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Read more at <https://ceramics.org/wind-turbine-reuses>

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By A. Rathnam, L. Grant, and S. T. Smith

International Journal of Applied Ceramic Technology

Impact testing of screen protectors for mobile devices

By A. Donatini, P. Georges, T. Fevre, et al.

International Journal of Applied Glass Science

Redox behavior of tin in aluminosilicate melts: Implications for the fining process

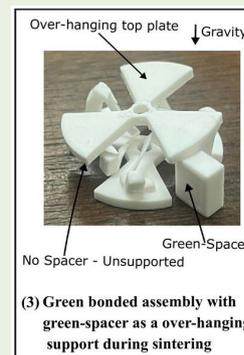
By S. M. Becerra, H. Özbayraktar, E. Kilinc, and J. C. Mauro

International Journal of Ceramic Science & Engineering

Stuck on glass: A review of polymer and polymer nanoparticle composite coatings in glass technology

By A. M. Schade, Y. Li, S. Louring, et al.

International Journal of Applied Glass Science



Credit: Rathnam et al., ACT



Read more at <https://ceramics.org/journals>

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ACSB A7, Vol. 105, No. 3, pp. 1–52. All feature articles are covered in Current Contents.

Solid-state batteries turn heads at CES 2026

The groundwork for solid-state batteries has been laid for decades, but the incentive to act on that potential really only picked up in the past 15 years. Now, this much-anticipated technology is on the cusp of its market revolution, as demonstrated during this year's CES.

CES is one of the largest annual consumer technology trade shows. CES 2026 took place January 6–9 and welcomed more than 148,000 attendees and more than 4,100 exhibitors. During the four-day event, several companies presented solid-state battery technologies for various applications.

Ultraslim mobile charging through SolidSafe Air

Solid-state batteries have the potential to be smaller than traditional lithium-ion batteries because their solid electrolyte doubles as the separator, which helps eliminate bulky components. At CES 2026, Better Mobile Xperience (BMX) demonstrated this potential with its new SolidSafe Air power banks.

BMX is a mobile accessory brand launched by the original founders of Hyper, the popular accessories brand for Apple devices. Its SolidSafe power banks make use of a semi-solid-state electrolyte to charge mobile phones. Compared to other power banks in the SolidSafe series, the Air model is the slimmest, with the 5,000 mAh version measuring just 6.8 mm thick.

The SolidSafe Air power banks are expected to be available for shipping from the BMX website by the second quarter of 2026.

Superfluidized solid-state battery breakthrough marks ProLogium's 20th anniversary

ProLogium Technology is a Taiwan-based energy innovation company focused on lithium ceramic battery research, development, and manufacturing. Ahead of CES 2026, the company announced it would unveil its new "Superfluidized All-Inorganic Solid-State Lithium Ceramic Battery" technology at the show as part of its 20th anniversary celebrations.



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The company also said it would be working with Germany's FEV Group and Taiwan's Darfon Energy Tech to use the new battery in electric bicycles and light vehicles, projects which "reflect our collaboration with leading customers to bring safer, higher-energy, and more environmentally adaptive technologies into mass production and real-world deployment," says Vincent Yang, founder and CEO of ProLogium, in the announcement.

Fast-charging electric motorcycle sparks excitement —but also skepticism

Electric vehicles are one of the most highly anticipated uses of solid-state batteries to enhance safety and range compared to current EVs. Estonian startup Donut Lab presented a solid-state-battery-powered electric motorcycle from its partner firm Verge at CES 2026, but the supposedly revolutionary product soon met with skepticism online.

Donut Lab's website claims that the solid-state battery can charge in five minutes, reach densities close to 400 Wh/kg, and successfully undergo 100,000 charge cycles. But these

characteristics go "directly against many of the known trade-offs between stability, degradation, and safety," notes a *Medium* article. Furthermore, the company offers "little information about manufacturing processes, no independent validations, and marketing-oriented communication," the article states.

Ultimately, "the Donut Lab case is an excellent reminder that deep innovation always lives in an awkward zone between disbelief and hope," the *Medium* article concludes. "Today we are not facing conclusive proof that solid batteries have arrived, but neither is this necessarily smoke and mirrors. This is an extraordinary statement that requires extraordinary evidence. And that evidence, if it exists, will soon be available."

Even though the electric motorcycle application is under scrutiny, some companies at CES 2026 announced plans to use Donut Lab's solid-state battery technology for other purposes. For example, ESOX Group confirmed it is working under a defense-specific licensing framework to deploy the technology across military and security applications, such as drones and unmanned ground vehicles. ■

A 'fitting' tribute to good science: Former PCSA chair creates first maternity lab coat

Over the past hundred years, white lab coats have grown into an iconic symbol of scientists and doctors working in professional research and medical settings. Yet even as our view of scientists has become more diverse, the design of lab coats remains trapped in a bygone fashion era that caters to very few body types.

"An average unisex lab coat has a cylindrical profile. ... Curvier women have to fit that cylinder to the widest part of their body, [which] leaves the rest of their body swimming in fabric," explains an article by small business Genius Lab Gear.

Furthermore, typical lab coats have three pockets, which are not enough for "scientists constantly moving around and working with many small tools and samples," the article says. In addition, "many common lab coat designs leave exposed skin in the most vulnerable areas."

As a result of these design choices, "96% of women and 87% of men had a problem with the fit of their lab coat around their body, while 93% of women and 89% of men had at least one complaint with the way their sleeves fit," the article concludes.

These design issues and statistics come from an informal survey that Genius Lab Gear founder Derek Miller conducted in 2022. The survey, which asked approximately 1,500 scientists what they love and hate about their lab coats, was born out of Miller's frustrations with his own lab coat.

Miller is a former scientist who served as chair of ACerS President's Council of Student Advisors in 2013. During his time working in both academic and industrial materials labs,



Genius Lab Gear founder Derek Miller in his booth at The Advanced Materials Show at MS&T25. Miller and his team created a line of lab coats designed to fit a wider variety of body types.

he experienced firsthand the challenges of an ill-fitting lab coat, which include wide sleeves that knock over glassware and a low collar that does not protect well against spills.

Miller founded Genius Lab Gear in 2018 to create products that "help make lab work easier," according to an interview he did on the *Beyond Your Science* podcast.

"One of my first products was the Pocket Scientist and its variations," he says, which are laser-cut stainless steel rulers engraved with additional science information, such as fundamental equations and the periodic table.

Following the informal survey about lab coats in 2022, Miller and his teammates started developing a line of lab coats that work well for more body types. In 2023, they launched lines of white and black lab coats for men and women called the Louis and the Curie, respectively, named after famous scientists Louis Pasteur and Marie Curie.

The Louis coats have more room in the shoulders, while the Curie coats flare more at the hips. Both feature a plethora of pockets and loops, and they also have an internal waist belt, knit cuffs, a back pleat, and a collar that can be worn both down as well as buttoned all the way up to the neckline.

Miller left the semiconductor field in 2024 to pursue Genius Lab Gear full time. This commitment allowed him and his teammates to develop the next generation of inclusive lab coats: the Alma Maternity for pregnant and nursing parents.

As explained in a Genius Lab Gear article about the latest lab coat line, numerous respondents in the original informal survey mentioned the total unavailability of a maternity lab coat. So, Miller launched another survey to specifically address maternity lab coats, and the new design was based on those 170 responses.

The Alma coat features several distinct elements compared to the existing Louis and Curie lines:

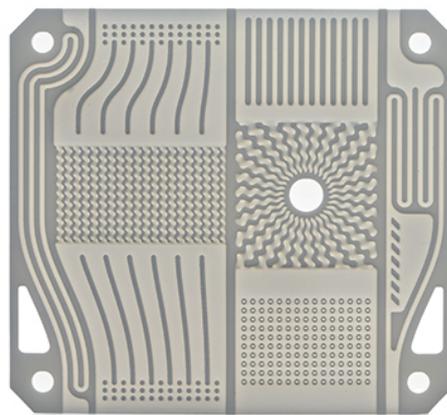
- **No pockets on the chest.** Respondents said that standard chest pockets became difficult to use for pens and utensils due to extra tightness and sensitivity. The Alma coat features extra stitches and loops on its sides to make up for the removal of chest pockets.
- **Two panel design with extra pleats.** Like other maternity clothes, the Alma coat has a two-panel construction with pleats on the front, which allows the coat to expand during the later stages of pregnancy.

The name Alma was decided by popular vote and refers to Alma Levant Hayden, the first Black woman scientist to gain a scientist position at a science agency in Washington, D.C. (she joined the National Institutes of Health in the 1950s). The word “alma” also means “nourishing” or “nurturing” in Latin, which adds another layer to the aptness of this name for a maternity lab coat, as noted in the Genius Lab Gear article.

The Alma Maternity coat became available to purchase online in November 2025 and can be found at <https://geniuslabgear.com/products/maternity-lab-coat-womens-white-cotton-scrub>.

In an Instagram post, Miller says that the team hopes this coat “will help expecting parents continue their research with less frustration and discomfort if it’s safe to do so and they choose to do so.” ■

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The insidious nature of microplastics: Glass bottle caps are an unexpected contaminant source

Among the various container materials, glass is considered one of the best thanks to its durable, nonporous nature and high scores on sustainability assessments. Its downsides generally have more to do with broken recycling systems than the glass itself.

While efforts are being made to improve glass recycling rates, an open-access study published last summer revealed another ancillary factor that impacts the sustainability of glass bottles. Fortunately, unlike recycling systems, this challenge has a straightforward solution.

In August 2025, researchers at the French Agency for Food, Environmental, and Occupational Health & Safety (ANSES) investigated the different levels of microplastic contamination in various beverages sold in France. Surprisingly, they found that beverages stored in glass bottles demonstrated higher levels of contamination than those stored in plastic bottles or aluminum cans.

The reason for this disparity is the caps used to seal glass bottles. As explained in the paper, the researchers confirmed that the microplastics found in glass bottles had the same color and composition as the paint on the caps, and this finding was

supported by tiny scratches on the caps that likely were caused by friction during the sealing process.

Following this finding, the researchers tested the effects of different cleaning processes on the level of microplastic contamination in glass bottles. They either placed caps on the bottles without any treatment, blew on the caps with an air bomb, or blew and rinsed the caps with filtered water and alcohol. The result? While an average of 287 particles per liter were found in bottles sealed with uncleaned caps, this number decreased to 106 particles per liter after blowing and to 87 particles per liter after blowing and rinsing.

In an ANSES press release, the researchers note that in addition to cleaning the caps, manufacturers could explore alternative storing and sealing processes to reduce friction when placing the caps or modify the caps' paint composition. In any case, this contamination source is one "manufacturers can easily take measures to address," the press release states.

The open-access paper, published in *Journal of Food Composition and Analysis*, is "Microplastic contaminations in a set of beverages sold in France" (DOI: 10.1016/j.jfca.2025.107719). ■

Corporate Partner news

McDanel Advanced Materials and Richland Glass announce strategic merger

Two Artemis portfolio companies, McDanel Advanced Materials and Richland Glass, announced a strategic merger that will bring customers a more expansive portfolio of advanced ceramics, optical technologies, and glass solutions. Both companies will continue to operate with the same teams and facilities. Read more: <https://bit.ly/4aMJ176>

Sauereisen Inc. achieves Build America, Buy America Act certification

Pennsylvania-based Sauereisen, provider of protective linings, coatings, and ceramic compounds for industrial uses, announced that their products now meet the Build America, Buy America Act (BABA) requirements. BABA certifies that Sauereisen products are manufactured in the United States, all materials meet domestic requirements, and they support the growth of U.S. industry.

Read more: <https://www.sauereisen.com/blog>

Starlab welcomes Mitsubishi as major space station customer

The Mitsubishi Corporation, a current investor in Starlab Space LLC, reserved and pre-purchased capacity on Starlab's commercial space station. Representative Issei Shinohara also joins Starlab's Board of Directors, solidifying Mitsubishi as both a customer and investor. Starlab Space LLC is a U.S.-led, global joint venture that aims to develop an artificial intelligence-enabled commercial space station and continue microgravity science and research after the retirement of the International Space Station.

Read more: <https://starlab-space.com/news>

Swindell Dressler contributes reactor technology to Terra CO2's low-carbon SCM plant

Swindell Dressler International Company contributed its first-ever custom design and built reactor technology to Texas-based Terra CO2's first commercial-scale plant. The plant is expected to produce 240,000 tons per year of Terra's OPUS supplementary cementitious low-carbon feedstock material, which enables cement production with up to 70% reduced CO₂ emissions compared to conventional Portland cement. Read more: <https://www.linkedin.com/company/swindell-dressler-international-company> ■



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Ceramics markets: A BCC Research Outlook

The global market for ceramics was valued at \$38.5 billion in 2024 and is expected to grow at a compound annual growth rate (CAGR) of 8.6% to reach \$62.5 billion by the end of 2030.

Ceramic materials are inorganic, non-metallic, crystalline substances formed by shaping and sintering natural or synthetic compounds at elevated temperatures. They offer a unique combination of properties found in both metals and polymers, and recent innovations have significantly minimized their natural brittleness.

Ceramics are being increasingly utilized in advanced applications, leading to the expansion of specialized segments (Table 1):

- **Bioceramics** are witnessing strong demand due to the rising need for orthopedic and dental implants. These ceramics, including alumina, zirconia, and calcium phosphates, exhibit biocompatibility, making them ideal for medical applications.
- **Electroceramics** play crucial roles in modern electronics, enabling applications in capacitors, piezoelectric devices, sensors, and semiconductors. The growing demand for consumer electronics, 5G infrastructure, and electric vehicles is driving the market for electroceramics, which includes barium titanate and lead zirconate titanate.
- **Polymer-derived ceramics** represent a cutting-edge class of materials synthesized from preceramic polymers through pyrolysis. These ceramics demonstrate superior high-temperature stability and oxidation resistance due to their unique nanostructure, making them useful in aerospace, coatings, and energy applications.

Type	2024	2025	2030	CAGR % (2025–2030)
Technical ceramics	17,125.21	18,272.59	26,001.06	7.3
Electroceramics	11,335.02	12,049.13	17,136.61	7.3
Bioceramics	7,609.73	8,142.41	12,107.44	8.3
Polymer-derived ceramics	906.97	999.49	1,723.91	11.5
3D-printed ceramics	866.75	1,059.17	3,616.49	27.8
Transparent ceramics	680.23	782.95	1,907.04	19.5
Total*	38,523.91	41,305.74	62,492.55	8.6

*Totals in this report's tables and figures may not match due to rounding.

- **3D-printed ceramics** are revolutionizing manufacturing by enabling complex geometries, reduced material waste, and customized designs. This segment is witnessing rapid growth, particularly in medical, aerospace, and electronics industries.
- **Technical ceramics**, also known as “engineered ceramics,” are gaining popularity in high-performance applications, including aerospace, defense, and industrial processing. These ceramics offer superior hardness, thermal resistance, and chemical stability, making them essential in extreme environments.
- **Transparent ceramics**, such as aluminum oxynitride and magnesium aluminate spinel, are gaining attention in defense, optics, and high-energy laser applications. These materials offer superior mechanical properties compared to traditional glasses and polymers, making them ideal for bulletproof windows.

The ceramics industry is characterized by intense competition, driven by continuous innovation and materials diversification. Global players, including Kyocera, CoorsTek, CeramTec, 3M, Morgan Advanced Materials, and

CUMI, are well-established and compete across multiple segments. Emerging segments, such as 3D-printed ceramics and polymer-derived ceramics, have attracted startups and niche technology firms such as Lithoz, 3DCeram, and Admatec, intensifying competition and innovation.

In 2024, the Asia-Pacific region led production and application for most ceramics due to its strong electronics, automotive, and healthcare sectors. Across all regions, sustainability and innovation in processing methods are becoming central to ceramic development.

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 utkantha.srivastava@bccresearch.com.

Resource

BCC Publishing Staff, “Ceramics markets: A BCC Research Outlook,” BCC Research Report AVM189B, July 2025. <https://bit.ly/July-2025-ceramics-markets> ■

Financing the responsible supply of energy transition minerals for sustainable development

As the world transitions to sustainable development and the achievement of net-zero emissions by 2050, the demand for specific minerals and metals, such as lithium, nickel, and copper, is surging. These minerals are crucial for the development of batteries, solar panels, and electric vehicles, and therefore are central to clean energy technologies and to enabling the energy transition.

However, the intensifying demand for energy transition minerals poses significant challenges for the environment and the local communities where mining occurs. Without transformative changes to mining practices, this demand could amplify the negative consequences historically associated with extractive industries.

In its most recent report, “Financing the responsible supply of energy transition minerals for sustainable development,” the International Resource Panel (IRP) underscores the finance sector’s pivotal role in fostering responsible mining.

In general, different sources of finance are required for each stage of a mining project. For example, geological surveys mainly require public financing; exploration mainly involves equity finance of small companies; mine construction is likely to be financed by a mixture of retained profits, loans, and equity; and mine closure and remediation should be financed by ring-fenced funds accumulated during operation.

The complexities and long timescales associated with mineral production, and the large quantity of capital needed to construct a mine and start producing minerals, make mining a high-risk industry, which requires high returns if it is to attract private investors. In recent years, many financial companies have committed to sustainability and used “sustain-

able finance” as a means to encourage the uptake of responsible practices.

There is no one set definition of sustainable finance, but in general, the rationale behind sustainable finance lies in the perception that the actions taken by financial actors can improve the performance of the companies in which they invest while generating benefits for the planet and society, as well as private returns to investors. The recent IRP report considers sustainable investing to be the use of one or more strategies out of the following:

- 1. Exclusionary screening:** The portfolio composition excludes pre-determined sectors as they are not compliant with environmental, social, and governance (ESG) paradigms.
- 2. Best-in-class screening:** The portfolio composition includes investments in ESG-compliant sectors and projects.
- 3. Norms-based principles:** Investments are screened against a set of norms that follow a set of standards or recognized best practices.
- 4. ESG assessment integration:** Investment managers include ESG indicators, metrics, and considerations in their financial analyses and assessments. Reporting and transparency practices also support ESG integration.
- 5. Sustainability-oriented investments:** Investments targeting sustainability (e.g., green and clean technologies, sustainable practices).
- 6. Impact investing:** Investments target specific ESG problems, and communities may be involved. Capital is provided to businesses and projects that can prove a clear and tangible ESG purpose.

7. Corporate and shareholder action:

The use of shareholder influence on corporate decisions and actions (namely, active ownership).

Addressing ESG issues is likely to involve extra costs for companies, and clarification of these cost issues is urgent. Calls for mining to implement a step change in respect of responsibility or sustainability are unlikely to be perceived as realistic if financial markets do not reward such practices. Governments may need to mandate differentiation of those products produced to high standards, through certification and incentive schemes, if they wish mining to be conducted responsibly.

The IRP report includes specific recommendations to ensure that the production of metals and minerals contributes to sustainable development: improved transparency and local engagement, incentivization for higher mineral recovery and recycling rates, improved management of mineral markets, reformed financial systems, and possibly the establishment of international institutions and frameworks.

By combining sustainable finance with responsible mining, the mining sector can contribute positively to local communities, host countries, and the global transition to low-carbon technologies.

About the author

Hosted by the United Nations Environment Programme, the International Resource Panel brings together scientists, governments, private sector, and civil society from across the world to inform decision-making and support just, sustainable, efficient, and circular development pathways. Learn more at www.resourcepanel.org. ■

*This article is excerpted from the International Resource Panel report “Financing the responsible supply of energy transition minerals for sustainable development” (October 2025). Read the full report at <https://wedocs.unep.org/handle/20.500.11822/47718>.

The evolving discipline of demand forecasting can improve competitiveness and control costs

What does the future hold? It is a question that everyone has contemplated at one time or another, and a mystery that has obsessed writers, mystics, philosophers, clerics, astrologers, and others for centuries.

For businesses, the question is more than philosophical. Discovering clues to what is next is essential to staying competitive, profitable, and responsive to the needs of the marketplace. Retailers that can anticipate consumer trends will stay a step ahead of competitors who just follow the crowd. For manufacturers, forecasting the future is critical for planning production schedules, ordering supplies, and controlling costs.

The ceramic and glass industry is one sector where both short- and long-term demand forecasting are necessary, as it is energy intensive and reliant on expensive capital equipment. That makes accurate forecasting essential to balancing the long production lead times in the industry with shifting demand from customers in construction, automotive, packaging, and other sectors.

Accurate forecasting involves planning for both demand and supply. Demand planning focuses on using data and expert insights to assess what customers will want. As an example, segments of the ceramic industry are responding to forecasts of strong growth in semiconductors manufactured with silicon carbide due to that material's improved efficiency and resistance to high temperatures when compared to silicon, the material traditionally used in semiconductors.¹

Supply planning is focused on the resources, materials, and costs to meet demand. In recent years, for example, forecasts for the global demand for electricity have predicted surging growth after years of stable supply, a trend that is causing increased costs and potential supply constraints (Figure 1).²

Managing the usage and cost of energy is a major function of demand forecasting in the ceramic and glass industries, as energy accounts for a large share of production costs.

Because energy contracts can be negotiated in advance, it makes good forecasting a potential cost saver. Forecasting also informs manufacturers when to build or rebuild furnaces, when to invest in automation, and when to add new production lines.

A forecasted double-digit growth in the demand for pharmaceuticals for weight loss and diabetes drove the decision of Mainz, Germany-based Schott to expand its manufacturing capabilities in India with the addition of syringe and cartridge glass tubing. With the investment, which was announced in August 2025, "We're ensuring a stable and consistent supply chain for critical drug delivery systems," said Pawan Kumar Shukla, president and managing director of Schott Glass India, in a news release.³

The industry overall is closely linked to the trends in commercial and residential construction, says Margarette Gagliardi in an email interview. Gagliardi is owner of AMG NewTech, a Charlottesville, Va.-based firm focusing on custom market research, technical studies, and consulting in advanced materials and emerging technologies. She has authored several market reports for the *Bulletin*, most recently the cover story on the nonferrous metals market for the March 2026 issue.

More than 60% of the ceramic industry's value comes from products such as tiles, bricks, and windows used in construction. Thus, "any factors affecting construction activity have a major impact



Credit: Andrey Metyev, Unsplash

Figure 1. Globally, energy demand is projected to grow 11–18% by 2050, according to McKinsey & Co.'s Global Energy Perspective 2024. Understanding the factors driving this trend is necessary to accurately manage the usage and cost of energy.

on both short- and long-term demand forecasts," Gagliardi says. These factors can include economic downturns, delays in permitting, problems with financing, weather, natural disasters, and changes in consumer preferences. Though some of these factors are difficult or even impossible to anticipate, others can be monitored closely.

Demand forecasting has advanced over time as has technology. The advent of enterprise resource planning systems in the 1980s was a big leap forward, as those systems enabled data from across business enterprises to be centralized, improving the quality of data used to make short- and long-term decisions.

Today, artificial intelligence and machine learning are advancing the next generation of accurate and nuanced demand predictions.⁴ These technologies enable the analysis of complex patterns in massive sets of data. They also have the potential to allow businesses to react more quickly to market changes, reducing the time between data collection and decision making.

These technologies are rapidly being adopted by executives. The IBM Institute for Business Value, in partnership with Oxford Economics, surveyed more than 2,000 global chief supply chain officers, operations executives, and automation executives. Its report, published in November 2024, stated that 90% of those surveyed said their organization's supply chain workflows will incorporate intelligent automation and AI assistants by 2026, and 64% of chief supply chain officers said generative AI is "completely transforming" their workflows.⁵

But AI is not necessarily a panacea for faster, more reliable forecasting, cautions Gagliardi, as their outputs require critical assessment.

"Human insight, industry experience, and contextual understanding are essential to validate projections and ensure forecasts truly reflect real-world conditions," Gagliardi says.

Data overload can be a problem as can incomplete or inaccurate data. Some manufacturing sectors are also cyclical and can be affected by significant one-off events, such as the COVID-19 pandemic or the imposition of trade tariffs. These situations are where the human factor continues to play a central role.

"The real issue is not the amount of data but the quality of it," Gagliardi says. "Forecasting is not only about using past and present data to predict the future, it is also about understanding the underlying factors driving trends. This [aspect] is where human experience and judgment play a critical role."

The field of demand forecasting is sure to evolve steadily, driven by advancements in AI and the dynamics of competition. In an article published by the Institute for Supply Management, Gaurav Sharma, a business analyst for Santa Clara, Calif.-based Applied Materials, outlined the trends likely to shape the future of demand forecasting⁴:

- Increased integration of AI and machine learning.
- Real-time data analysis, allowing swift reactions to market changes.

- Predictive analytics using advanced algorithms to anticipate future trends and consumer behaviors.
- Customization and personalization, as demand forecasting becomes more granular and individualized.

He concludes with the recognition that the insights and experience of seasoned industry experts will remain vital, as a collaborative approach among businesses, suppliers, customers, and perhaps even competitors will create a better understanding of market dynamics.

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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⁴G. Sharma, "Optimizing demand forecasting: Challenges and best practices," Institute for Supply Management. Published 19 March 2024. <https://bit.ly/4kqv7CQ>

⁵"Instant insights fuel faster supply chain innovation," in *The CEO's Guide to Generative AI*. IBM Institute for Business Value. <https://bit.ly/3NP8k7z>

*All references verified as of Feb. 27, 2026. ■

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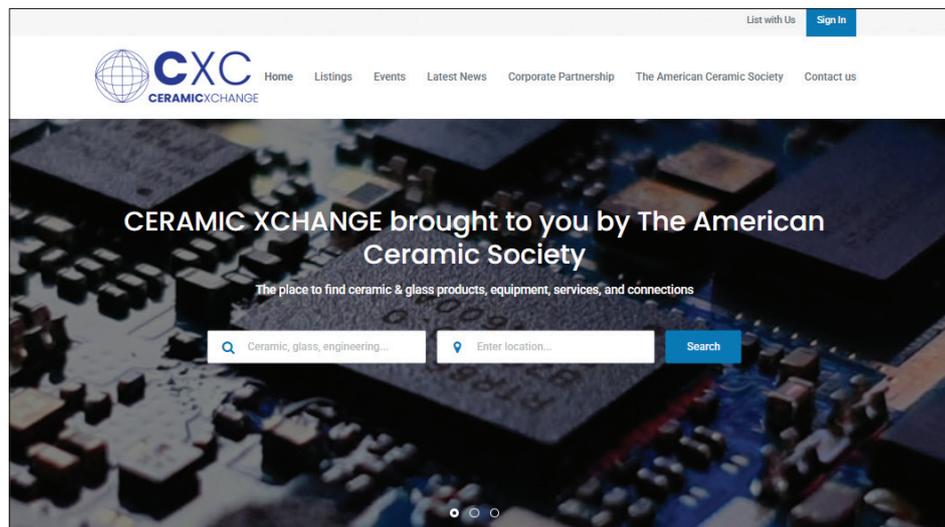
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SOCIETY DIVISION SECTION CHAPTER NEWS



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CERAMIC XCHANGE: Announcing ACerS' new online directory and technical resource



CERAMIC XCHANGE (CXC), brought to you by The American Ceramic Society, is the premier site for your technical ceramic and glass application needs. This new online directory and industry news source allows you to search through ACerS' curated community of Corporate Partners to find the tools and solutions for your day-to-day business needs.

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Contact Yolanda Natividad, ACerS associate director of membership and industry relations, at ynatividad@ceramics.org with your questions about CXC and the ACerS Corporate Partnership program. ■

ACerS GGRN is now the Graduate and Doctoral Student membership

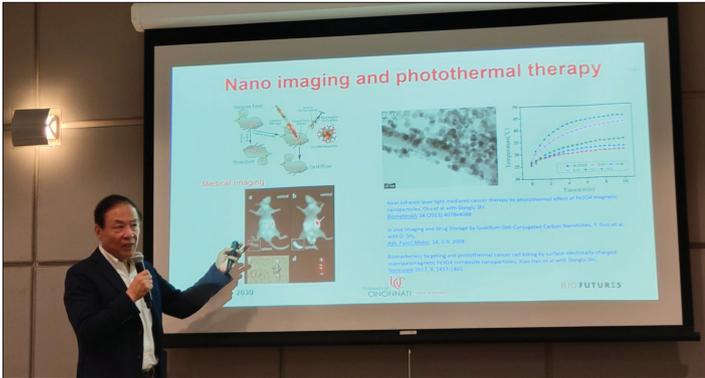
The ACerS Board approved a name change for the Global Graduate Researcher Network (GGRN) student membership to Graduate and Doctoral Student membership.

The goal of this change is to make it clear that ACerS student membership is open to all graduate and doctoral students, allowing them to economically join ACerS along with other ceramic and glass industry innovators. Please note that this change is simply a name modification; benefits and cost of this membership type remain the same.

Based upon the Board's approval, the ACerS Constitution as well as ACerS website and related managed sites have now been updated to replace all previous mentions of GGRN to Graduate and Doctoral Student membership.

We are excited to continue serving both graduate and doctoral students from around the world. For more information about Graduate and Doctoral Student membership, visit www.ceramics.org/gds. ■

ACerS Dayton/Cincinnati/Northern Kentucky Section holds local outreach activity



Donglu Shi speaks to attendee members about his research on nanoimaging and photothermal therapy.

An interdisciplinary research forum titled “Engineering better outcomes—A dialogue with the UC engineering community to build collaborations” was held on Jan. 15, 2026, at Cincinnati Children’s Hospital Medical Center (CCHMC). The event brought together faculty from engineering, science, and medicine to explore collaborative research opportunities at the interface of engineering and healthcare.

Engineering faculty presented recent advances in nanobiomedicine closely related to materials science, bioceramics, biomaterials, nanoparticles, medical devices, and nano-enabled diagnostic and therapeutic technologies. The forum highlighted the critical role of advanced materials in medical applications such as implants, drug and gene delivery, biosensing, and regenerative medicine.

The informal, discussion-driven format encouraged an open exchange of ideas and immediate feedback from basic and clinical researchers, helping identify new interdisciplinary research directions. These interactions are expected to catalyze future collaborations between engineering and medical faculty and to accelerate translational research.

This event demonstrated the strong relevance of bioceramics and advanced nanomaterials research to healthcare innovation, and it highlighted opportunities for researchers and students to engage with ACerS through membership, Divisions, and participation in Society-sponsored conferences and symposia.

The forum was organized by Mattia Quattrocchi and Paul Spearman of CCHMC. As part of local outreach activities, Donglu Shi of the University of Cincinnati assisted in identifying and coordinating university engineering faculty whose research aligns with clinical and translational interests at CCHMC. Shi serves as the outreach chair of the ACerS Dayton/Cincinnati/Northern Kentucky Chapter, facilitating connections between advanced materials researchers and biomedical and clinical collaborators. ■

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ACerS International Chapters come together for Chapter Happy Hour during ICACC 2026

Members of the ACerS International Italy, Germany, Japan, Israel, and United Kingdom Chapters co-hosted a happy hour at the Ocean Deck Restaurant during ICACC 2026 in Daytona Beach, Fla. ACerS Past President Monica Ferraris thanks Cristina Balagna from the Polytechnic University of Turin for her help and support in organizing the event. ■



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Hosted by: ACerS International Italy and Türkiye Chapters

Featured speakers: Vincenzo M. Sglavo and Ali Erçin Ersundu

EXPLORING THE MATERIALS SCIENCE ASPECTS OF TEA DRINKING DURING THE SONG DYNASTY (960–1279)

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Volunteer Spotlight: Carolina Tallon

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



Carolina Tallon is associate professor of materials science and engineering and a core member of the VT MADE Institute at Virginia Tech. She received her B.S. in chemical engineering from the University of Granada, Spain, and her Ph.D. in inorganic chemistry from the Institute of Ceramic and Glass and Universidad Autonoma de Madrid, Spain. She held several positions at the University of Melbourne, Australia, including postdoctoral researcher, lecturer, and academic convenor of the Hallmark Materials Research Initiative, before moving to Virginia.

Tallon's research focuses on the near net shaping and advanced manufacturing of ceramics for extreme environments, such as hypersonics, nuclear reactors, and high-temperature engines. Specifically, her group specializes in the processing of ultrahigh-temperature ceramics and the manipulation of their microstructure. She has twice co-chaired the international conference Ultrahigh-Temperature Ceramics: Materials for Extreme Environment Applications in 2015 and 2022.

Tallon joined ACerS in 2009 and is part of the Engineering Ceramics Division. She currently is chair of the Washington, D.C./Maryland/Virginia Section, and she has served on the John Jeppson Award Subcommittee (2021–2026) and the Kingery Award Subcommittee (2018–2021). Tallon has also been a scientific committee member of several symposiums at the International Conference and Expo in Advanced Ceramics and Composites, as well as served as a mentor in the ACerS Student Mentor Program. She received the 2020 Jubilee Global Diversity Award for her research contributions to the engineered ceramics field.

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

Names in the News

Members—Would you like to be included in the Bulletin's Names in the News? Please send a current head shot along with the link to the article to mmartin@ceramics.org.



Nitin Padture, FACerS, professor of engineering at Brown University, was named a recipient of the 2025 Humboldt Research Award by the Alexander von Humboldt Foundation in Germany. He will collaborate with his German host, Eva Unger at Helmholtz-Zentrum Berlin, and spend several extended stays there working toward better understanding of photovoltaic scalability, durability, and reliability. ■

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AWARDS AND DEADLINES



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AWARDEES AT ICACC 2026

Recipients of several Engineering Ceramics Division awards were recognized at the 50th International Conference and Expo on Advanced Ceramics and Composites. Congratulations to all awardees! (Conference recap on page 46.)

Mrityunjay Singh Bridge Building



Shunpei Yamazaki,
Semiconductor Energy
Laboratory, Japan

James I. Mueller Lecture



Stanley Whittingham,
Binghamton
University, N.Y.

Jubilee Global Excellence



Joanna Wojewoda-
Budka,
Polish Academy of
Sciences, Poland



Reeja Jayan,
Carnegie Mellon
University, Pa.



Fiona Spirrett,
The University of
Osaka, Japan

Global Young Investigator



Lyndsey McMillon-
Brown,
NASA Glenn Research
Center, Ohio

Global Star

Mali Balasubramanian,
Argonne National Laboratory, Ill.

Do Thi Mai Dung,
Nagaoka University of Technology, Japan

Peter Kroll,
University of Texas at Arlington, Texas

Tae Ho Shin,
Korea Institute of Ceramic Engineering
and Technology, Republic of Korea

Taeseup Song,
Hanyang University, Republic of Korea

more AWARDS AND DEADLINES

Nomination deadlines for Division awards: May 15, July 1, or August 1

Contact: Vicki Evans | vevans@ceramics.org

Division	Award	Deadline	Contacts	Description
GOMD	Alfred R. Cooper Scholars Award	May 15	Steve Martin swmartin@iastate.edu	Recognizes undergraduate students who demonstrated excellence in research, engineering, and/or study in glass science or technology.
EDIV	Edward C. Henry Award	May 15	Eric Patterson eric.patterson@nrl.navy.mil	Recognizes an outstanding paper reporting original work in the <i>Journal of the American Ceramic Society</i> or the <i>Bulletin</i> during the previous calendar year on a subject related to electronic ceramics.
EDIV	Lewis C. Hoffman Scholarship	May 15	Eric Patterson eric.patterson@nrl.navy.mil	Recognizes academic interest and excellence among undergraduate students in ceramics/materials science and engineering.
ECD	Mrityunjay Singh Bridge Building Award	July 1	Federico Smeacetto federico.smeacetto@polito.it	Recognizes individuals outside of the United States who have made outstanding contributions to engineering ceramics.
ECD	Global Young Investigator	July 1	Yuki Nakashima nakashima-yuki@aist.go.jp	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	Amjad Almansour amjad.s.almansour@nasa.gov	Recognizes the enormous contributions of James I. Mueller to the Engineering Ceramics Division and to the field of engineering ceramics. This award aims to recognize the accomplishments of individuals who have made similar contributions.
ECD	Jubilee Global Excellence Award	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	Kai He hekai23@gmail.com	Recognizes exemplary student research related to the mission of ACerS Energy Materials and Systems Division.

FOR MORE
INFORMATION:
ceramics.org/awards

Student-focused experiences at ICACC 2026

During the 50th International Conference on Advanced Ceramics and Composites (ICACC) in January 2026, students had the opportunity to step beyond traditional conference sessions and participate in hands-on learning, professional development, and community-building activities. These student-focused experiences were organized by the Ceramic and Glass Industry Foundation (CGIF) in collaboration with ACerS President's Council of Student Advisors (PCSA), with the shared goal of connecting materials science education to real-world applications.

A highlight of the week was a tour of the Kennedy Space Center, where students explored how ceramics and advanced materials enable aerospace innovation. The visit offered insight into how materials are selected, tested, and engineered to perform in extreme environments, bridging classroom theory with real-world engineering challenges.

For many, seeing these technologies in action provided a deeper appreciation for the role of materials science in space exploration and other high-impact industries.

The CGIF also supported the popular International Gathering and Networking for Individuals to Explore Materials Science and Engineering (IGNITE MSE) program, hosted alongside ICACC. The event brought together students and postdoctoral researchers for a full day focused on professional development and connection. Guest speakers from both academia and industry shared perspectives on research, career pathways, and emerging trends in the field. Students also connected with peers from diverse institutions, gaining insight into the broader materials science community.

The week concluded with the Shot Glass Competition, a hands-on design challenge that encouraged creativity, teamwork, and problem solving. Participants used pipe cleaners to build protective structures around shot glasses, which were then dropped from increasing heights. The friendly competition allowed students to apply materials science principles in a fun and engaging way.

These ICACC events highlight the CGIF's commitment to creating meaningful learning opportunities that bridge education, research, and industry. The momentum from these programs will continue throughout the year through additional CGIF-supported initiatives.



PCSA representative Milos Dujovic celebrates the winning team at the Shot Glass Competition.



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Students gather for a group photo during the 2026 Kennedy Space Center tour.



ACerS Past President Monica Ferraris shares insights with students during the guest speaker portion of IGNITE MSE.

In April 2026, the CGIF will take part in the ACerS Spring Meeting in Bellevue, Wash., where IGNITE MSE will again offer students a day of presentations, professional development, and networking. The meeting will also debut a new Glass Strengthening Competition, giving students another chance to engage in hands-on experimentation and collaboration.

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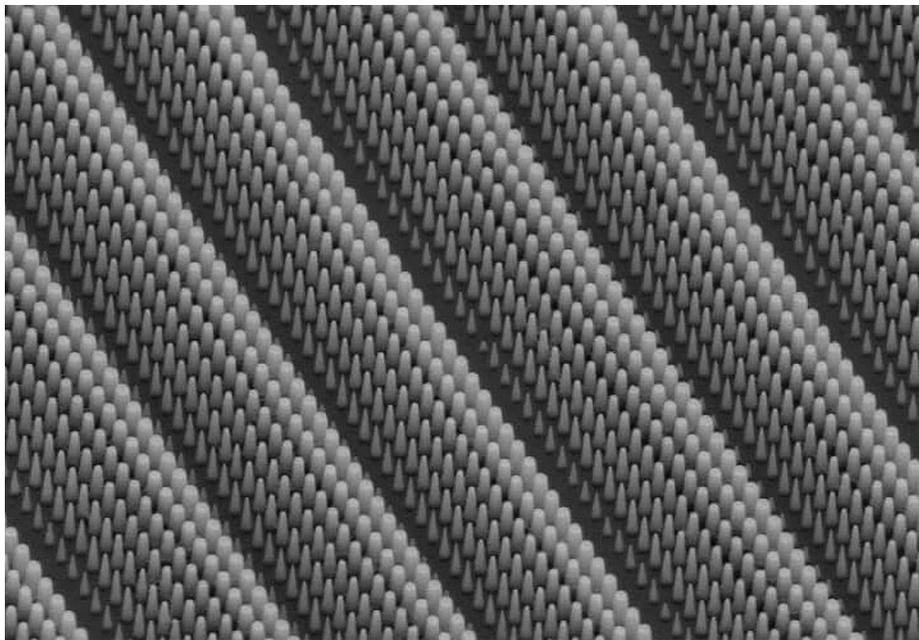
Glass photonics maintain performance due to single-mode light manipulation

Researchers in Harvard University's John A. Paulson School of Engineering and Applied Sciences (SEAS) showed that silica glass can accommodate a fair number of imperfections and still perform "remarkably well" as a photonic lens.

Traditionally, materials with a high refractive index are preferred for photonic lenses because they can bend light more effectively, enabling the creation of thinner, lighter, and more compact optical components. Silica glass has a low refractive index, however, so even though it is the ideal choice for many optical applications, usually it is not preferred for manipulating light on the micro- or nanoscale.

In May 2025, a team of researchers from China, Denmark, and Singapore made a significant discovery: despite its low refractive index, silica glass can sometimes rival high-refractive-index materials in reflectance if fabricated with enough repeating units and structural uniformity. This discovery suggests that the design of silica glass, rather than its inherently low refractive index, may be the deciding factor when choosing materials for photonic lenses.

In the new study conducted at Harvard SEAS, the researchers identified and experimentally verified regimes where silica glass surpasses titanium dioxide, a high-refractive-index material. They determined that unlike high-refractive-index materials, each etched nanopillar of silica supports only a single, clean path of light. This "single-mode" regime does



Scanning electron microscopy image of an "imperfect" silica metasurface fabricated at Harvard University. The final nanopillar shapes are not the desired cylindrical geometry.

not suffer from interference between multiple paths of light, so the desired phase profile and transmission of light can be achieved.

The researchers created several types of metasurfaces out of silica and titanium dioxide, including metagratings, metalenses, and vortex phase plates. In each case, the lack of multimode light propagation among the silica nanopillars meant the desired optical performance could be achieved even with a significantly higher number of fabrication errors, in contrast to the titanium dioxide-based metasurfaces.

In a Harvard SEAS press release, author Marco Piccardo, former Harvard SEAS researcher and now faculty at the University of Lisbon, explains that silica photonic lenses were overlooked because of obstacles in nanofabrication.

"As we are able now to etch very tall nanopillars with vertical sidewalls, we can make full use of this low-index platform," Piccardo says.

The open-access paper, published in *Nano Letters*, is "Silica meta-optics: When high performance does not need a high index" (DOI: 10.1021/acs.nanolett.5c04960). ■

Materials in the news

Micro/nanofab technique overcomes material limitations

Researchers from Max Planck Institute for Intelligent Systems and the National University of Singapore introduced an innovative optofluidic 3D micro- and nanofabrication technique that overcomes the material limitations of traditional two-photon polymerization. They use a femtosecond laser to generate localized thermal gradients and fluid flows inside a liquid, which drive a wide range of micro- and nanoparticles into pre-printed microtemplates. This light-driven assembly enables the printing of structures made from a wide range of materials, sometimes even combined, overcoming the previous limitation to polymers. For more information, visit <https://is.mpg.de/en/news>.

Self-healing composite repairs itself more than 1,000 times

Researchers at North Carolina State University created a self-healing fiber-reinforced composite that can repair itself more than 1,000 times. The material resembles conventional fiber-reinforced polymer composites, but with two more features. First, a thermoplastic healing agent is 3D printed onto the fiber reinforcement, creating a polymer-patterned interlayer that makes it two to four times more resistant to delamination. Second, carbon-based heater layers are embedded into the material. Electrically heating the layers causes the healing agent to melt and flow into cracks, thereby rebonding the delaminated interfaces. For more information, visit <https://news.ncsu.edu>.

Multicomponent layered carbides suggest tipping point for ‘high entropy’ classification

In a recent paper, a multi-institution group of researchers aimed to help clarify how the term “high entropy” is used in materials science.

High-entropy materials are materials that demonstrate improved properties thanks to their unique structure. In contrast to traditional doping strategies, which involve adding small amounts of foreign elements to a host lattice, high-entropy materials contain multiple principal elements in near-equimolar proportions that mix to form a new single-phase solid solution.

What makes the structure of high-entropy materials unique is its high configurational entropy: The specific arrangement of each atom within the single-phase solution is very disordered, so numerous stable arrangements of the components are possible.

While originally the term “high-entropy material” was applied to any material containing five or more elements in roughly equimolar proportions, recently, some groups have called attention to the nuances that are missed with this generous usage.

“Many published reports neglect to calculate configurational entropy to determine if a particular material should be classified thermodynamically as a high-entropy oxide,” a multi-institution group of researchers writes in an open-access *APL Materials* article. In other words, some multicomponent materials exhibit ordered rather than disordered arrangements of each atom, and these materials should be termed “compositionally complex” rather than “high entropy.”

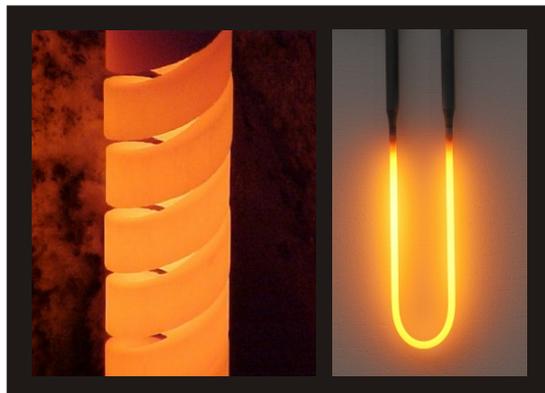
In the new paper, the researchers created 40 different MAX phases with varying numbers of metal combinations, all the way to nine metals, and then transformed these phases into 2D MXenes. They found that when using two to six metals, the resulting structures showed a more or less ordered atomic arrangement, meaning they achieved only “medium” entropy. In contrast, when using seven or more metals, the metals did not follow any preference for order—thus achieving true disorder or “high entropy.”

The paper, published in *Science*, is “Order-to-disorder transition due to entropy in layered and 2D carbides” (DOI: 10.1126/science.adv4415). ■

Simple chemical tweak may supercharge quantum computers

Researchers at the University of Chicago Pritzker School of Molecular Engineering and West Virginia University showed they can guide ultrathin films of iron telluride selenide into a topological superconducting state by slightly adjusting the chemical formula. Specifically, as the tellurium content increased past 70 wt.%, the material developed the protected surface states that make it useful for quantum computing. But near pure iron telluride, the topological surface state vanished. Several research teams are now working with the group to pattern these films and build prototype quantum devices. For more information, visit <https://pme.uchicago.edu/news>. ■

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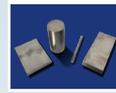
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Dumbbell-shaped ceramics are the victor for accurate compressive strength tests

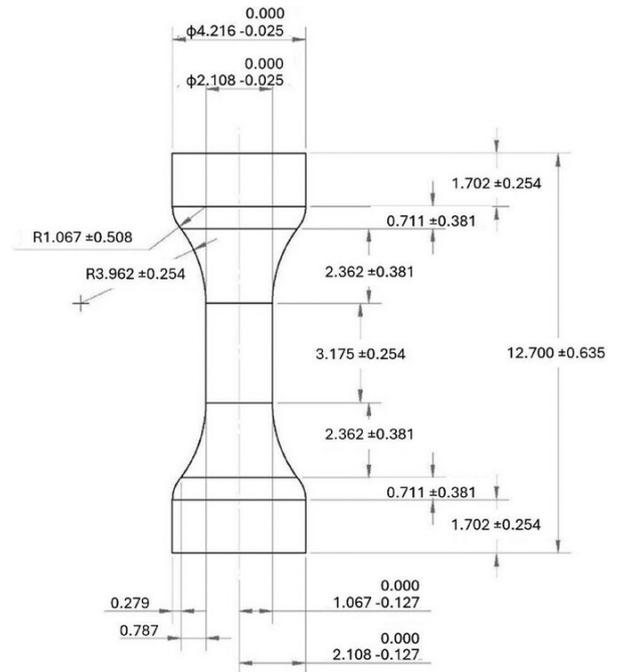
Researchers from the DEVCOM Army Research Laboratory revealed that dumbbell-shaped specimens are “the most appropriate and only specimen geometry that should be used to generate compression strength values for ceramics.”

Of the five standards currently in place to determine the quasi-static uniaxial compressive strength of ceramics, most use cuboid or cylinder-shaped test specimens. These specimens tend to form macrocracks at their ends upon loading, which then propagate into the specimen and lead to premature fracture.

This pitfall with current testing methods led investigators in the 1960s and 1970s to advocate for a different specimen geometry. The dumbbell geometry was one of the most promising alternatives, as an early study showed a consistent and repeatable strength value for dumbbell-shaped test specimens across a range of ceramics. But despite this early success, and the subsequent establishment of ASTM C1424, few other studies or standards have used dumbbell-shaped test specimens.

The authors of the recent paper summarized the few studies that used this geometry and then reported on their own experiments using the dumbbell shape. Based on this data, “The only appropriate means of generating representative and ‘true’ compression strength values for advanced ceramics at strain rates between $10^{-4}/s$ and $10^2/s$ is by using a dumbbell-shaped specimen,” they write.

The paper, published in *Journal of the American Ceramic Society*, is “Compression strength of advanced ceramics: An overview and data summary” (DOI: 10.1111/jace.70099). ■



The dumbbell geometry used in the recent study. It is a scaled-down version of the specimen developed by Dunlay, Tracy, and Perrone (1989). All dimensions are in millimeters.

Credit: Swab et al., *Journal of the American Ceramic Society*

Facilitating aerospace adoption: One-step laser synthesis of ultrahigh-temperature ceramics

Researchers at North Carolina State University developed a one-step, laser-based, polymer-derived ceramic synthesis process that could help facilitate widespread adoption of ultrahigh-temperature ceramics (UHTCs) in the aerospace industry.

There are two main methods for the commercial processing of UHTC powders: solid-state reactions and thin film deposition. Solid-state reactions effectively produce a large quantity of UHTC powders, but achieving high purity can be difficult due to incomplete reactions. On the other hand, thin film deposition can produce UHTC powders with very high purity, but it is more expensive and not meant for large-scale production. So, a scalable manufacturing process for UHTCs that produces high-quality powders is needed.

The new method uses a 120-watt CO₂ laser to create localized heating above 2,000°C in the preceramic polymer in roughly 30 seconds. Full conversion of the preceramic polymer into a solid ceramic occurs in under five minutes.

What makes this method unique is that it combines pyrolysis and cross-linking into a single step. Usually in polymer-derived ceramics processing, before pyrolysis occurs, the preceramic

polymer undergoes light- or thermal-based curing to link the material’s polymer chains and enhance its structural integrity. But in the NC State process, the laser is applied to the surface of a liquid preceramic polymer, causing it to crosslink and immediately undergo pyrolysis in essentially a one-step process.

The researchers used this process to successfully synthesize phase-pure hafnium carbide (sub-40 nm grain size), which has the highest melting temperature of any UHTC. The maximum yield of preceramic polymers to hafnium carbide was 54%, which is 18% higher than the yield reported for a furnace-based polymer-derived ceramics process.

Taking this process a step further, the researchers created hafnium carbide coatings on carbon-fiber-reinforced carbon composites. The coatings demonstrated strong adhesion, uniform coverage, and potential as a thermal- and oxidation-resistant layer, all beneficial properties for aerospace applications.

The open-access paper, published in *Journal of the American Ceramic Society*, is “Synthesis of hafnium carbide (HfC) via one-step selective laser reaction pyrolysis from liquid polymer precursor” (DOI: 10.1111/jace.20650). ■

ceramics in biomedicine

3D printing in vivo with ultrasound marks breakthrough in biomedical technology

By borrowing a technique from the field of drug delivery devices, California Institute of Technology (Caltech) researchers discovered a way to 3D print materials directly inside the body. This new method could eliminate the need to surgically insert certain biomedical devices in humans.

The approach, called deep tissue in vivo sound printing (“DISP”), involves first inserting a “bio-ink” into the body via a needle or catheter and then using ultrasound waves to guide and form the solution in place.

Ultrasound, which is commonly used in pregnancy scans, guides the solution into the desired shape by bouncing off different tissues and organs. An additional sound wave is then used to raise the temperature in that region by about 5 degrees Celsius, which coaxes the solution into a gel-like consistency. This phase transition is possible thanks to low-temperature-sensitive liposomes in the solution, which react to the additional degrees of heat and rapidly cross-link to create the hydrogel.

The researchers tested the effectiveness of this method—and biocompatibility of the ink—on mice with diseased bladders and within the deep leg muscles of rabbits. A gas vesicle in the solution served as an imaging contrast agent, allowing the process to be monitored.

The researchers found that DISP could successfully place a chemotherapy drug near the mice bladder tumor, which is often challenging to treat in humans due to the location of the tumor. DISP also successfully cross-linked deep within the leg muscles of the rabbits, showing its potential for tissue replacement in the future.

Based on these successes, the researchers conclude that the DISP method showcases “its potential for targeted therapeutic interventions and tissue replacement.” The researchers now plan to try printing in a larger animal model.

The paper, published in *Science*, is “Imaging-guided deep tissue in vivo sound printing” (DOI: 10.1126/science.adt0293). ■

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'Fairy circles' may help mark natural underground hydrogen deposits

The hydrogen sector has progressed significantly in the past few years, with low-emissions hydrogen production projects growing from just a handful of demonstrations to more than 200 committed investments since 2021. But many challenges remain to witnessing a full-fledged hydrogen economy, including producing enough hydrogen in a cost-effective and environmentally friendly manner to facilitate widespread adoption.

In May 2025, researchers led by the University of Oxford published a review paper that explored the possibility of sourcing hydrogen from Earth's crust. Geologic hydrogen could in theory serve as a good compromise to emissions-heavy production methods because it already exists and simply needs to be extracted. But questions surrounding the scale and location of geologic hydrogen have to date limited the potential of this hydrogen source.

Fortunately, Earth itself may provide clues as to geologic hydrogen's whereabouts, according to another recent study.

Fairy circles: One term, two very different causes

In European folklore, "fairy circle" refers to a naturally occurring ring or arc of mushrooms found typically in woodlands and grasslands. These circles allegedly grew due to fairies or other supernatural beings dancing at the site, but the true cause of these circles are underground fungi feeding on decaying organic matter in the soil.

But there is another geological phenomenon called "fairy circle" whose cause is less well understood. In contrast to fungal fairy circles, geological fairy circles are large-scale, shallow depressions in the ground devoid of vegetation. They are typically found in arid regions, such as Namibia (Figure 1), Australia, and northeast Brazil.

While previous theories suggest termites or water-stressed plants are the reason for the geological fairy circles, in 2014, researchers in France and Russia made the startling report that hydrogen seepage could be the reason for some of these depressions. This theory gained traction in the following decade as studies identifying similar structures around the world were published. The recent paper provides more insight into the mechanisms behind this phenomenon.

Hydrogen-induced fairy circles: A rising soufflé

The authors of the recent study come from the University of Vienna and OMV Exploration & Production GmbH in Austria and Itasca Consulting Group in the United States. They explain that the pressure of hydrogen gas as it rises to the surface causes the land to rise and then sink in a two-phase process between the gas and water flow—not unlike the motions of a baked soufflé.

Their model demonstrates how hydrogen gas up to 500 meters underground slowly rises and begins to displace



Credit: Mark Dumbleton / Shutterstock

Figure 1. Example of a fairy circle in Namib-Naukluft National Park, western Namibia.

the water in interstitial spaces between the sediment. In all models, the gas pressure increased linearly with time for 100 days, followed by 200 days of constant gas pressure, which then caused the rocky terrain above to rise.

Due to the changes in soil chemistry, the immediate vegetation would also die off, aligning with the characteristics of naturally occurring fairy circles. However, if the hydrogen source used for the model stopped emitting gas in the second phase, then the surface would sink into a depression due to the decrease in pore fluid pressure and consequent increase of effective stress from the high-gas area. This simulated depression is also known as mechanical compaction, and it closely mimics the way the fairy circles are formed naturally.

Fairy circles as hydrogen depth and yield indicators

This new understanding of how geological fairy circles are formed gives rise to questions surrounding the natural hydrogen found at these spots. Could fairy circles serve as landmarks for subsurface areas with large deposits of naturally occurring hydrogen? Some speculate that the size of the fairy circles may also be linked to the depth of hydrogen sources.

"These findings are a real breakthrough," says Bernhard Grasemann, deputy head of the Department of Geology, in the press release. "Fairy circles could thus serve as natural signposts in the future for finding underground hydrogen sources—a potentially inexhaustible and environmentally friendly energy source."

The paper, published in *Geology*, is "The mechanical genesis of 'fairy circle' depressions" (DOI: <https://doi.org/10.1130/G53384.1>). ■



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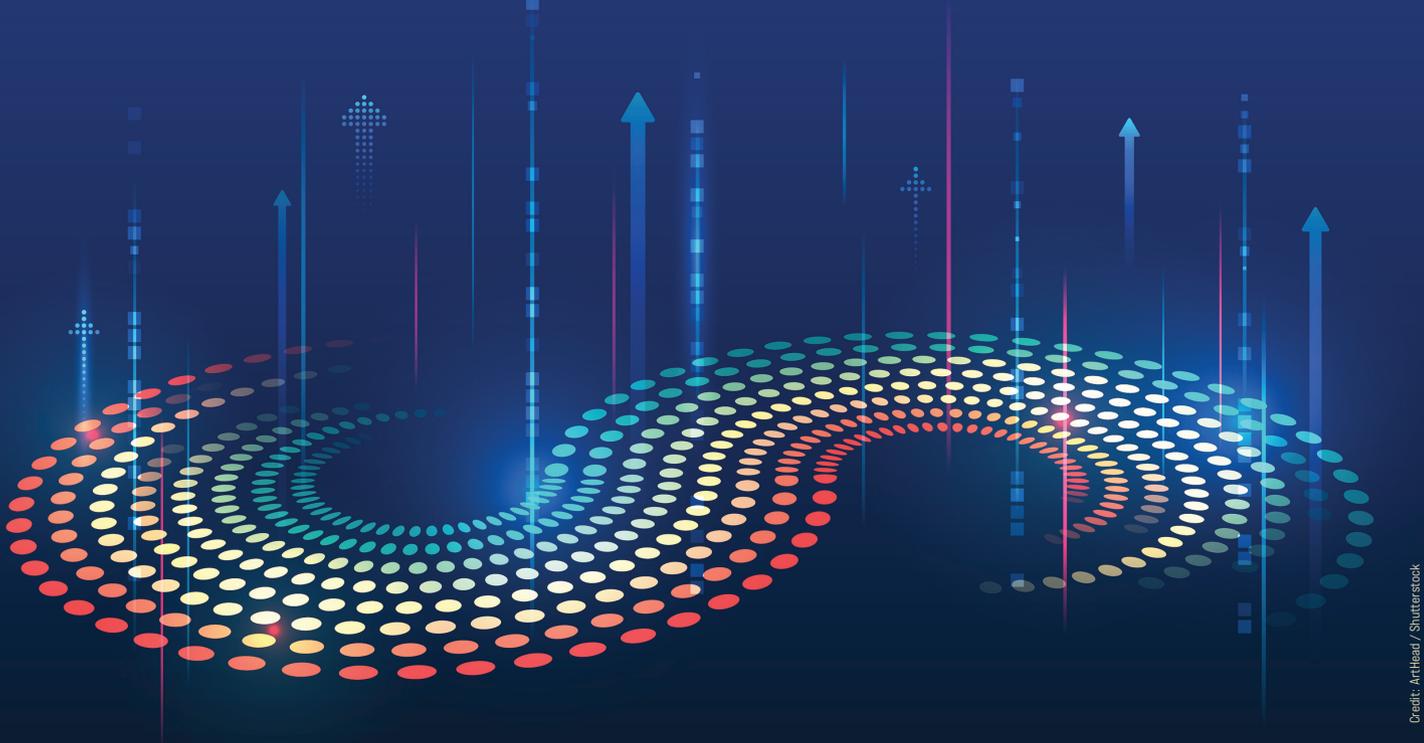
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Semantic data management: A data-centric approach to advanced manufacturing in the ceramics and glass industry

By Hein Htet Aung, Rishabh Kundu, Ozan Dernek, Quynh D. Tran, Roger H. French, and Laura S. Bruckman

“Ceramic processing is an ancient art but a young applied science.”¹

When Alfred University Emeritus Professor of Ceramic Engineering James S. Reed wrote these words in 1995, it had been only 10 years since Engineering Ceramics was established as a formal Division of The American Ceramic Society. Even now, more than 30 years later, ceramics manufacturing remains an area ripe with potential to develop solutions that optimize every aspect of the fabrication process, from minimizing energy requirements to enhancing structural control to reducing the number of processing steps.

In recent years, ceramics manufacturers (and the materials industry in general) have started relying more heavily on advanced manufacturing solutions to optimize the production process.^{2,3} Advanced manufacturing is a broad term that describes the integration of innovative technologies, such as data-driven, automated, and computer-coordinated processes, into traditional manufacturing operations to improve product

quality, speed, and efficiency.⁴⁻⁷ Advanced manufacturing technologies include additive manufacturing, robotics, Internet of Things, artificial intelligence, and big data, among others.

The adoption of advanced manufacturing technologies is supported by Contini et al.'s definition of a comprehensive set of key performance indicators (KPIs) to monitor economic, environmental, and social sustainability within the energy-intensive ceramics industry.⁴ The methodology for developing KPIs emphasizes the integration of sustainability with digitization and Industry 4.0 technologies, which are required to manage the vast amount of data and obtain constantly updated, real-time information essential for effective monitoring and data-driven decision-making. The limitations of traditional ceramics processing methods (see sidebar: "Traditional ceramics processing") directly influence three economic KPIs (cost, investment, and staff), four environmental KPIs (energy consumption, CO₂ emissions, waste, and material use), and one social KPI (training), in addition to other indirect implications.

Adopting advanced manufacturing technologies comes with its own set of challenges, however, in terms of both technology integration and personnel training.⁸ In this article, we focus on the challenge of data management specifically, and we introduce a semantic data management framework developed at Case Western Reserve University's Center for Materials Data Science for Stockpile Stewardship (MDS³ Center of Excellence) to address this challenge.

Data challenges in advanced ceramics manufacturing

Consistent fabrication of high-fidelity parts is a perennial goal for manufacturers. However, achieving repeatable and reproducible results in ceramics manufacturing is challenging because the underlying processes governing part fabrication involve complex mechanisms whose interactions can manifest as defects during the processing or post-processing steps.⁹ Due to this complexity, ceramics manufacturers often base decisions regarding process parameters, materials selection, and post-processing steps on trial-and-error approaches that are largely ad hoc and application specific. However, this Edisonian methodology for optimizing materials selection and post-processing steps requires intensive investment in time, labor, and capital.

Advanced manufacturing technologies depend on a vast range of parameters that influence material processability and part performance. These critical parameters span multiple fabrication stages, including feedstock preparation (e.g., characterizing particle morphology and ink rheology), optimizing the forming parameters, and determining the processing conditions for green body debinding and sintering.¹⁰ Substantial multimodal data can be generated and curated from these diverse sources across the fabrication stages during advanced manufacturing processes.

The volume and veracity of the generated data, coupled with the vast parameter space, pose significant challenges for data optimization and analysis. Inadequate data management and curation practices result in loss or neglect of historical data sets, requiring redundant and expensive data collection.

Furthermore, the current Edisonian approach and traditional design of experiment methodologies, which typically explore one factor at a time, are not equipped to capture the full scope of data streams and navigate the parameter space.

Another critical factor impeding the industrial adoption of additive manufacturing technologies specifically is the lack of unified standards and guidelines for qualifying and validating additively manufactured parts.¹¹ To address this need for standardization, both ASTM International and the International Organization for Standards have launched initiatives to form joint task groups and working communities.¹²

Traditional ceramics processing

Traditionally, ceramics processing begins with the beneficiation and formulation of the feedstock, i.e., a mixture of raw powders, liquids, and processing aids. This feedstock is consolidated into an unfired but shaped object called the green body, which is formed using techniques tailored to its rheology. The green body then undergoes drying, binder burnout, and optional surface treatments or machining before being sintered, which transforms the unfired shape into a dense consolidated body that may require further optional machining suitable for the intended applications.^{a,b}

Although the multitude of pathways or techniques that facilitate the aforementioned methodology are well established, defect control remains a challenge due to the presence of intrinsic defects, such as microcracks, and shaping constraints, which may hinder reproducibility. These methods also have long production times because of the multiple steps and high energy requirements, resulting in higher operational costs, negative environmental effects, and scaling constraints.

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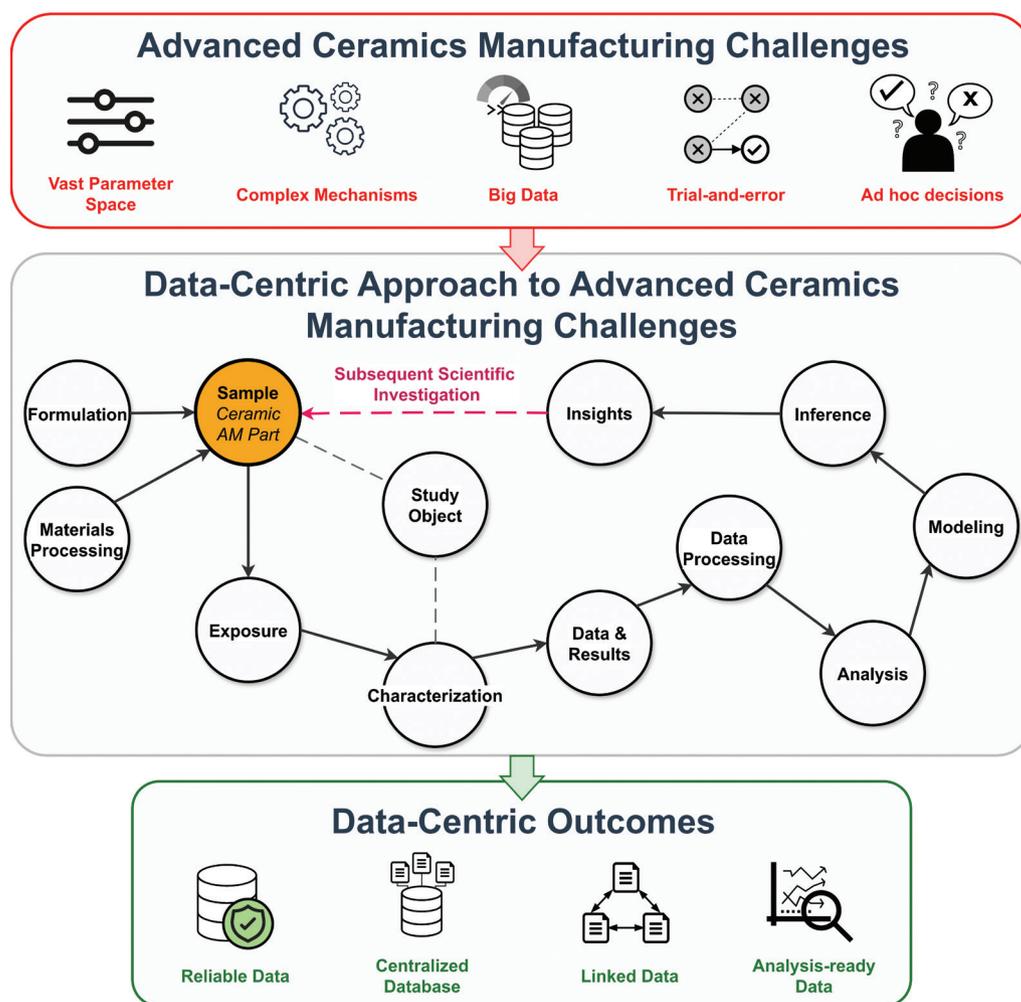


Figure 1. A schematic overview of the MDS³ Center of Excellence's study protocol for comprehensive materials experimentation.

Semantic data management for advanced ceramics manufacturing

Effective data management is critical to harnessing the wealth of data generated in advanced ceramics manufacturing. At the MDS³ Center of Excellence, we developed a semantic data management (SDM) framework for materials science and advanced manufacturing to enable reproducible, reliable research and production at scale with consistent materials properties.¹³⁻¹⁵

This SDM framework brings data-driven study protocols and study stages together from the materials science perspective by combining data science tools, materials ontologies, knowledge graphs, and the Semantic Web technology stack¹⁶ (i.e., Resource Description Framework, Linked Data, and OWL 2 Web Ontology Language) under one cohesive framework that adheres to the four guiding principles of shared data: findable, accessible, interoperable, and reusable (FAIR).^{17,18}

Study protocols and study stages

The MDS³ study protocol is a comprehensive design paradigm for conducting materials science experiments while consistently collecting and recording detailed (meta)data from

the study (Figure 1).^{19,20} The approach enables researchers to both explore large parameter spaces with sparse data and reuse extensive historical data for varied research questions.

The MDS³ study protocol consists of several stages:

1. A study object, commonly referred to as the sample, is acquired via material formulation and/or synthesis steps. It may undergo additional exposure or aging processes as well based on the focus of the study.
2. The properties of the study object are characterized, and (meta)data is collected.
3. The (meta)data is processed and analyzed, and final results are generated.
4. Models are trained on the generated results.
5. The models are used to infer new hypotheses that inform new studies, and the cycle continues.

At each stage, data about the sample, instrument, methods, and analysis scripts should be systematically recorded along with sufficient metadata to ensure full reproducibility.^{21,22}

All the data generated and collected during the study are categorized into appropriate study stages and labeled with the correct standard terms using the framework MDS-Onto.²³ This schema enables data from formulations (feedstock metadata)

to be linked to post-processing and aging data via the classes in MDS-Onto ontology and its semantic model, rather than being lost and fragmented in separate CSV files or proprietary data formats. Data about a formed part, such as feedstock, formulation batch, and detailed operational information, can be queried through this semantic link for analysis.

Components of the Semantic Web technology stack

The SDM framework enables machine-operable and AI-ready data by following Linked Data principles²⁴ and implementing components of the Semantic Web technology stack²⁵⁻²⁸: ontologies, Resource Description Framework (RDF), Web Ontology Language (OWL 2), and knowledge graphs.

An ontology is a formal representation of entities (i.e., terminologies, concepts) that form a unified vocabulary and taxonomy used within a community; they provide both human- and machine-operable language for AI-ready data. There are common vocabularies implicitly used and understood within a research area, but these vocabularies may not be intelligible to external researchers if the context is not provided.

For example, temperature is a frequently used concept in many disciplines. If only “Temperature” or “Temp” is recorded as the column header in a spreadsheet, external users of the data will not know if this parameter refers to the temperature of the sample, the instrument, or the room. So, they will need to employ guesswork to determine the meaning, resulting in unnecessary time spent on clarification. Similarly, if abbreviated variables such as “T” are used, context clues are needed to determine whether the abbreviation refers to temperature, thickness, or time. These issues can be mitigated by using an ontology and building the context into the data set so it leaves no room for interpretation.

The Resource Description Framework (RDF) is a language for describing, linking or connecting, and organizing related data into a graph of nodes and edges.²⁵ It was primarily developed to connect large volumes of heterogeneous data on the web. RDF links data in triples form (subject-predicate-object) by declaring that a relation (predicate) exists between a subject and an object. In essence, ontology categorizes the data represented as RDF triples in a graph.

An RDF triples example is `mds:Sample_1 cco:ont00001991 mds:CeramicMaterial`. In this case, `mds:Sample_1` is the subject, `cco:ont00001991` is a predicate reused from the Common Core Ontologies that means “is made of,” and `mds:CeramicMaterial` is the object. The sentence can be read colloquially as “`mds:Sample_1` is made of `mds:CeramicMaterial`” to declare that a sample is made of ceramic materials.

OWL 2 provides the language that ensures the relationships between the terminologies (classes), their properties, and data values use the same vocabulary that is formally defined for interoperability.²⁶ When the (meta)data is expressed using this vocabulary and the syntax provided by RDF to link data, then stored in JavaScript Object Notation for Linked Data, the data set now can be represented as a knowledge graph in the triples form, which provides several benefits that are not present in legacy data formats.

Knowledge graph databases allow the integration of data from multiple sources and mitigate the issues that may arise due to the multimodality of the data (the rich semantics embedded into the data set provide complex knowledge representation).²⁷ Furthermore, the queries in this database, especially on large data sets, are significantly more efficient because the knowledge graphs are nonrelational databases and utilize not-only-SQL query languages, such as SPARQL.²⁸ Additionally, RDF facilitates machine-reasoning and discovery of new relationships via reasoning engines, called “reasoners.” RDF also requires each data point to have a unified resource identifier, which ensures the findability of the data.

To give an example, the concept of temperature exists in the ontology as the class “temperature.” The temperature of a sample, of an instrument, or of a room are all members (i.e., subclasses) of that class and are linked to the corresponding entity. In other words, the “sampleTemperature” is connected to the sample, the “instrumentTemperature” is linked to the instrument, and so on. Furthermore, OWL 2 can be utilized to place a restriction that states all measurements in an experiment must be accompanied by temperature values. This method allows validation of the logic and consistency checks for data.

Collectively, these tools and approaches facilitate our SDM framework that adheres to FAIR data principles and requirements for AI-ready data.

MDS-Onto

MDS-Onto is an open-source materials data science ontology that was developed to build a common vocabulary among materials science domains such as ceramics, photovoltaics, and capacitors, among others.^{13,21} It is a modular, low-level ontology that describes highly granular domain concepts, such as a green body, and connects to the mid-level Common Core Ontology (CCO), which describes less granular concepts, such as mechanical processes. The connection goes further to the high-level Basic Formal Ontology (BFO),²⁹ where abstract concepts such as “entity” exist. Connecting to CCO and BFO also provides an interoperable foundation that allows MDS-Onto to expand or merge cohesively with existing domain ontologies.³⁰⁻³²

Ceramics is one of the materials science domains in MDS-Onto. As in the case of many materials science endeavors, advanced manufacturing processes in ceramics are time consuming and costly. Therefore, having the highest possible control over the components and being able to keep track of the material, system, and environmental conditions of a process is crucial. Especially in a research and development study, one would need to record every bit of (meta)data possible to determine the progress and future of the study. On the other hand, keeping track of the (meta)data that ensure the repeatability and interoperability of the study can be prohibitively difficult without the aid of SDM approaches.

The MDS-Onto materials science ontology, and the MDS-Onto Open effort as a whole,¹⁵ aims to bridge this gap and provide state-of-the-art tools and perspectives to ensure that the experimental and production processes are well documented with semantically enriched (meta)data, the historical data can

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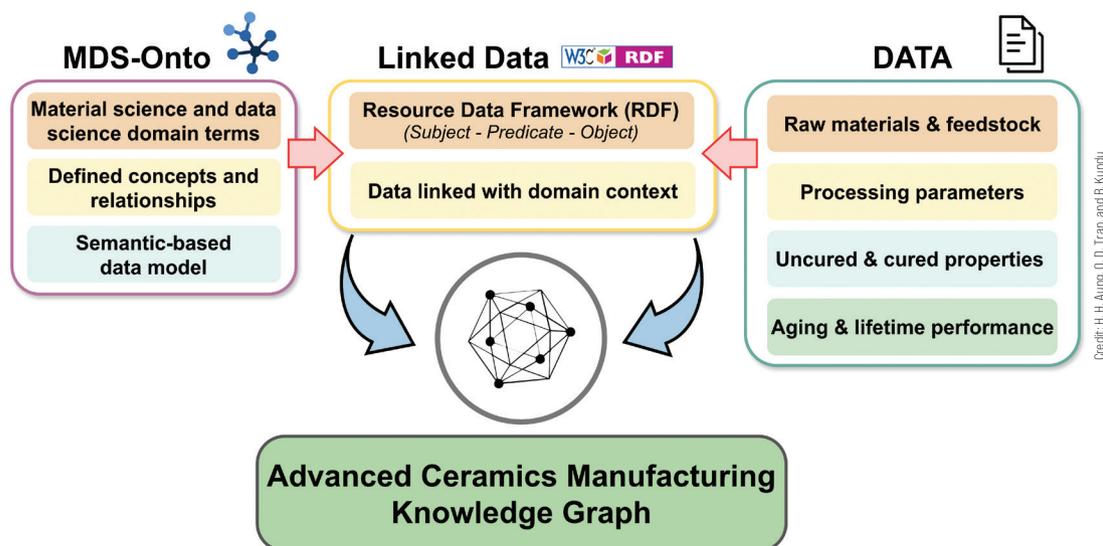


Figure 2. Multimodal data from sensors and measurements, for example, are stored as Resource Description Framework triples to link data under a cohesive framework. This framework forms a complete ceramic knowledge graph for query, learning, and reasoning.

be reused, the multimodal data is AI-ready, and everything is unified in a modern database. Furthermore, the data under this common semantic model will allow efficient multimodal data sharing for cross-domain studies, including experiments ranging from manufacturing processes and formulation to characterization, accelerated aging, and modeling.

SDM example

A ceramic knowledge graph database curated by the SDM approach would contain properties of raw materials, feedstock, (un)cured final products, and detailed instrumentation; operational details can be constructed where (meta)data are linked, as shown in Figure 2. For instance, in formulating feedstock materials for manufactured ceramic products, it is critical to record the batch or lot number and whether the material is from a fresh or previously used batch, as such variables can affect the final properties, performance, and degradation of the product. A user can then query for a known sample using its unique identifier in the knowledge graph and receive the information about the raw materials, the processing and printing conditions, properties, aging characteristics, and other specifications related to a material or a process.

While these types of queries can only return key-value types of information in traditional data formats (i.e., CSV), and the speed of the query is slowed down by the size of the database, knowledge graph databases allow contextually rich queries without facing any speed issues, even in massively large data sets. Here is an example list of questions that can be answered using a SPARQL query in a knowledge graph:

- Simple query: The date on which a sample A is printed.
- More complex: All samples that were printed at 150°C, and their hardness properties, the starting materials, and their viscosity measurements.

- Highly complex: All of the parts were printed at a number of locations, and their aging characteristics.

The SDM framework, which incorporates ontologies, knowledge graphs, RDF, and OWL 2, enables researchers to integrate heterogeneous data using an underlying semantic data model. They can then generate high-quality data for sharing and publishing and produce structured AI-ready data for AI/ML applications.

A shared data future through SDM

Advanced manufacturing has the potential to transform the ceramic manufacturing landscape, but there are both technological and personnel challenges to putting these technologies into practice. We present a new framework for semantic data management with study protocols and study stages supported by Semantic Web technology stack components that ceramic researchers can use to generate AI-ready data for AI and machine learning applications, especially for reasoning. This framework also improves FAIR principles by building truly shareable data with data provenance and metadata embedded with data, analysis, and models. Ideally, this framework will accelerate research and large-scale production of ceramics in advanced manufacturing by utilizing valuable historical data and knowledge and taking advantage of new AI/ML tools while reducing the overall research time and resources.

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Funding basic science:

Finding sources to fill the government gap

As publicly subsidized programs face budget cutbacks, U.S. researchers must cast a wider net to seek financial support for projects

By Randy B. Hecht

What does it take to fund science research that is not clearly aligned with profit objectives from the outset?

In an age when budgets are shrinking and research is expected to deliver a near-term return on investment, it is easy for science doubters to question the value of studies conducted in search of knowledge rather than monetization. But knowledge has value, even if that value has no immediate dollar sign attached to it. For example, without a study of “how bees optimize nectar foraging and distribution among a colony...we never would have developed an algorithm that allocates internet traffic among computer servers—a technology that powers the \$50 billion web-hosting industry,” notes David Shiffman, faculty research associate at Arizona State University, in the July–August 2025 issue of *American Scientist*.¹

Although federal funding for fundamental research is in decline in the United States, there are still agencies, foundations, corporations, nonprofits, and even crowdfunding sources available to researchers with basic science goals in mind. This article offers resources to support the search for funding.

THE GLOBAL STATE OF BASIC SCIENCE FUNDING

US funding cuts dull competitive edge

The New York Times headline on Dec. 2, 2025, did not mince words: “The U.S. Is Funding Fewer Grants in Every Area of Science and Medicine.”² The reporters found that

2025 saw “fewer new grants awarded in biology, geosciences, STEM education, computer science and engineering, math, physics, technology and innovation.” Just 758 grants were awarded for STEM education in 2025, a 30% drop from an average of 1,087 annually during 2015–2024. The number of engineering grants fell 17%, as did those for math and physics; technology and innovation grants declined by 13%.

The outlook was even bleaker: On Jan. 10, 2026, *The New York Times* reported that further proposed cuts to federal science programs would reduce science funding from \$198 billion to \$154 billion, which “would have been the largest reduction in federal spending on science since World War II.”³ On a similarly discouraging note, *Science* reported on Jan. 26, 2026, that as a result of reductions in the federal workforce during 2025, “10,109 doctoral-trained experts in science and related fields left their jobs” during the year, a number that “represents 14% of the total number of Ph.D.s in science, technology, engineering, and math or health fields employed at the end of 2024.”⁴

(Some positive news for scientists is that the proposed cuts met bipartisan opposition, and in February 2026, five bills were signed into law that “fund most scientific research agencies at much higher levels” than were allocated in the original budget proposal, according to an Association of American Universities article.⁵ Several of the bills also included provisions preventing various federal agencies from modifying or implementing changes to indirect cost negotiated rates.)

Europe and Asia ramp up science research

Where some see crisis, others see opportunity. European universities and research institutes were quick to offer employment to some of those displaced U.S. scientists, with one notable example being the €30-million Choose France for Science initiative launched in April 2025. The program aimed to recruit researchers based abroad to work in France, and so far it has resulted in the hire of 46 scientists, most previously employed at U.S. institutions and most studying climate, biodiversity, and sustainable societies.⁶

These immigration opportunities for scientists come as the European Union proposed doubling its research and innovation allocation to €175 billion (US\$206.627 billion) in the 2028–2034 budget for Horizon Europe, the EU’s primary research and innovation program.⁷ Yet this news carries an asterisk: On Sept. 29, 2025, the League of European Research Universities published a statement that “EU funding for basic research is now in jeopardy. If the ECF [European Competitiveness Fund] budget does not contribute to R&I—and particularly to basic research—only the European Research Council will explicitly fund fundamental research at EU level.”⁸

But Europe recognizes the value of basic science and is investing in it beyond the continent’s established research powerhouses. In September 2025, The Polish Academy of Sciences Institute of Physical Chemistry announced the creation of 20 postdoctoral positions within its Basic Sciences for Society Needs, positions that are co-funded under Horizon Europe.⁹

Events unfolding in Asia add further perspective. A Dec. 18, 2025, *DongA Science* article reports, “The South Korean government aims to become one of the world’s top five basic research powerhouses by 2030 by securing a 30% faculty participation rate, expanding the proportion of long-term projects (5+ years) to 70%, and abolishing phased evaluations for projects under five years.”¹⁰ It describes the Ministry of Science and ICT as committed to establishing a long-term research system and notes, “The government will also pursue an amendment to the ‘Basic Research Promotion Act’ to ensure that a certain percentage of its R&D investment is allocated to basic research.”

Japan’s Science and Technology Agency’s strategic basic research programs include the following¹¹:

- **JST-Mirai Program**, which “promotes research and development from a basic research stage to a stage where industry can decide whether they could make a business successful.”
- **CREST (Core Research for Evolutional Science and Technology)**, which supports “studies that aim for the creation of new values leading to innovations in science and technology...young researchers advance their research studies according to their unique ideas.”
- **ALCA-Next: Advanced Technologies for Carbon-Neutral**, which “promotes basic research on innovative technologies that are not just extensions of conventional technologies and that will bring about discontinuous innovation, with the aim of contributing to the realization of carbon neutrality by 2050.”

- **Moonshot Research and Development** “is driving high risk, high impact R&D towards ambitious and attractive targets...to solve issues facing future society.”
- **BOOST (Broadening Opportunities for Outstanding young researchers and doctoral students in Strategic areas)** “is a program for developing highly urgent national strategies.”

As *University World News* reported on Feb. 28, 2025, China’s National Natural Science Foundation, which oversees a billion-dollar science fund, seeks to overhaul its basic research funding system over the next five to 10 years.¹² The Foundation operates under the Ministry of Science and Technology.

“The government says young scientists have the potential to drive pioneering breakthroughs,” the article reports. “As part of the revamp, a new dedicated fund for young scientists pursuing basic research is being developed...It builds on recent initiatives such as China’s Research Funding Programme for Students, which since 2023 has supported high-achieving university students to kick-start their research careers with grants of between CNY100,000 (about US\$14,000) to CNY300,000 (about US\$41,400).”

THE FUNDAMENTALS OF FUND-SEEKING

Considering the above global funding dynamics, basic science research grantseekers in the U.S. are competing not just for funding but for maintaining the U.S. presence on the global stage. To win financing, researchers must be able to counter arguments against projects that launch without an immediate target for commercial or economic gain.

Ahead of the 2023 World Economic Forum annual meeting in Davos, Switzerland, European Research Council President Maria Leptin made her case for fundamental research in a blog post¹³: “Apart from the important cultural value of satisfying human curiosity and creating new knowledge, fundamental research leads to a better understanding of the natural world and establishes the essential foundation of knowledge needed to solve acute, practical problems,” she wrote. “The history of innovation shows that freedom for researchers to pursue their creative ideas, without strings attached, has been vital for countless discoveries, many of which have led to breakthrough technologies with enormous benefits for society and that have boosted the economy.”

She is not alone in that perspective. The directory below lists sources of funding from foundations, universities, research institutes, and government agencies that support basic science research.

Databases and resource libraries

Grants.gov maintains a database of grants available throughout the U.S. government and so is not dedicated exclusively to science grants. In addition to its “Search funding opportunities” page, available at <https://simpler.grants.gov/search>, it provides online tutorials and information about topics such as how to apply for federal funding opportunities, confirming that you are eligible to apply, and grant-writing tips. There is also an applicant FAQ at <https://www.grants.gov/applicants/applicant-faqs>.

Funding basic science: Finding sources to fill the government gap

GrantForward describes itself as “the only funding opportunity database and service built by academics for researchers.” The site “uses specialized data-crawling technology to constantly update our extensive database of sponsors and funding opportunities, allowing thousands of grant opportunities to be gathered from over 30,000 sponsors. Every grant opportunity is thoroughly analyzed and then verified by our team of specialists to ensure accuracy.” Learn more: <https://www.grantforward.com>

Science compiled a “Where to Search for Funding” reference, which provides links to prospects. It also contains information about how to get funding and “how not to kill a grant application.” Learn more: <https://bit.ly/4tysTVT>

The University of California, Los Angeles’ David Geffen School of Medicine hosts BioFund, a non-NIH funding database that includes basic science research opportunities. Learn more: <https://bit.ly/4tzo5jc>

The UMass Amherst Foundation hosts Private Foundations that Fund Academic Research: A Quick Guide, which introduces and links to funders and lists their funding priorities. Learn more: <https://bit.ly/4654224>

The Open Education Database offers 100 Places to Find Funding for Your Research, with links to (actually) 99 organizations and resources. Learn more: <https://bit.ly/4rO6yIJ>

The U.S. Department of Energy Office of Science provides links to Funding Opportunity Announcements at <https://science.osti.gov/bes/funding-opportunities> and information about its Early Career Research Program at <https://science.osti.gov/early-career>.

The U.S. National Science Foundation maintains a funding search database with more than 400 search results at <https://www.nsf.gov/funding/opportunities>.

Organizations funding science research

The Alfred P. Sloan Foundation funds “research and education in science, technology, engineering, mathematics and

economics.” Its Research page states that “Support for basic scientific research lies at the core of the foundation’s mission” and notes that the Foundation prioritizes “proposals for original projects...for which funding from the private sector, government, or other foundations is not yet widely available.” Website: <https://sloan.org>

The Chan Zuckerberg Initiative supports science “through targeted grantmaking and open competitions for research funds in specific issue areas.” Its science interests are often related to artificial intelligence. Website: <https://chanzuckerberg.com/science/science-funding>

The Simons Foundation supports “interdisciplinary projects that ... connect science to peoples’ existing interests and identities, with a focus on broadening participation in science.” The Foundation also strives “to go beyond the traditional role of funder by building and offering professional and organizational development programs.” Website: <https://www.simonsfoundation.org>

Some states maintain science grant support resources. For example, New York Grant Watch maintains a database of “grants for science, technology, engineering, and mathematics (STEM) programs, STEAM education, and scientific studies. Funding supports research, clinical trials, laboratory expenses, and advancements in science.” Website: <https://newyork.grantwatch.com/cat/30/science-grants.html>

Notably, grant awards may not be limited to residents of the state hosting the database. New York Grant Watch promotes opportunities for U.S., Canadian, and international nonprofit and for-profit grantseekers.

University resources

Many universities partner with commercial enterprises and research institutes that provide financial support for the pursuit of advances in basic science. For example, the Penn State Research Enterprise is “an ecosystem where businesses, educa-

JOIN THE CROWD(FUNDERS)

Crowdfunding started as a way to donate to survivors of natural disasters, people facing medical crises, or community organizations in need of support. However, its role in science research is no longer limited to students’ requests for financial support on GoFundMe.

Scientists who are tempted to go this route will need to do their research. The University of Illinois Urbana-Champaign’s Office of the Vice Chancellor for Research and Innovation created a Best Practices for Crowdfunding guide that provides advice and words of caution: <https://bit.ly/3Zz9vKQ>.

However, the guide was written in 2016 and last updated in 2021, so it does not account for some of the newer crowdfunding sites launched to finance science research. For example, Experiment is an “online platform for discovering, funding, and sharing scientific research”

run by “a team of scientists, designers, and technologists passionate about helping ideas grow. Our mission is to democratize science.” Website: <https://experiment.com>

There is also Crankstart, “a San Francisco-based family foundation devoted to bolstering the foundations of a just society...Crankstart also supports the arts, basic science and efforts to mitigate climate change.” In January 2026, the Foundation opened a search for a program officer to support its “national and international Environment and national Basic Science philanthropy.” According to the job posting, the Foundation “anticipates” making \$15–20 million in basic science grants during 2026. Website: <https://crankstart.org>

Ultimately, crowdfunding cannot close the gap left by reductions in government allocations for basic science research. But it may offer an additional resource for financing some projects. ■

SUPPORTING MARGINALIZED RESEARCHERS

If you are a woman or BIPOC scientist, you know that basic research is not alone in being underrepresented in STEM grantmaking. Funders have started to take note—and to do something about it.

“Growing BIPOC talent in STEM is not a feel-good moment,” says the 2030STEM mission statement. “It is a valid strategy for advancing the STEM enterprise.”

In 2025, the systems-level initiative announced the inaugural cohort of 2030STEM × Burroughs Wellcome

Fund Fellows. The new fellowship program is “designed to support early-to-mid-career STEM professionals initiating cutting-edge science while also catalyzing institutional STEM culture change.” Learn more: <https://2030stem.org/2025fellows>.

While STEM grant organizations with these priorities may not be focused specifically on basic science research, they may be good sources of funding for women- or BIPOC-led projects. ■

tion, and research come together. In the past decade more than 2,000 companies have partnered with Penn State on more than 9,000 projects.” Website: <https://research.psu.edu/#partnering>

The U.S. National Science Foundation’s Research Partnership program aims to “cultivate partnerships between academia, industry, nonprofits, government, civil society, and other sectors so they can pursue transformative research, solve societal problems, fuel economic progress, and build a future-ready workforce.” Website: <https://www.nsf.gov/focus-areas/research-partnerships>

Resources for science educators

The NEA [National Education Association] Foundation’s STEM grants “provide the resources for districts to build and expand their STEM programs and the professional learning for educators to lead them well.” Website: <https://bit.ly/4bR1uID>

STEMGrants.com compiled a list of funding available for K-12 nonprofits at <https://stemgrants.com/stem-grants-for-k-12-nonprofits>.

FOR A DEEPER DIVE

Center for Strategic and Innovation Studies: “Innovation Lightbulb: Basic research for breakthrough innovations” (<https://bit.ly/4rNg34A>)

Columbia Magazine: “A brief history of science funding” (<https://bit.ly/4aLI86t>)

Harvard Medicine: “A brief history of federal funding for basic science” (<https://bit.ly/3MHA0Lb>)

Science Philanthropy Alliance: “Science Philanthropy Indicators Report” (<https://indicators.sciphil.org>)

UC Davis Magazine: “Why is federally funded research so important?” (<https://bit.ly/4bSGhOy>)

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Credit: Chatchaiwa / Shutterstock

How do I say this?

The underappreciated importance of soft skills in the fields of science and engineering

By Gabriel Agnello

From the very moment of your birth, you embark on a lifelong exercise in learning.

While we sometimes consciously engage in these learning processes—we can all recall the late-night cram sessions before a big test—there are times that an experience only reveals itself as formative many years down the road.

When I look back on my more than 25 years in the scientific arena, there are a handful of seminal experiences that shaped me into the researcher I am today. But the most important of these experiences was not apparent to me until many years after I graduated school and established myself in the professional world.

The criticality of human communication and interaction

In 2002, I was working toward an M.S. in physics at the University at Albany, State University of New York when I secured my first paying gig as a research assistant in the newly formed nanoscale science and engineering department, now the independent College of Nanoscale Science and Engineering (CNSE). The early version of CNSE was deeply multidisciplinary by design, bringing together students and faculty from physics, chemistry, biology, geology, and several engineering fields under a single umbrella to work on shared projects with multifaceted goals. My own group (the first of three during my time at CNSE) consisted of two chemists, a geologist, and myself (a physicist).



Credit: Bhati, SSRG International Journal of Humanities and Social Science (CC BY-NC-ND 4.0)

Figure 1. Results of a survey from Bhati¹ ranking the importance of various soft skills in the hiring process, as seen by human resources professionals. The numbers on the bar plot reflect the number of votes for each selection.

A prominent feature of our program that was controversial and intensely disliked by most of the student body was the weekly department meeting held every Saturday morning at 9 a.m. Attendance was mandatory for all students and a minimum of five faculty members; repeated tardiness was subject to disciplinary action.

The meeting itself was not the problem. No, the source of our loathing—other than the fact that most of us were in our early to mid-20s and had social activities that ran late into Friday and often early into Saturday—was the meeting agenda. Each week a graduate student was scheduled to deliver a technical presentation to the group on either their research or a suitable review topic. Both students and faculty were encouraged to ask questions and give feedback, challenging the speaker’s technical command of the subject matter and/or their ability to appropriately engage the audience.

These Saturday morning meetings more closely resembled a high-pressure, high-stakes thesis defense rather than a casual conference presentation. You were expected to be perfect, regardless of how little or how much experience you had. These presentations, naturally, were harder and more stressful for newer students to produce and to deliver.

My own experience was emblematic of why these meetings had the reputation they did. To say I was emotionally exhausted and unsure of my own abilities after my first few turns would be a gross understatement. Time passed, and my attempts at giving a successful Saturday morning talk piled up. Some I felt good about, some not so much. In early 2004, I successfully defended my master’s thesis, and after about a year of working toward a Ph.D. (something I would complete many years later), I decided to leave and begin a career in industry.

During the first few years of my career as a scientist, I became more aware of how remarkably fortunate I was to have had those graduate school experiences. Those gatherings that so many of us dreaded with a white-hot passion had a hidden

purpose. The months of preparation culminating in us walking onto the stage to present something we felt only moderately good about on a dreary upstate New York morning was not meant to discourage us; it was meant to *teach* us an invaluable skill. Yes, mastering the technical aspects inherent to our chosen field was vital, but equally critical was strengthening the skill to effectively communicate your knowledge to an audience, especially when members of said audience may not have a technical background.

Though I was unaware of it then, I instinctively realized that practice rapidly eased my discomfort with the presenting process. As my peers and I became more familiar with how to carefully craft and deliver an effective message, we naturally transitioned into mentorship roles helping the younger students who were working on their first presentations.

This awareness of effective communication practices that I subconsciously developed at CNSE carried into how I approached my work as an industrial professional. I found myself assessing many aspects of my surroundings: How did my peers and I interact with one another? How did we communicate progress on business specific objectives to leadership? How cohesive and effective were our project teams? What was the overall state of worker morale?

Based on my past experiences at CNSE, my assessment was that there was much left to be desired in each of these areas. What is more, I now believe there is a systemic underappreciation of these communication skills in our institutions of higher learning, as well as on an operational level within the industrial entities receiving technical talent from them.

The importance of soft skills in the private sector

From a general perspective, the roles and importance of soft skills in the workplace have been studied for many years. In a recent paper by Bhati,¹ soft skills are broadly defined as “a mix of human skills, social skills, communication skills, personality

How do I say this? The underappreciated importance of soft skills in the fields of...

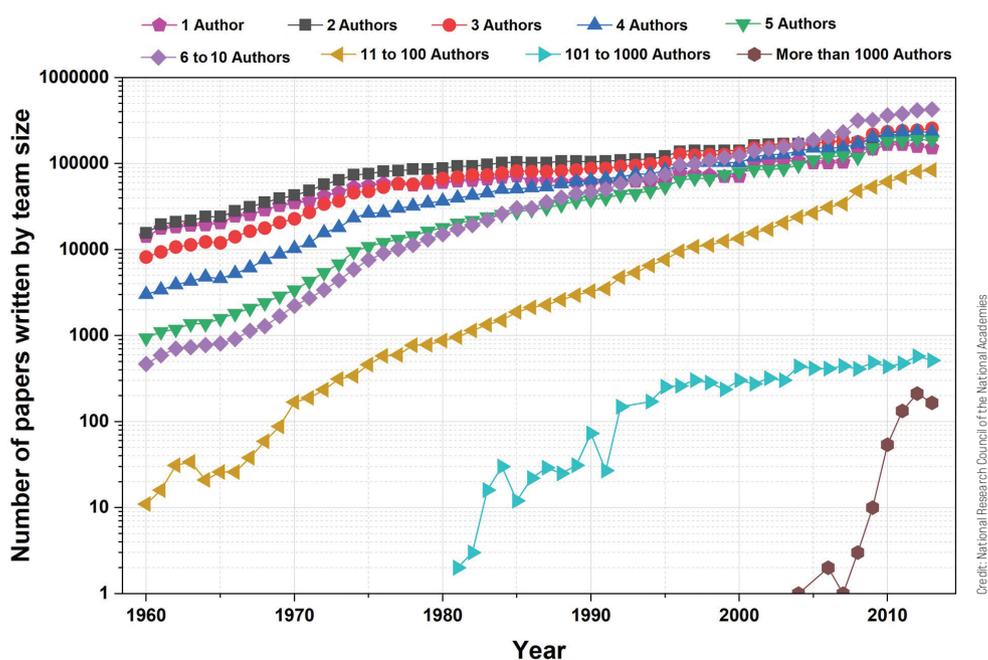


Figure 2. The number of scientific publications from 1960 to 2013 as functions of co-authorship. Plot recreated from data in Reference 4.

or personality traits, attitudes, occupational traits, and social and emotional intelligence that helps people find their environment, perform actively well, engage in teamwork, and complete tasks by applying hard skills.” If we take this definition at face value, soft skills extend beyond just the art of communication and into the basic understanding of others on occupational, emotional, and cultural levels. Also critical is the application of this understanding to the building and maintenance of functional teams with healthy and sustainable dynamics.

Professionals in the field of talent recruiting, as well as those in the management and mentorship roles responsible for retaining and developing talent, consider mastery of soft skills to be critically important. When asked by Bhati what they felt are the most important soft skills for prospective employees, human resources professionals across a diverse cross-section of industries showed a decisive preference for candidates demonstrating effective communication, leadership, and teamwork abilities (Figure 1).¹ A more expansive study from Wonderlic, the highly respected professional consulting firm, found that 93% of hiring leaders consider soft skills to be either “essential” or “very important” while many employers felt that soft skills outweigh technical skills in importance.²

These results naturally bring us to the question of how executive-level industrial leaders view the importance of soft skills in the workforce. In a study by Robles,³ executives were polled on their perceptions of the most important soft skills workers should possess in a company setting. The executives resoundingly chose communication, integrity, and courtesy as the primary qualities that they look for in their employees, confirming that not only are these types of personality traits required to gain employment but also to maintain it once there.

This focus on soft skills is mirrored by the trend toward larger and more collaborative studies taking place within the sciences. An exhaustive study published by the National Research Council of the National Academies elucidates the increased importance of collaboration and team thinking over the past several decades due to the advent of globalization and the entrenchment of the information age.⁴ A simple demonstration of this trend is shown in Figure 2, which tracks the number of scientific publications per year from 1960–2013 as functions of co-authorship. The data suggests that collaboration measured in terms of the number of co-authors per publication experienced a growth of several orders of magnitude over the past half century, where the most commonly reviewed/published papers in 2013 originated from technical teams that numbered anywhere from four to 10 members, in contrast to teams of only one or two members in 1960. It is reasonable to assume this trend has continued over the past 11 years, with the likelihood that it has accelerated.

Current approach to soft skills development for young scientists and engineers

Despite these trends, the literature suggests that science education at every level has struggled to adapt and evolve. Relevant courses in elementary through high school often expect students to work alone (simple laboratory exercises notwithstanding) with a goal of recalling learned information within the general structure of an exam.⁴ This educational philosophy is typically continued through the undergraduate level. Those who attend graduate school often do have the opportunity to work with peers, but they rarely receive any structured guidance on how to collaborate effectively.

As advanced study in any technical field requires a deep commitment to understanding the many intricacies inherent to a specific discipline, operating in an environment where a prominent level of cross-disciplinary collaboration is not encouraged—or, ideally, required—can lead to unintended consequences. Because the primary expectation for obtaining a master's or Ph.D. is the demonstration of the student's mastery of their research, the intense and singular focus required may lead to personal bias (either conscious or unconscious) toward other disciplines and those who specialize in them.⁴ Many students carry these tendencies into their first jobs, where they may find themselves ill equipped to navigate the abundance of technical and nontechnical interaction required for them to be successful. Unfortunately, studies in the literature that examine the efficacy of corporate programs and/or initiatives aimed at helping new hires adapt to their new environments are not widely available.

With this said, my own experiences coupled with personal knowledge of my colleagues' journeys from university study into industrial positions led me to believe there are enormous opportunities for growth and improvement in these areas. I have attempted to move the needle by actively encouraging my own teams to constructively challenge their own work and to seek the opinions of others both within and outside their area of expertise for valuable feedback and advice. For example, one direct report of mine had difficulty understanding why a simple report repudiating a certain line of thinking would not suffice as a deliverable and instead required them to work with those in disagreement to find common ground. The plain fact is that the building of professional networks can be invaluable tools for the scientist or engineer to ensure the robustness of their conclusions.

Addressing the issues and proposing solutions

For us in technical fields, there is good news and bad news. Starting with the bad news, there are long-standing issues that we all must admit exist and commit to finding solutions for. The good news is that the solutions are usually obvious and not difficult to implement. Some within our community have already proposed modifications to our educational approach to help address the present deficiencies in soft skills development.

Back in 2007, the late civil engineering professional Patricia "Pat" Galloway suggested in her textbook *The 21st-Century Engineer: A Proposal for Engineering Education Reform* that the prevalence of weak management and communication skills, lack of proper understanding of globalization and its impact on effective collaboration, steady reduction of requirements to obtain a four-year degree, and outdated mission statements are to blame for some of these shortcomings.⁵ She went on to suggest several corrective measures including, but not limited to, refinement of mission statements for the engineering profession to focus more on responsible dissemination and

communication of knowledge, professionalism and ethics, and the education of societal leadership on how technology can be used to improve the planet.

In the two decades since that seminal publication, significant progress has been made on some of these ambitious goals. For example, an interview-based study conducted by the Massachusetts Institute of Technology School of Engineering in 2018 found that multidisciplinary learning is increasingly seen as a fundamental skill that all engineering graduates should possess, and respondents said they expected engineering schools to increasingly focus on the development of "skills to be effective in a global environment."⁶ However, other areas that Galloway identified as being in need of improvement remain works in progress, such as the reimagining of higher education curriculum requirements to account for accelerated degree programs.^{7,8}

Although we cannot change the world overnight, the small steps we take today can improve how we communicate and collaborate with one another in the future. In my mind, we need to prioritize human interaction and cooperation while maintaining our focus on the technical mastery required within each of our crafts. There has never been a better time than now to start working together more effectively.

About the author

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Picture of ceramic tiles produced using Deklin's BioSintering technology.

Credit: Matt Jaworski, Deklin

Sustainable ceramics production: Environmental considerations in tile manufacturing

By Cathleen Hoel

Ceramics are often regarded as a sustainable material choice thanks to their high durability and chemical stability, which enable a long service life. But ceramics come with environmental baggage in other areas, such as raw material sourcing, processing, and disposal.

The specifics of this baggage are unique to each ceramic product, but in general, the ceramic tile industry serves as a prime example of sustainability challenges in ceramics manufacturing. Tiles are the top produced ceramic consumer item globally, amounting to more than 14.95 billion square meters in 2024.¹ (That is enough square meters to wrap around the Earth more than 1,200 times!) Population growth, increasing urbanization, and housing shortages drive increased tile production to meet the demand for new buildings, which amplifies the environmental concerns associated with tile manufacturing (Figure 1).

It all starts with the earth

Ceramic tiles are made from ball clay, feldspar, kaolin, and sand. While the ongoing war in Ukraine has caused geopolitical constraints on high-quality clay supplies,^{2,3} sand mining is a looming environmental crisis according to the United Nations Environment Programme.⁴

Sand is similar to water—highly abundant, but only a tiny fraction of it is useful for construction purposes. Desert sand particles are too round and impure for building materials, so coastal sand is scooped away at a rate of 50 billion metric tons a year to support the built environment.⁴

Removing marine sand greatly affects the surrounding environment—changing water currents, reducing biodiversity, increasing erosion, and reducing protection from storms. These changes exacerbate the impact of climate-related disasters.⁵

Sintering raw materials into tiles

After raw materials arrive at the factory, they are milled and spray dried into formable powders; the powders are then pressed into tiles, dried, sintered, glazed, finished, and packaged. A life cycle assessment (LCA) of three Italian tile factories estimated 13 million kg CO₂-eq for producing about 20 million square meters in 2019.⁶ That boils down to roughly 0.65 kg CO₂-eq per square meter. The sintering step alone accounted for 33% of the total production global warming potential.

Shipping and installing tiles

The LCA extended beyond CO₂-eq emissions during processing—it estimated the entire environmental impact of tile production from raw materials to end of life. It revealed shipping and installation as the most impactful stages due to our continued reliance on fossil fuel-powered vehicles for transport and the use of cementitious adhesives during installation.⁶ (Cement is a hot topic in sustainability research due to its high greenhouse gas emissions.⁷)

Disposal of old tiles

Used tiles fall under construction and debris (C&D) waste. In 2018, the U.S. generated as much C&D waste as municipal solid waste.⁸ Within the C&D waste stream, 12.3 million tons were brick and clay tile waste, of which 10.8 million tons were landfilled.

Metal oxide glazes are commonly used on ceramic tiles, and they carry the risk of leaching toxic heavy metals if not

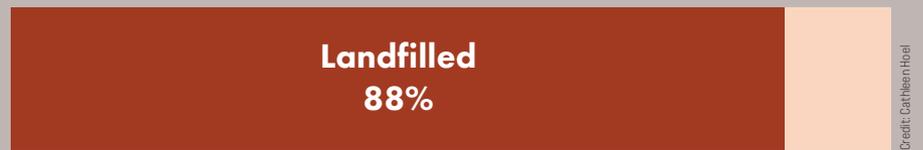
Global warming potential: **0.65 kg CO₂-eq/m²**



From mining to packaging

*Other includes pressing and drying, glaze milling and glazing and decoration, finishing and surface treatment, sorting and packing, and factory

US brick and clay tile waste: **12.3 million tons**



Credit: Cartheen Hoel

Figure 1. Ceramic tile production comes with various environmental challenges, including high embodied carbon and low reuse and recycling rates.

properly formulated, fired, or sealed.⁹ Reusing or recycling old tiles helps avoid the risk of groundwater contamination in landfills, but these options come with challenges as well.

Intact tiles can be donated for reuse, but this option requires extra handling care and grout removal. On the other hand, recycling tiles is complicated by the compositional variability across product lines, and the grout and glaze add another layer of complexity and heterogeneity. Combine that with the high energy required to break tiles down to small particles, and you can get a cost-prohibitive recycling process.¹⁰ It is no wonder, then, that tiles typically end up in landfills instead.

Innovating a sustainable ceramic lifecycle

The challenges demonstrated above through tile manufacturing are systemic to ceramics as a whole: environmental damage from mining, energy-intensive production—and all that work and beauty only to end up as a mound of shards in the landfill.

Change is needed to break this linear and energy-intensive consumption pathway, and fortunately, manufacturers are taking important steps toward efficiency using new equipment and data-driven analytics.¹¹ However, there are fundamental limits to how much current processes can be improved, and radical thinking is needed to achieve total material circularity and emissions reductions. Such paradigm-shifting activities include

- Reducing or eliminating the use of sand in tiles to reduce reliance on a critical raw material,
- Lowering the sintering temperature or completely eliminating the sintering step to reduce energy consumption,
- Using novel sustainable cementitious alternatives for installation to reduce the environmental impact during this stage,
- Developing glazes that do not contain toxic species and so avoid leaching concerns,

Sustainable ceramics production: Environmental considerations in tile manufacturing

- Eliminating the glaze or closely matching the composition to the tile to enable recycling, and
- Developing low-energy methods to break down sintered ceramics to enable recycling.

Some of the items on this list may sound like far-reaching ideas, but they are more achievable than they seem. For example, materials technology start-up Dekiln (Manchester, U.K.) has developed a processing method that eliminates the high-temperature sintering step.

“Our BioSintering technology lets us produce materials that have similar properties to ceramic tiles without the energy-intensive kiln firing step,” says Aled Roberts, CEO of Dekiln, in an email. “This bio-inspired approach is achieved by mimicking the way nature produces similar materials at low temperatures, such as seashells, tooth enamel, and pearl.

On top of reducing the energy required for processing, Dekiln uses scrap gypsum from drywalls as the primary raw material (accounts for more than 95% of the finished tile). In the U.S., 87% of drywall waste was landfilled in 2018.

“Not only does using waste gypsum further improve the green credentials by giving our tiles a high recycled content, but it also makes financial sense. Disposal of gypsum in the conventional way is costly, meaning companies are happy to pay us to take it off their hands,” says Roberts.

New technologies are harder to adopt when they require new manufacturing processes. So, at Dekiln, “Our strategy is to integrate our BioSintering process with existing ceramic tile production processes (sans the kilns)—making adoption and scale-up much cheaper and more straightforward,” says Roberts.

Learn more about Dekiln’s BioSintering process at <https://www.dekiln.com>.

About the author

Cathleen Hoel is a materials scientist and advocate for sustainability. She spent 14 years developing advanced ceramics at GE Aerospace Research Center (formerly General Electric Co.). Contact Hoel at cathleenhoel@gmail.com.

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Modeling and manufacturing challenges in the ceramics and glass industry

Ceramic and glass materials play critical roles in many aspects of today's ecosystems, from transportation and architecture to energy storage and medicine, to name a few. While these materials have been used for thousands of years, there is still much we do not understand about them, and thus there are numerous opportunities to improve their design and application.

Data-driven computer simulations have enabled rapid research and development of new materials with improved properties by reducing the need for numerous experimental samples. But mathematically modeling the relationship between a glass composition and its properties remains a challenge for several reasons, such as lack of knowledge concerning structural units for certain glass compositions and understanding how model uncertainties relate to experimental noise.

In a recent special issue review article titled "Statistical generic design of glass and optimization: Selective review on oxide glasses," Li et al. discuss the different statistical approaches for achieving composition-structure-property optimization of glass.¹ They cover the various models that tie together composition and property values, structure and property values, and also combined composition-structure-property (C-S-P) approaches, which have been used to create databases for different glass families.

The authors present several case studies for the statistical C-S-P models, covering binary alkaline earth phosphates, complex multicomponent phosphates, mixed alkaline earth aluminosilicates, and alkali-alkaline earth aluminoborosilicate glasses. They acknowledge that a validation process is needed, though, to assess the reliability of the C-S-P models when designing generic glass compositions.

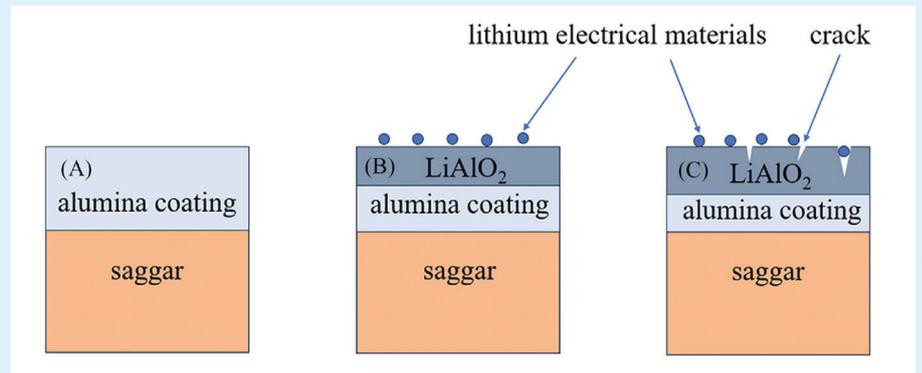


Figure 1. Schematic diagram of the corrosion mechanism of an alumina coating on a mullite-cordierite saggars: (A) original coating, (B) early-stage coating, and (C) late-stage coating.

Batteries are one application of ceramic and glass materials that have been the focus of much research and development in recent years. Currently, common cathode materials in lithium-ion batteries include layered LiCoO_2 , spinel-structured LiMn_2O_4 , olivine-structured LiFePO_4 , and ternary composite cathode materials. Preparation of these materials involves the use of a saggars, which is a specialized, high-temperature ceramic container for holding and protecting the cathode materials during the sintering/calcination process. Both oxide and nonoxide ceramics can be used for the saggars, with oxides including corundum, magnesia-alumina spinel, and mullite-cordierite types and nonoxides including graphite and silicon carbide types.

Zhang et al. cover the damage mechanisms and performance optimization methods for different types of saggars in their review article, "Mullite-cordierite saggars for sintering lithium-ion battery cathode materials: A review."² They start by discussing how the harsh operating conditions, such as high temperatures, strong alkalinity, and severe thermal shock, impact the current generation of saggars (Figure 1). They then suggest areas in which to focus future work.

They first propose developing gradient composite saggars using nonoxide ceramics to enhance thermal shock and corro-

sion resistance while also keeping costs down. They then advise designing the particle size distribution of saggars raw materials and using a two-step sintering process to achieve close packing. This structure can improve thermal shock resistance while maintaining high corrosion resistance due to the enhanced material density and bonding strength. Finally, they encourage developing high-stability coatings doped with rare earth oxides to assist stability in strongly alkaline environments and using industrial solid waste as raw materials for saggars production. This last initiative would reduce the production costs and environmental impact of lithium-ion batteries.

These articles are just two examples of the important research on grand challenges in the ceramics and glass industry that is being conducted and reported in ACerS journals. To read more, visit the ACerS journals homepage at <https://ceramics.onlinelibrary.wiley.com>.

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CERAMICS EXPO

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MAY 5-6, 2026

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BRINGING INNOVATION HOME TO CLEVELAND

Ceramics Expo returns to Cleveland, Ohio, on May 5-6, 2026. This homecoming reaffirms Ceramic Expo's position as the must-attend gathering for the industry.

"As we prepare to welcome the industry back to Cleveland for the 11th edition of Ceramics Expo, we are excited to build on the strong momentum of the past decade and continue the event's evolution as the leading meeting place for the technical ceramics and advanced materials community in North America," says Andrew A. Tucker, exhibition director.

Ceramics Expo 2026 will be supported by an expanded network of strategic partners and a strengthened technical conference program.

Register for **free*** at ceramicsexpousa.com

*Event passes must be claimed by May 4, 2026, to avoid a \$49 fee.

Ceramics Expo is North America's premier event for professionals across the technical ceramics and advanced materials supply chain.

Proudly supported by The American Ceramic Society as a Founding Partner, this annual event serves as a dynamic hub for engineers, decision-makers, and buyers to exchange technical expertise, discover groundbreaking applications, and forge connections with suppliers and manufacturers driving the latest advancements in materials, technologies, and industry trends.

"Cleveland's position as a hub for advanced manufacturing, materials science, and innovation makes it the ideal location to unite suppliers and manufacturers of ceramic engineering solutions with technical experts from electronics, semiconductors, advanced manufacturing, automotive, aerospace, and defense. As high-tech industries accelerate, Ceramics Expo remains a critical platform for collaboration, knowledge exchange, and commercial growth."

—Andrew A. Tucker, exhibition director

Advanced ceramics are revolutionizing industries such as electronics, semiconductors, aerospace and defense, electric vehicles, medical devices, and more, fueled by cutting-edge manufacturing techniques and supportive government initiatives.

Ceramics Expo 2026 offers attendees an unparalleled opportunity to explore these innovations and discover practical solutions by engaging with key suppliers from every segment of the technical ceramics and advanced materials supply chain. This year's powerhouse lineup of exhibitors includes GEO Corp Inc., Fritsch Milling and Sizing, GNPGraystar, STC Material Solutions, Lucideon, Saint-Gobain Ceramics, 3M Transportation & Energy Business, McDanel Advanced Material Technologies LLC, Huber Engineered Materials, and VERDER.

This year's fast-paced program spotlights the latest in technical ceramics and composites, from high-performance thermal management and wide-bandgap power electronics to precision laser machining, ceramic additive manufacturing, and next-generation semiconductor materials. You will also discover how industry, government, and academia are accelerating innovation through

WHAT TO EXPECT

- **State-of-the-art ceramic materials:** Discover the newest materials driving innovation across industries.
- **Advanced manufacturing processes:** Explore cutting-edge techniques such as 3D printing and precision machining designed to improve quality and reduce costs.
- **High-performance ceramic components:** See ceramic parts and solutions tailored to applications in aerospace, automotive, electronics, energy, and more.
- **Supplier and manufacturer showcases:** Meet leading suppliers and manufacturers from the upstream and midstream segments offering tailored solutions.
- **Technology demonstrations:** Witness live demos of ceramic technologies, materials testing, and product innovations pushing the industry's boundaries.



NASA tech transfer, national lab collaborations, and cutting-edge R&D. Plus, gain insights into supply chain resilience, reshoring strategies, and critical-materials challenges shaping global competitiveness.

A robust lineup of industry-leading speakers will provide valuable insights into these transformative topics, equipping attendees with the knowledge and connections needed to stay ahead in this rapidly evolving field. Featured speakers at Ceramics Expo 2026 include

- **Shawn Allan**, vice president and materials engineer at Lithoz America
- **Jon Goldsby**, branch chief at NASA Glenn Research Centre
- **Jonathan Volk**, head of strategy and innovations for in-space manufacturing and advanced materials at Star Lab
- **William Carly**, chief technology officer at MRF Furnaces
- **Katie Colbaugh**, materials science engineer at Leucite

With ACerS as a cornerstone of this event, we are proud to continue shaping the future of ceramics and advanced materials together. ■



WHO SHOULD ATTEND

- **Manufacturing engineers** seeking cutting-edge ceramic materials and innovative processing techniques.
- **Design engineers** looking for advanced ceramic solutions to integrate into end-user products.
- **Product managers** in industries such as automotive, aerospace, electronics, and energy, aiming to source high-performance ceramics.
- **Procurement and supply chain managers** sourcing materials and components for production.
- **R&D specialists** exploring new applications and developments in technical ceramics.
- **Operations directors** focused on improving efficiency and optimizing ceramic production processes.
- **Business development managers** looking for new partnerships and opportunities in the ceramics sector.

NEW FOR 2026: THE INNOVATION HUB

Discover the Innovation Hub at Ceramics Expo 2026—a vibrant, interactive space showcasing the latest advancements in ceramics, thermal materials, and engineering solutions. This dynamic area connects startups, researchers, students, and industry leaders as they unveil breakthrough technologies, spark fresh ideas, and shape the future of materials science. Key features include

- **Solutions Innovation Stage:** A dedicated platform for startup talks and product reveals across industries, featuring advanced materials pitches in a strategic location designed to maximize industry connections.
- **Student poster sessions** (new talent spotlight): Partnering with universities, this session highlights materials science students presenting research on ceramic processes, thermal conductivity, sustainability, and more. It is a unique opportunity to connect your R&D team with tomorrow's talent.
- **Live demos and testing activities:** Experience hands-on programming with live demonstrations and testing activities, including thermal conductivity and material stress testing. Engineers, designers, and decision-makers can see innovation in action.
- **Startup Zone:** A visible space for young companies to exhibit disruptive ceramic technologies, gain B2B exposure to investors and customers, and participate in the Innovation Challenge—a pitch competition judged by industry experts, offering support and prizes.

CELEBRATING A HALF CENTURY OF ENGINEERED CERAMICS AT ICACC 2026



All photos credit: ACerS

The Golden Jubilee Celebration of the 50th International Conference and Expo on Advanced Ceramics and Composites (ICACC) took place Jan. 25–30, 2026, in Daytona Beach, Fla. A record-setting winter storm swept across most of the United States right when ICACC was scheduled to begin, but fortunately, more than 760 attendees from 43 countries, including nearly 200 students, successfully traveled to the conference.

OPENING CEREMONY RECOGNIZES AWARD WINNERS AND TEASES UPCOMING COMMEMORATIVE BOOK

ICACC 2026 Program Chair Federico Smeacetto and other Engineering Ceramics Division leaders welcomed attendees to ICACC 2026 during the opening ceremony on Monday morning. They also recognized several individuals with special awards.

Joanna Wojewoda-Budka of the Polish Academy of Sciences, Reeja Jayan of Carnegie Mellon University, and Fiona Spirretti of The University of Osaka were announced as the Jubilee Global Excellence Award winners, and Lyndsey McMillon-Brown of NASA Glenn Research Center was announced as the Global Young Investigator Award winner. The five recipients of the 2026 Global Star Award were Mali Balasubramanian, Do Thi Mai Dung, Peter Kroll, Tae Ho Shin, and Taeseup Song.

Besides the award announcements, Smeacetto called out an upcoming commemorative book titled *Engineered Ceramics for Sustainable Development and Net-Zero Carbon Emissions*, which will honor the conference's 50th anniversary.

AWARD AND PLENARY LECTURES EXPLORE THE PAST AND FUTURE OF ENGINEERED CERAMICS

During the award and plenary session on Monday morning, four researchers described key developments and shared their expectations for the field of engineered ceramics.

Stanley Whittingham, Distinguished Professor of Chemistry and Materials Science and Engineering at Binghamton University, gave the 2026 James I. Mueller Lecture. His talk focused on the development and evolution of lithium-ion batteries, which he played a pivotal role in developing while working at Esso (now ExxonMobile) in the 1970s.

Shunpei Yamazaki, chairman and CEO of Semiconductor Energy Laboratory (SEL) Co., Ltd., was the recipient of the 2026 Mrityunjay Singh Bridge Building Award. His talk focused on the development of indium oxide-based semiconductors at SEL, which have the potential to enable low-power artificial intelligence systems.

Following the award lectures, the first plenary speaker, Steven Zinkle of the University of Tennessee, Knoxville, discussed the growing nuclear energy market and the role of ceramic materials in this sector. The second plenary speaker, Silke Christiansen of Fraunhofer Institute for Ceramic Technologies and Systems, discussed the complexity of modern data acquisition and analysis and overviewed the Institute's characterization and analysis capabilities.

STUDENTS ENJOY PROFESSIONAL DEVELOPMENT MIXERS, WORKSHOPS, AND COMPETITIONS

Student attendees at ICACC 2026 benefited from several events aimed at improving their professional networks and critical thinking skills.

On Sunday, the Ceramic and Glass Industry Foundation hosted the popular IGNITE MSE professional development program, which included talks by Monica Ferraris of Politecnico di Torino, Russell Maier of NIST, and Federico Rosei of the University of Trieste about their experiences navigating a career in science.

On Monday, ACerS Journals Managing Editor Brittney Hauke virtually hosted a workshop on how to write and read journal articles with the help of Amit Bandyopadhyay and Susmita Bose, editor-in-chief and editor, respectively, of the *International Journal of Applied Ceramic Technology*.

View more images from the conference on ACerS Flickr page at <https://bit.ly/ICACC-2026>. The 51st ICACC will take place Jan. 24–29, 2027, in Daytona Beach, Fla. ■



Yamazaki (center right) accepts the Bridge Building Award from the award's namesake, ACerS Past President Mrityunjay Singh (center left). ICACC 2026 Program Chair Federico Smeacetto (left) and ECD Chair Amjad Almansour (right) stand alongside them. Yamazaki holds the Guinness World Record for "Most patents credited as inventor."



Following the James I. Mueller Lecture, ACerS Past President Mrityunjay Singh (right) presented Whittingham with a diploma recognizing him as an Honorary Member of the World Academy of Ceramics. Whittingham's work on lithium-ion batteries won him and two peers the Nobel Prize in Chemistry in 2019.



This year's winning team of the Shot Glass Competition, "I Falchi Della Notte," came from Politecnico di Torino in Italy. Here they stand with ACerS President Mario Affatigato (left) after their successful drop from the very top of the lift.

UPCOMING MEETINGS



APRIL 12–17, 2026

HYATT REGENCY BELLEVUE ON SEATTLE'S EASTSIDE, BELLEVUE, WASH.

Six ACerS Divisions are collaborating to host the first-ever ACerS Spring Meeting in Bellevue, Wash. Each of the six Divisions will create its own programming, though collaborative sessions will take place as well. One registration fee will allow you access to all programming and events.

Register to attend!



MAY 31–JUNE 5, 2026

SHERATON SAN DIEGO HOTEL & MARINA, SAN DIEGO, CALIF.

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.

Register to attend!



JULY 12–16, 2026

THE RENAISSANCE CENTER, DETROIT, MICH.

Join us for the 13th American Conference on Neutron Scattering in Detroit, Mich. The conference will highlight the breadth and depth of recent world-wide research enabled by neutrons, along with the latest developments in neutron techniques and data analysis.

Register to attend!



OCT. 4–7, 2026

DAVID L. LAWRENCE CONVENTION CENTER, PITTSBURGH, PA.

The Materials Science & Technology (MS&T) technical meeting and exhibition series is a long-standing, recognized forum for fostering technical innovation at the intersection of materials science, engineering, and application.

Submit your abstract!

Calendar of events

April 2026

12 ★ Introduction to Thermal Spray Coatings: Science, Engineering, and Applications – Hyatt Regency Bellevue on Seattle's Eastside, Bellevue, Wash.; <https://ceramics.org/course/berndt-intro-thermal-spray-coatings>

12 ★ Fractography of Ceramics and Glass: An Introduction – Hyatt Regency Bellevue on Seattle's Eastside, Bellevue, Wash.; <https://ceramics.org/course/swab-fractography>

12-17 ACerS Spring Meeting – Hyatt Regency Bellevue on Seattle's Eastside Bellevue, Wash.; <http://ceramics.org/acersspring>

14-June 2 ★ Design and Failure of Refractories – Virtual; <https://ceramics.org/course/homeny-design-failure>

May 2026

4 ★ AI/ML Workshop: Transforming R&D, Manufacturing and Commercial Operations – Case Western Reserve University, Cleveland, Ohio; <https://ceramics.org/course/ai-workshop-ceramics-expo>

5-6 ➔ Ceramics Expo 2026 – Huntington Convention Center of Cleveland, Cleveland, Ohio; <https://ceramics.org/event/ceramics-expo-2026>

31 ★ Testing of Materials in Extreme Environments – Sheraton San Diego Hotel & Marina, San Diego, Calif.; <https://ceramics.org/course/hypersonic-testing-htcmc-gfmat>

26-June 4 ★ Foundations of Ceramic Processing – Virtual; <https://ceramics.org/course/carty-ceramic-processing>

31-June 5 12th International Conference on High Temperature Ceramic Matrix Composites and Global Forum on Advanced Materials and Technologies for Sustainable Development – Sheraton San Diego Hotel & Marina, San Diego, Calif.; https://ceramics.org/htcmc12_gfmat3

June 2026

1-Aug. 15 ★ Ceramic Essentials: A Technician Workshop – On-site at companies requesting the training; <https://ceramics.org/course/greschuk-ceramics-essentials>

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

8-10 Structural Clay Products Division & Southwest Section Meeting 2026 – DoubleTree by Hilton Canton Downtown, Canton, Ohio; <https://ceramics.org/clay2026>

10-12 16th Advances in Cement-Based Materials – University of Miami, Coral Gables, Fla.; <https://ceramics.org/cements2026>

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

July 2026

8-10 ➔ International Conference on Self-Healing Materials – Drexel University, Philadelphia, Pa.; <https://icshm2026.org>

12-16 ➔ American Conference on Neutron Scattering 2026 – Detroit Marriott at the Renaissance Center, Detroit, Mich.; <https://ceramics.org/acns2026>

14-18 ★ Properties and Testing of Refractories – Westerville, Ohio; <https://ceramics.org/course/homeny-properties-and-testing-refractories>

August 2026

31-Sept. 1 ➔ The International Conference on Sintering – Eurogress Aachen, Aachen, Germany; <https://www.sintering2026.org/en>

September 2026

6-11 ➔ 11th International Congress on Ceramics – Sapporo Convention Center, Sapporo, Japan; <https://www.ceramic.or.jp/icc11>

29-Oct. 1 ➔ International Thermal Conductivity Conference and International Thermal Expansion Symposium 2026 – Renaissance Columbus Westerville-Polaris Hotel, Westerville, Ohio; <https://ceramics.org/itcc2026>

October 2026

4-7 ACerS 128th Annual Meeting with Materials Science and Technology 2026 – David L. Lawrence Convention Center, Pittsburgh, Penn.; <https://ceramics.org/annual-meeting2026>

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

Entries in **BLUE** denote ACerS events.

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

★ denotes a short course

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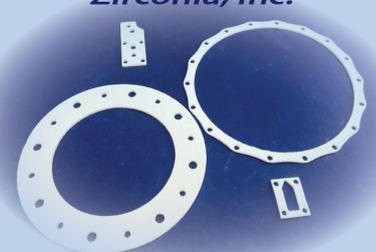
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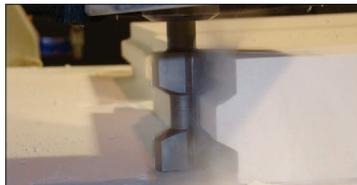
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From empiricism to algorithms: The grand challenge of AI-augmented ceramic design

For hundreds of years, humans relied on experience, intuition, and incremental experimentation to drive scientific innovation. This empirical tradition built the foundation of our modern industries.^{1,2}

But the landscape has changed. We are now developing materials and technologies that are expected to operate under increasingly extreme conditions, from the radiation-filled core of a nuclear reactor to the cold depths of outer space. Scientists and engineers must optimize numerous material properties simultaneously to ensure proper performance while also keeping sustainability metrics in mind.

To fulfill these requirements, today's ceramic systems are no longer simple binary or ternary compositions; they are multicomponent, multiphase, and application specific. Each new requirement adds another layer of complexity to an already vast compositional space, and the combinatorial space is now too large for intuition alone.

Limits of trial-and-error R&D

Traditional development workflows rely on sequential experimentation: propose a composition, synthesize, characterize, refine the experiment, repeat. Although effective in narrow domains, this approach becomes increasingly expensive and slow when design spaces involve dozens of variables, objectives conflict with one another, and/or experimental resources are limited.

Furthermore, traditional development workflows provide little quantitative understanding of uncertainty, making it hard to determine where the next most informative experiment will be. The grand challenge facing the ceramics and glass industry is therefore not simply to develop better materials but to fundamentally transform how we navigate complex materials design spaces (Figure 1).

Benefits of AI-augmented design

Artificial intelligence-augmented materials development workflows enable experimentalists to identify high-performing materials more efficiently, accelerating discovery while reducing environmental and resource costs.³ Rather than relying on random or intuition-driven experimentation, Bayesian optimization and active learning frameworks construct predictive models that explicitly quantify uncertainty. These approaches enable

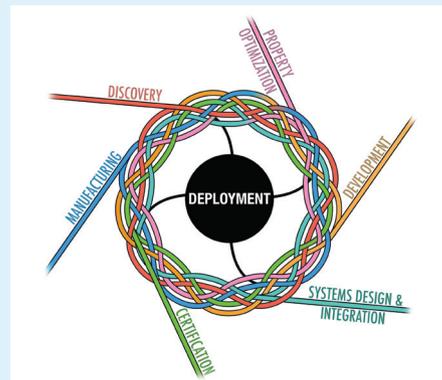
- Strategic selection of experiments,
- Simultaneous optimization of multiple competing objectives,
- Reduction in experimental burden and material waste, and
- Faster convergence to high-performing formulations.

Crucially, uncertainty-aware models do not replace domain expertise but rather amplifies it. Physics-based understanding, processing knowledge, and mechanistic insight can be integrated into models to ensure data-driven discovery remains physically meaningful.

The workforce challenge: Upskilling the professionals

Technological transformation, no matter how beneficial, brings a parallel challenge: How do we evolve the workforce toward proficiency and adoption? In the case of AI-augmented ceramics design, we must cultivate materials engineers who understand statistical reasoning, machine learning fundamentals, data curation and augmentation, and multiobjective optimization principles. Likewise, machine learning experts entering the ceramics field must appreciate phase equilibria, processing-structure-property relationships, and the realities of manufacturing.

Notably, ceramicists and materials scientists are not becoming programmers. Rather, fostering interdisciplinary literacy allows them to comfortably collaborate with algorithms as co-pilots.



Credit: Materials Genome Initiative

Figure 1. The Materials Genome Initiative, a federal multiagency initiative for accelerating materials discovery and deployment through computation and data transparency, demonstrates how AI-augmented modeling and data-driven experimentation is being used to accelerate materials discovery.

The future of ceramic design

The grand challenge before us in the ceramics and glass industry is not merely adopting new tools but also rethinking our development philosophy. By embracing AI-augmented design and investing in workforce upskilling, we can accelerate innovation while reducing cost, waste, and development time.

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