AMERICAN CERAMIC SOCIETY

bulletin

emerging ceramics & glass technology

SEPTEMBER 2015

Celebrating ACerS—2015 awards and honors

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- Inside look at 3M-Ceradyne merger •
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- Meeting previews: MS&T15, ICACC'16, EMA'16 •


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bulletin

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FROM THE AMERICAN CERAMIC SOCIETY

August 12, 2015 | The day's top ceramic and glass materials news from around the globe

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MS&T15 REGISTER NOW!

New atomic-scale observations could lead to engineering of ductile yet strong ceramics
By April Gocha
Researchers at the University of California, Los Angeles have made new observations that could help design ultrahigh temperature ceramics that overcome the materials' biggest limitation—brittleness.
Read more | Forward to a friend

New application method creates scale-up opportunity for diamond-like fuel-saving coating
By Stephanie Liverani
With fuel saving and lower emissions in mind, researchers at Fraunhofer Institute have developed a method for applying friction-reducing diamond-like coatings, which they say can be scaled up and easily integrated with existing technology.
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Apple patents method to manufacture harder zirconia ceramic
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Power of materials
These door handles use titanium dioxide to stop spread of germs
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ACSBA7, Vol. 94, No. 7, pp 1–56. All feature articles are covered in Current Contents.

news & trends

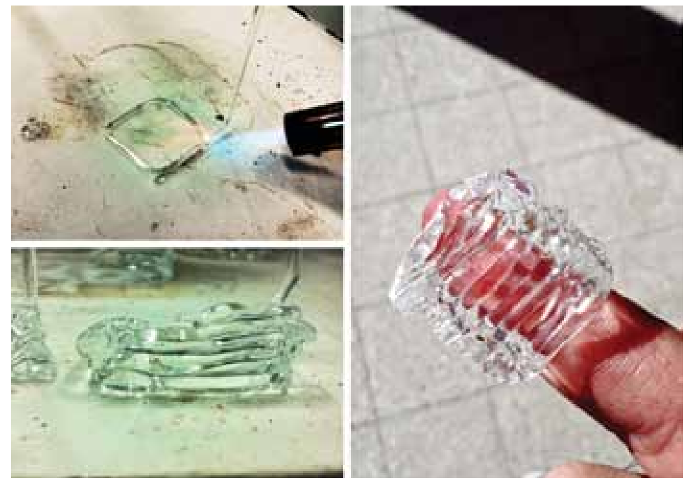
Micron3DP innovates 3-D printing with glass

The additive manufacturing revolution has infiltrated seemingly every type of material—concrete, metals, even ceramics.

Micron3DP (Hod Hasharon, Israel), a 3-D printing company that develops and builds all-metal extruders, now has experimented successfully with advanced 3-D printing methods for what may be the final frontier in 3-D printed materials: glass.

"This is the first time that glass has been printed in liquid hot form," according to a Micron3DP press release. "Micron had succeeded in printing 'soft' glass at a temperature of 850 degrees, as well as borosilicate glass at a melting temperature of 1,640 degrees Celsius."

According to an article on 3Dprint.com, Eran Gal-Or, R&D manager at Micron3DP, says that "Micron3DP made a successful 3-D printing test, and although efforts have been made in the past by other companies to print with this medium, this is the first time that glass has been printed in liquid hot form—and Micron has accomplished it by means of its innovative way of 3-D printing in an extremely hot extruder."



Micron3DP's patent-pending process 3-D prints molten glass into layered architectures.

The printer extrudes hot molten glass in single layers, which quickly harden before the next layer is laid down, to build up complex architectures.

Gal-Or says in an email that the company has a patent pending for the glass-printing technology, so it is not yet releasing further technical details or a glimpse of the printer in action.

According to the release, Micron3DP is "looking for a strategic investor for the molten glass-printing field, which is fast becoming the next HOT area." ■

Plan to cut airplane emissions could mean big things for ceramic-matrix composites

The United States Environmental Protection Agency is gearing up to develop standards to reduce emissions from airplanes, according to a recent *NY Times* article.

So how will the industry be able to comply? Similar to the auto industry, one relatively simple way to slash emissions is to make vehicles lighter.

Credit: Tim Wang; Flickr CC BY-SA 2.0

The body of Boeing's 787 Dreamliner integrates composites to save weight. GE plans to reduce engine weight by replacing nickel-based alloy tubine blades with ceramic matrix composites.

Lightweighting is nothing new to the aerospace industry. Planes that use lighter materials, namely composites, have been creeping into the industry for some time.

One notable example is the composite-clad body of Boeing's 787 Dreamliner.

"Only 1% of the weight of Boeing's 747 jumbo jet came from composite parts when that jet was introduced in 1969. That increased to 11% by 1995 on the 777, which has an all-composite tail section. ... Composites now account for half of the 787's weight, which, together with more efficient engines, cut fuel consumption by 20%," according to a *NY Times* article about the jet.

Lighter composite parts have infiltrated other parts of jets, too—GE is putting ceramic-matrix composites (CMCs) into jet engines with recent successful tests of moving CMC components.

GE's CMC turbine blades are as strong as metal, but with higher temperature resistance in a package that is just one-third the weight of traditionally used nickel alloys.

"Going from nickel alloys to rotating ceramics inside the engine is the really big jump. But this is pure mechanics," says Jonathan Blank, general manager of CMC and advanced polymer-matrix composite research at GE Aviation, in a GE Aviation press release. "The lighter blades generate smaller centrifugal force, which means that you can slim down the disk, bearings, and other parts. CMCs allow for a revolutionary change in jet engine design."

GE is not the only company working on CMC advances for airplanes. Boeing also recognizes the potential of CMCs with the recent completion of its own tests of new composite engine nozzles.

Regardless of the specific component, however, composites are certain to continue an upward trajectory in the aerospace industry.

Aerospace applications comprise the largest segment of the growing CMC market, which is predicted to expand to $2.4 billion by 2019, according to a recent market report. Those aerospace applications are predicted to grow at an annual rate of 14.06% from 2014 to 2019. ■

Business news

CoorsTek Membrane Sciences combines active ceramic membranes and electrochemistry (**coorstek.com**)…3M files patent infringement lawsuit to protect dental ceramic technology (**3M.com**)…Amedica Corp. provides update on FDA questions and femoral head testing protocol (**amedicacorp.com**)…Anderman Ceramics Ltd. now offers a comprehensive range of advanced ceramics (**earthwaterfire.com**)…Logan Clay Products celebrates 125th anniversary (**loganclaypipe.com**)…Molycorp signs restructuring support agreement with key creditors (**molycorp.com**)…Tytan 3D unveils the GAJA Multitool MAXX—3-D ceramic printer, milling machine, and more (**tytan3d.com/en**)…Murata Energy Solutions introduces solution to automate demand response (**murata.com**)…Corning to invest in Gen 8.5 LCD glass substrate finishing facility in Chongqing, China (**corning.com**)…Johnson Matthey agrees to sale of research chemicals business Alfa Aesar (**matthey.com**)…Kyocera breaks ground on new manufacturing plant in China for industrial cutting tools (**global.kyocera.com**)…Alcoa to close Poços smelter in Brazil (**alcoa.com**)…NexTech awarded NASA contract to develop methane/oxygen fuel cell system (**nextechmaterials.com**)…Sacmi and Sasil turn glass fiber manufacturing waste into raw materials (**sacmi.com**)…Schott offers single source for all active and passive glass components for lasers (**schott.com**)…Riedhammer presents the new generation of indirectly heated DRA rotary kilns (**riedhammer.de**)…SAMA's new generation of isostatic presses takes the market by storm (**sama-online.com**)…Lucideon publishes new testing brochure (**lucideon.com**)…H.C. Starck and Metasphere Technology partner in 3-D printing of metal powders (**hcstarck.com**) ■

Material ConneXion is a library with an impressive collection—a database of about 7,500 materials. ▶


Credit: Material ConneXion

Touch the future of new materials—literally

There is a library on the 17th floor of a building near Rockefeller Center in New York City—but you will not find a copy of *War and Peace* anywhere in the place. Instead, you will find things such as conductive glass, translucent cement, and aluminum foam.

The library is Material ConneXion, one of the largest subscription-based materials libraries on the globe, with about 7,500 innovative materials and processes in its database that spans a wide range of disciplines and industries focused on bridging the gap between science and design. It has more than a million active members from Fortune 500 companies, forward-thinking agencies, and areas of government in search of cultivating a creative, competitive, or sustainable edge in their respective establishments.

The New York City location is home to about 2,500 materials on exhibition for clients. George Beylerian founded the library in 1997, and he called Material ConneXion, "a 'petting zoo' for new materials as a resource for architects and designers." From the beginning, visitors have been encouraged to poke, pull, and grab any materials on display.

The already-impressive collection is growing all the time. Materials are selected through a strict review process, and more than 40 new materials are independently juried into the library every month.

"I feel that if we could class the 20th century as a 'synthetic century,' where we spent all of our energy and resources in manufacturing synthetic materials, I think ... or I hope ... the 21st century will be a 'biological century.' We finally understand nature more effectively, and, if we can use it effectively, it will allow us to create new materials, which will require less resources, less energy, and are just more complexly produced," Andrew Dent, vice president, library and materials research at Material ConneXion, says in a video about the library from *The Economist*.

See the video at https://www.youtube.com/watch?v=DUYL7nQVCh4. ■

Society and Division news

Welcome to our newest Corporate Members!

ACerS recognizes organizations that have joined the Society as Corporate Members. For more information on becoming a Corporate Member, contact Megan Bricker at mbricker@ceramics.org, or visit www.ceramics.org/corporate.

Denka DENKI KAGAKU KOGYO KABUSHIKI KAISHA

Denka Corporation
New York, N.Y.
www.denka.co.jp/eng/

G.W. SCHULTZ TOOL

G.W. Schultz Tool
Tavares, Fla.
www.gwschultz.com

Attend your Division business meeting at MS&T15

Five ACerS Divisions will hold executive and general business meetings at MS&T15, October 4–8, at the Columbus Convention Center in Columbus, Ohio.

- Basic Science: October 6, Noon–1 p.m.
- Electronics: October 5, Noon–1 p.m.
- Engineering Ceramics: October 7, Noon–1 p.m.
- Glass & Optical Materials: October 5, 4:30–5:30 p.m.
- Nuclear & Environmental Technology: October 6, 5:45–6:30 p.m.

The Manufacturing Division strategic planning session will be held October 3, all day at the Hilton Downtown Columbus Hotel.

For more information, contact your Division chair or Marcia Stout at mstout@ceramics.org.

MS&T15 registration for ACerS Distinguished Life and Senior, Emeritus members

ACerS offers complimentary MS&T15 registration for Distinguished Life Members and reduced registration for Senior and Emeritus members. These special offers are available only through ACerS. Registration forms are available at ceramics.org/meetings/117th-annual-meetingcombined-with-mst15 and should be submitted by **September 7, 2015**, to Marcia Stout at mstout@ceramics.org. Banquet tickets may also be purchased at time of registration.

Fore! Register for the Pittsburgh Section Annual Golf Outing

ACerS Pittsburgh Section will host its annual golf outing on September 14, at Cedarbrook Golf Course, in Belle Vernon, Pa. Early registration and prepay deadline is **September 1**. The fee is $100 per player. Register by phone at 412-788-7100, and visit the Pittsburgh Section's website for additional information at ceramics.org/sections/pittsburgh-section.

INTERNATIONAL YEAR OF LIGHT 2015

The United Nations General Assembly declared 2015 as the "International Year of Light and Light-based Technologies." The September ACerS *International Journal of Applied Glass Science* will mark the occasion with a special issue on the theme of "Glass and Light." According to *IJAGS* coeditor, David Pye, the Year of Light has captured the attention of the global scientific community, especially glass scientists. The special issue will include articles from 16 internationally recognizes experts in research of glass and light from eight countries.

Names in the news

Aldo R. Boccaccini wins top materials award


Boccaccini

Aldo R. Boccaccini, head of the Institute of Biomaterials, Department of Materials Science and Engineering, University of Erlangen-Nuremberg, Germany, will receive the DGM Award (DGM Preis 2015) from the German Materials Society. This award recognizes materials scientists for outstanding scientific or technological outputs in the general field of materials science and engineering. Boccaccini is an ACerS Fellow and member of the Basic Science Division.

Calling all potential Emeritus members

If you will be 65 years old (or older) by **December 31, 2015**, and will have 35 or more years of continuous membership in ACerS, you are eligible for Emeritus status. Emeritus members enjoy waived membership dues and reduced meeting registration rates. To verify your eligibility, contact Marcia Stout at mstout@ceramics.org.

Keramos reception to kick off MS&T15

The Keramos National Board of Directors invites all attendees to the first annual Keramos Reception, which will kick off MS&T15 on October 4 from 5–7 p.m., in the Bellows C Room at the Hilton Columbus Downtown in Columbus, Ohio. This year Keramos celebrates the 100th anniversary of its alpha chapter at the University of Illinois and will induct its 10,000th member.

Students and outreach

Student travel grants available for 76^{th} GPC

The Glass Manufacturing Industry Council is offering $400 travel grants to 20 students attending the 76^{th} Glass Problems Conference, November 2–5, 2015, in Columbus, Ohio. Students are also invited to attend the Anchor Hocking Plant Tour in Lancaster, Ohio, on November 2. To apply for a grant or register for the tour, contact Donna Banks at dbanks@gmic.org by **September 30.** ■

Student awards and competition at Electronic Materials and Applications 2016

The Electronic Materials and Applications 2016 (EMA 2016) conference follows its established tradition of supporting undergraduate and graduate student participation. Six awards with cash prizes for best student presentations and posters will be given at next year's event. The abstract deadline is **September 9, 2015**. Visit the EMA 2016 meeting site for more information at ceramics.org/meetings/electronic-materials-and-applications-2016. ■

Attention students: Plan ahead for MS&T15

Planning your itinerary for MS&T15?

ACerS' Nuclear & Environmental Technology Division is sponsoring two stipends—$500 each—to help fund students attending MS&T15 combined with ACerS 117^{th} Annual Meeting, October 4–8 in Columbus, Ohio. The nomination deadline is **September 1**. For complete details and the nomination form, visit ceramics.org/?awards=student-stipend-for-mstacers-annual-meeting.

Join fellow Material Advantage student members from around the world at MS&T15, and participate in special student activities and contests. The deadline for the MA Undergraduate Student Speaking Contest and the Undergraduate Student Poster Contest is **September 21**. For contest rules, visit materialadvantage.org.

Check out the popular Ceramic Mug Drop and the Ceramic Disc Golf contests, both to be held at MS&T15 on October 6. To participate, contact Brian Gilmore at Brian.Gilmore@pxd.com.

Students and outreach (continued)

Students will have the opportunity to tour Allied Mineral Products Inc. on October 5, Noon–5 p.m. ACerS' President's Council of Student Advisors is organizing the tour. For more information about all things MS&T15 or to register for the tour, contact Tricia Freshour at tfreshour@ceramics.org. ■

Awards and deadlines

ACerS/BSD Ceramographic Exhibit & Competition

Start working on your entry for the 2015 Ceramographic Exhibit & Competition, organized by the ACerS Basic Science Division! This unique competition at MS&T15 promotes microscopy and microanalysis as tools in the scientific investigation of ceramic materials. The Roland B. Snow award is presented to the Best of Show winner of the competition. Winning entries are featured on the back covers of the *Journal of the American Ceramic Society*. The deadline to submit posters (no digital files) is **September 21, 2015**. Find out more at ceramics.org/?awards=ceramographiccompetition-and-roland-b-snow-award. ■

Varshneya Glass Science Lectures nominations

The Glass & Optical Materials Division invites nominations for the Darshana and Arun Varshneya Frontiers of Glass Science and Glass Technology Lectures. The lectures encourage scientific and technical dialog in glass topics that define new horizons and highlight new research or new product development potential that is beneficial to the industry. Winners will present their lectures during the GOMD Annual Meeting, May 22–26, 2016, in Madison, Wis. Send nominations to Marcia Stout at mstout@ceramics.org by **November 16, 2015**. Download the nomination form at ceramics.org/?awards=darshana-and-arun-varshneya-frontiers-of-glass-lectures. ■

More ceramics news

Bangladesh Ceramic Society elects new 2015 executive committee

In its general meeting May 16 The Bangladesh Ceramic Society elected a new 2015 executive committee. Aftabuddin Ahmed, past-director of IGCRT, BCSIR and former visiting professor of chemistry at Ahsanullah University of Science & Technology (Dhaka, Bangalesh) is president.

Newly elected vice presidents include: Asif Ariff Tabani, managing director at Mirpur Ceramic Works Ltd.; S.B. Zaman, advisor at X-Ceramics Ltd.; Nasrin Farooque, past-director at IGCRT, BCSIR; and Mahbub Alam, managing director at Pawan Ceramic Tiles Ltd. Hedayetul Islam, technology instructor at the Bangladesh Institute of Glass & Ceramics, is now general secretary, and Abul Hossain, past-chief scientific officer at IGCRT, BCSIR, is treasurer. AJM Tahuran Negar, direcor-in-charge at IGCRT, BCSIR, is now joint secretary, and Monsur Rahman, past-general manager at the Bangladesh Insulator & Sanitary Ware Factory, is publicity secretary.

For more information, contact bcers1993@gmail.com. ■

In memoriam

Günther H. Frischat
Hamlin Jennings

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

Highlights from SeCerS Bioceramics Division meeting

The Serbian Ceramics Society (SeCerS) held its Bioceramics Division meeting July 10, at the University of Niš (Niš, Serbia). The agenda covered recent SeCerS activities, including elections for the division's board and officers.

Vojislav V. Mitić, president of SeCerS, announced that the Advances in Ceramics Applications IV conference will be held September 21–23, 2015, at the Serbian Academy of Sciences and Arts (Belgrade, Serbia). ■

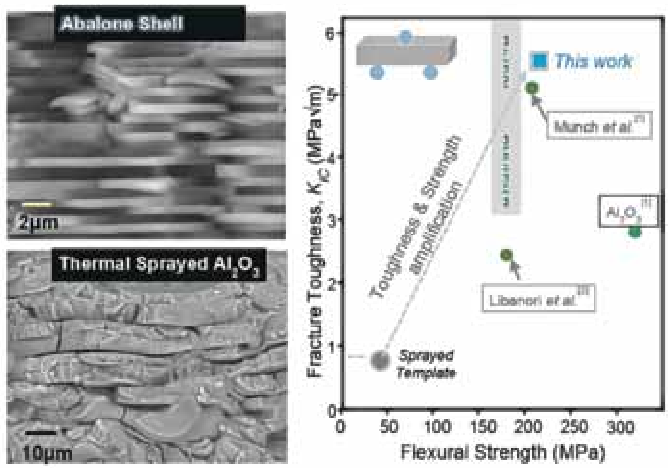
Credit: SeCerS

(Pictured left) Vojislav V. Mitić, president of SeCerS, and Stevo J. Najman, newly elected SeCerS Bioceramics Division chair, (right) lead the division meeting.

Thermal spray fabricates nature-inspired ceramic composites that mimic nacre

by Sanjay Sampath

Researchers from the Center for Thermal Spray Research at Stony Brook University in New York recently reported the ability to use thermal-sprayed ceramic deposits as templates for synthesis of ceramic–polymer composites with striking microstructure and mechanical behavior similar to those observed in nacre (mother-of-pearl).



Micrographs of the layered structure of thermal-sprayed Al_2O_3, which mimics that of nacre (left). On the right, an Ashby-type map depicts the materials' mechanical properties, which are similar to nacre and higher than reported values.

Credit: Reprinted with permission from John Wiley and Sons

Using a rod flame spray ceramic deposition process, the team produced layered and porous templates with porosity of 10–14 vol%.

To achieve the desired structure, the team separated the sprayed deposit from the substrate, and then infiltrated the freestanding template with a low-viscosity epoxy mixture. The epoxy components infiltrated the channels, and curing resulted in a hybrid composite with 5–10 vol% porosity and dramatic improvements in strength and crack initiation toughness.

The robust behavior is revealed in microstructural observation of the deformation zone, revealing several characteristics seen in nacre, including layer sliding and pullout, crack deflection, and branching. This initial data shows the technique is promising, with additional work underway to refine template architecture (thinner platelets), more appropriate polymers, and enhanced infiltration techniques.

A unique attribute of this approach is the intrinsic scalability of the technology. Thermal spray is a widely used manufacturing process for deposition of metallic, ceramic, and cermet coatings across a range of industrial sectors—gas turbines, aerostructures, heavy machinery, semiconductors, automotive products, and biomedical implants.

The paper, published in *Advanced Materials*, is "Bio-inspired hybrid materials from spray formed ceramic templates" (DOI: 10.1002/adma.201500303). ■

Research News

First solar cell made of highly ordered molecular frameworks

Researchers at Karlsruhe Institute of Technology have developed, for the first time, a functioning organic solar cell. It is based on novel metal–organic framework (MOF) compounds. The scientists now have produced MOFs based on porphyrines, which have interesting photophysical properties. The material is highly elastic and also might be used for flexible coating of deformable components. Computations suggest that the excellent properties of the solar cell result from an additional mechanism—the formation of indirect band gaps—that plays an important role in photovoltaics. The team expects that photovoltaic capacity of the material can be increased by filling pores in the crystalline lattice structure with molecules that can release and take up electric charges. For more information, visit kit.edu.

Visualizing the evolution of ceramic research

The authors of a new paper published in the *Journal of the American Ceramic Society* have mined bibliographic records "to follow and help understand the evolution of a research domain, at a level that cannot be captured by reading individual papers in a field of this size," according to the paper's abstract.

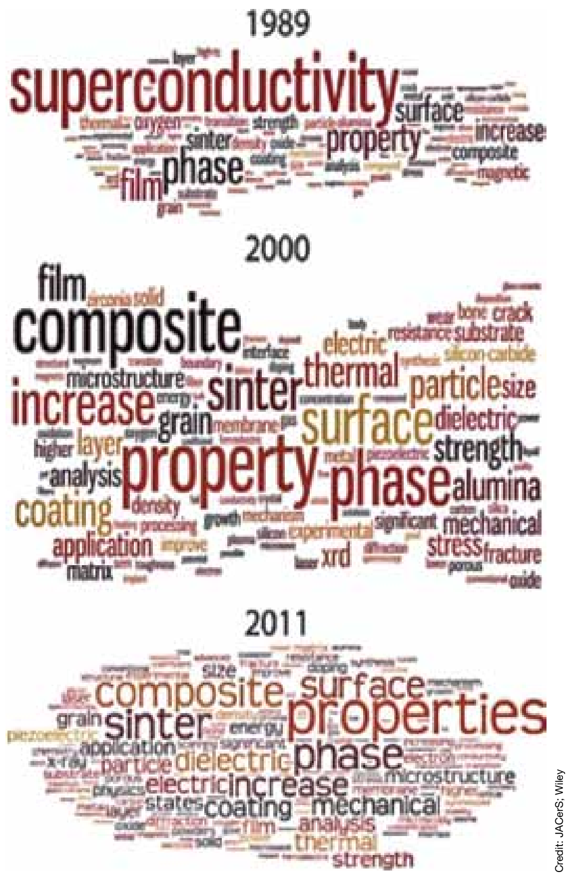
Authors Sylvain Deville and Adam J. Stevenson's field-encompassing analysis of 43 years of ceramic materials research, covering 253,000 records, shows specific patterns of keywords that provide insight into trends in the field.

"We think this data-mining and analysis technique can help identify future research directions, in combination, of course, with good knowledge of the field," Deville writes in an email. "The technique will be helpful to identify mature topics as well as fashionable ones and to track real-time analytics, too."

In addition to statistically analyzing the occurence and evolution of particular keywords in published literature at various points through the history of ceramic research, the authors also built co-word networks that analyze associations among authors, collaborations, or keywords to visually link individuals and topics. The networks can identify quickly predominant materials, techniques, or studied properties—information that could then identify possible areas for future research and opportunities for new connections.

Besides providing some interesting food for thought, the authors speculate their analysis also can provide insight into industry. Evolving trends can provide clues about what technologies are worthwhile industrially by indicating which trends are emerging or whether specific areas have died out.

The paper is "Mapping ceramics research and its evolution" (DOI: 10.1111/jace.13699). ■



Word clouds depict relative occurence of the most commonly used keywords in titles and abstracts at a particular time in the history of ceramics research.

New process recycles magnets from factory floor

A new recycling method developed by scientists at the Critical Materials Institute, a U.S. DOE Innovation Hub led by the Ames Laboratory, recovers valuable rare-earth magnetic material from manufacturing waste and creates useful magnets out of it. The process, which inexpensively processes and directly reuses samarium–cobalt waste powders as raw material, can be used to create polymer-bonded magnets that are comparable in performance to commercial-bonded magnets made from new materials. It also can be used to make sintered magnets. The product may be a more cost-effective choice for some applications, reducing the need for more expensive neodymium–iron–boron magnets. The researchers are now exploring other possibilities for the technology as well, including production of sintered samarium–cobalt magnets. For more information, visit science.energy.gov.

A diode a few atoms thick shows surprising quantum effect

A quantum mechanical transport phenomenon called negative differential resistance (NDR) demonstrated in synthetic, 2-D layered materials could lead to novel nanoelectronic circuits and devices, according to researchers at Pennsylvania State University and other universities. The researchers observed the effect in van der Waals materials consisting of a base of graphene followed by atomic layers of either molybdenum disulfide (MoS_2), molybdenum diselenide ($MoSe_2$), or tungsten diselenide (WSe_2). What caught the researchers' attention was a sharp peak and valley in their electrical measurements where there would normally be a regular upward slope. They were seeing a 2-D version of a resonant tunneling diode, a quantum mechanical device that operates at low power. For more information, visit news.psu.edu.

Visualizing the atomic surface structures of cerium dioxide nanocrystals

When it comes to reducing toxins released by burning fossil fuels, a catalyst needs to be reliable. Yet, a promising catalyst, cerium dioxide, has three distinct surfaces that behave differently. Now researchers at Northwestern University, Oak Ridge National Lab, and Argonne National Lab have glimpsed an atomically resolved view of the three structures. This information may provide insights into why the surfaces have distinct catalytic properties. Advanced chromatic- and spherical-aberration-corrected electron microscopy allowed the team to view the molecular organization and features of cerium and oxygen atoms within the lattice regions. The variation in surface defect density between the three facets appears to be responsible for their differences in catalytic activity and potentially opens options to modify faces of cerium dioxide nanoparticles to develop face-selective catalysts. For more information, visit science.energy.gov. visit upenn.edu. ■

Expanding horizons of varistors in electronics

by R. K. Pandey

A varistor is a simple two-terminal device primarily based on ceramic substrates. It is an indispensable component of almost all electrical and electronic circuits because of its unique ability to offer protection to the circuit and its electronic components, such as a diode or a transistor, from abrupt surges in voltage or current caused by violent weather or by instrumentation failure at power stations.

Despite their practical importance and long productive life, varistors today remain the unsung hero of electronics, especially when compared with more glamorous silicon-based transistors and diodes.

Nonetheless, new horizons for varistors began to unfold at Texas State University around 2011–2012. With the help of just a few undergraduate electrical engineering students and collaboration with faculty colleague William A. Stapleton, Texas State researchers began searching for new applications for varistors.

While studying the modified current–voltage characteristics of varistors based on iron titanate ceramic substrates, the team soon realized that varistors and transistors indeed are strongly coupled devices. During all these years, the full potential of varistor devices has not been realized fully. This led to the discovery of so-called varistor–transistor hybrid (VTH) devices.

Three types of transistors embedded in a varistor were identified: voltage-biased transistors (VBT); electric field effect transistors (E-FET); and magnetic field effect transistors (H-FET).

Forging ahead, the team stumbled into the discovery of a novel varistor—or, more precisely, a varistor-based magnetic sensor—with many applications, including exploration of new energy sources by well logging. Other devices that could be produced using the modified current–voltage characteristics of a varistor include signal amplifiers, low pass filters that include the range of human auditory systems, and audio amplifiers. The team hopes that by paving the pathway for expanded horizons of a varistors it has shown the way for new ceramic-based electronic technology to emerge. ■

Credit: R.K. Pandey; Texas State

Experimental setup to determine the effects of a magnetic field on the current–voltage characteristics of a varistor.

Sandia's falling-particle receiver drops ceramics like they are hot, because they are

Ceramic particles are taking the heat at Sandia National Labs.

There, scientists are testing the utility of falling-particle receivers to efficiently collect and store solar energy.

Sandia's receivers drop ceramic particles through a beam of concentrated sunlight, where the particles absorb solar energy and store that energy as heat. Because of the thermal stability of ceramic particles, the Sandia team hopes its receivers can operate more efficiently than conventional solar energy storage systems, which use molten salt.

The project—in which Sandia pairs up with partner institutions Georgia Institute of Technology, Bucknell University, King Saud University, and the German Aerospace Center (DLR)—was first funded by the Department of Energy's SunShot Initiative in 2012.

A new press release from Sandia reports that the project has moved beyond the development stage and has started testing. Sandia engineers now have lifted the falling-particle receiver on top of the National Solar Thermal Test Facility (Albuquerque, N.M.), where the receiver will continue testing through this year.

The facility—the only test facility for large-scale solar thermal power generation in the United States—consists of an 8-acre heliostat field, complete with 218 automated mirrors (heliostats) that surround a testing tower. When those mirrors coordinate on a single focal point, they intensify the sun's energy by 2,500 times, according to a video about the facility.

Although conventional molten-salt receivers operate at a cool 600°C, the Sandia team says its particle receiver can operate in excess of 1,000°C because of the heat resistance of the ceramic particles.

According to a 2013 project update for the SunShot program, the team tested the performance of several types of particles, including varieties of sintered bauxite.

Cliff Ho, who leads the project at Sandia, says that the team uses Carbo Accucast ceramic particles (~280 μm mean diameter) in the system—the same ceramic proppants that used in fracking. "These particles have a high solar absorptivity (>90%), high heat capacity, good durability and stability at high temperatures, and are commercially available," he writes in an email.

The receiver recirculates ceramic particles through the Thermal Test Facility's concentrated beam of reflected sunlight, where they absorb more solar energy with each pass, increasing the system's solar efficiency.

Once heated, the particles travel into an insulated holding tank, where their heat will be harnessed to power a turbine and generate electricity, according to a previous Sandia press release about the project.

According to the most recent press release, the team hopes to develop a prototype receiver that can exceed 90% thermal efficiency and achieve particle temperatures of at least 700°C.

"This technology will enable higher temperatures and higher-efficiency power cycles that will bring down the cost of electricity produced from concentrating solar power," Ho says in the release. "In addition, the ability to cheaply and efficiently store thermal energy directly in the heated particles will enable power production at night and on cloudy days."

Now that the receiver is installed on the tower, the system will undergo two phases of testing. In the first phase, scientists will test an insert in the receiver that slows down the falling particles, allowing them reach higher temperatures. The insert, designed by researchers at Georgia Tech, works like a Plinko board, with pegs that disrupt downward particle flow.

In the second phase of testing, the insert will be removed so that the team can collect results for free-falling particles, too.

"New Mexico is great for this project because our state has pretty consistent solar insolation throughout the year," engineer Josh Christian says in the release. "However, the biggest thing we need to know is how much power is going into the falling particle receiver. So a cloudy or hazy day is a big challenge for us. An ideal day for testing is a clear day with no clouds and no wind." ■

Credit: Randy Montoya

Technologists John Kelton and Daniel Ray inspect the falling-particle receiver during a cloud day atop the National Solar Thermal Test Facility at Sandia National Laboratories.

Can the US say goodbye to fossil fuels forever?

The challenge to convert the United States to 100% clean, renewable energy has seemed to have a big, flashing "in-progress" sign up until recently. Now green energy solutions are becoming more economical and mainstream. With each green-energy development, the carbon footprint gets a little smaller.

Engineers at Stanford University in California have developed roadmaps for a "state-by-state plan to convert U.S. to 100% clean, renewable energy by 2050," and they have outlined how this could work in a recent paper.

Mark Z. Jacobson, a professor of civil and environmental engineering at Stanford, and his colleagues are the first to illustrate how each state can replace fossil fuel energy with entirely clean, renewable energy in the next 35 years.

The plans are aggressive, though. They call for extensive changes to infrastructure and energy use—but the engineers say in the report that current barriers to implementing the roadmaps are not technical or economic.

"The main barriers are social, political, and getting industries to change. One way to overcome the barriers is to inform people about what is possible," Jacobson says in a *Stanford Report* article about the study. "By showing that it's technologically and economically possible, this study could reduce the barriers to a large scale transformation."

They analyzed the current amount and source of the fuel consumed—fossil fuels, nuclear power, and renewables—in the residential, commercial, industrial, and transportation sectors and calculated the fuel demands if all fuel use was swapped out for electricity in each sector.

"When we did this across all 50 states, we saw a 39% reduction in total end-use power demand by the year 2050," Jacobson says in the article. "About 6% of that is gained through efficiency improvements to infrastructure, but the bulk is the result of replacing current sources and uses of combustion energy with electricity."

If this plan to shift to all renewable energy is followed as Jacobson and colleagues lay out, they posit that CO_2 emissions from fossil fuels would be eliminated, saving $3.3 trillion a year globally by 2050.

The paper, published in *The Royal Society of Chemistry*, is "100% clean and renewable wind, water, and sunlight (WWS) all-sector energy roadmaps for the 50 United States" (DOI: 10.1039/c5ee01283j). ■

Credit: U.S. Department of Agriculture

Solar panels, here at the George Washington Carver Center in Beltsville, Md., may help the U.S. bid fossil fuels farewell.

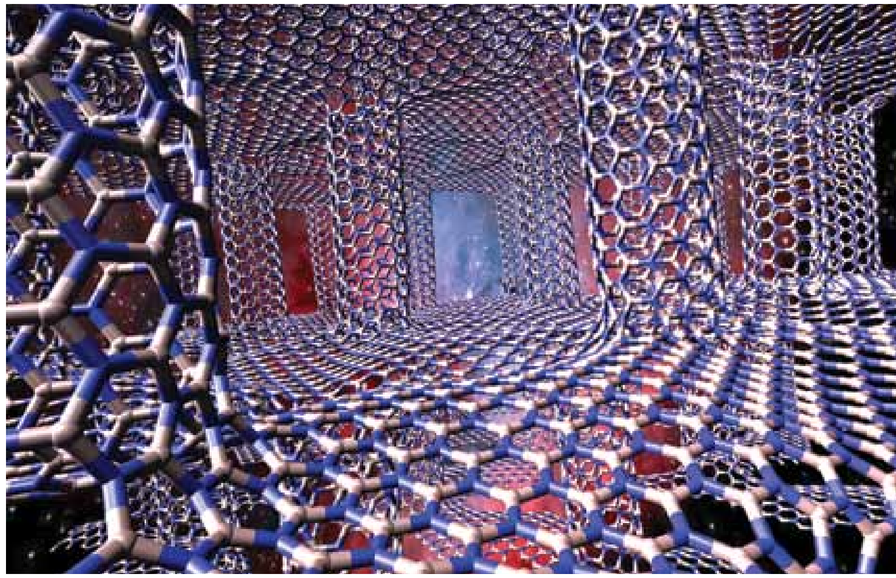
Time-to-market gap for commercially viable graphene in electronics may be narrowing

A lot of hype surrounds the potential use of graphene in commercially available electronics. There has never been more demand for increasing the speed, efficiency, and lifespan of personal handheld devices.

Physicists at the University of California, Berkeley, have now presented a graphene-based wideband microphone and a related ultrasonic radio that can be used for wireless communication with easy-to-scale-up technology.

These wireless ultrasound devices "complement standard radio transmission using electromagnetic waves in areas where radio is impractical, such as underwater, but with far greater fidelity than current ultrasound or sonar devices. They also can be used to communicate through objects, such as steel, that electromagnetic waves can't penetrate," according to a *Berkeley News* article about the study.

The physicists at UC Berkeley are not the only ones on the brink of developing graphene for practical commercial electronic applications. Recent research from Rice University in Houston, Texas, suggests that 3-D structures of boron nitride—aka "white graphene"—could be an effective tunable material to manage heat flow in electronic devices.


Credit: Shahsavari group; Rice U.

A 3-D structure of hexagonal boron nitride sheets and boron nitride nanotubes could be a tunable material to control heat in electronics.

This new type of 3-D thermal management system can "open up opportunities for thermal switches, or thermal rectifiers, where the heat flowing in one direction can be different from the reverse direction," says Rice researcher Rouzbeh Shahsavari in a *Rice News* article.

The UC Berkeley paper, published in the *Proceedings of the National Academy of Sciences of the United States*, is "Graphene electrostatic microphone and ultrasonic radio" (DOI: 10.1073/pnas.1505800112).

The Rice University paper, published in *Applied Materials and Interfaces*, is "Dimensional crossover of thermal transport in hybrid boron nitride nanostructures" (DOI: 10.1021/acsami.5b03967).

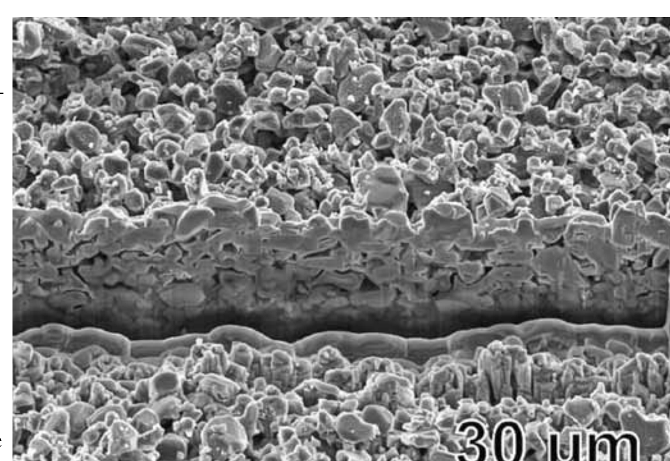
Acid etching of glass–ceramics achieves porous surface, reduced permittivity

Researchers at Technische Universität Wien in Vienna, Austria, have developed a simple nanostructuring technique that can precisely control the electromagnetic behavior of glass–ceramic circuit boards.

The TU Wien team developed an acid-etching technique that removes feldspar from fired glass–ceramics, leaving a nanoporous structure.

"Prior to the acid treatment, the permittivity measures between seven and eight but the nanopores reduce it by up to 30%. Not only that, but this can be achieved with a minimum of technological effort and using conventional tape systems that were not even produced with this etching process in mind. That is impressive," researcher Achim Bittner says in a TU Wien press release.

The technique improves performance of sensors and affords control over the manufacturing process. "The new etching technique can be used with pinpoint accuracy to imbue different parts of the glass–ceramics with different properties," the release states.



Credit: TU Wien

An electron micrograph shows the porous surface of glass–ceramics after etching, which have higher performance than nonporous versions of the material.

Lower permittivity of the porous surface may lead to improved antenna circuit boards. The team already has partnered with electroplating company Happy Plating (Austria) and other European partners to manufacture antenna circuit boards from the new materials "with very promising results."

Manufacturing with Heart helps manufacturers organize for positive change

Manufacturing with Heart is a new consulting and coaching company that empowers businesses through trust.

Change can be hard. But, if one can gather the momentum, the outcome is often worth it.

For Tanya Patrella and Butch Peterman, the outcome has been nothing less than success.

Patrella and Peterman founded a consulting and coaching business, Manufacturing with Heart, directed toward small manufacturers and takes a rather unconventional strategy toward change for the better.

Based on their experience at abrasives manufacturer Abrasive Technology (Lewis Center, Ohio), Patrella and Peterman recognized that the company's traditional hierarchical organization was limiting, time wasting, and just not working as effectively as they wanted.

So their vision for change toppled the conventional business operating structure and instead developed a process-centered organization focused on a positive work culture.

Peterman cofounded Abrasive Technology and continues to lead the company as president. Patrella also was an executive at the company for 25 years. The strategies they advocate and implement through Manufacturing with Heart are based on the changes they successfully implemented at Abrasive Technology.

And those changes are not trivial.

Time sheets and employee reviews? A waste of time. Hierarchical mangers? An ineffective leadership strategy. Overall business culture? Total rehaul.

Patrella and Peterman's unique work model invests in trust of employees through what they call heart culture. Their organization flattens the ladder of leadership, replacing the often-endless rungs of managers and supervisors with simply process engineers and coaches that focus on the company's work processes and employees' career and personal development, respectively.

Their leadership structure ditches time-wasting trivial oversight, instead empowering employees through trust. "Our efforts enabled employees to be more involved in daily decision making, engaged, collaborative, and accountable," Patrella says in an email.

The duo now offers coaching and consulting services to encourage and implement similar work environments in other companies.

Patrella and Peterman answered the following questions about their new vision and experience.

Q. What has been the biggest advantage you've seen in your company from this restructuring?

A. Hierarchical organization is structured around product line silos, which dramatically limit the ability of employees to really be involved and feel connected to the people around them and needs of the company and its customers. Process-centered organizations (PCOs) are aligned around processes, which foster collective creativity and encourage teams to make their own decisions.

Managers traditionally are tasked with process improvements and people development. Managers are often better with people issues or process issues—not both. In a PCO, the roles of the stereotypical VP or manager are divided. Process engineers define and monitor processes and are responsible for throughput, productivity, cost, and quality. Coaches counsel, support, build relationships, inspire, educate, mentor, discipline when needed, and provide training for employees. This structure creates a dual-servant leadership model.

The priority of leaders in a winning PCO is to lead change by effectively communicating with all employees and all teams. It's important that leaders focus on individual and team development—teaching, listening, and making supported decisions and doing it again. All this is done from their hearts with a baseline level of trust in everyone and in the direction headed. For performance reviews, we again did something unthinkable—we got rid of them!

Q. In your experience so far, what is the key ingredient that makes this organizational model work?

A. The key ingredient is that people are not "managed"—projects and processes are. This creates a comfortable workplace where people are free to be collaborative and creative. Associates now have a process engineer to help them with process improvements and a coach to help them with training and personal development.

Q. Can this structure work for any manufacturing company (or beyond?), or can only certain types of environments or leaders pull this off?

A. Any company could do it. The lead person of the company (owner, CEO, president) must have a core belief that people can be trusted and have the time, patience, and perseverance to stay the course and lead this type of effort.

Q. What has been the response from employees?

A. Those that like a collaborative, team approach and want to continue to learn like the organization. For associates who prefer a more structured environment, it does not work, so they usually leave after a short time. At Abrasive Technology, which is 45 years old, we have associates who have been with us for 35–40 years. The structure reduced our voluntary turnover by more than 75%. In addition, this structure is ideal for millennials. ■

Nanocatalyst-coated ceramic filter cleans smoke-filled air

Researchers at Korea Institute of Science and Technology have developed a nonsmoker's dream—a nanocatalyst that alleviates air of carcinogens and particulates from cigarette smoke.

According to the KIST press release, the catalyst removes 100% of the carcinogens acetaldehyde and nicotine and 100% of particle substances (such as tar) from a room filled with cigarette smoke.

Although acetaldehyde is the predominant carcinogen in smoke, cigarette smoke contains more than 7,000 other chemical compounds. Of those, 10% are known carcinogens.

The filter, a ceramic-based media encased with a Mn/TiO_2 nanocatalyst powder coating, uses oxygen free radicals to break down the harmful compounds in cigarette smoke.

Ozone decomposition on the nanocatalyst generates oxygen free radicals, which then react with compounds in cigarette smoke to oxidize and neutralize them, generating harmless water and carbon dioxide in the process.

According to the release, the KIST team fabricated a prototype air cleaner using the nanocatalyst filter and tested the device in a 30-square-meter smoking room filled with 10 puffing smokers. "About 80% of cigarette smoke elements were processed and decomposed to water vapor and carbon dioxide within 30 minutes, and 100% of them within 1 hour. The test condition was designed based on the processing capacity which could circulate the air inside the entire 30-square-meter smoking room once every 15 minutes."

Lead researcher Jongsoo Jurng adds in the release, "If the new equipment can be simplified and is economically feasible, it will be an important tool for keeping smoking rooms pleasant and clean. Also, from the convergence perspective, the new nanometer catalyst filter can be integrated with other air-cleaning products, such as air purifiers and air conditioners." ■

Credit: KIST

A nanocatalyst-coated ceramic filter purifies smoke-filled air in a smoking room.

The ancient Roman secret to more ductile concrete

Geophysicists at the Stanford University School of Earth, Energy, and Environmental Sciences (Stanford, Calif.) have discovered concrete-like rock deep within a dormant Italian volcano they say could explain how ancient Romans invented the compound used to build structures like the still-standing Pantheon and Colosseum.

In a recent Stanford University video, Tiziana Vanorio, assistant professor of geophysics, explains that the concrete rock—uncovered at the Campi Flegrei volcano near Naples, Italy—is located in the middle of a large caldera (a cauldron-like volcanic feature formed by collapse of land following a volcanic eruption). The video can be found at www.youtube.com/watch?v=DMD_6BfCiVI.

Vanorio explains in the video that in the Campi Flegrei caldera there is a caprock—a harder rock that lies overtop a weaker rock layer—that is rich in pozzolana, or volcanic ash specific to the region.

And upon studying the composition of the caprock, Vanorio and her colleagues also noticed that the caprock contained tobermorite and ettringite—fibrous minerals that also are found in manmade concrete, including ancient Roman concrete.

"Tobermorite and ettringite form a very intricate network of fibers. The caprock of Campi Flegrei—because of the network of fibers—is able to withstand much larger deformation without immediately breaking," concludes Vanorio.

The scientists think their discovery could help engineer more durable and resilient concrete formulations.

The paper, published in *Science*, is "Rock physics of fibrous rocks akin to Roman concrete explains uplifts at Campi Flegrei Caldera" (DOI: 10.1126/science.aab1292).

Credit: Marco Verch; Wikimedia CC BY 2.0

The secret to Roman concrete's strength, which allows structures like the Colosseum to remain standing today, may be in the rocks.

When ceramic powerhouses collaborate—
How the 3M–Ceradyne merger drives innovation

An insider's look into the labs of 3M and Ceradyne following 3M's acquisition of Ceradyne in 2012.

By April Gocha


Credit: 3M

David Gunderson


Credit: 3M

Biljana Mikijelj

It is not unusual to hear about advancements in the use of ceramics and glass materials. What is unusual is getting an exclusive, inside look into how innovation giant 3M integrated California-based Ceradyne Inc. into the fold; the accomplishments since 3M acquired the advanced technical ceramics manufacturer in 2012; and what is to come for the industry.

The approximately $860 million purchase of Ceradyne—a company that served demanding applications with operations in the United States, Canada, China, and Germany—was one of the largest in the history of 3M. Joel Moskowitz, ACerS Distinguished Life Member, cofounded Ceradyne in 1967 and helped the company grow into an international, publicly traded company with annual revenues of $500 million prior to the acquisition. Moskowitz passed away in March 2015.

As part of the acquisition, Ceradyne joined the Advanced Materials Division (AdMD) within 3M's Industrial Business Group, which provides valued materials for lightweight solutions and materials for performance in harsh environments to customers in a broad array of growth industries. 3M executives described Ceradyne as "an excellent complement to 3M's existing businesses in transportation, energy markets, and defense."

By joining 3M, Ceradyne predicted that its associates would have the opportunity to use the power of 3M's strengths—including global reach, culture of commercializing new products, and operational discipline—to accelerate its platform in serving customers with highly valued solutions. 3M also speculated the combination with Ceradyne would enable new technologies and innovations for uniquely tailored materials requiring advanced ceramics.

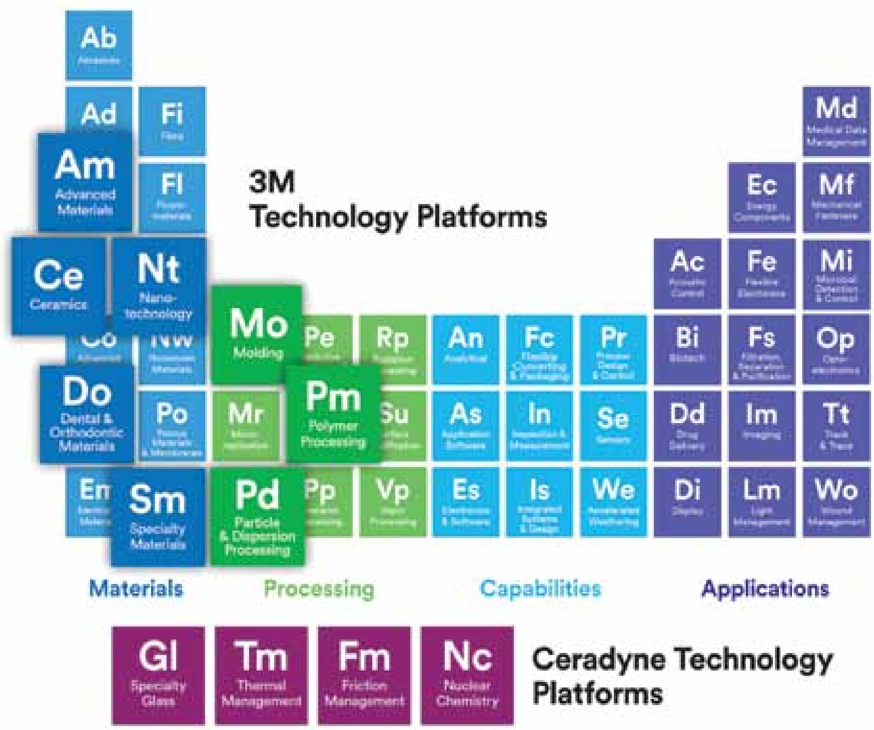
Join us as we dive into a Q&A dialogue with two of 3M's business and R&D leaders to gain insights into how 3M has integrated Ceradyne technologies. Providing insights from 3M is David Gunderson (DG), global business director for the advanced ceramics platform based in St. Paul, Minn., and Biljana Mikijelj, Ceradyne R&D director for the ceramics platform, who is now lab manager of the 3M ceramics team. Although Ceradyne is part of 3M, to help distinguish what each company has brought to the acquisition we will refer to them here as Ceradyne and 3M.

What fueled 3M's decision to acquire Ceradyne?

DG: 3M strives to improve lives with smarter, better products. With any acquisition, the goal is to go bigger and broader to leverage 3M's strengths and the diversity of its portfolio and global reach. For these reasons, the acquisition and possibilities with Ceradyne intrigued 3M on many levels. Pairing its technology platforms with Ceradyne's ceramic technology has opened doors for development of new, unique solutions unmatched in the industries 3M serves. But acquiring a company goes beyond potential products—3M considers multiple components. In particular, it looks for consistencies across four fundamentals: technology, manufacturing, global capabilities, and brand. Because of the strength of Ceradyne's alignment with 3M in these areas, it has been an exciting two years of growth.

3M currently has 46 technology platforms, so it was important that Ceradyne had technology and know-how that could complement and strengthen the current platforms (Figure 1). With more than 50 years of experience producing oxide ceramic technology, 3M has built a portfolio that was expanded by incorporating Ceradyne's non-oxide ceramics. With a goal of applying science to life, 3M has found ways to integrate Ceradyne into current applications and is focused on finding new applications that improve production efficiency and durability, lower costs, create new possibilities, and serve and protect people and property.

3M recognized very early on that Ceradyne's culture was similar, because Joel Moskowitz hired talent as does 3M. Both companies hire people who care about the work they are doing, and many are recognized globally as experts in their field. They take pride in what they do. The people at both companies also are interested in the long-term play and skillsets associated with understanding how to work with new technologies to innovate—not just short-term sales benefits. These shared



Credit: 3M

Figure 1. This periodic table of 3M's technology platforms calls out technology synergies in materials and processing between 3M and Ceradyne. Blending four additional technology platforms acquired through Ceradyne opens doors for numerous possibilities to help solve customer challenges.

values have solidified the companies' brand goals and have enhanced their manufacturing processes.

Prior to the acquisition, Ceradyne supplied 3M with ceramic dental brackets, providing 3M with considerable exposure to Ceradyne's culture. The more we at 3M learned about Ceradyne, the more intrigued we became as we peeled back layers and saw how the two companies could begin to collaborate and leverage technologies that are different from 3M's.

At 3M, we innovate and apply science to life, and Ceradyne has been helping us drive growth. Together we understand that to grow we need to find the right opportunities and take calculated risks. With this mentality, our companies have gained a collective knowledge and have entered new markets.

BM: 3M has a long history of using and developing advanced oxide-ceramic-based products, such as 3M Nextel Structural Ceramic Fibers, specialized abrasives, and translucent dental brackets (codeveloped with Ceradyne) during its 115-year history. Ceradyne's expertise in non-oxide ceramics meant 3M was acquiring an entirely new and complementary technology platform, including non-oxide ceramic materials and processes.

In many high-performance applications, products made of advanced technical ceramics meet specifications that similar products made of metals, plastics, or traditional ceramics cannot achieve. Non-oxide ceramics can withstand extremely high temperatures and combine hardness with light weight. They are highly resistant to corrosion and wear, and often have excellent electrical capabilities, special electronic properties, and low friction characteristics. Access to these types of performance benefits opens new markets and creates innovation potential for 3M.

The acquisition by 3M allowed Ceradyne to strengthen its broad product portfolio—which spanned defense, industrial, oil and gas, solar, electronics, medical, automotive/diesel, and nuclear applications—through strong, established relationships 3M had in these markets that Ceradyne did not. Additionally, some of Ceradyne's ceramics, such as boron nitride, have facilitated 3M's expansion into Japan. This, along with being an existent 3M supplier, resulted in a relatively easy integration into 3M's business.

Figure 2. 3M's Kempten, Germany, facility—which innovates and collaborates to solve customer challenges—has been named a 3M Corporate Global Center of Technical Excellence for Ceramics.

3M and Ceradyne have considerable expertise—What is the overall strategy to incorporate the many 3M and Ceradyne technologies into existing products?

DG: 3M and Ceradyne work to solve customer problems through their technologies. This is not new since the acquisition, because striving to find new ways to solve customer problems and driving innovation with disruptive technologies is an inherent part of both cultures. Since the acquisition, both companies have been able to continue incorporating the technologies into existing products. The implementation strategy was a three-pronged approach.

First, the processes for integrating were similar. At 3M, all technologies are owned at the corporate level, which does not allow any division or operating unit sole access. This is part of 3M's innovation culture, allowing its broader technical communities and global organizations access to education and deployment of technologies across all businesses and applications. 3M integrates products into its Corporate Research Group, a team comprised of hundreds of employees responsible for understanding the fundamentals of technology so they can make connections and incorporate technology quickly across the company. Through this process, the company has been able to involve more than 80 global subsidiary organizations in a "Jump Start" program for integrating Ceradyne, where country-specific opportunities were identified, prioritized, and resourced.

Second, there were already numerous overlaps in many applications and industries, so 3M paired Ceradyne technology experts with 3M application and product development experts in divisions where it made sense. Connecting Ceradyne's Thermally Conductive Fillers with 3M's Electronic Market Solutions Division (EMSD) or developing next-generation technical ceramics for 3M Evaporation Boats using 3M's film manufacturing capabilities are excellent examples.

BM: The third phase to the strategy centered on Ceradyne's Kempten, Germany, facility (formerly known as Elektroschmelzwerk Kempten (ESK)), which is where research and processing efforts are conducted in addition to those at the 3M Center in St. Paul (Figure 2). On top of R&D work, the Kempten facility manufactures products from advanced ceramics and powders (boron carbide, boron nitride, and calcium hexaboride) to friction-controlling functional coatings. Kempten is now a 3M Corporate Global Center of Technical Excellence for Ceramics, an exclusive club of four that includes Gendorf, Germany (fluoropolymers); Seefeld, Germany (dental materials); and 3M Sweden (hearing protection). Company-wide, 3M employees know that the first place to start when working to solve customer challenges is at these Centers of Technical Excellence for innovation and collaboration.

Disrupting the marketplace through an acquisition is not new to Ceradyne. In the past, it has acquired other companies, such as ESK. Because it was important for 3M to have brand and cultural synergies, the strategies to incorporate technologies into existing products have been very effective out of the gate.

What is the overall strategy to incorporate the many 3M and Ceradyne technologies into new uses and applications?

DG: The strategy relates back to why 3M decided to acquire Ceradyne. As I mentioned, Ceradyne met all four of the acquisition criteria, with one of the biggest strengths being that it also enabled 3M to continue to expand its technical platforms. We at 3M blend that with an overall strategy of finding new uses and applications for technologies. To get us there, we hire innovative people, provide them with the tools, freedom, and ability to take risks to invent new products that make a positive impact on the world. This model prevents complacency and allows our engineers to push the boundaries of innovation.

With our in-house technical community and laboratory networking and collaboration, we find where there is the most traction and then fund technologies that will enable new company growth. This strategy allows 3M to create the most advanced and high-performance material product solutions, giving it greater value proposition than competitors. But at the end of the day, it really comes down to our people, who have the right knowledge base and know-how.

BM: As David addressed, it is about giving staff the opportunity to apply these technologies. Mainly, this meant 3M using Ceradyne's technology to find new opportunities in energy, electronics, oil, and gas. These industries have larger applications that need ceramics because of problems with metals and alternative materials. To illustrate this point, 3M has been able to transition Ceradyne's expertise in boron nitride cooling fillers to electronics, an industry in which 3M has extensive expertise. Boron nitride is an adaptable ceramic material that provides thermal conductivity, temperature stability, chemical resistance, and electrical insulation. When the boron nitride

Figure 3. The 3M Ultra-Light-Weight Ballistic Bump Helmet helps protects lives by reducing fatigue and improving mobility, because it weighs 30% less than the closest alternative.

powder, which is produced in our Germany facility, is combined with 3M polymers, the product enables increased thermal conductivity to dissipate heat in electronics and prevent overheating. On the other hand, Ceradyne's fused silica, high-purity powders can achieve the opposite—reduce thermal conductivity, thereby keeping heat in applications such as power generation and batteries.

And, as with any good partnership, both companies are able to bring their unique strengths in the R&D process to get to market faster.

What are some examples of how 3M has integrated its own technology with that acquired from Ceradyne to improve specific products?

DG: Ceradyne is a key producer of lightweight composite and ceramic-based soldier protection systems, including ballistic helmets and body armor for military and law enforcement personnel. In the two years since the Ceradyne acquisition, 3M has been able to make important advances in how these systems are made by combining 3M and Ceradyne materials and production technologies to deliver the next level of lighter-weight, integrated armor products.

To enhance Ceradyne's product portfolio and overall performance, we have applied our expertise in adhesives to helmets and body armor. The body armor division was a very important part of Ceradyne founder Joel Moskowitz's work with the company, and it has been an honor to be part of this market and support his efforts of protecting every life and every soldier.

Ceradyne's technology included a hard ceramic outer shell to protect soldiers from projectiles, and the backside was a polymer material. When hit with impact, the ceramic shell fractures by design, meaning the polymer and ceramic layers need to be strongly bound to serve their purpose of capturing the fracture and protecting the wearer. Our adhesive know-how very effectively binds these layers together.

BM: As another example, 3M is bringing its knowledge of electronics and sensor technology to Ceradyne's body armor. Sensors will allow the person wearing the armor to determine if the vest is damaged. This is especially helpful for warriors in the field because if they drop the equipment or fall, they need confidence the armor will protect them from further threats.

3M also is incorporating its technologies, such as safety goggles and communication devices, with Ceradyne's next-generation ballistic helmets. The 3M Ultra-Light-Weight Ballistic Bump Helmet (ULW-BBH) was introduced in October 2014, and it eliminates trade-offs between protection level, weight, and comfort (Figure 3). These helmets are designed for air, water, and ground transportation to provide blunt-impact protection.

The ULW-BBH shell weighs 30% less than the closest alternative and is designed to reduce fatigue while improving mobility. The helmet uses the latest polymeric materials and is manufactured using a proprietary and seamless ballistic molding technology. The retention system's boltless design minimizes overall weight, removes a potential design weakness, and eliminates the possibility of bolts acting as secondary projectiles. ULW-BBH also uses a flexible rail system that is compatible with standard operational accessories, including night-vision goggles, hearing and vision protection equipment, lights, and communications devices.

3M also is expanding the use of Ceradyne's specialty glass into health care and dental markets (Figure 4). For example, 3M's dental bioactive glass powders provide protection for temperature-sensitive teeth. Markets for these materials include dental, wound care, hearing loss correction, and several other medical uses.

What new products or applications have resulted at 3M with the help of Ceradyne's technologies, knowledge, or know-how?

BM: Beyond body armor and helmets, the acquisition has resulted in a wealth of new products that have helped 3M's customers solve some of their most unique challenges.

Figure 4. 3M specialty glasses can be used in a wide variety of applications from wound care and dental to printing metalized tracing on solar panels. Not many suppliers have this type of solar technology and only a few in the world have the expertise.

Figure 5. 3M Ceramic Sand Screens are first-of-its-kind in the oil and gas market to replace metal screens.

Over the past decade, the U.S. has become a major supplier of oil, making it less dependent on imports. The 3M Ceramic Sand Screen is a disruptive technology that enhances this ability by enabling economic production of conventional and unconventional hydrocarbons in areas where it had not been cost effective before (Figure 5). These screens are based on sand and proppant flowback control technology that provide erosion resistance in demanding hydrocarbon well applications.

Traditional sand screen systems are typically made of metals that are vulnerable to erosion, which can lead to early failure. The net result of early failure is costly and timely workover or intervention, and reduced or lost hydrocarbon recovery. The new 3M ceramic sand screens offer a major improvement over conventional metal screens by utilizing the unique properties of technical ceramics and an advanced sand screen design, providing virtually no indications of erosion under reservoir conditions and improving oil and gas production by eliminating return of sand to the surface. With about 20 successful oil and gas well downhole installations globally, customers are realizing the added value of this unique ceramic technology.

3M Boron Nitride Cooling Fillers are another technology that has expanded since the acquisition. Cooling fillers, developed by the Kempten team, are engineered to increase thermal conductivity. These advanced materials have shown particular utility in applications such as automotive electronics and e-drive components, where it is essential to dissipate heat from small, confined spaces. Low-density, nonabrasive 3M boron nitride cooling fillers offer a cost-effective solution where conventional mineral or oxide-based fillers do not work nearly as well.

An example of an emerging application for boron nitride cooling fillers is simpler, lower-cost LED lighting systems. Traditional LED systems are composed of an LED, printed circuit board, thermal interface tape, and a cast aluminum secondary heat sink. 3M has developed a demonstration LED concept based on a functionally integrated system. The LED is placed on a directly metallized secondary heat sink made of a thermally conductive and electrically insulating polymer containing 3M boron nitride cooling filler, potentially reducing system costs by 25%. This demonstration has attracted considerable interest at industry events, including the Fakuma International Trade Fair for plastic processing in Friedrichshafen, Germany—an indication that this new LED design has the potential to be a significant growth market.

3M currently is exploring the unique chemistry of the element boron (whose compound is used in armor) and applying it to the nuclear industry as a safety material in nuclear reactors and spent fuel transport. Boron has two stable isotopes: ^{10}B and ^{11}B. The ^{10}B nucleus absorbs neutrons, which have no charge and are necessary to start nuclear reactions. In the nuclear industry, safety is a big concern, making it critical to control flux of neutrons available in the reactor. There are two facilities in the world with the capability to separate isotope ^{10}B from ^{11}B, one of which is 3M's facility in Quapaw, Okla. Ceradyne had acquired the facility, previously known as Eagle Picher Boron, prior to the 3M acquisition. 3M now is developing highly water-soluble, high-boron-content compounds that help give nuclear power plants more control of fission reactions and can help shut down reactors in emergency situations. The inclusion of enriched ^{10}B materials into commercial nuclear power plants provides increased safety margins.

What new areas of research and applications are 3M actively exploring with the help of Ceradyne's materials?

DG: We are not in a position to disclose these types of specifics, but I can provide an idea of where we are heading.

3M currently has 50 active pending projects that incorporate Ceradyne technologies into areas such as wound care, electronics (for solid-state sensors and insulators), and defense (for integrated goggles, communications, and sensor devices on helmets and armor). These projects span across all five major business groups—consumer, electronics and energy, health care, industrial and safety, and graphics.

In addition, 3M has identified six top growth areas that align with mainstream trends and customer needs, such as energy, electronics, and nuclear, that will drive 90% of growth in the next five years. Where Ceradyne's sales have come from in the past will be very different from where 3M is heading in the future. Armor vest sales, which had been strong, are currently declining due to demand, so business will come from various other markets and global growth (e.g., 3M Ceramic Sand Screens in Asia). Customer demand always will mold and shape the company's direction.

How has 3M's processing technology changed Ceradyne's innovations?

BM: One of 3M's strengths is the ability to develop large-scale processes for a variety of technologies to ensure consistency in manufacturing across the globe. The processes are comprehensive with various stage gates that start with an idea, move to evaluating the feasibility of the idea, and then proving out the feasibility. Once that happens, 3M makes sure the idea can be scaled up before committing to marketing opportunities and beginning beta tests before launch. This disciplined process prevents projects that are unlikely to pan out and sets a good foundation for success with a customer. 3M also is steeped in applying Lean Six Sigma, which has greatly lowered the cost of manufacturing. Ceradyne has been able to benefit from both of these processes, helping to ensure consistency in manufacturing and reduce costs.

In addition, 3M is the leader in microreplication and applying it to abrasives, lenses, and films to produce more consistent materials. Although changing the shape of ceramic material is difficult, through collaboration with the Center of Technical Excellence, we at Ceradyne are working to enable near net shape, a process that enables a desired shape without extensive grinding. This practice includes making specific, tiny shapes used in specialty abrasives. It also is very specialized technology, and we continue to look at how it can be applied to produce non-oxide particles.

3M also has introduced Ceradyne to a nontraditional process of starting with gels rather than powders, which has been used at 3M for 15–20 years (e.g., 3M Nextel Structural Ceramic Fibers and Textiles). We are continuing to explore how this process can be applied to future Ceradyne innovations. The ceramic fibers are made from sols, and under a proprietary process they are spun in a spool of continuous fiber that can be woven into fabrics. These fibers are very strong and can be used at high temperatures. Their most common application is in the aerospace industry, where high-temperature capability is needed but monolithic ceramics that can fail cannot be used. The fibers in the Nextel structural ceramic fibers and textiles are highly resistant to fracture. We are excited to continue exploring how we can use this in ceramic parts.

What has Ceradyne brought to the table that 3M could not achieve alone?

BM: Ceradyne brought 3M non-oxide ceramics along with expansive knowledge of the industry. It also brought deep knowledge and expertise. Its people have the industry know-how as well as a proven track record on how to apply the technology to meet customer needs and solve problems. Together we have been able to synergize our knowledge, staff expertise, and experience to create award-winning products. In fact, in 2013 the Enhanced Combat Helmets were named one of 100 greatest innovations of the year in *Popular Science*'s 26th annual "Best of What's New" issue.

Ceradyne also offered its high-temperature, high-pressure processes, such as hot pressing (HP) and hot isostatic pressing (HIP), which have assisted Ceradyne/3M in creating its non-oxide ceramics. HP or HIP is a technology used to produce some of the non-oxide ceramics that require a strong bond between elements. The normal process starts with powders, which are heated to form parts. Sintered parts shrink and densify, resulting in a pore-free article. When making an oxide ceramic, this can be achieved at relatively low temperatures and atmospheric pressures. But non-oxide ceramics require higher temperatures and application of pressure while heating.

The sintered reaction-bonded silicon nitride (SRBSN) process technology was acquired from Ford Motor Company, but Ceradyne has scaled it up and has a large production facility in Lexington, Ky., to advance its development. Joel Moskowitz also set the stage for Ceradyne to expand its knowledge and technology set beyond ceramics with the ESK acquisition and investment. He was the driving force in Ceradyne adding new technology, such as the ^{10}B isotope for nuclear safety and the polymeric material used in the Ballistic Bump Helmet. Ceradyne's expertise in these non-ceramic-based technologies further extended 3M's knowledge base.

What has 3M brought to the table that Ceradyne could not achieve alone?

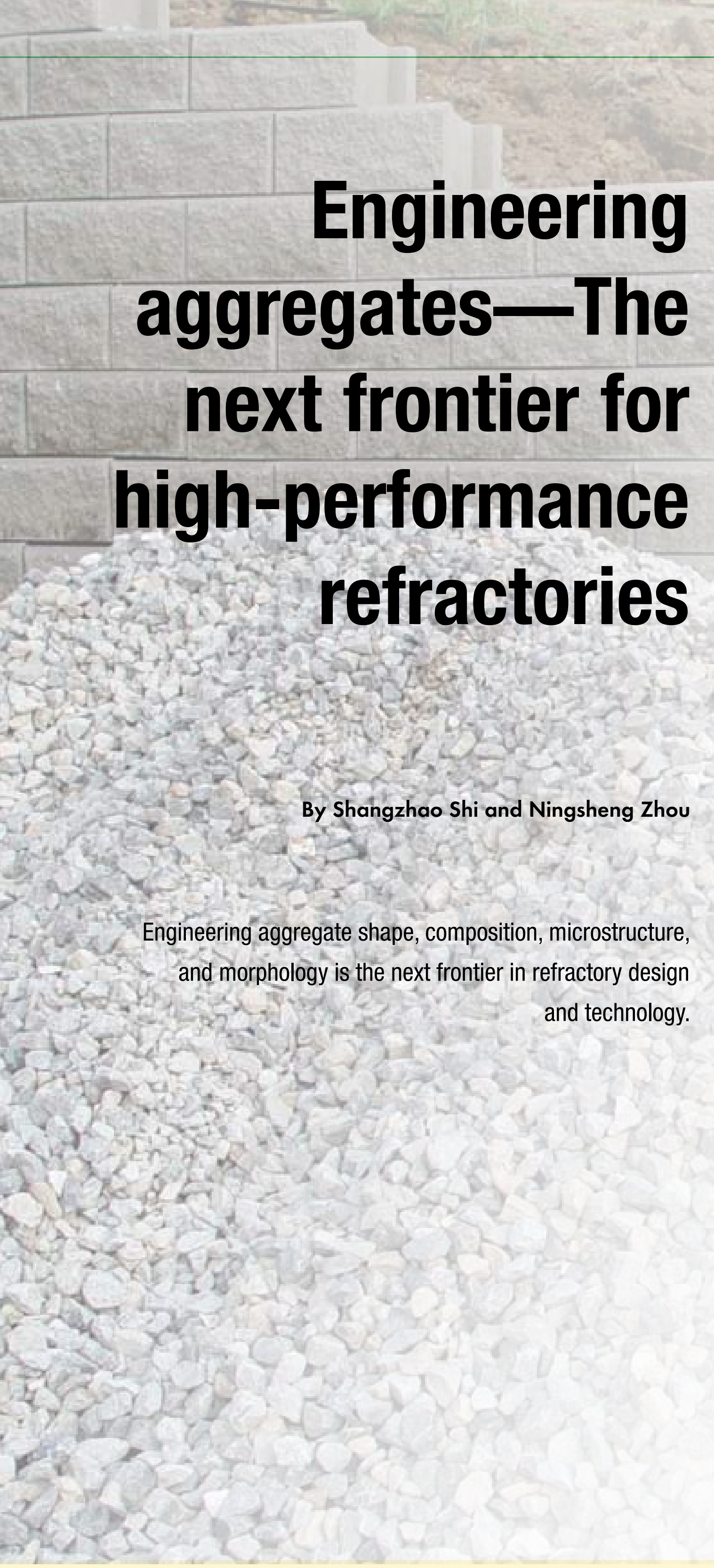
BM: 3M has helped Ceradyne take its efforts to the next level by giving it access to a larger customer base. 3M and Ceradyne overlapped in many market segments and geographies that they served. The only difference was that 3M had a larger, global reach and more marketing power in certain industries—oil and gas, energy, electronics, and automotive—elevating and expanding Ceradyne's footprint globally. In these areas, 3M simply used its global marketing channels to introduce existing Ceradyne technologies and products.

As an example, prior to the acquisition, Ceradyne was convinced it needed to sell sand screens through traditional channels (i.e., by partnering with sales companies). But with 3M's large presence and strong relationships in the oil and gas market, Ceradyne moved beyond that thinking and brought its product directly to the end user. There is nothing else in the industry like the ceramic sand screens, and this change in direction has helped the company expand and reach customers faster than it may have otherwise.

3M also implemented this approach with Ceradyne's friction shims in the automotive market. Friction shims have been part of the Ceradyne portfolio since it acquired ESK. Friction shims are metal foils with a coating of electroless nickel embedded with diamond particles, used to ensure a tight connection between components subject to high pressures and torque. Because 3M Friction Shims are lighter and more compact than conventional solutions, they have garnered increasing interest from automotive engineers seeking new ways to reduce vehicle weight and save space. Since the acquisition, Ceradyne has experienced significant growth because 3M opened the door to a strong customer base in the automotive industry, making it easier to contact buyers.

One particular area that left an impression on me was when we at Ceradyne were developing lightweight armor and needed specialized equipment to make enhancements. Through 3M expertise, we were able to build highly specialized equipment in the lab from concept to testing in just two to four months—something Ceradyne would never have been able to achieve without 3M. ■

For more information, contact 3M Advanced Materials Division at 1-800-367-8905 or 3M.com/Ceradyne.



Engineering aggregates—The next frontier for high-performance refractories

By Shangzhao Shi and Ningsheng Zhou

Engineering aggregate shape, composition, microstructure, and morphology is the next frontier in refractory design and technology.

Examples from recent decades recount great progress in engineering of refractories. Reducing calcium aluminate cement by adopting silica fume and ultrafine alumina powders in refractory castables greatly improved their high-temperature properties and helped shift a large fraction of refractories from prefired bricks to in-situ installed castables.[1] Replacing conventional carbon sources with nanoscale carbon brought about low-carbon refractories, leading to reduced carbon pick up in steel refining processes.[2] Mullite formed in-situ instead of admixed in the refractory matrix achieved much higher strength and thermal shock resistance for refractory products.[3] Use of nanosized silica improved flowability of castables.[4]

Further, a variety of new additives incorporated into shaped and unshaped refractories helped optimize phase distribution, structural bonding, damage resistance, etc. For example, organic-based dispersant helps improve the dispersion of ultrafine silica and alumina powders in castables;[5] boride- and carbide-based antioxidants help protect carbon from oxidation in carbon-bonded refractories;[6] barium-containing additives in aluminosilicate refractories improve corrosion resistance against aluminum melts;[7] and small amounts of alumina in nitride-bonded SiC refractories can improve strength by changing grain morphology.[8]

Today, refractories are not just fired mineral ores or their simple mixtures, but sophisticated products with carefully designed compositions and deliberately “built” microstructures. As De Guire[9] noted, refractories are engineered, high-performance “silent partners” of high-temperature processing industries. Although they are usually hidden from view, they enable technological advancement for making metals, cements, glasses, ceramics, and many chemicals.

Most past efforts in refractories engineering, however, focused on the matrix component. Today, attention has turned to the need to engineer refractory aggregate phases, too. Aggregate engineering should include design, fabrication, and use of aggregates with specific shape, microstructure, and chemical composition.

Capsule summary

AGGREGATE DESIGN

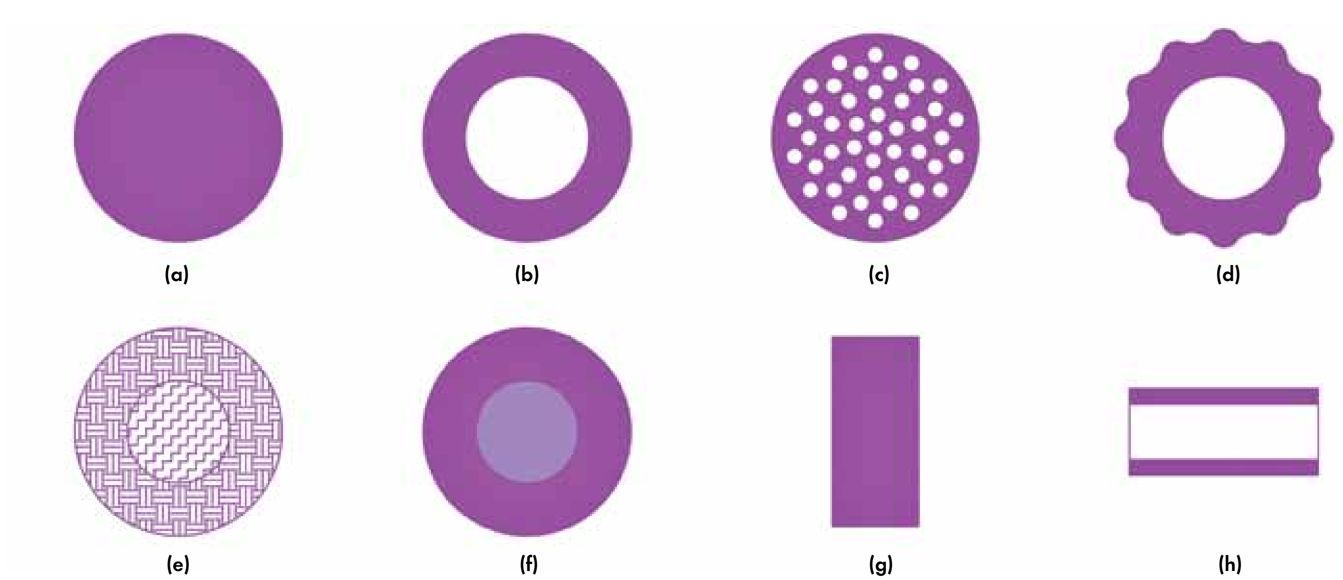
Research and development has led to significant improvements in the cement-matrix constituent of refractory formulations, especially castables. To fully optimize refractory design, the aggregates, too, must be improved.

SHAPE MATTERS

Spherical aggregate eliminates defects caused by irregular shapes and sharp corners. Rod- or tube-shaped aggregates may be useful for designing functionally graded refractories.

NEW OPPORTUNITY

It may be possible, by engineering the shape and size distribution of aggregate, to optimize refractory design for improved flow, higher thermal shock resistance, reduced wear, better thermal insulation, less corrosion, and more.



Credit: Shi and Zhou

Figure 1. Schematic illustrations of proposed designs of engineered refractory aggregates: (a) solid sphere; (b) hollow sphere; (c) porous sphere; (d) sphere with rugged surface; (e) core–shell sphere with different textures between core and shell; (f) core–shell sphere with different chemical compositions between core and shell; (g) columnar/rod aggregate; and (h) hollow column/tube aggregate.

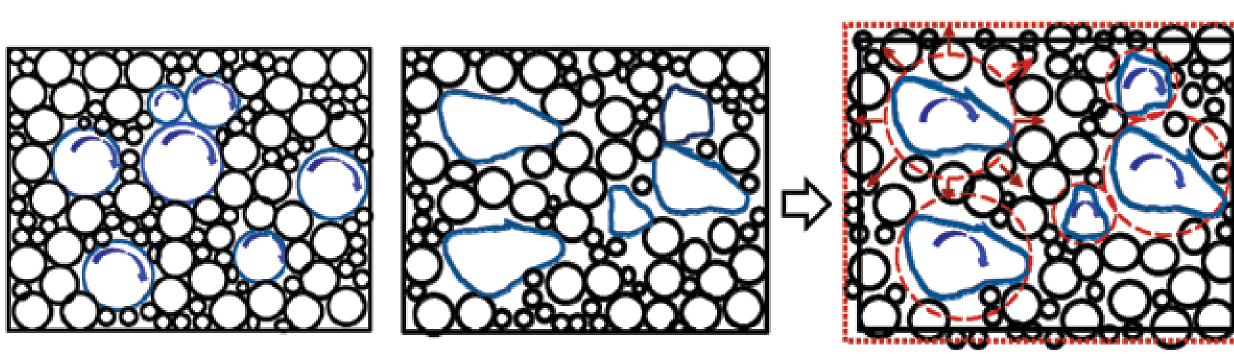
Because aggregates constitute a dominant part in most, if not all, refractories, engineering aggregates should lead to new breakthroughs in refractories processing and application technologies.

Figure 1 illustrates schematically several engineered structures for refractory aggregates that are expected to lead to substantial applications now and in the near future. Based on our experience, we predict the following advancements in refractory technology are possible by incorporating engineered refractory aggregates.

Flowability, structural uniformity, and easier installation

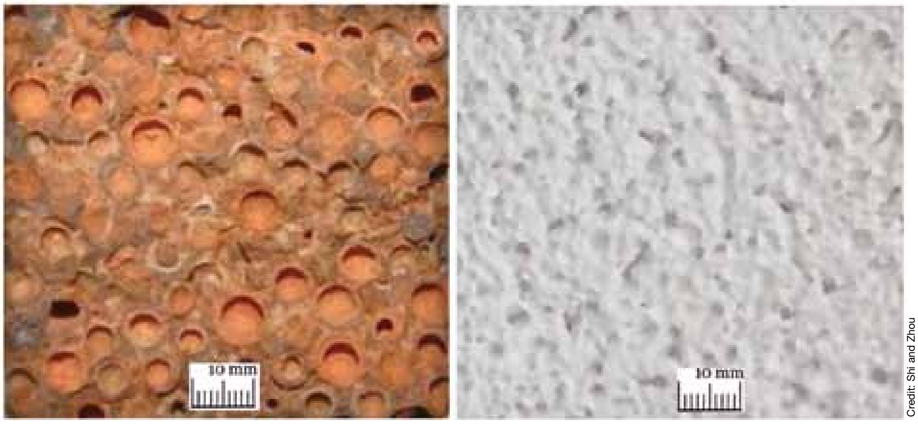
Conventional crushed aggregates have irregular shapes and larger surface area. Castables or shotcreting mixes require sufficient water to have satisfactory flowability and pumpability. The situation may become worse when using lightweight aggregates, because they are porous and absorb much more water when forming a wet mix. Therefore, high-water-content castables and gunning-mix installations require longer times for curing and drying. On the other hand, if aggregate shapes are irregular, dilatancy (increased shear viscosity with applied shear stress) may occur, leading to transportation and flow problems when they are forced to move (translation and rotation) during mechanical agitation. Installing dilatant castables often results in intolerable structural defects, such as voids and flaws, because castables with dilatancy have difficulty in reaching the desired positions.

Spherical particles can help overcome these problems. Spheres provide excellent flowability, because they rotate with little resistance. Figure 2 illustrates how dilatancy can be reduced in castables when spherical aggregates replace irregular aggregates. Castable mixes with spherical aggregates require less water because of their small surface area compared with similarly sized irregular aggregates. For applications that require lightweight aggregates, hollow spheres with dense shells or surface-sealed porous spheres will serve the purpose. Both structures can dramatically reduce water demand. In addition, similar to Curdy's[10] observations of spherical fillers in plastics, improved flowability can reduce wear of mixing and installation machines and allow filling of intricate part sections. Moreover, spherical character imparts isotropic behavior to the materials,



Credit: Shi and Zhou

Figure 2. Aggregate shape affects flow in densely packed systems. (a) Rotating spherical aggregates do not repel surrounding materials, and, therefore, dilatant flow does not occur. (b) Rotation of irregular aggregates (c) pushes surrounding materials away, which leads to dilatancy. Dilatancy adversely affects flowability and pumpability of castables.



(a) (b)

Figure 3. Lightweight, porous refractory castables made with (a) hollow spherical aggregates and (b) sacrificial pore formers. The structure of lightweight castable refractory comprises hollow spheres isolated by dense matrix. In contrast, porosity achieved by sacrificial pore formers connects into channels that make the castable weak and air permeable.

which reduces shrinkage and warpage of installed parts during drying.

Two examples borrowed from the oil-drilling industry offer analogous supporting evidence. The first example is glass spheres use in drilling slurries.[11] Many oil wells, especially off shore, are not drilled vertically but on an incline or horizontally. During nonvertical drilling operations, mechanical friction is a serious issue. Adding glass spheres into drilling fluids can solve this problem. (See also *ACerS Bulletin*, January/February 2014 article on engineered ceramic proppants for hydraulic fracturing to recover natural gas from shale deposits.) Glass spheres reduce friction similar to bearings for rotating parts in machines.

The second example is use of hollow glass spheres to reduce density of wellbore cements. Conventionally, cements contained bentonite as a lightweight ingredient, or the cement slurry was foamed using compressed nitrogen.[12] These methods of reducing density, however, also substantially decrease strength. In addition, nitrogen-foaming does not produce a stable and uniform lightweight structure in the cement because of nitrogen migration.[13] In contrast, adding hollow glass spheres produces a strong, lightweight, stable, and uniform cement structure because of their superior flowability, immobility of pores, and geometrical advantages for stress resistance.[14]

Dai et al.[15] addressed another issue regarding concrete installation. Because concretes have ingredients of various densities, light ingredients often float upward as vibration force is applied, which causes structural deviation from bottom to top. Dai disclosed a method that used spherical aggregates and made the density of different-sized aggregates identical. Because of good flowability and identical density, spherical aggregates resolved the floating-up issue and allowed formation of self-densified concrete.

Dense structures in corrosion-resistant and insulating refractories

Dense refractories favor corrosion resistance, because they prevent corrosive media (e.g., molten slags and corrosive gases) from penetrating into inner structures. Traditionally, dense refractories are made using dense aggregates, such as electrically fused alumina and magnesia. However, voids and flaws continue to exist in the structures because of mismatch between coarse aggregate and fine-grained matrix. Theoretically, the sintering mismatch problem can be overcome using aggregates with size distributions such that voids between larger aggregates are filled by smaller ones. With conventionally crushed aggregates, however, it is difficult to do so, because size and shape are difficult to measure accurately, and the predicted reduction of voids between aggregates is not very reliable.

This situation can be improved by using spherical refractory aggregates. German[16] used a geometric model to illustrate that volumetric density of regularly packed monosized spherical particles is 74% and density of randomly packed monosized spherical particles is ~64%, higher than that of irregular particles. In a geometric sense, void-free structures can be obtained by filling voids with smaller aggregates in size distribution. From a practical viewpoint, size measurement of spherical aggregates is accurate, and size classification of spherical particles is easier. Fully dense structures can be realized with a customized size distribution of spherical aggregates.

Spherical aggregates also improve lightweight thermal insulation, which performs better if the structure is "dense." Halapa and Soudier[17] raised a corrosion issue in some industries involving thermal processes, where many high-temperature devices (e.g., incinerators, cement kilns, and boilers) have installation parts, such as shells, tubular walls, and anchors, made of steel. Although shells and walls confine the process, anchors hold refractory insulation to protect shells and walls against high temperatures.

Because insulation has interconnected pores and channels, corrosive atmospheres, such as acidic and alkali gases or salt vapors, can attack metallic parts through passageways inside the insulating layers. Applying an impermeable refractory coating onto the installation parts could be a solution. Another approach is to make insulation with hollow refractory spheres to close the porosity and thereby make impermeable insulation structures. Figure 3 compares two lightweight structures fabricated with hollow spheres vs. sacrificicial pore formers. The advantage of the former is obvious—dense matrix between the spheres maintains strength. In fact, it is easy to control porosity by controlling the amount of hollow spheres.

Controlled permeability

Although aforementioned industrial processes require dense refractories, others may need gas-permeable structures. A typical example is gas-permeable brick installed in tundish bottoms to blow argon into molten steel contained in the vessel. To provide a uniform gas curtain

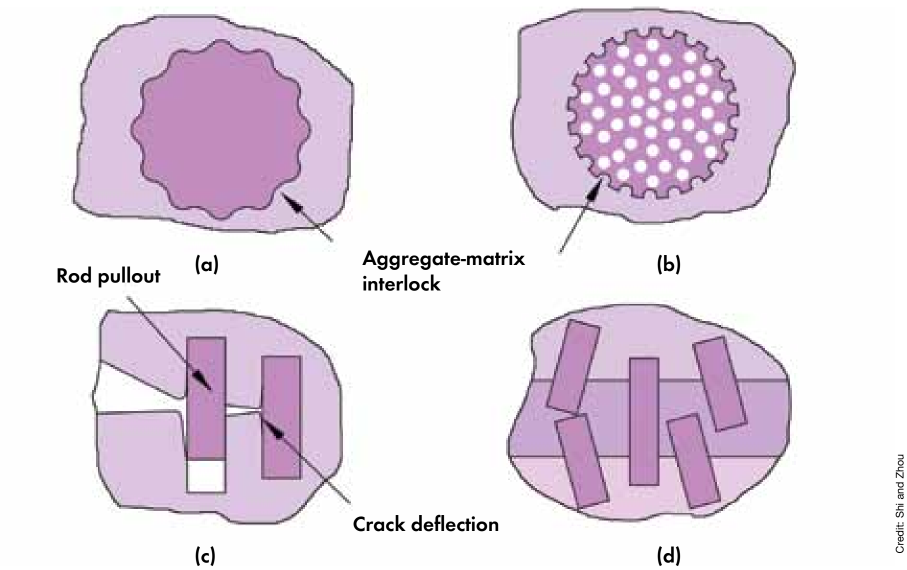


Figure 4. Strengthening of refractories with engineered aggregate. (a) Rugged surface and (b) porous surface aggregates interlock with the matrix and increase grip at the aggregate–matrix interface. (c) Columnar aggregate enhances thermal shock resistance in a similar manner to fiber-induced ceramic toughening. (d) Rod-shaped aggregates act as pins between layers of functionally graded materials.

to the melt, there should be vast gas passageways uniformly distributed in the refractory to diffusely supply argon. The gas passageway inside the refractory may be introduced by embedding metallic minitubes, sacrificial plastic strips, or organic fibers,[18] or by using appropriate size distribution of aggregates.[19,20]

The principle behind the latter approach is that if the amount of smaller aggregates is less than that needed for the most dense packing, unfilled voids between larger aggregates form passageways for argon. Number, size, and dispersion of passageways depend on aggregate size ratios. As discussed for dense structure, uncertainty of size and shape distribution of irregular aggregates could lead to structural deviation of passageways and, thus, affect performance of the refractory. On the other hand, size and shape of spherical aggregates are well-defined and may lend themselves to better control and design of passageway structures.

Strength, spalling resistance, and thermal shock resistance

Crushed aggregates have irregular shapes with sharp vertexes. The vertexes are vulnerable to crushing, which limits compressive strength of refractory bodies. Similarly, pores formed in lightweight refractories may have sharp tips because of either shape of sacrificial material (pore former) or coarsening of bubbles during foaming. These sharp tips can intensify tensile stress and cause body damage by crack propagation.

In contrast, spherical aggregates can bring higher strength to refractory bodies. Curdy[10] compared stress distribution in plastics with fiber, rod, random shapes, and glass sphere fillers. Stress around the first three types of materials concentrates at their ends, whereas stress around glass spheres distributes uniformly. This observation helps explain the effect of spherical aggregates on materials strengthening.

Wear resistance is a key property of refractories continuously subjected to wear by other objects, such as steel melts in a furnace or ladle. Although the contribution of aggregate wear to refractory damage is seldom considered, observations showed that damage actually takes place by aggregate spalling off the matrix. This indicates that the weak area in refractories is the aggregate–matrix interface, and strengthening this interface will enhance wear resistance.

Zhou and Shi[21] reported a method for interface strengthening using spherical aggregates with rugged surfaces. The rough surfaces formed a mortise and tenon interlock structure with the matrix. This structure eliminated the weak interface and created mutual gripping force between aggregate and matrix. Grip force helps prevent aggregates from spalling off the matrix, thus improving wear resistance of the whole body. Figure 4(a) illustrates an interlock structure formed between an aggregate of rugged surface and its adjacent matrix. Such structure also can form between matrix and aggregate of which the surface is distributed with open pores, as illustrated in Figure 4(b).

Other engineered shapes for aggregate, such as rodlike, tubular, and columnar shapes, may contribute to good thermal shock resistance. The mechanism for thermal shock resistance enhancement is illustrated in Figure 4(c). It is analogous to the toughening effect of fibers on engineered ceramics—elongated structural elements prevent cracks from propagating by direct crack bridging, crack path deflection, and aggregate pullout.

Functionally graded refractories

Functionally graded refractories have applications for sintering magnetic materials. These materials need refractory substrates to travel through kilns with temperature gradients from ambient temperature to 1,450°C, with heating rates between 50°C/h and 200°C/h and residence times of 20–40 h (Xu and Han[22]). Such a temperature profile requires substrates to have good thermal shock resistance. Silicon carbide is a good candidate because of its low thermal expansion, high strength, wear resistance, and good thermal conductivity. However, silicon carbide oxidizes at elevated temperatures that undermine its use.

On the other hand, zirconia partially stabilized by calcium oxide (Ca-PSZ) is oxidatively stable and chemically inert to manganese zinc ferrites despite its poor thermal shock resistance. A functionally graded refractory substrate was thus developed for sintering manganese zinc ferrites. The substrate is constructed with three layers: an inner layer of silicon carbide, which gives the substrate good thermal shock resistance; an outer layer of Ca-PSZ, which protects the substrate against oxidation and prevents the ferrite from reacting with the substrate; and an intermediate layer of silicon carbide and Ca-PSZ, which reduces thermal mismatch between outer and inner layers. Even with an intermediate layer, a certain degree of mismatch exists because of a large difference in thermal

Credit: Shi and Zhou

(a) (b) (c)

Figure 5. Pilot product examples of engineered refractory aggregates: (a) mullite-based hollow spheres with rugged surfaces; (b) high-purity mullite spheres with smooth surfaces; and (c) mullite/alumina-based rods. The spherical aggregates in (a) and (b) are 3–8 mm in diameter and (c) rod aggregates are 1–3 mm in diameter with an aspect ratio of 6–10.

expansion coefficients between silicon carbide and zirconia.

Although new approaches, such as multiple functionally graded layer composites, are in exploration, incorporating rodlike, columnar, or tubular aggregates could provide a solution. Elongated structural elements, such as these, could act as pins that lock mismatched parts together and prevent them from separation, as shown in Figure 4(d).

Columnar or tubular aggregates for structural reinforcement also may find applications in other functionally graded refractories for steelmaking. Such refractories may include gas-purging elements, long nozzles, submerged entry nozzles, and monolithic stoppers. These refractories perform specialized functions in continuous casting processes. They are subjected to severe thermal shock, wear and spalling, and corrosion.[23] They must have multiplex qualities to satisfy requirements for high reliability and durability. Incorporation of columnar or tubular aggregates into these functionally graded refractories could help make them robust.

Engineered refractory aggregates with core–shell structures may be useful for applications that require protecting the core material from attack by hostile environments. Aggregate with core–shell structure can be viewed as another type of functionally graded refractory. Hu et al.[24] disclosed an embodiment of core–shell structure with a polyethylene-sealed magnesia clinker. In this structure, magnesia clinker resists corrosion by low-iron and low-alkali slag, whereas the polyethylene seal protects magnesia from hydration during storage and installation. The core–shell structure concept can extend to more varieties and robust material systems and may warrant further exploration. For example, encapsulating a glassy phase into a high-alumina shell may prevent the glass from corrosion by alkali species, and sealing non-oxide materials inside oxide ceramic shells may protect non-oxides from oxidation. Besides differences in chemical composition, cores and shells also can have some difference in microstructure, such as porosity, shape, and texture of crystalline phases, as schematically shown in Figures 1(e) and (f).

Potential to eliminate environmental hazard of refractory fibers

Energy saving requires high-efficiency insulation, of which refractory-fiber-based materials seem to dominate at present. However, conventional ceramic fibers pose potential health hazards as irritants to skin, eyes, and upper respiratory systems. The United States Occupational Safety & Health Administration classifies any ceramic fiber less than 2.5 μm in diameter as a respirable and hazardous fiber (Nixdorf[25]), and about 1 fiber/cm^3 per 8-h exposure is the level commonly thought to be dangerous (Penumella[26]). Sekhar[27] proposed to eliminate ceramic fibers from refractory insulation by using highly porous refractory balls in high-temperature, fiber-free insulation with very low thermal conductivity.

Engineering aggregate composition along with shape

Aggregate engineering also includes composition design along with shape. The refractories industry has had but limited use of spherical aggregates. Alumina and zirconia bubbles are known for their high service temperatures, but they are weak in aggregate strength. Li[28] collaborated with a refractory raw-materials manufacturer to develop bauxite-based spherical aggregates. Zhou, et al.[1,29] and a related industrial partner developed mullite-based rugged and hollow balls to satisfy certain applications where service temperature ranges from 1,200°C to 1,450°C.

It is worthwhile to advance these spherical aggregates from alumino-silicates to other compositions, such as $MgO–SiO_2$, $Al_2O_3–MgO$, and $CA_6–MA$ (calcium hexaluminate–magnesium aluminate spinel). Spheres made of $MgO–SiO_2$ would have high service temperature, good thermal shock resistance, and good compatibility with basic refractory work lining during service. Spheres of $Al_2O_3–MgO$ should impart lower thermal conductivity to alumina-based, lightweight castables in addition to high-temperature resistance. Another attractive material system is the $CA_6–MA$ complex, which has high refractoriness and high thermal stability in reducing atmosphere. Refractory castables for applications that require high-temperature insulation and resistance to reducing atmosphere attack need a larger amount of $CA_6–MA$, and spherical aggregates may be of great benefit in this case.

State-of-the-art engineered shapes, structures, and chemical compositions advance refractory technology

Engineered refractory aggregates are state-of-the-art materials. This article presents a few shapes, structures, and chemical compositions and discusses their potential benefits in advancing refractory technology. Already, several aggregates with engineered shapes have been incorporated into pilot products. Figure 5 shows samples of mullite-based spherical aggregates with rugged (Figure 5(a)) and smooth (Figure 5(b)) surfaces. These spherical aggregates were fabricated by tumbling disk granulation. They can be made by other techniques as well, such as extrusion and slurry dripping. Figure 5(c) shows a sample of alumina-based rod aggregates produced by extrusion.

Because engineered aggregates have distinct advantages, they may become the dominant constituent in future refractories. It is worthwhile to invest effort and resources to develop technologies to transition from conventional refractory aggregates to engineered ones. The first step is to test and evaluate performance of refractories with engineered aggregates in various application situations and learn to use them correctly, efficiently, and safely. Meanwhile, appropriate technologies are needed for economically producing engineered aggregates. Further, the scope for aggregate engineering can be much broader than refractories. Because the transition from conventional aggregates to engineered aggregates calls for a large task, routes for research and development need to be well mapped to realize their full potential.

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Credit: ACerS

Honoring the ACerS Awards Class of 2015

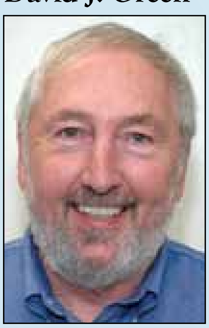
Over its long history, The American Ceramic Society has established a tradition of awards to recognize its members' outstanding contributions and accomplishments and to create career benchmarks for aspiring young scientists, engineers, and business leaders.

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 2015, three individuals will receive DLM honors: David J. Green, Martin P. Harmer, and Rishi Raj.

The Society will elevate 16 members to Fellow and recognize many more outstanding members with various Society, Division, and Class awards and lectures. Awards and lectures will be presented at ACerS's Annual Meeting, October 4 – 8, 2015, held in conjunction with MS&T15 in Columbus, Ohio.

2015 Distinguished Life Members

David J. Green



David Green was looking for a research topic for his master's thesis. As a young undergraduate student at the University of Liverpool in England, he originally studied chemistry—but he was always intrigued by the study of fracture.

When it was time to select a topic for his honors year specialization, a fellow student recommended he give metallurgy and materials science a try. Embarking on graduate school, he went to McMaster University (Hamilton, Ontario, Canada) to study fracture of metals.

However, when he arrived at McMaster University, he discovered there were no openings to study fracture of metals. Instead, a metallurgy professor directed Green to a guy down the hall who had a project on fracture of ceramics—specifically, zirconia.

So Green quickly changed his plans. "I can count very closely to the day when I started my ceramic career. It was when I took on this project with Dr. Pat Nicholson and started working on fracture of zirconia," he recalls.

At that time, there was interest in using ceramics in high-temperature engines, Green explains. This idea generated a lot of public interest and, as a result, Nicholson had obtained funding to perform research in this area—in particular, the fracture behavior of zirconia. This became the focus of Green's thesis.

Early in his career, Green joined a research center in California—the Rockwell International Science Center.

At Rockwell International he had the opportunity to study the thermal protection system of the space shuttle before and after its maiden voyage.

The most rewarding part of his career has been combining teaching with research during 28 years at Pennsylvania State University, and being able to share his research and learn from others in the field internationally, he says.

When it comes to being part of ACerS, Green was immediately drawn to the close-knit professional community.

"You could get to know people right away—people who were world-leading experts," he says.

In fact, Green can link his entire professional career to his close-knit ACerS network, from his first job at CANMET with the Canadian government and friends he made while there, to working with Fred Lange at Rockwell International, where he worked on space shuttle tile, to joining the Penn State faculty at the urging of Richard (Dick) Tressler.

In 2014, Green served as ACerS president. During his tenure as president, Green focused on launching the Ceramic and Glass Industry Foundation, outreach to Central and South American members, and promoting diversity in the Society. He is a Fellow of ACerS, 2005 recipient of the Sosman Lecture Award, and in 2006 became an Alexander von Humboldt Fellow. He serves as senior editor of the Society's flagship *Journal of the American Ceramic Society*.

Martin P. Harmer

Martin Harmer started his career with right hand on an old testament, making an oath.

Harmer did not take this oath lightly. His oath to continue studying ceramics, sworn to the field's old testament—W. David Kingery's "Introduction to Ceramics"—catalyzed a lauded career answering some of the biggest challenges in ceramic science and engineering.

As an undergraduate at the University of Leeds in the United Kingdom, Harmer initially struggled with a major. He switched from physics and chemistry, studied textiles for a bit—three weeks, to be precise, Harmer says—and was left still searching for his fit.

Then he remembered a presentation given to his high school class about ceramic materials. That lecture planted a seed of intrigue in Harmer's young brain, and that seed began to sprout. But switching yet again from the textiles major and into ceramics required the aforementioned oath to stick with ceramics—and stick with it he did.

During Harmer's final year of undergraduate study, the ceramics department at the University of Leeds appointed a new department head. Richard Brook was energetic and dynamic, and he inspired Harmer. So inspiring that Harmer decided to continue his graduate work at Leeds, studying with Brook.

It was during graduate school that Brook sent Harmer stateside, for the first time, to the University of California, Berkeley to gain electron microscope experience with renowned materials science professor Gareth Thomas. In addition to the invaluable experience Thomas imparted in the young scientist, Harmer also attended his first ACerS meeting during his time in the United States.

Harmer's oath—as well as his hard work and research experience—continued to serve him, as Lehigh University (Bethlehem, Pa.) offered him a faculty position upon completion of his Ph.D. He accepted, earned his degree, and has since spent the past 35 years building an impressive career at Lehigh. Harmer is currently Alcoa Foundation Distinguished Professor of materials science and engineering and director of the Center for Advanced Materials and Nanotechnology at Lehigh University.

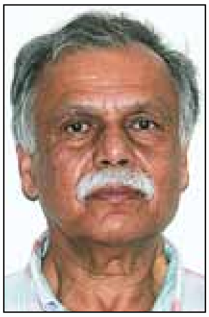
Harmer says the most rewarding aspect of his career is having the opportunity to interact with spectacular colleagues and students, together working to solve tremendous problems in the field—as he puts it, those mysterious processes that have long plagued the field. Harmer's publication record details significant contributions unraveling grain boundary complexions, microchemical ordering and domain structures in ferroelectrics, and critical characteristics of structural ceramics, among many others.

An ACerS member since 1981, Harmer has received an honorable list of Society awards, including ACerS Fellow designation, Richard M. Fulrath Award, Ross Coffin Purdy Award, Robert B. Sosman Memorial Award, Roland B. Snow Award, and W. David Kingery Award.

The Society has a Goldilocks effect on Harmer: "The size of the community is just right—ACerS is small enough to be personal and get to know others well, yet large enough that the depth of talent is deep." Members give back more than they take, a principle that has allowed the Society to become the tight-knit family that it is, Harmer says.

"A final comment concerns Harmer's quality of spirited optimism about the very subject of ceramics, about the value of committed research, and about the benefits of shared endeavor," mentor Richard Brook comments about Harmer. "He conveys a message—it is a serious message—but it is an intrinsically positive message."

Rishi Raj



Rishi Raj discovered ceramics about a decade after earning his Ph.D., but once he discovered them, he never looked back. Today he is recognized as a prominent thought leader in the field.

His college education started in India with a two-year degree in natural sciences, which he continued at the University of Durham, U.K., earning a B.S. in electrical engineering. After working on control systems for the now defunct Concorde aircraft, he came to the United States to enroll at Harvard University in an interdisciplinary program that bridged engineering and applied physics.

This proved to be a pivotal decision in Raj's intellectual formation, and interdisciplinary inquiry would become the foundation of Raj's research activities. "I love working with others who are experts in their areas," he explains.

At Harvard he studied under Michael Ashby and David Turnbull. Raj says these mentors were "big thinkers—they thought beyond the material, in very fundamental ways."

"There was never any doubt in my mind that I wanted an academic career," Raj says. His first academic appointment was to the faculty of the University of Colorado, Boulder. After a few years he moved to Cornell University, Ithaca, N.Y., where he spent his peak years. The environment, he says, was "very intellectual and very interdisciplinary." In 1996, Raj rejoined the faculty at University of Colorado, Boulder, where he is professor in the Materials Science and Engineering Program of the Mechanical Engineering Department.

It was during the Cornell years that Raj met Fred Lange, ACerS Fellow and 2002 Distinguished Life Member. Lange invited Raj to visit his lab at Westinghouse in Pittsburgh, Pa., where he was researching silicon nitride and silicon carbide for engines. Lange, who was studying how interfaces slide, shared with Raj a key publication—a paper based on Raj's Ph.D. work! Raj soon shifted his attention from metals to ceramics.

Since that serendipitous lab tour, Raj has studied oxides and non-oxides to understand a wide range of behavior phenomena, including high-temperature creep, superplasticity, interfaces and amorphous phases and their role in sintering and creep, sintering mechanisms, and polymer-derived amorphous materials.

The common thread through these lines of inquiry has been Raj's interdisciplinary approach to modeling the fundamental physics that govern materials properties and processing.

Reflecting on the influence of the Society on his career, Raj says he has "developed a lot of respect and reverence" for institutions "dedicated to searching for truth, and ACerS is one." "The Society provides a meeting place, which has a profound effect whether we realize it or not," he says.

Most recently, Raj has turned his attention to understanding electric field effects on sintering and defect chemistry, also called "flash sintering." Under an electric field, materials, such as zirconia, densify at low temperatures in very short times. This new line of inquiry brings together the entire arc of his career—electrical engineering, solid-state physics, modeling, processing, and decades of studying ceramic materials. "The science community is all fired up about it," he says, and he expects flash sintering will be the new paradigm in 10–15 years.

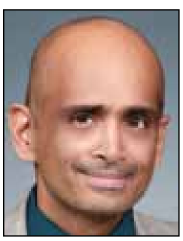
About this new research, Raj says "I hope that I can give it some structure while I can." In addition, he says, "Fred Lange really would have enjoyed flash sintering." ■

The 2015 Class of Fellows

Chen

Long-Qing Chen is Hamer Professor of materials science and engineering at Pennsylvania State University. He has a B.S. from Zhejiang University (Hangzhou, China); an M.S. from State University of New York at Stony Brook; and a Ph.D. from the Massachusetts Institute of Technology (Cambridge, Mass.). All degrees are in materials science and engineering.

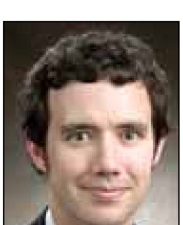
He has published over 400 papers on computational microstructure evolution and multi-scale modeling of metallic alloys, oxides, and energy materials.



Devanathan

Ram Devanathan is technical group manager in the Energy & Environment Directorate at Pacific Northwest National Laboratory in Richland, Wash. He leads a group of 40 scientists and engineers with expertise in materials characterization, multi-scale modeling, mechanical testing, radiation detection, mechanical design, prototyping, and robotics to develop innovative solutions for the nation's pressing energy and environmental challenges.

He received a B.Tech. in metallurgical engineering from the Indian Institute of Technology Madras (Chennai, India); a Ph.D. in materials science and engineering from Northwestern University (Evanston, Ill.); and an M.B.A. from Washington State University (Pullman, Wash.). He received ACerS Richard M. Fulrath Award in 2012 for excellence in ceramics research.



Fox

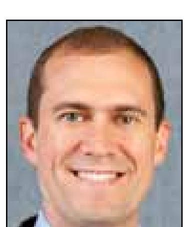
Kevin M. Fox is principal engineer in the Environmental Stewardship Directorate of the Savannah River National Laboratory (Aiken, S.C.). His current research focus is development of innovative waste form compositions for immobilization of nuclear wastes. He authored more than 25 peer-reviewed publications, co-edited six volumes, and has given more than 40 technical society presentations.

He received a B.S. in ceramic engineering from Alfred University (Alfred, N.Y.) and an M.S. in ceramic science and Ph.D. in materials science from Pennsylvania State University (State College, Pa.). He is a past chair of ACerS Nuclear and Environmental Technology Division and was recently honored with the Karl Schwartzwalder-Professional Achievement in Ceramic Engineering Award.

Goski

Dana G. Goski is director of research at Allied Mineral Products Inc., a global monolithic refractory producer headquartered in Columbus, Ohio. Originally from Canada, she finished her M.S. in chemistry at Dalhousie University in Nova Scotia under joint supervision from the National Research Council Canada ceramic laboratory. She completed her Ph.D. in the faculty of engineering, department of mining and metallurgy at the Technical University of Nova Scotia.

She has served ACerS as both a participant and chairperson for committees including membership, nominating, meetings, the former Central Ohio Section, Refractory Ceramics Divison, and Jeppson Award. She is the 2014–2015 chairperson for the ACerS Meetings Committee and a member of the Refractory Ceramics Division.



Jones

Jacob L. Jones is professor of materials science and engineering and director of the Analytical Instrumentation Facility at North Carolina State University (Raleigh, N.C.). He received B.S. and M.S. degrees in mechanical engineering and a Ph.D. in materials engineering from Purdue University (West Lafayette, Ind.).

Since 2004, he has published over 120 papers (23 in the *Journal of the American Ceramic Society*) and delivered over 80 invited presentations. He is a member of the Basic Science and Electronics Divisions, treasurer of ACerS Florida Section, and associate editor for the *Journal of the American Ceramic Society*. In 2010 and 2012, papers authored by Jones and his group received the Edward C. Henry "Best Paper" Award from ACerS Electronics Division.

Jones

Julian R. Jones is professor of biomaterials at Imperial College London, U.K., and visiting professor at Nagoya Institute of Technology, Japan. He graduated from the materials science program at the University of Oxford and obtained his Ph.D. from Imperial College London. His research focuses on the development of advanced materials for regenerative medicine and therepeutic applications.

He is a member of the Glass and Optical Materials Division and received the Robert L. Coble Award in 2010. He is co-chair of ACerS Technical Interest Group in Bioceramics.

Juenger

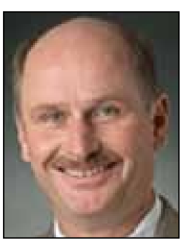
Maria Juenger is professor in the civil, architectural, and environmental engineering department at the University of Texas at Austin. She received her B.S. in chemistry from Duke University (Durham, N.C.) and a Ph.D. in materials science and engineering from Northwestern University (Evanston, Ill.).

Her research focuses on materials used in civil engineering applications, primarily chemical issues in cement-based materials, including phase formation in cement clinkering, hydration chemistry of portland cement, calcium sulfoaluminate cement, supplementary cementitious materials, and chemical deterioration processes in concrete.


Kaplan

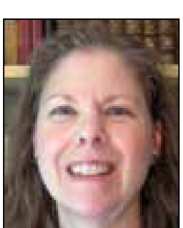
Wayne D. Kaplan holds the Karl Stoll Chair in Advanced Materials in the department of materials science and engineering at Technion–Israel Institute of Technology (Haifa, Israel). Since October 2014, he has been executive vice president of research at Technion.

He completed his B.S. in mechanical engineering and M.S. and D.S. in materials engineering at the Technion. He has published more than 125 manuscripts in reviewed and archived international journals, two textbooks, and presented over 70 lectures at international conferences. He is a former chair of the Basic Science Division.


Lanagan

Michael Lanagan is professor of engineering science and mechanics and materials science and engineering at Pennsylvania State University (State College, Pa.). He received his B.S. in ceramic engineering from the University of Illinois at Urbana–Champaign and a Ph.D. in ceramic science from Penn State.

His research focuses on dielectric materials for energy and medical applications, and he has authored or co-authored nearly 250 publications. He has been a member of ACerS since 1982 and participates in the Electronics Division.


Madsen

Lynnette D. Madsen has worked at the National Science Foundation headquarters in Arlington, Virginia, as the program director of ceramics since 2000. She has been directly responsible for more than 500 awards totaling $155M+.

She holds a B.A.Sc. in electrical engineering and B.A. in psychology (University of Waterloo, Ontario, Canada); M.Eng. in electronics (Carleton University, Ottawa, Ontario); and Ph.D. in materials science (McMaster University, Hamilton, Ontario). She has published 90 articles, been awarded two patents, and delivered more than 85 invited talks. She serves on ACerS Strategic Planning for Emerging Opportunities Committee, recently chaired the ACerS Presidential Committee on Diversity, and served as the 2013 chair of the Art, Archaeology and Cultural Science Division. Her first book, containing inspirational profiles of 100 successful female ceramic and glass scientists and engineers, is forthcoming.


Mauro

John C. Mauro is research manager and senior research associate in glass research at Corning, Inc. (Corning, N.Y.). He holds a B.S. in glass engineering science, B.A. in computer science, and Ph.D. in glass science all from Alfred University (Alfred, N.Y.).

He is a globally recognized expert in fundamental and applied glass science, statistical mechanics, computational and condensed matter physics, thermodynamics, and the physics of topologically disordered networks, and inventor or co-inventor of several new glass compositions for Corning, including Corning Gorilla Glass products. He is a past winner of the ACerS Norbert J. Kreidl Award, a 2015 winner of the Fultrath award, and serves as an associate editor of the *Journal of the American Ceramic Society*.


Medvedovski

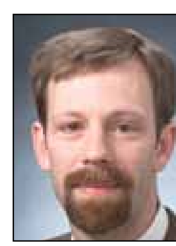
Eugene Medvedovski is senior materials engineer at Endurance Technologies Inc. (Calgary, Canada). He earned B.Sc. and M.S. degrees in ceramic engineering from the Mendeleev Moscow Chemical Engineering University (Russia) and Ph.D. in ceramic engineering on electroinsulating materials from the All-Union Research and Manufacturing Centre of Cable Industry (Moscow, Russia).

He is a member of ACerS Engineering Ceramics Division and has been co-organizer of ACerS symposia for years, serving also as a session chair. He is a past recipient of ACerS Global Star Award.


Paranthaman

M. Parans Paranthaman is distinguished research staff member and group leader of materials chemistry in the Chemical Sciences Division at Oak Ridge National Laboratory (Oak Ridge, Tenn.). He has a joint faculty appointment with the University of Tennessee, Knoxville, Bredesen Center.

He earned his Ph.D. in solid-state chemistry and materials science from the Indian Institute of Technology, Madras (Chennai, India) in 1988. He has authored or co-authored more than 350 publications and was issued 30 U.S. patents related to superconductivity, energy storage, and solar cells. He currently serves as an associate editor for the *Journal of the American Ceramic Society*.


Salem

Jonathan A. Salem is materials research engineer at NASA Glenn Research Center in Cleveland, Ohio. He received a B.S. in materials science from the University of Cincinnati in Ohio and an M.S. and Ph.D. in materials science and mechanical engineering from the University of Washington, Seattle.

He has authored or co-authored over 135 archival publications and six national or international standards on mechanical testing of ceramics. As a member of ACerS Engineering Ceramics division, he served as chair and is a past recipient of the Fulrath Award and first and second place prizes for technical presentations.


Thomas

Jeffrey J. Thomas is principal research scientist at Schlumberger-Doll Research (Cambridge, Mass.). He received a B.S. in applied and engineering physics from

Cornell University (Ithaca, N.Y.) and Ph.D. in materials science and engineering from Northwestern University (Evanston, Ill.), where his research focused on high-temperature ceramic processing.

He has published more than 60 peer-reviewed scientific articles, mostly on cement chemistry. He has been active in ACerS Cements Division for two decades and served as chair of the division in 2005–2006. He is also a two-time recipient of the Brunauer Award, a yearly best-paper award given by the Cements Division.

Wang

Haiyan Wang is professor in the electrical and computer engineering department at Texas A&M University (College Station, Texas). She worked as a director-funded postdoctoral fellow and permanent staff member at Los Alamos National Lab (N.M.) from 2003 to 2006. She has published more than 300 journal articles, presented 150 invited and contributed talks at various international conferences, and holds eight patents on thin film processing and architectures. She has organized nine symposia at international conferences and meetings. ■

Awards Banquet

The winners of the Society's 2015 awards will be recognized at the **ACerS Annual Awards and Honors Banquet, Monday, October 5**. 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 5, 2015**.

Society Awards

W. David Kingery Award *recognizes distinguished lifelong achievements involving multidisplinary and global contributions to ceramic technology, science, education, and art.*

Messing

Gary L. Messing is distinguished professor of ceramic science and engineering, head of the department of materials science and engineering, and co-director of the Center for Innovative Materials Processing by Direct Digital Deposition at Pennsylvania State University (State College, Pa.). He received a B.S. in ceramic engineering from the New York State College of Ceramics at Alfred University (Alfred, N.Y.) and a Ph.D. in materials science and engineering from the University of Florida (Gainesville, Fla.). He has published over 300 papers and co-edited 13 books, and his research focuses on improving ceramic materials for optical, piezoelectric, and structural applications by regulating microstructure evolution using innovative approaches, including seeding of phase transformations, sintering stress analysis, and templated grain growth. He is a past-president of ACerS, a Fellow, a Distinguished Life Member, and is a past recipient of the Robert Sosman, Edward Orton, and John Jeppson awards from ACerS.

John Jeppson Award *recognizes distinguished scientific, technical, or engineering achievements.*

Faber

Katherine T. Faber is the Simon Ramo professor of materials science at the California Institute of Technology (Pasadena, Calif.) and co-director of the Northwestern University-Art Institute of Chicago Center for Scientific Studies in the Arts at Northwestern University (Evanston, Ill.). Her research interests include fracture of brittle materials, toughening mechanisms, ceramic composites and coatings, porous ceramics, and cultural heritage science. She holds a B.S. in ceramic engineering from Alfred University (Alfred, N.Y.), an M.S. in ceramic science from Pennsylvania State University (State College, Pa.), and a Ph.D. in materials science and engineering from the University of California, Berkeley. She served as president of ACerS from 2006–2007 and is a Fellow and Distinguished Life Member.

Robert L. Coble Award for Young Scholars *recognizes an outstanding scientist conducting research in academia, in industry, or at a government-funded laboratory.*

Dillon

Shen J. Dillon is assistant professor at the University of Illinois at Urbana-Champaign. He received his Ph.D. in materials science and engineering from Lehigh University (Bethlehem, Pa.). His research seeks to understand and exploit fundamental thermodynamic and kinetic relationships at interfaces to inform improved design of energy conversion and storage systems. Emphasis is placed on utilizing advanced characterization techniques, particularly in-situ and operando approaches that provide new insights into materials response in complex environments. He is the author of over 50 journal articles.

Ross Coffin Purdy Award *recognizes authors who made the most valuable contribution to ceramic technical literature in 2013.*

"Microstructural evolution during vacuum sintering of yttrium aluminum garnet transparent ceramics: Toward the origin of residual porosity affecting the transparency," published in the *Journal of the American Ceramic Society*, Volume 96, No. 6, 1724–1731 (2013). **Rémy Boulesteix**, **Alexandre Maître**, **Lucie Chrétien**, **Yoël Rabinovitch**, and **Christian Sallé**

Boulesteix

Rémy Boulesteix is associate professor at the Science of Ceramic Processes and Surface Treatments, a mixed University of Limoges-National Center of Scientific Research center in Limoges, France.

Chrétien

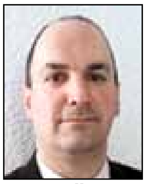
Lucie Chrétien is postdoctoral researcher at the Science of Ceramic Processes and Surface Treatments laboratory in Limoges, France.

Maître

Alexandre Maître is professor at the Science of Ceramic Processes and Surface Treatments laboratory in Limoges, France.

Rabinovitch

Yoël Rabinovitch is the CEO of Luxeram, a French company that specializes in transparent ceramics for luxury markets.

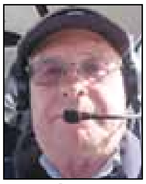


Sallé

Christian Sallé is a design engineer at Compagnie Industrielle des LASer in Limoges, France.

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 2014.*

"The missing boundary in the phase diagram of $PbZr_{1-x}Ti_xO_3$," published in *Nature Communications*, Volume 5, Article No. 5231 (2014). **N. Zhang**, **H. Yokota**, **A.M. Glazer**, **Z. Ren**, **D.A. Keen**, **D.S. Keeble**, **P.A. Thomas**, and **Z.-G. Ye**.



Glazer

Mike Glazer is emeritus professor of physics at the University of Oxford in England and visiting professor at the University of Warwick (Coventry, England). He has authored several books and served for many years as editor in chief of the *Journal of Applied Crystallography* and also founded the international journal *Phase Transitions*.


Keeble

Dean S. Keeble is a senior support scientist on the XPDF beamline at Diamond Light Source in the United Kingdom.


Keen

David A. Keen is research scientist at the ISIS Neutron Scattering Facility at the Rutherford Appleton Laboratory (Oxfordshire, United Kingdom) and a visiting professor in the physics department at Oxford University in England.


Ren

Zihe Ren is a postdoctoral fellow at the University of British Columbia, Canada.


Thomas

Pamela A. Thomas is pro-vice-chancellor of people and public engagement at the University of Warwick in the United Kingdom.


Ye

Zuo-Guang Ye is professor in the Department of Chemistry & 4D Labs at Simon Fraser University (Burnaby, British Columbia, Canada).


Yokota

Hiroko Yokota is assistant professor in the department of physics at Chiba University, Japan.


Zhang

Nan Zhang is a postdoctoral fellow in the chemistry department at Simon Fraser University (Burnaby, British Columbia, Canada).

NICE and CEC awards

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.


Folz

Diane C. Folz is senior research associate and instructor in materials science and engineering at Virginia Tech (Blacksburg, Va.). She works primarily in the area of microwave processing of materials. She holds a B.S. in materials science and engineering from the University of Florida (Gainesville, Fla.) and a Graduate Certificate in Engineering Education and M.S. in materials science and engineering from Virginia Tech. From 1994 to 2006, she served as the executive director of NICE. She is a member of ACerS, past-chair of ACerS Education and Outreach Committee, and past-chair of ACerS Florida Section, and is an evaluator for ABET. She has served as editor on six books and has more than 25 technical publications and two patents.

Ceramic Education Council: Outstanding Educator Award

recognizes truly outstanding work and creativity in teaching, directing student research, or general educational process of ceramic educators.

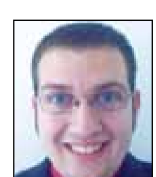

Martin

Steve W. Martin is the Anson Marston distinguished professor in engineering and faculty of materials science and engineering at Iowa State University (Ames, Iowa). He holds a Ph.D. in physical chemistry from Purdue University (West Lafayette, Ind.).

He is a past recipient of the George W. Morey Award in glass science from ACerS Glass and Optical Materials Division and an ACerS Fellow. His research specialization is the study of ionically conducting glassy solid electrolytes for batteries, fuel cells, optical materials, and fibers. He has published more than 190 articles and given more than 225 invited talks around the world. He is a member of ACerS and past-chair of ACerS Glass and Optical Materials Division. He also co-chaired the 2015 Annual Meeting of ACerS Glass and Optical Division. ■

Du-Co Ceramics Scholarship Award

recognizes an undergraduate student in ceramic or materials engineering for participation in ACerS activities.


Walden

Michael R. Walden is a senior at the Missouri University of Science and Technology (Rolla, Mo.). He will graduate in May of 2016 with a B.S. in ceramic engineering as well as minors in physics and chemistry. His current roles at MS&T include president of Keramos and vice president of Material Advantage. In addition to undergraduate research projects involving bioglass fibers and ZrB_2-composite refractories during his sophomore and junior years, he spent the summer of 2015 interning for GE Aviation in Dayton, Ohio. His plan after graduation is to seek a doctorate in materials science with a research field of either solid-state electronics or ultra-high-temperature ceramics.

Du-Co Ceramics Young Professional Award *is given to a young professional member of ACerS who demonstrates exceptional leadership and service to ACerS.*

Brennecka

Geoff Brennecka is assistant professor in the Metallurgy and Materials Engineering Department at the Colorado School of Mines. He holds B.S. and M.S. degrees in ceramic engineering from the University of Missouri-Rolla (now Missouri S&T) and a Ph.D. in materials science and engineering from the University of Illinois at Urbana–Champaign. His research focuses on functional electroceramics, specifically innovative processing and dynamic response of ferroelectrics, piezoelectrics, and related materials.

He serves in a leadership position for ACerS Electronics Division, was a chair of the Education Integration Committee, a member or chair of several ACerS awards committees, and is currently a member of the ACerS Board of Directors. He helped launch both ACerS President's Council of Student Advisors and the Young Professionals Network, and continues to be active in advisory roles for both.

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.*

Kyle S. Brinkman is associate professor in the department of materials science and engineering at Clemson University (Clemson, S.C.). He holds a B.S. in chemical engineering and M.S. in materials science and engineering from Clemson University and a Ph.D. in materials science and engineering from the Swiss Federal Institute of Lausanne in Switzerland.

Brinkman

He has authored or co-authored over 70 peer-reviewed technical publications and government reports. He serves as ACerS Material Advantage and Keramos faculty advisor for Clemson's undergraduate students in materials science and engineering. He is a member of ACerS Basic Science and Nuclear & Environmental Technology Divisions. ■

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.*

Fraunhofer Institute for Ceramic Technologies and Systems IKTS and **inopor GmbH** jointly won ACerS 2015 Corporate Environmental Achievement Award for their development of ceramic nanofiltration membranes for efficient water treatment. With this technology, water treatment without chemicals is possible with high water savings (recycling of up to 95%) as well as energy savings (by recycling hot water).

The Fraunhofer Institute for Ceramic Technologies and Systems IKTS (Dresden and Hermsdorf, Germany) covers the field of advanced ceramics from basic preliminary research to the entire range of applications.

inopor GmbH (Veilsdorf, Germany) is a wholly-owned subsidiary of Rauschert—a family-owned, German technology company with over 110 years of experience in manufacturing advanced technical ceramics.

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

Allied Mineral Products is the recipient of ACerS 2015 Corporate Technical Achievement Award for their development of a unique graphitic refractory castable, STACKCRETE® G, commercially used in blast furnaces.

Allied's research and technical team developed a graphitic-based refractory that is water dispersible. This material does not use alcohol-based solvents, which are common in monolithic graphitic systems. The result is reduced environmental impact and user friendliness.

Allied Mineral Products (Columbus, Ohio) has engineered, manufactured, and shipped monolithic refractories and precast shapes for over 50 years. The company has eight manufacturing facilities worldwide and two research and technology facilities with extensive testing capabilities. ■

Richard M. Fulrath Symposium and Awards

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

Symposium: Monday, October 5, 2:00–4:40 p.m.


Maria

Jon-Paul Maria

Title: *Entropically-stabilized oxides: A novel class of multicomponent materials*

Jon-Paul Maria is University Faculty Scholar and a professor of materials science and engineering at North Carolina State University in Raleigh, where his research focuses on new materials discovery, property engineering, advances in synthesis science, and new integration strategies to merge diverse materials.


Matsunaga

Tadashi Matsunaga

Title: *Functional ceramics derived from Si-based organics*

Tadashi Matsunaga is manager in the Polyimide and Specialty Products Business Unit at Ube Industries Ltd. (Ube, Japan). He holds B.E., M.E., and Ph.D. degrees in mechanical system engineering from Hiroshima University in Japan.


Mauro

John C. Mauro

Title: *What I talk about when I talk about the glass transition*

John C. Mauro is research manager and senior research associate of glass research at Corning Inc. (Corning, N.Y.). He is author of over 140 peer-reviewed publications and an associate editor of the *Journal of the American Ceramic Society*.


Shibata

Kenji Shibata

Title: *Development of lead-free (K, Na) NbO_3 piezoelectric films*

Kenji Shibata works as a project leader for SCIOCS Ltd. (Japan), where his research is focused on KNN films. He holds a B.A. in electronics and M.Eng. from Kyusyu University in Japan.


Takeda

Hiroaki Takeda

Title: *Lead-free electroceramics for high-temperature use*

Hiroaki Takeda is associate professor in the metallurgy and ceramics science department at Tokyo Institute of Technology in Japan. He has authored or co-authored over 150 peer-reviewed technical publications and is a member of ACerS Electronics Division. ■

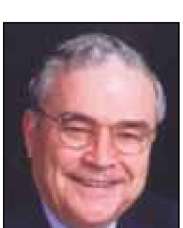
ACerS Award Lectures

ACerS Frontiers of Science and Society–Rustum Roy Lecture

Tuesday, October 6, 2015, 1:00–2:00 p.m.

Delbert E. Day, Curators' Professor emeritus of materials science and engineering and senior investigator of the Graduate Center for Materials Research at the Missouri University of Science and Technology, and former chairman and president of Mo-Sci Corporation (Rolla, Mo.)

Title: *Glass technology for better health*


Day

Delbert E. Day is a member of the National Academy of Engineering; is a Fellow, past-president, and Distinguished Life Member of ACerS; and has received the internationally recognized Phoenix Award for his technical achievements and contributions to the glass industry. His research focuses on glasses for biomedical applications, containerless processing of glass in microgravity, vitrification of nuclear waste, and structure and properties of mixed alkali glasses. He has published 400 technical papers and been awarded 66 U.S. and foreign patents. ■

ACerS Award Lectures

Edward Orton Jr. Memorial Lecture

PLENARY SESSION

Tuesday, October 6, 2015, 8:10–8:50 a.m.

Sylvia M. Johnson, chief materials technologist in the Entry Systems and Technology division at NASA Ames Research Center in Moffett Field, Calif.

Title: *Space: The materials frontier*

Johnson

Sylvia M. Johnson received a B.Sc. in ceramic engineering from the University of New South Wales, Sydney in Australia and an M.S. and Ph.D. in materials science and engineering from the University of California, Berkeley. A Fellow of ACerS since 1992, she served as vice president in 1996–1997 and as a board member from 2002–2005. She is a past recipient of the James I. Mueller Award from the Engineering Ceramics Division. She has worked extensively in silicon nitride and in the use of preceramic polymers, and was instrumental in reviving interest in ultra-high temperature ceramics. She is currently working on new thermal protection materials. ■

ACerS/NICE Arthur L. Friedberg Ceramic Engineering Tutorial and Lecture

Monday, October 5, 2015, 9:00–10:00 a.m.

Arun K. Varshneya, professor of glass science & engineering, emeritus at Alfred University and president of Saxon Glass Technologies (Alfred, N.Y.)

Title: *Principles of glass chemical strengthening science and technology*

Varshneya

Arun K. Varshneya holds an M.S. and Ph.D. from Case Western Reserve University (Cleveland, Ohio). He is known internationally for his solo-authored textbook on glass, "Fundamentals of Inorganic Glasses." His company, Saxon Glass Technologies, delivers glass chemical strengthening services for pharmaceutical and personal mobile communication device applications, one of the most-recognized developments being the strengthened glass cartridge for the EpiPen. He is a Fellow of ACerS, Distinguished Life Member, past-chair of ACerS Glass and Optical Materials Division, and served as treasurer of ACerS from 2008–2010. ■

Basic Science Division Robert B. Sosman Award and Lecture

Wednesday, October 7, 2015, 1:00–2:00 p.m.

Yuichi Ikuhara, professor and director of the Nanotechnology Center, Institute of Engineering Innovation at University of Tokyo, Japan

Title: *Grain boundary segregation, vacancies, and properties in oxide ceramics*

Ikuhara

Yuichi Ikuhara received his Ph.D. from the department of materials sciences at Kyushu University (Fukuoka, Japan). He is author and coauthor of ~600 scientific papers and has given more than 250 invited talks at international and domestic conferences. His current research focuses on interface and grain boundary phenomena, advanced transmission electron microscopy (STEM, HREM, EDS, EELS), high-temperature ceramics, electroceramics, phase transformation, theoretical calculations, and other areas. He is a Fellow of ACerS and a past recipient of ACerS Ross Coffin Purdy and Fulrath Awards. ■

October 4 – 8, 2015 | Greater Columbus Convention Center | Columbus, Ohio USA

JOIN US FOR THE ACerS 117TH ANNUAL MEETING!

Schedule changes for MS&T15!

Organizers have made several schedule changes this year to better serve the needs of MS&T's 3,500 attendees.

Women in Materials Science and Engineering Reception— Sunday, Oct. 4 | 6:00 – 7:00 p.m.

Welcome Reception and Exhibit Opening—Monday, Oct. 5 | 4:30 p.m.

MS&T Plenary Session and Award Lectures—Tuesday, Oct. 6 | 8:00 a.m.

Please see the calendar of events for full details.

hotel information

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

Reservation deadline: September 4, 2015

Hyatt Regency Columbus – (ASM HQ)
$184 per night (sgl/dbl)
Connected to the Columbus Convention Center

Crowne Plaza Columbus Downtown – (AIST and TMS HQ)
$177 per night (sgl/dbl)
One block from the Columbus Convention Center

Hilton Columbus Downtown – (ACerS HQ)
$189 per night (sgl/dbl)
Connected to the Columbus Convention Center

Red Roof
$149 per night (sgl/dbl)
Two blocks from the Columbus Convention Center

Hampton Inn and Suites Columbus Downtown
$172 per night (sgl/dbl)
Across from the Columbus Convention Center

Drury Inn and Suites
$156 per night (sgl/dbl)
One block from the Columbus 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.

lectures

Monday, October 5

NEW DAY

9:00 – 10:00 a.m.
ACerS/NICE Arthur L. Friedberg Ceramic Engineering Tutorial and Lecture
– **Arun K. Varshneya**, Alfred University and Saxon Glass Technologies
Principles of glass chemical strengthening science and technology

2:00 – 4:30 p.m.
ACerS Alfred R. Cooper Award Session
Cooper Distinguished Lecture
– **Martin C. Wilding**, Aberystwyth University
Cooper Scholar Lecture
– **Emily M. Aaldenberg**, Rensselaer Polytechnic Institute

2:00 – 4:40 p.m.
ACerS Richard M. Fulrath Award Symposium
– **Hiroaki Takeda**, Tokyo Institute of Technology
– **Tadashi Matsunaga**, UBE Industries Ltd.
– **John C. Mauro**, Corning Incorporated
– **Kenji Shibata**, SCIOCS Company Ltd.
– **Jon-Paul Maria**, North Carolina State University

Tuesday, October 6

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

ACerS Edward Orton Jr. Memorial Lecture
– **Sylvia M. Johnson**, NASA Ames Research Center
Space: The materials frontier

NEW DAY

1:00 – 2:00 p.m.
ACerS Frontiers of Science and Society–Rustum Roy Lecture
– **Delbert E. Day**, Missouri University of Science and Technology
Glass technology for better health

Wednesday, October 7

1:00 – 2:00 p.m.
ACerS Basic Science Division Robert B. Sosman Lecture
– **Yuichi Ikuhara**, University of Tokyo
Grain boundary segregation, vacancies and properties in oxide ceramics

Organizers: The American Ceramic Society (www.ceramics.org) · AIST Association for Iron & Steel Technology · ASM International · TMS The Minerals, Metals & Materials Society

Co-sponsored by: NACE International The Corrosion Society

special events

See Calendar of events for times and locations

NEW DAY

SUNDAY, OCTOBER 4

Women in Materials Science and Engineering Reception
Enjoy the chance to network with professionals and peers in a relaxed environment.

MONDAY, OCTOBER 5

NEW DAY

Welcome Reception and Exhibit Opening
Network with your colleagues, meet new people, and learn about the exciting membership offerings of the organizing societies.

ACerS 117th Annual Meeting
Newly elected officers take their positions during the annual membership meeting. All ACerS members and guests are welcome.

ACerS 117th Annual Honors and Awards Banquet
Enjoy dinner, conversation, and the presentation of Society awards. Purchase tickets by Monday at noon for $90 via meeting registration.

Experience Columbus
Meet Experience Columbus staff, who will provide information on local activities, sites, and self-guided tours in Columbus. The knowledgeable local staff will assist in getting your day planned and started.

You will be surprised by all of the activities and sight-seeing available to you during your stay in Columbus! Coffee and light pastries will be provided. Advance registration of $15 is required via the MS&T15 site at **www.matscitech.org**.

TUESDAY, OCTOBER 6

MS&T Young Professionals Reception
Attend this reception to meet and network with fellow young professionals.

MS&T15 Exhibit Happy Hour Reception
Network with colleagues and build relationships with qualified attendees, buyers and prospects!

Tasting Tour of German Village
Wear comfortable shoes for this walking and tasting tour through German Village. Immerse yourself in the unique heritage and old world architecture of this vibrant and historic neighborhood located just south of downtown Columbus. Purchase tickets for $49 via the MS&T15 site at **www.matscitech.org**.

ACerS short courses

Sign up by September 4
Separate registration required

Location: Hilton Columbus Downtown

SATURDAY, OCTOBER 3

Introduction to Two- and Three-component Phase Diagrams
9:00 a.m. – 5:00 p.m.
Instructor: Jeffrey D. Smith, Missouri University of Science and Technology

SUNDAY, OCTOBER 4

Understanding Why Ceramics Fail and Designing for Safety
8:00 a.m. – 4:30 p.m.
Instructors: Steve Freiman, Freiman Consulting Inc.; John J. (Jack) Mecholsky Jr., University of Florida

THURSDAY – FRIDAY, OCTOBER 8 – 9

Sintering of Ceramics
9:00 a.m. – 4:30 p.m.; 9:00 a.m. – 2:30 p.m.
Instructor: Mohamed N. Rahaman, Missouri University of Science and Technology

plenary lectures

TUESDAY, OCTOBER 6 AT 8:00 — 10:40 A.M.

NEW DAY

ACerS Edward Orton Jr. Memorial Lecture

Johnson

Sylvia M. Johnson, chief materials technologist, Entry Systems and Technology Division, NASA Ames Research Center

Title: ***Space: The materials frontier***
8:10 a.m.

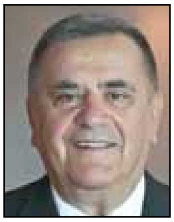
AIST Adolf Martens Memorial Steel Lecture

Bhadeshia

Harry Bhadeshia, Tata Steel Professor of Metallurgy, University of Cambridge and director, SKF Steel Technology Centre, University of Cambridge

Title: ***A complete theory for martensitic transformations***
9:00 a.m.

ASM/TMS Joint Distinguished Lecture in Materials and Society



Russo

Vincent J. Russo, executive director, Aeronautical Systems Center Wright-Patterson AFB (Retired)

Title: ***What is a splendid leader?***
9:50 a.m.

Pin Your ACerS Pride

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

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

JOIN US FOR THE ACerS 117TH ANNUAL MEETING!

Technical Meeting and Exposition

MS&T15

MATERIALS SCIENCE & TECHNOLOGY

October 4 – 8, 2015 | Greater Columbus Convention Center | Columbus, Ohio, USA

calendar of events

Accurate as of 08/07/2015 (times and locations are subject to change)

Legend:
CC = Greater Columbus Convention Center
Crowne = Crowne Plaza

SATURDAY, OCTOBER 3	TIME	LOCATION
Educational Courses		
Introduction to Two and Three Component Phase Diagrams	9:00 a.m. – 5:00 p.m.	Hilton
SUNDAY, OCTOBER 4		
Conference Activities		
Registration	Noon – 5:00 p.m	CC
Programming Support Desk	Noon – 5:00 p.m	CC
Society Member Lounges	Noon – 5:00 p.m	CC
Educational Courses		
Understanding Why Ceramics Fail and Designing for Safety	8:00 a.m. – 4:30 p.m.	Hilton
Advanced High Strength Steels	8:30 a.m. – 4:30 p.m.	Hyatt
Microstructures 101 and Beyond	8:30 a.m. – 4:30 p.m.	Hyatt
Robotics of Thermal Spray	8:30 a.m. – 4:30 p.m.	Hyatt
Additive Manufacturing Materials and Processes Workshop	1:00 p.m. – 5:30 p.m.	Crowne
Introduction to Materials Informatics with Open Source Tools	1:00 p.m. – 4:30 p.m.	Crowne
Material Advantage Student Functions		
Chapter Leadership Workshop (Material Advantage Chapter Officers Only)	10:00 a.m. – Noon	Hyatt
Undergraduate Student Speaking Contest Semi-Final 1	1:00 p.m. – 3:00 p.m.	Hyatt
Undergraduate Student Speaking Contest Semi-Final 2	1:00 p.m. – 3:00 p.m.	Hyatt
Undergraduate Student Speaking Contest Finals	4:00 p.m. – 5:00 p.m.	Hyatt
Student Networking Mixer	7:00 p.m. – 9:00 p.m.	Hyatt
Social Functions		
MS&T Women in Materials Science Reception NEW DAY	6:00 p.m. – 7:00 p.m.	CC
MONDAY, OCTOBER 5		
Conference Activities		
Registration	7:00 a.m. – 6:00 p.m.	CC
Programming Support Desk	7:00 a.m. – 6:00 p.m.	CC
Authors' Coffee	7:00 a.m. – 8:00 a.m.	CC
Society Member Lounges	7:00 a.m. – 6:00 p.m.	CC
ACerS Basic Science Division Ceramographic Exhibition and Competition — Drop off Ceramographs by 8:00 a.m. Monday	7:00 a.m. – 6:00 p.m.	CC
Poster Installation	4:00 p.m. – 6:00 p.m.	CC
Exhibition		
Exhibitor Set-Up	8:00 a.m. – 2:00 p.m.	CC
Exhibition Show Hours	4:30 p.m. – 6:00 p.m.	CC
Football Feature	4:30 p.m. – 6:00 p.m.	CC
Welcome Reception and Exhibit Opening NEW DAY	4:30 p.m. – 6:00 p.m.	CC
Lectures		
ACerS/NICE: Arthur L. Friedberg Ceramic Engineering Tutorial and Lecture NEW DAY	9:00 a.m. – 10:00 a.m.	CC
ACerS Richard M. Fulrath Award Session	2:00 p.m. – 4:40 p.m.	CC
ACerS Alfred R. Cooper Award Session	2:00 p.m. – 4:30 p.m.	CC
Alpha Sigma Mu Lecture	2:30 p.m. – 4:00 p.m.	CC
Material Advantage Student Functions		
ACerS Student Tour	Noon – 5:00 p.m.	CC
Undergraduate Student Poster Contest Installation	4:30 p.m. – 6:00 p.m.	CC
Graduate Student Poster Contest Installation	4:30 p.m. – 6:00 p.m.	CC
Social Functions		
ASM Women in Materials Engineering Breakfast (ticketed)	7:00 a.m. – 9:00 a.m.	Hyatt
MS&T Guest Tour – Experience Columbus	9:00 a.m. – 11:00 a.m.	CC
ACerS Annual Honor and Awards Banquet Reception	6:45 p.m. – 7:30 p.m.	Hilton
ACerS Annual Honor and Awards Banquet (Buy tickets by noon on Monday)	7:30 p.m. – 10:00 p.m.	Hilton
Annual Meetings		
ACerS 117th Annual Membership Meeting	1:00 p.m. – 2:00 p.m.	Hyatt

TUESDAY, OCTOBER 6

	TIME	LOCATION
Conference Activities		
Registration	7:00 a.m. – 6:00 p.m.	CC
Programming Support Desk	7:00 a.m. – 6:00 p.m.	CC
Authors' Coffee	7:00 a.m. – 8:00 a.m.	CC
Society Member Lounges	7:00 a.m. – 6:00 p.m.	CC
ACerS Basic Science Division Ceramographic Exhibition & Competition	7:00 a.m. – 6:00 p.m.	CC
Poster Installation	10:00 a.m. – 11:00 a.m.	CC
General Poster Session with Presenters	11:00 a.m. – 1:00 p.m.	CC
General Poster Viewing	1:00 p.m. – 6:00 p.m.	CC
Exhibition		
ASM Mini-Materials Camp	9:00 a.m. – 2:00 p.m.	CC
Exhibition Show Hours	10:00 a.m. – 6:00 p.m.	CC
Football Feature	10:00 a.m. – 6:00 p.m.	CC
Career Pavilion	10:00 a.m. – 6:00 p.m.	CC
Poster Session	11:00 a.m. – Noon	CC
MS&T Food Court	Noon – 2:00 p.m.	CC
Happy Hour Reception	4:00 p.m. – 6:00 p.m.	CC
Lectures (NEW DAY)		
MS&T Plenary	8:00 a.m. – 10:40 a.m.	CC
ACerS Frontiers of Science and Society - Rustum Roy Lecture	1:00 p.m. – 2:00 p.m.	CC
Material Advantage Student Functions		
Undergraduate Student Poster Contest Judging	10:00 a.m. – Noon	CC
Graduate Student Poster Contest Judging	10:00 a.m. – Noon	CC
ASM "DomesDay" Competition	10:15 a.m. – 1:30 p.m.	CC
Undergraduate Student Poster Contest Display with Presenters	11:00 a.m. – 1:00 p.m.	CC
Graduate Student Poster Contest Display with Presenters	11:00 a.m. – 1:00 p.m.	CC
Mug Drop Contest	11:15 a.m. – 12:15 p.m.	CC
Disc Golf Contest	12:30 p.m. – 1:30 p.m.	CC
Undergraduate Student Poster Contest Display	1:00 p.m. – 6:00 p.m.	CC
Graduate Student Poster Contest Display	1:00 p.m. – 6:00 p.m.	CC
Student Awards Ceremony	2:00 p.m. – 3:00 p.m.	CC
Social Functions		
ACerS Companion Breakfast	8:00 a.m. – 10:00 a.m.	Hilton
MS&T Guest Tour – Tasting Tour of German Village	10:00 a.m. – 1:00 p.m.	
ASM Tuxedo Pick Up	10:00 a.m. – 6:00 p.m.	Hyatt
Young Professionals Tutorial Luncheon (ticketed)	Noon – 12:45 p.m.	CC
Young Professionals Tutorial Lecture (open)	12:45 p.m. – 2:00 p.m.	CC
MS&T Young Professionals Reception	4:30 p.m. – 6:00 p.m.	CC

WEDNESDAY, OCTOBER 7

	TIME	LOCATION
Conference Activities		
Registration	7:00 a.m. – 5:00 p.m.	CC
Programming Support Desk	7:00 a.m. – 6:00 p.m.	CC
Authors' Coffee	7:00 a.m. – 8:00 a.m.	CC
Society Member Lounges	7:00 a.m. – 5:00 p.m.	CC
ACerS Basic Science Division Ceramographic Exhibition & Competition	7:00 a.m. – Noon	CC
Exhibition		
ASM Mini-Materials Camp	9:00 a.m. – 2:00 p.m.	CC
Exhibition Show Hours	9:30 a.m. – 2:00 p.m.	CC
Football Feature	9:30 a.m. – 2:00 p.m.	CC
MS&T Food Court	Noon – 2:00 p.m.	CC
General Poster Session Dismantle	2:00 p.m. – 3:00 p.m.	CC
Exhibitor Tear Down	2:00 p.m. – 9:00 p.m.	CC
Lectures		
ACerS Basic Science Division Robert B. Sosman Lecture	1:00 p.m. – 2:00 p.m.	CC
Material Advantage Student Functions		
Undergraduate Student Poster Contest Display	9:30 a.m. – 2:00 p.m.	CC
Graduate Student Poster Contest Display	9:30 a.m. – 2:00 p.m.	CC
Undergraduate Student Poster Dismantle	2:00 p.m. – 3:00 p.m.	CC
Graduate Student Poster Dismantle	2:00 p.m. – 3:00 p.m.	CC

THURSDAY, OCTOBER 8

	TIME	LOCATION
Conference Activities		
Registration	7:00 a.m. – Noon	CC
Programming Support Desk	7:00 a.m. – 1:00 p.m.	CC
Authors' Coffee	7:00 a.m. – 8:00 a.m.	CC
Educational Courses		
Sintering of Ceramics	9:00 a.m. – 4:30 p.m.	Hilton

FRIDAY, OCTOBER 9

	TIME	LOCATION
Educational Courses		
Sintering of Ceramics	9:00 a.m. – 2:30 p.m.	Hilton

JOIN US FOR THE ACerS 117TH ANNUAL MEETING!

Technical Meeting and Exposition

MS&T15

MATERIALS SCIENCE & TECHNOLOGY

October 4 – 8, 2015 | Greater Columbus Convention Center | Columbus, Ohio, USA

program-at-a-glance

Tentative schedule, subject to change

	Mon a.m.	Mon p.m.	Tue a.m.	Tue p.m.	Wed a.m.	Wed p.m.	Thu a.m.
ADDITIVE MANUFACTURING							
Additive Manufacturing of Metals: Microstructure, Material Properties, and Product Performance	•	•		•	•	•	•
Additive Manufacturing: In-situ Process Monitoring, Defect Detection, and Control					•	•	•
Materials Science of Additive Manufacturing	•	•		•	•	•	•
Novel Material and Process Development for Additive Manufacturing					•	•	
BIOMATERIALS							
Next Generation Biomaterials	•	•		•	•	•	•
Surface Properties of Biomaterials	•	•		•	•		
CERAMIC AND GLASS MATERIALS							
Advances in Ceramics, Glasses, and Composites by Women, their Mentors, and their Mentees	•	•		•	•	•	
Alumina at the Forefront of Technology	•	•		•			
Amorphous Materials: Common Issues within Science and Technology	•						
Ceramic Matrix Composites				•	•	•	
Ceramic Optical Materials					•	•	•
Glass and Optical Materials	•	•		•			
Innovative Processing and Synthesis of Ceramics, Glasses, and Composites				•	•	•	
Multifunctional Oxides	•	•		•	•	•	
Phase Transformations in Ceramics: Science and Applications					•	•	•
Robert B. Sosman Award Symposium: Structures and Properties of Grain Boundaries: Towards an Atomic-scale Understanding of Ceramics					•	•	
ELECTRONIC AND MAGNETIC MATERIALS							
Advances in Dielectric Materials and Electronic Devices	•	•		•	•	•	
Advances in Polar, Magnetic, and Semiconductor Materials: Extending Temperature Limits	•	•		•	•	•	•
Materials for Thermal Management of Electronic and Electrical Devices	•						
Pb-free Solders and Advanced Interconnecting Materials	•	•		•			
Semiconductor Heterostructures: Theory, Growth, Characterization, and Device Applications					•		
ENERGY							
Actinide and Lanthanide Materials	•	•		•	•		
Advanced Coating Materials for Energy and Environmental Applications	•	•					
Advanced Powder Processing for Energy Applications					•	•	•
Energy Storage V: Materials, Systems, and Applications Symposium					•	•	•
Hybrid Organic-Inorganic Materials for Alternative Energy	•	•					
Materials for Nuclear Applications and Extreme Environments	•	•		•	•	•	
Materials Issues in Nuclear Waste Management in the 21st Century	•	•		•	•	•	
FUNDAMENTALS AND CHARACTERIZATION							
Computational Design of Ceramics and Glasses				•	•	•	•
Data and Tools for Materials Discovery and Design	•	•		•	•	•	•
Deformation and Transitions at Grain Boundaries IV	•	•		•	•	•	•
Electron and Focused Ion Beam Microscopy Tools in Materials Characterization	•	•		•	•	•	
Interfaces, Grain Boundaries, and Surfaces from Atomistic and Macroscopic Approaches	•	•		•	•	•	•
International Symposium on Defects, Transport, and Related Phenomena		•		•	•	•	•
Large Fluctuations and Collective Phenomena in Materials II					•	•	•

FUNDAMENTALS AND CHARACTERIZATION (continued)

	Mon a.m.	Mon p.m.	Tue a.m.	Tue p.m.	Wed a.m.	Wed p.m.	Thu a.m.
Materials Property Understanding through Characterization	•	•		•	•	•	•
Measurement and Modeling of High Strain-rate Deformation	•	•					
Micromechanics of Advanced Materials III: A Symposium in Honor of James C.M. Li's 90th Birthday	•	•		•	•	•	
Multiscale Modeling of Microstructure Deformation in Material Processing	•	•		•			
Phase Stability, Diffusion Kinetics, and their Applications (PSDK-X)	•	•		•	•	•	•
Validating Materials Behavior for Predictive Materials Science and Engineering	•			•	•	•	•

GREEN MANUFACTURING AND SUSTAINABILITY

	Mon a.m.	Mon p.m.	Tue a.m.	Tue p.m.	Wed a.m.	Wed p.m.	Thu a.m.
7th International Symposium on Green and Sustainable Technologies for Materials Manufacturing and Processing		•		•	•	•	
Materials and Processes for CO_2 Capture, Conversion, and Sequestration	•	•		•			

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 Steel Metallurgy: Products and Processing	•	•		•	•	•	•
Shaping, Forming, and Modeling of Advanced High Strength Steels	•	•		•	•		
Steels for Oil and Gas Sectors: Advances in Metallurgy, Processing, and Performance	•	•					

MATERIALS-ENVIRONMENT INTERACTIONS

	Mon a.m.	Mon p.m.	Tue a.m.	Tue p.m.	Wed a.m.	Wed p.m.	Thu a.m.
Advanced Coatings for Wear and Corrosion				•	•	•	
Advanced Materials for Harsh Environments	•	•					
Corrosion and Oxidation of High Temperature Materials	•	•		•	•	•	•
Degradation of Nonmetallic Materials	•						
Materials Degradation in Oil and Gas Applications	•	•					
Materials Selection for Chemical Process and Other Aggressive Environments						•	•
Surface Protection for Enhanced Materials Performance: Science, Technology, and Application				•	•	•	•
Thermal Protection Materials and Systems				•	•		

NANOMATERIALS

	Mon a.m.	Mon p.m.	Tue a.m.	Tue p.m.	Wed a.m.	Wed p.m.	Thu a.m.
Boron, Boron Compounds, and Boron Nanomaterials: Structure, Properties, Processing, and Applications	•	•		•	•		
Controlled Synthesis, Processing, and Applications of Structural and Functional Nanomaterials	•	•		•	•	•	
Nanotechnology for Energy, Environment, Electronics, and Industry				•	•	•	•

PROCESSING AND PRODUCT MANUFACTURING

	Mon a.m.	Mon p.m.	Tue a.m.	Tue p.m.	Wed a.m.	Wed p.m.	Thu a.m.
Advanced Manufacturing Technologies		•		•	•	•	•
Advances in Metal Casting Technologies	•	•		•			
Avant-garde Developments in the Processing, Properties, and Performance of Multifunctional Ceramic- and Metal-Matrix Composites	•						
Deformation and Forming of Joined Materials	•						
Dimensional Control of High Temperature Alloys – Producers and Users Perspectives				•			
Failure Analysis and Prevention	•	•		•	•	•	•
Joining Dissimilar Materials for Energy and Mass Optimization for the Transportation Industry					•	•	
Joining of Advanced and Specialty Materials (JASM XVII)	•	•		•	•	•	•
Processing and Performance of Materials Using Microwaves, Electric and Magnetic Fields, Ultrasound, Lasers, and Mechanical Work – Rustum Roy Symposium	•	•					
Sintering and Related Powder Processing Science and Technologies	•	•		•	•	•	•
Smart Manufacturing	•						
Ultra High Performance Metals, Metal Alloys, Intermetallics, and Metal Matrix Composites for Aerospace and Defense Applications	•	•		•	•	•	•

SPECIAL TOPICS

	Mon a.m.	Mon p.m.	Tue a.m.	Tue p.m.	Wed a.m.	Wed p.m.	Thu a.m.
Continuous Improvement of Academic Programs (and Satisfying ABET Along the Way): The Elizabeth Judson Memorial Symposium	•	•					
Perspectives for Emerging Materials Professionals	•	•					

SAVE THE DATE
January 24 – 29, 2016

ceramics.org/icacc2016

40TH INTERNATIONAL CONFERENCE AND EXPOSITION ON ADVANCED CERAMICS AND COMPOSITES

Jubilee Celebration!

January 24 – 29, 2016 | Hilton Daytona Beach Resort and Ocean Center | Daytona Beach, Florida, USA

Organized by the Engineering Ceramics Division of The American Ceramic Society

2016 Program Chair

Andrew Gyekenyesi
Ohio Aerospace Institute/NASA Glenn Research Center
andrew.l.gyekenyesi@nasa.gov

ICACC16 continues its 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 14 symposia, six focused sessions, the 5th Global Young Investigator Forum, a new Emerging Technologies Symposium, and a special 40th anniversary Jubilee Symposium. These technical sessions, consisting of both oral and poster presentations, provide an open forum for scientists, researchers, and engineers from around the world to present and exchange findings on recent advances on various aspects related to ceramic science and technology.

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Fax: 1-386-253-8841

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Students: $132
U.S. government employee: Prevailing rate

Mention The American Ceramic Society to obtain the special rate. Room rates are effective until December 18, 2015 and are based on availability.

ICACC'16 SYMPOSIA

- **S1** Mechanical behavior and performance of ceramics and composites
- **S2** Advanced ceramic coatings for structural, environmental, and functional applications
- **S3** 13th International Symposium on solid oxide fuel cells (SOFC): Materials, science, and technology
- **S4** Armor ceramics
- **S5** Next generation bioceramics and biocomposites
- **S6** Advanced materials and technologies for direct thermal energy conversion and rechargeable energy storage
- **S7** 10th International Symposium on Nanostructured Materials: Functional nanomaterials and thin films for sustainable energy harvesting, environmental, and health applications
- **S8** 10th International Symposium on Advanced Processing and Manufacturing Technologies for Structural and Multifunctional Materials and Systems (APMT10)
- **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: Ultrahigh temperature ceramics (UHTCs) and nano-laminated ternary carbides and nitrides (MAX phases)
- **S13** Advanced materials for sustainable nuclear energy and fusion energy
- **S14** Crystalline materials for electrical, optical, and medical applications
- **FS1** Geopolymers, chemically bonded ceramics, eco-friendly, and sustainable materials
- **FS2** Advanced ceramic materials and processing for photonics and energy
- **FS3** Materials diagnostics, nondestructive evaluation, and structural health monitoring of ceramic components and systems
- **FS4** Additive manufacturing and 3-D printing technologies
- **FS5** Field assisted sintering and related phenomena at high-temperatures
- **FS6** Hybrid materials and processing technologies

Emerging technologies symposium: Carbon nanostructures and 2-D materials, and composites

40th Jubilee Symposium: Engineered ceramics—Current status and future prospects

5th Global Young Investigator Forum

TENTATIVE SCHEDULE OF EVENTS

Sunday – January 24

Welcome reception	5 p.m. – 7 p.m.

Monday – January 25

Opening awards ceremony and plenary session	8:30 a.m. – Noon
Concurrent technical sessions	1:30 p.m. – 6 p.m.

Tuesday – January 26

Concurrent technical sessions	8 a.m. – 6 p.m.
Exposition and reception	5 p.m. – 8 p.m.
Poster session A	5 p.m. – 8 p.m.

Wednesday – January 27

Concurrent technical sessions	8 a.m. – 5:30 p.m.
Exposition and reception	5 p.m. – 7:30 p.m.
Poster session B	5 p.m. – 7:30 p.m.

Thursday – January 28

Concurrent technical sessions	8 a.m. – 6 p.m.
40th Jubilee celebratory dinner	7 p.m. – 10 p.m.

Friday – January 29

Concurrent technical sessions	8 a.m. – Noon

40TH JUBILEE CELEBRATION EVENTS

In honor of the momentous 40th anniversary of ICACC, a special Jubilee Symposium is being organized. *Engineered Ceramics—Current Status and Future Prospects* will feature previous ECD Mueller and Bridge Building Award winners, past and current ECD officers, and past ICACC plenary speakers. The presentations will focus on the current status and future prospects of various technical topics related to advanced ceramics and composites as well as the 40-year journey of ceramics and composites from Cocoa Beach to Daytona Beach.

A 40th Jubilee celebratory banquet dinner will take place on Thursday, January 28 from 7 p.m. until 10 p.m. Be sure to make plans to attend this gala event.

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. ICACC'16 is your destination to collaborate with business partners, cultivate prospects, and explore new business opportunities.

Exhibit hours: Tuesday, January 26, 5 p.m. – 8 p.m. | Wednesday, January 27, 5 p.m. – 7:30 p.m.

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

Exhibit space is filling up fast. To reserve your booth, visit ceramics.org/icacc2016 or contact Mona Thiel at mthiel@ceramics.org or at 614-794-5834.

Exhibitor	Booth
AdValue	322
Alfred University	315
AVS Inc.	307
C-Therm Technologies Ltd.	220
Centorr Vacuum Industries Inc.	200
CM Furnaces Inc.	311
Dorst America	301
Eirich Machines Inc.	203
Element	222
Elkem Silicon Materials	303

Exhibitor	Booth
ESL ElectroScience	204
Gasbarre Products (PTX Pentronix Inc.)	207
H.C. Starck North American Trading LLC	305
Haiku Tech Inc.	313
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Exhibitor	Booth
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January 20-22 | DoubleTree by Hilton Orlando at Sea World®Orlando | Florida USA

ELECTRONIC MATERIALS AND APPLICATIONS 2016

ceramics.org/ema2016

CALL FOR PAPERS
Abstracts due September 28, 2015

INTRODUCTION

Electronic Materials and Applications 2016, jointly programmed by the Electronics Division and Basic Science Division of The American Ceramic Society, will take place at the DoubleTree by Hilton Orlando at Sea World® January 20–22, 2016. This international conference addresses emerging needs, opportunities, and key challenges in the field of electronic materials and applications.

EMA 2016 features 11 comprehensive symposia, plenary talks, invited lectures, contributed papers and poster presentations, and open discussions, as well as networking opportunities to find collaborations and facilitate scientific and technical advances. Technical presentations highlight advancements in materials and devices for electronics, sensors, energy generation and storage, photovoltaics, and LEDs.

Speakers include an international mix of university, industrial, and federal laboratory participants to exchange information and ideas on latest developments in theory, experimental investigation, and applications of electroceramic materials. Students are highly encouraged to attend and participate in a special student-run symposium, featuring graduate and undergraduate student research and sponsored by ACerS President's Council of Student Advisors.

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

ORGANIZING COMMITTEE

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ABSTRACT SUBMISSION INSTRUCTIONS

- Visit ceramics.org/ema2016
- Select "Submit abstract" to be directed to the Scholar One website.

If you have questions, please contact **Marilyn Stolz** at **mstoltz@ceramics.org** or **614-794-5868**.

CONFIRMED PLENARY SPEAKERS

Schlom

Darrell Schlom
Cornell University
Title: *Oxide materials for electronics*

Warren

James Warren
National Institute of Standards and Technology
Title: *The Materials Genome Initiative, data, and open science*

Detzel

Thomas Detzel
Infineon Technologies Austria AG
Title: *Power semiconductors*

TECHNICAL SESSIONS

S1 Multiferroic materials and multilayer ferroic heterostructures: Properties and applications
S2 Functional materials: Synthesis science, properties, and integration
S3 Use of thermal energy for electrical power generation and refrigeration: Fundamental science, materials development, and devices
S4 Ion-conducting ceramics
S5 Multifunctional nanocomposites
S6 Computational design of electronic materials
S7 Processing and microstructure of functional ceramics: Sintering, grain growth, and their impact on the materials properties
S8 Interface structure, orientation, and composition: Influence on properties and kinetics
S9 Recent developments in superconducting materials and applications
S10 Emerging functionalities in layered-oxide and related materials
S11 Advanced electronic materials: Processing, structures, properties, and applications

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A solid success—ACerS Cements Division Annual Meeting features cutting-edge research and presentations

Manhattan, Kansas—affectionately known as the "Little Apple"—is home to Kansas State University, where, on July 20–22, ACerS Cements Division held its 6th Advances in Cement-based Materials meeting.

The opening-day tutorial was on service life modeling, presented by Jacques Marchand, president and CEO at SIMCO Technologies (Quebec, Canada); Gianluca Cusatis, associate professor of theoretical and applied mechanics at Northwestern University (Evanston, Ill.); and Nick Santero, senior consultant at thinkstep and lecturer in mechanical engineering at the University of California, Berkeley.

The technical program offered nine sessions on topics from cement chemistry/hydration, to modeling, to nano/microscale material characterization, among many others.

The 2015 Della Roy Award was presented in memory of Hamlin Jennings, adjunct professor in the Department of Civil and Environmental Engineering at the Massachusetts Institute of Technology (Cambridge, Mass.), who passed away a few weeks before the meeting. To honor Jennings, Division chair Jeff Chen presented a video that included numerous tributes to Jennings from his former Ph.D. students and colleagues. (Visit ceramics.org/division-pages/cements-division to access the video.) ■

Credit: ACerS

Jeff Chen (center), ACerS Cements Division chair, presents certificates of appreciation to meeting co-chairs Kyle Riding (left) and Matt D'Ambrosia (right).

Credit: ACerS

Student poster winners. Front row, left to right: Kai Gong, Joshua Hogancamp, Morteza Khatib, and Ghazal Sokhansefat. Back row, left to right: Daniel Castaneda, Matt D'Ambrosia (meeting co-chair), George Scherer (standing in for his student, Lori Tunstall, who won) and Sakineh Ebrahimpourmoghaddamn (not pictured).

Powder injection mixer

The newly redesigned Ross Inline Solids/Liquid Injection Manifold (SLIM) Mixer includes an operator-friendly workbench for improved material handling. The mixer pumps liquid from a tank while it simultaneously draws powders and other minor components from a hopper. The processing method is ideal for a wide range of powders that are challenging to mix into liquid—materials like gum powders, fumed silica, starch, talc, titanium dioxide, carbon black, and bentonite clay are dispersed or dissolved in seconds or minutes. The Inline SLIM Mixer differs from other powder induction systems in that it does not require the use of a centrifugal pump, educator, or vacuum pump to create suction, so the system is less sensitive to changes in flow and viscosity.

Charles Ross & Son Co.
(Hauppauge, N.Y.)
www.mixers.com
800-243-7677

3-D printed materials development kit

Viridis3D's new RAM10 Materials Development Kit is an open materials development system designed to make R&D for 3-D printing of new materials fast, cheap, and easy. The kit—which includes fluids manifold, electronics, and spreader bars—is simple in construction and has very fast test cycle times with a small build volume. The development kit allows users to change powder, binder, firing parameters, tubing, and powder deposition subsystems, enabling distributed development of new materials sets.

Viridis3D LLC
(Woburn, Mass.)
www.viridis3d.com
781-305-4961

Accelerometer–gyroscope sensor

Murata's new SCC2000 series of combined accelerometer and gyroscope sensor devices are for use in tough environments, such as automotive and industrial applications. The series has best-in-class temperature dependency, shock sensitivity, and bias stability characteristics, and consists of a low-G three-axis accelerometer with two angular rate sensor options of either *x*- or *z*-axis detection combined with a 32-bit digital SPI interface. With a robust construction and the sensor's high performance, the SCC2000 series also is suitable for demanding environments, such as agricultural, construction, and other heavy-machinery applications.

Murata Manufacturing Co. Ltd.
(Kyoto, Japan)
www.murata.com
+81-75-951-9111

Microdiagnostic sample preparation system

3D-Micromac's microPREP is a novel laser micromachining system for high-throughput microdiagnostic sample preparation. Based on patented processing, microPREP automates laser cutting of a base structure followed by local laser thinning. Making use of a rugged pulsed laser source, the process is characterized by very low running costs, suitability for semiconductors, metals, ceramics, as well as compounds thereof, and a very high-targeted precision on the micrometer scale. The highly specialized system features an intuitive and user-friendly software control system with touchscreen operation.

3D-Micromac AG
(Chemnitz, Germany)
www.3d-micromac.com
+49-0-371-400-43-0

Machinable ceramic

Goodfellow Ceramic and Glass Division offers Shapal Hi-M soft, a composite sintered body of AlN and BN that specifically addresses machining difficulties associated with the brittleness and hardness of traditional ceramics. Shapal can be machined into small or complex shapes and is suitable for a wide range of applications, thanks to its excellent machinability, high thermal conductivity, and high mechanical strength. Additional advantages include excellent electrical insulation, low thermal expansion, low dielectric loss, excellent high-temperature properties, and suitability for vacuum applications.

Goodfellow Corp.
(Coraopolis, Pa.)
www.goodfellow-ceramics.com
800-821-2870

Calendar of events

September 2015

7–9 Glass Reflections: Glass in the Year of Light – Cambridge, U.K.; www.sgt.org

15–18 ➡ UNITECR 2015 – Hofburg Congress Center, Vienna, Austria; www.unitecr2015.org

20–23 Int'l Commission on Glass Annual Meeting – Centara Grand at CentralWorld, Bangkok, Thailand; www.icglass.org

19–25 ➡ The XIV Int'l Conference on the Physics of Non-Crystalline Solids – Niagara Falls, N.Y.; www.pncs-xiv.com

21–23 ➡ Advanced Ceramics and Applications IV: New Frontiers in Multifunctional Material Science and Processing – Belgrade, Serbia; www.serbianceramicsociety.rs/about.htm

October 2015

4–8 ➡ MS&T15, combined with ACerS 117th Annual Meeting – Greater Columbus Convention Center, Columbus, Ohio; www.matscitech.org

20–23 CERAMITEC 2015 – Messe Munich, Munich, Germany; www.ceramitec.de

November 2015

2–5 ➡ 76th GPC: 76th Glass Problems Conference – Greater Columbus Convention Center, Columbus, Ohio; www.glassproblemsconference.org

December 2015

14–17 ➡ CAMEE2015: Int'l Conference on Ceramic & Advanced Materials for Energy and Environment – Bangalore, India; www.icskc.in

January 2016

20–22 EMA 2016: ACerS Electronic Materials and Applications – DoubleTree by Hilton Orlando Sea World, Orlando, Fla.; www.ceramics.org

24–29 ICACC16: 40th Int'l Conference and Expo on Advanced Ceramics and Composites – Hilton Daytona Beach Resort/Ocean Walk Village, Daytona Beach, Fla.; www.ceramics.org

March 2016

6–11 ➡ Electric Field Assisted Sintering and Related Phenomena Far From Equilibrium – Tomar, Portugal; www.engconf.org/conferences

April 2016

7–11 ➡ ICG XXIV Int'l Congress – Shanghai, China; www.icglass.org

17–21 ➡ MCARE 2016: Materials Challenges in Alternative & Renewable Energy – Hilton Clearwater Beach Resort, Clearwater, Fla.; www.ceramics.org

25–29 43rd ICMCTF: Int'l Conference on Metallurgical Coatings and Thin Films – San Diego, Calif.; www2.avs.org/conferences/icmctf/

26–28 ➡ 2nd Ceramics Expo – IX Center, Cleveland, Ohio; www.ceramicsexpousa.com

26–28 5th Ceramic Leadership Summit – Cleveland, Ohio; www.ceramics.org

May 2016

8–11 ➡ ICCPS-13: 13th Int'l Conference on Ceramic Processing Science – Nara, Japan; unit.aist.go.jp/ifmri/tl-int/iccps13/

18–22 ➡ WBC2016: 10th World Biomaterials Congress – Montreal, Canada; www.wbc2016.org

June 2016

26–30 ➡ HTCMC 9 and GFMAT: 9th Int'l Conference on High-Temperature Ceramic-Matrix Composites and Global Forum on Advanced Materials and Technologies for Sustainable Development 2016 – Toronto Marriott Downtown Eaton Centre Hotel, Toronto, Canada ; www.ceramics.org

August 2016

21–23 ➡ ICC6: Int'l Congress on Ceramics – Dresden, Germany; www.icc-6.com

October 2016

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

January 2017

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

22–27 ICACC17: 41st Int'l Conference and Expo on Advanced Ceramics and Composites – Hilton Daytona Beach Resort/Ocean Walk Village, Daytona Beach, Fla.; www.ceramics.org

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

Entries in **BLUE** denote ACerS events.

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

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SEPTEMBER 2015

AMERICAN CERAMIC SOCIETY bulletin

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Lisa Rueschhoff
Guest columnist

Paying it forward with materials outreach

I have been the most indecisive person I know for as long as I can remember.

So it is no surprise that I had trouble choosing an undergraduate major. As a freshman at Iowa State University, I opted for "undeclared engineering"—presumably a major designed just for me, as the only thing I knew was that I wanted to be an engineer. As part of this noncommittal major, I attended informational sessions about each type of engineering to magically find my fit. I went to session after session, talked with students and professors from each field, waiting for something to click.

Then I attended a session on materials science and engineering, a department that I had not heard of before. Instead of monotonous lectures, the presentation consisted of materials science demonstrations, including blow torches and liquid nitrogen—how could I not be hooked? I was mesmerized by the ability to change material structures and properties through temperature. And, above all else, I was astounded with all the materials research happening on my campus alone.

I had the opportunity to work on research through the freshman honors program, which paired me with a materials science and engineering professor at Iowa State and a researcher at Ames National Laboratory. Together, the two were working on a collaborative project studying anode materials for lithium-ion batteries. After I had worked a semester on the project, they gave me the option to continue research into the summer—but only if I officially declared my major as materials science and engineering. The ultimatum was the push my indecisive self needed, and I continued working on the project for my remaining three years at Iowa State.

Throughout my undergraduate career, I became heavily involved with the local Material Advantage (MA) chapter, first as outreach chair and then chapter chair. With more than 50 annual outreach events, Iowa State's active MA chapter kept me busy continuing the very demonstrations that sparked my initial interest in materials science.

Credit: L. Rueschhoff

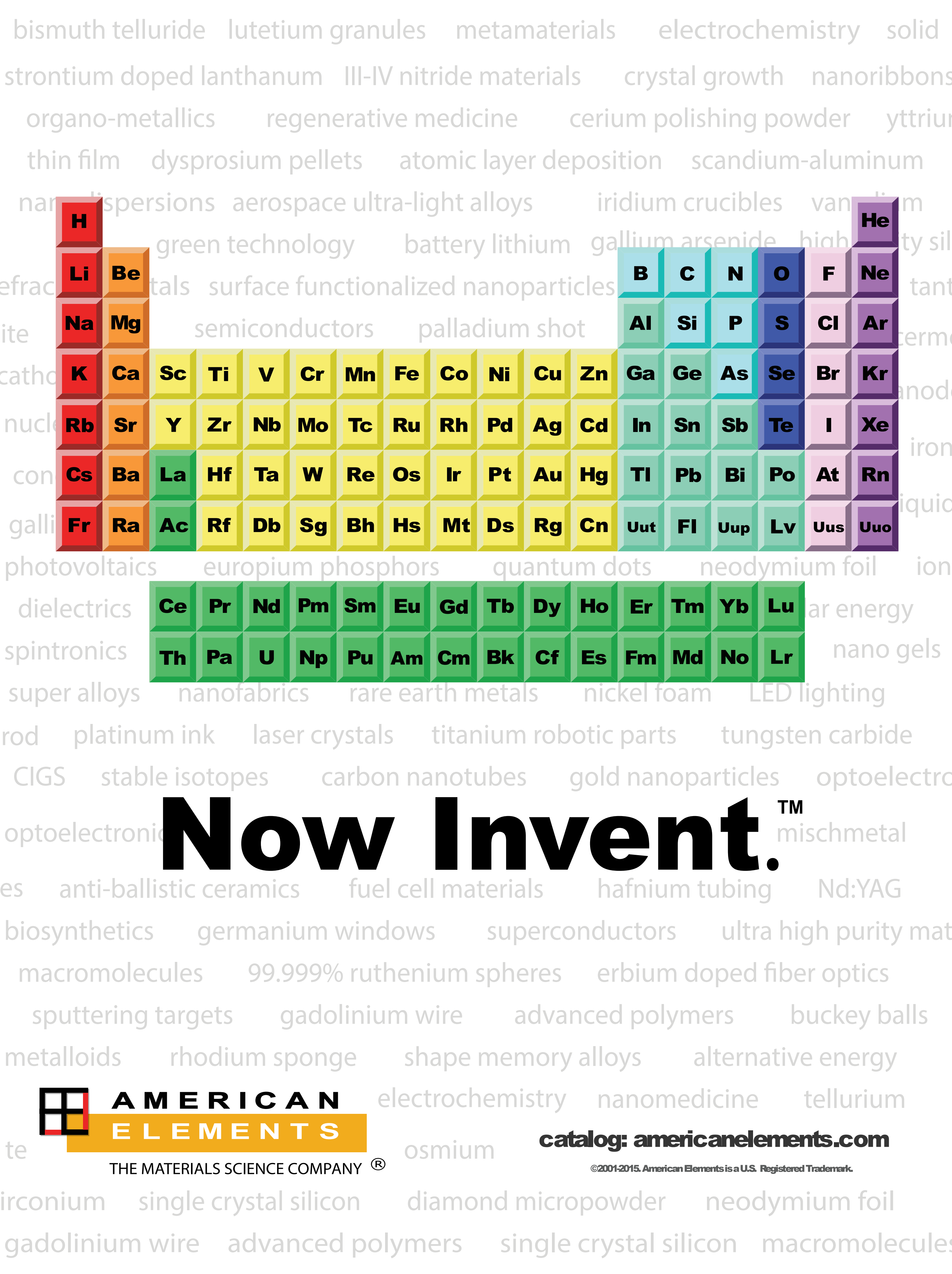
Lisa Rueschhoff demonstrates the "glass bead on a wire" lab activity (available in the ACerS Student Laboratory Kit) at the "Introduce a Girl to Engineering Day" day camp hosted by the Purdue University Women in Engineering Program.

For me, these outreach events are important to get young students in particular excited about and interested in science and to help spread the wonder of materials research. To help stress the value of research on a larger scale, I have twice participated in MA's annual Congressional Visits Day event in Washington, D.C. The event allowed me the opportunity to meet with senators and congressmen to stress the importance of materials and basic science research.

As a current Ph.D. candidate studying materials science at Purdue University, I truly feel that the decision I made four years ago to study materials changed my life. Because materials demonstrations are what first sparked my interest, I feel an obligation to pay it forward by continuing materials outreach demonstrations to help expose undergraduates to the excitement of materials engineering.

Last year I also became a member of the ACerS President's Council of Student Advisors (PCSA) as the Communications Committee Chair, which has given me even more opportunities to be involved in materials—specifically ceramics—outreach. PCSA is passionate about supporting outreach through materials demonstrations, so it offers two outreach kits, available through ACerS, with a third kit currently in the works. These kits are designed to help facilitate student laboratory activities, complete with materials necessary for demonstrations. For me, PCSA has been an exceptional networking and leadership experience, and it has given me even more opportunities to continue promoting materials outreach.

Lisa Rueschhoff is a Ph.D. candidate in Purdue University's School of Materials Engineering, where she researches room-temperature injection molding of silicon nitride. She is a member of her department's outreach committee, former board member for the MSE graduate student association, active in the Purdue Women in Engineering Program, and Communications Committee Chair for ACerS PCSA. Rueschhoff enjoys the finer things in life—Nebraska Husker football, cycling, and breweries. ■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