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American Ceramic Society Bulletin covers news and activities of the Society and its members, includes items of interest to the ceramics community, and provides the most current information concerning all aspects of ceramic technology, including R&D, manufacturing, engineering, and marketing. *American Ceramic Society Bulletin* (ISSN No. 0002-7812). ©2015. Printed in the United States of America. *ACerS Bulletin* is published monthly, except for February, July, and November, as a "dual-media" magazine in print and electronic formats (www.ceramicbulletin.org). Editorial and Subscription Offices: 600 North Cleveland Avenue, Suite 210, Westerville, OH 43082-6920. Subscription included with The American Ceramic Society membership. Nonmember print subscription rates, including online access: United States and Canada, 1 year $135; international, 1 year $150.* Rates include shipping charges. International Remail Service is standard outside of the United States and Canada. *International nonmembers also may elect to receive an electronic-only, email delivery subscription for $100. Single issues, January–October/November: member $6 per issue; nonmember $15 per issue. December issue (*ceramicSOURCE*): member $20, nonmember $40. Postage/handling for single issues: United States and Canada, $3 per item; United States and Canada Expedited (UPS 2nd day air), $8 per item; International Standard, $6 per item.

POSTMASTER: Please send address changes to American Ceramic Society Bulletin, 600 North Cleveland Avenue, Suite 210, Westerville, OH 43082-6920. Periodical postage paid at Westerville, Ohio, and additional mailing offices. Allow six weeks for address changes.

ACSBA7, Vol. 95, No. 7, pp 1–48. All feature articles are covered in Current Contents.

news & trends

Anticounterfeiting technique writes invisible watermark in ceramic or glass

Genuine watches and other often-imitated goods might soon have a fighting chance against counterfeiters, thanks to a new technique developed at École Polytechnique Fédérale de Lausanne in Switzerland that can help sort the fake from the genuine. An EPFL–based start-up company called Nanoga has patented a system that creates photonic watermarks on ceramic, glass, and metal materials.

Although the process was designed specifically for expensive Swiss watches, it could be used to ensure the manufacturing origin of other products as well.

What makes the technique so powerful is that it does not change the appearance of the product, but rather incorporates an invisible watermark into the material that can be seen only under ultraviolet light.

Nanoga uses vapor deposition to deposit its patented chemicals onto a material surface. Then it turns to lithographic printing to activate only areas within the desired pattern to create a UV-light-sensitive watermark.

The process can fabricate a thin film of patented chemicals in any desired pattern—whether a large watermark or a barely perceptible serial number.

The technique is not easy to reproduce because of the machinery, expertise, and patented chemicals that together generate the watermark, making it the ideal for anticounterfeiting efforts.

Credit: EPFL

A new type of photonic watermark for anticounterfeiting efforts is visible only under UV light.

A video featuring the EPFL scientists and the new photonic watermark in invisible action is available at youtu.be/4AGiyZ99iYI. ■

Morgan Advanced Materials and Penn State team up to establish new carbon science center

Continuing the trend toward novel industry–academia partnerships, Morgan Advanced Materials (Windsor, U.K.) and Pennsylvania State University (State College, Pa.) recently announced a collaboration to form a new R&D center focused solely on advancing carbon materials.

According to a Morgan press release, "Over the course of three years, Morgan is expected to make a multimillion pound investment aimed at establishing a truly world-class research facility. Once operational, the center is expected to continue to create a range of highly skilled research posts over the next few years."

The new Carbon Science Center of Excellence will be housed in a 30,000-square-foot mixed-use facility at Penn State's Innovation Park that is expected to complete construction in late 2017.

A *Centre Times Daily* article notes that the center plans to establish 15 new positions in its early stages, plus sponsored research and student opportunities, including internships and career development initiatives.

"The collaboration is a win–win situation for all involved," Neil Sharkey, Penn State's vice president of research says in a Penn State press release. "Our commitment to developing new methodologies and making further scientific discoveries in carbon science is closely aligned with Morgan's company vision, mission, and commitment to the markets it serves. Morgan's expertise and commercial insights will provide our researchers with a solid foundation to deliver commercially viable solutions that distinguish both Penn State and Morgan in a fiercely competitive marketplace, while contributing to job creation and economic development in the Pennsylvania Commonwealth."

Morgan already has established two other Centers of Excellence in the United Kingdom—one focused on insulating fiber and the other on structural ceramics. The Carbon Science Center of Excellence will be the company's first in North America.

Credit: Morgan Advanced Materials

Pennsylvania State University vice president of research Neil Sharkey (left) and Morgan Advanced Materials chief technical officer Mike Murray.

The new carbon science center will be located at Penn State partially because it has a world-class Materials Research Institute, which already is set up with a full characterization lab and nanofabrication lab.

"One of the big attractions about Penn State was that there were so many facets of research and development there," Morgan chief technology officer Mike Murray says in a *Centre Times Daily* article. "We feel it gives us a really exciting base from which we can build a close collaboration with Penn State over many years and perhaps beyond the current field of carbon science." ■

Business news

PPG reaches agreement with Vitro for sale of flat-glass operations (**ppg.com**)…NIST awards small businesses $3.3M for innovation research (**commerce.gov**)…HarbisonWalker International increases North American monolithics inventory (**thinkhwi.com**)…DOE announces $13M to advance fuel cell and hydrogen storage technologies (**energy.gov**)…Amedica announces closing of $12.7M public offering (**amedica.com**)…Kajaria Ceramics board approves KSPL merger with company (**businesswire.com**)…Kyocera to streamline US management structure (**kyocera.gov**)…Glassmaker Cardinal IG expanding in Indiana (**cardinalcorp.com**)…DOE announces up to $70M for new REMADE in America Institute (**energy.gov**)…GE sets world record for most efficient power plant (**ge.com**)…Asahi Glass and Solaria announce strategic partnership to deliver advanced photovoltaics (**asahi-glass.com**)…DOE announces $23M for small businesses focused on clean energy innovations (**energy.gov**)…Kinestral Technologies enters into partnership with AGC Group to develop dynamic glass (**kinestral.com**)…NIST launches competition for manufacturing centers in 11 states (**nist.gov**)…NREL receives $1.38M from DOE to commercialize clean energy technologies (**nrel.gov**)…NioCorp and IBC Advanced Alloys announce agreement to develop scandium alloys (**ibcadvancedalloys.com**)…China Ceramics regains compliance with Nasdaq listing requirements (**prnewswire.com**) ■

Improving 3-D printed ceramics with 'fluid dosing and deposition' technology

Unfold, a design studio based in Antwerp, Belgium, is using fluid dosing and deposition (FDD) 3-D printing technology to print artwork with abrasive materials, such as ceramics, according to a *3ders.org* article.

The technology, developed by ViscoTec, a German high-viscosity fluids specialist, previously has been marketed to consumer and industrial users of 3-D printing technology. But, Unfold is using the FDD system for more artistic endeavors, such as printing ceramic sculptures.

Last summer, ViscoTec released its FDD Starter Kit, “a 3-D printer add-on that enables users to incorporate ViscoTec’s fluid dosing and deposition technology into an existing desktop 3-D printer, bypassing the standard hot end of the 3-D printer and instead depositing silicones, adhesives, or other viscous materials, one drop at a time at room temperature,” the article explains.

Using ViscoTec’s method massively improved Unfold’s ceramic 3-D printing process, according to the article, “eliminating defects in 3-D-printed parts and stabilizing the entire procedure.”

In addition to stabilization, the technology allows Unfold to precisely define the dosed volume per revolution, and the material flow is controlled entirely by 3-D printer software rather than material properties—advantages that translate to significant cost savings when it comes to readjustment, the article explains.

“With the volumetric system from ViscoTec, we don’t need to recalibrate all 3-D printing parameters when we change the material,” Dries Verbruggen, a graduate of the Design Academy Eindhoven in the Netherlands, who is using the method to create unusual 3-D printed ceramic sculptures, explains in the article.

A particularly important feature of ViscoTec’s FDD technology is its ability to dose highly filled, abrasive media with precision and reduced wear.

Using this technology, Unfold can process ceramics with a solids content of 80%, grain sizes up to 63 μm, and a viscosity of about 250,000 mPa•s through a 3-D printer—specs that yield highly detailed, evenly printed ceramic objects.

Watch a video from ViscoTec to see the FDD technology in action at youtu.be/HWy4LH-sXR0. ■

Credit: ViscoTec; YouTube

Unfold design studio is using a new fluid-based technique to create 3-D printed ceramics.

European project revamps ceramic tile manufacturing to completely eliminate waste

Ceramic tile manufacturing generates an estimated 1.5 million tonnes of waste yearly from the European Union alone.

A European project called LIFECERAM is working toward completely eliminating waste from ceramic tile manufacturing by repurposing the material into new tile. According to a recent press release, the project has just completed testing that shows promising success.

The project—coordinated by the Instituto de Tecnología Cerámica of the Universitat Jaime I of Castellón in Spain and including the Spanish Association of Ceramic Tile and Paving Manufacturers and several commercial partners—began in 2013 with the goal of achieving absolutely zero waste in ceramic tile manufacturing.

The project has two goals: to develop an outdoor ceramic tile—“urban flooring”—using >80% waste content; and to develop a sustainable manufacturing process, using dry milling and granulation, to produce recycled tile.

The LIFECERAM team tested various milling conditions using the entirety of collected waste materials from ceramic tile manufacturing.

Credit: Judy van der Velden; Flickr CC BY-NC-ND 2.0

Ceramic tile manufacturing generates a lot of waste—but a new project in Europe is developing ways to repurpose all that waste into new outdoor tile.

"The composition of the new material closely matches the relative proportions in which the different ceramic waste products [scraps, sludges, and dusts] are generated," Javier García Ten, research leader at ITC, says in the release. "We have achieved the porosity, mechanical resistance, and environmental properties we set out to, and the end product can be processed at existing industrial installations, meaning no changes to processes or equipment at ceramics plants are necessary."

No processing changes at manufacturing plants are necessary, which means no added costs. And, because the process uses entirely waste materials, it saves material costs, too. According to García Ten, "The cost of the the product is 20% lower than similar porcelain tile because of the use of waste (only considering transport costs) and the low thermal energy required for granulation in comparison to spray drying."

But, García Ten explains, the project's success so far represents just one step along the way—key challenges remain.

"To recycle all types of ceramic waste (unfired and fired scraps, glaze, polishing sludge, etc.), the body preparation process is based on dry-milling technologies and granulation," García Ten writes via email. "Dry milling allows us to skip the rheological problems that arise when wastes with soluble salts are recycled. In addition, it is possible to use the very hard fired scraps as chamotte. However, currently there is not an industrial facility able to dry-mill and granulate the residues, because the Spanish ceramic sector is based on wet milling and spray drying."

LIFECERAM next is developing contacts at smaller companies equipped with dry mills in an effort to develop an industrial installation to prepare the pressing powder. ■

Supercomputer-powered materials database unleashes data deluge

Lawrence Berkeley National Laboratory (Berkeley, Calif.) recently publicly released a massive amount of materials science data—complete with user-friendly tools to explore and analyze that data. The data is housed in the Materials Project, a public database of material properties data launched by the United States Department of Energy's Office of Science in 2011.

According to a Berkeley Lab press release, "The idea behind the Materials Project is that it can save researchers time by predicting material properties without needing to synthesize the materials first in the lab. It also can suggest new candidate materials that experimentalists had not previously dreamed up. With a user-friendly web interface, users can look up the calculated properties, such as voltage, capacity, band gap, and density, for tens of thousands of materials."

The recent release introduced two new sets of data into the database. One set details the properties of 1,500 compounds investigated for multivalent intercalation electrodes, and the other set details 21,000 organic molecules applicable to liquid electrolytes and beyond.

"Not only do we give the data freely, we also give algorithms and software to interpret or search over the data," Kristin Persson, cofounder and director of the Materials Project, says in the Berkeley Lab press release.

Those tools are in the form of two new web applications, a Molecules Explorer and a Redox Flow Battery Dashboard. The Materials Project also expanded its Battery Explorer function to include other ions beyond lithium, too.

The Redox Flow Battery app, for example, allows scientists designing new batteries to examine whether specific molecules can meet the technical parameters required for battery performance and economic factors that help determine whether the resultant battery would be cost-effective.

The database now contains information for 66,708 inorganic compounds, 43,690 bandstructures, 21,954 molecules, 530,243 nanoporous materials, 2,936 elastic tensors, 941 piezoelectric tensors, 3,628 intercalation electrodes, and 16,128 conversion electrodes. Explore all the data at materialsproject.org. ■

Credit: Roy Kaltschmidt; Berkeley Lab

Berkeley Lab researcher Kristin Persson, director of the Materials Project.

Argonne National Lab warms up new incubator to grow energy technologies

Argonne National Lab (Argonne, Ill.) now offers its formidable resources to intrepid entrepreneurs through its brand new energy incubator program, Chain Reaction Innovations (CRI).

Commercializing new energy technologies is an expensive venture—and one that often takes much more time than other start-up technologies. "To help entrepreneurs bridge this commercialization valley of death, CRI will support cutting-edge innovators to work on early-stage technologies that can deliver game-changing impact to the energy industry," according to an ANL press release.

Accelerating innovations—from a slew of recent academia–industry partnerships and new efforts to open access to novel collaborations—is a priority. ANL is investing heavily in new ways to leverage and merge expertise and funding from varied sources into new initiatives that upend traditional silos of academic, commercial, and national lab research.

CRI now is accepting applications for its first cohort of energy innovators, who will receive two years of financial and technical support from CRI copartners ANL and the United States Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE). Awardees will get access to up to $350,000 of funds for research at ANL and up to $100,000 for a fellowship to cover living costs, benefits, and a travel stipend.

"This program gives innovators working on complex science challenges a jump-start by giving them laboratory tools and experts to work with from day one as well as a fellowship that pays their day-to-day costs and benefits so that they can work full time developing their technology," Andreas Roelofs, director of CRI, says in an ANL press release. "Traditionally, energy technologies take longer to produce a return on venture capitalists' investments because of their longer development time line. But embedding entrepreneurs for two years into Argonne National Laboratory to validate and scale their technologies will accelerate the path to the consumer and investor marketplaces and compress the return timeframe."

The incubation is all encompassing, too—ANL's tools include fabrication, validation, and scale-up facilities, in addition to one-of-a-kind resources, such as the Mira supercomputer (the sixth fastest in the world) and Advanced Photon Source (the nation's highest-energy X-ray source). Beyond the science, the incubator also will provide business strategy, market research, and financing resources.

See more about CRI in a short video available at youtu.be/ka737xZjQIM. ■

Credit: Argonne National Lab

Argonne National Laboratory in Argonne, Ill., is opening its doors to entrepreneurs with a new energy incubator program.

acers spotlight

Society and Division news

Names in the news

Brow named interim vice provost and dean for College of Engineering and Computing

Brow

ACerS past president Richard Brow, curators' professor of materials science and engineering at Missouri University of Science and Technology, is now interim vice provost and dean for the College of Engineering and Computing at Missouri S&T. Brow has been a member of the Missouri S&T faculty since 1998 and previously served as chair of the materials science and engineering department. "Dr. Brow's prior experience leading the materials science and engineering department, combined with his record of exceptional research and service to the university, make him a good fit to serve as interim vice provost and dean," says Robert Marley, provost and executive vice chancellor for academic affairs at Missouri S&T. "I appreciate his willingness to serve in this position as we prepare to conduct a national search for the vice provost and dean position." ■

Snow award increases to $1,500 for Ceramographic Competition

ACerS Basic Science Division (BSD) has increased the prize for the Roland B. Snow Award from $100 to $1,500 for 2016. The Snow Award will be presented to the Best in Show of the Ceramographic Exhibit and Competition during MS&T16 in Salt Lake City, Utah. Digital submissions can be sent ahead of time and the BSD will have posters printed and delivered to the event at no charge to the presenter. Start working on your entries now! For competition rules and additional information, visit ceramics.org/snowaward. ■

ACerS summits Denali as 'stowaway' with Society Fellow Ivar Reimanis

Alaska's Mount Denali—formerly known as Mount McKinley—is the highest elevation in North America, scraping the sky at 20,320 feet above sea level. Ivar Reimanis, ACerS Fellow and former Society director fulfilled a lifelong ambition on June 8 after a17-day climb. ■

Credit: Reimanis

ACerS Fellow, Ivar Reimanis, unfurls The American Ceramic Society flag at the summit of Denali in June.

Attend your Division business meeting at MS&T16

Six ACerS Divisions will hold executive and general business meetings at MS&T16 in Salt Lake City, Utah. General business meetings will be held Monday, Tuesday, or Wednesday in the Salt Palace Convention Center. Plan to attend to get the latest updates and share your ideas with Division officers. Check the final MS&T16 program for times and convention center room locations. Most Division Executive Committee meetings will be held Sunday afternoon, October 23 in the Salt Lake Marriott Downtown at City Creek hotel. To confirm times and locations, contact your Division chair or Marcia Stout at mstout@ceramics.org. ■

MS&T16 registration for ACerS Distinguished Life, Senior, and Emeritus members

ACerS offers complimentary MS&T16 registration for Distinguished Life Members and reduced registration for Senior and Emeritus members. These special offers are only available through ACerS and not offered on the MS&T registration site. Registration forms are available at ceramics.org/118th-annualmeeting and should be submitted by **September 1** to Marcia Stout at mstout@ceramics.org. Banquet tickets may be purchased at time of registration. ■

ACerS announces new Lifetime Membership option

ACerS now offers a new membership option. The newly minted Lifetime Membership is designed for ceramic and glass professionals and allows loyal ACerS members to avoid future dues increases, enjoy automatic annual membership renewal, and take advantage of enhanced benefits over time.

Benefits exclusively for Lifetime Members include eligibility for reduced senior registration rates for meetings beginning at age 60, identification as a Lifetime Member in the ACerS Member Directory, free inclusion in unlimited ACerS divisions and sections, Lifetime Member certification, and the exclusive Lifetime Member designation on membership cards.

Secure Lifetime Membership and its continuous benefits for a one-time payment of $2,000, which averages to about 17 years of ACerS membership at current dues rate.

To learn more about Lifetime Membership and to join this exclusive new group, contact Kevin Thompson, ACerS membership director, at kthompson@ceramics.org or 614-794-5894, or contact ACerS customer service at 240-646-7054. ■

Do you qualify for Emeritus member status?

If you will be 65 years old (or older) by December 31, 2016 and will have 35 or more years of continuous membership in ACerS, you are eligible for Emeritus status. Note that both criteria must be met. Emeritus members enjoy waived membership dues and reduced meeting registration rates. To verify your eligibility, contact Marcia Stout at mstout@ceramics.org. ■

In memoriam

Louis J. Appell, Jr.
Theo Hahn

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

Awards and deadlines

Upcoming awards deadlines for September 1

Submit nominations for Varshneya Frontiers of Glass Lectures

The Darshana and Arun Varshneya Frontiers of Glass lectures will be presented at PACRIM 12, in conjunction with the GOMD Annual Meeting, in May 2017 in Waikoloa, Hawaii. The lectures are designed to encourage scientific and technical dialog in significant glass topics that define new horizons, highlight novel research concepts, or demonstrate the potential to develop products and processes for the benefit of humankind. The award consists of a travel reimbursement up to $2,500, a commemorative glass piece, and a framed certificate. Nominations should be submitted to Marcia Stout at mstout@ceramics.org by **September 1**. Additional information can be found at ceramics.org/varshneya.

Nominate ACerS 2017 Class of Fellows

Nominees must be at least 35 years old and have been members of the Society for at least the past five years continuously. The nominee must be sponsored by seven ACerS members. Scanned and faxed signature forms are permitted in lieu of original mailed signature forms. Previously submitted nominations may be updated, as long as they do not exceed length limitations. Nominations are due **September 1**. Additional information and nomination forms for these awards can be found at ceramics.org/awards, or by contacting Marcia Stout at mstout@ceramics.org. ■

CeRTEV secures funding through 2018


Credit: CeRTEV

The Center for Glass Research, Technology, and Education in Vitreous Materials (CeRTEV) at the Federal University of São Carlos in Brazil recently secured funding through 2018. CeRTEV was established in 2013 with $22M from São Paulo State Research Foundation (FAPESP) for an 11-year research program. Since then, CeRTEV researchers have published 78 original and review articles—half are coauthored with international collaborators. Education and outreach comprise a key tenant of the center. The above image shows CeRTEV researchers explaining glass properties at the Glass World Exposition of the Brazilian Society for the Progress of Science Expo in July 2015. ■

CERAMICANDGLASSINDUSTRY FOUNDATION

CGIF supports student travel to ECerS summer school program in France

The Ceramic and Glass Industry Foundation supported travel for 15 students to attend the European Ceramic Society's (ECerS) summer school in Limoges, France, June 27–29. The event's theme was "Process, microstructure and properties of electroceramics: issues and recent advances" and was held the week before the ECerS Electroceramics XV Conference.

Limoges has a long tradition in ceramics—during the 17th century the city manufactured porcelain and is still internationally recognized in the field of functional ceramic materials and ceramic processes.

Topics covered during the summer school program included low-temperature synthesis, shaping, and innovative technologies; microstructure-properties relationships in heterogeneous ceramics; and functional ceramics.

> **"I cannot express enough my sincere gratitude to ACerS and the CGIF for the travel support, as this fantastic experience would not have been possible for me otherwise."**
> – Will Huddleston, Ph.D. student at Case Western Reserve University

Among the esteemed faculty chosen to teach at the summer school are several ACerS members, including Juan Claudio Nino from the department of materials science and engineering at the University of Florida.

"The summer school was excellent! The setting was fantastic and it allowed for extended and detailed interactions between instructors and students well beyond the presentations," says Nino.

Many students shared the same sentiment and found the unique opportunity to closely interact with professors enriching.

"The overall quality of the talks was exceptional and sparked a lot of discussion among the students," says Thomas Rudzik, a Ph.D. student at the Georgia Institute of Technology. "The combination of a high professor-to-student ratio with lots of time spent together provided a truly unique experience to interact with such distinguished professors from around the world."

Nopsiri Chaiyo, a Ph.D. student at King Mongkut's Institute of Technology Ladkrabang in Thailand, was pleased to have met a number of students from around the world. "In a way, we built a small community of people working in electroceramics," Chaiyo adds.

Yomery Espinal, a Ph.D. student at the University of Connecticut, also appreciated participating in a global discussion. "The summer school was a humbling reminder of the privilege it is to be working on new and significant science and to be able to share this information with colleagues around the world," says Espinal.

To support programs like this or learn more about the CGIF, visit foundation.ceramics.org or contact Marcus Fish, CGIF development director, at 614-794-5863. ■

Credit: Morgan Watt

Some Summer School 2016 Participants (from left): Fariza Si Ahmed, Morgan Watt, Thomas Rudzik, Yomery Espinal, Trygve Magnus Ræder, and Lyndsey Denis.

Students and outreach

Apply by December 31 for the Washington D.C. engineering internship

ACerS will support an intern in the Washington Internships for Students of Engineering (WISE) 2017 program. Students who are U.S. citizens or legal permanent residents and are a junior or senior entering their final year of undergraduate studies are eligible. WISE also accepts applications from engineering graduates who are beginning masters-level study in a technology policy-related degree. Applications are due **December 31 at noon (EST)**. Learn more at ceramics.org/2017wise. ■

Make time for an exclusive plant tour during MS&T16

Amedica Corp. invites MS&T16 student registrants to tour company facilities October 24 from noon to 5 p.m. in Salt Lake City, Utah. Amedica is a biomedical company that produces medical-grade silicon nitride. Register by **October 3** to secure your spot. Learn more at ceramics.org/acerstudenttour. ■

Show your stuff at the student paper and poster awards during EMA 2017

Next year's Electronic Materials and Applications (EMA 2017) conference will feature a student paper and poster competition. Awards will be given during the conference for best student oral and poster presentations. The deadline to submit abstracts is **September 7**. For more information, visit ceramics.org/EMA2017. ■

Students: Apply for stipend for MS&T16, ACerS 118th Annual Meeting

ACerS Nuclear and Environmental Technology Division (NETD) will sponsor four stipends ($500 each) to help fund students attending MS&T16 combined with ACerS 118th Annual Meeting, October 23–27 in Salt Lake City, Utah. Stipends are open to student members of the NETD and targeted at students with interests in the nuclear and/or environmental fields of ceramic and materials engineering. Submit nomination forms by **September 1**. For more information, visit ceramics.org/student-stipends-mst-acers. ■

Traveling to 77th GPC? Student grants available

The Glass Manufacturing Industry Council (GMIC) will offer $400 travel grants to 20 students attending the 77th Glass Problems Conference, November 7–10 in Columbus, Ohio. Students are also invited to attend the Holophane Plant Tour in Granville, Ohio, November 7 from noon to 4 p.m. Students must apply in advance to participate. To apply for a grant or register for the tour, contact Donna Banks at dbanks@gmic.org by **September 30**. ■

Be part of student contests at MS&T16

Join fellow Material Advantage (MA) student members from around the world at MS&T16 in Salt Lake City, Utah, October 23–27, and make time to participate in activities and contests exclusively for students.

Undergraduate student speaking and poster contests

Submit entries for the MA Undergraduate Student Speaking Contest and the Undergraduate Student Poster Contest by **October 3**. Rules for each contest can be found at materialadvantage.org/financial-opportunities/contests.

Design contests for students

Start working on your pieces for the ceramic mug drop and the ceramic disc golf contests. These popular contests will be held during MS&T16 on October 25. Thinking of entering this year? Contact Brian Gilmore at Brian.Gilmore@pxd.com with your intent to participate.

Contact Tricia Freshour at tfreshour@ceramics.org or 1-614-794-5827 with questions. For more information about student activities at MS&T16, visit matscitech.org/students. ■

Glass genome opens up new opportunities for functional glasses with tailored properties

Scientists at Corning Incorporated (Corning, N.Y.) and Aalborg University (Aalborg, Denmark) are working to develop a glass-specific genome that will allow exploration and tailoring of specific properties of glass. Using computer modeling, they are unlocking some of the mysteries of this amorphous material, including how glass structure affects its macroscopic properties.

"We have a good understanding of the basic physics of many glass properties," John Mauro, an author of the new *Chemistry of Materials* paper and senior research manager at Corning, writes via email. "However, for other properties, a solid physical understanding is still lacking."

Scientists are developing a glass-specific genome that will unlock some of the mysteries of this unique material.

In an attempt to fill that knowledge gap, the scientists examined how various models could be used to accurately predict how specific glass compositions will behave, and how those models could, in turn, be used to design glasses with optimized properties.

The authors—Mauro, Adama Tandia, K. Deenamma Vargheese, and Yihong Z. Mauro from Corning, and Morten M. Smedskjaer from Aalborg University—focused on glass produced via a fusion draw process. They explored how models of glass viscosity, refractory compatibility, liquidus temperature, diffusivity, compressive states, and elastic moduli together can aid data-driven design of superior glass compositions.

"We are very pragmatic in our modeling approach, taking advantage of physical insights wherever possible and supplementing [them] with empirical models and machine learning to offer accurate prediction of the full suite of properties that we care about," Mauro explains.

The results represent a step away from the trial-and-error approach to a more data-informed design strategy, which offers many benefits. Models will allow scientists to investigate completely unexplored composition spaces and predict their potentially unique properties, which ultimately can lead to the manufacture of new functional glasses.

But, of course, "the success of data-driven models relies on the quality of the data used as input," Mauro says.

In the future, "a major thrust will be constructing a glass database with high levels of quality control needed for accurate modeling. Another big step will be to use machine learning to uncover trends and relationships among glass compositions and properties that have not yet been discovered," Mauro adds. "Data-driven modeling can thereby be used in a 'reverse' sense as a tool to help guide new physical insights."

The paper, published in *Chemistry of Materials*, is "Accelerating the design of functional glasses through modeling" (DOI: 10.1021/acs.chemmater.6b01054). ■

Research News

Faster, precise silica-coating process for quantum dot nanorods

Materials researchers at North Carolina State University (Raleigh, N.C.) have fine-tuned a technique that enables them to apply precisely controlled silica coatings to quantum dot nanorods. By independently controlling the amounts of water and ammonia used, the NC State researchers were able to match or exceed the precision of silica coatings achieved by previous methods. In addition, using their approach, the NC State team completed the entire silica-coating process in a single day—up to 21 times faster than previous methods. In addition to saving time, the advance means the quantum dots are less likely to degrade, preserving their advantageous optical properties. For more information, visit news.ncsu.edu.

An accelerated pipeline to open materials research

At Oak Ridge National Laboratory (Oak Ridge, Tenn.), researchers are engineering a data solution by creating a novel infrastructure uniting the lab's imaging technologies with advanced data analytics. ORNL's Bellerophon Environment for Analysis of Materials (BEAM) platform combines scientific instruments with web and data services and high-performance computing resources through a user-friendly interface. Designed to streamline data analysis and workflow processes from experiments, BEAM gives materials scientists near-real-time processing, analysis, and visualization of large experimental datasets from the convenience of a local workstation. For more information, visit ornl.gov/news.

Aluminum–cerium alloy has potential to jump-start rare-earth production in the US

A bulk of the minerals mined from most rare-earth-mixed ores are not the most valuable of the rare earths—those come in small supplies. Cerium and lanthanum compose the majority of the ores, but those rare earths do not have many high-volume applications—which makes rare-earth mining a tricky business.

In fact, the rare-earth content of most mined rare-earth ores in the United States is up to half cerium, according to Oak Ridge National Laboratory (Oak Ridge, Tenn.). "The United States' most common rare-earth ore, in fact, contains three times more cerium than neodymium and 500 times more cerium than dysprosium."

However, scientists at Oak Ridge, Lawrence Livermore National Laboratory (Livermore, Calif.), and Eck Industries (Manitowoc, Wis.) are finding new uses for the most abundant minerals mined from rare-earth ores. The team has developed a new superstrong aluminum alloy that incorporates cerium, providing a potentially significant use for that surplus—and it just may be able to restart mining of rare-earth elements in the U.S.

"The aluminum industry is huge," ORNL scientist Orlando Rios says in an ORNL press release. "A lot of aluminum is used in the auto industry, so even a very small implementation into that market would use an enormous amount of cerium." Rios says that incorporating cerium into just 1% of the aluminum alloy market equates to a use for 3,000 tons of cerium.

In addition to creating a market value for cerium, however, the new alloy also offers some important material benefits—namely higher heat tolerance. That heat stability results because aluminum and cerium form an intermetallic compound inside the alloy as it melts, and that intermetallic has a high melting point, above 2,000°F.

Tests show the aluminum–cerium alloy is stable at 300°C, the researchers report, and is lighter than traditional materials used in the hot parts of engines, such as cast iron. So, engines could run hotter—which means more efficiently—and weigh less—which also saves fuel and energy.


Credit: Zachary Sims; ORNL

An ORNL scientist pours a new aluminum–cerium alloy from a furnace into a ladle for casting.

In addition to heat-tolerance, another important attribute of the new alloy is that it is easy to form.

"Most alloys with exceptional properties are more difficult to cast, but the aluminum–cerium system has equivalent casting characteristics to the aluminum–silicon alloys," David Weiss, vice president for engineering and research and development at Eck Industries, says in the ORNL release.

The research paper, published in *The Journal of The Minerals, Metals & Materials Society*, is "Cerium-based, intermetallic-strengthened aluminum casting alloy: High-volume co-product development."

Garnet-type fast ionic conductor for all-solid-state lithium battery

Researchers at Toyohashi University of Technology have developed a garnet-type, fast ionic conducting oxide as the solid electrolyte for an all-solid-state battery. The team confirmed that $Li_{6.5}La_{3-x}Ba_xZr_{1.5-x}Ta_{0.5+x}O_{12}$ (LLBZTO) garnet has a wide electrochemical potential window and, thus, could be used to construct an all-solid-state battery. The team's results indicate that LLBZTO garnet can be used as a solid electrolyte in an all-solid-state battery and contribute to the realization of a very safe rechargeable battery for large-scale power sources. For more information, visit tut.ac.jp/english.

Embedded novel luminescent nanoparticles pave way for high-tech future 'smart glass'

Australian researchers at the University of Adelaide have developed a method for embedding light-emitting nanoparticles into glass without losing the nanoparticles' unique properties, according to a university press release.

And this development could have potential applications in next-gen technology, including 3-D displays or remote radiation sensors.

The "smart glass" combines the properties of special light-emitting nanoparticles with well-known aspects of glass, such as transparency and malleability, the release explains.

"These novel luminescent nanoparticles, called upconversion nanoparticles, have become promising candidates for a whole variety of ultra-high-tech applications, such as biological sensing, biomedical imaging, and 3-D volumetric displays," Tim Zhao from the University of Adelaide's School of Physical Sciences and Institute for Photonics and Advanced Sensing (IPAS) explains in the release.

"Integrating these nanoparticles into glass, which is usually inert, opens up exciting possibilities for new hybrid materials and devices that can take advantage of the properties of nanoparticles in ways we haven't been able to do before. For example, neuroscientists currently use dye injected into the brain and lasers to be able to guide a glass pipette to the site they are interested in. If fluorescent nanoparticles were embedded into the glass pipettes, the unique luminescence of the hybrid glass could act like a torch to guide the pipette directly to the individual neurons of interest," Zhao continues.

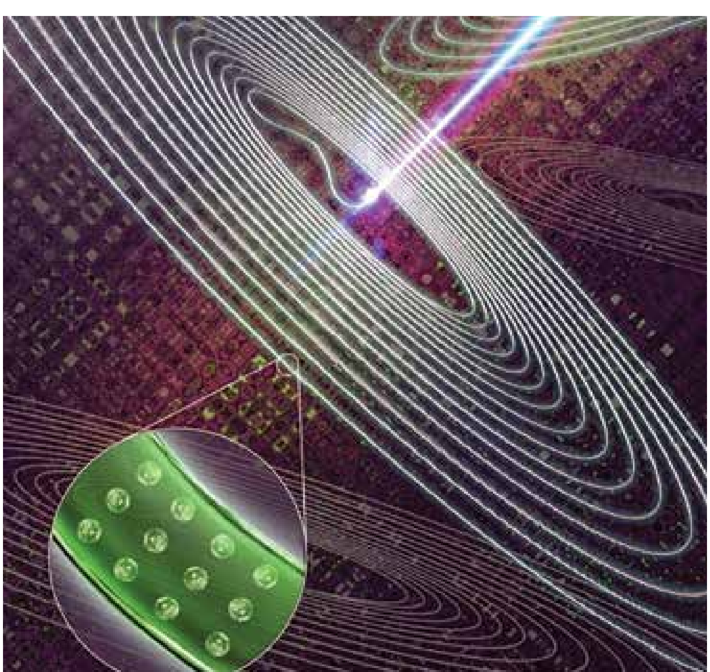
The researchers used upconversion nanoparticles specifically in their research, but they believe their "direct-doping" approach can be generalized to other nanoparticles with unique photonic, electronic, or magnetic properties. And that translates to many potential applications, depending on the properties of the nanoparticle, explains Zhao.

"If we infuse glass with a nanoparticle that is sensitive to radiation and then draw that hybrid glass into a fiber, we could have a remote sensor suitable for nuclear facilities," Zhao explains.

Until now, integration of upconversion nanoparticles into glass has relied solely on in situ growth of nanoparticles within the glass, as opposed to direct doping. But with the team's latest research, there has been "remarkable progress in this area," says Heike Ebendorff-Heideprem, deputy director of IPAS. But the progress has not come without limitations.

"The control over the nanoparticles and the glass compositions has been limited, restricting development of many proposed applications," explains Ebendorff-Heideprem. "With our new direct-doping method, which involves synthesizing the nanoparticles and glass separately and then combining them using the right conditions, we've been able to keep the nanoparticles intact and well dispersed throughout the glass. The nanoparticles remain functional, and the glass transparency is still very close to its original quality. We are heading toward a whole new world of hybrid glass and devices for light-based technologies."

The research, published in *Advanced Optical Materials*, is "Upconversion nanocrystal-doped glass: A new paradigm for photonic materials" (DOI: 10.1002/adom.201600296). ■



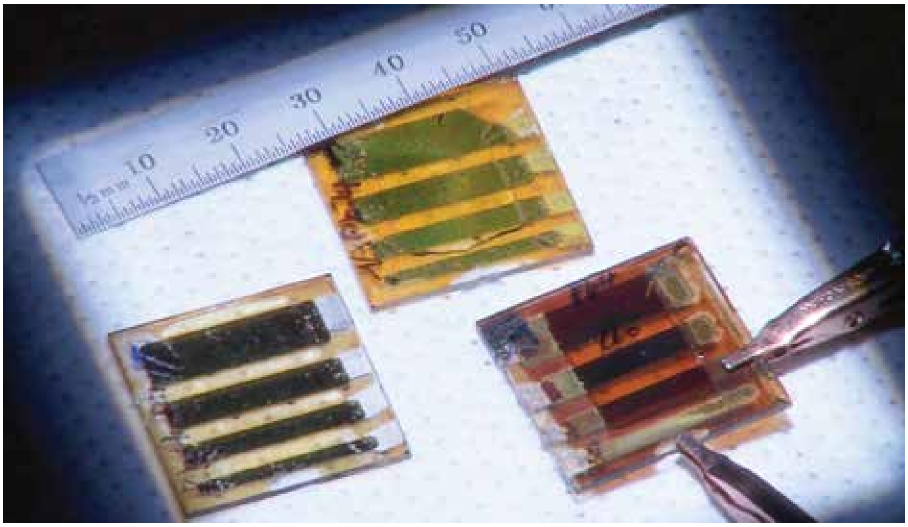
Credit: University of Adelaide

Graphic representation of nanoparticles embedded into glass.

Perovskite crystals 'flip' for better stability

Researchers from Los Alamos National Laboratory (Los Alamos, N.M.), Northwestern University (Evanston, Ill.), and Rice University (Houston, Texas) report that they are tinkering with perovskite crystal production methods to improve the performance of perovskite solar cells.

The team has developed a "new type of 2-D layered perovskite with outstanding stability and more than triple the material's previous power conversion efficiency," according to an LANL press release—and it is all in the flip of a crystal.


Credit: Los Alamos National Laboratory

Three types of large-area solar cells made with 2-D perovskites. Left shows a room-temperature cast film; upper middle is a sample with the problematic band gap; and right shows the hot-cast sample with best energy performance.

"Crystal orientation has been a puzzle for more than two decades, and this is the first time we've been able to flip the crystal in the actual casting process," Hsinhan Tsai, a Rice graduate student at LANL, says in the release. "This is our breakthrough, using our spin-casting technique to create layered crystals whose electrons flow vertically down the material without being blocked, midlayer, by organic cations."

The perovskite material was initially created at Northwestern, where Mercouri G. Kanatzidis, the Charles E. and Emma H. Morrison Professor of Chemistry, and Costas Stoumpos, a postdoctoral fellow in Kanatzidis' group, were exploring an interesting 2-D material that orients its layers perpendicular to the substrate, the release explains.

"The 2-D perovskite opens up a new dimension in perovskite research," Kanatzidis says. "It opens new horizons for next-generation stable solar cell devices and new optoelectronic devices, such as light-emitting diodes, lasers, and sensors."

Current 3-D perovskites have proven photophysical properties and power conversion efficiencies in excess of 20%, but they do not stand up well to light, heat, and humidity. So, the researchers have accepted the challenge to develop something that trumps the status quo.

The Northwestern team previously studied the 2-D perovskite crystals and found that the crystals "lost power when the organic cations hit the sandwiched gap between the layers, knocking the cells down to a 4.73% conversion efficiency because of the out-of-plane alignment of the crystals," the release explains.

But, they found that their new hot-cast production technique creates a more streamlined, vertically aligned 2-D material, which eliminates that gap and, therefore, boosts efficiency.

The team says its 2-D material currently can achieve 12% efficiency—and that makes it more applicable for commercial use.

"We seek to produce single-crystalline thin films that will not only be relevant for photovoltaics, but also for high-efficiency light-emitting applications, allowing us to compete with current technologies," says Aditya Mohite, principal investigator on the project.

A video from LANL about the research is available at youtu.be/CKshpvG1Lqo. ■

Credit: ACerS

Honoring the ACerS Awards Class of 2016

Over its long history, The American Ceramic Society has established a tradition of awards to recognize its members' outstanding contributions and accomplishments and to create career benchmarks for aspiring young scientists, engineers, and business leaders.

The most prestigious of ACerS awards is designation as a Distinguished Life Member, a recognition bestowed upon only two or three members each year. In 2016, three individuals will receive DLM honors: James E. Houseman, Harry L. Tuller, and Adrian C. Wright.

The Society will elevate 15 members to Fellow and recognize many more outstanding members with various Society, Division, and Class awards and lectures that will be presented at ACerS Annual Meeting, October 23–27, 2016, held in conjunction with MS&T16 in Salt Lake City, Utah.

2016 DISTINGUISHED LIFE MEMBERS

James E. Houseman

James E. Houseman has always been committed to his field. In fact, he jump-started his career while still in college, working as a design draftsman at Harrop Industries, Inc. (Columbus, Ohio)—a company where he would go on to spend the next 50 years.

He attended Case Institute of Technology in Cleveland, Ohio, and later Ohio State University in Columbus, where he earned both a B.S. and Ph.D. in ceramic engineering. And Houseman continues to give back to his alma mater long after his studies ended. He served on OSU's External Advisory Committee of the Ceramic Engineering Department from 1994–2000, and in 2008 was honored with OSU's Distinguished Engineering Alumnus Award for his many years of service and contribution.

His career at Harrop included time as applications/sales engineer in the Precision Furnace Division and a promotion to general manager of the Laboratory Instruments Division. He became Harrop's vice president of sales in 1976 and was elected president two years later—a position he held for 35 years—until becoming CEO and chairman, his current role within the company.

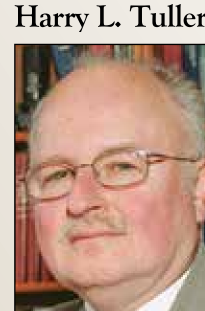
Houseman's leadership and service to ceramic engineering and manufacturing at Harrop spans decades, and he has spent just as much time supporting development in the field. Houseman has been a member of ACerS for nearly 50 years—he joined as a student member in 1966 and is currently a member of the Structural Clay Products and Manufacturing Divisions and the Southwest Section.

"Over the course of my 30+ years with ACerS, I have encountered very few people who are more committed to the Society and the ceramics industry than Jim Houseman," John Marra, senior technical advisor at the U.S. Department of Energy's Office of Environmental Management says of Houseman. "As the leader of one of the world's largest kiln manufacturers, he has frequently spearheaded Society efforts to engage with the industry. Beyond that, I can't think of an issue of the *Bulletin* that hasn't contained an ad from Harrop. Even during lean times, the support from Harrop has been undying."

Houseman became an ACerS Fellow in 1990 and was a charter member of ACerS President's Council of Industrial Advisors from 1993–2007. He served on ACerS Board of Directors from 1997–2003, and was elected treasurer in 1998. Houseman's leadership culminated with his serving as ACerS president in 2001.

And his service continues—Houseman is currently a founding trustee of The Ceramic and Glass Industry Foundation, ACerS philanthropic organization dedicated to helping the industry attract and train the next generation of ceramic and glass professionals.

Harry L. Tuller



Harry L. Tuller has steered his career path towards becoming an ACerS Distinguished Life Member by carving out a niche for himself over many years of careful research into the fundamentals of defect chemistry.

Tuller is professor of Ceramics and Electronic Materials at Massachusetts Institute of Technology (Cambridge, Mass.), where he also leads the Crystal

Physics and Electroceramics Laboratory.

Tuller's extensive research focuses on defects and their effects on the properties of metal oxides, materials critical for energy-related devices, such as sensors, fuel cells, batteries, and solar cells.

"Harry Tuller has been one of the premier international leaders in the general field of electroceramics over the last three decades," Gary Messing, Distinguished Professor of Ceramic Science and Engineering at Pennsylvania State University (State College, Pa.), says of Tuller.

Tuller also is a pioneer in solid state ionics, where his research on mixed ionic conducting materials has fueled development and improvement of solid oxide fuel cells. His work on sensor technology has demonstrated the robust possibilities of materials for gas sensitivity and beyond.

Tuller's research stretches further, too—careful studies of the defect chemistry of perovskite crystals, ion transport in oxide glasses, ionic conductivity in pyrochlore systems, electroceramic interfaces, and beyond have provided Tuller with expansive understanding of how defects affect materials' ionic conductivity.

Another prominent aspect of Tuller's research is microelectromechanical systems—Tuller's lab focuses on advancing this technology by integrating sensor, actuator, and photonic materials into microelectromechanical systems devices.

The extent and quality of this research is evidenced in Tuller's roster of over 445 published papers and 33 awarded patents. Tuller also serves as editor-in-chief of the *Journal of Electroceramics*.

Tuller got his start with B.S. and M.S. degrees in electrical engineering from Columbia University (New York City, N.Y.) and an Sc.D. in Solid State Science & Engineering, also from Columbia University. Tuller joined the faculty at MIT in 1975.

In addition to academic excellence, Tuller's vast experience with materials allowed him to cofound Boston MicroSystems Inc., a microelectromechanical systems technology company focused on silicon carbide-based devices.

An ACerS member since 1976, Tuller has received the ACerS F.H. Norton Award and the Edward Orton Jr. Award, and he became an ACerS Fellow in 1984. In addition, he has been elected to the World Academy of Ceramics, in addition to a slew of other prestigious awards.

Adrian C. Wright

Throughout his career, Adrian Carl Wright, professor emeritus at the University of Reading in Reading, United Kingdom, has strived to bring order to disorder. Not in a literal sense, but in terms of understanding glass structure and identifying glass bonding structures and the non-periodicity of these structures. Some say he created a new field of science—amorphography—the study of amorphous solid structures and their systematic classification.

There may have been an element of destiny involved. Wright was raised on the grounds of Stubbings House, a large estate in the Berkshire, England, countryside where his grandparents worked. (Queen Wilhelmina of the Netherlands waited out World War II as a guest of the estate.) In 1947, the home was bought by Sir Thomas Merton—an expert spectroscopist in the physics department at Oxford University. Merton set up a lab in his new home, too—one of the last private labs to exist in the U.K. Thus, from his earliest days, Wright was exposed to scientific thinking.

Merton recognized a kindred spirit in the young Wright and provided financial support for Wright to study chemistry at Bristol University. After graduating in only three years with the highest level of distinction, Wright earned a teaching certificate and returned to Bristol University to earn a Ph.D. in chemistry under Alan Leadbetter. The new Dr. Wright joined the physics faculty at the University of Reading in 1970, from which he retired to emeritus status in 2007.

Wright's Ph.D. work set the stage for his life's work studying glass structure with neutron scattering techniques. Initially, he studied the effect of radiation on the density of glasses and expanded the scope to an X-ray diffraction investigation of glass structures. His thesis had the deceptively modest title, "The Structure of Five Simple Glasses."

Interestingly, none were borates, although Wright's most substantive contributions to glass science would be in this composition area. During his Ph.D. work he developed neutron scattering techniques for probing glassy structures, which he later used to study structure of vitreous B_2O_3 and eventually resolve a long-standing debate about its structure.

"I was lured into borates by the late Al Cooper, who was in a dispute about boroxol groups in vitreous B_2O_3. Al asked whether neutron diffraction could help clarify this dispute," explains Wright. "A later meeting with Steve Feller at Coe College [Cedar Rapids, Iowa] led to the study of binary borate systems and a life-long friendship."

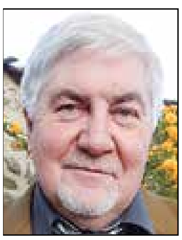
Like the field of amorphography that he effectively invented, Wright's career is further distinguished by networks he built between international glass communities. He is a Fellow of ACerS and member of the Glass and Optical Materials Division. He was president for two years of the Society of Glass Technology, and served on the Steering Committee and Council of the International Commission on Glass. Together with Steve Feller, he reinvigorated the International Conference on Borate Glasses, Crystals & Melts in 1996 after a 19-year hiatus, and it has been held every three years since.

"I've spent three sabbatical years in the States, and ACerS has served as my home away from 'home,' the Society of Glass Technology," Wright says. "The Society also provided a great forum for meeting my American friends—from New York to California!" ■

The 2016 Class of Fellows

Alexander

Michael L. Alexander is VP of research for Riverside Refractories Inc. (Pell City, Ala.). Alexander is president-elect of ACerS, a member of ACerS Refractory Ceramics Division, a member of the Unified International Technical Conference on Refractories, and currently serves on ACerS board of directors.



Cambier

Francis J. Cambier is director general of the Belgian Ceramic Research Center (Mons, Belgium). Cambier holds a doctorate in industrial chemistry and led ceramic courses at the Polytechnic Faculty of Mons University (Belgium) from 2001–2014. An ACerS member since 1983, Cambier is involved in various scientific advisory boards and acts as referee for several scientific journals.

Chen

Chonglin Chen is professor of physics at the University of Texas at San Antonio and joint professor at the Texas Center for Superconductivity at the University of Houston. Previously, Chen was postdoctoral fellow at the Los Alamos National Laboratory in New Mexico. His research interests include design-synthesis-microstructures-properties of interface engineered multifunctional oxide thin films.

Corman

Gregory S. Corman is principal scientist in the Ceramics Laboratory at GE Global Research (Niskayuna, N.Y.). Corman holds B.S. and Ph.D. degrees in ceramic science from Pennsylvania State University (State College, Pa.). At GE, he works on various aspects of ceramic matrix composite material and process development. Corman is a member of ACerS Engineering Ceramics Division and Keramos.

Day

Thomas E. (Ted) Day is CEO at Mo-Sci Corporation in Rolla, Mo. Day is chair of the board of trustees of The Ceramics and Glass Industry Foundation and a member of ACerS Glass and Optical Materials Division. He previously served as the ACerS treasurer (2010–2014). Additionally, Mo-Sci received the ACerS Corporate Technical Achievement Award in 2004 for the company's work in cancer therapies.

Flatt

Robert J. Flatt is professor of physical chemistry of building materials at ETH Zürich in Switzerland. He holds a master in chemical engineering and a Ph.D. from EPFL (Switzerland). His research focuses on cementitious materials, particularly concrete. Flatt is past recipient of ACerS Purdy and Brunauer awards and recently co-edited the book *Science and Technology of Concrete Admixtures* with Pierre-Claude Aïtcin.

Jacob

K. Thomas Jacob previously served as chairman of the Department of Metallurgy and the Materials Research Center at the Indian Institute of Science (Bangalore, India) and is currently emeritus professor at the same institute and senior scientist of the National Academy of Sciences, India. Through his research, Jacob has made extensive contributions to the fields of thermodynamics and phase equilibria, materials chemistry, chemical processing of ceramics, solid state sensors, and fuel cells.

Kato

Kazumi Kato is prime senior research scientist at the National Institute of Advanced Industrial Science and Technology in Nagoya, Japan. She has more than 280 peer-reviewed technical papers and 80 patents, including 10 U.S. patents. Kato's research focuses on solution chemistry for integration of nanometer sized functional oxides.

Kim

Young-Wook Kim is professor of materials science and engineering at the University of Seoul, Korea. He received M.S. and Ph.D. degrees in materials science and engineering from the Korea Advanced Institute of Science and Technology. Young-Wook is a member of ACerS Engineering Ceramics Division, where he has served as symposium organizer, session chair, and reviewer.

Luo

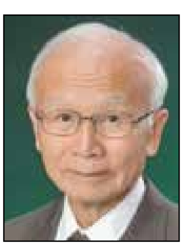
Jian Luo is professor of nano engineering and materials science and engineering at the University of California, San Diego. Luo received his M.S. in materials science and engineering and Ph.D. in ceramics in 2001 from the Massachusetts Institute of Technology (Cambridge, Mass.). Luo's research investigates solid interfaces and their role in controlling the fabrication and properties of a broad range of ceramic and metallic materials. Luo is a member of ACerS Basic Science Division and served as chair from 2012–2013.

Marra

Sharon L. Marra is senior VP and deputy director of the U.S. Department of Energy's Savannah River National Laboratory (Aiken, S.C.), where she manages lab operation, program direction, and safety. Her leadership background includes environmental compliance, immobilization research programs, robotics and remote systems, and environmental and chemical process technology. She has been an ACerS member for 30 years and previously served as chair of the Nuclear and Environmental Technology Division.

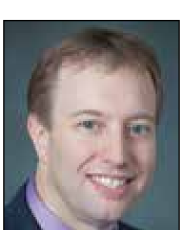
Michaelis

Alexander Michaelis is director of the Fraunhofer Institute for Ceramic Technologies and Systems IKTS (Dreseden, Germany) and is chair of Inorganic Nonmetallic Materials at Technische Universität (Dresden, Germany). Michaelis was awarded the ACerS ECD Bridge Building Award for his contribution in the field of energy and environmental technology and received the Fraunhofer Medal in 2014 for achievements in applied materials research.



Ohsato

Hitoshi Ohsato is a senior researcher at Nagoya Industrial Science Research Institute, Japan. He holds a doctorate of science from the University of Tokyo and a masters of engineering from Nagoya Institute of Technology. His research interests include microwave dielectrics, ferroelectrics, and piezoelectrics. As a member of ACerS Electronics Division, Ohsato has served as symposium organizer, program chair, and proceedings editor for PacRim.



Youngman

Randall E. Youngman is senior research associate in the characterization sciences research directorate at Corning Inc. (Corning, N.Y.). His current research interests include structure-property relations in inorganic glasses, nucleation and crystal growth in glass-ceramics, and network development in organic polymers. Youngman currently serves as chair of ACerS Glass and Optical Materials Division.

Zanotto

Edgar D. Zanotto has been professor of materials science and engineering at the Federal University of São Carlos, Brazil, and is currently director of the Center for Research, Technology and Education in Vitreous Materials and editor of the *Journal of Non-Crystalline Solids*. He has chaired six glass congresses and delivered over 300 conference presentations, including more than 110 invited and several plenary talks. Zanotto is a past recipient of ACerS Glass and Optical Materials Division (GOMD) Morey award and is currently chair-elect of GOMD. ■

Corporate Achievement Awards

Corporate Environmental Achievement Award recognizes and honors a single outstanding environmental achievement made by an ACerS corporate member in the field of ceramics.

NGK Spark Plug Co. Ltd. won ACerS 2016 Corporate Environmental Achievement Award for the development of a zirconia oxygen sensor for internal combustion engines that has more stable output and excellent durability compared to other sensors—features required for vehicle emission control systems to meet current air quality benchmarks. NGK's zirconia oxygen sensors contribute to reductions in harmful pollutants such as NO_x, CO, and HC and improve fuel economy.

Headquartered in Nagoya, Japan, NGK is a comprehensive ceramics processing manufacturer and holds a world leading share of spark plugs and automotive sensors for internal combustion engines. It also offers a broad lineup of packages, cutting tools, bioceramics, and industrial ceramics.

Corporate Technical Achievement Award recognizes a single outstanding technical achievement made by an ACerS corporate member in the field of ceramics.

Semiconductor Energy Laboratory Co. Ltd. (SEL) and Sharp Corp. jointly won ACerS 2016 Corporate Technical Achievement Award for development of a new c-axis aligned crystalline indium-gallium-zinc oxide (CAAC-IGZO) oxide semiconductor that is more stable and easier to process than previous oxide semiconductors and significantly extends battery life in devices such as mobile phones. Many mobile phone carriers have equipped their smartphone devices with CAAC-IGZO liquid crystal displays.

SEL was founded in Japan by Shunpei Yamazaki in 1980. SEL invents new technologies through research and development, obtains patents, and contributes to industrial development by licensing inventions.

Sharp Corp. is a worldwide developer of innovative products and core technologies that play a key role in shaping the future of electronics. As a leader in liquid crystal displays and digital technologies, Sharp offers one of the broadest and most advanced lines of consumer electronics, information products, and electronic components. ■

Society Awards

W. DAVID KINGERY AWARD recognizes distinguished lifelong achievements involving multidisplinary and global contributions to ceramic technology, science, education, and art.


Navrotsky

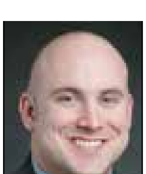
Alexandra Navrotsky is interim dean of the University of California Davis College of Letters and Sciences department of mathematical and physical sciences and director of the Nano and New Materials in Energy, the Environment, Agriculture, and Technology (NEAT) research group. Her research focuses on microscopic features of structure and bonding to macroscopic thermodynamic behavior in minerals, ceramics, and other complex materials. She is a past recipient of ACerS Ross Coffin Purdy Award.

JOHN JEPPSON AWARD recognizes distinguished scientific, technical, or engineering achievements.


Ohji

Tatsuki Ohji is prime senior research scientist at the National Institute of Advanced Industrial Science and Technology in Japan. He is a Fellow of ACerS, an academician of the World Academy of Ceramics, and has received numerous awards, including ACerS ECD Bridge Building Award. He currently serves on ACerS board of directors, is the ACerS Engineering Ceramics Division trustee, and a trustee of The Ceramic and Glass Industry Foundation.

ROBERT L. COBLE AWARD FOR YOUNG SCHOLARS recognizes an outstanding scientist who is conducting research in academia, in industry, or at a government-funded laboratory.


Martin

Lane W. Martin is associate professor of materials science and engineering and faculty scientist in the Materials Science Division at Lawrence Berkeley National Laboratory in Berkeley, Calif. His current work focuses synthesis, characterization, and utilization of functional complex oxide thin-film materials for an array of applications. Lane is a member of ACerS Basic Science and Electronics Divisions.

ROSS COFFIN PURDY AWARD recognizes authors who made the most valuable contribution to ceramic technical literature in 2014.

"*A 3.8-V earth-abundant sodium battery electrode,*" published in *Nature Communications*, 5: 4358 (2014). **Prabeer Barpanda**, **Gosuke Oyama**, **Shin-ichi Nishimura**, **Sai-Cheong Chung**, and **Atsuo Yamada**.


Barpanda

Prabeer Barpanda is assistant professor in the Materials Research Center at the Indian Institute of Science at Bangalore.


Oyama

Gosuke Oyama is a researcher at Asahi KASEI (Tokyo, Japan).


Nishimura

Shin-ichi Nishimura is senior researcher at the University of Tokyo, Japan.


Chung

Sai-Cheong Chung is senior researcher at the University of Tokyo, Japan.


Yamada

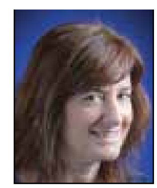
Atsuo Yamada is professor and researcher at the University of Tokyo, Japan.

RICHARD AND PATRICIA SPRIGGS PHASE EQUILIBRIA AWARD honors authors who made the most valuable contribution to phase stability relationships in ceramic-based systems literature in 2015.

"*High temperature investigation of the solid/liquid transition in the* PuO_2-UO_2-ZrO_2 *system,*" published in the *Journal of Nuclear Materials*, 467, 660-676 (2015). **Andrea Quaini**, **Christine Guéneau**, **Stéphane Gossé**, **Bo Sundman**, **Dario Manara**, **Anna L. Smith**, **David Bottomley**, **Patrick Lajarge**, **Markus Ernstberger**, and **Fiqiri Hodaj**.


Quaini

Andrea Quaini is a research engineer specializing in materials thermodynamics at the French Atomic Energy Agency in Saclay, France.


Guéneau

Christine Guéneau is senior research scientist in the Nuclear Energy Division of the French Alternative Energies and Atomic Energy Commission (Saclay, France).


Gossé

Stéphane Gossé is a research engineer at the Department of Physico-Chemistry in the Nuclear Energy Division of the French Alternative Energies and Atomic Energy Commission (Saclay, France).


Sundman

Bo Sundman is professor emeritus at the Computational Thermodynamics ivision at the Materials Science and Engineering Department of the Royal Institute of Technology, Sweden.


Manara

Dario Manara is research administrator of the European Commission's Joint Research Center at the Institute for Transuranium Elements (Karlsruhe, Germany).


Smith

Anna L. Smith is assistant professor in the Department of Radiation Science and Technology at the Delft University of Technology (Delft, Netherlands).


Bottomley

David Bottomley is head of sector in the Safety of Irradiated Nuclear Materials unit at the European Commission's Joint Research Center–Institute for Transuranium Elements (Karlsruhe, Germany).


Lajarge

Patrick Lajarge is technical officer of the European Commission's Joint Research Center at the Institute for Transuranium Elements (Karlsruhe, Germany).


Ernstberger

Markus Ernstberger is a technician and civil servant at the European Commission's Joint Research Center at the Institute for Transuranium Elements (Karlsruhe, Germany).


Hodaj

Fiqiri Hodaj is professor of materials science and engineering at Grenoble Institute of Technology–School of Engineering in Physics, Applied Physics, Electronics, and Materials Science, France.

DU-CO CERAMICS SCHOLARSHIP AWARD recognizes an undergraduate student in ceramic or materials engineering for participation in student activities.


Palvanov

Roman Palvanov is a student at the University of Wisconsin–Madison, where he studies materials science and engineering as he works toward his bachelor's degree. At UW, Palvanov is a Kemper Knapp Scholar, Wisconsin Academic Excellence Scholar, and on the dean's honor list. He is a member of his school's Material Advantage chapter. During the 2016–2017 academic year, he will study abroad at Kyushu University in Japan to research semiconductors and electronic thin-film devices.

DU-CO CERAMICS YOUNG PROFESSIONAL AWARD is given to a young professional member of ACerS who demonstrates exceptional leadership and service to ACerS.


Gorzkowski

Edward P. Gorzkowski III is acting head of the Ceramics and Rapid Prototyping Section at the U.S. Naval Research Lab in Washington, D.C. Gorzkowski earned his Ph.D. in materials science and engineering under the advisement of ACerS Distinguished Life Member and Fellow Martin P. Harmer and Helen Chan at Lehigh University in 2004. His research focuses on piezoelectric materials for sensor and actuator applications; processing of dielectric and ferroelectric materials; and unique processing methods to create bulk nano-structured ceramics, among other areas. Gorzkowski has organized ACerS symposia at several meetings, is a member of ACerS Electronics Division, is past-president of ACerS Young Professionals Network.

KARL SCHWARTZWALDER-PROFESSIONAL ACHIEVEMENT IN CERAMIC ENGINEERING AWARD is an ACerS/NICE award that recognizes an outstanding young ceramic engineer whose achievements have been significant to the profession and to the general welfare of all people.


Mauro

John C. Mauro is senior research manager–glass research at Corning Inc. (Corning, N.Y.). He is an expert in fundamental and applied glass science, statistical mechanics, computational and condensed matter physics, thermodynamics, and the physics of topologically disordered networks. An ACerS Fellow, Mauro is a past-recipient of ACerS Norbert J. Kreidl and Richard M. Fulrath Awards and Corning's S. Donald Stookey Award. He is also associate editor of the *Journal of the American Ceramic Society* and the *International Journal of Applied Glass Science*.

MEDAL FOR LEADERSHIP IN THE ADVANCEMENT OF CERAMIC TECHNOLOGY recognizes individuals who have made substantial contributions to the success of their organization and expanded the frontiers of the ceramics industry through leadership.


Sreeram

A.N. Sreeram is senior vice president and chief technology officer for The Dow Chemical Co. (Midland, Mich.), where he focuses on accelerating new product commercialization through strategic collaboration with Dow's businesses and customers. He holds more than 20 U.S.-issued patents and a doctorate from the department of materials science and engineering at Massachusetts Institute of Technology (Cambridge, Mass.).


Yamazaki

Shunpei Yamazaki is founder and president of Semiconductor Energy Laboratory, Co. Ltd., Japan. He received the Medal with Purple Ribbon from the Japanese prime minister for the innovation of MOS LSI element technology in 1997 and is 58th in "the top 100 living geniuses" identified and ranked by Synectics. In March 2011, he was recognized by the Guinness World Records as the individual who holds most patents with 6,314. He is a past-recipient of the Richard M. Fulrath Award and on the board of trustees for The Ceramic and Glass Industry Foundation. ■

Awards Banquet

Join us to honor the Society's 2016 award winners at **ACerS Annual Awards and Honors Banquet, Monday, October 24 at MS&T16**. Banquet tickets may be purchased with conference registration or by contacting Marcia Stout at mstout@ceramics.org. Tickets must be purchased by **noon on October 24, 2016**.

Richard M. Fulrath Symposium and Awards

To promote technical and personal friendships between Japanese and American ceramic engineers and scientists

Symposium: Monday, October 24, 2–4:20 p.m.

Hemrick

James G. Hemrick

A future for refractory ceramic technology based on a rich past

James Hemrick is senior research Engineer at Reno Refractories Inc. in Morris, Ala. He holds a Ph.D. and B.S. in ceramic engineering from the University of Missouri–Rolla and an M.S. in material science and engineering from the Georgia Institute of Technology. His research focuses on refractory ceramics, thermal management, and materials characterization. He is a member and past-chair of ACerS Refractory Ceramics Division, member of ACerS Meetings Committee, and member of Keramos.

Huey

Bryan D. Huey

High speed and tomographic AFM of functional materials

Bryan Huey is professor of engineering innovation at the University of Connecticut (Storrs, Conn.). His research group specializes in high-speed and tomographic AFM, multiferroics and ferroelectrics, inorganic and molecular perovskite solar cells, and nano-bio-mechanics. Huey is past chair of ACerS Basic Science Division, former co-organizer of the Electronic Materials and Applications conference, and current co-organizer for the 2017 U.S.–Japan dielectrics meeting.

Iwazaki

Yoshiki Iwazaki

Material design of dielectric and piezoelectric materials with first-principles calculation

Yoshiki Iwazaki is research group leader at Analysis Group, Research and Development Laboratory, Taiyo Yuden Co. Ltd., Japan. He is also research advisor of the Research Center for Functional Materials, National Institute for Materials Science. His research group focuses on the study of inorganic and organic material by using first-principles calculation and analysis with cutting-edge technology for unknown phenomenon in electroceramic materials and electronic devices.

Nakamura

Tomoyuki Nakamura

Development of dielectrics for monolithic ceramic capacitor

Tomoyuki Nakamura is senior manager of the Technology Development Group of the Capacitor Division at Murata Manufacturing Co. Ltd., Japan. He works to resolve issues related to dielectric ceramics for MLCCs for better commercialization.

Nakayama

Tadachika Nakayama

Ceramics/poylmer hybrids and their processing with nano-pulsed power technology

Tadachika Nakayama is associate professor in the Department of Science and Technology Innovation at Nagaoka University of Technology in Niigata, Japan. He is a member of ACerS Engineering Ceramic Division and won ECD's Global Star Award this year. He developed new material designs for ceramic/polymer hybrid nanostructured materials for thermal management, sensor, and energy harvester applications. ■

ACERS/NICE: ARTHUR FREDERICK GREAVES-WALKER LIFETIME SERVICE AWARD recognizes an individual who has rendered outstanding service to the ceramic engineering profession and who, by life and career, has exemplified the aims, ideals, and purpose of the National Institute of Ceramic Engineers.

Brosnan

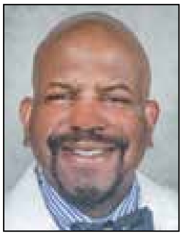
Denis A. Brosnan is Bishop Chair Emeritus of Clemson University, (Clemson, S.C.). Brosnan is a ceramic engineer who worked for 45 years with traditional ceramic products. His inventions resulted in introduction of novel aluminum thermite welding technologies in the European Community, and his efforts included licensing activities in the former Soviet Union. Brosnan is a past recipient of ACerS John Jeppson Award for his many contributions to the field.

CERAMIC EDUCATION COUNCIL: OUTSTANDING EDUCATOR AWARD recognizes outstanding work and creativity in teaching, directing student research, or in the general educational process of ceramic educators.

Huebner

Wayne Huebner is professor of ceramic engineering at the Missouri University of Science and Technology (Rolla, Mo.). The author of 100 papers, monographs and book chapters, his work involves preparation and characterization of electronic ceramics. He has graduated 10 Ph.D. students and 14 M.S. students and has recieved Missouri S&T's Faculty Excellence Award five times, the Outstanding Teacher Award four times, and the Outstanding Faculty Member in Ceramic Engineering eight times. Huebner is a member of ACerS Electronics Division and serves as associate editor of the *Journal of the American Ceramic Society*. ■

ACerS Award Lectures



ACERS FRONTIERS OF SCIENCE AND SOCIETY–RUSTUM ROY LECTURE

Tuesday, October 25, 2016, 1–2 p.m.

Cato T. Laurencin, Albert and Wilda Van Dusen Distinguished Endowed Professor of Orthopaedic Surgery, professor of chemical and biomolecular engineering, professor of materials science and engineering, and professor of biomedical engineering, University of Connecticut

Regenerative engineering: A convergence approach to next generation grand challenges

Cato T. Laurencin is professor and director of the Institute for Regenerative Engineering and the Raymond and Beverly Sackler Center at the University of Connecticut. Laurencin earned a B.S.E. in chemical engineering from Princeton University, an M.D. from Harvard Medical School, and a Ph.D. in biochemical engineering/biotechnology from the Massachusetts Institute of Technology. His research expertise focuses in biomaterials, nanotechnology, drug delivery, stem cell science, and a new field he has pioneered—regenerative engineering. ■

EDWARD ORTON JR. MEMORIAL LECTURE

PLENARY SESSION

Tuesday, October 25, 2016, 8–10:40 a.m.

Bruce Dunn, Nippon Sheet Glass Professor of Materials Science and Engineering at University of California, Los Angeles

Designing ceramics for next-generation energy storage systems

Bruce Dunn is an ACerS Fellow and a member the World Academy of Ceramics. He serves on several editorial boards, including the *Journal of the American Ceramic Society*. A continuing theme in his research is use of sol-gel methods to synthesize materials with designed microstructures and properties. His recent work on electrochemical energy storage includes 3-D batteries and pseudocapacitor materials. ■

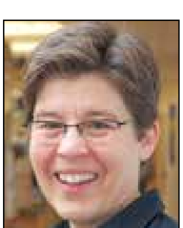
ACERS/NICE ARTHUR L. FRIEDBERG CERAMIC ENGINEERING TUTORIAL AND LECTURE

Monday, October 24, 2016, 9–10 a.m.

Aldo R. Boccaccini, professor of biomaterials and head of the Institute of Biomaterials at the University of Erlangen-Nuremberg, Germany

Bioactive glasses in soft tissue repair: What do we know so far?

Aldo R. Boccaccini holds an engineering degree from Instituto Balseiro (Argentina), Dr-Ing. from RWTH Aachen University (Germany) and Habilitation from TU Ilmenau (Germany). He also held post-doctoral appointments at the University of Birmingham (U.K.) and at the University of California at San Diego. His research focuses on glasses, ceramics, and composites for biomedical, functional, and structural applications. Boccaccini is a member of the World Academy of Ceramics, an ACerS Fellow, and member of ACerS Basic Science Division. ■



BASIC SCIENCE DIVISION ROBERT B. SOSMAN AWARD AND LECTURE

Wednesday, October 26, 2016, 1–2 p.m.

Jennifer A. Lewis, professor at the School of Engineering and Applied Sciences and the Wyss Institute for Biologically Inspired Engineering at Harvard University

Programmable assembly of colloidal suspensions

Jennifer A. Lewis is an engineering professor at Harvard University and cofounder of two companies that commercialize technology from her lab. Her work on microscale 3-D printing was highlighted as one of the "10 breakthrough technologies" by *MIT Technology Review*, while her bioprinting research was named "one of the top 100 science stories" by *Discover Magazine*. She is an ACerS Fellow and has received numerous awards, including the National Science Foundation's Presidential Faculty Fellow Award, the Langmuir Lecture Award from the American Chemical Society, and the Materials Research Society Medal Award. ■

Materials Genome Initiative accelerates materials discovery: *A Q&A with James A. Warren*

As the Materials Genome Initiative marks its fifth year, we take stock of its progress and future role in data-driven materials development.

By April Gocha

The Materials Genome Initiative launched in 2011 to discover, manufacture, and deploy advanced materials in the United States twice as fast, at a fraction of the cost.

According to mgi.gov, accelerating discovery and deployment of advanced material systems will be crucial to achieving global competitiveness in the 21st century. Therefore, MGI goals drive policies, resources, and infrastructure to foster and accelerate materials discovery at U.S. institutions.

Since MGI's launch, the U.S. government has invested multiple hundreds of millions of dollars into the initiative through funding opportunities, unique partnerships, and the creation of new centers and facilities focused on materials discovery. We asked James A. Warren, technical program director of materials genomics at NIST's Materials Measurements Laboratory, about current progress and future directions of MGI. What follows are his responses (JW) to our questions.

What successes has MGI produced in the five years since it launched? What do you anticipate for its future directions, goals, and accomplishments?

JW: MGI is fostering acceleration of the discovery, design, development, and deployment of new materials by creating a Materials Innovation Infrastructure. This infrastructure is built from linked computational tools, experimental tools, and digital data. The MGI approach was not, in and of itself, a new idea, and already had been successfully implemented many times—with large returns on investment.

For example, IBM Research was kind enough to share the following story about its efforts in the mid-2000s to design polymeric materials using computer-aided methods. The program, which included efforts in synthesis and application (performance), found that the most fruitful approach was a tight collaboration between laboratory and computational work that focused on speeding up cycles of informative experiments. This strategy led to nine U.S. patent filings and 15 scientific publications on unique materials or material processes that we would not have invented without computational modeling—including one case in which the company accurately simulated and predicted the properties of a high-value polymer before it was synthesized and tested.

James A. Warren

Many more examples, including Ford Motor Company's design of a new aluminum alloy for engine applications—and a return on investment of about 7:1—can be found in the National Research Council 2008 report *Integrated Computational Materials Engineering*.[1] More recently, there has been strong evidence that the alloys used in the Apple Watch were designed in about two years, placing the product design cycle nearly in sync with the materials design cycle—a remarkable accomplishment.[2] Indeed, such successes are a crucial inspiration for MGI.

However, in general, the means for such rapid development lie out of reach for most materials developers and users. Hence, the successes of MGI will be marked by creation, and subsequent use, of the newly developed MGI infrastructure. In other words, success is marked by the uptake of technologies that reduce barriers to discovery, design, development, and deployment of new materials into manufactured products. Measuring this effect is something of great interest to the effort, but it is highly nontrivial.

The U.S. government has made considerable investments in this infrastructure, and, not surprisingly, we are starting to see returns as the research curve bends from basic to applied. We should note, however, that investments are still ramping up in this space, and returns will be even larger down the road. Ultimately, in some cases, we will be able to trace design of new materials directly to the existence of this infrastructure. However, the infrastructure will ideally be so seamless that its influence is noticeable only by its absence.

Some of the most visible efforts in the MGI involve amassing large amounts of data, which then can be mined using machine learning and related techniques. It is clear from these efforts that we can discover things when sufficiently high-quality data are aggregated around a topic of interest. There are several approaches to amassing materials data: compute it from models with known reliability; conduct high-throughput experiments; and provide the data infrastructure to enable publication and discovery of the vast amounts of materials data being generated worldwide. Below I briefly address each:

• ***Compute it.*** Perhaps the most familiar example of success within the framework of the MGI involves construction of databases of compound properties computed using density functional theory (usually at 0 K). There are many active, MGI-funded projects (e.g., Materials Project, AFLOWLIB, and OQMD) that have yielded considerable insights and discoveries pointing the way to new materials for thermoelectrics, batteries, and other applications.[3]

• ***Conduct high-throughput experiments.*** Many researchers have pursued high-throughput experiments to provide sufficient data to apply machine learning techniques to discover new materials with improved properties.[4] At this time, these approaches are built around bespoke codes and tools, coupled with access to beam lines, which are a scarce resource. Getting more widely accessible high-throughput experimental methods is essential to the ultimate success of MGI, because the existing paucity of experimental data is a critical impediment to materials discovery.[5]

• ***Provide the data infrastructure to enable publication and subsequent discovery of materials data.*** To meet the infrastructural needs demanded by MGI, NIST has implemented a program that revolves around data and model exchange, data and model quality, and new methods and metrologies that can flow from this infrastructure as it matures. Simultaneously, within its Material Measurement Laboratory, NIST has established an Office of Data and Informatics, with a focus on the provision of the highest-quality reference data and development and dissemination of best practices in data science. At this time, NIST is deploying several tools, including a materials data repository (materialsdata.nist.gov) for depositing data, a materials data curation system (https://mdcs1.nist.gov), and, to facilitate discovery, a materials resource registry (http://mgi.nist.gov/materials-resource-registry). Uptake of these tools, and their counterparts being developed under MGI funding, will be a strong measure of the initial success of MGI.

I would be remiss if I did not note that there are many complementary efforts to NIST's effort to build this data infrastructure. For instance, the DOE has funded the Predictive Integrated Structural Materials Science (PRISMS) center, based at the University of Michigan (Ann Arbor, Mich.), which is focused on establishing a unique scientific platform that will enable accelerated predictive materials science for structural metals. This platform includes the Materials Commons, a repository for materials research data as well as a host of simulation tools.

Other data infrastructure efforts include the Materials Project's MPContrib effort, a new addition to the infrastructure long under development at Lawrence Berkeley National Laboratory (Berkeley, Calif.); the Materials Data Facility, supported by the Center for Hierarchical Materials Design at Northwestern University (Evanston, Ill.); and the efforts of Citrine Informatics (Redwood City, Calif.), a small company focused on hosting vast amounts of materials data and providing analytical capabilities to enable materials discovery.

Tell us more about the Materials Resource Registry.

JW: The Materials Resource Registry (MRR) is a considerable programmatic focus for NIST. The MGI is supported by NIST through three primary programmatic thrusts, all joined by the thread of digital data. Specifically, NIST is now devoting considerable effort, in concert with its partners in industry, academia, and government, to develop the tools, standards and techniques for establishing model and data exchange infrastructure; establishing best practices and new methods to ensuring data and model quality; and developing the analytical tools to enable data-driven materials science.

When NIST first began its efforts to support MGI, it was natural to assume that NIST would focus on its historical primary mission—development and delivery of the highest-quality data and models. What came as a bit of a surprise, at least for me, was the need to develop a significant amount of infrastructure to enable information exchange. And at the top of the pyramid of this data infrastructure is the NIST Materials Resource Registry. One of the most exciting things about the Materials Resource Registry is that we can do it now and do it well. This year will see worldwide deployment of this approach. An instance of the NIST Materials Resource Registry can be found at http://bit.ly/MaterialsResourceRegistry.

The simplest way to think of the Materials Resource Registry is as a yellow pages or phone book, but with a lot more information, enabling in-depth, worldwide searches of available resources. Conceptually, the idea of a registry is simple and already has been of considerable use in fields outside materials science, particularly astronomy.

Indeed, in 2014, realizing it could capitalize on progress made in other disciplines, NIST hired Robert Hanisch, formerly of the Virtual Astronomical Observatory (VAO), as founding director of the Office of Data and Informatics. VAO, working with its counterparts worldwide, achieved something remarkable: a system that enabled discovery and access of astronomical data from a remarkable number of instruments from many countries.[6] At the top of the VAO infrastructure was a registry, and NIST has transferred this concept to create the NIST Materials Resource Registry, which is powered by an advanced software stack developed by NIST's Information Technology Laboratory.

The power of the Materials Resource Registry lies in its simplicity. The goal is to create a listing of high-level entities, such as research organizations, data repositories, services, or software packages (not, typically, a specific data set). The aim of the registry is to enable people to find the resource so they can access it at the resource home (e.g., institutional website or domain repository). The Materials Resource Registry does not host materials data, only the metadata describing the resource and, thereby, directs searchers to the resource.

The registry is designed so that entries can be added in minutes by the resource host (e.g., owner or curator), and, if an institution so desires, a local version of the Materials Resource Registry can be instantiated onsite (the source of the software can be found on GitHub). Resources can be added to the registry by the owner of the registry instance or by external participating institutions and their representatives. Usually there is some vetting to ensure the authenticity of the source before an institution will allow an outsider to add to their registry.

The multiple instances of the Materials Resource Registry, coupled with a protocol, such as the Open Archive Initiative Protocol for Metadata Harvesting, enables metadata from each instance of the Materials Resource Registry to be harvested by the other registry instances, yielding global awareness of available resources. Thus, as we gain worldwide acceptance for the concept of the Materials Resource Registry, discoverability of resources will become ever easier. To gain this acceptance, NIST is leading an effort within the Research Data Alliance, an international organization devoted to eliminating barriers to sharing research data.

Although the MGI goal of halving the materials development time is somewhat arbitrary, it was important to set a target so that the initiative could ultimately benchmark its progress against current practices. Ultimately, the raw material of the materials innovation infrastructure is digital data, and the Materials Resource Registry is the means to discover what is out there in terms of the performance of existing materials and in the predictive models needed to discover the next great material. Without this discovery capability, the data remain essentially in the dark—and out of the research work.

What do you think about the challenges of specification standards and the problem of data provenance in constructing ceramic material property databases?

JW: This is, of course, a long-standing challenge where NIST continues to strive to improve the existing state-of-affairs. In general, research domains need to develop better practices across their communities, which involves working toward consensus, and then develop the means to enforce these standards. Indeed, for decades NIST has collaborated extensively with ACerS on this problem, yielding products like the Ceramics WebBook.

Ultimately, in my opinion, the challenges can be broken down into a few issues:

- **What is the existing (sub)culture of data curation?** Can we find our own data? Now that we have a full born-digital data lifecycle, should we be doing a better job managing data for our own research?
- **We need tools that implement standards without too much disruption of current practices.** Requiring researchers to modify their workflows is fraught with pitfalls and is an approach unlikely to succeed anytime soon.
- **A top-down approach, surprisingly, can work well, if we let communities grow standards from the minimal to the exact—top to bottom.** This is counterintuitive, but an attempt to develop monolithic standards yields results that are unlikely to be widely adopted because of the enormous costs associated with implementing the standard. This is especially true for process descriptions, such as those that dominate materials fabrication and characterization, where standard workflows are found only in rigid industrial settings, not research labs. NIST relies on consensus-based standards and understands that some level of standardization is often preferable to none. Yet, as I have indicated above, this part of the problem is more about communities and people coming to consensus than specific, externally imposed standards.

So, after these caveats, NIST is approaching this problem in a twofold manner: develop tools to enable the attachment of metadata, such as provenance and other relevant information about the data; and work with communities to develop standards for this metadata, with the understanding that the standards should be ones the community is prepared to adopt (and, so, often will be very "lightweight"). These ideas are manifested in the Materials Data Curation System (https://mdcs1.nist.gov, and the source at https://github.com/usnistgov/MDCS) and the metadata schema library that provides templates for those who chose to either adopt or extend the standards (https://github.com/MDCS-community).

How has the approach to research data changed in the digital age?

JW: Today, all data are essentially born digital, but we have yet to fully capitalize on this reality. As discussed, researchers are unable to easily share their data with colleagues, let alone publish data in a manner that has maximum utility. However, this is not the fundamental problem. Indeed, it is often the case that researchers

- Do not, or cannot, save all of their data;
- Cannot find their own data, even if they saved it; or
- Cannot figure out what their own data mean, even after a relatively short amount of time, let alone reuse the data of a fellow researcher or student.

These issues have nothing to do, per se, with widespread discovery of information, but only researchers' ability to perform the process of data discovery on their own data. Acknowledging this problem is the beginning of the process of designing the tools and infrastructure to materials data discovery. This also is why NIST has been investing a great deal of effort in the development of the Materials Data Curation System. With this tool, and others like it, we believe people can significantly improve their own data management, thereby improving the quality and "shelf life" of materials research.

How do you foresee that availability and access to data could change how research is performed, interpreted, and built upon?

JW: As I elucidated above, once a researcher has access to a great deal of data about a problem, a great deal of science can be done. Of course, the traditional modality of science is not mooted by MGI approaches, only enhanced. That is, theories and models must be validated and extended to encompass available experimental data. This is possible only to the extent that such data are available.

In that sense, MGI promises to extend the reach and speed of science and engineering by more tightly integrating experiment and computation, by making the results of each more readily available. Of course, one of the true measures of progress in the sciences is extension of existing models beyond their current range of applicability, or even, more importantly, invalidation of a model in favor of an improved description. The proliferation of data promises to accelerate this central scientific paradigm.

In addition, improved access and organization of massive amounts of data will reduce the likelihood of duplication of efforts across research domains (although some is always necessary) and also raises the potential for increases in cross-field fertilization. This outcome is not a foregone conclusion, however, because the increases in data also will test our ability to keep up with the proliferation of sources in this data deluge.

Indeed, this is likely a fascinating research topic in itself. Recently we put these ideas to the test through the Materials Science and Engineering Data Challenge, a competition led by the Air Force Research Laboratory, NIST, and NSF to foster new, high-quality, materials research based upon shared research data. The details of this competition can be found at bit.ly/29MRaz4.

Finally, with the coming availability of large amounts of data—and the associated tools to evaluate its quality—we are entering an era where the so-called fourth paradigm of data-driven materials science is firmly within our grasp. Although such approaches necessarily must complement existing approaches, as we move in our understanding from correlation to causation, these methods offer the opportunity to stand on the shoulders of our colleagues, and, thereby, obtain insights that otherwise would be beyond our horizon.[7,8]

For more information, contact Warren at james.warren@nist.gov.

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Credit: Harper International

Figure 1. Rotary furnace system.

Combining expertise and innovation to design advanced combination furnace systems

By Colleen Marren

Customized engineering and unique dual-function rotary furnaces solve thermal processing challenges.

Thermal processing of advanced and high-purity materials requires equipment that can reliably balance high-quality product output, safety, and economic production. In today's market, companies must balance a variety of product lines, each requiring the same standards. Harper International understands that each product requires its own customized processing solution. Advancements in Harper's rotary furnaces allow for the interchange of process tube materials or shapes to utilize one thermal system for a variety of advanced material product lines and material developments (Figure 1).

An indirectly fired rotary furnace is a continuous thermal system that applies heat to the incoming process material over multiple thermal control zones. The complete system includes feeding, heating, cooling, and gas handling and provides a very efficient method for processing powders. Rotary tube furnaces primarily are used because of their efficiency in heat transfer and mass transfer for powders as well as minimizing material-handling requirements.

A rotary tube furnace transfers heat from the heat chamber to a rotating tube, which contains the process materials and the required special atmosphere. Specifically, the furnace transfers heat from the tube wall to the bed of material being processed. Maintaining the process tube at a small angle and rotating it causes the material to continuously convey through heating and cooling sections. Rotary furnaces have one of the highest thermal efficiencies and lowest operating costs compared with other types of equipment.

The following are two cases in which Harper designed unique combination furnaces to fit specialized needs for advanced material development.

Case study 1: Alloy/ceramic tube rotary furnace combination system

ECRIM, a leading ceramic microelectronic materials company, develops advanced ceramic materials for applications requiring high thermal conductivity, such as high-power LED lighting products and other heat-sink substrates.

Beginning production before proper research and development can waste countless hours and raw materials, which often are sparse in any new project, and result in inconsistent and low-quality products. Therefore, ECRIM first develops the necessary processing for its new materials in a process development mode. After optimizing various parameters—including residence time, tube rotation rate, tube inclination angle, temperature profile, atmosphere flowrate, powder bed depth, and feed rate—the company then uses those parameters to demonstrate its ability to scale up production while maintaining precise product requirements.

ECRIM's development of new processes and products necessitates that its equipment can easily vary processing parameters. The company needed a rotary furnace to obtain excellent gas–solid contact, controlled atmosphere with gas-tight rotary seals, material mixing, and continuous production of its products.

Tube material selection

Rotary furnaces use a variety of tube materials, including alloys, graphite, silicon carbide, and aluminum oxide. Harper carefully selects the tube material in a rotary furnace to ensure that it can withstand the process atmosphere and temperature. Selecting the improper tube material can have many unwanted consequences, the most obvious of which is product contamination. Serious consequences also can occur if hazardous materials and/or hazardous gases are processed inside the tube, because it is the only object separating the process environment and ambient atmosphere.

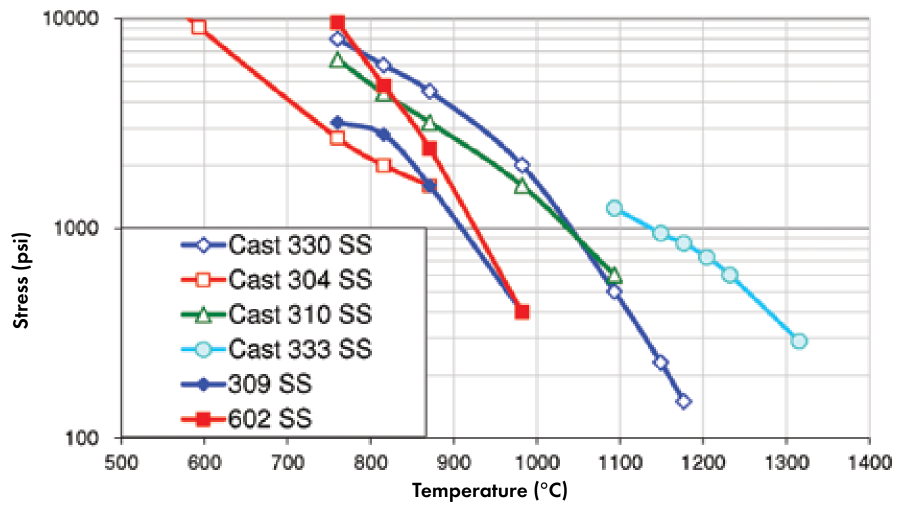


Figure 2. Temperature versus allowable creep stress of stainless steel alloy process tubes.

Ceramic tubes can shatter if they experience too much stress under the improper conditions, which can cause substantial damage inside the furnace. Alloy tubes can crack if they experience high stress or react with the process environment. Cost, thermal shock, and creep stress also are important in tube selection. Figure 2 shows the correlation between process tube material type, temperature, and maximum allowed stress for several stainless steel alloys.

Maximum allowed stress is based on the amount of creep (deformation) a tube can withstand before rupture. Typically, manufacturers design furnace tubes so that after 10,000 hours at maximum process temperature, the tube deforms less than 1% because of creep stress. Stress on the tube varies based on rotational speed and amount of material inside the tube, diameter of the tube, suspended length of the tube, and thickness of the tube.

Manufacturers consider cast and wrought alloys for high-temperature applications. Figure 2 shows that cast alloys often have higher allowable creep stress. Also, some materials are available only in cast form because they lack sufficient ductility to be worked into a wrought tube, such as high chromium content alloys.

Users strongly prefer alloy tubes in rotary thermal systems requiring diameters greater than ~9–12 in., because they are significantly less expensive, have shorter lead times, and do not suffer catastrophic brittle failure. Thermal stress increases with tube diameter, causing an increased probability of tube failure for brittle ceramics. Large-diameter tubes with high costs and long lead times often are not practical or economical, because ceramic tubes can fail at any time from random defects.

Users should consider ceramic tubes when a product that requires high purity is being treated or the metals in the alloy tube have potential to react with the product or off-gases created during production. Ceramic tubes resist corrosion and are useful in high-temperature applications. Commonly used ceramic tubes include quartz, silicon carbide, aluminum oxide, and, in some cases, graphite.

Manufacturers use graphite tubes and muffles in furnaces requiring high temperatures or high purity. They are best suited for environments between 1,000°C and 3,000°C and under inert atmospheres, such as nitrogen or argon. Graphite tubes are not suitable for oxidizing environments, because carbon will oxidize at these temperatures.

Silicon carbide tubes come in many forms, including nitride-bonded silicon carbide, reaction-bonded silicon carbide, recrystalized silicon carbide, solid-state-sintered silicon carbide, and liquid-phase-sintered silicon carbide. Silicon carbide tubes are best used for processes requiring

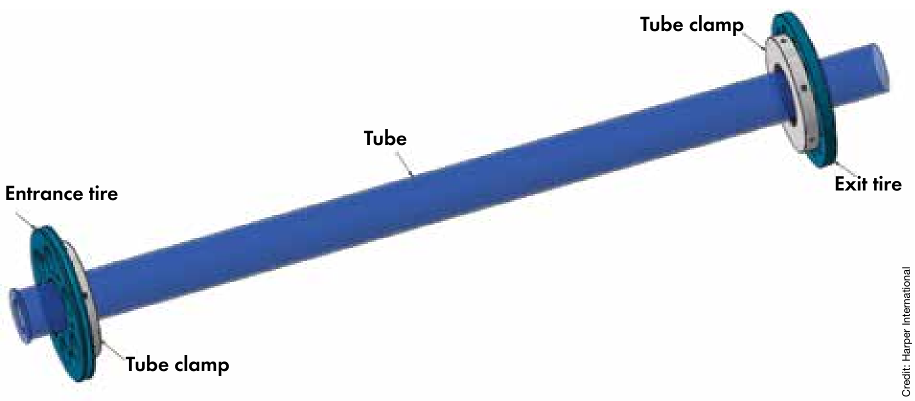


Figure 3. Harper dual-material tube assembly uses tube clamps instead of welded-on flanges.

an air atmosphere at temperatures below 1,400°C, depending on the grade of silicon carbide. Many economical grades of silicon carbide are porous, making a controlled atmosphere difficult.

Aluminum oxide tubes, similar to silicon carbide tubes, come in many grades. Aluminum oxide tubes that can tolerate some thermal stresses are highly porous and, thus, are best for processes that do not require a controlled atmosphere environment. Aluminum oxide tubes are preferred for processes requiring temperatures ≤1,600°C, depending on tube size and mass rate of the process material. However, aluminum oxide tubes cannot easily tolerate thermal shock and must be heated and cooled very slowly.

Quartz tubes are suitable for processing at temperatures <1,300°C and are suitable for oxidizing, reducing, or inert atmospheres as well as many high-purity applications. These tubes are not permeable and have a very low coefficient of thermal expansion compared with most ceramic tubes. However, quartz tubes are brittle and can break because of random defects.

ECRIM's production demanded a quartz process tube based on strict product purity, temperature requirements that reached 800°C, and need for an atmosphere containing a precise composition of nitrogen and air for a tightly controlled oxidation reaction. With the required tube diameter, a quartz tube is significantly more expensive than an alloy tube and could break during ECRIM's research and development period. However, an alloy tube, even though it can withstand the required temperatures, introduces contamination risks.

Therefore, ECRIM worked with Harper to design a single, continuous thermal rotary processing system that could easily interchange between an alloy and a quartz tube.

System design

Harper's equipment design solution uses an alloy tube for process development, followed by a quartz tube for significant quantity production of high-purity material. In addition to being multifunctional, this strategy eliminates contamination between research and development material and production material.

The single thermal processing system features three individually controlled temperature zones. Users can easily optimize the temperature profile during process development. The furnace also features a clamshell design that allows the top half of the furnace to open, exposing the furnace's internal section. The top half of the clamshell is hinged at one end and opens via pneumatic actuation, making it easy to access the furnace tube, insulation, and heating elements without a crane.

The rotary tube furnace features a completely sealed rotary tube system and enclosed discharge collection to maintain atmosphere integrity. The exit hood, entrance hood, and rotary seals are on rails to allow the seal to move with the expanding tube. This is especially important when using the alloy tube, which has a thermal expansion of ~1.35%—much larger than the quartz tube.

Tube rotation and tube inclination directly affect residence time. The user controls tube rotation by a programmable logic controller system via a variable frequency drive. Thus, ECRIM can easily change the rate of tube rotation and resulting material residence time during process development. A pneumatic adjustable jack controls tube inclination to easily adjust the system without a crane.

This furnace is unique because of its ability to use a quartz or alloy tube. A Harper rotary tube on this scale often is supported via flanges welded to the exterior of the tube. These flanges are then bolted to tire assemblies, which are set upon casters. The casters are designed to be gentle on the tube and constructed to resist heat. This dual material rotary furnace system uses tube clamps instead of flanges welded to the exterior of the tube (Figure 3). Features designed on the exterior circumference of the tube secure these tube clamps. ECRIM can interchange the same tire easily between quartz and alloy tube assemblies. A variable speed drive connected to the tire through a V-belt to the reactor tube, mounted at the end fixed from expansion, rotates the tube.

ECRIM removes the tube assembly by unlocking and sliding away the feeder, on rails, from the entrance seal assembly. The entrance seal assembly and exit hood assembly also are on rails, allowing them to be unlocked and slid out of the way for tube removal. Users can easily remove and replace the tube after pneumatically opening the furnace clamshell. ECRIM now has flexibility to test and develop new materials utilizing alloy or ceramic tubes for its processes. This furnace will support the company's mission to produce advanced ceramic materials for applications requiring high thermal conductivities. Harper's design of this dual functionality furnace supports requirements to work with multiple types of tubes, saving money, time, and facility space.

Case study 2: Rotary/mesh belt rotary furnace combination system

A national laboratory, which had limited available floor space, contacted Harper to assist design of a single, continuous thermal processing system. To enable process development for commercial production of carbon materials, the lab needed a continuous thermal processing system to operate at temperatures up to 1,050°C and in a variety of atmospheres. The lab wanted to vary carbon precursor materials in composition, particle size, moisture content, density, and shape. These variations in precursor materials required two distinctive types of furnace systems: a rotary furnace and a mesh belt furnace.

Precursors with good flow properties that require shorter residence time and better gas–solid contact are ideal for rotary systems. However, for fragile precursors, a rotary furnace is not an option because mixing and tumbling throughout the tube would be detrimental to the product. Tube rotation rate and inclination control residence time in a rotary furnace. Materials requiring longer and more controlled residence time also are unsuitable for a rotary furnace, because long residence times require a very small angle of inclination and a slow tube rotation rate, making it extremely difficult to control residence times more than two hours.

A mesh belt furnace is a continuous thermal system that applies heat to the incoming process material via multiple thermal control zones. Either gas or electric heating powers the system. A muffle can control atmospheres in the reaction chamber. Further, if a customer requires an inert atmosphere, the product conveyed on the belt can enter a purge chamber before entering the heated zone of the furnace. Process materials are continuously fed directly onto the belt or placed in crucibles for thermal processing. Because the belt moves through the heated section supported by the alloy muffle, the process material continues to progress through the length of the furnace supported on the belt. The belt conveys the material through each temperature control zone, and belt speed controls the soak time in each zone. Once thermally processed, material travels through a cooling section and then an exit purge chamber before unloading.

To meet all required design aspects, initially it seemed that the laboratory required two separate furnaces. Harper first considered a traditional rotary furnace and a traditional mesh belt furnace. However, this client had very limited space and limited resources, so two stand-alone furnaces were not optimal. The Harper team instead designed a multifunctional thermal processing system that can be transformed from a rotary tube furnace to a mesh belt furnace using a single thermal platform (Figure 4).

Figure 4. Mesh belt/rotary thermal combination system designed for a national laboratory with space constraints.

System design

The single thermal processing system featured a clamshell design that allows the top half of the furnace to open, exposing the internal section. The rotary tube furnace features a completely sealed rotary tube system and enclosed discharge collection to maintain atmospheric integrity. Four zones of control allow adjustments to heat-up rate, soak period, and cooling rate. The user controls process capacity by adjusting the angle of the system's inclination, along with rotational speed of the tube and feed rate from the screw feeder system.

Akin to autobots in the movie *Transformers*, the user reconfigures the main parts of the system in quick succession to transform the system between mesh belt and rotary tube systems. If starting with the rotary tube system, users remove the screw feeder, rotary tube (via clamshell access), and entrance and exit hoods. Next, users install the alloy muffle, cooling section, purge chambers, and mesh belt. The mesh belt drive stands and the heating chamber remain in place, so minimum number of subassemblies are reconfigured. The mesh belt thermal system also is atmospherically controlled, with purge chambers located at entrance and exit ends of the furnace system. Four zones of control allow for adjustments to the thermal profile. Harper also designed the internal alloy muffle with several exhaust ports at key locations for removal of corrosive off-gases.

Both furnace systems are gas-tight and operate under a variety of atmospheres, including reactive and corrosive gases. The systems can operate in the 1,000°C range, with thermal processing cycle variations from 30 minutes to 10 hours.

This leading national laboratory now has the flexibility to test and develop new carbon materials from a variety of sources, including renewable materials, to support its mission to advance the future of materials research. Harper's design of this dual functionality furnace supports requirements to work within limited laboratory space and the need for flexibility in processing a wide variety of materials in rotary and mesh belt furnace systems.

About Harper International

Harper International (Buffalo, N.Y.) develops complete thermal processing solutions and technical services for the production of advanced materials. The world of advanced ceramic materials continues to change at an accelerated pace. Design of the above custom furnace systems demonstrates Harper's commitment to provide solutions, investments, and new concepts to achieve the needs of its valued customers.

About the author

Colleen Marren is an applications engineer with Harper International. Contact Marren at cmarren@harperintl.com. ■

Spark plasma sintering in a flash

Development of a novel flash spark plasma sintering process enables rapid heating and consolidation of materials at larger volumes than are possible with other rapid-sintering techniques.

By Salvatore Grasso, Theo Saunders, Ruth Mckinnon, Elinor Castle, Peter Tatarko, Baoli Du, Francesco Gucci, Min Yu, Harshit Porwal, Ben Milsom, and Mike Reece

Many processes and devices use Joule heating to achieve high temperatures, including electric-current-assisted sintering. These techniques became widely available in the 1990s with the commercialization of spark plasma sintering units produced in Japan. During the past few years, we have experienced renewed interest in rapid consolidation of materials, and total discharge times have been reduced to a few seconds.

As in the case of incandescent lamps and resistive heating elements, flash sintering techniques use localized Joule heating developed within the consolidating particles using—typically—a die-less configuration. Heating rates are extreme (10^4–10^6 °C/min), and the sintering temperature is reached almost instantaneously. The flash sintering literature suggests that any ceramic, ranging from insulating oxides (Al_2O_3) to conductive ceramics (ZrB_2), can be consolidated in a few seconds.

Depending on processing conditions, the resulting materials might have microstructures that are far from equilibrium, resulting in novel functional and structural properties.

A distinctive difference between flash sintering and previously developed electric-current-assisted sintering techniques is the possibility to heat materials to a temperature sufficient to make them current carrying. This opens the possibility of densifying materials that are insulators at room temperature. As highlighted in our recent review,[1] conductivity and temperature dependence of conductivity of the sintering sample are key parameters in the flash sintering process.

Credit: Adam Tudball, Kennametal Manufacturing Ltd.

Figure 1. A large-scale SPS machine (7-m tall) used to scale up flash spark plasma sintering.

Flash spark plasma sintering

We have developed a flash process using a spark plasma sintering machine, which we termed flash spark plasma sintering. This allowed us to produce sample volumes tens-of-hundreds of times larger than those previously reported in flash sintering literature and enabled us to gain a better understanding of the mechanisms operating during flash sintering. This was achieved using a readily available spark plasma sintering machine capable of accurately controlling, recording, and reproducing the flash spark plasma sintering process (Figure 1).

Figure 2 shows the timeline for evolution of our flash sintering work. During the past few years, flash spark plasma sintering tooling configu-

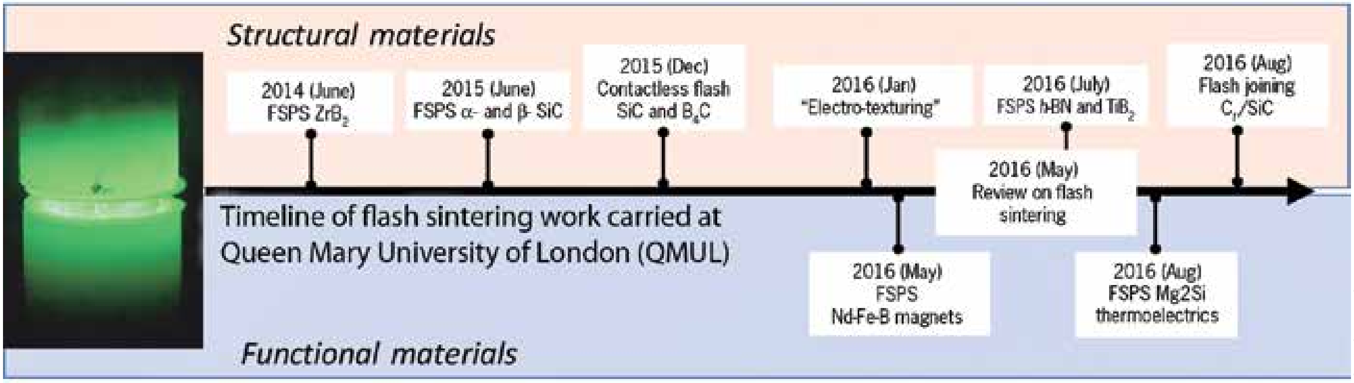


Figure 2. Evolution of flash spark plasma sintering-related work from initiation in June 2014. We pioneered the development of flash spark plasma sintering, contactless flash sintering, and flash joining.

rations and the investigated materials have evolved continuously. The top of the line in Figure 2 refers to consolidation of ultra-high-temperature and structural ceramics. Material compositions include ZrB_2,[2] SiC/B_4C, and hexagonal-BN/TiB_2 composites, with sample sizes of 20–60 mm in diameter. Even though these materials are considered difficult to densify, flash spark plasma sintering produces complete densification on a time scale hundreds of times shorter than required for conventional spark plasma sintering (Figure 3).[3]

The newly developed flash spark plasma sintering technique is not limited to conductive ceramics and has been extended by other researchers to consolidation of 3YSZ. By optimizing tool design, we achieved homogeneous temperature distribution and densification within sintered samples. We also demonstrated the possibility of achieving fully dense materials from raw powders in <100 s.

We extended the work to flash joining of C/SiC ceramic-matrix composites.[4] The flash route avoids thermal degradation of carbon fibers while achieving a joint with good mechanical strength. A further extension of the flash spark plasma sintering work is development of contactless flash sintering, where we achieved even higher volumetric powder densities. Thus, we are able to realize very rapid densification of SiC/B_4C composites (two-phase composites made from a powder mixture) in 2–3 s of discharge time.

We recently applied the flash spark plasma sintering technique to consolidate functional materials. This includes work on high-performance permanent magnetic materials, where there is a drive to develop materials with reduced dependence on critical rare-earth elements. There is rapid sinter-forging of the material during the flash spark plasma sintering process, which produces significant crystallographic texturing through platelike grain growth and alignment. This leads to development of highly anisotropic magnetic properties and, because of the nanoscale characteristics of the platelike grains that form, much greater coercivities (>1600 $kA \cdot m^{-1}$) when compared with conventional "die-upset forged" magnets.

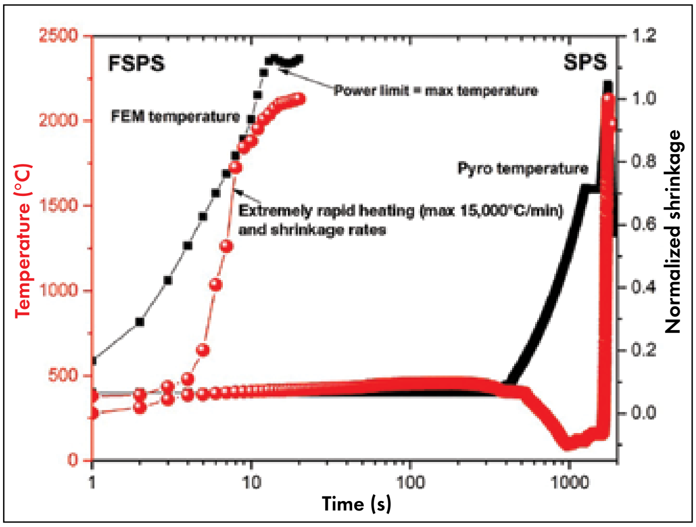
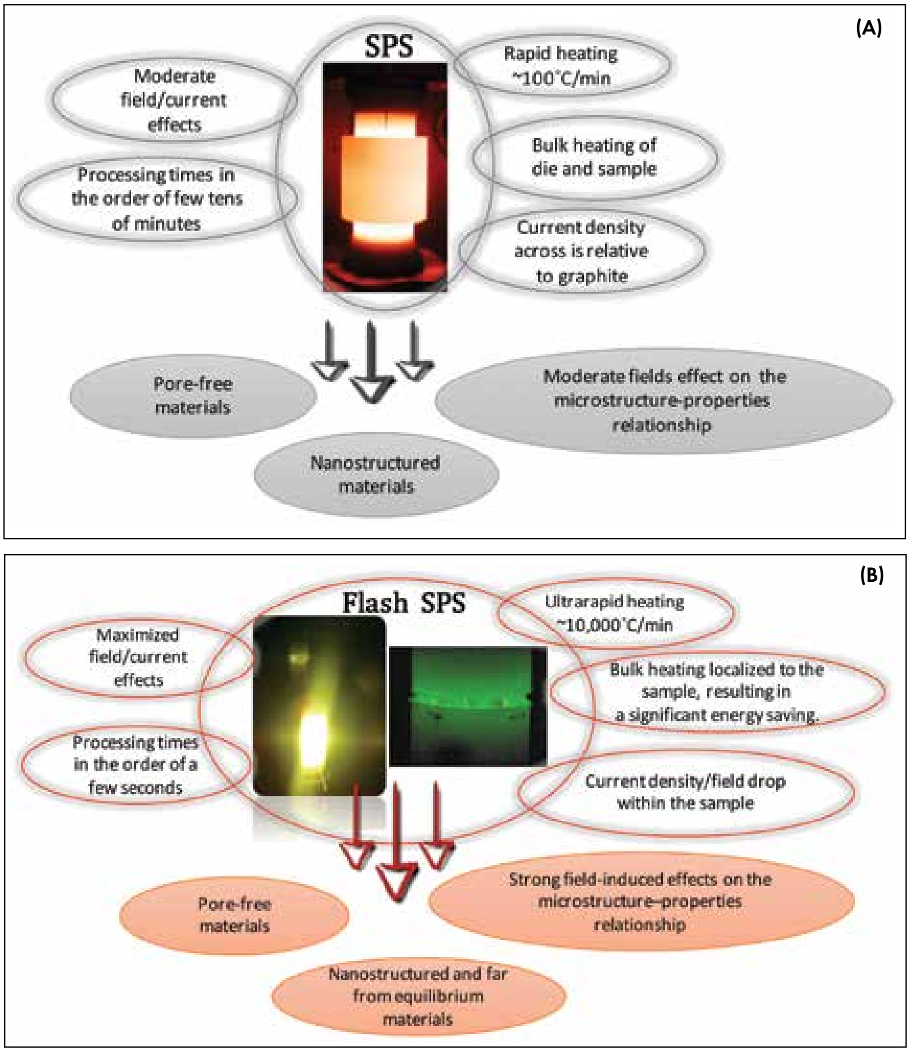


Figure 3. Shrinkage curves and temperature profiles plotted as a function of time for spark plasma sintering and flash spark plasma sintering of SiC. Discharge time for flash spark plasma sintering is 20 s and at least 100 times longer for spark plasma sintering. Sample temperature was estimated using finite-element modeling.

The enhanced coercivity highlights the potential of the technique to produce less expensive and more sustainable heavy rare-earth-free permanent magnets. We achieved an increased figure of merit in the case of Mg_2Si-based thermoelectrics by flash spark plasma sintering versus spark plasma sintering because of reduced electrical resistivity of nonequilibrium microstructures produced by the flash process.[5]

Figure 4 shows that flash spark plasma sintering has some unique features compared with other consolidation techniques, such as spark plasma sintering. Flash spark plasma sintering allows bulk heating (hundreds of grams of powder) at rates not otherwise achievable. Neglecting, for a moment, any possible contribution of electric field to the consolidation process, extremely high heating rates allow unexplored temperature profiles for materials consolidation. According to our preliminary analysis, extremely high heating rates and increased consolidation temperatures experienced by the samples might be sufficient to explain the rapid consolidation produced during flash spark plasma sintering (Figure 3).

Traditional materials science is not able to capture the far-from-equilibrium processing features imparted by flash spark plasma sintering. More work is required to differentiate strong temperature effects (i.e., accelerated sintering kinetics) from weaker ones attributed to electric fields, such as differential heating (at different scales), electrochemistry, ion migration, electro-plasticity, magnetism, and polarization.



Credit: Salvatore Grasso

Figure 4. (A) Parallel comparison between spark plasma sintering and (B) flash spark plasma sintering, including processing benefits (top) and the corresponding improvement on materials microstructures and functionalities.

However, flash spark plasma sintering has several technological advantages over spark plasma sintering (Figure 4). Flash spark plasma sintering allows rapid and complete densification (relative density >98%), with heating rates approaching 10,000°C/min. This reduces production times from tens of hours to tens of seconds. The process can consolidate nanostructured materials with very limited grain coarsening. In addition, automation of the process is easy using a die-less configuration and can be scaled-up to 30–50 cm diameters using commercially available spark plasma sintering machines.

Researchers can more accurately tailor the microstructures and properties of a wide range of materials by intensively investigating flash spark plasma sintering and by extending the range of processing parameters (i.e., current densities, voltages, waveforms, and frequencies). Further, researchers can optimize tooling design using finite-element modeling to achieve a more even temperature distribution while maintaining extremely high heating rates.

We also can further stretch flash spark plasma sintering. For example, we can use the process to densify refractory materials without the need for sintering additives, and the technique has unexplored potential in terms of microstructure design to achieve improved functionalities. We also can use the process to fabricate metastable composites containing phases that would decompose or degrade if processed according to conventional sintering routes (i.e., nonflash).

Finally, the bright future of flash processing is not limited to consolidation—in the next few years, we expect to see applications in any manufacturing process that involves heating.

Credit: Adam Tudball, Kennametal Manufacturing Ltd.

Research team at Queen Mary University of London: (left to right) Ruth Mckinnon, Maurizio Di Leo, Min Yu, Elinor Castle, Salvatore Grasso, Theo Saunders, Ben Milsom, Mike Reece, Francesco Gucci, Harshit Porwal, and Baoli Du.

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Salvatore Grasso, Theo Saunders, Ruth Mckinnon, Elinor Castle, Peter Tatarko, Baoli Du, Francesco Gucci, Min Yu, Harshit Porwal, Ben Milsom, and Mike Reece are associated with the School of Engineering and Material Science and Nanoforce Technology Ltd. at Queen Mary University of London (London, U.K.). Contact Reece at m.j.reece@qmul.ac.uk.

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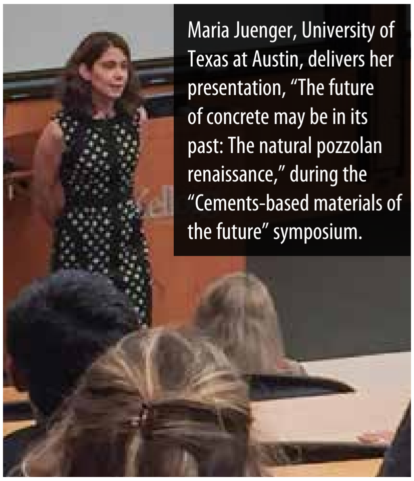
(Credit for all photos: ACerS.)

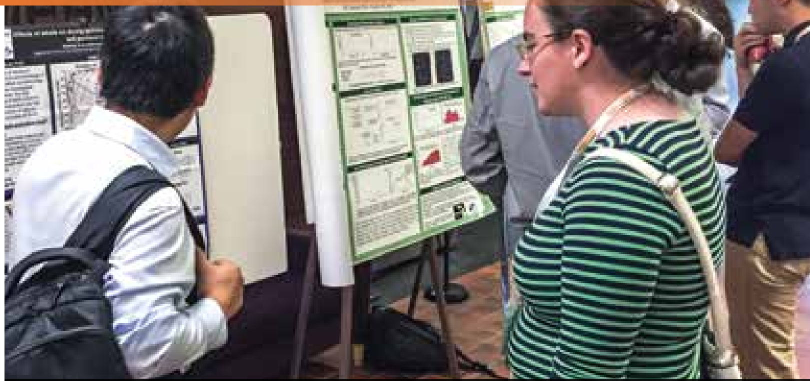
A solid future: Cements conference looks at 'a vision of things to come' for the industry

ACerS Cements Division held a successful meeting July 10–13 at Northwestern University in Evanston, Ill., and brought together 113 academics, students, and cements professionals from around the globe.

The three-day event kicked off with a poster session and reception that featured more than 30 poster presentations. A new YouTube video contest was also held prior to the conference to promote the ACerS Cements Division meeting and its research activities.

Technical sessions featured the Cements Division Annual Business Meeting and the Della Roy Lecture and Reception, delivered by Joseph J. Biernacki from Tennessee Technological University. Biernacki's thought-provoking presentation, "What do artificial intelligence, synthetic life-chemistry and nuclear fusion have to do with cement? (A vision of things to come)," offered predictions for the future of the cements industry and factors affecting long-term research and development.


Maria Juenger, University of Texas at Austin, delivers her presentation, "The future of concrete may be in its past: The natural pozzolan renaissance," during the "Cements-based materials of the future" symposium.


Conference attendees exchange information about their latest research during the poster session at the 7th Advances in Cement-Based Materials conference in Evanston, Ill.

The Stephen Brunauer Award also was presented during the annual business meeting to the author of the best refereed paper on cements published during the previous calendar year in the *Bulletin* or the *Journal of the American Ceramic Society*. This year's winner was a two-part article titled "An application of computer-aided molecular design (CAMD) using the signature molecular descriptor. Identification of surface tension reducing agents and the search for shrinkage reducing admixtures," published in the *Journal of the American Ceramic Society*.

To wrap up the event, a symposium was held to honor Surendra Shah, professor at Northwestern University, featuring talks on the future of concrete, industry trends, and innovations in concrete technology. ■

resources

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.

Calendar of events

September 2016

4–8 ESG 2016/SGT100: Society of Glass Technology Conference – Sheffield, U.K.; www.sgt.org

18–21 ISFGMS 2016: 14th Int'l Symposium on Funtionally Graded Materials/Multiscale and Multifunctional Structures – University of Bayreuth, Bayreuth, Germany; www.isfgms2016.org

28–29 59th Int'l Colloquium on Refractories 2016 – Aachen, Germany; www.ecref.eu

October 2016

1–6 ➨ 6th Int'l Conference on Electrophoretic Deposition – Gyeongju, South Korea; www.engconf.org/conferences

23–27 MS&T16, combined with ACerS 118th Annual Meeting – Salt Lake City, Utah; www.ceramics.org; www.matscitech.org

November 2016

8–10 ➨ 77th Conference on Glass Problems – Greater Columbus Convention Center, Columbus, Ohio; www.glassproblemsconference.org

13–15 ➨ CerSJ-GOMD Joint Symposium on Glass Science and Technologies – Kyoto University, Kyoto, Japan; www.talab.h.kyoto-u.ac.jp

January 2017

18–20 EMA 2017: ACerS Electronic Materials and Applications – DoubleTree by Hilton Orlando Sea World, Orlando, Fla.; www.ceramics.org/ema2017

22–27 ICACC'17: 41st Int'l Conference and Expo on Advanced Ceramics and Composites – Hilton Daytona Beach, Daytona Beach, Fla.; www.ceramics.org/icacc2017

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JOIN US FOR THE ACerS 118TH ANNUAL MEETING

ACerS AWARD LECTURES

Monday, October 24

9:00 – 10:00 a.m.
ACerS/NICE Arthur L. Friedberg Ceramic Engineering Tutorial and Lecture
– **Aldo R. Boccaccini**, Institute of Biomaterials, University of Erlangen-Nuremberg, Germany
Bioactive glasses in soft tissue repair: What do we know so far?

2:00 – 5:00 p.m.
ACerS Alfred R. Cooper Award Session

Cooper Distinguished Lecture
– **G. Neville Greaves**, Cambridge University, U.K., and Wuhan University of Technology, China
Where inorganic meets organic in the glassy state: Hybrid glasses and dental cements

2016 Alfred R. Cooper Young Scholar Award Presentation
– **Matthew A. Tuggle**, Clemson University
Novel approaches to glass optical fibers

2:00 – 4:40 p.m.
ACerS Richard M. Fulrath Award Session
– **Tadachika Nakayama**, Nagaoka University of Technology, Japan
Ceramics polymer hybrids and their processing with nanopulsed power technology
– **Yoshiki Iwazaki**, Taiyo Yuden Co. Ltd., Japan
Material design of dielectric and piezoelectric materials with first-principles calculation
– **James G. Hemrick**, Reno Refractories Inc.
A future for refractory ceramic technology based on a rich past
– **Tomoyuki Nakamura**, Murata Manufacturing Co. Ltd., Japan
Development of dielectrics for monolithic ceramic capacitor
– **Bryan D. Huey**, University of Connecticut
High-speed and tomographic AFM of functional materials

Tuesday, October 25

MS&T Plenary Session
8:00 – 10:40 a.m.

ACerS Edward Orton Jr. Memorial Lecture
– **Bruce Dunn**, University of California, Los Angeles
Designing ceramics for next-generation energy storage systems

1:00 – 2:00 p.m.
ACerS Frontiers of Science and Society–Rustum Roy Lecture
– **Cato T. Laurencin**, University of Connecticut
Regenerative engineering: A convergence approach to next- generation grand challenges

Wednesday, October 26

1:00 – 2:00 p.m.
ACerS Basic Science Division Robert B. Sosman Lecture
– **Jennifer A. Lewis**, Harvard University
Programmable assembly of colloidal suspensions

HOTEL INFORMATION

Reservation deadline: September 29, 2016

For best availability and immediate confirmation, make your reservation online at **matscitech.org**.

Salt Lake Marriott Downtown at City Creek
(ACerS HQ)
Rate: $194 single or double occupancy
Adjacent to the Salt Palace Convention Center

U.S. Government rate rooms are extremely limited; proof of federal government employment must be shown at check-in or higher rate will be charged. U.S. Government rate is the prevailing government rate.

ACerS SHORT COURSE

Thursday, October 27 | 9:00 a.m. – 4:40 p.m.
Friday, October 28 | 9:00 a.m. – 2:30 p.m.
Salt Lake Marriott Downtown at City Creek

Sintering of Ceramics
Instructor: Mohamed N. Rahaman, Missouri University of Science and Technology

VISIT THE EXPO!

Monday, October 24
Welcome reception | 4:30 – 6:00 p.m.

Tuesday, October 25
Show | 10:00 a.m. – 6:00 p.m.
Happy hour | 4:00 – 6:00 p.m.

Wednesday, October 26
Show | 9:00 a.m. – 2:00 p.m.

Find the program and exhibit at matscitech.org

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SPECIAL EVENTS

Sunday, October 23

MS&T Women in Materials Science Reception
6:00 – 7:00 p.m.

Monday, October 24

Experience Salt Lake City
Join us from 9:00 –10:00 a.m. to meet with local tour organizers who will provide information on local activities, sites, and self-guided tours in Salt Lake City. The knowledgeable local staff will assist in getting your day planned and started. You will be surprised by all the activities and sightseeing available to you during your stay! Advance registration is not required.

Welcome Reception and Exhibit Opening
4:30 – 6:00 p.m.
Network with your colleagues, meet new people, and learn about the exciting membership offerings of the organizing societies.

ACerS 118th Annual Meeting
1:00 – 2:00 p.m.
The president reports on Society activities and newly elected officers take their positions during the annual membership meeting. All ACerS members and guests are welcome.

ACerS 118th Annual Honors and Awards Banquet
6:45 – 10:00 p.m.
Purchase tickets for $90 via meeting registration.

Tuesday, October 25

Salt Lake City tour
8:30 a.m. – 2:00 p.m.
Price per person: $65 (includes lunch)
A 30-mile adventure, which includes visits to Temple Square; the State Capitol building; This Is the Place Heritage Park; historic districts, with mansions and cathedrals; University of Utah; Pony Express Station; historic Fort Douglas; Trolley Square; Union Pacific Depot; and dozens more of Salt Lake City's top attractions. Purchase tickets for $65 at **matscitech.org**.

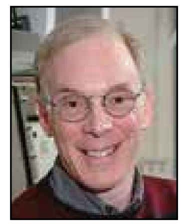
MS&T Young Professionals Reception
4:30 – 6:00 p.m.
Attend this reception to meet and network with fellow young professionals.

MS&T16 Exhibit Happy Hour Reception
4:00 – 6:00 p.m.
Network with colleagues and build relationships with qualified attendees, buyers, and prospects!

MS&T PLENARY LECTURES

Tuesday, October 25 | 8:00 – 10:40 a.m.

ACerS EDWARD ORTON JR. MEMORIAL LECTURE



Bruce Dunn, professor, Department of Materials Science and Engineering, University of California, Los Angeles, Nippon Sheet Glass Chair

Designing Ceramics for Next-Generation Energy Storage Systems

AIST ADOLF MARTENS MEMORIAL STEEL LECTURE

David K. Matlock, university emeritus professor, Advanced Steel Processing and Products Research Center, The George S. Ansell Department of Metallurgical and Materials Engineering, Colorado School of Mines

Enhancing the Fatigue Performance of Steel: Have We Learned Anything from the Past?

ASM/TMS JOINT DISTINGUISHED LECTURE IN MATERIALS AND SOCIETY

Julie A. Christodoulou, director, Naval Materials, S&T Division, Sea Warfare and Weapons Department, Office of Naval Research

Elegant Solutions Exploration and Outcomes That Matter

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Be on the lookout for these special collectible buttons. Get yours by attending ACerS lectures and special events —

- ACerS Annual Meeting
- Edward Orton Lecture
- Alfred R. Cooper Award Session
- Rustum Roy Lecture
- Richard M. Fulrath Award
- Robert B. Sosman Lecture
- Arthur L. Friedburg Lecture
- ACerS Lounge

Stop by the ACerS lounge to #PinYourACerSPride, and enter for your chance to win a daily prize. Stay tuned for more information!

Technical Meeting and Exhibition

MS&T16

MATERIALS SCIENCE & TECHNOLOGY

JOIN US FOR THE ACerS 118TH ANNUAL MEETING

Legend:
SPCC = Salt Palace Convention Center
MDCC = Salt Lake Marriott Downtown at City Creek

CALENDAR OF SELECT EVENTS

Accurate as of 8/7/16 (times and locations are subject to change)
See **matscitech.org** for full calendar of events.

SUNDAY, OCTOBER 23	TIME	LOCATION
Conference Activities		
Registration	12:00 p.m. – 5:00 p.m.	SPCC
Material Advantage Student Functions		
Undergraduate Student Speaking Contest Semifinals 1 and 2	1:00 p.m. – 3:00 p.m.	SPCC
Undergraduate Student Speaking Contest Finals	4:00 p.m. – 5:00 p.m.	SPCC
Student Networking Mixer	7:00 p.m. – 9:00 p.m.	SPCC
Social Functions		
MS&T Women in Materials Science Reception	6:00 p.m. – 7:00 p.m.	SPCC
MONDAY, OCTOBER 24		
Conference Activities		
Registration	7:00 a.m. – 6:00 p.m.	SPCC
ACerS Basic Science Division Ceramographic Exhibit and Competition	8:00 a.m. – 6:00 p.m.	SPCC
Exhibition		
Welcome Reception and Exhibition Grand Opening	4:30 p.m. – 6:00 p.m.	SPCC
Career Pavilion	4:30 p.m. – 6:00 p.m.	SPCC
Lectures		
ACerS/NICE: Arthur L. Friedberg Ceramic Engineering Tutorial and Lecture	9:00 a.m. – 10:00 a.m.	SPCC
ACerS Richard M. Fulrath Award Session	2:00 p.m. – 4:40 p.m.	SPCC
ACerS Alfred R. Cooper Award Session	2:00 p.m. – 5:00 p.m.	SPCC
Material Advantage Student Functions		
ACerS Student Tour	12:00 p.m. – 5:00 p.m.	SPCC
Graduate and Undergraduate Student Poster Contest Installation	4:30 p.m. – 6:00 p.m.	SPCC
Social Functions		
ACerS Annual Honor and Awards Reception and Banquet	6:45 p.m. – 10:00 p.m.	MDCC
Annual Meetings		
ACerS Electronics Division Business Meeting	12:00 p.m. – 1:00 p.m.	SPCC
ACerS 118th Annual Membership Meeting	1:00 p.m. – 2:00 p.m.	SPCC
ACerS Glass & Optical Materials Division Business Meeting	5:00 p.m. – 6:00 p.m.	SPCC
ACerS Nuclear & Environmental Technology Division Business Meeting	5:45 p.m. – 6:45 p.m.	SPCC
TUESDAY, OCTOBER 25		
Conference Activities		
Registration	7:00 a.m. – 6:00 p.m.	SPCC
ACerS Basic Science Division Ceramographic Exhibit and Competition	7:00 a.m. – 6:00 p.m.	SPCC
Annual Meetings		
ACerS Basic Science Division Business Meeting	12:00 p.m. – 1:00 p.m.	SPCC
ACerS Engineering Ceramics Division Business Meeting	12:00 p.m. – 1:00 p.m.	SPCC
Conference Activities		
Poster Installation	10:00 a.m. – 11:00 a.m.	SPCC
General Poster Session with Presenters	11:00 a.m. – 1:00 p.m.	SPCC
General Poster Viewing	1:00 p.m. – 6:00 p.m.	SPCC
Exhibition		
ASM Mini-Materials Camp	9:00 a.m. – 2:00 p.m.	SPCC
Career Pavilion	10:00 a.m. – 6:00 p.m.	SPCC
Happy Hour Reception	4:00 p.m. – 6:00 p.m.	SPCC
Lectures		
MS&T Plenary Lectures	8:00 a.m. – 10:40 a.m.	SPCC
ACerS Frontiers of Science and Society—Rustum Roy Lecture	1:00 p.m. – 2:00 p.m.	SPCC
Material Advantage Student Functions		
Graduate and Undergraduate Student Poster Contest Display with Presenters	11:00 a.m. – 1:00 p.m.	SPCC
Mug Drop Contest	11:15 a.m. – 12:15 p.m.	SPCC
Disc Golf Contest	12:30 p.m. – 1:30 p.m.	SPCC
Graduate and Undergraduate Student Poster Contest Display	1:00 p.m. – 6:00 p.m.	SPCC
Student Awards Ceremony	2:00 p.m. – 3:00 p.m.	SPCC
Social Functions		
ACerS Companion Breakfast	8:00 a.m. – 10:00 a.m.	MDCC
Salt Lake City Tour	8:30 a.m. – 2:00 p.m.	SPCC
MS&T Young Professionals Reception	4:30 p.m. – 6:00 p.m.	SPCC
WEDNESDAY, OCTOBER 26		
Conference Activities		
Registration	7:00 a.m. – 5:00 p.m.	SPCC
ACerS Basic Science Division Ceramographic Exhibit and Competition	7:00 a.m. – 5:00 p.m.	SPCC
Annual Meetings		
ACerS Art, Archaeology & Conservation Science Division Meeting	12:00 p.m. – 1:00 p.m.	SPCC
Exhibition		
ASM Mini-Materials Camp	9:00 a.m. – 2:00 p.m.	SPCC
General Poster Viewing	9:30 a.m. – 2:00 p.m.	SPCC
Lectures		
ACerS Basic Science Division Robert B. Sosman Lecture	1:00 p.m. – 2:00 p.m.	SPCC
THURSDAY, OCTOBER 27		
ACerS Basic Science Division Ceramographic Exhibit and Competition	7:00 a.m. – 12:00 p.m.	SPCC

PROGRAM-AT-A-GLANCE

Tentative Schedule, subject to change

ADDITIVE MANUFACTURING

	Mon a.m.	Mon p.m.	Tue a.m.	Tue p.m.	Wed a.m.	Wed p.m.	Thu a.m.
Additive Manufacturing for Surface Engineering of Materials					•	•	
Additive Manufacturing of Composites and Complex Materials	•	•		•	•		
Additive Manufacturing of Metals: Microstructure, Material Properties, and Product Performance	•	•		•	•	•	•
Additive Manufacturing of Shape Memory, Superelastic Alloys, and Multifunctional Materials	•	•					
Additive Manufacturing: In Situ Process Monitoring, Defect Detection, and Control					•	•	•
Recent Developments in Additive Manufacturing: Process and Equipment Development and Applications					•	•	•

BIOMATERIALS

	Mon a.m.	Mon p.m.	Tue a.m.	Tue p.m.	Wed a.m.	Wed p.m.	Thu a.m.
Nanomaterials Working in the Near-Infrared: Biomedical Applications				•	•	•	•
Next-Generation Biomaterials	•	•		•	•	•	•
Surface Properties of Biomaterials	•	•		•			

CERAMIC AND GLASS MATERIALS

	Mon a.m.	Mon p.m.	Tue a.m.	Tue p.m.	Wed a.m.	Wed p.m.	Thu a.m.
Ceramic-Matrix Composites	•			•	•	•	
Ceramic Optical Materials	•	•		•	•		
Glass, Amorphous, and Optical Materials: Common Issues within Science and Technology	•	•		•	•	•	•
Innovative Processing and Synthesis of Ceramics, Glasses, and Composites	•	•		•	•	•	
Multifunctional Oxides					•	•	•
Phase Transformations in Ceramics: Science and Applications	•	•		•			
Zirconia-Based Materials for Cutting Edge Technology				•	•	•	

ELECTRONIC AND MAGNETIC MATERIALS

	Mon a.m.	Mon p.m.	Tue a.m.	Tue p.m.	Wed a.m.	Wed p.m.	Thu a.m.
Advances in Dielectric Materials and Electronic Devices	•	•		•	•		
Emerging Interconnect and Pb-Free Materials for Advanced Packaging Technology				•	•	•	
Semiconductor Heterostructures: Theory, Growth, Characterization, and Device Applications	•	•					

ENERGY

	Mon a.m.	Mon p.m.	Tue a.m.	Tue p.m.	Wed a.m.	Wed p.m.	Thu a.m.
3-D Graphene for Energy Conversion and Storage	•	•		•			
Energy Storage VI: Materials, Systems, and Applications Symposium					•	•	•
Materials and Processes for CO_2 Capture, Conversion, and Sequestration				•	•	•	
Materials Development for Nuclear Applications and Extreme Environments	•	•		•	•	•	•
Materials Issues in Nuclear Waste Management in the 21st Century	•	•		•	•	•	•

FUNDAMENTALS, CHARACTERIZATION, AND COMPUTATIONAL MODELING

	Mon a.m.	Mon p.m.	Tue a.m.	Tue p.m.	Wed a.m.	Wed p.m.	Thu a.m.
3rd International Workshop of In Situ Studies with Photons, Neutrons, and Electrons Scattering	•	•		•			
Advancements in In Situ Electron Microscopy Characterization					•	•	
Computational Design of Ceramics and Glasses					•	•	•
Heterogeneity during Plastic Deformation—Synergy between Experimental Investigation and Simulation	•	•		•	•	•	•
ICME Accelerated Materials Discovery in Process and Product Development					•		
Interfaces, Grain Boundaries, and Surfaces from Atomistic and Macroscopic Approaches—Fundamental and Engineering Issues	•	•		•	•	•	•
International Symposium on Defects, Transport, and Related Phenomena	•	•		•	•		
Materials Property Understanding through Characterization	•	•		•	•	•	•
Measurement and Modeling of Medium to High-Strain-Rate Deformation	•	•					
Modeling of Multiscale Phenomena in Materials Processing and Advanced Manufacturing						•	•
Multiscale Modeling of Microstructure Deformation in Material Processing	•	•					
Phase Stability, Diffusion Kinetics, and Their Applications (PSDK-XI)		•		•	•	•	•
Symposium on Applications of Low-Emittance Synchrotron X-ray Sources to Mesoscale Materials Studies				•	•		
Symposium on Large Fluctuations and Collective Phenomena in Materials III				•	•	•	•

IRON AND STEEL (FERROUS ALLOYS)

	Mon a.m.	Mon p.m.	Tue a.m.	Tue p.m.	Wed a.m.	Wed p.m.	Thu a.m.
Advanced High-Strength Steel Design/Technological Exploitation	•	•		•	•	•	•
Advances in Zinc-Coated Sheet Steel Processing and Properties	•						
Ferrous Metallurgy: From Past to Present	•						
Gas/Metal Reactions, Diffusion, and Phase Transformation during Heat-Treatment of Steel					•	•	•

Technical Meeting and Exhibition

MS&T16

MATERIALS SCIENCE & TECHNOLOGY

OCTOBER 23 – 27, 2016 | SALT PALACE CONVENTION CENTER | SALT LAKE CITY, UTAH, USA

JOIN US FOR THE ACERS 118TH ANNUAL MEETING

	Mon a.m.	Mon p.m.	Tue a.m.	Tue p.m.	Wed a.m.	Wed p.m.	Thu a.m.
MATERIALS–ENVIRONMENT INTERACTIONS							
Advanced Coatings for Wear and Corrosion Protection	•	•		•			
Advanced Materials for Harsh Environments	•	•					
Advanced Materials for Oil and Gas Applications—Performance and Degradation						•	•
Degradation of Nonmetallic Materials	•						
High-Temperature Corrosion of Structural Materials					•	•	•
Materials Degradation in Supercritical CO_2 Power Cycles	•	•					
Materials Selection and Characterization for Corrosion Control	•	•		•			
Materials Tribology		•					
Surface Protection for Enhanced Materials Performance: Science, Technology, and Application					•	•	•
Thermal Protection Materials and Systems	•	•					
NANOMATERIALS							
Controlled Synthesis, Processing, and Applications of Structural and Functional Nanomaterials				•	•	•	•
Nanotechnology for Energy, Environment, Electronics, Healthcare, and Industry	•	•		•			
Responsive Functional Nanomaterials	•	•		•			
PROCESSING AND MANUFACTURING							
Advanced Manufacturing Technologies					•	•	•
Advances in Metal-Casting Technologies	•	•					
Avant-Garde Developments in the Processing, Properties, and Performance of Multifunctional Ceramic- and Metal-Matrix Composites						•	
Boron, Boron Coatings, Boron Compounds, and Boron Nanomaterials: Structure, Properties, Processing, and Applications		•			•	•	•
Construction and Building Materials for a Better Environment	•	•					
Failure Analysis and Prevention	•	•		•	•	•	•
Joining of Advanced and Specialty Materials (JASM XVIII)	•	•		•	•	•	•
Light-Metal Technology	•	•		•			
Mechanochemical Synthesis and Reactions in Materials Science	•	•		•	•	•	•
Panel Discussion on Advanced Manufacturing				•			
Processing and Performance of Materials Using Microwaves, Electric and Magnetic Fields, Ultrasound, Lasers, and Mechanical Work—Rustum Roy Symposium		•		•	•	•	
S2P: Semi-Solid Processing of Alloys and Composites	•	•		•	•	•	
Scaling Up from the Laboratory: Strategies, Examples, Challenges, and/or Solutions for Advanced Metal Manufacturing		•	•				
Shaping and Forming of Composite Materials	•						
Sintering and Related Powder-Processing Science and Technologies	•	•		•	•	•	•
Solid-State Processing					•		
8th International Symposium on Green and Sustainable Technologies for Materials Manufacturing and Processing			•		•	•	•
Ultra-High-Performance Metals, Metal Alloys, Intermetallics, and Metal-Matrix Composites for Aerospace, Defense, and Automotive Applications	•	•		•	•	•	
SPECIAL TOPICS							
Accelerated Insertion of Materials (AIM) Qualification	•	•					
Art and Cultural Heritage: Discoveries and Education				•	•	•	
Curricular Innovations and Continuous Improvement of Academic Programs (and Satisfying ABET Along the Way): The Elizabeth Judson Memorial Symposium	•	•					
International Standards for Properties and Performance of Advanced Ceramics – 30 Years of Excellence					•		
Materials Genome Initiative/Materials Today – Data Grand Challenge	•						
Perspectives for Emerging Materials Professionals	•	•					

SUBMIT YOUR ABSTRACTS by September 7, 2016

ELECTRONIC MATERIALS AND APPLICATIONS 2017

JANUARY 18-20, 2017 | DOUBLETREE BY HILTON | ORLANDO, FLA. USA | ceramics.org/ema2017

INTRODUCTION

Electronic Materials and Applications 2017 is an international conference focused on electroceramic materials and their applications in electronic, electromechanical, magnetic, dielectric, and optical components, devices, and systems. Jointly programmed by the Electronics Division and Basic Science Division of The American Ceramic Society, EMA 2017 will take place at the DoubleTree by Hilton Orlando at Sea World, January 18–20, 2017.

EMA 2017 is designed for researchers, engineers, technologists, and students interested in basic science, engineering, and applications of electroceramic materials. Speakers include an international mix of university, industrial, and federal laboratory participants exchanging 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.

The technical program includes plenary talks, invited lectures, contributed papers, poster presentations, and open discussions. EMA 2017 features 16 comprehensive symposia focused on optoelectronic, magnetoelectronic, and photonic ceramics; thermal energy conversion; multifunctional nanocomposites; superconductors; ion-conducting ceramics; and materials for millimeter wave applications. Other symposia emphasize broader themes covering processing, microstructure evolution, and integration; effects of surfaces and interfaces on processing, transport, and properties; mesoscale phenomena; and computational design of electronic materials.

Please join us in Orlando, Fla., to participate in this unique experience!

ORGANIZING COMMITTEE

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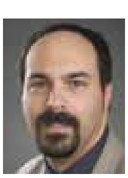
Colorado School of Mines
geoff.brennecka@mines.edu

Ming Tang
Basic Science Division
Rice University
mt20@rice.edu



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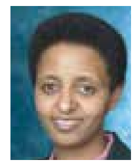
PLENARY SPEAKERS



Sossina Haile

Walter P. Murphy professor of materials science and engineering, Northwestern University

Neil Alford

Professor of physical electronics and thin-film materials, vice-dean (research) faculty of engineering, Imperial College London

TECHNICAL SESSIONS

S1: Advanced electronic materials: Processing, structures, properties, and applications

S2: Advanced processing for electronic and electrochemical systems: Crystals, films, and devices

S3: Ceramic photonic materials and applications

S4: Computational design of electronic materials

S5: Energy sustainable optoelectronics and magnetoelectronics

S6: Fundamentals to applications for the use of thermal energy for power generation and refrigeration

S7: In situ experiments of microstructure evolution and properties

S8: Interfaces and surfaces in energy-related ceramic materials

S9: Interfaces in microstructural evolution: Structure, properties, anisotropy, and motion

S10: Interfacial phenomena in multifunctional heterostructures: From theory to transport processes

S11: Ion-conducting ceramics

S12: 5G materials for the millimeter wave revolution

S13: Mesoscale phenomena in ceramic materials, nanostructures, and microstructures

S14: Multifunctional nanocomposites

S15: Superconducting materials and applications

S16: Failure: The greatest teacher

DOUBLETREE by HILTON ORLANDO AT SEA WORLD®

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Rate:
Single/double/triple/quad – $149

ceramics.org/icacc2017

SUBMIT YOUR ABSTRACTS BY AUGUST 22!

41ST INTERNATIONAL CONFERENCE AND EXPOSITION ON

ADVANCED CERAMICS AND COMPOSITES

Organized by the Engineering Ceramics Division of The American Ceramic Society

January 22 – 27, 2017 | Hilton Daytona Beach Resort and Ocean Center | Daytona Beach, Fla., USA

2017 Program Chair

Jingyang Wang

Shenyang National Laboratory for Materials Science Institute of Metal Research, Chinese Academy of Sciences

jywang@imr.ac.cn

The 41st International Conference and Exposition on Advanced Ceramics and Composites (ICACC) continues a strong tradition as the leading international meeting on advanced structural and functional ceramics, composites, and other emerging ceramic materials and technologies. The technical program consists of 15 symposia, three focused sessions, the 3rd Pacific Rim Engineering Ceramics Summit, and 6th Global Young Investigator Forum. These technical sessions, consisting of 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 in various aspects related to ceramic science and technology. This conference reached a milestone in 2016 celebrating its 40-year journey of ceramics and composites.

We look forward to seeing you in Daytona Beach, Fla., in January 2017!

Hilton Daytona Beach Resort

100 North Atlantic Ave., Daytona Beach, FL 32118
Phone: 386-254-8200

Rates:	One to four occupants:	$165
	Students:	$136
	U.S. government employees:	Prevailing rate

Mention The American Ceramic Society to obtain the special rate. Room rates are effective until December 16, 2017, and are based on availability.

ICACC17 TECHNICAL PROGRAM

S1 Mechanical behavior and performance of ceramics and composites

S2 Advanced ceramic coatings for structural, environmental, and functional applications

S3 14th International symposium on solid oxide fuel cells (SOFC): Materials, science, and technology

S4 Armor ceramics—Challenges and new developments

S5 Next-generation bioceramics and biocomposites

S6 Advanced materials and technologies for direct thermal energy conversion and rechargeable energy storage

S7 11th International symposium on functional nanomaterials and thin films for sustainable energy harvesting, environmental, and health applications

S8 11th International symposium on advanced processing and manufacturing technologies for structural and multifunctional materials and systems (APMT11)

S9 Porous ceramics: Novel developments and applications

S10 Virtual materials (computational) design and ceramic genome

S11 Advanced materials and innovative processing ideas for the production root technology

S12 Materials for extreme environments: Ultra-high-temperature ceramics (UHTCs) and nanolaminated ternary carbides and nitrides (MAX phases)

S13 Advanced materials for sustainable nuclear fission and fusion energy

S14 Crystalline materials for electrical, optical, and medical applications

S15 Additive manufacturing and 3-D printing technologies

FS1 Geopolymers, chemically bonded ceramic, ecofriendly, and sustainable materials

FS2 Advanced ceramic materials and processing for photonics and energy

FS3 Carbon nanostructures, 2-D materials, and composites

6th Global Young Investigator Forum

3rd Pacific Rim Engineering Ceramics Summit

SUBMIT YOUR ABSTRACTS BY AUGUST 22!

ceramics.org/icacc2017

TENTATIVE SCHEDULE OF EVENTS

Sunday, January 22

Conference registration	2 – 7 p.m.
Welcome reception at Hilton	5:30 – 7 p.m.

Monday, January 23

Conference registration	7 a.m. – 6 p.m.
Opening awards ceremony and plenary session	8:30 a.m. – Noon
Companion coffee	9 – 10:30 a.m.
Lunch on own	Noon – 1:20 p.m.
Concurrent technical sessions	1:30 – 5:30. p.m.
Young Professionals Network, GGRN, student mixer	7:30 – 9 p.m.

Tuesday, January 24

Conference registration	7:30 a.m. – 6 p.m.
Concurrent technical sessions	8:30 a.m. – Noon
Lunch on own	Noon – 1:20 p.m.
Concurrent technical sessions	1:30 – 6 p.m.
Exhibits and poster session A, including reception	5 – 8 p.m.

Wednesday, January 25

Conference registration	7:30 a.m. – 5:30 p.m.
Concurrent technical sessions	8:30 a.m. – Noon
Lunch on own	Noon – 1:20 p.m.
Concurrent technical sessions	1:30 – 5 p.m.
Exhibits and poster session B, including reception	5 – 7:30 p.m.

Thursday, January 26

Conference registration	7:30 a.m. – 6 p.m.
Concurrent technical sessions	8:30 a.m. – Noon
Lunch on own	Noon – 1:20 p.m.
Concurrent technical sessions	1:30 – 5 p.m.

Friday, January 27

Conference registration	8 a.m. – Noon
Concurrent technical sessions	8:30 a.m. – Noon

Current as of July 25, 2016

EXHIBITION INFORMATION

Reserve your booth today for the premier international advanced ceramics and composites expo. Connect with decision makers and influencers in government labs, industry, and research and development fields. ICACC17 is your destination to collaborate with business partners, cultivate prospects, and explore new business opportunities.

Exhibit hours: **Tuesday, January 24, 5 – 8 p.m.** | **Wednesday, January 25, 5 – 7:30 p.m.**

Exhibit location: Ocean Center Arena, 101 North Atlantic Ave., Daytona Beach, FL

Exhibit space is filling up fast. To reserve your booth, visit ceramics.org/icacc2017 or contact Mona Thiel at mthiel@ceramics.org or 614-794-5834.

Exhibitor	Booth
Alfred University	315
AVS	307
Centorr	200
CM Furnaces	311
C-Therm	220
Gasbarre (PTX)	207
H.C. Stark	305
Haiku Tech	214
Harper International Corp.	317
MEL Chemicals	313
Microtrac	306
Netzsch Instruments	300
NIST	111-113
Noritake	302
Oxy-Gon Industries, Inc.	320
Reserved	216
Sonoscan	221
TA Instruments	210
Tev Tech	212
Thermal Wave	321
Verder Scientific (Carbolite)	206
Zircar Ceramics	304

new products

Spectrometer

Bruker's Tensor II is a high-performing yet compact Fourier transform infrared spectrometer. The spectrometer combines the highest sensitivity and outstanding flexibility with an intuitive and easy-to-operate interface. Tensor II provides outstanding performance for highest sensitivity and offers flexibility and expandability for unlimited in-compartment sampling and coupling technology. The instrument is reliable and virtually maintenance-free, and it has a large sample compartment to accommodate most sampling accessories.

Bruker Optics (Billerica, Mass.)
bruker.com
978-439-9899

Ceramic adhesive

Aremco's new Ceramabond 685N is a single-part, dispensable, zirconium silicate-based adhesive and sealant system that bonds tenaciously to galvanized metals, dense ceramics, and ceramic cloth, paper, and rope products. The adhesive offers a maximum temperature resistance of 1370°C. Ceramabond 685N is an easy-to-apply, fast-setting, thixotropic, water-dispersible paste, which contains no asbestos or volatile organic compounds. After it is cured, the adhesive exhibits tensile-shear strength of 500 psi, linear shrinkage of less than 2%, and exceptional chemical, moisture, and thermal shock resistance.

Aremco Products
(Valley Cottage, N.Y.)
aremco.com
845-268-0039

Tumble blender

Ross tumble blenders now come standard with motors equipped with electromagnetic brakes as an added safety feature. The braked motor allows the tumbling V-cone or double-cone vessel to safely decelerate to a complete stop at the proper upright position. The blender is available in standard sizes from 0.25 to 100 ft^3. Ross offers tumble blenders with various options, such as vacuum capability, heavy-duty design for high-density applications, heating/cooling jacket, explosion-proof motor, and PLC controls. Ross offers assistance from planning and engineering to delivery and start-up.

Charles Ross & Son Co.
(Hauppauge, N.Y.)
mixers.com
800-243-ROSS

Dust collector

RoboVent's new Spire dust collector addresses the needs of robotic welding operations where space is at a premium. Spire has the smallest footprint in the industry, while allowing robotic welding facilities to meet air-quality regulations. Spire was specifically designed to complement the most common robotic welding applications used in the automotive industry, although it can be applied to many other industries as well. Spire is a flexible, cost-effective alternative to centralized ducted systems.

RoboVent (Sterling Heights, Mich.)
robovent.com
888-ROBOVENT

3-D reconstruction software

FEI has released the latest version of its Auto Slice & View 3-D reconstruction software, which makes 3-D imaging faster, easier, more accurate, and cost effective. The software works with all of FEI's current DualBeam focused ion beam and scanning electron microscope platforms to enable 3-D structure and composition of samples at the nanometer scale. Slice & View 4.0 offers enhanced productivity, precision, and accuracy, and it is easy to use. Current users of version 3.0 can upgrade to the new 4.0 version.

FEI Co. (Hillsboro, Ore.)
fei.com
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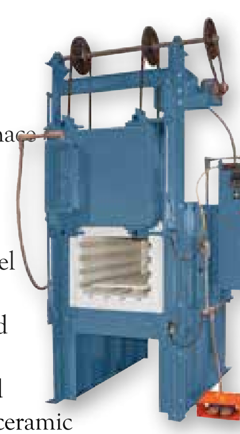
Box furnace



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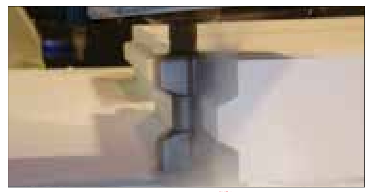

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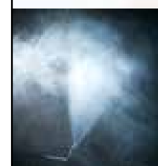

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deciphering the discipline

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 (PCSA).

Scott McCormack
Guest columnist

How to decide where to study your Ph.D.

As I prepared to finish my undergraduate degree, I asked myself where I should continue my graduate education. I already had a decent idea about what sort of research I wanted to pursue—in my opinion, it does not get any better than materials for high-temperature engines. So I had the "what"—I just had to figure out the "where." My homeland of Australia? Europe? The United States?

Each continent has pros and cons when considering a Ph.D. For example, in Australia, because I had already completed my honors thesis, it would take me just three years to complete my studies. This sounded fantastic when compared to the U.S., where it would take more than five years and I would have to enroll in classes. After completing four years of classes during my undergraduate studies, I was rather over classes—instead, I was eager to explore laboratory work. Europe's Ph.D. programs had a similar timeframe as Australia, but they first encouraged a two-year masters degree, resulting in similar overall time as U.S. programs.

Although duration is an important factor, there are other considerations, too. For instance, money is incredibly important—particularly research funding. The U.S. government offers significant funding for scientific research, especially for high-temperature materials because of their relation to military and space applications. This is one criterion where Australia was lacking. Although the Australian government had offered what is called an Australian Postgraduate Award, an award that guaranteed personal tax-free funding, there was talk of the Australian government cutting STEM funding. So, although my personal finances were far superior in Australia than the U.S., actual research funding was inferior.

Next on the checklist is opportunity for growth. When I think of opportunity, I like to consider personal growth as well academic growth. I firmly believe that our ability to engineer new ideas is constrained by our experiences. So, the more experiences you have, the more creative you will be. Based on this, moving out of my comfort zone would be the best solution—instantly slashing my homeland from the choices. So which continent has the best opportunities for growth, Europe or the U.S.? The U.S. and Europe offer similar opportunities for research growth, both having a large selection of national research facilities. From historical and cultural perspectives, the answer was Europe. But, on the other hand, I would have to learn multiple languages. Being Australian, the only language I was proficient in was Australian–English, which made the U.S. more appealing.

After mulling over these different considerations, I finally decided to travel to the U.S. to pursue my Ph.D. research. My choice turned out to be fantastic—the research project I work on is highly funded, allowing me to travel around the U.S. to national laboratories, including Argonne National Laboratory, Oak Ridge National Laboratory, and Brookhaven National Laboratory, to conduct in-situ high-temperature X-ray and neutron powder diffraction experiments. In addition, each year my advisor gives me a month off for travel, so I have been able to experience American culture by traveling around the country.

All in all, it is difficult to decide where to pursue ones' research ambitions for a Ph.D. But the best advice I can give when considering graduate study is to go somewhere else—somewhere far away from your roots. Only there you will truly learn about yourself and the science of the world around you.

The world—a map of options.

Scott McCormack is a true blue Aussie who has ventured out from the gum leaves to pursue a Ph.D. in materials science and engineering at the University of Illinois at Urbana-Champaign. McCormack grew up in the small secluded coastal town of Eden, located on the far south coast of Australia. He obtained a bachelor's degree and completed an honors thesis in materials engineering at the University of Wollongong in New South Wales, Australia. ■

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