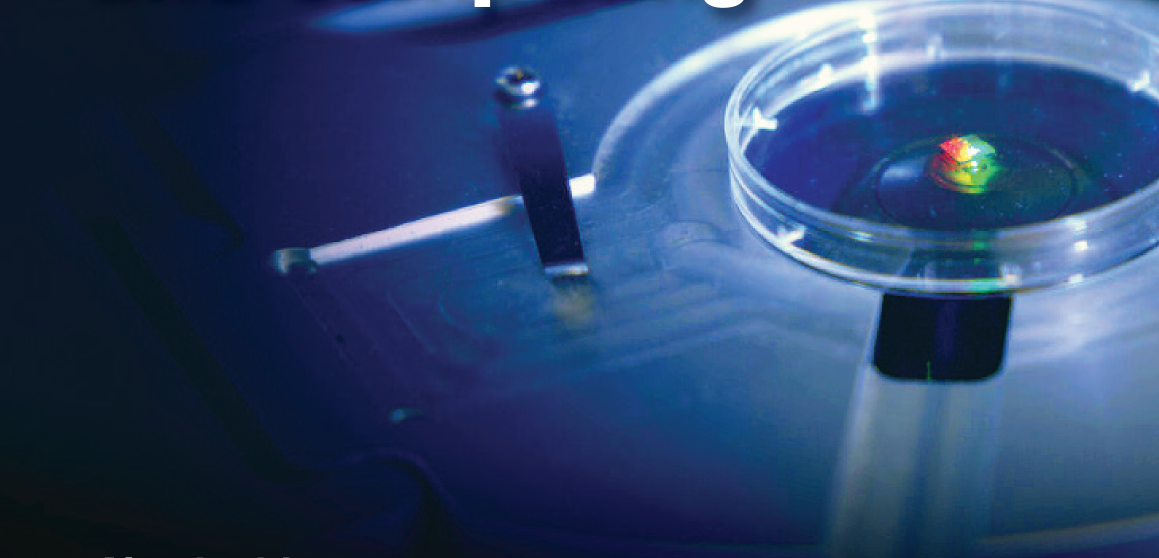
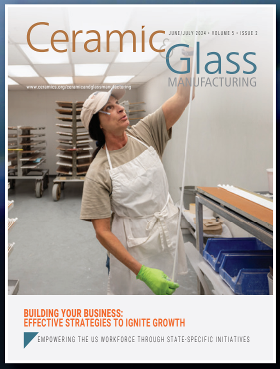
AMERICAN CERAMIC SOCIETY
bulletin
emerging ceramics & glass technology
JUNE/JULY 2024

Quantum systems:
Materials and technologies for a new age of sensing and computing



New issue inside:



Also inside...

EMERGING PROFESSIONALS

Kreidl award abstract | 2024–2025 ACerS Board members and directors

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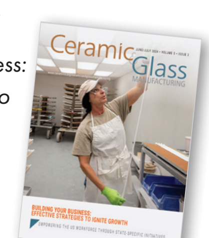

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bulletin

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As seen on *Ceramic Tech Today*...

Credit: cobalt123, Flickr (CC BY-NC-SA 2.0)

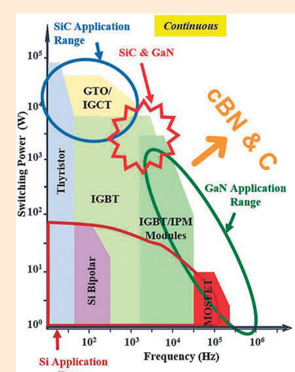
Colored glass: From alchemy to empirical chemical design

What gives colored glass its brilliant hues? Since the early days of alchemy, our understanding of and control over the design of colored glasses has improved enormously, opening the door to a host of practical applications.

Read more at www.ceramics.org/colored-glass-alchemy

Also see our ACerS journals...

Prospective view of nitride material synthesis
By N. Stoddard and S. Pimputkar
International Journal of Ceramic Engineering & Science



Credit: Stoddard and Pimputkar, *IJCES* (CC BY 4.0)

Performance improvement of iron chalcogenide films grown at high laser repetition rates by pulsed laser deposition
By S. Mou, J. Ye, R. Zhu, et al.
Journal of the American Ceramic Society

A comprehensive study of dielectric, modulus, impedance, and conductivity of $SrCeO_3$ synthesized by the combustion method
By H. Verma, A. Tripathi, and S. Upadhyay
International Journal of Applied Ceramic Technology

Effect of femtosecond laser irradiation on structure–terahertz property relationship in sodium borosilicate glasses
By N. J. Tostanoski, R. E. Youngman, and S. K. Sundaram
International Journal of Applied Glass Science

Journal of the American Ceramic Society | International Journal of Applied Ceramic Technology | International Journal of Applied Glass Science | International Journal of Ceramic Engineering & Science

Read more at www.ceramics.org/journals

American Ceramic Society Bulletin is the membership magazine of The American Ceramic Society. It covers news and activities of the Society and its members and provides the most current information concerning all aspects of ceramic technology, including R&D, manufacturing, engineering, and marketing. *American Ceramic Society Bulletin* is published monthly, except for February, July, and November. Subscription included with The American Ceramic Society membership. Nonmember subscription rates can be found online at www.ceramics.org or by contacting customer service at customerservice@ceramics.org.

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ACSBA7, Vol. 103, No. 5, pp. 1–64. All feature articles are covered in Current Contents.

The importance of education outreach to a fulfilling career

Dear students,

I want to congratulate you on your ongoing efforts in education outreach. You have come a long way since I first became involved with education outreach in the 1990s.

My journey began when ACerS President Robert Eagan (1990–1991) asked me to establish an Education Committee for ACerS. A key focus was on education outreach to inform the general public about the importance of ceramics and glass and to encourage high school students to consider ceramic science and engineering as a career. A second focus was on continuing education through short courses and on organizing activities for students at the various ACerS meetings.

Our first education outreach project was to develop a Ceramic Demonstration Kit. We involved industry by soliciting examples that illustrated various applications of ceramics. Early kits contained a space shuttle tile, superconductor demonstration set, oxygen sensor, and about 10 additional samples. We distributed these kits, along with instructions on how to use them, to universities and colleges with ceramic engineering and materials science and engineering departments. We provided training sessions at ACerS Annual Meetings and encouraged people to add items from their local industries.

Since those early kit days, I am amazed at how ACerS students have expanded the kits, for example, by developing in-depth curriculum modules for each lesson and establishing partnerships with teachers and schools. I encourage everyone to check out the Materials Science Classroom Kits on the Ceramic and Glass Industry Foundation webpage at https://foundation.ceramics.org/classroom-kits.

I also want to share my firsthand experience seeing how actively engaged and enthusiastic students are about education outreach. In 2002, I was invited by an interdepartmental team at the University of Utah to develop a lesson plan for fifth- and sixth-grade students to learn about air quality issues and measure carbon dioxide emissions. Following the development and implementation of this project in local schools, I obtained a small program grant from the National Science Foundation to expand on this project. Under the expanded program, sixth-grade students would develop outreach projects to educate their community, the governor, and the Utah State Legislature about air quality issues.

I was amazed by the dedication and enthusiasm of these student ambassadors. Their efforts encouraged the governor of Utah to proclaim several energy-saving and pollution reduction initiatives, such as "Change a Light Day" and "Stop Idling Day." Within two years, the students' efforts resulted in the major school districts establishing policies to reduce pollution from school buses. Within three years, the Utah State Legislature passed a law limiting emissions due to idling.

Twenty years later, the Government of Utah remains fully involved in air quality and energy issues, setting firm policies and goals to reduce vehicle pollution and to replace coal-fired electricity generation with renewable sources. The outreach by the students played an important role in these changes in awareness and policy.

Finding time to conduct outreach while going to school or establishing a career is challenging. But I hope when you students reach the end of your careers that you look back and consider the education outreach activities as a highlight.

I just turned 80 in February 2024, and when I look back on my career, there are many things I'm proud of. I conducted research on silicon nitride and other ceramic and composite materials to solve energy and pollution problems, served as an executive in a small business, consulted with the Department of Energy and a variety of companies, wrote a textbook ("Modern Ceramic Engineering") and other books, and taught materials science and engineering courses at the University of Utah. But the most satisfying outcomes resulted from the outreach activities. The impact from these activities sometimes took years to fully develop, but when they did, I could not have been happier with the results.

You students are the outcome of those efforts started in 1990. I take great satisfaction in seeing you run with what we started. Your efforts have accomplished what was our original goal: you have educated the general public, you have introduced ceramic and glass science to thousands of students and their parents and teachers, and you have recruited many students into an amazing materials science career.

The message I hope to leave with you today is that your science or business career is certainly important, but when you look back decades from now during retirement, you may realize that your education outreach and community efforts are equally important. Keep up the good work and don't be afraid to innovate.

Sincerely,

David W. Richerson, FACerS
Retired, University of Utah Department of Materials Science and Engineering

news & trends

The rise of quantum: New centers channel funding and research into advancing next-generation quantum systems

By Helen Widman

The use of computer modeling and simulations has skyrocketed in recent years as researchers aim to identify promising new material structures and compositions faster and at lower costs than traditional trial-and-error experiments.

The emerging field of quantum computing offers the possibility to identify materials even faster and more accurately. Interest in this possibility is so intense that *Tech Briefs* magazine made quantum computing in materials science the cover story for its March 2024 issue (https://www.nxtbook.com/smg/techbriefs/24TB03/index.php).

Before quantum computers can be used to identify promising materials, though, novel materials and procedures must be developed to create these next-generation computing systems. In the past year, many new quantum technology research centers were launched around the world to address this need. Below is an overview of some new centers and facilities announced since the beginning of 2024.

NORTH AMERICA

Stewart Blusson Quantum Matter Institute

The University of British Columbia received $5.8 million in investments from the Canada Foundation for Innovation and the B.C. Knowledge Development Fund to develop a crystal growth facility, which will aid in the synthesis of quantum materials that have not been easily accessible before. Materials scientists from the University of British Columbia's Stewart Blusson Quantum Matter Institute will lead these efforts. Learn more at https://qmi.ubc.ca/news.

UCLA Center for Quantum Science and Engineering

The University of California, Los Angeles (UCLA) plans to turn a sprawling former shopping mall site into the UCLA Research Park, which will house a new quantum research innovation hub led by UCLA's Center for Quantum Science and Engineering. The goal is to unite researchers and partners across disciplines to not only develop a new

Corporate Partner news

Alteo joins the European Cluster of Ceramics

Specialty alumina producer Alteo joined the European Cluster of Ceramics based in Limoges, France, as of Jan. 1, 2024. This new collaboration aims to consolidate Alteo's presence in strategic sectors such as aerospace, defense, electronics, energy, luxury, and healthcare. https://www.alteo-alumina.com/en/news

Borregaard recognized for its commitment to environmental transparency

Borregaard was recognized for leadership in corporate transparency and performance on climate change and water security by global environmental nonprofit CDP, securing a place on its annual "A List." https://www.borregaard.com/company/news-archive

Bullen Ultrasonics receives 2023 Gold HIRE Vets Medallion Award

Bullen Ultrasonics was one of 859 recipients of the 2023 HIRE Vets Medallion Award, presented during a virtual award ceremony by the U.S. Department of Labor on Nov. 8, 2023. This federal award program recognizes employers who successfully recruit, hire, and retain veterans. A press release reports that 9% of the company's employees are veterans or reservists. https://www.bullentech.com/news

Lucideon participates in Foundation Industry Strategy Workshop to lower carbon emissions

Lucideon and other leaders from across industry participated in the Foundation Industry Strategy Workshop, organized by the Foundation Industries Sustainability Consortium, to explore opportunities to drive low carbon innovation in the production of vital materials used across everyday life. https://www.lucideon.com/insights/news

Nabaltec AG expands cooperation with OTH Amberg-Weiden

Nabaltec AG expanded its cooperation with the University of Applied Sciences Amberg-Weiden through the PartnerCircle partnership agreement. This agreement includes intensive cooperation through lectures, excursions, joint research projects, regular events, and a company presence via digital media on site in the lecture hall. https://nabaltec.de/presse/pressemitteilungen ■

quantum industry workforce but to also create innovations in communications, computing, and other areas. Learn more at https://newsroom.ucla.edu.

Quantum New Mexico Institute

The University of New Mexico (UNM) is partnering with Sandia National Laboratories to launch the Quantum New Mexico Institute, which will be jointly located at UNM facilities and Sandia Labs. The goal of this center is to help affirm New Mexico as a national leader in quantum research and education. Learn more at https://news.unm.edu.

IBM Quantum Innovation Center

The University of Southern California (USC) is partnering with IBM to establish USC's IBM Quantum Innovation Center, which will welcome researchers and students alike. This new center is a part of USC President Carol Folt's Frontiers of Computing "moonshot," a $1 billion initiative that supports innovations like quantum computing. Learn more at https://today.usc.edu.

Texas Quantum Institute

The Texas Quantum Institute, established by The University of Texas at Austin, aims to bridge basic research and applied science in the field of quantum computing. The Institute will be led by co-directors Elaine Li and Xiuling Li and unite more than 30 researchers. Learn more at https://news.utexas.edu/science-technology.

EUROPE

Copenhagen Center for Biomedical Quantum Sensing

The Novo Nordisk Foundation awarded a grant of DKK 150 million (US$21.5 million) to establish the Copenhagen Center for Biomedical Quantum Sensing. This international collaboration will be led by the University of Copenhagen, Technical University of Denmark, and the University of Texas at Austin and will focus on quantum sensing technology innovations to improve healthcare and medical diagnoses. Learn more at https://novonordiskfonden.dk/en/news.

Finnish Quantum Flagship

The Finnish Quantum Flagship (FQF) is a collaboration between several Finnish organizations that seeks to foster a developing workforce in quantum technology and initiate new quantum research activities. The project will take place from 2024 to 2031 and is funded by €13 million from the Research Council of Finland. The FQF includes Aalto University (coordinator), the VTT Technical Research Centre of Finland, the University of Helsinki, the University of Jyväskylä, Tampere University, the University of Oulu, and the CSC-IT Centre for Science. Learn more at https://www.helsinki.fi/en/faculty-science/news.

Fujitsu Advanced Computing Lab Delft

Fujitsu and Delft University of Technology in the Netherlands established the Fujitsu Advanced Computing Lab Delft to develop diamond-spin quantum computing technologies as part of an industry–academia collaboration through the Fujitsu Small Research Lab initiative. Learn more at https://www.fujitsu.com/global/about/resources/news.

King's Quantum

King's College London launched the King's Quantum research center with the goal of advancing quantum technology research in areas such as healthcare, security, and industry. The center will be directed by James Millen. Learn more at https://www.kcl.ac.uk/news.

Center for Doctoral Training in Quantum Technology Engineering

The University of Southampton received funding from the Engineering and Physical Sciences Research Council to launch the Center for Doctoral Training in Quantum Technology Engineering. Director Tim Freegarde says the center will be a crucial part in government plans to transform Britain into a quantum-enabled economy by 2033. Learn more at https://www.southampton.ac.uk/news.page. ■

SOCIETY DIVISION SECTION CHAPTER NEWS

Meet the 2024–2025 officers and Board members

President-elect

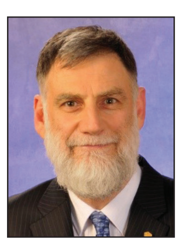
MARIO AFFATIGATO, FACERS
Fran Allison and Francis Halpin Professor of Physics
Coe College
Cedar Rapids, Iowa

I have been quite passionate about The American Ceramic Society since joining it (again) as an incoming assistant professor at Coe College in 1994. My attendance at the Glass & Optical Materials Division meetings strengthened my sense of belonging. Of all the scientific conferences I attended, the ACerS meetings were friendly, full of information that mattered to me, and rich in leadership opportunities.

After 30 years of membership, my opinion of the Society and its role—nationally and internationally—in serving the ceramics and glass communities has become even more passionate. In the many service opportunities I have been afforded—including being editor of one of the Society's journals, service on GOMD's Executive Committee, selection to the Society's Board of Directors, and participation in numerous Committees including Publications, Finance, and Fellows—I have come to believe that we are served by an incredible staff and a myriad of exceptional colleagues who volunteer their time and energy.

The Society has recovered well from the financial tribulations of the COVID-19 pandemic. But these remain challenging times for science and the discipline of ceramics. I wish to serve as ACerS president to continue strengthening the Society in multiple ways: adding to its financial stability, growing its national and international reputation as the world's hub for ceramics and glass science and art, enhancing its diversity, and ensuring that the Society meets the needs of industry, students, young and mid-career professionals, researchers in academia and government, and international colleagues for decades to come.

Directors



CHRISTOPHER C. BERNDT, FACERS
University Distinguished Professor
Swinburne University of Technology
Melbourne, Australia

I am a ceramicist who has evolved from a metallurgical and materials science background. My post docs were at Stony Brook University in New York and NASA Lewis/Glenn in Ohio. I was a professor in the materials science and engineering department at Stony Brook before returning to Australia.

I am a fundamental materials scientist who implements materials engineering concepts to solve issues of critical commercial and industrial importance. As director of the Australian Research Council's Surface Engineering for Advanced Materials Center, I lead a team of 19 academics, seven post docs, and 25 graduate students who work with industry partners to achieve joint outcomes.

Joining the Board would provide an opportunity to contribute to a professional society that has had an immense impact on the careers of my students, post docs, and me. I have experience in working at the board level of professional societies, industrial organizations, and university committees. I have also interacted extensively with national labs and industry.

My contributions will be from a global perspective, which is a vital mission for ACerS concerning sustainability and growth. In other words, the footprint of ACerS must grow well beyond North America, and I am positioned to promote such an initiative.

Finally: I am proud to have mentored many students who have become leaders in their fields of expertise.

FOR MORE INFORMATION:

ceramics.org

RUYAN GUO, FACERS

Robert E. Clarke Endowed Professor of Electrical and Computer Engineering
The University of Texas at San Antonio
San Antonio, Texas

My leadership experience in academic institutions (chairing department and directing graduate programs) and in the federal government (as engineering program director of the National Science Foundation), coupled with my management of federal and industrial funded research, positions me well to navigate the evolving landscape impacting our community. I would like to play an active role that motivates members and Divisions to both make and embrace paradigm-shifting breakthroughs in ceramic science and engineering, as well as address priorities and challenges facing the academic and industrial communities served by our Society.

Having held a full professor position at the University of Texas at San Antonio, a growing minority-serving institution, and previously at The Pennsylvania State University, a top-tier research university, I bring experience and insights that span interdisciplinary research and faculty/student engagements. I also served as the director/co-director of several National Science Foundation Research Experiences for Undergraduates, Office of Naval Research STEM education programs, and Department of Energy workforce development programs and have been a faculty advisor for a community college as well as several professional student chapters. I am committed to fostering the success of the next generation.

I understand the mechanisms of our volunteer-driven organization, having served on various Society Committees and as the program chair, Division chair, and trustee of the Electronics Division. ACerS has been an integral part of my professional journey since 1986 when I joined as a student member; I am passionate about extending my experiences to benefit fellow Society members at various stages of their careers.

My leadership, research, and academic background, combined with my enthusiasm, have prepared me to make meaningful contributions as a member of the Board of Directors.

RODNEY TRICE, FACERS

Professor of materials engineering
Purdue University
West Lafayette, Ind.

The American Ceramic Society has been my technical home since I returned to graduate school in 1995. I recognize the value this organization has had on my career, and as such, have volunteered for ACerS since 2002.

By serving the organization at many different levels, culminating as chair of the Meetings Committee for four years, I believe I can offer leadership to the organization that would continue to grow the Society as we work toward increased internationalization of membership (particularly among young professionals) with attention to diversity. Furthermore, I have come to know the staff members of ACerS as well as most past and current leaders of the Society, and I believe this will help me serve well.

I believe what I could contribute to the Board is a simultaneous respect for the history of ACerS while also embracing the necessary changes to move the organization forward. Remembering our past ensures a commitment to the ACerS core mission: the promotion of ceramic science and engineering for the benefit of our members and society. As such, I am committed to our meetings model, our publications, recruiting new members, and other priorities. In the future, I relish opportunities for our Society to take calculated risks to continue growing our membership, embracing emerging areas that use ceramics, and furthering our efforts in diversity and inclusion.

In summary, I welcome the opportunity, working within a team environment, to position ACerS to flourish into the next century. ■

more SOCIETY DIVISION SECTION CHAPTER NEWS

2024–2025 ACerS officers

The new slate of ACerS officers has been determined. There were no contested offices and no write-in candidates, automatically making all nominees "elected." ACerS rules eliminate the need to prepare a ballot or hold an election when only one name is put forward for each office. The new term will begin Oct. 9, 2024, at the conclusion of ACerS 126th Annual Meeting at MS&T24.

ACerS President-elect

To serve a one-year term from Oct. 9, 2024, to October 2025

Mario Affatigato

ACerS Board of Directors

To serve three-year terms from Oct. 9, 2024, to October 2027

Christopher C. Berndt
Ruyan Guo
Rodney Trice

Division and Class Officers

To serve a one-year term Oct. 9, 2024, to October 2025, unless otherwise noted

Art, Archaeology & Conservation Science Division

Chair: **Christina Bisulca**
Vice chair: **Fumie Iizuka**
Secretary: **Tami Clare**
Treasurer: **Xiao Ma**
Trustee: **Darryl Butt**
DEI representative: **Christina Bisulca**

Basic Science Division

Chair: **Amanda Krause**
Chair-elect: **Ricardo Castro**
Vice chair: **Fei Peng**
Secretary: **Ming Tang**
Secretary-elect: **TBD**
DEI representative: **Victoria Blair**

Bioceramics Division

Chair: **Annabel Braem**
Chair-elect: **Hrishikesh Kamat**
Vice chair: **Ashutosh K. Dubey**
Secretary: **Anamika Prasad**

Cements Division

Chair: **Prannoy Suraneni**
Chair-elect: **Alex Brand**
Secretary: **Kendra Erk**
Trustee: **Matt D'Ambrosia**
DEI representative: **Kendra Erk**

Education and Professional Development Council

Co-chair: **Steven Naleway** (2022–2024)
Co-chair: **Brian Gorman** (2023–2025)

Electronics Division

Chair: **Matjaz Spreitzer**
Chair-elect: **Mina Yoon**
Vice chair: **Reeja Jayan**
Secretary: **Aiping Chen**
Secretary-elect: **TBD**
Trustee: **Geoff Brennecka**
DEI representative: **Brady Gibbons**

Energy Materials and Systems Division

Chair: **Yang Bai**
Vice chair: **Charmayne Lonergan**
Secretary: **Jianhua Tong**
Program chair: **Sepideh Akhbarifar**
DEI representative: **Marissa Riegel**

Engineering Ceramics Division

Chair: **Young-Wook Kim**
Chair-elect: **Jie Zhang**
Vice chair/Treasurer: **Amjad Almansour**
Secretary: **Federico Smeacetto**
Trustee: **Michael Halbig**
Parliamentarian: **Manabu Fukushima**
DEI representative: **Federico Smeacetto**

Glass & Optical Materials Division

Chair: **Michelle Korwin-Edson**
Chair-elect: **Mathieu Bauchy**
Vice chair: **Jessica Rimsza**
Secretary: **Jose Marcial**
DEI representative: **TBD**

Manufacturing Division

Chair: **Sarah Whipkey**
Chair-elect: **Bai Cui**
Vice chair: **Chao Ma**
Secretary: **Rehan Afzal**
Counselor: **William Carty**
DEI representative: **Manoj K Mahapatra**

Refractory Ceramics Division *(term began March 2024)*

Chair: **Austin Scheer**
Vice chair: **John Waters**
Secretary: **Brett Ervin**
Program chair: **Rebecka Annunziata**
Trustee: **Dana Goski**
DEI representative: **Bill Headrick**

Structural Clay Products Division

Chair: **Bryce Switzer**
Chair-elect: **Mike Rixner**
Vice chair: **Marian Clark**
Secretary: **TBD**
Trustee: **Jed Lee** ■

FOR MORE INFORMATION:

ceramics.org/members

Greater Missouri Section elects new officers

In March 2024, the Greater Missouri Section elected a new slate of officers for 2024–2026 at the 59th Annual Greater Missouri Section and Refractory Ceramics Division Symposium on Refractories in St. Louis, Mo.

Chair: **Jason Lonergan** (Missouri S&T)
Vice-chair: **Kaitlyn Zdvorak** (Christy Refractories)
Secretary: **Kenneth Domann** (Rath Group)
Treasurer: **Patty Smith** (Missouri S&T)
Counselor: **Jeff Smith** (Missouri S&T)

Also appointed were:

Programming Committee chair: **Brady Gould** (Christy Refractories)
Social Committee chair: **Kaitlyn Zdvorak** (Christy Refractories)
Nominating Committee chair: **Chris Perry** (Christy Refractories)

The Programming and Social Committees are seeking volunteers to help organize plant tours, social events and outings, and other outreach activities. Please contact Jason Lonergan at jlonergan@mst.edu to get involved. ■

more SOCIETY DIVISION SECTION CHAPTER NEWS

ACerS International Taiwan Chapter meets with ACerS president Rajendra K. Bordia

On March 5, 2024, members of the ACerS International Taiwan Chapter met virtually with ACerS president Rajendra K. Bordia. Discussions included encouraging members to join multiple Divisions, increasing membership through Associate and GGRN memberships, and nominating fellow Chapter members for ACerS awards. ■

ACerS president Rajendra K. Bordia, left, talking with members of the ACerS International Taiwan Chapter.

ACerS International Japan Chapter co-hosts International Session at the 2024 Annual Meeting of the Ceramic Society of Japan

The ACerS International Japan Chapter and the International Committee of the Ceramic Society of Japan co-hosted the International Session at the 2024 Annual Meeting of the Ceramic Society of Japan in Kumamoto, Japan, on March 14, 2024.

Members of the ACerS International Japan Chapter and the International Committee of the Ceramic Society of Japan at the 2024 Annual Meeting.

Japan Chapter chair-elect Yoshihiko Imanaka delivered opening remarks, and then several ACerS members gave invited talks: Nicola H. Perry of the University of Illinois Urbana-Champaign and Yukio Sato of Kumamoto University, Japan, both 2023 winners of the Richard M. Fulrath Award, and Japan Chapter secretary Tessa Davey of Bangor University (Wales, U.K.). ■

ACerS International Northeast India Chapter organizes 4th Global Ceramic Leadership Roundtable

The ACerS International Northeast India Chapter organized the 4th Global Ceramics Leadership Roundtable at Indian Institute of Technology Roorkee.

Attendees at the 4th Global Ceramic Leadership Roundtable.

ACerS past president Sanjay Mathur (2022–23) informed attendees about recent ACerS activities and the Society's growth, and Northeast India Chapter chair Lalit Kumar Sharma updated the audience on the Chapter's activities.

Sharma thanked former ACerS president Mrityunjay Singh (2015–16) for being the one who conceived the Global Ceramics Leadership Roundtable idea in India, and then Northeast India Chapter vice-chair Manoj Kumar provided more details about the event. K.K. Pant, director at IIT Roorkee, spoke about IIT's role in this year's roundtable and thanked the Northeast India Chapter for organizing it at IIT-Roorkee. ■

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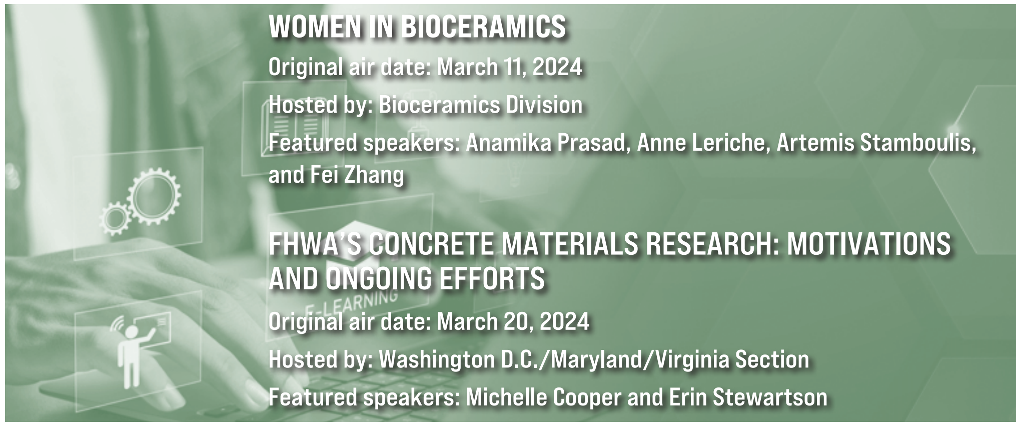
WEBINARS TO WATCH

Check out these recent additions to the ACerS Webinar Archives:



WOMEN IN BIOCERAMICS

Original air date: March 11, 2024

Hosted by: Bioceramics Division

Featured speakers: Anamika Prasad, Anne Leriche, Artemis Stamboulis, and Fei Zhang

FHWA'S CONCRETE MATERIALS RESEARCH: MOTIVATIONS AND ONGOING EFFORTS

Original air date: March 20, 2024

Hosted by: Washington D.C./Maryland/Virginia Section

Featured speakers: Michelle Cooper and Erin Stewartson

ACerS members can view these webinars and other past recordings by visiting the ACerS Webinar Archives at www.ceramics.org/webinararchives.

MEMBER HIGHLIGHTS

Ceramic Tech Chat: Jessica Rimsza

Hosted by ACerS Bulletin editors, Ceramic Tech Chat talks with ACerS members to learn about their unique and personal stories of how they found their way to careers in ceramics. New episodes publish the third Wednesday of each month.

In the April 2024 episode of Ceramic Tech Chat, **Jessica Rimsza**, staff scientist at Sandia National Laboratories, discusses her work on modeling disordered and complex material systems, describes what is involved in organizing a scientific conference, and explains how joining a professional society can help young researchers define their identity as a scientist.

Check out a preview from her episode on her approach to materials modeling.

"I think you might have heard the analogy before that if you're holding a hammer, every problem looks like a nail. And so I think if someone has a favorite type of modeling, you run the risk of being surrounded by a lot of nails and then finding yourself in trouble. So for me, I think it's better to say, 'Okay, what is the question?' first and then pick the best technique to solve it later."

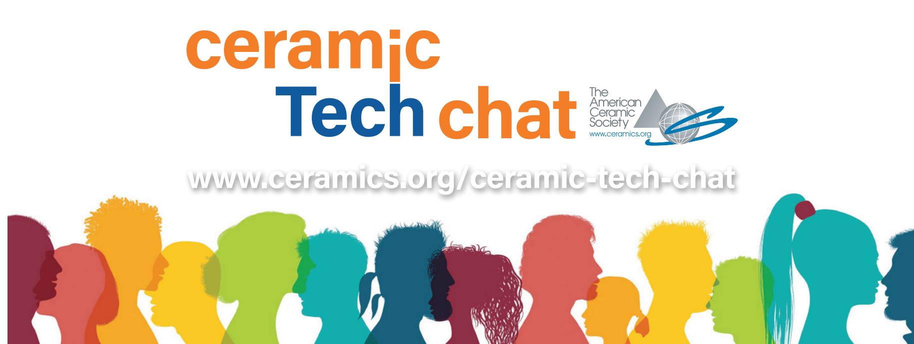
Listen to Rimsza's whole interview—and all our other Ceramic Tech Chat episodes—at https://ceramictechchat.ceramics.org/974767. ■

IN MEMORIAM

E. Lowell Swarts

Leon W. "Pete" Riker

Some detailed obituaries can also be found on the ACerS website, www.ceramics.org/in-memoriam.



more MEMBER HIGHLIGHTS

Volunteer Spotlight: Christina Rost

ACerS Volunteer Spotlight profiles members who demonstrate outstanding service to the Society.

Christina Rost is assistant professor of materials science and engineering at Virginia Tech. She earned an M.S. in physics from Indiana University of Pennsylvania and a Ph.D. in materials science and engineering from North Carolina State University.

She studies complex oxide synthesis and local characterization using X-ray spectroscopy for a variety of functional applications.

Rost previously served as a mentor for the ACerS Mentor Program. She also successfully petitioned the Washington D.C./Maryland/Virginia Section to expand its borders to include all of Virginia.

We extend our deep appreciation to Rost for her service to our Society! ■

ACerStudent Engagement: Shannon Rogers

Shannon Rogers is a Ph.D. student in materials science at Colorado School of Mines. She is part of ACerS President's Council of Student Advisors (PCSA) and recently led a volunteer effort representing the Ceramic and Glass Industry Foundation at the National Science Teaching Association conference in Denver, Colo.

"I attribute a significant influence in my career direction from the opportunity to join PCSA and ACerS. My experiences, people I've met, and places I have traveled to due to the Society have helped me grow into the engineer, scientist, and outreach enthusiast I am today!"

You can take advantage of these opportunities as well by becoming a student member of ACerS. Visit ceramics.org/members/membership-types to learn more. ■

AWARDS AND DEADLINES

Bioceramics Division announces winners of YouTube video contest

The Bioceramics Division announced the winners of its recent YouTube video contest. The winning submissions showcased recent innovations and technological advancements in the field of bioceramics. Congratulations to the winners:

First place: *Biomechanically tunable scaffolds as testbeds of cancer bone metastasis for bone regeneration* – **Hanmant Gaikwad, Sharad Jaswandkar, and Preetham Ravi**, North Dakota State University (https://www.youtube.com/watch?v=NrO_LZyDafM)

Second place: *Let's talk about: Bioceramics | BGCs | Applications & new ideas* – **Efraín Esaú De La Rosa García**, Technological Institute of Saltillo, Mexico (https://www.youtube.com/watch?v=UWZTLoWcfE8) ■

FOR MORE INFORMATION:

ceramics.org/members/awards

Nomination deadlines for Division awards: July 1, July 31, or Aug. 4, 2024

Contact: **Vicki Evans** | **vevans@ceramics.org**

Division	Award	Deadline	Contacts	Description
ECD	**Bridge Building**	July 1	Jie Zhang jiezhang@imr.ac.cn	Recognizes individuals outside of the United States who have made outstanding contributions to engineering ceramics.
ECD	**Global Young Investigator**	July 1	Amjad Almansour amjad.s.almansour@nasa.gov	Recognizes the outstanding young ceramic engineer or scientist whose achievements have been significant to the profession and to the general welfare of the community around the globe. Nominations are open to candidates from industry, academia, or government-funded laboratories around the world.
ECD	**James I. Mueller Lecture**	July 1	Young-Wook Kim ywkim@uos.ac.kr	Recognizes the enormous contributions of James I. Mueller to the Engineering Ceramics Division and to the field of engineering ceramics. This award aims to recognize the accomplishments of individuals who have made similar contributions.
ECD	**Jubilee Global Diversity**	July 1	Michael Halbig michael.c.halbig@nasa.gov	Recognizes exceptional early- to mid-career professionals who are women and/or underrepresented minorities (i.e., based on race, ethnicity, nationality, and/or geographic location) in the area of ceramic science and engineering.
EMSD	**Outstanding Student Researcher**	July 31	Sepideh Akhbarifar sepideha@vsl.cua.edu	Recognizes exemplary student research related to the mission of ACerS Energy Materials and Systems Division.
BSD	**Graduate Excellence in Materials Science (GEMS)**	August 4	Amanda Krause krause@cmu.edu	Recognizes the outstanding achievements of graduate students in materials science and engineering. The award is open to all graduate students who are giving an oral presentation in any symposium or session at the 2024 Materials Science & Technology meeting. ■

Nomination deadline for Society awards: Aug. 1 or Sept. 1, 2024

Contact: **Erica Zimmerman** | **ezimmerman@ceramics.org**

Society award	Deadline	Description
Samuel Geijsbeek PACRIM International Award	August 1	Recognizes individuals who are members of the Pacific Rim Conference societies for their contributions to ceramic and glass technology that have resulted in significant industrial and/or academic impact, international advocacy, and visibility of the field. Industrial candidates will be evaluated based on the technology's development and commercialization, its current usefulness and importance, its uniqueness, and its economic significance.
Darshana and Arun Varshneya Frontiers of Glass Lectures	September 1	Lectures encourage scientific and technical dialogue in glass topics of significance that define new horizons, highlight new research concepts, or demonstrate the potential to develop products and processes for the benefit of humankind. ■

CERAMICANDGLASSINDUSTRY FOUNDATION

ACerS volunteers attend the 2024 National Science Teaching Association conference in Denver

With eight volunteers, three days of science, and two exciting demonstrations, ACerS members introduced teachers from around the country to ceramic and glass materials science at the 2024 National Science Teaching Association (NSTA) conference.

The NSTA National Conference on Science Education took place March 20–23, 2024, in Denver, Colo. NSTA, which boasts more than 40,000 members, hosted thousands of teachers at the conference this year.

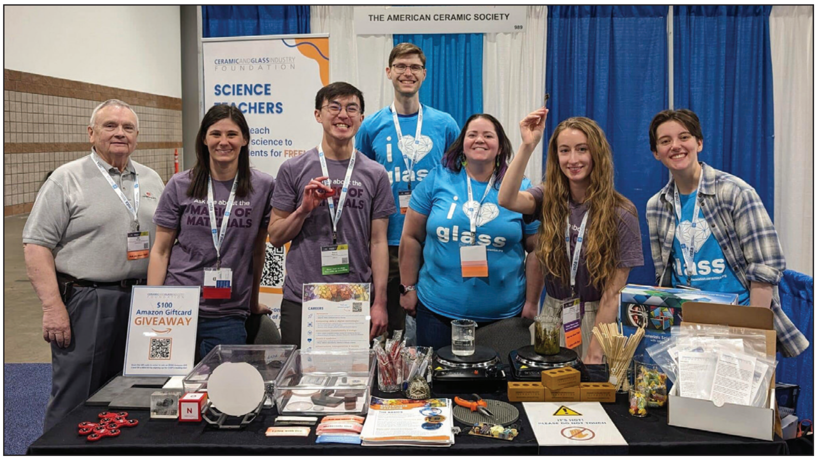
A group of ACerS members attended the conference to represent the Society and the Ceramic and Glass Industry Foundation (CGIF), including Shannon Rogers, Ph.D. student in materials science at Colorado School of Mines. Rogers wanted to participate in outreach with the ACerS Colorado Section, and she came up with the idea to bring ACerS and the CGIF presence to the Denver conference.

“We met with more teachers than we could count, wowed them with our demonstrations, periodic table pens, and all the free resources volunteers and ACerS staff have spent years putting together,” Rogers says. “Most were overjoyed, grateful, and said they would definitely sign up for the Kit Grant Application.”

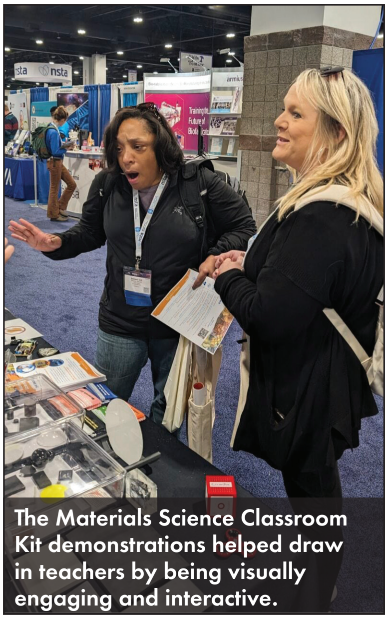
The volunteers demonstrated the Candy Fiber Pull and Shape Memory Alloys lessons from the CGIF’s Materials Science Classroom Kit. They also helped spread awareness about the CGIF Kit Grant, which helps teachers bring the kit materials and full lesson plans into their classrooms.

The CGIF is grateful for the student and ACerS volunteers who helped facilitate such a successful experience at the 2024 NSTA conference.

Apply for the CGIF Kit Grant at https://foundation.ceramics.org/kit-grant-application. Help expand the CGIF’s presence at outreach events like this one by visiting ceramics.org/donate. ■



ACerS volunteers from left to right: Bill Long, Amanda Bellafatto, Wayne Yeo, Nathan McIlwaine, Pandora Picariello, Shannon Rogers, and Sierra Astle. Not pictured: Scott Thompson.



The Materials Science Classroom Kit demonstrations helped draw in teachers by being visually engaging and interactive.

ACerS volunteer Nathan McIlwaine, Ph.D. candidate at The Pennsylvania State University, demonstrates the Candy Fiber Pull lesson from the Materials Science Classroom Kit.

Electronic chemicals and materials: The global market

By BCC Publishing Staff

The global market for electronic chemicals and materials was valued at $59.4 billion in 2022 and is expected to grow at a compound annual growth rate (CAGR) of 5.0% to reach $76.0 billion by 2027.

Chemicals and materials play a crucial role in the electronic industry, serving as both components and processing agents across all stages of production (Table 1). Throughout the forecast period, semiconductors and integrated circuits are estimated to be the highest consumers and fastest-growing application segment of electronic chemicals and materials (Table 2).

Some applications of ceramics in electronic devices include

- **Wafers:** Wafers are highly engineered, thin, round disks that serve as the substrate material on which most semiconductor devices are fabricated. Silicon is by far the most common wafer material, but other materials include silicon carbide, gallium nitride, and gallium arsenide.
- **Chemical mechanical planarization (CMP) slurries:** CMP slurries are used to remove small volumes of surface material from hard, crystalline workpieces. The slurries originally were used to planarize oxide layers in devices, but their application has extended into planarizing metal, which expands the scope of their market. Some of the chemicals used in CMP slurries include fumed silica, colloidal silica, alumina, alkalis, and acids.
- **Capacitors:** Capacitors store electrical energy by accumulating electric charges on two closely spaced surfaces that are insulated from each other. Barium titanate is used in capacitors because of its high dielectric constant and piezoelectric and ferroelectric properties.
- **Magnetic tape:** Magnetic tape is a medium for magnetic storage made of a thin, magnetizable coating on a long, narrow strip of plastic film. Chromium dioxide is considered one of the best magnetic recording particulates.

The key competitive strengths of leading players in this market entail a broad product line, manufacturing excellence, strong research and development infrastructure and investments, advanced quality control systems, expertise in production processes, and low total cost of ownership.

The last two decades saw a continued shift in electronics component manufacturing from the Americas to the Asia-Pacific due to the availability of cheap labor and lucrative foreign investment policies by national governments in Asia. China, Taiwan, South Korea, Hong Kong, and Vietnam are leading contributors to the overall market from the region.

About the author

BCC Publishing Staff provides comprehensive analyses of global market sizing, forecasting, and industry intelligence, covering markets where advances in science and technology are improving the quality, standard, and sustainability of businesses, economies, and lives. Contact the staff at Helia.Jalili@bccresearch.com.

Resource

BCC Publishing Staff, "Electronic chemicals and materials: The global market," BCC Research Report SMC043F, June 2023. https://bit.ly/BCC-June-2023-electronics

Table 1. Global market for electronic chemicals and materials, by product, through 2027 ($ millions)

* Others include metals, low-dielectrics, and miscellaneous chemicals.

Product	2021	2022	2027	CAGR % (2022–2027)
Wafers	15,999.8	16,756.6	22,186.9	5.8
Polymers	10,499.9	10,901.8	13,824.1	4.9
Printed circuit board laminates	9,799.9	10,125.9	12,532.8	4.4
Gases	7,999.9	8,206.7	9,798.4	3.6
Photoresist chemicals	3,799.9	4,031.7	5,696.7	7.2
Wet chemicals and solvents	3,500.0	3,650.4	4,734.4	5.3
Chemical mechanical planarization slurries	2,123.8	2,245.0	3,114.2	6.8
Others*	3,400.0	3,489.8	4,069.0	3.1
Total	57,123.2	59,407.9	75,956.5	5.0

Table 2. Global market for electronic chemicals and materials, by application, through 2027 ($ millions)

* Others include memory disks and general metal finishing.

Product	2021	2022	2027	CAGR % (2022–2027)
Semiconductors and integrated circuits	34,751.1	36,266.3	47,175.7	5.4
Displays	12,358.5	12,848.0	16,399.4	5.0
Printed circuit boards	7,586.5	7,809.8	9,487.4	4.0
Others*	2,426.8	2,483.8	2,894.2	3.1
Total	57,123.0	59,407.9	75,956.5	5.0

Jonathon Foreman
ACerS journals managing editor

Early career research in ceramics and glass

There are many commendable early career researchers who are positively impacting the ceramics and glass community, yet their efforts often go unrecognized. To celebrate our younger members and their accomplishments, *Journal of the American Ceramic Society* launched the 2[nd] Century Trailblazers initiative in 2023 (https://ceramics.org/trailblazers).

The 2[nd] Century Trailblazers initiative aimed to elevate the work of researchers who received their Ph.D. degrees within the past 10 years by inviting select authors to submit manuscripts to *JACerS*. The initiative culminated in the *JACerS* March 2024 issue (Figure 1), which solely contains papers submitted through the initiative. View the whole issue at https://ceramics.onlinelibrary.wiley.com/toc/15512916/2024/107/3.

Of the articles in this issue, *JACerS* editor-in-chief John Mauro recognized the paper by Xufei Fang, "Mechanical tailoring of dislocations in ceramics at room temperature: A perspective," as the best contribution. Fang presented this paper at ACerS Annual Meeting at MS&T in October 2023, and he is now leading the effort to organize a *JACerS* special issue on the topic of dislocations in ceramics. Researchers interested in submitting their manuscript for this special issue can contact ACerS journals managing editor Jonathon Foreman at jforeman@ceramics.org for further information.

Many 2[nd] Century Trailblazer authors have contributed other articles to the ACerS journals prior to and since that special issue. Papers by these authors and others have been assembled into a new Topical Collection, "Early career research in ceramics and glass," which is roughly organized based on the topics of dislocations, defects and crystal structures, processing, and ceramics designed and evaluated for specific applications.

Among the articles in the first section is "Dislocation loop evolution in Kr-irradiated ThO_2." As the article's name suggests, the authors describe their observations of the changes that occur with increasing dosing of krypton ions. They use molecular dynamics to explore the mechanisms and kinetics of the observed changes to the structural defects.

Credit: ACerS

Figure 1. Cover of the March 2024 *JACerS* special issue featuring 2[nd] Century Trailblazers.

In the second section, the rapid communication "Synthesis of high entropy monoboride $(Mo_{0.25}W_{0.25}Cr_{0.25}Ta_{0.25})B$ powders with abundant twins from oxides" explores low-cost fabrication methods for high-entropy ceramics. This class of materials has garnered much interest because the strained crystal structure in these materials, which is caused by the very different sizes of constituent atoms, results in unique properties. Twinned high-entropy borides, the focus of the rapid communication paper, have the potential to be extremely hard.

The use of artificial intelligence is growing, and early career researchers are embracing ethical application methods, including modeling and simulations. In the third section, the authors of the article "Artificial Intelligence-based determination of fracture toughness and bending strength of silicon nitride ceramics" trained and tested a convolutional neural network model with the goal of predicting fracture toughness and bending strength directly from microstructure images. Their results demonstrated relatively high AI-determination accuracy, considering the use of various kinds of sintering additives and the wide range of relative densities.

Glass and ceramic materials have the potential to address specific unmet societal needs, for example, real-time measurement of radiation exposure. People who work near X-rays and nuclear sources often wear personal dosimeters, which passively measure accumulated dosing via a radiation sensitive film. The films are usually processed outside the workplace after the dose is accumulated, so they lack real-time information.

In the fourth section, the authors of "Gallosilicate glass and fiber for radiation detection" synthesized a material that, much like the films of dosimeters, changes color when exposed to ultraviolet, X-ray, and gamma radiation. The color change can be reversed by heat treating the material. They demonstrated the material's potential to be used for real-time monitoring, which holds great promise to eventually replace dosimeters as personal radiation detectors.

To see the full lineup of articles in the Topical Collection "Early career research in ceramics and glass," go to ACerS Publication Central at https://ceramics.onlinelibrary.wiley.com. Click on the "Collections" menu and select "Topical Collections" from the drop down. You will see this collection along with others created over the past few years. You can also directly access this collection using the link https://bit.ly/June2024-EarlyCareer. ■

Quantum dots may lead to cost-effective mid-infrared light sources and sensors

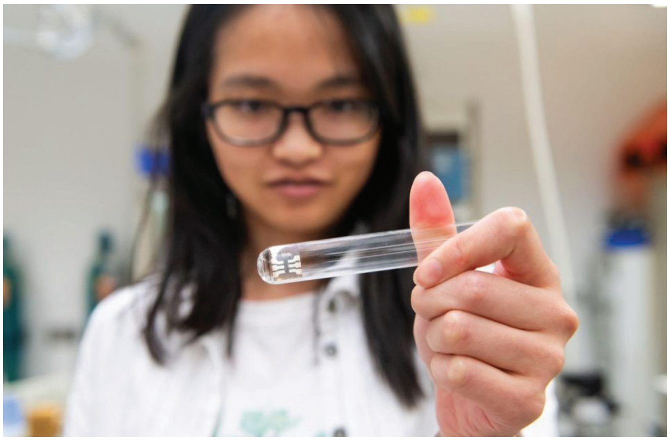
Researchers at the University of Chicago developed a quantum-dot-based infrared light source that is as efficient as current commercial devices.

Quantum dots are semiconductor nanocrystals used commercially in display applications for visible light, such as high-end televisions. The process of expanding the operating range of quantum dot technology from visible light to the mid-infrared spectral region is an ongoing endeavor.

In the recent study, Philippe Guyot-Sionnest's group at the University of Chicago explored whether implementing a cascade mechanism could improve the quantum efficiency of HgSe–CdSe quantum dot light sources. Conventional mid-infrared lasers, which are based on epitaxially grown III-V semiconductors, use the cascade mechanism to improve quantum efficiency. The semiconductors are structured so that electrons will travel through ("cascade" down) a series of distinct energy levels called quantum wells, emitting some energy as light each time. By using dozens of quantum wells in a series, a higher optical gain and multiple photons per electron are obtained. But these gains come at the expense of a higher required electrical voltage.

It is predicted that a cascade mechanism in quantum dots would result in orders-of-magnitude lower operation current and largely temperature-independent performance. But so far, no groups have achieved the predicted performance.

In the new study, Guyot-Sionnest and his team used knowledge gained from previous studies they conducted on HgSe–CdSe quantum dots to construct a mid-infrared light source with a cascade architecture. Testing revealed a vastly improved performance, with quantum efficiency reaching about 4.5%, or the same efficiency as commercial devices. However, compared to the commercial devices, which usually require currents on the order of kA cm$-_2$, the cascade mid-infrared quantum dot device worked at currents on the order of A cm^{-2}.



Credit: Jean Lachat, University of Chicago

University of Chicago graduate student Xingyu Shen holds a device that uses quantum dots to produce mid-infrared light.

The researchers believe that with further tinkering, the device could easily surpass existing methods for generating mid-infrared light.

The paper, published in *Nature Photonics*, is "Mid-infrared cascade intraband electroluminescence with HgSe–CdSe core–shell colloidal quantum dots" (DOI: 10.1038/s41566-023-01270-5). ■

Advancing the quantum world's new best friend—stabilized charge states in hexagonal boron nitride

Researchers at the University of Technology Sydney in Australia described a way to stabilize the –1 charge state in hexagonal boron nitride (hBN) using a new experimental setup.

hBN has emerged as a potential material for hosting quantum bits (qubits) on a smaller scale than diamond, the conventional quantum material. The boron-vacancy center in hBN can exist in various charge states, but only the –1 charge state is suitable for spin-based applications. Unfortunately, the boron-vacancy center's charge state can flicker, switching between the –1 and 0 states. This instability makes it unreliable for use in quantum technologies.

To stabilize the –1 charge state, the Australian researchers used a confocal photoluminescent microscope integrated with a scanning electron microscope to monitor the boron-vacancy center while simultaneously manipulating the charge states with an electron beam and laser. From this analysis, they determined that the electron beam causes quenching of the boron-vacancy center's photoluminescence intensity. On the other hand, the laser beam causes the photoluminescence emission to recover.

They then used a layered heterostructure device to inject excess electrons (or holes) into a sample of hBN via either excitation by a 532 nm laser (from below) or irradiation by a 5 keV electron beam (from above). The layered heterostructure device consisted of gold contacts and a pair of graphene electrodes that encapsulated the hBN flakes.

With this setup, the researchers successfully stabilized the −1 charge state in the hBN boron-vacancy centers. hBN flake thickness influenced the parameters needed for stabilization, as well as the densities of both vacancy defects and charge traps.

The next phase of this research will focus on pump-probe measurements to optimize defects in hBN.

The paper, published in *Nano Letters*, is "Manipulating the charge state of spin defects in hexagonal boron nitride" (DOI: 10.1021/acs.nanolett.3c01678). ■

First naturally occurring mineral to display unconventional superconductivity identified

Researchers led by Ames National Laboratory reported the presence of unconventional superconductivity in a naturally occurring mineral.

Superconductivity is the property of certain materials to conduct electricity without energy loss when cooled below a critical temperature. Conventional superconductors have low critical temperatures and are insensitive to nonmagnetic impurities in their structure. In contrast, unconventional superconductors typically have much higher critical temperatures and are sensitive to defects, which can change or suppress the critical temperature.

Only the mineral covellite (CuS) shows superconductivity in samples that form naturally. Lab-grown samples of three other minerals—parkerite ($Ni_3Bi_2S_2$), miassite ($Rh_{17}S_{15}$), and palladseite ($Pd_{17}Se_{15}$)—are the only other naturally occurring minerals known to display superconductivity.

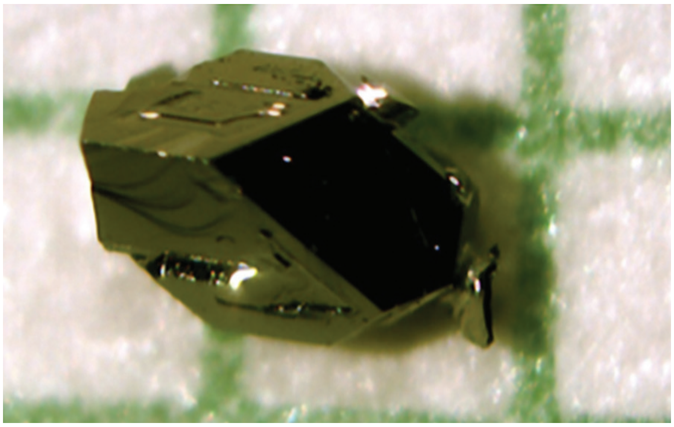
Until the new study, no research groups had reported seeing unconventional superconductivity in a naturally occurring mineral. But as the Ames-led researchers explained in their open-access paper, the superconducting properties of miassite feature several characteristics that do not align with conventional understanding.

"[Miassite shows] an anomalously high upper critical field greater than 20 T, exceeding the Pauli limit of about 10 T. In contrast, the upper critical field of palladseite is about 3.3 T, below the Pauli limit, while in elemental superconductors, covellite, and parkerite the upper critical field is orders of magnitude smaller," they write.

Several other variables also defy predictions of the Bardeen–Cooper–Schrieffer theory, which explains the mechanism of conventional superconductivity. These unusual experimental observations "motivated us to clarify its superconducting pairing state," the researchers write.

They synthesized high-quality miassite crystals using a high-temperature flux growth technique and then used three different tests to analyze miassite's superconductivity.

The main test they used, London penetration depth, determines how deeply a weak magnetic field penetrates the superconductor's bulk from the surface. In conventional superconductors, this length is basically constant at low temperature. But in unconventional superconductors, it varies linearly with temperature.



Credit: Paul Canfield, Ames National Laboratory

Example of a high-quality miassite crystal grown by researchers at Ames National Laboratory.

The researchers found that miassite behaved as an unconventional superconductor in the London penetration depth test. Miassite's critical temperature and critical magnetic field also behaved as expected for unconventional superconductors when defects were introduced into the mineral's structure through high-energy electron bombardment.

"[This study] establishes miassite as the only mineral known so far that reveals unconventional superconductivity in its clean synthetic form," the researchers write. However, it is unlikely that unconventional superconductivity will be present in natural miassite crystals "because of unavoidable impurities that quickly destroy nodal superconductivity," they clarify.

The open-access paper, published in *Communications Materials*, is "Nodal superconductivity in miassite $Rh_{17}S_{15}$" (DOI: 10.1038/s43246-024-00456-w).

Research News

Silicon carbide data storage technology could preserve information for millions of years

Researchers from Germany, Japan, and the United States proposed a novel concept for long-term, high-density data storage using silicon carbide. Their approach leverages the unique properties of atomic-scale silicon vacancies to store and retrieve digital information. They created these defects using focused ion beams. The energy required to write a single bit using this method is lower than the energy consumption of magnetic disk drives and solid-state drives. The writing speed is also faster than other optical data storage media. However, the reading speed is limited by the emission rate of the silicon defects. For more information, visit https://www.nanowerk.com/spotlight/spotid=64956.php.

Making diamonds at ambient pressure via liquid metal alloy system

Researchers from the Institute for Basic Science in the Republic of Korea grew diamonds under conditions of 1 atmosphere pressure and at 1,025°C using a liquid metal alloy system. Conventional belief is that diamonds can only be grown using liquid metal catalysts in the gigapascal pressure range and 1,300–1,600°C temperature range. This study breaks that paradigm and offers the possibility to scale up diamond growth. Additionally, initial formation occurs without the need for diamond or other seed particles commonly used in conventional synthesis methods. For more information, visit https://www.ibs.re.kr/cop/bbs/BBSMSTR_000000000738/selectBoardList.do.

High-temperature electrical tests reveal potential of various packaging materials for SiC sensors

NASA Glenn Research Center research electronics engineer Robert S. Okojie and intern Thomas M. Deucher investigated the electrical properties of several ceramic and glass packaging materials to determine which may perform better than aluminum nitride at temperatures of more than 800°C.

Aluminum nitride is the material currently used to package silicon carbide (SiC)-based electronics. However, at temperatures above 800°C (1,472°F), which could be experienced during space missions, there are increasing signal instabilities due partially to leakage of the current through the aluminum nitride packaging.

In the recent study, Okojie and Deucher tested four ceramics—aluminum nitride, silicon nitride, beryllium oxide, and yttrium oxide—as well as silicon dioxide glass as possible packaging materials. They tested bulk and surface resistivities at temperatures up to 1,200°C (2,192°F); samples were thermally cycled twice in nitrogen while the resistivities were measured in situ.

Based on these experiments, they determined that beryllium oxide maintained the highest bulk and surface resistivity values at 1,200°C, with 28 and 34 kΩ, respectively. In contrast, aluminum nitride had the lowest resistivity values, with 6.8 kΩ cm for bulk and 0.64 kΩ cm for surface.

However, silicon nitride was identified as the most promising candidate for packaging material, despite its lower thermal conductivity relative to aluminum nitride. Its attractiveness lies in its low mismatch in coefficient of thermal expansion with SiC and relative resistivity stability compared to aluminum nitride.

While this study focused specifically on packaging for SiC-based pressure sensors, "the characterization of these materials at elevated temperature may prove useful in [other SiC-based] applications," the researchers conclude.

The paper, published in *Journal of the American Ceramic Society*, is "Temperature effects on electrical resistivity of selected ceramics for high-temperature packaging applications" (DOI: 10.1111/jace.19548). ■

Atom-by-atom: Imaging structural transformations in 2D materials

Researchers at the University of Illinois Urbana-Champaign developed a method to visualize the thermally induced rearrangement of 2D materials, atom-by-atom, from twisted to aligned structures using transmission electron microscopy. They observed a new and unexpected mechanism for this process, whereby a new grain was seeded within a monolayer that had its structure templated by the adjacent layer. Researchers have speculated that this mechanism may happen, but there were no direct visualizations at the atomic scale proving or disproving the theory until this study, which directly tracked the movement of individual atoms to see the tiny, aligned domain grow. For more information, visit https://mrl.illinois.edu/news/66189. ■

ceramics in the environment

Pilot fog catcher system simultaneously collects and cleans water

Researchers led by ETH Zurich developed a system for simultaneously harvesting and cleaning the water collected from fog nets.

Fog nets are used by people living in arid countries such as Peru, Bolivia, and Chile to catch droplets of water from the misty air. These droplets then trickle down the mesh and are collected to provide water for drinking, cooking, and washing.

In areas with air pollution, hazardous substances also collect in the droplets of water. As such, any water harvested from the fog is not clean enough to be used untreated. But establishing treatment facilities to properly clean the water may not be economically feasible for these communities.

In August 2023, researchers at ETH Zurich in Switzerland and Max Planck Institute for Polymer Research in Germany published an open-access paper describing a system for simultaneously harvesting and cleaning the water collected from fog nets. The system, which requires little maintenance and only a small but regular dose of sunlight, has potential as an affordable system for communities that harvest water from polluted air.

The system consists of a metal mesh coated with anatase titanium dioxide nanoparticles embedded in a polymer matrix. The polymers ensure that droplets of water collect efficiently on the mesh and then trickle down into a container as quickly as possible before they can be blown off by the wind. The titanium dioxide acts as a chemical catalyst, breaking down the organic pollutants contained in the droplets to render them harmless.

Half an hour of sunlight is enough to activate the titanium dioxide for 24 hours. With periods of sunlight often rare in areas prone to fog, this quality is very useful.

Picture of a fog net in Lima, Peru. Fog nets provide people living in dry but foggy areas with a stable water source, but air pollution can make the collected water unsafe for use.

The researchers tested the system in the lab and in a small pilot plant in Zurich. It demonstrated a good fog harvesting performance and exceptional organic pollutant reduction values of 85% and 94% when the ultraviolet index was low and high, respectively, during outdoor tests.

Additionally, the system successfully treated water contaminants such as diesel or bisphenol A, "underpinning the possibility of using such a concept in a real-world environment against a range of pollutants," the researchers write in the paper.

The open-access paper, published in *Nature Sustainability*, is "Photocatalytically reactive surfaces for simultaneous water harvesting and treatment" (DOI: 10.1038/s41893-023-01159-9). ■

Replacing concrete seawalls with vinyl may adversely affect oyster populations

Researchers with the Sarasota Bay Estuary Program (Sarasota, Fla.) found replacing concrete seawalls with vinyl may adversely affect oyster populations.

Oysters are a crucial component of global ocean health. These animals not only filter and clean the surrounding water, but they can also serve as barriers to storms and tides, preventing erosion and protecting productive coastal ecosystems.

Oysters were once plentiful in coastal areas throughout the United States. But decades of overfishing, habitat loss, pollution, and disease proved devasting for the mollusks, leaving oyster populations at historic lows.

While significant progress is being made toward oyster reef restoration along the U.S. Atlantic and Gulf coasts, the use of vinyl seawalls may be detrimental to these initiatives.

Seawalls are vertical onshore structures that protect populated land areas against tides, currents, waves, and storm surges. Vinyl seawalls have grown in popularity compared to traditional concrete due to being less costly and unsusceptible to saltwater.

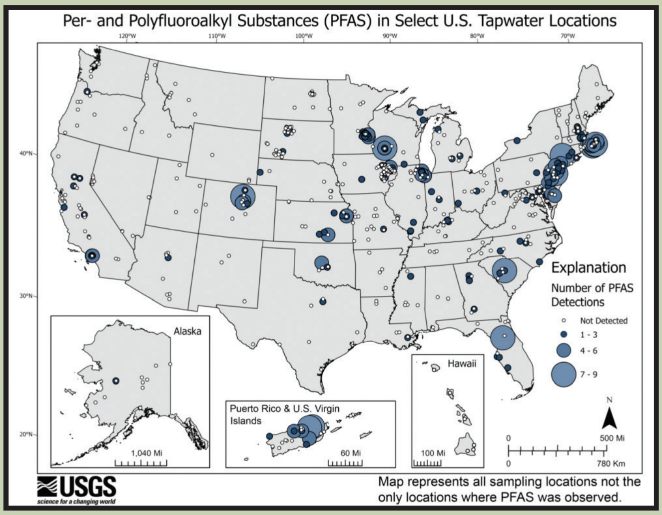
In the recent study, the researchers observed 32 seawalls in the Sarasota Bay area, 16 concrete and 16 vinyl. All the concrete seawalls had many oysters growing on them. But only six vinyl seawalls had any oysters attached, and only a few at that.

"It doesn't look like they have the same capacity to allow oysters to attach," says program director Dave Tomasko in an *Observer* article. "And so that is not a good thing for the bay."

The researchers are not sure why oysters are failing to attach to vinyl seawalls. But they suggest it could be due to the vinyl being too smooth, in which case manufacturers could "roughen up" the surface in some manner. Alternatively, there could be additives in the vinyl that are toxic to oysters, in which case different additives could be used.

"We are WAY early on this topic, … [but] we would be remiss if we did not mention this as a relevant topic to raise with policy makers and regulators—as well as the general public," Tomasko says in a director's note on the study. ■

EPA finalizes limits on 'forever chemicals' in US drinking water



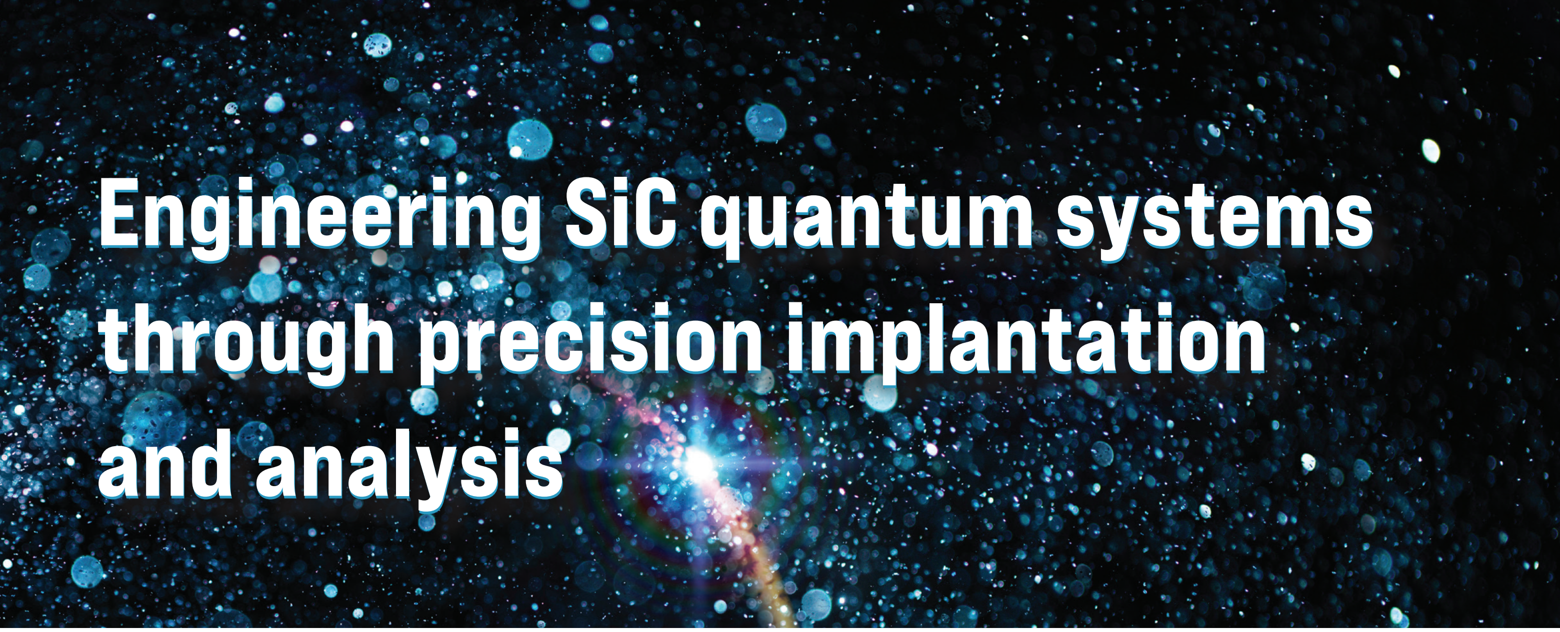
A map by the United States Geological Survey showing the number of PFAS detected in tap water samples from select sites across the nation. As of July 2023, at least 45% of the nation's tap water is estimated to have one or more types of PFAS.

On April 10, 2024, the U.S. Environmental Protection Agency (EPA) issued the first legally enforceable national drinking water standards for several common types of per- and polyfluoroalkyl substances (PFAS) chemicals.

PFAS are a large group of synthetic chemicals used in a variety of consumer products due to their ability to resist heat, grease, and water. But these chemicals also have numerous negative environmental and health effects, so many any U.S. states have passed laws regulating the presence of PFAS in consumer products. These laws do not tackle the problem of PFAS that already exist in the environment, however.

Until this year, no federal regulations existed to address PFAS pollution. Under the new EPA rule, drinking water concentrations of perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS), two of the most prevalent PFAS chemicals, will be capped at about 4 parts per trillion. This value is the lowest limit that the EPA believes is technologically possible, reflecting scientists' understanding that there is no safe exposure level for them. Three other common PFAS will be limited to 10 parts per trillion, either measured on their own, in combination with each other, or with one otherwise unregulated chemical.

These compounds represent only a fraction of the entire class of PFAS, which is estimated to include between 4,700 chemicals (per the European Environment Agency) and 15,000 chemicals (per the EPA). But even these limited regulations will protect some 100 million people from exposure and prevent tens of thousands of serious illnesses, according to the EPA. ■



Engineering SiC quantum systems through precision implantation and analysis

By Nazar Delegan

Silicon carbide holds much promise as a platform for quantum systems. New research at Argonne and Sandia National Laboratories unlocks this potential through precision engineering and analysis.

Quantum information science holds immense promise for revolutionizing computation, communication, and sensing. Central to these advancements are solid-state defect centers in wide bandgap semiconductors.

Defect centers are tiny imperfections in a material's atomic lattice caused by various factors, including missing atoms (vacancies), atoms in places that are typically vacant (interstitial atoms), and the presence of foreign atoms not inherent to the material's compositional makeup. These defects can have specific spin states associated with them. These discrete spin energy states can be used as quantum bits (qubits) for storing and manipulating information. While similar to the binary system of 0s and 1s in classical computing, qubits have added unique behaviors such as superposition, enabling significantly higher information density.

Diamond-hosted nitrogen-vacancy centers have attracted the most attention in the field of solid-state quantum information processing as possible spin defects for qubits. But silicon carbide (SiC), a sought-after wide bandgap semiconductor that is typically used for high-power electronic and harsh environment applications, also holds much promise as a quantum platform.[1]

SiC benefits from better material availability, scalability, and fabrication methodologies than diamond.[2–4] Most importantly, SiC can host a variety of interesting optically active spin defects, some of which can be coherently driven at room temperature.

There are challenges with using SiC as a platform for quantum information systems, however, that must be addressed to enable scaling of this technology. Researchers at Argonne National Laboratory and Sandia National Laboratories recently conducted a study to address one of these challenges: implanting qubits in SiC with extreme precision.[5] The results of their efforts are described in the sections below.

Challenges to scalable quantum technologies based on spin defects in semiconductors

Some of the most interesting optically active spin defects in SiC are the neutrally charged divacancy complexes (VV^0), which consist of a neighboring silicon atom and carbon vacancy. These defects feature mid-gap electronic energy states, which separate them from the host material's energy bands. This separation allows the defects to behave like isolated and discrete energy levels reminiscent of atomic systems, which, with the help of some intermediate energy levels, make it easy to initialize and readout the qubits' spin states.[2–4]

While this "isolated atomic system" approximation is quite useful for quantum processing, designing and harnessing VV^0 defects for use as qubits is extremely difficult. The energy level structures in these defects are defined by the intricate interplay between the defect's symmetry group, spin-lattice coupling, and the broader host material's electrostatic environment. This reliance on numerous variables makes the VV^0 defects intrinsically sensitive to their local charge, magnetic, crystallographic, and strain environments—all of which can have diverse and difficult-to-quantify effects on the spin defect's quantum performance.[6]

The inherent variability in spin-defect environments and, by extension, properties and performances poses a significant challenge to the deterministic and homogeneous synthesis of spin defects, limiting the full potential of defect-based quantum technologies. Because of this limitation, many state-of-the-art quantum demonstrations rely on pre-screened defects that are hand picked because they show the best properties for the intended experimental demonstration. Concurrently, any unidentified sources of variance are actively dismissed as being due to limited characterization capabilities at the relevant scales.

Basics of nanoimplantation

Nanoimplantation is a technique commonly used in the semiconductor industry. It enables the manipulation of material properties and behaviors by introducing a wide array of defects and dopants into materials at the nanoscale.

The approach involves extracting atomic species from a source material via thermal or electrostatic means, and then these ions are accelerated toward a solid target material. During impact, the energized ions will displace atoms in the target material and create defects, such as vacancies and interstitials, or embed themselves in the target material as dopants. The size, distribution, and type of defects generated can be tailored by precisely controlling the ion beam parameters, such as energy and dosage.

The nanoimplantation technique developed at Sandia uses a series of electromagnetic lenses to focus the accelerated ions down to areas as small as 25 x 25 nm^2. Learn more about the specifics of the Sandia technique in References 7 and 8. ■

In response to this challenge, researchers globally are involved in a focused, multifaceted, and multimodal effort to understand the causes behind defect-to-defect variability on both the nano- and microscale. Understanding these causes will improve researchers' deterministic and homogeneous synthesis capabilities.

The development of tools capable of generating and studying crystallographic defects has been essential to progress in this field of research. In the recent work led by Argonne and Sandia National Laboratories,[5] we explored the interplay between VV^0 spin defects and their host material (4H-SiC single crystal wafers ranging from a few mm to 6 inches) using a focused ion beam nanoimplantation technique developed at Sandia (see sidebar "Basics of nanoimplantation") and X-ray nanodiffraction performed at the Advanced Photon Source at Argonne.[7,8]

Mapping strain effects on the behavior of VV^0 spin defects

The photoluminescence mapping in Figure 1a shows the precise control of VV^0 synthesis in 4H-SiC that is possible using the ion beam nanoimplantation technique developed at Sandia. The implantation arrays were composed of identical implantation columns and fluence rows starting at 10,000 ions/spot and decreasing down to 10 ions/spot. The columns allowed for statistical repeatability, whereas the rows allowed for isolation of the implantation fluence effect and creation of a single defect regime.

The device used for nanoimplantation can allow for implantation spot sizes as small as 25 x 25 nm^2. However, the equipment calibration was slightly off during testing (noticed post-situ), so the obtained implantation spot sizes were about 66 x 56 nm^2.

Processing of the samples at 850°C in argon resulted in a significant increase of VV^0 photoluminescence. This increase is explained by the diffusive mobilization of implantation-generated silicon and carbon vacancies, which formed additional divacancy centers while reducing local damage. Unfortunately, lower ion fluences did not reveal single VV^0 defects with expected count rates, which may have been due to charge state instability from excessive local damage caused by implantation or insufficient thermal processing.

To better understand the mechanisms underlying these observations, we probed the local strain profiles at the defect scale using a nondestructive coherent nanoscale focused X-ray technique.[9] The synchrotron X-ray beam was focused

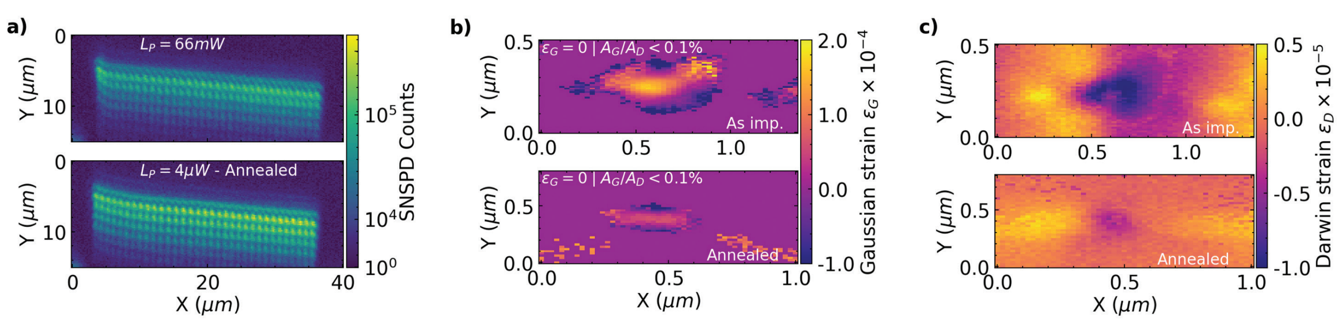


Figure 1. a) Photoluminescence map of VV^0 defects obtained via silicon implantation of 4H-SiC with 10,000, 5,000, 1,000, 500, 100, 50, and 20 ions/spot per row, organized from top to bottom. The implantation array curvature is due to experimental error, resulting in initial array drift during implantation. L_p is the laser power used to obtain the spectra. b) 2D tensile strain profile extracted from the Gaussian component of the two-component fitting model for a 10^4 ion/spot implantation with the as-implanted spot shown above and the annealed spot below. The strain is set to 0 when the area of the Gaussian component is less than 0.1% of the Darwin component. c) Strain response of the host 4H-SiC crystal extracted from the Darwin component for the as-implanted spot above and annealed sample below. It needs to be noted that the interaction volume from the Darwin and Gaussian components differ greatly and as such the extracted strain cannot be compared directly numerically, but it can be considered qualitatively.

down to an effective pencil beam width of about 25 nm and rastered across an area of 0.5 μm by 1.3 μm with steps of 25 nm. The data obtained from this probe provided a full set of 2D detector diffraction data per spatial pixel of the sample projected along the direction of the exit beam. This data was then collapsed, normalized, and systematically fitted per-pixel with a two-component model.

The Gaussian component of the model represented the diffracting areas of the nanoimplantation spot (Figure 1b), while the Darwin component represented the pristine 4H-SiC bulk (Figure 1c). This mapping allows us to extract a lower bound 2D strain profile of each implantation spot, with in-depth information partly projected along the *x*-axis.

From this map of the data, a phenomenological model emerges. It shows a tensile nano-implanted core surrounded by a compressive bulk area with local strains of about 2×10^{-4} and 1×10^{-5}, respectively, as shown in Figures 1b and 1c. The drastically increased strain in the as-implanted samples is in alignment with the difference in photoluminescence observed between these samples, requiring orders of magnitude lower excitation to achieve similar levels of emission as seen in Figure 1a.

We note a drastic change in the overall local strain profile, indicating a diffusive-like strain relaxation mechanism with order of magnitude reduction in both the strain profiles post annealing. Work is ongoing to quantify these variations as a function of implantation fluences on the single defect level, as well as to develop more sophisticated thermal treatments.

Strikingly, our investigations revealed the presence of previously undocumented crystallographic features in 4H-SiC. For example, extended screw dislocations demonstrated large changes in the strain profile over short distances, specifically variations of 1.14×10^{-4} over 0.28 μm, as shown in Figure 2b.

This strain variation is likely underestimated due to the depth convolution of the strained features. But even at this lower bound for the observed strain, if two VV^0 defects were to be located 0.28 μm away from each other (see theoretically plausible locations for P1 and P2 in Figure 2b), they would present a spectral shift of about 2.4 meV and 1.14 MHz for the zero-phonon line and ground-state splitting, respectively, as a result of the different strain environments of each defect (Figure 2a).

It is not unreasonable to propose that the large variation of material properties in a given material result from these ubiquitous and sparse crystallographic defects, which are found on the order equal to or more than 10^3 cm^{-2} (for thicknesses of 500 μm) in typical high-quality 4H-SiC. If a streamlined process for identifying these defects is implemented, it presents the possibility of using such local crystallographic defects to engineer unique systems and devices, paving the way for a slew of advanced quantum relevant control schemes.

Summary and outlook

Advancing the use of SiC as a platform for quantum information systems requires an understanding of the relationship between spin defects and their host materials at the nano- and microscales. This paper investigated the role of crystallographic attributes, namely strain profiles and lattice symmetries, in shaping the electrostatic environments and optical properties of quantum spin defects, focusing on the case of divacancy centers in 4H-SiC.

Our study reveals that local crystallographic features are the source of varied strain profiles and reduced lattice symmetries, leading to fluctuations in the optical properties of quantum spin defects. By conducting experiments at length scales of less than 1 μm, we gained insights into the inter-qubit variability in the solid state, laying the groundwork for strain engineering and deterministic localization of spin-defect systems.

Overall, the experimental platforms and demonstrations presented in this work contribute to the scalability and integration of quantum and classical technologies by understanding the inhomogeneity of spin defects and by demonstrating novel synthesis and characterization capabilities. By gaining a deeper understanding of defect formation dynamics and their manipulation at the nanoscale, we aim to harness the full potential of quantum spin defects for transformative applications in quantum computing, communication, and sensing.

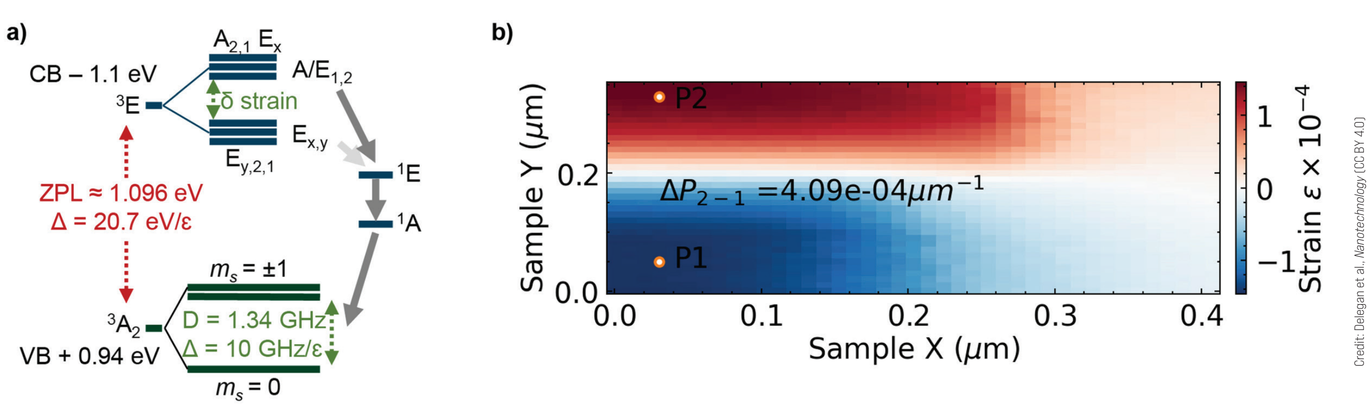


Figure 2. a) Energy level diagram of VV^0 defects in 4H-SiC as a function of strain relative to the conduction band (CB) and valence band (VB). b) At about 10 nm step size in a high-resolution raster nanodiffraction scan of a screw-dislocation running in-plane, we note a drastic change in strain from tensile to compressive, showing a 1.14×10^{-4} variation in strain over 0.28 μm. P1 and P2 are theoretically plausible locations for two VV^0 defects within the same optical spot-size.

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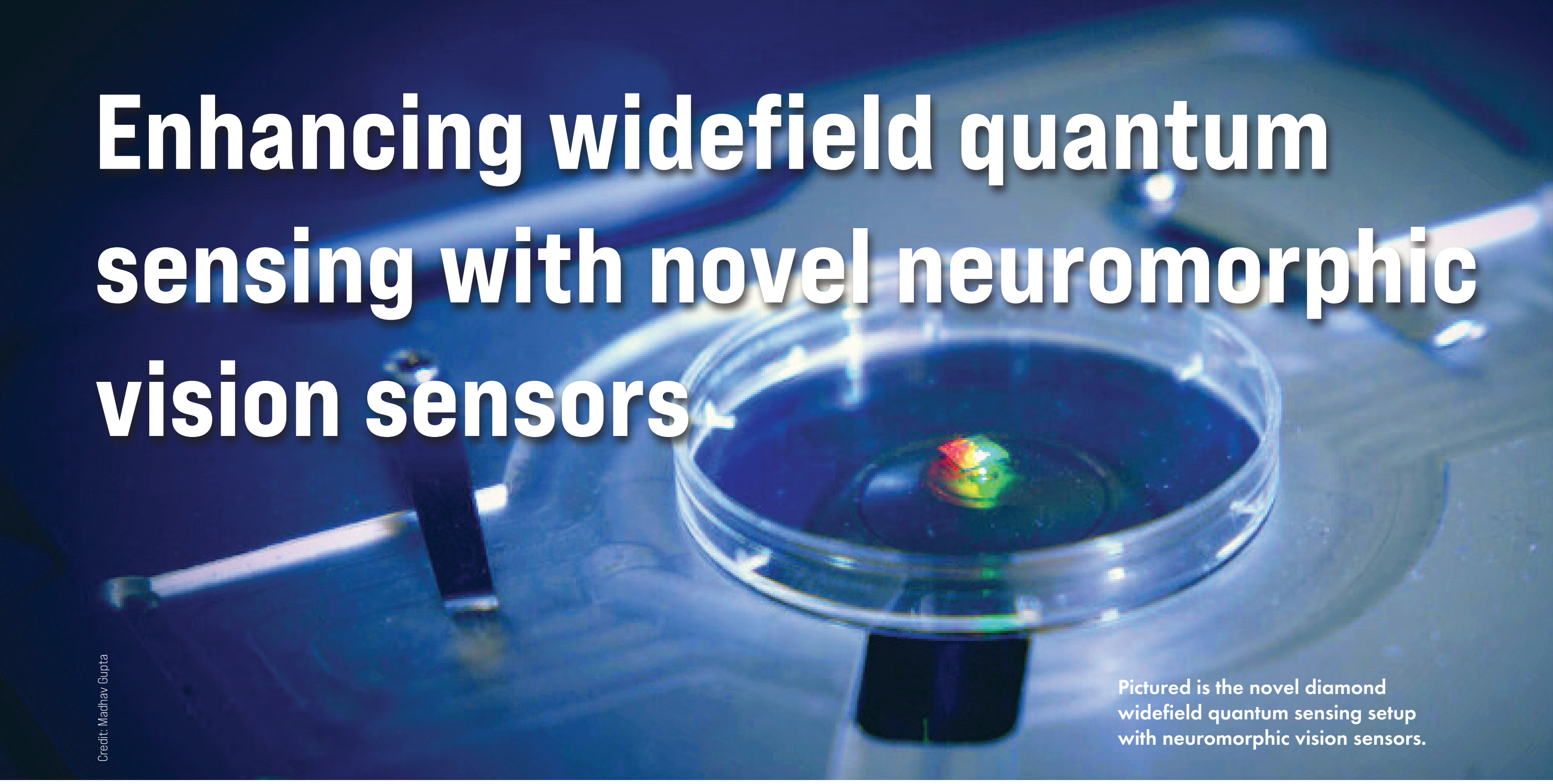
Enhancing widefield quantum sensing with novel neuromorphic vision sensors



Pictured is the novel diamond widefield quantum sensing setup with neuromorphic vision sensors.

By Madhav Gupta and Zhiqin Chu

A novel method of performing widefield quantum sensing using neuromorphic vision sensors may pave the way to further advance the field of quantum sensing.

Quantum technologies, such as quantum computing, quantum communications, and quantum sensing, are poised to be among the most revolutionary technologies of the 21st century.

Over the past few decades, a plethora of material systems have been extensively studied and characterized for use in quantum technologies,[1,2] such as superconducting systems, trapped ions, ultracold atoms, and quantum dots. Solid-state defect centers in diamond are one of the most promising systems.

Defect centers are tiny imperfections in the diamond's atomic lattice caused by various factors, for example, missing atoms (carbon vacancies), atoms in places that are typically vacant (interstitial carbon), and the presence of foreign atoms that are not carbon (typically nitrogen). Some of these defects affect the diamond's optical properties, allowing it to absorb incident radiation with specific energies.

Nitrogen-vacancy (NV) centers, which consist of a nearest-neighbor pair of a nitrogen atom (substituted for a carbon atom) and a lattice vacancy, are one of the most promising types of defect centers for quantum applications due to their exceptional electronic spin properties at room temperature.

Researchers have used NV centers in diamonds to develop quantum sensors that detect magnetic fields, electric fields, or temperatures with extreme sensitivity approaching the quantum limit.[3] Quantum sensors based on customized methods, such as confocal and widefield-based fluorescence microscopes, serve as the gold standard for quantum sensing technology.

The widefield diamond quantum sensing approach is particularly desirable because it allows for parallel readout of spatially resolved NV fluorescence. Since the first experimental demonstration in 2010,[4] the NV-based widefield quantum sensing platform has developed rapidly and is now deployed for practical applications in various areas, including biomedical, condensed matter physics, and integrated circuit inspecting.

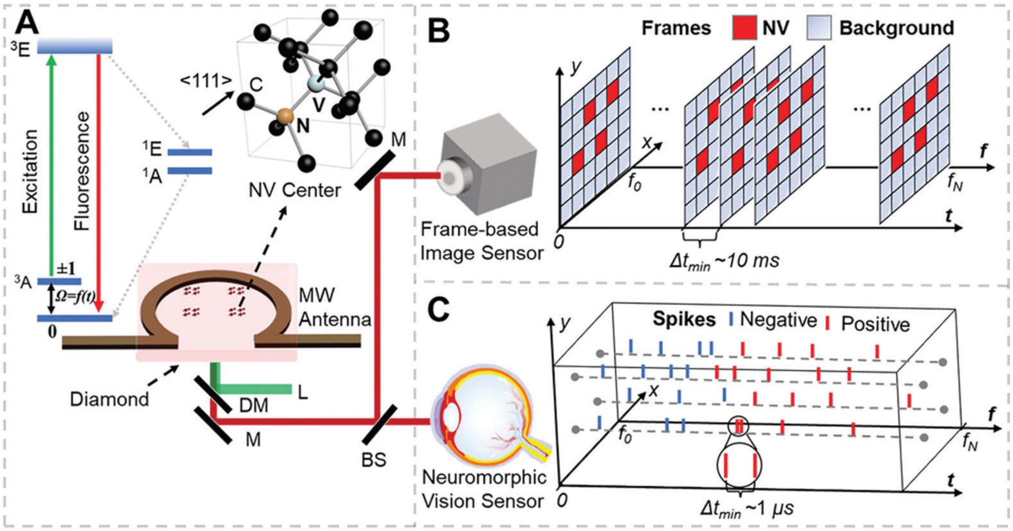
There are several challenges in the field of widefield quantum sensing, though, as explained in the next section. To address these challenges, we explored a novel method of performing widefield quantum sensing that uses neuromorphic vision sensors as the fluorescence detectors instead of the commonly used frame-based cameras (Figure 1).[5]

Current challenges in widefield quantum sensing

Simultaneously achieving high temporal resolution and sensitivity remains a key challenge in widefield quantum sensing. This difficulty is largely due to the transfer and processing of massive amounts of data from the frame-based sensor to capture the widefield fluorescence intensity of spin defects in diamonds. This data transfer can significantly limit the temporal resolution, which is typically no more than 100 fps due to the use of frame-based image sensors. As a result, the potential to use widefield quantum sensing for dynamic magnetometric measurements has been exploited only to a limited extent.

Several studies propose different approaches to improve the temporal resolution in widefield quantum sensing, but each approach has its limitations. For example, the down-sampling method may introduce artifacts into the data; frequency multiplexing involves complicated implementation while providing limited speed-up; advanced sensing arrays with single-photon avalanche diodes require complex circuit integration; and in-pixel demodulation with lock-in cameras sacrifices sensing precision. In each case as well, the fundamental limitation still lies in the monitored fluorescence intensity changes with image frames associated with a vast amount of data, leading to unsatisfactory performance in widefield quantum sensing.

Figure 1. A) Overview of NV-based widefield quantum sensing: energy level diagram and atomic structure of NV centers, and the experimental apparatus of widefield quantum diamond microscope. L: laser; DM: dichroic mirror; BS: beam splitter; M: mirror. B) Schematic showing the working principle of frame-based widefield quantum sensing, in which a series of frames are output from a frame-based sensor recording both fluorescence intensity and background signals. C) Schematic showing the working principle of proposed neuromorphic widefield quantum sensing, in which fluorescence changes are converted into sparse spikes through a neuromorphic vision sensor.



Exploring the potential of neuromorphic sensors

To overcome this bottleneck, we propose using a neuromorphic vision camera to pre-process fluorescence intensity data near the sensor device.

Unlike traditional sensors that record light intensity levels, neuromorphic vision sensors process light intensity changes into "spikes" similar to biological vision systems. Additionally, the neuromorphic pixels work independently and asynchronously, enabling the immediate readout of detected fluorescence change without waiting for the other pixels. These features of neuromorphic vision sensors result in highly compressed data volume and reduced latency, which allow for significantly enhanced temporal resolution (≈μs) and dynamic range (>120 dB).

Neuromorphic vision sensors are also effective in scenarios where image changes are infrequent, such as object tracking, because the event data that constitute the time-varying fluorescence spectrum are generated only when the light change surpasses a threshold. This requirement reduces redundant static background signals and overcomes the limitations of frame rate in the frame-based approaches, enabling low-latency measurements.

This study, to the best of our knowledge, is the first to use neuromorphic vision sensors to perform wide-field diamond quantum sensing.[5] We started by conducting a thorough theoretical evaluation to demonstrate the feasibility of our idea and to guide our following experiments. We then adapted an off-the-shelf neuromorphic event camera and compared it to a state-of-the-art highly specialized frame-based camera.

Our neuromorphic method demonstrated a 13× improvement in temporal resolution with comparable precision as compared with the frame-based approach. We also successfully used this technology to monitor dynamically modulated laser heating of gold nanoparticles coated on a diamond surface, a recognizably difficult task using existing approaches.

Conclusion

The essence of widefield quantum sensing is to detect changes in the number of photons across space and time, presenting a complex trade-off in both spatial and temporal domains. Our event-based working process offers the ability to detect sparse events adaptively in both space and time, thus matching well with the requirement of quantum sensing.

We anticipate that our proposed method will revolutionize widefield quantum sensing, significantly improving performance at an affordable cost. Our study also has significant potential for further development in other applications. For example, in addition to its application in dynamic temperature measurement, it can be readily extended to magnetic field sensing, which has implications for the manipulation of magnetic skyrmions, spin-assisted super-resolution imaging, and detection of neuron action potential, among other possibilities.

Furthermore, neural network algorithms could be used to map the raw events back to the original spectrum because they preserve the derivative function relationship, i.e., directly infer the observables, such as temperature and magnetic field, potentially optimizing the precision further. Integration of electronic synapse devices could also enable in-sensor or near-sensor algorithm execution, paving the way for the development of intelligent quantum sensors.

We are excited to witness the new opportunities in scientific research and practical applications that our study brings.

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Evolving the lever rule: Short-range order configuration modeling of zinc borate glasses

By Brian Topper, Doris Möncke, and Christos Varsamis

Borate and boron-containing glasses have long held a prominent position in glass science since the advent of glass chemistry in the 19th century, when their good glass formability and versatility was discovered.[1]

Within this glass family, zinc borates were identified early on as a system worth investigating. They were touted as "beautiful, sparkling glasses," uniquely possessing both high refractive index and good ultraviolet transparency.[2] Yet it was only in the past few decades that the short-range order structure of these glasses started to be revealed, mostly thanks to advances in characterization technologies. Understanding the short-range order structure of these glasses is important because the microscopic structural units determine the material's macroscopic properties.

The earliest structural work on zinc borates came out of Bray's pioneering lab in the early 1980s.[3] Raman spectra reported in the following decade unambiguously showed the presence of boroxol rings, borate rings, metaborate triangles, pyroborate dimers, and orthoborate monomers.[4] Contemporary studies confirmed this diverse structural picture of the "zinc metaborate" glass.[5,6]

In our recent work,[7] we aimed to quantify the short-range order (SRO) of the binary zinc borate system across the entire glass-forming range. However, given the results found in References 4–6 and our initial assessment of the vibrational spectra, the system would be extremely difficult to analyze via band decomposition of spectroscopic measurements due to heavy overlap of the spectral features. So, a modified lever rule was used to account for the observation of all types of borate species at a composition lying between the meta- and orthoborate modification levels.

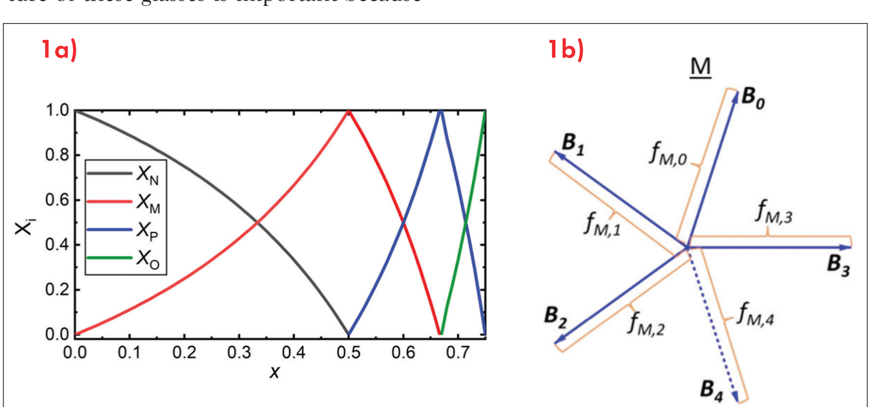

Figure 1. (a) Older notation of the lever rule used in discussion of SRO structure in binary borate glasses xMO–(1-x)B_2O_3, where the mole fractions $X_i(x)$ (i = N, M, P, O) correspond to the species neutral N $(BO_{1.5})^0$, metaborate M $(BO_2)^-$, pyroborate P $(BO_{2.5})^{2-}$, and orthoborate O $(BO_3)^{3-}$. (b) Theoretical short-range order metaborate configuration with all SRO building block molar fractions ($f_{M,i}$) of equal length.

Evolving the lever rule

The conventional lever rule says that when a modifier is introduced into the fully polymerized glass, nonbridging oxygens are created on network formers. As more modifiers are added, the creation of more nonbridging oxygens is necessitated, and so on. The conventional lever rule is depicted in Figure 1a, wherein x denotes the fraction of modifier added to B_2O_3 and X_i represents the fraction of individual borates units: neutral (N), metaborate (M), pyroborate (P), and orthoborate (O).

The short-range order configuration (SROC) model reimagines each of the nodes as a five-dimensional vector space where the basis is the set of short-range order (SRO) building blocks. The building units are B_j, where j is the number of bridging oxygen atoms per boron (Figure 1b). To apply this model, the molar fraction of the SRO building blocks at each node must be determined experimentally.

Experimental design

We prepared xZnO–(1–x)B_2O_3 glasses by combining oxide starting materials in platinum crucibles and melting them in an electric furnace. After removal from the furnace, different cooling rates were obtained by either splat quenching or casting and annealing. We then used vibrational spectroscopy (Raman scattering, infrared reflectance), nuclear magnetic resonance, differential scan-

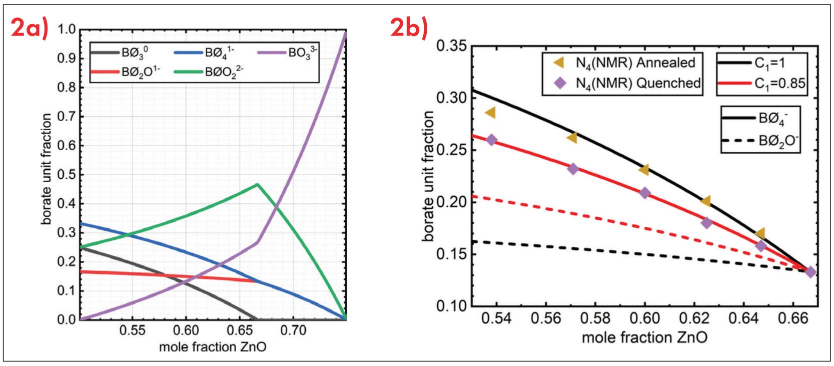

Figure 2. (a) Theoretical fraction of short-range order structural units in binary zinc borate glasses with the fictive temperature-dependent constant set to 1. Note that beyond x=0.667 the fractions of metaborate triangles and tetrahedra are identical. (b) Comparison of theoretical and experimental (B_4 only) fraction of metaborate type species in the bulk glass-forming range; NMR data by R. Youngman, Corning.

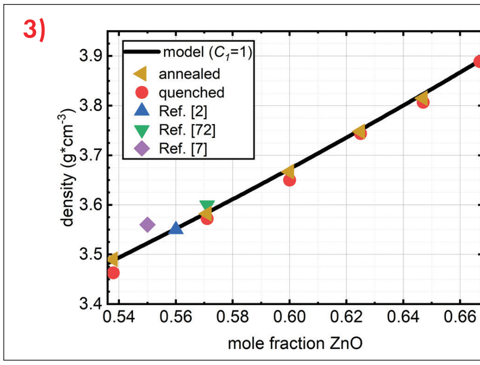

Figure 3. Predicted density using SROCM with fictive temperature dependent constant set to 1 compared to experimental values for binary zinc borate glasses measured in this study (orange triangles and red circles) along with several literature values.

ning calorimetry, and density measurements to characterize the samples. Structurally, the evolution of the borate framework was seen to be sensitive to the ZnO content over the entire glass-forming range.

Application of the SROC model

The SROC model was carefully applied by using the data from spectroscopic measurements. SROCs for the theoretical M, P, and O species were determined to describe the structure over the interval $0.5 \leq x \leq 0.75$. By adjusting the unique SROC contribution at a given x by applying the thought process depicted in Figure 1a, the short-range order structure of zinc borate glasses was determined as a function of x over the entire glass-forming range, as depicted in Figure 2a.

Differences between the structure and physical property measurements of annealed and quenched glasses motivated the introduction of a fictive temperature-dependent constant (C_1) to capture the cooling rate dependence of the metaborate equilibrium. The fraction of tetrahedral boron as determined by nuclear magnetic resonance is plotted for the quenched (purple diamonds) and annealed (orange triangles) glasses in Figure 2b. The prediction of tetrahedral boron by the model for the bulk glass-forming range by quantifying the structure at x=0.5 and x=0.67 is exceptional, with deviation between modeled and experimental tetrahedral boron being as low as 1%.

The model's utility was confirmed by testing its ability to predict glass density (Figure 3). This test was carried out by taking the unique volume fraction and mass of the individual borate units as done by Feller et al.[8] As with the model's prediction of tetrahedral boron, the modeled density mirrored experimental results closely, with the error being approximately 0.004 $g \bullet cm^{-3}$, or about 0.1%.

Conclusions

The new SROC model developed in this study enabled the determination of binary zinc borate glass structure over the entire composition range. The model is suitable for modified glasses in general, as there is no a priori reason limiting its application to only zinc borates. Ultimately, the model presents itself as a mathematically simple and surprisingly powerful new tool for the glass scientist, particularly with its ability to describe and quantify disproportionation reactions in borate glasses and melts.

Acknowledgments

We are grateful for Randall Youngman from Corning for 11B NMR measurements.

About the authors

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Editor's note

Topper presented the 2024 Kreidl Award Lecture at the Glass & Optical Materials Division Annual Meeting on May 21, 2024. Learn more about the conference at https://ceramics.org/gomd2024.

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WELCOME TO THE 'EMERGING PROFESSIONALS' ISSUE

By Michael Thuis

The modern student is entering an increasingly transient world. From artificial intelligence to quantum computing to climate change, the problems materials scientists and engineers face are growing more multifaceted. The next generation of ceramists must be prepared not only with a technical appreciation of their field but also a full social, ethical, and professional understanding to craft a successful career.

The 2023–2024 PCSA delegates at the PCSA annual meeting in October 2023.

For students, fulfilling all these expectations is difficult to navigate alone. That is why, as an ACerS community, we are building a home for students to equip themselves with these essential skills and tools.

The ACerS President's Council of Student Advisors is working this year to integrate these ideas further into the ACerS ecosystem. Halfway through 2024, the Council's 38 delegates, from 19 universities and five countries, have already expanded new and existing programs through the PCSA's five committees.

- **The Conference Programming Committee** arranged for student-focused activities at every ACerS conference in 2024. The Committee also created a conference guide to help students become oriented at their first conference.
- **The Professional Development Committee** continues to expand the library of ACerS student webinars focused on early career development. This expansion coincides with supporting IGNITE MSE, a new professional development program organized by the Ceramic and Glass Industry Foundation that runs in conjunction with select ACerS conferences.
- **The Education Committee** shared Materials Science Classroom Kit lessons and Mini Kits at the 2024 National Science Teaching Association conference, which is the largest conference for science teachers in the U.S.
- **The Recruitment and Retention Committee** worked tirelessly last year to recruit leaders from the ACerS community from nontraditional backgrounds, with a particular focus toward fostering the ACerS community in Africa. Their work allowed this year's PCSA delegation to be the largest to date.
- **The Communications Committee** continues to grow the PCSA's social media presence and is working to communicate PCSA initiatives with a broader scientific audience.

The PCSA Communications Committee also led the rebranding and expansion of the annual student section in this year's June/July *Bulletin*. The new "Emerging Professionals" section aims to better showcase young ACerS members along every step of their journey, from undergraduates to recent graduates. The section consists of two parts:

- **Research articles**: Three full-page articles describe research based on this issue's theme, "Ceramics for digital technologies." These articles are contributed by Material Advantage, Global Graduate Research Network, and Young Professionals Network members.
- **"Science for Society" articles**: This two-page spread features three stories on the IGNITE MSE poster topics of outreach and community engagement; technology for social good; and inclusivity, diversity, and ethics in research.

This year also features two bonus articles contributed by ACerS members and staff, which describe the need for inclusivity in Q&A sessions at scientific conferences and the success of new diversity scholarships funded by ACerS, respectively.

I hope you find this year's "Emerging Professionals" issue of the *ACerS Bulletin* insightful.

Michael Thuis is a Ph.D. candidate at Northwestern University studying in the Haile Lab. As the 2023–2024 PCSA Council Chair, he has worked to expand the presences of the PCSA in the ACerS community while sharing lessons learned. ■

New architectures and materials for electronic packaging

By Javier Mena-Garcia

It can be difficult to imagine our daily routine without the electronic devices and gadgets that enable everything from our energy infrastructures to transportation systems to communication networks. The importance of electronics to modern life is recognized by the outpouring of funding and initiatives in recent years to support the manufacture of semiconductor chips,[1] which form the heart of today's electronics.

Developing new ways to package semiconductor chips is a focus of these programs. Traditionally, the performance of electronic devices was improved by making semiconductors smaller, which allowed more to be placed on each chip and increased processing power. However, semiconductors are now so small they are running up against the laws of physics. So, instead of shrinking chips further, designing novel strategies for combining (packaging) semiconductors together can reduce power consumption and increase processing power.[2]

3D packaging is an emerging approach to chip design that involves using traditional circuit connection methods to achieve vertical stacking of memory layers directly on a processor chip. This architecture provides the benefits of miniaturization while also reducing the time required for data transfer due to the processing and memory chips being closer together. To make the most use out of this architecture, however, ferroelectric materials that can be deposited at low temperatures on the chip must be developed.[3]

In addition to new architectures, designing materials with enhanced electrical and thermal properties is another way to improve the performance of electronics. For example, ceramic matrix composites (CMCs) may play a role in future circuits.

CMCs consist of fibers, modifiers, and filler materials placed within a ceramic matrix. CMCs are frequently talked about in the context of aerospace structural components, but they are also being considered for use in electronics because, depending on the fillers, they can exhibit higher thermal conductivity and higher electrical resistivity while simultaneously preserving a low dielectric loss.

As a Ph.D. candidate in professor Clive Randall's group at The Pennsylvania State University, I have investigated the feasibility of fabricating CMCs for electronics using cold sintering.[4] Cold sintering uses a transient transport phase (typically liquid) and pressure to enable densification of a ceramic system at much lower temperatures than traditional methods.[5]

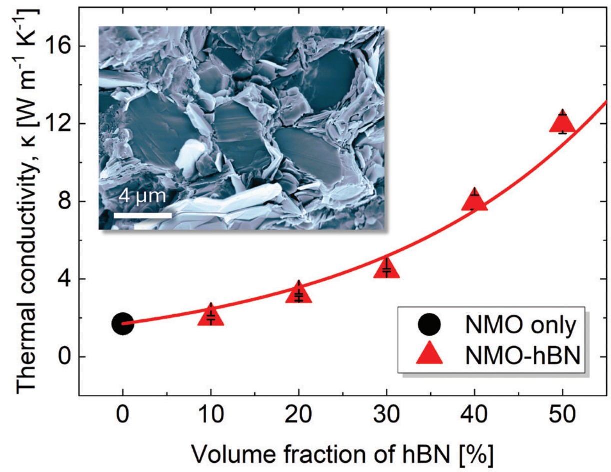

Figure 1. Inset picture: Scanning electron microscopy image of engineered microstructure of sodium molybdate (NMO) with 40 vol.% of hexagonal boron nitride (hBN) filler, enabled by cold sintering. Main graph: Improvement of thermal conductivity as a function of filler volume fraction. Adapted from Reference 5.

To achieve CMCs with low dielectric loss and enhanced thermal conductivity, we engineered grain boundaries in the ceramic matrix using filler materials with strong covalent bonds and wide band gaps, such as hexagonal boron nitride and diamond (Figure 1). The integration of these fillers into the CMC also decreased the composite's effective relative permittivity, brought the thermal coefficient of resonance frequency closer to zero, and improved the electrical insulation breakdown strength.

I feel fortunate to conduct research that advances the electronics field. The scientific discoveries and inventions we have and will make are key to realizing a more sustainable world.

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Javier Mena-Garcia is a Ph.D. candidate in materials science and engineering at The Pennsylvania State University. He studies structure–property relationships in ceramic matrix composites enabled by cold sintering. He is a Fulbright alumnus from Mexico, who enjoys going on long road trips with his wife, Cristy, and playing basketball. ■

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The ins and outs of multilayer ceramic capacitors

By Sevag Momjian

Long gone are the days when computers filled an entire room. Now, digital devices the size of your palm can perform operations in seconds that used to take computers days.

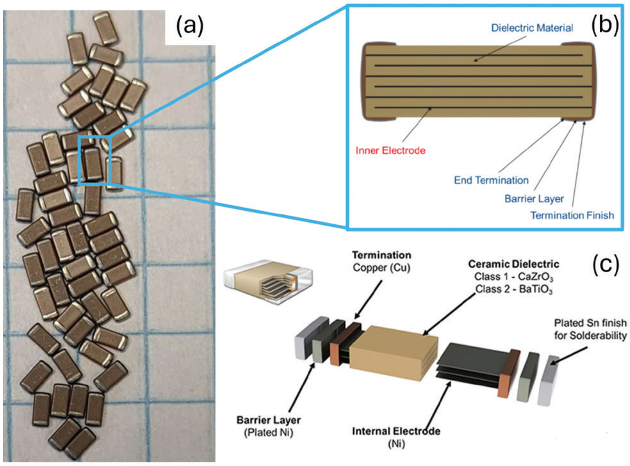
Miniaturization of these electronic packages results from smaller circuit components and compact hybrid integrated circuit designs. These circuits consist of active and passive components. Active components, such as transistors, perform all computational and memory processes. Passive components supply charge to the processing chips.

Multilayer ceramic capacitors (MLCCs) are one of the most common passive components (Figure 1a). MLCCs serve various roles in electronic packaging, including as energy storage devices, transient energy suppliers, and noise filters for electromagnetic signals. In general, MLCCs consist of dielectric (electrically insulating) materials placed between metal electrodes, typically nickel or silver-palladium alloys, in thin alternating layers (Figure 1b). These electrodes are connected on opposite sides of a metal termination layer (Figure 1c).

There are two main classes of dielectrics used in MLCCs. Class I or "linear" dielectrics are stable and reliable over a wide temperature range but store less energy per volume. Class II or "nonlinear" dielectrics store more energy per volume but have a smaller operating temperature range and are less stable. $BaTiO_3$, which undergoes a phase transition from the ferroelectric to paraelectric phase at 125°C, is a Class II dielectric.[1] This phase transition limits the operating temperature range for $BaTiO_3$-based MLCCs, but it remains the preferred dielectric in hybrid integrated circuits due to the need for high volumetric efficiency.

MLCCs are produced by a co-firing process. First, nanoscale ceramic powder is mixed with a plasticizer and binder to form a slurry, which is then tape cast and dried into a large sheet. Next, metal electrodes are screen printed onto these sheets, which are then stacked, laminated, and cut into shape. Following burnout of the binder at about 400°C, the MLCCs are co-fired at about 1,200°C, which densifies and fuses the dielectric and electrode layer. Finally, metal termination layers are applied.

MLCC technology has advanced the miniaturization trend by reducing layer thickness to less than a micron and increasing the number of layers to hundreds, achieving typical dimensions of about 0.02 inches by 0.01 inches. But while decreasing layer thickness enhances capacitive volumetric efficiency, it poses challenges to reliability. Heightened electric fields within the thinner layers accelerates diffusion of oxygen vacancies to the ceramic–electrode interface, causing degradation.[2] For this reason, MLCCs account for about 30% of failures in hybrid integrated circuits.



Credit: (a) Sevag Momjian; (b,c) KEMET Corporation

Figure 1. (a) Typical MLCCs used in hybrid integrated circuits. (b) Schematic of basic MLCC with alternating electrode (gray) and dielectric (beige) layers. (c) Structure and material makeup of an MLCC.

Finding a balance between volumetric efficiency and reliability requires advances in manufacturing and particle design. Manufacturing advances include fast firing in the initial co-firing step, which reduces interface roughness and differences in a layer's thickness. A second firing step at a lower temperature and higher oxygen partial pressure oxidizes the $BaTiO_3$–metal interface, which moves oxygen vacancies away from the interface and into the $BaTiO_3$ grains.

Regarding particle design, decreasing particle size results in smaller grains with more grain boundaries, which can act as barriers to the migration of oxygen vacancies and improve reliability. Compositional engineering can lower oxygen vacancy concentrations as well and improve the dielectric's temperature stability.

New models and tests are also being developed to understand and predict the degradation behavior and lifetime of MLCCs. These methods, when paired with our knowledge of defect and crystal chemistry, further guide innovations in dielectric design.

Together, this partnership between modeling and experimentation will help guide development of next-generation MLCCs.

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Sevag Momjian is a Ph.D. candidate at The Pennsylvania State University in professor Clive Randall's group. He studies the cold sintering of dielectrics materials and the mechanisms enabling such densification. Outside of school, he enjoys playing soccer, tennis, and cooking. ■

From experiment to digital-powered materials science: My transition from academia to research at Leonardo Labs

By Alessandro De Zanet

Materials research and digital technologies are extremely intertwined fields nowadays. On the one hand, advanced materials are core components of the state-of-the-art computing, communication, and sensing technologies that make our world go round. On the other hand, systems powered by artificial intelligence and high-performance computing architectures are enabling the rapid design, analysis, and upscaling of new materials.

The increasing importance of and reliance on computational tools to advanced materials research has been discussed in some previous *Bulletin* articles.[1,2] The topic gained new relevance to me after I graduated with my Ph.D. and entered the workforce as a Research Fellow at Leonardo Labs in April 2023.

Leonardo Labs are extensions of Leonardo (Rome, Italy), a global player in the aerospace and defense sector. These technological hubs, which are spread across the entire Italian peninsula, create synergies with local research ecosystems and Leonardo manufacturing sites. They focus on the research and development of cutting-edge technologies in several research areas, including Materials Technologies, Quantum Technologies, and Applied Artificial Intelligence, to name a few.

I work in the Materials Technologies area at Leonardo Labs in Rome, Italy. In my role, I carry out research on adhesion technologies and ceramic materials, with a strong focus on the importance of digitalization at all stages of the product development process, from early stages to its release and often beyond.

Before joining Leonardo Labs, I conducted mainly experimental work for my Ph.D. research on nonoxide ceramic matrix composite joints. This research was interesting and allowed me to acquire a lot of materials knowledge and experimental skills, but I only had a small taste of everything that falls under the umbrella of computational tools.

In the fast-paced world of industry, however, relying only on experimental methods to identify and develop new materials and processes will not let you keep pace with your competitors. For this reason, I have dedicated myself to enriching my toolkit as an experimental researcher with new computational skills.

For instance, I am exploring the use of finite element analysis (FEA) to virtually assess dissimilar joints and coatings. I use existing data for model pre-validation and training, and then I use the model to determine the most promising solutions for real-world testing. To improve predictability of the FEA model, we follow an iterative process: compare virtual results with real experiment outcomes, adjust the model based on discrepancies, and refine through multiple cycles. This process of continuous validation and adjustment enhances the model's accuracy, making our predictions more reliable over time.

Executing these simulations, however, requires a balance between achieving high accuracy and managing computational time demands. Fortunately, our organization benefits from access to a proprietary supercomputer named davinci-1.[3] The davinci-1 supercomputer plays a pivotal role in our company's ambitious strategy of achieving comprehensive digitalization and integration of artificial intelligence across all processes. Its computational abilities free us from the typical constraints of processing power, thus allowing us to perform extensive simulations involving complex models swiftly and without sacrificing accuracy.

Of course, even as I am dedicating myself to enriching my toolkit, it is impractical to master every skill. Fostering collaborations with experts from diverse backgrounds and expertise becomes essential, and fortunately Leonardo Labs is structured to allow for such cross-disciplinary collaborations, internally and externally.

As I continue to advance in my professional career, I look forward to the collaboration and upskilling opportunities that Leonardo Labs affords me. But I also want to note the importance of actively participating in international professional societies, such as ACerS. These societies allow for interaction with professionals from all sectors and to stay updated on the main trends in the world of ceramics and the broader materials research community.

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Alessandro De Zanet is a Materials Research Fellow at Leonardo Labs (Rome, Italy). His research focuses on adhesion technologies and the development of innovative ceramic-based solutions to address materials challenges. He is co-chair of the ACerS Young Professionals Network. Beyond his professional pursuits, Alessandro is passionate about spending quality time with family and friends. ■

SCIENCE FOR SOCIETY

IGNITE MSE: Igniting student passion for materials research

For many ACerS members, their passion for materials research is driven by a desire to create a positive impact on society through their scientific endeavors. ACerS student members can share this passion at ACerS conferences through IGNITE MSE, a special student professional development event organized by the Ceramic and Glass Industry Foundation.

IGNITE MSE poster sessions are designed to showcase the human side of research, with submissions focused on outreach and community engagement; technology for social good; and inclusivity, diversity, and ethics in research.

Drawing on this format, we have invited student-written articles from each of these topic areas for the June/July *Bulletin*. Read the articles below and learn more about IGNITE MSE by visiting https://foundation.ceramics.org/ignite-mse.

IGNITE MSE

Navigating through the noise: Key factors for effective outreach in an age of information overload

[OUTREACH AND COMMUNITY ENGAGEMENT]

By Rishabh Kundu

In an era where billions of gigabytes of data are generated daily,[1] effectively disseminating information—particularly in scientific realms—presents significant challenges. Hence, strategic approaches to outreach and community engagement become imperative.

Through insights gained from more than five years of engagement in outreach initiatives, I aim to highlight several essential factors that can significantly aid in fruitfully getting the word out about science.

Target audience

Identifying a specific audience and tailoring your content for them will allow information to be communicated more effectively. While aspiring to engage a wide and varied demographic is commendable, crafting a "one-size-fits-all" delivery approach is challenging when you consider the diverse viewpoints held by each individual, as influenced by their age and cultural background.

Appropriate platform

Once you have established the target audience, it is important to determine their primary sources/platforms of information. Attempting to engage teenagers effectively through LinkedIn, for instance, would not be ideal because they typically do not use that platform.

Engaging content

Even with the right place (*appropriate platform*) and the right people (*target audience*), the content needs to be engaging to capture and hold the audience's attention. For example, when introducing high school students to materials science at institutional open house days, I incorporate interactive elements into my demonstration, such as posing questions with multiple correct answers. This format keeps all avenues of engagement open regardless of their response—and an engaged audience is an attentive audience.

Feedback

While we may be passionate about the topics we are promoting, it is ultimately the audience's interest we must spike. So, seeking feedback from the target audience is crucial to supporting effective engagement. I learned the value of feedback during my undergraduate studies, when I delivered a presentation on heat shields to high school students. I crafted the presentation based on my interests, but the students expressed boredom and disinterest in the subject matter. Though initially disheartening, their feedback taught me a valuable lesson—what inspires me may not necessarily captivate others. So, I revised the content based on their feedback, resulting in a more effective presentation.

Iteration

Outreach is a recursive process, meaning it requires timely follow-ups to maintain engagement and retention. Even if you develop an engaging content plan that ticks all the boxes above, information is quickly forgotten if you do not review or revisit it again.[2]

This list is not exhaustive, and I welcome feedback and discussions from peers involved in outreach activities or those motivated to embark on such endeavors.

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Rishabh Kundu is an incoming Ph.D. student at Case Western Reserve University. He has been recognized as an ACerS Global Ambassador and is highly engaged in outreach efforts focusing on materials science and sustainability. Contact Rishabh at kundurishabh@gmail.com. ■

From Himalayan roots to technological heights: Experiencing the impact of science on society

[TECHNOLOGY FOR SOCIAL GOOD]

By Seema Negi

Technological advancements and innovations do not happen in a void; as innocuous as a development may seem, new devices are bound to have some level of impact on society. Whether this impact is beneficial or not, however, is an open question.

My first encounter with the impact that technology can have on local communities was in my childhood home of Thatyur, a small village in the Himalayan heartland of Uttarakhand, India. A defining moment in the history of this area was the construction of the Tehri Dam, the tallest dam in India. This significant development reshaped the landscape and required the mass relocation of many villages and their inhabitants. But it also brought new job opportunities that many members of my community, including my relatives, embraced. Our school trips to the dam further fueled my interest in engineering, showing me the tangible benefits of technology in our daily lives.

In 2007, I gained a deeper appreciation for how technology can address social and environmental issues during my time at Govind Ballabh Pant Engineering College in Pauri. As a member of the robotics club, I built robots using recycled materials, a project that showcased the possibilities for sustainable manufacturing. In addition, the lack of internet access meant we had to rely on books and senior students' knowledge, which emphasized to me the importance of shared knowledge and resourcefulness in technological innovation.

In 2014, when I was studying materials science at the Indian Institute of Technology Gandhinagar, I became the senior student sharing their knowledge when I taught students from institutes with fewer resources about various advanced material characterization techniques. This experience showed me the power of technology in promoting educational equity.

Later during my studies, in 2017, I was introduced to the world of 3D printing. I researched and demonstrated that a cheap resin printer can be used to 3D print ceramics. This demonstration shows the possibilities for resource-constrained colleges and universities to partake in basic 3D printing research as well.

My work with ceramic slurries for 3D printing helped accelerate the development of a silver-based ink with higher stability. This ink is now being used in an educational project called "Electricity on Paper," which teaches electrical concepts to kids.

Reflecting on my journey, I see technology as a bridge connecting individuals, ideas, and solutions, surpassing geographical and resource limitations. My experiences affirm the role of technology as a catalyst for social good.

Seema Negi is a Ph.D. candidate at the Indian Institute of Technology Bombay who develops photosensitive ceramic slurries for 3D-printed ceramics. In her spare time, Seema enjoys dancing, knitting, and cooking. ■

Alloying my love of pottery with my love of materials science

[INCLUSIVITY, DIVERSITY, AND ETHICS IN RESEARCH]

By Alex I. Tam

Growing up, my father drilled into me that "the hard work of today is the success of tomorrow." Rather poetically, this mantra is reflected in my Chinese name, which contains the character for "complete."

As a child, I would grip my pencil so tightly while completing assignments that it left indents in my hand. Outside of school, I worked in my maternal grandmother's antique shop, helping sell porcelain pillows, antiques, and clay idols.

This job gave me an interest in art, and in both middle school and college, I spent time working on pottery and porcelain at the town's craft center. During that time, I experimented briefly with crazing, which involves choosing glazes with different thermal expansion coefficients than the base ceramic so a web of tiny cracks will appear and cover the final surface.

This love of pottery and crazing, in addition to my interest in studying the Japanese language, led to my discovery of the Japanese artform of kintsugi. In contrast to crazing, which only introduces small line fractures into the glaze, kintsugi involves breaking the entire ceramic vessel and then joining the pieces back together using lacquer and gold. The repaired ceramic gives the effect of permanent evanescence because the breaking of a singular moment is captured in all eternity.

This idea that something can be complete "because of" rather than "despite" the cracks is echoed in my undergraduate studies in materials science. Engineering of grain boundaries is a major tool in the design of ceramics and composite materials. By deliberately introducing cracks into a ceramic's microstructures, it can halt the transmission of defects while increasing the material's strength.

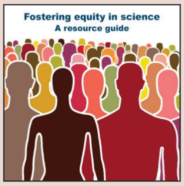
These lessons from pottery and materials science about "completeness" changed my understanding of the concept. Like everyone, I am not without my internal contradictions. But these flaws play a role in bolstering my character and integrity.

In addition, my memories working in the antique shop and listening to my father's and grandparents' stories help me cherish my current opportunities: my grandparents never went to university as I am doing now. So, through my internal flaws and bonds with others, I can learn to improve myself, thus living up to my "complete" name.

Alex I. Tam is a third-year undergraduate student at the University of California, Davis, working with professor Subhash H. Risbud on the characterization of novel superconductors and professor Mingwei Zhang on the characterization of novel high-entropy alloys. His hobbies include studying other languages, reading history books, and experimenting with porcelain. ■

DEI at ACerS

The American Ceramic Society values and seeks diverse and inclusive participation within the field of ceramic science and engineering. Learn more about how you can foster diversity, inclusivity, and equity in the sciences on the ACerS "Fostering equity in science" resource page at https://ceramics.org/fostering-DEI.



More inclusive Q&A sessions will lead to more learning

By Chris Rom

Conference presentations and academic seminars are a key way to share ideas across institutions and build networks with other researchers. However, the question and answer (Q&A) sessions that follow are not fully inclusive: Women ask fewer questions than their share of the audience.[1]

This finding comes from a study led by Alecia Carter, professor in evolutionary anthropology at University College London. Her team collected data from 247 academic seminars across biology and psychology departments in 10 different countries, counting the men and women in the audience and tallying the questions asked by each group. They found that, on average, women composed 51% of the audiences but asked only 32% of the questions.

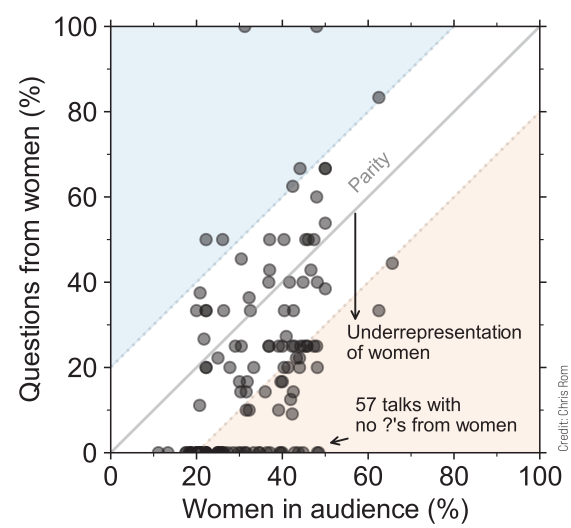


Figure 1. Percentage of women in the audience versus the percentage of questions from women (n = 133 Q&A sessions). Data were collected at in-person conference presentations and academic seminars attended by the author between 2018 and 2024.

Frustrated by the inequity their work revealed, I wondered: Does this problem happen in my communities of ceramics and solid-state chemistry? I replicated their methods at the public talks I attended during my graduate and postdoc studies.* Figure 1 shows that this imbalance also affects my communities, including at a recent ACerS conference.

Q&A sessions provide the benefits of additional learning and enhanced visibility for audience members who ask questions, but women are missing out on these benefits. As a community, we also miss out on the thought-provoking questions that would be asked if Q&A sessions were fully inclusive.

We can and should do better, but how? Raising awareness helps. In 2015, Stanford University graduate student Natalie Telis and colleagues noticed a huge imbalance in the Q&A sessions at the genetics conference they were attending.[2] They discussed the issue on Twitter, which led to a mid-conference presentation on the problem along with a rule change: The first question after each talk must come from a student. Subsequent Q&A sessions at that conference were nearly, though not quite, gender balanced.

Another approach is to pause between the talk and Q&A session so audience members can discuss amongst themselves. Carter et al. suggested that this strategy may help by "[giving] people time to formulate a question and try it out on a colleague."[1] However, evidence on the classroom equivalent of this Q&A strategy (the think-pair-share pedagogical technique) suggests it may not lead to more inclusive public Q&A.[3]

A third option is to enable audience members to ask questions anonymously to remove the pressure of off-the-cuff public speaking. Various online platforms exist to anonymously solicit questions via a QR code, such as Slido and Google forms. But this approach comes at the cost of visibility for those who ask questions.

Despite the tradeoffs with each method, I believe they are better options than the status quo. We should experiment and assess how effective these and other strategies are at encouraging participation from all types of people. If we improve the format of Q&A sessions, we will become more effective at learning from each other and solving big challenges.

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About the author

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*I did not count nonbinary attendees or question-askers to protect their privacy, as small datasets risk being identifiable (ethical approval CSU IRB #3835).

Celebrating underrepresented students with the CGIF's Underrepresented Student Scholarship Fund

By Helen Widman

The Underrepresented Student Scholarship Fund, a program sponsored by the Ceramic and Glass Industry Foundation (CGIF) and ACerS, serves to support underrepresented undergraduate students studying materials science. The CGIF partners with the National Society of Black Engineers (NSBE) and the Society for Hispanic Professional Engineers (SHPE) on this annual scholarship.

In 2023, the CGIF awarded three students with the scholarship: Megan Bynoe (NSBE), Alejandra Almaraz (SHPE), and Fernanda Garcia (SHPE). Learn more about each student's research and goals in the bios on this page.

Help the CGIF support underrepresented students in materials science by contributing to the Underrepresented Student Scholarship Fund at https://ceramics.org/donate. ■

Megan Bynoe, NSBE

Bynoe is a fourth-year undergraduate student in materials science and engineering at Rutgers, The State University of New Jersey. The goal of her research is to create 3D-printed ceramics for aerospace applications, and her dream role after graduation in 2024 involves continuing to work in the aerospace industry. She is also an ambassador for the Rutgers School of Engineering, where she gives tours to prospective engineering students and emphasizes the importance of diversity in the engineering field.

"I think the beauty of bringing in diversity is that you're always going to have different diversity of thought with that, too. I think that is really important because that's how you can move on, that's how you can be challenged, that's how new ideas come about."

– Megan Bynoe

Full profile: https://foundation.ceramics.org/cgif-news/megan-bynoe

Alejandra Almaraz, SHPE

Almaraz is president of SHPE at Boise State University in Idaho, where she studies materials science and engineering. She uses aerosol jet printing to deposit nanoparticle-based inks consisting of titanium carbide MXenes. She hopes to one day use her research to combine materials science with biomedical applications while also encouraging women and Hispanic youth to pursue careers in STEM. She also serves as an officer of the Society of Women Engineers.

"I just think it is super important to have all the different perspectives and for young minds to be able to see that people of color and women are welcome in fields that are traditionally white male dominated."

– Alejandra Almaraz

Full profile: https://foundation.ceramics.org/cgif-news/alejandra-almaraz

Fernanda Garcia, SHPE

Garcia is a materials science and engineering student at California Polytechnic State University. She conducted her senior project on batteries and polymers and knows that she wants her future career in materials science to provide opportunities for giving back to young women in STEM. She feels passionate about supporting migrant students in STEM through her volunteer efforts, such as at Girls in Engineering Camp, Baskin Girls in Engineering Camp, and The Mary Louise Academy Summerfest engineering camp in New York, among others.

"Support comes in so many different shapes. Something that I encourage a lot of women to do is to get into science and to try it out and see if that's for them. There are a lot of females who are inside, who feel lonely, and would love to have more females. We're here to help. And for those who are already in STEM, I would say to just keep going: We're almost there."

– Fernanda Garcia

Full profile: https://foundation.ceramics.org/cgif-news/fernanda-garcia

Failure analysis takes center stage at 59th Annual Symposium on Refractories

James G. Hemrick, center, poses with the Planje award plaque and previous award recipients.

(All photos credit: ACerS)

ACerS Greater Missouri Section and Refractory Ceramics Division held the 59th Annual Symposium on Refractories in St. Louis, Mo., March 26–28, 2024.

This year's symposium, organized by program co-chairs Kenneth Andrew Domann of Rath Group and Brett Ervin of Imerys, had the theme "Unleashing refractory potential: Root cause analysis." A diverse range of topics were covered under this theme during the presentations, from fracture toughness analysis to post-mortem investigations and more.

During the opening session, Refractory Ceramics Division chair Bob Hunter welcomed the 238 attendees, who came from 11 countries. The attendance of some students was made possible by travel grants offered by the Refractory Ceramics Division.

Refractory consultant Tom Vert gave the keynote speech on conducting a root cause analysis. He used the example of a steel ladle argon system breakout and walked attendees through the process of analyzing the breakout. He likened the process to being a detective, such as in the crime drama television series Columbo.

James G. Hemrick of Oak Ridge National Laboratory was this year's recipient of the Theodore J. Planje St. Louis Refractories Award. This award is given to those who show excellence in the field of refractories. Jeff Smith of Missouri S&T presented Hemrick with the award, and Hemrick then posed with many previous award recipients for a photo.

Beau Billet of the Edward Orton Jr. Ceramic Foundation (far left) and Refractory Ceramics Division chair Bob Hunter (far right) pose with students at the tabletop expo.

In addition to the presentations, attendees got to explore the latest refractory products in the tabletop expo.

Almatis staff pose with the eclipse glasses they gave away during the tabletop expo at the 59th Annual Symposium on Refractories.

Vendors showcased their offerings, providing attendees with a hands-on experience and the chance to engage directly with industry representatives. From cutting-edge refractory materials to advanced testing equipment, exhibitors showcase their innovations through live demonstrations, samples, and interactive displays.

Vendors also had plenty of fun giveaways for the attendees. For example, Almatis handed out eclipse glasses for people and their families to enjoy the solar eclipse crossing through much of North America on April 8, 2024.

View more photos from the event at https://bit.ly/Refractories2024. Next year's symposium will take place in St. Louis, Mo., in March 2025. ■

PACC-FMAs 2024 welcomes swell of attendees for week of talks and sloths

Despite a forecast filled with thunderstorms, the weather remained sunny and warm for attendees at this year's Pan American Ceramics Congress (PACC) and Ferroelectrics Meeting of Americas (FMAs), held April 7–11, 2024, in Panama City, Panama.

The PACC-FMAs 2024 meeting chairs were ACerS president and Fellow Rajendra Bordia, ACerS past president and Distinguished Life Member Sylvia Johnson, and ACerS past president and Fellow Sanjay Mathur on the PACC side and ACerS Distinguished Life Member Amar Bhalla organizing FMAs.

This year, the conference witnessed a surge in attendance compared to 2022, when countries were still learning how to navigate the COVID-19 pandemic. More than 220 attendees from 23 countries attended PACC-FMAs, including 64 students.

Of the students who attended, ACerS sponsored the attendance of a record 53 students from several South American countries thanks largely to the work of Alfred University Inamori Professor Steven Tidrow.

Below are highlights from PACC-FMAs 2024.

PLENARY TALKS SHARE HOPE FOR FUTURE

The conference began on Monday, April 8, with an introduction by meeting chairs Bordia, Johnson, and Bhalla, who shared their excitement for the conference's growth and high student attendance.

Three plenary talks followed the introduction, and each speaker echoed the meeting chairs' hopes for the future. The first plenary speaker, Olivia Graeve of the University of California, San Diego, discussed her research on materials for extreme environments but then also talked about her ENLACE summer research program. This program, which started in 2013, brings both high school and university students from all over Mexico and the United States to conduct research at UC San Diego each summer. While the scientific aspects of the program are important, Graeve emphasized that the most critical takeaway is the friendships from both sides of the border.

The second plenary speaker, Manvendra Dubey of Los Alamos National Laboratory, described the historical trends driving climate change and steps that can be taken to tackle this dire challenge. Fortuitously, Dubey ended up demonstrating Graeve's point that friendships made at a young age last a lifetime when he and Bordia discovered they used to be classmates back in university in India, a realization they had not made prior to the conference.

The third plenary speaker was Steven Tidrow, who as mentioned earlier helped identify and raise funds for students to attend PACC-FMAs. His talk focused on building bridges, not fences in education and used examples from his experience developing university programs.

a)

b)

c)

CAREER TALKS DEMONSTRATE MANY PATHWAYS TO MATERIALS SCIENCE

On Wednesday, April 10, students had the opportunity to learn about the many pathways to materials science in a career talks session organized by Johnson. This session was the first of its kind, and almost 20 young and senior professionals shared their journeys in materials science with attendees in 10-minute blocks.

SLOTH SANCTUARY TOUR PROVIDES BREATH OF FRESH AIR

After two and a half days of insightful and rigorous talks, attendees had the opportunity to explore Panama through an ACerS-arranged tour of the Gamboa Sloth Sanctuary. During this outing, attendees also took a boat ride on the Gatun Lake, an artificial lake that forms a major part of the Panama Canal.

View more photos from PACC-FMAs 2024 at https://bit.ly/PACC-FMAs2024. The next PACC-FMAs will take place in spring 2026 at a location to be determined in Central or South America. ■

a) Attendees saw sloths, poison dart frogs, butterflies, hummingbirds, and native vegetation during a tour of the Gamboa Sloth Sanctuary.

b) From left: Meeting chairs Sylvia Johnson, Rajendra Bordia, and Amar Bhalla.

c) ACerS president Rajendra Bordia (center, black suit) met with student attendees during a networking reception on Wednesday, April 10. Steven Tidrow (next to Bordia) helped coordinate the attendance of a record-number of students from South America.

(All photos credit: ACerS)

UPCOMING DATES

HOTEL BONAVENTURE,
MONTREAL, QC, CANADA

The theme for the 10th International Congress on Ceramics will be “Enabling a better world through ceramic and glass materials.”

DAVID L. LAWRENCE CONVENTION CENTER,
PITTSBURGH, PA.

The Materials Science & Technology (MS&T) technical meeting and exhibition series is a long-standing, recognized forum for fostering technical innovation at the intersection of materials science, engineering, and application. At MS&T, you can learn from those who are on the cutting edge of their disciplines, share your work with the leading minds in your field, and build the valuable cross-disciplinary collaborations unique to this conference series.

HILTON DAYTONA BEACH RESORT AND OCEAN CENTER, DAYTONA BEACH, FLA.

The 49th International Conference & Exposition on Advanced Ceramics & Composites (ICACC 2025) will provide a platform for state-of-the-art presentations and information exchange on cutting-edge ceramic and composite technologies.

HILTON CITY CENTER,
DENVER, CO.

Jointly programmed by the Electronics Division and Basic Science Division, this conference is designed for those interested in electroceramic materials and their applications.

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INDUSTRY NEWS

LANDMARK CERAMICS EXPANDS ITS SOLE PLANT

Landmark Ceramics UST, Inc. announced it is investing $71.9 million to expand its tile production in Mt. Pleasant, Tenn. Landmark plans to create 78 new jobs at its North Main Street location. The expansion in Maury County increases Landmark Ceramics' footprint by more than 400,000 square feet and increases its installed production capacity to 80 million square feet a year. The project includes the creation of a highly automated logistics hub. Landmark is a subsidiary of Italian-based Gruppo Concorde.

Landmark specializes in the production and marketing of high-quality porcelain tile. *Credit: Landmark Ceramics UST*

The agreement has a customer option to renew for an additional 10-year period. *Credit: SINTX Technologies*

SINTX SIGNS LONG-TERM AGREEMENT WITH AEROSPACE MANUFACTURER

SINTX Technologies, Inc. entered into a 10-year agreement with a leading manufacturer of aerospace components and systems to manufacture and supply ceramic aircraft engine components. Valued at potentially $8 million over its life, the agreement represents the largest customer agreement to date for SINTX and continues its strategic shift to expand its customer base beyond the biomedical sector and into aerospace, defense, and energy, the company says.

FIRST GLASS PLANT CARBON-CAPTURE TRIAL BEGINS

C-Capture says it has started Europe's first carbon-capture trial on a mainstream flat glass manufacturing plant. The trial is under way in St. Helens, U.K., at a Pilkington glass manufacturing site. The company says the project will prove the ability of its carbon-capture technology to remove carbon dioxide from the flue gas emissions of three industries that are difficult-to-decarbonize. Carbon-capture trials will follow in the cement and energy-from-waste industries.

One of C-Capture's carbon capture solvent compatibility units has been deployed at Pilkington U.K.'s glass production site. *Credit: C-Capture*

General Shale is headquartered in Johnson City, Tenn. *Credit: General Shale*

GENERAL SHALE ACQUIRES SUMMITVILLE TILES

General Shale acquired Summitville Tiles, an Ohio-based producer of ceramic tile and thin brick solutions. Founded in 1928, General Shale is the North American subsidiary of Vienna, Austria-based Wienerberger AG, the world's largest producer of clay brick. General Shale operates 28 manufacturing facilities, 26 retail stores, and a network of more than 200 distributors throughout the U.S. and Canada.

Representatives from the region in Serbia attended the groundbreaking ceremony. *Credit: Schott Pharma/Sasa Krstic*

SCHOTT PHARMA BEGINS CONSTRUCTION ON SERBIA PLANT

Schott Pharma is investing a double-digit million euro amount in a new production site for drug containment solutions and delivery systems in Jagodina, central Serbia. A groundbreaking ceremony took place at the end of December 2023, and in the first phase of construction, Schott Pharma will create 130 new jobs, with 350 planned for the expansion phase.

O-I said the project will support up to 1,200 jobs across four furnaces. *Credit: O-I Glass*

O-I QUALIFIES FOR DOE FUNDS FOR DECARBONIZATION PROJECT

O-I Glass, Inc. was selected by the U.S. Department of Energy to begin award negotiations for up to $125 million in Bipartisan Infrastructure Law and Inflation Reduction Act funding. The company plans to rebuild four furnaces across three facilities in California, Ohio, and Virginia to reduce carbon dioxide emissions by an estimated 48,000 metric tons per year. O-I says the project will demonstrate the functionality of combining multiple technologies across different glass colors and container types.

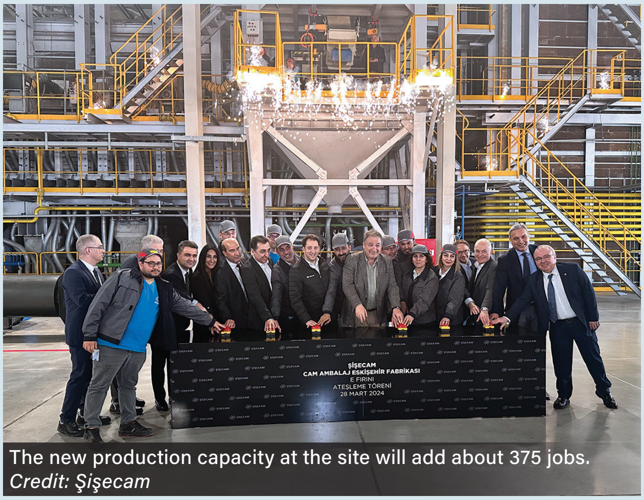
CERION EXPANDS ITS CERAMIC NANOMATERIALS OPERATIONS

Cerion Nanomaterials expanded its ceramic research and development operations, responding to increased demand for ceramic nanomaterials from the aerospace, automotive, electronics, energy, and defense sectors. The company says it increased its capacity for managing thermal reactions in both oxidative and reducing atmospheres, invested in increasing and refining pre-processing and post-processing stages to ensure the precision processing of raw material feedstocks and finished products, and upgraded its in-house analytical center.

Cerion designs custom ceramic nanomaterials for high-volume manufacturing. *Credit: Cerion Nanomaterials*

WORLD'S LARGEST GLASS PRODUCTION SITE IN TÜRKIYE

Global glass maker Şişecam says it has created the world's largest glass production site. With the launch of a new glass packaging furnace and the completion of a cold repair on a glassware furnace, the site in Eskişehir, Türkiye, has a consolidated capacity of about 1 million tons. In addition to its sites in Türkiye, Şişecam operates production facilities in Germany, Italy, Bulgaria, Romania, Slovakia, Hungary, Bosnia and Herzegovina, Russian Federation, Georgia, Ukraine, Egypt, India, and the U.S.



The new production capacity at the site will add about 375 jobs. *Credit: Şişecam*

BUILDING YOUR BUSINESS: EFFECTIVE STRATEGIES TO IGNITE GROWTH

By David Holthaus

Earlier this year, a 105-year-old manufacturer announced it had changed its name. To the observer, the new name was not a major change, but it reflected the company's strategic decision to expand into new markets.

McDanel Advanced Ceramic Technologies, a company started by the McDanel family in 1919, formally changed its name to McDanel Advanced Material Technologies. The new appellation signified McDanel's strategic plan to expand its technology portfolio, which was historically focused on high-purity advanced ceramics. Now, McDanel provides a broader range of material technologies and solutions focused on applications in the aerospace, defense, medical, and semiconductor markets.

"All our new business development efforts are moving toward that direction and growing the business in those four key sectors," says Jason Salley, vice president of sales for the Beaver Falls, Pa.-based company.

As businesses both old and young look to keep growing, they can draw from a playbook of growth strategies that deliver results when carried out effectively. In McDanel's case, the company is using several growth strategies following its acquisition in 2022 by Artemis Capital Partners, a Boston-based private equity firm focused on buying and building differentiated manufacturers of industrial technology. Learn about the growth strategies that McDanel and other companies are deploying in the following sections.

McDanel Advanced Material Technologies plans to focus on four high-growth markets in the future: aerospace, defense, medical, and semiconductors. *Credit: McDanel Advanced Material Technologies*

NEW MARKETS

McDanel works with thousands of customers who buy its traditional line of tubular advanced ceramic products that provide protection in corrosive, high-temperature, and high-stress environments. Its products are mainly used in the furnace and heat-treatment industries, but those markets can be cyclical and static, traits that do not usually lend themselves to strong growth.

McDanel has a portfolio of high-purity materials and a range of machining and R&D capabilities. Pictured is one of the company's traditional tubular advanced ceramic products. *Credit: McDanel Advanced Material Technologies*

"We had to really get strategic about what we wanted the business to be and what we wanted to focus on," Salley says. McDanel will continue to serve its traditional core customers, he says, but their future progression will be focused on four markets: aerospace, defense, medical, and semiconductors.

"We want to focus on highly technical, what I call highly 'sticky' markets and applications," Salley says. "These are the most technical applications that exist in the market."

Getting qualified to provide those applications can eliminate some cyclicality and also provide an entry point to serve legacy customers in new ways, he explains.

SINTX Technologies is another company that has branched into new markets. The Salt Lake City, Utah-based company's core product is silicon nitride, which traditionally is used in biomedical applications. In 2021, the company entered the armor market, installing equipment and renovating a facility in Salt Lake City to provide high-performance ceramic armor plates for personnel, aircraft, and vehicles. With the expansion, the company says it is poised to capture a portion of the global ceramic armor market, which is projected to reach $3.5 billion in 2027.

"Our expertise in advanced ceramics has positioned us as a leader and innovator in the protective armor industry well into the future," says Sonny Bal, CEO of SINTX.

SINTX Armor, a 10,000-square-foot facility in Salt Lake City, Utah, manufactures high-performance ceramic armor plates for personnel, aircraft, and vehicles. *Credit: SINTX Technologies*

ACQUISITIONS

In March 2024, McDanel announced it had acquired Rayotek Scientific, a manufacturer of advanced optical window and mirror systems for the aerospace, defense, space, and semiconductor industries. Founded in 1992 by a group of physicists and nuclear engineers, the San Diego-based company specializes in sapphire, glass, and fused silica windows, mirrors, and other optical systems.

"They add a new dimension to our portfolio and give us a broader scope of materials and capabilities that we can bring to bear," Salley says.

More acquisitions are planned, with the current goal to "purchase two to three acquisitions to bolt on to the McDanel platform, all geared around our four core markets," Salley says.

Acquisitions can be a way to quickly enter new markets. In October 2023, Du-Co Ceramics launched a new metallized product line that generates parts for high-current feedthrough capacitors, transformers, EMI filters, and other systems for the electronics market. Du-Co entered the market through the acquisition of New Jersey-based Mitronics Products.

Saxonburg, Pa.-based Du-Co manufactured custom, green-machined, and glazed ceramic components for Mitronics for several decades when the acquisition took place.

"They were ready to exit the business and reached out to us to see if we had interest in acquiring them," says Tom Arbanas, Du-Co's president. "Since the core of their product was made by Du-Co Ceramics, it made perfect sense for us to proceed with the acquisition and enter this new market."

Du-Co Ceramics moved equipment from a recent acquisition into its Monroe, N.C. plant, where it has room to grow. *Credit: Du-Co Ceramics*

SINTX entered the armor market through an asset purchase agreement with B4C, LLC of Dayton, Ohio, which enabled the acquisition of equipment and technical processes required to make ballistic armor plates.

"This acquisition is a very significant diversification of our products into the U.S. military, Department of Defense, and law enforcement segments," Bal says.

Key acquisitions can also help accomplish strategic goals quickly. In November 2023, glass maker Verallia finalized the acquisition of three companies from the Santaolalla Group that brought it five new glass waste processing plants in Spain and Portugal. The investments are part of the Madrid-based company's strategy of increasing the percentage of cullet use in its production process and will help it make progress toward its carbon-dioxide reduction targets, the company says.

"This acquisition and the investment we are doing all over Europe to increase our cullet capacity treatment is fully aligned with our ESG [environmental, social, and governance] roadmap," Verallia CEO Patrice Lucas says.

FOCUS ON QUALITY AND CUSTOMER SERVICE

Providing top-flight products and exceptional customer service builds a loyal customer base and earns repeat business.

Lithoz GmbH, the Vienna-based provider of ceramic 3D printing systems, reported that 2023 was a record year of growth, with a 30% increase in 3D printers sold in 2023 over 2022. Most of its machines sold in 2023 were to customers that already owned multiple Lithoz printers, the company says.

"By establishing these interconnected machine parks, Lithoz is driving the growth of serial production in ceramic 3D printing," says Johannes Homa, Lithoz CEO. "We're working consistently with our customers to scale up to mass production."

One of its customers, German manufacturer Steinbach AG, used Lithoz technology and serial production to meet a demand for 12,000 tiny but complex parts per year for a maker of surgical robots.

Lithoz also provides supporting software, training, and expertise to allow its customers to achieve that level of serial production, says spokesperson Alice Elt.

"We really want to enable the serial production of highly improved, more functional, and efficient parts," she says. "We have already seen a lot of interest in this idea of part customization for improved functionality, especially when looking at the medical field, and see this offering as likely being a major factor for our growth in coming years."

INVEST IN INNOVATION

Innovation helps businesses stay competitive by offering products, services, or processes that differentiate them in the market and open new revenue streams and opportunities.

At Bosch GmbH, the 138-year-old manufacturer created an internal startup incubator now called "grow platform," which finances and scales digital business model innovations that originate from its corporate research and development arm, its business divisions, or its regional units. It maintains a portfolio of funded start-ups that receive support from Bosch corporate, as well as access to resources, R&D, and key partners. Grow platform has locations in five continents, making it able to access markets worldwide.

"We are able to scale regional business models quickly and globally, taking into account country, target group, and culture-specific aspects," the company says. Since 2019, the portfolio has generated average revenue growth of 64% year over year, the company says.

Bosch Advanced Ceramics is part of the innovation platform, and in 2022 it announced that it had produced the first 3D-printed microreactor made of technical ceramics. Working with the Karlsruhe Institute of Technology, the company created microreactors that can withstand the extreme conditions caused by high-temperature chemical reactions.

INVEST IN EMPLOYEE TRAINING AND DEVELOPMENT

Providing ongoing training and development opportunities for employees enhances their skills and knowledge, as a well-trained workforce is essential for maintaining quality standards and adapting to changing market demands.

Most states have workforce development programs. One is Ohio TechCred, which launched in 2019. The program allows Ohio-based businesses to identify the specific qualifications they need and employees they want to upskill toward more advanced positions. Working with a training provider, such as The American Ceramic Society, the employer can apply online and the state will reimburse up to $2,000 for training upon completion of a credential. Businesses of all sizes from any industry are eligible to receive up to $30,000 per application period and up to $180,000 per year in reimbursement when credentials are earned. Through this process, workers are better prepared to work in the advanced manufacturing economy.

In 2023, 398 employers were approved for funding through the November round of Ohio TechCred. Artificial intelligence credentials were one of the top credentials requested, highlighting the need within the business community for AI-related training for their workforce.

Learn more about state workforce development programs on page 8 of this issue.

STRATEGIC PARTNERSHIPS AND COLLABORATIONS

Strategic partnerships or collaborations with other businesses in the industry can leverage complementary strengths and resources, enabling quicker market response.

In 2023, the U.K-based materials development and testing firm Lucideon and the National Composites Center in the U.K. signed a memorandum of understanding to develop advanced ceramic composites. Lucideon will focus on providing analysis and evaluation, as well as supporting the development of advanced materials and applications. The National Composites Center will concentrate on system and product design and industrial scale development.

"Due to global challenges such as energy security and net zero, there is an increasing need for new, affordable technologies that will endure longer durations in increasingly harsh environments," says Tim Abbott, Lucideon's business manager. "The collaboration will provide the marketplace with end-to-end capability to address these challenges."

EFFECTIVE NETWORKING AND PROMOTION

Trade shows can be an efficient way to meet potential customers, market new products and services, and stay abreast of trends in the industry. Post-COVID-19-pandemic, trade shows have returned to being events that attract large numbers of industry professionals, engineers, executives, and buyers from the technical ceramic market.

The leading trade fair in the U.S. is Ceramics Expo. First held in 2015 in Cleveland, Ohio, Ceramics Expo now attracts more than 3,000 visitors, more than 300 exhibitors, and more than 20 leading speakers to its conference stages. It was held this year in April in Novi, Mich.

The largest industry trade fair in Europe is Ceramitec, held in Munich, Germany. More than 430 exhibitors from more than 30 countries registered for the 2024 show, organizers reported. Traditionally held every three years, Ceramitec organizers this year shortened the cycle to every two years, and the next show will be held in 2026. Shorter innovation cycles in the technical ceramics industry made the rotation change necessary, organizers explain.

Uniceramics Expo is the biggest ceramics exhibition in Asia. It is estimated that 1,200 exhibitors and 150,000 professional visitors attended the 2024 show, which was held this year in April in Foshan, Guangdong, China.

The new logo for HarbisonWalker International, which reflects its identity as Calderys' brand in the Americas. *Credit: HarbisonWalker International*

NEW BRAND IDENTITY

Raising awareness of new products and capabilities can be enhanced by the creation of a new brand identity, which can help tell a company's story and connect with customers. In June 2023, HarbisonWalker International (HWI), based in Pittsburgh, Pa., unveiled a new brand identity to reflect its new life as a member of Paris-based Calderys, a global refractories company. Both businesses were purchased by Platinum Equity, a private equity firm that then combined Calderys and HWI to create one of the world's largest refractories producers.

With HWI now representing Calderys' brand in the Americas, the new brand maintained the well-known HWI acronym and font while adopting the symbolism of the Calderys brand: flames, the caldera of a volcano, and the containing of heat.

"The new visual identity of HWI … is a significant step on our journey to form a unified business that incorporates the best of both brands to create a global high-growth leader," says Michel Cornelissen, president and CEO of Calderys Group.

EMPOWERING THE US WORKFORCE THROUGH STATE-SPECIFIC INITIATIVES

By David Holthaus

The U.S. workforce has experienced a dynamic shift in recent years as skepticism toward 4-year college degrees increases. This changing market requires workforce skills and training adaptation to ensure U.S. workers remain competitive.

Passed in 2014, the Workforce Innovation and Opportunity Act, or WIOA, aims to modernize the nation's workforce system by increasing eligible participants' employment, retention, and salary nationwide. Learn more about WIOA at https://www.dol.gov/agencies/eta/wioa.

While WIOA provides the policy foundation to create programs encouraging a highly skilled and competitive workforce, it also recognizes the necessity for state-specific solutions and strategies that align with industry standards. Discover each of the 50 state-specific workforce development programs below.

STATE-SPECIFIC WORKFORCE DEVELOPMENT INITIATIVES

Alabama

The AlabamaWorks initiative partners with businesses, education providers, and local workforce development boards to support job training and employment opportunities. Specific initiatives can include on-the-job training, and employers may receive up to 75% reimbursement. Learn more: https://wioa-alabama.org/on-the-job-training-2

Alaska

Alaska's Department of Labor and Workforce Development has a State Training and Employment Program (STEP). Some benefits of participating in this program are increased earning potential and a competitive edge for employers. Learn more: https://awib.alaska.gov/training-programs/step.htm

Arizona

Arizona's workforce development initiatives, which are administered through Arizona@Work, include the Incumbent Workforce Training Program, On-the-Job Training, and the Customized Training Program. Learn more: https://arizonaatwork.com/recruit-talent/training-programs

Arkansas

Arkansas Future Fit creates training programs intended to address critical roles within the manufacturing industry, in collaboration with community colleges. The program is aimed at high school graduates, military veterans, and underrepresented populations. Learn more: https://www.arkansasedc.com/business-resources/existing-business/programs-training/future-fit-arkansas-workforce-training-aedc

California

California's Employment Training Panel (ETP) is an employer-driven program that provides funding to help enhance workforce skills through

Credit: iStock

training, targeting high-wage and long-term employment in sectors such as technology, manufacturing, and health care. Learn more: https://etp.ca.gov/planning-your-training/training-opportunities

Colorado

The Colorado First and Existing Industry (CFEI) grants provide customized job training for companies relocating to or expanding in Colorado. These grants support designing and implementing training programs that help workers acquire new skills for a better future. Learn more: https://cccs.edu/cfei-customized-job-training-grants

Connecticut

Connecticut's Incumbent Worker Training Program grants primarily focus on the manufacturing sector. This program provides financial assistance from $5,000 to $50,000 per calendar year to Connecticut manufacturers for employee training and aims to improve productivity, innovation, and competitiveness. Learn more: https://portal.ct.gov/DECD/Content/Business-Development/07_Identify_Develop_Talent/Train-Talent/Incumbent-Worker-Training-Program

Delaware

The Delaware Pathways is a collaborative workforce development program that prepares students, employees, and organizations for in-demand careers. The program's website can be searched for specialized training opportunities based on location. Learn more: https://delawarepathways.org

Florida

The Florida Job Growth Grant Fund supports public infrastructure and workforce training. The fund aims to encourage more businesses to choose Florida as a site for expansion and improve the workforce's skills to meet employers' needs. Learn more: https://www.floridajobs.org/jobgrowth

Georgia

Georgia's Quick Start program has operated for more than 40 years and is free for any qualified company. Quick Start offers customized training in a variety of sectors including automotive, manufacturing, and biotechnology, using advanced strategies and equipment. Learn more: https://www.georgiaquickstart.org/who-we-are

Hawaii

Hawaii's Employment & Training Fund (ETF) supports businesses in upgrading their existing employees' skills. There are two types of ETF funding sources:

1. ETF Macro: ETF Macro provides specific training in high-growth occupational or industry areas.
2. ETF Micro: For individuals and businesses looking to upgrade the job skills of their employees in areas like management, health, medical training, soft skills training, and more.

Learn more: https://labor.hawaii.gov/wdd/employers/etf

Idaho

The Idaho Workforce Development Training Fund aims to help businesses offset the costs of training new or current employees. The combination of private and public funds promotes innovation, economic growth, and ROI for this state by increasing wages, major capital investments in its main industries, and job creation. Learn more: https://wdc.idaho.gov/grants

Illinois

The Illinois workNet initiative connects job seekers with training programs, including those at community colleges and programs approved by WIOA, tailored to industries such as information technology and commercial driving. Learn more: https://www.illinoisworknet.com/Training/Pages/WIOATrainingProgramSearch.aspx

The state also supports business growth through the Illinois Employer Training Investment Program (ETIP), which funds employee upskilling in the manufacturing industry. Learn more: https://ima-net.org/etip

Indiana

Next Level Jobs Indiana trains state residents for high-demand positions in advanced manufacturing, construction, health, life sciences, information technology, business services, transportation, and logistics industries with the prospect of increased earnings following certification. Learn more: https://nextleveljobs.org

Iowa

Iowa's 260F (Iowa Industrial New Jobs Training Program) provides job training services for employees of eligible businesses. These eligible businesses will work with community colleges to assess training needs and provide the appropriate funding to complete an approved course at little to no cost. Learn more: https://workforce.iowa.gov/employers/build-your-workforce/training-programs-and-tax-credits/260f

Kansas

The Workforce AID (Aligned with Industry Demand) initiative, launched by the Kansas Department of Commerce and the Kansas Board of Regents, aims to create a workforce with high-demand skills. Approved organizations can get reimbursement of up to 50% of training costs. Learn more: https://www.kansascommerce.gov/program/workforce-services/ktrain

Kentucky

The Bluegrass State Skills Corporation (BSSC) Grant Reimbursement Program offers grants to businesses for training new, highly skilled workers. Businesses in manufacturing, agribusiness, nonretail service or technology, headquarters operations, hospital operations, and more can apply for training reimbursements. Learn more: https://ced.ky.gov/Workforce/BSSC

Louisiana

The Louisiana Incumbent Worker Training Program (IWTP) is an employer-driven program that trains workers to upgrade their skills with customized training solutions. While some requirements exist, the program is available for most companies in this state. Learn more: https://www.laworks.net/workforcedev/iwtp/iwtp_mainmenu.asp

Maine

The Maine Quality Centers (MQC) program provides customized workforce training for new and expanding businesses throughout the state. From safety training to comprehensive programs that teach workers how to operate heavy machinery or develop management skills, this program covers on-demand courses for Maine residents. Learn more: https://www.mccs.me.edu/workforce-training/maine-quality-centers.

The Competitive Skills Scholarship Program (CSSP) helps workers pursue two- and four-year degree programs that target high-wage, in-demand occupations. Learn more: https://www.mainecareercenter.gov/cssp.shtml

Maryland

The Partnership for Workforce Quality (PWQ) in Maryland provides matching training grants to small and midsized businesses in manufacturing and technology. This partnership reimburses up to 50% of the costs of qualified projects. Learn more: https://commerce.maryland.gov/grow/partnership-for-workforce-quality-pwq

Massachusetts

The Massachusetts Workforce Training Fund Program (WTFP) offers training resources to improve job skills and organizational competitiveness. Learn more: https://www.mass.gov/info-details/workforce-training-fund-programs-wtfp

Michigan

Michigan's Going PRO Talent Fund supports employee training to foster the development of new and in-demand skills. Training funded by this program can include upskilling current workers, offering apprenticeships, and creating customized training. Learn more: https://www.michigan.gov/leo/bureaus-agencies/wd/programs-services/going-pro-talent-fund

Minnesota

The Minnesota Job Skills Partnership (MJSP) awards grants to educational institutions for the development and delivery of training programs in collaboration with businesses. The grants can be up to $400,000 and help educational institutions create and deliver custom training courses. Learn more: https://mn.gov/deed/business/financing-business/training-grant/partnership

Mississippi

The Mississippi Workforce Enhancement Training Fund (WET Fund), administered by the Mississippi Community College Board, is designed to support the training needs of businesses and help create and retain high-quality jobs. The program offers customizable training services to new and existing businesses and industries across the state. Learn more: https://acceleratems.org/employer-resources

Missouri

The Missouri One Start program is designed to help businesses with tailored workforce strategies, including customizable recruitment and training solutions. The program serves new and existing businesses needing training for workers in technical skills and competencies. Learn more: https://missourionestart.com

Montana

The Incumbent Worker Training Program (IWT) offers funding assistance to small Montana-based businesses wanting to train or upskill their current employees. It supports specialized skill development to keep businesses and workers competitive. Learn more: https://prosperamt.org/incumbent-worker-training-iwt-grants

Nebraska

The Nebraska Worker Training Program provides competitive grants to businesses to train employees. The program aims to enhance the workforce's skills, increase productivity, and maintain the competitiveness of Nebraska businesses in national and global markets. Learn more: https://www.dltgrants.info/Grant-Details/gid/59181

Nevada

Nevada's Train Employees Now (TEN) initiative funds workforce training for employers expanding or relocating to the state. It may fund up to 75% of eligible costs to help businesses improve their worker's skills. Learn more: http://www.employmentincentives.com/state_incentives/documents/Nevada/SummTrainEmplyeesNow.pdf

New Hampshire

The New Hampshire Job Training Fund offers grants to businesses looking to train or retrain employees. This includes funding for projects that upgrade employee skills, increase productivity, and help companies in New Hampshire stay competitive in their industry. Learn more: https://www.nhes.nh.gov/services/employers/work-invest-nh.htm

New Jersey

The New Jersey Department of Labor and Workforce Development offers training grants to enhance worker skills, with a focus on underrepresented populations, such as women, minorities, and veterans. Learn more: https://www.nj.gov/labor/research-info/grants.shtml

New Mexico

The Job Training Incentive Program (JTIP) in New Mexico funds training for newly created jobs in eligible businesses, with emphasis on technology and manufacturing sectors. The program reimburses 50–90% of employee wages and offers programs to manufacturing, retail, and certain green industries. Learn more: https://edd.newmexico.gov/business-development/edd-programs-for-business/job-training-incentive-program

New York

The New York State Workforce Development Initiative provides grants and incentives to businesses that commit to creating and retaining jobs, primarily through workforce development and training efforts. These programs will provide funding of up to 90% for eligible businesses. Learn more: https://www.nyserda.ny.gov/All-Programs/Building-Operations-and-Maintenance-Workforce-Development-Training-Program

North Carolina

The NCWorks Customized Training Program supports education and training for new, expanding, and existing businesses in North Carolina. Learn more: https://www.commerce.nc.gov/grants-incentives/workforce-grants/customized-training

North Dakota

The TrainND program, supported by the North Dakota Department of Commerce, provides customized training services to businesses in that state, including upskilling employees in job roles in competitive industries. Learn more: https://trainnd.com

Ohio

The Ohio TechCred program reimburses employers who help their employees earn technology-focused credentials to keep Ohio's workforce competitive in a tech-driven economy. This program may reimburse up to $2,000 per student per course. Learn more: https://techcred.ohio.gov

Oklahoma

Oklahoma Works is an initiative that brings Oklahomans into the workforce with training and education. Employers can access resources for training and retaining their workforce by an eligible provider. Learn more: https://oklahoma.gov/workforce/job-seekers/training.html

Oregon

The Oregon Workforce and Talent Development Board (WTDB) creates a highly skilled workforce in Oregon by including strategies and apprenticeship programs that support the training and upskilling of employees across various sectors. Learn more: https://www.oregon.gov/workforceboard/employers/pages/Employers.aspx#apprenticeshipPrograms

Pennsylvania

The Workforce & Economic Development Network of Pennsylvania (WEDnetPA) initiative allows Pennsylvania companies to train new and existing employees through customized skills and information technology training programs, offering direct assistance and making the Pennsylvanian workforce more productive and competitive. Learn more: https://www.wednetpa.com

Rhode Island

Real Jobs Rhode Island is a workforce development program designed to ensure that Rhode Island employers have the tools to compete and grow while providing targeted education and skills training to Rhode Island workers. The program facilitates business, education, and government partnerships. Learn more: https://dlt.ri.gov/employers/real-jobs-rhode-island

South Carolina

South Carolina's Workforce Development offers training solutions delivered through an extensive network of workforce centers. These programs support employers in accessing and training a skilled workforce, including through training and apprenticeship programs. Learn more: https://scworks.org/workforce-system/partners/state-workforce-development-board

South Dakota

South Dakota UpSkill provides training opportunities for workers across the state. The program assists individuals in learning the skills required for in-demand jobs by connecting them with a job recruiting officer, training, and tools to kickstart their professional careers. Credit: https://dlr.sd.gov/workforce_services/individuals/sdupskill/default.aspx

Tennessee

Tennessee Reconnect is primarily an initiative to allow adults to earn an associate degree or technical certificate free of tuition and fees, but it also supports workforce development by improving the qualifications of the state's workforce. Learn more: https://tnreconnect.gov

Texas

Texas offers the Skills Development Fund, a program that provides customized training opportunities for Texas businesses and workers to increase their skill levels and wages. Employers can collaborate with local community colleges to create training programs to meet workforce needs and industry standards. Learn more: https://teex.org/twc-skills-development

Utah

Utah's Custom Fit program is designed to provide companies with customized employee training. The program offers significant funding to offset training costs, making it easier for businesses to prepare their workforce for industry needs. Learn more: https://business.utah.gov/articles/custom-fit-provides-tailored-training

Vermont

For more than 30 years, the Vermont Training Program (VTP) has supported employees by funding pre-employment, on-the-job, and skill upgrade training. While it caters to various sectors, technology-based businesses can especially benefit from this workforce development initiative. Learn more: https://accd.vermont.gov/economic-development/vtp

Virginia

Virginia's FastForward program is a workforce training initiative that provides short-term training courses through community colleges. These programs help Virginians gain the credentials and skills needed for in-demand technology, health care, and skilled trades jobs. Learn more: https://fastforwardva.org/program-details

Washington

Career Connect Washington is an initiative that aims to create a system where young people and high school graduates can access education and training directly for in-demand jobs, such as through apprenticeships and hands-on learning experiences. Learn more: https://washingtonstem.org/ccw-lights-up-equitable-career-pathways

West Virginia

West Virginia Invests is a financial aid program that covers tuition and fees for those enrolled in certificate or associate degree programs in high-demand fields at West Virginia's community and technical colleges. Learn more: https://www.collegeforwv.com/programs/invest-grant

Wisconsin

The Wisconsin Fast Forward program offers grants to businesses to help train workers in key industries, including advanced manufacturing and information technology. Learn more: https://wisconsinfastforward.com

Wyoming

The Wyoming Works program provides students resources to gain skills and credentials, leading to employment in Wyoming's top industries and encouraging community colleges to create in-demand programs. Learn more: https://communitycolleges.wy.edu/wyoming-works-program

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VOLUME 5

Ceramic & Glass MANUFACTURING

Issue	Theme
April 2024	Nanomaterial manufacturing: Scale-up and commercial production
June/July 2024	Tips for establishing and expanding your business
September 2024	ESG trends in ceramics and glass
December 2024	Commercialization of academic and national lab R&D

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CACT Center for Advanced Ceramic Technology

2024 Summer Industrial Short Courses at AU

Scientific and technological advances shape the face of industry today. Engineers, technologists, and managers need to keep up with the swift changes in the field, meaning they must be lifelong learners. Each summer, Alfred CACT seeks to increase individuals' expertise in the field of ceramics and glass through its industrial short course offerings. CACT can work with you to develop custom content that can be conducted either on campus or at your site, or join us at one of the following programs, currently accepting registrations.

Fracture Analysis & Failure Prevention of Glass and Ceramics
When: June 10 – 14, 2024
Instructors: Dr. James Varner, Professor of Ceramic Engineering Emeritus at Alfred University and Dr. Jeffrey Swab, Senior Research Scientist with the Army Research Laboratory, Aberdeen Proving Ground.

Computational Methods for Glass & Ceramics
When: July 15 – 18, 2024
Instructors: Dr. Collin Wilkinson, Assistant Professor of Glass Science at Alfred University and Rebecca Welch, Visiting Scholar at Alfred University.

For course outlines and registration details, visit:
www.alfred.edu/about/community/short-courses/

For more information visit:
www.Alfred.edu/CACT

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Calendar of events

June 2024

16–19 ➡ 5th International Symposium on New Frontier of Advanced Silicon-Based Ceramics and Composites (ISASC-2024) – Seogwipo KAL Hotel, Jeju Island, Republic of Korea; https://www.isasc2024.org

17–19 ACerS 2024 Structural Clay Products Division & Southwest Section Meeting in conjunction with the National Brick Research Center Meeting – Sheraton Oklahoma City Downtown Hotel, Oklahoma City, Okla.; https://ceramics.org/clay2024

19–21 14th Advances in Cement-Based Materials – Missouri University of Science and Technology, Rolla, Mo.; https://ceramics.org/cements2024

23–27 ➡ American Conference on Neutron Scattering (ACNS 2024) – Crowne Plaza Knoxville Downtown University, Knoxville, Tenn.; https://ceramics.org/acns2024

July 2024

14–18 International Congress on Ceramics – Hotel Bonaventure, Montreal, Canada; https://ceramics.org/ICC10

15–19 ➡ 15th International Conference on the Structure of Non-Crystalline Materials, 15th European Glass Society Conference, and the SGT Annual Conference – Churchill College, Cambridge, U.K.; https://sgt.org/mpage/ESG15NCM15

30–Aug. 1 ★ Tools for Visualizing and Understanding the Structure of Crystalline Ceramics – Virtual; https://ceramics.org/professional-resources/career-development/short-courses/tools-for-visualizing-understanding-structure-of-crystalline-ceramics-2024

August 2024

4–9 Gordon Research Conference – Mount Holyoke College, South Hadley, Mass.; https://ceramics.org/event/gordon-research-conference

18–22 ➡ 14th International Conference on Ceramic Materials and Components for Energy and Environmental Systems – Budapest Congress Center, Budapest, Hungary; https://akcongress.com/cmcee14

19–23 ➡ Materials Challenges in Alternative Renewable Energy (MCARE) 2024 – The Lotte Hotel Jeju, Jeju Island, Republic of Korea; https://www.mcare2024.org/index.php

25–28 ICG Annual Meeting 2024 – Songdo Convensia, Incheon, Republic of Korea; https://ceramics.org/event/icg-annual-meeting-2024

October 2024

6–9 ACerS 126th Annual Meeting with Materials Science and Technology 2024 – David L. Lawrence Convention Center, Pittsburgh, Pa.; https://ceramics.org/mst24

January 2025

26–31 International Conference and Expo on Advanced Ceramics and Composites (ICACC 2025) – Hilton Daytona Beach Oceanfront Resort, Daytona, Fla.; https://ceramics.org/icacc2025

February 2025

25–28 EMA 2025: Basic Science and Electronics Division Meeting – Hilton City Center, Denver, Colo.; https://ceramics.org/event/ema-2025-basic-science-and-electronic-materials-meeting

May 2025

4–9 16th Pacific Rim Conference on Ceramic and Glass Technology and the Glass & Optical Materials Division Meeting – Hyatt Regency Vancouver, Vancouver, Canada; https://ceramics.org/pacrim16

January 2026

25–30 International Conference and Expo on Advanced Ceramics and Composites (ICACC 2026) – Hilton Daytona Beach Oceanfront Resort, Daytona, Fla.; https://ceramics.org/icacc2026

May 2026

31–June 5 12th International Conference on High Temperature Ceramic Matrix Composites (HTCMC 12) and Global Forum on Advanced Materials and Technologies for Sustainable Development (GFMAT 2026) – Sheraton San Diego Hotel & Marina, San Diego, Calif.; https://ceramics.org/htcmc12_gfmat2026

August 2026

31–Sept. 1 ➡ The International Conference on Sintering – Aachen, Germany; https://www.sintering2026.org/en

Dates in **RED** denote new event in this issue.

Entries in **BLUE** denote ACerS events.

➡ denotes meetings that ACerS cosponsors, endorses, or otherwise cooperates in organizing.

★ denotes a short course

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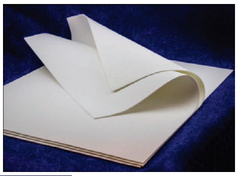

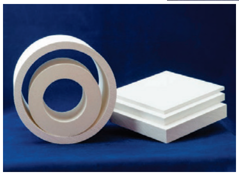

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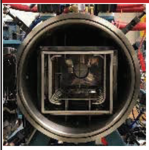

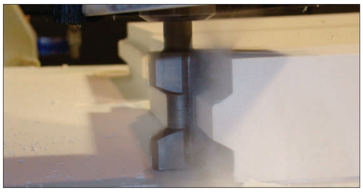

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