AMERICAN CERAMIC SOCIETY

bulletin

emerging ceramics & glass technology

OCTOBER/NOVEMBER 2020

Latin America—Indigenous invention

Ceramic researchers and companies pursue homegrown solutions to global challenges in Latin America

ACerS Annual Meeting and MS&T20 | Aerospace materials | Student exchange experience

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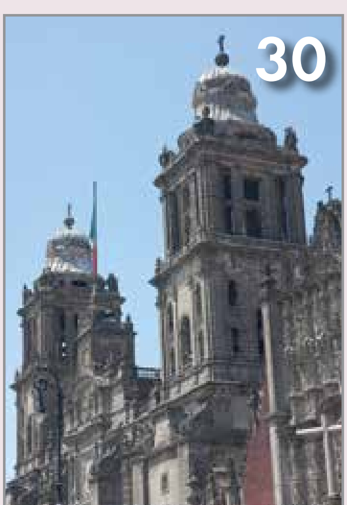
Latin America—Indigenous invention

Ceramic researchers and companies pursue homegrown solutions to global challenges in Latin America

Industry partnerships drive the focus of much academic research across Latin America, but financial performance is not the only goal—efforts to address environmental impacts and pursue sustainability play large roles in research as well.

by Alex Talavera and Randy B. Hecht



Latin America market snapshots

by Alex Talavera and Randy B. Hecht

Deep dives into Brazil, Chile, and Colombia

And overviews of Argentina, Canada, Mexico, Panama, Peru, and United States

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Corrections

In the September 2020 *Ceramic & Glass Manufacturing*, figures 4, 5, and 6 in the article "Flexibility matters" were misnumbered. They are corrected in the digital version of the issue.

In the September 2020 *Bulletin*, photos for Long-Qing Chen and Zibin Chen were switched in the Annual Awards section. It will be corrected in the *Bulletin Online Archive* version.

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http://bit.ly/acerstwitter http://bit.ly/acerslink http://bit.ly/acersgplus http://bit.ly/acersfb http://bit.ly/acersrss

As seen on *Ceramic Tech Today*...

Credit: UGA CAES/Extension, Flickr (CC BY-NC 2.0)

Sorbent-based purification may make biogas production economically feasible for farmers

Production of methane fuel from biogas, a natural byproduct of organic wastes, may be a way for farmers to turn a profit, but the current processing methods are too expensive for small farmers. Researchers at Lawrence Livermore National Laboratory developed a composite sorbent that may make the production process economically feasible.

Read more at www.ceramics.org/upgradedbiogas

Also see our ACerS journals...

A green composite material of calcium phosphate cement matrix with additions of car tire waste particles
By C. F. Revelo and H. A. Colorado
International Journal of Applied Ceramic Technology

Ecofriendly synthesis of MWCNTs by electric arc in aqueous medium: Comparative study of 6B pencil and mineral graphite
By C. G. Kaufmann Jr, R. Y. Sun Zampiva, S. Arcaro, et al.
International Journal of Applied Ceramic Technology

Glass foams produced by glass waste, sodium hydroxide and borax with several pore structures using factorial designs
By R. C. da Silva, E. T. Kubaski, and S. M. Tebcherani
Journal of the American Ceramic Society

Sign up to get journal tables of contents and new content alerts. See this *CTT* post for more information: https://ceramics.org/August2020tips.

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

Read more at www.ceramics.org/journals

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ACSBA7, Vol. 99, No. 8, pp 1– 68. All feature articles are covered in Current Contents.

news & trends

The hidden history of Vietnamese ceramics

When it comes to the history of ceramics in Asia, many people immediately think of China.

The history of Chinese ceramics traces back over thousands of years. Porcelain in particular holds an important place in the history, as the material was invented in China over centuries and then exported throughout the world. Even today people refer to porcelain as “fine china” in reference to this history.

Of course, China is not the only Asian country with a history of ceramics. However, for some countries like Vietnam, the history of ceramics was lost in time—until recently, that is.

Credit: Hungda, Wikimedia (CC BY-SA 3.0)

Example of Chu Dau vases. Only recently was the rich history of ceramics in Hái Dúóng Province, Vietnam, uncovered.

Credit: VTV World, YouTube

(Left) The Vase of Annam inscription; the red characters are the ones in question. (Center) How the characters are read if Bui Thi Hy is the name of the potter. (Right) How the characters are read if translated "a Bui artisan drew this for fun."

Vietnam's role in the global ceramic trade of the 15th and 16th centuries came to light in the 1980s following reexamination of an ancient vase that previously was attributed to a Chinese workman. Today, Chu Dau ceramics (named for a village in Hái Dúóng Province, Vietnam) are recognized as a unique type of Vietnamese ceramic distinct from the Chinese and Japanese ceramics of the same period.

In September last year, a subdivision of Vietnam Television called VTV World released a three-part documentary looking at this hidden history of Vietnamese ceramics. Below is a summary of that history.

The story begins: Vase of Annam

The Vase of Annam is a Chu Dau ceramic located in the Topkapi Sarayi Museum in Istanbul, Turkey. It first came to the attention of the art world in 1933, when British civil servant and antiquarian Robert Lockhart Hobson published an article about it in *Transactions of the Oriental Ceramic Society 1933–1934*.

In the article, Hobson attributed the vase to a Chinese workman named Chuang, based on how he translated the 13 Chinese characters written along the shoulders of the vase. But more than 40 years later, a reexamination of the characters by Southeast Asian art historian Roxanna Brown in 1977 revealed something startling.

Brown realized the characters should be translated as Vietnamese rather than Chinese. (The Vietnamese written language is based on Chinese characters, hence the confusion.) When translated this way, the potter's name became Bui, and the character "Thi" placed after the name identified the potter as female.

The other characters along the vase's shoulders indicated the potter Bui Thi Hy lived in the Nam Sách District of Hái Dúóng Province, Vietnam, and she made the vase in 1450. And with these clues, the search for Bui Thi Hy began.

In 1980, a Japanese diplomat named Makoto Anabuki sent a letter to local authorities of the then Hái Dúóng Province in Vietnam to learn more about the mysterious potter. (Hái Dúóng has since split into two provinces, Hái Dúóng and Húng Yên.)

"What was the person named Bui Thi Hy like?" he asked.

Anabuki would not know it, but his simple question would set off a years-long search for answers and lead to the uncovering of Chu Dau's rich ceramic history.

Discovering Chu Dau ceramics

Prior to Anabuki's letter, no one in Hái Dúóng Province was aware the craft of ceramics had existed in their locality.

"There were antiques in government and private collections, but they were wrongly categorised as ceramics from Bat Trang, 16 km north of Ha Noi," a Southeast Asian Archaelogy article on the history of Chua Dau ceramics explains. "The closest matches local archaeologists could find were inscriptions found on oil lamps by craftsman

Dang Huyen Thong in Thanh Lam District, located only two kilometres from Chu Dau."

After reading the letter, the provincial Museum and archeologist Tang Ba Hoanh decided to investigate the vase's origins. And since 1980, seven excavations in Hái Dúóng Province—plus the excavation of a shipwreck off the shores of Hôi An city in 1997–1999—revealed ancient ceramic kilns and tens of thousands of artifacts.

Many of the ceramics come from the village of Chu Dau in Hái Dúóng Province. The Chu Dau ceramics are made from white clay collected in Chí Linh, a city in Hái Dúóng Province where six rivers intersect. And compared to Chinese and Japanese ceramics made during the same period, Chu Dau ceramics are unique.

"It has its own style of inscription, design, and making-skills. It is truly Vietnamese," Nguyen Van Cuong, director of the Vietnam National Museum of History, says in part three of the documentary.

Unfortunately, war at the end of the 16th century destroyed Chu Dau, including all big ceramic kilns in Nam Sách District. That is why no one was aware of the area's history until Anabuki's letter in 1980.

But the question still remains—who was Bui Thi Hy?

Bui Thi Hy: The search for truth

The question is not just who Bui Thi Hy was—some researchers debate if she existed at all.

The debate arises from how one chooses to read the Chinese characters. As seen on the previous page, if the characters "Bui," "Thi," and "Hy" are placed together, then the inscription reads as "written by or painted by Bui Thi Hy." But if the characters "Hy" and "But" are read together instead, then the inscription reads "a Bui artisan drew this for fun."

For people who believe in the former translation, there are other documents they point to as proof of Bui Thi Hy's existence. For example, the stone lotus pillars located at Vien Quang Pagoda in Gia Loc District, Hái Dúóng Province feature inscriptions that read "Bui Thi Hy funded for building the pagoda." (Opponents say because the inscriptions appear to be reinscribed, they cannot be taken as proof.)

Likely the surest proof, though, comes from genealogical documents kept by the Bui family still living in Nam Sách District. These documents include an ancestor named Bui Thi Hy.

"However, whether she made the blue-and-white vase in Turkey and how that vase was transported from Nam Sách District to Istanbul is a question experts are trying to answer by collecting further evidence," the third part of the documentary explains.

Though the question of Bui Thi Hy's existence and role in the ceramic trade remains, experts emphasize she was ultimately the catalyst, not focus, of this story.

"The most important thing is that the Vietnamese blue-and-white vases were introduced to the world, illustrating a prosperous time for Vietnamese ceramics," says Augustine Ha Ton Vinh, senior investment advisor to Vietnam's Special Economic Zone and Integrated Resorts, in part three of the documentary.

And those prosperous times may come back. To honor the area's history, Chu Dau villagers are actively working to revive the ancient craft.

The three-part documentary can be found on VTV World's YouTube channel at https://www.youtube.com/c/VTVWorldVN. ■

Global markets for emerging materials in aerospace

By Robert Eckard

Global markets for emerging aerospace materials are expected to temporarily slide in the wake of the COVID–19 epidemic, dropping sharply from $14.7 billion in 2019 to an estimated $13.2 billion in 2020. However, markets will return to growth in the ensuing period, increasing to $19.9 billion in 2025 at a compound annual growth rate (CAGR) of 8.6% globally.

The advanced metal alloy segment accounts for the majority of the market, at an estimated $10.9 billion in 2020 and advancing to $15.4 billion by 2025 at a CAGR of 7.2%. The advanced composites and adhesives category will slide from $2.6 billion in 2019 to $2.3 billion in 2020 before returning to growth and surging to $4.5 billion in 2025 at a CAGR of 14.3%.

Increasing demand for improved fuel efficiency, enhanced performance, and increased safety is driving the aerospace industry to deploy new lighter weight, stronger materials that were once considered too costly or too difficult to use for day-to-day production activities. For example,

- **Carbon fiber-based composites:** Manufacturers are transitioning away from aluminum toward carbon fiber-based composites and honeycomb structures. However, adoption of these materials is still limited by cost, which can be several times higher than an equivalent amount of metals or metal alloys.
- **Ceramic matrix composites:** Ceramic matrix composites are still very much an emerging technology. To date, the primary targeted uses for these materials is in relation to the engine system—they are used as a coating or external refractory layer for superalloys in turbine-based engines.

The commercial passenger aircraft segment accounts for the largest value of the segments examined in this report, accounting for about 48% of markets for emerging aerospace materials in 2019. Commercial cargo transport aircraft represents the second largest segment, but it trails commercial passenger markets considerably with around 19% of the total market. In the wake of COVID–19, commercial transport aircraft is expected to surge ahead of passenger aircraft in terms of growth rates. These planes are being increasingly called upon to support the movement of goods, including rapid shipments that are increasingly becoming the norm.

About the author

Robert Eckard is a research analyst for BCC Research. Contact Eckard at analysts@bccresearch.com.

Resource

R. Eckard, "Global markets for emerging materials in aerospace" BCC Research Report AVM192A, July 2020. www.bccresearch.com. ■

Table 1. Examples of recent patents concerning emerging aerospace materials

Publication number	Publication date	Title	Standard applicant
WO2020052129A1	19 Mar 2020	Rare-earth aluminum alloy material having high ductility and high strength and preparation method therefor	Ka Fung Industrial Tech Huizhou Co Ltd [China]
US10590000B1	17 Mar 2020	High temperature, flexible aerogel composite and method of making same	Nasa [U.S.],Us Administrator Of National Aeronautics And Space Administration [U.S.]
US2020078860A1	12 Mar 2020	Titanium Alloys	Questek Innovations Llc [U.S.]
RU2715237C1	26 Feb 2020	Epoxy resin composition, cured epoxy resin product, prepreg and fibre-reinforced composite material	Toray Industries [Japan]
RU2714345C1	14 Feb 2020	Method of producing a gradient nanocomposite heat-shielding coating	Gosudarstvennyj Nauchnyj Tsentr Rossijskoj Federatsii Fed Gosudarstvennoe Unitarnoe Predpriyatie Iss [Russia]
AU2018298209A1	13 Feb 2020	Hydraulic fluid and fuel resistant sealants	Prc Desoto Int Inc [U.S.]
RU2713990C1	12 Feb 2020	One-piece multilayer shell with stiffeners and method of its formation	Aktsionernoe Obshchestvo Uralskij Nauchno Issledovatelskij Institut Kompozitsionnykh Mat [Russia]
RU2714146C1	12 Feb 2020	One-piece multilayer shell with flange and method of its formation	Aktsionernoe Obshchestvo Uralskij Issledovatelskij Institut Kompozitsionnykh Mat [Russia]
EP3606978A1	12 Feb 2020	Epoxy-silicone hybrid sealant composition with low shrinkage and lower postcuring properties with chemical resistance for aerospace applications	3m Innovative Properties Co [U.S.]
RU2714146C1	12 Feb 2020	One-piece multilayer shell with flange and method of its formation	Aktsionernoe Obshchestvo Uralskij Issledovatelskij Institut Kompozitsionnykh Mat [Russia]
RO133845A0	30 Jan 2020	Centrifugal compressor rotary assembly made of advanced composite polymeric materials reinforced with carbon fibers	Institutul Nat De Cercetare Dezvoltare Turbomotoare Comoti [Romania]
WO2020011065A1	16 Jan 2020	Novel high-strength multi-function laminated rib-containing plate and process	Yu Changhe [China]
US2020017738A1	16 Jan 2020	Epoxy-Silicone Hybrid Sealant Composition with Low Shrinkage and Lower Postcuring Properties with Chemical Resistance for Aerospace Applications	3M Innovative Properties Co [U.S.]
EP3591011A1	08 Jan 2020	Paint composition, preparation and use thereof	Fundacion Tecnalia Res & Innovation [Spain]

acers spotlight

SOCIETY, DIVISION, SECTION, AND CHAPTER NEWS

Help us help you

The American Ceramic Society is conducting market research to better understand the needs, interests, and challenges that impact professionals working in ceramics and glass.

A member satisfaction and needs assessment survey will be sent to ACerS members and customers in late September. As part of a distinguished community of academics, researchers, and industry professionals, your participation in this survey will inform ACerS about what you value.

Research results will serve as the first step in a long-range strategic planning process for the Society. Your input will help ACerS deliver high-quality products and services for your betterment, and that of future generations with an interest in ceramics and glass.

Please watch for the survey in your email. All members are urged to complete the survey, which will help us provide the information, products, and services to best serve you. Everyone who completes the survey will be eligible to be entered into drawings for 15 prizes valued between $100 and $500.

Thank you in advance for taking the time to share your valuable feedback—and for helping us help you!

Section News

The Washington DC/Maryland/Northern VA Section will host a webinar on September 30 at 2 p.m. called "Determining the Mechanical Properties of Ceramics and Glasses" by Jeffrey Swab.

For more information and to register, visit www.ceramics.zoom.us/webinar/98468451616. ■

Remembering Ted Day, former ACerS treasurer and CGIF chair

The Society was deeply saddened to learn of the passing of Thomas Edwin "Ted" Day on Sept. 14, 2020, a few weeks shy of his 60th birthday.

Ted led a life characterized by caring and compassion as a family man, pharmacist, businessman, philanthropist, Society volunteer, and leader in his Rolla, Mo., community.

"Ted was an energetic, enthusiastic guy, the epitome of *joie de vive*, one who didn't see life's limitations or problems, only the opportunities and the adventure," says Richard Brow, Curator's Professor of Ceramic Engineering at Missouri University of Science and Technology in Rolla, Mo. Brow and Day served together on the ACerS Board of Directors from 2010–2014.

The son of ACerS Distinguished Life Member and past president Delbert Day, Ted began his professional career in pharmacy. In the mid-1990s, Ted joined the Phelps County Regional Medical Center, where he served as director of pharmacy and then as ancillary services director, a position in which he oversaw all clinical patient services.

Ted left PCRMC in 1998 to assume the role of CEO at Mo-Sci Corporation, a glass manufacturing company founded in 1985 by Prof. Day to commercialize inventions developed in his lab at Missouri S&T. Today, Mo-Sci develops and manufactures custom high-tech glass products for the healthcare, energy, automotive, defense, and industrial sectors.

"Ted was a visionary, one who could see potential and make it a reality. He was an astute businessman, one who built the company his father started into an international specialty materials powerhouse, while never losing his enthusiasm and excitement about what Mo-Sci was producing and about the people who made it possible," says Brow.

Ted returned to PCRMC in the mid-2010s to serve as its Foundation's president and chair of its Board of Trustees. He and his wife, Kim, donated initial funding for the Phelps Health Delbert Day Cancer Institute, in honor of the work of Prof. Day, especially his biomedical inventions.

Ted's roles as a healthcare provider and business leader intersected with the commercialization of a copper-containing borosilicate glass called Mirragen that promotes healing of wounds that resist conventional treatment and offers new hope to patients suffering, for example, from diabetic and quadriplegic wounds. Mo-Sci spun off a new company, ETS Wound Care, to manufacture wound care products, and Ted served as its CEO.

Ted saw his success as a means to improve his local and global community. With his wife, he established the TKD Foundation to "turn innovative ideas into real help for humankind." Funded with profits from ETS Wound Care, the Foundation supports education, healthcare, community, and new nonprofit organizations that share their vision for a world where people's most basic needs are met.

Ted was passionate about reaching out to young people. When high school students from Conrad Weiser High School's Science Research Institute program in rural Pennsylvania reached out to Mo-Sci requesting sample glass fibers, he took the time to go visit them and see their projects. He followed up by inviting several students and teachers to come to Mo-Sci to pitch ideas for new products.

This experience was a continuation of the hands-on approach Ted took with his dedication to philanthropy and outreach. In 2015, he helped to found ACerS's philanthropic arm, the Ceramic & Glass Industry Foundation, with the mission to recruit and retain a qualified workforce for the ceramic and glass industry. He served as its first chair from 2015–2018.

"Ted had a passion to help people and to give back to the community. His contribution of time, treasure, and talent to The American Ceramic Society and its Ceramic and Glass Industry Foundation was extraordinary. We will miss him greatly," says Mark

Mecklenborg, ACerS executive director.

Ted joined the Society in 1998 and became a Fellow in 2016. Mo-Sci is a Diamond Corporate Partner of the Society.

At the time of his death, Ted was also a member of the Missouri S&T Board of Trustees.

"As a member of the Missouri S&T Board of Trustees, he played the same vital role that he did when serving on the Boards of The American Ceramic Society and the Ceramic and Glass Industry Foundation—a clear-eyed visionary, a data-driven, results-oriented, compassionate colleague, one who loved the institution and respected those in it," says Brow.

Ted, like his father, was an accomplished pilot, and it was common for them to fly themselves to ACerS conferences. The first question on greeting the Days was always, "Did you fly or go commercial?" He piloted himself through life with grace and joy. His final trip now completed, we are grateful to have shared the journey with him. ■

In memoriam

Edwin Beauchamp
Thomas E. "Ted" Day
Amory Houghton
Wing Lo
Charles Joseph Rickey

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

Names in the news


Fergus

Jeffrey W. Fergus, associate dean for undergraduate studies and program assessment and professor of materials engineering in the Samuel Ginn College of Engineering at Auburn University, will receive the 2020 ABET Award at the 2020 ABET Awards Celebration, which will be held as a virtual event on Oct. 31, 2020.


Graeve

Olivia Graeve, University of California, San Diego professor of mechanical and aerospace engineering, received the Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring from the White House.


Hu

Juejun Hu, associate professor at Massachusetts Institute of Technology, was selected winner of the 2020 Vittorio Gottardi Prize of the International Commission on Glass.


Laurencin

Cato T. Laurencin, designated University Professor and Albert and Wilda Van Dusen Distinguished Endowed Professor of Orthopedic Surgery at the University of Connecticut, is the recipient of the 2020 Von Hippel Award, the Materials Research Society's highest and most prestigious honor.

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.

Ceramic Tech Today blog
www.ceramics.org/ceramictechtoday

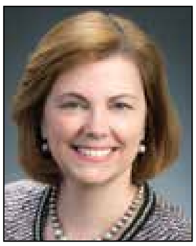
Society, Division, Section, and Chapter news (continued)

ACerS leaders for 2020–2021

ACerS is pleased to introduce the 2020–2021 Society leadership. New officers and directors will be installed at the 122nd Virtual Annual Business Meeting on Oct. 5, 2020.

Society officers and directors

Executive Committee


Goski

President
Dana Goski
Vice president of research and development
Allied Mineral Products Inc.
Columbus, Ohio


Dickey

President-elect
Elizabeth Dickey
Distinguished professor and associate department head
North Carolina State University
Raleigh, N.C.


Ohji

Past president
Tatsuki Ohji
Fellow scientist
National Institute of Advanced Industrial Science and Technology
Japan

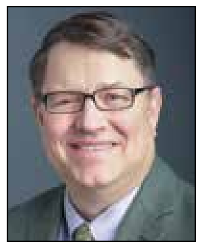

Houseman

Treasurer
Stephen Houseman
President
Harrop Industries Inc.
Columbus, Ohio


Mecklenborg

Secretary
Mark Mecklenborg
Executive director
The American Ceramic Society
Westerville, Ohio

Board of Directors (new)


Butt

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


Hemmer

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


Naito

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


Wang

Jingyang Wang
CAS Distinguished Professor and division head
Shenyang National Laboratory for Materials Science, Institute of Metal Research, Chinese Academy of Sciences
Shenyang, China

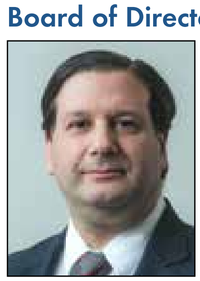

Chan

Helen Chan
New Jersey Zinc Professor
Lehigh University
Bethlehem, Pa.

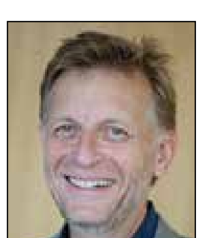

Ferraris

Monica Ferraris
Full professor of science and technology of materials
Politecnico di Torino
Turin, Italy

Board of Directors (returning)


Affatigato

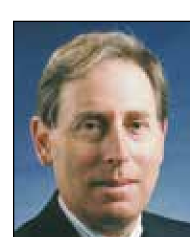
Mario Affatigato
Fran Allison and Francis Halpin Professor of Physics
Coe College
Cedar Rapids, Iowa


Kieffer

John Kieffer
Professor
University of Michigan
Ann Arbor, Mich.


Headrick

William Headrick
Senior research engineer
RHI Magnesita
Pevely, Mo.


Freiman

Parliamentarian
Stephen Freiman
Freiman Consulting Inc.
Potomac, Md.

Volunteer Spotlight

Brennecka

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

Geoff Brennecka earned B.S. and M.S. degrees in ceramic engineering from the University of Missouri-Rolla (now Missouri University of Science and Technology) and a Ph.D. in materials science and engineering from the University of Illinois at Urbana-Champaign. After eight years at Sandia National Laboratories, Brennecka joined the faculty of the Colorado School of Mines in 2014, where he is the Ben Fryrear Endowed Chair for Innovation.

Brennecka started his engagement with ACerS via the ACerS/NICE Student Congress while an undergraduate, which led to his helping to establish and mentor the ACerS President's Council of Student Advisors and Young Professionals Network. He has served on the Board of Directors for both ACerS and the Ceramic and Glass Industry Foundation, is an editor of the *Journal of the American Ceramic Society*, and was chair of the Electronics Division.

Brennecka is also president of Keramos and on the Administrative Committee of the IEEE-UFFC Society. He is a Fellow of ACerS and recipient of an NSF CAREER award, the IEEE Ferroelectrics Young Investigator Award, Du-Co Ceramics Young Professional Award, and Karl Schwartzwalder Professional Achievement in Ceramic Engineering Award.

Rimsza

Jessica Rimsza earned her B.S. and a Ph.D. in materials science and engineering from the University of Arizona and the University of North Texas, respectively. After a postdoctorate at Sandia National Laboratories, she joined the staff member in 2018 in the Geochemistry Department. Her research focuses on molecular scale modeling of glass and ceramic materials, with a focus on surface properties.

Rimsza served as past chair and programming chair for ACerS President's Council of Student Advisors. She co-chaired GOMD 2020, which due to COVID-19, was replaced with the Virtual Glass Summit. Currently, Rimsza co-chairs ACerS Education and Professional Development Council, and she is a member of ACerS Meetings Committee.

She received the Graduate Excellence in Materials Science award and won the Best in Session Award for Semiconductor Research Corporation's Techon Conference. ■

AWARDS AND DEADLINES

Nomination Deadline: Jan. 15, 2021

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

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

FOR MORE INFORMATION:

www.ceramics.org/awards

Society Awards	Description
Frontiers of Science and Society - Rustum Roy Lecture	Given each year by a nationally or internationally recognized individual in the area of science, industry, or government. Generally the committee selects the lecturer, but suggestions from membership are invited.
Edward Orton, Jr. Memorial Lecturer	Selection is based on scholarly attainments in ceramics or a related field. Generally the committee selects the lecturer, but suggestions from membership are invited.
Arthur L. Friedberg Ceramic Engineering Tutorial and Lecture	Given to an individual who has made outstanding contributions to ceramic engineering that relate to the processing or manufacturing of ceramic products. The awardee must be a member of EPDC and ACerS.
Robert B. Sosman Award	Awarded by the Basic Science Division in recognition of outstanding achievement in basic science that results in a significant impact to the field of ceramics.
John E. Marquis Memorial Award	Given by ACerS Manufacturing Division to the author(s) of the 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, which is judged to be of greatest value to the members and to the industry.
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.
Ross Coffin Purdy Award	Given to the author(s) who made the most valuable contribution to ceramic technical literature during the calendar year two years prior to the year of selection. The 2021 Purdy award is for the best paper published in 2019.
Richard and Patricia Spriggs Phase Equilibria Award	Given to the author(s) who made the most valuable contribution to phase stability relationships in ceramic-based systems literature during the previous calendar year (2020).
Education and Professional Development Council Outstanding Educator Award	Recognizes outstanding work and creativity in teaching, in directing student research, or in the general educational process (e.g., lectures, publications) of ceramic educators.
Morgan Medal and Global Distinguished Doctoral Dissertation Award	Recognizes a distinguished doctoral dissertation in the ceramics and glass discipline.
The Anna O. Shepard Award	Presented by ACerS Art, Archaeology & Conservation Science Division to an individual(s), this award recognizes outstanding contributions to materials science applied to art, archaeology, architecture, or cultural heritage.

Awards and deadlines (cont.)

2020 Division awardees

Cements Division
Best paper: "A critical comparison of 3D experiments and simulations of tricalcium silicate hydration," *Journal of the American Ceramic Society* 101(4), 1453–1470 (2018) by **Jeffrey Bullard, John Hagedorn, Tyler Ley, Qinang Hu, Wesley Griffin, & Judith Terrill**

Electronics Division **Edward C. Henry Award**
Best paper: "Fabrication of $0.24Pb(In_{1/2}Nb_{1/2})O_3$-$0.42Pb(Mg_{1/3}Nb_{2/3})O_3$-$0.34PbTiO_3$ transparent ceramics by conventional sintering technique," *Journal of the American Ceramic Society* 102, 1240–1248 (2019) by **Ichiro Fujii, Saki Nakashima, Takahiro Wada**

Electronics Division **Lewis C. Hoffman Scholarship**
Eric Knowles, North Carolina State University ■

STUDENTS AND OUTREACH

Virtual Winter Workshop scheduled for January 2021

The 2021 ACerS Winter Workshop will be held virtually in late January or early February. The program was specifically designed to accommodate students across time zones from Europe to the United States. The two sessions of approximately five hours each will consist of technical presentations and professional development activities.

Noted scientists will deliver presentations on recent research in fields including machine learning for materials discovery; additive manufacturing of ceramics; and ceramics for medical, energy, and space applications. Professional development activities will include networking sessions and facilitated discussions on building your career in a diverse environment. Registration information will be available soon at www.ceramics.org/winter-workshop-2021. ■

ACerS Morgan Medal and Global Distinguished Doctoral Dissertation Award

The purpose of this award is to recognize a distinguished doctoral dissertation in the ceramics and glass discipline. The awardee must have been a member of the Global Graduate Researcher Network and have completed a doctoral dissertation as well as all other graduation requirements set by their institution for a doctoral degree within 12 months prior to the application deadline. The nomination deadline is **Jan. 15, 2021**. For more information, visit www.ceramics.org/doctoraldissertationaward. ■

Grad Students: Choose GGRN to advance your career

Build an international network of peers within the ceramic and glass community by joining the Global Graduate Researcher Network. GGRN is ACerS membership option that addresses the professional and career development needs of graduate level research students who have a primary interest in ceramic and glass materials. Membership in GGRN is only $30 USD per year. Visit www.ceramics.org/ggrn to learn how GGRN membership can help you in your future career. You may also contact Yolanda Natividad, ACerS member engagement manager, at ynatividad@ceramics.org with questions. ■

Did you graduate recently? ACerS has a gift for you!

ACerS Associate Membership connects you to more than 10,000 professionals from more than 70 countries. ACerS can help you succeed by offering you the gift of a FREE Associate Membership for the first year following graduation. Your second year of membership is only $40. Associate members have access to leadership development programs, special networking receptions, volunteer opportunities, and more.

Let ACerS make your transition to a seasoned professional easier. Start your free year-long membership by visiting www.ceramics.org/associate or contact Yolanda Natividad, ACerS member engagement manager, at ynatividad@ceramics.org. ■

CERAMICANDGLASSINDUSTRY FOUNDATION

PACK Fellowship makes technical webinars available

PACK is a National Science Foundation-funded international research experience fellowship opportunity for graduate students (U.S. citizens or permanent residents only) to conduct research at the University of Kiel in Germany. PACK is a collaborative effort of **P**enn State, The **A**merican **C**eramic Society, and University of **K**iel.

A PACK Fellowship provides graduate students further training and exposure in an international setting. It allows them to develop and strengthen collaborations between researchers in identified areas of research and to work toward solving complex issues.

The fellowship provides support for travel, lab fees, and boarding. In addition to research, selected students get an opportunity to attend relevant courses at University of Kiel, get exposure to entrepreneurship training, and participate in professional development activities. PACK Fellows also have opportunities for participation in peer-to-peer based knowledge transfer activities, interdisciplinary seminars, and regularly scheduled retreats. There are additional opportunities to visit other labs and research sites in Germany, interact with researchers at Penn State, and attend annual meetings of The American Ceramic Society and Energy Harvesting Society.

The PACK technical seminars are offered monthly and are available to view online. The most recent seminars include

• "Controlling cells by structural and mechanical materials cues," presented by Christine Selhuber-Unkel of Heidelberg University,

• "Aeromaterials: Structuring thin films into 3D—from capacitors to cell templates," presented by Rainer Adelung of Christian-Albrechts-University of Kiel, and

• "Computation-guided discovery of transparent crystals with ultrahigh piezoelectricity," presented by Long-Qing Chen of Penn State University.

The seminars are available for viewing at www.packfellowship.org/seminars.

Applicants can be from any science or engineering discipline, and applications to become a PACK Fellow are accepted year-round. Program information and the application process is available at www.packfellowship.org/about.

PACK Fellow George Kotsonis of Penn State presents his research at the University of Kiel.

research briefs

Topological data analysis reveals hidden medium-range order in glass

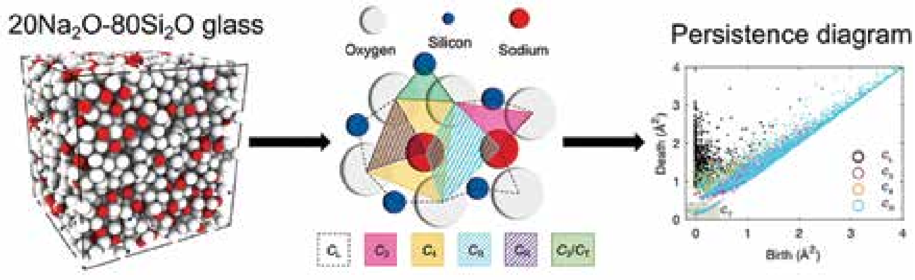
Researchers at Aalborg University in Denmark, along with a collaborator at the University of California, Los Angeles, demonstrated how a topological method called persistent homology could help reveal a glass's medium-range order and its contribution to the first sharp diffraction peak (FSDP).

The FSDP interests glass researchers because it describes the longest separated repeating "unit" in the amorphous structure. In other words, it is a descriptor of medium-range order. Medium-range order plays an important role in control of an amorphous material's physical properties, so determining what the FSDP describes is of more interest than investigating other diffraction peaks that instead describe short-range order.

Researchers have suggested numerous structural origins for FSDP, including quasi-crystalline and ring-type structures or layer-like and cluster-like regions. The growing use of simulations in research has helped deepen our understanding of the FSDP by either supporting or undermining certain models.

Recently, some studies have proposed another type of data analysis that may prove useful in understanding the FSDP and medium-range order more generally—persistent homology.

Persistent homology is a type of topological data analysis, i.e., an analysis that focuses on analyzing the qualitative properties of a geometric object that are preserved under continuous deformations, such as stretching and bending. In other words, the "shape" of the data provides useful information about the data.



Schematic overview of the process of obtaining a persistence diagram. Here, the trajectory information for a $20Na_2O$-$80SiO_2$ glass at 300 K (oxygen: white; silicon: blue; sodium: red) is used to construct the persistence diagram.

In regard to glass, researchers view persistent homology as useful because it can provide a global perspective on the system rather than being limited to analyzing specific parts of the structure, such as happens in standard ring analyses, for example.

However, previous studies that applied persistent homology to amorphous structures containing medium-range order faced some challenges. In persistent homology, a concept called "loops" is used to understand how points of data relate to each other. In previous studies, researchers categorized loops using a mathematical grouping termed "optimal cycle," but categorizing loops this way provided no direct geometrical interpretation of loops.

Finding a different way to categorize loops would likely lead to more meaningful data, and that was the goal of the researchers of the recent study.

Instead of using the "optimal cycle" approach, the researchers grouped loops into characteristic regions based on the number of atoms each loop contained. And in their recent open-access paper, "we show that this produces meaningful data in a consistent manner (i.e., method should be transferable to different amorphous systems)," Søren S. Sørensen, first author and Ph.D. candidate at Aalborg University, says in an email.

In particular, Sørensen says based on loop sizes, they were able to define geometrical interpretations of the characteristic regions, which enabled easier structural interpretation of the glass.

The researchers were not done yet, though. Once they decided on the new

Research News

Face shield or face mask to stop the spread of COVID-19?

Researchers from Florida Atlantic University used qualitative visualizations to test how face shields and masks with valves perform in impeding the spread of aerosol-sized droplets. They found although face shields block initial forward motion of expelled droplets, the droplets move around the visor with relative ease and spread out over a large area depending on light ambient disturbances. Visualizations for the face mask equipped with an exhalation port indicate a large number of droplets pass through the exhale valve unfiltered, which significantly reduces its effectiveness as a means of source control. The researchers say this study illustrates face shields and masks with exhale valves may not be as effective as regular face masks. For more information, visit http://www.fau.edu/newsdesk/research.php.

Scientists probe the chemistry of a single battery electrode particle both inside and out

Researchers led by SLAC National Accelerator Laboratory placed a single battery cathode particle, about the size of a red blood cell, on a needle tip and probed its surface and interior in 3D with two X-ray instruments. They discovered cracking and chemical changes on the particle's surface varied significantly from place to place and corresponded with areas of microscopic cracking deep inside the particle that sapped its capacity for storing energy. The team plans to apply this technique to other electrode materials they have studied in the past, with particular attention to how charging speed affects damage patterns. For more information, visit https://www6.slac.stanford.edu/news/news-center.aspx.

method by which to group loops, they turned their attention to improving analysis of persistence diagrams (the diagrams presenting loops obtained from persistent homology analysis).

Previously, comparing persistence diagrams relied on qualitative interpretation, which made comparison difficult. So the researchers compared persistence diagrams using a quantitative method called the accumulated persistence function (APF).

APF is a cumulative sum of all points in a persistence diagram weighted by the points' lifetime. "This means that the APF characterizes the persistence diagram completely and is especially well-suited for data where 'shortlived' loops or voids (as found in glasses) are real structural features and not noise," the researchers write.

Equipped with their new methodology for determining characteristic regions and the APF, the researchers analyzed medium-range order structure—particularly the FSDP—in sodium silicate glasses, the structures of which they generated using molecular dynamics simulations.

The researchers determined the FSDP originated from structural features of oxygen/sodium atom packing in the sodium silicate glass. Importantly, the new definitions of characteristic regions allowed the researchers to deduce how different types of loops contribute to the FSDP.

"[We] believe this approach may lead to the settlement of the long-lasting debate regarding the origin of the FSDP in glassy systems," they write in the conclusion. "More generally, it can be applied to analyze and categorize molecular dynamics data and reveal hidden medium-range order in various amorphous materials."

The open-access paper, published in *Science Advances*, is "Revealing hidden medium-range order in amorphous materials using topological data analysis" (DOI: 10.1126/sciadv.abc2320).

Understanding electron transport in graphene nanoribbons

Researchers from École polytechnique fédérale de Lausanne employed advanced computer simulations to learn how electrical conductivity of graphene nanoribbons is affected by chemical functionalization with guest organic molecules that consist of chains composed of an increasing number of aromatic rings. They discovered the conductance at energies matching the energy levels of the corresponding isolated molecule was reduced by one quantum, or left unaffected based on whether the number of aromatic rings possessed by the bound molecule was odd or even. For more information, visit https://www.springer.com/gp/about-springer/media/research-news.

Bioinspired ceramic–metal composite stands its ground against cutting tools

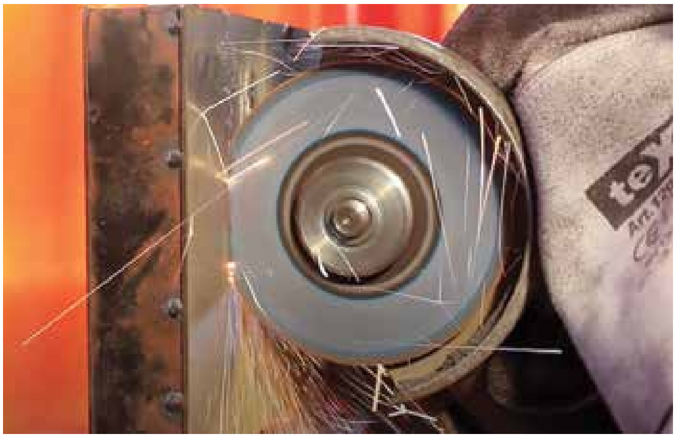
A team of researchers in the U.K. and Germany developed a ceramic–metal composite that, despite being just 15% as dense as steel, is nearly uncuttable. They accomplished this feat by developing the composite to work with the power of cutting tools rather than against them.

The structure of the composite—a flexible aluminum core embedded with alumina spheres—mimics the structure of nacre and many other naturally occurring materials that are stronger as a whole material than as their individual units.

To make the cellular aluminum core, the team mixed aluminum powder with a titanium foaming agent and then cold-compacted and extruded the material into rods. They cut these rods into smaller pieces and stacked them together with 13-mm-diameter alumina spheres in a steel box.

Heating the combination to 760°C in a furnace melded the individual components together to create Proteus—a cellular aluminum core with 73% porosity, studded with embedded ceramic spheres and bordered by steel alloy faceplates.

Putting this material to the test against an angle grinder (equipped with sapphire-finished cutting discs) and a drill, the



Researchers in the U.K. and Germany developed a ceramic–metal composite that, despite being just 15% as dense as steel, is nearly uncuttable.

researchers showed the composite resists most damage beyond surface cuts, performing better than rolled homogeneous armor.

When a cutting tool slices into Proteus and encounters an alumina sphere, it breaks apart into fine particulate matter—creating a "sandpaper-like, vibrating interface with the cutting disc," the researchers write in the paper describing their findings. The abrasive action of the alumina particulates quickly wears down cutting surfaces, preventing the tool from penetrating further into the composite. In addition, the small alumina particles better resist penetration "due to the increase of their system level resistance under high strain rates," the researchers note.

In other words, the material is willing to sacrifice a few alumina spheres to protect its overall integrity, allowing it to last much longer against cutting tools.

But an abrasive surface is not all the composite has in its arsenal. The natural frequency of the material also works against cutting tools—as the tool spins, it generates vibrational frequencies that interact with those of the spheres, essentially amplifying vibrations at the interface and further wearing down the tool before it can make significant progress into the material.

Combined, these features give Proteus a one-two-three punch—a highly abrasive interface, heat generated at the interface due to that friction, and vibrations—that work together against the cutting tool, destroying it before it can destroy the material.

In addition, the researchers speculate in the paper that localized heating could enable a phase change in alumina, densifying it to further resist cutting.

Although the team is still investigating the full mechanism and full potential of Proteus, they believe "The configuration of our new architected material can be tailored to a broad range of applications."

The open-access paper, published in *Scientific Reports*, is "Non-cuttable material created through local resonance and strain rate effects" (DOI: 10.1038/s41598-020-65976-0).

Weak concrete, heavy trucks—understanding reasons for sewer line failure

Researchers at The Ohio State University looked to develop a more encompassing model to account for the numerous factors and uncertainties that affect behavior of concrete sewer pipes.

Many drinking water and wastewater systems in the United States desperately need repair. An assessment by the American Society of Civil Engineers in 2017 rated the overall condition of these systems at D and D+, respectively. The assessment estimated nearly $150 billion would be needed to fix and maintain these systems—yet only $45 billion is designated for this purpose. And as systems age and the population continues to grow, the gap between needed funding and available funding will continue to widen as well.

Funding, unfortunately, is not a problem that researchers can solve. However, understanding how systems age and why systems fail are questions they can address. And the answers

Research News

Machine-learning helps sort out massive materials' databases

Researchers at École polytechnique fédérale de Lausanne and the Massachusetts Institute of Technology used machine-learning to organize the chemical diversity found in the ever-growing databases for metal-organic frameworks (MOFs). Currently, there are over 90,000 MOFs published, and the number grows every day. Though exciting, the sheer number of MOFs makes it difficult to know if a proposed MOF is truly a new structure and not some minor variation of a structure that has already been synthesized. The researchers found the major databases have bias toward particular structures. For more information, visit https://actu.epfl.ch.

Recharging N95 masks for continued usage

Researchers from India's Tata Institute of Fundamental Research and Israel's Technion-IIT discovered a method to restore the filtration efficiency of N95 masks to out-of-box levels as long as the mask is not structurally compromised. The method involves tossing an N95 into a standard washing machine to clean it and then recharging it by sandwiching the mask between two electrodes at high voltage to recover its 95% efficiency. For more information, visit https://publishing.aip.org/publications/latest-content.

Credit: PxHere

Researchers at The Ohio State University found weak concrete and heavy trucks are two factors that contribute to failure of concrete sewer pipes.

to these questions will help the people who do decide funding better understand the urgency of the situation.

Many factors, including material properties, geometry, and loading, affect the behavior of water infrastructure, and each factor comes with different levels of significance and uncertainties. So determining which factors play the biggest role in failure can be difficult.

"To address the high computational demands [involved with calculating so many factors], past studies chose a selected number of variables related to deterioration, material, geometry, and loading properties to estimate the probability of failure of pipes," the OSU researchers write in their paper. "However, the selected variables may not include all significant variables. This subsequently leads to treatment of influential variables as deterministic, which negatively affects results of reliability analysis by disregarding the corresponding uncertainties."

To develop a more encompassing model, the researchers developed a surrogate model based on Bayesian additive regression trees, a regression method that supports uncertainty quantification. It allowed them to evaluate the stress to sewer pipes by each variable individually and in combination.

After conducting several statistical analyses using the Ohio Supercomputer Center, they identified several factors that appear to most influence formation of cracks that threaten structural integrity.

- **Material properties of the concrete pipes**, including tensile strength, compressive strength, and elastic modulus coefficient.
- **Variables associated with trucks driving on the road above the pipes**, including wheel load and number of trucks.
- **Properties of the soil**, including backfill density and bedding elastic modulus.

The researchers focused on performance of pristine buried concrete sewer pipes and did not consider impacts of degradation over time. "However, the importance of corrosion for the serviceability and structural integrity of these structures over their service life warrants comprehensive sensitivity analyses for deteriorated sewer pipes in future investigations," they write.

They add that other pipe configurations and more details on different soil types should be investigated as well.

The paper, published in *Structure and Infrastructure Engineering*, is "Significant variables for leakage and collapse of buried concrete sewer pipes: a global sensitivity analysis via Bayesian additive regression trees and Sobol' indices" (DOI: 10.1080/15732479.2020.1762674). ■

Researchers improve understanding of insulator-metal transition in vanadium dioxide films

Researchers from the Institute for Theoretical and Applied Electromagnetics at the Russian Academy of Sciences and the Moscow Institute of Physics and Technology used the framework of blow-up overheating instability to improve understanding of the insulator-metal transition in vanadium dioxide.

The insulator-metal transition refers to the switch from being insulating to conductive in some materials once they reach a certain temperature. The transition in vanadium dioxide occurs closest to room temperature, at 340 K (67°C or 152°F), so harnessing vanadium dioxide's transition in

An example of thermochromic glass, a type of passive smart glass technology that changes tint in response to heat. Researchers are actively investigating the use of vanadium dioxide in such glass.

applications is much easier to achieve compared to other materials that exhibit this transition. However, though the existence of an insulator-metal transition in vanadium dioxide was confirmed in 1959, the mechanism behind this transition remains hotly debated more than 60 years later.

There are several theories as to what causes the transition, but the overheating instability and the blow-up regime framework is one applied in recent years to understand the transition. Overheating instability refers to conditions in which a system's heat generation exceeds heat removal, causing sample temperature to increase over time. This instability can lead to the blow-up regime, which is when the rate of temperature increase is faster than exponential. (In formal terminology, the temperature becomes infinite in a finite time.)

These terms are generally used to explain observances in plasmas, semiconductors, and superconductors. But in the early 2010s, several papers suggested the overheating mechanism also plays a role in the voltage-induced insulator-metal transition in vanadium dioxide. This suggestion was since developed in further studies, but one intriguing feature observed in numerous experiments remains unexplained—nonhomogeneous development of the overheating in homogeneous samples.

In the recent paper, the Russian researchers looked to explain the nonhomogeneous overheating and how it relates to the insulator-metal transition within the framework of blow-up overheating instability.

At the beginning of their paper, they emphasize their goal is to provide a general explanation for the observances rather than construct a detailed theory of the phenomenon.

"The problem of the IMT [insulator-metal transition] in VO_2 includes two aspects: microscopic and macroscopic. The microscopic aspect of the problem is a separate task, which is of interest and importance. ... Here we consider only the macroscopic part of the problem. Thus, we do not discuss the physical nature of the IMT itself," they write.

For their study, the researchers focused on investigating thin films of vanadium dioxide. Bulk samples of vanadium dioxide also exhibit the insulator-metal transition, but they tend to crack after several transition cycles because of changes in the crystal structure. In contrast, thin films are durable and can survive many transition cycles, thus making them more promising for applications.

The researchers first wanted to determine whether vanadium dioxide film structure affected occurrence of nonhomogeneous overheating. So they compared data on high-quality epitaxial vanadium dioxide films, which came from a 2013 paper, to data on nanocrystalline granular vanadium dioxide films, which came from experiments they performed.

They found qualitative observations of the insulator-metal transition in granular and epitaxial films were similar despite differences in the characteristic parameter values. "Thus, we conclude that a macroscopic mechanism of the IMT in the vanadium dioxide films is universal and independent of the film structure," they write.

Following this conclusion, the researchers created models to study more closely the occurrence of nonhomogeneous overheating near the insulator-metal transition temperature.

They determined small local perturbations in the uniform temperature distribution leads to localized areas of overheating and blow-up, which thus raises temperature in that area high enough to cause the transition from insulating to conductive behavior. These localized blow-ups then grow and merge together, turning into a narrow, overheated conductive channel in the insulating environment.

The researchers note the mathematical description they proposed to explain this blow-up overheating mechanism is similar to that used to describe the superconductor-normal state transition in commercial high-T_c tapes. However, "the hot channel in high-T_c tapes is directed across the current flow in contrast to the IMT where instability develops along the current direction," they write.

The paper, published in *Physical Review B*, is "Blow-up overheating instability in vanadium dioxide thin films" (DOI: 10.1103/PhysRevB.101.214310). ■

advances in nanomaterials

Liquid crystals offer way to reconfigure optical properties of metalenses

Researchers from Case Western Reserve University, Harvard School of Engineering and Applied Sciences, and University of Calabria (Italy) explored using liquid crystals to gain dynamic control over the optical properties of metalenses.

Metalenses are a type of metasurface, i.e., artificially nanostructured surface, that can focus light without causing image distortion. They were selected as among the Top 10 Emerging Technologies by the World Economic Forum in 2019, but they still face a few limitations compared to traditional lenses, including lower light transmission efficiency and size restraints.

One limitation of metalenses that scientists are looking to overcome is the lack of dynamic control over optical properties. Metalenses are generally designed to fulfill a single functionality, which "presents a barrier to potential application where differing optical responses may be necessary," the researchers write in their paper.

The researchers note numerous studies in recent years have explored different methods by which to design reconfigurable metasurfaces, such as mechanical and thermal approaches. They decided to explore yet another approach—using liquid crystals to modify a metalens' optical properties.

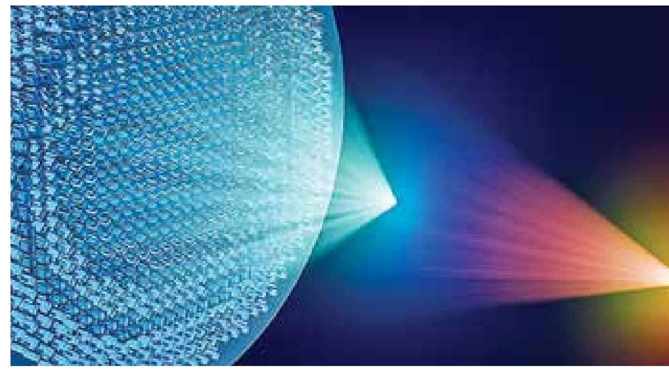
Liquid crystals are a birefringent complex fluid, meaning the fluid has two different refractive indices that correspond to the polarization of light.

Previous studies investigated creating reconfigurable optics using conventionally sandwiched liquid crystal cells with one of the two plates coated with a metasurface. However, "Opposed to these implementations involving a bulky [liquid crystal] cell, we propose in this work to harness the wetting properties of the metalens to replace the air between the planar nanostructures," the researchers write.

The researchers used three common thermotropic rod-shaped nematic liquid crystals—MBBA (Sigma-Aldrich), E7 (Merck), and BL009 (Beam Co.)—to modify the optical properties of metalenses composed of fused silica nanopillars on a fused silica substrate.

They found infiltrating the metalens with liquid crystals noticeably affected the optical properties. In particular, there was a loss in focusing ability following infiltration because "The metalens structures are designed for ambient conditions, ... They are not designed to accommodate the relatively small index contrast produced by infiltration of [nematic liquid crystals] whose refractive indices are similar to the constituent material," they write.

The researchers note more studies are needed on controlling the local molecular orientation of liquid crystals and on designing metalenses to better accommodate infiltration. However, "This is just the first step, ... and we have already been contacted by companies interested in this technology," Giuseppe Strangi, senior author and physics professor at Case Western, says in the press release.



Credit: Case Western Reserve University

Researchers in the U.S. and Italy found infiltrating metalenses with liquid crystals may allow dynamic control of the lenses' optical properties.

The paper, published in *Proceedings of the National Academy of Sciences USA*, is "Optical properties of metasurfaces infiltrated with liquid crystals" (DOI: 10.1073/pnas.2006336117). ■

Understanding uniform deposition of 2D materials for printed electronics

In a recent paper, an international team of researchers led by the University of Cambridge propose an explanation for the mechanism behind a possible solution they discovered in 2017 to uniformly deposit inks based on 2D materials.

2D materials have unique electronic and optical properties that make them of interest for use in printed electronics, a nascent branch of electronics manufacturing that involves using established printing techniques, such as screen printing, ink-jet printing, or gravure printing, to deposit conductive materials onto a given substrate in a predefined pattern.

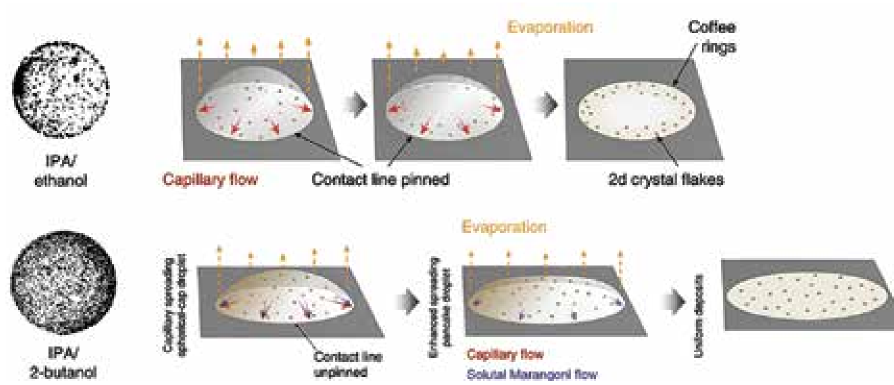
Researchers have attempted to create printed electronics by depositing inks based on 2D materials, but the way such inks are created leads to difficulties with deposition.

The inks are often created through liquid-phase exfoliation, a group of approaches that exfoliate 2D materials from bulk materials directly in a liquid media. These dispersions are then used for device fabrication.

"However, this direct adaption without elaborate ink formulation through control over composition, rheology, and fluidic properties presents challenges in achieving uniformly deposited functional structures and, hence, device reproducibility and scalability," the researchers write in their open-access paper.

One parameter hindering the uniform deposition is how the ink dries. When inks based on 2D materials dry, they exhibit the coffee-ring effect, a type of capillary flow. In particular, different evaporation rates across the droplet cause liquid evaporating from the edge to be replenished by liquid from the interior—leading to ring-shaped, nonuniform deposition of the ink.

"Although various strategies have been developed to suppress the [coffee-ring effect], none of these are generally applicable for 2D crystal inks due to problems of dispersion stability, postprocessing requirements, or the effect of ink



Credit: Hu et al., Science Advances (CC BY 4.0)

Inverted optical micrographs of dried isopropanol-based droplets (top) and isopropanol/2-butanol-based droplets (bottom). The accompanying illustrations show the differences between their drying mechanisms: coffee-ring effect (top) and Marangoni flow (bottom).

additives on material functionality," the researchers write.

In 2017, the researchers investigated black phosphorus ink formulation and made a surprising discovery—they achieved uniform ink deposition when using a mixture of isopropanol and 2-butanol for the solvent in the liquid-phase exfoliation process.

Isopropanol is widely used as a solvent for graphics inks. But traditionally, use of isopropanol solvent to process inks based on 2D materials led to nonuniform deposition. Why did mixing 2-butanol with isopropanol change the deposition outcome?

That question went unanswered in the 2017 paper. So the researchers looked to answer it in the recent study.

They observed that while droplets were "pinned" (the outer edge remained stationary) at the early stage of drying in the isopropanol case, droplets expanded at an almost constant speed and did not pin until later in the isopropanol/2-butanol case—thus suppressing the coffee-ring effect.

In the results section, the researchers propose Marangoni flows in the isopropanol/2-butanol mixture prevented the droplets from pinning.

The Marangoni effect describes how fluid flow along the interface of two fluids is affected by differences in the fluids' surface tensions.

In the case of inks made using the isopropanol/2-butanol solvent, isopropanol evaporates faster than 2-butanol. So the isopropanol along the contact line (edge) of the droplet evaporates first, leaving mostly 2-butanol behind. This evaporation causes a difference in surface tension between the 2-butanol-rich edge and isopropanol-rich center of the droplet, "leading to a Marangoni flow from thicker areas to thinner areas" and uniform spreading of the 2D materials, the researchers write.

The researchers printed arrays of nonlinear optical saturable absorbers, room temperature gas sensors, and photodetectors to demonstrate the potential of inks created using the isopropanol/2-butanol solvent. For all devices, the performances were "well within acceptable statistical variations for printed device manufacturing from 2D crystal inks, addressing one of the most challenging obstacles toward their additive manufacturability."

The 2017 open-access paper, published in *Nature Communications*, is "Black phosphorus ink formulation for inkjet printing of optoelectronics and photonics" (DOI: 10.1038/s41467-017-00358-1).

The 2020 open-access paper, published in *Science Advances*, is "A general ink formulation of 2D crystals for wafer-scale inkjet printing" (DOI: 10.1126/sciadv.aba5029). ■

Focused ion beam milling may improve accuracy of zirconia fracture toughness measurements

Researchers from the American Dental Association Science & Research Institute in Chicago, in collaboration with a colleague from Argonne National Laboratory, explored using focused ion beam milling to improve accuracy of zirconia fracture toughness measurements.

Typically, fracture toughness of advanced ceramics is measured using one of the three methods introduced in ASTM C1421–18: single-edge precracked beam (SEPB), surface crack in flexure (SCF), or single-edge V-notched beam (SEVNB). But for yttria-stabilized zirconia, the SEVNB method is not recommended.

"For the SEVNB method to be comparable to other standard methods, such as the SEPB and SCF methods, it is critical to create a notch-tip that closely approximates a sharp crack," the researchers write in their open-access paper. However, due to yttria-stabilized zirconia's fine grain size of a few hundred nanometers, "machining a notch-tip radius of sufficient sharpness in 3Y-TZP [3 mol% yttria stabilized tetragonal zirconia polycrystal] for the SEVNB method [is difficult]."

To create a notch-tip radius of sufficient sharpness, the researchers explored using focused ion beam milling, a technique commonly used in the semiconductor industry but gaining use in biological fields. It involves using a focused ion beam to either image a sample (low beam) or sputter/mill small volumes of materials at specified locations (high beam).

Use of focused ion beam milling to improve fracture toughness measurements of dental ceramics was first reported in 2008, when researchers in Germany reported fracture toughness test results from focus ion beam-notched ceria-doped zirconia. In the recent paper, the researchers note rapid progress of instrumentation has made focused ion beam systems more accessible in both academia and industry today, and thus they wanted to investigate preparing zirconia samples using focused ion beam milling as well.

They created a V-shaped notch at the center of each yttria-stabilized zirconia specimen before sintering using a modified saw blade technique. After sintering, they added an additional notch to six of the 11 specimens using the focused ion beam technique.

Analysis of the samples found the focus ion beam-notched specimens demonstrated lower fracture toughness values ($5.64 \pm 1.14\,\mathrm{MPa}\sqrt{\mathrm{m}}$) compared to specimens with saw blade-notches only ($8.90 \pm 0.23\,\mathrm{MPa}\sqrt{\mathrm{m}}$). This finding aligned with the results from the 2008 study, which also observed a decrease in fracture toughness values as notch root radius decreased.

In 1994, round robin testing on the same type of yttria-stabilized zirconia using the SCF method yielded a fracture toughness of $4.36 \pm 0.44\,\mathrm{MPa}\sqrt{\mathrm{m}}$. This finding would appear to support the hypothesis that focus ion beam-notched samples are more accurate than traditionally notched samples. "However, it is not possible to make conclusive statements about the comparability of this method with other standard methods, such as the SCF and SEPB methods, without further testing," the researchers write.

Though further testing is needed to fully understand the effects of notch geometry on measurements, as well as comparability of the focused ion beam milling technique with other methods, "[Focused ion beam milling] may be promising as a technique to generate nanometer-sized notches in ceramics for fracture toughness measurements," they conclude.

Credit: Bin im Garten, Wikimedia Commons (CC BY-SA 3.0)

Example of a metal-free zirconia dental bridge. Researchers led by the American Dental Association Science & Research Institute in Chicago found focused ion beam milling may improve accuracy of zirconia fracture toughness measurements.

The open-access paper, published in *Journal of Biomedical Materials Research Part B: Applied Biomaterials*, is "Fracture toughness of zirconia with a nanometer size notch fabricated using focused ion beam milling" (DOI: 10.1002/jbm.b.34668).

Polymer-coated bricks store energy

Researchers at Washington University in St. Louis turned regular red bricks into energy storage units using organic electronics.

Organic electronics is an emerging field of electronics based on organic materials, such as some polymers and organic molecules. Compared to classical electronics, which are based on inorganic materials, organic electronics are more flexible, cover larger areas, and cost less to produce. However, organic electronics have lower energy density and reduced performance next to inorganics, so it is best to view the technologies as complementary rather than competing.

One polymer that is being researched extensively for organic electronics is poly(3,4-ethylenedioxythiophene), or PEDOT. PEDOT possesses excellent chemical and physical stability as well as high electrical conductivity.

PEDOT can be synthesized in several ways, but vapor-phase polymerization is a particularly promising strategy. This process, which uses an oxidizing agent in vapor form to cause molecules called monomers to bond together to form polymers, results in conformal coatings of low electrical resistance in a single step.

Usually, ferric (Fe^{3+}) ions are used as the oxidizing agent, and they are introduced into the process in the form of ferric-ion-containing salts. However, ferric-ion-containing salts are corrosive, can be quite expensive, and are chemically unstable because they undergo hydrolysis over time, which challenges the reproducibility of experiments.

The PEDOT vapor-phase polymerization process could be less expensive and more sustainable if an alternative source of ferric ions is used—and that is what the Washington researchers identified in their research.

In nature, there are three main oxides of iron: hematite (Fe_2O_3), magnetite (Fe_3O_4), and wüstite (FeO). Hematite is the most abundant of the three oxides, and it contains ferric ions. Compared to ferric-ion-containing salts, hematite is safe to handle and affordable.

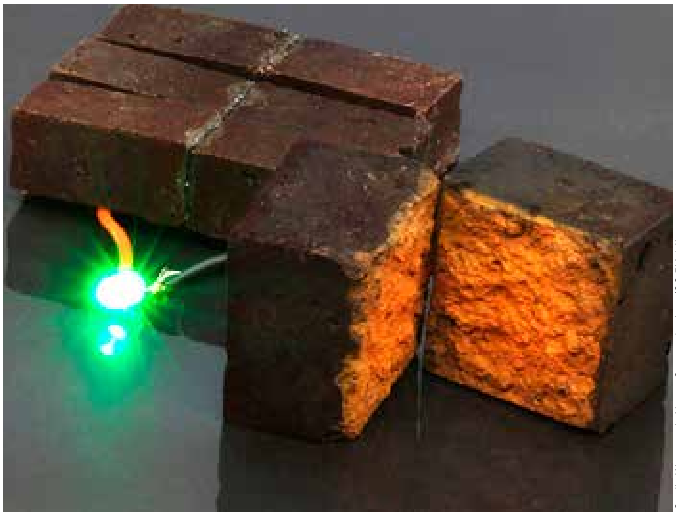
In 2019, the Washington researchers published a study exploring how they might separate ferric ions from hematite for use in the PEDOT polymerization process.

They used hydrochloric acid vapor to dissolve rust, a hydrated form of hematite ($Fe_2O_3{\cdot}nH_2O$). The reaction freed aquated ferric ions to react with monomer vapor and initiate the polymerization of PEDOT into freestanding, nanofibrillar films.

Upon testing, the PEDOT films were found to have high conductivity and high electrochemical stability, thus showing "Rust-based vapor-phase polymerization is a novel approach for producing high-performing conducting polymers," they write.

Following this study, the researchers began to consider ways to maximize the potential of this synthesis method. And that is where bricks come in.

Conventional red bricks get their red coloring from hematite, meaning they contain the ferric ions necessary to initiate vaper-phase polymerization.



Example of polymer-coated bricks that store energy like a battery. When connected in series, the bricks serve as a supercapacitor module capable of powering a green light-emitting diode.

Compared to the rusted steel sheet used in the original study, "A fired brick's open microstructure, mechanical robustness and ~8 wt% α-Fe_2O_3 content afford an ideal substrate for developing electrochemical PEDOT electrodes and stationary supercapacitors that readily stack into modules," the researchers write in a new paper.

Using the synthesis process developed in 2019, they dissolved the hematite contained in bricks to enable a reaction that coated the bricks in a PEDOT film. They then showed how these PEDOT-coated bricks could be used as electrodes in a symmetric supercapacitor.

In a Washington press release, assistant professor of chemistry Julio D'Arcy explains the potential these bricks have to transform the built environment.

"PEDOT-coated bricks are ideal building blocks that can provide power to emergency lighting," he says. "We envision that this could be a reality when you connect our bricks with solar cells—this could take 50 bricks in close proximity to the load. These 50 bricks would enable powering emergency lighting for five hours."

In addition, "a brick wall serving as a supercapacitor can be recharged hundreds of thousands of times within an hour. If you connect a couple of bricks, microelectronics sensors would be easily powered," he adds.

The 2019 paper, published in *ACS Applied Energy Materials*, is "Converting rust to PEDOT nanofibers for supercapacitors" (DOI: 10.1021/acsaem.9b00244).

The 2020 open-access paper, published in *Nature Communications*, is "Energy storing bricks for stationary PEDOT supercapacitors" (DOI: 10.1038/s41467-020-17708-1). ■

Tinted semitransparent solar panels for agrivoltaics

Researchers from several universities in the United Kingdom and Italy investigated using tinted semitransparent solar panels to overcome a limitation of agrivoltaics.

Agrivoltaics refers to the practice of co-locating photovoltaic infrastructure and agriculture by planting crops under photovoltaic panels. Supporters of agrivoltaics note numerous benefits to both photovoltaics and crops, but one potential downside to the system is lower crop yield of plants that do not grow well in shade.

"For example, for lettuce, the total biomass yield under agrivoltaic installation in Montpellier (France) was 15–30% less than the control conditions (i.e., full-sun conditions). When growth of tomato was tested in Japan, the yield in an agrivoltaic regime was about 10% lower than for conventional agriculture," the researchers write in their open-access paper.

The researchers propose the key to overcoming this limitation is not simply to let more light through—the key is customizing which wavelengths of light get through.

In conventional agrivoltaics, opaque and neutral semitransparent solar panels absorb electromagnetic radiation uniformly across the entire visible spectrum. However, visible wavelengths are not absorbed uniformly by the underlying plants.

Chlorophylls, the main photosynthetic pigments in plants, absorb wavelengths mostly in the red (≈600–700 nm) and blue (≈400–500 nm) regions of the electromagnetic spectrum; wavelengths in the green region (≈500–600 nm) are rarely absorbed.

At the same time, other pigments such as carotenoids and anthocyanins absorb wavelengths in the blue and green regions, respectively, with the purpose of dissipating excess/harmful solar energy to protect the photosynthetic apparatus.

Taken together, "part of the solar energy absorbed in the blue and green portions of the electromagnetic spectrum is dissipated without contributing to photosynthesis," the researchers write.

Representative examples of basil leaves from plants grown under (H) clear glass panels and (I) tinted semitransparent solar panels. The white horizontal bar represents 50 mm.

Based on this knowledge, a solar panel that absorbs blue and green wavelengths while allowing red wavelengths to pass through may mitigate the detriments of shade because the wavelength most important to photosynthesis is still reaching the underlying plants.

In their study, the researchers created tinted semitransparent solar panels that absorb preferentially blue and green wavelengths, leaving most of the red wavelengths for photosynthesis. They installed the solar panels over beds of basil and spinach for testing.

Compared to plants grown under panels of clear glass, plants grown under the tinted semitransparent solar panels demonstrated more efficient photosynthetic use of light (up to 68% for spinach) and a preferential redirection of metabolic energy toward tissues above ground (up to 63% for basil). In addition, the amount of protein extracted from both plants was increased in leaf (basil: +14.1%; spinach: +53.1%), stem (basil: +37.6%; spinach: +67.9%), and root (basil: +9.6%; spinach: +15.5%).

There was a loss in the yield of marketable biomass for both basil (-15%) and spinach (-26%). However, when electricity generation is taken into consideration, "our experimental data has shown that agrivoltaics could give a substantial overall financial gain calculated to be +2.5% for basil and +35% for spinach compared with classical agriculture," they write.

In the conclusion, the researchers note a few limitations of their study and areas for more exploration. For example, the study does not allow conclusions to be drawn on the effect of agrivoltaics on plants where underground tissues might have different functions, such as storage in tubers.

"Further experimental trials using semi-transparent solar panels with specific, targeted optical properties might permit the development of novel methods for tailoring the content of specific nutrients in crops," they write.

The open-access paper, published in *Advanced Energy Materials*, is "Tinted semi- transparent solar panels allow concurrent production of crops and electricity on the same cropland" (DOI: 10.1002/aenm.202001189). ■

ceramics in manufacturing

Support bath simplifies additive manufacturing of polymer-derived ceramics

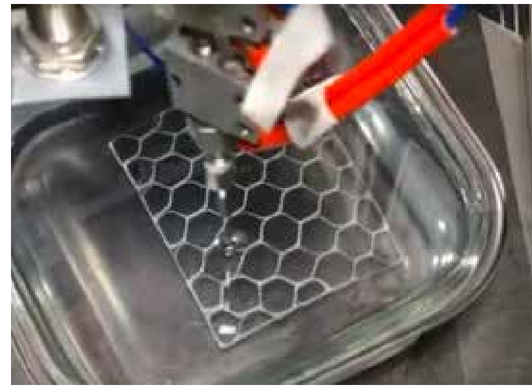
Researchers at the University of Texas at Dallas successfully demonstrated the use of gel-like viscoplastic fluid to support preceramic polymers during the printing process of polymer-derived ceramics.

Polymer-derived ceramics are a class of ceramics obtained by pyrolysis of polymer precursors. Compared to powder-based methods of ceramic fabrication, use of preceramic polymers allows fabrication of dense ceramics in near net shape without sintering. As such, polymer-derived ceramics hold great potential in commercial manufacturing applications, and the numerous research and development activities since the first reports of such ceramics in the 1960s have extended significantly the possible applications of polymer-derived ceramics.

In theory, polymer-derived ceramics should lend themselves well to additive manufacturing, as the polymer state is viscous and could presumably be ejected quite easily from a nozzle. However, preceramic polymers tend to have low viscosity, making it difficult to control flow of the material.

Currently, the main method for 3D printing polymer-derived ceramics is stereolithography, or methods in which a photosensitive resin is laid down layer-by-layer and cured using UV light. But stereolithographic fabrication of polymer-derived ceramics faces several limitations.

"Stereolithography is too slow for large scale applications. In addition, the method makes use of very expensive and a limited range of raw materials (photosensitive resins), while additional care must be taken owing to the environmentally hazardous solvents used to clean up parts," Majid Minary says in an email.



Credit: Majid Minary, YouTube

Using viscoplastic fluid to support preceramic polymers during 3D printing could make the process technologically and economically feasible.

Minary is associate professor of mechanical engineering at the University of Texas at Dallas. His lab conducts research on ceramic materials for composite applications, and since 2015, they have studied additive manufacturing techniques as well, mostly in regard to metals at micro/nanoscale for electronics and sensors.

About two years ago, Minary's lab combined those two areas of research when they started work on 3D printing polymer-derived ceramics. "We were inspired by work in the biological community in printing hydrogels for tissue engineering applications as well as work for soft robotics," Minary says. In particular, they were inspired by studies that used viscoplastic fluids to provide support to liquid precursors during the 3D printing process.

Viscoplastic or "yield stress" fluids are materials that reversibly switch from a semisolid to a liquid state when subjected to sufficiently high shear stress. In the biological studies, a nozzle was used to inject liquid precursors into containers filled with semisolid, gel-like viscoplastic fluids. The motion of the nozzle through the viscoplastic fluid caused shear stress, which led the fluid to liquify. Once the nozzle extruding the liquid precursor moved on, the viscoplastic fluid returned to a semisolid state, thus holding the liquid precursor in place until it could be cured and removed as a solid piece.

Minary and his colleagues were curious if viscoplastic fluids would support low-viscosity preceramic polymers as well. However, they knew that unlike the other studies, which used liquid precursors that cure at low temperatures, preceramic polymers require thermally induced curing at elevated temperatures over 120°C.

In a recent paper, Minary and his colleagues developed through an iterative process a viscoplastic fluid based on mineral oil and silica nanoparticles that could handle higher temperatures. Then, they used this fluid to support successful fabrication of polymer-derived silicon oxycarbide parts.

The three-step process used to fabricate the silicon oxycarbide (SiOC) parts includes

1. Injecting the preceramic polymer into the viscoplastic fluid,
2. Curing the polymer at 160°C (while still in the fluid), and
3. Removing the cured polymer from the fluid and placing it in a furnace to undergo pyrolysis at 900°C.

The researchers note the process can be extended readily to other preceramic polymers, such as silicon carbide and silicon carbon nitride, and can be extended to ceramic composites as well by adding chopped ceramic fibers and/or functional nanoparticles.

Minary says they are actively collaborating with a company and a national lab to expand this work to hypersonic and harsh environment applications.

The paper, published in *ACS Applied Materials & Interfaces*, is "Three-dimensional printing of ceramics through 'carving' a gel and 'filling in' the precursor polymer" (DOI: 10.1021/acsami.0c08260). ■

Latin America–Indigenous invention

Ceramic researchers and companies pursue homegrown solutions to global challenges in Latin America

By Alex Talavera and Randy B. Hecht

Industry partnerships drive the focus of much academic research across Latin America, but financial performance is not the only goal—efforts to address environmental impacts and pursue sustainability play large roles in research as well.

From a market perspective, Latin America is significantly bigger than you may realize. The Pew Research Center projects that Europe's population will peak in 2021—and by 2037 will be eclipsed by Latin America and the Caribbean, which will grow to 768 million by 2058.[1]

Combine those demographics with newly published World Bank research about the COVID-19 pandemic's impact on the productivity gap between developed and emerging economies,[2] and you may perceive the Latin American market's value with new appreciation. ACerS members in the region say that matters not just macroeconomically but also at the industry level.

A window to the world

"We are facing issues common with many countries around the world, like in Africa or Asia. When you provide a solution for these countries, you can make an impact on half the world," says professor Henry Colorado of Colombia's University of Antioquia. Latin American colleagues offer not only research expertise, he says, but also a more global mindset.

Professor Victor Carlos Pandolfelli of the Federal University of São Carlos hopes the United States will "open a bit more to the importance of networking with the world—and not waiting for the world to go to United

Capsule summary

LARGE POTENTIAL

By 2037, Latin America and the Caribbean are expected to eclipse Europe in population. Taken in consideration with World Bank research on the COVID–19 pandemic's impact, and the potential for Latin America as a global market is larger than many people realize.

CORPORATE FUNDING

For some countries in Latin America, corporate underwriting is essential to conducting academic research. That reality makes the market a key driver of areas of research focus.

SUSTAINABLE FOCUS

Even as industry partnerships drive the focus of research, projects must consider sustainability and humanitarian factors as well. Universities and companies throughout Latin America are working to address environmental impacts of their products.

States. I think that attitude will change due to a new, different world we'll be living in."

This year's international report looks at the state of the industry in Brazil, Colombia, and Chile to assess the opportunities for joint research and ventures with Latin American partners.

Brazil: Pursuing eco-innovation and Industry 4.0 advances

Companies open to collaboration with university researchers will find Brazil not only welcomes, but to some extent requires, their participation. Faculty members must adhere to strict parameters for use of university or government funding—which, for example, often cannot cover salaries for postdocs or administrative staff.

"Most of the funds I have, including the building where I have my office and a laboratory, were sponsored by a company," Pandolfelli says. That reality makes the market a key driver of his areas of research focus.

"We are the top country in Latin America in production of articles and scientific papers," he says. "In the materials area, and specifically in the ceramic area, I would point out three major research areas: refractories—that is, high-temperature materials—glass, and sensors." Of the three areas, industry plays the most prominent role in refractories, which also has the highest concentration of MSc and Ph.D. candidates. There are few jobs available in industry for those who specialize in glass, most of whom become academics, but Pandolfelli estimates that 60% of those who do graduate study in refractories go on to careers in industry.

Those with a concentration in sensors are more likely to teach, but some launch startups, Pandolfelli says. "There are just a few major industries in Brazil that produce electronics here. Most of the electronics come from abroad. In the refractory area, we have a much broader menu because the steel industry requires top quality products of the refractory producers," he says.

Sustainability strategies

One of Pandolfelli's areas of research interest is "how to adapt to the refractory area and high-temperature ceramic materials to industry 4.0," which involves extensive data mining and simulations. His goal is to help advance the capacity to develop products that are not just competitive in price and performance but also friendly to the environment. "We are carrying out research to have material and tech knowledge that is competitive for the present and will match with the needs of the future," he says.

Environmental concerns were the topic of the July 28 *Online Symposium on Materials and Sustainability*, co-presented by the Federal Universities of São Carlos and Rio Grande do Sul along with Portugal's Polytechnic Institute of Viana do Castelo.

And the schedule for the next Brazilian Ceramic Society Congress includes two seminars whose titles translate as *Circular economy: The sustainability bridge for intensive use of natural/chemical materials and energy in the ceramics and buildings industry* and *Asbestos-free fiber cement, the renewable material.*

Data-driven R&D

By law, intellectual property that emerges from research is owned equally by the university and whatever company funded the work. "The IP is co-shared, but the industry which funded the given research contract has the privilege of having a licensing agreement," says professor Edgar Zanotto, an ACerS member who works for the Federal University of São Carlos and is editor of the *Journal of Non-Crystalline Solids*. It can be frustrating negotiating with industry partners who balk at those terms. Inventors receive 1% of royalties.

Another challenge for Brazil is retaining its homegrown talent in physics, chemistry, and materials engineering. The country has excellent masters and doctoral students in those fields, but with postdoc salaries scarce, many find employment abroad.

And high-tech equipment, which is not manufactured in Brazil, presents a third complication for Zanotto and his colleagues. "We have to import this equipment, which is hard enough, okay. But sometimes we get some funding and we import equipment," he says. "However, when they break, and they often break, it's very expensive to get them fixed. Sometimes I had to fly a technician from Europe. And that's the problem, keeping up with advanced research equipment."

Despite these challenges, Zanotto is conducting research in three fields. The first is the fundamentals of crystal nucleation, crystal growth, and crystallization of glass. The second is glass-ceramics, "using the accumulated knowledge of nucleation crystallization to develop or to improve glass-ceramics with different types of properties in applications." And the third is "using computer simulations and machine learning to develop new glasses with exotic combinations of properties."

He embarked on this third field just two years ago and explains why he finds it exciting. "Suppose some industry needs glass which has a very high index of refraction, or special lenses, and a very low glass transition temperature (T_g) to be molded at very low temperatures. You can use machine learning to feed a given algorithm with data. And then you train the algorithm and ask it to suggest

Credit: Edgar Zanotto

Edgar Zanotto (front center) and his colleague and students in the Center for Research, Technology and Education in Vitreous Materials, located in Brazil.

combinations of these compositions that would lead to very high refractive index, very low T_g, for instance. We are doing that already."

Colombia: Seeking convergence of industrial and social progress

As in Brazil, academic research in Colombia depends on corporate underwriting, whether from domestic or international partners. Without it, research projects are not economically sustainable, says Colorado, whose work is concentrated in the diverse fields of composites, ceramics, arts, additive manufacturing, and solid waste management.

"I try not to work for a specific industry," he says. "The work I do in waste management and circular economy, for instance, can be used in several sectors and industry types."

But he adds that even as industry partnerships drive the focus of research, projects must consider sustainability and humanitarian factors, not just financial performance. "I always want my research converted into a successful product," he says, but his further goal is to advance solutions for the environment, communities, small companies, or even local communities in need. "I am an engineer, and I like to work with industry because it's one of the ways research becomes a real solution," he says.

Low-tech practices are common in his region, so these partnerships provide an opportunity to raise industrial awareness of more advanced products and methods as they address social issues. His favorite success story

LATIN AMERICA MARKET SNAPSHOTS

Brazil, Chile, and Colombia provide perspectives on Latin America's role in the world economy

By Alex Talavera and Randy B. Hecht

A look at the capabilities and challenges driving the region's growth as a foreign commerce force with which to be reckoned.

Unless otherwise noted, the information on each region comes from the CIA World Factbook at https://www.cia.gov/library/publications/the-world-factbook.

Brazil: South America's resourceful global trader

Brazil accounts for nearly half of the South American land mass and shares borders with every country in the region with the exceptions of Ecuador and Chile. The majority of its population of nearly 212 million lives along the Atlantic coast and is particularly concentrated in urban areas in the southeast. The most populous cities are Sao Paulo (22 million) and Rio de Janeiro (13.5 million); the capital city, Brasilia, is home to 4.6 million.

According to 2011 estimates (the latest available from the CIA World Factbook), the remainder of the country included 32.9% agricultural land and 61.9% forest. But those figures predate the fires that saw deforestation rates peak at 2,200 square kilometers per month in July 2019—between double and quadruple the highest monthly rates recorded in each of the preceding four years.[1] Land management and environmental protection are of particular concern in Brazil, whose natural resources include alumina, bauxite, beryllium, gold, iron ore, manganese, nickel, niobium, phosphates, platinum, tantalum, tin, rare earth elements, uranium, petroleum, and timber.

As home to much of the Amazon and other great waterways, the country is also a standout in its use of hydropower. Hydroelectric plants generate 64% of total installed electricity capacity, followed by other renewable sources (18%), fossil fuels (17%), and nuclear fuels (1%).

In 2017, Brazil's purchasing power parity GDP was $3.248 billion ($15,600 per capita), a 1% annual growth rate after two consecutive years in which GDP fell by 3.5%. Services generated 72.7% of GDP, followed by industry (20.7%) and agriculture (6.6%). Leading industries include textiles, shoes, chemicals, cement, lumber, iron ore, tin, steel, aircraft, motor vehicles and parts, and other machinery and equipment. The country's labor force is 104.2 million; services employ 58.5%, followed by industry (32.1%) and agriculture (9.4%).

Brazil has achieved a strong positive balance of trade, with $217.2 billion in 2017 exports against 153.2 billion in imports. Transport equipment, iron ore, soybeans, footwear, coffee, and automobiles are among the leading exports, and the country's chief export partners are China, the U.S., Argentina, and the Netherlands. Leading imports include machinery, electrical and transport equipment, chemical products, oil, automotive parts and electronics, and chief import partners are China, the U.S., Argentina, and Germany.

One notable resource constraint threatens to limit Brazil's capacity for continued sustainable economic advances: its rate of population growth, which stands at just 0.67%. "Brasilia has not taken full advantage of its large working-age population to develop its human capital and strengthen its social and economic institutions," the CIA World Factbook notes, "but is funding a study abroad program to bring advanced skills back to the country. The current favorable age structure will begin to shift around 2025, with the labor force shrinking and the elderly starting to compose an increasing share of the total population."

To learn more about this market, see the U.S. International Trade Administration's *Brazil Commercial Guide*,[2] the World Bank's *Doing Business in Brazil* guide,[3] and resources available through the Brazilian–American Chamber of Commerce.[4]

Chile: Going to great lengths in foreign commerce

From its northern border with Peru to its termination at the southern tip of South America, Chile covers 2,700 miles. To put that in perspective, if you traveled from Cabo San Lucas to Vancouver, you would still have to log another 280 miles to cover a distance equal to the length of Chile. By contrast, the country runs only about 217 miles across at its widest point and not even 10 miles at its narrowest.[5]

From prehistory to the present, that long, skinny terrain was dotted with 481 volcanoes, as tallied by the Smithsonian Institution's Global Volcanism Program database.[6] Although only 105 of those have been active in the past 10,000 years, Chile's natural resource wealth owes a debt to volcanic eruptions dating to the Cenozoic Era that produced deposits of copper, iron, silver, molybdenum, manganese, and coal.[5]

The capital city of Santiago is home to 6.7 million people, roughly a third of the national population of nearly 18.2 million; 90% of Chileans live in the central third of the country and 87.7% are in urban areas. The labor force numbers 8.9 million, of whom 67.1% work in services, followed by 23.7% in industry and 9.2% in agriculture.

For 2017, Chile's purchasing power GDP was $452.1 billion ($24,500 per capita). Although this reflects an increase of 1.5% over the previous year, that growth rate was down for the third consecutive year, a shift driven largely by a reduction in copper prices. With the exception of 2009, Chile averaged annual real growth of almost 5% for every year from 2003 through 2013.

Services account for 63% of GDP, followed by industry (32.8%) and agriculture (4.2%). Leading industrial sectors include copper, lithium, other minerals, foodstuffs, fish processing, iron and steel, wood and wood products, transport equipment, cement, and textiles.

Chile has a positive balance of trade, with exports of 69.23 billion against imports of $61.31 billion. Copper, its top export, generates 20% of government revenue. Additional leading export commodities include fruit, fish products, paper and pulp, chemicals, and wine. The country's largest export partners are China, the U.S., Japan, South Korea, and Brazil. Among imports, the leading commodities are petroleum and petroleum products, chemicals, electrical and telecommunications equipment, industrial machinery, vehicles, and natural gas. China, the U.S., Brazil, Argentina, and Germany are Chile's largest import partners.

This level of foreign commerce activity, along with its market-oriented economy and global confidence in its financial institutions and policy, have enabled Chile to attain South America's strongest sovereign bond rating. However, its income inequality is ranked as the worst among members of the Organisation for Economic Cooperation and Development; Chile became the first South American member of the OECD in 2010.

For more information about this market, see the U.S. International Trade Administration's *Chile Commercial Guide*,[7] the World Bank's *Doing Business in Chile* guide,[8] and resources available through the North American–Chilean Chamber of Commerce.[9]

Colombia: Resources, reforms, and rising trade profile

With its Caribbean and Pacific beaches, Andean peaks, and Amazonian waterways, Colombia is home to diverse topographies and ecosystems. Like its neighbor Brazil, the country holds vast spans of land that have not given way to urbanization—forests and agricultural land occupy, respectively, 54.4% and 37.5% of its terrain. But as in Brazil, demand for timber has sparked deforestation in the Amazon jungle.

Another hydropower champion, Colombia generated 69% of its total installed electricity capacity via hydroelectric plants in 2017—but in a country of 49 million people, one million lack access to electricity. Its exploitable resources include petroleum, natural gas, coal, iron ore, nickel, gold, copper, and emeralds. These assets are key to Colombia's foreign trade activity but also increase its vulnerability to market fluctuations.

The Colombian labor force numbers 25.76 million. Services represent 62% of employment, followed by industry (21%) and agriculture (17%). Major industries include textiles, food processing, oil, clothing and footwear, beverages, chemicals, cement, gold, coal, and emeralds.

In 2017, the country's purchasing power parity GDP was $711.6 billion, or $14,400 per capita, and prior to that year, real GDP growth averaged 4.7% annually for a decade. But despite that performance, 28% of the population lives below the poverty line. Services generate 62.1% of GDP, followed by industry (30.8%) and agriculture (7.2%). In 2017, industrial production fell by 2.2%.

For 2017, export volume was $39.48 billion against import volume of $44.24 billion. Leading exports include petroleum, coal, emeralds, coffee, nickel, cut flowers, bananas, and apparel, while leading imports are industrial equipment, transportation equipment, consumer goods, chemicals, paper products, fuels, and electricity. Colombia's chief trading partners are the U.S., Panama, and China on the export side and the U.S., China, Mexico, Brazil, and Germany for imports.

Colombia ranks fourth worldwide in coal production and is the world's third-largest exporter of both coffee and cut flowers. It is also Latin America's fourth-largest producer of oil, after Brazil, Mexico, and Venezuela. But it continues to face obstacles to sustained growth. The CIA World Factbook notes: "Colombia's economic development is hampered by inadequate infrastructure, poverty, narcotrafficking, and an uncertain security situation, in addition to dependence on primary commodities (goods that have little value-added from processing or labor inputs)."

In April 2020, Colombia became the third Latin American country (along with Chile and Mexico) to join the Organisation of Economic Cooperation and Development. (Costa Rica is in the final stages of completing its requirements.) Colombia's admission to the OECD is the culmination of five years of reform efforts that conformed the country's legislation, policies, and practices to OECD standards. These reforms covered such areas as labor practices, judicial reform, corporate governance of state-owned enterprises, antibribery measures, and establishment of a national policy on industrial chemicals and waste management.

To learn more about pursuing opportunities in this market, see the U.S. International Trade Administration's *Colombia Commercial Guide*,[10] the World Bank's *Doing Business in Colombia* guide,[11] and resources available through AmCham Colombia.[12] ■

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[8]World Bank's *Doing Business in Chile*. Available at https://www.doingbusiness.org/content/dam/doingBusiness/country/c/chile/CHL.pdf

[9]North American–Chilean Chamber of Commerce. Available at http://www.nacchamber.com

[10]"Colombia Commercial Guide." *U.S. International Trade Administration*. https://www.trade.gov/knowledge-product/exporting-colombia-market-overview?section-nav=5277

[11]"Doing Business 2020: Economy Profile Colombia." *The World Bank*. https://www.doingbusiness.org/content/dam/doingBusiness/country/c/colombia/COL.pdf

[12]AmCham Colombia. https://amchamcolombia.co/es ■

Latin America—Indigeneous invention

Pan-American Market Snapshot

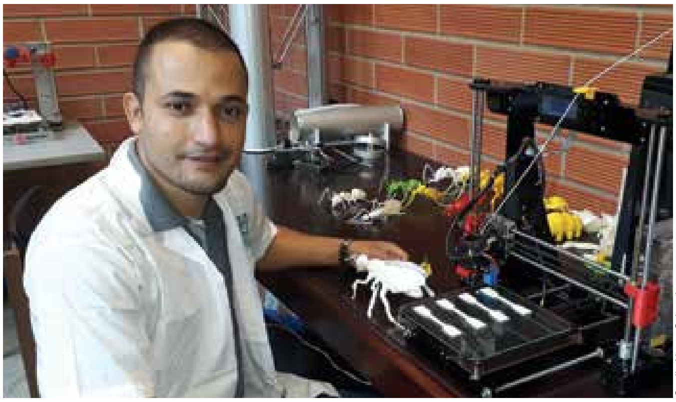
Country	Purchasing Power Parity GDP	Import Volume	Chief Imports	Export Volume	Chief Exports	Chief Trading Partners
Argentina	$922.1 billion $20,900 per capita	$63.97 billion	Machinery, motor vehicles, petroleum and natural gas, organic chemicals, plastics.	$58.45 billion	Soybeans and derivatives, petroleum and gas, vehicles, corn, wheat.	**Imports:** Brazil 26.9%, China 18.5%, US 11.3%, Germany 4.9% **Exports:** Brazil 16.1%, US 7.9%, China 7.5%, Chile 4.4%
Brazil	$3.248 trillion $15,600 per capita	$153.2 billion	Machinery, electrical and transport equipment, chemical products, oil, automotive parts, electronics.	$217.2 billion	Transport equipment, iron ore, soybeans, footwear, coffee, automobiles.	**Imports:** China 18.1%, US 16.7%, Argentina 6.3%, Germany 6.1% **Exports:** China 21.8%, US 12.5%, Argentina 8.1%, Netherlands 4.3%
Canada	$1.774 trillion $48,400 er capita	$442.1 billion	Machinery and equipment, motor vehicles and parts, crude oil, chemicals, electricity, durable consumer goods.	$423.5 billion	Motor vehicles and parts, industrial machinery, aircraft, telecommunications equipment; chemicals, plastics, fertilizers; wood pulp, timber, crude petroleum, natural gas, electricity, aluminum.	**Imports:** US 51.5%, China 12.6%, Mexico 6.3% **Exports:** US 76.4%, China 4.3%
Chile	$452.1 billion $24,600 per capita	$61.31 billion	Petroleum and petroleum products, chemicals, electrical and telecommunications equipment, industrial machinery, vehicles, natural gas.	$69.23 billion	Copper, fruit, fish products, paper and pulp, chemicals, wine.	**Imports:** China 23.9%, US 18.1%, Brazil 8.6%, Argentina 4.5%, Germany 4% **Exports:** China 27.5%, US 14.5%, Japan 9.3%, South Korea 6.2%, Brazil 5%
Colombia	$711.6 billion $14,400 per capita	$44.24 billion	Industrial equipment, transportation equipment, consumer goods, chemicals, paper products, fuels, electricity.	$39.48 billion	Petroleum, coal, emeralds, coffee, nickel, cut flowers, bananas, apparel.	**Imports:** US 26.3%, China 19.3%, Mexico 7.5%, Brazil 5%, Germany 4.1% **Exports:** US 28.5%, Panama 8.6%, China 5.1%
Mexico	$2.463 trillion $19,900 per capita	$420.8 billion	Metalworking machines, steel mill products, agricultural machinery, electrical equipment, automobile parts for assembly and repair, aircraft, aircraft parts, plastics, natural gas and oil products.	$409.8 billion	Manufactured goods, electronics, vehicles and auto parts, oil and oil products, silver, plastics, fruits, vegetables, coffee, cotton. Mexico is the world's leading producer of silver.	**Imports:** US 46.4%, China 17.7%, Japan 4.3% **Exports:** US 79.9%
Panama	$104.1 billion $25,400 per capita	$21.91 billion	Fuels, machinery, vehicles, iron and steel rods, pharmaceuticals.	$15.5 billion	Fruit and nuts, fish, iron and steel waste, wood.	**Imports:** US 24.4%, China 9.8%, Mexico 4.9% **Exports:** US 18.9%, Netherlands 16.6%, China 6.5% Costa Rica 5.4%, India 5.1%, Vietnam 5%
Peru	$430.3 billion $13,300 per capita	$38.65 billion	Petroleum and petroleum products, chemicals, plastics, machinery, vehicles, TV sets, power shovels, front-end loaders, telephones and telecommunication equipment, iron and steel, wheat, corn, soybean products, paper, cotton, vaccines and medicines.	$44.92 billion	Copper, gold, lead, zinc, tin, iron ore, molybdenum, silver; crude petroleum and petroleum products, natural gas; coffee, asparagus and other vegetables, fruit, apparel and textiles, fishmeal, fish, chemicals, fabricated metal products and machinery, alloys.	**Import:** China 22.3%, US 20.1%, Brazil 6%, Mexico 4.4% **Export:** China 26.5%, US 15.2%, Switzerland 5.2%, South Korea 4.4%, Spain 4.1%, India 4.1%
United States	$19.49 trillion $59,800 per capita	$2.361 trillion	Agricultural products 4.9%, industrial supplies 32.9% (crude oil 8.2%), capital goods 30.4% (computers, telecommunications equipment, motor vehicle parts, office machines, electric power machinery), consumer goods 31.8% (automobiles, clothing, medicines, furniture, toys).	$1.553 trillion	Agricultural products (soybeans, fruit, corn) 9.2%, industrial supplies (organic chemicals) 26.8%, capital goods (transistors, aircraft, motor vehicle parts, computers, telecommunications equipment) 49.0%, consumer goods (automobiles, medicines) 15.0%.	**Imports:** China 21.6%, Mexico 13.4%, Canada 12.8%, Japan 5.8%, Germany 5% **Exports:** Canada 18.3%, Mexico 15.7%, China 8.4% Japan 4.4%

involves how rubber tire waste on Colombia's roads was reused in flexible tiles produced by both large corporations and smaller businesses.

The environment is both a beneficiary of Colorado's research and the origin of some of his fields of study. "With respect to materials science, I am very interested in continuing my work in the amazing structure and properties of some plants and natural fibers from the Amazonia," he says. In addition to continuing to teach engineering, he plans to pursue further research in the circular economy of ceramics and composites, cultural and art materials, and sustainable manufacturing.

More climate-friendly ceramics

The push for increased sustainability in ceramics is not restricted to university labs. The multinational Corona is among Colombian companies that have adopted improved environmental practice as a corporate value. The company's business divisions include bathrooms and kitchens; surfaces, materials and paints; tableware; and industrial minerals and energy, and its operations include 20 plants in Colombia, two in the U.S., and three each in Mexico and Central America, as well as a global procurement office in China.



Credit: Henry Colorado

Henry Colorado, professor at the University of Antioquia, Colombia, likes to work with industry because it is "one of the ways research becomes a real solution."

"In terms of the design and development of refractories with regard to environmental concerns, the key driver is the reduction of heat loss in order to reduce fuel consumption and emissions," says Carlos Mesa, Latin America sales director of the

From the Andes to the Amazon to the Panama Canal, plans to establish a research triangle for nanotechnology

June marked 10 years since researchers from Argentina, Bolivia, Colombia, Costa Rica, Ecuador, Peru, and Venezuela founded the Nanoandes Network to promote nanotechnology programs in each country, initially by launching schools of nanoscience. Within five years, the organization notes on its ResearchGate page, 12 Latin American countries were home to more than 300 undergraduate, master's, doctoral, and post-doctoral researchers. Today, there are Nanoandes schools in Cartagena, Colombia; Quito, Ecuador; La Paz, Bolivia; Merida, Venezuela; and San Jose, Costa Rica, that offer theoretical and practical nanoscience workshops.

Each country seeks to make its imprint on nanotechnology advances.

The Argentine government's Nanoscience and Nanotechnology Institute, an arm of the National Atomic Energy Commission, houses a Micro and Nano Manufacturing lab for development of nanostructured films and materials, particularly for nuclear applications, as well as MEMS and nanosensors. Its application focus extends to use in medicine, industry, robotics, and agriculture.

Another prominent player is the Argentine Nanotechnology Foundation, which promotes both research and ventures by providing labs, equipment, and staff in support of "high-level nano developments." It also sponsors programs to foster entrepreneurship in this arena. These initiatives are in keeping with the Argentine government's focus on business development: the Foundation notes on its website that the National Agency for the Promotion of Research, Development and Innovation has "launched a new call for development and innovation projects that provide technological solutions" and is offering funding between 4–16 million Argentine pesos (US $55,000–220,000) for projects in "nanotechnology, modern biotechnology, biomedical engineering, mechatronics, and artificial intelligence."

In Panama, the company Empresas Carbonea is branching out from its traditional business of tempered glass hardware and tools to a nanotechnology-based coating for new glass or the restoration of old glass as well as concrete, metal, electronics, wood, and ceramics.

Nanotech+b is another Panamanian company working in materials development. It supplies Coltan (columbita–tantalite) to customers in the microelectronics, telecommunications, and aerospace industries. "Tantalite is the primary source of Tantalum (Ta), an element with high volumetric efficiency and electrical stability in a wide temperature range (-55 ºC to 125 ºC)," the company's website states, while "Columbita is the source of Niobium (Nb), used in metal alloys with applications in aeronautics" and is valued for its superconductivity. Nanotech+ sources Coltan from mines in the Democratic Republic of Congo, Venezuela, Bolivia, and Brazil and is seeking strategic partners for the establishment of a Coltan refinery in Panama for production of tantalite and niobium dioxides.

Meanwhile, Peru is working to establish a means of converting Amazon waste into nanomaterials. CONCYTEC (the National Council of Science, Technology, and Technological Innovation) and the World Bank are supporting a research project at the Pontificia Universidad Católica del Perú whose aim is to develop "a technological process that allows the production of graphene from Amazon forest waste."

In an announcement in June, CONCYTEC said the project "will develop an ad hoc technology to use waste from the Madre de Dios forest industry as a carbon source to produce graphene." The announcement quoted the project's principal researcher, Omar Troncoso Heros: "This technology will contribute to the modification of the basically extractive model of the region to a model of high added value, the forestry industry is one of the most important in the Peruvian Amazon, therefore increasing its productivity is vital for its development. Our initiative aims to develop a process that makes it possible to take advantage of forest waste, thus starting a nanotechnology industry in Peru."

Nanotechnology may be in its infancy in Latin America, but scientists, government agencies, and commercial enterprises are committed to investing in the region's resources to pursue innovation in this field.

Footnotes

a Empresas Carbone's website is available at https://www.empresascarbone.com/en/products/nanotechnology.

b Nanotech+'s website is available at https://nanotechnology.com.pa.

company's ERECOS refractories subsidiary. He adds the company applies circular economy principles to its manufacturing process. "Refractories that are uninstalled from a kiln or other equipment are thoroughly cleaned and used as a key input in the production of new refractories. This [process] helps reduce the dependence on virgin raw materials that have to be sourced from mines," he says.

Corona's mining practices include storing topsoil and organic layers for restoration after the mining activity is concluded, after which it gives local farmers access to land that is now being used for dairy cattle grazing and to raise strawberry and potato crops.

In partnership with the Spanish company Cementos Molins, Corona began operations at a new cement plant in the second half of 2019. The plant was constructed adjacent to the company's high-grade limestone quarry to reduce transportation costs and emissions. Its design incorporates filters that minimize emissions of dust, nitrogen oxide gases, sulfur oxide gases, and its equipment's energy consumption is 15% lower than that of other cement plants in the region. Water treatment plants and closed-circuit systems facilitate reuse of water.

The company also adopted use of noise-reducing technologies "to mitigate the impact of the cement plant on the surrounding natural environment and native animals" and conducted biodiversity studies that led to "the development of wildlife corridors (or green corridors) aimed to protect native and endangered species."

Chile: Transforming copper into an element of global trade

Chile's industrial sector is built quite literally from the ground up. Copper, the country's top export, is the source of 20% of government revenue.[3] (The state-owned CODELCO—the National Copper Corporation—is the world's largest producer of copper and molybdenum.) And copper's economic impact extends across the ceramic sector spectrum, from refractories to nanotechnology.

Founded more than 60 years ago, Refractory Iunge works in such sectors as copper, steel, cement, lime, and oil refineries and has licensing or partnership agreements with Allied Mineral, HarbisonWalker International, and Refractorios Peruanos SA (REPSA).

As in other countries, the industry is conscious of its responsibility to address environmental impacts. Pablo Valenzuela, one of the company's owners and a member of the board, notes recycling is a company tradition. "The copper industry uses mainly magnesia chrome bricks," he says. "Chrome may be in certain shapes and forms dangerous to the health. We have been trying to work very closely with copper producers in Chile to try to recycle those products and not end with them hidden or dumped in a place where they may harm human and animal health and the environment."

A copper-based nano process

Copper's antibacterial, antifungal, and antiviral properties provided Chile with a point of entry into nanotechnology research and development. Nanoprocess, one enterprise that emerged as a result, has "the infrastructure to produce 500 kilograms of copper nanoparticles in aqueous suspension per year, dispersed and stabilized in deionized water, free of solvents and synthetic additives."

The company adds: "The validated nanotechnology is modular, each module is capable of producing 10 kg of nano particles of high purity per day, and we can expand the number of modules according to the market requirement. We have the logistics to send concentrations of nano particles dispersed in water, in drums of 120 or 200 Lt, in sealed containers, anywhere in the world."

See the directory for information about additional companies in Chile that are using copper as a launchpad for

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Available on ACerS Publication Central (https://ceramics.onlinelibrary.wiley.com), Content Collections are groupings of articles curated by the editors of ACerS journals to highlight a single theme in ceramics and glass research.

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Check out the collection at http://bit.ly/ACerSAmericasCollection.

Credit: Corona

Quality control and testing at GAMMA Insulators, the utility products manufacturing subsidiary of Corona in Sabaneta, Colombia.

nanotechnology research and development as well as organizations that are cultivating advances in these areas as a means of promoting prosperity and social value.

Mining and mindset

Silica is another area of industry activity in Chile, where Minera Toro owns and oversees an estimated 3,000 hectares of mining properties. Those sites have a combined monthly production capacity of 6,000 tons of washed, graded sand. The company has stated a commitment to CO_2 neutral operations and use of renewable energy. An additional goal of its sustainability model is promoting social and economic progress as a means of reducing regional inequalities in this increasingly urbanized country.

What else does Chile have to offer to prospective research or commercial partners in the U.S.? Valenzuela stresses the importance of integrating this market and other Latin American markets

The multinational Corona is among Colombian companies that have adopted improved environmental practices as a corporate value.

Directory of companies, government agencies, associations, institutes, and universities in Latin America

ARGENTINA

Fundación Argentina de Nanotecnología
Phone: +54 11 2033-1455
Email: info@fan.org.ar
Website: https://www.fan.org.ar

Universidad Nacional de San Martin
Instituto de Nanosistemas
Phone: +54 11 2033-1400 ext. 6113
Email: ins@unsam.edu.ar
Website: http://www.unsam.edu.ar/institutos/ins/eng/index.asp

Website for porphyrin nanomaterials design and development: http://www.unsam.edu.ar/institutos/ins/eng/research/porphyrin.asp

BRAZIL

ABCERAM
Associação Brasileira de Cerâmica
Brazilian Ceramic Society
Phone/Fax: +54 11 3768-7101 / 11 3768-4284
Email: abceram@abceram.org.br
Website: http://abceram.org.br

ANFACER: Associação Nacional dos Fabricantes de Cerâmica Para Revestimentos, Louças Sanitárias e Congêneres

National Association of Manufacturers of Ceramics for Coverings, Sanitaryware, and Related Products
Phone: + 55 11 3192-0600
Email: info@anfacer.org.br
Website: http://ceramicsofbrazil.com/en

Centro Multidisciplinar para o Desenvolvimento de Materiais Cerâmicos

Multidisciplinary Center for Development of Ceramic Materials
Website: http://www.cmdmc.com.br/conheca/quem.php

The Center is a joint research venture of teams at the Universidade Federal de São Carlos, Universidade Estadual Paulista, Universidade de São Paulo, and Instituto de Pesquisas Energéticas.

Eirich Group
Phone: +55 11 4619-8900
Email: eirich@eirich.com.br
Website: https://eirich.com.br/en/industries/ceramics
(Dedicated ceramics page in English)

https://eirich.com.br/categoria_download/ceramica
(Downloadable brochures in English about services for specific ceramic sectors)

Products and services encompass raw materials, mixes, ceramic bodies and finished products such as clay bricks. Process expertise spans press bodies, granules, plastic bodies, slurries, and fiber materials. Industry experience includes glazings, refractories, structural ceramics, sanitary ceramics, oxide and non-oxide ceramics and ferrites.

Instituto de Pesquisas Energéticas e Nucleares
Nuclear and Energy Research Institute
Phone: +55 11 2810-5000
Website: https://www.ipen.br/portal_por/portal/default.php

Dedicated webpages for research in biomaterials, materials characterization, composites, crystals and monocrystalline fibers, ceramic materials, photonic materials, metallic materials, nuclear materials, polymeric materials, extractive metallurgy, physical metallurgy, material transformation processes, surface treatment, and glass and glass-ceramic.

LNNano
Brazilian Nanotechnology National Laboratory
Phone: +55 19 3517-5088
Email: lnnano.dir@lnnano.cnpem.br
Website: https://lnnano.cnpem.br

A research lab open to academia and industry, LNNano conducts applied and basic research designed to develop sustainable products and processes for the domestic and international markets. Among its areas of focus is developing "sophisticated techniques for joining, preparing, processing and characterizing metallic and ceramic alloys," the website notes, as well as "production of advanced materials from renewable sources and residues from industrial and agricultural activities." LNNano is also the headquarters of the Binational Brazil-China Center of Nanotechnology, a joint venture of the Brazilian Ministry of Science, Technology and Innovation and the Chinese Academy of Sciences.

Refratarios Paulista
Phone: +55 19 3019-1250
Website: https://www.rpa.ind.br/home/Default.asp?v=en

Production capabilities include cordierite, mullite, high alumina refractories, and hybrid refractory materials whose ceramic structure is reinforced with silicon carbide.

Sao Paulo University
Phone: +55 11 3091-6706 (Department of Applied Physics)
Email: secfap@if.usp.br
Website: https://www5.usp.br/#english
Website: http://web.if.usp.br/cristal

Universidade Estadual Paulista
Phone: +55 11 3170-3700
Website: https://www.unip.br/?lang=en

Universidade Federal de São Carlos
Phone: +55 16 3351-8111
Email: Anselmo Ortega Boschi, daob@ufscar.br
Areas of research interest: Ceramic coatings, technological development, processing of ceramic materials, ceramic tile floors

Email: Márcio Raymundo Morelli, morelli@ufscar.br
Areas of research interest: Synthesis of ceramic powders, combustion reaction, formulation and processing of ceramic materials, sintering, ceramic substrates, solid oxide fuel cells, use of inorganic residues in ceramic matrices

Universidade de São Paulo
Webpage, Materials Engineering Research Group:
http://dgp.cnpq.br/dgp/espelhogrupo/8444026717250923

Verdés
Email: contato@verdes.com.br
Phone: +55 11 4024-8211
Website: http://www.verdes.com.br/en/equipments/Ceramic

into a more global outlook and cautions against being "too localist" in business. Relative to the U.S., Canada, and Mexico, the remainder of the Americas market is small today. "But it's not always going to be that way," he says. "It's important to understand what's going on, especially with local players, and be prepared to develop business relations in Latin America."

In economically and politically volatile times, no enterprise can afford to overlook a country or region in the global marketplace. To learn more about opportunities in this region, consult the resources available through the Association of American Chambers of Commerce in Latin America and the Caribbean,[4] the umbrella organization of the American Chambers of Commerce in 23 countries. Its membership extends to 20,000 companies that account for more than 80% of U.S. investment in the region.

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[4]Association of American Chambers of Commerce in Latin America and the Caribbean. https://www.aaccla.org

Directory of companies, government agencies, associations, institutes, and universities in Latin America (cont.)

Credit: Alex Talavera

CHILE

CEDENNA/Centro para el Desarrollo de la Nanociencia y la Nanotecnología
Center for the Development of Nanoscience and Nanotechnology

Contact form: https://cedenna.cl/en/contact-us
Website: https://cedenna.cl/en

CEDENNA conducts research in nanoscience and nanotechnology and the manipulation of materials at the atomic, molecular, and macromolecular scales. Its work encompasses simulations, magnetic nanostructures, chemistry of nanostructures, chemical physics, packaging technology, and nanobiomedicine.

IMEX JCN

Phone: +56 2 2699-6623
Sales email: ventas@jcn.cl
Contact form: https://www.jcn.cl/contacto
Website: https://www.jcn.cl

The company produces and markets Nano Copper that is free of contaminants (99.9% pure) and available in all particle sizes.

Leitat

Phone: +56 2 321-0500
Website: https://www.leitat.cl

A private nonprofit technology center, Leitat's mission is to create and transfer economic, social, and sustainable value to companies and entities through applied research and technology processes, including production of nanocapsules and development of materials.

Minera Toro

Phone: +56 9 5608-7990 / 3376-7422
Email: Patricio Fierro pfierro@mineratoro.cl
Website: https://www.mineratoro.cl

Nano7

Phone: +56 9 9697-4723
Email: ingrid.carcamo@nano7.cl
Website: http://nano7.cl

The company's products target glass and ceramic requirements in the mining and construction industries, including abrasive glass, electrical and electronic equipment and panels, solar panels, and heavy machinery and mining CAT trucks.

NANOPROCESS

Phone: +56 55 2 865-008 or +56 9 7388-7657
Email: contact@nanoprocess.tech
Website: https://nanoprocess.cl

The company manufactures copper nanoparticles for incorporation in a wide variety of technological developments and production processes.

NANOTEC

Phone: +56 22 5106000 - +56 98 2302187
Email: info@nanotecchile.com
Website: http://www.nanotecchile.com/eng

The company collaborates with clients on joint R&D projects to develop new copper-based nanotechnology processes and products.

Recsol

Phone: +56 72 249-1555 / +56 72 249-1416
Contact form: http://www.recsol.cl/contacto.php (also includes the names and email addresses of the general manager and the commercial and product managers)

Website: http://www.recsol.cl

The company creates solutions related to wear in steel, cement, and thermoelectric plants. Its production line includes bimetallic plates and casting, impact elements, ceramics, and fabrication of mining equipment.

Universidad de Concepción

Contact page: http://www6.udec.cl/pexterno/contacto (address and phone details for all campuses plus email contact form)

Website: http://udec.cl/pexterno

Directory of companies, government agencies, associations, institutes, and universities in Latin America (cont.)

COLOMBIA

3D Solutions
Phone: +57 1 743-8434
info@3dsolutions.com.co
https://www.3dsolutions.com.co

The company develops additive manufacturing systems for dentistry and medicine.

Grupo Corona
Contact page: https://empresa.corona.co/contacto
Website: https://empresa.corona.co

This Colombian multinational serves clients in the home, construction, industry, agriculture, and energy sectors. It manufactures and sells products organized under four business divisions—bathrooms and kitchens; surfaces, materials, and paints; industrial supplies; and energy management—and is developing a new line of business in the production and sale of cement in collaboration with Cementos Molins de España. The company's subsidiary, Gamma, manufactures such refractory products as bricks, concrete, mortar, and thermal insulation.

ITM Institución Universitaria
Phone: +57 4 440-5100
Website: https://www.itm.edu.co

Here is where the Research Group on Advanced Materials and Energy works on the design of biofunctionalized gold nanoparticles stimulated by electromagnetic fields.

QuadCarbon
Phone: +57 318 795-6098
Email: info@quadcarbon.com.co
Website: https://www.quadcarbon.com.co/index.php

The company's business centers on the import and commercialization of raw materials, such as carbon fiber reinforcements, glass and aramid fibers, and resins used in shaping materials.

Universidad Autónoma de Occidente
+57 2 318 8000
Email: Faruk Fonthal Rico, ffonthal@uao.edu.co
Website: https://www.uao.edu.co/la-universidad/summary-uao

The University is home to the Research Group on Advanced Materials for Micro and Nanotechnology, whose lines of investigation include optoelectronics materials.

Universidad de Antioquia, Colombia
+57 4 219-8332
Email: Henry Colorado, henry.colorado@udea.edu.co
Website: http://www.udea.edu.co/wps/portal/udea/web/home

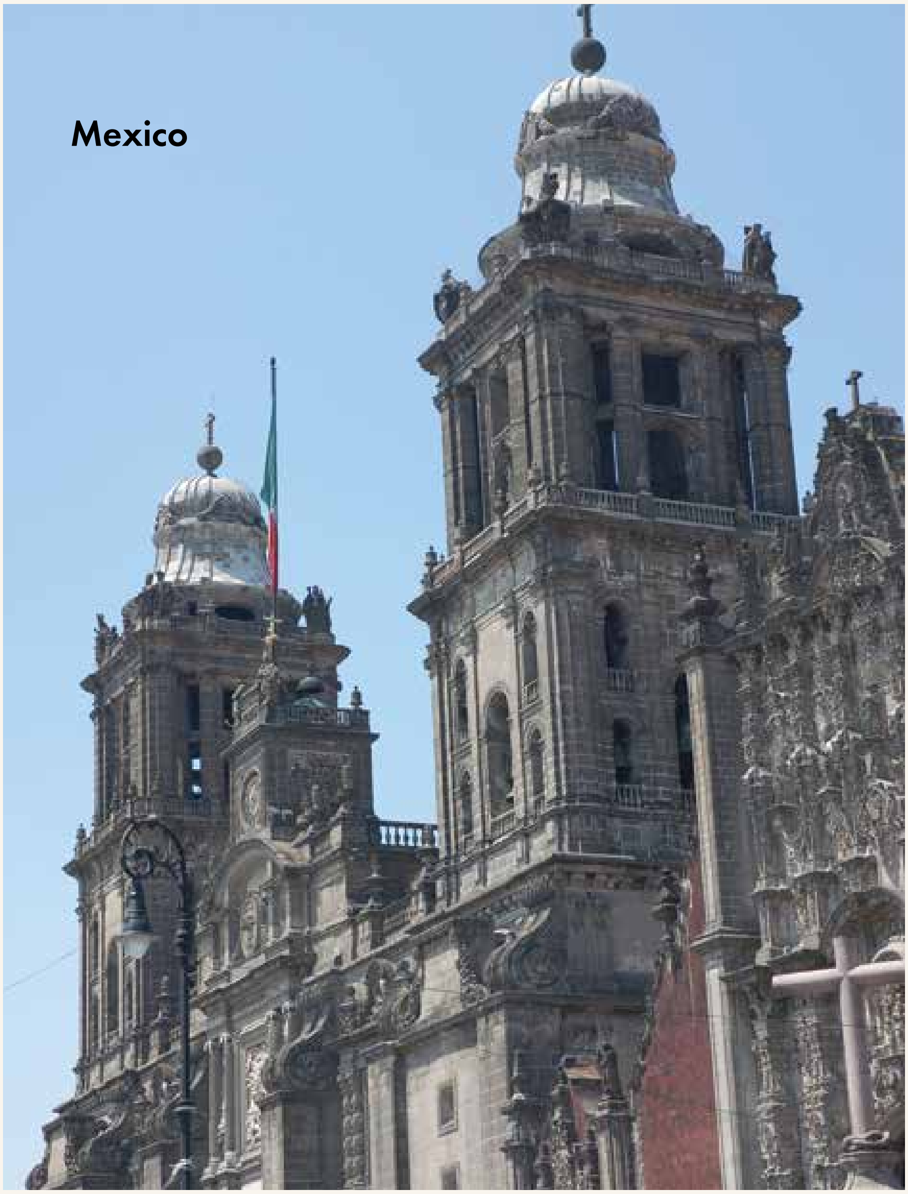
See our main article for our interview with professor Colorado, an ACerS member.

Universidad de Los Andes
Phone: +57 1 339-4999
Website: https://uniandes.edu.co

The University houses a Microelectronics Center for the characterization and manufacture of micro and nanoscale devices. Its clean room conforms to controlled environment class 1000 standards.

Universidad Nacional de Colombia, Manizales
Phone: +57 6 887-9300
Email: arosalesr@unal.edu.co
Website: https://www.manizales.unal.edu.co

Among the team's lines of investigation are simulation of magnetic systems, growth of magnetic materials, semiconductor nanostructures, and thermal materials.



Credit: Randy B. Hecht

COSTA RICA

Instituto Tecnológico de Costa Rica TEC
Phone: +506 2550-2213
Email: infome@tec.ac.cr
Website: https://www.tec.ac.cr/en

The School of Materials Science and Engineering houses a Materials Research and Extension Center whose lines of inquiry include degradation and protection of materials, characterization of materials and nondestructive tests, materials mechanics, and advanced technologies for the development and application of materials. The Center offers a variety of services to industry, including thermal and thermochemical treatments, metallography and macrography, X-ray diffraction, electron microscopy, mechanical tests, and nondestructive tests.

LANOTEC
National Laboratory of Nanotechnology
Phone: +506 2519-5832
General email: lanotec@cenat.ac.cr
Director: Jose R. Vega-Baudrit jvegab@gmail.com
Website: https://www.lanotec.org

The Center provides services in microscopy, spectrophotometry and thermal measurements, and physical–chemical measurements. An English-language digital brochure of its recent projects is available for download at https://www.lanotec.org/research.

Universidad de Costa Rica
Phone: +506 2511-1330 / 2511-1350
Website: https://www.ucr.ac.cr

The University houses the Materials Science and Engineering Research Center, which engages in "multidisciplinary scientific and technological research … dedicated to the study at the microscopic level of physical and chemical properties of materials, for their development and adaptation in industrial processes."

Center phone: +506 2511-6573
Center email: cicima@ucr.ac.cr

Directory of companies, government agencies, associations, institutes, and universities in Latin America (cont.)

Credit: Randy B. Hecht

ECUADOR

Centro de Nanociencia y Nanotecnología
Center for Nanoscience and Nanotechnology
Phone: +59 3 2398-9492
Email: cencinat@espe.edu.ec
Website: http://www.espe-innovativa.edu.ec/cencinat

The Center, which operates under the auspices of the Universidad de las Fuerzas Armadas (Armed Forces University), houses a nanomaterials characterization lab and engages in the following areas of research and capabilities: transmission electron microscopy, scanning electron microscopy, atomic force microscopy, X-ray diffractometry, sunlight simulator, and mechanical profilometry.

MEXICO

Note: Our 2013 international report was a dual profile of Mexico and Canada. Access the earlier report about Mexico, including that year's directory, at https://bulletin-archive.ceramics.org/2013-10.

CIMAV
Center for Research in Advanced Materials
Phone: +52 81 1156-0800
Email: Servando Aguirre, servando.aguirre@cimav.edu.mx
Website: https://cimav.edu.mx/en

A product of collaboration between government, academia, and industry, CIMAV encompasses 10 public and 14 private research centers, two incubators, and eight institutions of higher education (domestic and international). Its areas of focus include the design, synthesis, modification, and characterization of micro and nanometric-level materials. Research teams' advanced materials projects are developed for energy, environmental, and medical applications.

CIMAV Laboratorio Nacional de Nanotecnología
Website: https://ntch.cimav.edu.mx

Among the nanostructured materials and applications being researched at the lab are technology for production of carbon nanotubes; development of composite materials (metals–CNTs and ceramics–CNTs); production of silica aerogels; electrocatalysts for fuel cells, aerogels, and activated carbon; and micro and nanostructured polymeric sensors. A more extensive overview of all areas of research can be found at https://ntch.cimav.edu.mx/lineas-de-investigacion.

Consejo Nacional de Ciencia y Tecnología
National Science and Technology Council
Phone: +55 5322-7700
Website: https://www.conacyt.gob.mx/index.php

This government agency fosters and provides funding for "the development of scientific research, technological development and innovation in order to promote the technological modernization of the country." Its Advanced Materials Research Center carries out technological research and development as well as training in such areas as materials chemistry and physics, functional materials, coatings, nanostructured catalytic materials, polymer-based composite materials, and computational simulation of materials and processes. A more extensive overview of its programs and capabilities can be found at https://www.conacyt.gob.mx/index.php/comunicacion/comunicados-prensa/10-contenido-estatico/70-centro-de-investigacion-en-materiales-avanzados.

The government agency also oversees the Center of Advanced Technology (CIATEQ), whose work in the formulation and synthesis of polymers is a key area of focus in plastics and advanced materials. A more extensive overview of this work can be found at https://www.ciateq.mx/index.php/oferta-tecnologica/plasticos-y-materiales-avanzados.html.

Instituto Potosino de Investigación Científica y Tecnológica
Phone: +55 444 834-2000
Website: https://www.ipicyt.edu.mx

The Division of Advanced Materials engages in synthesis, characterization, and use of new materials and nanostructures for emerging applications. Areas of research focus include generation of alternative energy sources, organic electronics, gas sensors, and nanomedicine. The National Laboratory for Nanoscience and Nanotechnology Research and the National Supercomputing Center (used to conduct molecular simulations related to physiochemical, electronic, and magnetic properties) also operate under the auspices of IPICYT.

NANOCRON NANOTECNOLOGIA SA
Contact page: http://nanocron.com/index.php/contacts
Website: http://nanocron.com

The company specializes in "research, development, and production of nanoparticles with dimensions less than 200 nm, among which are metals, metal oxides and nanocomposites" as well as manufacture of nanopowders and nanodispersions for a variety of applications used in diverse industries.

PANAMA

Universidad Tecnológica de Panamá
Phone: +507 560-3061
Email: maytee.zambrano@utp.ac.pa, carlos.medina@utp.ac.pa
Website: http://gitts.utp.ac.pa/en

In addition to offering materials science, materials manufacturing, and nanotechnology courses, the University operates the Research Group on Advanced Technologies of Telecommunications and Signal Processing, where teaching and research follow four primary fields: applied information theory, wireless communication systems, signal processing for communication systems, and electrical engineering.

INDICASAT-AIP
Phone: +507 517-0700
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Website: http://indicasat.org.pa/home

The Institute for Scientific Research and High Technology Services of Panama operates under the auspices of the National Secretariat of Science, Technology and Innovation. Its areas of priority are biodiversity, biotechnology, and biomedicine. Rolando Gittens' areas of research specialization include biomaterials, orthopedic and dental implants, and osseointegration of titanium.

ECOROADSA
Phone: +507 6832-2829 / 343-0897
Email: info-panama@ecoroadsa.com
Website: www.ecoroadsa.com

The company develops and commercializes technologies for environmentally friendly and sustainable road construction. Its nanotechnology-based product Zycotherm enables a chemical bond with asphalt cement that promotes adhesion and allows lower mixing temperatures.

NANOTECH+
Phone: +507 787-5322
Website: https://nanotechnology.com.pa

PERU

Universidad Nacional de Ingeniería
National Engineering University
+51 1 481-1070
Website: https://www.uni.edu.pe

The materials science research priority is nanoscience and nanotechnology—including nanomaterials and metallurgy and nanostructured materials—with the goal of establishing nanoscience strategies for Peru. Additional areas of focus include thin films, renewable energy, and advanced magnetic materials.

Universidad San Ignacio de Loyola
+51 1 317-1000
Email: Dra. Mercedes Puca Pacheco, Nanotechnology and Advanced Materials Research Unit, mercedes.puca@usil.pe
Website: https://www.usil.edu.pe/en/node/118 (English-language home page)

University research is focused on development of next-generation nanometric materials for technology, electronics, and medicine. Among its areas of investigation are synthesis and characterization of magnetic and metallic nanoparticles, nanostructure polymers, and graphene/graphene oxide as well as synthesis of polymeric nanocomposites reinforced with graphene.

Universidad Nacional Mayor de San Marcos
Mail: sanmarcosaldia@unmsm.edu.pe
Website: http://www.unmsm.edu.pe

Universidad Nacional De Trujillo
Phone: +51 44 633-952
Email: materiales@unitru.edu.pe
Website: https://www.unitru.edu.pe

REGISTER NOW

ACerS ANNUAL MEETING at

ACerS VIRTUAL ANNUAL MEETING

The Society will hold its Annual Business Meeting, Division, and committee meetings this fall—online! We invite all members and prospective members to attend.

ANNUAL BUSINESS MEETING

ACerS will host its 122nd Annual Membership Meeting on Monday, Oct. 5, 10–11 a.m. E.T.

The annual meeting will feature the outgoing president's State of the Society report, the incoming president's vision, new officer inductions, and a members' town hall and question and answer session. This meeting is a great opportunity to be proactive and get involved with the Society's present and future. Visit www.ceramics.org to register.

DIVISION MEETINGS

Division business meetings will also be virtual. Details on registration will be forthcoming.

- **Art, Archaeology, & Conservation Science**: Wednesday, Oct. 7, 1 – 2 p.m.
- **Basic Science Division**: Monday, Oct. 5, 11:30 a.m. – 12:30 p.m.
- **Bioceramics Division**: TBD
- **Electronics Division**: Monday, Oct. 5, 12:30 – 1:30 p.m.
- **Energy Materials and Systems Division**: Monday, Oct. 5, 1:30 – 2:30 p.m.
- **Engineering Ceramics Division**: Tuesday, Oct. 6, 10 – 10:50 a.m.
- **Manufacturing Division**: TBD

2020 AWARD LECTURES

See schedule at matscitech.org/mst20

- **Edward Orton, Jr. Memorial Lecture**
- **Frontiers of Science and Society – Rustum Roy Lecture**
- **Richard M. Fulrath Award Lectures**
- **ACerS/EPDC Arthur L. Friedberg Ceramic Engineering Tutorial and Lecture**
- **ACerS GOMD Alfred Cooper Award sessions**
- **D.T. Rankin Award** (Energy Materials and Systems Division)

MATSCITECH.ORG/MST20

The American Ceramic Society www.ceramics.org Annual Meeting

AIST ASSOCIATION FOR IRON & STEEL TECHNOLOGY STEEL PROPERTIES & APPLICATIONS

TMS FALL MEETING

SHORT COURSE ONLINE

To learn more, visit the course website.

SINTERING OF CERAMICS

Dates: **Oct. 10–14, 2020 I Oct. 20–22, 2020**
Time: **10:30 a.m. to Noon**
Instructor: **Ricardo Castro**
University of California, Davis

Sintering is a ubiquitous processing step for manufacturing ceramics for a diverse set of applications. While commonly related to powder processing of ceramic parts, its important roles in other processes, such as additive manufacturing, nanotechnology, and thin films, are less commonly discussed. This course will cover the principles and practices in sintering, giving students sufficient background to be able to

- Perform sintering of powders to achieve specified target microstructures,
- Understand the difficulties encountered in practical powder sintering,
- Take practical steps to rectify the problems encountered in producing required target microstructures, and
- Understand how sintering aspects help optimization of related ceramic processes.

Engineers and scientists in industry, national laboratories, and academia involved in the research, development, and production of ceramics, as well as professionals interested in continuing education in this area are encouraged to participate in this course.

#MST20

MS&T20

MATERIALS SCIENCE & TECHNOLOGY

MS&T20 VIRTUAL

NOV. 2-6, 2020

WHERE MATERIALS INNOVATION HAPPENS

Due to COVID-19, MS&T20 will now be held as a virtual event, Nov. 2-6, 2020. As a registrant, you will be able to watch live plenary and award sessions, visit our virtual exhibit, join in virtual networking and student events, and have access to hundreds of on-demand technical presentations and posters—all at a fraction of the price of participating in a traditional, in-person MS&T conference.

Mark your calendar today and plan to join your colleagues at MS&T20 Virtual. Additional event details will be available soon. Visit matscitech.org/MST20 in the coming weeks for information on how to register for this event.

EXHIBITION

VIRTUAL EXHIBITION—

MS&T is excited to launch a new virtual opportunity for your company to showcase its brand and services to a global network of scientists, engineers, students, suppliers, and business leaders responsible for shaping the future of materials science and technology. Attendees can visit exhibitors to learn about their products and services and network through our interactive online environment. The MS&T20 virtual exhibition will showcase companies displaying products and services from the materials science community, including

- Additive Manufacturing
- Artificial Intelligence
- Biomaterials
- Ceramic and Glass Materials
- Electronic and Magnetic Materials
- Energy
- Fundamentals and Characterization
- Iron and Steel (Ferrous Alloys)
- Materials-Environment Interactions
- Modeling
- Nanomaterials
- Processing and Manufacturing

CONTACT US TO JOIN THE MS&T20 VIRTUAL EXHIBITION—

Association for Iron & Steel Technology (AIST)

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The American Ceramic Society (ACerS)

MONA THIEL
National Sales Director
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1-614-794-583

PLENARY SESSION

Visit the MS&T Plenary Speakers web page to view the complete abstracts and bios.

AIST ADOLF MARTENS MEMORIAL STEEL LECTURE

Nina Fonstein
Scientific advisor, ArcelorMittal, USA
Effects of retained austenite stability and microstructure refinement on properties of advanced high strength sheet steels

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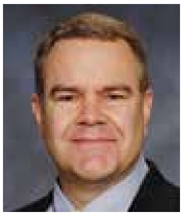
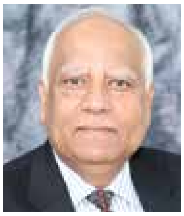


Charles H. Ward
Chief Manufacturing and Industrial Technologies Division, Air Force Research Laboratory, USA
Integrating materials and manufacturing

ACERS EDWARD ORTON JR. MEMORIAL LECTURE



Mrityunjay Singh
Chief scientist, Ohio Aerospace Institute, USA
Additive manufacturing: Disruptive threat to global supply chains and enabler for sustainable development

Organizers:

The American Ceramic Society www.ceramics.org · AIST Association for Iron & Steel Technology · TMS The Minerals, Metals & Materials Society

MATSCITECH.ORG/MST20

SUBMIT YOUR ABSTRACT

VIRTUAL MEETING

ELECTRONIC MATERIALS AND APPLICATIONS (EMA 2021)

JAN. 19– 22, 2021

ceramics.org/ema2021

Organized by the ACerS Electronics and Basic Science Divisions

Electronic Materials and Applications 2021 (EMA 2021) is an international conference focused on electroceramic materials and their applications in electronic, electrochemical, electromechanical, magnetic, dielectric, biological and optical components, devices, and systems. Jointly programmed by the Electronics Division and Basic Science Division of The American Ceramic Society, EMA 2021 will be a virtual event on the same planned dates, Jan. 19–22, 2021.

EMA 2021 is designed for scientists, engineers, technologists, and students interested in basic science, engineering, and applications of electroceramic materials. Participants from across the world in academia, industry, and national laboratories exchange information and ideas on the latest developments in theory, experimental investigation, and applications of electroceramic materials.

Students are highly encouraged to participate in the meeting. Prizes will be awarded for the best oral and poster student presentations.

ORGANIZING COMMITTEE

ELECTRONICS DIVISION

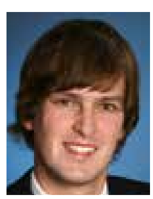
Xiong

Hui (Claire) Xiong
Boise State University
clairexiong@boisestate.edu

Andrew

Jennifer Andrew
University of Florida
jandrew@mse.ufl.edu

BASIC SCIENCE DIVISION



Rheinheimer

Wolfgang Rheinheimer
Technische Universität Darmstadt, Germany
wolfgang.rheinheimer@gmail.com

Garcia

Edwin Garcia
Purdue University
redwing@purdue.edu

SCHEDULE OF EVENTS

WEDNESDAY, JANUARY 20, 2021

Plenary session 1	9:45 – 11 a.m.
Concurrent technical sessions	11 a.m. – 4 p.m.
Networking session	4 – 5 p.m.

THURSDAY, JANUARY 21, 2021

Plenary session 2	10 – 11 a.m.
Concurrent technical sessions	11 a.m. – 5 p.m.
Student & Young Professionals networking session	5:30 – 6:30 p.m.

FRIDAY, JANUARY 22, 2021

Concurrent technical sessions	11 a.m. – 5 p.m.
Failure: The greatest teacher	5 – 6 p.m.

TECHNICAL PROGRAM

S1 – Characterization of Structure-Property Relationships in Functional Ceramics

S2 – Advanced Electronic Materials: Processing Structures, Properties, and Applications

S3 – Frontiers in Ferroic Oxides: Synthesis, Structure, Properties, and Applications

S4 – Complex Oxide Thin Films and Heterostructures: From Synthesis to Strain/Interface-engineered Emergent Properties

S5 – Mesoscale Phenomena in Ferroic Nanostructures: From Patterns to Functionalities

S6 – Emerging Semiconductor Materials and Interfaces

S7 – Superconducting and Magnetic Materials: From Basic Science to Applications

S8 – Structure-Property Relationships in Relaxor Ceramics

S9 – Ion-Conducting Ceramics

S10 – Point Defects and Transport in Ceramics

S11 – Dislocations in Ceramics: Processing, Structure, Plasticity, and Functionality

S12 – Evolution of Structure and Chemistry of Grain Boundaries and Their Networks as a Function of Material Processing

S13 – 5G Materials and Applications Telecommunications

S14 – Agile Design of Electronic Materials: Aligned Computational and Experimental Approaches and Materials Informatics

S15 – Functional Materials for Biological Applications

OFFICIAL NEWS SOURCES

SUBMIT YOUR ABSTRACT

45TH INTERNATIONAL CONFERENCE AND EXPOSITION ON ADVANCED CERAMICS AND COMPOSITES

ceramics.org/icacc2021

VIRTUAL MEETING

FEB. 8–12, 2021

Organized by the Engineering Ceramics Division of The American Ceramic Society

Due to uncertainty surrounding the current global pandemic, meeting organizers, along with the meetings team at The American Ceramic Society, have decided to move the 45th International Conference & Exposition on Advanced Ceramics & Composites meeting to a fully virtual format for 2021, running live sessions containing pre-recorded talks on a new date: Feb. 8–12, 2021. This conference will be the first-ever Virtual ICACC organized by ACerS Engineering Ceramics Division, and we would like for you to be a part of it.

This conference has a strong history of being the preeminent international meeting on advanced structural and functional ceramics, composites, and other emerging ceramic materials and technologies, and this year is no different.

The technical program will reflect the growth and success of ICACC by featuring 18 symposia, five focused sessions, one special focused session, and the 10th Global Young Investigator Forum. These technical sessions, consisting of both oral and poster presentations, will provide an open forum for scientists, researchers, and engineers from around the world to present and exchange findings on recent advances on various aspects related to ceramic science and technology. The technical program reflects critical areas of interest within ceramics and advanced composites, with a particular emphasis on current trends in research, development, engineering, and application of advanced ceramics.

Hisayuki Suematsu
Program chair, ICACC 2020
Nagaoka University of Technology, Japan
E-mail: suematsu@nagaokaut.ac.jp

Focused Sessions

- ❖ Special Focused Session on Diversity, Entrepreneurship, and Commercialization
- ❖ 10th Global Young Investigator Forum

FS1: Bio-Inspired, Green Processing, and Related Technologies of Advanced Materials

FS2: Materials for Thermoelectrics

FS3: Molecular-level Processing and Chemical Engineering of Functional Materials

FS4: Ceramic/Carbon Reinforced Polymers

FS5: Fractography of Ceramics

Symposia

S1: Mechanical Behavior and Performance of Ceramics and Composites

S2: Advanced Ceramic Coatings for Structural, Environmental, and Functional Applications

S3: 18th International Symposium on Solid Oxide Cells (SOC): Materials, Science, andTechnology

S4: Armor Ceramics – Challenges and New Developments

S5: Next Generation Bioceramics and Biocomposites

S6: Advanced Materials and Technologies for Rechargeable Energy Storage

S7: 15th International Symposium on Functional Nanomaterials and Thin Films for Sustainable Energy Harvesting, Environmental, and Health Applications

S8: 15th International Symposium on Advanced Processing and Manufacturing Technologies for Structural and Multifunctional Materials and Systems (APMT15)

S9: Porous Ceramics: Novel Developments and Applications

S10: Modeling and Design of Ceramics and Composites

S11: Advanced Materials and Innovative Processing Ideas for Production Root Technologies

S12: On the Design of Nano-laminated Ternary Transition Metal Carbides/Nitrides (MAX Phases) and Borides (MAB Phases), and Their 2D Counterparts (MXenes, MBenes)

S13: Development and Applications of Advanced Ceramics and Composites for Nuclear Fission and Fusion Energy Systems

S14: Crystalline Materials for Electrical, Optical, and Medical Applications

S15: 4th International Symposium on Additive Manufacturing and 3D Printing Technologies

S16: Geopolymers, Inorganic Polymers, and Sustainable Materials

S17: Advanced Ceramic Materials and Processing for Photonics and Energy

S18: Ultra-High Temperature Ceramics resources

Calendar of events

September 2020

29 Ceramic Manufacturing Solutions Conference – VIRTUAL ONLY EVENT; www.ceramics.org/CMSC

October 2020

13 Fluorine Forum 2020 ONLINE; http://imformed.com/get-imformed/forums/fluorine-forum-2020-revised

26–30 81st Conference on Glass Problems (GPC2020) – VIRTUAL EVENT ONLY; https://glassproblemsconference.org

November 2020

2–6 ACerS 122nd Annual Meeting with Materials Science & Technology 2020 – VIRTUAL EVENT ONLY; www.matscitech.org

TBA 7th Int. Conference on Electrophoretic Deposition (EPD 2021) – Santa Fe, New Mexico; http://www.engconf.org/conferences/materials-science-including-nanotechnology/electrophoretic-deposition-vii-fundamental-and-applications

29–Dec 3 2020 MRS Fall Meeting & Exhibit – VIRTUAL EVENT ONLY; www.mrs.org/fall2020

January 2021

19–22 Electronic Materials and Applications (EMA2021) – VIRTUAL EVENT ONLY; www.ceramics.org/ema2021

February 2021

8–12 45th International Conference and Expo on Advanced Ceramics and Composites (ICACC2021) – VIRTUAL EVENT ONLY; www.ceramics.org/icacc2021

March 2021

15–17 China Refractory Minerals Forum 2021 – InterContinental Dalian, Liaoning, China; http://imformed.com/get-imformed/forums/china-refractory-minerals-forum-2020

24–29 2nd Global Forum on Smart Additive Manufacturing, Design and Evaluation (SmartMADE) – Osaka University, Nakanoshima Center, Japan; http://www.jwri.osaka-u.ac.jp/~conf/Smart-MADE2021

27–31 The Int'l Conference on Sintering 2022 – Nagaragwa Convention Center, Gifu, Japan; https://www.sintering2021.org

April 2021

25–30 International Congress on Ceramics (ICC8) – Bexco, Busan, Korea; www.iccs.org

May 2021

1–4 6th Ceramics Expo – I-X Center, Cleveland, Ohio; https://ceramics.org/event/6th-ceramics-expo

16–19 Ultra-high Temperature Ceramics: Materials for Extreme Environment Applications V – The Lodge at Snowbird, Snowbird, Utah; http://bit.ly/5thUHTC

17–20 China Ceramitec 2021 – Messe München, Germany; https://www.ceramitec.com/en

23–28 14th Pacific Rim Conference on Ceramic and Glass Technology (PACRIM 14) – Hyatt Regency Vancouver, Vancouver, British Columbia, Canada; www.ceramics.org/PACRIM14

June 2021

7–9 ACerS 2021 Structural Clay Products Division & Southwest Section Meeting in conjunction with the National Brick Research Center Meeting-Omni Austin Hotel Downtown, 700 San Jacinto Street, Austin, Texas; www.ceramics.org

28–30 MagForum 2021: Magnesium Minerals and Markets Conference – Grand Hotel Huis ter Duin, Noordwijk, Amsterdam; http://imformed.com/get-imformed/forums/magforum-2020

July 2021

18–23 Materials Challenges in Alternative & Renewable Energy 2020 (MCARE 2020) combined with the 4th Annual Energy Harvesting Society Meeting (EHS 2020) – RESCHEDULED-Hyatt Regency Bellevue Bellevue, Wash.; www.ceramics.org

September 2021

14–17 20th Biennial Worldwide Congress Unified International Technical Conference on Refractories – Hilton Chicago, Chicago, Ill.; www.ceramics.org

October 2021

NEW DATE

12-15 International Research Conference on Structure and thermodynamics of Oxides/carbides/nitrides/borides at High Temperature (STOHT) – Arizona State University, Ariz.; https://mccormacklab.engineering.ucdavis.edu/events/structure-and-thermodynamics-oxidescarbidesnitridesborides-high-temperatures-stoht2020

17–21 ACerS 123rd Annual Meeting with Materials Science & Technology 2021 – Greater Columbus Convention Center, Columbus, Ohio; www.ceramics.org

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

Entries in **BLUE** denote ACerS events.

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

denotes virtual meeting

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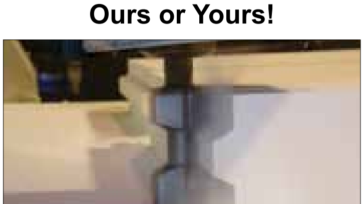

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OCTOBER–NOVEMBER 2020

‡Find us in *ceramicSOURCE* 2020 Buyer's Guide

AMERICAN CERAMIC SOCIETY bulletin

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deciphering the discipline

A regular column offering the student perspective of the next generation of ceramic and glass scientists, organized by the ACerS Presidents Council of Student Advisors.

Iva Milisavljevic
Guest columnist

From ceramics to Schnitzels: Student exchange programs are part of life-long learning process

Credit: Iva Milisavljevic

Figure 1. Examples of architecture in Frankfurt, Germany. Student exchange programs give students the valuable opportunity to gain both research and culture experience, Milisavljevic says.

I have always believed personal and professional growth begins once we develop a positive attitude toward the growth itself and open our minds to new ideas and life-long learning.

As a Ph.D. student in ceramic engineering at Alfred University working under the supervision of Dr. Yiquan Wu, I had the opportunity to put this belief into practice when I participated in the Collaborative Exchange Research and Materials in Ceramic Sciences (CERAMICS) program in 2019.

Wu established the CERAMICS program with NSF CAREER award funding in 2016. The program provides students from the United States an opportunity to visit institutes and research facilities at companies abroad to collaborate, promote knowledge exchange, and establish good relations between the institutions.

I traveled to Germany to visit laboratory equipment manufacturer Edmund Bühler GmbH for an experimental demonstration that may help with my work on transparent ceramics.

One of the most significant challenges in current transparent ceramic processing technology is the fabrication of highly dense bodies with minimum porosity because the presence of even the smallest pores can limit the product's optical transparency and, therefore, application in various optical devices.

Edmund Bühler has a specialized furnace they use for processing amorphous materials in a novel manner. We believe the processing method is promising for creating transparent ceramic materials as it would enable the formation of ceramic materials with grain sizes smaller than the wavelength of the incident light. So, my goal of visiting was to learn about this technique, test its applicability to ceramic materials, and bring the knowledge back to further our research at Alfred University.

I had visited Germany before, but I was very excited for this trip. After a long flight and a two-hour train ride through the scenic countryside south from Frankfurt, I arrived in Bodelshausen, a small town in western Germany, where the Edmund Bühler headquarters and manufacturing facility are located.

During my visit, I learned about the company's 140-year-long history, their business practices and products, and even saw a part of their manufacturing facility. Then, after a detailed step-by-step training from their senior engineer on how to operate one of their furnaces, I conducted experiments using the novel processing method.

The processing method involves melting the material above its liquidus temperature in the melt-spinning furnace, which the company modified for my experiments, followed by a fast quenching to room temperature. The final product of this process—an amorphous material that exhibits high chemical homogeneity—can be used as a raw material to make nanoceramics or even transparent nanoceramics through further processing with sintering equipment.

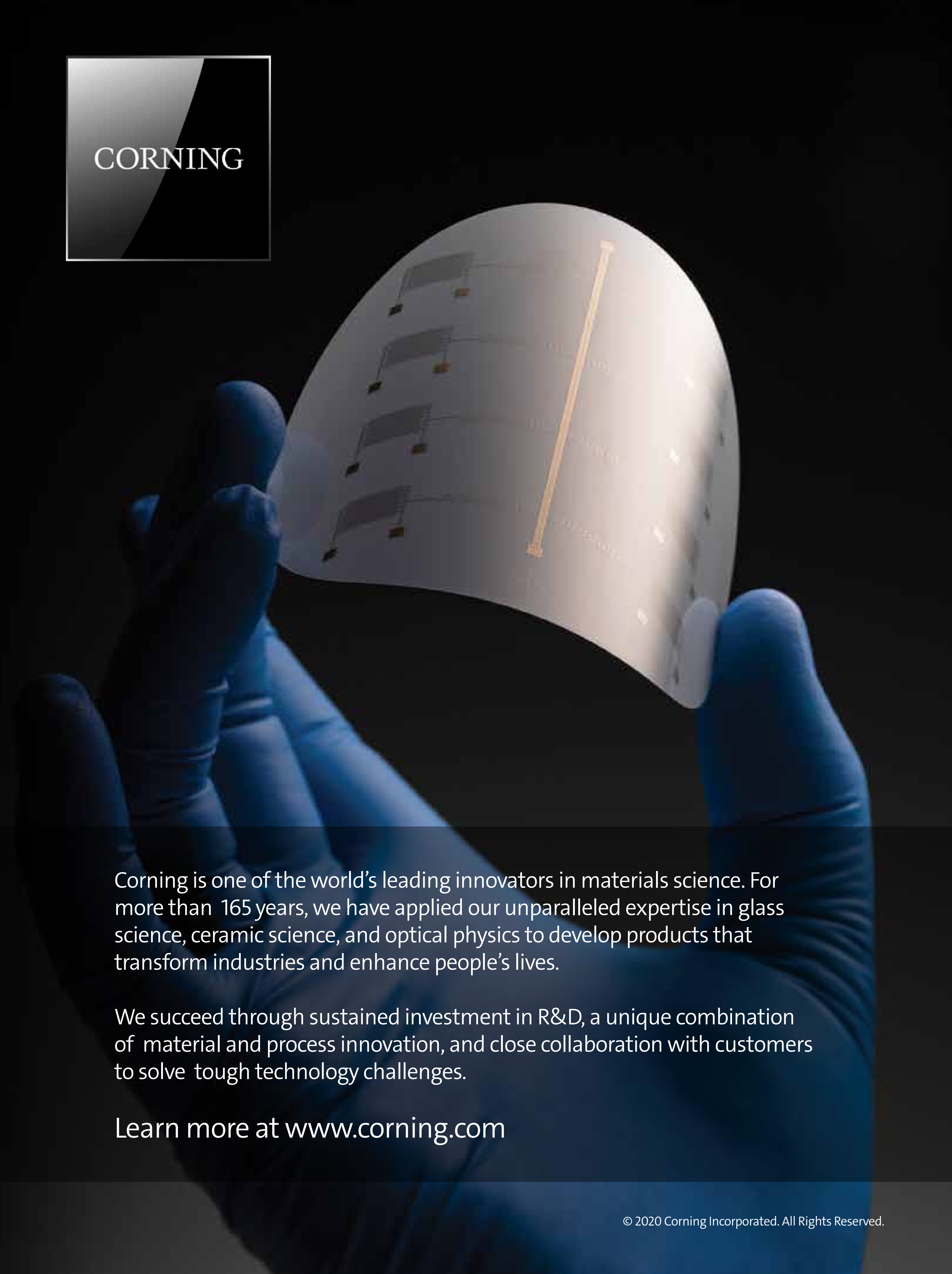
After I finished my experiments and said goodbye to my lovely hosts from Edmund Bühler, I finished the research part of my trip. After that, I headed back to Frankfurt to explore that beautiful city for another two days before departing for the U.S.

As I walked down the busy streets of Frankfurt, I witnessed a remarkable fusion of the colorful traditional and stunning modern architecture of this city (Figure 1). As an unavoidable part of any trip, I tasted some of the local cuisine specialties. I enjoyed a *Currywurst* sausage with *Kartoffeln* (potatoes) and *Sauerkraut* (sour cabbage), and later on a famous *Schnitzel* (boneless cutlet coated in breadcrumbs) and *Brätzel* (pretzel) with a glass of local beer.

I left Germany with a smile on my face, partly because of the successful visit to Edmund Bühler, which provided me with new ideas and opportunities for my research, and partly because of the valuable culture experience I gained as well.

I am so grateful for the opportunity I was given to participate in the CERAMICS program. I always recommend to my friends and peers to consider spending at least some time abroad during their studies because it can help them expand their views, open their minds, and gain valuable research and culture experience. I look forward to my next opportunity to travel and participate in a student exchange program related to ceramics science.

Iva Milisavljevic is a third-year Ph.D. student in ceramic engineering at Alfred University, working in Yiquan Wu's research group. Her main research interests are the novel solid-state single-crystal growth method and ceramic processing methods for transparent ceramics fabrication. She resides in Upstate New York, where she enjoys long walks and hiking in many of the state parks.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