AMERICAN CERAMIC SOCIETY
bulletin
emerging ceramics & glass technology
JUNE/JULY 2025

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     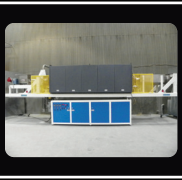 

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The "Emerging Professionals" section showcases young ACerS members along every step of their journey, from undergraduates to recent graduates.

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Cover image

Ludowici clay shingle tile on a home in Jackson Hole, Wyo.
Credit: Precision Construction & Roofing

AMERICAN CERAMIC SOCIETY
bulletin

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As seen on *Ceramic Tech Today*...

Credit: Wikimedia (Public domain)

Ceramic coins and their various functions throughout history

Most coins are made of metal due to the material's durability and inherent value. However, throughout history, ceramic coins have been used as legal tender as well—in addition to other purposes.

Read more at https://ceramics.org/ceramic-coins

Also see our ACerS journals...

Optimizing the design parameters for chamotte particle-reinforced geopolymers
By A.C.C. Trindade, P.F. McNutt, S.S. Sood, et al.
Journal of the American Ceramic Society

High-modulus glass fiber for wind renewable energy generation: Selective review on the recent research and development
By H. Li, G. Demirok, S. Atilgan, et al.
International Journal of Applied Glass Science

Mechanical and electrothermal properties of lightweight graphite/geopolymer composites
By S.M. Jabbar, D.H. Hameed, and I.A. Disher
International Journal of Applied Ceramic Technology

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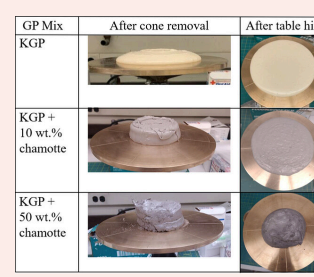
By M. Asante-Amankwa and A. Andrews
International Journal of Ceramic Engineering & Science



Credit: Trindade et al., *JACerS*

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 https://ceramics.org/journals

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POSTMASTER: Please send address changes to American Ceramic Society Bulletin, 470 Olde Worthington Road, Suite 200, Westerville, OH 43082-8985. Periodical postage paid at Westerville, Ohio, and additional mailing offices. Allow six weeks for address changes.

American Ceramic Society Bulletin (ISSN No. 0002-7812). ©2025. Printed in the United States of America.

ACSBA7, Vol. 104, No. 5, pp. 1–56. All feature articles are covered in Current Contents.

news & trends

Chinese imports threaten local ceramics production in Thailand

From the ceramic swallows of Portugal to the pie birds of Great Britain, many cultures around the world have embraced feathered friends as iconic symbols in their mythology and artwork. But what happens when that cultural heritage becomes commoditized? Ceramic manufacturers in Thailand are currently struggling with that question amid a surge of low-cost Chinese versions of their traditional "rooster" bowl.

The rooster bowl is a major product of Lampang province in northern Thailand. This piece of white clay kitchenware is immediately distinguishable from other bowls by the distinctive hand-painted artwork on its side, which consists of a chicken flanked by a peony flower and banana tree.

The Dhanabadee Ceramic Museum in Lampang, the capital of Lampang province, traces the history of the rooster bowl to 1955. That year, Chinese immigrant E. Simyo Saechin found a deposit of kaolin clay in the Jae Hom district. He and his friends used this clay to open the first ceramic factory in Lampang province.

Credit: T-Thai, YouTube

Artists at the Dhanabadee Ceramic Museum paint the iconic Thai "rooster" design on white clay bowls.

Though rooster imagery existed prior to this point in Chinese artwork, Saechin and his friends standardized the Thai rooster bowl design with the peony flower and banana tree. The popularity of the design spread rapidly, and by the 2000s, there were several hundred ceramic factories in the province producing rooster bowls. In 2012, Saechin's daughter and son established the Dhanabadee Ceramic Museum to compile the history of Lampang ceramics.

Unfortunately, since the COVID-19 pandemic, local ceramic production in Lampang province has started to decline. This decline is due to Chinese manufacturers shifting their focus toward ASEAN markets to bypass the recent challenges of selling their products in European markets.

In contrast to traditional rooster bowls, which cost about 20–30 baht, a knock-off Chinese rooter bowl only costs 5 baht. Because local ceramic producers cannot compete with this price, the number of ceramic factories in Lampang province dropped from 328 to 89, according to Preecha Srimala, president of the Lampang Ceramic Association, in a *Bangkok Post* article.

Despite Lampang ceramicists requesting help from the Thai government to combat the effect of Chinese imports, the *Bangkok Post* article reports that this help is not forthcoming. Commerce Minister Phumtham Wechayachai said that imposing trade barriers or tariffs on Chinese ceramics could lead to retaliatory measures on Thai agricultural products, so the Thai government did not plan to intervene in the matter.

Without new measures to better protect Thailand against Chinese products, "more companies are likely to shut down," says Payong Srivanich, chairman of the Joint Standing Committee on Commerce, Industry and Banking, in the *Bangkok Post* article. ■

Corporate Partner news

Owens-Illinois' Rebecca Schilling recognized as 2025 Women MAKE Award honoree

Rebecca Shilling, global director of environmental affairs at O-I Glass, Inc., was recognized as a 2025 Women MAKE Award honoree by the Manufacturing Institute. The Women MAKE Awards, formerly the STEP Ahead awards, recognize women in science, technology, engineering, and production careers who exemplify leadership within their companies. Read more: https://www.o-i.com/media-center

Plibrico employees send joy with Cards for Hospitalized Kids

In March 2025, Plibrico employees around the country dedicated time to creating handwritten cards that will be sent to children who are hospitalized through the Cards for Hospitalized Kids program. This Chicago-based nonprofit has delivered more than a million cards to hospitalized kids around the country. Read more: https://plibrico.com/news

PRCO America joins ResponsibleSteel

PRCO America recently joined ResponsibleSteel, a global certification initiative for the steel industry. In a press release, PRCO America President Bill Porter writes, "PRCO America is committed to making the effort and investing the time and resources needed to achieve the decarbonization and the rationalization of our processes so that our children and our children's children can enjoy the same world as we have." Read more: https://prco-america.com/2025/03/responsible-steel ■

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Environmental sensing and monitoring technologies: Global markets

The global market for environmental sensing and monitoring technologies was valued at $29.7 billion in 2023 and is expected to grow at a compound annual growth rate (CAGR) of 5.7% to reach $41.4 billion by the end of 2029.

Table 1. Global market for environmental sensing and monitoring technologies, by type, through 2029 ($ millions)

Type	2023	2024	2029	CAGR % (2024–2029)
Particulate	10,496.4	11,160.6	15,247.1	6.4
Chemical	7,453.1	7,808.4	9,937.4	4.9
Biological	5,925.2	6,394.3	9,341.3	7.9
Moisture	2,033.3	2,093.3	2,427.0	3.0
Temperature	1,766.8	1,835.4	2,231.8	4.0
Noise	1,289.6	1,315.4	1,427.7	1.7
Others*	715.7	734.9	789.0	1.4
Total	29,680.1	31,342.3	41,401.3	5.7

*Other segments include barometric pressure sensors, rainfall sensors, and wind speed and direction sensors.

The growing awareness of environmental issues, such as climate change, air and water pollution, and natural resource depletion, has led to increased government initiatives and corporate responsibility programs to address these challenges. These projects have created a need for reliable and accurate environmental monitoring tools.

Environmental sensors are made in thousands of forms with varying output formats. But the main sensor types are particulate sensors, chemical sensors, biological sensors, temperature sensors, moisture sensors, and noise sensors (Table 1). The particulate sensor segment has the largest market share, with 35.4% in 2023. In contrast, noise sensors were the smallest segment due to many countries categorizing noise as a nuisance rather than a pollution source.

Technological advances have made environmental monitoring solutions more efficient, cost-effective, and versatile. For example,

- **IoT integration:** Internet of Things-enabled sensors can collect data in real time and transmit it to centralized platforms for analysis. This streamlined data process facilitates the creation of large-scale environmental monitoring networks.
- **Miniaturization:** Sensor miniaturization has enabled the development of wearable sensors for health monitoring, as well as allowed integration into drones and satellites for remote sensing applications.
- **Improved data analytics:** Applying sophisticated algorithms, such as machine learning, to sensor data allows for anomaly identification, future trend prediction, and optimized monitoring strategies.

China, the U.S., the U.K., and Germany are the major countries that applied for and published environmental sensing and monitoring technologies patents in 2023–2024. About 75% of the patents granted during this period use intelligent systems based on IoT and machine learning and are equipped with remote systems and satellite monitoring.

Technologies for air pollution sensing and monitoring have witnessed the widest range of developments. According to the World Health Organization, roughly one in nine deaths worldwide can be attributed to air pollution—amounting to 7 million premature deaths each year. As a result, air pollution has moved from being seen as an environmental concern to a health concern in many countries.

Five companies—Robert Bosch GmbH, Veralto Corp. (formerly part of Danaher Corp.), Honeywell International Inc., Merck KGaA, and PerkinElmer Inc.—hold a major share in the global market for environmental sensor and monitoring technologies, each with distinct strengths and strategies to secure their market share. However, technology companies such as IBM, Microsoft, and Amazon have recognized the potential of environmental sensors and are now entering the market by offering comprehensive IoT platforms and solutions.

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, "Environmental sensing and monitoring technologies: Global markets," BCC Research Report IAS030E, November 2024. https://bit.ly/November-2024-environmental-sensing ■

By Lisa McDonald
Bulletin editor

Preserving natural heritage: Inside Imerys' first Biodiversity Report

Credit: Imerys S.A.

Screenshot from Imerys' first Biodiversity Report.

Biodiversity, or the variety of life on Earth, underpins everything we need to survive, from food and clean water to medicines and shelter. Minerals are also essential to human life, and they are found everywhere in our daily lives, from cosmetics to construction.

Mineral extraction can be a very disruptive process to natural ecosystems, damaging the soil and causing biodiversity loss. Unfortunately, geological deposits of industrial minerals are rare, thus constraining options for extraction sites.

Because biodiversity destruction cannot always be fully avoided, how can companies balance the benefits of minerals with the need to protect biodiversity?

France-based multinational group Imerys S.A. has implemented numerous initiatives to reduce the impact of their activities on biodiversity. The company has now published its first voluntary Biodiversity Report to showcase these initiatives and help other companies turn sustainability commitments into concrete actions.

Stages of biodiversity mitigation

The first stage of biodiversity mitigation is avoidance, or identifying and preventing negative impacts on biodiversity before they occur. Avoidance strategies may involve choosing an alternative site, adjusting the project design, and modifying a project's perimeter to preserve ecosystems.

The second step of biodiversity mitigation is minimization, or focusing on reducing residual impacts throughout a project's lifecycle. Minimization strategies may involve modifying infrastructure design; adapting the planning of operations and the behaviors of employees and suppliers on-site; limiting the impacts generated by operational activities, such as dust, noise, or light; and managing habitats.

By combining scientific expertise, local adaptation, and employee engagement, Imerys is actively working to minimize its impact on natural heritage, as demonstrated in the sidebar "Imerys' minimization activities around the world."

When impacts on nature cannot be completely avoided or minimized, the third step of biodiversity mitigation is restore, or repairing what extractive activities are altering. Restore strategies may involve implementing actions as soon as possible after any disturbance and monitoring progress to make adjustments and ensure effectiveness.

The fourth step of biodiversity mitigation is offset, or counterbalancing the impacts of a project by implementing measures to conserve or enhance biodiversity elsewhere. Offset strategies may involve habitat restoration, creation of new habitats, or protecting existing ecosystems offsite to ensure no net loss or even net gain in biodiversity.

Toward balanced coexistence with nature

Preserving nature is a complex task that combines global thinking and local action. Through Imerys' first Biodiversity Report, the company provides a clear roadmap of scientific strategies and concrete actions that can be taken to help preserve natural heritage.

Imerys' minimization activities around the world

A safer home for the world's fastest bird in the UK

Imerys adapted the infrastructure at its West Thurrock site to protect the peregrine falcon, a protected species. Working with the London Peregrine Partnership, the company installed a nesting box away from industrial activities to provide the species with a safe breeding space. Additionally, the company developed an emergency rescue plan for fledglings and installed cameras to monitor the nest. After four years, more than 10 chicks have hatched safely.

Preserving bat habitats in France

Imerys took a variety of measures at its Ploemeur site to minimize impact on local wildlife. For instance, the company suspends all activity during breeding periods and adjusts working hours to avoid disturbing nocturnal species. More specifically, to protect bats that live in the area, the company uses ultrasound to locate roosts and then installs one-way devices on trees, allowing the bats to leave safely and find alternative refuges in preserved areas.

Limiting the spread of invasive species in Thailand

At Imerys' site in Ranong, a biodiversity survey identified 80 Acacia mangium trees, an invasive species that threatens native vegetation. To restore balance, the company applied a method called girdling, which involves removing a strip of bark to naturally kill the trees while leaving the trunks standing as habitats for wildlife. This approach reduced the trees' number from 80 to 30. To reinforce the success of these invasive control actions, the company also plants local and endemic species at the site. ■

Download Imerys' first Biodiversity Report at https://bit.ly/Imerys-Biodiversity-Report-2025.

Also check out Imerys' website, which features a series of articles highlighting successful initiatives to avoid, minimize, restore, and offset the impacts of industrial operations on nature: https://www.imerys.com/news. ■

By David Holthaus
Industry reporter

Distributed acoustic sensing: The growing potential of fiber-based environmental monitoring


Credit: Pacific Northwest National Laboratory

Offshore wind turbine siting and monitoring is just one example of the crucial role that distributed acoustic sensing can play in environmental applications.

The Rhône Glacier is one of the natural wonders of Switzerland, a massive river of ice that is among the most visited glaciers in the world. It is not only an entrancing tourist destination, but its health is critical to the larger ecosystem—it is the source of the Rhône river, a major waterway, and helps fill Lake Geneva, the largest body of water in Switzerland.

But the Rhône Glacier, like many glaciers around the world, is receding. Accurately measuring how fast that is happening is essential to understanding the glacier's evolution and forecasting expected changes in the years ahead. Those changes have major implications for tourism as well as energy security, as the glacier's flow sustains hydroelectric power generation in the region.

But measuring glacial runoff over time can be difficult. Glaciers are in constant (albeit slow) motion, and instruments can fall over, be lost, or damaged. Satellite sensing can help, but nothing can match on-the-ground monitoring. That is why researchers sponsored by the International Glaciology Society experimented with an emerging measurement technique called distributed acoustic sensing (DAS) in summer 2020.

DAS uses fiber-optic cables laid along or buried under the ground to detect vibrations in the surrounding environment. The cables are connected to an instrument called an interrogator that repeatedly sends pulses of light through the fibers. When local vibrations cause the cables to shift, the light pulse is disrupted, and some of it bounces back to the light source. This "backscattering" is evidence of energy moving the cable, and its strength and frequency can be analyzed and turned into measurements.

In the Rhône Glacier study, the team used a fiber-optic cable positioned across nine kilometers of the glacier. This setup allowed them to capture and record the cable's vibrations, enabling precise, real-time measurements of meltwater from the critical glacier.

"This study demonstrates the ability of in-situ glacier DAS to be used for quantifying proglacial discharge and points the way to a new approach to measuring glacier runoff," the authors concluded in their open-access paper, which was published in *The Journal of Glaciology* in August 2024 (DOI: 10.1017/jog.2024.46).

Tracking movements of glacial ice is a novel example of how DAS can be used to help monitor the environment. Currently, the technique is mainly used by the oil and gas industry to monitor well structures and pipelines to detect leaks or failures caused by underground activity. But it is also finding increasing usage by seismologists as an early warning system for earthquakes.

Gene Ichinose, a staff scientist at Lawrence Livermore National Laboratory, Livermore, Calif., uses the technology in his seismology research. In an interview, he says that "DAS is transforming seismology" because it allows an entire seismic wave field to be recorded. Furthermore, the availability of preexisting, unused fiber-optic cables that are no longer being used for telecommunication purposes (so-called "dark fibers") have greatly increased the amount of data that can be captured.

"You can transform up to 100 kilometers of cable into a string of virtual seismometers," he says.

The use of dark fibers for DAS also comes with great cost benefits, as they are already installed and so just need to be leased or loaned. In a recent experiment, Ichinose and his colleagues made use of 80 kilometers of unused telecommunications fiber, "and we got 8,000 virtual sensors out of it," he says.

Besides glacier monitoring and seismology, DAS has many other potential applications in climate science. For example, DAS has become a tool for measurements in the bitter cold of the Arctic. A team from Albuquerque, N.M.-based Sandia National Laboratories used DAS to record climate signals such as the timing and distribution of sea ice breakup, ocean wave height, and sea ice thickness on the Alaska North Slope.

These environmental applications of DAS are not just limited to government and academic groups—companies are starting to explore the use of DAS to support the clean energy transition. One of the leading commercial firms developing such applications is Silixa, based in Elstree, England. Among its projects is a contract with a U.K. oil and gas firm, Perenco, which will use a DAS system to monitor carbon dioxide injections into a depleted reservoir. It is part of a larger project to develop large-scale storage of recovered carbon dioxide gas from industrial emissions. The DAS system will be used to provide continuous monitoring of the storage wells for leaks.

In January 2024, Silixa was purchased by Luna Innovations, a Roanoke, Va.-based firm that has been a leader in the fiber-sensing technology space. The acquisition "further strengthens our position as an enabler of energy transition by extending our reach into exciting new growth sectors, such as carbon capture and storage, as well as into monitoring processes that will help sustain ecosystems and safeguard fragile environments," says Luna CEO Scott Graeff in a news release.

Among Luna's projects is one that provides monitoring services for one of the largest offshore wind projects in the United States—Dominion Energy's Coastal Virginia project. Luna's sensing system will be used to monitor the wind farm's cable system that transports power to shore, tracking temperature and acoustics along the entire cable circuit as well as identifying external threats, such as anchor drag from nearby ships.

The state of California has a goal to source 100% of its electricity for powering homes and businesses from renewable sources by 2045. Offshore wind turbines are expected to play a significant role in this transition, but siting appropriate locations is critical, as an uneven or unstable seabed is a potential safety issue.

A recent research project turned existing fiber optic cables on the seafloor of the central California coast into a DAS array to detect conditions on the seabed and to track whale migration, which can also impact wind turbines. The project found that "DAS can improve both seafloor geophysics and whale monitoring, which are two key issues for emerging energy generation in deep-water locations," according to the resulting report, which published in a seismology journal in January 2025 (DOI: 10.1785/0220240359).

With its cost effectiveness, safety, and data-gathering capacity, DAS is a technology expected to grow in importance for both tracking and measuring the impact of climate change.

About the author

David Holthaus is an award-winning journalist based in Cincinnati, Ohio, who covers business and technology. Contact Holthaus at dholthaus@ceramics.org. ■

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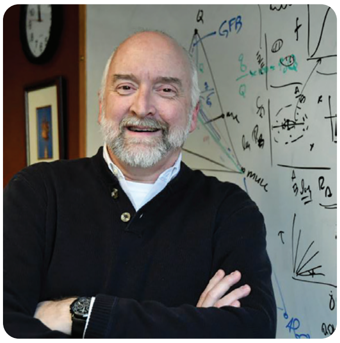

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SOCIETY DIVISION SECTION CHAPTER **NEWS**

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Meet the 2025–2026 officers and Board members

President-elect

SHIBIN JIANG, FACERS
President and CEO
AdValue Photonics Inc.
Tucson, Ariz.

Adjunct research professor of optical sciences
University of Arizona
Tucson, Ariz.

During my time studying and living in China, France, and the U.S., I have worked for both universities and industrial companies; founded four successful businesses; and served as a volunteer for various societies, including SPIE, Optica, IEEE Photonics Society, and the International Commission on Glass.

Among all these endeavors, I have remained an active member of The American Ceramic Society since 1993, dedicating my time and resources to serve ACerS in various Society and Division-related capacities. Beyond my volunteering roles, my professional career and businesses have benefited significantly from the Society.

I am highly honored to be considered for ACerS president-elect, and one of my top priorities is to further strengthen the collaboration among students and professionals around the world in both academia and industry. My industrial and academic working experiences and multinational background enable an in-depth understanding of each party's needs and concerns, which can help ACerS plan and foster initiatives that will advance ACerS' mission and organizational growth.

In conclusion, I am enthusiastic about the potential growth and continued success of ACerS, and I am proud to help ACerS continue to fulfill its role as a leading global professional society.

Directors

PALANI BALAYA, FACERS
Associate professor of mechanical engineering
National University of Singapore
Singapore, Republic of Singapore

ACerS has been my primary professional organization since 2011. As an active member, I have served in various Society and Division-related capacities, including several leadership roles: lead organizer of Symposium 6 on Energy Storage during ICACC (since 2015), chair of the Engineering Ceramics Division (2022–2023), and chair of the Edward Orton Jr. Memorial Lecture Committee (2024–2025). During my time as ECD chair, I implemented an initiative to recruit new members, which resulted in more than 100 new GGRN members.

Outside of ACerS, I served on the Intergovernmental Panel on Climate Change as a representative from Singapore (January 2009 to May 2011) and acted as a coordinating lead author for a chapter on direct solar energy in the IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation. I also organized the 12th International Conference on Ceramic Materials and Components for Energy and Environmental Applications in Singapore (July 22–27, 2018), which attracted about 700 participants.

I feel it is a privilege to be considered for the ACerS Board of Directors. If elected, I will address the sustainable growth of ACerS by working with other groups and organizations to expand support for studies into critical research areas, such as energy storage, as well as enhance membership from the Asia-Pacific region.

YUTAI KATOH, FACERS

Director of Materials Science and Technology Division
Corporate Fellow
Oak Ridge National Laboratory
Oak Ridge, Tenn.

The American Ceramic Society has been my primary technical society for more than 20 years. Throughout this time, the Society has provided me with numerous volunteering opportunities, including service to its Divisions and organization of symposia at various conferences. The effort I invested in these activities has greatly benefited my scientific research and career development.

I am deeply grateful to the Society for its strong international and inclusive culture, as well as the networking and leadership opportunities it offers. While I hope to have made meaningful contributions to the Society through my past volunteer work, I am eager to continue supporting the next generations of ceramic scientists and engineers through service on the ACerS Board of Directors.

Participating in the 2024 ACerS strategic planning process gave me valuable insights into the challenges and opportunities facing the Society. I would be excited about more actively engaging in strategic development as the landscape of ceramics R&D and the community continue to evolve. I am particularly interested in identifying emerging growth opportunities, fostering the engagement of new leaders from the existing pool of ceramic research and technical professionals, and enhancing international collaborations through the extensive network I have developed locally, nationally, and internationally.

YIQUAN WU, FACERS

Inamori Professor of ceramics and materials science
New York State College of Ceramics at Alfred University
Alfred, N.Y.

Being part of the ceramics community is a source of great pride for me. As a lifetime member of both The American Ceramic Society and the European Ceramic Society, I am committed to actively serving the professional ceramics community.

I am honored for the opportunity to serve as a member of the ACerS Board of Directors and eager to collaborate with my ACerS colleagues to foster the Society's growth through dedicated service and contributions that align with its mission. My efforts will focus on key priorities outlined in the ACerS strategic plan, including membership growth and engagement, diversity, international outreach, and mentoring young professionals. Through my role on the Board, I look forward to strengthening and expanding international collaborations between ACerS and ceramic communities worldwide. ■

more SOCIETY DIVISION SECTION CHAPTER NEWS

ACerS President-elect

To serve a one-year term from Oct. 1, 2025, to October 2026

Shibin Jiang

ACerS Board of Directors

To serve three-year terms from Oct. 1, 2025, to October 2028

Palani Balaya
Yutai Katoh
Yiquan Wu

Division and Class officers

To serve a one-year term from Oct. 1, 2025, to October 2026, unless otherwise noted.

2025–2026 ACerS officers

The new slate of ACerS officers has been determined. There were no contested offices and no write-in candidates, automatically making all nominees "elected." ACerS rules eliminate the need to prepare a ballot or hold an election when only one name is put forward for each office. The new term will begin Oct. 1, 2025, at the conclusion of ACerS 127th Annual Meeting at MS&T25.

Art, Archaeology & Conservation Science Division

Chair: **Fumie Iizuka**
Vice chair: **Tami Clare**
Secretary: **Xiao Ma**
Treasurer: **Annika Blake-Howland**
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Register now for ACerS Pittsburgh Section Annual Golf Outing

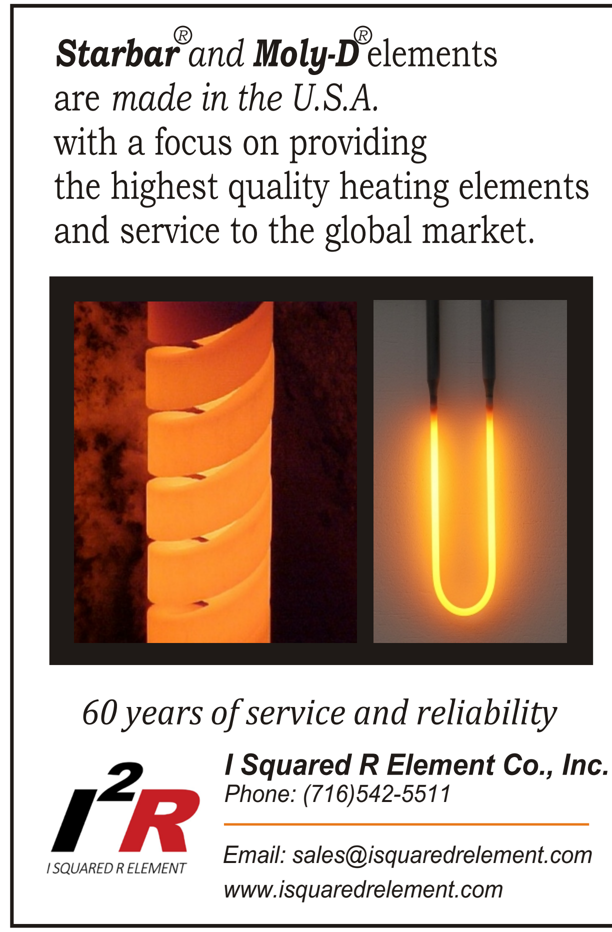
Registration is open for the ACerS Pittsburgh Section 2025 Golf Outing. This year, the event will take place at Birdsfoot Golf Club on Monday, Sept. 8, 2025. Please register and prepay by **Aug. 19, 2025**. To register, complete the registration form at https://bit.ly/PittsburghSectionGolf2025 and return to Mike Clark at mclark@thinkhwi.com. ■

ACerS Dayton/Cincinnati/Northern Kentucky Section hosts distinguished speaker at UC Department of Mechanical and Materials Engineering

On March 14, 2025, the Department of Mechanical and Materials Engineering at the University of Cincinnati hosted Joerg Lahann, Wolfgang Pauli Collegiate Professor of Chemical Engineering at the University of Michigan, as a distinguished speaker. His seminar was titled “Protein nanoparticles as multi-functional drug delivery carriers.”

Following Lahann’s talk, graduate students asked him several thought-provoking questions about nanoparticle design, surface functionalization, cell targeting, and drug loading and release. Lahann also met with Hyunjun Kim, chair of the ACerS Dayton/Cincinnati/Northern Kentucky Section, and several University of Cincinnati faculty members from the College of Engineering and the College of Medicine to discuss opportunities for research collaborations on nanomaterials and nanomedicine applications. ■

Joerg Lahann (third from left) stands with Section Chair Hyunjun Kim (second from right), Section Social/Outreach Chair Donglu Shi (second from left), and other University of Cincinnati faculty and graduate students after the seminar.



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

The ACerS International Japan Chapter and the International Committee of the Ceramic Society of Japan co-hosted the International Session at the Annual Meeting of the Ceramic Society of Japan in Shizuoka, Japan, on March 5, 2025.

Opening remarks were given by Japan Chapter Chair-elect Yoshihiko Imanaka. Invited talks were given by Cordova-Udaeta Mauricio from Waseda University, Japan; Zhuravleva Mariya from the University of Tennessee, Knoxville; and Veber Philippe and Buse Gabriel from the West University of Timisoara, Romania. Three 2024 Richard M. Fulrath Award winners also presented invited talks: Fujii Ichiro from the University of Yamanashi, Japan; Izawa Kazuyoshi from Kyocera Corp., Japan; and Funahashi Shuichi from Murata Manufacturing Co., Ltd., Japan. ■

Members of the ACerS International Japan Chapter and the International Committee of the Ceramic Society of Japan at the 2025 Annual Meeting of the Ceramic Society of Japan.

ACerS International Taiwan Chapter members attend workshop on powder processing technology

Members of the ACerS International Taiwan Chapter attended the 3rd Taiwan–Japan Workshop on Powder Processing Technology for High-Quality Products. This workshop was first held in 2019 but then suspended due to the COVID-19 pandemic. It aims to enhance Taiwan's industry capabilities, foster international collaboration, and facilitate knowledge exchange between academia and industry.

ACerS International Taiwan Chapter members at the Taiwan–Japan Workshop on Powder Processing Technology for High-Quality Products.

This year's workshop was hosted at the National Taiwan University's Institute of Applied Mechanics International Conference Hall and organized by former ACerS International Taiwan Chapter Chair Wei-Hsing Tuan. It featured multiple Japanese companies sharing the latest advancements in ceramic powder processing technologies. ■

more SOCIETY DIVISION SECTION CHAPTER NEWS

WEBINARS TO WATCH

Check out these recent additions to the ACerS Webinar Archives:

NOVEL FABRICATION OF 0-3 SOFT MAGNETIC NANOCOMPOSITES FOR IMPROVED ON-CHIP POWER COMPONENTS

Original air date: March 28, 2025

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

Featured speaker: Sara Mills

BEYOND THE DEGREE: CAREERS IN CERAMICS AND GLASS

Original air date: April 1, 2025

Hosted by: ACerS President's Council of Student Advisors

Featured speakers: Olivia Brandt, Fox Thorpe, and S. Manisha Vidyavathy

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

MEMBER HIGHLIGHTS

Volunteer Spotlight: Austin Scheer

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

Austin Scheer is an applications engineer at Ransom & Randolph in Maumee, Ohio. He received a B.S. in ceramic engineering from Missouri University of Science and Technology and has work experience primarily in the refractory and foundry industries.

Scheer's work focuses primarily on investment casting research for commercial and aerospace foundries as well as jewelry and dental investments.

Scheer is past chair of the Refractory Ceramics Division and part of the Michigan/Northwest Ohio Section.

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

Ceramic Tech Chat: Joe Cesarano

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.

In the April 2025 episode of Ceramic Tech Chat, **Joe Cesarano**, founder and president of Robocasting Enterprises, explains how he helped develop a 3D printing method called robocasting, provides examples of its applications, and shares tips on how to successfully bring your ideas to market.

Check out a preview from his episode, where he describes the serendipitous accident at Sandia National Laboratories that unlocked this slurry-based fabrication technique.

"So, we had this slurry sitting on a roller and we had lost track of it. And about three weeks later we realized, 'Hey, we need to do something with this.' And we opened it up, and it had the perfect rheology for robocasting."

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

FOR MORE INFORMATION:

ceramics.org/membership

more MEMBER HIGHLIGHTS

Celebrating ACerS members and their experiences

This year marks the 30th anniversary of ACerS President Monica Ferraris as a proud member of The American Ceramic Society, and she could not be happier.

"The contribution of knowledge, networking, friendship, publication, [and] common projects has been absolutely incredible for me," Ferraris shares. For those working in glasses or ceramics, she emphasizes that ACerS is the place to be.

This sentiment resonated with numerous professional and student ACerS members who were interviewed at the 49th International Conference and Expo on Advanced Ceramics and Composites, which took place in Daytona Beach, Fla., in January 2025.

Networking is a key benefit for Gisèle Lecomte-Nana, an individual ACerS member who highlights how ACerS has collaborated with her work in supporting Society memberships within developing countries. Meanwhile, Mike Hill, a Sapphire Corporate Partner individual member, values the Society's membership magazine, the *ACerS Bulletin*, as an essential resource for his R&D work, underscoring its importance in advancing his research and keeping him connected to the latest developments in the field.

ACerS also plays a pivotal role in professional development, with members such as Milos Dujovic, a GGRN graduate student member, pointing to both the IGNITE MSE program and ACerS Thermal Spray Coatings Workshop as instrumental in expanding his expertise. For Nathan McIlwaine, a Material Advantage student member, the Mechanical Properties of Ceramics and Glass Short Course was a standout, directly aiding his Ph.D. studies by providing focused insights and resources from experts such as George Quinn, course instructor and key contributor in some of the ASTM standards.

View the recently completed video, which features even more ACerS members sharing their personal ACerS experiences, on the ACerS website homepage at https://ceramics.org. Share the video with colleagues or friends who may also benefit from joining ACerS. You can also direct them to https://ceramics.org/membership/join for more information about joining this great community.

For ACerS members interested in adding their voice, more interviews will be conducted at ACerS Annual Meeting at MS&T 2025 in Columbus, Ohio. Reach out to Yolanda Natividad at ynatividad@ceramics.org to let her know if you are interested in participating. ■

Individual Membership

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AWARDS AND DEADLINES

Nomination deadline for Society awards: Sept. 1, 2025

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

Society award	Deadline	Description
Darshana and Arun Varshneya Frontiers of Glass Lectures	September 1	Lectures encourage scientific and technical dialogue in glass topics of significance that define new horizons, highlight new research concepts, or demonstrate the potential to develop products and processes for the benefit of humankind.

Nomination deadlines for Division awards: July 1, Aug. 1, or Aug. 15, 2025

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

Division	Award	Deadline	Contacts	Description
ECD	**Mrityunjay Singh Bridge Building**	July 1	Amjad Almansour amjad.s.almansour@nasa.gov	Recognizes individuals outside of the United States who have made outstanding contributions to engineering ceramics, international collaboration, and outreach.
ECD	**Global Young Investigator**	July 1	Federico Smeacetto federico.smeacetto@polito.it	Recognizes the outstanding young ceramic engineer or scientist whose achievements have been significant to the profession and to the general welfare of the community around the globe. Nominations are open to candidates from industry, academia, or government-funded laboratories around the world.
ECD	**James I. Mueller Lecture**	July 1	Jie Zhang jiezhang@imr.ac.cn	Recognizes the accomplishments of individuals who made similar contributions as James I. Mueller to the Engineering Ceramics Division and to the field of engineering ceramics.
ECD	**Jubilee Global Excellence**	July 1	Michael Halbig michael.c.halbig@nasa.gov	Recognizes exceptional early- to mid-career professionals who are women and/or underrepresented minorities (i.e., based on race, ethnicity, nationality, and/or geographic location) in the area of ceramic science and engineering.
EMSD	**Outstanding Student Researcher**	August 1	Charmayne Lonergan clonergan@mst.edu	Recognizes exemplary student research related to the mission of ACerS Energy Materials and Systems Division.
BSD	**Graduate Excellence in Materials Science (GEMS)**	August 15	Eve Mozur evemozur@mines.edu	Recognizes the outstanding achievements of graduate students in materials science and engineering. The award is open to all graduate students who are giving an oral presentation in any symposium or session at the 2025 Materials Science & Technology meeting. ■

The Ceramic and Glass Industry Foundation awards 2024–25 scholarSHPE recipients

The Ceramic and Glass Industry Foundation (CGIF) once again partnered with the Society for Hispanic Professional Engineers (SHPE) to provide scholarships to students from underserved communities studying materials science and engineering. The 2024–25 scholarship cycle awarded two recipients through SHPE: Carolina Mejia and Eridani (Dani) Rojas.

Mejia is a fourth-year undergraduate student studying materials engineering at California Polytechnic State University. She serves as treasurer of the university's Society for the Advancement of Materials and Process Engineering club and works with the university's Prototype Vehicles Laboratory, a student-run organization that aims to break boundaries in engineering. Mejia plans to pursue a master's degree in mechanical engineering after graduation, and as a first-generation student, she is grateful for the support that the scholarship has provided.

"Thank you for supporting me while I further my education and attend graduate school," she says. "Your help is truly invaluable."

Rojas is a third-year undergraduate student in materials science and engineering at Boise State University in Idaho. He works as a simulation programmer in the university's Computational Materials Engineering Laboratory, leveraging the use of molecular dynamics simulations to answer questions in the scientific community. He is involved with Boise State's SHPE Chapter and the Organización de Estudiantes Latino-Americanos (OELA). Like Mejia, Rojas plans to pursue a master's degree following graduation.

"I'm a father, husband, and student. These are all things I'm incredibly proud of, but it comes at the cost of having to wear many hats," he says. "So, receiving this scholarship helps ensure that I complete my education, which in turn, will help provide for my new family. Because of that, I am really grateful."

CERAMIC AND GLASS INDUSTRY FOUNDATION

Carolina Mejia

Eridani (Dani) Rojas

You can support other underrepresented students in materials science such as Mejia and Rojas by donating to the Underrepresented Student Scholarship Fund at foundation.ceramics.org/get-involved/donate. ■

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Ceramic sherds discovery in Australia demonstrates cultural complexity of early societies

Credit: Ulm et al., *Quaternary Science Reviews* (CC BY 4.0)

South Island Headland Midden, a terrestrial deposit on the island of Jiigurru. Left: View across excavation to Blue Lagoon and reef flat. Right: Terrestrial laser scanning of final sections in progress.

Until recently, researchers struggled to find evidence of local Aboriginal pottery manufacture and use in Australia, despite the firmly established culture of pottery production in other nearby regions. But the discovery and analysis of pottery sherds on the island of Jiigurru provides evidence for the cultural complexity of these early societies.

Jiigurru is part of the Lizard Island group, which is comprised of five islands surrounding a deep lagoon. When humans first occupied Jiigurru about 6,500 years ago, it was only 30 kilometers from the mainland. This proximity made it possible for various cultures to develop sophisticated watercraft technology and open-sea navigational skills to reach the island. For example, Jiigurru played a key role in ceremonies, initiations, and other important activities based on stories passed down from the Elders of the Guugu Yimithirr nation, an Aboriginal people of far north Queensland.

In 2006, pottery sherds were found on the island of Jiigurru. While analysis of the sherds suggested they were locally manufactured, dating the sherds was not successful due to them being rounded and worn down by coastal processes. However, further excavations uncovered more samples, and in a recent open-access paper spearheaded by researchers at the Australian Research Council, they confirmed the discovery of the oldest dated ceramics found in Australia.

The ceramic sherds in this study were recovered from the South Island Headland Midden, a terrestrial deposit on Jiigurru. The 82 highly fragmented sherds, which were distributed in a dense shell deposit comprising interlocking large reef shellfish species, had an average length of 17.7 mm and average thickness of 5.1 mm.

Radiocarbon dating of the sherds suggested that ceramic deposition occurred between 2950–2545 cal BP and 1970–1815 cal BP (cal BP stands for "calibrated years" or "calendar years" before the present). The oldest occupation layers dated to 6510–5790 cal BP, making Jiigurru the earliest offshore island occupied on the northern Great Barrier Reef.

The radiocarbon dating of the sherds overlaps with late Lapita and post-Lapita ceramic traditions of southern Papua New Guinea. The Lapita culture refers

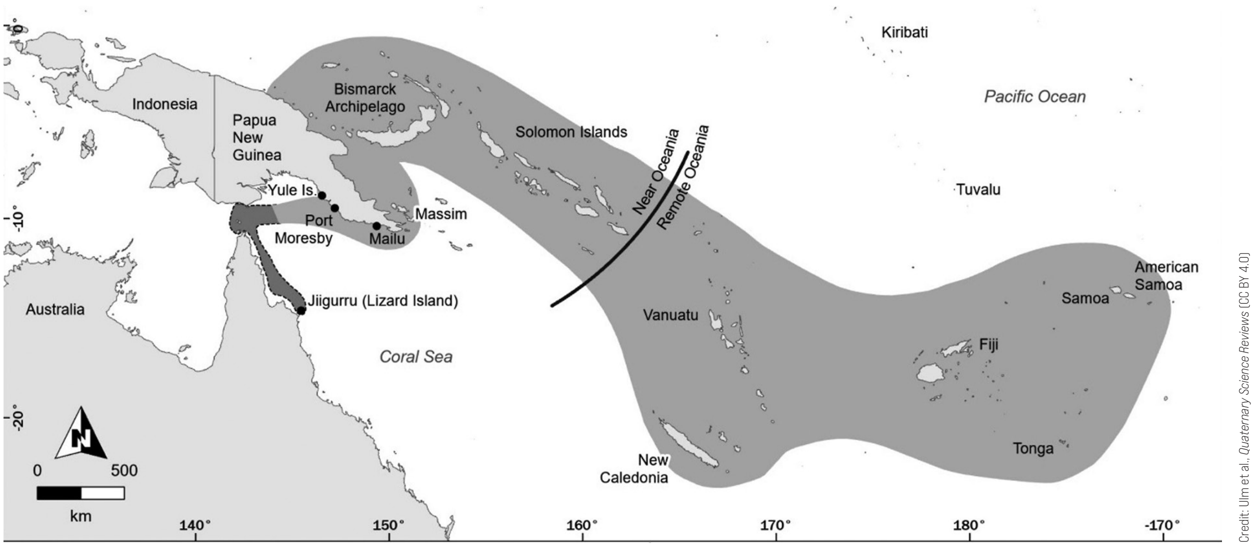
Materials in the news

Curved neutron beams deliver industrial benefits

A team including scientists from the National Institute of Standards and Technology successfully made beams of neutrons travel in curves. Researchers have previously created curved beams out of other particles, such as photons or electrons, but not neutrons. They accomplished this feat using a custom-built diffraction grating array consisting of silicon scored with tiny lines. The curved neutron beam could enhance neutron-based techniques for investigating the properties of materials that are difficult to explore by other means, such as chiral molecules. For more information, visit https://www.nist.gov/news-events/news.

Advanced thermal management tech for electronic devices

University of Tokyo researchers designed novel capillary geometries that push the boundaries of thermal transfer efficiency. Currently, the most promising methods for chip cooling involve flowing water through microchannels embedded directly into the chip. The efficiency of this technique is constrained, however, by the sensible heat of water, i.e., the amount of heat needed to increase the temperature of a substance without inducing a phase change. The new 3D microfluidic channel structures help maximize the efficiency of heat transfer. For more information, visit https://www.iis.u-tokyo.ac.jp/en/news/4747.



Map of known Lapita cultural area showing the location of Jiigurru. Dashed extension of the Lapita cultural area into Torres Strait and northeast Australia indicates possible Lapita distribution or influence.

to the culture of an ancient group of people considered to be the original human settlers of Melanesia, much of Polynesia, and parts of Micronesia between 1600 and 500 BCE. Their manufacture and use of fired pottery has been found extensively in Papua New Guinea and its islands, and even today many of these communities still make and use pottery.

Compositional analysis of the sherds using scanning electron microscopy and energy dispersive X-ray spectrometry indicated the vessels were locally manufactured because they belonged to three temper and clay groups locally sourced to northeast Australia, and most likely to Jiigurru. Based on the thickness of the sherds, they appeared to come from thin-walled vessels, which require less clay to manufacture and are lighter to transport. Additionally, red-slip, a common characteristic of Lapita ware, was identified on two of the sherds.

Based on all these findings, the researchers proposed that

- Pottery traditions in the three regions of Torres Strait, Jiigurru, and the south coast of Papua New Guinea have ancestral links back to the earliest Lapita ceramics in the Bismarck Archipelago of northeastern Papua New Guinea, 3,000–3,300 years ago.
- Northeast Australian Aboriginal communities not only had sophisticated canoe voyaging technology and open-sea navigational skills, but they were significantly involved in ancient maritime networks across the Coral Sea region, including Jiigurru. Thus, Aboriginal communities were not isolated or geographically constrained, as previously believed.

The authors conclude, "The pottery sherds at Jiigurru and the antiquity of offshore island occupation demonstrated in this study open a new chapter in Australian, Melanesian, and Pacific archaeology and point to a deep history of cultural interaction across the Coral Sea."

The open-access article, published in *Quaternary Science Reviews*, is "Early Aboriginal pottery production and offshore island occupation on Jiigurru (Lizard Island group), Great Barrier Reef, Australia" (DOI: 10.1016/j.quascirev.2024.108624). ■

Materials in the news (continued)

Clay-based 'brilliantly luminous' chemical nanotool

University of Missouri researchers created tiny, clay-based materials called fluorescent polyionic nanoclays that can be customized for many uses, such as medical imaging, disease detection, and biomarker tagging. They synthesized the materials by covalently incorporating fluorophores onto the surface of nanoclays through either a co-condensation approach or a grafting-from strategy. The nanoclays possess a high degree of functionality, meaning the researchers can control how many and what kinds of fluorescent molecules are attached to the surface. For more information, visit https://showme.missouri.edu/topics/research.

'Elegant' detection of single spins using photovoltage

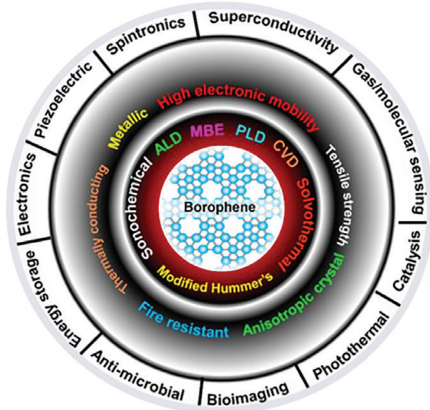
Researchers at Helmholtz Center Berlin for Materials and Energy developed a new method using photovoltage to detect the individual and local spin states of optically active defects in diamonds. The method developed from the idea that such defects not only possess a spin state but also electrical charge. Probing these charges was possible using a variant of atomic force microscopy. Besides diamond, this method could be used in other solid-state systems where electron spin resonance of spin defects has been observed. For more information, visit https://www.helmholtz-berlin.de/pubbin/newsroom?sprache=en. ■

The rise of borophene: Inside the design and application of this emerging material system

This year marks the 10th anniversary since borophene made its debut on the experimental stage. First predicted by theory in the mid-1990s, this 2D sheet of boron atoms has made a name for itself among the Xenes due to its metallic character, impressive Young's moduli (surpassing graphene), and exceptional electron mobility and thermal conductivity.

The tendency of borophene to rapidly oxidize in air and form clusters has presented hurdles to commercialization. But researchers have found ways to overcome these challenges and successfully use borophene in energy, sensing, and biomedical applications.

As borophene continues to find new applications in various fields, the amount of literature on this material is growing fast. In response, a group of researchers from Australia and India published an open-access review article to provide a "bird's eye view" of borophene's journey to date and discuss future opportunities. Highlights from the 52-page review article are below.



Credit: Kumar et al., *Progress in Materials Science* (CC BY 4.0)

Bird's eye view of the subject areas covered for synthesis, properties, and applications of borophene.

Borophene properties: Structural origins and dopant possibilities

In contrast to other Xenes, borophene exhibits numerous crystallographic phases. These phases all form distinct "ridges" of closely spaced boron atoms along the surface of a borophene sheet, which significantly impacts the material's electronic and chemical properties.

This structural variability provides opportunities to tune borophene's properties without the need for dopants, which is fortunate because "strong in-plane boron–boron bonds make doping challenging," the researchers write. However, microwave doping, which uses microwave irradiation to achieve homogeneous volumetric heating and uniform distribution of dopants, provides an amicable and facile approach for doping of borophene.

Recently, density functional theory has become a popular method to explore the effect of structure and composition on borophene's properties. Examples of such studies are available at https://bit.ly/42r83MV and https://bit.ly/4cJeH4B.

Borophene-based heterostructures and hybrids

As noted above, borophene has the tendency to rapidly oxidize in air. Integrating borophene with other functional components to form heterostructures and hybrids can stabilize the material for application.

Examples of some successful borophene-based heterolayers and hybrids:

- Quantum-dot-dispersed borophene nanosheets for broadband photonic nonvolatile memory (https://bit.ly/4jD9TzS)
- Borophene-supported rhodium nanoparticles for hydrogen evolution reactions (https://bit.ly/3EAkQU3)
- Graphene oxide–borophene heterostructures for microwave absorption (https://bit.ly/4ipv33q)

Applications of borophene

Thanks to its unique properties, borophene can find application in a wide variety of fields. The last section of the review paper provides examples from each of these fields, including electronics, magnetism, superconductivity, sensing, catalysis, energy storage, triboelectric and piezoelectric nanogenerators, and biomedical applications.

Hurdles to commercialization

Borophene still faces several hurdles to commercialization:

- **Synthesis challenges:** Molecular beam epitaxy and atomic layer deposition methods are reliable but expensive. Conversely, chemical vapor deposition synthesis is affordable, but more work is needed for large-scale production with high reproducibility.
- **Device integration challenges:** Researchers are working to overcome poor interface quality and contact resistances of borophene with devices. Clean transfer techniques for borophene from its native substrate to an arbitrary destination substrate also require further development, as well as ways to prevent oxidation.
- **Fundamental knowledge challenges:** Our understanding of surface and interface chemistry in borophene is currently limited. Additionally, explorations are needed on the role of crystal defects and the impact of intentionally induced post-growth defects on physical properties.

Despite these hurdles, the structural design engineering offered by borophene is "unmatched" and thus provides impetus to "address such concerns" and "realize its potential," the researchers conclude.

The open-access paper, published in *Progress in Materials Science*, is "The rise of borophene" (DOI: 10.1016/j.pmatsci.2024.101331). ■

ceramics in the environment

Saving our coasts: Cementing beach sand with electricity may help prevent erosion

Coastal erosion is a natural process that occurs when strong wave action, sea level rise, and coastal flooding wear down or carry away rocks, soils, and/or sands along the coast. However, the rise in frequency and intensity of extreme weather events is causing costs to erode faster than before, requiring immediate action.

Electrical stimulation is a long-standing approach to soil stabilization, and a recent study by Northwestern University researchers show how it could play a key role in saving our coastlines.

An illustration of how electricity can strengthen sand along ocean coastlines. The inset shows a microscopy image of a "natural cement" (in blue) formed among grains of sand.

Electrically induced soil stabilization

In the mid-1800s, scientists posited the idea of an electric "double layer," which consists of two parallel layers of opposite electrical charge that exist at the interface between a solid and a liquid. In the case of wet soil, the water layer is positively charged and the soil layer is negatively charged.

In the 1930s, researchers tried to make use of this charge difference by applying an electric field to wet soil in hopes of driving the water out. By the 1960s, the emerging field of electro-osmotic stabilization was being used to stabilize soils in large-scale civil engineering projects, such as dams.

Simply driving the water out of the soil can lead to shrinking and crack formation due to the extensive drying. But the applied electric field can also induce physicochemical changes in the soil. Along with electro-osmotic stabilization, then, researchers became interested in electrochemical stabilization, which aims to induce microstructural changes in the soil through chemical reactions.

One of the biggest benefits of electrically induced soil stabilization is its ability to work on clay soils. Clay is a significant component in soils globally. It is commonly found near water and in coastal areas, which are vulnerable to flooding. This type of soil is also prone to landslides. Landslides kill more than 4,000 people every year. That number is expected to increase as torrential rains increase in frequency due to climate change. So, a reliable method to stabilize clay soils is urgently needed.

Biocement produced by bacterial metabolism is another technology with great promise for stabilizing various soil types. But this method requires the microbes to grow and thrive in the soil, which does not work well in clay. So, electrically induced soil stimulation can be a good choice in areas with high clay content.

Mineralization on the beach

In the recent open-access article by the Northwestern researchers, they aimed to use electrochemical stabilization to induce mineralization of beach sands. They ran an electric current through sand saturated by seawater, and it resulted in the near-instantaneous precipitation of calcium carbonate, magnesium hydroxide, and hydromagnesite between the sand grains. These minerals improved the mechanical and hydraulic properties of the sand, hardening it against the effects of erosion and wave action.

Notably, if shoreline conditions change, the hardening process is reversible. As senior author Alessandro Rotta Loria, the Louis Berger Associate Professor of Civil and Environmental Engineering, explains in a Northwestern press release, "The minerals form because we are locally raising the pH of the seawater around cathodic interfaces. If you switch the anode with the cathode, then localized reductions in pH are involved, which dissolve the previously precipitated minerals."

The open-access paper, published in *Communications Earth & Environment*, is "Electrodeposition of calcareous cement from seawater in marine silica sands" (DOI: 10.1038/s43247-024-01604-3).

Other environmental applications of electrically induced mineralization

Scientists are already looking at ways to use electrically induced mineralization in a range of processes. For example, mine tailings can be converted to dolomite, an anhydrous carbonate mineral, using electrical stimulation. Dolomite can be used to replace Portland cement in concrete. Thus, this process helps clean up mine tailings as well as reduces the carbon intensity of concrete production.

In time, it may even be possible to remediate soil contaminated with per- and polyfluoroalkyl substances, the so-called forever chemicals. More information on that possibility can be found at https://bit.ly/3GkDJuI. ■

Eggshell 'bioplastic' pellets enable closed-loop system of agriculture fertilization

In a recent open-access paper, researchers at the University of Saskatchewan in Canada proposed a novel fertilizer system that can overcome challenges with current agricultural practices.

Modern fertilizers are often coated with microplastics to make the nutrients release more slowly. After the fertilizer is released, these microplastics do not break down, contributing to the global plastic pollution problem.

Furthermore, distributing too much fertilizer or excessive irrigation can result in fertilizer runoff into local waterways. This runoff can lead to nutrient pollution, which results in excessive growth of algae and oxygen depletion in the water and can cause the death of aquatic animals.

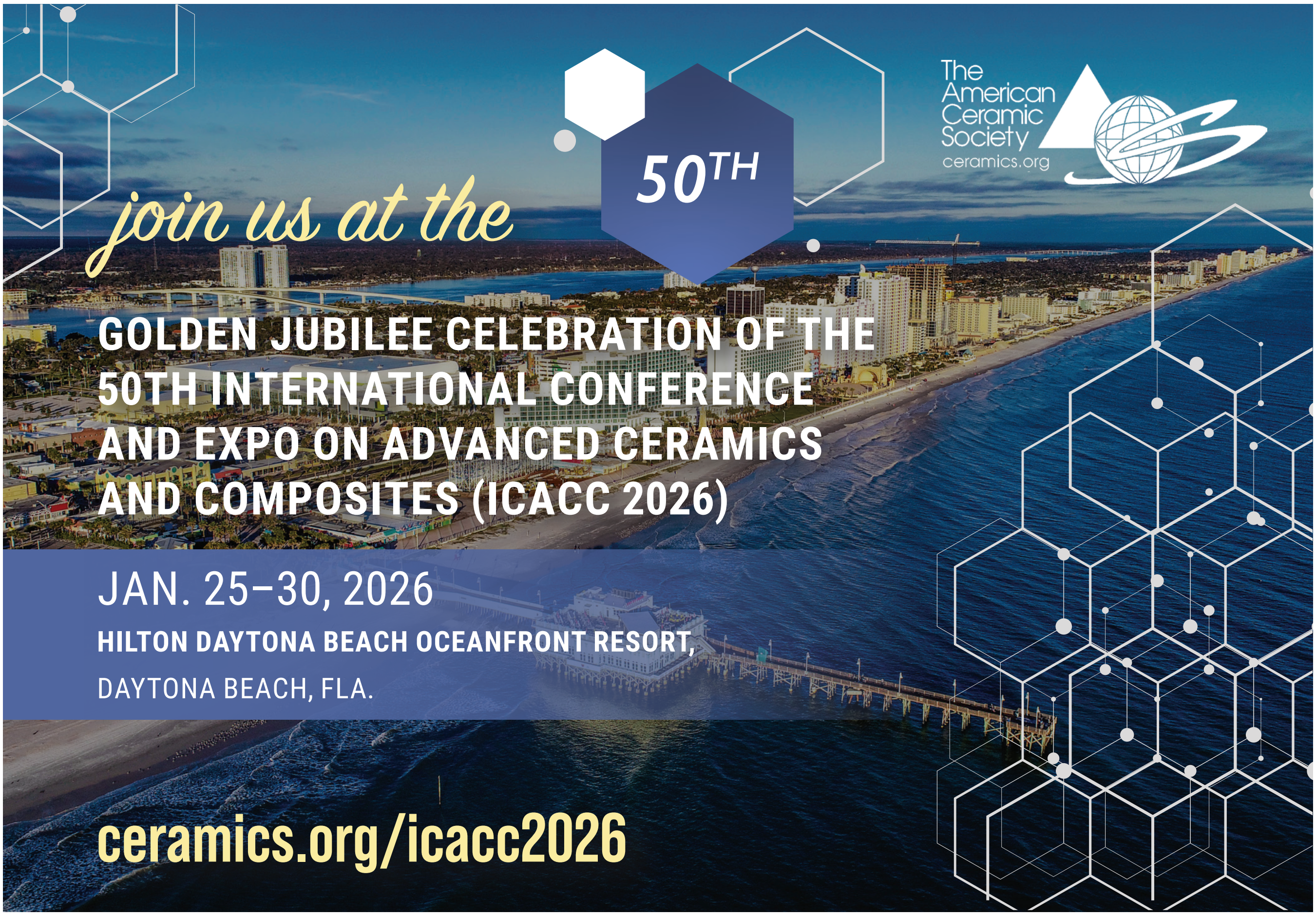
Finally, phosphate, one of the nutrients commonly used in fertilizers, is mainly obtained through the environmentally destructive process of strip mining.

To overcome these challenges, the University of Saskatchewan researchers created "bioplastic" pellets consisting of chitosan, eggshells, and wheat straw. The pellets can adsorb phosphate from water and then be distributed over agricultural land as a fertilizer source.

This first study on the pellets tested their adsorption capabilities in a controlled laboratory environment. The researchers now plan to study the pellets' capabilities in real water samples with more complex matrices that contain competitive ions.

University of Saskatchewan chemistry professor Lee Wilson, left, and Ph.D. candidate Bernd Steiger, right, hold the bioplastic pellets.

The open-access paper, published in *RSC Sustainability*, is "Eggshell incorporated agro-waste adsorbent pellets for sustainable orthophosphate capture from aqueous media" (DOI: 10.1039/D3SU00415E). ■



Ancient solutions for modern problems: Using clay roof tiles to protect against wildfire

By David Jensen

Ludowici clay shingle tile on a home in Jackson Hole, Wyo. Areas vulnerable to wildfire have increased dramatically in recent decades.

Evidence suggests that natural disasters such as hurricanes, floods, and wildfires are increasing in both frequency and severity,[1] causing significant damage to existing structures and communities. As architects and builders begin constructing buildings to survive these varied threats, it is important to consider climate resilience as a deciding factor in material selection.

Roofs are the part of homes most vulnerable to ignition during wildfire, and many conventional roofing materials are combustible. In addition to this short-term risk, the materials typically are designed to last only a couple decades, necessitating replacement over time and increasing a structure's embodied carbon.[2]

By using clay roof tiles, builders and homeowners can mitigate the risk of destruction from wildfires while also greatly extending a roof's lifespan—thus minimizing the structure's contributions to climate change.

Growing wildfire risks for homeowners

Since the 1990s, the number of continental U.S. homes found within the wildland–urban interface (WUI) has more than doubled, meaning that hundreds of thousands of houses are in close proximity to wild vegetation. Wildfires cause most of their insurable damage in these WUI areas because there are more fuels for flames and fewer barriers to limit their spread.

In addition to an expansion in development, the amount of land burning in the United States has been increasing largely due to climate change, with surface area growth of 240% between the 1990s and 2010s.[3]

Weaknesses of predominant construction

Structures in the WUI are at risk of ignition from two main sources during wildfires: embers and flames. Embers, known in some cases as firebrands, are pieces of burning debris that become airborne during wildfires, often carried for miles before landing. These embers frequently spark secondary fires on structures or vegetation where they land.

Strategic limiting of adjacent vegetation and potential fire sources can protect buildings to some degree from direct contact with flames. However, it is not possible to prevent or limit embers in the same way due to their airborne nature. As a result, embers are responsible for more damage and pose a greater threat to buildings.

Because of their horizontal slopes, roofs are the part of a structure most exposed to embers during a wildfire. Certain roofing materials, such as wood shake shingles, are extremely vulnerable to sparks of this type. These shingles are a threat not only to the buildings they are installed on but also to structures surrounding them. Because they are made of wood, these shingles create more embers as they burn and can lead to further destruction in affected areas.[4]

Benefits of clay tiles in architecture

The use of clay roof tiles in architecture has a long history, tracing back 10,000 years to both China and the Middle East. From these two regions, the common usage of clay roof tiles spread throughout Asia and Europe, and European settlers brought this roofing tradition to the Americas.[5]

Clay roof tiles offer numerous benefits compared to other contemporary roofing materials. For one, clay roof tiles offer significant resistance to damage from wildfires. In the case of Ohio-based manufacturer Ludowici Roof Tile, our tiles experience a peak temperature of 2,100°F (1,149°C) during firing and are incombustible afterward. Due to this high level of fire resistance, clay roof tiles are typically rated as Class A roofing materials by ASTM guidelines. This incombustibility sets clay roof tiles apart from many other roofing materials—while certain types of asphalt shingle and composite roofing materials can achieve similar ASTM ratings, it may be possible for them to burn under specific conditions.

Another advantage of clay roof tiles is their visual adaptability. Through the use of glazes and engobes, the color of tiles can be significantly modified. In some instances, this ability is used to replicate other materials, such as wood shake shingles (Figure 1). In geographic areas where wood shake shingles have an extensive history and significance in regional architecture, clay roof tiles can enable property owners to replicate the appearance of shake without its vulnerability to fire.

The most significant benefit that clay tiles provide for exterior architecture stems from their longevity. While roofing materials such as asphalt shingles, wood shakes, and screw-down metal panels have an expected functional lifespan ranging from 15 to 30 years, we at Ludowici have observed our and other clay tiles remaining intact and fully functional after more than 100 years of use in unforgiving environments. Thus, in addition to reducing costs for building owners, clay roof tiles significantly minimize the embodied carbon of homes and other structures.[6]

Historical precedent for fire-driven clay tile demand

While current building practices do not prioritize the use of clay roof tiles, the threat of tragic disaster has a history of leading to widespread changes in architectural design. For example, the Great Chicago Fire of 1871 decimated tens of thousands of buildings in that city, and a subsequent fire in 1874 tore through much of what had been rebuilt. City insurers grew fed up with the idea of providing insurance to new buildings designed with the same vulnerabilities as the destroyed structures and began a pressure campaign to institute stricter building standards. Despite initial resistance, they eventually prevailed, and a ban on wooden roofing and flammable structures took effect within Chicago.

This ban led to a surge in demand for fire-proof building materials such as brick, architectural terracotta, and clay roof tiles. The prominent incorporation of these elements into buildings has come to be recognized as a defining aspect of that era's architecture and has allowed many of these structures to survive to the present day.[7]

Credit: Gates Building Envelope

Figure 1. Wood shake shingles (left) are shown alongside Ludowici clay tile (right) during a reroofing project. By using engobes and surface effects, the appearance of genuine wood can be replicated without the corresponding fire risk.

Outlook on the clay tile market

As more homes become vulnerable to wildfire, it is important to design new buildings that are resistant to conflagration. The roof is the most vulnerable part of a building during a wildfire, and many roofing options are combustible. Emissions from producing building materials play a large role in driving climate change, and when materials need to be replaced emissions continue to increase.

While not a predominant choice now, the threat of fire has historically led to wider adoption of clay materials in architecture. Traditional ceramic roof tiles offer a fire-resistant and noncombustible roofing option, with a lifespan long enough to minimize embodied carbon and protect homeowners for decades to come.

About the author

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LUDOWICI®: Founding and future goals

Ludowici is an Ohio-based manufacturer of architectural clay tiles. Since 1888, their materials have been used on landmarks including London's Savoy Hotel, the New York Life Building, and the White House.

The company was founded as the Celadon Terra Cotta Company in Alfred, N.Y. After a successful lobbying effort by Celadon's president and others, Alfred University gained its College of Ceramics in 1900, and the company was able to collaborate with leading ceramicists of the era. The corporation became known as Ludowici-Celadon after a 1906 merger, and in the following years, it grew to operate tile factories in five states.

Clay roof tile usage in the United States declined through the 20th century, and Ludowici's market shrank. By the 1960s, the company's operations were consolidated around its single remaining factory in New Lexington, Ohio. Over the following decades, business improved as Ludowici shifted its focus to specialized work for restoration and high-end architecture projects that leaned into the adaptability of clay for architectural uses.

Today Ludowici is a specialist in options for roof, floor, and wall tiles. Traditional ceramic handbuilding techniques are employed side-by-side with advanced digital design to allow for a wide degree of customization. Along with dozens of standard tile profiles, Ludowici offers more than 50 standard options for color-permanent glazes and engobes.

Learn more about the company and its products by visiting https://ludowici.com. ■

ACerS-NIST PHASE EQUILIBRIA DIAGRAMS

NIST Standard Reference Database 31

The American Ceramic Society
www.ceramics.org

NIST
UNITED STATES DEPARTMENT OF COMMERCE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

PHASE
Equilibria Diagrams
www.ceramics.org/phase

Climate-resilient construction

What material innovations and evolving standards are making possible

By Randy B. Hecht

Sustainability and circularity did not used to be priorities in construction. But starting with the introduction of ecological architecture in the 1960s and the energy crisis in the 1970s, the concept of sustainable development took hold and now guides many national building standards around the world.

Recent materials science advances and innovations are creating new opportunities to reduce construction companies' carbon footprint and promote more environmentally friendly design and building practices. For example, "companies are starting to use recycled materials in their buildings. This [practice] helps reduce the environmental impact of construction and can also save businesses money," note co-authors Julia L. Freer Goldstein and Paul Foulkes-Arrelano in their book, *Materials and Sustainability: Building a Circular Future* (Routledge, 2024).

The authors add that environmental impact lies not only in the materials used but also in "how the products are manufactured and how they are handled at the end of their useful life. No discussion of efficient manufacturing would be complete without addressing the entire life cycle of materials."

As a result, green advocates are watching not just which materials are being used in construction but also how manufacturers operate their facilities—from the chosen energy sources to waste management practices. This heightened awareness of operations supports the transition to a circular economy.

Another emerging and increasingly relevant trend in the construction industry involves integrating climate resiliency strategies into building design and construction. While the advances mentioned above aim to manage the construction industry's impact on the environment, others seek to manage climate events' impact on buildings. That has given rise to the term "building resiliency," which refers to a building's ability to function as temperatures reach new extremes, sea levels rise, and fierce weather events and wildfires become more commonplace.

The Whole Building Design Guide, a project of the National Institute of Building Standards, cautions on its website: "As the built environment faces the impending effects of global climate change, building owners, designers, and builders must design facilities to optimize building resiliency." (https://www.wbdg.org/do/sustainable)

As nature changes, so too must building standards, materials, and designs. Numerous research and development projects—some still in the lab, others already on the market—will help make the necessary changes a tangible reality.

MATERIAL INNOVATIONS

Net-zero and carbon-trapping concrete

Cement and concrete are the literal foundation of the construction industry, but these materials also contribute substantially to global carbon emissions. Many research groups are working to develop alternatives to traditional Portland cement, including companies started by ACerS Fellows Richard Riman (Solidia Technologies) and Yet-Ming Chiang (Sublime Systems). Two other recent developments in this area are described below.

Fortera: A mix maverick on the market

San Jose, Calif.-based Fortera is "a five-year-old company that's effectively 18 years in the making," says co-founder and CEO Ryan Gilliam, a climate tech serial entrepreneur with a Ph.D. in materials engineering.

Its low- to zero-CO_2 cementitious product, ReAct, is a "reactive calcium carbonate polymorph, known as vaterite, which can be blended into ASTM C150, C595, or C1157 cements or mixed into concrete during batching." The solution has its origin in an earlier venture, Calera, which mimicked the way coral reefs and shells form in nature to develop a new type of cement that captures CO_2.

Calera was awarded more than 100 patents, but "the technology just wasn't grounded in economics," Gilliam says. In 2019, he revisited the technology from a fresh perspective: Instead of competing with cement companies, he could collaborate with them and integrate the product with their existing materials via their existing feed stocks, "from quarry to kiln."

"That allowed us to drive down the cost to make a product that's economically competitive, even without a green premium," Gilliam says. "Reducing capital costs, reducing operating costs, getting to large scale matters more than anything if you're going to have a meaningful impact."

To that end, Fortera plants use standard tanks and other off-the-shelf equipment rather than anything proprietary that could complicate the adoption process.

"When these plants are making a million tons a year of cement, and they've already paid their capital costs, the last thing they want to do is shut down to make modifications," Gilliam says.

Product data and documentation are available on the Fortera website at https://forteraglobal.com/react-product/#productdataanddocumentation.

Making waves with carbon-trapping concrete

Rather than simply reducing carbon emissions, can existing emissions be trapped in concrete and turned into new building materials? This concept is what Alessandro Rotta Loria, Louis Berger Associate Professor of Civil and Environmental Engineering at Northwestern University's McCormick School of Engineering, is working on.

The genesis of his idea is not new: Minerals such as calcium carbonate and magnesium hydroxide can form when an electrical current is applied to sea water. In theory, this process could be used to manufacture structures in sea water. However, the speed of production is inadequate for industrial purposes.

Rotta Loria imagined taking things a step further: "Can we use external CO_2 to boost the process? And the answer is yes. The process we have developed consists of applying an electrical current to sea water, and at the same time to inject CO_2 gas, which can be sequestered at an earlier stage."

This approach makes it possible to convert the gas to mineral form and accelerate the mineralization process that occurs in sea water. Next, his team puts the resulting magnesium hydroxide in contact with the water so it can react and be converted to forms of magnesium carbonate that act as carbon sinks.

The biggest challenge in the process was "developing the knowledge that allows us to fully control the process," Rotta Loria says, which is "sensitive to variables such as the flow rate of the CO_2 that is injected, the magnitude of the electric stimulation applied, or the flow rate of the water that is present in the reactors."

As with all R&D breakthroughs, another challenge is making the project commercially viable. Rotta Loria's team is working with San Pedro Garza García, Mexico-based building materials company Cemex, which is sponsoring the research, to "upscale the process and hopefully bring it to market."

Another approach to sequestering carbon in building materials, developed by ACerS member Brian Gorman, is described in the September 2024 issue of the *ACerS Bulletin*.

Material innovations beyond concrete

While cement and concrete are major focuses for sustainability research in the construction industry, all aspects of construction can benefit from novel material formulations and designs. Some of the most cutting-edge advancements are recognized each year by North American media company Green Builder Media through its annual Sustainable Products of the Year list.

One of this year's winning products is ACRE, "a sustainable, versatile building material made from upcycled rice hulls" that manufacturer Modern Mill offers as a substitute for wood. The company says ACRE "can be easily cut, routed, sanded, and customized with regular woodworking tools." Furthermore, "The material is also easy on blades and has minimal melting or static." (https://bit.ly/Building-with-ACRE)

Another winning product, introduced by manufacturer ClarkDietrich, is "a new line of low embodied carbon (LEC) steel framing products," including a metal drywall framing system, structural steel, and floor framing that the company says allows for "greater freedom in designing sustainable buildings." (https://bit.ly/LEC-steel-framing)

View the full list of Green Builder's 2025 Sustainable Products of the Year at https://www.greenbuildermedia.com/blog/2025-sustainable-products-of-the-year.

Green roofs are not a new idea, but they are attracting renewed interest as a means of cooling buildings and their surrounding environments—and contributing to climate resiliency. But getting those results involves more than landscaping roofs and letting nature take its course. In the two-part series “Ensuring green roofs deliver” (https://bit.ly/4lDiIeL) and “Mistakes and misconceptions surrounding green roofs” (https://bit.ly/4il9a5q), FacilitiesNet reviews the decisions that determine whether green roofs will perform as intended.

BOOKS FOR A DEEPER DIVE

Recent years have seen numerous books published on the topic of sustainable construction. Below are some of the new books on this topic publishing in 2025.

3D Concrete Printing: State of the Art and Applications

Publish date: January 2025

Publisher: Wiley–ISTE

Description: Discusses issues relating to concrete materials, overviews current printing processes, and describes the mechanical behavior of printed structures.

Development and the Sustainable City: The Limits of a Technical Approach

Publish date: January 2025

Publisher: Wiley–ISTE

Description: Examines rapid growth in cities, as well as the sustainability issues it poses, in several ways.

Advances in Bio-Based Materials for Construction and Energy Efficiency

Publish date: February 2025

Publisher: Elsevier

Description: Discusses bio-based materials and biotechnologies for infrastructure application, building energy efficiency, and pollution treatment.

Climate Resilient Construction and Building Materials

Publish date: April 2025

Publisher: Cambridge Scholars Publishing

Description: Integrates several research papers on climate resilient building techniques and materials.

Advances in Sustainable Concrete for Construction

Publish date: June 2025

Publisher: Springer

Description: Explains sustainability of concrete in the context of current extraction, formulation, and use scenarios.

Sustainable Construction Management: Research and Practice Companion

Publish date: June 2025

Publisher: Springer

Description: Presents sustainable construction management strategies, practices, methods, and procedures. ■

EVOLVING STANDARDS

Overview of green building rating and certification systems

Numerous frameworks exist to rate the sustainability of buildings, each with their own pros and cons. One entity that helps keep track of them all is the National Institute of Building Sciences (NIBS).

Established by the U.S. Congress, NIBS is authorized “to conduct research, establish performance criteria, promote standards adoption, and accelerate collaboration between public and private stakeholders to advance transformational technologies in the built environment.”

Its projects include the Whole Building Design Guide (https://www.wbdg.org), which maintains the Federal Facility Criteria, an electronic library containing more than 6,000 documents “direct from participating federal agencies,” including “construction guide specifications, manuals, standards and many other essential criteria.” Its resources also include a tools page that provides brief descriptions of and links to desktop and web-based estimation, calculation, assessment, and tracking tools used in the building industry (https://www.wbdg.org/ar/tools).

In addition, the website offers an extensive review webpage called Green Building Standards and Certification Systems, which includes a discussion of emerging trends; an explanation of the differences between prescriptive, performance, and outcome-based green codes; and a resource guide. There is also an explanation of how green building rating and certification systems work and a chart that compares systems commonly used in the U.S. market, including

- **BREEAM: Building Research Establishment Environmental Assessment Method** (https://breeam.com/breeam-usa)
- **LEED: Leadership in Energy and Environmental Design** (https://www.usgbc.org/leed)
- **Green Globes** (https://thegbi.org/greenglobes/why-green-globes)
- **Living Building Challenge** (https://living-future.org/lbc)
- **Phius: Passive House Institute US** (https://www.phius.org)
- **SITES** (https://www.sustainablesites.org)
- **WELL Building Standard** (https://www.wellcertified.com/certification/v2)
- **Fitwel** (https://www.fitwel.org)

A second chart covers international systems used in places such as Singapore (https://bit.ly/4cJByNy), Hong Kong (https://www.beamsociety.org.hk/en), Japan (https://bit.ly/440qOI7), the Middle East and North Africa (https://gsas.gord.qa), South Africa (https://bit.ly/3EfdHbL), and the United Arab Emirates (https://bit.ly/4iGbLXX). The chart also describes EDGE (https://edgebuildings.com), which was adopted by the International Finance Corporation, a member of the World Bank Group.

LEED v5 is ratified

As climate change unleashes more frequent and more damaging natural disasters, green building standards must evolve to remain relevant. A 2023 investigation by Politico's *E&E News* and the nonprofit First Street Foundation, which models likely climate impacts, found that 800 LEED-certified buildings constructed in the preceding decade were "at extreme risk of flooding." (https://bit.ly/4cDLJmp)

That September, the U.S. Green Building Council began drafting the standards that would become LEED v5 (https://www.usgbc.org/leed/v5). Its website notes that the new certification was developed to "champion solutions to align the built environment with critical imperatives including decarbonization, quality of life, and ecological conservation and restoration. LEED v5 will drive real-world impact and positive change." Following two rounds of public comment in 2024, LEED v5 was ratified in March 2025.

The Council presents the new framework on its website as "designed to drive the market towards a near-zero carbon reality that is equitable, resilient, and promotes the wise, safe use of all resources." It provides these definitions of its three core areas of impact:

- **Decarbonization** refers to targeted "reductions in operational, embodied, refrigerants, and transportation emissions."
- **Quality of life** encompasses "improving health, well-being, resilience, and equity for building occupants and their communities, making spaces not just environmentally friendly but also people friendly."
- **Ecological conservation and restoration** emphasizes "strategies that limit environmental degradation and contribute to the restoration of ecosystems, ensuring that our built environment exists harmoniously with nature."

According to its LEED v5 FAQ (https://bit.ly/3Y2bB5B), "there will likely be some period of overlap when it is possible to register for either LEED v4/4.1 or LEED v5." Projects registered under v4 and 4.1 will be given the opportunity to upgrade to v5.

PDFs of the LEED v5 frameworks for Building Design and Construction, Building Interior and Construction, and Building Operations and Maintenance are available for download at https://www.usgbc.org/leed/v5.

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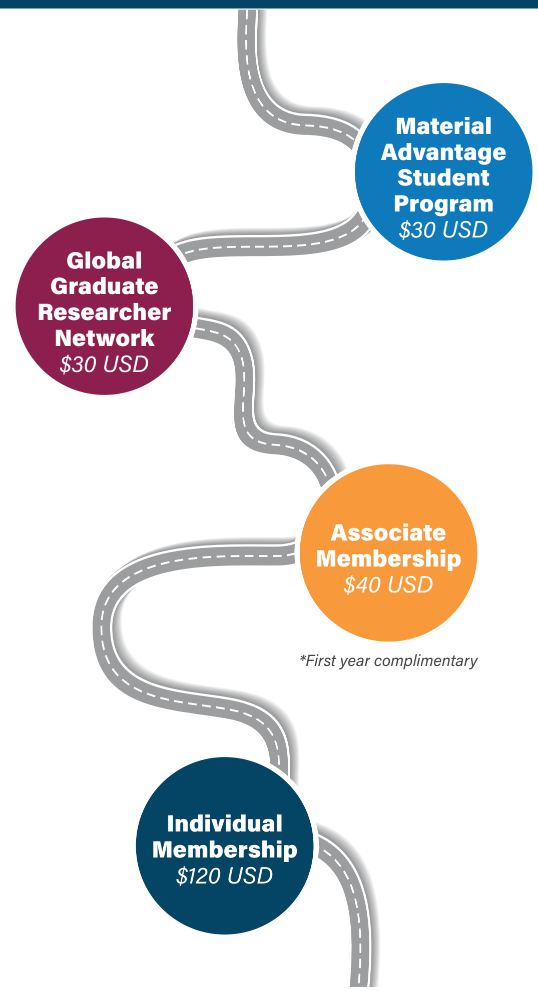

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A brief history of dislocations in ceramics: From Steinsalz to quantum wires

By Xufei Fang

Dislocations in ceramics have enjoyed a long yet underappreciated research history. This brief historical overview and reflection on current challenges provides new insights into using this line defect as a rediscovered tool for engineering functional ceramics.

Dislocations, or one-dimensional line defects, are one of the most fundamental defect types next to zero-dimensional point defects; two-dimensional planar defects, including grain boundaries; and three-dimensional defects, such as precipitates.

As the main carriers for plastic deformation in crystalline solids, dislocations have been extensively studied in metals, which have good deformability. Ceramics, in contrast, are perceived as brittle in the materials science community, exhibiting little or almost no dislocation plasticity at room temperature.

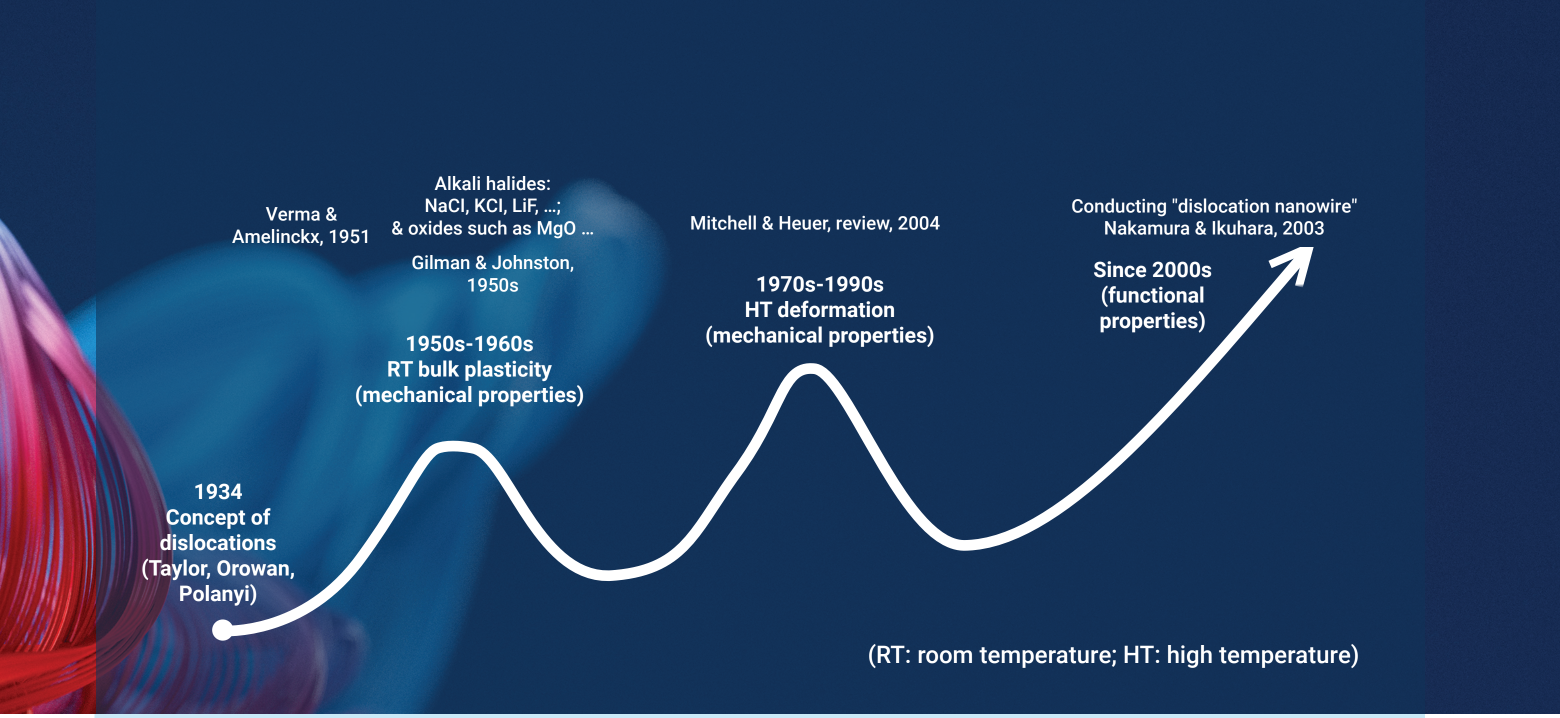
Yet it was fundamental studies on dislocations in ceramics back in the 1950s that significantly contributed to the understanding of dislocations in solids in the early days. In recent years, dislocations in ceramics are seeing a renewed interest owing to the potential advanced functional properties they can help unlock.[1]

In this article, some historical highlights for dislocations in ceramics are gathered, aiming to offer a broader view of the research endeavors as well as the challenges for this reemerging—yet still outlier—topic. This line of historical evolvement hopefully will inspire readers, especially students, to rethink engineering of ceramic materials, which to date has focused primarily on point and planar defects.

A brief historical overview

While plastic deformation today is most often associated with metals, early-stage observations of bulk plastic deformation was documented in minerals, particularly rock salt (*Steinsalz* in German) in the 1920s.[2] This plastic deformation occurred even at room temperature under tensile loading!

In 1934, G. Taylor, E. Orowan, and M. Polanyi independently conceived the concept of dislocations to explain the mechanism of plastic deformation in solids.[3] In the decades since, roughly three major research waves involving dislocations in ceramics have occurred (Figure 1).



Credit: Xufei Fang

Figure 1. Three major research waves involving dislocations in ceramics have occurred since the concept of dislocations was conceived in 1934. The first two waves focused primarily on dislocation-mediated mechanical properties, with a focus on bulk properties at both room temperature and high temperature. The third wave focuses more on dislocation-mediated functional properties, such as electrical conductivity.

Note: The extensive research on plastic deformation of alkali halides (e.g., rock salt) predating the concept of dislocations is not included in this figure.

Although the focus here is on ceramics, for reasons of completeness and overlapping of the continuous endeavor in dislocations in semiconductors, readers may refer to the short historical review by T. Figielski[4] and the monograph by D. Holt and B. Yakobi.[5]

First wave: Room-temperature dislocations in ionic crystals

Probably the first direct observations of dislocations in ceramics were made on silicon carbide featuring spiral growth patterns induced by screw dislocations, which were independently reported by V. Verma and S. Amelinckx in their back-to-back articles in *Nature* in 1951.[6] Shortly after, extensive research on dislocation multiplication, motion, and nucleation in lithium fluoride crystals was carried out by Gilman and Johnston,[7] who used a chemical etching method to directly visualize the dislocation etch pits. This etch pit technique has played a significant role in understanding dislocation behaviors to date.

More studies on dislocations in ionic crystals were later summarized by M. Sprackling in his monograph, *The Plastic Deformation of Simple Ionic Crystals*, in 1976.[8] Meanwhile, for oxides with ionic bonding, J. Pask's group,[9] R. Stokes et al.,[10] and A. Argon and E. Orowan[11] pioneered dislocation research in magnesium oxide in the 1950s and 1960s (primarily at room temperature in bulk deformation, including tensile tests).

Charged dislocations, or linear defects that carry an electric charge, are a unique aspect of ceramics with ionic bonding. This phenomenon caught particular attention in the late 1950s, following the seminal work of J. Eshelby et al.[12]

This interest in charged dislocations extended until about the 1980s, with one of the most comprehensive reviews on charged dislocations by R. Whitworth publishing in 1975,[13] followed by Y. Osip'yan et al. in 1986.[14] The latter focused on the interaction between electric charges and moving dislocations in II-VI group semiconductors, covering the electroplastic effect (dislocation plasticity affected by an electric field) and photoplastic effect (dislocation plasticity influenced by light illumination). Another short review by P. Haasen appeared in 1985, addressing dislocation–point defect interactions in ionic crystals, primarily alkali halides.[15]

Second wave: High-temperature dislocations in structural ceramics

Moving on to the 1970s, research on dislocations in ceramics shifted to focus on high-temperature deformation under loading, most likely due to demands in the aerospace industry looking to use high-temperature structural ceramics.[16,17] Representative materials investigated were alumina, zirconia, titania, spinel ($MgAl_2O_4$), and forsterite (Mg_2SiO_4).[17] During this period, transmission electron microscopy was extensively used, providing more direct evidence as well as revealing the complexity of the dislocation structure and configuration.

Realizing the importance of dislocation plasticity in structural ceramics at high temperatures and the fact that in this temperature range "interaction of point defects with dislocations is especially significant," T. Mitchell et al. assembled an overview titled "Interaction between point defects and dislocations in oxides,"[18] after the workshop (with almost the same title) held in the Laboratoire de Physique des Materiaux of the French National Center for Scientific Research in 1978.

Third wave: Dislocation engineering for functional ceramics

In 1983, W. Shockley, the founding father of the junction transistor, speculated that dislocations in semiconductor crystals could be used as microwiring,[19] which could be pictured as a conductive tube (along the dislocation core) filled with metallic elements. This concept was experimentally achieved 20 years later by A. Nakamura et al. in the laboratory of Y. Ikuhara.[20] They successfully deformed bulk single-crystal sapphire at 1,400°C and then diffused titanium along the dislocations to achieve an about 10^{13} higher conductivity compared to the pristine, insulating sapphire. Based on these proofs-of-concepts, they declared the dislocation-based nanowire design an example of "dislocation technology."[20,21]

About a decade later, S. Szot et al. summarized the use of dislocations in the near-surface regions of bulk oxides, such as strontium titanate and titania, to tune the ceramics' physical and chemical properties.[22] Besides bulk materials, scattered studies also report dislocation-tuned electrical conductivities in oxide thin films, as reviewed by M. Armstrong et al.[23]

Recently, more momentum in the area of dislocation-mediated functional ceramics has been driven by the Ceramics Group led by J. Rödel at Technical University of Darmstadt. The group focused on the mechanical imprinting of dislocations into bulk oxides using high-temperature deformation to achieve enhanced electromechanical properties in ferroelectrics (e.g., barium titanate)[24] and to regulate the electrical conductivity (e.g., in titania)[25] via dislocation self-doping, contrasting the conventional chemical doping strategies using point defects.

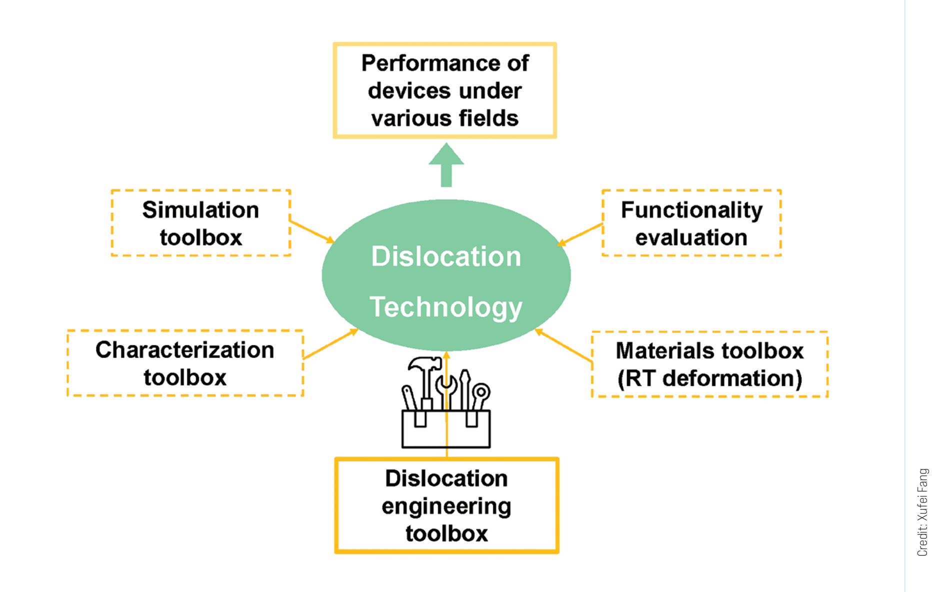


Figure 2. Overview of the dislocation engineering toolbox, which consists of several mini toolboxes to achieve dislocation-based functional ceramic technology.

The current author, stemming from Rödel's group, has focused on mechanical tailoring of dislocation densities and plastic zone sizes at room temperature across length scales in the model perovskite oxide strontium titanate. His group has also extended the materials systems to potassium tantalate and beyond, with the goal to bring down the temperature required for cost-effective dislocation engineering.[26,27]

For a list of more researchers who have made significant contributions to dislocation science in general, readers may refer to the entertaining webpage by H. Föll.[28]

Current challenges and the dislocation engineering toolbox

There is still a long way to go to achieve commercialized dislocation-based functional ceramic technology. While dislocations generated via mechanical deformation face the long-standing challenge of crack formation, dislocations produced via novel sintering and other fabrication methods cannot yet achieve precise control of the dislocation structures, except for bicrystal fabrication (which can be rather costly).

To this end, the dislocation engineering toolbox can aid development and scaleup of dislocation technologies (Figure 2). This toolbox, which was first presented in Reference 1, consists of several mini toolboxes containing experimental techniques for investigating dislocations in ceramics. It includes resources for not only mechanical deformation across length scales at both room temperature and elevated temperatures, but it also includes novel sintering and other fabrication routes including, for example, flash sintering, thin film growth, bicrystal fabrication, and irradiation.

Materials toolbox

Inspired by the discovery of room-temperature bulk plasticity in strontium titanate,[29] potassium niobate,[30] and potassium tantalate,[27] the question has been put forward: Are there more perovskite oxides that are plastically deformable at room temperature?[26] If so, that would help facilitate cost-effective mechanical deformation for dislocation engineering.

The author's group recently reviewed the literature and summarized 44 ceramic compounds that exhibit meso-/macroscale dislocation plasticity at room temperature.[31] This number appears encouraging. Nevertheless, predictions are not available at this stage due to the lack of fundamental understanding concerning dislocation mobility in the majority of ceramics at room temperature, which requires further extensive characterization and simulation.

Characterization toolbox

A comprehensive characterization toolbox for dislocation structure ranging from the atomic scale up to the bulk scale is necessary for a complete picture of the fundamental mechanisms of dislocations in ceramics. But currently, the methods in this toolbox are not sufficiently efficient. For instance, capturing reliable 3D reconstruction of the dislocation core structure, which is believed to be most critical for understanding why certain ceramics exhibit good dislocation mobility at room temperature, remains a challenging task. Artifacts can be induced easily from 2D analysis even in state-of-the-art transmission electron microscopy. It is indispensable to obtain accurate experimental information as reliable input for atomistic simulations.

Simulation toolbox

The simulation toolbox on dislocations in ceramics may be categorized into two major branches: one on the functional/transport properties and the other on the mechanical/mobility properties. In examining the dislocation–point defect interaction and pipe diffusion, M. Puls and J. Rabier pioneered the simulation of edge dislocations in rock salt and magnesium oxide in the 1980s.[32] In the perovskite oxide strontium titanate, one of the early atomistic simulations to address the role of edge dislocation on the defect chemistry and oxide ion transport was carried out by D. Marrocchelli et al. in 2015.[33]

J. Amodeo, P. Carrez, P. Cordier, and colleagues systematically studied the dislocation motion in magnesium oxide using atomistic simulations, with the aim to provide a more quantitative description of plastic flow in the Earth's mantle.[34,35] The same group also modeled dislocation cores in more perovskites including magnesium silicate, calcium titanate, and strontium titanate. In the meantime, P. Hirel, M. Mrovec, C. Elsässer, and colleagues were examining dislocations in strontium titanate and potassium niobate,[36,37] motivated by the aforementioned discovery of room-temperature bulk plasticity in these perovskite oxides.

The simulation toolbox for dislocations in ceramics is clearly still in its infancy. In particular, the interatomic potential remains the most pressuring bottleneck, primarily due to the complex interatomic interactions involving ionic/covalent bonding and extended/dissociated core structures, with the latter heavily relying on accurate experimental observations of core structures, as mentioned above.

Attempts in constructing neural network potentials using density functional theory for large models were made most recently on some ceramics as a potential solution.[38] Scaling it up from atomic scale to address dislocation multiplication, mobility, and hardening at the microscale and eventually connecting to the continuum level remains largely unexplored.

Functionality evaluation toolbox

Evaluation of dislocation-tuned functional properties in different structures ranging from thin films to bulk materials are readily available. What is truly critical is the dislocations' long-term stability, which will be directly linked to the performance of future dislocation-based devices. Under such conditions, the complexity will not only arise from the dislocation mesostructure involving different dislocation types (edge, screw, and mixed), kinks, and jogs,[39] but it will also be due to the interactions between dislocations as well as other types of defects, such as point defects and eventually planar defects, e.g., domain walls (single or polycrystalline materials) or grain boundaries (polycrystalline materials).

Future dislocation technologies

It may seem premature to address dislocation-based functional devices because few attempts to create such devices have been made so far. However, based on the functionalities shown in the research studies described above, we can already posit that these devices may soon find application in a variety of fields, including thermal, electrical, light, magnetic, and mechanical loading technologies.

In addition, a principle noted by W. Shockley at the 1953 March meeting of the American Physical Society may enable the use of dislocations in ceramics for emerging applications.[40] He noted that broken/dangling bonds in crystals with diamond structure may lead to a one-dimensional band of edge states that "may be partially filled, thus causing each dislocation to become a one-dimensional degenerate-electron-gas conductor." This behavior suggests dislocations may be able to act as quantum wires[41,42] or conductive nanowires.[21]

Concluding remarks

Looking back over the historical development of dislocations in ceramics, there appears to be exciting times ahead for this field. The ground-laying works currently being carried out to overcome the pressing bottlenecks in dislocation engineering in various functional ceramics, irrespective of their brittle nature, may eventually catalyze the realization of dislocation technology for a new generation of functional ceramics.

Acknowledgments

The author acknowledges the European Research Council (ERC Starting Grant, Project MECERDIS, No. 101076167) for funding the fundamental research. The author would like to thank A. Zelenika and O. Preuß for retrieving and vetting some of the literature from the pre-internet era.

Disclaimer

Due to the long history and vast amount of literature on this topic scattered in different fields, some novel dislocation-based discoveries and researchers who made significant contributions may not have made it into this review. Readers are invited to contact the author for discussions and exchanges of facts.

About the author

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Uncovering structure–property relationships of iron phosphate nuclear waste glasses

By Jayani Kalahe and Jincheng Du

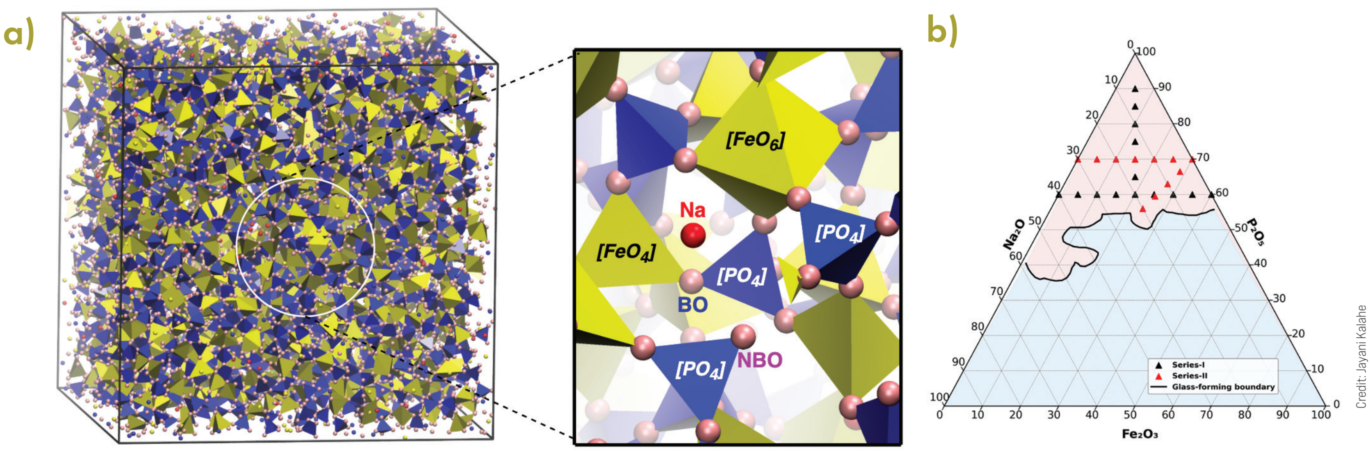

Figure 1. (a) An illustration of a simulated $60P_2O_5–35Fe_2O_3–5Na_2O$ glass from molecular dynamics simulations and polyhedral connections. Blue: Phosphorous, Yellow: Iron, Red: Sodium, and Pink: Oxygen. (b) Ternary phase diagram with all simulated glasses used in the quantitative structure–property relationship analysis. Figures created based on data in References 2–4.

Among the glass-forming systems, phosphate glasses have several unique physical and processing properties that are different from conventional silicate glasses, making them potential candidates for applications ranging from biomedicine to photonics to nuclear energy.

Iron phosphate glasses are a particularly promising alternative to borosilicate glasses for high-level nuclear waste vitrification.[1] They have low melting temperatures and can accommodate a wide range of waste components. Plus, some compositions of iron phosphate glasses provide exceptional chemical durability that is even higher than conventional borosilicate waste glasses.

Despite their advantages, the atomic-scale structural characteristics and associated property relationships of phosphate glasses, particularly iron phosphate glasses, remain less understood. The formation of P–O–Fe^{3+} linkages, which withstand hydrolytic attacks better than P–O–P linkages, is considered to be the primary reason for the enhanced chemical durability of these glasses. However, the addition of iron oxide (Fe_2O_3) as an intermediate component and varying the iron redox ratio increase the glass's structural complexity. So, comprehensive insights into the glass's structure–property relationships are needed.

Exploring structure using molecular dynamics

This study systematically employed molecular dynamics (MD) simulations to investigate structure–property relationships in iron phosphate glasses. Several series of sodium iron phosphate glasses (NFP) were simulated following a typical melt-quench process, and a typical simulated glass structure is shown in Figure 1.[2–4]

Distinct bonding environments revealed

It is known from previous experiments that pair distribution functions for P–O bonds in sodium iron phosphate glasses show a split in the first peak. Experimental studies previously attributed the dual peak behavior to nonbridging (P–NBO, ~1.47 Å) and bridging (P–BO, ~1.52 Å) oxygens bonded with P^{5+}. Our simulations accurately captured this distinct bonding environment (Figure 2),[3] with the simulated average P–O bond distance (~1.5 Å) closely matching previously reported experimental data.

Iron redox states and their influences

We also used MD simulations to characterize the coordination environments for Fe^{3+} and Fe^{2+} ions, revealing critical insights into their distinct structural roles. Fe^{3+} ions predominantly act as network formers, occupying tetrahedral units, while Fe^{2+} ions predominantly act as network modifiers, occupying positions near phosphate groups and disrupting

$P–O–Fe^{3+}$ bonds, thus increasing structural disorder.[4] Fe–O bond distances and coordination numbers were found to be indifferent to composition changes.

Medium-range order and network connectivity

The medium-range order was assessed through distributions of phosphate structural units (Q_n). Increasing Fe_2O_3 content replaced chain-like fragments (Q_2) with more crosslinked structures (Q_4), enhancing network connectivity via robust $P–O–Fe^{3+}$ linkages. Sodium ions, primarily serving as charge compensators, further influenced connectivity by distinctly altering structural networks at various compositions.

Three primary links were identified by polyhedral linkage analysis: $Fe^{3+}–O–Fe^{3+}$, P–O–P, and $P–O–Fe^{3+}$. Bonding of $[FeO_x]–[FeO_x]$ exhibited mostly corner-sharing with a noticeable presence of edge-sharing in specific compositions, while $[PO_5]$ units shared corners exclusively with $[PO_5]$ and $[FeO_x]$ units.

Preferences of modifiers toward formers

The preferences of glass modifiers toward former cations were investigated. Sodium ions consistently preferred Fe^{3+}, acting mainly as charge compensators. A sodium deficit to balance $[FeO_4]^-$ units led to the formation of five- and six-coordinated Fe^{3+} units, confirmed by coordination and bond angle analyses. Conversely, Fe^{2+} ions exhibited a strong affinity toward P^{5+}, identifying Fe^{2+} as a network modifier. This preferential bonding impacts the local structural environment, affecting the overall network connectivity and overall durability of iron phosphate glasses.

Leveraging QSPR for property prediction

Quantitative structure–property relationship (QSPR) analysis was used to predict glass properties. Descriptors such as F_{net} (theoretically derived structural descriptor), P–O–P and $P–O–Fe^{3+}$ linkages, and bridging oxygen percentage were used to predict glass properties, such as dissolution rate, density, and mechanical properties.

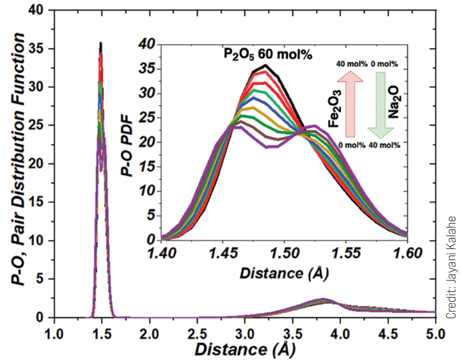

Figure 2. Bonding environments of $60P_2O_5–35Fe_2O_3–5Na_2O$ glass. Figure created based on data in Reference 3.

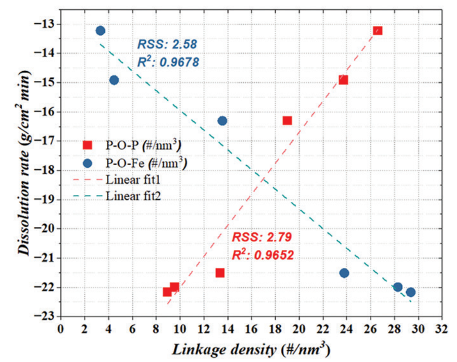

Figure 3. Correlations between dissolution rates (logarithm) and linkage densities. Figure created based on data in References 4 and 5.

As expected, the density of P–O–P linkages positively correlated with dissolution rates, while that of $P–O–Fe^{3+}$ linkages exhibited a negative correlation, with high coefficient of determination (R^2) values and low residual sum of squares (RSS) confirming model accuracy (Figures 3).[4,5] This approach was extended to more than 30 simulated glasses. The F_{net} descriptor, incorporating MD-derived structural and bond energy parameters, showed excellent correlation with density and elastic moduli.

Conclusions

This study provides a comprehensive understanding of the interplay between composition, iron redox effect, and network connectivity on the atomic structure and properties of iron phosphate glasses. Integrating MD simulations with QSPR analysis demonstrates a cost- and time-efficient approach for predicting and optimizing glass performance in critical applications, such as nuclear waste immobilization.

Acknowledgments

This work was funded by ARPA-E, U.S. Department of Energy (DE-AR0001613). We gratefully acknowledge our project manager Robert Ledoux and collaborators at Pacific Northwest National Laboratory (PNNL) and Citrine Informatics for their support. We thank the computational time granted from the University of North Texas (UNT) Research Computing Services and the Texas Advanced Computing Center. Special thanks go to T.S. Mahadevan (UNT), Xiaonan Lu (PNNL), Brian J. Riley (PNNL), John D. Vienna (PNNL), Miroslava Peterson (PNNL), James Saal (Citrine), and Kyle Miller (Citrine) for their helpful discussions.

About the authors

Jayani Kalahe completed her Ph.D. in materials science and engineering in winter 2024 under the supervision of Professor Jincheng Du at the University of North Texas (UNT). She now serves as a postdoctoral researcher at UNT. Contact Kalahe at jayanikalahe@my.unt.edu.

Editor's note

Kalahe presented the 2025 Kreidl Award Lecture at the Glass & Optical Materials Division Annual Meeting on May 6, 2025. Learn more about the conference at https://ceramics.org/pacrim16.

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MEET OUR GRADUATE STUDENTS

Montana Weidman

Montana Weidman is a master's student in Materials Science and Engineering at Alfred University, continuing from her undergraduate degree in the same field. Mentored by Drs. Scott Misture and Collin Wilkinson, her work centers on additive manufacturing of fully dense silicon carbide ceramics. She focuses on tailoring slurry rheology to optimize sintering and microstructure. Montana is also active in outreach and mentorship, and plans to pursue a PhD in ceramic and glass engineering.

Cooper Howard

Cooper Howard is a PhD candidate in Ceramic Engineering at Alfred University, holding both bachelor's and master's degrees in the field. Advised by Dr. Scott Misture, his research explores pressureless sintering of ultrahigh temperature ceramics, with a focus on silicon carbide and the role of boron as a sintering aid. He is passionate about advancing ceramic processing methods and plans to pursue a career in teaching and materials research mentorship.

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Danielle Perry

Danielle Perry is a PhD candidate in Materials Science and Engineering at Alfred University, where she has also earned bachelor's degrees in Biomaterials Engineering and Biology, and a master's in Biomaterials Engineering. Her research focuses on bioactive glass composites doped with therapeutic ions for tissue repair, particularly ACL injuries. Danielle's work combines bioactive glass with biodegradable polymers for 3D printing, with the goal of advancing healthcare materials and applications.

Lauren Meyer

Lauren Meyer is a first-year PhD student in Glass Science at Alfred University, working under Dr. Collin Wilkinson. With a background in Physics, Mathematics, and Computer Science from Coe College, Lauren specializes in computational glass research. Lauren's work uses molecular dynamics simulations and statistical mechanics to predict temperature-dependent viscosities of glasses. This research aims to accelerate the development of novel glass systems by reducing the reliance on time-intensive experimental methods.

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WELCOME TO THE 'EMERGING PROFESSIONALS' ISSUE

By Nathan McIlwaine

"The art of life lies in a constant readjustment to our surroundings."
–Kakuzō Okakura–

As climate challenges and environmental remediation efforts reshape manufacturing, numerous fields are undergoing rapid technological change, including transportation (electric vehicles), energy (renewable and clean sources), and chemicals (sustainable polymers). Materials scientists and engineers are critical to this progress, as every innovation depends on the intentional selection and design of materials.

In this landscape, ceramics—and the materials and processes that rely on them—continue to evolve. This transformation presents both significant challenges and exciting opportunities for the ceramic and glass workforce.

To meet these demands, students need more than technical knowledge—they require mentorship and access to meaningful resources. ACerS fosters this environment of support, with the President's Council of Student Advisors (PCSA) playing a key role. This year, 51 delegates from 10 countries across four continents have advanced this mission through the focused efforts of five dedicated committees.

- **The Conference Programming Committee** organized student-focused activities at ICACC and EMA 2025, including miniature golf and the annual shot glass competition. They also managed the student information booth at each conference, with an emphasis on engaging first-time attendees.
- **The Professional Development Committee** supported the planning and organization of the IGNITE MSE student event at MS&T 2024. They also organized the "Beyond the Degree" career webinar and are planning a webinar on negotiation strategies for entering the workforce.
- **The Education Committee** developed website resources for the CGIF Classroom and Mini Materials Science Kits, including a kit calculator, a list of "Do's and Don'ts" for performing the experiments, and a feedback form. They also helped coordinate the delivery of kits to three countries for international outreach events.
- **The Recruitment and Retention Committee** created a visa support webpage on the CGIF website. The webpage includes mentor–mentee resources and a welcome video to help incoming international delegates. They also designed a PCSA alumni pin for business attire at future ACerS conferences.
- **The Communications Committee** continues to manage all PCSA social media accounts, including committee posts, delegate spotlights, and "Day in the Life" videos, and maintains the internal quarterly PCSA bulletin. They also launched a new PCSA LinkedIn group.

The 2024–2025 PCSA delegates as well as ACerS Past President Rajendra Bordia (center) at the PCSA annual meeting in October 2024.

Credit: ACerS

The "Emerging Professionals" section of the June/July *Bulletin* is a yearly expansion on the PCSA's commitment to student development. Coordinated by the Communications Committee, this section highlights the experiences of young ACerS members and consists of three parts:

- **Research articles**: Three full-page articles describe research based on this issue's theme, "Constructing for a changing climate."
- **Science for Society articles**: Three short stories based on the IGNITE MSE poster topics of outreach and community engagement; technology for social good; and inclusivity, diversity, and ethics in research.
- **Future Focus articles**: Two full-page articles exploring more effective methods for educating the public about materials science and the importance of mentoring in supporting the next-generation workforce.

I hope you enjoy this thought-provoking look at the next generation of young professionals in the field.

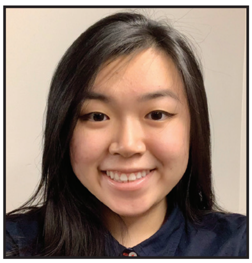
Nathan McIlwaine is a Ph.D. candidate at The Pennsylvania State University studying in the Maria Research Group. As the 2024–2025 PCSA Council Chair, he has actively engaged with PCSA members, fostered connections with the broader ACerS community, and supported key committee initiatives. ■

Material Advantage Student Program

The Material Advantage Student Program offers students membership benefits and access to The American Ceramic Society (ACerS), Association for Iron & Steel Technology (AIST), ASM International, and The Minerals, Metals and Materials Society (TMS). Learn more at https://ceramics.org/material-advantage.

Constructing wellness: Why infrastructure needs preventive care

By Tiffany Liu



Proactively identifying and implementing measures against potential failures can provide big, long-term cost savings. Yet while the benefits of preventive care are highly recognized and promoted in the medical field,[1] this same mentality often struggles to find a foothold in the rapidly expanding construction industry.

Infrastructure decisions exist in the context of fluctuating budgets, limited access to necessary materials and manpower, and changing political priorities, among other factors. As a result, short-term economic outlooks often determine critical engineering parameters.[2]

Consequences of this short-term planning are exacerbated by the changing climate, which subjects existing architectural designs to stresses they are not equipped to handle. For example, prolonged heat waves cause railroad tracks to buckle and house foundations to crack due to increased thermal fatigue and soil shrinkage, respectively.[3,4] Meanwhile, increased air and water pollution is causing steel to corrode at faster rates.[5]

How can the investment needed for preventive care be justified to higher-ups? Several regulatory changes may help encourage the shift from reaction to prevention in construction.

First, tax incentives may encourage companies to contribute directly to future solutions.[6] For example, new tax credits could be offered to companies that allocate additional funds to mechanical integrity budgets or participate in pilot programs to evaluate new technologies under real-world operating conditions. Such programs can help derisk technologies that may otherwise be stuck in academic research laboratories.

Another change would be implementing stricter design margins in new construction to account for accelerated degradation modes driven by environmental pressures and heightened mechanical demands.[7] Selecting materials with superior material properties right from the outset reduces raw material demands and avoids the costs associated with frequent replacements and downtime.

High-performing materials do more than just reduce long-term maintenance costs—they safeguard companies from increasingly common supply chain disruptions caused by natural disasters and changing geopolitical dynamics. Infrastructure strategies based on past pricing and performance expectations are no longer reliable, so new models should be developed to account for these risks.

More recently, attention has turned to digital infrastructure, which could serve as a testing ground for new materials technologies and assist the development of smarter, more adaptive strategies for addressing the rapidly developing impacts of climate change. Numerous feature articles and columns exploring the adoption of conventional and artificial intelligence-based digital solutions can be found in the April 2025 issue of the *ACerS Bulletin*.

Credit: Erik Mclean, Unsplash

Materials science has always pushed the frontier of what is possible, but progress at the edge means little when implementation lags behind. As infrastructure wears and environmental pressures grow, the solution is not just to develop better materials; we need to communicate and make the case for preventive investment.

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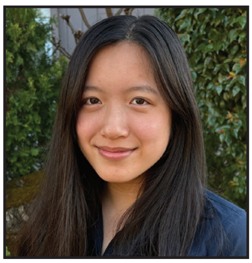
Tiffany Liu is a fourth-year undergraduate student at the University of Illinois Urbana-Champaign. As part of Marie Agathe Charpagne's research group, she studies the corrosion mechanisms of additively manufactured alloys. In her spare time, she enjoys playing Catan and hanging around makerspaces.

ACerS Global Graduate Research Network

ACerS Global Graduate Researcher Network (GGRN) membership addresses the professional and career development needs of graduate-level research students who have a primary interest in ceramics and glass. Learn more at https://ceramics.org/ggrn.

Upgrading soil monitoring capabilities: Neutron radiography detects ceramic-enhanced microplastic movement

By Thai Nguyen



As of 2024, the world's plastic production is more than 450 million metric tons per year. Of this total, an estimated 20 million tons enter the environment annually, where natural weathering processes break it down into the increasingly alarming pollution known as microplastics.[1]

Microplastics are small plastic particles less than 5 millimeters in size. Since 2004, microplastics have been identified as an environmental threat and a concern to human health. When microplastics enter the soil, they can affect enzymatic and microbial activities, which could reduce seed germination time and slow root development of crop plants. They can also enter the food chain through root uptake via miniscule "cracks" in crop vegetables.[2] As microplastics move further up the food chain, they become more concentrated, and accumulation in the body can potentially cause endocrine disruption, increasing the risk of cancer and reproductive system disorders.[3]

Considering these potentially toxic effects on farmland and human health, it is important to study the ways in which microplastics travel through soil. Researchers have previously used density separation based on sifting and chemical treatment to isolate microplastics from soil samples.[4] However, this method cannot pinpoint the specific locations of microplastic particles as they move through the soil, limiting our understanding of their transport and accumulation patterns.

To address this gap, my research at the University of California, Davis McClellan Nuclear Research Center explores a new approach using neutron radiography to track microplastic movement. This method involves embedding nuclear ceramic particles into microplastics, which can then be imaged using neutron beams. This functionality allows specific microplastic particles to be traced in real time as they move through the soil.

I used gadolinium oxide (Gd_2O_3) particles in my work because gadolinium has the highest neutron absorption at 48890 barns. I created the samples using a synthesis process described by La et al.,[5] which involved adhering Gd_2O_3 powder to an epoxy resin and then shaving the composite to create microplastics. I then mixed and imaged varying amounts of the ceramic-enhanced microplastics in potting soil.

Initial results showed promising microplastic detection capabilities using this method. Specifically, higher amounts of Gd_2O_3 incorporated into the plastic yielded much brighter spots under neutron imaging (Figure 1).

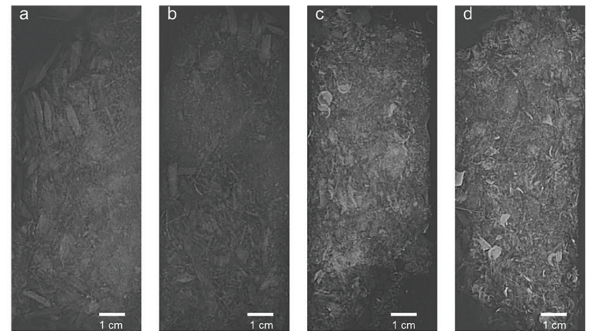


Figure 1. a) 100 g potting soil, b) 100 g potting soil mixed with 0.67 g of 0 wt.% Gd_2O_3 shaved particles, c) 100 g potting soil mixed with 0.67 g of 16.6 wt.% Gd_2O_3 shaved particles, d) 100 g potting soil mixed with 0.67 g of 25 wt.% Gd_2O_3 shaved particles.

Next steps include creating a small-scale lab simulation of farmland exposed to a source of microplastic pollution as well as environmental factors, such as rainfall and sunlight. Imaging samples from this small-scale plot will allow the prediction of microplastic movement similar to real-world scenarios.

The growing prevalence of microplastics in the environment poses a significant threat to agricultural systems and human health. The innovative use of neutron radiography, as explored in this research, can help researchers address this issue by enabling real-time, precise localization of microplastic particles. I look forward to further enhancing our understanding of microplastic behavior.

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Thai Nguyen is a Ph.D. student in materials science and engineering at the University of California, Davis in the research group of Subhash Risbud. Her research focuses on neutron radiography of ceramic composites and soft materials. In her free time, she enjoys cooking and discovering new recipes.

ACerS Young Professionals Network

ACerS Young Professionals Network (YPN) aims to provide support, community, and leadership opportunities to members as they transition from students to successful professionals in the broader ceramics society. Learn more at https://ceramics.org/ypn.

Ultrahigh-temperature ceramics: Empowering better energy usage in next-generation systems

By Kartik Nemani

Operating at higher temperatures can significantly enhance system efficiency in advanced aerospace, energy, and thermal systems. But operating at these higher temperatures requires materials that can withstand increased atmospheric stresses, such as larger thermal gradients and accelerated oxidation mechanisms.

Ultrahigh-temperature ceramics (UHTCs) can enable components to withstand these stresses while maintaining functionality.[1] These ceramics have melting points above 3,000°C, and they offer exceptional oxidation resistance, thermal shock tolerance, and chemical stability. Such qualities make UHTCs ideal for thermal protection systems in hypersonic vehicles, spacecraft, nuclear fuel claddings, and turbine components.

Despite their potential, UHTCs face significant barriers to widespread adoption. For example, UHTC production typically requires extremely high sintering temperatures (about 2,000–2,200°C), which complicates controlled grain growth and porosity and consumes significant amounts of energy. Furthermore, many UHTCs have densities above 12 g/cm^3, which is significantly higher than aerospace-grade alloys. This extra mass is untenable in weight-sensitive systems such as reentry vehicles or satellites, where every additional kilogram can translate to substantial increases in launch costs and fuel requirements.

While these drawbacks are nontrivial, recent innovations offer viable solutions that justify continued investment in UHTCs. For example, advancements in additive manufacturing and electric-field-assisted sintering methods enable the fabrication of architected UHTCs with myriad structures, which help reduce material usage while preserving thermal performance and an optimized strength-to-weight ratio.

Ceramic–metal composites and fiber-reinforced UHTCs combine the best of both worlds: the toughness and lower density of metals with the thermal resilience of ceramics. Likewise, functionally graded materials tailor properties across a component by using UHTCs only where necessary, such as in the outer skins or hot zones of aircraft, while maintaining lighter support structures internally.

Emerging material classes such as high-entropy ceramics and MAX phases offer lower thermal conductivity, enhanced oxidation resistance, and improved processability compared to traditional UHTCs. Additionally, 2D ceramic materials can serve as UHTCs with added capabilities, such as electromagnetic interference shielding and energy harvesting.[2]

Thanks to these advancements, even if UHTC components remain heavier or more costly to produce, their benefits to overall system-level efficiency far outweigh the material penalties. In aerospace and nuclear power, where operational efficiency and reliability are mission critical, these paybacks can be transformative.

Ultimately, the future of sustainable engineering lies not just in new fuels or engines but in materials that perform under extreme conditions. Despite challenges, UHTCs are poised to be the thermal backbone of next-generation, energy-efficient systems. With innovative processing methods and structural designs, they shift from burdens to strategic assets enabling—not just withstanding—high-efficiency performance.

UHTC development at DOE National Labs

The perspective below is from Jorgen Rufner, senior materials scientist and Advanced Manufacturing Group Lead at Idaho National Laboratory

"Smart selection and strategic use of UHTC components are essential, especially as more technologies demand materials that can survive extreme environments. However, UHTCs often depend on rare or specialized elements and energy-intensive processing, making them vulnerable to supply chain disruptions driven by geopolitical and resource constraints.

These limitations highlight the need for resilient supply strategies and diversified sourcing, an area where U.S. Department of Energy National Labs are actively developing solutions in large-scale manufacturing and energy-efficient materials by design."

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Kartik Nemani is a post-doctoral research fellow at the University of Alabama at Birmingham. His research focuses on MXenes for ultrahigh-temperature applications and polymer-derived ceramics. Beyond his research, he enjoys cooking, bird watching, and expressing creativity through mixed-media painting. ■

SCIENCE FOR SOCIETY

IGNITE MSE: Igniting student passion for materials research

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

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

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

IGNITE MSE

Greening bioceramics: The organic route to hydroxyapatite

[TECHNOLOGY FOR SOCIAL GOOD]

By Gowtham Rajan

Since the 1970s, bioceramics have become a significant player in the medical materials market, bringing countless benefits to patients including more personalized healthcare products and improved long-term outcomes.[1] But while bioceramics do a lot of good in application, they like other materials are often produced using less-than-ideal manufacturing processes, which reduces their overall score on life cycle assessments.

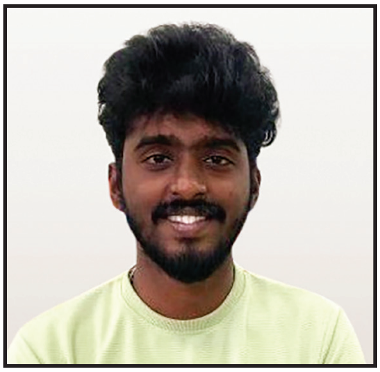
To maximize the social good of bioceramics both in and outside of application, researchers are exploring the possibility of using various organic wastes, such as fruit peels and plant leaves, as raw materials for bioceramics. If successful, the waste-derived bioceramics will perform just as well in application while also providing a new market for existing waste streams.

For example, sugarcane processing results in a byproduct called sugarcane bagasse, which finds limited application as a fertilizer or biofuel due to its high moisture content and difficult-to-breakdown structure. But sugarcane bagasse contains significant calcium content, which could potentially be used as a raw material to produce hydroxyapatite (HAp)—the most common calcium phosphate-based bioceramic used in biomedical applications today.[2]

During my undergraduate studies in the Department of Ceramic Technology at Anna University (Chennai, India), I explored the synthesis of HAp from sugarcane bagasse. We employed calcination to extract calcium oxide from the waste material, which we then reacted with phosphate precursors to form HAp. The process yielded approximately 1–3 wt.%, and the HAp demonstrated excellent bioactive properties. This methodology was also successfully extended to other organic wastes such as orange peels, showcasing its versatility across diverse raw materials.

The synthesized HAp was further shaped using 3D printing techniques and heat-treated to enhance its mechanical properties.[3,4] To evaluate its biomedical potential, we tested the material with a type of cancer cell called osteosarcoma cells. The results showed remarkable biocompatibility and bioactivity, indicating its suitability for bone implants and medical devices.

The development of bioceramics from organic waste represents a significant step toward sustainable materials science. By reducing the environmental impact of bioceramics production, these materials can benefit the social good throughout their entire lifecycle.



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Gowtham Rajan is a project associate at Indian Institute of Technology Madras working under the guidance of N. V. Ravikumar. His research focuses on additive manufacturing of ceramics. Outside of his professional work, Gowtham enjoys playing football and creating portrait art.

Gaffer's Guild: Building knowledge and community through a shared love of glassblowing

OUTREACH AND COMMUNITY ENGAGEMENT

By Azriel Carr

With more than 800 student clubs and organizations across campus, students at Iowa State University have no shortage of exciting communities and spaces to immerse themselves in. However, nestled in the corner of the Student Innovation Center's first floor, one unique club stands out: the Gaffer's Guild glassblowing club.

The Gaffer's Guild is a tight-knit community of students, faculty members, alums, and city locals who all share a love for glassblowing. The 70+ guild members, including myself, are free to blow glass any day of the week. All that is needed is an idea and a partner, and members have the liberty to come in and let creativity run wild.

The Guild thrives off the idea of members working together on projects. This collaboration is required in part for safety reasons—having at least two members in the studio whenever glassblowing takes place ensures backup in case of an emergency. But a bigger reason for partnering up is it allows for simultaneous knowledge sharing and community building.

Glassblowing is an ancient art form that has been passed down for generations by experienced gaffers teaching the classic techniques of reticello, filigrana, and zanfirico, among others, to young pupils. By continuing this storied practice, we can confidently move beyond asking "*Can* we do it?" to instead asking "*How* will we do it?"

One of my most memorable experiences in the Guild so far has been glassblowing with what is now my Friday nights group. When I first began attending the weekly meetup, I struggled to create objects beyond thick vases and single-color paperweights. But with the help of skilled glassblowers such as Elizabeth Krenkel, Devon Schuler, and Jayce Abens, I was able to sharpen and refine my basic glassblowing skills, so now I can make beautiful flowers, goblets, fish, and more.

Whether it is requesting help on certain techniques or just bantering about our daily lives, the Gaffer's Guild members have become an integral part of my time at Iowa State University. Through this "home away from home" within the Student Innovation Center, I have found a new passion for glassblowing that connects me to generations of artisans, and maybe someday I will contribute to the legacy of this revered field.

Azriel (Azzy) Carr is an undergraduate student at Iowa State University studying materials engineering with a specialization in ceramics. When she is not conducting ground-breaking research or studying at Parks Library, she spends her time creating wonderful works of art in the Gaffer's Guild glassblowing studio. ■

The importance of DEI initiatives in unprecedented times

INCLUSIVITY, DIVERSITY, AND ETHICS IN RESEARCH

By Brittney Hauke

When 2025 first started, I thought I knew what to expect from the year. But as January turned into February, it quickly became apparent that things were not going to be "business as usual." Federal directives to freeze or cancel grant funding for research projects including certain topics—notably diversity, equity, and inclusion (DEI)—quickly turned academic life upside down.[1]

At its core, DEI initiatives are organizational frameworks that seek to promote the fair treatment and full participation of all people. While recent years have seen some controversies surrounding the specific acronym "DEI" and the broader DEI movement,[2] these concepts have been around for decades, and countless studies have demonstrated the benefits of fostering more diverse, equitable, and inclusive working environments.[3]

Though federal-level DEI programs are currently up in the air, many states and organizations are working hard to ensure the next generation of scientists can benefit from these initiatives at a local level. In March 2025, I participated as a speaker at one such local event: the first-ever Cosmic Pathways. This free, one-day conference, hosted at the City College of New York, helped expose high schoolers and undergraduate students to careers and opportunities in the physical sciences.

While it was exciting to see so many students gain access to resources that could help shape their future, two undergraduate students asked me how I felt about starting a postdoctoral position with the federal funding situation. They understand what is happening, and I fear the government's actions will drive such bright, talented, creative, and inspiring young scientists away from these fields.

I do not have all the answers for how we can weather this storm. But I do know we cannot stop striving for a scientific community that welcomes everyone.

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Brittney Hauke graduated with her Ph.D. in materials science and engineering from The Pennsylvania State University in May 2025 and is now a postdoctoral researcher in the Mauro Group. In her free time, she enjoys reading, video games, photography, weight lifting, and hiking. ■

DEI at ACerS

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

FUTURE FOCUS

POTTER'S FABLE: Exploring ceramics through comics

By Srividhya Rajagopalan Vasumathi, Karthick Arunachalam, Manivasakam Munusami, Muthuabi Annamalai, and Manisha Vidyavathy

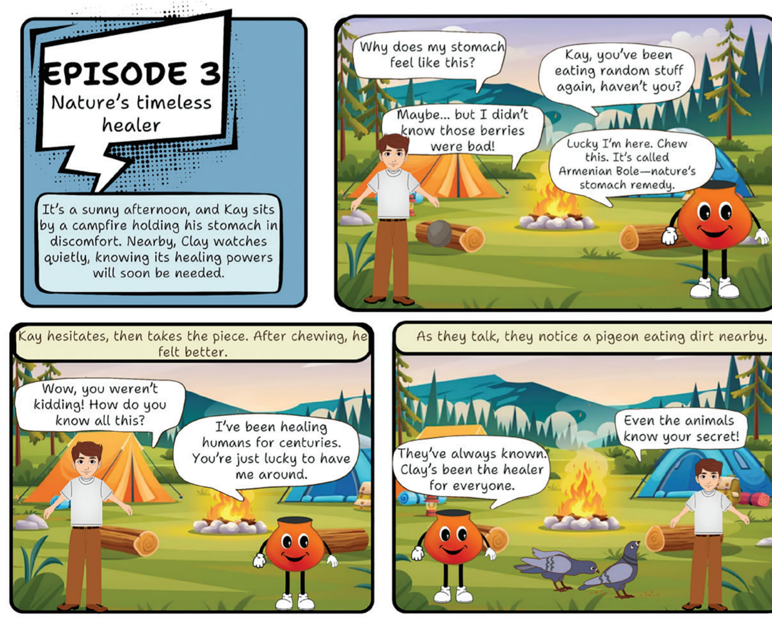
Ceramics is a fascinating yet intricate field, often unfamiliar to those outside materials science and engineering. But even for those in the materials world, ceramic engineering is commonly perceived as a field dominated by complex equations, phase diagrams, and intricate processing techniques.

What if ceramics could be made engaging, fun, and accessible? That is exactly what Potter's Fable aims to do—explaining ceramic concepts via comics!

Potter's Fable is an innovative outreach initiative in the Department of Ceramic Technology at Anna University (Chennai, India). This initiative, led by the editorial team of the Indian Ceramic Society's (InCerS) Student Chapter at Anna University, aims to bridge the gap between academic research and public understanding by using comic strips to simplify and illustrate complex ceramic concepts. Ideally, Potter's Fable will capture the attention of and inspire interest in ceramics among people who may not have any prior knowledge of the field.

Besides breaking down fundamental ceramic concepts, Potter's Fable traces the journey of ceramic technology from its historical roots to its modern applications in space exploration, healthcare, and electronics. By highlighting the evolution of ceramic materials, the series showcases how this field continues to shape technological advancements.

The development of each comic is a collaborative effort between students and faculty. Once a relevant topic is selected, it is translated into an engaging visual narrative, ensuring that even those with no technical background can grasp its core ideas.



Credit: Manisha Vidyavathy

The InCerS Student Chapter editorial team responsible for Potter's Fable. From left: Manivasakam Munusami, Karthick Arunachalam, Manisha Vidyavathy, Srividhya Rajagopalan Vasumathi, and Muthuabi Annamalai.

The first edition of Potter's Fable, which was launched internally at Anna University on Oct. 23, 2024, explored traditional ceramics and its fundamental principles. Encouraged by the success of the first edition, the team is now working on an expanded series featuring advanced ceramic topics, including electronic ceramics, bioceramics, ultrahigh-temperature ceramics, ceramics in the automobile sector, and more. Furthermore, the team is working to copyright Potter's Fable, after which it will be made available to the public.

Through Potter's Fable, we aim to spark curiosity, educate young minds, and highlight the incredible impact of ceramics—from ancient civilizations to futuristic technologies. By blending storytelling with science, we hope to inspire the next generation of engineers, researchers, and enthusiasts.

About the authors

Srividhya Rajagopalan Vasumathi, Karthick Arunachalam, Manivasakam Munusami, and Muthuabi Annamalaiare are undergraduate students in ceramic technology, and Manisha Vidyavathy is professor and head of the Department of Ceramic Technology at Anna University (Chennai, India). Contact Vidyavathy at mvidyavathy40@gmail.com. ■

Launching toward greatness with the ACerS Mentor Program

By Helen Widman

Mentee Sara Dockins, right, met her mentor Todd Steyer for the first time in person at MS&T24 in Pittsburgh, Pa.

One phrase that Sara Dockins strives to live by is "networking is just one letter away from not working." This mindset may be how Dockins, a young professional and recent Clemson University graduate, managed to cultivate a lasting connection with a mentor who lives across the country.

Dockins's mentor, Todd Steyer, works as the chief engineer for materials and manufacturing R&D at the Boeing Company in California and has been a part of The American Ceramic Society (ACerS) since he was a student himself.

Throughout the past two years, Dockins and Steyer have embarked on a mentorship journey together through the ACerS Mentor Program. The program offers a variety of match options, including student, faculty, industry, and most recently, conference mentor pairings, which helps tailor the experience to different career pathways.

"What attracts me to participate in the mentoring program is just giving back to my home organization, having been a member of ACerS now since graduate school," Steyer says. "There's so many life decisions that are happening there [in school], so having an opportunity to mentor and partner with others who are going through that is really exciting."

Dockins and Steyer first matched through the ACerS Student Mentor Program when Dockins was finishing up her junior year at Clemson studying materials science and engineering with a minor in chemistry. After discovering their mutual interest in ceramics and aerospace applications, they decided to continue their professional relationship through the program for another year.

"It was really cool to have a mentor for that long because we've kind of grown together and we know how each other thinks when it comes to professional styles and things like that," Dockins says. "It's very neat and helpful to have that connection with someone."

While the duo has chatted over video calls for most of their professional relationship—delving into a variety of professional and technical topics—they finally received the chance to meet in person at MS&T24 in Pittsburgh, Pa. For Dockins, meeting Steyer at the ACerS Mentor Program mixer was a highlight of the conference.

> "You can learn a lot in a classroom, you can learn a lot through paper and pencil—but it's the life experiences that you can't necessarily learn unless you either do them or someone has done them, and they're sharing them with you."
>
> – SARA DOCKINS

"It was just a really cool, full-circle moment because I'd been meeting [Steyer] screen to screen for two years and it was like, I know he's a real person, but it's a whole other thing to see someone face to face," Dockins says. "Having those conversations, it was like I was meeting up with an old friend even though I'd never technically met him in person before."

Steyer's favorite piece of advice to give to mentees such as Dockins is that mentorship is about what they want to get out of it.

"It's okay to have something you want from mentoring and to be able to structure what you want to get out of that time together," Steyer says. "You're really partnering for the future you."

Steyer also believes in the importance of building hobbies and interests into mentoring relationships to learn about what each other is passionate about and how that can take shape in career paths.

Dockins' goal is to use her degree in a future career that involves the aerospace industry. With Steyer working in the aerospace industry and Dockins having served as president of the Clemson Rocket Engineering Team last year, the match has left a positive impact on both mentor and mentee.

She also finds that having a mentor to lean on and learn from makes all the difference, especially as a student transitioning into a full-time career.

"You can learn a lot in a classroom, you can learn a lot through paper and pencil—but it's the life experiences that you can't necessarily learn unless you either do them or someone has done them, and they're sharing them with you," she says.

The ACerS Mentor Program accepts applications for both mentors and mentees starting in October each year. Learn more about the different facets of the program and get involved at https://ceramics.org/mentorship. ■

Jonathon Foreman
ACerS journals managing editor

Environmentally friendly production and usage of ceramics

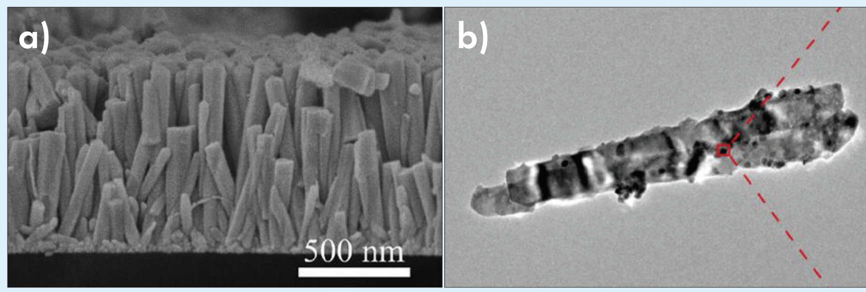
Ceramic materials have been used to construct buildings for millennia. In recent years, though, manufacturers have become increasingly interested in finding ways to produce and use these traditional materials more sustainably.

Efforts to reduce environmental impact during construction include reducing energy consumption, substituting low-carbon and recycled materials for carbonaceous minerals, and using local resources to minimize transportation costs and energy use. This last approach is exemplified in the article "Effect of treated palm fibers on the mechanical properties of compressed earth bricks stabilized by alkali activated binder-based natural pozzolan."[1] Kamwa et al. produced geopolymer construction bricks using local clay soil, volcanic ash, and water glass with an alkaline activator both with and without palm fibers. They found the fibers did not affect the curing of the geopolymer, and adding the fiber content increased the compressive strength up to 0.4% fiber by weight.

In the article "Research on the performance and strengthening mechanism of composite-enhanced recycled aggregate concrete," Liang et al. explored ways to improve the performance of concrete by using aggregate obtained from construction waste.[2] Typically, recycled aggregate contains cracks and pores that weaken the new concrete. So, the authors investigated using water glass along with cement silica and organic silica as surface treatments to strengthen the interfaces between the recycled aggregate and new concrete.

They report that both approaches improved strength compared to the concrete fabricated from untreated recycled aggregate. They attributed the improvements to a hydrated calcium silicate gel filling the gaps in the interfacial zone between the aggregate and the new mortar, improving adhesion.

Functionalized building materials can also actively reduce pollution. In the Editor's Choice article "Enhanced environmental purification with novel Pd/ZnO nanorod-decorated building materials through piezo-photocatalytic synergistic effect,"[3] Tian et al. grow zinc oxide nanorods on glazed ceramic tiles using hydrothermal methods. Palladium is subsequently deposited via photoreduction of palladium chloride (Figure 1). The coated tiles effectively reduced the concentration of organic dye when stressed by ultrasonic and simulated solar energies.



Credit: Tian et al., JACerS

Figure 1. a) Zinc oxide nanorods grown on glazed tile and b) enlarged nanorod decorated with palladium.

Özdemir et al. sought similar catalytic activity, albeit with common construction materials and industrial waste products. As indicated by the article title "Red mud incorporated clay roof tiles as visible light-active photocatalysis for building applications,"[4] the authors explored the effects of using the waste stream from aluminum production, called red mud, on the physical and catalytic properties of clay roof tiles.

The authors identified three mechanisms behind the degradation of organic dyes under light excitation: photolysis, adsorption, and photocatalytic activity. The first is inherent photodegradation of the dye solution without any additional material (in this case, the tiles). The second indicates physical removal of the dye through adherence to the tile. The third is enhanced photodegradation resulting from chemical interactions with the tiles.

The authors attribute the latter phenomenon to photoinduced redox reactions with Fe^{2+}/Fe^{3+}. While the clay contains iron, iron and other similarly catalytic metals are present in the red mud at higher concentrations.

These are but a few of the many research paths being explored for enhancing environmental sustainability in the production and usage of ceramics. Other interesting areas reported in The American Ceramic Society journals include engineering porosity for reduced weight, filtration, and improved insulating properties; creating "self-heating" electrothermal geopolymer cements; and enabling carbon-free energy production. Members have free access to the wealth of information available through https://ceramics.onlinelibrary.wiley.com.

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Join us in San Diego for the combined 12th International Conference on High Temperature Ceramic Matrix Composites and 3rd Global Forum on Advanced Materials and Technologies for Sustainable Development.

calendar

Calendar of events

June 2025

9–11 ACerS Structural Clay Products Division & Southwest Section Meeting in conjunction with the National Brick Research Center Meeting – Birmingham, Ala.; https://ceramics.org/clay2025

11–13 15th Advances in Cement-Based Materials – Boulder, Colo.; https://ceramics.org/cements2025

11–27 ★ Foundations of Ceramic Processing – Virtual; https://ceramics.org/course/carty-ceramic-processing

23–26 ★ Summer 2025 Hypersonic Workshop – Virtual; https://ceramics.org/course/summer-virtual-hypersonic-workshop

July 2025

8–11 ➠ The 8th International Conference on the Characterization and Control of Interfaces for High Quality Advanced Materials – Highland Resort Hotel & Spa, Fujiyoshida, Japan; https://ceramics.ynu.ac.jp/iccci2025/index.html

16–18 ★ Properties and Testing of Refractories – Westerville, Ohio; https://ceramics.org/course/homeny-properties-and-testing-refractories

August 2025

21 ★ Ultrahigh-Temperature Ceramics for Hypersonic Applications — Livermore, Calif; https://ceramics.org/course/mccormack-opila-uhtc-hypersonic-applications

September 2025

16–Dec. 4 ★ Refractory Manufacturing – Virtual; https://ceramics.org/course/homeny-refractory-manufacturing

17–18 ★ Tools for Visualizing and Understanding the Structure of Crystalline Ceramics – Virtual; https://ceramics.org/course/sparks-crystalline-ceramics

28–Oct. 1 ACerS 127th Annual Meeting with Materials Science and Technology 2025 – Greater Columbus Convention Center, Columbus, Ohio; https://www.matscitech.org/MST25

October 2025

5–9 ➠ International Symposium on Green Processing of Advanced Ceramics (IGPAC 2025) – Ise-Shima/Mie, Japan; https://igpac2025.com

27–30 ➠ Unified International Technical Conference on Refractories – JW Marriott Cancún Resort & Spa, Cancún, Mexico; https://unitecr2025.com

29 ★ Hypersonic Workshop – Washington, D.C.; https://ceramics.org/course/hypersonic-workshop-dc

November 2025

30–Dec. 3 ➠ The 14th International Conference on High-Performance Ceramics — Haikou, China; https://cicc14.ceramsoc.com

January 2026

25–30 Golden Jubilee Celebration of the 50th International Conference and Expo on Advanced Ceramics and Composites (ICACC 2026) – Hilton Daytona Beach Oceanfront Resort, Daytona, Fla.; https://ceramics.org/icacc2026

March 2026

24–26 ➠ ceramitec 2026 – Trade Fair Center Messe, München, Germany; https://ceramics.org/event/ceramitec-2026

April 2026

12–16 ACerS Spring Meeting — Bellevue, Wash.; http://ceramics.org/acersspring

May 2026

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

June 2026

7–12 ➠ Solid State Studies in Ceramic Science Gordon Research Conference – South Hadley, Mass.; https://www.grc.org/solid-state-studies-in-ceramics-conference/2026

15–25 ➠ CIMTEC 2026 – Perugia, Italy; https://ceramics.org/event/cimtec-2026

August 2026

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

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

Entries in **BLUE** denote ACerS events.

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

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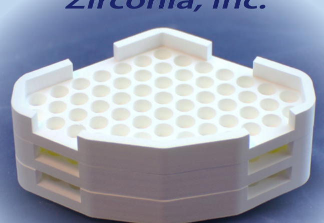

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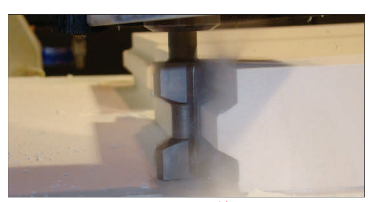

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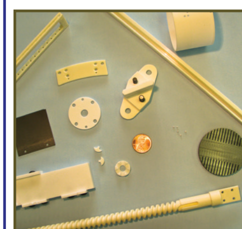

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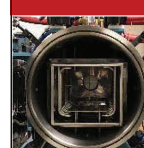

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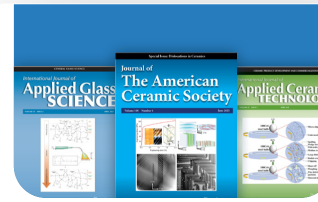

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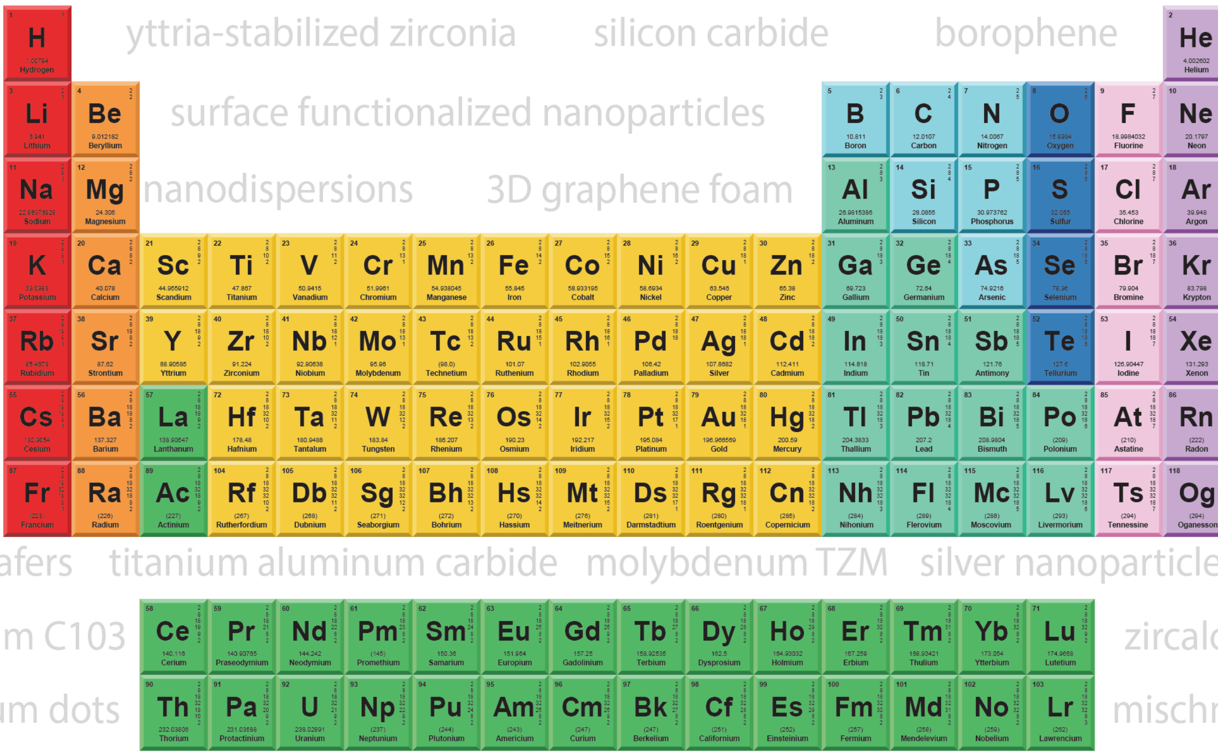

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