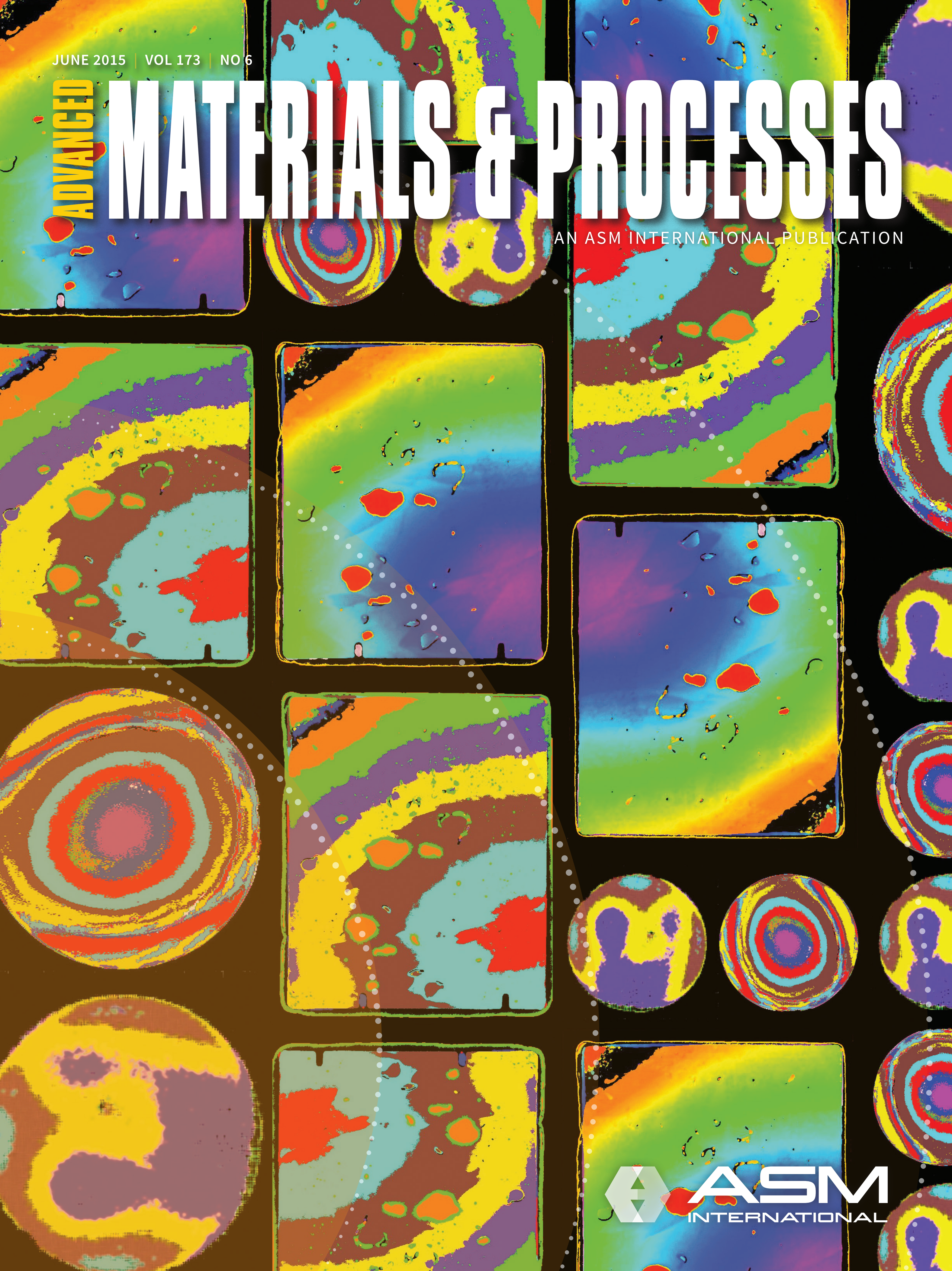
JUNE 2015 | VOL 173 | NO 6

ADVANCED MATERIALS & PROCESSES

AN ASM INTERNATIONAL PUBLICATION



ASM INTERNATIONAL

Discover what's possible through ASM Education.

Advance your skills, learn from our respected international experts, and earn CEUs. ASM's accredited courses offer a variety of learning options that fit your career goals, schedule, and budget. Stay current in your career or stand out with an ASM certificate program.

Course	Date	Location
Introduction to Thermal Spray	7/6-7	ASM World Headquarters
Thermal Spray Technology	7/8-9	ASM World Headquarters
Thermal Spray for Gas and Oil Industries	7/10	ASM World Headquarters
Welding Inspection and Quality Control	7/27-30	ASM World Headquarters
Medical Device Design Validation and Failure Analysis	8/3-4	ASM World Headquarters
Heat Treating for the Non-Heat Treater	8/3-5	ASM World Headquarters
Nitinol for Medical Devices	8/5-7	ASM World Headquarters
Heat Treatment, Microstructure & Performance of Carbon & Steel Alloys	8/10-12	ASM World Headquarters
Fractography	8/10-13	ASM World Headquarters
Fastener Metallography Techniques and Interpretation	8/17-18	Allied High Tech Products, Rancho Dominquez, CA
Steel Metallography	8/17-20	ASM World Headquarters
Elements of Metallurgy	8/17-20	ASM World Headquarters
Corrosion	8/31-9/3	ASM World Headquarters

FOR MORE UPCOMING COURSES OR TO REGISTER, VISIT: asminternational.org/learning

ASM INTERNATIONAL

AUTHORIZED IACET PROVIDER

JUNE 2015 | VOL 173 | NO 6

ADVANCED MATERIALS & PROCESSES

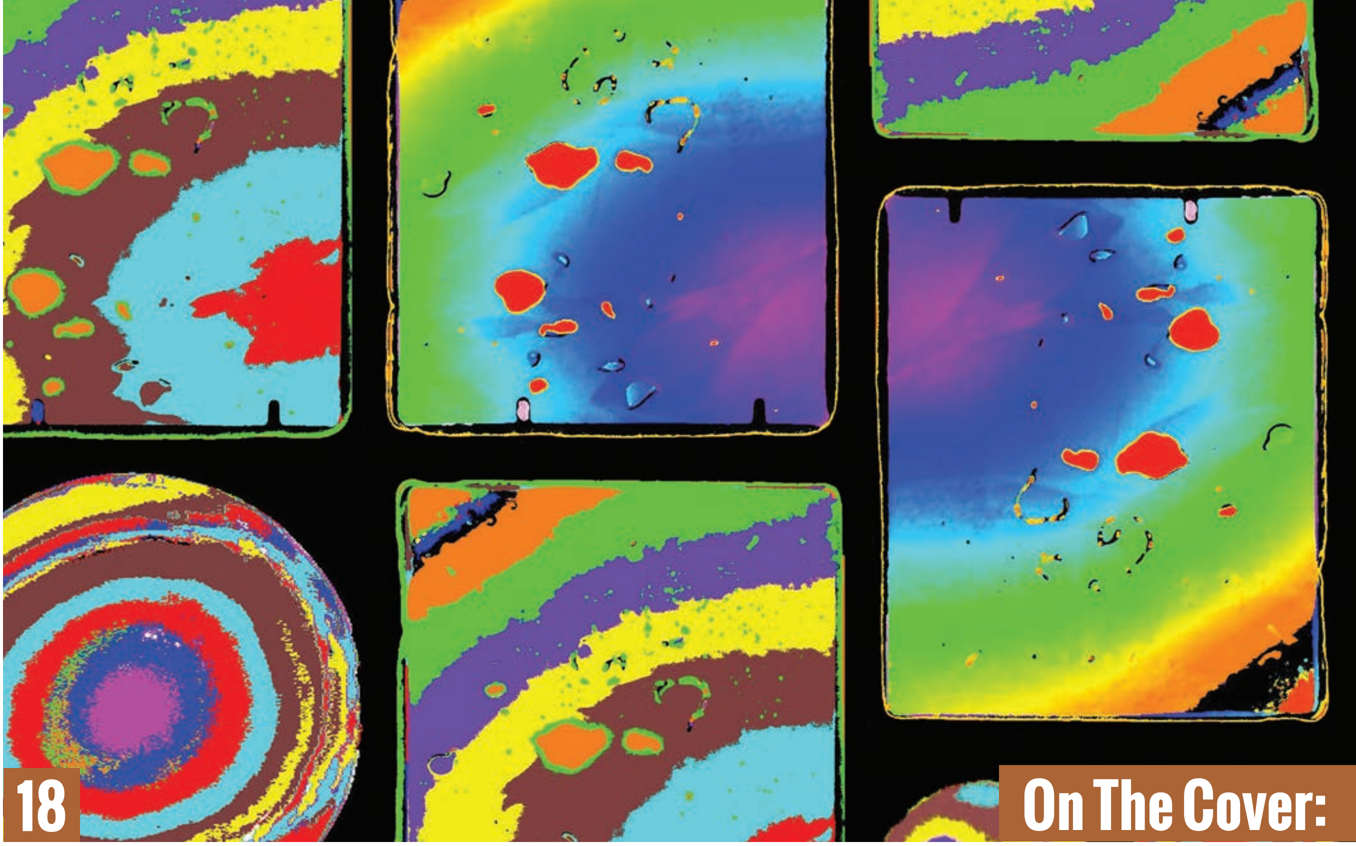
AN ASM INTERNATIONAL PUBLICATION

TESTING TECHNOLOGIES

ACOUSTIC MICROSCOPY

P.18

ASM INTERNATIONAL

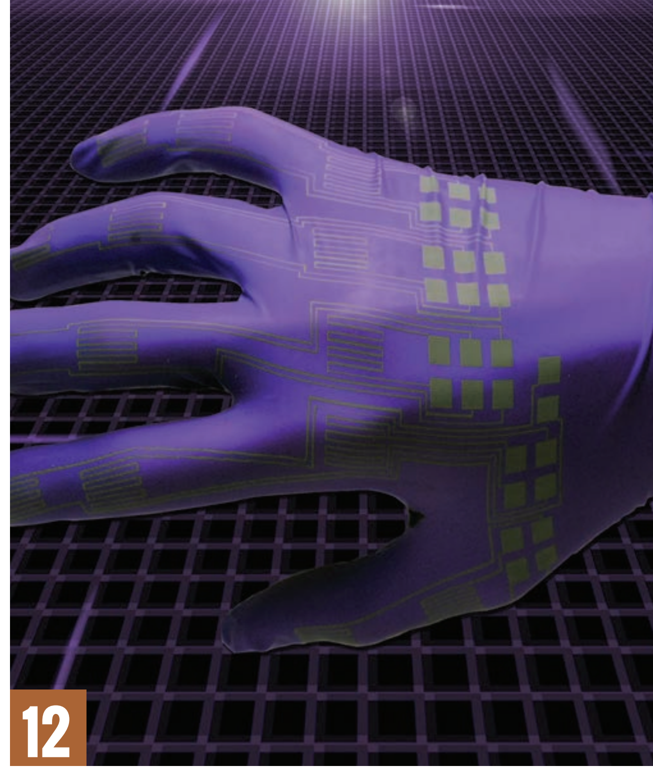


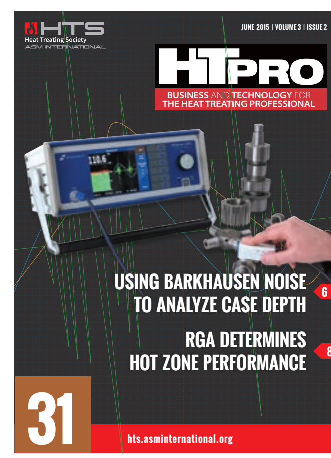
On The Cover:

Time difference mode image of solder thickness in an IGBT module with a tilted raft. Courtesy of Sonoscan Inc., Elk Grove Village, Ill. sonoscan.com.

ADVANCED MATERIALS & PROCESSES
JUNE 2015 | VOL 173 | NO 6

FEATURES





TRENDS

INDUSTRY NEWS

DEPARTMENTS

Advanced Materials & Processes (ISSN 0882-7958, USPS 762080) is published monthly, except bimonthly July/August and November/December, by ASM International, 9639 Kinsman Road, Materials Park, OH 44073-0002; tel: 440.338.5151; fax: 440.338.4634. Periodicals postage paid at Novelty, Ohio, and additional mailing offices. Vol. 173, No. 6, June 2015. Distributed at no charge to ASM members in the United States, Canada, and Mexico. International members can pay a $30 per year surcharge to receive printed issues. Subscriptions: $461. Single copies: $45. POSTMASTER: Send 3579 forms to ASM International, Materials Park, OH 44073-0002.
Change of address: Request for change should include old address of the subscriber. Missing numbers due to "change of address" cannot be replaced. Claims for nondelivery must be made within 60 days of issue. Canada Post Publications Mail Agreement No. 40732105. Return undeliverable Canadian addresses to: 700 Dowd Ave., Elizabeth, NJ 07201. Printed by Publishers Press Inc., Shepherdsville, Ky.

Check out the Digital Edition online at amp.digitaledition.asminternational.org

ASM International serves materials professionals, nontechnical personnel, and managers wordwide by providing high-quality materials information, education and training, networking opportunities, and professional development resources in cost-effective and user-friendly formats. ASM is where materials users, producers, and manufacturers converge to do business.

ADVANCED MATERIALS & PROCESSES

ASM International
9639 Kinsman Road, Materials Park, OH 44073
Tel: 440.338.5151 • Fax: 440.338.4634

Frances Richards, *Editor-in-Chief*
frances.richards@asminternational.org

Julie Lucko, *Editor*
julie.lucko@asminternational.org

Jim Pallotta, *Creative Director*
jim.pallotta@asminternational.org

Kate Fornadel, *Layout and Design*
kate.fornadel@asminternational.org

Annie Beck, *Production Manager*
annie.beck@asminternational.org

Press Release Editor
magazines@asminternational.org

SEEKING INSPIRATION

As I write this column, it turns out that today—May 20—is World Metrology Day and 2015's theme is *Measurements and Light*. This year is the "International Year of Light and Light-based Technologies," designated by the United Nations to honor innovations that are expected to become enabling technologies for the future. World Metrology Day celebrates the signatures of representatives from 17 nations at The Meter Convention held May 20, 1875, laying the groundwork for global collaboration in measurement science. For some reason, I find this very inspiring. If any of you are working on light-based technologies, we'd like to hear about your research.

Likewise, other inspiring concepts seem to spring from attending a variety of lectures, conferences, and networking events. One impressive talk I heard recently was the commencement speech at my daughter's graduation from Ohio University a few weeks ago. Keith Wandell, president and CEO of Harley-Davidson, discussed several aspects of his life and career, beginning with graduating from college and wondering, "Now what?" The most memorable part of his talk focused on perseverance. He became CEO just as the worldwide economy had tanked and motorcycle sales were plummeting. He shared the motto his team lived by during those dark times, "The other side of fear is courage." His group adopted this idea as a mantra, making it possible to go to work and keep trying new ideas, which were eventually successful. Wandell also advised, "It's critical to have a sense of humor. If you don't have one, get one. You're going to need it."

Looking back on ASM's triple trade show (AeroMat, ITSC, IMS) held recently in California, several inspiring moments occurred. The venue featured excellent plenary speakers, interesting technical sessions, and fun networking events. One of the most inspiring talks was John Grotzinger's lecture about NASA's $2.5 billion Curiosity Rover Mission to Mars. He started his speech by thanking the audience for the materials developments that make space missions possible. He then shared a dramatic video of the "seven minutes of terror" involved in landing Curiosity. Viewing the video helped reinforce his point about zero tolerance for error in the landing sequence. He emphasized, "Planning is everything, but plans are useless." By this he meant that rapid scientific advances were enabled by being flexible and he stressed the importance of extensive testing.

In closing, Grotzinger offered a twist on the usual advice about setbacks, "If at first you fail, don't try again. Work to understand the root cause of failure, then try again." His team of more than 500 scientists and engineers was tasked with discovering if problems stemmed from design flaws or manufacturing issues. Once the root cause was found, progress could resume. One problem that wasn't discovered until touchdown involves Curiosity's wheels: They are too thin to withstand the surprisingly hazardous terrain. Made of aluminum to save weight, the wheels were quickly being destroyed by rolling over pointy rocks. The solution is having the rover take a longer and smoother path as it heads toward Mount Sharp, and to drive backwards instead of forward.

Next up were three intriguing plenary presentations on the following day covering aerospace materials trends, thermal barrier coatings, and 3D microstructure characterization. Along with with the Expo Hall and a festive evening aboard the Queen Mary, the overall event was truly inspiring. If you were there, we'd like to hear your feedback.

F. Richards

frances.richards@asminternational.org

Discover what's possible through ASM Education.

Advance your skills, learn from our respected international experts, and earn CEUs. ASM's accredited courses offer a variety of learning options that fit your career goals, schedule, and budget. Stay current in your career or stand out with an ASM certificate program.

Course	Date	Location
Introduction to Thermal Spray	7/6-7	ASM World Headquarters
Thermal Spray Technology	7/8-9	ASM World Headquarters
Thermal Spray for Gas and Oil Industries	7/10	ASM World Headquarters
Welding Inspection and Quality Control	7/27-30	ASM World Headquarters
Medical Device Design Validation and Failure Analysis	8/3-4	ASM World Headquarters
Heat Treating for the Non-Heat Treater	8/3-5	ASM World Headquarters
Nitinol for Medical Devices	8/5-7	ASM World Headquarters
Heat Treatment, Microstructure & Performance of Carbon & Steel Alloys	8/10-12	ASM World Headquarters
Fractography	8/10-13	ASM World Headquarters
Fastener Metallography Techniques and Interpretation	8/17-18	Allied High Tech Products, Rancho Dominquez, CA
Steel Metallography	8/17-20	ASM World Headquarters
Elements of Metallurgy	8/17-20	ASM World Headquarters
Corrosion	8/31-9/3	ASM World Headquarters

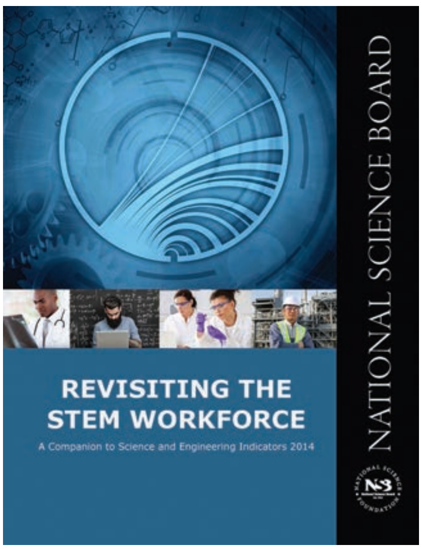
FOR MORE UPCOMING COURSES OR TO REGISTER, VISIT: asminternational.org/learning

ASM INTERNATIONAL

AUTHORIZED IACET PROVIDER

MARKET SPOTLIGHT

NEW REPORT CALLS FOR STEM-CAPABLE WORKFORCE



Courtesy of NSB.

Does the U.S. have too many or too few STEM workers? A new report from the National Science Board (NSB), the policymaking arm of the National Science Foundation, explores this topic. *Revisiting the STEM Workforce* shares insights about longstanding workforce debates and aims to spark constructive discussions about this critical component of the U.S. economy. Based on its biennial *Science and Engineering Indicators* report, the STEM report highlights the growing need for STEM knowledge and skills in today's economy. In 2010, 16.5 million individuals—including many in non-STEM jobs such as sales and marketing—reported that their job required at least a bachelor's degree level of science and engineering (S&E) expertise. This represents about three times the number of individuals working in occupations classified as S&E (5.4 million).

The report underscores that a consensus definition of the STEM workforce does not exist. Depending on the definition used, the STEM workforce includes employees across a wide range of disciplines and jobs, possessing everything from a non-degree certificate to a Ph.D. What is typically called the STEM workforce is actually a complex aggregate of sub-workforces. Each has its own unique makeup based on occupation, education level, geography, sector, and a host of other factors. Broad generalizations fail to capture this complexity, according to analysts.

"The report's take-home message is that STEM knowledge and skills enable both individual opportunity and national competitiveness," says NSB Chairman Dan Arvizu. "Ensuring access to high quality education and training experiences for all students at all levels and for all workers at all career stages is absolutely essential." *To read the full report, visit tinyurl.com/n6g8mx3.*

FEEDBACK

TITANIUM: THE OXIDE IS THE MAIN STORY

In his article on the early history of titanium ("Metallurgy Lane," March 2015), Charles Simcoe refers to the interest of Kennecott Copper Corp. in newly available samples from the Bureau of Mines in the late 1940s. Actually, Kennecott's interest in titanium predates these events and eventually took a different direction. The Canadian subsidiary of Kennecott discovered a large ilmenite ($FeTiO_3$) deposit on the north shore of the St. Lawrence River in Quebec in 1946 after two years of exploration. This turned out to be the world's largest ilmenite deposit. Kennecott's interest in titanium was due to potential competition with copper.

Coincidentally, the New Jersey Zinc Co. was also interested in ilmenite as a source of titanium dioxide, an alternative to zinc oxide white pigment. The two companies joined forces, with New Jersey Zinc developing an electric smelting process at its pilot plant in Pennsylvania. In 1948, jointly owned Quebec Iron and Titanium Corp. (QIT) was formed with the construction of a production-scale smelter at St. Joseph-de-Sorel about 40 miles northeast of Montreal. Conversion of ilmenite to a TiO_2-rich slag and a high purity iron began in 1950 and this plant became a leading source of raw material for the titanium dioxide pigment industry. The market for this pigment developed rapidly in subsequent decades to a multimillion ton per year business, with additional sources from TiO_2-rich beach sands deposits around the world.

The market for titanium metal never really took off in the manner that was originally expected, largely due to the difficulty and expense of extraction and fabrication. QIT, now Rio Tinto, Fer et Titane, supplies various grades of TiO_2 slag to the worldwide pigment industry as well as high purity iron for ductile iron castings, high purity steel billets, and iron and steel powders. Upgraded slag with ~95% TiO_2 content is sold to pigment producers using the chloride process and to titanium metal producers.

Joseph Capus, ASM Life Member

We welcome all comments and suggestions. Send letters to frances.richards@asminternational.org.

OMG!
OUTRAGEOUS MATERIALS GOODNESS

24-carat golden bicycle.

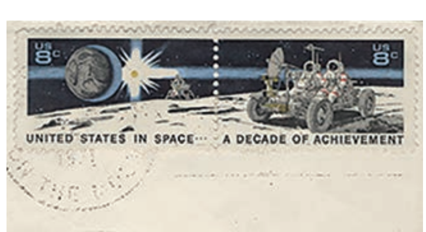
NEW BICYCLE IS THE GOLD STANDARD

Goldgenie, UK, created a golden bicycle based on a Giant road cycle—24-carat gold was applied to the entire bike, from the drop handlebars to the wheel stays and every bit in between, even the chain and wheels. The only exceptions appear to be the suede seat, brake hoods, and racing tires. While it is doubtful anyone will ever actually ride the bike, company director Frank Fernando maintains it can be ridden. “This men’s bike is not only a work of art to admire, but also to enjoy riding if you are brave enough to face the stares of astonishment,” he says. If the gold is not decoration enough, the company will also add diamonds to the entire frame for the $470,345 asking price. A selection of finishes for the saddle and handlebars, including exotic skins and leathers, is also available. *goldgenie.com/us.*

MAIL MEMENTOS TO THE MOON

Astrobotic Technology Inc., Pittsburgh, launched MoonMail—a program for the public to send mementos to the moon on the company’s first commercial lunar mission. The new offering (valued at $460) is an opportunity to commemorate major life events—graduations, weddings, birthdays, a loved one’s memory—with a lasting symbol on the moon. “With MoonMail, people from around the world can send a memento on Astrobotic’s lunar lander,” says CEO John Thornton. “They’ll make history by participating in the first commercial moon landing.”

Each participant receives a kit with prepaid postage to mail their item to Astrobotic, along with a map of the moon landing site, a photo of the moon pod on the moon, and a certificate of authenticity recognizing them as a “space pioneer.” Mementos will be placed inside the moon pod attached to Astrobotic’s lunar lander, which will remain on the moon for future generations. *www.moonmail.co.*



Apollo 15 Lunar Mail cover, 1971. Postmaster General’s Collection. Courtesy of USPS.

The concrete walls of Trajan’s Market in Rome have stood the test of time for nearly 2000 years, even surviving a major earthquake in 1349. Courtesy of Marie Jackson.

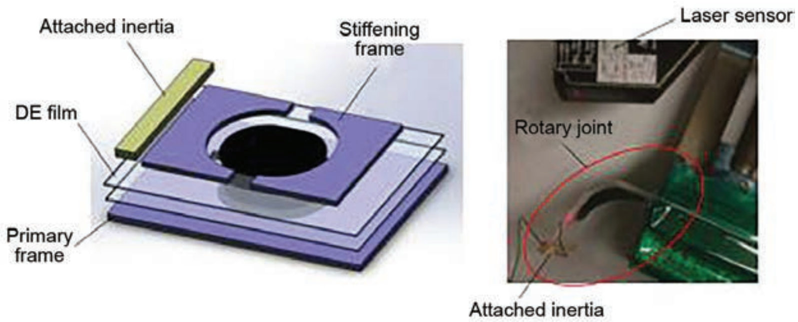
ROMAN CONCRETE SECRETS REVEALED

An international research team reveals important clues to the longevity of such Roman architectural marvels as the Pantheon, Trajan’s Market, and the Colosseum. Led by University of California, Berkeley, Lawrence Berkeley National Laboratory, and Cornell University, the team found that the long-term resilience of the concrete is due to mineralogical changes that occur as the Roman volcanic ash-lime mortar cures. Romans developed a standard formula for making this mortar about 2000 years ago. The mortar binds cobble-sized fragments of tuff and brick, and it was used in the concrete walls of many monuments in Rome.

Researchers studied a reproduction of the Roman architectural volcanic ash-lime mortar as it cured over 180 days. They compared this material to Roman mortar samples dating back 1900 years. Formation of a durable calcium-alumino-silicate mineral acts to bind and reinforce interfacial zones in the mortar, preventing obstacles to the growth of microcracks. *berkeley.edu.*

Are you working with or have you discovered a material or its properties that exhibit OMG - Outrageous Materials Goodness?
Send your submissions to Julie Lucko at julie.lucko@asminternational.org.

METALS | POLYMERS | CERAMICS



The structure of the rotary joint (left) and the system to measure joint rotation (right). Courtesy of Jianwen Zhao/Harbin Institute of Technology, UCLA.

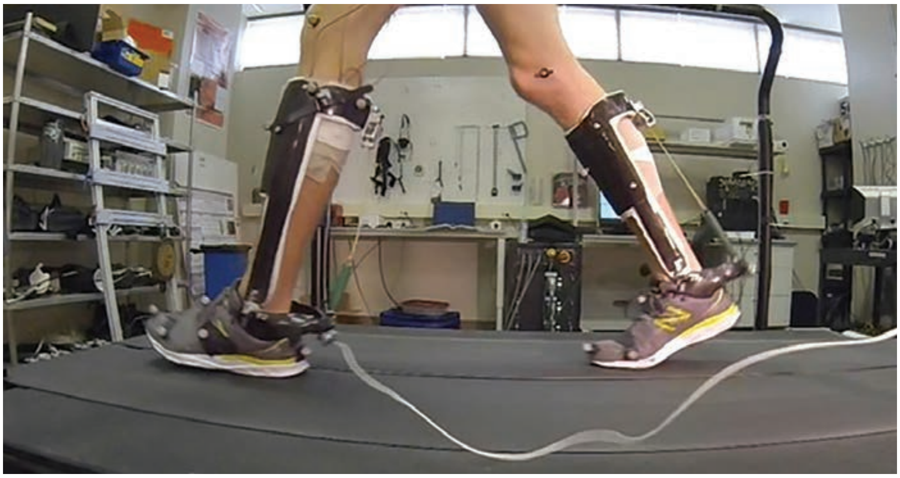
RESONANCE PHENOMENON HELPS ROBOTIC BIRDS SOAR

Researchers from the Harbin Institute of Technology, China, and the University of California, Los Angeles (UCLA), discovered a new resonance phenomenon in a dielectric elastomer rotary joint that can make the artificial joint bend up and down, like a flapping wing. "The dielectric elastomer is a kind of electro-active polymer that can deform if you apply a voltage on it," says Jianwen Zhao, an associate professor at Harbin. He says that most studies on dielectric elastomers use a static or stable voltage to stimulate the joint motion, which makes the joint bend at a fixed angle. Zhao and his team are interested in seeing how the artificial joint reacts to an alternating or periodically changing voltage.

"We found that alternating voltages can make the joint continuously bend at different angles. When the rotational inertia of the joint or the applied voltage is large enough, the joint can deform to negative angles, in other words, it can bend beyond 90 to 180 degrees," says Zhou. He adds that this new phenomenon makes the dielectric elastomer joint a good candidate for creating a soft and lightweight flapping wing for robotic birds, which would be more efficient than wings based on electrical motors due to the higher energy conversion efficiency (60-90%) of the dielectric elastomer. *www.en.hit.edu.cn, ucla.edu.*

CARBON-FIBER EXOSKELETON BOOSTS WALKING EFFICIENCY

Research results show that humans can get better "gas mileage" while walking using an unpowered exoskeleton to modify the structure of their ankles. The device puts an extra spring in each human step, reducing metabolic energy consumption by 7% below walking in normal athletic



Treadmill results show that exoskeleton devices boost walking efficiency by 7% in able-bodied adults. Photo courtesy of Marc Hall, NCSU.

BRIEFS

The Watchman LAA Closure Technology medical device from **Boston Scientific Corp.,** Marlborough, Mass., received approval from the **U.S. FDA,** Silver Spring, Md. It consists of a delivery catheter plus a device that is permanently implanted in the left atrial appendage (LAA) of the heart. The device prevents LAA blood clots from entering the bloodstream, which could potentially cause a stroke. It is made of a self-expanding Nitinol frame with an attached woven plastic cap. *bostonscientific.com.*

Rolls-Royce, London, chose Bristol as the location for a center of advanced fan system composite technology development, creating a hub of composite knowledge in the UK. The hub will benefit from manufacturing techniques being developed in partnership with the National Composites Centre (NCC), part of the **University of Bristol.** The advanced manufacturing facility will develop next-generation fan blades and cases made of carbon-fiber composite materials for future Rolls-Royce aero-engines. *rolls-royce.com, www.bris.ac.uk.*

shoes. The finding may benefit both able-bodied people who are frequently on their feet, such as military infantry, as well as victims of stroke or other gait impairments.

North Carolina State University, Raleigh, and Carnegie Mellon University, Pittsburgh, researchers tested the efficacy of a lightweight lower-leg device that uses a spring and clutch system working in tandem with calf muscles and the Achilles' tendon while people walk. The streamlined, carbon-fiber device weighs about as much as a normal loafer, around 500 g, and is not motorized so it requires no energy from batteries or other external fuel sources.

Study participants, nine able-bodied adults, strapped the exoskeleton devices on both legs and walked at a normal speed on a treadmill after completing some practice training. Subjects also walked without exoskeletons for a baseline comparison. Researchers tested exoskeletons with springs that varied in stiffness. The spring that provided the most benefit was moderately stiff. Walking with exoskeletons with springs that were too stiff or too compliant resulted in normal or higher-than-normal energy costs for participants. *For more information: Gregory Sawicki, 919.513.0787, greg_sawicki@ncsu.edu, www.ncsu.edu.*

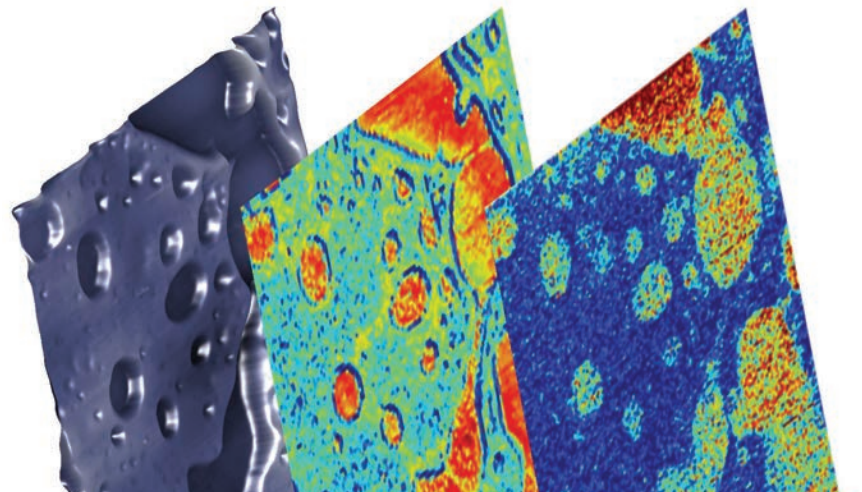
BRITISH UNIVERSITIES FORM CONSORTIUM TO OPTIMIZE RAILROAD STEEL

The University of Huddersfield, UK, will take part in a new $3 million railway steel development project backed by major funding groups. The Rail Safety and Standards Board and the Engineering and Physical Sciences Research Council have combined to provide funds for three linked programs of research into new materials that will reduce heavy maintenance and renewal costs for rail tracks.

A panel of leading industrial and academic figures appraised the Institute of Railway Research-led consortium's proposal and then approved a two-year investigation into developing a fundamental understanding of how different characteristics of steel microstructures respond to rail-wheel contact conditions. This understanding will establish the design rules for the optimum rail steel microstructure that is best at resisting degradation resulting from the contact between wheel and rail. The study will also provide much needed data on the economic impact of the increased rail life to facilitate wider and rapid deployment of more degradation-resistant steels. *www.hud.ac.uk.*

The Institute of Railway Research is coordinating a new project that explores the nature of steel used for railroad tracks and wheels.

TESTING | CHARACTERIZATION



For a 500-nm-deep polymeric thin film made of polystyrene (lighter) and poly-2-vinylpyridine (darker), one multimodal instrument imaged, from left, surface topography, elasticity of the bulk material, and buried chemical behavior. Courtesy of ORNL.

TRIPLE THREAT INSTRUMENT PROBES CHEMISTRY, TOPOGRAPHY, MECHANICS

Atomic force microscopes (AFMs) scan surfaces to reveal details at a resolution 1000 times greater than that of optical microscopes, which is ideal for analyzing physical features but does not work for chemical analysis—researchers must use mass spectrometers. A team from the DOE's Oak Ridge National Laboratory, Tenn., has combined these capabilities into one instrument that can probe a sample in 3D and overlay information about surface topography, atomic-scale mechanical behavior near the surface, and chemistry at and beneath the surface. This multimodal imaging allows scientists to explore thin films of phase-separated polymers important for energy conversion and storage.

"Combining the two capabilities marries the best of both worlds," says project leader Olga Ovchinnikova. "For the same location, you get not only precise location and physical characterization, but also precise chemical information."

This new technique for functional imaging allows probing of regions on the order of nanometers to characterize a sample's surface hills and valleys, elasticity throughout deeper layers, and chemical composition. Previously, AFM tips could penetrate only 20 nm to explore a substance's ability to expand and contract. Adding a thermal desorption probe to the mix allows scientists to probe deeper, as the technique cooks matter off the surface and removes it as deep as 140 nm. *ornl.gov.*

ENGINEERS PREPARE TO ANALYZE ORION HEAT SHIELD

Engineers from three NASA field centers are working together at NASA's Marshall Space Flight Center in Huntsville, Ala., to remove and analyze 180 small squares of an ablative material called Avcoat—the outer coating of the heat shield that protected the Orion crew module during its 2014 flight test. NASA is developing the spacecraft to carry future astronauts on new missions to an asteroid and to Mars. Charred during the test flight known as Exploration Flight Test 1, or EFT-1, the 16.5-ft-diameter heat shield arrived at Marshall on March 9. It was installed in the center's seven-axis milling machine, which uses computer-aided tools to manufacture parts and cut large metal or composite materials or structures. Built for NASA by Lockheed Martin of Huntsville, the machine is the largest of its kind in the world except its twin at NASA's Michoud Assembly Facility in New Orleans.

BRIEFS

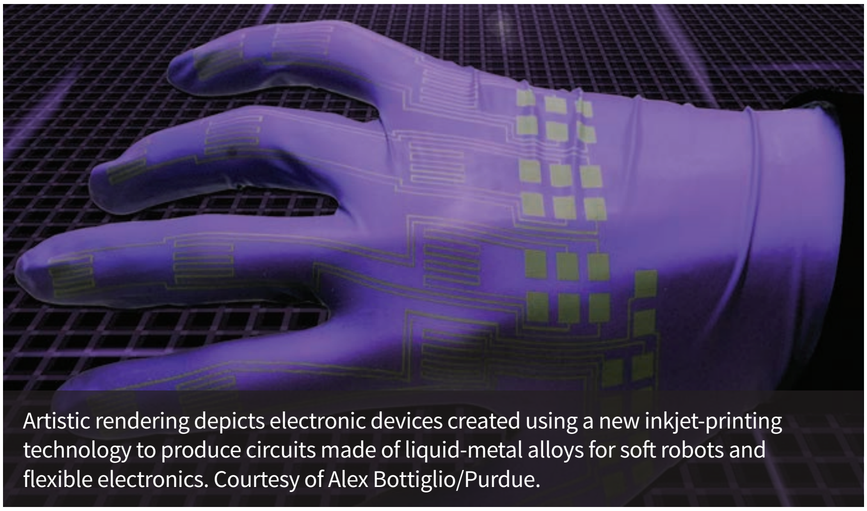
A novel x-ray scattering concept by researchers at **Lawrence Berkeley National Laboratory's Advanced Light Source** (ALS), Calif., is receiving $2.4 million in support from the **Gordon and Betty Moore Foundation.** Funding will enable development of a new spectrometer to study materials via x-ray scattering. The grant is part of the Foundation's *Emergent Phenomena in Quantum Systems* initiative, which "strives to deepen our understanding of the complex collective behavior electrons exhibit in materials and engineered structures." *lbl.gov.*

Grafoid Inc., Canada, acquired analytical services provider **MuAnalysis Inc.,** Ottawa, Ontario. MuAnalysis provides analysis to the electronics, photonics, life sciences, and manufacturing industries and offers expertise in electron microscopy, optical microscopy, materials and failure analysis techniques, and reliability testing. The company is Grafoid's third advanced technology acquisition within the last 12 months, joining **Braille Battery Inc.,** Sarasota, Fla., and **Alcereco Inc.,** Kingston, Ontario. *grafoid.com.*

The milling machine features a fixed, rotating structure that enables researchers to inspect the 5000-lb heat shield and remove samples of the ablated material from its surface. The team is removing the final scorched squares of ablative material—and the data-gathering sensors embedded in many of them—by hand. The sensors, designed and fabricated at Ames, collected critical entry environment and thermal protection performance data during the EFT-1 flight. Once those final pieces are removed for analysis, the milling machine will be used for a final pass to smooth the denuded heat shield, a series of 320,000 honeycomb-like cells covering the entire surface. Charred blocks, sensors, and other materials will be shipped to research teams at Ames and other NASA facilities. Teams who tested and qualified the materials prior to flight will now analyze the thermal performance. Data gleaned from the material and from the heat shield's behavior during reentry will help researchers refine predictive computer models and assist with development of safer, more cost-effective ways to design and build these protection systems. *nasa.gov.*

Engineers from NASA's Ames Research Center in Moffett Field, Calif., and NASA's Marshall Space Flight Center in Huntsville, Ala., remove segments of a heat-resistant material called Avcoat from the surface of the Orion heat shield. Courtesy of NASA.

PROCESS TECHNOLOGY



Artistic rendering depicts electronic devices created using a new inkjet-printing technology to produce circuits made of liquid-metal alloys for soft robots and flexible electronics. Courtesy of Alex Bottiglio/Purdue.

INKJET PRINTING WITH LIQUID METAL

New research shows how inkjet-printing technology can be used to mass-produce electronic circuits made of liquid-metal alloys for soft robots and flexible electronics. Elastic technologies could enable a new class of pliable robots and stretchable garments that people might wear to interact with computers or for therapeutic purposes. However, new manufacturing techniques must be developed before soft machines become commercially feasible, says Rebecca Kramer, assistant professor of mechanical engineering at Purdue University, West Lafayette, Ind.

"We want to create stretchable electronics that might be compatible with soft machines, such as robots that need to squeeze through small spaces, or wearable technologies that don't restrict motion," explains Kramer. "Conductors made of liquid metal can stretch and deform without breaking."

One potential manufacturing approach uses inkjet printing to create devices made of liquid alloys. Printable ink is made by dispersing the liquid metal in a nonmetallic solvent using ultrasound, which breaks up the bulk liquid metal into nanoparticles. This nanoparticle-filled ink is compatible with inkjet printing.

"Liquid metal in its native form is not inkjet-able," says Kramer. "So what we do is create liquid metal nanoparticles small enough to pass through an inkjet nozzle. Sonicating liquid metal in a carrier solvent, such as ethanol, both creates nanoparticles and disperses them in the solvent. Then we can print the ink onto any substrate. Ethanol evaporates away so just liquid metal nanoparticles are left on a surface."

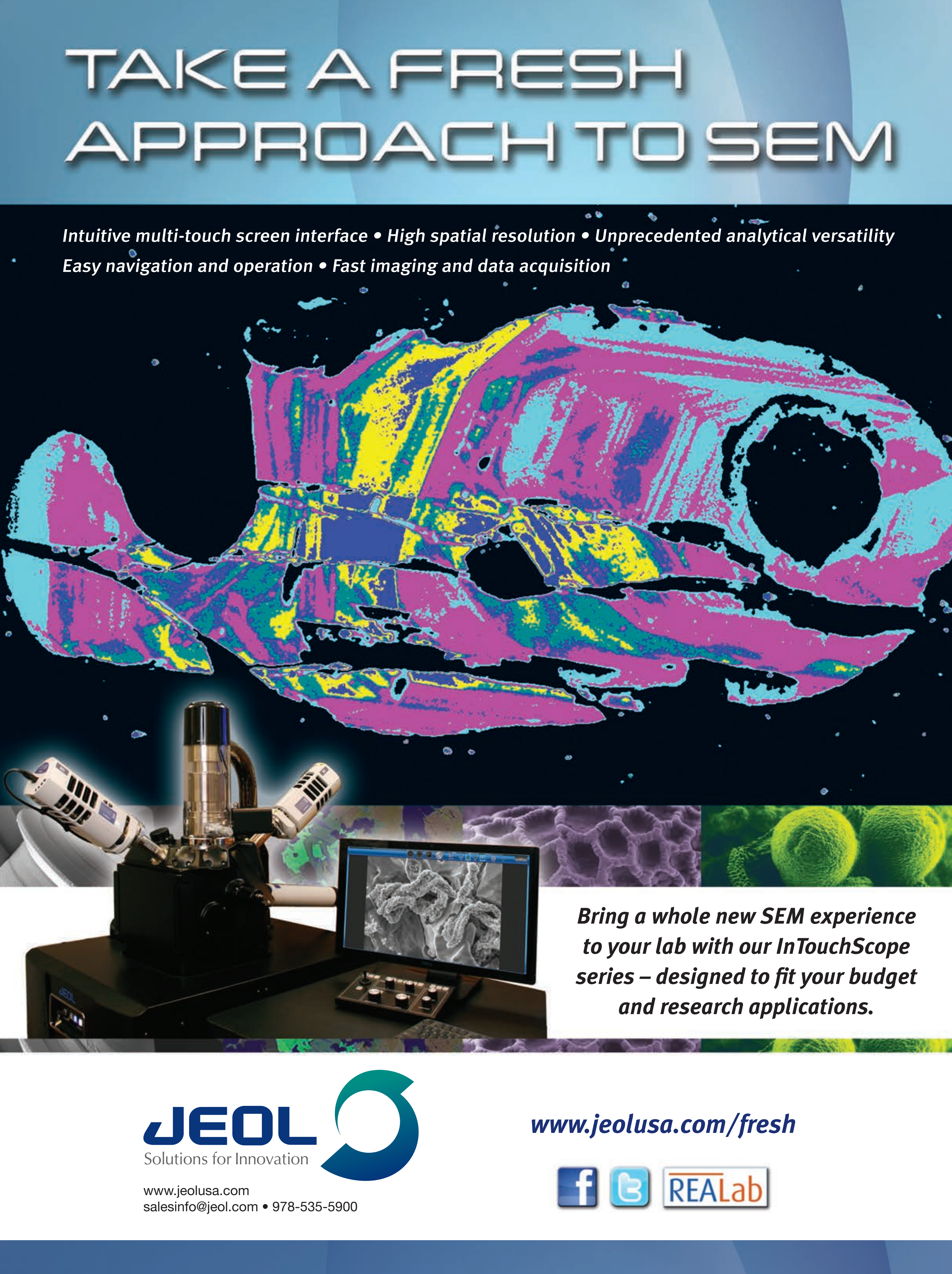
After printing, the nanoparticles must be rejoined by applying light pressure, making it conductive. This step is necessary because liquid-metal nanoparticles are initially coated with oxidized gallium, which prevents electrical conductivity. It is possible to select which portions to activate depending on particular designs, suggesting that a blank film might be manufactured for a multitude of potential applications. The process could make it possible to rapidly mass-produce large quantities of the film. Future research will explore how the interaction between the ink and the surface being printed on might be conducive to making specific types of devices. *For more information: Rebecca Kramer, 765.494.2219, rebeccakramer@purdue.edu, www.purdue.edu.*

NEW PATENT COVERS ALUMINUM ACID ETCHING

Houghton International Inc. and Houghton Technical Corp., Valley Forge, Pa., announce that the Canadian Patent Office issued Patent No. 2,618,915, *Methods and Compositions for Acid Treatment of a Metal Surface.* This patent is directed towards Houghton's technology for aluminum acid etching, which is formulated to provide a uniform fine matte satin finish on aluminum and aluminum alloys prior to anodizing and/or coloring. Unlike alkaline etching, this technology produces a superior matte finish while significantly reducing aluminum removal and sludge waste. It is performed at lower temperatures and requires less processing time compared to conventional caustic etch systems. *houghtonintl.com.*

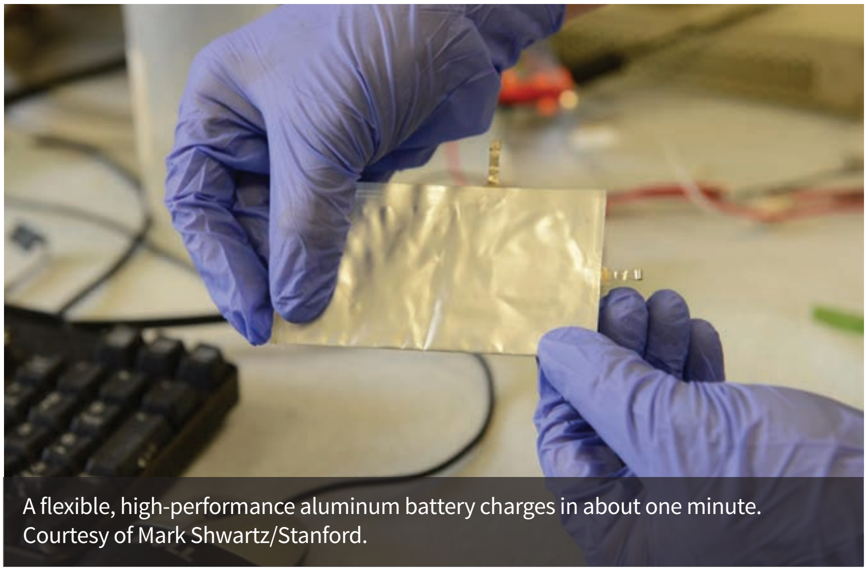
BRIEF

Messe Düsseldorf, Germany, an international trade show organizer for the metallurgy industry, launched a new sector portal called **Metsearch,** which offers a comprehensive product and company database for various metalworking disciplines. The portal features sector and company news along with background information on the industrial segments of national and international trade fairs, as well as monthly highlights about different topics of interest to metallurgists. *metsearch.net.*



TAKE A FRESH APPROACH TO SEM
Intuitive multi-touch screen interface • High spatial resolution • Unprecedented analytical versatility
Easy navigation and operation • Fast imaging and data acquisition
Bring a whole new SEM experience to your lab with our InTouchScope series – designed to fit your budget and research applications.
JEOL
Solutions for Innovation
www.jeolusa.com
salesinfo@jeol.com • 978-535-5900
www.jeolusa.com/fresh
REALab

ENERGY TRENDS



A flexible, high-performance aluminum battery charges in about one minute. Courtesy of Mark Shwartz/Stanford.

ALUMINUM BATTERY CHARGES IN ONE MINUTE

Stanford University, Calif., scientists invented the first high-performance aluminum battery that is fast-charging, long-lasting, and inexpensive. "We developed a rechargeable aluminum battery that may replace existing storage devices, such as alkaline batteries, which are bad for the environment, and lithium-ion batteries, which occasionally burst into flames," says Hongjie Dai, professor of chemistry. "Our new battery won't catch fire, even if you drill through it."

Aluminum has long been an attractive battery material, mainly due to its low cost, low flammability, and high-charge storage capacity. For decades, researchers have unsuccessfully tried to develop a commercially viable aluminum-ion battery. A key challenge is finding materials capable of producing sufficient voltage after repeated cycles of charging and discharging. An aluminum-ion battery consists of two electrodes—a negatively charged anode made of aluminum and a positively charged cathode. "People have tried different kinds of materials for the cathode," says Dai. "We accidentally discovered that a simple solution is to use graphite, which is basically carbon. We identified a few types of graphite material that give us very good performance." For the experimental battery, the team placed the aluminum anode and graphite cathode, along with an ionic liquid electrolyte, inside a flexible polymer-coated pouch. "The electrolyte is basically a salt that's liquid at room temperature, so it's very safe," adds Dai. *For more information: Hongjie Dai, hdai1@stanford.edu, www.stanford.edu.*

PLASTIC BATTERY IS SAFE FOR ENVIRONMENT

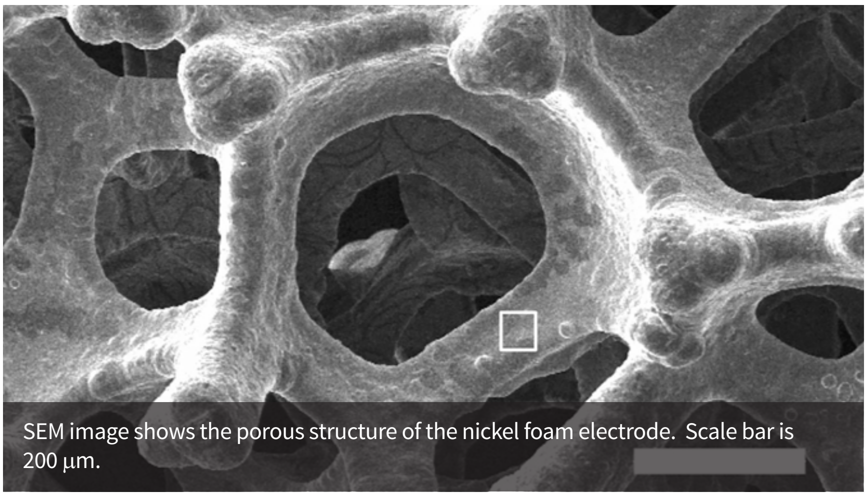
Researchers at the University of Houston developed an efficient conductive electron-transporting polymer, a long-missing puzzle piece that will allow ultrafast battery applications. The discovery relies on a "conjugated redox polymer" design with a naphthalene-bithiophene polymer, which has traditionally been used for applications including transistors and solar cells. With use of lithium ions as dopant, researchers found it offered significant electronic conductivity and remained stable and reversible through thousands of cycles of charging and discharging.

The breakthrough addresses a decades-long challenge for electron-transport conducting polymers, says Yan Yao, assistant professor of electrical and computer engineering. Researchers have long recognized the promise of functional organic polymers, but until now have not been successful in developing an efficient electron-transport conducting polymer to pair with the established hole-transporting polymers. The lithium-doped naphthalene-bithiophene polymer exhibits significant electronic conductivity and is stable through 3000 cycles of charging and discharging, according to the researchers. *For more information: Yan Yao, yyao4@uh.edu, www.egr.uh.edu.*

BRIEF

Scientists at the **DOE's Lawrence Berkeley National Laboratory,** Calif., quantitatively show in a new study that electric vehicles (EVs) will meet the daily travel needs of drivers longer than commonly assumed. Many drivers and much prior literature on the retirement of EV batteries assumed that the battery will be retired after losing 20% of its energy storage or power delivery capability. The new study shows that the daily travel needs of drivers continue to be met well beyond these levels of battery degradation. *science.energy.gov.*

SURFACE ENGINEERING



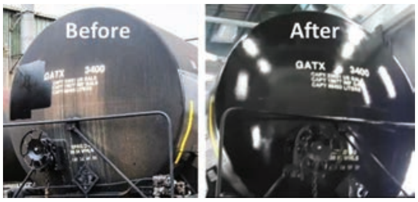
SEM image shows the porous structure of the nickel foam electrode. Scale bar is 200 μm.

NEW ELECTRODE FOR SPLITTING WATER

University of New South Wales, UK, scientists developed a highly efficient oxygen-producing electrode for splitting water that could potentially scale up industrial hydrogen production. The technology is based on an inexpensive, specially coated foam material that lets the bubbles of oxygen escape quickly. "Our electrode is the most efficient oxygen-producing electrode in alkaline electrolytes reported to date, to the best of our knowledge," says Chuan Zhao of the School of Chemistry. "It is inexpensive, sturdy, and simple to make, and can potentially be scaled up for industrial scale water splitting."

Inefficient and costly oxygen-producing electrodes are one of the major barriers to the widespread commercial production of hydrogen by electrolysis, where the water is split into hydrogen and oxygen using an electrical current. Unlike other water electrolyzers that use precious metals as catalysts, the new UNSW electrode is made entirely of two non-precious and abundant metals—nickel and iron. Commercially available nickel foam, which contains holes roughly 200 μm across, is electroplated with a highly active nickel-iron catalyst, reducing the amount of costly electricity required for the water-splitting to occur. *For more information: Chuan Zhao, +612.9385.4645, chuan.zhao@unsw.edu.au, www.unsw.edu.au.*

INDUSTRIAL COATING PROTECTS OXIDIZED TANK CARS



Oxidized tank car before and after with Nano-Clear Industrial coating. Courtesy of PRNewsFoto/Industrial Solutions USA.

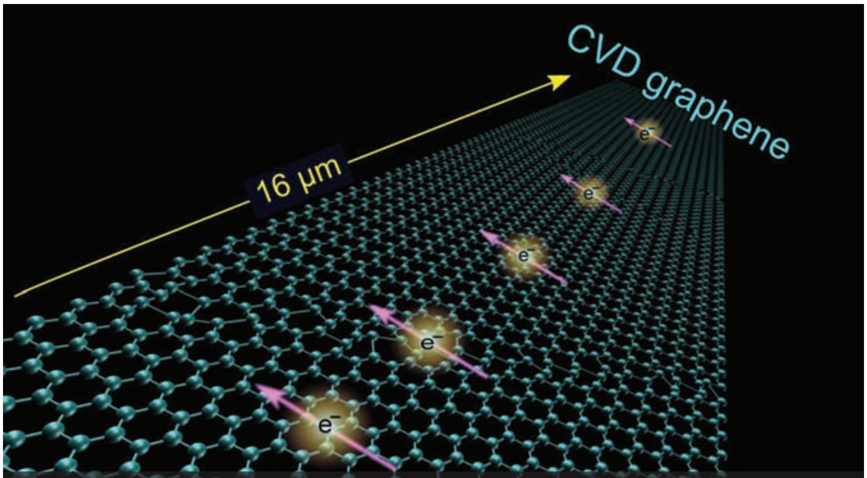
Over the last two years, Industrial Solutions USA, Sioux Falls, S.D., has conducted two application demonstrations at GATX's Hearne, Texas, facility using Nano-Clear Industrial (NCI) coating manufactured by Nanovere Technologies, Mich. NCI was spray applied over two highly oxidized tank cars and over one newly painted tank car. The coated tank cars were then put back into service throughout the U.S. for a 12-month performance study to provide a long-term, best practice solution to the epoxy paint oxidation issue on tank cars.

The black epoxy mastic currently used on the tank cars is continually exposed to high levels of UV rays and oxidizes rapidly. Highly oxidized epoxy paint coatings fall short in areas of abrasion, chemical, and corrosion resistance. UV tests conducted during the two-year study on the NCI coating by two different OEMs confirm no discoloration, chalking, or delamination from the substrate or between coats after 1500 hours (the equivalent of 18 months), and 4000 hours, respectively. NCI penetrates deep into the smallest pores of paint, enhancing the underlying color and improving gloss while also increasing resistance to UV rays, abrasion, corrosion, and chemicals. Nano-Clear eliminates the need to prematurely repaint, saving millions of dollars in maintenance costs and thousands of pounds of VOCs. *industrialsolutionsusa.com.*

BRIEF

ASTM International, West Conshohocken, Pa., announces a new *Standard Specification for Nickel-Cobalt Alloy Coating.* The document outlines requirements for corrosion-resistant coatings of electrodeposited nickel-cobalt on metallic substrates and electrodeposited nickel-cobalt used for electroforming. It also incorporates a classification scheme that establishes service conditions for thickness, classes of deposits based on the level of monitoring, and type based on supplemental coatings used after deposition. Coating thickness ranges from 5 to >30 μm and can be applied to machined parts, springs, latches, threaded parts, fasteners, and other components. *astm.org.*

NANOTECHNOLOGY



Graphene may enable spintronics to complement traditional electronics. Courtesy of M. Venkata Kamalakar, et al.

NEW WAY TO GROW METAL NANOSTRUCTURES

Michael Tringides, physicist at the DOE's Ames Laboratory and professor of physics and astronomy at Iowa State University, saw unusual atom movement when a few thousand lead atoms were dropped onto a flat, smooth lead-on-silicon surface, all at low temperatures, on an area just one-twentieth the width of a human hair. Scientists expected to see "random-walk diffusion" with atoms milling around, appearing to have no idea where they're going or that any fellow atoms are near them. Typically, atoms eventually run into each other and create small structures.

"Instead, we saw atoms very focused and working together to quickly create tiny lead nanostructures," says Tringides. "That kind of *collective diffusion* is really the exception to the rule in atom movement. Plus, we were surprised by how fast well-organized crystal structures nucleate at such cold temperatures, where movement is typically slow."

This collective, fast diffusion could represent a new way to grow perfect, tiny metal nanostructures. "Understanding the basic science of how materials work at these nanoscales may be key to making nanotransistors, nanoswitches, and nanomagnets smaller, faster, and more reliably," says Tringides. *For more information: Michael Tringides, 515.294.6439, mctringi@iastat.edu, physastro.iastate.edu.*

GRAPHENE FOR FUTURE SPINTRONIC DEVICES

Researchers at Chalmers University of Technology, Sweden, discovered that large area graphene can preserve electron spin over an extended period, and communicate it over greater distances than previously thought. This could open the door to spintronics development, with an aim to build faster and more energy-efficient memory and processors in computers. Spintronics is based on the quantum state of the electrons and the technology is already used in advanced hard drives for data storage and magnetic random accesses memory. Graphene is a promising candidate for extending spintronics use in the electronics industry. The thin carbon film is not only an excellent electrical conductor, but also theoretically has the rare ability to maintain the electrons with the spin intact.

Researchers conducted their experiments using CVD graphene, produced through chemical vapor deposition (CVD). This method gives the graphene a lot of wrinkles, roughness, and other defects. But it also has advantages—there are good prospects for the production of large area graphene on an industrial scale. CVD graphene can also be easily removed from the copper foil on which it grows and is lifted onto a silicon wafer, which is the semiconductor industry's standard material. Although the quality of the material is far from perfect, the group shows parameters of spin that are up to six times higher than those previously reported for CVD graphene on a similar substrate. *www.chalmers.se/en.*

BRIEF

A breakthrough in artificial photosynthesis was achieved through a system that captures carbon dioxide emissions before they are vented into the atmosphere and then, powered by solar energy, converts the emissions into valuable chemical products, including biodegradable plastics, pharmaceutical drugs, and even liquid fuels. Scientists with the **DOE's Lawrence Berkeley National Laboratory,** Calif., and the **University of California, Berkeley,** created a hybrid system of semiconducting nanowires and bacteria that mimics the natural photosynthetic process. The artificial system synthesizes the combination of carbon dioxide and water into acetate, the most common building block for biosynthesis. *lbl.gov, berkeley.edu.*

TECHNICAL SPOTLIGHT

ACOUSTIC IMAGING TECHNIQUES EFFECTIVELY MAP BURIED LAYER CONTOURS

Acoustic microscopy advances enable mapping of the point-by-point contour of tilted or warped interfaces, as well as individual material layer thicknesses.

Acoustic microscopes pulse ultrasound into a sample and use the return echoes to find and image cracks, delaminations, and other gap-type flaws in manufactured parts and products. New developments in microscope technology, such as those taking place at Sonoscan Inc., enable mapping of the point-by-point contour of tilted or warped interfaces, as well as individual material layer thicknesses.

If all layers are flat and parallel to each other, the acoustic image map of any internal interface will contain uniform color pixels because they are all the same distance from the scanning ultrasonic transducer. However, an assembly may contain interfaces that are tilted or warped, as shown in Fig. 1. In some instances, both warped *and* tilted interfaces are present in the same assembly.

In many applications, design constraints require these buried layers to be flat, horizontal, and of uniform thickness, although acoustic imaging may show different internal geometry. For example, power insulated gate bipolar transistor (IGBT) modules often struggle with buried layers. Fast-switching IGBT modules are frequently used to handle heavy loads in critical applications such as railroad engines, heavy mining equipment, and electric automobiles. Due to high current levels, the silicon die that actually performs the switching must disperse large amounts of heat.

IGBT modules are designed so that heat flows downward through ceramic plates called *rafts* to a metal heat sink that dissipates heat into the surrounding air (Fig. 2). If the heat sink, raft, and die are all horizontal and parallel, and if there are no voids (air bubbles) or other gaps in the solder bond, heat will flow downward (arrows in Fig. 1) at the designated rate. However, if voids are present or the raft (and perhaps the die itself) are tilted, heat flow will not meet specifications, likely causing the die to overheat and fail electrically.

Acoustic microscopes can image internal material interfaces fairly quickly because the transducer that pulses the ultrasound and receives the echoes from the internal features moves laterally at speeds that can exceed 1 m/s. In addition, the speed of ultrasound through production materials such as metals, ceramics, and polymers is typically measured in thousands of m/s.

Because most sample thicknesses are measured in millimeters, the pulse is launched and echoes are received in a few millionths of a second. Consequently, the moving transducer can receive echoes from thousands of locations per second as it scans. Echoes may come from a solid-to-solid material interface, or in the case of gap-type defects, a solid-to-gas (e.g., air) material interface. Each location contributes one pixel to the sample's acoustic image.

IGBT modules are imaged by scanning the transducer, which is inverted, across the surface of the metal heat sink at the bottom of the assembly. Because the transducer's ultrasound needs to be coupled to the surface, contact is maintained by a water plume. At each location, the return echo's amplitude provides information about the two materials at the interface. Solid-to-solid interfaces tend to have lower amplitude echoes. Solid-to-gas interfaces reflect virtually 100% of the ultrasound and thus produce much higher amplitude echoes that become bright white pixels in the acoustic image. While imaging the depth in a sample where two solid materials are supposed to be joined, there should be no white areas indicating voids, delaminations, or other gaps.

The elapsed time from pulse launch to echo return is also measured and recorded. This indicates that the image comes from within the vertical extent of the depth of interest (known

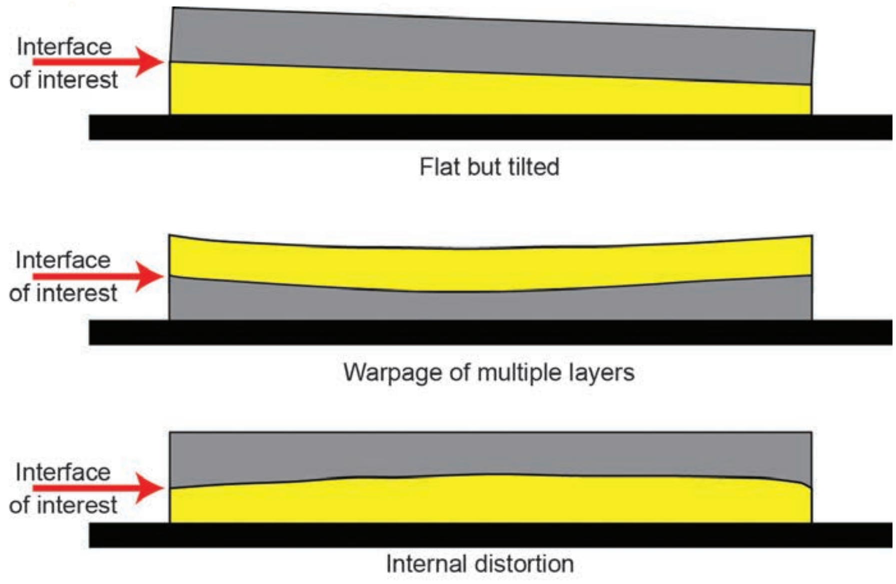


Fig. 1 — Three major types of internal nonplanarity.

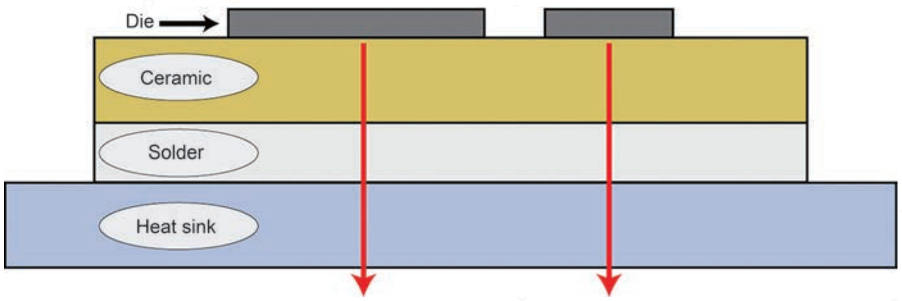


Fig. 2 — Arrows show desired path of heat dissipation from an IGBT module.

as a gate) defined before transducer scanning begins. Because the acoustic velocity of the material or materials is known, the elapsed time of an echo's travel from an interface within the gate can be converted into distance. The precise depth of the echo at each location can thus be known by using a program called the *time difference mode*—and the range of depths can be displayed by a sequence of pixel colors.

Figure 3a shows a time difference acoustic image of the area of one warped ceramic raft in an IGBT module. The image was gated to include the solder layer and top surface of the raft beneath the solder. The transducer pulsed ultrasound into the module from below, and the time difference mode mapped the surface of the warped raft. Where the raft surface is highest, the solder is thinnest. A 2D side view image through this IGBT module would look something like the diagram in Fig. 4, where solder thickness varies. In the diagram, black items indicate voids in the solder.

In Fig. 3a, solder is thickest (and raft surface lowest) in the magenta region near the lower right corner. Solder is thinnest (and raft surface highest) in the small red region at the upper left. Tilting and warping of the raft diminishes its heat-flow uniformity. In some IGBT modules, the raft is warped rather than simply tilted.

The red features away from the upper left corner indicate voids in the solder. In both the ceramic raft and voids, red areas identify items in contact with the heat sink through which the ultrasound was pulsed. Each void blocks heat flow and, collectively, may reduce flow to critical and undesirable levels.

Figure 3b uses colors to identify the local depth range of the solder. During inspection, this type of map makes it easier to pinpoint unacceptable solder thickness. The same technology is used to examine internal material interfaces in a much different application—manufacturing polycrystalline diamond (PCD) material for use in cutting tools such as oilfield drill bits.

The material is made by sintering a layer of PCD on top of a tungsten carbide layer. The tungsten carbide (WC) makes the tool stronger and adds to its footprint, making it easier to mount. These sintered layers form a wafer that can be cut into individual tool bits, with the top PCD layer used to perform the actual cutting.

The desirable outcome of sintering is a wafer with a uniformly thick layer of PCD on top. Such a wafer, whose layers are shown in Fig. 5, can be electromechanically sliced into the maximum number of tool bits for a given application. Wafer price depends on the number of good tool bits that can be cut from it. Tool bits where the PCD layer varies as little as possible from the ideal thickness are desirable because any cutting tool breakdown requires an expensive and time-consuming repair.

Imaging wafers acoustically produces a map showing the local depth of the interface between the PCD and WC, i.e., the PCD thickness. Figure 6 shows the acoustic images of two 55-mm wafers. Each color represents a vertical extent of 0.05 mm. The ideal thickness for this application is roughly 0.60 mm, represented by the boundary between the brown and pale blue regions on the two wafers.

The left wafer features many obvious variations in PCD thickness over short distances. Over the whole wafer, PCD thickness ranges from about 0.45 mm to 0.80 mm. The thickest region is near the center, represented by the magenta color. The result is that only a small portion of this wafer is usable. In contrast, the wafer on the right features a total PCD thickness variation of just 0.20 mm, offering a significantly larger area to be sliced into tool bits.

In both the IGBT sample and the diamond sample discussed here, one face of the buried layer is flat and horizontal—i.e., the top of the PCD wafer, and the top of the IGBT module's solder where it interfaces with the rigid metal heat sink. If a buried layer were distorted on both of its surfaces, this acoustic method could image both of the buried layer's surfaces in separate images and map the thickness of the distorted buried layer. **~AM&P**

For more information: Tom Adams is a consultant for Sonoscan Inc., 2149 E. Pratt Blvd., Elk Grove Village, IL 60007, 847.437.6400, info@sonoscan.com, www.sonoscan.com.

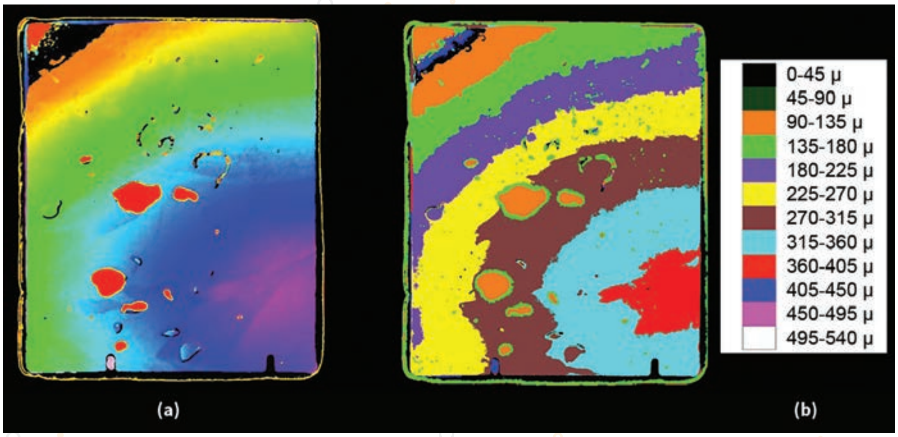


Fig. 3 — Time difference mode image of solder thickness in IGBT module with a tilted raft (a). Scale indicates solder thickness (b).

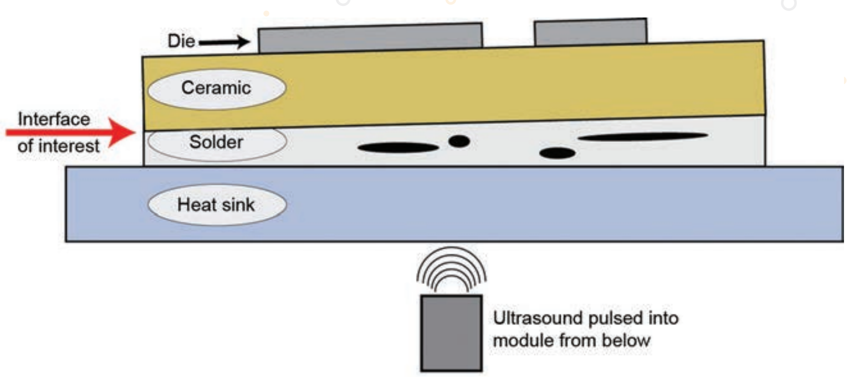


Fig. 4 — Diagrammatic side view of a module with a tilted raft.

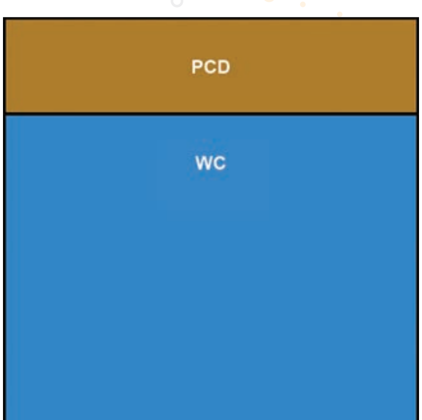


Fig. 5 — Side view diagram of a portion of an ideal polycrystalline diamond/tungsten carbide wafer.

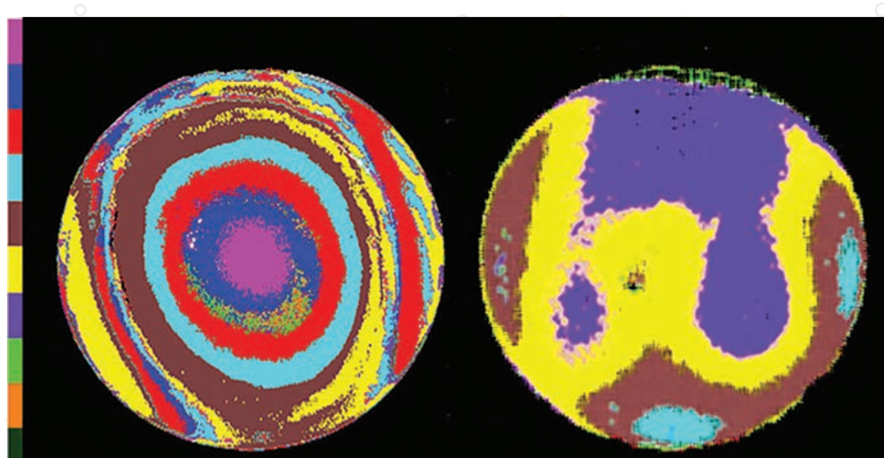


Fig. 6 — Time difference mode images of two wafers exhibiting extreme variation in PCD thickness (left), and much less variation with far more usable area (right).

STEEL REINFORCEMENT BAR: A TENSILE TESTING GUIDE

Steel rebar is commonly used around the world to reinforce concrete. Understanding the basics of rebar tensile testing is critical to ensuring product quality.

Jeff Shaffer, Instron, Grove City, Pa.

Steel reinforcing bar, or rebar, is embedded in concrete to improve the overall strength of the surrounding concrete. Material product standards help guarantee that rebar produced throughout the world exhibits the same physical, chemical, and mechanical properties regardless of the source. Proper mechanical testing is necessary to determine if the rebar meets its published specifications, ensuring product quality. Mechanical testing requirements for rebar can vary, but typically fall into these main categories:

- Tensile
- Bend
- Compression
- Fatigue

Other related product testing, such as slip testing of mechanical splices (couplers), may also be required. This article primarily focuses on the common—yet sometimes challenging—tensile test.

TENSILE TESTING AND STANDARDS

At the global level, technical committees governed by the International Organization for Standardization (ISO) develop product and testing standards for reinforcement bar products. In addition to specifying properties such as minimum upper yield strength (Reh), Rm/Reh ratio, and elongation values for ribbed steel bar products, ISO product standards, such as ISO 6935-2, also specify how to measure tensile properties. Unique testing requirements are included directly in the standard and additional reference is made to ISO 15630-1, which focuses specifically on test methods for similar products. ISO 15630-1 provides further references to the more general metals tensile testing standard, ISO 6892-1, where applicable.

On a regional level, many countries also have local standards organizations that may have existed even before the global ISO committees were formed. They often maintain their own product and testing standards or can elect to adopt global ISO standards where appropriate. For example, in the U.S., ASTM has established product and testing standards for rebar. Product standards such as ASTM A615, A706, A955, and A996, provide minimum product specifications and also include unique testing details for determining tensile properties. Reference may also be made to additional testing requirements found in ASTM A370. This steel testing standard covers mechanical testing of steel products. It then includes further reference to the primary metals tensile testing standard, ASTM E8.

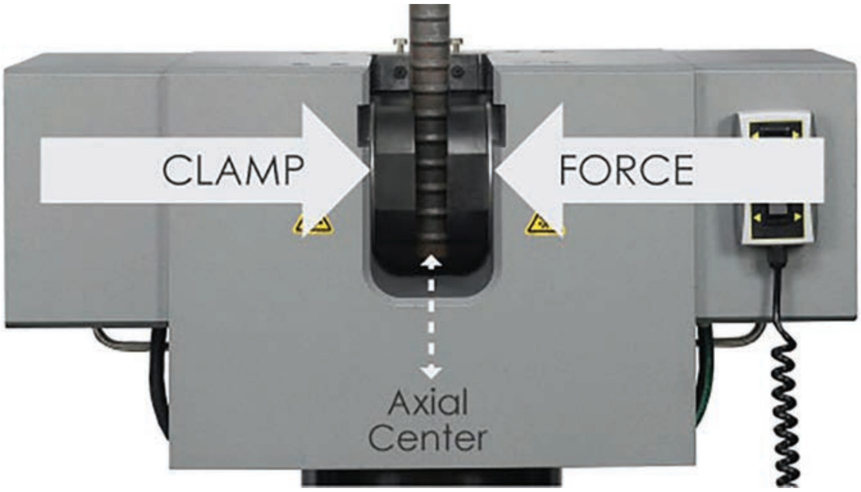
Regardless of the governing body, the information provided in most global and local standards is quite detailed and intended to help users understand the following basic testing requirements:

- Required equipment
- Associated terminology and symbols
- Specimen preparation

TABLE 1—COMMON REBAR PRODUCT AND TESTING STANDARDS

	ISO	ASTM
Rebar product standard	6935-2	A615
Rebar testing standard	15630-1	A370
Metals tensile test standard	6892-1	E8

Uncoiled rebar with slight bends over length.



Instron DuraSync side-acting grips clamping rebar specimen on center.

Abundant scale accumulation on lower grip after one test.

Number 18 (57 mm) bar separation (recoil) after failure.

- Testing procedures or methods
- Calculations or results to be determined

Even though standards provide these details, some aspects may still be left to interpretation, which can often lead to variations in testing performance. Additionally, if a lab is testing products to a variety of global or local standards, it can be challenging to fully understand and capture subtle differences in terminology and methodologies.

This article attempts to clarify areas commonly misinterpreted or misunderstood by users. The content is intended to be general and summary in nature so it can be applied regardless of which test standard is followed.

EQUIPMENT CONSIDERATIONS

Accommodating bent specimens: As standards indicate, rebar specimens must be straightened prior to tensile testing. As a result, many test pieces may still have a slight bend or nonlinearity over their length. Therefore, load frame and grips that are able to accommodate slightly bent specimens are best.

Grips that mechanically clamp on center are recommended in order to maintain axial alignment. Hydraulic side-acting grips are best for addressing bent specimens because the mechanical balancing (synchronizing) between the two sides allows them to always clamp on center even when side loads from bent specimens act against the jaws closing. This helps improve alignment and eliminates resetting of grips between tests. Resetting is typically associated with hydraulically synchronized grip designs that cannot clamp on center when specimen side loads exist. Failure to reset these types of grips between tests can allow misalignment between upper and lower grips.

Specimen deformations and scaling: Grip jaws (faces) must accommodate deformations and scale common on rebar specimen surfaces. Scale buildup in the teeth of the jaws can lead to specimen slippage. Tooth patterns that are too aggressive can cause premature specimen failures and may also prevent the specimen halves from being easily removed after the test. Therefore, tooth profiles should allow scale to fall away naturally or be easily brushed away between tests. They should also alleviate failures potentially caused by grips. If the broken specimen halves remain stuck in the jaw faces, operators must dislodge them through use of a hammer or other means, which can reduce efficiency and add to operator fatigue and frustration.

The grip's mechanical functions should also be protected against falling scale. If scale is allowed to get between moving parts, critical surfaces can be galled and lead to poor performance or grip failure. Regular removal of scale from testing equipment is important to help prevent unnecessary wear and tear.

Violent specimen failures: Because rebar specimens release a lot of stored energy during tensile failure, the testing system must be able to withstand the shock that results from specimen recoil. Grips are most impacted and must be robust enough to absorb the energy and still hold the broken specimen halves so they do not eject from the testing frame. Flying specimen pieces could become a safety hazard to the operator and can also damage equipment. For these reasons, hydraulically actuated grips (wedge or side-acting) are recommended.

Extensometers: Extensometers are not always required when testing rebar.

Manual, clip-on style rebar extensometer.

If a distinct *yield point* (upper yield strength—ReH) is visible, yield strength can be determined without an extensometer by reporting the stress value at this point. *Elongation after fracture* (ASTM and ISO) and *total elongation at maximum force* (ISO) can both be determined manually after the test from marks placed on the specimen surface.

However, there are many times when an extensometer must be used in order to calculate results such as *offset yield* (Rp 0.2) or when determining elongation values automatically from an extensometer instead of manually from specimen marks. In these cases, extensometers typically have large gauge lengths compared to those used on machined metal specimens. They must also be robust enough to withstand scale falling on them during testing and be able to attach to the uneven surface of deformed bars. Depending on the deformations, they can be attached to the flat surfaces in between deformations or on a longitudinal rib if one exists.

The most common extensometers used in rebar testing are manual clip-on style instruments attached directly to the rebar prior to running the test. If the instrument is not designed to remain "on" through failure, it must be manually removed after yielding occurs, but before the specimen fails. Manual instruments designed to withstand specimen failure offer advantages, but will likely experience faster wear of the knife edges if frequently used through failure.

AutoX750 testing #11 (36 mm) rebar on an Instron 1500 KPX.

Most manual instruments are also designed with a fixed gauge length. However, when testing many sizes of rebar with varying gauge lengths, it is necessary to have several extensometers that have different lengths. Some manual instruments are available that can be configured for several different gauge lengths, allowing a single instrument to cover most common requirements. Such devices require the operator to manually configure the instrument properly between tests that require a different gauge length.

Automatic contacting instruments offer several advantages over manual devices. Automatic removal and attachment allow the operator to stay out of the test space, eliminating risks associated with specimen failures. The gauge length is set automatically from software inputs and is infinitely adjustable over the entire travel of the instrument, allowing a single instrument to cover all specimen requirements. It can also be left on through failure if desired. Automatic instruments are likely the best solution if automatic recording of elongation measurements is required.

TESTING SPEEDS AND CONTROL

One challenging aspect of complying with test standards is determining how to properly and efficiently execute the tensile test. Despite standards providing specific details for allowable test speeds and control modes for different stages of the test, performing tests properly can still be difficult. This may be due to both standard interpretation challenges and test equipment limitations. Details that influence test control and speeds can be found scattered throughout various sections of test standards. Referencing more than one standard might be necessary in order to have all the required test setup information. This can make it very difficult to fully understand all aspects of the test sequence and how to make it work on a given testing system.

For rebar tensile testing, breaking the test into separate stages is helpful. This applies regardless of which test standard is being followed. The five basic regions include:

- Pretest
- Preload
- Elastic region
- Yielding
- Plastic region

Pretest: During the pretest stage, the machine is prepared for testing. The proper grips are installed and test opening adjustments are made. Prior to installing the specimen, the force (load) measurement should be set to zero. Once the specimen is loaded into the system, the force should not undergo any further "zeroing" as this will affect the test results. If using a manual extensometer for measuring strain, it should be attached to the specimen while making sure to properly set the knife edges at the instrument's gauge length. Strain measurement should then be set to zero prior to loading the specimen.

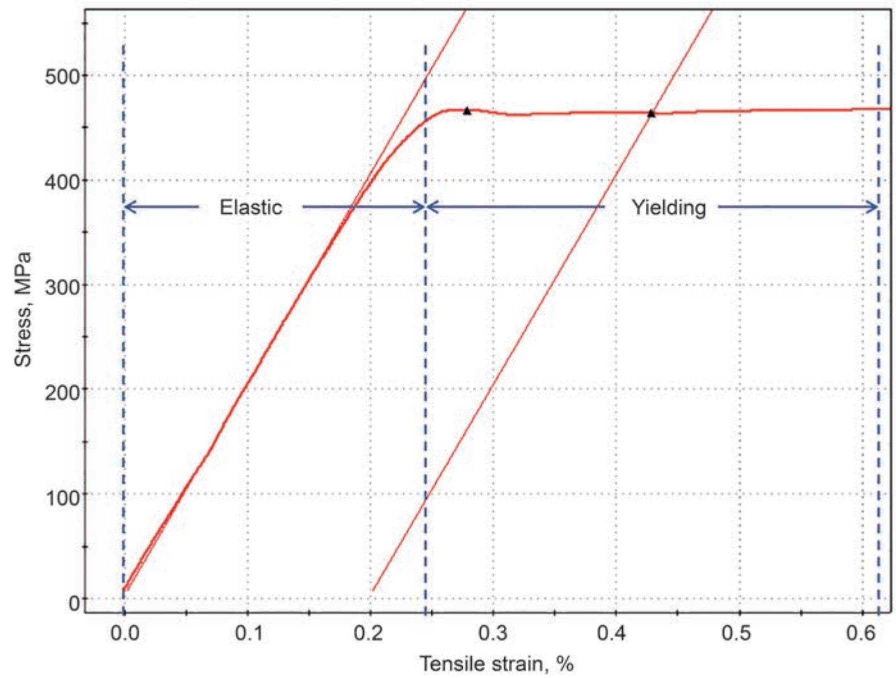
Preloading: The preloading stage is used to apply a minimal preload

(<5% of expected yield strength) to the specimen in order to properly seat it in the grips and to also aid in pulling the specimen straight prior to testing. A plot of stress or force versus crosshead or actuator displacement will typically show significant displacement for a minimal increase in load due to the grips and load string pulling tight (taking up system compliance). If a preload is not applied and an extensometer is being used, many rebar specimens will show negative strain at the beginning of the test as the specimen straightens. Because of this and/or system compliance, data obtained during the preloading portion of the test is often ignored or not recorded on the *stress-strain* graph.

On servo-controlled systems, preloading is usually done slowly using crosshead or actuator displacement feedback for controlling the test speed. Controlling preloading from load, stress, or strain feedback is not recommended as it could lead to undesirable and rapid acceleration until the specimen is pulled tight in the grips.

Depending on the amount of system compliance or slack that was taken up during the preload, it may be necessary or desirable to zero the strain measurement at the end of preloading. However, caution must be taken to not adversely affect overall strain measurement. In either case, test results that rely on strain from the extensometer should be adjusted so any nonlinear behavior at the very beginning of the test curve does not adversely affect test results.

Elastic region (before yielding): The elastic region or straight line portion of the test as seen on the stress-strain plot often exhibits some initial nonlinear behavior due to further straightening of the rebar specimen. If using an extensometer, this may appear as slightly negative strain at the beginning of the test and is generally considered normal for rebar. Depending on the standard being followed, a variety of test control and target speeds are allowed during the elastic region and until the onset of yielding. The control and associated rate used may depend on equipment limitations or the specific product being tested.



Elastic and yielding regions of a rebar stress-strain curve.

When running tests on servo-controlled systems, it is important to keep the following scenarios in mind. If using crosshead or actuator displacement control, it is generally acceptable to use the same control and speed through both the elastic and yielding portions of the test. However, if stress or strain feedback control is used, the test must switch to crosshead or actuator displacement control just before or at the onset of yielding.

Yielding: Once yielding begins, many rebar grades exhibit a defined yield point that appears as an abrupt bend in the stress-strain test curve. It is then followed by a period of specimen elongation with little to no increase in force. Because of this, servo-controlled systems must be regulated using crosshead or actuator displacement feedback to maintain a constant rate of travel throughout yielding. It is important to note that using stress control during yielding will cause the test to accelerate excessively, which is in direct violation of the standards. This can also cause the yield point (upper yield) to be masked or smoothed and cause yield strength results to be higher than expected. Likewise, strain control from an extensometer can also become erratic during yielding and is not recommended when testing rebar.

Plastic region after yielding: As standards clearly define, it is acceptable to increase test speed after yielding is complete. For servo-controlled machines, the best way to control the test during this final region is from crosshead or actuator displacement feedback (same as yielding). However, speed can be increased according to the standard being followed. This allows the test to be completed in a shorter period of time while still producing acceptable and repeatable results.

A NOTE ON NOMENCLATURE

Test standards incorporate terms, result names, and symbols to properly identify critical information sought during testing. It is important to fully understand this information in order to ensure standards compliance and proper results reporting. If testing to multiple standards, it is also necessary to understand the similarities and

TABLE 2–COMMON TERMS FOR REBAR TENSILE TESTING RESULTS

	ISO	ASTM
Yield Point (distinct)	Upper yield strength (ReH)	Yield point (drop of beam or halt of pointer)
Yield strength (offset method)	0.2% Proof strength, non-proportional elongation (Rp 0.2)	Yield strength (0.2% offset)
Maximum stress	Tensile strength (Rm)	Tensile strength
Ratio of tensile strength/yield strength	Rm/ReH	Not required
Strain at maximum force	% Total elongation at maximum force (Agt)	Not required
Elongation after fracture	% Elongation after fracture (A or A_5)	% Elongation

differences between these items. In some cases, standards organizations use different terms or result names to refer to the same property. The table above shows a few common examples of result names that are found in ISO and ASTM standards.

SUMMARY

Global and local rebar product and testing standards define specifications and mechanical testing requirements. These standards help to ensure consistent quality of rebar produced throughout the world. It is critical for any tensile testing program to make sure there is compliance with required standards and that standards being followed are up-to-date. To further reduce the risk of incorrectly passing or failing product, it is also essential to regularly evaluate all aspects of the testing process and take corrective actions as necessary. Evaluation should include equipment (machine, grips, extensometers), specimen preparation, setup (software and hardware), test control (automatic or manual), calculation of results (automatic or manual), and graph analysis. **~AM&P**

For more information: Jeff Shaffer is manager of product marketing and management for the Industrial Products Group of Instron, 900 Liberty St., Grove City, PA 16127, 724.450.4965, jeff_shaffer@instron.com, www.instron.com.

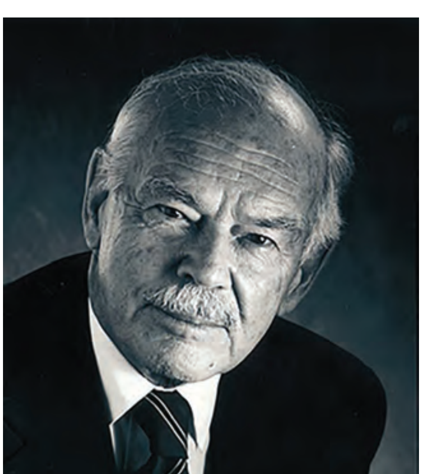
METALLURGY LANE

Metallurgy Lane, authored by ASM life member Charles R. Simcoe, is a continuing series dedicated to the early history of the U.S. metals and materials industries along with key milestones and developments.

STEEL MINIMILLS–PART I

FROM 1900 TO 1960, THERE WAS LITTLE CHANGE IN THE STEELMAKING INDUSTRY. STEEL MINIMILLS CAME ON THE SCENE IN THE LATE 1960s.

From 1900 to 1960, there was not much change in the steelmaking industry. The business was dominated by a few large companies, led by United States Steel Corp. Steel minimills came on the scene in the late 1960s and into the 1970s. Besides being much smaller than the big mills, minimills feature three distinct factors that set them apart: Only scrap is used in the charge for the melting furnaces; electric arc furnaces (EAFs) are used for melting; and steel is solidified into billets using continuous casting, which feeds billets directly into the rolling mills. Scrap had been melted in EAFs since the early part of the 20th century, but only for making tool steels, high alloy steels, and stainless steels where scrap had to be high quality to meet specifications. Scrap was also used in large quantities in the open hearth process to make ordinary carbon steels and engineering alloy steels.



Gerald Heffernan built the first minimill in North America in Ontario, Canada, and the second mill in St. Paul, Minn. Courtesy of amm.com.

During the 1960s, big steel companies were changing production methods to the new basic oxygen converter that removed carbon from the molten metal delivered from blast furnaces. This reduced the scrap market to very low levels with low prices, giving further advantage to minimills against big steel and its capital requirements for blast furnaces and basic oxygen converters. At the same time, big steel was adjusting to conversion to continuous casting. All these factors opened the door for minimills to make small bars and shapes not required to meet the specifications of higher quality steel.

THE FIRST MINIMILL

The first continuous caster was installed in 1959 at the Premium Steel Co. in Alberta, Canada. The work was done under Gerald Heffernan, a metallurgical engineer from the University of Toronto. Only a portion of production was put through the caster with the rest turned into ingots, which had to be rolled or forged into billets. Premium Steel was purchased in 1963 by Stelco, a big steel company in Ontario, to gain access to this growing western market. With his share of the sale and other financial backing, Heffernan built the first minimill in North America in 1964, called Lake Ontario Steel Co. (Lasco). Lasco was the first steel plant to put all hot metal through a continuous caster. Heffernan adopted a new management philosophy, developing training for many different job requirements with a focus on safety. His management style would become standard for the minimill industry.

F. Kenneth Iverson, CEO of Nucor, led the minimill industry for the first 25 years. Courtesy of aimehq.org.

The second plant built in North America was North Star Steel Co. in St. Paul, Minn., also engineered by Heffernan. North Star was financed by Cargill with minority stockholders including Heffernan. It went on stream in 1968, producing 200,000 tons per year in bars and shapes. One potential customer was Vulcraft in Norfolk, Neb., a company that assembled small bars and angle shapes into roofing beams for shopping malls and big box buildings. Vulcraft's president, F. Kenneth Iverson, visited North Star to discuss buying steel, but came away determined to build his own minimill to supply five assembly plants. The parent company, Nuclear Corp. (Nucor), selected a site in Darlington, S.C., near one of the fabrication plants. This minimill became the third in North America and had capacity of 200,000 tons per year. Startup difficulties, combined with Heffernan

Hot rolling of sheets. Courtesy of Bethlehem/ISG and library.fordham.edu.

Nucor's minimill in Darlington, S.C., had initial capacity of 200,000 tons per year. Circa 1969. Courtesy of nucor.com.

not being involved, nearly bankrupted the company. Even so, it went into full production in 1971. This plant became so successful that Nucor built two more minimills near its assembly plants in Norfolk, Neb., and Jewett, Texas.

HEFFERNAN'S THIRD MILL

When Cargill bought out the minority shareholders of North Star Steel in 1972, Heffernan sold his shares and founded Co-Steel. He partnered with Texas Enterprise to build his third minimill, Chaparral Steel Co., in Midlothian, Texas. Chaparral was equipped with the latest technology in EAFs and continuous casters and had capacity of 200,000 tons per year, common with these first minimills. With constant upgrading of equipment and processes, Chaparral produced one million tons per year in 10 years, and two million tons per year after another 20 years.

Through the leadership of Iverson and Heffernan, the minimill industry developed into 30 plants in the U.S. and eight in Canada during the 1970s. Typical of these additional minimills was Auburn Steel Co. in Auburn, N.Y., built in 1974 with capacity of 400,000 tons per year. As with most of the new minimills, it did not have an in-house market as did Nucor with its Vulcraft Division and Chaparral with the oil industry. Instead, the mills were subject to the business cycles of the steel industry. Most of them were acquired by bigger and more financially secure corporations. Nucor purchased Auburn Steel and at the same time built a Vulcraft plant nearby to use the output. In 1975, minimills had a combined output of six million tons—a small percentage of total steel production, which was more than 100 million tons that year.

FIRST MINIMILL FOR FLAT PRODUCTS

A huge breakthrough in the minimill industry was Iverson's new plant dedicated to producing flat products for Nucor. Flat products required the highest quality steel, which was still the mainstay of the integrated steel industry. Big steel thought this area could not be invaded by companies that relied on scrap for feedstock. Iverson's plant was built in 1988 at Crawfordsville, Ind., and the heart of the process was a new continuous casting machine from Siemens in Germany. This enabled Nucor to cast slabs 2 in. thick by 52 in. wide, ready to enter the rolling mill to produce hot coil bands for cold rolling to sheet product used by the automotive, appliance, and other industries. The new plant could produce two million tons per year and cost $1 billion to build. This was the beginning of multimillion-ton plants, although the term "minimills" remains in use.

STEEL BEAMS AND RAILROAD RAILS

At about the same time, Nucor teamed with a Japanese company, Yamato Steel Co., to produce structural products, wide flanged beams, and railroad rails in a new mill at Blytheville, Ark., with capacity of 2.8 million tons per year. This was another breakthrough that had a great impact on the integrated steel industry. The sheet mill at Crawfordsville was immediately so successful that Nucor built a second sheet mill at Hickman, Iowa, with capacity of two million tons per year. This was the start of minimill production of flat products and structural products that would make significant inroads into the primary business of integrated steel. For 25 years, Nucor led the industry in technology, production, management philosophy, and market penetration. And Nucor's CEO, F. Kenneth Iverson, was the most important individual in developing the U.S. minimill industry.

IVERSON LEADS INDUSTRY

F. Kenneth Iverson was born and raised in Downers Grove, Ill. He attended Northwestern University in 1943 and served in the Navy from 1944 until 1946, then returned to college at Cornell University where he received a bachelor's degree in aeronautical engineering. Iverson continued his engineering education with a master's in mechanical engineering at Purdue University. He was a member of both ASM International and AIME and received honorary doctorates from the University of Nebraska and Purdue University. He was inducted into the National Academy of Science-Engineering Division in 1994 and awarded the National Medal of Technology. Iverson retired in 1996 for health reasons and died in 2002 at age 76.

For more information: Charles R. Simcoe can be reached at crsimcoe1@gmail.com.

PROGRESS REPORT: MATERIALS GENOME INITIATIVE

Technical societies meet to discuss building the materials data infrastructure.

A workshop report released by ASM International through its Computational Materials Data Network outlines actions that professional societies can take to convene the materials community to drive development of a materials data infrastructure: This framework aims to transform the way the materials community collaborates on materials and manufacturing innovation. By focusing on development of a series of materials community workshops, the report offers an approach that can bring the community one step closer to the overall goal of the Materials Genome Initiative—a future where materials are created and implemented twice as fast and at a fraction of the cost than they are today.

ASM International convened the January workshop that resulted in the new report, *Building the Materials Data Infrastructure: A Materials Community Planning Workshop.* The meeting brought together representatives from more than a dozen professional societies to address the December 2014 *Materials Genome Initiative Strategic Plan* objective to "identify best practices for implementation of a materials data infrastructure." The meeting focus was to identify a series of multiagency workshops that could engage the different components of the materials community to establish needs, identify barriers, and define methods to overcome them.

"This timely workshop provided valuable engagement across disparate materials communities and addressed how to identify and overcome the challenges recently laid out in the 2014 Materials Genome Initiative Strategic Plan," says James Warren, technical program director for materials genomics at the Material Measurement Laboratory of the National Institute of Standards and Technology.

Participants built on an analysis of previous workshop results and studies to identify needs and outline a four-year timeline for future activities that could address these needs. These actions fall into three broad categories:

DATA MANAGEMENT

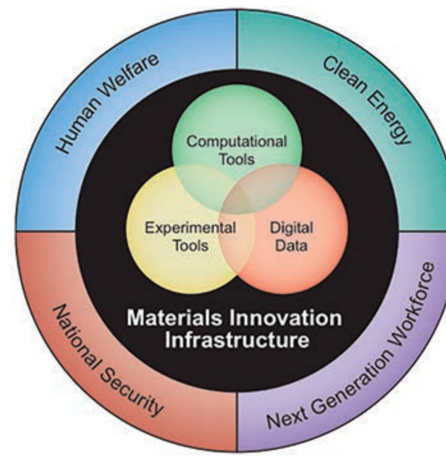
- Establish a materials data quality roadmap by convening a broad-scope workshop supplemented by later meetings on specific data quality topics, such as quality standards, uncertainty quantification, curation practices, and data gathering codification.
- Develop a materials community data registry—a listing of databases—by leveraging experience with existing data registries in other fields, such as the Virtual Astronomical Observatory Registry.

DATA SHARING

- Develop business models to encourage participation in the materials data infrastructure by conducting a series of forums with disparate materials communities.
- Identify connections between publishing articles and data through a series of publishing forums involving publishers, data generators, and other stakeholders.

EDUCATION, TRAINING, AND OUTREACH

- Develop data management workforce training through a set of workshop efforts, including communication and training in current tools and capabilities as well as curriculum development for both materials professionals and those in undergraduate and graduate programs.



Courtesy of whitehouse.gov.

Professional societies are uniquely positioned to lead many of these initiatives, as their ability to convene a range of materials experts across industry, academia, and national and federal laboratories is critical to bringing the materials innovation infrastructure to fruition.

"The role of professional societies in supporting the development of the materials data infrastructure is a conversation that needs to continue in order to build a robust and effective system," explains Scott Henry, director of content and knowledge-based solutions at ASM. "With access to a broad range of expertise as well as the ability to work across traditional boundaries, professional societies will continue to be a driving force toward a future of rapid and more efficient materials and manufacturing innovation."

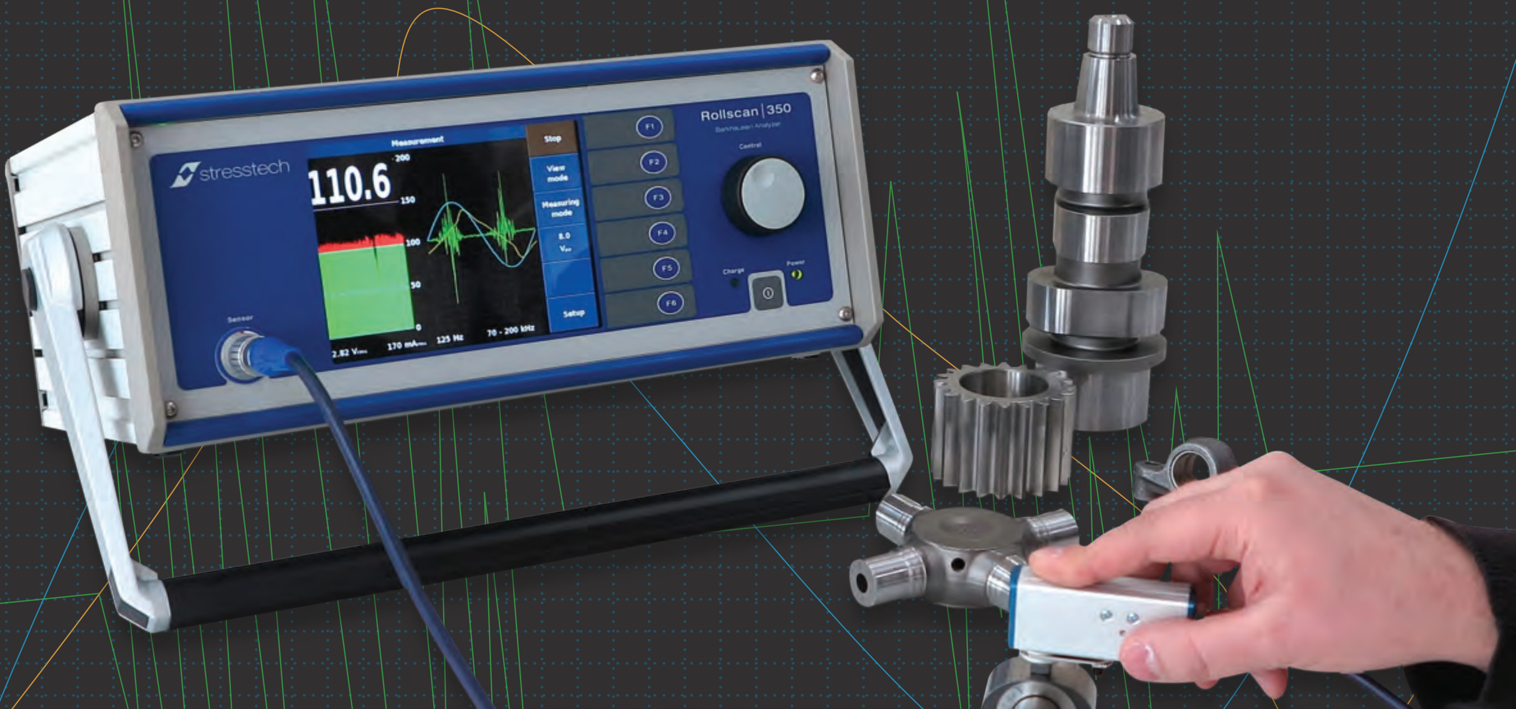
For more information and to access the full report, visit asminternational.org/web/cmdnetwork. ~AM&P

HTS Heat Treating Society
ASM INTERNATIONAL

JUNE 2015 | VOLUME 3 | ISSUE 2

HTPRO

BUSINESS AND TECHNOLOGY FOR THE HEAT TREATING PROFESSIONAL



USING BARKHAUSEN NOISE TO ANALYZE CASE DEPTH 6

RGA DETERMINES HOT ZONE PERFORMANCE 8

HTS Heat Treating Society
ASM INTERNATIONAL

HTPRO
BUSINESS AND TECHNOLOGY FOR THE HEAT TREATING PROFESSIONAL

EDITORIAL OPPORTUNITIES FOR *HTPro* IN 2015

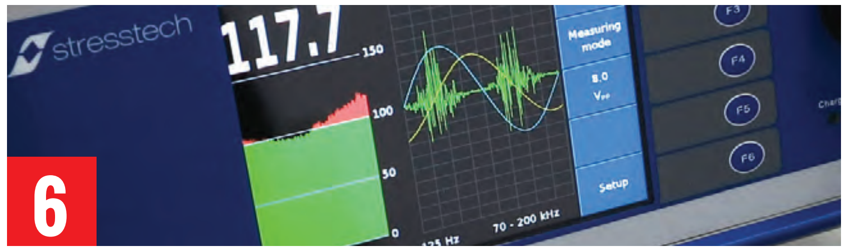
The editorial focus for *HTPro* in 2015 reflects some key technology areas wherein opportunities exist to lower manufacturing and processing costs, reduce energy consumption, and improve performance of heat treated components through continual research and development.

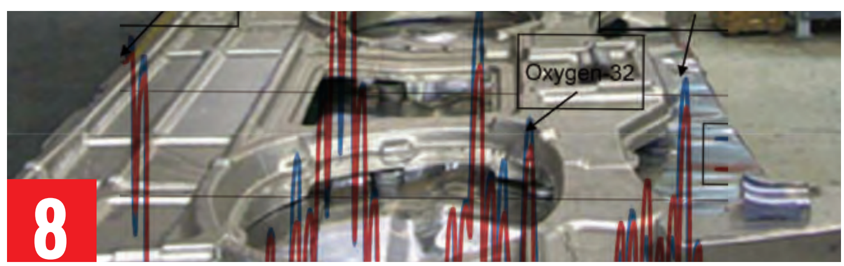
October Thermal Processing in Automotive Applications

November Atmosphere/Vacuum Heat Treating

To contribute an article to one of the upcoming issues, contact Frances Richards at frances.richards@asminternational.org.

To advertise, contact Erik Klingerman at erik.klingerman@asminternational.org.





DEPARTMENTS

ABOUT THE COVER

Testing a camshaft lobe for grinding retemper burn using Rollscan 350 Barkhausen noise analysis equipment. American Stress Technologies Inc., astresstech.com.

HTPro is published quarterly by ASM International®, 9639 Kinsman Road, Materials Park, OH 44073, 440.338.5151, asminternational.org. Vol. 3, No. 2.

Dissemination: Disperse throughout. Information dissemination to Heat Treating Society members and the heat treating community in general is a high priority for the Society. One method of providing information on the latest developments in heat treating technology is through conferences and expositions, which offer a platform to share knowledge from worldwide experts to a large cross section of industry participants. The HTS Technology and Programming Committee is continually reviewing this key service to provide events with the highest member value, including the biennial Heat Treat Show and regional events that address specific topics and audiences.

Heat Treat 2015 is just around the corner, taking place in Detroit from October 20–23. The show is once again co-located with the American Gear Manufacturers Association (AGMA). Interest in the technical program is very high, with 145 abstracts submissions from worldwide sources. New initiatives this year include joint programming with AGMA on the show floor; special student/young professional activities; and a return of the Heat Treating "Master Series" Sessions, which will focus on the pioneers whose research transformed heat treating technology.

Discussions about future shows are already taking place. The colocation with GearExpo (AGMA) continues to benefit both organizations and will continue in 2017 in a Midwest venue yet to be decided.

HTS will host the 2016 IFHTSE Congress on April 18-22 in Savannah, Ga. The event is sponsored by the ASM Heat Treating Society and the International Federation for Heat Treatment and Surface Engineering. A call for papers is open with abstract submissions due by September 30.

HTS is also planning a regional technical conference and exhibit in Queretaro, Mexico, in late 2016. This event will showcase heat treating resources available to this important automotive manufacturing market.

HTS is always looking for fresh ideas. If you are interested in participating in helping to plan these highly valued events for members and the heat treating community in general, think about joining the HTS Technology and Programming Committee. Review the Committee Purpose on the HTS website at hts.asminternational.org and contact joanne.miller@asminternational.org.

Ed Kubel
Contributing Editor
ed.kubel@asminternational.org

JONES RECEIVES 2015 GEORGE BODEEN HEAT TREATING ACHIEVEMENT AWARD


Jones

Mr. Roger A. Jones, corporate president of Solar Atmospheres Inc., Souderton, Pa., is the recipient of the 2015 George H. Bodeen Heat Treating Achievement Award. Established in 1996, the award recognizes distinguished and significant contributions to the field of heat treating through leadership, management, or engineering development of substantial commercial impact. Jones is recognized "for advancing the thermal processing industry through technological developments in fixturing materials, methods, and the application of partial pressure atmospheres in vacuum furnaces for ferrous, stainless steels, and brass alloys."

After graduating from Hocking Technical College, Jones joined ABAR Corp. in 1975. In 1978, he joined Vacuum Furnace Systems Corp., founded by his father William R. Jones, FASM. In 1983, he helped found Solar Atmospheres Inc., serving as vice president, became president in 1993, and became corporate president in 2001. He has been a member of the Metal Treating Institute since 1983, serving on the Board of Trustees (1998-2004, and 2009-present), and as president (2004-2005).

Jones has been a member of the ASM Philadelphia Liberty Bell Chapter since 1983, and served as chapter president from 1993-1994. He was chair of the ASM Heat Treating Society (HTS) Immediate Needs Committee and the HTS Education Committee, served on the Nominating Committee for two terms, and is a member of the HTS Technology & Programming Committee. He was elected to the HTS Board in 2005, served as vice president (2001-2013) and is the current president of HTS. He received the chapter's William Hunt Eisenman Award in 2001 and Distinguished Service Award in 2004. Under his leadership, Solar Atmospheres received the chapter's "Outstanding Company Support Award" in 1996 and 2006.

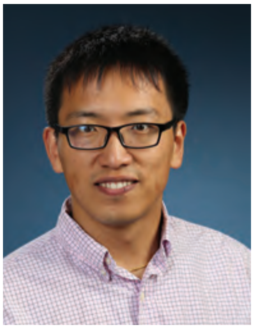
The Bodeen award will be presented at the HTS General Membership Meeting on Wednesday, October 21, at the ASM Heat Treating Society Conference and Exposition in Detroit.

FIRST ASM HTS/SURFACE COMBUSTION EMERGING LEADER AWARD TO BE PRESENTED AT HEAT TREAT 2015

The ASM HTS/Surface Combustion Emerging Leader Award was established in 2013 to recognize an outstanding early-to-mid-career heat treating professional whose accomplishments exhibit exceptional achievements in the heat treating industry. The award was created in recognition of Surface Combustion's 100-year anniversary in 2015.

The award acknowledges an individual who sets the highest standards for HTS participation and inspires others to dedicate themselves to the advancement and promotion of vacuum and atmosphere heat treating technologies. The recipient of the award has not yet been selected.

ZHANG WINS 2015 HTS/BODYCOTE BEST PAPER IN HEAT TREATING AWARD


Winner of the HTS/Bodycote 2015 Best Paper in Heat Treating Award, Lei Zhang.

The winner of the 2015 HTS/Bodycote Best Paper in Heat Treating Award is entitled, "Enhancement of Carbonitride Tool-Retained Austenite and Microhardness Prediction" by Lei Zhang, a Ph.D. student in material science engineering at Worcester Polytechnic Institute (WPI). He received assistance from his advisor Dr. Richard D. Sisson, Jr., FASM, and post-doctoral fellow, Liang He. Zhang's research focus is the nondestructive testing (NDT) of surface hardness and case depth for steel after the carburizing process.

The award will be presented at the HTS General Membership Meeting on Wednesday, October 21, at the ASM Heat Treating Society Conference and Exposition in Detroit.

The ASM Heat Treating Society established the Best Paper in Heat Treating Award in 1997 to recognize a paper that represents advancement in heat treating technology, promotes heat treating in a substantial way, or represents a clear advancement in managing the business of heat treating. The award includes a plaque and $2500 cash prize endowed by Bodycote Thermal Process-North America.

CALL FOR PAPERS

A call for papers is now open for the 23rd International Congress of Advanced Thermal Processing to be held April 18-22, 2016 in Savannah, Ga. The event is sponsored by the ASM Heat Treating Society and the International Federation for Heat Treatment and Surface Engineering.

Prospective authors wishing to present papers should submit a title and ~300-word abstract for consideration. Submission **deadline is September 30**. For more information, visit asminternational.org/web/ifhtse/home.

ASM HEAT TREATING SOCIETY 2015
CONFERENCE & EXPOSITION

HEAT TREAT 2015-28th ASM HEAT TREATING SOCIETY CONFERENCE AND EXPOSITION

OCTOBER 20-22 • COBO CONVENTION CENTER • DETROIT

The ASM Heat Treating Society (HTS) and the American Gear Manufacturers Association (AGMA) once again are co-locating to create an exciting mix of education, technology, networking, and exposition opportunities—all at the 28th Heat Treating Conference and Exposition and Gear Expo. The event is recognized by industry, academia, and government professionals as the premier heat treating gathering in North America. It will offer a full technical program covering a broad scope of heat treating technology, networking opportunities, and a firsthand look at equipment, supplies, and services from exhibitors.

TECHNICAL PROGRAM

There's a lot to look forward to at the 28th ASM Heat Treating Society Conference and Exposition. The event will serve as a great place to foster improved communication between industry, government, universities, and research institutes. The conference program addresses challenges the industry faces today and in the future, and provides additional value to existing and potential HTS members.

This year, the 2015 Heat Treat Mini Materials Camp will be held in Detroit. Since 2011, the Heat Treat Society has partnered with the ASM Materials Education Foundation supporting a Mini Materials Camp during their annual event. When asked about the significance of supporting outreach for young people, officers say, "They are the future of the Heat Treating Society and outreach is an important part of the HTS mission. By partnering with the ASM Materials Education Foundation to deliver a Materials Camp with a focus on heat treatment, we are bucking the trend and demonstrating to youth that HEAT Treating can be COOL!"

Technical programming includes presentations by more than 120 authors on the topics of advancements in heat treating, atmosphere technologies and process control, vacuum processes and technology, emerging technologies, quenching and cooling, surface engineering, and many more. Special sessions include "New Directions and Opportunities in Heat Treating" and a joint education short course with AGMA on "Heat Treatment of Gears." The Master Series is also returning by popular demand.

Professor Alan Taub, chief technical officer for LIFT (Lightweight Innovations for Tomorrow), an industry-led, government funded consortium, will give a special keynote presentation. In his role as chief technical officer, Taub conducts research in advanced materials and processing.

Registration will open in late June. Visit the HTS website for details on the technical program and registration at asminternational.org/web/hts/home.

EXHIBIT HALL HOURS

Tuesday, October 20	9:00 a.m. – 6:00 p.m.
Wednesday, October 21	9:00 a.m. – 5:00 p.m.
Thursday, October 22	9:00 a.m. – 4:00 p.m.

NEW STUDENT ACTIVITY AT HEAT TREAT 2015

Are you a current college student studying materials science and engineering? If so, your registration for the 28th ASM Heat Treating Society Conference and Exposition is **FREE!** College students can attend the event free of charge through the new "THIS IS HEAT TREAT" program that includes a special student reception and opportunities to connect directly with companies that you might want to work for by spending time with them in their booths.

Get a taste of your future within the heat treating industry for free by registering as a student and bringing your Student ID with you to the show.

HEAT TREAT 2015 ORGANIZING COMMITTEE

Chair: Richard D. Sisson, Jr., Worcester Polytechnic Institute

Committee Members:

- **Lauralice Canale,** Universidade de São Paulo, Brazil
- **Rafael Colás,** Universidad Autonoma de Nuevo Leon, Mexico
- **Hanshan Dong,** University of Birmingham, England
- **Kip Findley,** Colorado School of Mines, Golden
- **Bozidar Liscic,** University of Zagreb, Croatia
- **Olga Rowan,** Caterpillar Inc., Peoria, Ill.
- **Brigitte Haase Sandstedt,** Hochschule Bremerhaven, Germany
- **Satyam Sahay,** John Deere Technology Center, India
- **Volker Schulze,** Karlsruhe Institute of Technology, Germany
- **Božo Smoljan,** University of Rijeka, Croatia
- **Marcel A. J. Somers,** Technical University of Denmark
- **Eva Troell,** Swerea, Sweden
- **Gang Wang,** Tsinghua University, China
- **Emilia Wołowiec-Korecka,** Lodz University of Technology, Poland
- **Piotr Zawistowski,** Seco/Warwick Corp., Meadville, Pa.

MEMBERS BENEFIT FROM COLLABORATIVE WORK AT CHTE

Bringing great minds together to work on solutions that address heat treating challenges is why the Center for Heat Treating Excellence (CHTE) at Worcester Polytechnic Institute (WPI) was founded. Today, under the direction of Diran Apelian, Alcoa-Howmet Professor of Mechanical Engineering at WPI and director of the Metal Processing Institute, and Richard Sisson, George F. Fuller Professor of Mechanical Engineering and director of CHTE, it is a thriving collaborative effort with 20 members worldwide.

Apelian says CHTE's success comes from members working together with WPI faculty and students. "The center's intent is to enhance the position of the heat treating industry by applying research that solves real-world problems. Member-driven research enhances the industry's technology base, profitability, public image, and the education of its members," he explains.

"We value being able to interact with other companies and organizations in noncompetitive discussions," says Ian Donaldson, director of advanced engineering applications at GKN Sinter Metals. "Members are involved in the strategic direction of CHTE, have early access to new ideas, and by working with students and fellow members on common issues, we all benefit from fresh ideas and innovative solutions."

John Deere, one of the founding members of CHTE, was active in the U.S. Department of Energy's Industries of the Future Program, which created a Vision 2020, seeking solutions to address the heat treating industry's need to stay competitive. "The greatest benefit to us is networking with other corporations, suppliers, and users on research projects," says Bob Gaster, senior staff engineer at John Deere.

CHTE tested and modeled Thermatool's precision slot quench ring for fellow member Timken with winning results.

"A group like this is rare. We have the opportunity to connect with credible industrial experts on similar issues. It significantly reduces the time it takes to get answers." Gaster also appreciates the fact that CHTE members can leverage research dollars and work on multiple research projects at the same time.

COLLABORATION AT WORK

Thermatool, a global organization that serves the thermal processing industry, and Timken Co., a global manufacturer of bearings, conducted simulation testing at CHTE demonstrating that Thermatool's precision slot quench ring offered a crucial heat treating method to meet Timken's industrial demands. "CHTE provides an avenue of communication between members for trusted, independent analysis. This is the type of value that CHTE brings to its members," says Thermatool president Mick Nallan. "It's why we joined and continue to stay actively involved."

ABOUT CHTE

The CHTE collaborative is an alliance between the industrial sector and university researchers to address short-term and long-term needs of the heat-treating industry. Membership in CHTE is unique because members have a voice in selecting quality research projects that help them solve today's business challenges.

Research projects are member driven. Each research project has a focus group comprising members who provide an industrial perspective. Members submit and vote on proposed ideas, and three to four projects are funded yearly. Companies also have the option of funding a sole-sponsored project. In addition, members own royalty-free intellectual property rights to precompetitive research and are trained on all research technology and software updates.

CHTE projects now in progress include:

- Nondestructive Testing for Hardness and Carburization
- Improving Furnace Alloys and Fixtures
- Gas Quench Steel Hardenability
- Induction Tempering

CHTE is located in Worcester, Mass., on WPI's New England campus. The university was founded 150 years ago this year. For more information about CHTE, its research projects, and member services, visit wpi.edu/+chte, call 508.831.5592, or email Rick Sisson at sisson@wpi.edu, or Diran Apelian at dapelian@wpi.edu.

USING MAGNETIC BARKHAUSEN NOISE TO ANALYZE CASE DEPTH

Magnetic Barkhausen noise (MBN) analysis is a nondestructive test method used since the 1980s to evaluate conditions in a variety of steel components. Primary applications include detection of thermal damage induced during grinding and evaluation of case depth in case-hardened parts. For example, the Stresstech Group uses its Rollscan Barkhausen noise analysis equipment (Fig. 1), which combines MBN technology with x-ray diffraction and hole drilling to solve processing problems including those related to heat treatment. Further, MBN can be used as a process control tool due to its fast, nondestructive operation.

Fig. 1 — Rollscan 350 Barkhausen noise analysis equipment.

UNDERSTANDING BARKHAUSEN NOISE

MBN occurs when magnetic domains are forced to reorient or resize, typically in the presence of an alternating external magnetic field. In ferromagnetic materials, the magnetization process is not continuous, but is made up of a series of discrete changes in magnetization that appear to be step-like. Each step, or rapid change in magnetization, is known as a Barkhausen jump. Magnetizing a volume of material and measuring its magnetization via an inductive pickup enables observation of Barkhausen jumps. The signal containing the jumps, which occur in a stochastic manner, exhibits white noise-like power spectra up to approximately 2 MHz. The stochastic nature, together with the static sound heard when the pickup is connected to a speaker, is the source of the term *Barkhausen noise.* Quantity and intensity of Barkhausen jumps are affected by mechanical stresses, both residual and applied, along with microstructural variations such as hardness and carbon content.

When measuring MBN using the traditional method, the sample is magnetized with an alternating magnetic field (typically 125 Hz), and the signal containing Barkhausen noise is amplified and filtered in a frequency range of hundreds of kilohertz (70–200 kHz is standard on the Rollscan analyzer). After all extraneous data is removed, the root mean square (rms) of the remaining MBN signal is calculated and reported in real-time. This method is frequently used to detect grinding retemper burn and heat treatment-related issues such as decarburization.

Many Barkhausen noise analysis applications require only near-surface analysis. Measurement depth, $D(x)$, is determined using the following equation:

$$D(x) = \frac{\int_{f_1}^{f_2} g(f)\, e^{[-Ax_n \sqrt{f}]}\, df}{\int_{f_1}^{f_2} g(f)\, df} \qquad \text{(Eq 1)}$$

where $g(f) = 1$ for random white noise, $A = \sqrt{\pi\mu/\rho}$ with permeability μ and conductivity ρ, and f_1 and f_2 are the frequency limits of 70-200 kHz on the noise-like signal that is MBN. The calculation yields a skin depth of 0.1 mm in hardened and tempered steel (assuming conductivity of $10^6/\Omega \cdot m$ and relative permeability of 200). This measurement depth is effective for evaluating properties such as surface hardness and stress, but not other important characteristics such as case depth.

EVALUATING CASE DEPTH

Evaluating case depth, which is typically measured in millimeters, requires greater depth sensitivity. This is achieved by decreasing the frequency for magnetizing and analysis, as lower frequencies penetrate deeper. However, the signal is exponentially damped with depth, which is a problem with this method. Thus, most of the information comes from the surface and shallow depths.

The solution used in Stresstech's equipment is to simply correct for or remove shallow depth information, thus leaving information from deeper in the part. Two measurements used to accomplish this are a shallow, high-frequency magnetizing voltage sweep (MVS) measurement and a deep, low-frequency MVS measurement (Fig. 2).

An MVS measurement is a constant measure of BN rms while increasing peak-to-peak voltage of the magnetizing signal from zero to some value that results in saturation (similar to *H* in magnetic hysteresis). This provides a relationship between BN rms and magnetizing voltage for

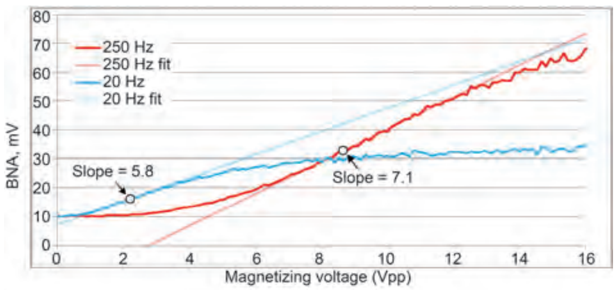


Fig. 2 — Magnetizing voltage sweeps with fitted maximum slopes.

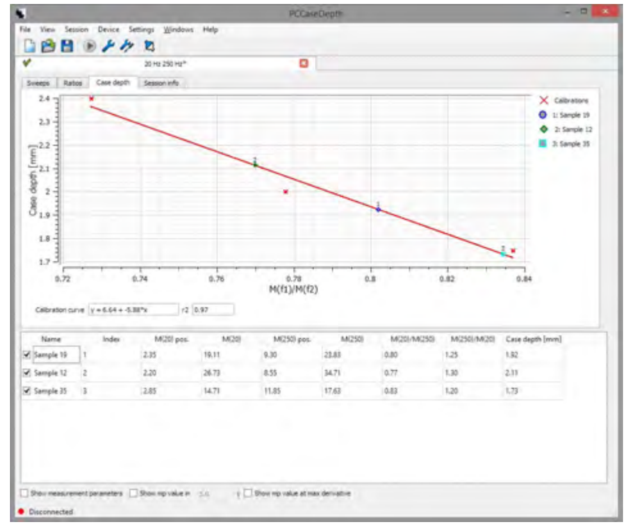


Fig. 3 — Case depth-measurement software including calibration curve.

a given frequency. The slope *m* with respect to magnetizing voltage is calculated from this relationship to find the maximum value, m_{max}.

This leaves a maximum MVS slope for both deep and shallow frequency measurements. Calculating the ratio of the two m_{max} values effectively corrects for the surface. This value is correlated to case depth in a manner similar to the way other NDT methods are correlated to properties (Fig. 3).

Correlation typically involves generating a sample set with known varying case depths and measuring them using the MVS slope-ratio method. Case depths are verified via traditional methods (sectioning and metallography) to establish the relationship between MVS slope ratio and case depth. This enables associating MVS slope ratio values with specific case depths.

PROS AND CONS

Sectioning and metallography are used extensively to measure case depth. This is labor intensive, slow, and expensive. In contrast, the BN MNS slope-ratio method is fast, inexpensive and easy. A measurement takes approximately 30 seconds. Equipment is low maintenance and requires no consumables, and once equipment and correlation are set up, it requires minimal training to make a measurement. In addition, this nondestructive method saves labor used to section parts and eliminates scrap.

However, one disadvantage that the BN MVS slope-ratio method has compared with traditional destructive methods involves accuracy. It is common to have an $r^2 \geq 0.85$ when correlating MVS slope ratio to case depth, but it will not be accurate beyond tens of microns. As with other NDT methods, accuracy varies on a case-by-case basis.

For more information: James Thomas, American Stress Technologies Inc., 540 Alpha Dr., Pittsburgh, PA 15238, 412.784.8400, james.thomas@astresstech.com, www.astresstech.com.

RESIDUAL GAS ANALYZER DETERMINES DIFFERENCES IN GRAPHITE AND ALL-METAL HOT ZONE VACUUM OPERATION

Residual gas analysis shows that graphite is more economical than all-metal design and is capable of producing contamination-free surfaces.

Trevor Jones* and Reàl J. Fradette, Solar Atmospheres Inc., Souderton, Pa.

A residual gas analyzer (RGA) is a type of mass spectrometer that can detect atomic mass in the range of 1 to 300, but is typically used in the 1 to 50 range (Fig 1). The RGA does not detect solids, only gases with less than 100 AMU (atomic mass unit). Sampling atmospheric pressures as low as 5 x 10^{-12} torr is possible, but pressure in vacuum furnace equipment is typically at the 10^{-6} torr level. The RGA provides a semiquantitative measurement of remaining gases in a vacuum system; it does not provide absolute values, but instead compares relative amounts of residual gases that remain in the system. RGAs are also used as sensitive helium leak detectors. Integrity of vacuum seals and quality of vacuum at pressures below 10^{-5} torr is determined by checking for air leaks, virtual leaks, and other contaminants before a process is initiated.

Fig. 1 — A residual gas analyzer provides a semiquantitative measurement of remaining residual gases in a vacuum system.

TYPICAL RGA SETUP

A proper setup for an RGA is to position the sensor to an extension from the vacuum chamber with a valve, initially isolating the sensor from the chamber. A turbomolecular pump backed by an oil-sealed rotary vane pump provides the vacuum to the sensor. Initially, the valved-off sensor connection is pumped down to 5 x 10^{-5} torr or lower prior to opening the valve to the main chamber. Figure 2 shows components of the RGA setup.

MOLECULES IN ATMOSPHERE AND VACUUM

There is no such thing as a perfect vacuum, as trace amounts of gases are always present in a vacuum chamber or system. A typical atmosphere contains about 1 x 10^{20} molecules/cm^3, while a typical high vacuum contains about 1 x 10^{10} molecules/cm^3. Residual gas molecules remaining in the vacuum system can include water vapor (H_2O). The amounts and types of gases present in dry atmospheric air are provided below:

Gas	Vol%	Gas	Vol%
Nitrogen	78.08	Helium	0.0005
Oxygen	20.93	Krypton	0.0001
Argon	0.93	Hydrogen	0.00005
Carbon dioxide	0.03	Xenon	0.0000087
Neon	0.0018		

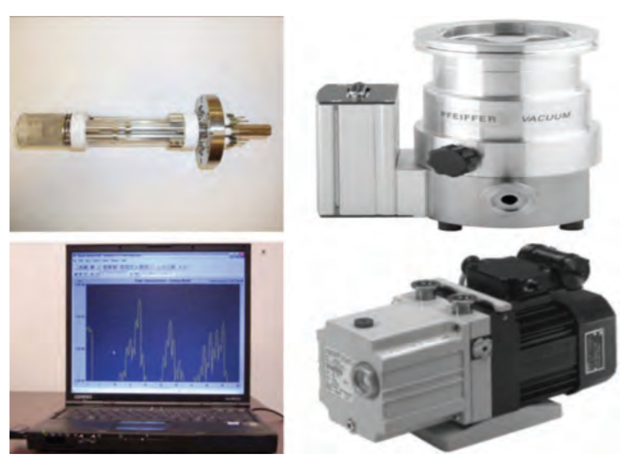


Fig. 2 — Components of a typical RGA setup. Clockwise from top left: sensor, turbomolecular pump, oil-sealed rotary vane pump, and computer for recoding and analysis.

*Member of ASM International and Heat Treating Society

Major gas loads present in high vacuum are shown here:

Pressure, torr	Major gas load
10^{-3}	Water vapor (75-95%)
10^{-7}	H_2O, CO, CO_2
10^{-10}	CO, H_2

RGA SCANS OF VACUUM FURNACE

Logarithmic and linear plots of residual gases detected using RGA in a typical vacuum furnace pumped down to the 10^{-4} torr range are shown in Figs. 3 and 4, respectively. In Fig. 3, water has an atomic mass of 18 (hydrogen = 1 × 2 = 2, plus oxygen = 16 for a total of 18). The logarithmic plot clearly shows residual gases compared to residual water vapor, while the linear scale plot (Fig. 4) shows that water is the major player.

TYPES OF VACUUM FURNACE LEAKS

Vacuum furnaces are prone to air and water leaks. An RGA is used to help determine what type of leak is occurring. Most involve some type of air leak due to bad seals and joints. An air leak less than 20 microns/h is acceptable, while a higher leak rate indicates a more serious problem. Figure 5 shows two RGA plots that reflect acceptable and unacceptable conditions. The atomic masses of nitrogen and oxygen peak with a serious air leak.

Figure 6 is an RGA plot of a furnace water leak. The highest peak is for the water residual component.

ALL-METAL VS. GRAPHITE HOT ZONES

Many vacuum furnace processes require a very deep vacuum and minimal residual carbon gas to prevent contamination of the final product surface. Identical laboratory furnaces with 10-in. diameter by 18-in. long hot zones were used to determine relative residual gases remaining in the furnaces. One furnace had a graphite-insulated hot zone with graphite elements, and the other had an all-metal molybdenum/stainless steel shielded design with molybdenum elements. The furnaces had identical pumping systems using Varian 8-in. diffusion pumps.

Prior to residual gas analysis, both furnaces were prepared as follows:

1. Bake out at 2250°F for 2 h and vacuum cool to <125°F
2. Open furnace door for 5 min
3. Pump down to 5 x 10^{-5} torr
4. Ramp up at 20°F/min to 2200°F
5. Hold for 1 h

Figure 7 shows a log scale plot of ambient temperature residual gas analysis results for both furnaces. Results indicate that air components and carbon are more prevalent in the graphite-insulated furnace. This is expected due to the higher surface area of the graphite felt material than the

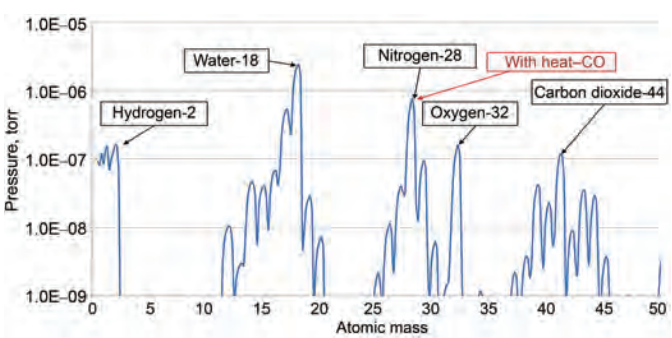


Fig. 3 — Residual gas analysis log scale plot of residual gases.

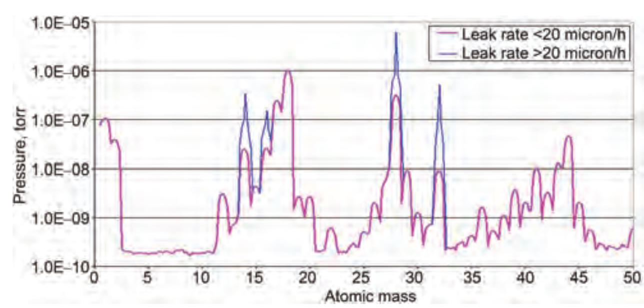


Fig. 5 — Residual gas analysis for a furnace with an acceptable air leak rate and serious leak rate.

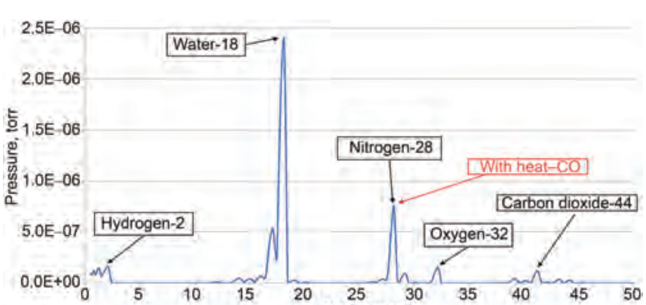


Fig. 4 — Residual gas analysis linear scale plot of residual gases.

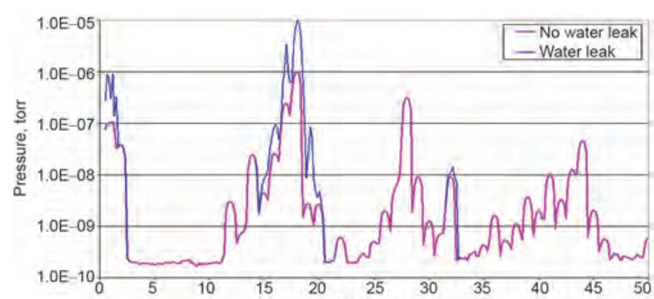


Fig. 6 — Residual gas analysis for a furnace with and without a water leak.

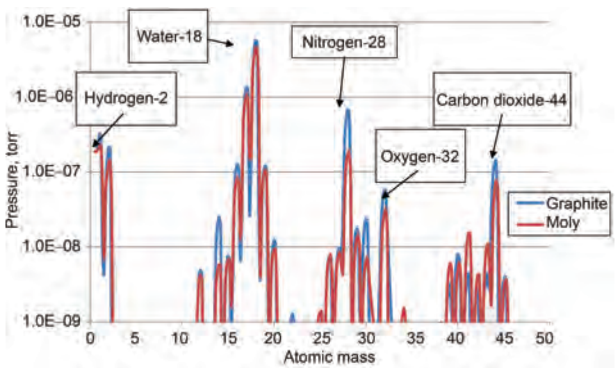


Fig. 7 — Log scale plot of residual gas analysis results in graphite and all-metal (molybdenum) hot zones at ambient temperature and 5 x 10^{-5} torr.

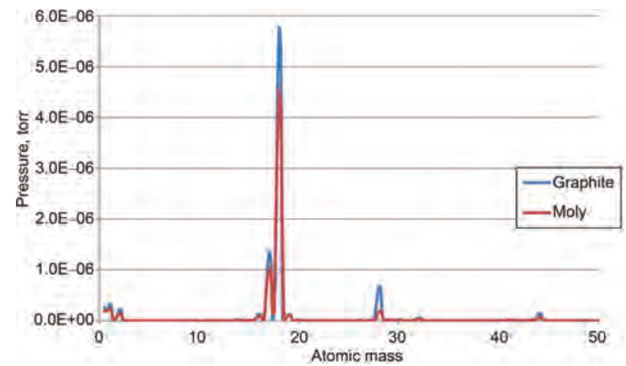


Fig. 8 — Linear scale plot of residual gas analysis results in graphite and all-metal (molybdenum) hot zones at ambient temperature and 5 x 10^{-5} torr.

all-metal design, and also to its retention of water vapor and collection of air components when the furnace is open. In addition, the graphite carbon molecules contribute to the carbon dioxide residual gas. Figure 8 shows a linear RGA plot of the above ambient temperature tests. Figure 9 includes traces of residual gases that remained in the residual gas analyzer.

Residual gas trends with changes in vacuum and temperature are shown in Fig. 10. Water, air, and carbon values are higher in the graphite design.

Residual gases in the all-metal and graphite hot zones when the furnaces are held at a temperature of 2200°F are shown in Fig. 11. The graphite hot zone shows a significantly larger number for water and air when held at this temperature.

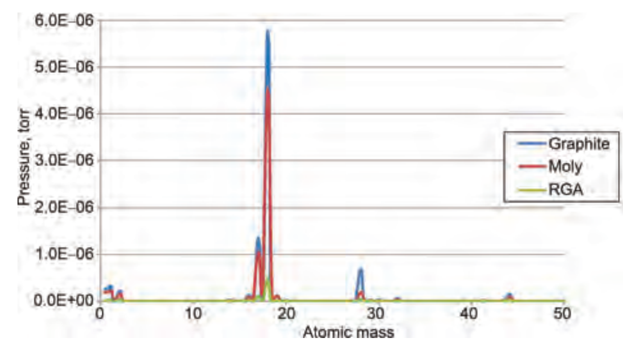


Fig. 9 — Linear scale plot of residual gas analysis results, including traces of residual gases remaining in the residual gas analyzer (RGA), for graphite and all-metal (molybdenum) hot zones at ambient temperature and 5 x 10^{-5} torr.

ANALYSIS OF RGA RESULTS

Results show that a molybdenum all-metal hot zone should be used for processing materials that must meet critical surface contamination requirements. However, these critical materials represent a very small portion (<10%) of all the materials being processed in vacuum today.

To successfully minimize or eliminate surface contamination in a furnace with a graphite hot zone, the following conditions must apply:

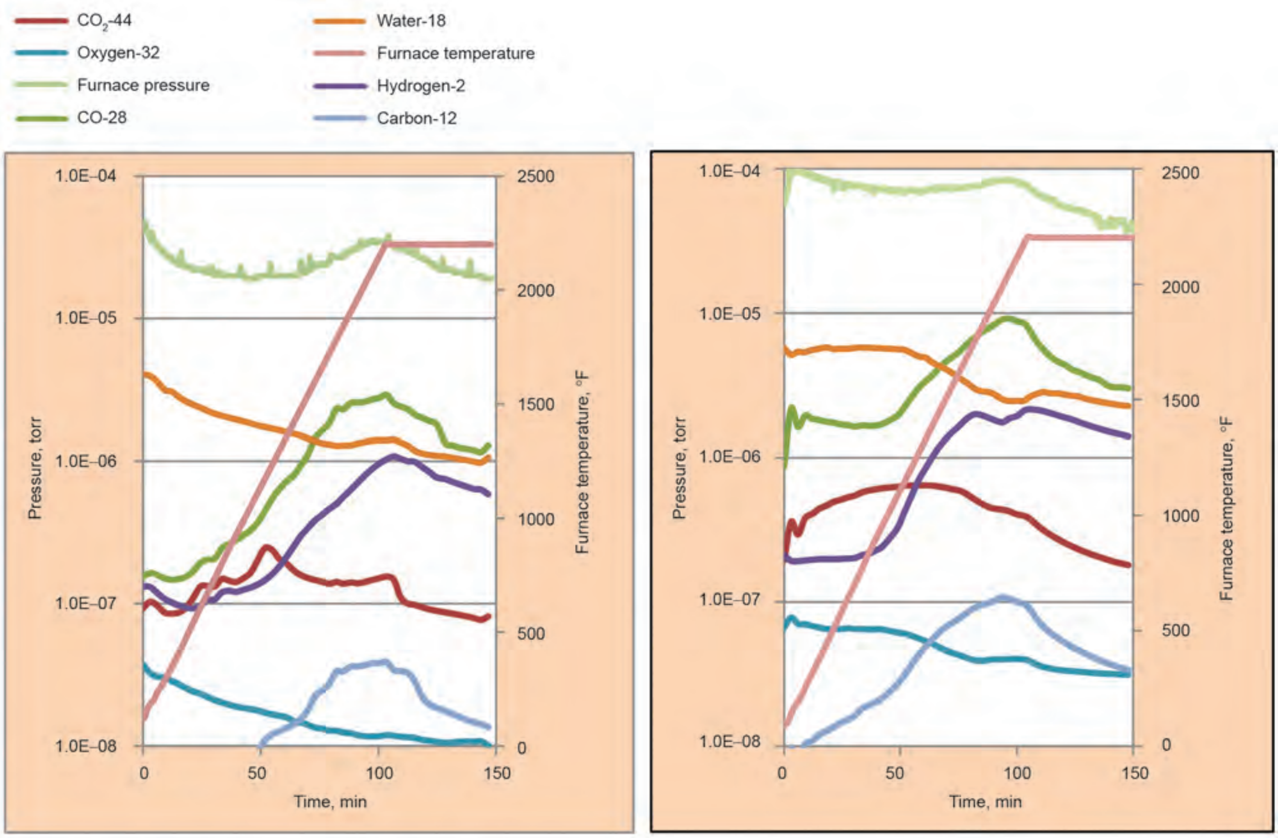
- Work must be clean
- The furnace must have a proven low leak rate
- The furnace must be able to achieve a low vacuum initial pump down
- The furnace must be baked out on a consistent schedule to minimize internal contamination

Figure 12 shows an example of a critical material (titanium bulkhead forgings) that can be processed in a graphite hot zone furnace. A final acceptable surface condition can be achieved in a graphite furnace that has been properly prepared.

Disadvantages of a molybdenum all-metal design compared with a graphite design include:

- Roughly 30% higher material cost than graphite
- Less efficient and requires a larger, more expensive power supply
- About 50% lower projected service life
- Embrittlement of the molybdenum as it ages (grain growth)
- Distortion including creep and buckling due to metallization reactions
- Difficult to repair compared with the graphite design

Differences in power requirements between molybdenum and graphite hot zones are illustrated in Fig. 13, which shows power consumed during heating of furnaces to 2200°F for the above test preparation and holding at temperature for two hours. The graphite hot zone furnace is approximately 30% more efficient than the molybdenum hot zone furnace, which represents a considerable savings on power costs over the life of the hot zone.



(a) (b)

Fig. 10 — Residual gas trends as a function of vacuum and temperature in molybdenum hot zone (a) and graphite hot zone (b).

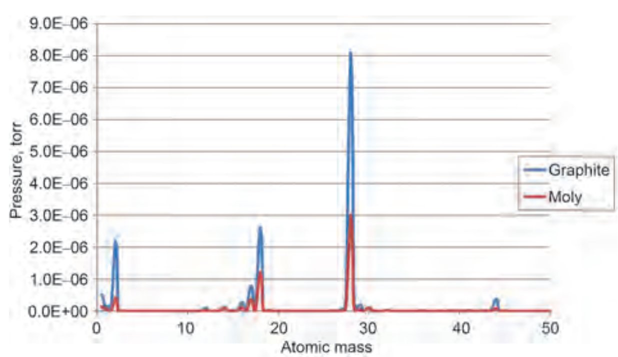


Fig. 11 — Linear scale plot of residual gas analysis results in graphite and all-metal (molybdenum) hot zones held at a temperature of 2200°F. Water and air measurements are higher in the graphite hot zone.

Fig. 12 — Titanium bulkhead forgings successfully processed in a graphite insulated vacuum furnace to meet final stringent surface contamination requirements.

CONCLUSIONS

Water vapor is the dominant gas remaining in the vacuum system at ambient temperature. Roughly 20% less water vapor occurs in a molybdenum hot zone compared with a graphite zone in ambient air. Carbon monoxide begins to exceed water vapor as the dominant gas above 1500°F. There is 50% less carbon monoxide in a molybdenum hot zone compared to a graphite zone, with sources including H_20 reaction with graphite, solvents, and diffusion pump oil. Graphite and molybdenum hot zones can produce contamination-free surfaces with proper techniques including clean work, low leak rates, low initial pump down, and precycle bake-outs. Molybdenum furnaces have inherently lower vacuum levels. Graphite furnaces consume less power, require lower capital investment, and have longer life. Graphite furnaces consume 30% less power than molybdenum, and those with molybdenum hot zones have a higher capital investment, shorter life, and are more difficult to maintain.

This article is adapted from a presentation by Trevor Jones at 2014 Furnaces North America.

For more information: Reàl Fradette is senior consultant, Solar Atmospheres Inc., 1969 Clearview Rd., Souderton, PA 18964, rfradette@solaratm.com, www.solaratm.com.

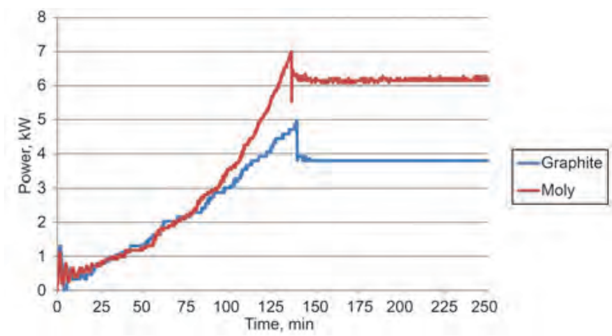


Fig. 13 — Plots of power consumption in furnaces with graphite and all-metal hot zones heated to 2200°F and held for two hours show that the graphite hot zone is about 30% more efficient.

ASMNEWS

Board Nominees Announced

Frazier for VP; Clauser for Treasurer; Cerreta, Deacon, and Seal for Trustees

The ASM Nominating Committee, chaired by Robert J. Fulton, FASM, announced the nominees for ASM vice president and trustee for 2015-16 and three members of the Board of Trustees for 2015-18.

In accordance with the ASM Constitution, these nominees will be voted on at the ASM Annual Business Meeting on October 5, during MS&T15 in Columbus, Ohio. Once elected, the vice president will automatically become ASM president for 2016-17. In accordance with Article IV, Section 3 of the ASM Constitution, the ASM Board of Trustees has also announced its nominee for ASM Treasurer for 2015-2016.

Officers and members of the Board who will continue serving in 2015-2016 include: Mr. Jon D. Tirpak, FASM, who will become president in October; Dr. Sunniva R. Collins, FASM, who will serve as immediate past president; and trustees Jacqueline M. Earle, John Keough, FASM, Dr. Zi-Kui Liu, FASM, Dr. Kathryn Dannemann, Dr. Tirumalai Sudarshan, FASM, and Dr. David B. Williams, FASM.

Retiring from the Board at this year's Annual Business Meeting will be immediate past president, Prof. C. Ravi Ravindran, FASM, and trustees Dr. Iver Anderson, FASM, Mitchell Dorfman, FASM, and Dr. James C. Foley, FASM.

ASM's 2015 Nominating Committee, left to right: Anthony Petric, FASM, Marissa Reigel, John Marcin, FASM, Susan Hartfield-Wunsch, Prabir Chaudhury, John Hayden, Michael O'Brien, Beth Armstrong, Robert Fulton, FASM (Chair), Maria Winnicka, and Richard Blackwell, FASM (2014 Chair).

About the President-Elect and Board Nominees

Jon D. Tirpak, P.E., FASM
President-Elect

Tirpak

Since studying metallurgical engineering at Lafayette College, ASM International has supported Jon Tirpak, FASM, throughout his entire career. After being commissioned as 2nd Lieutenant in the Air Force, he landed at the Materials Laboratory in the Birthplace of Aviation, Dayton, Ohio. In 1982, attendance at his first ASM Dayton Chapter meeting launched his professional association with the organization. Between assignments at Wright Patterson AFB and special projects in Washington, Tirpak earned a master's degree in materials engineering at the University of Dayton. Captain Tirpak was assigned to the Ballistic Missile Office at Norton AFB in Southern California. He was tasked with integrating the Air Force's nuclear testing requirements, which exposed him to the Defense Nuclear Agency, Department of Energy, and the Nevada Test Site. Tirpak attended several Westec and Aluminum Lithium conferences, and through associations at one of those events, was invited to help found AeroMat with many other dedicated ASMers.

Departing the Air Force in 1988, he returned to Dayton as a contractor with the Air Force Materials Laboratory and Manufacturing Technology Directorate. The Dayton Chapter welcomed him back with plenty of leadership opportunities, including an invitation to Washington to participate in the Federal Affairs Committee of ASM, introducing him to the national operations of the Society. After a brief stint in Ann Arbor, Mich., with a fluid power company, Tirpak moved to Charleston, S.C., at the request of SCRA Applied R&D, a technological and economic engine for the Palmetto State.

In This Issue

ASM INTERNATIONAL
Submit news of ASM and its members, chapters, and affiliate societies to Frances Richards, editor, ASM News | ASM International
9639 Kinsman Road | Materials Park, OH 44073 | P 440.338.5151 ext. 5563 | F 440.338.4634 | E frances.richards@asminternational.org
Contact ASM International at 9639 Kinsman Road, Materials Park, OH 44073 | P 440.338.5151 ext. 0 or 800.336.5152 ext. 0 (toll free in U.S. and Canada) | F 440.338.4634 | E MemberServiceCenter@asminternational.org | W asminternational.org

HIGHLIGHTS ASM BOARD NOMINATIONS

For the past 14 years, he has served as executive director of the Forging Defense Manufacturing Consortium leading multiple, million-dollar R&D programs. Tirpak's ASM volunteerism includes service on committees that oversee New Products and Services, Federal Affairs, Finance, Investment, Web, Student Trustee Selection, and the 100th Anniversary Awards. He received the Hammer Award from Vice President Al Gore for "reinventing government" and is a Licensed Metallurgical Engineer in S.C.

Dr. William E. Frazier, III, FASM
Nominee for Vice President


Frazier

Dr. William E. Frazier, FASM, has been an active member of ASM International since joining the Society as a student in 1977. He received his B.S., M.S., and Ph.D. degrees in materials engineering from Drexel University. He is a graduate of the Naval Aviation Executive Institute's Senior Executive Management Development Program, and the Defense Systems Management College's Advanced Program Management Curriculum.

Frazier is a Navy executive with 35 years of experience in naval aviation materials science and engineering. His position is Navy Senior Scientist for Materials Engineering and he serves as the chief scientist of the Air Vehicle Engineering Department at the Naval Air Systems Command. In this capacity, he provides technical direction and develops strategic plans for the research, development, and transition of naval aviation technologies.

Frazier is also the technical architect and driving force behind several thrust areas. He developed cross disciplinary, multi-organizational program and R&D roadmaps in the following areas: Additive manufacturing of structurally critical metallic components; nano-materials and meta-materials technology; durable aircraft materials and structures; corrosion-resistant alloy development; erosion-resistant rotor blade materials; and integrated structural health management.

Frazier is a recognized expert in materials selection, qualification, and certification, failure analysis, light alloy development, materials processing, and manufacturing technology. He has authored more than 90 technical publications, edited six books, and holds two U.S. Patents. Frazier was an ASM Trustee from 2003 thru 2007 and has also served on numerous committees including the AeroMat Committee and the Emerging Technologies Awareness Committee. Currently he serves as an associate editor for the *Journal of Materials Engineering and Performance* and he is a key reader for *Materials Transaction A.*

Craig D. Clauser
Nominee for Treasurer


Clauser

Craig D. Clauser is president and owner of Craig Clauser Engineering Consulting Inc., which he founded in 2005. The company provides metallurgical engineering services nationwide, primarily in failure analysis and process improvement.

He is a magna cum laude graduate of Lehigh University with a B.S. and M.S. in metallurgical engineering and materials science and a registered professional engineer. Clauser joined Westinghouse Electric Power Generation as a metallurgical engineer in the Materials Engineering Laboratory after graduating and subsequently became Laboratory Manager. The laboratory serviced the Steam Turbine, Gas Turbine, and Heat Transfer Divisions at Lester, Pa. In 1977, Clauser joined Phoenix Steel Corp. where he served as technical director. Phoenix produced carbon and alloy plate in Claymont, Del., and heavy wall, pilger forged tubing in Phoenixville, Pa., and was a leader in clean steel technology. In 1986, he joined Consulting Engineers and Scientists Inc. in Malvern, Pa., where he was an engineer and senior vice president until starting his own firm.

Clauser joined ASM in 1967 and was Philadelphia Chapter Chairman in 1983. He also served as chairman of the ASM Chapter Operations Committee and the Handbook Committee. He is currently a member of the ASM Content, Failure Analysis, and Handbook Committees as well as the ASM Finance and Investment Committees. He was the Delaware Valley Metals Man of the Year in 1993 and Philadelphia Liberty Bell Chapter Albert Sauveur Lecturer in 2001. Clauser is also a member of NSPE, ASTM, NACE, ASME, and AWS.

Dr. Ellen K. Cerreta
Nominee for Trustee


Cerreta

Dr. Ellen K. Cerreta is the group leader for the Materials in Radiation and Dynamic Extremes Group (MST-8) at Los Alamos National Laboratory. She received her B.S. in aerospace engineering from the University of Virginia and her M.S. and Ph.D. degrees in materials science and engineering from Carnegie Mellon University. After graduation, Cerreta accepted a post-doctoral position within the materials science division of Los Alamos. She was converted to staff in 2003. Since that time, her work has included the study of the mechanical behavior of materials and microstructural characterization with a focus on the relationship between microstructure and dynamic materials properties. At Los Alamos, Cerreta leads a number of projects to investigate dynamic materials performance and utilizes this information to advance predictive capabilities for strength and damage in extreme environments.

She has been a member of ASM since 2004 and her work with ASM has been multifaceted. Cerreta has served for almost 15 years as a reviewer for *Materials Transactions A* and since 2012 as a key reader for the journal. She was a member of the ASM International Membership Committee from 2003-2009 where she worked to develop programs to attract early career professionals to the Society. Most recently, she served on the AM&P Editorial Committee and was chair in 2012. Cerreta is also an active member of TMS, where she is currently vice chair of the Structural Materials Division.

Dr. Ryan Deacon
Nominee for Trustee


Deacon

Dr. Ryan M. Deacon is a materials scientist in the Materials Engineering and Research group of the DuPont corporation. He also serves as the corporate failure analyst, conducting failure investigations and material analyses for all DuPont businesses. Prior to joining DuPont, Deacon was a senior professional staff member at the Johns Hopkins University Applied Physics Laboratory (JHUAPL), where he worked in both technical services and research & development. While at JHUAPL, he oversaw the laboratory's metallography and microscopy facilities, and participated in a number of research programs related to materials characterization and development. Deacon was a founding editor and is the current editor-in-chief of the journal *Metallography, Microstructure, and Analysis,* the official journal of the International Metallographic Society.

Deacon earned his B.S., M.S., and Ph.D. degrees in materials science and engineering from Lehigh University. Since joining ASM International in 1997, he has held a number of volunteer positions within the Society. While in graduate school, he served the Lehigh Valley Chapter in numerous executive board positions and received the chapter's Outstanding Young Member Award. He was also a member of the Emerging Professionals Committee, Membership Committee, and the Materials Advantage Committee, and in 2013 was chair of the Chapter Council.

Deacon has authored or co-authored a number of publications in the fields of corrosion and materials characterization, is listed on several patents, and is a recipient of the Jacquet-Lucas Award for Excellence in Metallography. He is also a member of TMS, NACE, MAS, and AMS.

Prof. Sudipta Seal, FASM
Nominee for Trustee


Seal

Sudipta Seal, FASM, University Distinguished Professor and UCF Pegasus Professor, joined the Advanced Materials Processing and Analysis Center (AMPAC) and Mechanical Materials Aerospace Engineering at the University of Central Florida (UCF) in fall 1997 after postdoctoral work at Lawrence Berkeley National Laboratory in California.

At UCF, he served as Nano Initiative Coordinator for VP-Research. He is director of the Nanoscience Technology Center and the Advanced Materials Processing Analysis Center, as well as professor and interim chair of materials science and engineering and holds an appointment with the College of Medicine. He is the recipient of the 2002 Office of Naval Research Young Investigator Award (ONR-YIP), JSPS fellowship, Alexander Von Humboldt Fellow, ASM IIM Lecturer award, Royal Society of England - Visiting Professor Distinguished Fellowship at Imperial College, UK, Academic Trail Blazer Award, and the Schwartz Tech award.

Seal has won multiple teaching and research awards from UCF and was awarded the UCF Dean's Advisory Board Faculty Award for Excellence. He has published more than 350 journal papers, conference proceedings, book chapters, and three books on nanotechnology. He also has 44 issued patents and many pending. Seal received his BTech-Hons from the Indian Institute of Technology (KGP) in metallurgy and materials engineering, worked for TATA Steel India, MMet, University of Sheffield, UK, and received his Ph.D. from the University of Wisconsin, Milwaukee. He is an active ASM member and has served on many Society committees.

Official ASM Annual Business Meeting Notice

The Annual Business Meeting of members of ASM International will be held in conjunction with MS&T15 on:

Monday, October 5

4:00 - 5:00 p.m.

Greater Columbus Convention Center, Columbus, Ohio

The purpose of the ASM Annual Business Meeting is the election of officers for the 2015-16 term and transaction of other Society business.

ASM Nominations

The ASM International Constitution provides that members of the Society may submit additional nominations after the Nominating Committee has made its official report. Article V, Section 6 reads: "After publication of the Nominating Committee's report on nominees, and the Board report on its nominee for Treasurer, and at any time prior to July 15 of the same year, additional nominations for any or all of the vacancies may be made in writing to the Secretary at Headquarters. Such nominations must be signed by at least five individuals or Chapter Sustaining Members, each from any combination of at least 10 Chapters and/or ASM Committees. Such nominees shall be processed by the Secretary for compliance with Section 4 of this Article. This shall be the only way in which additional nominations may be made. The membership of ASM International shall be duly notified of such additional nominations."

Gujarat Hosts Plasma Technology Seminar

On March 27, the Gujarat Chapter helped organize a one-day seminar on "Industrial Applications of Plasma Based Technologies" with the Institute for Plasma Research and the Gujarat Council of Science & Technology in Gujarat, India. The seminar was sponsored by the Department of Science & Technology, Government of India, and included 45 participants from a wide range of industries.

Gujarat Chapter volunteers, from left to right: Nirav Jamnapara, Ms. Shital, and Ragesh Bateriwala.

Milwaukee Holds H.R. Bergmann Seminar

The Milwaukee Chapter held its 57th annual Bergmann Memorial Seminar on April 14 at the Milwaukee School of Engineering's Alumni Partnership Center in the historic Blatz Brewery building. The seminar covered "Understanding Material Concerns in Component Design" and featured speakers from both academia and industry.

From left to right: Travis Myers, Ben Church, Don McCann, Govindarajan Muralidharan, Nick Sonnentag, Dan Kiedrowski, and Jim Myers.

Iowa State Students Visit Capitol Hill

Iver Anderson, FASM, and students from Iowa State University took part in the annual Material Advantage Congressional Visits Day in Washington. The program is designed for students to meet with their representatives to discuss the importance of materials science funding.

Hartford Celebrates Student Night and Materials Camp

Alpha Sigma Mu, CT Alpha Chapter 2015 Inductees were recognized on April 28 during the Hartford Chapter's Student Night.

From left to right: H.D. Brody (chapter advisor), William Masinda, Matthew Mckinney, Rebecca Stern, Aliya Carter, Yasemin Kutes, John Corsi, Sapna Gupta, John Scovill, Gabrielle Charno, Rishabh Jain, and Dr. Amber Black.

On April 20, 66 students and seven teachers from four Connecticut high schools that focus on engineering, science, and math attended the 2015 Hartford Area Materials Camp. UConn Material Advantage Chapter students served as group guides.

Students from Wilbur Cross and Hyde High Schools in New Haven, Hartford Public High School, and University High School for Science and Engineering.

Houston Honors Past Chairs

The Houston Chapter held its annual event honoring past chairs and their spouses on March 3 at the Post Oak Grille. The guest speaker was Chelsea Dacus who gave an interesting talk on the Glassell Gold Collection of the Museum of Fine Arts Houston.

First row, from right to left: Joel Russo, Marco Deuterio, Michael Pendley, Bob Badrack, David Fitzgerald, Mike Andrus, and William Howie. Second row, from right to left: Bill Bailey, George Sellnau, Edgar Zapata, John Starkweather, and Robert Koester.

HIGHLIGHTS ASM MEGA SHOW

AeroMat, ITSC and Microstructural Characterization of Aerospace Materials & Coatings came together last month at the Long Beach Convention Center for a Mega Event.

More than 2000 attendees from 34 countries attended the Mega Show. The event featured over 129 booths and 450 oral and poster presentations.

Terry Mosier, ASM International Associate Managing Director, welcomed the crowd.

Top left: Plenary Speaker - Dr. John Grotzinger, Chief Scientist and Head of Strategic Planning for the Mars Rover Mission

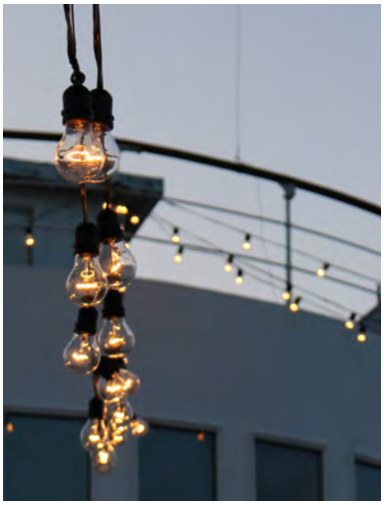
Top right: AeroMat Plenary - Mr. Humberto Luiz de Rodrigues Pereira, VP Engineering and Technology at Embraer

Bottom left: ITSC Plenary - Dr. Robert Vassen, Professor of Mechanical Engineering at Ruhr University Bochum

Bottom right: IMS Plenary - Dr. Frank Muecklich, Professor at Saarland University

The *JTST* Volume 23 Best Paper Honorable Mention presented by Christian Moreau, Thermal Spray Society President.

ASM MEGA SHOW HIGHLIGHTS



More than 500 attendees enjoyed the sold out networking event on the historic Queen Mary. Guests were treated to fine dining and drinks while enjoying hand-rolled cigars and dueling piano entertainment. Custom fireworks concluded the event to the delight of all who were there.

HIGHLIGHTS NEW WiME COMMITTEE FORMS

FROM THE FOUNDATION

MATERIALS CAMP®
ASM MATERIALS EDUCATION FOUNDATION

Materials Camp is Magical Experience

Ron Shealer, Mount Nittany Middle School Teacher

This past summer, a unique opportunity arose to attend one of the ASM Materials Education Foundation's Materials Camps. My experience was truly international in nature, as my colleague and I chose to attend a five-day residential camp in Ottawa, Canada. With safety glasses, closed-toed shoes, long pants, notebooks, pens and laptops packed, and passports in hand, we headed off to Canada.

First thing Monday morning, everyone gathered in the cafeteria for breakfast. We then moved to the main classroom and began introductions. It was obvious we had a rather diverse group attending the camp. There were approximately 30 participants, the majority from Canada, plus two from the U.S. and two from France. Each day, a different material category was covered with a presentation that was followed by experimentation time in the science lab. Materials included crystals, metals, polymers, ceramics/glass, and composites. The goal was to prepare teachers for materials science topics at the high school level, but as I discovered, middle school teachers could also benefit.

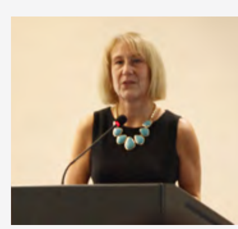
During the lab time, a variety of hands-on experiments helped to reinforce the lecture material. Some things I had seen or tried before, but many I had not. More than once, I felt like I had become part of a David Copperfield show, as some of the material properties seemed magical. Materials did things that seemed unlikely or impossible. Through the camp, I gained a greater understanding and appreciation for many of the materials we use every day in technology education. I could now see these materials from a different viewpoint: The technology teacher had become a scientist.

However, the true transformation was not realized until the trip home. I caught myself examining recycling codes on the bottoms of plastic cups and recalled how each of the materials had reacted in our experiments. All I could do was shake my head and smile, as things would never be the same.

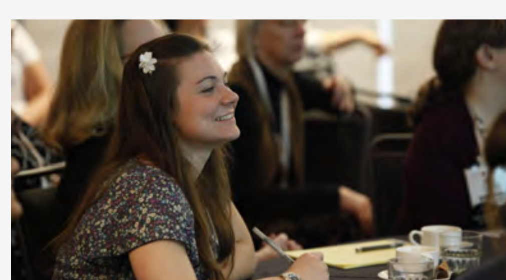
New Committee Champions Women in Engineering

ASM International's newest committee, the Women in Materials Engineering (WiME) committee, focuses on providing women-specific programming including networking opportunities, and guidance for mentoring, leadership, career development, and retention of female engineers. The committee formed in 2013 as a task force charged with determining how ASM could better serve and increase the number of women members. The group formed into a committee in 2014 with Diana Essock, FASM, as Chair, and held a successful breakfast lecture at MS&T14, where Dr. Kathleen Buse gave a rousing talk on "Women Persisting in the STEM Professions."

The WiME committee is seeking volunteers (both men and women) for its four subcommittees. The events subcommittee works on networking events and organizes the breakfast lecture at MS&T. The recognition and promotion subcommittee identifies and supports nomination of ASM women for technical awards, fellowship, and encourages leadership participation at the chapter and national level. The chapter focus/Leadership Days subcommittee is creating a presentation and guidebook about how chapters can provide mentoring and career development opportunities for young professionals. The career and leadership development subcommittee is building an online forum for discussion and reference information relevant to issues facing women in engineering, along with developing a webinar series. To join a subcommittee or learn more, contact vicki.burt@asminternational.org.



The WiME committee held its inaugural breakfast lecture at MS&T in October 2014. Dr. Kathleen Buse presented research on women who persist in STEM careers.



VOLUNTEERISM COMMITTEE

Profile of a Volunteer

Rob Sparling, Principal, Materials/Failure Group, Giffin Koerth Forensic Engineering

Sparling

Rob Sparling is on a mission: To inspire a new generation of materials engineers to form strong communities that improve their professional and personal lives. Sparling is a senior engineer for Giffin Koerth, Canada's largest forensic engineering firm. In a field that provides critical data for legal matters, he sees the need for both technical and communication skills in the courtroom, during investigative interviews and in written reports—and he sees ASM as a venue for improving those skills.

Sparling joined ASM while studying at McMaster University in Hamilton, Ontario, and attended occasional meetings during his 12 years in aerospace engineering. Now a senior engineer focused on failure analysis and forensics, he was inspired to help reinvigorate the Ontario Chapter, which had dwindled down to about 15 members. "I saw the need for a sense of community among engineers and a way to meet people and bounce ideas off each other," says Sparling.

He has served as chapter treasurer, vice chair, and chair—and helped boost membership to about 40 by focusing on university students with events ranging from welding demonstrations to dodgeball games. "Engineers need face-to-face relationships to solve problems, work on research papers, or find job openings," says Sparling. "Students expect LinkedIn and the Internet to give them a network, but that's shortsighted. We need relationships beyond email. That makes ASM more important than ever." He sees ASM as not only a "premier purveyor of materials information," but also the resource that helped him meet and hire two excellent forensic engineers.

Sparling is passionate about recognizing excellence among Canadian materials engineers and hopes to strengthen the ASM Canada Council and their annual awards for excellence. "Professional development is part of who we are as engineers. With ASM and MSNT, I make it a personal goal to gain knowledge and stay relevant," he says.

EMERGING PROFESSIONALS

Geopolymers: Alternatives for Sustainable Development

Behzad Majidi, Laval University

Majidi

In 2013, world cement production was approximately 4 billion metric tons. The process is highly material and energy consuming, with CO_2 emissions attributed to Portland cement production alone comprising roughly 8% of global emissions. Thus, high energy usage and CO_2 emissions combined with high consumption of limestone-based raw materials make Portland cement production unsustainable.

Geopolymers present a promising alternative. In the 1950s, Victor Glukhovsky first introduced alkali-activated cements, which were then developed, formulized, and named geopolymers by Joseph Davidovits in the 1970s. Total CO_2 emissions for the production of geopolymer cements is estimated to be only one-sixth that of Portland cement.

A wide range of natural clays and industrial residues, such as Tungsten mine residue, red mud, and blast furnace slag, have been successfully used in the production of geopolymers. It is important to note that annual global production of red mud exceeds 70 million metric tons and it is considered one of the most important industrial waste disposal problems. Use of these materials in the production of geopolymers provides a convenient and economical way to dispose of these industrial byproducts. In addition to fewer environmental issues, superior properties of geopolymers such as high compressive strength, short setting time, fire resistance, and high resistance to chemical attacks make them serious alternatives to Portland cement. Several applications of geopolymer composites have been reported in the aerospace industry.

A critical question is, "Why does the industry, in particular the construction industry, have such an inertia to shift to geopolymer alternatives?" The answer seems to be that Portland cement has been in widespread use over the last two centuries and, therefore, strong knowledge and experience have been developed about its properties and long-term behavior. On the contrary, geopolymer technology is new and a conservative view to new materials exists in industry.

How many more years can Portland cement sustain production? Is now the right time to invest in geopolymers? In any case, a turning point will arrive soon in the industry—a time to go green and switch to a sustainable solution.

HIGHLIGHTS MEMBERS IN THE NEWS

Asthana Receives Engineering Educator Award

Rajiv Asthana, FASM, professor at the University of Wisconsin-Stout, received the Distinguished Engineering Educator Award of The Engineers' Council from Sonja Domazet, council president at the 60th annual honors and awards banquet on February 28 in Universal City, Calif. The award is given to individuals "who are outstanding in professional qualities and have a top reputation for engineering accomplishments and leadership." Asthana is editor of the *Journal of Materials Engineering and Performance* and is the Fulton and Edna Holtby Endowed Chair in manufacturing at Stout.

Sonja Domazet and Rajiv Asthana.

Apelian Honored for Sustainable Stewardship

Diran Apelian, Alcoa-Howmet Professor of Mechanical Engineering at Worcester Polytechnic Institute (WPI) and director of WPI's Metal Processing Institute, received the Audubon Society's Joan Hodges Queneau Palladium Medal. Established by the society in 1977 and administered by the American Association of Engineering Societies (AAES), the medal recognizes individuals who encourage cooperation between engineers and environmentalists to create solutions to environmental problems. Apelian was recognized "for articulating an inspiring vision of sustainable stewardship of our earth's resources and then rallying varied disciplines and constituencies within the science and engineering community to collaborate meaningfully toward outcomes that satisfy the interests of industries and conservationists alike." The award was presented on April 20 at the annual AEES awards banquet in Washington.

Apelian (second from left) with, from left, AAES chair James Melsa, TMS president Patrice Turchi, and TMS executive director James Robinson.

Helfrecht Named Goldwater Scholar

Purdue University junior Ben Helfrecht was named a 2015 Goldwater Scholar. The Barry Goldwater Scholarship and Excellence in Education Program, established by Congress in 1986, awards up to $7500 to sophomores and juniors pursuing research careers in science, math, or engineering. Helfrecht, of Batavia, Ill., studies materials science in the School of Materials Engineering and the Honors College. He researches atomic mechanisms at work in electronic materials and how these mechanisms influence material properties and behavior.

Helfrecht

IN MEMORIAM

Karl Thomas Aust, FASM, Life Member, passed away on April 3. He received his B.A.Sc, M.A.Sc, and Ph.D. in metallurgical engineering from the University of Toronto in 1946, 1948, and 1950, respectively. He was employed at U.S. Metals Refining Co. as a physical metallurgist from 1946 to 1947, at Kaiser Aluminum and Chemical Corp. as a research metallurgist from 1950 to 1952, then at Johns Hopkins University as a research associate from 1952 to 1955, and General Electric Research and Development Center as a research metallurgist from 1955 to 1967. In 1967, Aust returned to his alma mater as a professor of metallurgy and materials science at the University of Toronto. During this time, he also held visiting scholar and scientist positions at universities and research institutes in the U.S., Germany, France, and Japan. In 1991, he officially retired to the status of Professor Emeritus but continued to be active in research and co-supervised graduate students until 2013. In his career, Aust published more than 250 scientific papers that established him as a pioneer in grain boundary engineering and the development of revolutionary nanocrystalline materials. Among his many awards, he received the American Institute of Mining, Metallurgical and Petroleum Engineers' Mathewson Gold Medal, a Guggenhiem Fellowship to the École des Mines Paris, Hoffman Award, Japan Society for the Promotion of Science Awards, Yamada Science Foundation Award, Gauss Professorship at the Gottingen Academy of Science, and the Canadian Metal Physics Medal.

Aust

Word has been received at ASM Headquarters of the deaths of John Hunter and Joseph Hepp.

PRODUCTS & LITERATURE

Guyson Corp., Saratoga Springs, N.Y., announces a **robotic blast system** with two turntables on a shuttle transfer cart that facilitates loading and unloading during the automated grit blasting cycle. The RB-72 TT was designed for production descaling and surface preparation of components up to 66 in. in diameter and weighing up to 4000 lb. A six-axis Fanuc M-710iA robot is mounted on a pedestal in a vestibule at the rear of the blasting enclosure and isolated from the grit-blast environment by a custom-tailored suit of laminated fabric. The robot is used to direct two pressure-blast nozzles attached to the end-of-arm tooling. *guyson.com.*

Rigaku Corp., Japan, launched the new CT Lab GX series of industrial **3D x-ray micro computed tomography (CT) imagers.** The CT Lab GX has capacity for ultra-high-speed measurement. In 3D mode, a CT scan can be achieved in 8 seconds and image reconstruction in 15 seconds. The software included with the system is designed so that any user can easily perform volume measurement and image rendering with easy-to-use settings. Fine structures can be observed by selecting a field-of-view and resolution in the software, with a minimum resolution of 4.5 μm, and the maximum number of pixels at 8000 × 8000. *rigaku.com/en.*

Kyocera Corp., developed a new series of **hybrid cermet materials** offering 50% improvement in both abrasion and fracture resistance over conventional materials used as industrial cutting tool inserts. TN620 and PV720 cermet grades are suitable for a wide variety of metal cutting applications ranging from high-speed to low-speed machining. Materials feature a surface-hardening hybrid structure to improve abrasion resistance and a high-melting-point hybrid bonded phase to ensure high quality machining with improved surface finish. *global.kyocera.com.*

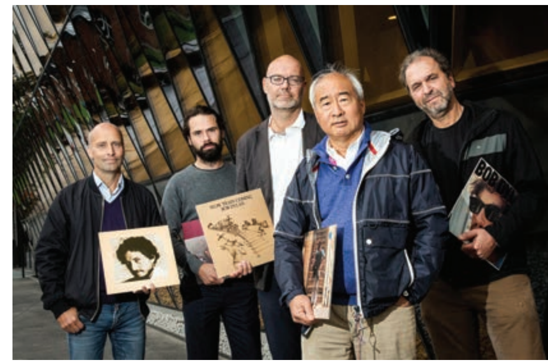
Phenom-World, the Netherlands, announces Phenom XL, said to be the world's fastest **desktop SEM** to handle large samples. It is equipped with a chamber that, despite its small size, allows analysis and full imaging of large samples up to 100 × 100 mm. It also features a proprietary venting/loading mechanism that is said to ensure the fastest vent/load cycle in the world. A compact motorized stage enables users to scan the full sample area, yet is small enough to fit on a standard table. *phenom-world.com.*

EMPLOYMENT OPPORTUNITY

STRESS RELIEF

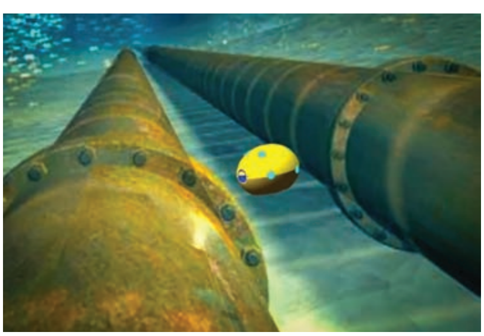
BOB DYLAN ON SCIENCE

An internal contest between a band of researchers at Karolinska Institutet (KI), Stockholm, will choose one winner for quoting Bob Dylan in the most scientific articles before going into retirement. Seventeen years ago, Jon Lundberg and Eddie Weitzberg, today both professors at KI, had an article published in *Nature Medicine* titled Nitric Oxide and Inflammation: The Answer is Blowing in the Wind.



Jonas Frisén, Konstantinos Meletis, Jon Lundberg, Kenneth Chien, and Eddie Weitzberg. Courtesy of Gustav Mårtensson.

"We both really like Bob Dylan, so when we set about writing an article concerning the measurement of nitric oxide gas in both the respiratory tracts and the intestine, the title fit perfectly," says Weitzberg. A few years later they saw an article written by Jonas Frisén and Konstantinos Meletis, both working in other departments at KI. "The title was Blood on the Tracks: A Simple Twist of Fate—a Bob Dylan song, and the article contained additional Dylan references," Weitzberg notes. Lundberg and Weitzberg then emailed Frisén to launch the internal competition. "It's important that the quote is linked to the scientific content, and that it reinforces the message and raises the quality of the article as such, not the reverse," says Frisén. The winner will be treated to lunch at a popular Swedish restaurant. *www.ki.se.*



Screen shot from an animated video shows how the robot could be used to perform ultrasound scans. Courtesy of the researchers.

FOOTBALL-SIZED ROBOT AIDS SHIP SECURITY

Massachusetts Institute of Technology, Cambridge, researchers unveiled an oval-shaped submersible robot, a little smaller than a football, with a flattened panel on one side so that it can slide along an underwater surface to perform ultrasound scans. Originally designed to look for cracks in nuclear reactor water tanks, the robot could also inspect ships for the false hulls and propeller shafts that smugglers frequently use to hide contraband. Due to their small size and unique propulsion mechanism—which leaves no visible wake—the robots could be concealed in clumps of algae or other camouflage. Fleets of them could swarm over ships at port without alerting smugglers and giving them the chance to jettison their cargo. *web.mit.edu.*

3D-PRINT YOUR LAPTOP

Using PLA filament, a small London-based team 3D printed their own Raspberry-Pi-based laptop, with a battery life of six to eight hours and Wi-Fi enabled out of the box. It is being sold as a kit—a Raspberry Pi-powered laptop kit "you build yourself" called the Pi-Top—which includes a 13.3-in. screen, keyboard, and touchpad.

Creators note the hardest part was "getting the support structure right so it could survive the beating and pressure that a normal laptop experiences." The team printed the initial prototype using a Rostock Max V2 Kit with an E3D metal hotend. The laptop shell was printed out of PLA filament during a 160-hour time span, with 0.2-mm layers and 30% infill. The shell is printed in three separate pieces, two at the same time and the larger piece on its own. *pi-top.com.*

The Pi-Top, a laptop you 3D print yourself, has all the functions of a normal laptop.

ADVANCED MATERIALS & PROCESSES EDITORIAL PREVIEW

JULY/AUGUST 2015

Materials in Sports & Recreation

Highlighting:
- Modern Materials for Sporting Goods
- Testing High-Performance Equipment
- Advanced Designs for Elite Athletes

Advertising Bonus:
- Signet Ad Study

Special Supplement:
International Thermal Spray and Surface Engineering newsletter covering coatings in automotive and industrial applications.

Advertising closes June 5

SEPTEMBER 2015

High-Tech Materials & Processes

Highlighting:
- Bulk Nanostructured Metals
- Transparent Polycrystalline Ceramics
- MS&T15 Show Preview

Bonus Distribution:
- MS&T15 Conference & Exposition
  October 4-8, Columbus, Ohio

Advertising closes August 4

Subscriptions/Customer Service:
800.336.5152 ext. 0
MemberServiceCenter@asminternational.org

Sales Staff:
Skip Wolfe, *Director, Sales and Marketing*
440.338.5151 ext. 5226
skip.wolfe@asminternational.org

***AM&P*/ASM Web Media**
Erik Klingerman, *National Sales Manager*
440.338.5151 ext. 5574
erik.klingerman@asminternational.org

***iTSSe*/Affiliate Sponsorships**
Kelly Thomas, CEM.CMP, *Manager, Events*
440.338.1733
kelly.thomas@asminternational.org

AD INDEX

SUCCESS ANALYSIS

SPECIMEN: SYNTHETIC DIAMOND

VITAL STATISTICS

Diamond's extreme properties, such as having the widest spectral band of any known material—extending from ultraviolet to far infrared and the mm-wave microwave band—combined with exceptional heat dissipation and mechanical hardness, have led to new applications in a diverse range of optical industries, from spectroscopy to high-power laser machining.

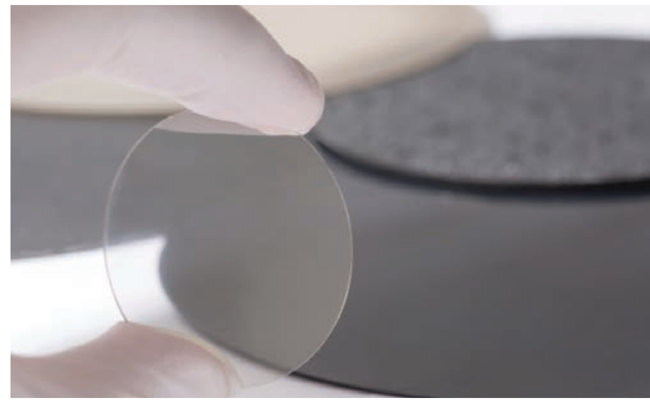
Advances in new growth methodologies enabled by chemical vapor deposition (CVD) mean that synthetic diamond is no longer rare or unique. This CVD growth platform enables controlled fabrication of uniform and repeatable synthetic diamond over large diameters (>100 mm) and thicknesses (>3 mm) with properties such as absorption tailored to each application. While characteristics of natural diamond such as variability are attractive in the gem industry, they limit industrial use by optical engineers. Synthetic CVD diamond addresses these challenges.

SUCCESS FACTORS

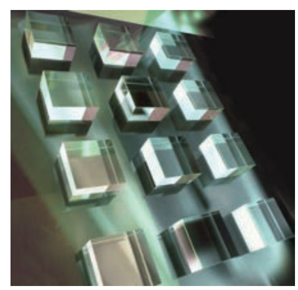
"Quantum information processing using defects nanoengineered into diamond is currently a very exciting area. At the same time, its exploitation in high-power laser systems for machining and processing materials is already of great commercial interest," says Andrew Bennett, principal research scientist at Element Six. In 2014, the company announced a three-year, European Union-funded project that will use single crystal diamond to massively increase the output power of lasers. With the European Commission's Seventh Framework Program for Research and Technological Development, the goal is to develop an ultrafast pulse disk laser. The project will help design a new laser with high average output power to increase productivity and precision in micromachining transparent materials. "As part of the effort, we're looking to further develop our low-loss, high purity single crystal CVD diamond material to rapidly conduct heat off a titanium sapphire thin-disk, which will be used as the laser gain material," says Bennett.

ABOUT THE INNOVATORS

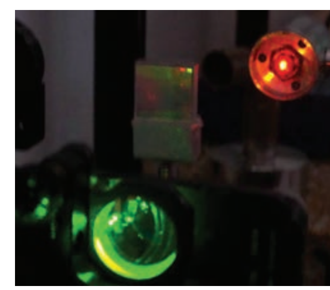
Andrew Bennett has been with Element Six since 2011 as a principal research scientist and is responsible for managing the company's optical research program, working closely with customers and academic institutes. Element Six designs and develops synthetic diamond supermaterials and is a member of The De Beers Group.



Optical grade CVD diamond manufactured by Element Six.



A single crystal synthetic diamond provides unmatched purity for ATR prisms in IR spectroscopy.



Wavelength conversion and beam quality improvement using a diamond Raman laser.

WHAT'S NEXT

"I see three areas that offer great promise for this advanced material," says Bennett. "First is synthetic diamond's role in the development of extreme UV lithography capabilities, and the goal in this area is to help electronic devices operate faster and more efficiently. Next, I think we will witness great advancements with getting diamond inside the cavity of disk lasers, increasing power output. Although synthetic diamond is already used in lasers, if we can get it inside the cavity, we can double the cooling efficiency and help these lasers move to higher average powers and higher brightness. Lastly, I expect we will see noteworthy applications with Raman lasers. The world is full of different lasers, but those that are powerful, reliable, and efficient are rare. With Raman lasers based on synthetic diamond, we're able to reach more wavelengths with high optical efficiency."

Contact Details

Andrew Bennett
Element Six • Fermi Ave., Harwell Oxford, Didcot
Oxfordshire OX11 0QR, UK • +44 (0) 1235 441098
technologies@e6.com, www.e6.com