AMERICAN CERAMIC SOCIETY
bulletin
emerging ceramics & glass technology
OCTOBER/NOVEMBER 2022

Turkey's advanced R&D inspires tomorrow's innovations

ACerS announces 2022–23 leaders | Solar energy markets | Glass etymology

contents

October/November 2022 • Vol. 101 No.8

feature articles

The American Ceramic Society

ACerS Annual Meeting Events

124th Annual Membership Meeting
Monday, Oct. 10 at 1–2 p.m
David Lawrence Convention Center, Room 407
Pittsburgh, Pa.

Annual Honor and Awards Banquet
Monday, Oct. 10 at 7:30–10 p.m.
Omni William Penn Hotel
(Ticketed event)

departments

columns

meetings

resources

Cover image

Image of the Turkish flag with the Ortaköy Mosque in the background. Located in Beşiktaş, Istanbul, Turkey.
Credit: Meg Jerrard, Unsplash

online
www.ceramics.org

October/November 2022 • Vol. 101 No.8

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As seen on *Ceramic Tech Today*...

Credit: Pilsen Steel, YouTube

Ensuring safe production of metal goods: A review of alumina spinel castables for steel ladles

Alumina spinel castables play an important role in the steel industry as lining for the ladle sidewalls and bottom. A new review paper provides a detailed overview of these castables, including how various parameters affect their properties and performance.

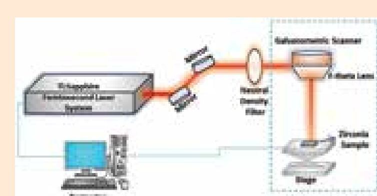
Read more at www.ceramics.org/alumina-spinel-castables

Also see our ACerS journals...

Silver/selenium/chitosan co-substituted bioceramic coatings of Ni–Ti alloy: Antibacterial efficiency and cell viability
By Y. Say, B. Aksakal, and Z. A. Sinirlioglu
International Journal of Applied Ceramic Technology

Characterization of cordierite based h-BN doped ceramics as an electronic substrate/circuit board material
By C. Tekin, E. Ercenk, Ş. Yılmaz, and A. Ş. Demirkıran
International Journal of Applied Ceramic Technology

Femtosecond laser microstructuring of monolithic zirconia: Effects of laser parameters on resin bond strength
By Y. Okutan, Y. Gundogdu, H. S. Kilic, et al.
International Journal of Applied Ceramic Technology



Effect of material properties on interaction of ceramic and glass flyer plates with hypervelocity jet
By T. Deniz and R. O. Yıldırım
International Journal of Applied Ceramic Technology

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

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POSTMASTER: Please send address changes to American Ceramic Society Bulletin, 550 Polaris Parkway, Suite 510, Westerville, OH 43082-7045. Periodical postage paid at Westerville, Ohio, and additional mailing offices. Allow six weeks for address changes.

ACSBA7, Vol. 101, No. 8, pp 1– 48. All feature articles are covered in Current Contents.

California startup pitches electric vehicle 'subscription' as alternative to ownership

For emissions-conscious drivers who are considering swapping their gas-guzzling vehicles for electric cars, two top concerns for potential buyers are the availability of public chargers and the cost of the cars themselves. While the United States government is allocating significant funds to address the first concern through the National Electric Vehicle Infrastructure Formula Program, the second concern remains a big hurdle.

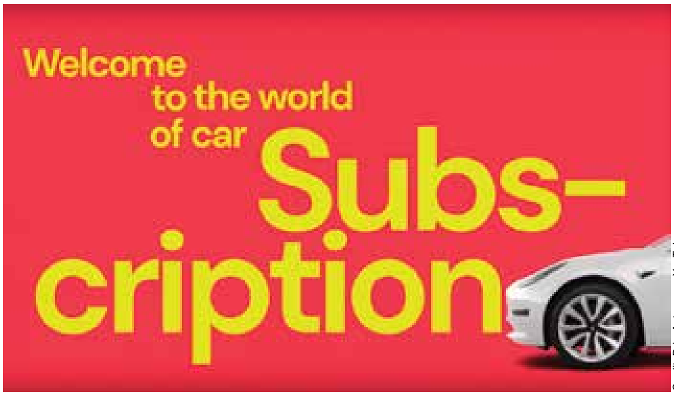
According to Kelly Blue Book, the average electric car price in the United States hit $66,000 in June 2022, an increase of 13.7% compared to a year ago. Even with tax credits for buyers of electric vehicles included in the recently passed Inflation Reduction Act, the requirements to qualify for credit are extremely limiting and will not help the majority of would-be buyers.

In light of this hurdle to ownership, a California startup is pitching an alternative vision for achieving widespread EV adoption—an electric vehicle subscription service.

Santa Monica-based Autonomy is the rebranded name of NextCar Holding Company, a vehicle subscription platform that originally launched in October 2020. In January 2022, NextCar founders Scott Painter and Georg Bauer officially rebranded the company after acquiring the Autonomy brand and IP brand library from Micro Focus.

Autonomy pitches the vision that its EV subscription service will allow anyone to drive electric without the long-term commitment of a traditional loan or lease. Subscribers need only pay a $500 security deposit plus a flexible initial fee and then will pay customized monthly payments to drive an electric vehicle of their choice from the Autonomy fleet.

The Autonomy subscription covers title, registration, routine maintenance (e.g., tires, brakes, and wipers), emergency roadside assistance, and liability insurance coverage common with leasing agreements. However, unlike leasing



Credit: DriveAutonomy, YouTube

agreements, which typically require a minimum commitment of two or three years, Autonomy's contract only requires a commitment of three months, after which consumers can deactivate their subscription at any time with 28 days' notice.

Autonomy also just teamed up with Digisure, a provider of software for screening, claims administration, and insurance, to launch a month-to-month car insurance coverage option for subscribers.

"Being able to provide Autonomy subscribers with fully digital auto coverage that's month to month, without them having to buy annual insurance and is tailored to their needs, is core to delivering on our promise of providing easy and affordable access to electric vehicles," says Scott Painter, Autonomy cofounder and CEO, in a press release.

Autonomy's fleet initially consisted of Tesla's Model 3 sedan, but the company has since made deals with other companies including General Motors and Ford Motor Co., as well as expanded to other Tesla models. Currently, subscribers looking to switch to a different car in the fleet have to pay another initial fee, but North Bay Business Journal reports that Autonomy is considering implementing a $250 switching fee instead for those who want to try something different.

For now, Autonomy subscriptions are offered only in California. However, Autonomy aims to expand nationwide, and the company recently partnered with automotive retailer AutoNation to help support its geographic as well as electric vehicle product expansion. ■

Electrifying Africa—Swedish-Kenyan mobility startup Roam debuts electric buses and motorcycles

While the car subscription service proposed by California-based startup Autonomy in the story above offers a more affordable way to drive electric vehicles, this option is not an ideal solution for expanding access to electric transportation in countries without the necessary public infrastructure.

A Swedish-Kenyan mobility startup is developing an alternative business model for implementing electric mobility in emerging countries.

Roam was founded in 2017 under the name Opibus, before being renamed this year "to better represent our unfolding path on the [African] continent," according to the Roam website.

The company formed out of a student project at Linköping University to identify places where electric mobility could have the largest possible impact. The Kenyan capital of Nairobi was chosen as the ideal test market and headquarters.

In Kenya, which has East Africa's largest economy, more than 90% of domestically produced electricity comes from renewable sources, thus presenting a strong platform for clean electric mobility.

Roam initially focused on converting vehicles to electric for the safari, mining, and utility markets. Cost of conversion starts at just under $40,000 for a Toyota Land Cruiser or Land Rover, and the 10-to-14-day process involves sourcing parts from all over the world.

The company has since expanded to develop domestically produced electric alternatives to traditionally fossil-fueled vehicles, starting with electric buses and electric motorcycles.

The electric bus and motorcycle projects launched into high gear last fall when Roam announced it raised $7.5 million in pre-Series A round funding to advance both projects.

In January 2022, Roam started piloting its all-electric bus—the first ever designed and developed in Africa—in preparation for commercial launch of the buses later this year. Ten buses will be tested at scale during this initial commercial deployment period, with the goal to extend electric bus services across Africa by the end of 2023. Along with bus deployment, several charging points will be installed around Nairobi using Roam's existing range of products.

While the electric bus project addresses needs in the public transportation industry, the electric motorcycle project aims to help electrify the motorcycle taxi and delivery, so called "boda-boda," industry.

The boda-boda industry is the fastest growing form of self and casual employment in Kenya and in many other countries. Unlike cars and buses, motorcycles cost much less to buy and run, perform well on inadequate infrastructure, can carry flexible kinds of loads, can access very remote areas, and can maneuver easily through traffic and congestion.

Currently, most of the motorcycles in Kenya are imported from other countries. So, Roam's goal with the motorcycle project is two-fold—increase domestic production of supplies while also electrifying the sector.

Roam began designing and developing the electric motorcycle in 2019. The final version of the motorcycle, called Roam Air, is now available for preorder.

Unlike the initial pilot motorcycle, which featured a single battery module,

*NOTE: The Roam Air costs $1,500 and comes with one battery; the second battery can be added on for an additional $550.

Credit: Roam

Swedish-Kenyan mobility startup Roam aims to help electrify Africa through its electric mobility product offerings.

the Roam Air has room for two 3.24 kWh battery packs.* This dual module allows one battery to be in use while the other is charging. The included portable charger can be plugged into any external 110/220V AC socket.

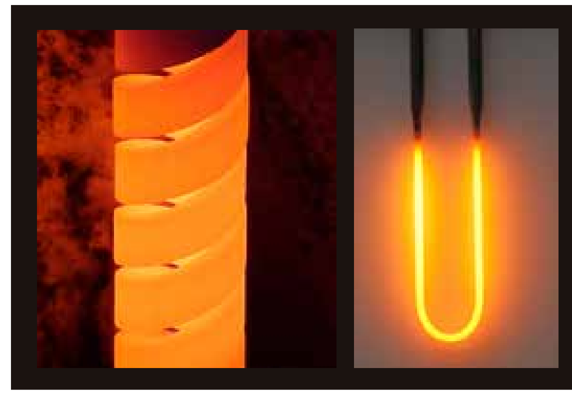
Because the Roam Air was designed with boda-boda riders in mind, its frame is engineered to accommodate a storage compartment in the tank and increased carrying capacity on the subframe (payload of 485 lbs or 220 kg). The motorcycle itself, when set up with one battery, weights 298 lbs (135 kg).

Top speed for the motorcycle is 56 mph (90 km/h), and each battery is good for up to 56 miles of range.

To help make the Roam Air available across Africa, Roam partnered with Uber to conduct the pilot program and has now agreed to supply Uber with 3,000 of the motorcycles by the end of 2022. Roam also signed a major supply agreement with M-KOPA, a Nairobi-based connected asset financing platform, to enable credit sales of the Roam Air, thereby lowering the barrier to entry for customers through affordable payment plans.

Roam's efforts to electrify Africa are being acknowledged globally—the company was recognized as one of TIME's 100 Most Influential Companies of 2022.

In addition to cleaner mobility, Roam is committed to gender equality in the workplace. Their website states that of the company's nearly 100 employees, 40% are female in all areas. ■



Unified International Technical Conference on Refractories set for November 2023

The Unified International Technical Conference on Refractories (UNITECR) takes place from Sept. 26–29, 2023, in Frankfurt, Germany. The German Refractory Association, a founding member of UNITECR, will organize and host this world conference.

The conference theme is more relevant than ever: "The Carbon Challenge—Steps and Leaps to Master the Future." The path to CO_2 neutrality will keep the refractory industry and its steel, glass, cement, and chemical customers busy for many years to come. The transformation from fossil fuels to green hydrogen in high-temperature processes will impact material and lining concepts. At this conference, initial answers and proposed solutions, scientific results, and practical implementation examples will be presented.

"For the extensive congress program, we are looking for speakers from universities conducting research and development to refractory companies and raw material suppliers to plant or furnace construction companies," explains Thomas Kaczmarek, managing director and head of planning for UNITECR 2023.

The task will be to present the latest developments in science and research, technology, and practical implementation to the participants.

"And everything with a view to climate protection, circular economy, and future CO_2 reduction," says Kaczmarek.

Nine subject areas were defined in the Scientific Committee, which will provide a framework for the congress program.

"There is a wide range, from use of raw materials and manufacturing processes to applications in the steel, cement, and glass industries or digitization, testing, and standardization," explains Kaczmarek.

Visit the UNITECR website at www.unitecr2023.org to submit an abstract, learn more about the conference, and to sign up for the UNITECR 2023 informational newsletter. The abstract deadline is **Nov. 30, 2022.**

Direct inquiries may be addressed to Janina Geller, European Centre for Refractories GmbH, at geller@ecref.eu.

Titanium dioxide ban illustrates the differing approaches to chemicals regulation in the EU and US

A California man recently filed a proposed class-action lawsuit against Mars, Inc. for putting consumers at risk by having titanium dioxide (TiO_2) as a food additive in their Skittles candy.

TiO_2 is a white pigment used in a wide variety of products, including paints, paper, textiles, cosmetics, pharmaceuticals, and food. It has been used as a food additive since the 1960s, when the United States Food and Drug Administration approved it in 1966 (food additive code INS171), followed by the European Union in 1969 (food additive code E171).

Specifications guiding use of TiO_2 in food have undergone minor revisions over the years, but that changed last year when the European Food Safety Authority (EFSA) released an updated assessment on the safety of TiO_2 as a food additive. Unlike previous assessments, the new report does not rule out a concern for genotoxicity (i.e., damage to genetic information within a cell) due to new data and strengthened analytic methods, particularly related to TiO_2 in ultrafine nanomaterial form.

The European Commission announced a ban in January 2022 on TiO_2 as a food additive in the European Union. A six-month phasing out period started on February 7, and the full ban went into effect starting August 7.

The United Kingdom, which left the European Union in 2020, notably will not be banning this additive. The U.K.'s Food Standards Agency and Food Standards Scotland reviewed the EFSA opinion and decided the evidence did not support the conclusions made. They are now conducting a risk assessment on TiO_2 that should be ready for release in early 2023.

Likewise, the United States' Food and Drug Administration is not changing its regulations regarding the use of TiO_2 as a food additive, which restricts it to 1% of a food's weight. Regardless, the California


Credit: Public Domain Pictures

Skittles candy is now at the center of a proposed-class action lawsuit over the use of titanium dioxide as a food additive.

filing against Mars argues that the company's failure to warn consumers about the potential dangers of TiO_2 amounts to a fraud of omission, as well as other violations of California law.

In June 2022, *The Guardian* provided a thoughtful look at how the current treatment of TiO_2 as a food additive illustrates the larger picture of how the EU and U.S. differ in their approach to chemicals regulation.

"The U.S. often waits until the harm is done, and the EU tries to prevent it to a certain extent. It often seems the U.S. favors the market over protection," Tatiana Santos, chemicals manager at the European Environmental Bureau, says in *The Guardian* article.

The EU and U.S. lists of chemicals that are allowed in food and other products will likely grow even farther apart in the coming years. In April 2022, the European Commission published a restrictions roadmap that may lead to bans of up to 12,000 chemicals over the next five years in an effort to "detox" industry. In a first, the plan focuses on banning entire classes of chemical substances so as to end the industry practice of tweaking chemical formulations slightly to evade bans. ■

Each month, we will be highlighting articles from different areas of glass science in the online blog *Ceramic Tech Today*.

INTERNATIONAL YEAR OF GLASS 2022

International Journal of Applied Glass Science special issue celebrates IYOG

By Eileen De Guire

Mario Affatigato and Alicia Durán, editor-in-chief and co-editor, respectively, of *International Journal of Applied Glass Science* (IJAGS), dedicated the July 2022 issue (Volume 13, Issue 3) to the International Year of Glass. Affatigato and Durán served as guest editors for the issue, curating 16 articles, of which three are open access. Durán also is leading the global International Year of Glass celebrations.

The editors resisted the temptation to publish a retrospective issue highlighting the profound contributions that glass already made to the advancement of science, engineering, and human well-being. Appropriately, they kept the focus on the future and what solutions glass can contribute to the hefty challenges that lie ahead.

Affatigato says in the cover's caption, "The United Nations' declaration making 2022 the International Year of Glass allowed the global glass community to celebrate the wonders of this amazing material. Taken as a whole, the articles in this issue highlight the breadth of our field and the continuing promise of glass as a material unparalleled in human history."

The result is a well-balanced issue that covers the interdependent triad of structure, properties, and applications. Grand challenges in energy, communication, and medicine lead to glass applications in pharmaceutical packaging, industrial glass, battery anodes, optical fibers, and photocatalysts. Several papers address properties of glass, such as thermal properties for heat management, indentation and abrasion properties, and the elusive glass relaxation phenomenon. Other papers work to unlock the mysterious and intriguing structure of glass.

Access the special issue at https://bit.ly/IJAGS-celebrating-IYOG. ACerS members have access to all ACerS journals by logging into the Society's website. ■

Access the special issue at https://bit.ly/IJAGS-celebrating-IYOG. ACerS members have access to all ACerS journals by logging into the Society's website.

IJAGS SPECIAL ISSUE TABLE OF CONTENTS

Title	Authors
The uniqueness of glass for passive thermal management for optical fibers OPEN ACCESS https://doi.org/10.1111/ijag.16543	John Ballato and Peter D. Dragic
Glass: The best material for pharmaceutical packaging https://doi.org/10.1111/ijag.16559	Emanuel Guadagnino, Massimo Guglielmi, and Fabiano Nicoletti
A Corning perspective on the future of technical glass in our evolving world OPEN ACCESS https://doi.org/10.1111/ijag.16560	Jeffrey T. Kohli, Mathieu Hubert, Randall E. Youngman, and David L. Morse
Indentation and abrasion in glass products: Lessons learned and yet to be learned https://doi.org/10.1111/ijag.16549	Arun K. Varshneya, Guglielmo Macrelli, Satoshi Yoshida, Seong H. Kim, Andrew L. Ogrinc, and John C. Mauro
Impact of a temperature-dependent stretching exponent on glass relaxation https://doi.org/10.1111/ijag.16548	Brittney M. Hauke, Matthew Mancini, and John C. Mauro
Atomistic molecular dynamics in polyethylene oxide and polymethyl methacrylate blends having significantly different glass transition temperatures https://doi.org/10.1111/ijag.16553	Junko Habasaki
Chemical approach to the glass structure and properties https://doi.org/10.1111/ijag.16551	Natalia Vedishcheva, Alberto López-Grande, and Francisco Muñoz
A century of structural and vibrational spectroscopy in vitreous silica: A short review https://doi.org/10.1111/ijag.16572	B. Hehlen
High-coordinated alumina and oxygen triclusters in modified aluminosilicate glasses https://doi.org/10.1111/ijag.16565	Rebecca S. Welch, Sierra Astle, Randall E. Youngman, and John C. Mauro
Curved lattices of crystals formed in glass https://doi.org/10.1111/ijag.16574	Evan J. Musterman, Volkmar Dierolf, and Himanshu Jain
Iron-phosphate glass-ceramic anodes for lithium-ion batteries https://doi.org/10.1111/ijag.16557	Shibin Qi, Xiangyu Li, Yuanzheng Yue, and Yanfei Zhang
Development of photocatalysts based on TiO_2 films with embedded Ag nanoparticles https://doi.org/10.1111/ijag.16575	María Virginia Roldán, Estanislao Porta, Alicia Durán, Yolanda Castro, and Nora Pellegri
Development of a force field for modeling lithium borosilicate glasses https://doi.org/10.1111/ijag.16570	Shingo Urata, Tatsuya Miyajima, Noriyoshi Kayaba, Lu Deng, and Jincheng Du
Radiation-induced darkening and its suppression methods in Yb^{3+}-doped silica fiber core glasses https://doi.org/10.1111/ijag.16561	Chongyun Shao, Chunlei Yu, Yan Jiao, Georges Boulon, Malgorzata Guzik, Lei Zhang, Fengguang Lou, Meng Wang, Weibiao Chen, and Lili Hu
Direct monitoring of immediate release of Zn from zinc-doped bioactive glass OPEN ACCESS https://doi.org/10.1111/ijag.16568	Dagmar Galusková, Hana Kaňková, Anna Švančárková, Lenka Buňová, and Dušan Galusek
A comprehensive study of the batch-to-melt conversion process of a high-boron alkaline earth aluminosilicate glass https://doi.org/10.1111/ijag.16582	Hong Li, Manuela Reben, Jason Dobyne, Qingwei Wang, and Xiaoyun Liu

Solar energy markets

By BCC Publishing Staff

The global solar power market was worth $158.8 billion in 2021 and is estimated to grow at a compound annual growth rate (CAGR) of 15.3% to reach $371.7 billion in 2027.

Solar power technologies are renewable energy technologies that in some way harness the power of the sun to create energy, mainly in the form of electric power. Current solar power plants use one of two technologies: photovoltaic (PV) systems or concentrated solar power (CSP) systems.

PV systems use solar panels, either on rooftops or in ground-mounted solar farms, to convert sunlight directly into electric power. These systems have emerged as one of the most competitive sources of new power generation capacity after a decade of dramatic cost declines.

The bulk of solar PV cells and modules that are currently produced on a global scale are based on crystalline silicon (c-Si) cell-type technology. There is, however, a small but significant subset of alternative technologies within the broader solar PV segment that are increasing each year and which many see as the future of the solar PV industry and market. For example,

- **Second-generation PVs:** The most widely used second-generation PV technologies are thin-film technologies, such as cadmium telluride, copper indium gallium (di)selenide, amorphous silicon, and gallium arsenide. Each of these technologies requires fewer raw materials during their manufacture or can take advantage of a more streamlined, simplified manufacturing process than traditional c-Si cell technologies. They are commercially viable and deployed on a relatively large scale.
- **Third-generation PVs:** Third-generation PVs encompass a diverse set of technologies that range from those that are still in a highly theoretical stage to others that are in the earliest stages of commercial deployment in mostly specialized applications or niche markets. Third-generation PV technologies include organic photovoltaics/plastic solar cells, multijunction photovoltaics, and concentrating photovoltaics.
- **Fourth-generation PVs:** Fourth-generation PV technologies combine the low cost/flexibility of polymer thin films with the stability of novel inorganic nanostructures. They are designed to maximize the harvesting of solar radiation, and thereby efficiently generate electricity.

Supplemented by strong government incentive programs, the Asia-Pacific solar PV market is expected to lead the market during the forecast period (2022–2027). China is one of the largest exporters to Europe and Middle East markets. However, due to anti-subsidy and anti-dumping policies, Chinese manufacturers are expected to reduce their stock in the region by selling it at the lowest possible prices.

Table 1. Global solar power market, by technology, through 2027 ($ millions)

Technology	2021	2022	2027	CAGR % (2022–2027)
Solar photovoltaics	149,584.2	170,590.2	334,530.0	14.4
Concentrated solar power	9,210.1	11,956.8	37,170.0	25.5
Total	158,794.2	182,547.0	371,700.0	15.3

CSP systems uses lenses or mirrors and tracking systems to concentrate sunlight, then use the resulting heat to generate electricity from conventional steam-driven turbines. CSP and other solar thermal power technologies faced a setback in the last decade due to the increase in solar PV and heat pump installations. But with the increase in major projects that are currently being undertaken by private and public corporations, it is estimated that these technologies will be on the rise in coming years.

CSP technologies are reducible to their components, which are typically produced by different manufacturers. The four component groups used to assemble CSP technologies are

- **Reflective surfaces**, e.g., polished aluminum panels, reflective films, and solar mirrors.
- **Solar thermal receivers**, i.e., surfaces or tubes receiving concentrated, reflective sunlight and containing a thermal medium for the absorption of solar thermal energy.
- **Solar collector assemblies**, i.e., structural frames used to support the reflective surfaces and ST receivers.
- **Deployable hydraulic and motion control systems**, which orient solar collectors and allow them to track the sun.

Spain accounts for almost one-third of the world's CSP capacity, followed by the United States. Spain announced in its National Energy and Climate Plan the intention of adding 5 GW of CSP capacity between 2021 and 2030.

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, "Solar energy markets" BCC Research Report EGY165B, August 2022. www.bccresearch.com. ■

SOCIETY DIVISION SECTION CHAPTER NEWS

Welcome new ACerS Corporate Partner

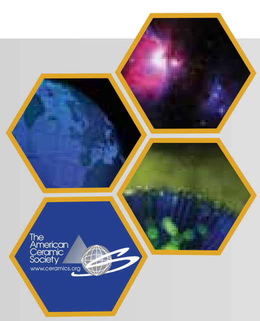
ACerS is pleased to welcome its newest Corporate Partner.

MINEREX

To learn about the benefits of ACerS Corporate Partnership, contact Kevin Thompson, industry relations director, at (614) 794-5894 or kthompson@ceramics.org. ■

Thailand Chapter co-hosts International Conference and Exhibition on Science, Technology and Engineering of Materials

The Thailand Chapter and Nakhon Pathom Rajabhat University will co-host the International Conference and Exhibition on Science, Technology and Engineering of Materials (ISTEM2022), held concurrently with the 11th International Symposium on Feedstock Recycling of Polymeric Materials 2022 (ISFR2022), on Nov. 29–Dec. 2, 2022, at Nongnooch Pattaya Garden and Resort, Thailand.



Free to ACerS members

Frontiers of Ceramics & Glass Webinar Series

SEPTEMBER 21, 2022
4 P.M. EASTERN U.S. TIME

Title: *Surface characterization and benchmark part standardization of additively manufactured ceramic parts*

PRESENTER:
TAYLOR BARRETT – Ph.D. student, University of North Carolina, Charlotte

Title: *SCHOTT: 130 years of innovation in glass and glass-ceramics*

PRESENTER:
CHARLES LAKEMAN – SCHOTT North America R&D

Sponsored by the ACerS Carolinas Section

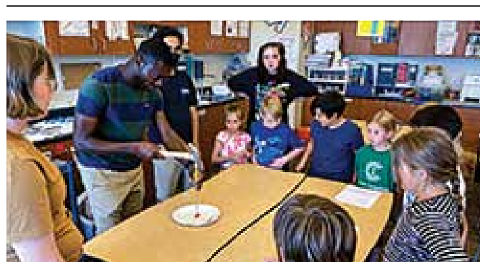
OCTOBER 3, 2022
2 P.M. EASTERN U.S. TIME

Title: *Reversible electrochemical cells for interconversion between fuel and electricity*

PRESENTER:
SOSSINA HAILE – Northwestern University

Hosted by: Energy Materials and Systems Division

Colorado Section conducts outreach at local camp



Graduate students in the Colorado Section recently taught hands-on materials science modules at the Rocky Mountain Dyslexic Camp to foster STEM competency and belonging in dyslexic children.

FOR MORE INFORMATION:

ceramics.org

ACerS Pittsburgh Section Annual 2022 Golf Outing photos and results

Thank you to all who participated in the Annual Pittsburgh Golf Outing. A few minutes of rain did not stop a great day! Many thanks to the following hole sponsors for their support:

Aluchem
Chiz Brothers
Fusion Ceramics Inc.
Harbison Walker International
Henry F. Teichmann
Imerys / KT Clay
Northern Graphite Corp
Standard Ceramic
Swindell Dressler

For more photos, visit the ACerS Pittsburgh Section webpage at https://ceramics.org/members/member-communities/sections/pittsburgh. ■

▲ 1st place team: Ryan Deatrick, Mike Marasco, Joe Bruce, and Robert Christenson.

▲ 2nd place team: Rob Conn, Leslie Fenwick, and Mike Neiport.

▲ 3rd place team: Dan Gahagan, Lynda Harasty, Bill Harasty, and Todd Barson.

more
SOCIETY
DIVISION
SECTION
CHAPTER
NEWS

ACerS leaders for 2022–2023

ACerS is pleased to introduce the 2022–2023 Society leadership. New officers and directors will be installed at the 124th Annual Business Meeting on Oct. 10, 2022, at ACerS Annual Meeting at MS&T22 in Pittsburgh, Pennsylvania.

Society officers and directors

Executive Committee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Director and chair
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Middletown, Md.


Mecklenborg

Secretary
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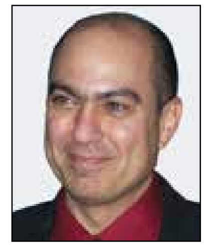
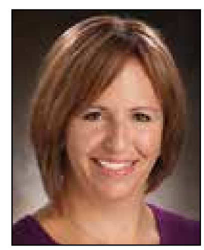
Executive director
The American Ceramic Society
Westerville, Ohio

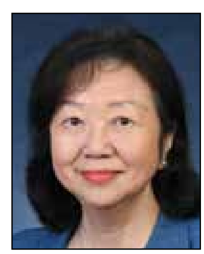
Board of Directors (new)


Cesarano

Joseph Cesarano
President and founder
Robocasting Enterprises LLC


Reigel

Marissa Reigel
Manager of material performance
Savannah River National Laboratory
Aiken, S.C.

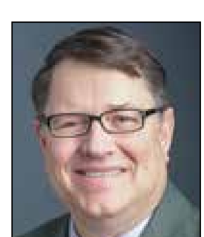

Wong-Ng

Winnie Wong-Ng
Research chemist
National Institute of Standards and Technology (NIST)
Gaithersburg, Md.

Board of Directors (returning)


Breder

Kristin Breder
Senior principal scientist
Saint-Gobain Research North America
Northborough, Mass.


Butt

Darryl Butt
Dean of the College of Mines and Earth Sciences
Director of the Energy Frontiers Research Center, MUSE
University of Utah
Salt Lake City, Utah

Graeve

Olivia Graeve
Professor in the Department of Mechanical and Aerospace Engineering
Director of the CaliBaja Center for Resilient Materials and Systems
University of California, San Diego
San Diego, California

Hemmer

Eva Hemmer
Assistant professor
University of Ottawa
Ottawa, Ontario,
Canada

Jiang

Shibin Jiang
President and CEO
AdValue Photonics Inc.
Tucson, Ariz.

Naito

Makio Naito
Professor
Joining and Welding,
Research Institute
Osaka University
Osaka, Japan

Freiman

Parliamentarian
Stephen Freiman
Freiman Consulting Inc.
Potomac, Md.

more SOCIETY DIVISION SECTION CHAPTER NEWS

Volunteer spotlight

ACerS Volunteer Spotlight profiles a member who demonstrates outstanding service to the Society.

Henry Colorado is full professor in the School of Engineering and director of the CCComposites Lab (cements, ceramics and composites) at Universidad de Antioquia in Medellín, Colombia. He obtained a B.S. and M.S. in mechanical engineering from Universidad Nacional de Colombia in Bogotá, Columbia (with honors) in 2005 and a secondary M.S. and Ph.D. in materials sciences at University of California, Los Angeles in 2013.

An active ACerS member, Colorado was the Colombian country chair for the PACC-FMAs meeting in July 2022. He was instrumental in organizing and planning the event since 2019. He has published more than 150 papers.

We extend our deep appreciation to Colorado for his service to our Society! ■

On July 2, 2022, Colorado summited Mont Blanc along the Trois Monts route. Mont Blanc is the highest mountain in the Alps and Western Europe, rising more than 4,800 meters above sea level.

Ceramic Tech Chat: Rick Weber

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 second Wednesday of each month.

In the August episode of Ceramic Tech Chat, Rick Weber, president and founder of Materials Development Incorporated, describes how his company develops instruments to test materials in extreme environments, discusses some recent experiments they have on the International Space Station, and shares what he thinks the future of materials science research in space will look like. Check out a preview from his episode, which features Weber describing some challenges with conducting research in space.

"There's a time lag between when you implement a command. The commands are implemented from the JAXA [Japanese Aerospace Exploration Agency] control room in Tsukuba near Tokyo. And it takes about four seconds to relay up and to be processed and for something to happen. So if you want to change laser power or gas pressure or something like that, there's this brief delay. And one needs to factor that in and really sort of anticipate the next move. The other small challenge is that the space station orbits around 200 miles up and it talks to the ground by satellites and by pickup stations. On about every hour, there's a region where it's no longer connected. So you can have outages that run from a few seconds to maybe as much as 20 minutes occasionally. So, … ideally you want to time an experiment so you haven't got a sample in its ideal state for the measurement just as you go dark."

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

IN MEMORIAM

Garth Austin

Joseph Keaney

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

Names in the news

Members—Would you like to be included in the Bulletin's Names in the News? Please send a current head shot along with the link to the article to mmartin@ceramics.org. The deadline is the 30th of each month.

John S. McCloy, FACerS, director of the School of Mechanical & Materials Engineering at Washington State University, and his team climbed partway up Mount Rainier in Washington state. Pictured is McCloy at 11,100 feet on the Ingraham Flats, with the Little Tahoma peak in the background.

AWARDS AND DEADLINES

Nomination deadline: Jan. 15, 2023
Society awards will be presented at the Annual Awards Banquet in October 2023.

Contact: Erica Zimmerman | ezimmerman@ceramics.org | 614.794.5821

Society Awards	Description
Distinguished Life Membership	ACerS highest honor given in recognition of a member's contribution to the ceramics profession. Nominees need to be current members who have attained professional eminence because of their achievements in the ceramic arts or sciences, service to the Society, or productive scholarship.
Fellows	Recognizes outstanding contributions to the ceramic arts or sciences; through broad and productive scholarship in ceramic science and technology, by conspicuous achievement in ceramic industry or by outstanding service to the Society.
W. David Kingery Award	Recognizes distinguished lifelong achievements involving multidisciplinary and global contributions to ceramic technology, science, education, and art.
John Jeppson Award	Recognizes distinguished scientific, technical, or engineering achievements in ceramics.
The European Ceramic Society-American Ceramic Society Joint Award	Recognizes individuals who foster international cooperation between The American Ceramic Society and the European Ceramic Society, in demonstration of both organizations' commitment to work together to better serve the international ceramics community.
The Rishi Raj Medal for Innovation and Commercialization Award	Recognizes one individual whose innovation lies at the cusp of commercialization in a field related, at least in part, to ceramics and glass.
Medal for Leadership in the Advancement of Ceramic Technology	Recognizes individuals, who through leadership and vision in an executive role, have made significant contributions to the success of their organization and in turn have significantly expanded the frontiers of the ceramics industry.
Corporate Environmental Achievement Award	Recognizes an outstanding environmental achievement made by an ACerS corporate member in the field of ceramics.
Corporate Technical Achievement Award	Recognizes an outstanding technical achievement made by an ACerS corporate member in the field of ceramics.
Richard M. Fulrath Awards	Promote technical and personal friendships between Japanese and American ceramic engineers and scientists. The awards recognize individuals for excellence in research and development of ceramic sciences and materials. Nominees must be 45 or younger at the time of award presentation.
Karl Schwartzwalder-Professional Achievement in Ceramic Engineering Award	Recognizes an outstanding young ceramic engineer whose achievements have been significant to the profession. A nominee must be between 21 and 40 years of age, and must be a member of EPDC and ACerS.
Robert L. Coble Award for Young Scholars	Recognizes an outstanding scientist who is conducting research in academia, in industry or at a government laboratory. Candidates must be an ACerS member and must be 35 years old or younger.
Du-Co Ceramics Young Professional Award	A young professional member of ACerS who demonstrates exceptional leadership and service to ACerS.

FOR MORE INFORMATION:

ceramics.org/members/awards

Society Awards	Description
Frontiers of Science and Society - Rustum Roy Lecture	Given each year by a nationally or internationally recognized individual in the area of science, industry, or government. Generally the committee selects the lecturer, but suggestions from membership are invited.
Edward Orton, Jr. Memorial Lecturer	Selection is based on scholarly attainments in ceramics or a related field. Generally the committee selects the lecturer, but suggestions from membership are invited.
The Navrotsky Award for Experimental Thermodynamics of Solids	Awarded biennially to an author who made the most innovative contribution to experimental thermodynamics of solids technicalliterature during the two calendar years prior to selection.
Ross Coffin Purdy Award	Given to the author(s) who made the most valuable contribution to ceramic technical literature during the calendar year two years prior to the year of selection. The 2023 Purdy award is for the best paper published in 2021.
Richard and Patricia Spriggs Phase Equilibria Award	Given to the author(s) who made the most valuable contribution to phase stability relationships in ceramic-based systems literature during the previous calendar year (2022).
Morgan Medal and Global Distinguished Doctoral Dissertation Award	Recognizes a distinguished doctoral dissertation in the ceramics and glass discipline.

2022 Division awardees

Cements Division

Brunauer Award

"Shifting factor—A new paradigm for studying the rheology of cementitious suspensions," by **Sara Mantellato** and **Robert J. Flatt**, ETH Zurich, Switzerland; *Journal of the American Ceramic Society*, 2020, 103(6), pp. 3562–3574

Student poster awards

First: **Connor Szeto**, Georgia Tech

Second: **Anita Zhang**, Princeton University

Third: **Diandian Zhao**, Columbia University

Early Career Award

Shiho Kawashima, Columbia University

Manufacturing Division

John E. Marquis Award

"From concept to industry: Ultrafast laser welding," by **Richard M. Carter**, Heriot-Watt University, Scotland; *The American Ceramic Society Bulletin*, May 2021, Vol. 100, No. 4; pp. 20–27.

Electronics Division

Edward C. Henry Award

"The influence of oxygen vacancies on piezoelectricity in samarium-doped $Pb(Mg_{1/3}Nb_{2/3})O_3$–$PbTiO_3$ ceramics," by **Yang Li**, **Marcell Borbely**, and **Andrew Bell**, The University of Leeds; *Journal of the American Ceramic Society* 104, 2678 (2021).

Lewis C. Hoffman Scholarship

Kyle Sprecker, University of Wisconsin – Madison ■

Announcing launch of new online awards portal

ACerS recently partnered with the online awards management solutions company OpenWater to provide a streamlined award nomination experience for our members. The new software allows collaboration among nominators and the ability to start a nomination and save its progress. ACerS award subcommittees will also use this system to access the nominations and score the applications. The portal will launch November 1 for the 2023 awards cycle. ■

more AWARDS AND DEADLINES

Nomination deadline: Jan. 15 and Jan. 23, 2023
Division awards will be presented at the Annual Awards Banquet in October 2023.

Contact: Erica Zimmerman | ezimmerman@ceramics.org | 614.794.5821

Division	Award	Nomination Deadline	Description
AACS	Anna O. Shepard	Jan. 15, 2023	Presented to an individual(s), who has made outstanding contributions to materials science applied to art, archaeology, architecture, or cultural heritage.
BIO	Young Scholar	Jan. 15, 2023	Recognizes excellence in research among current degree seeking graduate students and postdoctoral research associates.
BIO	Global Young Bioceramicist	Jan. 15, 2023	Recognizes the outstanding young ceramic engineer and material scientist, who has made significant contributions to the area of bioceramics, for human healthcare around the globe. Nominations are invited from the candidates from academia, industry, or government-funded national laboratory across the world.
BIO	Larry L. Hench Lifetime Achievement	Jan. 15, 2023	Presented to a deserving individual(s) in recognition of lifetime dedication, vision, and accomplishments in advancing the field of Bioceramics, particularly toward innovation in the field and contribution of that innovation to translation of technology towards clinical use.
BIO	Tadashi Kokubo	Jan. 15, 2023	Presented to a deserving individual(s) in recognition of their outstanding achievements in the field of bioceramics research and development.
BSD	Early Discovery	Jan. 15, 2023	Recognizes an early career member of ACerS who has demonstrated a contribution to basic science in the field of glass and ceramics.
BSD	Robert B. Sosman Award	Jan. 15, 2023	Awarded in recognition of outstanding achievement in basic science that results in a significant impact to the field of ceramics.
Cements	Early Career	Jan. 15, 2023	Recognizes an outstanding early career scientist who is conducting research in the field of cement and concrete in academia, industry or a government funded laboratory.
EPDC	Greaves-Walker Lifetime Service Award	Jan. 15, 2023	Presented to an individual who has rendered outstanding service to the ceramic engineering profession and who has exemplified the aims, ideals, and purpose of EPDC.
EPDC	Arthur L. Friedberg Engineering Tutorial and Lecture	Jan. 15, 2023	Given to an individual who has made outstanding contributions to ceramic engineering that relate to the processing or manufacturing of ceramic products. The awardee must be a member of EPDC and ACerS.
EPDC	Outstanding Educator	Jan. 15, 2023	Recognizes truly outstanding work and creativity in teaching and mentoring, in directing student research, or in the general educational process (e.g., lectures, publications on education, workshops, textbooks, short courses, videos, interest lectures) among ceramic/glass educators.

Division	Award	Nomination Deadline	Description
GOMD	**Norbert J. Kreidl**	Jan. 21, 2023	Recognizes research excellence in glass science, and is open to all degree-seeking graduate students (M.S. or Ph.D.) or those who have graduated within a twelve month period of the annual GOMD meeting.
GOMD	**George W. Morey**	Jan. 21, 2023	Recognizes new and original work in the field of glass science and technology. The criterion for winning the award is excellence in publication of work, either experimental or theoretical, done by an individual.
GOMD	**L. David Pye Lifetime**	Jan. 21, 2023	Recognizes a lifetime of dedication, vision, and accomplishments in advancing the fields of glass science, glass engineering, and glass art.
GOMD	**Stookey Lecture**	Jan. 21, 2023	Recognizes an individual's lifetime of innovative exploratory work or noteworthy contributions of outstanding research on new materials, phenomena, or processes involving glass, that have commercial significance or the potential for commercial impact.
GOMD	**Varshneya-Mauro-Jain Guru-Chela Travel Fund**	Jan. 21, 2023	Recognizes the special bond of knowledge, trust, and growth between a teacher ("Guru") and a student ("Che-la"), benefiting both.
MFG	**John E. Marquis**	Jan. 15, 2023	Presented to the author or authors of the paper on research, engineering or plant practices relating to manufacturing in ceramics and glass published in the prior calendar year (2022) in a publication of the SOCIETY, which is judged to be of greatest value to the members and to the industry ■

STUDENTS AND OUTREACH

ACerS Mentor Programs

ACerS offers both a student mentor program and faculty mentor program.

Space is limited! Be sure to sign up early to ensure a spot in the 2022–2023 programs.

ACerS Student Mentor Program

- If you are a student seeking to gain technical expertise in your field of study, professional development skills, practical advice, encouragement, or support, then please consider applying for the program.
- If you have been successful in your materials science career and are seeking to give back in any of these areas, then please consider applying to be a mentor.

ACerS Faculty Mentor Program

- If you are a faculty member seeking to gain pedagogical expertise, professional development skills, practical advice, encouragement, or support, then please consider applying for the program.
- If you have been successful in your university career and are seeking to give back in any of these areas, then please consider applying to be a mentor.

Sign up to be a mentor and/or mentee at https://ceramics.org/mentorship. Registration for the 2022–2023 term will open in October 2022. ■

Grad students: Choose GGRN to advance your career

Build an international network of peers within the ceramic and glass community by joining the Global Graduate Researcher Network. GGRN is ACerS membership option that addresses the professional and career development needs of graduate level research students who have a primary interest in ceramics and glass.

Membership in GGRN is only US$30 per year. Visit www.ceramics.org/ggrn to learn how GGRN membership can help you in your future career. You may also contact Yolanda Natividad, member engagement manager, at ynatividad@ceramics.org if you have any questions. ■

CERAMIC AND GLASS INDUSTRY FOUNDATION

CGIF Kit Grant recipients help increase diversity in STEM

Students patiently wait their turn to try out the pyrometer in the lab at the University of Minnesota, Twin Cities (UMN). It is not every day they get to learn about hot temperatures with a radiation tool that looks like a laser gun. Later during the field trip, they also will get to witness the unfurling presence of liquid nitrogen—but that part really is just for fun.

Koen Verrijt and Brady Bresnahan are materials science and engineering Ph.D. candidates in the Poerschke group at UMN, and through this outreach effort they hope to expose more students to the allure of materials science.

"It is more so focusing on the students that have yet to have that (lab) experience and bringing that to them to try and excite them," Bresnahan says.

Verrijt and Bresnahan volunteer with an outreach organization called Science for All (SFA). SFA is a research group with a mission to support and promote STEM in the urban Twin Cities area by going to middle and high schools and performing scientific experiments. SFA is unique to other STEM outreach organizations because it focuses specifically on underrepresented populations with hopes to increase diversity in STEM.

Verrijt and Bresnahan wanted to incorporate materials science into SFA this year. Throughout the school year, SFA volunteers visit the schools they partner with to foster relationships with the students and introduce them to scientific concepts.

At the end of the year, the students come to UMN for a day-long field trip, and all the lessons they learn are demonstrated in a real lab setting.

"Each of the days went well and the kids seem to enjoy working with fire as well as breaking the glass and watching it sag," Bresnahan says. "Overall success, and then we also did the liquid nitrogen experiments that are on the Ceramic and Glass Industry Foundation website."

Brady Bresnahan, left, holds a torch for students during an outreach event at the University of Minnesota, Twin Cities.

Verrijt and Bresnahan applied for a Kit Grant from the CGIF and received Materials Science Classroom Kits to use for the big field trips. They focused on the CGIF classroom kit experiments "Hot or Not" and "Thermal Shock," adding in some liquid nitrogen to keep the energy flowing.

While Verrijt and Bresnahan share a passion for materials science, they also share a compassion for underrepresented groups in the STEM population.

"It is unfortunate that people who are in the U.S. that should have the same opportunities as me just are not [able to], based on where they are living, their home life, and we are wanting to make that accessible to them," Bresnahan says.

SFA reminds students that STEM does not have to be boring or difficult. Ela Engen, SFA co-president, believes that showing the fun side of STEM is crucial for engaging students.

"Oftentimes in school settings, STEM is challenging or hard," Engen says. "[They think] you have to be good at it to succeed rather than seeing the excitement and the trial, and doing the experiments really helps foster that interest."

On one of the field trip days, Bresnahan explains that students used the pyrometer in the lab during the "Hot or Not" experiment with a refractory brick.

"They really enjoyed being able to use, essentially, a laser gun," Bresnahan says. "But they also were shocked when one side was glowing red hot, and then the other was like, you could touch it with your hand, and it would be fine."

The goals of SFA align with those of Verrijt and Bresnahan: exciting underrepresented students about materials science.

"I hope that they think back about this and go into that direction and realize it is a really good field to be in with a lot of opportunities," Verrijt says. ■

Through muscle regeneration, graphene-polymer matrix lowers risk of rotator cuff retear injuries

In a recent paper, University of Connecticut School of Medicine researchers led by Cato Laurencin, ACerS Fellow and Albert and Wilda Van Dusen Distinguished Professor of Orthopaedic Surgery, presented a new regenerative engineering method based on graphene for treating rotator cuff tears.

Of the hundreds of muscles that make up a human's muscular system, the rotator cuff is notorious as one of the most common areas for tendon-and-muscle-related injuries in adults.

The rotator cuff is a group of muscles and tendons that surround the shoulder joint. They keep the head of the upper arm bone firmly within the shallow socket of the shoulder.

An estimated two to four million people in the United States experience some type of rotator cuff problem every year, particularly partial or complete tears that separate the tendons from the bone.

Following a tear, the tendons and muscles will begin to retract, and associated degenerative changes will begin to set in, including muscle atrophy, fat accumulation, and fibrosis formation.

There currently is no way to reverse the muscle degenerative changes, so most rotator cuff repair procedures focus solely on reattaching the tendons to the shoulder joint. But the success of these surgeries is hindered by the remaining fat accumulation and muscle atrophy, which increase the chances of retear.

Thus, developing regenerative engineering approaches to treat muscle degeneration is essential to improve treatment and long-term recovery success for patients with rotator cuff tears.

In the new paper, the UConn researchers explain that graphene offers several potential benefits to muscle regeneration.

1. **Promotes myogenesis**. Myogenesis is the formation of skeletal muscular tissue. Several studies indicate that electroconductive materials like graphene can significantly promote myoblast proliferation and differentiation, even without the use of external electrical stimulation. (Myoblasts are the embryonic precursors of muscle cells.)
2. **Increases intracellular calcium levels**. Studies show that high concentrations of calcium ions stimulate myogenesis, but it can reduce intracellular calcium levels, which inhibits myoblast differentiation and proliferation. Electroactive materials like graphene may help increase intracellular calcium levels.
3. **Inhibits lipid formation**. Several studies suggest a graphene matrix may have an inhibitory effect on lipid (fat) formation.

"These effects provide strong motivations for using graphene matrices for reducing fat formation after massive rotator cuff tendon tears," the researchers write.

Using an electrospinning fiber production method, they fabricated an aligned nanofibrous structure composed of graphene nanoplatelets and poly(l-lactic acid). They then tested the potential of this mesh by trying to grow muscle on it in a petri dish.

The petri dish experiment proved successful regarding all three potential benefits listed above.

1. The researchers observed alignment of myoblasts along the nanofiber direction, which suggests the matrices induced cellular orientation. This alignment provides an essential topographical cue to enhance myoblast growth and differentiation, in addition to the electrical cues. These combined cues resulted in high differentiation and maturation of myoblasts into myotubes (multinucleated fibers).
2. They detected higher intracellular calcium ion levels in myoblasts on the graphene-polymer matrix, which corre-

Credit: Pexels

Tears in the rotator cuff are one of the most common injuries related to tendons and muscles in the adult population. Regenerative engineering methods may help improve treatment of such tears.

lated with the enhanced myotube formation.

3. They confirmed that graphene suppressed lipid production, which suggests the inhibitory effect of graphene on adipogenesis (the formation of fat-laden cells).

Following this experiment, the researchers investigated the efficacy of using the graphene-polymer matrix to treat rats who had chronic rotator cuff tears with muscle atrophy.

Overall, histological analysis showed the matrix implantation induced a reversal of muscle degeneration. Additionally, histological staining of the internal organs showed no obvious tissue damage, inflammation, toxicological effects, or any material accumulation in the organs at 8 and 16 weeks after matrix implantation.

Finally, the researchers used histological staining to investigate the effect of matrix implantation on tendon healing. They found that addressing the muscle degeneration reduced retraction stress on the tendon and improved tendon healing.

"The [current] goal of massive rotator cuff tendon tear treatment is to improve tendon morphology and tensile properties. Here, we showed that reversing rotator cuff muscle degeneration is the real key to addressing the real problem," the researchers conclude.

A UConn press release reports that the next step is studying the matrix in a large animal. Eventually, the researchers hope to develop the technology in humans.

This work was funded by NIH National Institute of Arthritis and Musculoskeletal and Skin Diseases Grant No. DP1AR068147 and National Science Foundation Emerging Frontiers in Research and Innovation Grant No. 1332329.

The paper, published in *Proceedings of the National Academy of Sciences*, is "Muscle degeneration in chronic massive rotator cuff tears of the shoulder: Addressing the real problem using a graphene matrix" (DOI: 10.1073/pnas.220810611). ■

Ultrafast high-temperature sintering offers rapid, pressureless production of high-quality glasses

Researchers from the University of Maryland, Alfred University, and the University of California, San Diego used an ultrafast high-temperature sintering (UHS) method to achieve rapid, pressureless sintering of high-quality silica glasses.

Current methods of fabricating silica glass can be expensive and slow. While new sintering methods such as spark plasma sintering, flash sintering, and laser sintering demonstrate potential for addressing some of the silica glass manufacturing challenges, they face limitations as well.

The researchers of the new study are led by University of Maryland professor Liangbing Hu and ACerS Fellows Yiquan Wu (Alfred professor) and Jian Luo (UC San Diego professor). The UHS method they used for this study is one Hu and Luo previously developed in 2020 to rapidly synthesize ceramics. It involves sandwiching a pressed green pellet of precursor powders between two strips of carbon and then quickly heating the pellet through radiation and conduction.

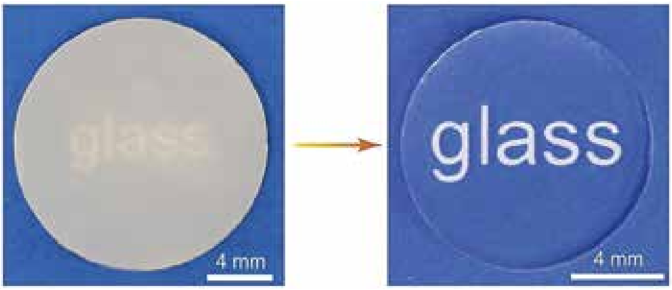
For this study, they placed a pressed pellet of amorphous silica nanoparticles (average particle size of 11 nm) in direct contact with the carbon heater. They then heated the pellet to about 1600 K in approximately 10 seconds, after which they held the pellet isothermally for 10 seconds before rapidly cooling the pellet down at a rate of up to 10^2 K/s.

Before the UHS process, the precursor pellet had a low relative density of about 35% and was semitransparent due to the uniformly distributed nanopores between the nanoparticles. However, after sintering, the silica glass exhibited relative densities of more than 98% and had a visible transmittance of about 90% in a wide wavelength range (400–1,000 nm).

The researchers compared the flexural strength of the UHS glass to a commercial float glass slide using a three-point bending test. The measured flexural strength of the sintered glass was about 70 MPa, which was comparable with that of commercial float glass (~58 MPa), thus indicating "that the fast cooling does not undermine the mechanical properties of the sintered glass by UHS," they write.

To further explore the effects of sintering silica glass with the UHS process, the researchers ran several additional experiments with different sintering parameters. They found the UHS process could densify micro silica powder (average particle size of 44 μm) to a relative density of more than 98% at 1600 K for 5 seconds. The UHS process also allowed rapid doping of metal ions to develop colored or rare earth element doped glasses.

"The work has successfully demonstrated the UHS proof–of–concept for the rapid processing of silica glass and can be further extended to sinter other functional glasses and transparent materials," Wu says in an email. "Importantly, the UHS technique can be developed into a high-throughput experimental platform, as one of the key components to the success of glass materials informatics."



Credit: Photo courtesy of Liangbing Hu.

Optical images of the starting glass powder compact (left) and ultrafast high-temperature sintered transparent pellet (right).

The paper, published in *Small*, is "Rapid pressureless sintering of glasses" (DOI: 10.1002/smll.202107951). ■

Direct ink writing opens the door to complex-shaped objects with isotropic structural color

ETH Zurich researchers showed how to additively manufacture complex-shaped objects with isotropic structural color.

Structural color is produced by the interaction of light with micro- or nanostructures. Because structural color does not rely on chemicals to induce color, it is not affected by chemical changes and can last for much longer than traditional pigments.

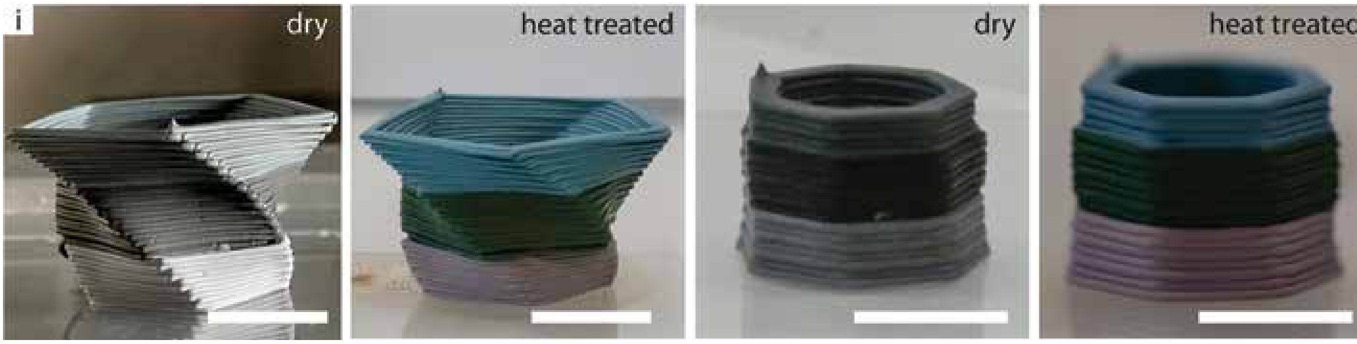
Iridescence, or a change in color based on viewing angle and orientation, is often a key indicator that a material relies on structural color rather than pigment. However, not all structural colors are iridescent. When there is enough disorder present at the nanoscale, different wavelengths of incoming light will scatter evenly, producing a single color that looks the same regardless of the viewing angle.

Researchers found they can replicate this angle-independent "isotropic" structural color using colloidal particles, or small solid particles that are suspended in a fluid phase. However, current examples are limited to the two-dimensional and simple geometries generated by casting, coating, and pressing processes.

"To partially fill this gap, additive manufacturing technologies have recently been exploited to produce three-dimensional photonic objects with intricate geometries and increased shape complexity," the ETH Zurich researchers write.

To date, experiments using additive manufacturing have been restricted either to 2D demonstrations or to 3D crystalline structures with angle-dependent photonic properties. To achieve complex 3D shapes with isotropic structural color, the ETH Zurich researchers used direct ink writing (DIW) as the additive manufacturing process. Designing colloidal inks that were printable via this process required close evaluation of the ink's viscoelastic properties.

"On the one hand, top-down printing through the DIW technique demands a colloidal ink with rheological properties



Side views of twisted and hexagonal vases manufactured by multimaterial 3D printing of colloidal inks containing 200 nm (blue), 250 nm (green), and 300 nm (pink) silica particles. Scale bar: 1 cm.

that allow for the extrusion of filaments into distortion-free printed structures. On the other hand, the bottom-up assembly of particles into a colloidal glass depends on the formation of a highly packed arrangement of particles without the onset of crystallization," they explain.

To meet these opposing demands, they designed a water-based colloidal ink that consisted of silica particles, carbon black, and rheology modifiers. (The carbon black particles act as an absorption medium between the silica particles to reduce multiple scattering of the incoming light.)

The volume fraction of particles within the ink was initially low to enable direct ink writing. But it eventually reached the maximum packing limit desired for glass formation when the liquid and gel phase of the ink was removed by heat treatment.

Drying of the as-printed object at 25°C changed its color from black to gray. However, further heat treatment at the higher temperature of 200°C led to a strong and vivid green color.

"The fact that the color is angle-independent suggests that a photonic colloidal glass with length scales on the order of the wavelengths of visible light was formed upon drying at this higher temperature," the researchers write.

They used scanning electron microscopy to confirm that the 200°C-treated sample featured a glass-like microstructure of densely packed silica particles without long-range order. Surprisingly, they achieved this structure using a single set of monodisperse particles. Previous studies relied on increased polydispersity of the colloids to prevent crystallization and induce glass formation.

"Thus, it is likely that the predominantly elastic behavior of the ink is not only important for printing distortion-free three-dimensional structures, but also plays a role in suppressing crystallization of the monodisperse colloidal particles," they write.

The researchers then demonstrated the potential of their process by printing several samples featuring different colors, which were tuned by changing the size of the silica colloidal particles present in the initial ink.

Additional testing showed that heat does not significantly affect the structural color. Samples subjected to a heat treatment at 350°C for 1 hour in air experienced only a slight reduction in color intensity, likely due to the partial oxidation and removal of the carbon black. By using a protective argon atmosphere, the researchers successfully preserved the color even after heating a sample up to 1,000°C.

The open-access paper, published in *Nature Communications*, is "Three-dimensional printing of photonic colloidal glasses into objects with isotropic structural color" (DOI: 10.1038/s41467-022-32060-2). ■

Model reveals how to attain dynamic control of ferroionic states in ferroelectric nanoparticles

In a recent open-access paper, researchers from the United States and Ukraine used finite element modeling to fill the gap in knowledge concerning how surface-charge dynamics influence the behavior of ferroelectric materials.

Ferroelectric materials exhibit spontaneous electric polarization that can be reversed through application of an external electric field. While much is known about the bulk behavior of ferroelectric materials, much less is known about their surface behavior despite there being a known irregular phenomenon that occurs in this area.

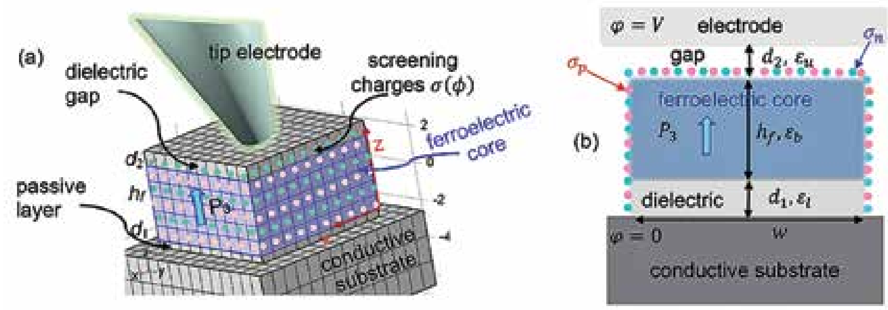
"Indeed, since the early days of ferroelectricity, it has been recognized that the discontinuities of polarization at surfaces and interfaces [of ferroelectric materials] create a bound charge as a consequence of fundamental Maxwell electrostatics," researchers write in a 2018 review article.

They explain that this bound charge gives rise to a depolarization field opposite to the polarization direction. To reduce the energy of the depolarization field and stabilize the ferroelectric phase, charge-compensating processes need to be implemented, such as creating 180° domain structures with antiparallel polarization stripes or surface-compensating free charges that counteract the polarization bound charges.

When determining the behavior of ferroelectric materials, these screening charges traditionally are excluded from consideration and analysis because they are assumed to be (a) always present and (b) irrelevant to the material's macroscopic physics.

"This assumption is well justified for bulk ferroelectrics close to equilibrium, where the role of surface effects can be expected to be minor. This postulate, however, is no longer true on the nanoscale, when the free energies of surface ionic and electronic screening become comparable to the bulk free energy of the ferroelectric," the researchers write.

Scientists have observed a range of highly unusual phenomena in nanoscale



(a) Side view and (b) vertical cross-section of a parallelepiped-shape nanoparticle consisting of a uniaxial ferroelectric core sandwiched between two dielectric layers. The direction of the uniaxial polarization is shown by the blue arrow.

ferroelectric systems since the 1990s, such as hot electron and X-ray emission and fusion. However, it is only with the advancement of nanoscale probing techniques that scientists began describing the role of surface-charge dynamics in these phenomena.

In the recent open-access paper, the U.S. and Ukrainian researchers used finite element modeling to fill the gap in knowledge concerning the behavior of ferroelectric nanoparticles dispersed within highly polarized nonlinear media.

The dispersion of ferroelectric nanoparticles within highly polarized nonlinear media, such as liquid crystals, is viewed as a promising way to design advanced and tunable electro-optical devices and nonlinear optical elements. While there are many examples of these systems being realized experimentally, more theoretical studies are needed to help explain the experimental observations.

To set up their finite element model, the researchers used constitutive equations for relevant order parameter fields based on the Landau-Ginzburg-Devonshire phenomenological approach, along with electrostatic equations and elasticity theory.

For geometry, they considered a parallelepiped-shaped nanoparticle consisting of a uniaxial ferroelectric core sandwiched between two dielectric layers of either same or different physical natures (e.g., gaseous, soft matter, liquid).

The model revealed that polarization and susceptibility in these systems is very sensitive to the concentrations, formation energies, and relaxation times of the screening charges. As a result, the researchers could continuously switch the state of the ferroelectric core between paraelectric-like, ferroionic, antiferroionic, mixed antiferroionic–ferroionic, and ferroelectric-like ferroionic states by modifying the above properties.

"Obtained results are not only promising for advanced applications of ferroelectric nanoparticles in nanoelectronics and optoelectronics, they also offer strategies for experimental verification," they conclude.

The open-access paper, published in *Acta Materialia*, is "Dynamic control of ferroionic states in ferroelectric nanoparticles" (DOI: 10.1016/j.actamat.2022.118138). ■

M7C3: Unveiling the structure of a misunderstood carbide

Researchers from New Mexico Institute of Mining and Technology and Technion–Israel Institute of Technology used a variety of imaging techniques to reveal the atomistic structure of M_7C_3-type carbides.

M_7C_3 carbides (M=Cr, Fe) are extensively used for heat resistance and wear critical applications. However, since the discovery of these carbides in the 1930s, their exact structure has been a source of confusion for scientists.

"A. Westgren [1935] first described Cr_7C_3 as having a trigonal *P31c*-structured lattice with parameters a = 1.39 nm,

c = 0.454 nm. In 1964, Herbstein and Snyman determined, based on extensive XRD analysis, that the structure is actually hexagonal, belonging to the $P6_3mc$ space group with the lattice parameters a = 0.6882 nm, c = 0.454 nm. However, in the same year (1964), Fruchart and Bouchaud found that Cr_7C_3 has a *Pmcn*-structured orthorhombic lattice," the researchers write.

The currently accepted structural configuration of M_7C_3 carbides is the orthorhombic configuration with lattice parameters a = 0.702 nm, b = 1.216 nm, and c = 0.453 nm. However, some publications still refer to the hexagonal configuration of M_7C_3.

"It is, therefore, our understanding that there is much confusion with regards to the exact Bravais lattice, the derived atomic positions, or even the number of configurations possible for this phase, depending on formation conditions," the researchers write.

This ambiguity hinders attempts at using data-driven methods to tailor the carbide's growth characteristics, stability, and mechanical properties. The researchers hope their study will help resolve this debate so computational efforts can proceed more smoothly.

They used an as-cast $AlCrFe_2Ni_2$ with 0.18 wt.% carbon as the model system. The material consisted of four coexisting phases: FCC, B2, BCC and $(Cr,Fe)_7C_3$. Images of the $(Cr,Fe)_7C_3$ phase were gathered using electron backscattered diffraction, transmission electron microscopy diffraction, and high-resolution scanning transmission electron microscopy.

After gathering the images, they used the CrystalMaker software (version 10.5) to visualize the lattice images and determine which suggested structural configuration matched with the experimentally gathered data.

The researchers concluded that, at least for the composition studied here, there exists only one variant of the M_7C_3 carbide—the hexagonal $P6_3mc$ polymorph.

"Our suggested metallic atom coordinates are consistent with all lattice images taken from 9 different zone axes and are consistent with the required symmetry operations, as evident by the Kikuchi patterns," they write.

Surprisingly, their results indicated that a carbon atom had to be positioned in the middle of each octahedral complex, a location which all previous works considered to be vacant.

"All in all, it is clear that although all M_7C_3 structures suggested over the years are very similar, there are subtle nuances shown in the HAADF [high angle annular dark field] images that we believe have been fully addressed by our suggested hexagonal structure," they conclude.

More generally, the researchers believe that the methodology used in this work—i.e., cross-correlated examination of structural data obtained from several complimentary sources combined with simple analytical tools—can help clarify the structure of other materials for which a discrepancy is found in the literature.

The paper, published in *Acta Materialia*, is "M_7C_3: The story of a misunderstood carbide" (DOI: 10.1016/j.actamat.2022.117985). ■

Tactile graphics enable universal visualization of data

Researchers led by Baylor University explored creating lithophanes featuring data found in the chemical sciences to make scientific data accessible to everyone regardless of eyesight level.

Usually when students face difficulties reading a scientific paper, they will turn to the figures in hopes that the graphical representation of data can bolster their understanding. However, for students with visual impairments, traditional pictures and graphs do not add much in way of enlightenment because they cannot see the flat, 2D-printed images.

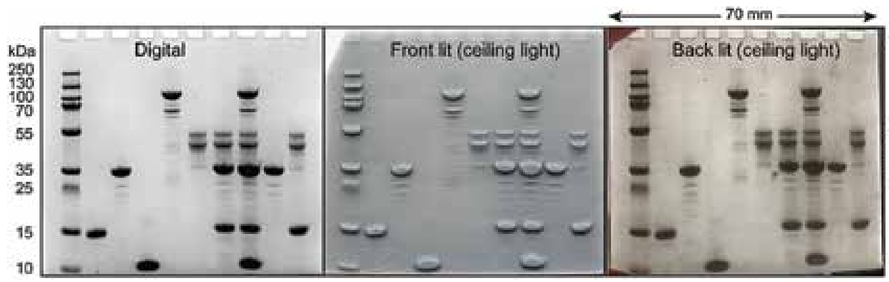
Tactile graphics—raised lines, textures, and elevated illustrations—are an alternative image format that likely would benefit students with visual impairments. Unfortunately, examples of tactile illustrations in the literature are few and far between, and the ones that exist face challenges such as low resolution, high cost, or specialized knowledge.

Thus, there is a need for a high-resolution, low-cost, and portable data format that preferably can be visualized by anyone regardless of eyesight level. "Such a format will enable blind and sighted individuals to share—to visualize and discuss—the exact same piece of data," the researchers write.

Their study investigated the possibility of creating tactile graphics using a lithophane. Lithopanes are etched or molded artworks, typically less than 2 mm in thickness, traditionally made from porcelain or wax but now more commonly from plastic. The surface appears opaque in ambient "front" light, but the lithophane glows like a digital image when backlit, i.e., held in front of a light source.

Lithophanes can now be 3D printed from any 2D image by converting the image to a 3D topograph. Despite this ease of fabrication, the use of lithophanes as a universally visualized data format has never been reported, according to the researchers.

For this study, the researchers focused on creating and testing lithophanes



From left to right: Digital source image of sodium dodecyl sulfate–polyacrylamide gel electrophoresis (SDS-PAGE), frontlit lithophane, and backlit lithophane.

featuring data found in the chemical sciences. They chose this topic area because while exclusion of students with visual impairments in chemistry "can be viewed as a virtue … on the basis of laboratory safety and the 'visual' nature of chemistry … exclusion from chemistry impedes learning in other fields that might be more inclusive," the researchers write.

In addition, the researchers state that four of the authors have been blind since birth or childhood and are among the small group of people who earned Ph.D. degrees in the chemical sciences while being blind.

Lithophanes were created using a small commercial 3D printer and initially focused on the most common data type in biochemistry: sodium dodecyl sulfate–polyacrylamide gel electrophoresis (SDS-PAGE). Additional lithophanes highlighting other types of data were fabricated as well, including a scanning electron microscopy of a butterfly chitin scale, a mass spectrum of a protein with gas phase phosphate adducts, an electronic (ultraviolet-visible) spectrum of an iron-porphyrin protein, and a textbook-style secondary structure map of a seven-stranded β sheet protein.

The testing cohort consisted of sighted students with or without blindfolds and five people with vision impairments who have experienced total blindness or low vision since childhood or adolescence. They were asked to interpret the lithophane data by tactile sensing or eyesight.

The average test accuracy for all five lithophanes was 96.7% for blind tactile interpretation, 92.2% for sighted interpretation of backlit lithophanes, and 79.8% for blindfolded tactile interpretation. In contrast, the accuracy of interpretation of digital imagery on a computer screen was 88.4% by eyesight.

For about 80% of questions, tactile accuracy by blind chemists was equal or superior to visual interpretation of lithophanes. The researchers speculate this disparity is attributable in part to the higher educational level of the blind cohort.

"Four of the five blind persons tested in this study have earned Ph.D.s in the chemical sciences, whereas the sighted participants were undergraduate students enrolled in undergraduate biochemistry, who might have misinterpreted the spectrum," they write.

Although the study did not examine chromatic data, the researchers expect that the visualization of colored data—such as heatmaps and 2D color plots—could be accomplished with lithophanes projecting a monotonic grayscale.

"This research is an example of art making science more accessible and inclusive. Art is rescuing science from itself," says Bryan Shaw, Baylor professor of chemistry and biochemistry and lead author of the recent study, in a Baylor press release.

The open-access paper, published in *Science Advances*, is "Data for all: Tactile graphics that light up with picture-perfect resolution" (DOI: 10.1126/sciadv.abq2640). ■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Turkey's advanced R&D inspires tomorrow's innovations

Credit: Meg Jerrard, Unsplash

By Alex Talavera and Randy B. Hecht

Turkey banks on "innovation active" enterprise and technology to strengthen its economic and foreign commerce potential.

"One of our principles is to render the state active in the enterprises that are to the general benefit of the nation, especially in the economic field, in order to achieve a prosperous and well-cultivated country."[1]

Those contemporary-sounding words were actually spoken by Mustafa Kemal in 1923, the year Türkiye Cumhuriyeti—the Republic of Turkey—was founded. Better known as Kemal Atatürk and the country's first president, he introduced a series of five-year industrialization plans in the 1930s.

Those plans evolved in the 1960s into five-year economic development plans that continue to serve as roadmaps for growth today. The current plan spans the years 2019–2023. It addresses a broad portfolio of economic aims, from agricultural production, rural employment, and poverty reduction to encouraging entrepreneurship and innovation, increasing energy efficiency, and employing digital transformation to boost productivity and competitiveness in priority sectors.[2]

In a 2018 speech that alluded to these priorities,[3] President Recep Tayyip Erdoğan identified areas that he sees as key to securing Turkey's future.

"Our technological depth, which we need in the areas of nanotechnology, materials, aviation, aerospace and defense, is growing with every passing day," he said. "Initiatives regarding national technology will render it possible for us to grow stronger in economy and world politics."

Tracking progress through a pandemic

Of course, like every other country, Turkey had no way of knowing that plans launched in 2019 would be sidetracked one year later by the COVID-19 pandemic—or that they would then be subjected to further risks from global inflation and the fallout of Russia's war against Ukraine.

Perhaps in part resulting from these disruptions, there is a shortage of hard data measuring the impact of the current five-year plan on the country's performance targets.

The Turkish Statistical Institute (TURKSTAT) published findings of a 2020 Innovation Survey in November 2021.[4] (The next survey results will be published in November 2023.) According to the report, 67.3% of large companies (250 employees or more) and 38.5% of enterprises with 10 or more employees met the country's "innovation active" standard during the survey period of 2018–2020. It also notes that 31.9% of companies in that category received public financial support, while 54.8% of those classified as "not innovation active enterprises" cites high costs as "the most hampering factor."

In July, TURKSTAT published its annual analysis of "central government budget appropriations and outlays on R&D," which it reported totaled TRY20,249,000,000 for 2021.[5] That amount in Turkish lira converts to US$1,113,348,742 at the exchange rate on August 27 and, according to the agency, represents 0.28% of Turkey's Gross Domestic Product for the year. The report notes that this amount is slated to rise to TRY26,307,000,000 (US$1,446,435,150) for 2022, "according to the provisional results based on initial budget appropriations."

Universities received 48.3% of the total "for general advancement of knowledge," while industrial production and technology were allocated just 10.3%. "According to the calculations based on the initial budget appropriations, it has estimated that the highest appropriation for R&D will be allocated to universities for general advancement of knowledge with 38.4% in 2022," the report says, while the share for industrial production and technology will drop to 8.4%.

Officials at Turkey's Ministry of Industry and Technology declined to respond to repeated requests for an interview or comments in connection with this article.

From campus to global commerce

The distributions of government funding for R&D create an environment in which the private sector must collaborate with universities.

"In Turkey, the universities are fairly flexible in the sense that they promote the faculty members to engage with industrial research," says Ender Suvacı, founder and chief technology and innovation officer at Entekno Industrial Technological and Nanomaterials Co. (Eskişehir, Turkey). He also serves on the faculty at Eskişehir Technical University.

In an interview with the *Bulletin*, he explained that when Turkish companies need academic research support, they usually begin by contacting a university's Technology Transfer Office, which is responsible for matching companies with the right person at the university. Industry can also make direct contact with their preferred researchers, but the Technology Transfer Office usually gets involved regardless. Its role extends to negotiating ownership of technologies or patents that emerge from joint research, the number of days for which faculty members are contracted, and the amount the contracting company will pay for research activities and related expenses.

Credit: Entekno Industrial Technological and Nanomaterials Co.

"Although we say we are in cosmetic and electronic applications, we are developing and manufacturing environmentally friendly and sustainable specialty particulate materials." – Ender Suvaci, founder and chief technology and innovation officer at Entekno Industrial Technological and Nanomaterials Co.

Intellectual property ownership may be put into a signed agreement at the beginning, but it can be left open at the outset, with the question to be revisited as the project achieves certain milestones.

"The main motivation to do this is not to put IP ownership negotiation in front of the collaboration," Suvacı says. "They prefer to start, see the potential, and then discuss more."

In either case, "academic entrepreneurship" is encouraged at Turkey's universities, and private enterprise depends on academic research labs and facilities for access to equipment and tools and as a means of managing R&D investment expenses.

Connecting the ceramic microdots

Entekno's portfolio includes inorganic powders, ceramic additives, and cosmetic additives. The business was launched as an outgrowth of research Suvacı conducted for an international company that sought his help developing size and shape controlled electroceramic particles that at the time were not commercially available and had to be produced in a laboratory. After they were developed, his collaboration partner wanted to increase production capacity, and with that decision, Entekno was born in 2008, initially as a university start-up.

The unifying factor in those three product lines is development of novel ceramic particle systems. "Although we say we are in cosmetic and electronic applications, we are developing and manufacturing environmentally friendly and sustainable specialty particulate materials," Suvacı says. "We are tailoring particle systems, which have unique properties, and they make a significant impact wherever they are used."

It was while he and his team were investigating novel zinc oxide forms that they realized they were one of the few nano zinc oxide manufacturers in the world.

"While we were working in the area of electroceramics, we wanted to exploit how we could do something different with zinc oxide in a different sector, and we found out that zinc oxide is a great UV filter," Suvacı says. "With this technology, we were working in the electroceramic area, but we converted our particle synthesis–structure–property understanding to develop the new generation particle technology, which is called MicNo. Today, MicNo-ZnO particles are successfully commercialized in the global cosmetic industry."

Because MicNo has unique micron sized platelet morphology, it serves the company as a platform technology. Its use expanded in response to the COVID-19 pandemic when Entekno integrated antimicrobial and antiviral actives within the MicNo particles, which are called as MicNo-Hyg. The company then collaborated with sanitaryware manufacturing partners to create ceramic surfaces that exhibited broad-spectrum antimicrobial activity. "So far, seven million pieces of ceramic products have been produced by using MicNo-Hyg," Suvacı says.

He sees Entekno as an innovation company with a global scope. It serves customers on four continents and collaborates with them on research projects supported by a safety level-II microbiology lab and three product application laboratories on cosmetic formulations, hygiene, and piezoelectrics. In addition, the company prioritizes information-sharing that enables customers to easily adapt new technologies within their systems. Funding for projects has come not only from customers but also from the European Union and The Scientific and Technological Research Council of Turkey (TÜBİTAK). As an example, Entekno received an EU-funded Eurostar grant for its collaboration with CTS Denmark on "development of new generation lead-free ceramics for consumer electronics."

Entekno also seeks innovation in its management of human resources. To that end, Suvacı and Entekno's managing partner Oktay Uysal are developing an Entekno Academy to provide ongoing internal training designed to promote professional development even for the 14% of his employees who hold doctorates. Suvacı mentions, for example, having a professor of microbiology deliver seminars on the biology of microorganisms and viruses to the Entekno team.

The Academy is expected to contribute to achieving business objectives, give existing employees a greater sense of purpose, and aid in attracting new candidates in a market with human capital constraints. Alongside that final point is Suvacı's goal of increasing the number of women who are hired by Entekno and supported in rising to executive positions at the company.

He also envisions training in methodologies and in developing employees' English-language skills so they are better equipped to serve global customers. Suvacı has a feeling of personal investment on that count, as he completed his master's degree and Ph.D. at The Pennsylvania State University, where "I met the wonderful world of ceramic powders. Really, that's how it started."

An "affordable luxury" import arrives

In July 2022, news broke that Eczacıbaşı Building Products (İstanbul, Turkey) would be expanding into the U.S. market. The company's announcement noted that its flagship brand,

Credit: Eczacıbaşı Building Products

In January 2022, Eczacıbaşı Building Products announced that VitrA received four new awards at Good Design Awards 2021. This award program, organized jointly by The Chicago Athenaeum: Museum of Architecture and Design and The European Centre for Architecture Art Design and Urban Studies, is one of the world's oldest and most prestigious design competitions. With these awards, VitrA now has 44 Good Design Awards. Pictured are the winning ArchiPlan bathroom collection and Atelier 01 tile series.

VitrA, has a 30% share of the market in Turkey but that exports generate most of its revenue.[6]

Although the U.K. and Germany are the company's two largest export markets, followed closely by France, its fastest-growing markets are China and India. But "you can't really consider yourself a global player unless you are in the United States," says Jeremy Cressman, who was named director of the Americas. The expansion plans also target Canada and perhaps Latin America.

In an interview with the *Bulletin*, Cressman noted that Eczacıbaşı Building Products has been a member of the UN Global Compact since 2006 and that this alignment is core to the brand's identity in other foreign markets. However, U.S. codes and standards, led by development in California and the Green Building Council, will be the company's targets to adhere to in this market.

These codes are not expected to introduce significant advances in water reduction. However, Cressman does expect them to make an impact in terms of the manufacturing process, materials used, material transparency, health product declarations, and environmental product declarations.

"Those are the basis for transparency in every aspect of supply chain and product development, from actual raw material extraction to conversion to how a ceramics piece is fired in the kiln and how much energy is consumed in doing that, to packaging, and its full cycle including recyclability, or reuse," Cressman says.

He also sees an opportunity for product distinction. "We're entering the markets here with kitchen sinks. And we're making kitchen sinks with fireclay. So an ancient process at high temperature to make the most durable ceramic piece you can make." Conversely, the company will not be offering composite sinks because "there is no way to call that a sustainable process."

The first products are expected to arrive in the U.S. in early November and will feature European styles and designers. Over the long term, Cressman expects that the portfolio will expand to reflect "design influences in the U.S. market, especially the kitchen and bath dealer designs, kitchen designers themselves, bathroom designers, and interior designers," he says.

"We don't have direct plans to work with anyone immediately. It is fair to say that it is on our roadmap," he says.

Looking ahead to 2023, he expects to introduce fireclay shower pans, which have been successful in Europe.

"These are heavy ceramic made at high temperatures, sizes up to 60 inch like an alcove tub, and they are nonslip, they are beautifully formed shape and texture," Cressman says. "The [U.S.] market tends to sell acrylic bases, or they tend to rely on the tile contractor to do a full waterproofing of a tile floor for the shower. These bases would be labor saving, as well as durable, heavy, and beautiful. It is a new product that would come to the U.S. sometime in late 2023."

Plans beyond that for next year are "very open at this point" but involve "looking for distribution partners in the affordable luxury area."

Pursuing multisector glass breakthroughs

Founded in 1935 under Atatürk's directive, Şişecam Group today has operations in 14 countries on four continents. In emailed responses to *Bulletin* questions, Glass Technologies Director İlkay Sökmen provided insights into the company's R&D priorities during the International Year of Glass and an overview of its future objectives and targets.

The company has a nearly half-century history of pioneering what it refers to as a "corporate R&D culture in Turkey." In 1976, it established one of the country's first private sector R&D centers, its Glass Research Laboratory in Istanbul. The LEED Gold-certified Şişecam Science, Technology, and Design Center launched in Kocaeli in 2014; the 9,400-square-meter facility houses 27 specialized laboratories staffed by 231 researchers whose areas of focus Sökmen described as "ranging from basic research to laboratory-scale pilot manufacturing trials."

With consolidated net sales of TRY40.2 billion (US$2.4 billion) in the first half of 2022, the company made a total of TRY2.8 billion (US$168 million) in investments for that period.*

"Şişecam allocates almost one percent of its turnover to R&D activities, carrying out joint projects in close contact and cooperation with numerous universities and research institutions in Turkey and around the globe," Sökmen wrote. "Şişecam is also engaged in pre-competitive collaboration with institutions and organizations operating in similar sectors, whenever needed."

How are the company's investment priorities evolving? Areas of concentration during the past five years include cold repairs, technology harmonization, acquisitions and new investments. Sökmen cited Şişecam's U.S. soda investment—which she noted is the largest-ever Turkish investment in the U.S.—as well as a Hungarian glass packaging facility (the company's first such plant in Europe), acquisition of the Italian refractory manufacturer Refel, and, on the domestic side, a further glass packaging investment in Eskişehir.

Developed by Şişecam Group, patented antimicrobial V-Block Technology is put on the market by Paşabahçe, Şişecam's leading glassware brand. The initial V-Block product range includes various tumblers, tea glasses and saucers, mugs, and bowls.

*The U.S. dollar amounts are calculated on the basis of the exchange rate as of the end of the first fiscal half, June 30, 2022, as reported on OANDA.com.

The company also maintains float lines for architectural and automotive glass investments in Turkey. "With this investment, the current annual flat glass production capacity in Turkey will increase by 30%," Sökmen stated. In keeping with those projections, the company invested in "a new patterned glass furnace with a capacity of 600 tons per day and processing line with a capacity of 20 million square meters per year." This investment is designed to capitalize on emerging solar energy opportunities.

She added that as companies must comply with increasingly stringent sustainability regulations, Şişecam invested in Basalia Technology, a Turkish bioeconomy invention that "converts all kinds of waste into harmless substances."

Integrating R&D and sustainability targets

Among studies underway at Şişecam are those focused on "production processes and value-added product development projects, especially for architecture, automotive, and renewable energy sectors, and important practices for efficient use of energy and reducing carbon footprint in all processes up to the end consumer," Sökmen wrote. These projects keep with the company's efforts to contribute to global achievement of net zero emissions by 2050.

"With this perspective, one of the most important trends in Şişecam R&D is recycling. Şişecam attaches great importance to all activities related to increasing the use of cullet in glass production. Using 10% glass cullet in production, 2.5% energy saving can be ensured in the production of glass," Sökmen wrote.

Also in development: novel designs for next-generation glass furnaces to minimize and eventually phase out the use of fossil fuels. This work is in the study phase, with teams dedicated to such areas of investigation as integrated furnace models, improvement of heat transfer efficiency, new refractory materials, and new glass melting and production technologies. The company also introduced product innovations such as next-generation glass fiber products for wind turbine blade manufacturers that are made using advanced fiber production technology and reinforced with nanomaterials.

MARKET SNAPSHOT

Trade, treaties, and tariffs

Bicontinental Turkey relies on cross-border commerce, but U.S. export partners face some barriers to entry

By Alex Talavera and Randy B. Hecht

Next year marks the centennial of the Republic of Turkey, which emerged as the successor to the Ottoman Empire with the 1923 signing of the Treaty of Lausanne (the final accord signed at the end of World War I). The country borders Bulgaria and Greece on the European side and Armenia, Georgia, Iran, Iraq, and Syria in Asia, but most of its boundaries are coastline: along the Black Sea to the north and the Aegean Sea to the west and south.

The CIA World Factbook rates Turkey as having an upper middle-income, diversified Middle Eastern economy. At the same time, it notes that an attempted coup in 2016 and a 2018 currency recession resulted in "economic instability" ahead of the COVID-19 pandemic, which sparked an increase in poverty and unemployment.[a]

These economic woes were exacerbated in 2022 by skyrocketing inflation that Turkish government statistics acknowledged reached 78.6% as of June. However, *The Guardian* reported that "opposition parties and economists said recent hikes in oil and gas prices meant the real rate of inflation was almost double the official figure."[b] The Russian invasion of Ukraine and its impact on trade in the Black Sea region pose additional economic and supply chain challenges.

Turkey's 2022 population is estimated to be 83,047,706, but less than 40% of the country was engaged in the labor force during 2021. According to International Labour Organization data, the workforce was 32,618,920 that year; women comprised for 32.5% of the total, and children ages 7–14 accounted for another 2.6%.[c]

In 2020, the real GDP (purchasing power parity) is estimated to have been $2.394 trillion, or $28,400 per capita.[a] Leading industries in the country include textiles, food processing, automobiles, electronics, mining (coal, chromate, copper, boron), steel, petroleum, construction, lumber and paper. Within the agricultural sector, leading products are milk, wheat, sugar beets, tomatoes, barley, maize, potatoes, grapes, watermelons and apples. Natural resources found in abundance in Turkey include coal, iron ore, copper, chromium, antimony, mercury, gold, barite, borate, celestite (strontium), emery, feldspar, limestone, magnesite, marble, perlite, pumice, pyrites (sulfur), and clay.

Turkey operated at a trade deficit in 2020, with exports of $203.29 billion against imports of $232.01 billion. Leading export commodities include cars, vehicle parts, refined petroleum, delivery trucks, jewelry, clothing, and apparel, while gold, refined petroleum, crude petroleum, vehicle parts, and scrap iron are notable commodity imports. In 2019, the country's major trade partners included the United Kingdom, Iraq, Italy, and the United States for exports and Germany, China, Russia, the United States, and Italy for imports.

The Commerce Department's International Trade Administration cites Turkish government statistics that show goods from the U.S. accounted for nearly 5% of total imports into Turkey in 2021. However, it adds this note of caution: "An increase in tariffs in 2018 and 2019 on a range of U.S. products may put some U.S. exporters at a disadvantage relative to their European competitors, who share a Customs Union agreement with Turkey and therefore do not face the same trade barrier."[d]

Additional details and foreign commerce support are available via the International Trade Administration's Turkey Country Commercial Guide (https://bit.ly/3TQjYO2), the U.S.–Turkey Business Council (https://bit.ly/3esx9o3) and the Turkish American Chamber of Commerce, Industry and Maritime Trade (https://bit.ly/3erzwaL).

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[d]"Turkey - Country Commercial Guide," U.S. Commerce Department International Trade Administration. Last updated 26 July 2022. Accessed 6 Sept. 2022. https://www.trade.gov/country-commercial-guides/turkey-market-overview ■

The COVID-19 pandemic inspired the invention of "a special coating that neutralizes viruses and bacteria on glass surfaces," Sökmen wrote. "Patented Antimicrobial V-Block Technology, developed by Şişecam, aims to prevent the spread and reproduction of viruses and bacteria that can be transmitted by person-to-person contact on glassware."

In 2021, Şişecam collaborated with 45 Turkish and 39 international universities, research institutions, and private sector R&D units. It sees Ph.D. programs as essential to providing qualified researchers for ongoing projects. Sökmen noted that as a result of the company's collaborations with seven universities, "we have nine projects, which will result in the employment of 23 doctorates."

This year, Şişecam's 37th annual International Glass Conference has the theme "Inspiration for Tomorrow: Celebrating International Year of Glass." It will be conducted in a hybrid format November 17–18, with onsite activities held in Istanbul.

"Inspiration for Tomorrow" could also be Turkey's national economic development slogan. The country envisions a future born of "innovation active" entrepreneurship and technological advances—but it must navigate today's economic uncertainties and supply chain challenges to get there.

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[4]"Innovation Research, 2020," Turkish Statistical Institute. 24 Nov. 2021. Accessed 6 Sept. 2022. https://data.tuik.gov.tr/Bulten/Index?p=Innovation-Survey-2020-37457

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Policy and product development

TÜBİTAK: Turkey's national institute for science and technology R&D

By Alex Talavera and Randy B. Hecht

The Scientific and Technological Research Council of Turkey, or TÜBİTAK, is the Turkish government's advisory agency on science and research and the Secretariat of the Supreme Council for Science and Technology. Its board members are drawn from a mix of academia, industry, and research institutions.

In addition to fulfilling its science and technology policy-making responsibilities, the organization manages R&D institutes in line with national priorities. Its description of the scope of its work states that TÜBİTAK "funds research projects carried out in universities and other public and private organizations, conducts research on strategic areas, develops support programs for public and private sectors, publishes scientific journals, popular science magazines and books, organizes science and society activities, and supports undergraduate and graduate students through scholarships."

Affiliated institutes are organized under two TÜBİTAK organizational bodies.

- The Marmara Research Center (MAM) oversees eight divisions: Environment and Cleaner Production, Energy Institute, Genetic Engineering and Biotechnology, Food Institute, Chemical Technology Institute, Polar Studies Institute, Materials Institute, and Institute of Earth and Marine Sciences.
- The Information and Information Security Advanced Technologies Research Center (BILGEM) oversees five divisions: Information Technologies, Advanced Technologies Research Institute, Cyber Security, National Electronics and Cryptology Research, and Software Technologies Research Institute.

The Materials Institute's research encompasses (critical) metallic and structural materials and sensor materials and systems (e.g., photonic technologies, CBRN sensors, acoustics, lasers, medical devices, nanomaterials and coatings, and millimeter wave and terahertz technology). MAM maintains a research project list at https://bit.ly/3RsGCdK, but it has not been updated since 2020.

TÜBİTAK reports that as of 2022, it has bilateral cooperation agreements with 92 institutions from 65 different countries. These agreements cover joint research projects as well as scientific meetings and scientist exchanges and visits. Links to information about existing programs are listed at https://bit.ly/3RK8Sbv.

Hasan Mandal, chairman of TÜBİTAK and of its Board of Directors, completed his Ph.D. and post-doctoral studies at Newcastle University in the United Kingdom. He began his career as a professor of ceramic engineering and is a member of the World Academy of Ceramics and a former president of the European Ceramic Society. Mandal declined to respond to repeated requests for an interview in connection with this year's international report.

The 53rd award ceremony for TÜBİTAK's Research Project Contest for High School Students was held in June 2022. President Recep Tayyip Erdoğan, center, spoke at the ceremony and highlighted the work his administration has done to transform and improve the Turkish education system.

Credit: Republic of Turkey Ministry of National Education

Turkey's advanced R&D inspires tomorrow's innovations

Directory of Turkish companies, associations, institutes, government agencies, and universities *All links included in this directory worked as of Sept. 1, 2022*

CORPORATIONS

Ahenksan Metal

Mimarsinan Organize Bölgesi, 23. Cadde, No: 82, Melikgazi, Kayseri
Phone: 90-352-503-0166
Website: https://www.ahenksan.com
Contact: info@ahenksan.com

The company manufactures and supplies a product line that includes acrylic, cement, ceramic, chromate, copper, duplex, lime, metal, mold, refractory, rubber, and surface coatings.

Akcoat

Sakarya 2. OSB No. 1 Road No:18 54300 Hendek, Sakarya
Phone: 90-264-323-3031
Website: https://www.akcoat.com
Email: akcoat@akcoat.com

The company's five primary product groups are enamel, ceramic, nonstick decorative coatings, pigment, and glass.

Burcam

Yeniceköy, Yeniceköy Mh Fatih Sultan Mehmet Han Blv. Burcam Blok, D:No:1, 16440 İnegöl, Bursa
Phone: 90-224-718-6056
Website: https://burcam.com.tr/en/en_en
Email contact form: https://burcam.com.tr/en/contact

The company's glass services encompass cutting, drilling, rodaging and sandblasting processes, CNC channel and processing, bizote and form operation, and screen and digital printing processes.

Burmas

Şirinevler Mh. Ankara Cd. No:743 Yıldırım, Bursa
Phone: 90-224-341-3316
Website: http://burmas.com.tr
Email: export@burmas.com.tr

Çölyen Cam

Phone: 90-384-213-1464
Website: www.colyencam.com.tr
Email: info@colyencam.com.tr

Established in 1973 to serve wholesalers and retailers in the glass sector, the company's products include insulating glass materials, double glass, tempered glass, glass processing, and jumbo sizing machines.

Entekno Industrial Technological and Nanomaterials Co.

Yesiltepe Mah. Ismet Inonu-2 Cad. No:2/57 Tepebasi, Eskisehir
Phone 90-541-320-3677
Website: https://www.enteknomaterials.com
Email: info@enteknomaterials.com

Entekno was founded in 2008 "to develop and produce advanced materials and/or technologies and to realize the usage of these materials into real applications." With a focus on how nano particle solutions can be developed to benefit society, the company developed its MicNo® ZnO particle technology for broad-spectrum protection against UV rays.

R&D teams at Entekno explore a variety of fields of science and technology, including production of inorganic powder materials, modification of powder surfaces, composite materials production and development, improvement of physical, chemical, and thermochemical properties of materials and nanomaterials synthesis and development. Its projects include development of lead-free piezoelectric ceramics, safe nanomaterials synthesis, textured advanced ceramics production, high-purity materials production, flame retardant materials production, and production of nanoadditives for nanocomposites.

In addition, Entekno produces inorganic powders, including barium titanate, strontium titanate, barium carbonate, bismuth oxide, tantalum pentoxide, and aluminium hydroxide.

ESAN

Kyrenia Mah. River St. No: 1-3 Maltepe, 34852, Istanbul
Phone: 90-216-581-6400
Website: https://www.esan.com.tr/tr/tarihce
Email contact form: https://www.esan.com.tr/tr/iletisime-gecin

Founded in 1978, Esan's refractory activities encompass industrial minerals (production and commercial products), metallic mines, laboratory services and engineering, and consultancy.

Eczacıbaşı Building Products

Kanyon Office Büyükdere Caddesi 185 Levent 34394, Istanbul
Phone: 90-212-371-7000
Website: https://www.eczacibasi.com.tr/tr/anasayfa
Email contact form: https://www.eczacibasi.com.tr/tr/iletisim

Etiler Madencilik A.Ş.

Aşık Veysel, Buğday Sk. No:11 D:B Blok, 34707 Ataşehir, İstanbul
Phone: 90-216-688-3900
Website: https://www.etilermadencilik.com.tr/en
Email: info@etilermadencilik.com.tr

The company produces "all-in (raw) and drained (refined) clay for the needs of domestic and foreign ceramic industry" and has "an annual production capacity of 750 thousand tons of refined clay and 12 thousand tons of raw clay." Its white silica sand "is prepared in a washing plant equipped with modern equipment" and is available in bulk or in smaller quantities. The company maintains its own R&D facilities and labs to provide Q&A oversight on raw materials specifications and production.

Kaleseramik Çanakkale Kalebodur Seramik San. Inc. (Kale)

Büyükdere Cad.Kaleseramik Building 34330 Levent, Istanbul
Phone: 90-212-371-5253
Website: https://www.kale.com.tr
Email: İletişim@kale.com.tr

Kümaş Magnesite Industry Inc.

Barbaros Mah. Kardelen Sk. Palladium Tower Blok No:2 Inner Door No:27 Ataşehir, Istanbul
Phone: 90-216-576-2011
Website: http://www.kumasref.com/tr-TR
Email contact form: http://www.kumasref.com/iletisim,PG_1.html

Drawing on the natural magnesite ore found in Turkey's Kütahya-Eskişehir-Bilecik triangle, the company launched in 1972 to produce sinter magnesite, basic refractory bricks and mortar, iron-steel, and cement. It began fused magnesite production in 2008 and today also supplies fused magnesite, fused oxychrome, and calcined magnesite derivative products as industrial raw materials. In addition, its factory manufactures magnesite, dolomite, and alumina refractory bricks and mortars.

Directory of Turkish companies, associations, institutes, government agencies, and universities *All links included in this directory worked as of Sept. 1, 2022*

Matel Hammadde Sanayi ve Ticaret A.Ş.
Yalı Mahallesi, Ziya Gökalp Cad. No: 3 34844 Maltepe, Istanbul

Phone: 90-216-441-2283

Website: https://www.matel.com.tr/tr/urun

Email: matel@materl.com.tr

The company's Clay Group produces refined clays as well as clays for tiles and sanitaryware. Its Feldspar Group produces K- and Na-feldspars as well as syenite. The Kaolin and Quartz and Silica Groups round out the organization. The website notes that the company's laboratory is "capable of conducting all analyses required for ceramic industry and all kinds of chemical, mineralogical and physical analyses in Bilecik. In the laboratory, we perform required in-company quality controls and also meet the laboratory demands of other companies in the region and conduct intensive R&D works on industrial raw materials."

MDA Advanced Technology Ceramics Inc.
Organized Industrial Zone Technology Boulevard, Eskisehir

Phone: 90-222-236-1880

Website: https://mdaceramic.com/#

Email: info@mdaceramic.com

Miltas Nano
Istanbul Anadolu Yakasi O.S.B Gazi Bulvari, No: 51/A, Tuzla, Istanbul

Phone: 90-216-593-1303

Website: https://nanomiltas.com

Email: info@nanomiltas.com

The company develops complex nanomanufacturing systems that can produce nanoparticles, nanofibers, and a combination of the two. It uses a hybrid technology developed using magnetic field atomization techniques.

Nanografen
GOSB Technopark 1st Production Building, Unit 5, Gebze, Kocaeli

Phone: 90-262-678-8900

Website: http://nanografen.com.tr

Email: info@nanografen.com.tr

The company's mission statement says, "We offer robust, reliable, cost-effective, and fast processes for upscaling graphene, improve thermal stability, electrical conductivity, and mechanical properties of composite materials by using graphene in polymer matrix and provide significant weight reduction in materials. We decrease the risks of plastic materials on environment by increasing the use of carbon technologies and produce value-added graphene based materials by recycling of organic and inorganic waste."

Polat Mining Industry and Trade Inc.
Büyükdere Cad. Polat Han No:87 34387 Mecidiyekoy, Istanbul

Phone: 90-212-213-6095

Website: https://www.polatmaden.com.tr

Email: polamaden@polatholding.com

The company's products include granular and micronized quartz, micronized and broken Na-feldspar, and ceramic clays.

Şişecam
İçmeler Mah. D-100 Karayolu Cad. No:44A 34947 Tuzla, Istanbul

Phone: 90-850-206-5050

Website: https://www.sisecam.com.tr/en

Email contact form: https://www.sisecam.com.tr/en/contact-us/contact-us

In addition to being a prominent global player in the glass industry, the company maintains business lines in soda and chromium compounds and announced further expansion of its operations in February 2022 with the acquisition of Italian refractory manufacturer Refel. Şişecam's production operation span 14 countries on four continents, and its customers are located in 150 countries worldwide. Its areas of business include flat glass, glassware, glass packaging, automotive glasses, and glass fiber as well as in soda and chromium compounds.

ASSOCIATIONS, INSTITUTES, AND GOVERNMENT AGENCIES

Ministry of Energy and Natural Resources
Türk Ocağı Street No:2 06520 Çankaya, Ankara

Phone: 90-312-546-4646

Website: https://enerji.gov.tr/homepage

Turkey's natural resources include coal, iron ore, copper, chromium, antimony, mercury, gold, barite, borate, celestite (strontium), emery, feldspar, magnesite, perlite, pumice, pyrites (sulfur), and clay. The Ministry website reports that Turkey "has approximately 40% of the world's natural stone reserves," including marble, travertine, and granite. "Main natural stone types consist of crystalline limestone (marble), limestone, travertine-formed limestone (onyx), conglomerate, breccia, and rocks of magmatic origin (granite, syenite, diabase, diorite, serpentine, etc.)."

Ministry of Industry and Technology
Mustafa Kemal District Dumlupınar Boulevard (Eskişehir Road 7.km) 2151. Street No:154/A 06530 Çankaya, Ankara

Phone: 90-312-444-6100

Website: https://www.sanayi.gov.tr/anasayfa?lang=en

Contact: info@sanayi.gov.tr

SERFED
Turkish Ceramics Federation
Ataturk Mah. Namik Kemal Cad. Ekincioglu Sok. No:44/1 Atasehir, Istanbul

Phone:90-216-629-0100

Website: https://www.serfed.com

Contact: info@serfed.com

Member associations include:

- SERKAP (Ceramic Tile Manufacturers Association)
- SERSA (Ceramic Sanitary Ware Manufacturers Association)
- SERHAM (Ceramic, Glass and Cement Raw Materials Manufacturers Association)
- SEREF (Technical Ceramics and Refractory Manufacturers Association)
- EBK (Eskişehir Bilecik Kütahya Ceramic Business Cluster)
- TSD (Turkish Ceramics Association)

TÜBA
Turkish Academy of Sciences
Vedat Dalokay Caddesi No: 112 Çankaya 06670 Ankara

Phone: 90-312-442-2903

Website: https://www.tuba.gov.tr/en

Contact: tuba@tuba.gov.tr

The Academy, which marked its 30th anniversary in September 2022, is the umbrella organization for the following working groups:

- Science and Education Policies
- Information Technologies and Communication
- Environment, Biodiversity, and Climate Change
- Energy
- Food and Nutrition
- Cancer
- Stem Cell
- Health Sciences and Technologies
- Sustainable Environment and Finance

TÜBİTAK
The Scientific and Technological Research Council of Turkey
Tunus Caddesi No:80 06680 Kavaklıdere, Ankara

Phone: 90-312-468-5300

Website: https://www.tuba.gov.tr/en

Contact: ozelkalem@tubitak.gov.tr

Marmara Research Center website: https://mam.tubitak.gov.tr/en

Contact: MAM.bilgi@tubitak.gov.tr

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Turkey's advanced R&D inspires tomorrow's innovations

Directory of Turkish companies, associations, institutes, government agencies, and universities *All links included in this directory worked as of Sept. 1, 2022*

TurkishGlass

Ceyhun Atıf Kansu St. N: 20 Balgat, Ankara

Phone: 90-312-447-2740

Website: https://www.turkishglass.org

Email: info@turkishglass.org

TurkishGlass is the association representing the glass manufacturers, glass processors, and glass exporters in Turkey. Exports of Turkish glass are delivered to 175 countries each year. This professional association is focused predominantly on flat glass, glassware, and glass packaging.

UNIVERSITIES

Bilkent University

Website: https://unam.bilkent.edu.tr/en

Institute of Materials Science and Nanotechnology (UNAM)

Director: Hilmi Volkan Demir

Phone: 90-312-290-2513

Email: unam@unam.bilkent.edu.tr

The university is home to Turkey's National Nanotechnology Research Center, the Institute of Materials Science and Nanotechnology. UNAM is described on the website as a multidisciplinary organization that "incorporates over 10 laboratories with distinct interests, united only by their shared interest in cutting-edge nanotechnology research. Each research group focuses on a certain aspect of nanoscale phenomena, varying from biotechnology to fiber optics, but research at UNAM falls under eight general categories (optics, photonics, materials science, nanobiotechnology, neuroscience, computational nanotechnology, micro & nanofluidics, MEMS & NEMS, and two-dimensional materials)." A full list of areas of research with links to each research team's page can be found at unam.bilkent.edu.tr/en/research-fields.

Istanbul Technical University

İTÜ Ayazağa Campus, Rectorate Building, 34469 Maslak, Istanbul

Phone: 90-212-444-1488

Website: https://www.itu.edu.tr/en

Email: ardek@itu.edu.tr

Koç University

Rumelifeneri Yolu 34450, Sarıyer, Istanbul

Phone: 90-212-338-1000

Website: https://www.ku.edu.tr/en

Email: information@ku.edu.tr

The website contains limited English-language information about the university's fields of research. But a faculty page for Seda Keskin Avcı offers access to additional detail (https://mysite.ku.edu.tr/skeskin). She holds three positions at the university: professor in the Chemical and Biological Engineering Department; associate dean for research in the College of Engineering; and director of the Nanomaterials, Energy and Molecular Modeling Research Group (NEMO). She can be reached by phone at 90-212-338-1362 or by email at skeskin@ku.edu.tr.

Marmara University

Center for Nanotechnology & Biomaterials Applications and Research

Göztepe Campus 34722 Kadıköy, Istanbul

Phone: 90-216-777-0000

University website: https://www.marmara.edu.tr

Center for Nanotechnology & Biomaterials Applications and Research website: https://nbuam.marmara.edu.tr/en/research/research-area

Email: nano@marmara.edu.tr, oguzhan@marmara.edu.tr

Marmara University is home to the Center for Nanotechnology & Biomaterials Applications and Research, whose fields of inquiry fall within several categories: nanotechnology research, controlled drug release systems and smart nanofiber and nanoparticles; nanostructured composite materials, tissue engineering products and biomaterials; and 3-dimensional biography and production of medical diagnostic materials.

The Center's research teams have been awarded patents in Turkey, Europe, and the U.S., and patent applications now under review include *Osteogenic Osteoconductive Biocompatible Composite Nanofiber Scaffold for Repair of Bone and Cartilage Tissue Damage* (Oğuzhan Gündüz, Sabri Altıntaş, Mustafa Şengör, Hasan Bedir, and Güneş Ece Akalın) and *A Production Method for a Viable Cell Loaded Polymer/Enzyme Hydrogel and an Artificial Cornea Layer Produced by Said Method* (Songul Ulag, Mustafa Sengor, Ahmet Zeki Sengil, Nazmi Ekren, and Oguzhan Gunduz).

Middle East Technical University

Üniversiteler Mahallesi, Dumlupınar Bulvarı No:1 06800 Çankaya, Ankara

Phone: 90-312-210-2000

Website: https://www.metu.edu.tr

Email and phone directory: https://www.metu.edu.tr/contact-info

The university offers an undergraduate and graduate degrees in metallurgical and materials engineering and graduate programs in cement engineering, micro and nanotechnology, and polymer science and technology.

Sabanci University

Phone: 90-216-483-9600

Website: https://www.sabanciuniv.edu

Website: https://fens.sabanciuniv.edu/tr

Email (Graduate Office): su-fens-gradoffice@sabanciuniv.edu

Email (Dean's Office): fensinfo@sabanciuniv.edu

The Faculty of Engineering and Natural Sciences offers undergraduate and graduate degrees in materials science and nano engineering.

Yıldız Technical University

Barbaros Bulvari 34349, Yildiz, Istanbul

Phone: 90-212-383-7070

Website: https://yildiz.edu.tr

Website: http://www.met.yildiz.edu.tr

Email directory page: https://yildiz.edu.tr/rehber

The university describes itself as prioritizing "R&D studies focusing on future technologies" (in particular, defense technologies, clean energy, biotechnology and digital technologies) and quantifies its R&D performance in terms of publications, projects and entrepreneurship studies. Its Technology Transfer Office, located in YTU Yıldız Technopark, "acts and an interface for the use of academic knowledge, science and know-how…in line with the needs of industry."

Its Department of Metallurgical and Materials Engineering is equipped with laboratories with the following research capabilities: casting, electron microscopy, raw material and mineral processing, heat treatment, chemical analysis, composites, corrosion, mechanical inspection, metallurgical pretreatment and production metallurgy, microscopy and metallurgy, plastic forming, ceramics, powder metallurgy, biomaterials, polymeric materials, and glass research. ■

Credit: avramdeluxe, Flickr (CC BY 2.0)

What's in a word? Glass by any other name

By Mario Affatigato

The material now known as "glass" has gone by numerous names over the centuries. Tracing the etymological origins of these names provides insight into the characteristics that various civilizations and people saw and valued in the material.

Figure 1. Ancient Egyptian glass vessel dating between 1450–1350 B.C.E.

It seems appropriate during this International Year of Glass to ruminate about the multiple names given to this wondrous material over the centuries and around the world.

The etymological origins of these names are not only interesting but also provide insight into the characteristics that various civilizations and people saw and valued in the material.

Some of the most ancient civilizations—Egyptian, Mesopotamian—did not have a name for the material (yet). In ancient Egypt, the hieroglyph for glass meant "the stone that flows," and this same description was used by the ancient people of Mesopotamia.[1] This definition led to confusion as molten metals also flow, and people began to believe glass always contained (or was!) metal.

The ancient Greeks started by using more generic terms like *kyanos* (lapis lazuli and other minerals), *lithos chyte* (molten stone, likely taken from the Egyptian term), and *krystallos* (rock crystal, but its original meaning was ice). Herodotus mentions earrings made of "melted stone," which is accepted as a possible mention of glass, but this reference remains uncertain.

Eventually, the Greeks settled on the word ὑαλος[2] pronounced *hualos*. Some scholars speculate that there is a connection to the Proto-Germanic glasam (note the similar pronunciation).[3] But most often, the noun is associated with the word heyin "to rain" (from "ὑω" which means "to rain").[4] In any case, the word originally described glass but also any kind of crystalline stone.

In the sense of meaning the material glass, it is used (perhaps for the first literary time in this clear sense) in Plato's "Timaeus,"[5] where he writes

> *"...so long as the water occupies the interspaces of earth which are forcibly contracted, the portions of water which approach from without find no entrance, but flow round the whole mass and leave it undissolved. But when portions of fire enter into the interspaces of the water, they produce the same effects on water as water does on earth; consequently, they are the sole causes why the compound substance is dissolved and flows. And of these substances those which contain less water than earth form the whole kind known as 'glass'..."*

In Roman sources, glass was originally transliterated from the Greek as *hyalus* or *crystallus*. Both these words convey a sense of material transparency or translucence. By the time of Lucretius (1st century B.C.E.), the word *vitrum* came into use, and it is employed in this sense in his book "De Rerum Natura" (On the Nature of Things).

Vitrum was possibly developed from the root of *videre*, "to see," generating the word *vid- trum-*, meaning "something that lets you see through, a transparent thing."[6] Other scholars point to the word as coming from the Proto-Indo-European root *wódr*, meaning water. By the time Pliny the Elder wrote about grapes that had been left on the vine until they acquired a glassy transparency, the word *vitrum* was already in common use, and thin, glassblown items were well known. Interestingly, the Hungarian word for glass, *üveg*, derives from the Old Iranian root **āpakā*, also meaning water.

The geographical extent of the Roman Empire and the advent of Latin as the lingua franca for much of Western Europe led to the dominance of the word *vitrum* for glass. Thus, in our modern European languages, we use *vetro* (Italian), *vidrio* (Spanish), *vidro* (Portuguese), *verre* (French), and even *gwydr* (Welsh).

It is also important to note that *vitreus*—meaning "like glass"—was interpreted by the Romans not as "transparent like glass" but instead as "shining, bright, and sparkling like glass." The reader may recall that ancient glasses often were made from impure sources and were not always truly transparent. Metaphorical expressions like *vitreos talos*—"glass ankles"— and *vitrea Circe*—indicating, perhaps, "fragile Circe"—were already in use.[6]

Credit: Luis Garcia, Wikimedia (CC BY-SA 3.0)

Figure 2. Ancient Roman blown glass, found in Spain. Dated between 350–400 C.E.

A different ancient pathway to naming glass comes from the Russian and Slavic languages. Here the root is from the Proto-Slavic *stьklo*, which in turn comes from the Proto Indo-European, *(s)teyg-*, meaning to be sharp or to sting. From this root we get *stekló*, the Russian word for glass. And we also get *sticla* (Romanian), *szkło* (Polish), *stikls* (Latvian), *stiklo* (Lithuanian and Bulgarian), *stiklo* (Bulgarian), and *sklo* (Ukrainian).

Another beautiful word for glass comes from the Arabic *zujaj*. Its root is ز ج ج (z-j-j), which in one of its forms means "to make come out narrow and long, to glaze, to glass." This meaning is particularly beautiful as the ancient Egyptians and Greeks also spoke of the flowing nature of glass.

In Pliny the Elder's original version of the discovery of glass ("Historia Naturalis"),[7] written during Roman times, he describes a famous legend on the discovery of glass:

> *"The story is, that a ship, laden with nitre, being moored upon this spot, the merchants, while preparing their repast upon the sea-shore, finding no stones at hand for supporting their cauldrons, employed for the purpose some lumps of nitre which they had taken from the vessel. Upon its being subjected to the action of the fire, in combination with the sand of the sea-shore, they beheld transparent streams flowing forth of a liquid hitherto unknown: this, it is said, was the origin of glass."*

Pliny was well aware of the mythological aspect of this story, and of the fact that the Egyptians had older glass. His "Historia Naturalis" shows he was well versed in contemporary techniques for glassmaking,[8] and was able, for instance, to dispute the story of "unbreakable glass," describing it as being "...told with more frequency than truth."[6]

What about the English name "glass"? Its origin is ancient, and the word can be traced from the Middle English *glæs*,[9] meaning glass and glass vessel (a common polysemy), itself from the older Proto-Germanic *glasam*, and tracing all the way back to the Proto Indo-European root **ghel*, meaning "to shine."

Interestingly, this root also shows up—with evolutions carried out in time—in words like amber (*glær* in Old English), gold and gild. The word origin is now reflected in many modern Northern European languages: *glas* (German, Dutch, Swedish, Danish); *klaasist* (Estonian); and glass (Norwegian, English).

Not all ancient or modern civilizations needed a word for the material. Asian civilizations had enough alternatives (like jade and rock crystal) to inhibit the development of a glass industry, and valuable native products that could be traded for glass when needed. Thus, the name for glass often came from transliteration as the material was brought into the country.

The Japanese word, *garasu*, for example, is imported and a transliteration of the Dutch word *glas*. In China, the word *boli* 玻璃 comes from the Prakrit (India) and means "crystal" or "quartz." As happened in Greece and elsewhere, the modern meaning has shifted to refer specifically to glass. In Hindi and Nepalese, the word कांच (*kanch*) is used, and it derives from the Sanskrit *kācá*, also meaning glass. The existence of this old term might be due to the constant and very old relationship with the various Persian empires and their famous areas of glass production.

In summary, the words used to name the material we call glass today have a long and important history that addresses the wonderful—and still important—qualities of the material. Transparency, shine, brightness, the ability to flow like a liquid, even brittleness. Our love affair with glass and its properties has a long history indeed.

Credit: Brooklyn Museum (CC BY 3.0)

Figure 3. Arab glass lamp from the 13th-14th century.

Acknowledgments

The author would like to thank professors Efstratios Kamitsos (Athens, Greece), Angela Ziskowski (Cedar Rapids, Iowa), and Arun Varshneya (Alfred, New York) for helpful comments on the content of this article.

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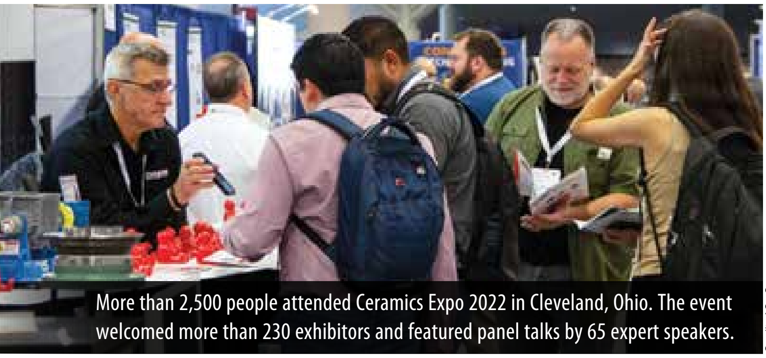
ceramics expo 2022: Balancing the cost of innovation



More than 2,500 people attended Ceramics Expo 2022 in Cleveland, Ohio. The event welcomed more than 230 exhibitors and featured panel talks by 65 expert speakers.

Credit: ACerS

Since returning as an in-person event in 2021 following the height of the COVID-19 pandemic, Ceramics Expo once again experienced a highly successful turnout in Cleveland, Ohio, on Aug. 30–31, 2022..

The leading annual supply chain exhibition and conference for the advanced ceramic and glass industry kicked off Monday night with a VIP networking reception and casino night, followed by two days of exhibiting and conference talks. However, unlike previous years, the reception welcomed additional guests attending the all-new Thermal Management Expo that ran alongside Ceramics Expo this year.

This year at Ceramics Expo was especially meaningful for the glass manufacturing sector due to the United Nations designation of 2022 as the International Year of Glass.

"This is the first time a material has been designated for an International Year, and it points to the many important ways glass—as well as ceramics!—have impacted humanity through millennia, and will continue to do so in the future," says ACerS executive director Mark Mecklenborg.

The cost of innovation was a recurring theme that panelists touched on throughout both days of conference talks.

While everyone expressed relief that business is starting to resemble pre-pandemic operations, they also noted that federal assistance programs such as the Paycheck Protection Program loans are no longer available, leaving companies to face lingering pandemic-related costs themselves.

The often-high price of ceramics is one topic that panelists debated. Though ceramics offer much value regarding performance, their high price point may limit their appeal to customers.

During a panel on continued development of ceramic matrix composites, panelist Jim Weigner of Lockheed Martin said one way to combat this perception is to have engineers clearly communicate the benefits of ceramic materials with management and salespeople. Then, they can ensure the customer understands how high initial cost can lead to lower operational costs over the material's lifetime.

Later, during a panel on the future of the technical ceramics market, panelist Anand Raghu of Morgan Advanced Materials suggested that engineers consider ways of increasing a part's value without affecting the cost, for example, by improving the speed or scalability of production.

Additionally, during a panel on improving industry efficiency, panelist Jimmy Hutto Jr. of Imerys emphasized the importance of ensuring equipment is running to its potential so the benefits are fully realized.

Finally, fulfilling a customer's needs sometimes requires acknowledging they do not need the most advanced (and pricier) option. Plus, the less expensive option may offer surprising additional benefits. During the industry efficiency panel, panelist Bruce Lung of the Department of Energy's Advanced Manufacturing Office gave the example of replacing compressed air systems with a leaf blower to clean floors, which cleaned the floors faster and at a much lower price.

Despite cost concerns, panelists also expressed much hope for the future of ceramics in various markets, particularly high-tech fields such as aerospace, medicine, and semiconductors.

During the opening plenary, American Elements CEO Michael Silver identified five applications that he believes will be the next "monster growth areas" for ceramics: mixed metal oxides, MXenes, ceramic fibers, aerospace composites, and electrolytes and cathodes.

While high-tech areas received the most attention, panelist Kelleen Loewen of Superior Technical Ceramics noted that the future of ceramics is not just in highly technical areas. She shared her experience working with companies needing grinding wheels and abrasive grains, an equally important application of ceramics.

See more pictures from Ceramics Expo 2022 at https://bit.ly/CEX2022.

Next year, Ceramics Expo will move from Cleveland to the Suburban Collection Showplace in Novi, Mich. It will revert to its usual springtime scheduling, May 1–3, 2023. ■

Bruce Lung of the DOE Advanced Manufacturing Office (second from right, talking) shared a government perspective on improving industry efficiency during a panel on Day 2 of Ceramics Expo.

Credit: ACerS

Kelleen Loewen of Superior Technical Ceramics (right) reminds the audience of the less technical but equally important applications of ceramics during a panel on Day 2 of Ceramics Expo.

Credit: ACerS

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NEW this year—The Materials Science and Technology Partnership has engaged the commercial exhibition firm Event Partners to sell and manage the full exhibition at MS&T22. In addition, Event Partners will co-locate two commercial exhibitions run by the company within MS&T22: The Advanced Materials Show and the first-ever Nanotechnology Show.

The Materials Science & Technology 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.

JAN. 17–20, 2023
Register soon!

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ceramics.org/ema2023

DOUBLETREE BY HILTON ORLANDO, ORLANDO, FLA.

EMA 2023 is an international conference focused on electroceramic materials and their applications in electronic, electrochemical, electromechanical, magnetic, dielectric, and optical components, devices, and systems. Jointly programmed by ACerS Electronics Division and Basic Science Division.

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Register soon!

47TH INTERNATIONAL CONFERENCE AND EXPO ON ADVANCED CERAMICS AND COMPOSITES (ICACC 2023)

ceramics.org/icacc2023

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

The 47th ICACC returns as an in-person conference. The conference will provide a platform for state-of-the-art presentations and information exchange on cutting-edge ceramic and composite technologies.

JUNE 4–9, 2023
Save the date!

2023 GLASS & OPTICAL MATERIALS DIVISION ANNUAL MEETING (GOMD 2023)

ceramics.org/gomd2023

HOTEL MONTELEONE, NEW ORLEANS, LA.

ACerS Glass & Optical Materials Division will hold its annual meeting in New Orleans, La., from June 4–9, 2023.

Calendar of events

October 2022

9–12 ACerS 124th Annual Meeting with Materials Science & Technology 2022 – David L. Lawrence Convention Center, Pittsburgh, Pa.; https://ceramics.org/MS&T22

12–13 AM Ceramics 2022 – Fraunhofer IKTS, Winterbergstraße, Dresden, Germany; http://www.am-ceramics.dkg.de

30–Nov 3 7th International Conference on Electrophoretic Deposition – LaFonda on the Plaza, Santa Fe, N.M.; http://engconf.us/conferences/materials-science-including-nanotechnology/electrophoretic-deposition-vii-fundamentals-and-applications

November 2022

6–8 Total Solutions Plus (TPS) – Hyatt Regency, Indian Wells, Calif.; https://www.ctdahome.org/tsp/2022/index.shtml

30–Dec 2 ASEAN Ceramics – IMPACT Forum Hall 4, Bangkok, Thailand; https://aseanceramics.com/thailand/#thai-about

December 2022

7–9 ➡ 7th Highly-functional Ceramic Expo Tokyo – Makuhari Messe, Chiba, Japan; https://www.ceramics-japan.jp/en-gb.html

January 2023

17–20 Electronic Materials and Applications 2023 (EMA 2023) – DoubleTree by Hilton Orlando at Sea World Conference Hotel, Orlando, Fla; https://ceramics.org/EMA23

22–27 47th International Conference and Expo on Advanced Ceramics and Composites (ICACC 2023) – Hilton Daytona Beach Oceanfront Resort, Daytona, Fla; https://ceramics.org/ICACC23

May 2023

17–19 ➡ 8th Highly-functional Ceramic Expo Osaka – INTEX Osaka, Osaka, Japan; https://www.ceramics-japan.jp/en-gb.html

June 2023

4–9 ACerS Glass & Optical Materials Division Annual Meeting (GOMD 2023) – Hotel Monteleone, New Orleans, La; https://ceramics.org/gomd2023

5–8 ACerS 2023 Structural Clay Products Division & Southwest Section Meeting in conjunction with the National Brick Research Center Meeting - Omni Austin Hotel Downtown, Austin Tx; https://ceramics.org/SCPD2023

August 2023

21–24 Materials Challenges in Alternative & Renewable Energy 2023 (MCARE 2023) combined with the 6th Annual Energy Harvesting Society Meeting (EHS 2023) – Hyatt Regency Bellevue, Bellevue, Wash.; https://ceramics.org/mcare-ehs-2023

27–31 ➡ The International Conference on Sintering 2023 (Sintering 2023) – Nagaragawa Convention Center, Gifu, Japan; https://www.sintering2021.org

September 2023

26–29 ➡ Unified International Technical Conference on Refractories (UNITECR) with 18th Biennial Worldwide Congress on Refractories – Kap Europa, Frankfurt am Main, Germany; https://unitecr2023.org

July 2024

14–19 International Congress on Ceramics – Hotel Bonaventure, Montreal, Canada; www.ceramics.org

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

Entries in **BLUE** denote ACerS events.

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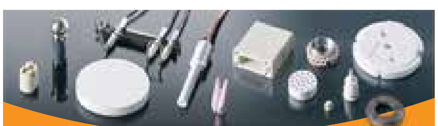

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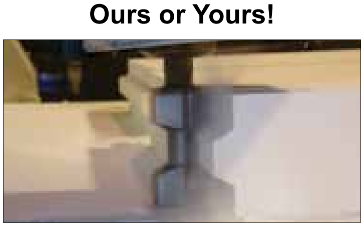

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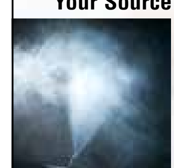

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Omer Yucel

Guest columnist

A postgraduate journey from Türkiye to the United Kingdom

My higher education journey started in Türkiye at Eskişehir Technical University (ESTU) and now continues in the United Kingdom at the University of Birmingham (UoB). As a former and current student of these two universities, I used my experiences to compare what it is like studying and doing academic research in these two countries.

UoB was established more than one hundred years ago, in May 1900. In contrast, ESTU is a very recent institute. It used to be a part of Anadolu University before some faculties were separated from the main university and established as ESTU in May 2018.

ESTU used the experiences and facilities inherited from Anadolu University to create a college that ensures both a good education and useful connections with domestic companies to its students. Master's students spend two years at ESTU (one year for modules and one year for a dissertation).

In contrast to ESTU, UoB's long history has allowed it to make excellent links with many companies worldwide, and its educational quality is viewed as one of the best in the world.[1] Finishing a master's degree takes only one year at UoB.

There are professors who research ceramic materials at both universities.[2,3] As a lucky individual, I was a part of professor Servet Turan's group at ESTU and now joined professor Jon Binner's group at UoB.

From nanomaterials and batteries to armor, Turan's group studies a wide range of topics. His extraordinary knowledge of ceramics led me to choose him as my advisor. My master's dissertation aimed to find an alternative to zirconia additives in boron carbide ceramics.

As a leading researcher in aerospace, Binner's team has an important impact on ultrahigh-temperature ceramics. As a part of the team, I am working on the additive manufacturing of ceramic matrix composites, specifically via the technique of fused deposition modeling.

The quality of facilities is an important criterion for research, especially for postgraduate studies. While UoB's facilities allow for ceramic materials to be produced and characterized in a wide variety of ways, I was surprised they do not have ovens for spark plasma sintering and gas pressure sintering, which I had at ESTU. Spark plasma sintering decreases research time for advanced ceramics, which is one of the most important matters for scientists. Gas pressure sintering is suitable for producing bigger samples.

Many people would agree that funding is one of the most important parts of research. Without funding, research cannot take place. While UoB brings in a lot of funding for research, school tuition fees are high. Fortunately, the university offers many scholarship opportunities for international students to make attendance affordable. In contrast, while ESTU has much lower tuition fees, research funding is scarce. Most universities in Türkiye lack research funds, and so finding funding is often the hardest part for students in the country.

Credit: Omer Yucel

Jon Binner's research group, University of Birmingham, 2022.

Besides research funding, the cost of living is another consideration for students. ESTU is in a city called Eskişehir, which is a medium-sized city next to the capital of Türkiye. According to Numbeo, the world's largest cost of living database, the cost of living for a single person is 53.22% cheaper in Eskişehir than in Birmingham (without rent). When we compare rents, Eskişehir is 87.74% cheaper than Birmingham.[4] While income rates in the U.K. are much higher than in Türkiye, this fact does not help a student living on research stipends.

As my comparison above illustrates, students must consider many parameters when choosing an international university, from the type of research conducted there to the cost of living in that area. Every student will weigh the value of these parameters differently to determine the best educational choice to contribute to their future career.

In my case, I would like to thank the Ministry of Education of Turkey for providing me with an International Graduate Education Scholarship (YLSY). This scholarship is provided to Turkish citizens to help them study abroad and then find a job at public universities or companies after finishing their education. It helped provide me with the necessary funds to study at UoB.

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[3]Servet Turan, professor of materials science and engineering, Eskişehir Technical University. https://bit.ly/3erY1V2

[4]"Cost of living comparison between Eskisehir, Turkey, And Birmingham, United Kingdom," Numbeo. https://bit.ly/3B5MGIl

Omer Yucel is a Ph.D. student at the University of Birmingham under the supervision of professor Jon Binner. He studies additive manufacturing of ceramic matrix composites. In his spare time, he likes enjoying the United Kingdom's "outstanding" nature through running and hiking. He is also a member of the yoga group at UoB.

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