AMERICAN CERAMIC SOCIETY

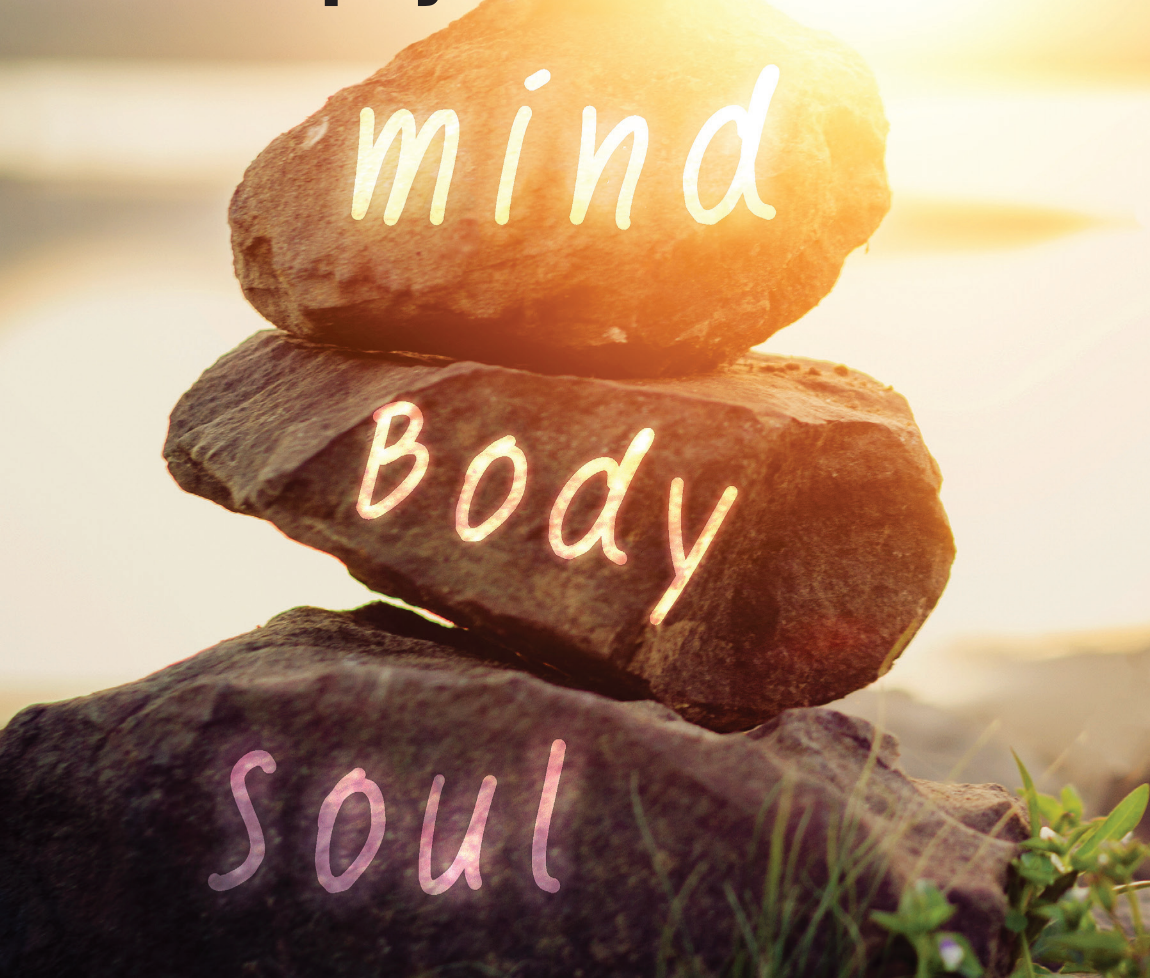
bulletin

emerging ceramics & glass technology

DECEMBER 2023

Holistic health:

How ceramics and glass contribute to our physical and mental wellbeing



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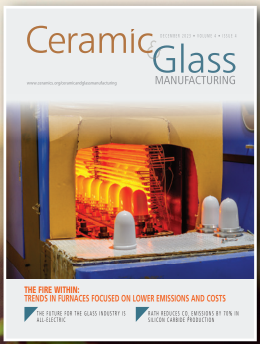

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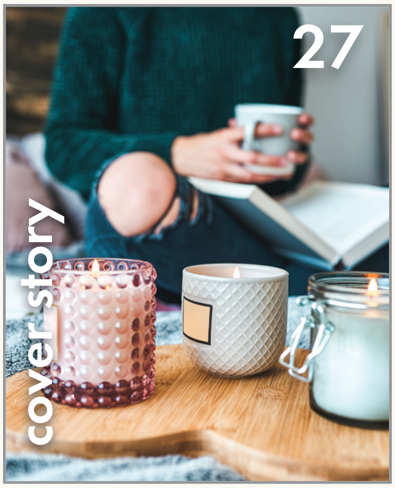

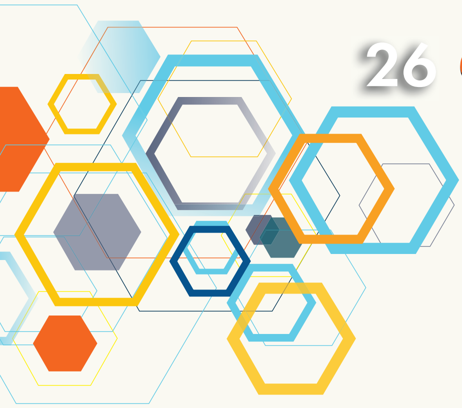

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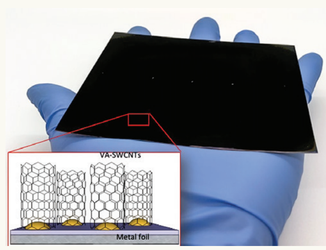


Credit: Lawrence Livermore National Laboratory

Advancements in producing carbon nanotubes on flexible metal substrates

Growing carbon nanotubes on metal foils rather than traditional silicon or quartz substrates would allow the process to be easily integrated into large-scale manufacturing processes. But metal foils present other challenges, such as reactivity at high temperatures. Lawrence Livermore National Laboratory researchers published a review paper summarizing efforts to overcome these challenges.

Read more at www.ceramics.org/nanotube-substrates

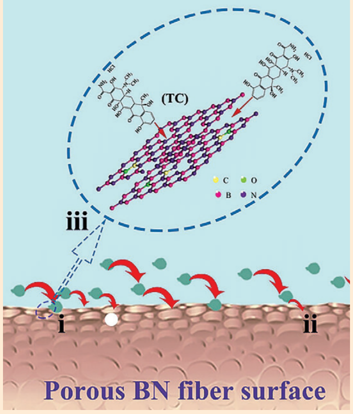
Also see our ACerS journals...

Pore size regulation of BN fibers and its effect on tetracycline adsorption
By Z. Liu, K. Zhao, D. Li, et al.
Journal of the American Ceramic Society

Characterization of hydroxyapatite from recycled fish scale and its application as a filler in a biodegradable food tray
By K. Kongthong, J. Trongnit, R. Sriwoon, et al.
International Journal of Applied Ceramic Technology

A critical review of bioactive glasses and glass-ceramics in cancer therapy
By A. Moeini, T. H. Chinijani, A. M. Khachatourian, et al.
International Journal of Applied Glass Science

Acoustic properties of piezoelectric cubic crystals
By A. Ballato and J. Ballato
International Journal of Ceramic Engineering & Science



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ACSBA7, Vol. 102, No. 9, pp. 1–64. All feature articles are covered in Current Contents.

Eileen De Guire
Editor

One chapter closes as a new chapter opens

Dear ACerS members and readers,

The time has come for me to turn the page to a new chapter in the book of my life. I will retire from ACerS at the end of December 2023. This *ACerS Bulletin* is the last with my name at the top of the masthead.

As I reflect on the already written chapters of my life, it has been an extraordinary journey. I have worked as a research ceramic engineer, consultant, and editor. Along the way, I helped myself to a 17-year sabbatical to raise four children, all busy living their best lives.

When I reentered the workforce, I found an opportunity to rejoin the community as an editor. This position has been a great fit for me, and my 20-plus years as an editor (13 years at ACerS) have been stimulating, rewarding, and a lot of fun.

Many have heard me say, “I know a little bit about everything, and not much about anything.” I find great satisfaction in hearing about your work, helping you tell your stories, and helping the broader world understand the impact of our members’ work and why it is deserving of resources.

This career has given me the opportunity to meet and work with the best minds from around the world in industry, academia, and national labs. Many of you have become cherished friends.

I am truly grateful to all who have been part of my story along the way as colleagues, supervisors, friends, and acquaintances. It would be too risky to try naming you all, but please know that I deeply value our interactions and collaborations across the arc of my career.

The next chapter at ACerS opens with two exceptionally talented women stepping into my roles.

Amanda Engen will assume the senior management role of director of communications and workforce development. She joined ACerS’ Ceramic and Glass Industry Foundation two years ago to develop and manage outreach programs. Because of her work, literally hundreds of thousands of middle and high school students know what engineered ceramics and glasses are and how they are used. She holds a Ph.D. in mass communications from the University of Florida, Gainesville, and has several years of experience teaching writing and communications and building workforce development programs. She will oversee *ACerS Bulletin* and communications operations as well as drive ACerS’ young but vibrant Learning Center for workforce development.

Lisa McDonald joined ACerS five years ago after earning two B.A.s in physics and communication studies from Coe College (Cedar Rapids, Iowa) and followed her passion to earn a master’s in science communication from Laurentian University (Sudbury, Ontario, Canada). Her undergraduate research on tellurium vanadate glasses at Coe College with ACerS Board member Mario Affatigato and an internship with the ATLAS Experiment at CERN in Switzerland made her an excellent addition to our staff. She joined ACerS as a science writer and was quickly promoted to associate managing editor of the *ACerS Bulletin*. With the Jan/Feb 2024 issue, she takes the helm as editor of the *Bulletin*, *Ceramic & Glass Manufacturing*, and *Ceramic Tech Today*.

Both Amanda and Lisa’s contact information is on the masthead. They will be happy to hear your ideas!

And my next chapter? You may still see me around a bit helping ACerS with special projects. This community is hard to leave!

With thanks and best wishes,

Eileen

Director of technical content and communications
Editor, *ACerS Bulletin* and *Ceramic & Glass Manufacturing*

Corning's contributions to space technology

To the editor:

We, as scientists who have had the privilege of working in research and development for Corning Incorporated, wish to address a significant omission in the December 2022 edition of *The American Ceramic Society Bulletin*.

In the feature article titled "Star power! How glass and ceramics push us deeper into space," the author attempts to trace the use of glass and glass-ceramics for both land and space-based telemetry as well as the use of various ceramic and ceramic composite materials used in thermal protection systems for launch vehicles and satellites. Although the author meticulously details the companies that developed and supplied materials for space applications, she regrettably overlooked the pivotal role Corning played in advancing space technology.

This glaring omission is an insult to a company with an illustrious history that began at the dawn of America's space program. In 1961, Corning's heat-resistant windows protected the first Americans sent into space in the Mercury space capsules. Corning supplied the window glass for John Glenn's historic orbit of the Earth and continued to supply every window for American-manned space shuttles. Corning's high purity fused silica (HPFS) heat-shield windows were used on the Apollo 11 Lunar Module. And more recently, Corning's HPFS was employed in the camera optics on NASA's Curiosity Rover on Mars.

Moreover, Corning's history of providing innovative materials for land-based telescopes is legendary, as exemplified by the undertaking in 1935 to produce the 200-inch primary mirror blank for the Hale Telescope located on Mt. Palomar. Since then, Corning has supplied fused silica mirror blanks for many large telescopes, including


Credit: *Am. Ceram. Soc. Bull.* 1990, 69(12):1922–24

Corning manufactured this 2.7-meter hex-sealed fused silica primary blank for the McDonald Observatory in 1965.

the Harlan J. Smith Telescope, the Lowell Discovery Telescope, and the Simonyi Survey Telescope housed at the Vera C. Rubin Observatory in Chile. Additionally, Corning has famously played a key role in the construction of telescopes used in space, notably the primary mirror blank for the Hubble Space Telescope, the Kepler Telescope, and NASA's James Webb Space Telescope, which houses three telescopes with mirrors made by Corning.

Ironically, the only mention of Corning Incorporated in the article appears in a description underneath a photo of Marvin Bolt, a curator at the Corning Museum of Glass (CMOG), who, it should be noted, has never been associated with Corning Incorporated. In the photo, Bolt is holding an early telescope from around 1650 CE. Anyone who has toured the Optics Gallery at CMOG would undoubtedly be awed by the illuminated first casting of the 200-inch Pyrex® disk. This colossal 20-ton casting, which is the centerpiece of the museum's Innovation Gallery, represents the monumental efforts that Corning's scientists, engineers, and workers have devoted to providing glass to advance celestial research.

Although only a small part of Corning's larger history in space technology, we have made personal contributions that furthered the use of glass-ceramics in space exploration. It was our privilege to invent and characterize Corning's Macor® machinable glass-ceramic, which provided shaped insulation around the Space Shuttle's windows and doors.

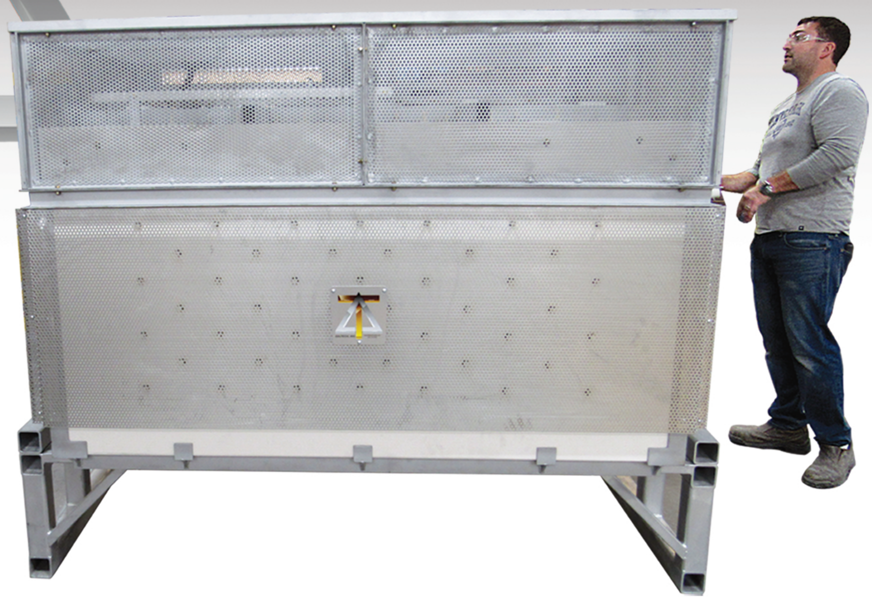
We believe Corning's story is exceptional and one to be proud of. This letter is an effort on our part to pay homage to those who's ingenuity and hard work gave us the glass and glass-ceramics that protected our astronauts and helped America's scientists peer deeper into space.

Sincerely,
George H. Beall, FACerS, DLM
David G. Grossman, FACerS, FSGT

George Beall is a Corporate Fellow in Corning's Research Group. He can be reached at BeallGH@corning.com.

David Grossman is a retired senior research associate from Corning's R&D Group. He can be reached at GrossmanDG@msn.com.

Editor's note: The editors regret that the omission of Corning's contributions to space science was, indeed, an oversight on our part. We appreciate Beall and Grossman for reminding us and our readers of the many significant accomplishments of Corning glass scientists, engineers, technicians, and production staff that enabled the advances of space science and technology. Their contributions, in no small part, have enabled the space industry that exists today and will extend into the future.



news & trends

Mitigating the spread of respiratory illnesses: DOD funds research into portable, easy-to-use breath analyzers

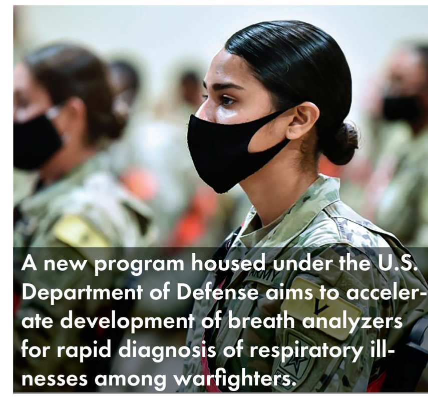
With COVID-19 infections and hospitalizations again on the rise, people's waning interest in testing is picking back up again as well. Unfortunately for us, that means a return to the dreaded days of nasal swabs, which remain the most common testing method for COVID-19.

Despite the ongoing debate over whether nasal or throat swabs are the most accurate at detecting the SARS-CoV-2 virus, people agree that neither test is very comfortable. And even the fastest version of each respective test still takes 15 minutes to confirm results—a lengthy period when mass testing hundreds of thousands of people during a global health crisis.

Instead of swabs, breath analyzers are emerging as an alternative testing method for medical diagnostics.

Breath analyzers are handheld devices that use selective gas sensing elements to detect certain chemical compounds in a person's breath. Based on the compounds detected, conclusions can be drawn about the person's physical condition.

Breath analyzer tests are easily administered—no need for intrusive sample collection—and can provide results almost immediately. These factors have made breath analyzers a key tool for law enforcement officers, who use breath analyzers during traffic stops to measure the amount of alcohol in a driver's breath.


A new program housed under the U.S. Department of Defense aims to accelerate development of breath analyzers for rapid diagnosis of respiratory illnesses among warfighters.

Credit: Jose Rodriguez (Army), U.S. Department of Defense

But researchers are working to expand the use of breath analyzers in the medical field, where it could transform how diseases and disorders are diagnosed. ACerS Fellow Pelagia-Irene (Perena) Gouma, Edward Orton, Jr., Chair in

Ceramic Engineering at The Ohio State University (OSU), has made many contributions in this area.

Gouma began exploring the use of breath analyzers for medical diagnostics in 2003, following her invention of a selective ammonia gas sensor that can discriminate and measure ammonia gas in a complex environment. Since then, she also led development on breath analyzers that can be used to diagnose the flu, sleep apnea, and COVID-19, among other diseases and disorders.

In August 2023, Gouma's expertise in breath analysis was recognized when her group at OSU was the third organization to receive funding under the U.S. Department of Defense's new EXHALE Program.

The EXHALE Program is a partnership between the Defense Department's Defense Threat Reduction Agency and Defense Innovation Unit. Launched in May 2023, it aims to accelerate development of portable, easy-to-use breath analyzers for rapid diagnosis of respiratory illnesses among warfighters.

The prototype breath analyzers developed through the EXHALE Program will be acquired by the Defense Department through an Other Transaction Authority (OTA) agreement. OTAs have been a feature of the government acquisition system for decades, but it is only recently that the Defense Department started making heavy use of this acquisition mechanism.

Per the OTA, there is potential to pursue follow-on production of the breath analyzers if the pilot project succeeds in addressing the program metrics. In anticipation of the pilot project's success, OSU formed a start-up to commercialize the technology, as reported in an OSU press release.

The other two organizations that received EXHALE funding, companies Owlstone and Detect-Ion, issued press releases detailing the prototypes they plan to develop with this funding.

Press releases

OSU press release: https://bit.ly/OSU-DOD-breath-analyzers

Owlstone press release: https://bit.ly/Owlstone-DOD-breath-analyzers

Detect-Ion press release: https://bit.ly/Detect-Ion-DOD-breath-analyzers

Ceramic materials in cosmetic and toiletry products

By BCC Publishing Staff

The global market for cosmetic and toiletry ingredients reached a value of $24.4 billion in 2020 and is expected to grow at a compound annual growth rate (CAGR) of 4.2% to reach $30.5 billion by 2026.

The cosmetic and toiletry ingredient industry is considered a segment of the overall chemical industry. This section of the chemical industry represents approximately 20% of the total chemical industry output, producing more than 5,000 different types of chemicals and compounds.

The chemicals and compounds used in cosmetics and toiletries can be classified based on the function they serve (Table 1). Among these categories, ceramic materials can be found to serve several functions.

Absorbents and anti-caking agents. Various types of silicon dioxide and magnesium silicates are used to absorb moisture and prevent caking in makeup.

Abrasives. Calcium phosphate and alumina were once used as the abrasive base of toothpastes, but they had the disadvantage of reacting with other chemical ingredients. Today, the common abrasives are silicon dioxide and titanium dioxide.

Colorants. Titanium dioxide is a white pigment that, when combined with naturally mined and synthetic iron oxides, can produce a range of colors for almost every skin type. Zinc oxide, which becomes a fluffy white powder when refined, adds a bright white color to creams, lotions, and face powders. Pearlescent pigments, or pearls, that sparkle and reflect light are often prepared by precipitating a thin layer of color onto thin platelets of mica.

Fillers. Fillers are inert, generally inexpensive materials that are used to extend and fully develop colors. Common filler materials include kaolin, talc, silicon dioxide, and mica.

Light protection. Both titanium dioxide and zinc oxide can reflect, absorb, and scatter ultraviolet rays. For this reason, they are common ingredients in sunscreen products.

Occlusives. Occlusive ingredients create a physical barrier on top of the skin to keep skin moist and hydrated. Zinc oxide is an occlusive ingredient that is used to create barrier creams.

Synthetic fragrance production. To create synthetic odoriferous compounds for use in perfumes, oxidation is a main reaction used. Manganese dioxide is often used in the oxidation process.

Nanomaterials are starting to make their way into cosmetic and toiletry products. For example, nanoscale particles of titanium dioxide and zinc oxide are used in sunscreens to increase the ability of the product to block ultraviolet radiation. Additionally, different types of nanoclays and nanocomposites are being produced and sold as barrier films.

In the future, molecular manufacturing could be employed to produce more specific and better functioning nanoparticles, which could expand the use of nanoparticles in hair and skincare products. More factors influencing the global market for cosmetic and toiletry ingredients can be seen in Figure 1.

Figure 1. Drivers and challenges in the cosmetic and toiletry ingredient industry.

Table 1. Global market for cosmetic and toiletry ingredients, by function, through 2026 ($ millions)

Function	2020	2021	2026	CAGR% (2021–2026)
Cleansers and foamers	5,088.6	5,159.8	6,187.6	3.7
Specialty additives	4,859.1	4,930.8	5,991.5	4.0
Fragrances	3,924.4	4,017.7	5,249.1	5.5
Moisturizers	3,831.7	3,904.7	4,825.1	4.3
Processing aids	4,014.7	4,043.3	4,716.1	3.1
Active ingredients	2,687.1	2,741.2	3,501.8	5.0
Total	24,405.6	24,797.4	30,471.1	4.2

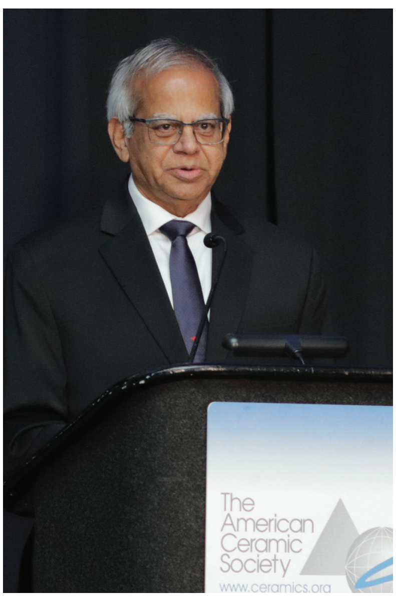
About the author

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

Resource

BCC Publishing Staff, "Global markets for chemicals for cosmetics & toiletries" BCC Research Report CHM018J, January 2022. https://bit.ly/BCC-Cosmetics-2022

SOCIETY DIVISION SECTION CHAPTER NEWS



Welcome new ACerS Corporate Partners

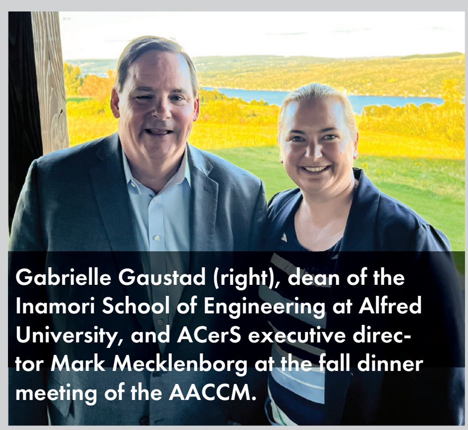
ACerS is pleased to welcome its newest Corporate Partners:

Akcoat Advanced Chemical Coating Materials

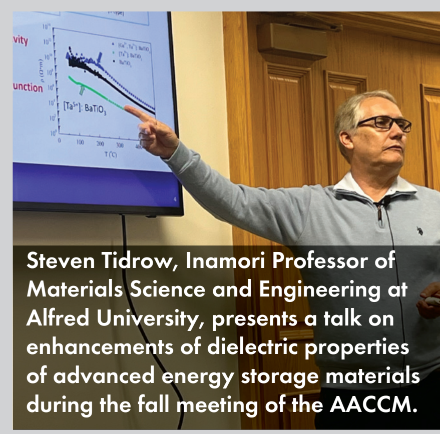
SINAPTIC Technologies

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

Alfred University hosts AACCM Fall Meeting



Gabrielle Gaustad (right), dean of the Inamori School of Engineering at Alfred University, and ACerS executive director Mark Mecklenborg at the fall dinner meeting of the AACCM.



Steven Tidrow, Inamori Professor of Materials Science and Engineering at Alfred University, presents a talk on enhancements of dielectric properties of advanced energy storage materials during the fall meeting of the AACCM.

Alfred University hosted the fall meeting of the Association of American Ceramic Component Manufacturers (AACCM) on Sept. 13–14, 2023. Approximately 20 AACCM members attended the event, which included presentations by several faculty from Alfred University's Inamori School of Engineering and tours of the Inamori School's McMahon Engineering building and local ceramics manufacturing businesses. ■

Michigan/Northwest Ohio Section attends baseball game

Members of the ACerS Michigan/Northwest Ohio Section gathered to cheer on the Toledo Mudhens as they took on the Columbus Clippers on Sept. 14, 2023. Guests gathered at The Coop and enjoyed complementary tickets into the game, along with buffet-style food service and a variety of beverages. ■

Left to right: Scott Cooper, Sekyung Chang, Beth Swiler, Bill Walker, Udaya Vempati, Daniel Johnson, and Dan Swiler.

FOR MORE INFORMATION:

ceramics.org

SoCal Section tours American Museum of Ceramic Art

The ACerS Southern California Section held a networking and social outing with a weekend visit to the American Museum of Ceramic Art in Pomona, California.

The museum has a variety of ceramic items, from mass produced steins and mugs from the 1850s, fine art ceramics from the 1950s studio pottery movement, and pieces made in recent times. Renovation is currently underway on more than half of the museum, and completion is expected next year.

After viewing the museum, the group toured the adjacent building that houses a large space for artists in residence; kilns for various standard, salt, and soda firing methods; and classroom space for workshops and introductions to clay. As engineers and scientists, the members were fascinated to see how artists leverage the chemistry and properties of clay to produce such a large variety of colors, textures, and shapes.

Large high fire sculptural work at the entrance to the museum. The natural clay makes the brown color near the bottom and a cobalt spray was used to create the blue colors on top.

Inside the artists in-residence studio: buckets of glazes, drying racks with unfired glaze ware. The large fume hoods are over two indoor kilns.

more SOCIETY DIVISION SECTION CHAPTER NEWS

Pittsburgh Section holds annual golf outing

The ACerS Pittsburgh Section held the Annual Pittsburgh Golf Outing on Sept. 11, 2023. The day boasted wonderful weather and fun for all.

The Section thanks the following hole sponsors for their support:

- Aluchem
- Chiz Brothers
- Fusion Ceramics Inc.
- Harbison Walker International
- Henry F. Teichmann
- Imerys / KT Clay
- Refractory Anchors
- Standard Ceramic
- Swindell Dressler

All proceeds from the outing go toward the Pittsburgh Sections' J. Earl Frazier Memorial Scholarship Fund, which will be awarded to a college senior majoring in ceramics, materials science, and/or engineering.

Thanks to all the winners, participants, and staff at The Links at Spring Church for helping make the outing a huge success!

a) First place: Mike Clark, Ben Burk, Tim Close, and Dave Hartwich
b) Second place: Scott Carter, Nick Kreitzer, John Sklarsky, and Bryan Kraus
c) Third place: Dan Gahagan, Lynda Harasty, and Bill Harasty

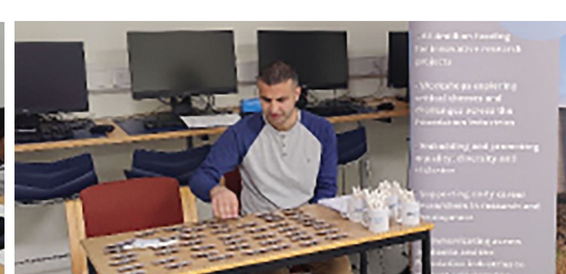
UK International Chapter co-hosts one-day meeting on 'Inorganic materials for resource and energy efficiency'

The ACerS United Kingdom International Chapter and TFIN+ co-organized a one-day meeting at the University of Sheffield on "Inorganic materials for resource and energy efficiency." The meeting, which welcomed more than 50 delegates, included speakers from the Universities of Leeds, Manchester, and Sheffield; London South Bank University; Queen Mary University London; and Johnson Tiles.

The meeting provided an excellent platform to promote knowledge and collaboration in the ceramics community. The emphasis was on resource and energy efficiency in manufacturing and application, for example, in areas ranging from low-temperature ceramic processing to improved thermal barrier coatings for more efficient jet engines.

The meeting formed part of a yearly sequence of ceramic meetings that will continue in 2024 to help the ceramics industry and community create innovative solutions toward net-zero carbon emission.

Ge Wang from the University of Manchester gave a lecture to the attendees during the one-day meeting at the University of Sheffield.



Amir Khesro prepares to greet attendees as they arrive for the one-day meeting at the University of Sheffield.

Southwest India International Chapter holds inauguration ceremony

ACerS past president Sanjay Mathur and Indian Ceramic Society president Sudipta Saha officially inaugurated the ACerS Southwest India Chapter on Sept. 22, 2023, with C. D. Madhusoodana as chair, Ravi Kumar as secretary, and S. Chandrashekar as treasurer. The event was jointly organized with the Karnataka Chapter of the Indian Ceramic Society.

In addition, a meeting on "Research-to-business (R2B) on ceramics and advanced materials—Innovative and emerging materials" welcomed 83 delegates, who listened to talks by 17 speakers from industry, government, and academia. The event ended with a panel discussion that featured nine experts deliberating on R2B barriers and ways to overcome them. ■


Group picture of meeting participants.

Inauguration of the ACerS Southwest India Chapter.


Inaugural address by ACerS past president Sanjay Mathur.


ACerS past president Sanjay Mathur, left, and Indian Ceramic Society president Sudipta Saha sign an updated memorandum of understanding between the two societies.

more SOCIETY DIVISION SECTION CHAPTER NEWS

Refractories industry takes on the carbon challenge at UNITECR 2023

The Unified International Conference on Refractories, 18th Biennial Worldwide Congress on Refractories took place in Frankfurt, Germany, Sept. 26–29, 2023. Organized by the German Refractories Association, the conference welcomed more than 1,100 attendees to hear 219 talks, view 53 posters, and talk to 34 exhibitors.

From left, with certificates, Peter Quirmbach, Christopher Parr, and Nancy Bunt were named UNITECR Distinguished Life Members during UNITECR 2023 in Frankfurt, Germany, Sept. 26–29, 2023.

©Jennifer Wolf | Industriefotografie. Used with permission.

The theme of the conference was "The carbon challenge: Steps and leaps to master the future." The program fulfilled this theme with forward-looking sessions on topics such as hydrogen fuel for steelmaking, refractory recycling, and modeling and digitalization.

"UNITECR 2023 in Frankfurt was a great success and topped our already high expectations, and I want to thank all who contributed to it! Our industry accepts the carbon challenge and works on solutions," says Andus Buhr, UNITECR 2023 president.

Besides the strong attendance, organizers were especially pleased that half of the participants were less than 45 years old and about 21% were women.

A highlight of the social program was a gala reception where ACerS Fellows Nancy Bunt and Christopher Parr were named UNITECR Distinguished Life Members along with Peter Quirmbach, a former ACerS member.

UNITECR 2025 will be held Oct. 27–20, 2025, in Cancun, Mexico. To start planning, visit www.unitecr2025.com.

Ceramic Tech Chat: John Mauro

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

In the September 2023 episode of Ceramic Tech Chat, John Mauro, Dorothy Pate Enright Professor of Materials Science and Engineering at The Pennsylvania State University, shares his experience working with glass in the worlds of industry and academia, discusses the do's and don'ts of publishing your research in journals, and talks about the similarities between scientific and fantasy fiction writing.

Check out a preview from his episode, in which Mauro describes the importance of storytelling in scholarly publishing.

"What we're trying to do with technical writing is also to tell a story. We need to motivate the story, we need to tell it in a way that flows, and we want to grab the reader from early in the process. We want to make them understand what's going on in a way that's coherent, that's interesting. We want to emphasize the key points, and we want to do it in a way that people actually like reading it. And like I said, that's usually not the case in technical writing, where it's like, 'Okay, just the facts, please.' But if you write something in a way that is enjoyable to read and provides a good reading experience, then more people will read it, and it will ultimately have a bigger impact."

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

IN MEMORIAM

Joe Cochran

L. Stanley Zielinski

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

Volunteer spotlight

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

Jamie L. Weaver is research chemist in the Material Measurement Laboratory at the National Institute of Standards and Technology. She has Ph.D. in chemistry from Washington State University, as well as a B.A. in art conservation from the University of Delaware and a B.S. in general physical science from Washington State University.

Weaver's research focus areas are the metrology of light elements (e.g., lithium, boron, nitrogen, helium, chlorine) and solid-state materials resilience. She has made contributions in the fields of cultural heritage preservation, battery chemistry, nuclear waste glass science, and glass durability. In 2021, she and colleagues received a U.S. Department of Commerce Bronze Medal Group Award for their work studying the filtration properties of cloth materials used in the production of facemasks.

Weaver is currently chair of the Art, Archeology, & Conservation Science Division.

We extend our deep appreciation to Weaver 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. The deadline is the 30th of each month.

Virginia Tech team members, from left: Leyla Nazhandali, Dwight Viehland, Jean Hereman, and Christina Rost.

Dwight Viehland, the Jack E. Cowling Professor of materials science and engineering at Virgina Tech, will serve as principal investigator of a new Sensing and Cyber Center of Excellence, which received $10 million in funding from the Department of Defense. This initiative, which includes collaborators at The Pennsylvania State University and the Army Research Laboratory, will provide numerous research opportunities for graduate students. Other ACerS members in the multidisciplinary team led by Viehland include Christina Rost (Virginia Tech) and Susan Trolier-McKinstry (Penn State). ■

AWARDS AND DEADLINES

2023 Ceramographic Exhibit

Roland B. Snow Award for Best in Show

"Glide plane" on Nb–$SrTiO_3$–by **Chukwudalu Okafor**; TU Darmstadt, Germany

Optical Microscopy category

First: *"Glide plane" on Nb–$SrTiO_3$*–by **Chukwudalu Okafor**; TU Darmstadt, Germany

Second: *Domain frosted window*–by **Oliver Preuss**; TU Darmstadt, Germany

Third: *MXene marvel on Mars*–by **Ken Aldren Usman**; Purdue University, Indiana

Scanning Electron Microscopy category

First: *SiC pumpkin*–by **Kartik Nemani**; Purdue University, Indiana

Second: *MXene nanosaurus*–by **Anupma Thakur**; Purdue University, Indiana

Third: *The Grand Canyon*–by **Joseph Wood**; University of California, Davis

Transmission Electron Microscopy category

First: *Hot air balloon trip*–by **Chao Shen**; Purdue University, Indiana

Second: *MXene anatase eagle*–by **Nithin Chandran**; Purdue University, Indiana

Third: *MXene morpho butterfly*–by **Anupma Thakur**; Purdue University, Indiana

Society awards: NEW nominations deadline: March 1, 2024
Contact: Erica Zimmerman, ezimmerman@ceramics.org

ACerS changed the Society award nominations deadline from January 15 to March 1 to allow sufficient time for nomination preparations and submissions. Society awards will be presented at the Annual Awards Banquet during ACerS Annual Meeting at MS&T in October 2024.

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

Society awards (cont.)	Description
Karl Schwartzwalder-Professional Achievement in Ceramic Engineering Award	Recognizes an outstanding young ceramic engineer whose achievements have been significant to theprofession. A nominee must be between 21 and 40 years of age, and must be a member of EPDC and ACerS.
Robert L. Coble Award for Young Scholars	Recognizes an outstanding scientist who is conducting research in academia, in industry or at a government laboratory. Candidates must be an ACerS member and must be 35 years old or younger.
Du-Co Ceramics Young Professional Award	A young professional member of ACerS who demonstrates exceptional leadership and service to ACerS.
Frontiers of Science and Society - Rustum Roy Lecture	Given each year by a nationally or internationally recognized individual in the area of science, industry, or government. Generally the committee selects the lecturer, but suggestions from membership are invited.
Edward Orton, Jr. Memorial Lecturer	Given each year by a nationally or internationally recognized individual who best represents the past tradition of the Orton Lecturer. Generally, the committee selects the lecturer, but suggestions from membership are invited.
The Navrotsky Award for Experimental Thermodynamics of Solids	Awarded biennially to an author who made the most innovative contribution to experimental thermodynamics of solids technical literature during the two calendar years prior to selection. (Next awarded in 2025)
Ross Coffin Purdy Award	Recognizes the author(s) who made the most valuable contribution to ceramic technical literature during the calendar year two years prior to the year of selection. The 2024 Purdy award is for the best paper published in 2022..
Richard and Patricia Spriggs Phase Equilibria Award	Recognizes the author(s) who made the most valuable contribution to phase stability relationships in ceramic-based systems literature during the previous calendar year (2023)..
Morgan Medal and Global Distinguished Doctoral Dissertation Award	Recognizes a distinguished doctoral dissertation in the ceramics and glass discipline. ■

more AWARDS AND DEADLINES

Class and Division awards: Nominations due Jan. 15, 21, or 31, 2024
Contact: Vicki Evans, vevans@ceramics.org

Class	Award	Deadline	Description
EPDC	Greaves-Walker Lifetime Service Award	Jan. 15, 2024	Recognizes an individual who has rendered outstanding service to the ceramic engineering profession and who has exemplified the aims, ideals, and purpose of EPDC.
EPDC	Outstanding Educator Award	Jan. 15, 2024	Recognizes outstanding work and creativity in teaching, directing student research, or in the general educational process (e.g., lectures, publications) of ceramic educators.
EPDC	Arthur L. Friedberg Engineering Tutorial and Lecture	Jan. 15, 2024	Recognizes an individual who has made outstanding contributions to ceramic engineering that relate to the processing or manufacturing of ceramic products. The awardee must be a member of both EPDC and ACerS.

Division	Award	Deadline	Description
AACS	Anna O. Shepard	Jan. 15, 2024	Recognizes an individual(s) who has made outstanding contributions to materials science applied to art, archaeology, architecture, or cultural heritage.
BSD	Early Discovery	Jan. 15, 2024	Recognizes an early career member of ACerS who has demonstrated a contribution to basic science in the field of glass and ceramics.
BSD	Robert B. Sosman Lecture	Jan. 15, 2024	Recognizes an outstanding achievement in basic science that results in a significant impact on the field of ceramics.
BIO	Young Scholar	Jan. 31, 2024	Recognizes excellence in research among current degree-seeking graduate students and postdoctoral research associates.
BIO	Global Young Bioceramicist	Jan. 31, 2024	Recognizes a young ceramic engineer or materials scientist who has made significant contributions to the area of bioceramics, for human healthcare around the globe.
BIO	Larry L. Hench Lifetime Achievement	Jan. 31, 2024	Recognizes an individual's lifetime dedication, vision, and accomplishments in advancing the field of bioceramics, particularly toward innovation in the field and contribution of that innovation to the translation of technology towardclinical use.
BIO	Tadashi Kokubo	Jan. 31, 2024	Recognizes an individual's outstanding achievements in the field of bioceramics research and development.
Cements	Early Career	Jan. 31, 2024	Recognizes an outstanding early career scientist who is conducting research in the field of cement and concrete in academia, industry, or a government-funded laboratory.
GOMD	Norbert J. Kreidl	Jan. 21, 2024	Recognizes a young engineer or materials scientist who has conducted excellent research in glass science. Nominations are open to all degree-seeking graduate students (M.S. or Ph.D.) or those who have graduated within a twelve-month period of the annual GOMD meeting.
GOMD	George W. Morey	Jan. 21, 2024	Recognizes new and original work in the field of glass science and technology. The criterion for winning the award is excellence in publication of work, either experimental or theoretical, done by an individual.
GOMD	L. David Pye Lifetime Achievement	Jan. 21, 2024	Recognizes an individual's lifetime of dedication, vision, and accomplishments in advancing the fields of glass science, glass engineering, and glass art.
GOMD	Stookey Lecture	Jan. 21, 2024	Recognizes an individual's lifetime of innovative exploratory work or noteworthy contributions to outstanding research on new materials, phenomena, or processes involving glass that have commercial significance or the potential for commercial impact.
MFG	John E. Marquis Memorial Award	Jan. 15, 2024	Recognizes the author(s) of a paper on research, engineering, or plant practices relating to manufacturing in ceramics and glass, published in the prior calendar year in a publication of the Society, that is judged to be of greatest value to the members and to the industry. ■

STUDENTS AND OUTREACH

FOR MORE INFORMATION:

www.ceramics.org/students

2024 ACerS Mentor Program applications now open

Sign up today for The American Ceramic Society's Mentor Programs!

ACerS Mentor Programs connect members in an impactful way to help them grow personally and professionally. The programs are designed to equip participants with the insight, tools, and connections necessary to make a lasting impact in their current and future career.

ACerS offers the following Mentor Programs:

- Student mentor program
- Faculty mentor program
- Industry mentor program

Space is limited. The deadline to sign up for the 2024 Mentor Programs is **Dec. 15, 2023**. Sign up at https://ceramics.org/mentorship.

ACerS GGRN—graduate student membership for ceramic and glass students

Have you made the decision to further your education by obtaining a master's or Ph.D.? If that degree includes ceramics or glass, GGRN membership is your first step on the path toward post-graduate success.

ACerS Global Graduate Research Network provides graduate students with the benefits of an ACerS membership for only $30 per year. Join ACerS as a GGRN and enjoy these benefits:

- Student leadership opportunities
- Mentorship programs
- Outreach initiatives

Visit www.ceramics.org/ggrn to learn more about what GGRN can do for you and to join.

GLOBAL GRADUATE RESEARCHER NETWORK
THE AMERICAN CERAMIC SOCIETY
CERAMICS.ORG/GGRN

CERAMICANDGLASSINDUSTRY FOUNDATION

Westerville Central students learn the science behind hot glass at Glass Axis

The sound of breaking glass fills the parking lot at Glass Axis as a group of high school students equipped with safety goggles watch, jostling each other for the best view. A graduate student volunteer then pulls the group back into focus and begins explaining the scientific principles behind the demonstration they just saw.

The high school students are from Westerville Central High School (Westerville, Ohio) and are enrolled in Jody Christy's materials science course. Christy brought nearly 80 of these students to Glass Axis in Columbus, Ohio, for an interactive field trip, which was facilitated by the Ceramic and Glass Industry Foundation (CGIF) and funded by a grant from the Westerville Fund of the Columbus Foundation.

The field trip involved three stations for the students: first, a live hot glass demonstration conducted and narrated by Glass Axis facilities manager and instructor Rose McVey; second, a panel discussion with ceramic and glass industry professionals; and third, a glass breaking demonstration with graduate students from Alfred University and a CGIF candy fiber pull demonstration that uses melted hard candy to mimic stretched hot glass.

The glass breaking demonstration involved showing the differences between tempered and nontempered glass, the stress and tension layers in glass, and the diverse ways that glass is used in society. Volunteers from The Ohio State University, Missouri University of Science and Technology, Colorado School of Mines, and GE Research also attended.


Westerville Central students watch Glass Axis facilities manager and instructor Rose McVey wield hot glass during her live demonstration.

Christy, who originally began teaching materials science when there was a course vacancy, had no idea that the field was an option when she was in school.

"I learn by hands-on, so I teach hands-on," she says. "So that's why I love the course: it's hands-on. And the best part is kids take the course because they [think] it's an easy class, and it's not that it's easy, it's just taught in a way that you don't realize you're learning."

The three-hour event, dubbed a Glass Learning Opportunities Workshop (GLOW), helped introduce materials science concepts that the students will be learning in Christy's course later this year. One of Christy's most exciting moments as a teacher is when her students use scientific concepts on their own after learning about them.

"That's the key, is they come in and they do things and then I tell them about what happened, and then later, I'll hear them use those science words again, and I'm like 'My children are learning!' And I get excited," she says.

The goal of GLOW is to increase students' awareness of glass science and materials science in general, in addition to their awareness about the potential career paths these fields offer in central Ohio.

The CGIF is grateful that the Westerville Fund of the Columbus Foundation was able to make GLOW possible for these Westerville students.

Help CGIF attract more students to the field of materials science and engineering by visiting ceramics.org/donate.


Volunteers for the GLOW event in a group photo wearing "I heart glass" t-shirts.

research briefs

Glass-coated DNA scaffolds demonstrate potential as lightweight and high-strength materials

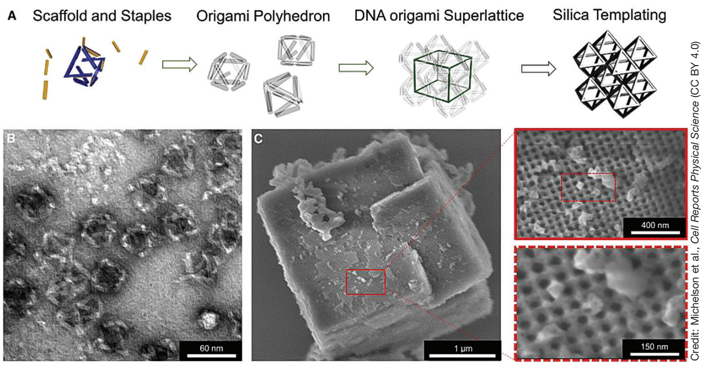


Illustration of the nanoscale-ordered frameworks formed by DNA assembly and silica templating methods. These frameworks demonstrate a high compressive strength, which puts this material at the top of the performance in its class.

Researchers at Columbia University, the University of Connecticut, and Brookhaven National Laboratory collaborated to show that glass-coated DNA scaffolds have potential as lightweight and high-strength materials.

DNA, or deoxyribonucleic acid, is the molecule that stores and transmits genetic information in biological systems. But in recent decades, researchers found they could use this molecule's unique chemical and structural properties to create programmable nanostructures for applications both within and outside of biological contexts, such as digital data storage.

Since 2006, DNA origami has emerged as one of the most promising assembly techniques in DNA nanotechnology. This technique involves using numerous short "staple" strands of DNA to direct the folding of a long "scaffold" strand. Compared to traditional assembly strategies, DNA origami scaffolds have fixed dimensions and allow for the attachment of molecules at prescribed positions.

Researchers have used DNA origami scaffolds as platforms for chemical reactions, as templates for patterning protein molecules, and for organizing single-walled carbon nanotubes, among other applications. They have also used DNA origami to construct 3D objects, not just planar structures.

The new study explored if a DNA origami scaffold could be transformed into a more stable solid-state material, namely glass.

Oleg Gang, materials scientist at Brookhaven's Center for Functional Nanomaterials and professor at Columbia University, and Brookhaven postdoctoral researcher Aaron Michelson achieved this transformation by coating the DNA origami scaffold in a thin layer of silica, only about 5 nm thick. However, it was not until they connected with University of Connecticut associate professor Seok-Woo Lee, who was a user at the Brookhaven's Center for Functional Nanomaterials, that they were able to test the glass-coated scaffold's mechanical properties.

Testing revealed that the glass-coated DNA scaffold was four times stronger than steel but had a density about five times lower. The scaffold achieved this impressive result because the glass coating did not contain any flaws, which was only possible because of the small scale.

A Columbia University press release reports that the researchers are now exploring whether carbide ceramics can be used to coat the DNA origami scaffold. They also plan to experiment with different DNA origami structures to achieve an even stronger material.

The open-access paper, published in *Cell Reports Physical Science*, is "High-strength, lightweight nano-architected silica" (DOI: 10.1016/j.xcrp.2023.101475).

Alumina and titania improve corrosion resistance of thermal barrier coatings to molten glass

Researchers from Akdeniz University and Kırklareli University in Turkey explored whether alumina and titania could improve the resistance of ceria-yttria-stabilized zirconia (CYSZ) thermal barrier coatings (TBCs) to molten glass.

When dust in the air is sucked into an aircraft engine, the solid particles can chip or fracture the TBC, which protects the engine's components from extreme heat in the combustion chamber. Worse, when the service temperature exceeds 1,150°C, these dust particles will melt and cling to the coating as molten glass.

This molten glass can lead to more severe and widespread damage than the solid particles. Over time, the molten glass will penetrate through the TBC and infiltrate the microstructure. Upon cooling, the glass will solidify, generating high stress within the TBC. This stress leads to crack initiation and propagation, which shortens the lifetime of the TBC.

To guard against this molten glass, researchers have suggested various solutions, such as laser surface modification of the TBC or adding an additional protective coating. But these methods require post processing steps, which add time and cost to the production process.

Instead, researchers have investigated ways to make the TBC itself more resistant to molten glass, such as by doping the coating with different additives. For example, yttria-stabilized zirconia (YSZ) coatings doped with alumina and titania demonstrated improved corrosion resistance in previous studies. This improvement was attributed to the additives triggering the glass to rapidly crystalize, thus stopping it from penetrating the coating.

In the new study, the Turkish researchers investigated whether these additives would improve the resistance of ceria-stabilized TBCs as well. Ceria, or cerium(IV) oxide, can be added to a TBC to decrease the mismatch between the YSZ and underlying metal layer's coefficients of thermal expansion. This reduced mismatch leads to an increased lifespan for the coating.

Testing revealed that, as in the case of YSZ coatings, the addition of alumina and titania improved the corrosion resistance of CYSZ coatings. While alumina addition alone triggered nucleation, crystallization, and solidification of the molten glass, alumina and titania collectively were required to fully stop glass penetration into the TCB.

Additionally, the researchers found that porosity of the coating was directly proportional to molten glass penetration. In other words, a decrease in coating porosity led to less molten glass entering the microstructure.

"For this reason, the coatings of gas turbine engines, which are in excessive contact with [molten glass], should be produced with less porosity to minimize the drops on thermal cycle performance," the researchers conclude.

The paper, published in *Journal of the Korean Ceramic Society*, is "Effect of molten glass on degradation of stabilized zirconia thermal barrier coatings" (DOI: 10.1007/s43207-022-00268-z).

Hydrophobic ceramic surfaces significantly reduce adhesion of simulated lunar dust

Researchers from the University of Nebraska-Lincoln and NASA Langley Research Center used a novel laser ablative patterning process to induce hydrophobicity on the surface of two ceramic materials with potential in long-term lunar surface activity: boron carbide (B_4C) and molybdenum aluminum boride (MoAlB).

Research News

Making magnetism appear in nonmagnetic materials

Researchers led by the Universitat Autònoma de Barcelona managed to modify the magnetic properties of a thin layer of cobalt nitride by applying electrical voltage without the use of wires. They placed the cobalt nitride in a liquid with ionic conductivity and applied voltage to the liquid via two platinum plates. This voltage generated an induced electric field that caused the nitrogen ions to leave the cobalt nitride and caused magnetism to appear in the sample, which changed from nonmagnetic to magnetic. For more information, visit https://www.uab.cat/web/newsroom-1345830290494.html.

3D-printed reactor core for efficient solar fuel production

In recent years, engineers at ETH Zurich developed the technology to produce liquid fuels from sunlight and air. At the heart of the production process is a solar reactor that contains a porous ceramic structure made of cerium oxide. Within this structure, a thermochemical cycle takes place for splitting water and CO_2 captured previously from the air. Using a new 3D printing technique, the engineers developed special ceramic structures for the reactor. Initial testing shows that these structures can boost the production yield of solar fuels. For more information, visit https://ethz.ch/en/news-and-events/eth-news/news/2023.html.

Lunar dust is a serious problem for space researchers. In addition to clogging equipment and tearing spacesuits, the electrostatic properties of lunar dust can interfere with survey instruments.

To keep dust from collecting on equipment, researchers have mainly focused on active mitigation strategies, such as magnetic wands and electrodynamic dust screens. But these methods require either additional structures or the adoption of new materials, which can add time, complexity, and cost to a mission.

Instead, dust mitigation can take place passively by modifying the equipment's surface to prevent adhesion of particulates. For example, engineering the surface to be hydrophobic, or water repellant, can reduce the possibility of adhesion, not only for dust but for pathogens as well.

Laser ablation, which removes material from a solid surface by irradiating it with a laser beam, is one way that researchers can engineer a surface to be hydrophobic. Numerous studies using this technique have shown that laser pulse duration and wavelength can drastically affect the laser ablation mechanisms.

In the new study, the researchers used a laser ablative patterning process that involved a picosecond-pulsed ytterbium fiber laser with a wavelength of 1,030 nm.

After patterning, the surfaces of both B_4C and MoAlB transitioned from being hydrophilic (contact angle <90°) to hydrophobic (contact angle >90°). This transition had a marked effect on dust adhesion, with both the patterned B_4C and MoAlB samples exhibiting effectively reduced dust adhesion.

However, the only slightly hydrophobic B_4C most effectively reduced adhesion of fine dusts (≤5 μm), while the near superhydrophobic MoAlB effectively reduced adhesion of all lunar dusts (up to 32 μm).

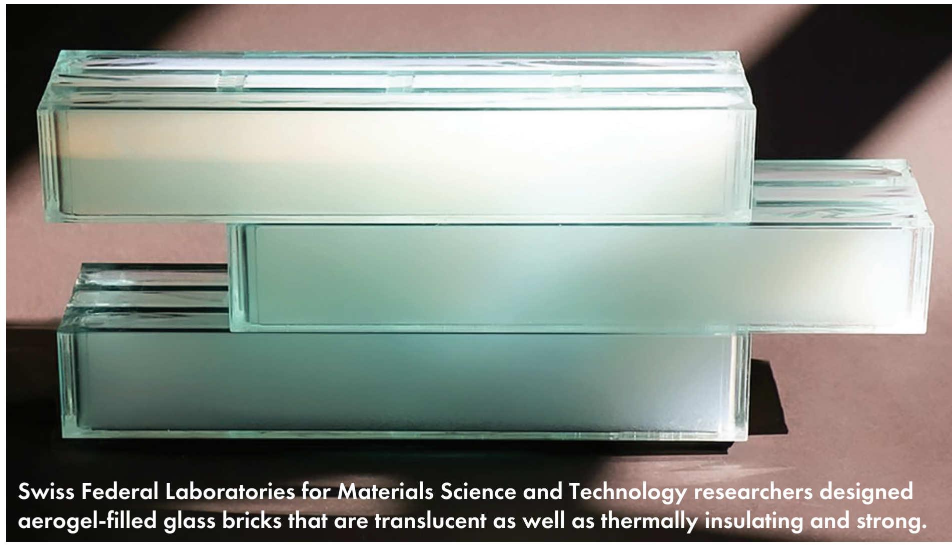
"These initial tests suggest a correlation between surface treatment and particulate adhesion," the researchers write. "The correlation will be further studied by our team to interpret the electrostatic interaction mechanisms between the hydrophobic ceramic surfaces and lunar dust simulant."

The open-access paper, published in *Journal of the American Ceramic Society*, is "Laser ablative patterning of B_4C and MoAlB ceramics for hydrophobic surfaces" (DOI: 10.1111/jace.19283). ■

Cathode active materials for lithium-ion batteries could be produced at low temperatures

Researchers at Hokkaido University and Kobe University developed a new method to synthesize lithium cobalt oxide at temperatures as low as 300°C and durations as short as 30 minutes. Lithium cobalt oxide can typically be synthesized in two forms: a layered rocksalt structure and a spinel-framework structure. The layered structure is used for the cathode in lithium-ion batteries. The new synthesis process relies on the discovery that the presence of water molecules in the starting materials significantly improves crystallinity of the end product. For more information, visit https://www.global.hokudai.ac.jp/blog/news-all. ■

Aerogel-filled glass bricks provide translucency as well as insulation and loadbearing capabilities


Swiss Federal Laboratories for Materials Science and Technology researchers designed aerogel-filled glass bricks that are translucent as well as thermally insulating and strong.

Credit: Swiss Federal Laboratories for Materials Science and Technology

Researchers from Swiss Federal Laboratories for Materials Science and Technology developed a translucent and insulating glass brick by filling it with silica aerogel.

Glass blocks can be a desirable option for maximizing natural light exposure in buildings. However, as with the energy efficiency tradeoffs that windows experience, "The design of glass blocks has not been improved sufficiently with respect to the thermal properties for decades," the researchers write in an open-access paper describing their invention.

Aerogels are ultralightweight, highly porous solids formed by replacing the liquid in a gel with a gas. They typically are made from silica, though other compositions—including carbon, metals, and organic materials—are available as well.

Aerogel is known as the "world's best insulating solid material," and it has been used to insulate industrial equipment and spacecraft since the 1990s. In the past two decades, the construction industry has adopted aerogel as well, in the form of insulating blankets and polycarbonate panels. But its use in residential and commercial buildings remains limited because of its high cost compared to traditional insulation materials, such as fiberglass and mineral wool.

The researchers' new aerogel-filled glass bricks are made from three materials: regular float glass, epoxy, and silica aerogel granulate. The glass panes are connected with epoxy spacers made from transparent epoxy resin. The cavities of the brick structure are filled with aerogel granules, which have a high optical clarity of more than 90% visible light transmittance per centimeter.

They used the open-source software THERM 7.6, a program developed by Lawrence Berkeley National Laboratory, to run 2D thermal simulations and determine the ideal brick design.

The final design consisted of four 12-mm float glass panes connected with epoxy spacers, with the side, bottom, and top faces sealed with a 1.5-mm epoxy layer. The spacers were cast directly in between the glass panes with the help of silicon molds. The brick's total dimensions were 500 mm (length) by 136 mm (thickness) by 84 mm (width).

The light transmissivity of the aerogel-filled glass bricks was estimated to be at least 38%, which is slightly lower than aerogel-filled polycarbonate panels. With such transmittivity, "a wall made of translucent bricks would provide roughly the same light transmission as a wall of the same area, where roughly 20–40% of this wall would be made of windows and the rest of an opaque material," the researchers write.

Furthermore, the measured thermal conductivity of the bricks was 53.0 mW/(m·K), which means these bricks have "the highest insulation performance reported in literature or available on the market, and at the same time adds the feature of light transmission," the researchers add.

The bricks also had a compressive strength of almost 45 MP, which suggests that, unlike aerogel-based polycarbonate panels, the bricks would be suitable for use in load-bearing structures, such as in a wall cladding with vertical loads.

Thus, "[This aerogel] glass brick combines loadbearing, daylighting, and thermal insulating function into one universal element," the researchers write.

In addition to the brick's strength, translucency, and thermal insulation properties, the researchers note that its use would reduce construction time and cost. Only a single layer of brick is required to obtain good insulating properties, and no other finishing layers are needed.

Before the bricks can be commercialized, more research is needed to optimize the brick design and cladding, as well as determine the optimal adhesive for binding the bricks together. A press release states that the researchers have filed a patent application for the aerogel-filled glass brick.

The open-access paper, published in *Journal of Building Engineering*, is "Get the light & keep the warmth–A highly insulating, translucent aerogel glass brick for building envelopes" (DOI: 10.1016/j.jobe.2022.105600).

Holistic health:
How ceramics and glass contribute to our physical and mental wellbeing

By Margareth Gagliardi

The relaxing sound of a fountain. A blue marine pool. Freshly made yogurt. The silky softness of a body cream. An enticing citrus scent. Holistic health relies on the five senses to provide a broad approach to physical, mental, and spiritual wellbeing.

Since ancient times, ceramics and glass have contributed to holistic health. For example, from the functional side, analysis of artifacts from 20,000 years ago confirmed that human beings have for millennia used clay containers of different shapes and sizes, such as vases, bowls, and dishes, to safely store, mix, cook, and serve foods and beverages.[1] They also used clay vessels to store beauty products, such as the miniature ceramic bottles that archeologists discovered from 5000 B.C.E. containing traces of cerussite and beeswax, two components of early cosmetics.[2]

Table 1. The global health and wellness market, 2022–2028 ($ in billions)*

Segment	2022	2023	2028	CAGR% 2023–2028	Source
Sport, fitness, and recreational activities	1,443.8	1,900.7	2,279.3	3.7	Ref. 5
Traditional, complementary, preventive, and personalized medicine	1,309.1	1,490.1	2,869.1	14.0	Ref. 6
Wellness tourism	814.6	923.6	1,658.4	12.4	Ref. 7
Nutrition and weight management	623.3	668.5	985.5	8.1	Ref. 8,9
Beauty and personal care	518.6	557.4	807.7	7.7	Ref. 10
Wellness real estate	343.3	417.8	1,119.2	21.8	Ref. 11
Mental wellness	148.4	160.3	232.3	7.7	Ref. 12
Workplace wellness	56.6	60.1	79.6	5.8	Ref. 13
Total	5,257.7	6,178.5	10,031.1	10.2	Refs. 3,4

*Report data was independently verified by specialty market research firm AMG NewTech (Charlottesville, Va.)

Additionally, ancient people used ceramics and glass to communicate historical and religious ideas and to express emotions. For instance, decorative ceramic and glass mosaic tiles can be found in the homes, temples, mosques, and palaces of the Roman and Byzantine Empires and Umayyad Caliphate.

In current times, ceramics and glass have gained increasing importance in the wellness sector due to their unique aesthetic and functional properties. During the last century, technological advancements, engineered materials, and innovative processes enabled new techniques aimed at enhancing aesthetics and rejuvenating health.

Recently, the wellness industry has shifted away from being a domain for the most privileged by introducing a variety of options to reach out to broader and more diverse demographics. For example, companies are marketing affordable materials and devices that can be used at home, in addition to offering customized plans that meet the needs of a given individual.

The health and wellness industry was hit hard during the COVID-19 pandemic, but that hardship ultimately generated an even stronger consumer interest in aesthetics, nutrition, health, sports and fitness, mental wellbeing, and rest and relaxation.

People are pursuing a better lifestyle by giving priority to regular physical exams, improved personal care, better diets, exercise, and outdoor activities. As a result, the global health and wellness market reached nearly $5.3 trillion in 2022 (Table 1), and it is projected to grow at a 10.2% compound annual growth rate (CAGR) to reach $10.0 trillion in 2028.[3,4]

This article reviews the main applications of ceramics and glass in the health and wellness industry (Figure 1), and it describes how ceramics and glass help fulfill the current needs of this sector.

FACTORS DRIVING DEMAND IN THE HEALTH AND WELLNESS INDUSTRY

According to the United Nations, seniors aged 65 and over are the fastest growing demographic group worldwide.[14] This segment accounted for 9% of the global population in 2019 but is expected to rise to 16% by 2050.

As people grow older, there is not only an increased need for products that prevent and treat physical and mental disorders and diseases, but there is also greater demand for cosmetics, anti-aging cream, personal care products, and procedures that help rejuvenate the body.

Men, too, are becoming larger consumers of cosmetics and personal care products in markets around the world. The Connecting the Dots 2022 report from insights firm GWI states that since 2018, beauty and cosmetic products have represented the "fastest-growing interest" among male consumers, increasing by 21% between 2018 and 2021.[15]

As a result of the COVID-19 pandemic, more people are aware of the need for products and activities that help support mental health. At the same time, many consumers of all ages are increasingly seeking out foods that are not only grown with fewer chemicals and through more sustainable methods, but foods that are cooked or processed to maintain their nutritional properties.

Other trends that shape today's health and wellness industry include

- Greater utilization of electronics and smart devices,
- Introduction of virtual and augmented reality,
- Diffusion of e-commerce for direct sales to consumers,
- Redesigning the home to incorporate health and wellness areas,
- Wider selection of amenities and services offered in spa resorts and wellness clubs to attract new customers,
- Focus on providing long-lasting experiences at these facilities,
- Reconnecting with nature through natural and sustainable products, and
- Discovering wellness practices from different cultures.

The following sections provide an overview of the various sectors of the health and wellness industry that are evolving and adapting to meet these demands. Table 2 presents a small sampling of the many companies offering products used in this industry.

SPORT, FITNESS, AND RECREATIONAL ACTIVITIES

With estimated revenues of $1.9 trillion in 2023, sport, fitness, and recreational activities currently represent the largest segment of the global health and wellness industry with 30.8%.[5]

The *ACerS Bulletin* dedicated its December 2021 issue to this large sector

Figure 1. Glass and ceramic materials have many applications in the health and wellness industry.
a) Sport, fitness, and recreational activities: wear-resistant and lightweight components, platforms for augmented and virtual reality.
b) Nutrition and weight management: cookware and tableware, countertops and backsplashes.
c) Beauty and personal care: cosmetic ingredients and containers, massage tools.
d) Traditional, complementary, preventive, and personalized medicine: bioactive and biocompatible implants, displays, vials.
e) Mental and workplace wellness: sound therapy, aromatherapy, art therapy, games, religious objects.
f) Wellness tourism and real estate: mosaics and antibacterial tiling, glass panes, heater components, biohacking.

to recognize the importance of sports in society and explain how ceramic and glass materials contribute to enhanced performance and provide safety in sports. Two major highlights from that article include

1. Sports equipment and apparel benefit primarily from the addition of carbon fibers and fiberglass to produce composite materials, and
2. Ceramic coatings are used to confer specific functionalities to sports textiles.

Currently, a main application of ceramic components in sports is as wearable sensors. Other emerging applications of ceramics in sports are for production of wear-resistant and lightweight components. For example, CeramicSpeed (Holtstebro, Denmark) manufactures silicon nitride ball bearings designed to replace traditional steel ball bearings and reduce the weight of bikes, especially those used for racing. Corrosion-resistance, durability, and performance are other distinctive qualities.

"Longevity of a well-built, high-quality ceramic bearing, in many cases, can be up to 10 times longer than commonly used stock bearings," explains Martin Banke, executive vice president at CeramicSpeed, in a *road.cc* article.[16] "The second advantage of ceramic bearings over stock steel bearings is their performance under load in reducing drag. Performance cyclists are performance driven, and all data shows that the best performing bearings for reducing drag are ceramic bearings."

MTX Braking (Salt Lake City, Utah) produces ceramic brake pads for mountain and road bikes that are more durable, quiet, and heat-resistant than conventional metallic pads (Figure 2). Meanwhile, Kogel (El Paso, Texas) manufacturers other ceramic bike parts, such as brackets and derailleur cages.

Not only bikes use ceramics. Piezoelectric ceramic components, for instance, incorporated into smart skis convert ski vibrations into electrical energy, helping to keep the skis in contact with the snow.

Glass is gaining increased importance in home fitness, specifically in the building of low-budget home gyms.[17] Floor-to-ceiling and wall-to-wall glass panes are used to create workout spaces within larger areas, such as basements, and act as noise barriers while enabling light transmission from and to surrounding rooms.[18]

HILO Smart Mirror (Montreal, Canada) has introduced two very compact smart mirrors (round and square) that can be easily mounted on every wall throughout the house. The smart

Credit: Fanatik, YouTube

Figure 2. Close-up of the MTX Braking gold label heavy-duty ceramic brake pad. A blend of Kevlar and copper fibers are embedded in the ceramic.

mirrors are made from diamond-coated glass to protect against fingerprints, dust, scratches, and water.

HILO's smart mirrors can be used as gym mirrors to check the body during a workout, amplify natural lights, and create the illusion of space. They also incorporate a display that allows the user to upload fitness apps and shows workout sessions the user can take, such as cardio and yoga classes. The smart mirror is interactive and features augmented reality and artificial intelligence software to virtually try cosmetic and hair products and purchase them electronically.

Glass and ceramic components have also become an integral part of virtual reality (VR) fitness gadgets and equipment aimed at making exercise more fun and appealing. According to the Virtual Reality Institute, a research organization studying the health impact of virtual and augmented reality,[19] "VR is not just fun exercise. It is the first generation of exercise equipment capable of meaningful live biofeedback," the organization says.

VR fitness sessions can be attended on a variety of electronic devices, including head-mounted displays, smartphones, tablets, laptops, and smart TVs. Although more in-depth studies are needed to fully assess the effects of VR, a preliminary review performed by the University of Minnesota in 2020 suggested that "VR exercise has the potential to exert a positive impact on individual's physiological, psychological, and rehabilitative outcomes compared with traditional exercise."[20]

The market for VR fitness is estimated to reach $17.4 billion in 2023, and it is forecast to have very rapid growth through 2032 with a CAGR of 31.2%,[21] as more people prefer to exercise at home and look for personalized fitness sessions.

Scratch-resistant glass, such as the Gorilla Glass made by Corning (Corning, N.Y.), is used for fabrication of smartwatches and other wearable devices designed to monitor various physical parameters, such as heart rate, blood pressure, stress level, energy expenditure, and sleep patterns.

Garmin (Olathe, Kan.) sells a complete series of smartwatches with durable glass specifically designed for sports and fitness. These wearable devices meet the needs of both amateurs and professionals and are also capable of displaying training metrics, e.g., training readiness, morning report, recovery, training tips, daily suggested workouts, and training status.

PICKLEBALL SCORES WITH THE HELP OF CERAMIC PADDLES

By Laurel Sheppard

Credit: Michael & Sherry Martin, Flickr (CC BY-NC-ND 2.0)

Pickleball is a paddle sport that combines elements of tennis, badminton, and ping-pong. It is played either indoors or outdoors on a badminton-sized court using a slightly modified tennis net.

Pickleball traces its origin to 1965, when Washington state congressman Joel Prichard and businessman Bill Bell improvised the game using assorted sports equipment to entertain their bored families. But the popularity of the sport has exploded in recent years, with a report by the Association of Pickleball Professionals estimating that more than 36.5 million people played the sport in 2022.[a]

With this increased interest in pickleball, what was once a simple wooden paddle has morphed into paddles that feature numerous high-tech designs and materials, including ceramics.

For example, the face material on a pickleball paddle determines how heavy the paddle is and what type of player should use them. Ceramic materials are often used in pickleball paddle faces, such as

- **Composite-faced paddles**, typically fiberglass reinforced, are one of the most common paddle face types. They are suitable for all levels, including power and spin players.
- **Graphite-faced paddles**, which incorporate a thin layer of graphite on the paddle's core, are lightweight and best for control players.
- **Carbon-fiber-faced paddles** are a recent addition to the game, resulting in extremely durable paddles. Thus, they are suitable for power players and those who "abuse" their paddles.
- **Hybrid-faced paddles** combine several materials, including all those previously discussed, and are suitable for all-around players.

Most pickleball paddles range in price from $60 to $230. Aluminum-faced paddles are some of the least expensive and so are a good choice for beginners or recreational players looking for an inexpensive option. Once a player decides to invest in the game, however, they may want to choose one of the other, ceramic-based options.

References

[a]J. Golden, "Pickleball popularity exploded last year, with more than 36 million playing the sport," *CNBC.* Published 5 Jan. 2023. Accessed 19 Oct. 2023. https://www.cnbc.com/2023/01/05/pickleball-popularity-explodes-with-more-than-36-million-playing.html

Table 2. Select companies involved in the health and wellness industry.*

Company (Location)	Annual revenue (millions)*	Website	Role in value chain
SPORT, FITNESS, AND RECREATIONAL ACTIVITIES			
CeramicSpeed (Holtstebro, Denmark)	$5.6	www.ceramicspeed.com	Manufacturer of ceramic bearings for bikes
Corning (Corning, N.Y.)	$14,189	www.corning.com	Manufacturer of scratch-resistant and strengthened glasses for smartphones, smartwatches, and other applications
Fitbit (San Franscisco, Calif.)	$1,210	www.fitbit.com	Producer of smartwatches and trackers for sport and fitness
Fossil Group (Richardson, Texas)	$1,682	www.fossil.com	Manufacturer of wellness smartwatches
Garmin (Olathe, Kan.)	$4,860	www.garmin.com	Producer of smartwatches and other gadgets for sport and fitness
HILO Smart Mirror (Montreal, Canada)	$1	www.hilosmartmirror.com	Producer of smart mirrors
Kogel (El Paso, Texas)	$2.1	www.kogel.cc	Manufacturer of ceramic bearing, brackets, and other components for bikes
MTX Braking (Salt Lake City, Utah)	<$1	www.mtxbraking.com	Manufacturer of ceramic brake pads
TRADITIONAL, COMPLEMENTARY, PREVENTIVE AND PERSONALIZED MEDICINE			
Apple (Cupertino, Calif.)	$394,328	www.apple.com	Manufacturer of augmented reality head mounted displays for the healthcare sector
Corning (Corning, N.Y.)	$14,189	www.corning.com	Manufacturer of container glass for the health care sector
Gerresheimer (Dusseldorf, Germany)	$1,915	www.gerresheimer.com	Producer of specialty glass for the healthcare sector
Lithoz (Vienna, Austria)	$7.9	www.lithoz.com	Producer of 3D printing equipment for ceramics for the healthcare sector
Microsoft (Redmond, Wash.)	$211,915	www.microsoft.com	Manufacturer of augmented reality head-mounted displays for the healthcare secto
Stephanie Imports (Brookline, NY)	$7	www.stephanieimports.com	Supplier of ceramic pill boxes
Vuzix (West Henrietta, N.Y.)	$11.8	www.vuzix.com	Manufacturer of augmented reality wearable displays for the healthcare sector
WELLNESS TOURISM			
Amerec (Cokato, Minn.)	$4.4	www.amerec.com	Manufacturer of commercial glass-based saunas
Atlas Concorde (Spezzano di Fiorano, Italy)	$632.4	www.atlasconcorde.com	Producer of porcelain tiles for spas and wellness centers
Daltile (Dallas, Texas)	$1,700	www.daltile.com	Producer of ceramic tiles for commercial spas and pools
KLAFS (Baden-Wuerttemberg, Germany)	$142.3	www.klafs.com	Producer of commercial and residential spas, baths, saunas, and pools
SaunaRay (Collingwood, Canada)	$1.5	www.saunaray.com	Producer of commercial saunas with ceramic heaters and glass fixtures
Sommerhuber (Steyr, Austria)	$6.6	www.sommerhuber.com	Manufacturer of ceramic loungers, massage tables, and other ceramic components for commercial spas
NUTRITION AND WEIGHT MANAGEMENT			
Bormioli Rocco (Parma, Italy)	$271.6	www.bormiolirocco.com	Manufacturer of glass for tableware
Caraway (New York, N.Y.)	$10	www.carawayhome.com	Producer of ceramic-coated nonstick cookware and ovenware
Florim (Fiorano Modenese, Italy)	$605.5	www.florim.com	Manufacturer of kitchen porcelain slabs and tiles
Iris Ceramica Group (Fiorano Modenese, Italy)	$580	www.irisceramicagroup.com	Manufacturer of kitchen porcelain slabs and tiles
Kyocera (Kyoto, Japan)	$12,443	www.global.kyocera.com	Producer of ceramic knives, nonstick coated cookware, and other kitchen tools
Schott (Mainz, Germany)	$2,951	www.schott.com	Producer of glass-ceramic cooktops
The Cookware Company (Irvington, N.Y.)	$35	www.cookware-co.com	Producer of ceramic-coated nonstick cookware and ovenware
Xtrema (Hagerstown, Md.)	$9.5	www.xtrema.com	Manufacturer of pure ceramic cookware

*Financial data obtained from most recent annual reports for public companies or estimated based on google.com for private firms.

Table 2 (continued). Select companies involved in the health and wellness industry.*

Company (Location)	Annual revenue (millions)*	Website	Role in value chain
BEAUTY AND PERSONAL CARE			
X3M (St. Paul, Minn.)	$34,229	www.3m.com	Producer of glass microspheres for cosmetics
BioMin Technologies (Stoke-on-Trent, U.K.)	$2.5	www.biomin.co.uk	Producer of bioactive-glass-based toothpaste
Groupe Pochet (Paris, France)	$512	www.groupe-pochet.fr	Manufacturer of container glass for cosmetics and personal care
Heinz-Glas (Kleintettau, Germany)	$35.1	www.heinz-glas.com	Manufacturer of container glass for cosmetics and personal care
Lavien (Pine Brook, N.J.)	$1.4	www.laviencosmetics.com	Producer of ceramic sculpting tools for Chinese medicine practice gua sha
Potters Industries (Malverne, Pa.)	$37.3	www.pottersindustries.com	Producer of glass microspheres for cosmetics
Prizmalite Industries (New York, N.Y.)	$2.5	www.prizmalite.com	Producer of glass microspheres for cosmetics
Schott (Mainz, Germany)	$2,951	www.schott.com	Manufacturer of bioactive glass
Verescence (Puteaux, France)	$432	www.verescence.com	Manufacturer of container glass for cosmetics and personal care
Vidraria Anchieta (São Paulo, Brazil)	$6.2	www.vidrariaanchieta.com.br	Manufacturer of container glass for cosmetics and personal care
WELLNESS REAL ESTATE			
TheraSauna (Bettendorf, Iowa)	$2.5	www.therasauna.com	Producer of ceramic heaters for saunas
Bardelli Group (Vittuone, Italy)	$29.2	www.gruppobardelli.com	Manufacturer of mosaic tiles for wellness areas, kitchen, bathrooms, and swimming pools
Country Floors (New York, N.Y.)	$11.6	www.countryfloors.com	Manufacturer of ceramic tiles for wellness and comfort
Gruppo Geromin (San Stino di Livenza, Italy)	$15.8	www.gruppogeromin.com	Manufacturer of home spas and saunas with glass and ceramic components
Sunray Saunas (Richmond, Va.)	$2.5	www.sunraysaunas.com	Producer of home saunas with ceramic heaters and tempered glass
MENTAL WELLNESS			
Adam Frezza & Terri Chiao (Brooklyn, N.Y.)	$3	www.eternitystew.com	Producer of ceramic puzzles
ALEA Mosaik (Munich, Germany)	$3	www.alea-mosaic.com	Producer of ceramic mosaic tiles for artwork
Alpine (Commerce, Calif.)	$33.5	www.alpine4u.com	Manufacturer of indoor ceramic fountains
Lamps Plus (Los Angeles, Calif.)	$422.2	www.lampsplus.com	Manufacturer of indoor ceramic fountains
MumGaya Ceramics (Port St. Lucie, Fla.)	$2.5	www.mumgaya.com	Producer of ceramic games
Sunnydaze Décor (Eau Claire, Wis.)	$4.4	www.sunnydazedecor.com	Supplier of ceramic wellness fountains
WORKPLACE WELLNESS			
Dezine (Mississauga, Canada)	$6.2	www.dezinecorp.com	Supplier of corporate wellness gifts made from ceramics and glass
Knack (Seattle, Wash.)	$16.4	www.knackshops.com	Supplier of corporate wellness gifts made from ceramics and glass
Loved and Found (Addison, Texas)	$0.5	www.lovedandfoundbox.com	Supplier of corporate wellness gifts made from ceramics and glass
Merchery (Brussels, Belgium)	$1.7	www.merchery.co	Supplier of corporate personalized ceramic mugs
Metron Branding (Troy, Mich.)	$2.5	www.metronbranding.com	Supplier of corporate wellness gifts made from ceramics and glass

*Financial data obtained from most recent annual reports for public companies or estimated based on google.com for private firms.

TRADITIONAL, COMPLEMENTARY, PREVENTIVE, AND PERSONALIZED MEDICINE

The market for products and services aimed at improving wellness by combining traditional, complementary, preventive, and personalized medicine is another large segment of the total health and wellness industry, with revenues estimated at nearly $1.5 trillion in 2023, corresponding to a market share of 24.1%.[6]

Industrialization, economic development of disadvantaged regions, and a growing elderly population are causing an increase in healthcare spending to treat a variety of diseases, such as cardiovascular disorders, mental illness, diabetes, and cancer, and prevent the occurrence of new medical conditions. These factors will drive the market for wellness products and service used in traditional, complementary, preventive, and personalized medicine to expand at a very rapid 14% CAGR during the next five years.[6]

Ceramics and glass occupy a very important place in traditional medicine as they have become fairly popular in the manufacturing of implantable devices, as detailed in the December 2020 *ACerS Bulletin*. In fact, as of 2023, these materials account for approximately 20% of the $178 billion biomaterials market.[22]

Unlike metals, ceramics and glass can be formulated to be inert, resorbable, or bioactive, and they have better wear resistance and biocompatibility than polymers. These properties are often needed to ensure fast patient recovery and are particularly desirable to improve the quality of life of older patients.

The advent of ceramic 3D printing, which allows for the quick fabrication of complex ceramic shapes that mimic body organs and tissues, is expected to contribute to a very strong growth of the medical ceramic market.[23] According to MarketsandMarkets, global sales of 3D-printed medical devices are projected to exceed $3 billion in 2023 and to expand at a very rapid CAGR of 17.1% during the next five years.[24]

To benefit from this growth, Lithoz (Vienna, Austria) has introduced a lithography-based ceramic manufacturing system optimized for medical applications that achieves the high precision needed to fabricate custom implants and patient-specific solutions. The system is suitable for processing ceramic materials such as alumina, zirconia, hydroxyapatite, tricalcium phosphate, and silicon nitride.

"You can now actually manufacture implants with 3D printing and generate those open, porous, interconnected networks that allow the ingrowth of the bulk of the blood vessels and the removal of metabolic products, which is important for the healing process," Daniel Bomze, director of medical solutions at Lithoz, explains in an interview with *TCT Magazine Europe*.[25] "There are other ways to shave these materials, but only additive manufacturing allows you to create the geometry of the pore and the connection between the pores."

Furthermore, ceramics and glass are gaining growing relevance in complementary, preventive, and personalized medicine. These fields are evolving toward a greater utilization of wearable devices, sensors, portable instruments, and equipment for telemedicine, and ceramics and glass can be found as integral components of all these devices.

For example, point-of-care testing (i.e., diagnostic testing that can be done at home without the need for a lab) uses microfluidic devices based on glass[26] or low-temperature cofired ceramics,[27] while piezoelectric ceramics are used for energy harvesting in wearable medical devices.[28]

State-of-the-art glass display technologies are enabling the incorporation of augmented reality in telemedicine. The combination of advanced display technology and augmented reality with other capabilities provided by artificial intelligence and 5G wireless communication is expected to bring enormous benefits in the field of remote healthcare. These technologies will ameliorate home medical care, reduce healthcare costs, improve emergency services, facilitate training of practitioners, and foster preventive medicine. For instance, Vuzix (West Henrietta, N.Y.) sells smart glasses that enable doctors to share images and communicate in real-time with other medical experts around the world.

Also noteworthy is the use of ceramics and glass for products that are less technologically advanced, such as containers for vitamins, health supplements, and prescription pills. Ceramic pill cases have been around for centuries, and, even after the advent of plastic, they continue to have their appeal as they prevent product contamination, keep pills organized, protect them from moisture, and isolate them from extreme temperatures. Pill boxes are available in a multitude of colors, handcrafted designs, shapes, and sizes.

WELLNESS TOURISM

Wellness tourism refers to travelling activities aimed at promoting individual wellbeing and preventing physical and mental disorders and diseases. Wellness

EPINEPHRINE AUTO-INJECTORS: THE GLASSY HEART INSIDE THIS LIVE-SAVING TECHNOLOGY

By Eileen De Guire

Credit: Arun Varshneya, Saxon Glass Technologies

For people who suffer from food or bee sting allergies, access to the drug epinephrine can be lifesaving. According to ClinCalc.com,[a] in 2020, 1.2 million patients received an estimated 1.7 million epinephrine prescriptions in the U.S. alone.

Because epinephrine must be administered within minutes of the onset of anaphylaxis symptoms, many patients carry epinephrine auto-injectors, which feature a borosilicate glass cartridge that contains the drug.

Saxon Glass Technologies, Inc. (Alfred, N.Y.) developed an ion-exchange glass strengthening process for the borosilicate glass cartridge. This strengthening process ensures that the auto-injectors can be filled, assembled, shipped, and carried by patients without breaking—so it will be ready to save a life.

References

[a]"Epinephrine: Drug usage statistics, United States, 2013–2020," *ClinCalc.com*. Accessed 31 Oct. 2023. https://clincalc.com/DrugStats/Drugs/Epinephrine

tourism is different from medical tourism in that the first targets prevention and general wellness, while the second focuses on medical care and treatments.

Valued at $924 billion in 2023, wellness tourism currently represents 14.9% of the total health and wellness industry market, with revenues estimated to rise at a 12.4% CAGR from 2023 to 2028.[7]

"We've heard that wellness is now at the forefront of everybody's mind, and self-care rituals are really important to everybody—and they're taking that with them when they travel," says Kenneth Ryan, vice president of global wellness and spa & fitness operations at Marriott International, in a *Hotel Business* article.[29] "This has had a profound shift in what's going on and driving powerful growth. We're seeing high demand in our spas and the best revenues ever—well over 2019—and really strong rates."

Wellness tourism can be done by staying in resorts and retreats or cruise trips that offer a broad range of activities, including yoga, meditation, weight loss and detox programs, body massages, Ayurveda therapies, spas, saunas, hot springs, Turkish baths, and thermal waterparks.

The most popular routines take place in spas and baths inspired by other cultures, mainly the ancient Romans or the Ottoman Empire. These routines typically start with a warm temperature treatment.

A tepidarium, for example, is a low-to-medium-humidity room with walls, benches, and ergonomic loungers heated to provide temperatures ranging between 35°C and 40°C (i.e., at or just a little above normal body temperature). The tepidarium allows the body to pleasantly relax, relieve stress, and regenerate, and it is generally recommended for people affected by blood circulation issues or frequent colds.

In contrast to a tepidarium, in a caldarium, the temperature of walls, floors, and benches can be regulated so that the air can reach up to 60°C while humidity can go up to 100%. These warmer and humid conditions help with muscle relaxation, make the skin softer, and soothe and detoxify the body.

The laconicum (or laconium) is similar to the caldarium but has much lower humidity, between 15% and 20%. A variant is the herbal laconicum, which features herbs warmed on stones to enhance relaxation by the addition of aromatherapy.

In contrast to these humidity-based spa rooms, saunas use dry air at very high temperatures, normally between 80°C and 100°C, to reduce stress and boost the immune system. Finnish saunas are well-known for reaching even higher temperatures, as high as 120°C.

Steam rooms combine the same high humidity as a caldarium but at the same high temperatures as a sauna. This combination of high humidity and temperature helps achieve body hydration and better blood circulation while relieving stress. Relaxation can be further boosted using aromatic oils.

KLAFS (Baden-Wuerttemberg, Germany) sells and installs a broad range of the different heat-treatment rooms described above, with many incorporating ceramic mosaics and glass.

A Turkish bath, or hammam, is composed of two sections, one that emphasizes sweating and cleansing, and the other dedicated to mental repose and tranquility. The warm or hot treatment can be followed by bathing in the cold water (12°C to 20°C) of a frigidarium to bring pores and blood vessels back to their normal size and increase blood flow.

In addition to these traditional spa setups, many routines and facilities in wellness resorts are now being designed to conform to the new trend of biohacking.

"Biohacking is the targeted autoregulation and regeneration of the body," explains Karl-Ludwig Resch of the German Institute of Health Research on KLAFS' website.[30] "Stimulating environments with heat, cold, light, movement, or current pulses create stimuli that positively influence the body in a targeted and finely dosed manner."

An example of ceramics and glass used in biohacking are the LED bulbs for red and blue light therapy. This therapeutic technique uses wavelengths of red and blue light to help treat skin conditions, such as scarring and loss of elasticity (red light) and enlarged pores and breakouts (blue light).

NUTRITION AND WEIGHT MANAGEMENT

With a global market valued at $685.5 billion in 2023, nutrition and weight management account for a substantial share of the health and wellness industry, at 10.8% of the total. This segment is also forecast to have healthy growth during the next five years with an 8.1% CAGR.[8,9]

Since ancient times, ceramics and glass have contributed to the preparation of healthy, natural, and nutritious foods and have also played a very important role in their conservation and safety. Cookware made from earthenware, stoneware, porcelain, and flameware can be found in virtually every kitchen (Table 3).[31]

Earthenware is the oldest type of pottery and is made from common clay. Sintered at low temperatures (between 950°C and 1,100°C), it is porous as well as lightweight and fragile. It is suitable for cooking at low or medium heat and can be used for slow cooking of delicate foods (e.g., gravy and sauces) or to sauté or stew vegetables and meats.

Earthenware holds an important role in many ethnic cuisines. Mediterranean fish soups, Balkan ghivetch (vegetable stew), Chinese clay pot rice (a mix of rice, meat, seafood, and vegetables), and Japanese shabu-shabu (thinly sliced meat with vegetables) are just a few examples of dishes that get their qualities from clay pot cooking. Traditional Dahi, or Indian yogurt, is prepared in a clay pot. Thanks to the capability of the porous earthenware to absorb water, the cultured milk transforms into a thick, creamy, and delicious curd.

Stoneware (Figure 4a), unlike earthenware, is manufactured from fire and ball clays (i.e., kaolinitic clays) and sintered at higher temperatures (between 1,180°C and 1,250°C). Thus, it is less porous, has a low absorbency rate (i.e., does not absorb its contents), and cooks evenly.

Porcelain (Figure 4b) is made primarily from kaolin, quartz, and feldspar and is sintered between 1,200°C and 1,450°C, obtaining a ceramic that is white, translucent, very hard, and highly dense. It has a natural nonstick surface, and these impressive properties makes porcelain more expensive than earthenware and stoneware.

Table 3. Where ceramic cookware can be used.[31]

	Microwave	Oven	Stovetop	Dishwasher
Stoneware	Yes	Yes	No	Yes
Porcelain	Yes	Yes	No	Yes
Glazed earthenware	No	Yes	Maybe	Maybe
Unglazed earthenware	No	Yes	Maybe	No
Flameware	Yes	Yes	Yes	Yes

Flameware is a relatively modern ceramic cookware product that is specially formulated to withstand the thermal shock of heating directly on a stovetop. Because of the diligent testing required to ensure safety, only a few clay manufacturers make flameware products, for example, Xtrema (Hagerstown, Md.), which specializes in pots that are 100% flameware, including the handles.

As explained by Erik Bergstrom, digital media manager at Xtrema, in an Xtrema blog post, Xtrema nonstick surfaces are more durable than traditional coated nonstick pans because the flameware is made of one solid ceramic piece. As such, there is no risk of the coating wearing away and exposing an underlying metal surface.[32]

"Many cookware materials contain harsh chemicals such as heavy metals, which can pose a risk to your family's health. For example, unlined copper pans can react with acidic foods like tomatoes or leach copper into your food," he says. "Pure ceramic is nonreactive and nontoxic, so it's completely safe for handling food. Without a metal core, there's no risk of metals leaching into your dishes."

The company's products are microwave and dishwasher safe, and they can be used on glass, electric, or gas stoves, as well as in regular ovens, toaster ovens, grills, and also in campfires and open fires.

Safety cannot be neglected when preparing food. Materials selection must be aimed at preventing transfer or leaching of chemicals from the pot to the meal. For this reason, more attention is being paid to eliminating potentially toxic compounds from ceramic glazes, such as lead and cadmium.

Also in recent years, nonstick cookware based on ceramic coatings has grown as a popular alternative to the traditional nonstick pans coated with per- and polyfluoroalkyl (PFAS) chemicals, which are known to cause serious health issues if inhaled or consumed following degradation of the coating. Advanced nonstick ceramic coatings have been enabled by the introduction of nanomaterials, such as silica and titania nanoparticles and nanoclays.

Ceramic tableware is evolving toward becoming not only more functional but also serving as a way to bring art to food. Potters are coordinating with chefs to create bowls, dishes, and other utensils that enhance food appearance while being in harmony with the atmosphere of the dining area and its ethnic or cultural setting.[33]

Credit: a) Public domain image, in the collection at Germanisches Nationalmuseum

Credit: b) Public domain image, in the collection at Cleveland Museum of Art

Figure 4. Examples of stoneware and porcelain. a) Böttger stoneware teapot, b) Meissen porcelain teapot.

Besides cookware and tableware, ceramics are present in the kitchen in other forms. Kyocera (Kyoto, Japan), for example, is well-known for producing ceramic kitchen knives (Figure 5).

Ceramic tiles find application not only as flooring material but also for walls, countertops, and backsplashes. Porcelain slab countertops are being used to replace granite and engineered stone and represent the fastest growing segment of the U.S. countertop market.[34]

Florim (Fiorano Modenese, Italy), for instance, produces porcelain tiles and slabs as large as 63 inches by 125 inches, with thickness up to 2 cm. These tiles and slabs come in different textural effects (e.g., marble, stone, wood, and metal), colors, and styles (e.g., classic, retro, and futuristic).[35]

In addition to ceramics, glass is very common in the kitchen, and not just as drinking glasses and bottles made from soda–lime–silica formulations. For example, though much of today's glass bakeware is thermally strengthened soda–lime–silica glass, some manufacturers, mostly from outside the U.S., still manufacture borosilicate glass bakeware. Borosilicate glass is a material characterized by a low coefficient of thermal expansion, good chemical resistance, and higher melting point than soda–lime–silica glass.

Figure 5. A sampling of the ceramic kitchen knives produced by Kyocera.

Figure 6. The Schott CERAN brand of glass-ceramic cooktops has been named Brand of the Century four times by the ZEIT publishing group, in 2013, 2016, 2019, and 2022.

Corning pioneered glass-ceramic bakeware with the CorningWare product line following S. Donald Stookey's discovery of recrystallization in the lithium silicate glass system in the 1950s. Today, glass-ceramics also find use as flat cooktops, which are used to transfer heat from radiant or induction burners. Glass-ceramic cooktops are gaining increasing market share as more consumers convert from gas stoves to avoid relying on fossil fuels. Schott (Mainz, Germany) is a major player in this area (Figure 6).

Induction cooktops are gaining in popularity because they are more energy efficient than other types of stoves, heat faster, and their response time to temperature adjustments is shorter. They consist of an electric coil placed below the cooktop that creates an electromagnetic field, which interacts with the magnetic cookware to generate heat.

The main drawback of induction cooktops is that cookware used on it must be magnetic, which means that only some types of cookware are suitable for this type of burner, such as cast iron (with and without enamel) and stainless steel with low nickel content. Aluminum, copper, glass, and ceramic cookware cannot be used with induction cooktops.

At the present time, induction cooktops have a share of only 8% of the total cooktop and range market,[36] with global revenues estimated to reach $24.1 billion in 2023. But their sales are forecast to rise at a healthy CAGR of 8.3% through 2028.[37] To take advantage of this market growth, some producers of porcelain slabs, such as SapienStone, a subsidiary of Iris Ceramica Group (Fiorano Modenese, Italy), are integrating induction cooktops into their slabs.

Ceramic materials are also used as additives in food. For example, titanium dioxide is used to enhance the white color or opacity of food products. Silicon dioxide is added to serve as an anticaking agent (avoid clumping).

BEAUTY AND PERSONAL CARE

Beauty and personal care currently represent 9.0% of the health and wellness industry, with global revenues estimated to reach $557.2 billion in 2023 and growing at a 7.7% CAGR through 2030.[10]

Both glass and ceramics find use in this sector for their unique functional and aesthetic properties (see the article "Ceramic materials in cosmetic and toiletry products" on page 8 of this issue). For example, borosilicate glass has long been used as a bulking agent in the form of flakes, either uncoated, silicone-coated, or combined with various pigments.

Another common glass form is represented by microspheres, that is, microscopic rounded particles with diameter ranging from 1 micron to 1,000 microns. They are added to creams, lipsticks, skin care lotions, foundations, and eye shadows to improve their rheology and create a soft and silky texture. In addition, they blend well with other ingredients, contributing to a natural look, and have a slight abrasiveness suitable for exfoliation and scrubbing. Plus, they scatter light, making small skin imperfections and wrinkles less visible. Hollow microspheres are less transparent than the solid ones, but they are preferred when there is also a need to enhance emulsification of oil or fat-based formulations.

A common method for producing glass microspheres is by ejecting very fine glass powder through a gas flame; as the viscosity of the glass decreases, surface tension causes the particles to become rounded. Hollow microspheres are obtained with a similar process, but a blowing agent such as sodium sulfate or sodium silicate is added to the glass powder.

Glass microspheres for cosmetics and personal care can be manufactured from different types of glass, including soda–lime–silica formulations, borosilicate, and bioactive glass. Prizmalite Industries (New York, N.Y.), for example, produces highly transparent soda–lime–silica microspheres with an average diameter of between 3 microns and 6 microns and very tight particle distribution. They are very effective for disguising wrinkles and skin imperfections and for reducing gloss in foundations and eye shadows.

"Most materials are composed of particles of irregular or uneven forms [crystalline structures]. These uneven 'surfaces' reflect light as diffuse reflection, where the reflected light bounces off randomly and in all directions," the Prizmalite website states.[38] In contrast, glass has a smooth surface, so light only transmits or reflects in a consistent direction and angle. Thus, it "fools" the eye and "disguises any underlying wrinkles, discoloration, or uneven pigmentation," according to the Prizmalite website.

By comparison, 3M (St. Paul, Minn.) sells solid microspheres made from amorphous magnesium silicate with an average diameter of 5 microns. These white microspheres are ideal for producing creams as they create low friction, are easily dispersible, allow for high solid loading, and can be surface treated. Another example is Potters Industries (Malverne, Pa.), which supplies calcium aluminum borosilicate microspheres with mean diameters of 11 microns and high chemical resistance with low alkali leaching.

The microsphere market is projected to reach $7.3 billion in 2023 and grow at a CAGR of 9.1%.[39] The cosmetics industry will be one of the most significant segments driving industry growth in the U.S. because this country is the largest beauty market worldwide, with the presence of many major cosmetic brands.

Bioactive glass also finds application in many cosmetics and personal care products, including anti-aging creams, antibacterial soaps, make-up, deodorants, skin care products, sunscreens, and nail polishes. Bioactive glass can be used for various functions, such as antimicrobial agents, anti-oxidative components, skin-soothing ingredients, anti-wrinkle aids, anti-odor additives, protective materials against high temperatures and ultraviolet radiation, and nail strengthener.

Schott (Mainz, Germany), a world leader in specialty glass, offers calcium sodium phosphosilicated bioactive glass powder produced in dedicated glass melting tanks and grinding facilities to ensure the high purity requested for cosmetic applications. The company also offers a mica-based version formulated to improve dispersion and enhance aesthetics.

Bioactive glass is also an ingredient in some toothpaste brands. In 2021, BioMin Technologies (Stoke-on-Trent, U.K.) received FDA clearance to sell its bioactive glass toothpaste in the U.S., although it had been available in other countries for more than a decade.

During brushing, BioMin's bioactive-glass-based toothpaste dissolves in saliva and forms fluoroapatite, an acid-resistant mineral layer that coats the tooth surface, strengthening the enamel and reducing tooth sensitivity. The company also sells an alternate version in which chlorine replaces fluorine. This product generates a hydroxyapatite layer very quickly, but the film is less resistant to acids.


Credit: Fraîcheur Ice Globes, YouTube

Figure 7. Fraîcheur Ice Globes, an example of a borosilicate glass face-massaging tool.

Spherical face-massaging tools made from borosilicate glass are becoming quite popular (Figure 7). Borosilicate ensures resistance to a wide range of temperatures, which allows the tools to be cooled in the refrigerator or immersed in hot water. Thanks to their perfectly rounded shape, these tools can be easily rolled on the skin. They are marketed as being able to improve blood circulation; remove fine lines, eye bags, and dark circles; soothe the skin; shrink pores; and repair sunburns.

Glass cups are also sometimes used in cupping therapy, though durable silicone or plastic cups are more common because they can more easily be moved in stroking sweeps across the body.

Glass is one of the most important materials for packaging of cosmetics and personal care products. In fact, the glass cosmetic packaging market was valued at $5.2 billion in 2022,[40] of which $3.5 billion is accounted for by glass bottles (67.3% of the total),[41] and this market is projected to grow at a 4.4% CAGR through 2032.

With its inertness, lack of porosity, and impermeability, glass ensures formulation stability. It can be manufactured in gloss or matte finish and in clear, blue, green, amber, and other colors. Additionally, it can be easily molded in a variety of shapes and sizes, such as perfume bottles, jars for creams, nail polish bottles, and painted containers. Containers offer many options in terms of lids and closures (plastic, wood, cork, ceramic, and metal) allowing for the creation of articles that range from being relatively inexpensive to high-end luxury products.

Ceramics also have some relevant applications in the beauty and personal care industry, such as serving as packaging material. One of the most captivating features of ceramics is that they can be made with different compositions (porcelain, earthenware, composites), formed into very complex shapes, and painted or glazed to achieve a multitude of colors. After they are emptied from their content, ceramic containers can be recycled as art or decorative objects or for other uses (e.g., office supply organizers, candle holders, pots for plants, candy boxes).

In addition to their aesthetic qualities, ceramics have a number of functional properties that come in handy in a range of applications, such as: bowls and spatulas for preparing beauty recipes (e.g., facial masks and skin creams); cleaning tools for make-up brushes; anti-slip soap dishes; make-up organizers; dispensers and closures for bottles and jars; stylish nail files for manicures and

Figure 8. In these screenshots from a video by Sun Stream Infrared Saunas owner Kevin Halsey, he overviews the types of heaters used in infrared saunas, including ceramic tubes (a) and carbon panels (b).

Credit: Sun Stream Infrared Saunas, YouTube

pedicures; foot files for softening rough and dry skin; wear-resistant nail drill bits for shaping natural and acrylic nail tops; porcelain heating elements for hair straightening irons; and heated round hair brushes to reduce static electricity.

Ceramics also find application in some ethnic cosmetic practices. Gua sha, for example, is a Chinese traditional healing technique that uses ceramic sculpting tools to massage and slightly scrape the skin with the purpose of improving blood flow and lymphatic drainage. Gua sha can be applied to a person's face to remove surface impurities and wrinkles and achieve a better skin complexion, or to other parts of the body to relieve pain and stiffness.

Clay facial masks are also a popular product in the cosmetic and personal care industry, with silica, alumina, potassium oxide, and calcium oxide being common components in these masks.[42]

WELLNESS REAL ESTATE

Wellness real estate refers to structures designed and built to ensure holistic wellbeing for their residents. This sector is projected to generate global revenues of $417.8 billion in 2023, corresponding to 6.8% of the total health and wellness industry, and is the fastest growing segment with a CAGR of 21.8% through 2028.[11]

In the near future, more new homes and communities are expected to incorporate wellness elements such as gyms, saunas, spas, and pools. As discussed earlier, ceramics and glass are fundamental for the construction of these amenities and to achieve a better performance.

For example, ceramics can be found in lamps for infrared saunas. Infrared saunas use heaters to emit radiation in the near or far infrared spectrum, which are needed to evaporate water from the human body. By comparison, traditional saunas use hot air and steam to heat the body by convection and conduction. As such, infrared saunas are more effective in transforming heat into body energy, providing health benefits such as improved blood circulation, faster muscle recovery, joint pain relief, and stress reduction.

The heaters used in infrared saunas are typically made from either ceramics or nanostructured carbon fibers (Figure 8). Ceramic heaters are less expensive than carbon heaters, but carbon heaters are generally considered more efficient and durable, with heat penetrating deeper into the skin.

Some manufacturers have introduced high-performance ceramic heaters to eliminate some of these drawbacks. For example, TheraSauna (Bettendorf, Iowa) produces a solid ceramic heater rather than a conventional tubular ceramic. The heater is characterized by a 96% conversion efficiency and can be regulated to reach any temperature between 50°C and 230°C. By comparison, carbon fiber heaters do not have a temperature controller and typically operate only at 110°C.

Many homes constructed with wellness in mind incorporate glazed ceramic tiles to enhance hygiene. Ceramic tiles are easy to clean, help keep bacteria away, and do not release volatile organic compounds. In addition, they are available in a large selection of shapes, colors, and patterns, and can be used to create the desired atmosphere in every room, thus increasing the sense of comfort.

Tiny mosaic tiles are particularly well-suited to provide special effects. Appiani, a subsidiary of Bardelli Group (Vittuone, Italy), manufactures ceramic mosaics using the single press kiln firing technique, which consists of dry pressing together enamel and clay powders before sintering. This approach allows the company to obtain tiles with unique aesthetic appeal as well as high resistance to various environmental conditions, including wear and abrasion, impact, winds, and frost.[43]

Additionally, Appiani has introduced a patented antibacterial mosaic technology that removes 99.9% of bacteria from treated surfaces.

Mosaics are also popular for hydrotherapy pools. These pools combine warm water with hydro massages to provide relief from physical and mental conditions, such as muscular stiffness, back pain, arthritis, and anxiety.

MENTAL AND SPIRITUAL WELLBEING

With global revenues estimated to reach $160.3 billion in 2023, mental wellness represents a relatively smaller share of the total health and wellness industry with 2.6%. This segment is forecast to have fairly good growth through 2028 with a CAGR of 7.7%.[12]

Several holistic practices can be employed to achieve mental and spiritual wellbeing. Recently, sound healing has been rediscovered to promote relaxation and improve mental strength. Sound can be in the form of music or atypical tones, such as those produced by chimes or fountains. Small ceramic fountains that feature a gentle water cascade have become fairly common to provide a calming and soothing effect.

Aromatherapy is another technique that helps relaxation and sleeping. Ultrasonic ceramic diffusers are popular for producing mists containing scented oils. For those consumers who prefer more traditional alternatives, there is a broad range of artistic ceramic candle holders or incense burners available on the market.

Alternative methods to pursue mental wellbeing are through art therapy and lighthearted entertainment. Ceramic mosaics have been used for thousands of years to create artwork. Ceramic puzzles are fun to play with and, once completed, become a form of art. Additionally, ceramics and glass can be manufactured in the shape of dominos, marbles, tic tac toe, backgammon, and chess pieces, among other games.

Spiritual wellbeing can also be attained through religious faith or by other means that help to find a sense of purpose in life, such as meditation. Ayurveda is an ancient Indian alternative medical practice that combines meditation, herbal medicine, special diets, and yoga to achieve holistic wellbeing. All products used in the Ayurveda discipline are based on very pure ingredients. For example, traditional neti pots for nasal cleaning are manufactured from lead-free ceramics made from natural clay.

WORKPLACE WELLNESS

Workplace wellness includes all those activities and programs implemented at the corporate level with the aim of helping employees feel better physically, mentally, and spiritually. Examples are stress management, weight loss, fitness, and medical screening programs.

This sector is currently worth $60.1 billion, corresponding to less than 1% of the global health and wellness industry, and is projected to grow at a 5.8% CAGR during the next five years.[13] Large and small companies are offering these programs to their employees primarily with the purpose of increasing productivity, reducing health-related absenteeism, and as a means to attract new talents.

Presently, ceramics and glass find no direct application in these programs, but they still have a significant role in general workplace wellness because they are commonly used in corporate presents given to employees to boost motivation, morale, relaxation, and self care. Indeed, most corporate wellness gifts include items such as candle holders, ceramic essential oil diffusers, aromatherapy mist bottles, tea carafes, mugs, fitness trackers, and sunlight lamps.

CONCLUSIONS

There are numerous ways ceramics and glass contribute to the $6.2 trillion health and wellness industry. Since their origins many thousands of years ago, people have adapted these materials to the changing times. Rooted in solid foundations, yet not afraid to experiment with innovative technologies and products, manufacturers of ceramics and glass will continue to take on new challenges to help the health and wellness industry flourish.

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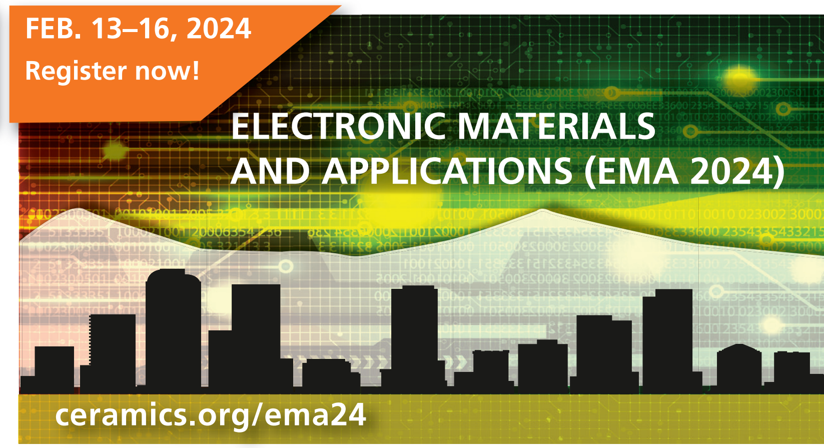
UPCOMING DATES

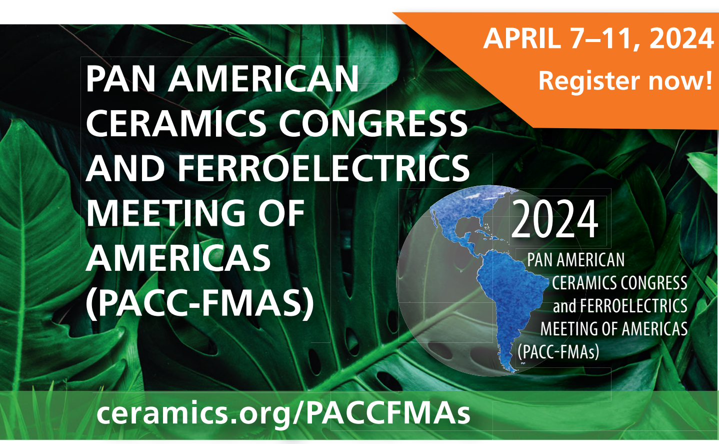
HILTON DAYTONA BEACH RESORT/OCEAN WALK VILLAGE, DAYTONA BEACH, FLA.

This conference has a strong history of being one of the best international meetings on advanced structural and functional ceramics, composites, and other emerging ceramic materials and technologies.



HILTON CITY CENTER, DENVER, COLO.

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



HILTON PANAMA, PANAMA CITY, PANAMA

In 2022, the first PACC conference was held jointly with the Ferroelectric Meeting of Americas (FMAs) to facilitate interactions in and among the countries of the Americas and to provide an insight into the work being done in these countries for others around the world. The 2024 PACC will also be jointly held with the FMAs.

GOLDEN NUGGET LAS VEGAS HOTEL & CASINO, LAS VEGAS, NEV.

Join ACerS Glass & Optical Materials Division for a program featuring six symposia involving glass! The conference will provide an open forum for glass scientists and engineers from around the world to present and exchange findings on recent advances related to glass science and technology.

ACerS celebrates 125 years during Annual Meeting at MS&T23

All photos (Credit: ACerS)

ACerS celebrated its global history during its 125th Annual Meeting at the 2023 Materials Science & Technology technical meeting and exhibition, held October 1–4 in Columbus, Ohio.

"Being able to celebrate 125 years of ACerS with so many members, both domestic and international, in the Society's hometown was a gratifying experience," says Mark Mecklenborg, ACerS executive director. "We look forward to continuing the growth of our global impact and strengthening our engagement with our international members and other materials societies."

Below are highlights from ACerS 125th Annual Meeting at MS&T23.

ACERS ANNOUNCES LAUNCH OF ACERS INTERNATIONAL BRANDING

In recognition of ACerS' significant global membership, outgoing ACerS president Sanjay Mathur announced a new branding initiative during the Annual Business Meeting on Monday, Oct. 2.

The new brand extension, ACerS International, will be used to increase awareness of how ACerS serves the scientific and technological needs of the global ceramic and glass community outside the United States. International activities and collaborations will feature the ACerS International logo, as well as ACerS International Chapters.

More information about the new ACerS International branding initiative can be found on the ACerS website at https://ceramics.org/acers-international.

Incoming ACerS president Rajendra Bordia, right, accepts the ceramic gavel from outgoing ACerS president Sanjay Mathur during the Annual Business Meeting.

In the same vein as the new ACerS International brand, incoming ACerS president Rajendra Bordia said that he plans to focus on enhancing the value of membership during his year in office.

AWARD LECTURES IMAGINE A TECHNOLOGY-DRIVEN, SUSTAINABLE WORLD

The increasing frequency and severity of both natural and anthropogenic hazards has intensified the urgency to develop new technologies and processes that reduce our environmental impact. Many of the award talks at this year's Annual Meeting highlighted some of the ways that ceramic and glass scientists can help society embrace sustainability.

The award talks started on Monday morning with the Arthur L. Friedberg Ceramic Engineering Tutorial and Lecture, given by University of Alabama at Birmingham professor Kathy Lu. She described the maturation of polymer-derived ceramic technology, which allows for difficult-to-synthesize ceramics to be created using far less energy than traditional methods.

On Tuesday morning, Clemson University professor Kyle Brinkman delivered the biannual Navrotsky Award for Experimental Thermodynamics of Solids lecture on the potential of crystalline hollandite materials as a nuclear waste form, in contrast to today's common glassy waste forms. This year's Cooper Scholar recipient, student John Bussey of Washington State University, also talked about cleanup of nuclear waste, specifically salt formation and detection in nuclear waste glasses.

University of Jena professor Lothar Wondraczek delivered the Cooper Session Distinguished Lecture on the atomic structure and properties of some emerging glass systems, which have potential for applica-

Attendees enjoyed meeting up with old friends during the various receptions and mixers at ACerS Annual Meeting at MS&T23.

The 2023 Annual Past Presidents Meeting at MS&T23 witnessed a superb turnout. In person (from left): L. David Pye (2007–2008), Katherine T. Faber (2006–2007), Dana Goski (2020–2021), Edwin R. Fuller (2009–2010), Elizabeth Dickey (2021–2022), Mrityunjay Singh (2015–2016), Sylvia M. Johnson (2018–2019), Sanjay Mathur (2022–2023), Rajendra Bordia (2023–2024), Mark Mecklenborg (ACerS executive director), Marina Pascucci (2010–2011), Daniel Tipsord (ACerS treasurer, 2022–2025), David W. Johnson Jr. (1994–1995), and James E. Houseman (2001–2002). On screen (clockwise from top left): George G. Wicks (2011–2012), Tatsuki Ohji (2019–2020), and John E. Marra (2004–2005). Image courtesy L. David Pye.

tion in gas separation and solid electrolytes, among other devices.

On Tuesday afternoon, University of Tennessee Knoxville Weston Fulton Professor Sergei V. Kalinin delivered the Edward Orton Jr. Memorial Lecture on the "rise of autonomous science." He discussed how artificial intelligence-based computational and analysis techniques can accelerate the development of materials discovery while reducing the need for trial-and-error experiments.

Also on Tuesday afternoon, Ohio Aerospace Institute chief scientist Mrityunjay Singh delivered the Rustum Roy Lecture on additive manufacturing, which may also help preserve resources during manufacturing.

On Wednesday afternoon, Carnegie Mellon University Teddy and Wilton Hawkins Distinguished Professor Elizabeth Dickey delivered the Robert B. Sosman Lecture on using defects to improve the functionality of electronic ceramics.

Additionally, new this year, the Bioceramics Division organized an awards session.

CGIF LAUNCHES NEW IGNITE MSE PROGRAM FOR STUDENTS

In addition to the usual student programming, the Ceramic and Glass Industry Foundation launched a new program called IGNITE MSE. This program, which focuses on professional development and career exploration for undergraduate and graduate students, will run in conjunction with select conferences affiliated with ACerS.

The debut of IGNITE MSE at MS&T23 involved a professional development symposium on Monday morning, followed by a career panel luncheon and a meet-and-greet event in the ACerS lounge. Featured IGNITE MSE posters appeared during the larger poster session on Tuesday, and a hot glass and networking reception took place at Glass Axis (Columbus, Ohio) on Wednesday evening.

NETWORKING EVENTS AND ACERS 125-YEAR AFTERGLOW CELEBRATION

The Annual Meeting offered numerous networking opportunities, including the Diversity in Science reception and LGBTQ+ and Allies Networking Mixer, both on Sunday night.

On Monday evening, following ACerS Annual Honor and Awards Banquet, the Society held an Afterglow reception to celebrate ACerS' 125 years. The event featured a magician and dueling pianists.

Visit the ACerS Flickr page at https://bit.ly/ACerSAnnualMeeting2023 for more photos from ACerS Annual Meeting at MS&T23.

ACerS 126th Annual Meeting at MS&T24 will take place in Pittsburgh, Pennsylvania, from Oct. 6–10, 2024.

ACERS STUDENTS TOUR OWENS CORNING PLANT DURING MS&T 2023

As the sun rose on the final day of ACerS Annual Meeting at MS&T23, 11 undergraduate and graduate students boarded a bus to Newark, Ohio, home to the Owens Corning Newark fiberglass plant and the destination of this year's ACerS President's Council of Student Advisors plant tour.

Upon arriving at the facility, students were greeted by Clayton Smith and Moeed Andrabi, the tour guides for the day and members of the human resources staff at the Newark facility. After the mandatory safety seminar, students were fitted with personal protective equipment before setting off to the factory floor.

Two factories comprise the Newark plant: the wool factory and the pipe factory. The tour began in the wool factory, which is responsible for manufacturing fiberglass insulation for both interior and exterior uses. The next stop—the pipe factory—is where the fiberglass mats are then rolled into various diameters to fit over piping.

ACerS student members on the Owens Corning plant tour during MS&T 2023.

The students were joined for lunch by team members from different divisions within the Newark plant, who talked to them about career and leadership roles within Owens Corning and Newark's push for automation and sustainability.

Calendar of events

January 2024

28–Feb 2 48th International Conference and Expo on Advanced Ceramics and Composites (ICACC 2024) – Hilton Daytona Beach Oceanfront Resort, Daytona Beach, Fla; https://ceramics.org/icacc2024

February 2024

13–16 Electronic Materials and Applications (EMA 2024): Basic Science and Electronic Materials Meeting – Hilton City Center, Denver, Colo.; https://ceramics.org/ema2024

March 2024

6–8 18th Annual Indian Ceramics Asia – Helipad Exhibition Centre, Gandhinagar-Gujarat, India; https://www.indian-ceramics.com

26–28 59th Annual St. Louis Section/Refractory Ceramics Division Symposium on Refractories – Hilton St. Louis Airport Hotel, St. Louis, Mo.; https://ceramics.org/event/59th-annual-st-louis-section-refractory-ceramics-division-symposium-on-refractories

April 2024

7–11 Pan American Ceramics Congress and Ferroelectrics Meeting of Americas – Hilton Panama, Panama City, Panama; https://ceramics.org/PACCFMAs-2024

9–12 ceramitec 2024 – Munich, Germany; https://ceramitec.com/de/muenchen

22–24 Mineral Recycling Forum 2024 – Hilton Imperial Hotel, Dubrovnik, Croatia; http://imformed.com/get-imformed/forums/mineral-recycling-forum-2024

30–May 1 ➨ Ceramics Expo 2024 – Suburban Collection Showplace, Novi, Mich.; https://ceramics.org/event/ceramics-expo-2024

May 2024

19–23 2024 Glass & Optical Materials Division Annual Meeting – Golden Nugget Las Vegas Hotel & Casino, Las Vegas, Nev.; https://ceramics.org/gomd2024

June 2024

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

23–27 ➨ American Conference on Neutron Scattering (ACNS 2024) – Crowne Plaza Knoxville Downtown University, Knoxville, Tenn.; https://ceramics.org/event/american-conference-on-neutron-scattering-acns-2024

July 2024

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

August 2024

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

October 2024

6–10 ACerS 126th Annual Meeting with Materials Science and Technology 2024 – David L. Lawrence Convention Center, Pittsburgh, Pa.; https://ceramics.org/event/acers-126th-annual-meeting-with-materials-science-and-technology-2024

Dates in RED denote new event in this issue.

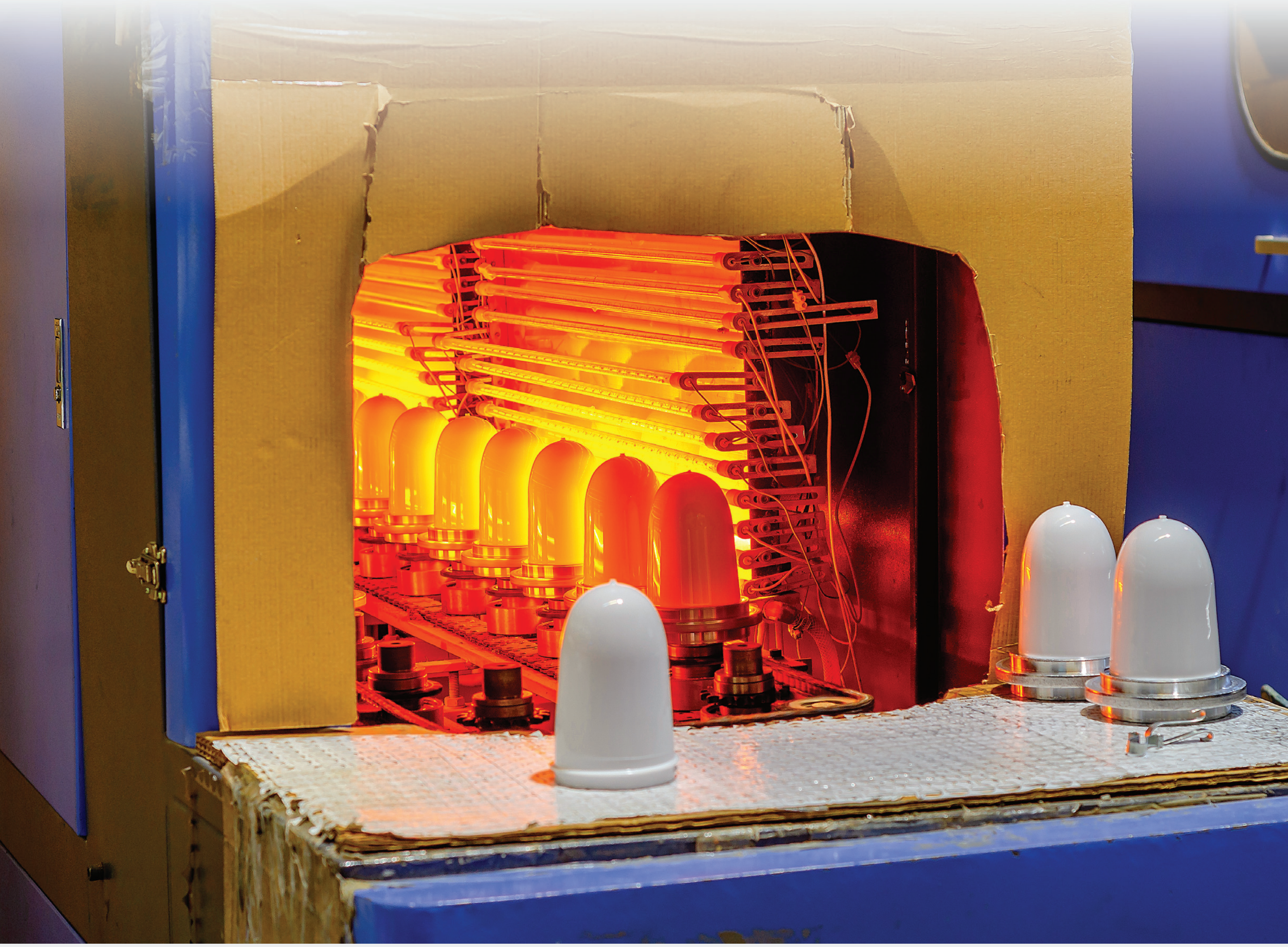
Entries in BLUE denote ACerS events.

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

DECEMBER 2023 • VOLUME 4 • ISSUE 4

Ceramic & Glass MANUFACTURING

www.ceramics.org/ceramicandglassmanufacturing



THE FIRE WITHIN: TRENDS IN FURNACES FOCUSED ON LOWER EMISSIONS AND COSTS

THE FUTURE FOR THE GLASS INDUSTRY IS ALL-ELECTRIC

RATH REDUCES CO_2 EMISSIONS BY 70% IN SILICON CARBIDE PRODUCTION

MAXIMIZE ACERS BENEFITS AND VISIBILITY TO 10,000+ CERAMIC AND GLASS PROFESSIONALS AROUND THE WORLD

ACerS offers three types of corporate membership: Corporate Partner, Sapphire Corporate Partner, and Diamond Corporate Partner. Each offers its own set of benefits, categorized below as marketing/advertising benefits and individual/employee benefits. Choose the partnership level that best fits your company and employees!

CORPORATE PARTNER

$750/year

Marketing/advertising benefits

- *ACerS Bulletin*: one free ¼ page, four-color ad
- *ACerS Bulletin*: be seen in the Corporate Partner News section
- Print and electronic media: 5% discount off all advertising
- Website: landing page with link to your site
- Expos: $200 booth discounts at ACerS expos
- Meetings: 10% discount off sponsorships
- Career Center: unlimited complimentary online job postings
- Corporate Awards: only Corporate Partners are eligible
- Visibility: gain exposure to ACerS 10,000+ members and subscribers
- BCC Research Reports: 15% discount off all orders and one complimentary research report
- *ceramicSOURCE*: enhanced listing in ACerS online buyer's guide
- Webinars: opportunity to present webinars to ACerS members at discounted rates

Individual/employee benefits

- Membership: five (5) ACerS Individual memberships
- Meetings: 50% registration discount for one (1) ACerS-hosted meeting
- Workshops/short courses/online courses: discounted member rates for all company employees
- Networking: invited to exclusive events at select ACerS meetings
- Webinars: free business, management, and professional development webinars available for all employees

SAPPHIRE CORPORATE PARTNER

$3500/year

Sapphire Corporate Partners receive all the benefits of a Corporate Partnership with the following upgraded benefits:

Upgraded benefits

- *ACerS Bulletin*: one free ½-page, four-color ad
- Membership: ten (10) ACerS Individual memberships
- Meetings: two (2) complimentary registrations to any ACerS-hosted meeting
- Meetings: 20% discount off sponsorships
- Workshops/short courses/online courses: additional 20% discount off the member rates for all company employees
- Webinars: opportunity to present webinars to ACerS members at discounted rates

DIAMOND CORPORATE PARTNER

$7500/year

Diamond Corporate Partners receive all the benefits of a Sapphire Partnership with the following upgrades and additional benefits:

Upgraded benefits

- *ACerS Bulletin*: one full-page, four-color ad
- Membership: fifteen (15) ACerS Individual memberships
- Meetings: four (4) complimentary registrations to any ACerS-hosted meeting
- Meetings: 30% discount off sponsorships
- Workshops/short courses/online courses: additional 30% discount off the member rates for all company employees

Additional benefits

- Website: prominent logo placement on ACerS home page with link to your site
- Webinar: opportunity to present a webinar to ACerS members at no cost
- ACerS Annual Awards Banquet: complimentary VIP table for ten (10)

ACERS INDIVIDUAL MEMBERS ENJOY THE FOLLOWING BENEFITS:

- Members-only access to online Communities and Member Directory
- Online access to ACerS technical journals
- *ACerS Bulletin* magazine and Bulletin Archives Online
- ACerS *Ceramic & Glass Manufacturing* magazine
- *Ceramic Tech Today* newsletter, covering the latest ceramic and glass materials news
- *C&GM Weekly* newsletter, covering the latest ceramic and glass industry news
- Discounted registration rates at ACerS technical meetings, workshops, and training courses
- Discounts on technical publications, Phase Equilibria Diagrams, and ceramic and glass materials courses
- Invaluable networking opportunities

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INDUSTRY NEWS

DURAVIT BUILDS CLIMATE-NEUTRAL PLANT

Duravit AG says it is building the world's first climate-neutral ceramic production facility. It is being built in the Canadian province of Québec. The site will create 240 jobs, with production scheduled to start in early 2025. Ceramic sanitaryware products will be manufactured there using renewable energies. Duravit says it will use the world's first electric roller kiln powered by electricity from hydropower. The parts produced there are planned for the North American market.

The plant will be the first production site for Duravit AG in North America.

The agreement is designed to meet a demand for materials that survive in ever-harsher environments.

AGREEMENT TO DEVELOP ADVANCED CERAMIC COMPOSITES

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

SAINT-GOBAIN SIGNS AGREEMENT FOR SOLAR POWER

Saint-Gobain signed a 15-year renewable electricity supply agreement with TotalEnergies for the purchase of solar power for its 125 industrial sites in North America. This 100-MW agreement is expected to offset Saint-Gobain's North American CO_2 emissions from electricity by 90,000 metric tons per year. The project is expected to come online by the end of 2024. It is the third power purchase agreement signed in North America by Saint-Gobain.

Saint-Gobain expects to reduce its North American scope 2 emissions by more than 70%.

Saverglass caters to spirit, champagne, fine wine, and sparkling wine brands and industries around the world.

AUSTRALIAN PACKAGING COMPANY BUYS GLASS BOTTLE MAKER

Orora Ltd. acquired Saverglass SAS for 1.29 billion euro. Saverglass designs and manufactures high-end bottles for the premium and ultrapremium spirit and wine markets. Based in Australia, Orora is a manufacturer of packaging products. France-based Saverglass will become the centerpiece of Orora's global glass business unit, the companies say.

OWENS CORNING PROMOTES FISTER TO CFO


Todd Fister

Owens Corning named Todd Fister as the company's new chief financial officer. He succeeds Ken Parks, who stepped down to pursue another professional opportunity. Since 2019, Fister has served as president of the $3.7 billion insulation segment, leading a team of approximately 8,000 employees. Under his leadership, the business grew revenue by 30%. Fister was also instrumental in developing the company's enterprise strategy launched in 2021.

THERMAL BATTERY MILESTONE ACHIEVED

Sunnyvale, California-based Antora Energy says it reached the highest temperature demonstrated to date for thermal batteries at full scale, storing energy above 1,800°C with a thermal battery the company developed. The thermal battery system, which can deliver zero-emissions heat and power, is operational at Wellhead Electric Company, Inc.'s facility near Fresno, California. The company is backed by investors, including Breakthrough Energy Ventures, Lowercarbon Capital, Shell Ventures, BHP Ventures, Trust Ventures, Fifty Years, Grok Ventures, and Impact Science Ventures.


Antora developed a modular, factory-assembled, commercial-scale thermal battery.

Hartmann & Bender was founded in 1897.

LATTIMER GROUP ACQUIRES EQUIPMENT MANUFACTURER

The Lattimer Group acquired Hartmann & Bender, a manufacturer of variable equipment and spare parts for the container glass industry. The acquisition includes Hunprenco, a plunger and cooler manufacturer based in Hunmanby, U.K. Hunprenco also has additional facilities for specialized machining and surface coatings for the glass industry. Lattimer Group companies, Lattimer Ltd., Hunprenco Ltd., and Hartmann & Bender GmbH will remain distinct for the foreseeable future, the Lattimer Group says.

Zeiss head of additive manufacturing technology Claus Hermannstädter, left, and ORNL interim associate laboratory director Rick Raines.


ORNL DEAL TO EVALUATE 3D-PRINTED PARTS

A licensing agreement between the Department of Energy's Oak Ridge National Laboratory and research partner Zeiss will enable industrial X-ray computed tomography to perform rapid evaluations of 3D-printed components using ORNL's machine learning algorithm, Simurgh. The licensing is part of a five-year research collaboration between ORNL and Zeiss, supported by DOE's Advanced Materials and Manufacturing Technologies Office and a Technology Commercialization Fund award.

THE FIRE WITHIN: TRENDS IN FURNACES FOCUSED ON LOWER EMISSIONS AND COSTS

By David Holthaus

The heart of nearly any ceramic or glass production is the furnace, where raw materials are treated with such intense heat that they are transformed into stable, durable, new products. Space shuttle tiles, hip implants, automobile windshields, refractory bricks, and bathroom fixtures must first pass through the fire before they are ready for use.

While the fundamental principles of high-temperature firing remain constant, the methods and equipment employed to carry out the process continue to evolve in response to shifting labor, environmental, and economic conditions. Manufacturers have continued to innovate to meet sustainability goals, reduce energy consumption, and improve the quality of their products.

Nutec Bickley is a furnace maker based in Santa Catarina, Mexico, whose customers include large, advanced ceramic manufacturers. The company manufactures industrial kilns used for refractories, technical ceramics, sanitaryware, electrical insulators, and other products.

Several of the company's biggest customers have committed to transforming their operations over the next two to three decades to become carbon neutral, says Alberto Cantu, vice president of sales. It is a coming transformation that will undoubtedly change their firing processes and fuel sources.

"We are definitely going to see less natural gas in the future," Cantu says.

Moving away from natural gas as a primary fuel is a long-term prospect that will depend on economics and advances in technology. In the near-term, companies are taking other steps to improve energy efficiency.

For example, Nutec Bickley recently installed a 125-meter-long tunnel kiln for an advanced ceramics manufacturing client that produces ceramic cores used in the aerospace industry. The kiln was designed to work year-round at an operating temperature of 1,200°C. Its combustion system uses air traveling back through the

A Nutec Bickley engineer completes a furnace installation. *Credit: Nutec Bickley* tunnel kiln to mix with fuel gas injected through the burners. The system is expected to produce cost savings and a payback period of two years or less, Cantu says.

Manufacturers are increasingly converting their furnace operations to electric to reduce the emissions from their production processes. Cantu says he is seeing conversions in cases where firing takes place in lower temperature regimes at or below 600°C.

"The easiest thing to do is to change everything in your operation to electric," he says.

As a result, his company has seen a surge in the demand for electric kilns.

"We've made more electric kilns in the last four years than in the previous 40," he says.

A Nutec Bickley engineer monitors temperature gauges and internal pressure. *Credit: Nutec Bickley*

The conversion to electric can come with tradeoffs, says Doug Jeter. He is director of sales and marketing for Harrop Industries, a Columbus, Ohio-based maker of custom-designed industrial kilns and ovens. Firing with natural gas can mean more uniform and consistent end products, he says.

"Our customers are mostly concerned about a quality product," he says. "With natural gas you get a lot of mixing in the kilns, and heat transfer can be better."

To aid in product uniformity, Harrop built one of the first large-scale kilns using microwave assist technology.

"The bigger your product gets, the harder it is to heat everything uniformly from the outside," Jeter says. "Just like a microwave at home, it heats from the inside out. The benefit is in potentially more uniform firing."

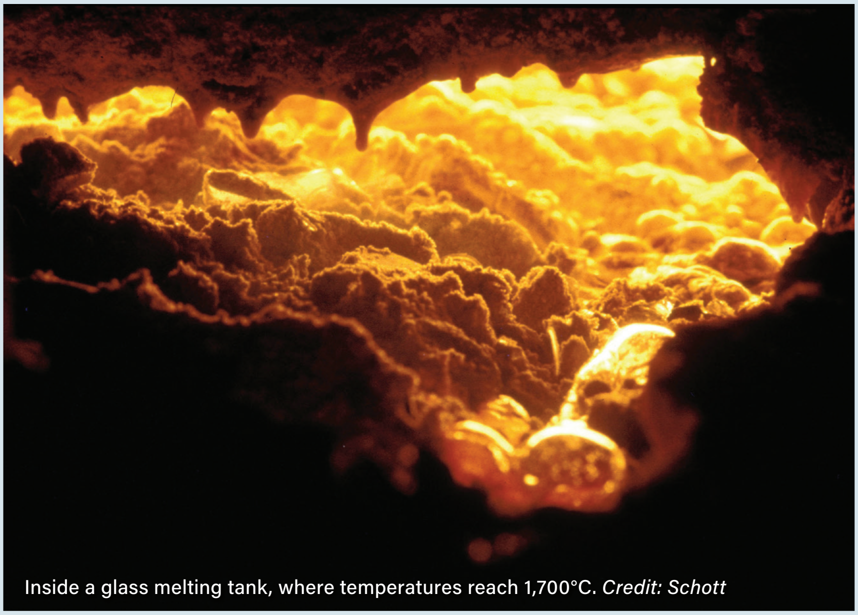
Electric firing could be prone to losing power, which could result in an expensive loss of product, he points out.

"Gas tends to be very reliable," he says.

Natural gas is also relatively inexpensive in the U.S., and, depending on the source of the electric power, converting to electric may not provide the environmental benefits it promises.

"Emission from your stacks may go down, but if the electricity is generated by coal, it's still a carbon emission," he says.

O-I Glass, the Perrysburg, Ohio-based glass maker, is sticking with gas at its new plant in Kentucky on which it broke ground in April 2023. The Bowling Green plant is the first O-I facility built to use the company's MAGMA technology at full-scale.



Inside a glass melting tank, where temperatures reach 1,700°C. *Credit: Schott*

MAGMA stands for Modular Advanced Glass Manufacturing Asset. It is a flexible production system that the company says will allow it to respond more quickly to customer needs and emerging markets.

The MAGMA melter is about a third of the size of a traditional furnace, and its smaller size will allow the addition of more lines as markets grow, or to permit the company to enter new markets, O-I Glass says.

Unlike a traditional furnace, the MAGMA melter can be moved and redeployed to be closer to customer filling lines, the company says. Its size also allows for smaller production runs and adaptability to product changes.

The glassmaking giant piloted the technology at its plants in Streator, Illinois, and Holzminden, Germany. The first phase of construction for the Kentucky facility is expected to be complete in mid-2024, the company says.

While gas remains a reliable and economical fuel source, more companies, particularly those in Europe, are converting their operations to different fuel sources. Hornberg, Germany-based Duravit AG in July 2023 announced that it is building what it called the world's first climate-neutral ceramic production facility. The plant is being built in the Canadian province of Québec and will be the company's first production site in North America.

For the firing process, Duravit will use an electric roller kiln powered by electricity from hydropower. The technology will save 11,000 tons of CO_2 per year compared to a conventional ceramic factory, the company says. The maker of ceramic sanitaryware says the plant is expected to begin production in 2025. The kiln and related equipment are being provided by SACMI, the Imola, Italy-based machine maker.

In Germany, Ardagh Group is nearing completion of a hybrid furnace that will use 80% renewable electricity and 20% gas. Ardagh says the new furnace will invert the current fuel mix of its container glass production, which is a blend of approximately 90% gas and 10% electricity. The new hybrid technology, which the company calls its NextGen Furnace, will reduce CO_2 emissions by as much as 60% in the furnace. The Luxembourg-based maker of glass bottles operates 65 metal and glass production facilities in 16 countries, employs more than 21,000 people, and reports sales of approximately $10 billion.

There is also a trend toward incorporating more automation in furnace technology, Jeter says. Newer furnaces are equipped with sensors and control systems that enable real-time monitoring and adjustment of temperature, atmosphere, and other parameters, improving process control, reducing downtime, and improving the consistency of the products.

Manufacturers are seeking ways to control their processes remotely, either from a booth in the plant or from their mobile phones. Increasing automation minimizes the demand for labor and the need for manual intervention, he says, which can help as businesses try to navigate the nationwide shortage of trained specialists.

The leading edge of furnace technology may be the experiments in using hydrogen as a fuel. Research into whether hydrogen can be used consistently as a fuel and how it might affect the products has been under way.

Jeter says his company has not had any firm inquiries about building a kiln using 100% hydrogen as fuel. Cantu says he is skeptical about the promise of hydrogen as major challenges exist to its adoption.

But major manufacturers have invested in pilot projects. In July 2023, the Schott group announced it had succeeded in producing a test melt using 100% hydrogen. The test was a leap forward from its tests conducted 2022, in which 35% hydrogen was added to a melting tank that had previously been operated exclusively with natural gas.

"For the first time, we succeeded in completely using hydrogen for a holding time of 10 days on a laboratory scale," says Matthias Kaffenberger, melting technology manager at the Mainz, Germany-based glass maker.

In December 2022, Encirc, the U.K.-based glass manufacturer, and Diageo, the spirits giant responsible for Smirnoff, Johnnie Walker, and many other brands, announced a partnership to create the world's first net-zero glass bottles at scale by 2030. An ultralow carbon hybrid glass furnace at Encirc's plant in Elton, England, is expected to begin glass production in 2027. By 2030, the partnership expects to produce up to 200 million net zero bottles of Smirnoff, Captain Morgan, Gordon's, and Tanqueray per year.

The companies say the furnace will reduce carbon emissions by 90%, with an energy mix of green electricity and low-carbon hydrogen. It is expected that carbon-capture technology will harness the remaining carbon emissions by 2030. The furnace will be powered by zero-carbon electricity and hydrogen from a nearby plant.

The expanded hydrogen supply at the Mainz plant enabled the longer test and solved one of the biggest challenges in hydrogen firing.

"The real issue is: what is your source of hydrogen?" Jeter says. "Where are you going to get hydrogen at a regulated pressure and a regulated flow and enough of it to heat your kiln?"

Schott officials also point out that green hydrogen produced from renewable energy is not yet available in sufficient quantities largely due to the lack of an extensive infrastructure for an industrial hydrogen supply.

"We urgently need to take further steps and come up with timely solutions for a functioning infrastructure," says Jens Schulte, a member of the Schott board of directors.

But the trend toward carbon neutrality is expected to move forward, as companies continue to make long-term commitments to making their operations more environmentally friendly. Many observers say they expect to see a mix of technologies, including carbon capture, be used in the efforts.

THE FUTURE FOR THE GLASS INDUSTRY IS ALL-ELECTRIC

By René Meuleman

Meuleman is the solutions and technology lead for green glass at Paris-based Schneider Electric. This article was originally presented at the 14th International Seminar on Furnace Design at Vsetin, Czech Republic, in 2017. View the original article at https://www.eurotherm.com. Reproduced with permission.

Glass melting has been carried out for nearly 6,000 years, and, for most of that time, wood was used as the energy source. It was only comparatively recently, around 1880, that the industry began to use fossil fuels like oil and natural gas. At this time, the regenerator had already been invented to improve the efficiency of steel blast furnaces, and this invention was soon adapted by the glass industry on the early port furnaces, very similar to how we know them today. During those thousands of years of glassmaking, less than 150 years' worth of fossil fuels were used, and it is possible that they will not be around for another 150 years.

Although new fossil fuel resources have recently become available, the world has at last begun to understand that burning them results in unavoidable carbon emissions, and therefore this method must come to an end. Glass melting still needs to continue at this point in time because we have not yet discovered a viable replacement material. It is therefore likely that glass will be around for many centuries to come and that the inevitable future for a carbon efficient glass industry will be "all-electric."

HISTORY

With no disrespect to past furnace design developments and the great achievements that have been made, they are mostly still based on original technology. Traditional side and end port furnaces are proven technology that has been developed and tweaked to a level of efficiency, low emissions, and life expectancy that simply cannot be improved any further. Since the efficiency level came down to 2.4 MWh/ton in around 1990, no big improvements have been achieved. Consequently, further CO_2 and NO_x emission reductions slowed to halt as well.

Oxy-fuel firing, batch preheating, waste heat recovery, submerged burners, etc. are great advances, but the bottom line remains the same: they all increase the complexity of the melting system and CAPEX, do not avoid CO_2 emissions, and in most cases cannot reduce NO_x emissions any further. The use of fossil fuels has become the fundamental problem and technology cannot overcome these issues sufficiently.

THE FUZZINESS OF POLITICS

Just as with many other raw materials, as soon as we start believing that resources are coming to an end, we find new ones. That is also applicable for fossil fuels. So why should we even start considering diverting from fossil fuels? Science has proven that CO_2 emissions are related to global warming, which will likely lead to serious environmental issues for humanity. Legislation, customers, and common sense will force the industry to step away from fossil fuel firing sooner or later.

By 2050, the EU aims to cut greenhouse gas emissions to 80% below 1990 levels. Milestones to achieve this goal are 40% emissions cuts by 2030 and 60% by 2040. All sectors need to contribute. One famous Dutch beer brewer is putting a lot of effort into reducing its carbon footprint and estimates that 53% of this footprint is related to its packaging material. The pressure to reduce emissions comes from many sides. No matter which side we agree or disagree with, it will impact how glass is melted in the future.

TECHNOLOGICAL EVIDENCE

Most glass melting furnace technology goes back 100 years or more. Over the years, different developments have led to huge energy efficiency and emission improvements, and many furnace suppliers are still working on enhancements, forced by the fact that fossil fuel energy remains cheap. However, that will change, and probably much faster than many of us expect.

As previously mentioned, most of those improvements implicate a more complex technology that results in additional maintenance and CAPEX, the use of nonenvironmentally friendly chemicals, and limitations to equipment lifespan. Most glass smelters perceive their melting process as complex enough and are not keen on modifying it further. They want to focus on their core business, without the issues of managing and maintaining complex industrial installations requiring high numbers of technical personnel. Keeping the system simple has been a key argument for many decades.

Now that the world around us seems to be changing rapidly, our efforts to extend the lifetime of furnaces up to 15 years or more is working against us. In fact, most glass manufacturers only have one opportunity every 10 to 15 years to introduce a new innovative melting process, so it is not surprising that having to

Credit: Ardagh Group

live with that decision for the next 15 years makes them extremely risk averse. Who can blame them? It reminds me of a comment made by one of our customers: "In God we trust, but here you have to come with facts." Technological research and development needs to provide evidence of improvements, otherwise politics forces us to rely on expectations.

ELECTRICAL HEATING

Electrically heated furnace technology is almost as old as regenerative furnace technology. In fact, the first furnace patent on electrical melting was issued to Sauvageon in France, in 1907. A first successful cold top furnace ran in Norway from 1920 to 1925 using carbon electrodes. Cornelius in Sweden had operating furnaces as early as 1925, producing amber and green glass.

In 1952, the industry started to use molybdenum electrodes, and around 1975 high current SCR's (thyristors) became available, leading to the principle of solid-state furnace boosting systems we know today. Most modern traditional container, fiber, and float furnaces are now equipped with electrical furnace boosting, contributing 10% to 50% of the melting power.

THE EFFICIENCY OF ALL-ELECTRIC MELTING

Even in the early days, all-electric melting efficiency at 4.4 GJ/ton (1.3 MWh/ton) was already close to today's most efficient fossil fuel fired furnaces at 4 GJ/ton (1.1 MWh/ton). Since the introduction of all-electric furnaces, huge efficiency improvements have been achieved, reducing energy usage levels to 2.8 GJ/ton (0.78 MWh/ton) (20% cullet) or less. The power consumption is not likely to go below 2.6 GJ/ton (0.72 MWh/ton). Most of the electrical power ends up in the melting process anyway, and only relatively low energy losses come from transformers, busbar, and control efficiency. Compared to traditional fossil fuel heating at 4 GJ/ton (1.1 MWh/ton), energy use is around 35% less.

An electrical furnace is naturally easy to control and maintain, but it is important to consider the engineering of the electrical system alongside the furnace design. Like a burner system for a traditional furnace, the electrical system is not a sub system but should be part of the total design and needs to be fully integrated. Bringing steelwork, refractory, cables, busbars, electrodes, transformers, and control together in one design is essential for the efficiency success of the whole system.

ADVANTAGES OF ALL-ELECTRIC MELTING

Compared to high-efficiency, fossil-fuel-fired smelter systems, all-electric furnaces are sophisticated but very straightforward in design. Regenerators or burner skids are not required, and expensive high-temperature crowns are not necessary. Higher pull rates can be achieved without any problems. No combustion related CO_2, thermal NO_x or SO_x emissions are released. Potentially less evaporation of volatile and expensive raw materials, such as boron and lithium, will occur, which makes exhaust filtering much easier. Also, the carryover problem will almost vanish. Smaller furnaces could be considered. For example, one furnace that feeds one forehearth which feeds one IS machine might become a new concept for bottle manufacturing.

DISADVANTAGES OF ALL-ELECTRIC MELTING

Although all-electric furnace concepts are very simple in principle, there are some implications to consider when changing over to this technology. At room temperature, glass or glass compositions are electrical insulators. To start the electrical heating process, it needs to run through a preheating sequence similar to the method used in container and float furnaces.

An all-electric furnace also needs a stable, reliable power grid, and due to different melting and fining behaviors, the glass composition needs to be changed. Electrical tariffs need to come down in price, and in order to lower the carbon footprint, electricity would need to come from renewables instead of coal-fired power plants.

Electrodes need to be maintained by advancing them in case wear leads to higher resistance. There are new methods to counter electrode wear, which would need to be investigated further. Another issue, especially for the container industry, might be how this kind of furnace would handle extremely high amounts of cullet, which may result in different ways cullet and batch are managed.

FLEXIBILITY IS REQUIRED

Electrical power tariffs are strongly related to availability, and the electrical energy market is changing rapidly. Suppliers and utilities subsidized by government grants are investing in wind, biomass, and solar power generation. Citizens also invest in solar panels instead of keeping their money at zero interest in banks. Buzzwords such as "smart grid," "tariff tweaking," "peak shaving," and "frequency control" have become familiar terms, and it is recognized that money can be saved if our electrical energy consuming system becomes more flexible.

To lower the risk of total grid failure, some utilities offer money to be in control of huge industrial loads, to be able to temporarily switch them off when needed. More refined is the method of controlling the network's frequency (dynamic fractional frequency reuse) by tweaking the power consumption of some massive power consumers. Basically, electrical power consumers are financially rewarded if they make part of their electrical power consuming system available for remote power control. Lower peak power demand can lead to lower tariffs. In that case, a dynamic load management system capable of controlling parts of the electrical system to ensure that agreed peak power levels are not exceeded will lower the overall cost of electrical energy.

A glass furnace, containing a huge amount of molten glass, can or should be able to accommodate the flexibility needed to profit from these rewards, grants, and lower electrical tariffs. Glass manufacturing, being part of the high energy consumer community and rapidly changing energy market, needs to look for furnace designs that better fit both today's and tomorrow's requirements. Sophisticated data analysis and (model-based) control strategies should help operators to calculate the available freedom of control, allowable melting energy fluctuations, allowable fossil-to-electric ratio fluctuations, and predict the impact on glass quality. The bottom line is that there is no escape from thinking "out of the box" and stepping away from tradition.

RATH REDUCES CO_2 EMISSIONS BY 70% IN SILICON CARBIDE PRODUCTION

By Heinz Wallner

Heinz Wallner is head of production at RATH's Krummnußbaum plant in Lower Austria. View the original article, published on the RATH website in October 2023, at https://www.rath-group.com/en/news. Reproduced with permission.

At the RATH plant in Krummnußbaum, two new vacuum nitriding furnaces, used exclusively for the production of silicon carbide plates and bricks in a nitrogen atmosphere, are now being operated with electricity. The result: CO_2 emissions are around 70% lower than with the previous gas-fired furnace, and fossil fuels are reduced to a minimum. By operating these furnaces electrically, RATH is taking a global pioneering role in the refractory industry.

Efficient, resource-saving use of materials and a sustainable approach to the environment in the manufacture of its premium products for application temperatures up to 1,800°C are highly relevant to internationally operating refractories manufacturer RATH. Great focus is therefore being placed on the continuous and innovative optimization of production.

This focus can be clearly seen at RATH's Krummnußbaum plant in Lower Austria: Two furnaces, in which silicon carbide plates and bricks for the lining of domestic waste incinerators are produced in a nitrogen atmosphere, have been operated electrically since February 2022. Only thermal post-combustion is still gas-powered. In other words, three out of 10 industrial furnaces are now operated electrically at this RATH plant.

Encouragingly, CO_2 emissions have been reduced by around 70% in the electrically powered furnaces compared to our gas-powered furnace. For SiC production, this means a CO_2 reduction per ton of fuel of about 1.9 tons.

Moreover, the electric operation of these two furnaces makes RATH a pioneer in the industry when it comes to silicon carbide production in a nitrogen atmosphere.

LOWER ENERGY REQUIREMENTS THANKS TO HEAT TREATMENT PROCESS CONVERSION

By changing the heat treatment process from gas to electricity, the existing material and geometry of the firing boxes were adapted and integrated into the firing chamber. To enable the products inside the boxes to be exposed to a nitrogen atmosphere, the firing boxes have to be subjected to high temperatures. The aforementioned changes allow for shorter heating and firing times for this energy and time-intensive process, which in turn results in lower energy requirements.

In terms of product quality, the balance is also positive.

In the run-up to the acquisition, RATH carried out trials in small batches in collaboration with the furnace manufacturer. The furnaces were ordered after numerous tests had been carried out in external laboratories and had yielded optimum quality. The procedure has paid off—the product quality is outstanding.

The biggest challenge was to define the best process parameters for the firing. In addition, the electrical infrastructure (transformer station) had to be expanded and a cooling system had to be installed for the two furnaces.

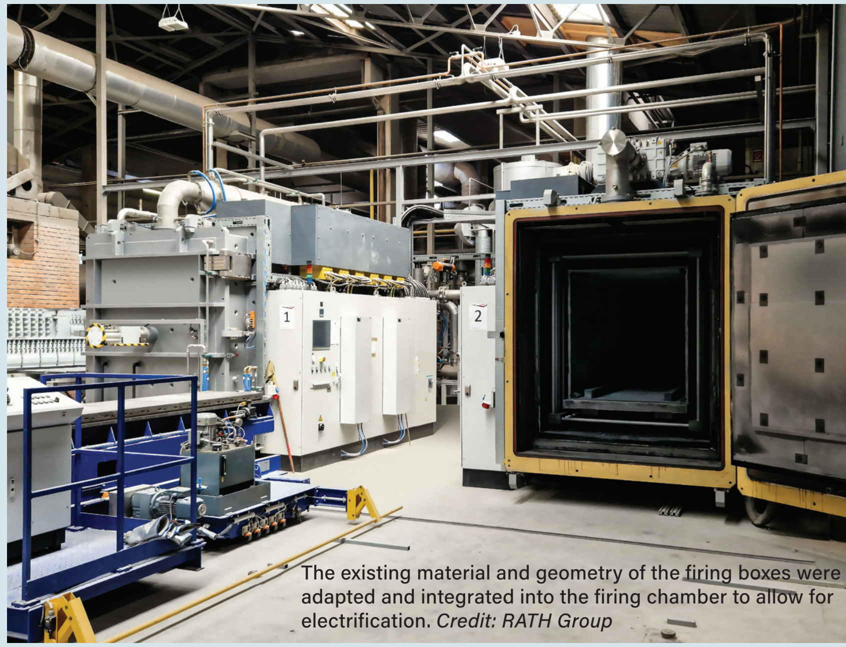
An electrically operated furnace at RATH's Krummnußbaum plant in Lower Austria. *Credit: RATH Group*

ELECTRICITY FROM THE COMPANY'S OWN PHOTOVOLTAIC PLANT

When it comes to energy generation, RATH in Krummnußbaum is also future-oriented.

A photovoltaic system was erected on the roofs of the factory halls and put into operation in 2020. This 696 kWp photovoltaic plant generates up to 700 MWh per year, which means that around 20% of the daily electricity requirement currently comes from solar energy. The photovoltaic system results in a reduction of around 350 tons in CO_2 emissions per year.

Since 2020, around 99% of the electricity produced annually by this self-consumption plant has been used directly at the Krummnußbaum plant. Any surplus energy is fed back into the grid.



The existing material and geometry of the firing boxes were adapted and integrated into the firing chamber to allow for electrification. *Credit: RATH Group*

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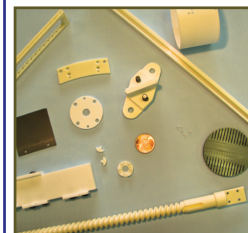

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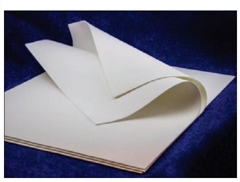

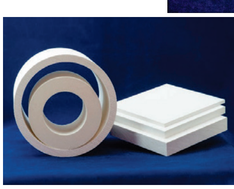

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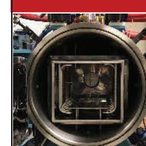

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Sadaf Batool

Guest columnist

Challenges in fabricating 3D-printed scaffolds for bone tissue regeneration

Though bone has a remarkable innate ability to heal itself after damage and illness, external support is required for bone repair to treat large defects and infections. This external support can take the form of structures that hold the damaged parts in place and/or bioactive materials that help stimulate regeneration.

Bone autografts and allografts are currently the gold-standard for treating bone defects. However, both these methods have several limitations, such as immune system rejections, morbidity issues, and transfer of infectious diseases. On the other hand, metals, wood, polymers, and calcium phosphate-based materials have been used for centuries as external support materials. But these materials suffer from challenges involving biocompatibility, immune system rejection, poor mechanical strength, and stress shielding effect, respectively.

To get optimal benefits from scaffolding, scaffolds should emulate the innate hierarchical structure of bone.[1] Specifically, scaffolds should have an interconnected porous structure for active transport of cells and nutrients to the growing bone, as well as adequate mechanical strength to support the damaged bone. An ideal scaffold would also be biocompatible, osteoinductive, biodegradable, and bioresorbable.

All these requirements cannot be fulfilled using conventional fabricating methods. But recently, additive manufacturing techniques have allowed scaffolds to be fabricated with these desired properties. Additionally, these techniques provide flexibility in geometry design so defects of any shape and size can be treated.[2]

Typically, 3D-printed scaffolds are created using an organic–inorganic hybrid structure that features synthetic and biopolymers matrices reinforced with metallic and/or bioceramic nanoparticles. This hybrid approach faces some challenges, however.

For one, synthetic polymers have poor biocompatibility and are generally nonbiodegradable, while biopolymers have poor mechanical strength. The biopolymer limitation can be overcome by crosslinking the polymers in such a way as to form a complex network that maintains its structure in vivo for a regeneration period. However, once this structure is achieved, it becomes difficult for the metallic/bioceramic nanoparticles to interact well with the polymeric chains, which leads to issues with the flowability and stability of the ink during printing.

This issue of nanoparticle aggregation can be overcome in several ways. For example, the nanoparticles' surfaces can be functionalized to interact with the polymer chains via noncovalent linkages. Or, the mixture could be sonicated for an extended period so the nanoparticles have time to settle themselves in the empty interstitial space between polymers.

After successful ink formation, process parameters must be carefully considered to ensure the ink flows and cures as desired. As crosslinking is done after printing, the printed scaffold needs to maintain its structural integrity until that process takes place.[3] To maintain ink stability, printer head pressure and temperature must be held steady during printing. The bed temperature is also critical to maintaining ink stability.

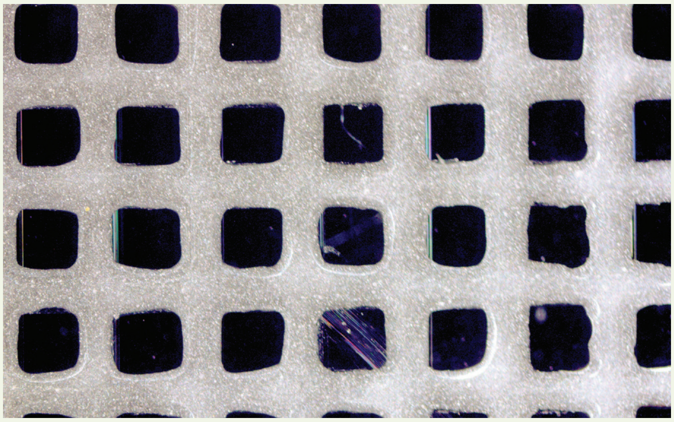

Figure 1. Close-up image of the calcium magnesium phosphate scaffold, created using gelatin and a ceramic bioink.

I have personal experience with creating bioinks, as my Ph.D. research is focused on creating ceramic composites for bone tissue regeneration. So far, I have created bioinks based on gelatin and calcium magnesium phosphate, which I used to print a grid structure of four layers (Figure 1).

The bioink was prepared by the oxidative polymerization method, and the conditions that allowed for each layer to be printed with intact structure and uniform porosity were optimized after hundreds of failed reactions. The printed structure was stable and showed excellent bioactivity and cell proliferation results.

Some analyses of my printed structures are ongoing. In future experiments, I hope to increase the number of layers so that the scaffold can be used for commercial applications.

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Sadaf Batool is a Ph.D. candidate in nanoscience and engineering at the National University of Sciences and Technology, Islamabad, Pakistan. Her doctoral dissertation is based on the synthesis and fabrication of calcium magnesium phosphate-based composites for bone tissue regeneration. She conducted part of her doctoral dissertation work at the Institute of Biomaterials at Friedrich Alexander University Erlangen-Nuremberg, Germany, with funding from the Higher Education Commission of Pakistan. She likes to do photography, cooking, and traveling in her free time.

WELCOMING NEW FACULTY

Dr. Collin Wilkinson

Alfred University would like to introduce you to our latest faculty member Dr. Collin Wilkinson has been hired as Assistant Professor of Glass Science. Collin earned a Bachelor's in Physics at Coe College followed by a Ph.D. in Material Science at the Pennsylvania State University. He served as director of research and development and CTO of small startups focusing on next-generation recycling technology through material informatics. Collin is the inventor or co-inventor of several new glass compositions for green applications ranging from reducing greenhouse gases to improved glasses for renewable energy applications. Collin joined the faculty at Alfred University in 2022 and his current research revolves around building computational tools for simulations of extreme conditions, understanding the fundamental physics of glassy materials, and engineering better solutions for sustainable glass technology. Collin is the author of over 50 peer-reviewed publications and 4 patents. He is additionally the chair of the undergraduate research committee at Alfred University where he has created a research program for undergraduates from around the world in glass and ceramics.

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