solubilize phosphorus. Initially, an exhaustive characterization of the rock was carried out, determining a phosphorus content of 5.5% (w/w). Advanced analytical techniques such as X-Ray Fluorescence (XRF), Atomic Absorption (AA), X-Ray Diffraction (XRD) and Fourier Transform Infrared Spectroscopy (FTIR) were used to identify the elemental and mineralogical composition. An innovative component was the production of sulfuric acid by A. thiooxidans (ATCC-13977) in a 5-liter reactor for 21 days. Key parameters such as sulfate concentration, pH, biomass growth and dissolved oxygen were monitored to ensure optimal production. Biogenic acid was then applied to the phosphate rock at two concentrations (20% and 30% w/w) under constant agitation at 300 rpm. This stage aimed to evaluate the phosphorus leaching capacity. Subsequently, the solid residue was characterized (XRF, XRD, FTIR) and the resulting liquid was analyzed by UV-Vis spectroscopy to quantify solubilized phosphorus, calcium and magnesium, which allowed direct measurement of the efficiency of the process and the potential of the biological acid as a sustainable alternative.

5:20 PM

(ICACC-S16-023-2026) Thermal curing kinetics of preceramic polymers from time-resolved infrared spectroscopy

P. Polisetty*[1]; G. Pugsley[1]; A. Braum[1]; A. Caron[1]; D. Hallinan[1]

1. Florida State University, USA

Extreme environments, such as those experienced in aerospace and at hypersonic speeds, challenge the performance of conventional materials and motivate the development of advanced ceramics with low density, erosion/corrosion resistance, and high modulus. Traditional ceramic processing often results in brittle, porous structures that are constrained by mold geometry and have limited design flexibility. Preceramic polymers (PCP) address these limitations by enabling the fabrication of complex shapes via advanced manufacturing and reduction of porosity via polymer infiltration pyrolysis (PIP) cycles. Crucial to the efficiency of PIP is the ceramic yield, which is greatly affected by PCP curing. This study investigates the thermal curing behavior of StarPCS silyl-modified polymers SMP-10 and SMP-877. Attenuated total reflectance Fourier transform infrared spectroscopy was used to track changes in absorbance of key functional groups to monitor chemical transformations under an inert argon atmosphere. The curing process, driven by hydrosilylation, was modeled as an irreversible first-order reaction, with normalized peak areas representing concentration. Curing rate constants and activation energies were quantified. Crosslinking was found to occur primarily between 150 °C and 250 °C. This study provides insight into improving the rate and energy efficiency of advanced ceramic production.

Friday, January 30, 2026

FS6 Innovative material processing for diverse resource circulation loops

FS 6- Innovative material processing for diverse resource circulation loops III

Room: Ballroom 3
Session Chairs: Thandazile Moyo-Mahlangu, The Pennsylvania State University; Alberto Mannu

8:30 AM

(ICACC-FS6-009-2026) Circular economy: A guiding light in sustainability-informed materials selection, discovery, design and development (Invited)

K. Ma*[2]; J. M. Schoenung[1]

1. Texas A&M University System, USA
2. Texas A&M University, Materials Science and Engineering, USA

Materials discovery is advancing at an accelerated rate, in part with the assistance of artificial intelligence. Historically, materials selection has been driven by performance and cost considerations. With increasingly ambitious sustainability goals, the materials selection, discovery, design, and development processes must be guided by additional attributes including circularity, chemical intensity, and carbon footprint. Early incorporation of end-of-life management strategies must be accompanied by the elimination of toxic substances and minimization of energy demands to effectively reduce the burden on society caused by materials advancement. The concept of sustainability-informed materials selection, discovery, design, development (SIMS-D^3) will be presented as an innovative approach. A suite of rapidly evolving tools, databases, resources, and methods to support this approach will be described. Select case studies on lead (Pb)-containing materials, flame retardants in plastics, and compositionally complex materials such as high entropy materials will be included to illustrate the opportunities presented by applying this approach.

9:00 AM

(ICACC-FS6-010-2026) Sustainable porous materials from weak alkali activation of waste glass

E. Bernardo*[1]; F. Carollo[1]; F. Lanero[1]; P. Sgarbossa[1]

1. Universita degli Studi di Padova Dipartimento di Ingegneria Industriale, Italy

Recent investigations support the peculiar mechanism behind the activation of glass operated by diluted alkaline solutions (not exceeding 5M NaOH or KOH). Suspensions harden, upon drying at 40-80 °C, by the welding of adjacent particles, simply due to the condensation of hydrated surface layers. The approach is in favour of sustainability since, starting from discarded fractions of glass cullet, it minimizes the activators and favours the obtainment of porous bodies, useful for thermal insulation (and associated energy savings) and remediation of wastewaters. Porous bodies may be determined by direct foaming, operated by compounds releasing gas abundant gas during the hardening, despite the limited addition (e.g. borates), or by indirect methods, corresponding to salt templating and replica. In the first case, the porosity may be controlled by the content of NaCl added to the glass mass (up to 120 wt%); pores are determined by dissolution of percolating particles, embedded in more stable glass-based cementitious matrix. In the second case, polymer scaffolds, from vat stereolithography of acrylates, are coated with activated glass suspension. In both cases, the open-celled structure favours application in filtration and photocatalytic destruction of pollutants in wastewaters, helped by the preliminary infiltration of catalysts.

9:20 AM

(ICACC-FS6-011-2026) Utilization of CaO in the synthesis of CaFe-based layered double hydroxides for arsenic immobilization

Y. O. Zubair*[1]; S. Fuchida[2]; K. Oyama[3]; C. Tokoro[4]

1. Waseda University, Sustainable Energy & Environmental Society Open Innovation Research Organization, Japan
2. Tokyo University of Marine Science and Technology, Marine Resources and Energy, Japan
3. Faculty of Engineering, Kyushu University, Japan
4. Faculty of Science and Engineering, Waseda University, Japan

This study aims to utilize calcium oxide (CaO) as a low-cost, sustainable precursor for synthesizing CaFe-based layered double hydroxide (CaFe-LDH) to remove and immobilize arsenic (As(III/V)) from contaminated water. CaFe-LDH was prepared by coprecipitating CaO and Fe(III) at alkaline pH. Its performance was evaluated through isotherms ([As] = 15–400 mg/L, CaFe-LDH = 1 g/L, time = 24 h) and kinetic experiments ([As] = 1.5 mg/L, CaFe-LDH = 0.1 g/L, time = 5–1440 min) at pH 6.5. Pre- and post-treatment characterizations were performed using XRD, FTIR, XPS, XAFS, FE-SEM, and EDS to identify structural transformations and removal mechanisms. The CaFe-LDH achieved maximum adsorption capacities of 217.7 mg/g for As(III) and 179.3 mg/g for As(V). CaFe-LDH transformed into secondary products like $CaCO_3$ and amorphous FeO(OH). As(III) was partially oxidized to As(V) (29.3–49.7%) at the $CaCO_3$–water interface in the presence of Ca^{2+} and bound to FeO(OH), while As(V) was immobilized through Ca-bridge ternary complexes (FeO-Ca-As), coprecipitation with $CaCO_3$, and coagulation. The As-loaded solids demonstrated remarkable stability and were classified as non-toxic waste. This study demonstrates the potential for a sustainable solution in the treatment of As-contaminated water.

S4 Advanced Materials for Thermoelectric and Thermionic Energy Conversion

S4- Theories and machine learning

Room: Ballroom 1 -2
Session Chair: Woochul Kim, Yonsei University

9:00 AM

(ICACC-S4-014-2026) Multiscale modeling and prediction of transport properties and efficiency in polycrystalline thermoelectrics (Invited)

S. Nakhmanson*[1]

1. University of Connecticut, Materials Science and Engineering, USA

Thermoelectric efficiency of nanostructured materials or composites is strongly dependent on their morphology, i.e., embedded interfacial networks, as well as transport properties of such interfacial areas. Relatively few experimental and theoretical investigations have been focused on probing the interfacial transport properties of relevant materials due to obvious difficulties associated with such studies. Here we present a recently developed multiscale approach, combining predictive atomistic-level simulations with finite element method based mesoscale-level modeling, for evaluating the transport properties and efficiency of nanostructured thermoelectrics, including their figure of merit ZT(T). In addition to highlighting the capabilities of our computational approach, we discuss the results obtained for a number of popular nanocrystalline thermoelectric systems, including the so-called Artificial Interfacial Solids (AIS), and cultivate some ideas for improving their performance.

9:30 AM

(ICACC-S4-015-2026) Machine learning for the discovery and optimization of thermoelectric materials (Invited)

H. Kleinke*[1]

1. University of Waterloo, Chemistry, Canada

Artificial intelligence (AI) studies to predict or suggest efficient thermoelectric materials have become increasingly important. Previous machine learning (ML) studies have used different literature sources or density functional theory calculations as input. We developed a machine learning pipeline trained with multivariable inputs on a massive public dataset to predict total thermal conductivity using four test sets: three publicly available datasets and one dataset created using all our own previous results. Due to the inclusion of this massive dataset, our model presents a promising possibility to further expand the understanding of the selection of features with various thermoelectric materials. Among the several supervised ML models implemented, eXtreme gradient boosting algorithms (XGBoost) was revealed to be the best on five-fold validations. Additionally, with the aid of feature selection and importance analysis, useful chemical features were chosen that ultimately led to higher accuracy in the test sets. During my talk, I will present the extension onto the other key properties including the thermoelectric figure-of-merit, which brings us into the exciting situation to predict the performance simply based on the chemical formula. This can be conveniently done online using our web page especially designated for this task.

10:20 AM

(ICACC-S4-016-2026) Discovery of stable, low-work function materials with graph neural networks and foundational interatomic potentials

P. Schindler*[1]

1. Northeastern University, Mechanical and Industrial Engineering, USA

The discovery of new materials with stable, ultra-low work function surfaces (<2 eV) is critical for advancing efficient thermionic energy converters and next-generation electron emission technologies. Machine learning approaches based on graph neural networks (GNNs) have demonstrated accurate predictions of structure-property relationships, promising to speed up the discovery of materials candidates with targeted properties. Moreover, the recent rise of foundational interatomic potentials that promise applicability across the periodic table and structural types opens a new avenue to directly predict materials properties that can be derived from the potential energy surface or its derivative. Here, we present our recently developed equivariant GNN architecture (that incorporates symmetry-breaking and force-informed features) that predicts both the stability of a surface (i.e., its surface or cleavage energy) and its work function with high fidelity. We further thoroughly benchmark state-of-the-art foundational interatomic potentials to calculate the surface stability directly from slab and bulk energy predictions. Finally, we evaluate the out-of-distribution generalization performance of these new models and show that they surpass prior state-of-the-art architectures, therefore enabling rapid screening for stable surfaces with tuned work functions.

10:40 AM

(ICACC-S4-017-2026) Predicting the lattice thermal conductivity of 2D materials via machine learning approaches

Y. Zhao*[1]; Z. Yang[3]; C. Zhang[2]; S. Shin[1]; L. Shen[1]

1. National University of Singapore, Department of Mechanical Engineering, Singapore
2. National University of Singapore, Physics, Singapore
3. Jinan University, Department of Electronic Engineering, China

Two-dimensional (2D) materials with novel thermal transport properties are favorable for thermal management and thermoelectric devices due to the unique monolayer structure with excellent flexibility. To accelerate the investigation on lattice thermal conductivity (κ_L) of 2D materials, we trained machine learning models based on the collected 2D κ_L data, high-throughput calculated elastic properties, and extracted structural and elemental features. The feature importance of shear and bulk modulus is higher than that of other features, indicating a more dominant role of these two features in the trained models. The gradient boosting regression (GBR) model performs better than the neural networks, and the Pearson correlation between collected and predicted κ_L values reaches 0.90, implying a high ranking capability of the GBR model. Then, the κ_L values of 2457 2D structures collected from the C2DB database are predicted efficiently. By comparing the calculated and predicted κ_L values for three candidates, we found that the current machine learning model performs well when interpolating but a bit poorly when extrapolating. Our work provides the database and machine learning models on the lattice thermal conductivity of 2D materials, contributing to more efficient screening of lower or higher κ_L.

S10 Integrated computational -Experimental modeling ad design of ceramics and composites

S10- Integrated computational-experimental modeling and design of ceramics and composites

Room: Ballroom 4
Session Chair: Yang Chen, University of Bath

8:30 AM

(ICACC-S10-024-2026) Numerical-analytical models in penetration problems: Retrospective and prospective view

E. Kartuzov*[1]; V. Kartuzov[1]

1. Institut problem materialoznavstva imeni I M Francevica Nacional'noi akademii nauk Ukraini, Computer Simulation, Ukraine

This report provides a critical overview of key contributions from ICACC symposia, tracing the evolution of numerical-analytical models in penetration mechanics—from early concepts of the 1970s–1990s to present-day multiphysics and multiscale approaches. Initial models, based on the local interaction hypothesis, balanced computational efficiency with predictive reliability and were developed in close connection with experimental studies of indentation. Modern frameworks account for complex failure modes, phase changes, anisotropy, and material heterogeneity—factors essential for modelling high-energy impact scenarios. The report reviews successful combinations of numerical-analytical and finite element methods used to assess the ballistic performance of metals, ceramics, and composite structures. It also explores how indentation data inform model calibration at micro- and nano-scales. Recent trends point to the integration of AI, multidisciplinary approaches, and parallel computing to enable real-time simulations. Persistent challenges include improving representations of failure and phase transitions, addressing scale effects, and strengthening the role of experimental validation. In conclusion, modern penetration modelling is positioned as a critical tool supporting the development of advanced protective materials and systems across high-demand applications

8:50 AM

(ICACC-S10-025-2026) Effects of water on the tribochemical reactions of ZnDTP additives; Neural network molecular dynamics simulation analysis

H. Numata*[1]; S. Sekita[1]; C. Suzuki[1]; S. Fukushima[1]; Y. Ootani[1]; N. Ozawa[2]; M. Kubo[1]

1. Institute for Materials Research, Tohoku University, Japan
2. Tohoku University, New Industry Creation Hatchery Center, Japan

Enhancing the energy efficiency and reliability of mechanical systems is critical for a sustainable society. Because of their low density and high hardness, ceramic materials are promising for sliding components in applications such as automotive engines. To protect these components, lubricating oils contain anti-wear additives such as zinc dialkyldithiophosphate (ZnDTP), which mitigate wear by forming a protective tribofilm. Optimizing this capability requires understanding the tribofilm formation process. However, the detailed mechanism remains unclear, as the in-situ observation of these intricately coupled frictional and chemical processes at the atomic scale is extremely challenging. This study employs large-scale molecular dynamics (MD) simulations with a neural network potential (NNP) to elucidate the effects of interfacial water on ZnDTP-derived tribofilm formation. Our simulations confirmed the initial process of tribofilm formation, where shear-induced decomposition of ZnDTP leads to the adsorption of phosphorus and sulfur onto the surface. Furthermore, we found that alkyl groups generated during this decomposition also adsorb to the surface and subsequently react with water to form alcohols. In the presentation, we will discuss the alcohol formation mechanism and other effects of water, such as subsequent reactions under sliding.

9:10 AM

(ICACC-S10-026-2026) Influence of coexisting molecules on tribochemical reactions of MoDTC: Neural network molecular dynamics simulation analysis

S. Sekita*[1]; H. Numata[1]; C. Suzuki[1]; S. Fukushima[1]; Y. Ootani[1]; N. Ozawa[2]; M. Kubo[1]

1. Institute for Materials Research, Tohoku University, Japan
2. Tohoku University, New Industry Creation Hatchery Center, Japan

To achieve efficient energy use, reducing friction loss is essential. Molybdenum dithiocarbamate (MoDTC), a lubricant additive, reduces friction of ceramics by forming a molybdenum disulfide (MoS_2) film through a tribochemical reaction. While a detailed analysis of this reaction is crucial for developing superior additives, in-situ observation of friction interface is difficult. Therefore, molecular dynamics simulations are needed to clarify reactions at the atomic scale. In our previous research using neural network molecular dynamics (NNMD), we found that friction induces chemical reaction of MoDTC to form $Mo_2S_6O_2$ which can be a precursor of

MoS_2. On the other hand, in actual friction systems, water molecules which coexist at the sliding interface can negatively affect lubricant additive performance. In this study, we analyzed the effect of water on the reaction of MoDTC, with NNMD simulation. Our analysis revealed that molybdenum (Mo) atoms form Mo-O bonds with oxygen atoms from water molecules during friction, leading to the formation of Mo-O networks. This result represents the initial stage of MoO_3 formation, which can hinder the friction reduction effect of MoS_2. In the presentation, we will discuss the effect of water on tribofilm formation quantitatively.

9:30 AM

(ICACC-S10-027-2026) Fiber orientation analysis of direct-ink write ceramic matrix composites using machine learning

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Direct ink writing (DIW) of ceramics is considered an attractive additive manufacturing technique because it can quickly produce complex near-net shape components at a low cost. An important feature of DIW is that any high aspect ratio material added into the ink will align with the print direction, largely due to the shear stress generated in the nozzle. This characteristic is especially valuable for composites because, with careful selection of print parameters, we can control how well aligned the fibers are for tailored material properties. To study this phenomenon, we developed a machine learning workflow using popular convolutional neural networks for an ensemble approach to rapidly segment X-ray computed tomography datasets of C/SiC created under various print parameters. We additionally used an orientation analysis pipeline to perform a comparative study. With this pipeline, we have a high-throughput method for investigating the multi-objective effects of print speed, nozzle size, nozzle length, and ink rheology on the fiber orientation, which is an important feature that we want to predict.

S12 Atomically Layered Carbides, Nitrides, Borides, and Related Materials- From Bulk to Low Dimensional Derivates

S12-Atomically Layered Carbides, Nitrides, Borides, and Related Materials: From Bulk to Low Dimensional Derivates III

Room: Flagler C

Session Chairs: Antoine Guitton, Université de Lorraine – CNRS – Arts et Métiers Institute of Technology – LEM3; Martin Magnuson, Linkoping University

8:30 AM

(ICACC-S12-015-2026) Fermi surface topology and anisotropic band structure of oxygen-terminated $Ti_3C_2T_x$ MXene (Invited)

M. Magnuson*[1]

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Understanding and tailoring the electronic properties of MXenes requires detailed knowledge of their Fermi surface and band structure. This study investigates the fermiology of $Ti_3C_2T_x$ MXene with pure oxygen termination ($Ti_3C_2O_x$), revealing its electronic band topology and orbital characteristics. Epitaxial thin films were synthesized via magnetron sputtering and selectively etched to achieve oxygen-only termination. Surface order and composition were verified using LEED and XPS, and synchrotron-based angle-resolved photoemission spectroscopy (ARPES) was used to map the band structure and Fermi surface across the Brillouin zone. The results show a metallic, anisotropic 2D electronic structure with highly dispersive Ti 3d-derived bands near the Fermi level. Conical band crossings, reminiscent of Dirac points, appear at ~1.5 eV below the Fermi energy. The Fermi surface shows sixfold symmetry with hexagonal warping, indicating in-plane hole-like conduction and out-of-plane electron-like states. Polarization-dependent ARPES distinguishes orbital contributions from surface oxygen. These findings show that despite oxygen termination, which typically induces semiconducting behavior, $Ti_3C_2O_x$ remains metallic due to orbital hybridization. This fermiological description opens pathways for band engineering in MXenes, with implications for transparent conductors, energy storage, and catalysis.

9:00 AM

(ICACC-S12-016-2026) Defects as drivers in MAX phases: Micro/nanostructure-property relationships (Invited)

A. Guitton*[1]; A. Heinzelmeier[1]; T. Weidner[2]; C. Couchet[3]; M. Josse[1]; L. Capolungo[4]; L. Dezerald[3]; J. Guénolé[1]; T. Grosdidier[1]; A. Mussi[2]; V. Taupin[1]

1. Université de Lorraine – CNRS – Arts et Métiers Institute of Technology – LEM3, France
2. Univ. Lille, CNRS, INRAE, Centrale Lille, UMR 8207 – UMET – Unité Matériaux et Transformations, France
3. Department of Materials Science and Engineering, Institut Jean Lamour, Universite de Lorraine, France
4. Los Alamos National Laboratory, Material Science and Technology Division, USA

It is well established that crystalline defects govern many fundamental mechanisms in crystalline materials, and understanding their influence remains a central scientific challenge. In this context, MAX phases ($M_{n+1}AX_n$, with n = 1-3, where M is a transition metal, A is an A-group element, and X is carbon and/or nitrogen) stand out as a unique class of layered materials. They exhibit a rich spectrum of crystalline defects, from elementary point defects to complex extended defects. This diversity not only makes MAX phases ideal model systems for exploring defect-property relationships, but also provides a fertile ground for discovering novel mechanisms in layered ceramics. In this contribution, we review and provide new insights into the role of crystalline defects in MAX phases. We will first discuss their impact on deformation mechanisms, with particular attention to zonal dislocations involved in kink band formation. We will then examine how defects influence hydrogen sorption when MAX phases act as catalysts, before addressing their role in diffusion processes. Taken together, these perspectives underscore the pivotal role of defects in shaping both the functional and structural behavior of this unique family of materials.

9:30 AM

(ICACC-S12-017-2026) Radiation response of chemically complex MAX phases in the (Zr,Ti,Hf,Nb,V/Ta)-(Al,Sn)-C system (Invited)

K. Lambrinou*[1]; I. Ehikhioya[1]; J. A. Hinks[1]; N. Goossens[2]; S. Huang[3]; J. Vleugels[3]

1. University of Huddersfield, School of Computing and Engineering, United Kingdom
2. Empa, High Performance Ceramics, Switzerland
3. KU Leuven, Materials engineering, Belgium

The MAX phases exhibit excellent compatibility heavy liquid metal (Pb/LBE) and a great capacity for dynamic recovery of radiation-induced defects above 600°C. This makes them promising materials for certain nuclear applications, such as fuel cladding coatings for Gen-IV lead-cooled fast reactors (LFRs). This work aims at synthesizing chemically complex MAX phases (CC-MAX) with exceptional radiation tolerance. Chemical complexity reduces the mobility of radiation-induced defects, provides numerous defect “sinks”, and limits defect accumulation leading to void swelling. In this study, 211 CC-MAX ceramics were synthesized by reactive hot-pressing (RHP) in the (Zr,Ti,Hf,Nb,V/Ta)-(Al,Sn)-C system from mixed Zr/Ti/Hf/Nb/V or Ta hydride powders and Al/Sn/C elemental powders.

Scanning electron microscopy, electron probe microanalysis, and X-ray diffraction showed that the CC-MAX ceramics were made of 211 solid solution MAX phases with traces of Al_2O_3, whilst electron backscatter diffraction revealed basal plane alignment perpendicular to the direction of applied pressure during RHP. Radiation tolerance was assessed in situ in the transmission electron microscope by means of helium ion irradiation (6 keV He^+, flux: 10^{14} ions/cm^2s) in the 350-800°C range to a maximum dose of 10 dpa. The irradiated samples were thin (<100 nm) foils lifted out from the CC-MAX ceramics using focused ion beam.

10:00 AM

(ICACC-S12-018-2026) Advances in hybrid Ti_3SiC_2 carbon fibres (MAXCarbon) for aerospace, energy and hydrogen technologies

F. Jung*[1]; L. R. Aretz[2]; T. Tonnesen[2]; T. Gries[1]

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2. Rheinisch-Westfalische Technische Hochschule Aachen, Chair of Ceramic, Germany

The demand for materials capable of withstanding extreme temperatures and corrosive environments is increasing across the aerospace, energy, and hydrogen technologies sectors. Conventional high-performance fibres such as carbon and SiC are limited by oxidation and insufficient chemical stability. To address these limitations, MAXCarbon, a hybrid fibre combining the mechanical performance of carbon fibres with the thermal and environmental stability of Ti_3SiC_2 MAX phases, is being developed at RWTH Aachen. Recent progress has been achieved in the transformation of carbon fibre textiles (woven, stitched, and nonwoven) into MAXCarbon, and the corresponding physical properties and transformation processes have been investigated. Mechanical testing of single filaments demonstrated promising performance: the normalised tensile strength was on average 57% higher than that of SiC fibres and reached approx. 60% of carbon fibres. While the current synthesis route is limited to textile structures, a concept for extending the process to fibre rovings will be presented. Applications of MAXCarbon as continuous fibre reinforcement for CMCs remain a central focus. Furthermore, due to their excellent corrosion resistance and electrical conductivity, the hybrid fibres provide opportunities in the hydrogen economy, with potential to replace conventional carbon-based components in electrochemistry.

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*Denotes Presenter