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ADVANCED MATERIALS & PROCESSES

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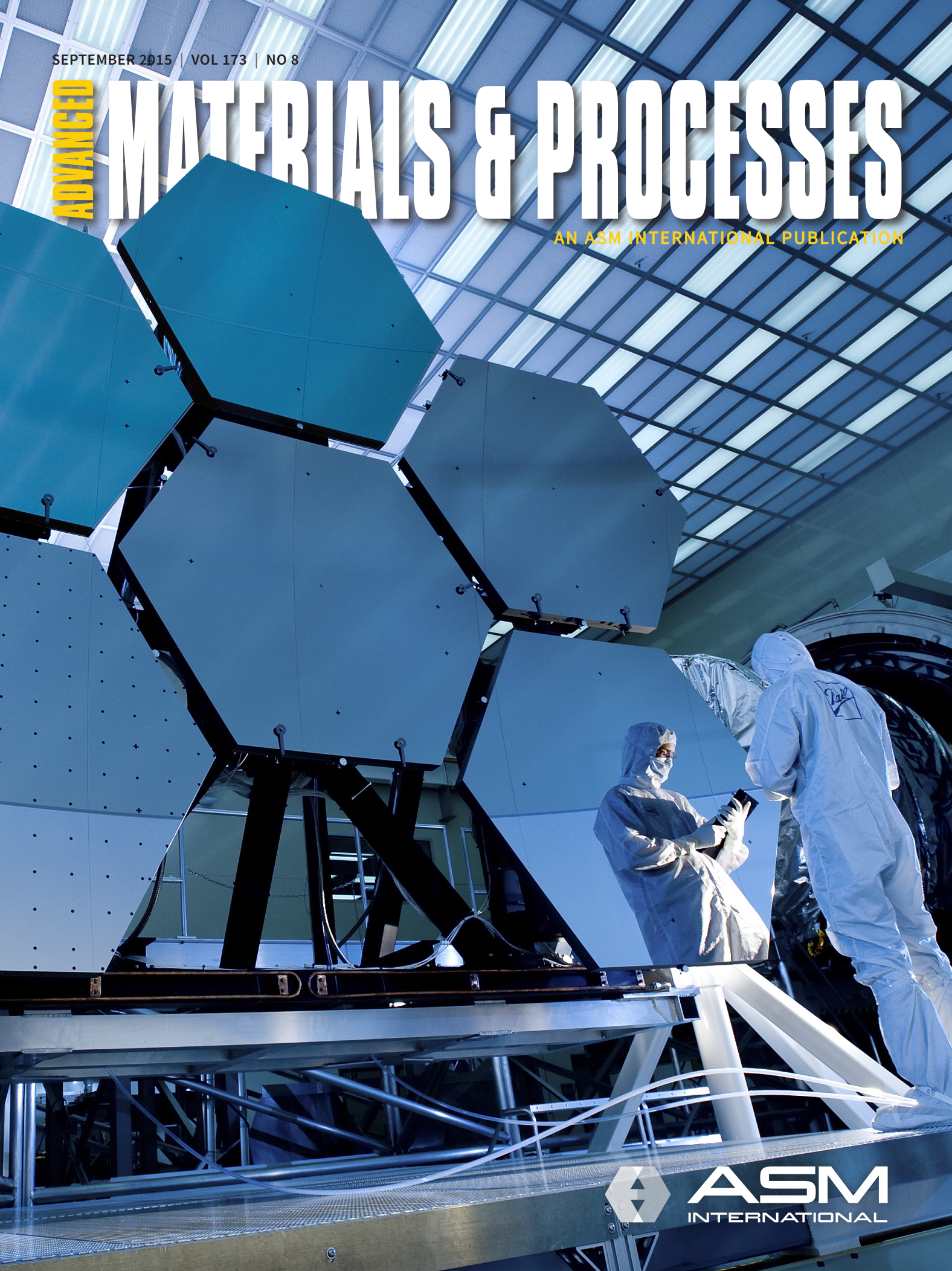

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HIGH-TECH MATERIALS & PROCESSES

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P.20

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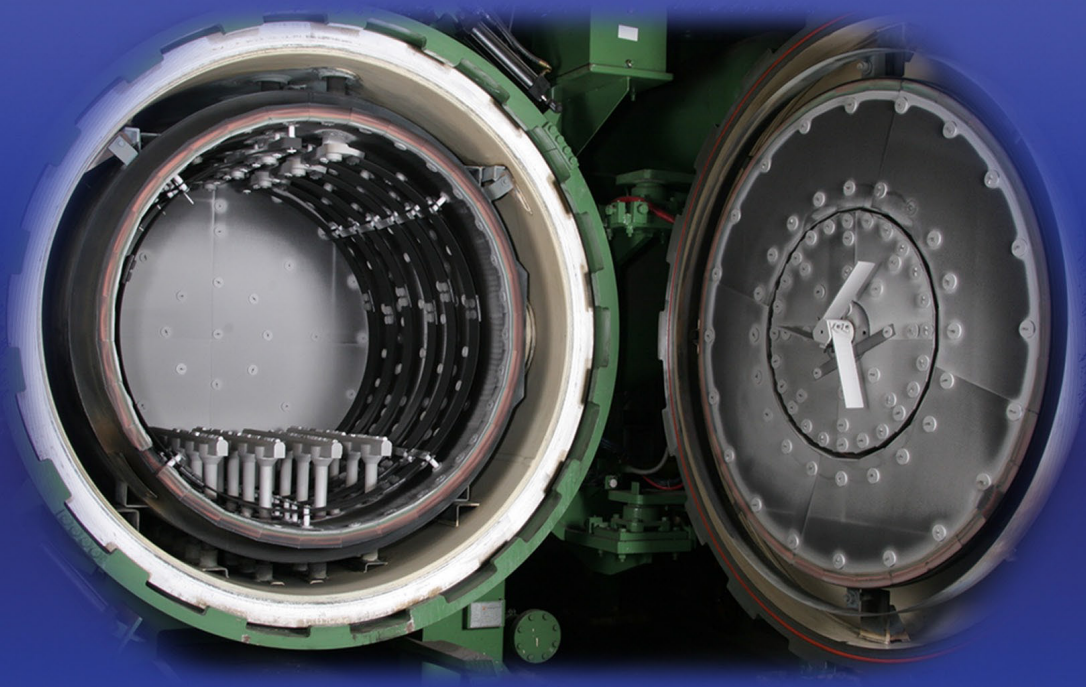

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Practical Fracture Mechanics	10/19-20	IMR Test Labs, Lansing, NY
Titanium and Its Alloys	10/19-22	ASM World Headquarters
Metallurgy for the Non-Metallurgist™	10/19-22	ASM World Headquarters
Applied Techniques of Failure Analysis	10/19-22	ASM World Headquarters
Practical Fractography	10/21-22	IMR Test Labs, Lansing, NY
Metallurgy of Steel for the Non-Metallurgist	11/2-4	ASM World Headquarters
Aluminum and Its Alloys	11/3-5	ASM World Headquarters
Metallographic Techniques Blended	11/9-10	Buehler Limited, Lake Bluff, IL
Introduction to Heat Treating	11/9-11	ASM World Headquarters
Reverse Engineering: A Material Perspective	11/9-11	ASM World Headquarters
Metallographic Interpretation	11/9-12	ASM World Headquarters
Advanced Heat Treating	11/12-13	ASM World Headquarters
Design for Additive Manufacturing - Materials, Processes, andGeometries	11/16-17	America Makes, Youngstown, OH
Stainless Steel for Design Engineers	11/16-17	ASM World Headquarters

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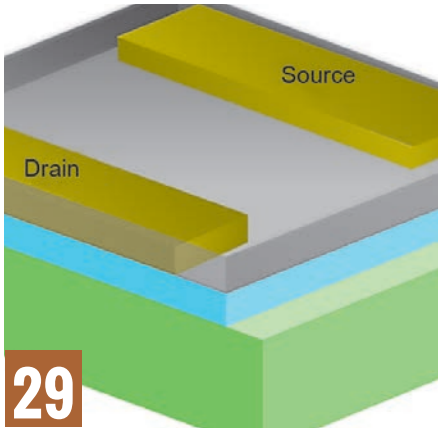
On The Cover:

Jake Lewis of Ball Aerospace is reflected in one of the mirrors on a James Webb Space Telescope Array that was in the x-ray and cryogenic facility for testing. Courtesy of NASA/MSFC/David Higginbotham/Emmett Given.

BERYLLIUM OPTICS ENABLE ADVANCED SPACE TELESCOPES

Don Hashiguchi, James Marder, and Roger Paquin

Beryllium won a lengthy competition as the material of choice for the mirrors on the James Webb Space Telescope, set to launch in 2018.



29

TECHNICAL SPOTLIGHT

TESTING INORGANIC AND ORGANIC MATERIALS WITH A NEW ION SOURCE

Learn about a new monatomic and gas cluster ion source for XPS instruments.

34

METALLURGY LANE

PIONEERS IN METALS RESEARCH–PART I

Charles R. Simcoe

Steel pioneer Henry Marion Howe was an industrialist, scientist, teacher, writer, and lifelong researcher.

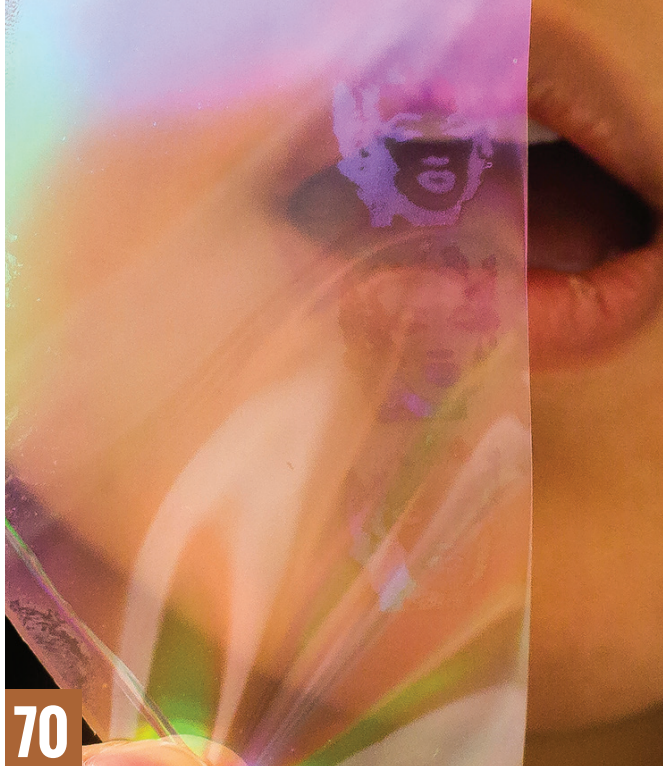
59

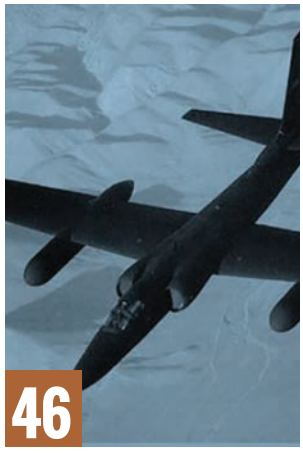
ASM NEWS

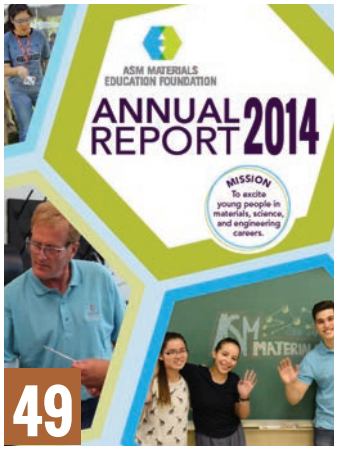
The monthly publication about ASM members, chapters, events, awards, affiliates, and other Society activities.

ADVANCED MATERIALS & PROCESSES
SEPTEMBER 2015 | VOL 173 | NO 8

FEATURES







TRENDS

INDUSTRY NEWS

DEPARTMENTS

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SUMMER IS FLEETING, FALL BRINGS MEETINGS

Summer is rapidly drawing to a close and once again many of us will be immersed in the whirlwind of attending fall conferences and getting a new school year underway, whether as professors, students, parents, or some combination of the above. Here in the Midwest, our summer was filled with periods of heat and drought peppered by torrential rainfall and flooding, while other parts of the country fared much worse with wildfires and water sanctioning. Thinking back on summer and how fast it flew by (as usual), one day stands out to me—August 10.

On this particular day, I was en route to Austin for a 3D printing conference and ended up spending 12 hours in various airports due to conference calls and flight delays. The teleconference involved ASM's Emerging Technologies Awareness Committee and included a lively discussion of how ASM can best play an important role in the additive manufacturing revolution, especially with regard to metal. Incoming VP William Frazier of NAVAIR shared some great ideas, as did other committee members, one of which involves forming an additive manufacturing technical committee. Coincidentally, the 3D printing conference I attended the next day had a similar focus—additive manufacturing of complex metal parts. The company that put on the meeting, Stratasys Direct Manufacturing, recently conducted a survey of more than 700 business leaders, gauging their perspectives on the future of additive manufacturing. One of the survey findings is that additive metal use is expected to nearly double over the next three years and now is the time to get involved. As CEO Joe Allison put it, "For any manufacturers out there that haven't started using 3D printing, they better start looking at it now, or they'll fall behind and it will be difficult to catch up."

On the very same day, as I spent hours upon hours watching airport screens, it was all over the news about Warren Buffett buying Precision Castparts. Several times throughout the day, I heard my fellow travelers wondering, "What is Precision Castparts?" Because many of its employees are ASM members, I actually knew the answer. Buffett himself wasn't familiar with the company until three years ago and now he's buying the company for $37.2 billion—his biggest purchase *ever*—a deal expected to be finalized early next year. In a company statement, he said, "I've admired PCC's operation for a long time. For good reasons, it is the supplier of choice for the world's aerospace industry, one of the largest sources of American exports." The company makes complex structural investment castings and forged components, machined airframe components, and critical fasteners for aerospace applications, serving customers such as Boeing, Airbus, and others. If anyone has opinions on the pending purchase, we'd like to hear them.

Next up is MS&T15 in Columbus, Ohio, and our Heat Treat show in Detroit, both taking place in October. At ASM, we're enjoying the seasonal activity of preparing for these events and we hope to see you there! With a fantastic lineup of keynote speakers, technical sessions, and multiple networking opportunities, these are two fall meetings you won't want to miss. Be sure to check out our show previews included in this issue.

F. Richards

frances.richards@asminternational.org

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MARKET SPOTLIGHT

Courtesy of CMU College of Engineering.

In conjunction with the first National Maker Faire and the White House Week of Making held in Washington in June, Carnegie Mellon University (CMU) experts created a Top 10 list for 3D metal printing. "We have many faculty working to improve 3D printing of metals, from powder properties and manufacturing outcomes to cost and public policy issues," says Jack Beuth, professor of mechanical engineering. "Much of this learning is being applied to jet engine parts, but the technology is already beginning to trickle down to a wide variety of custom metal components and replacement parts." Beuth's research focuses on mapping outcomes of various 3D printing methods to make the process faster and cheaper when applied to metals. *engineering.cmu.edu.*

FEEDBACK

THE JOY OF TITANIUM

The articles on the early titanium industry (March, April, May issues) brought back many memories. I was released from active duty by the Army in 1953 and needed a job. I found out that Titanium Metals Corp. was staffing its technical department, which sounded exciting though I knew nothing about titanium. Tom Redden was head of the metallurgy department and I was the first metallurgist he hired. Tom had come from National Lead and his experience with titanium was as a paint whitener. The second hire was Dwayne Day from Battelle. Tom decided we would study the Ti-Al-Mo-V system. Dwayne was to work on sheet alloys and my assignment was for bar.

We explored the system from Ti-8-1-1 to Ti-1-8-8 and everything in between. This was a total joy even though I was hampered by little knowledge of titanium metallurgy. We knew there was a phase transformation somewhere between 1800° and 1900°F and we knew nothing of the metallography. It was Titanium 101 without a professor. The only alloys we studied that became commercial were Ti-4Al-3Mo-1V and 8-1-1. Ti-4Al-4Mo-4V was my favorite and I could heat treat it to more than 180 ksi, but Ti-6Al-4V would allow no rivals then.

Tom left for a job with GE Jet Engines and Hal Kessler replaced him. We now had a different agenda. Hal was convinced that 6-4 could be heat treated and that became my assignment. I decided on a solution and age procedure just as I had used on aluminum. But first I looked at only the solution treated condition to determine what aging would do. A technician quenched the samples in 100°F intervals from 1400° to 1900°F. He came to me the next day and asked if he could use water instead of oil because he didn't like the smoke and oil messing up the floor. I told him that would be fine as long as the specimens didn't crack. All future heat treat specifications called for water quenching thanks to this lab technician.

In the middle of the heat treat program, panic set in. Pratt & Whitney reported that the Ti-Al-Fe alloy parts were cracking. It was all hands on deck because the titanium program supported by the Air Force was about to sink. The immediate suspect was hydrogen, so samples were vacuum heat treated and subjected to sustained load tests. We didn't know if the hydrogen could easily be extracted and we didn't know if a reasonable limit could be set. The program was a total success and the limit in future specifications became between 100 and 150 ppm. This resulted in a paper entitled "Hydrogen in Titanium" delivered by Max Parris who had joined us from Battelle.

I resumed the 6-4 program and easily achieved the 160 ksi level Hal wanted. All titanium heat treat specifications are based on our ASM paper "The Heat Treatability of Ti-6Al-4V." This was reported at the Metal Show in Philadelphia to an overflow audience. I still appreciate Hal because he had me deliver the paper when he could have claimed all the glory. Those four years were the most fun of my career and had a profound effect on my life.

Russell Sherman, FASM

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

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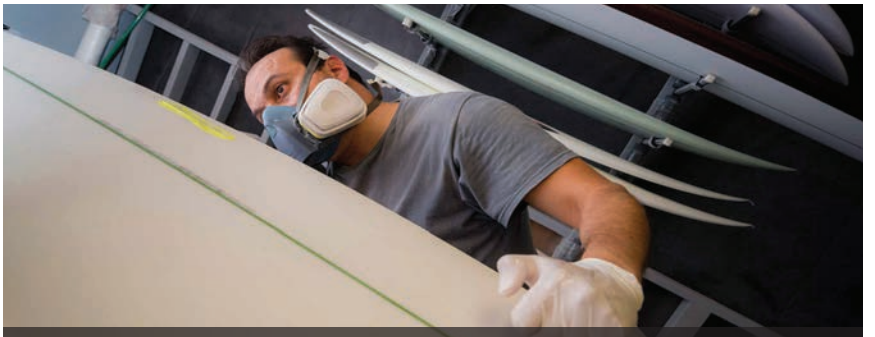


Workers at Avila Surfboards in Oceanside, Calif., prepare the world's first algae surfboard blank for the application of a fiberglass shell. Courtesy of Erik Jepsen/UC San Diego Publications.

SUSTAINABLE SURFING

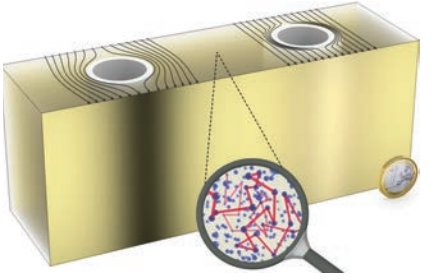
Researchers at the University of California, San Diego created the world's first algae-based, sustainable surfboard. Today's polyurethane surfboards are made exclusively from petroleum.

In order to make the precursor of the polyurethane foam core of a surfboard from algae oil, students first determined how to chemically change the oil obtained from laboratory algae into different kinds of polyols. Mixed with a catalyst and silicates in the right proportions, these polyols expand into a foam-like substance that hardens into the polyurethane that forms a surfboard's core.

Although the board's core is made from algae, it is pure white and indistinguishable from most plain petroleum-based surfboards. "In the future, we could make the algae surfboards 'green' by adding a little color from the algae to showcase their sustainability," says biology professor Stephen Mayfield. "But right now we wanted to make it as close as we could to the real thing." *For more information: Stephen Mayfield, smayfield@ucsd.edu, www.ucsd.edu.*

INVISIBILITY CLOAKS AS TEACHING TOOLS

Real-life invisibility cloaks do exist, in a manner of speaking—researchers have engineered systems that bend light around an object, shielding it from detection. But most are tiny and only work at very small wavelength ranges, rendering them unimpressive to average observers. Now, a group of researchers from the Karlsruhe Institute of Technology (KIT), Germany, developed a portable cloak that can be taken into classrooms and used for demonstrations. It can't hide a human, but it can make small objects disappear from sight without specialized equipment.



In a diffusive light-scattering medium, light moves on random paths. A normal object casts a shadow; an object with an invisibility cloak does not. Courtesy of R. Schittny, KIT.

The cloak was constructed from a light-scattering material. By dispersing light, the material slows down the effective propagation speed of the light waves through the medium. The light can then be sped up again to make up for the longer path length around the hidden object. An object is placed inside a hollow metal cylinder coated with acrylic paint, which diffusely reflects light. The tube is embedded within a block of polydimethylsiloxane, a commonly used organic polymer, doped with titanium dioxide nanoparticles that make it scatter light. *kit.edu/english.*

NEW FURNITURE MATERIAL WITHSTANDS FIRE AND WATER

Resource-saving wood-polymer composites (WPCs) are the latest trend in materials for garden furniture and other outdoor applications, especially for terrace decking and panels used for weatherboarding and fencing. Researchers at the Fraunhofer Institute for Wood Research, Wilhelm-Klauditz-Institut WKI, Germany, are collaborating with industrial partners to develop materials suitable for pressing into moisture-resistant WPC boards for indoor furniture manufacturing.

The boards are composed of roughly 60% wood particles and 40% thermoplastic material, generally polypropylene or polyethylene. Both wood and plastic components can be sourced from recycling streams. The wood component in WPC boards can be replaced by other lignocellulose products derived from the fibrous part of plants such as hemp or cotton or the husks of rice grains and sunflower seeds. All of these materials are 100% recyclable and formaldehyde-free. *www.wki.fraunhofer.de/en.html.*

WPC board without (above) and with (below) flame-proofing. Courtesy of Fraunhofer WKI.

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.

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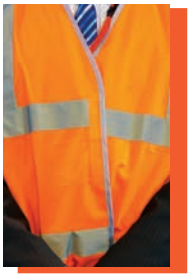

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Dutch startup company MX3D plans to build the world's first 3D printed bridge across an Amsterdam canal.

HIGH-STRENGTH STEEL SHEET SUITS AUTOMOTIVE APPLICATIONS

Several hot rolled medium carbon-manganese-boron steel sheets with tensile strength of 200-220 ksi after hot stamping and quenching are currently used to make safety and structural components on automobiles. However, a newly designed medium carbon, hot rolled high-strength steel sheet (HPHSS) was recently developed to exceed the strength of C-Mn-B sheet. This HPHSS sheet can be used in hot stamping of safety and structural parts, truck frames, and other high stressed components. Additional uses for the new sheet include defense, oil and gas, and construction applications.

Uncoated HPHSS sheet has sufficient corrosion resistance to minimize surface loss after hot stamping and water quenching—only post-stamp painting is required. HPHSS sheet for special applications can be coated by galvanizing, galvannealing, aluminizing, or other standard coating processes. After stamping, components are subjected to quenching and tempering to reach the desired combination of strength, fatigue strength, and impact strength. Production costs of uncoated HPHSS sheet are 15-20% higher than costs associated with C-Mn-B sheet. High specific tensile strength provides significant weight reduction compared to aluminum alloy sheets. For example, 0.08-in. thickness hardened HPHSS sheet substitutes at least 0.45-in. thickness hardened 6xxx series aluminum alloy sheet with a projected weight reduction of at least 48% without sacrificing stiffness and durability. *supersteel@cogeco.ca.*

ROBOT TO 3D PRINT A STEEL BRIDGE

Dutch designer Joris Laarman created a new research and development company called MX3D, which specializes in building six-axis robots that can 3D print metal and resin in mid-air. The technique allows for large-scale objects like infrastructure to be printed in the exact spot where they live, which has vast implications for the construction industry and opens up a wealth of new design possibilities.

The finished bridge will be approximately 24 ft long, support normal Amsterdam foot traffic, and feature an intricate design that looks more handcrafted than the detailing on most bridges. Because 3D printing allows for more granular control of detail than traditional industrial manufacturing, designs can be much more ornate. Most 3D printers use resin or plastic to construct objects. This bridge will be made of a new steel composite created by the University of Delft. As strong as regular steel, it can be dolloped out by a 3D printer, drop by drop. The result? A 3D printed bridge as strong as any other, Laarman says. *mx3d.com.*

SMART MATERIALS CAMOUFLAGE LIKE SQUID

Researchers from the University of Bristol, UK, created artificial skin that can be transformed at the flick of a switch to mimic one of nature's masters of camouflage—the squid. The team

BRIEF

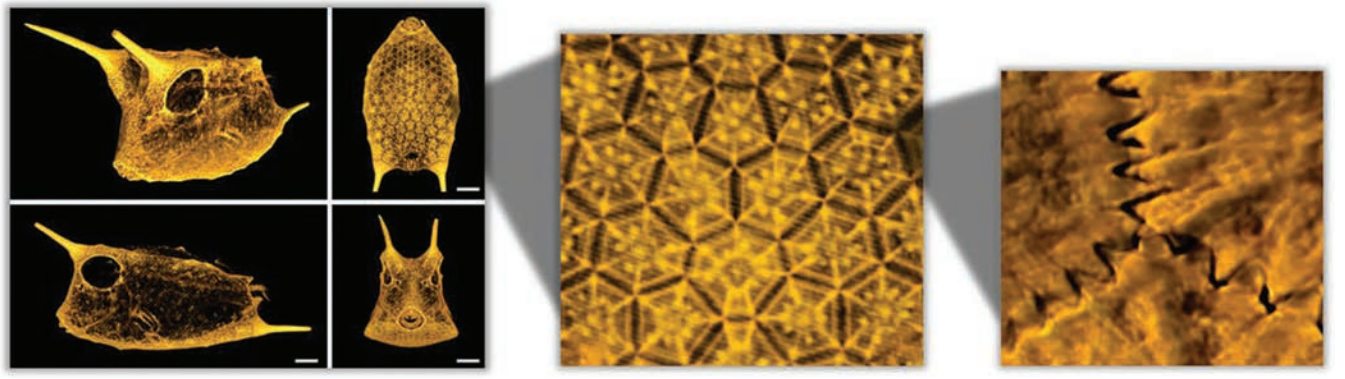
Operations will begin soon at **Carpenter Technology Corp.'s** new superalloy powder facility in Alabama as part of a multilevel agreement with **United Technologies Corp.'s (UTC) Pratt & Whitney Division.** Carpenter will supply Pratt & Whitney with superalloy powder for up to 20 years once qualifications are satisfied. As part of the agreement, UTC's aerospace business units agreed to purchase alloy steel bar/billet, nickel superalloy powder, stainless bar/billet, and strip laminate products from Carpenter for a period of 10 years. Carpenter currently supplies UTC's aerospace businesses with a portion of their overall demand for nickel, stainless, and strip laminate products. *cartech.com/aerospace.*

designed a smart materials system, inspired by biological chromatophores, which creates patterns that change and morph over time and mimic biological patterning. The artificial skin, made of an electroactive dielectric elastomer, can effectively copy the action of biological chromatophores—small pigmented cells embedded on a cephalopod's skin, which can expand and contract and that work together to change color and texture.

The system achieves the dynamic pattern generation by using simple local rules in the artificial chromatophore cells, so that they can sense their surroundings and manipulate their change. By modeling sets of artificial chromatophores in linear arrays of cells, researchers explored whether the system was capable of producing a variety of patterns. They found that it is possible to mimic complex dynamic patterning seen in real cephalopods such as the Passing Cloud display, which is when bands of color spread as waves across the skin. This visual effect acts to distract and divert predators. *www.bristol.ac.uk.*

Three prototype artificial cephalopod chromatophores shown in unactuated states. Chromatophores are made of dielectric elastomer using tape coated with black carbon grease electrodes. Courtesy of University of Bristol.

TESTING | CHARACTERIZATION



The boxfish gets its name from its boxy shape (left). Its shell is composed of several hexagonal scutes that provide body support and armored protection (center). Scutes are connected by toothlike joints called sutures (right). Courtesy of Jacobs School of Engineering/ UC San Diego.

BOXFISH INSPIRES NEW ARMOR DESIGNS

Engineers at the University of California, San Diego, discovered that the unique armor of the boxfish draws its strength from hexagon-shaped scales and the connections between them, which could inspire advanced body armor and flexible electronics design. The scales, called *scutes*, are connected by sutures similar to the connections in a baby's skull, which grow and fuse together as the baby develops.

Most fish have overlapping scales, says Steven Naleway, a materials science and engineering Ph.D. student. "We are currently investigating what mechanical advantage scutes and sutures might provide. The boxfish has survived for 35 million years with this armor, so the design has proved very successful in nature," he explains.

Each scute has a raised starlike structure in the center that distributes stress across the entire surface. Under the scutes, an inner layer forms a complex structure in which collagen fibers interlock. This structure creates a flexible inner layer in the armor, which is difficult to penetrate due to the interlocking collagen fibers. Together, the outer and inner layers of the boxfish armor provide unique protection. Meanwhile, connections between the scutes, called sutures, make the armor even stronger. Upon impact, the sutures' zigzag patterns essentially lock in and keep the scutes from breaking apart. These sutures are different from many of those found elsewhere in nature, says Naleway.

Researchers used scanning electron microscopy to characterize the surface structure of the scutes. They also took cross sections and used microcomputer tomography to characterize dense regions. Mechanical testing results left researchers wondering why the boxfish has a design that excludes overlapping scales. These structures are now being studied with support of the U.S. Air Force for potential use in advanced armor designs. *ucsd.edu.*

TECHNICAL PROGRAM ANNOUNCED FOR ISTFA 2015

The International Symposium for Testing and Failure Analysis (ISTFA 2015), being held November 1-5 in Portland, Ore., features more than 22 technical sessions, 106 presentations, four user groups, and 18 tutorials. The technical program is now live and includes the latest research and developments in the field of electronic device failure analysis on topics such as emerging failure analysis techniques, fault isolation, sample preparation, counterfeit electronics, and more. Other special programs taking place at ISTFA include mainstays like the annual ISTFA video and photo contests and the return of the popular "Tools of the Trade VIP Expo Tour," as well as a new student poster contest. Three educational workshops will be held on Saturday, October 31: Fault Isolation, Packaging Failure Analysis, and Beam-Based Defect Localization. Albert Yu-Min Lin, National Geographic Explorer, serves as this year's keynote speaker and will discuss his groundbreaking work on using noninvasive computer techniques to explore archaeological sites, including that of Genghis Khan. *istfa.org.*

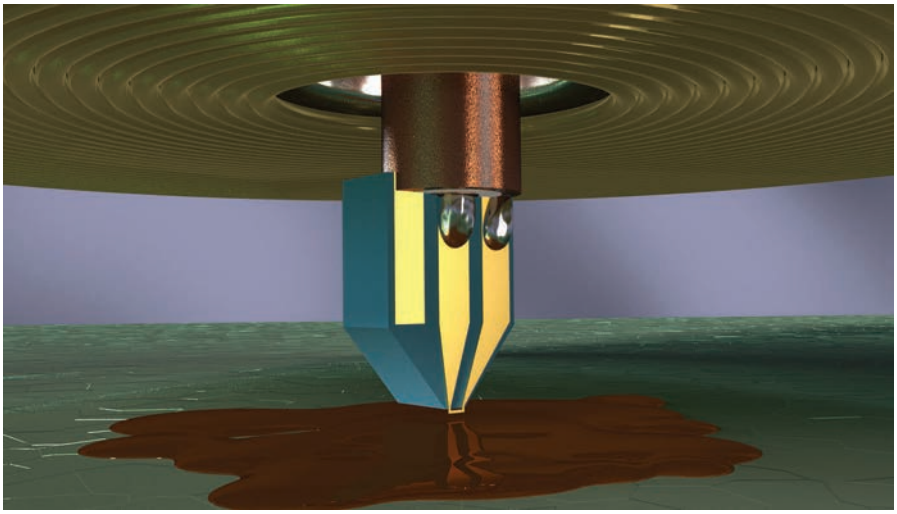
ELECTRON SPIN RESONANCE EXPLORES TINY OBJECTS

Researchers at the National Institute of Standards and Technology (NIST), Gaithersburg, Md., devised a way to shrink a research instrument generally associated with large machines that make bulk measurements of samples down to a pinpoint-precision probe.

The team's electron spin resonance (ESR) probe takes a large-scale technique used for decades as a way to explore bulk materials properties and for the first time makes it useful for investigating tiny objects or specific areas. The new probe is expected to have a broad range of applications in fields ranging from chemistry to semiconductor design and manufacturing.

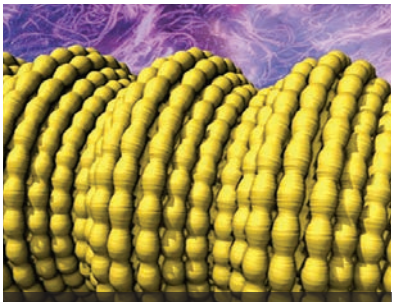
"Our new approach brings more than 20,000 times improvement in sensitivity over conventional ESR and allows for investigation of all sorts of samples that were never thought possible," says Jason Campbell.

ESR is widely used in chemistry and biology research because it can reveal how molecules stick together. It is also used in anthropology, fuel science, physiology, and meteorology. But the technique's sensitivity limits relegate it to analyzing materials in bulk, with this limitation stemming from the need to place samples into a small resonant chamber. The new approach removes the resonant chamber entirely. Instead, microwave energy is introduced by forcing a high-frequency current through a microscopic wire, which acts as a tooth-like probe tip that can be moved within a few micrometers of the sample material. Using this approach, specific points on a surface can be examined. *nist.gov.*



A NIST technique makes electron spin resonance useful for exploring tiny objects for the first time.

EMERGING TECHNOLOGY



UT Dallas scientists constructed novel fibers by wrapping sheets of tiny carbon nanotubes to form a sheath around a long rubber core.

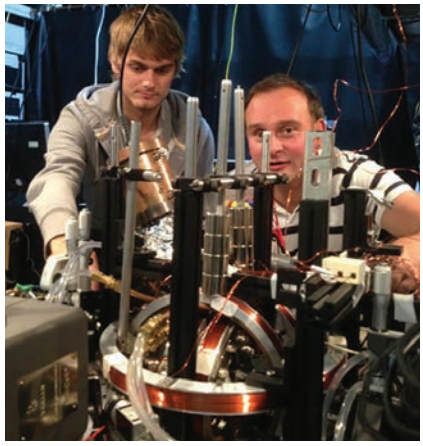
NEW FIBERS COULD ENABLE MORPHING AIRCRAFT

An international research team based at The University of Texas at Dallas created electrically conducting fibers that can be reversibly stretched to more than 14 times their initial length and whose electrical conductivity increases 200-fold when stretched. The team is using the fibers to make artificial muscles, as well as capacitors whose energy storage capacity increases about tenfold when stretched. These new fibers and cables might one day be used as interconnects for superelastic electronic circuits, far-reaching robots and exoskeletons, morphing aircraft, and super-stretchy charger cords for electronic devices.

Fibers were constructed by wrapping lighter-than-air, electrically conductive sheets of tiny carbon nanotubes to form a jelly-roll-like sheath around a long rubber core. The fibers differ from conventional materials in several ways. For example, when conventional fibers are stretched, the resulting increase in length and decrease in cross-sectional area restricts the flow of electrons through the material. But even a "giant" stretch of the new conducting sheath-core fibers causes little change in their electrical resistance, says Ray Baughman, director of the NanoTech Institute at UT Dallas. Key to the performance of the new fibers is the introduction of buckling into the carbon nanotube sheets. Because the rubber core is stretched along its length as the sheets are being wrapped around it, when the wrapped rubber relaxes, the carbon nanofibers form a complex buckled structure, which allows for repeated stretching. *utdallas.edu.*

QUANTUM TECHNOLOGY GETS A BOOST FROM MICROWAVES

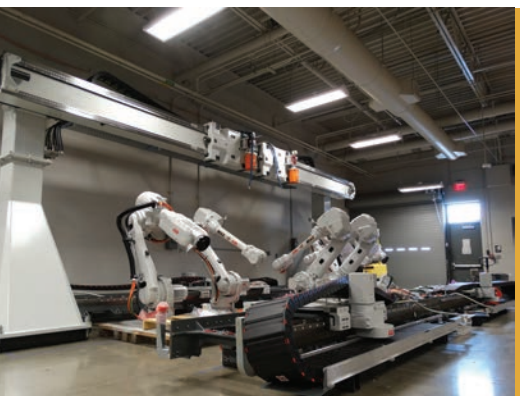
Scientists at the University of Sussex, UK, discovered a way to use everyday technology found in kitchen microwaves and mobile telephones to bring quantum physics closer to helping solve enormous scientific problems that the most powerful supercomputers can't even think about. A team led by Professor Winfried Hensinger froze single charged atoms to within a millionth of a degree of absolute zero with the help of microwave radiation. This technique will simplify the construction of quantum technology devices including powerful quantum sensors, ultra-fast quantum computers, and ultra-stable quantum clocks. Quantum technologies make use of highly strange and



Winfried Hensinger (right) and Seb Weidt freeze individual atoms using microwaves. Courtesy of University of Sussex.

counterintuitive phenomena predicted by the theory of quantum physics.

"The use of long-wavelength radiation instead of laser technology to cool ions can tremendously simplify the construction of practical quantum technology devices enabling us to build real devices much faster," says Hensinger. Quantum technologies could revolutionize the understanding of science, such as solving the origin of the universe. Freezing atoms puts them into the lowest possible energy and is a step toward harnessing the strange effects of quantum physics, which allow objects to exist in different states at the same time. "Besides finding an easy way to create atoms with zero-point energy, we have also managed to put the atom into a highly counterintuitive state—where it is both moving and not moving at the same time," explains Hensinger. *sussex.ac.uk.*



BRIEF

Wichita State University's National Institute for Aviation Research, Kansas, and **Dassault Systemes,** Waltham, Mass., will partner to create an advanced manufacturing center on campus. The **3DExperience Center,** which will be located in the Experiential Engineering Building when it opens late next year, will focus on enabling advanced product development and manufacturing of next-generation materials and technologies. *wichita.edu.*

Parts of the 3DExperience Center are already coming together in a temporary home at the National Center for Aviation Training.

PROCESS TECHNOLOGY

LIFT's first project aims to decrease the wall thicknesses of ductile iron cast parts by up to half.

LIFT EXPLORES IRON ALLOYS IN THIN-WALL CASTINGS

Casting parts from molten iron is a standard process that has been recently transformed by technological advances. LIFT (Lightweight Innovations for Tomorrow), Detroit, will investigate innovations in melt processing as its first technology acceleration project. Grede, Southfield, Mich., and Michigan Technological University, Houghton, will lead the project, which focuses on reducing the amount of metal used to make automotive transmission differential cases, similar to core product designs provided by Grede and Eaton. By integrating and implementing improved manufacturing methods with different alloys, the wall thicknesses of ductile iron cast parts could be decreased by up to 50%, achieving 30-50% weight savings in various parts.

LIFT, operated by the American Lightweight Materials Manufacturing Innovation Institute (ALMMII), is one of the founding institutes in the National Network for Manufacturing Innovation. ASM is part of the LIFT consortium and will assist with education workforce development initiatives. *www.lift.technology.*

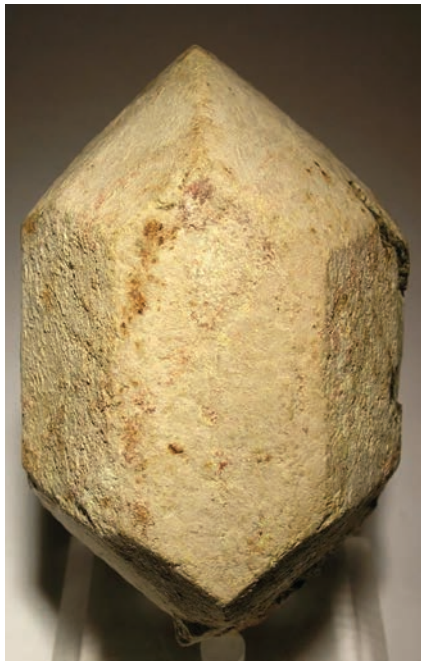
NEW LIGHT METAL FOUNDRY ANNOUNCED

Linamar Corp., Ontario, and GF Automotive (part of Georg Fischer AG), Switzerland, will cooperate in North America, Europe, and Asia to provide integrated casting and machining solutions to automotive, industrial, and commercial customers. Linamar manufactures precision forged and machined metallic components, modules, and systems for engine, transmission, and driveline systems. GF Automotive manufactures lightweight cast components and systems for automotive and industrial applications. The companies will build a new light metal foundry in the southeastern U.S. to produce high-pressure die castings for powertrain, driveline, and structural components. *linamar.com.*

NEW TECHNIQUE HOLDS PROMISE FOR URANIUM EXTRACTION

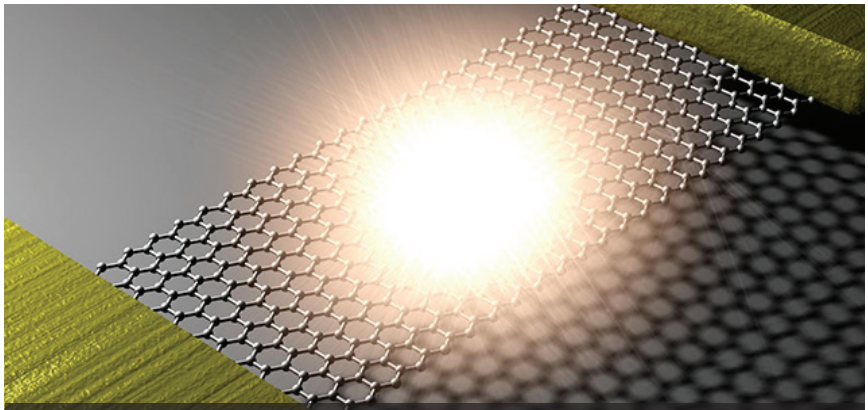
A research team at Murdoch University, Australia, recently discovered a technique to extract uranium from brannerite, a mineral often considered a waste product. Researchers say the knowledge could produce results within two to three years. Ph.D. candidate Rorie Gilligan says the discovery started from simple curiosity about where uranium volume was lost in extraction, which led him to the often overlooked brannerite. "The assumption has been that brannerite can't be processed," says Gilligan. "I found a number of papers from the 1950s and 60s exploring brannerite extraction, which gave us a starting point."

The research fit into an ongoing project headed by Aleks Nikoloski aimed at understanding uranium extraction. Over the past three years, Gilligan has been running trials on both pure brannerite specimens and mixed mineral conditions likely to occur in natural deposits. Conventional wisdom suggests increasing the acid or alkaline environment will increase the rate of leaching for hard-to-extract minerals, but researchers found this wasn't the case with brannerite. "At first I couldn't believe the results. We were getting an extraction rate of 80-90% for a mineral that was supposed to be refractory," says Nikoloski. The project is now attracting interest from uranium-mining countries worldwide, including Australia, China, Russia, and Canada. *www.murdoch.edu.au.*



Brannerite. Courtesy of Rob Lavinsky/irocks.com.

ENERGY TRENDS



Schematic illustration of electrically biased suspended graphene and light emission from the center of the suspended graphene. Courtesy of Young Duck Kim/ Columbia Engineering.

PEROVSKITE SOLAR CELLS HOLD PROMISE

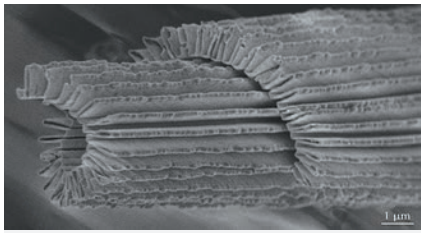
The ad hoc team on Perovskite PV Cells at the Global Research Center for Environment and Energy based on Nanomaterials Science (GREEN), NIMS, Japan, has successfully developed perovskite solar cells with good reproducibility and stability with excellent semiconducting properties. Perovskite solar cells are promising low-cost and highly-efficient next-generation solar cells because they can be produced through low-temperature processes such as spin coating and generate a large amount of electricity due to their high optical absorption together with high open-circuit voltage. In order to identify the semiconducting properties of perovskites and formulate guidelines for the development of highly efficient solar cell materials, NIMS launched the ad hoc team.

The team created perovskite solar cells with a simplified structure while strictly eliminating moisture and oxygen by employing a fabrication technique developed for the organic solar cells in the past. These new cells are stable and have no hysteresis in the current-voltage curve. Further, the solar cell material serves as an excellent semiconductor with ideal diode properties, say researchers. *www.nims.go.jp/GREEN/en/index.html.*

NANO-ACCORDIONS HELP CREATE TRANSPARENT CONDUCTORS

Researchers from North Carolina State University, Raleigh, created stretchable, transparent conductors that work due to the structures' nano-accordion design. "There are no conductive, transparent, and stretchable materials in nature, so we had to create one," says Abhijeet Bagal, a Ph.D. student in mechanical and aerospace engineering. "Our technique uses geometry to stretch brittle materials, which is inspired by springs that we see in everyday life," Bagal explains. "The only thing different is that we made it much smaller."

Researchers created a 3D polymer template on a silicon substrate. The template is shaped like a series of identical, evenly spaced rectangles. In addition, it is coated with a layer of aluminum-doped zinc oxide, which is the conducting material, and an elastic polymer is applied to the zinc oxide. Researchers then flip the whole thing over and remove the silicon and template. What's left behind is a series of symmetrical, zinc oxide ridges on an elastic substrate. Because both zinc oxide and the polymer are clear, the structure is transparent. And it is stretchable because the ridges of zinc oxide allow the structure to expand and contract, like the bellows of an accordion. The structure can be stretched repeatedly without breaking. And while there is some loss of conductivity the first time the nano-accordion is stretched, additional stretching does not affect conductivity. *ncsu.edu.*

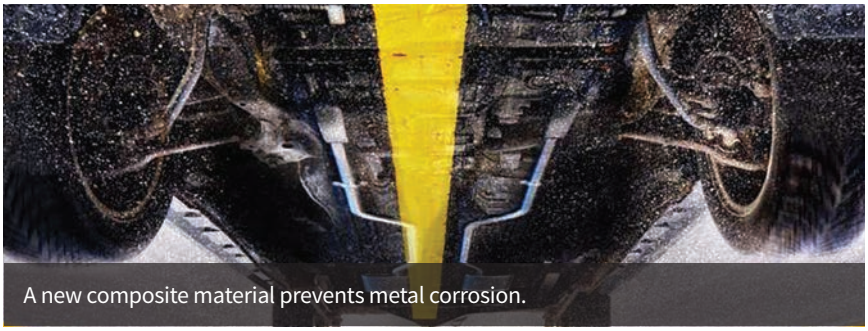


A new stretchable, transparent conductor could be used in flexible electronics, stretchable displays, or wearable sensors. Courtesy of Abhijeet Bagal.

BRIEF

Swiss PV start-up **Flisom,** which began in 2005 on the campus of the **Swiss Federal Laboratories for Materials Science and Technology (EMPA),** is developing roll-to-roll production technologies for low-cost, high-performance CIGS thin film solar cells on flexible plastic foil. The 4500 m^2 pilot plant has a production capacity of 15 MW installed solar energy. The company's founder and chairman believes these cells have great potential for providing highly efficient solar modules and solar systems with low installation costs. *www.flisom.ch, www.empa.ch.*

SURFACE ENGINEERING



A new composite material prevents metal corrosion.

NEW COMPOSITE WITHSTANDS CORROSION AT HIGH MECHANICAL STRESS

Materials researchers at the INM–Leibniz Institute for New Materials, Germany, developed a composite material that prevents metal corrosion in an environmentally friendly way, even under extreme conditions. "This patented composite exhibits its action by spray application," explains Carsten Becker-Willinger, head of the Nanomers Program Division. "The key is the structuring of this layer—the protective particles arrange themselves like roof tiles. As in a wall, several layers of particles are placed on top of each other in an offset arrangement; the result is a self-organized, highly structured barrier." The protective layer is just a few micrometers thick and prevents penetration by gases and electrolytes. It provides protection against corrosion caused by aggressive aqueous solutions, including salt solutions such as salt spray on roads and seawater, or aqueous acids such as acid rain.

After thermal curing, the composite adheres to the metal substrate and is both abrasion-stable and impact-resistant. The composite can be applied by spraying or other commonly used wet chemistry processes and cures at 150°-200°C. It is suitable for steels, metal alloys, and metals such as aluminum, magnesium, and copper, and can be used to coat any shape of plates, pipes, gear wheels, tools, or machine parts. *For more information: Carsten Becker-Willinger, +49.068.1930.0196, carsten.becker-willinger@leibniz-inm.de, tinyurl.com/ohhw6wy.*

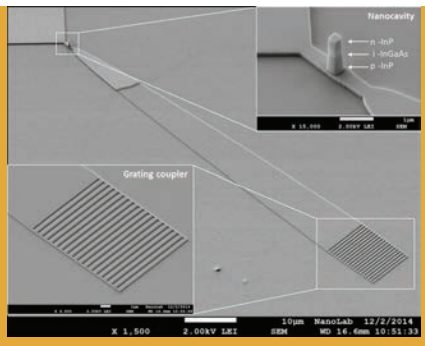
NEW LASER METHOD APPLIES DIAMOND-LIKE COATINGS

Coating engine components with hard carbon reduces friction to almost zero—a development that could save billions of liters of fuel worldwide every year. Now researchers developed a new laser method to apply the coating on the production line. Scientists already know how to coat components with diamond-like carbon to minimize friction. But researchers developed a laser arc method with which layers of carbon almost as hard as diamond can be applied on an industrial scale at high coating rates and with high thicknesses. By applying carbon coatings to engine components such as piston rings and pins, fuel consumption can be reduced. "Systematic application of our new method could save more than 100 billion liters of fuel each year over the next 10 years," says Andreas Leson from the Fraunhofer Institute for Material and Beam Technology IWS, Dresden. Carbon-based coatings are already used in volume production. But the team succeeded in producing hydrogen-free ta-C coatings on an industrial scale at a consistent level of quality. These tetrahedral amorphous carbon coatings are significantly harder and thus more resistant to wear than conventional diamond-like coatings.

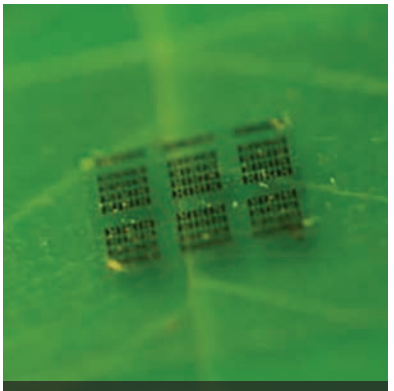
The laser arc method generates an arc between an anode and a cathode (the carbon) in a vacuum. The arc is initiated by a laser pulse on the carbon target. This produces a plasma consisting of carbon ions, which is deposited as a coating on the workpiece in the vacuum. To run this process on an industrial scale, a pulsed laser is vertically scanned across a rotating graphite cylinder as a means of controlling the arc. The cylinder is converted evenly into plasma thanks to the scanning motion and rotation. To ensure a consistently smooth coating, a magnetic field guides the plasma and filters out any particles of dirt. The laser arc method can be used to deposit very thick ta-C coatings of up to 20 µm at high coating rates. *For more information: Andreas Leson, +49.351. 83391.3317, nanofair.com.*

BRIEF

A nanoLED SEM image by **Eindhoven University of Technology (TU/e),** the Netherlands, won a competition held by **Oxford Instruments Plasma Technology,** UK. Submitted by Ph.D. candidate Victor Dolores-Calzadilla from the Photonic Integration Group at TU/e, the SEM image titled "Integrated nanoLED for Photonic Circuits" was achieved using a combination of three Oxford plasma processing tools and demonstrates plasma etch and deposition technology. *oxford-instruments.com/SEM-2015.*



NANOTECHNOLOGY



A cellulose nanofibril computer chip rests on a leaf.

WOODEN SEMICONDUCTOR CHIPS ARE BIODEGRADABLE

In an effort to alleviate the environmental burden of electronic devices, a team of University of Wisconsin-Madison researchers collaborated with researchers in the Madison-based U.S. Department of Agriculture Forest Products Laboratory (FPL) to develop a surprising solution: A semiconductor chip made almost entirely of wood. The research team, led by UW-Madison electrical and computer engineering professor Zhenqiang "Jack" Ma, demonstrated the feasibility of replacing the substrate, or support layer, of a computer chip with cellulose nanofibril, a flexible, biodegradable material made of wood. "The majority of material in a chip is support. We only use less than a couple of micrometers for everything else," says Ma. "Now the chips are so safe you can put them in the forest and fungus will degrade them. They become as safe as fertilizer." *wisc.edu.*

NANOSPIRALS COMBAT COUNTERFEITING

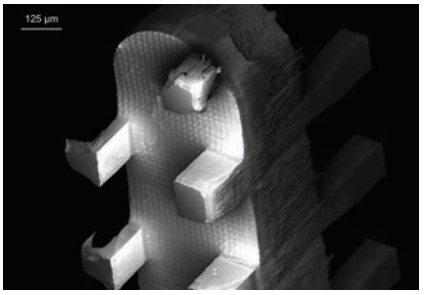
Take gold spirals about the size of a dime and shrink them down about six million times. The result is the world's smallest continuous spirals—nanospirals—with unique optical properties that are almost impossible to counterfeit when added to identity cards, currency, and other valuable objects. Students and faculty at Vanderbilt University, Nashville, Tenn., fabricated these tiny Archimedes' spirals and then used ultrafast lasers to characterize their optical properties. The spirals have solid arms and are much smaller than traditional ones: A square array with 100 nanospirals on a side is less than a hundredth of a millimeter wide. When these spirals are shrunk to sizes smaller than the wavelength of visible light, they develop unusual optical properties. For example, when they are illuminated with infrared laser light, they emit visible blue light. A number of crystals produce this effect, called frequency doubling or harmonic generation, to various degrees. The strongest frequency doubler previously known is the synthetic crystal beta barium borate, but the nanospirals produce four times more blue light per unit volume. The combination of the unique characteristics of their frequency doubling and response to polarized light gives the spirals a unique, customizable signature that would be extremely difficult to counterfeit, according to researchers. *vanderbilt.edu.*

Scanning electron microscope image of a single gold nanospiral. Courtesy of Haglund Laboratory, Vanderbilt University.

REALIZING THE FULL POTENTIAL OF NANOFIBERS

Researchers at Massachusetts Institute of Technology, Cambridge, developed a new technique for producing nanofibers that increases the rate of production fourfold while reducing energy consumption by more than 90%, enabling inexpensive, efficient nanofiber production.

"We demonstrated a systematic way to produce nanofibers through electrospinning that surpasses the state of the art," says Luis Fernando Velásquez-García, a principal research scientist at MIT. "But the way that it's done opens a very interesting possibility. Our group and many other groups are working to push 3D printing further, to make it possible to print components that transduce, that actuate, that exchange energy between different domains, like solar to electrical or mechanical. We have something that naturally fits into that picture. We have an array of emitters that can be thought of as a dot-matrix printer, where you would be able to individually control each emitter to print deposits of nanofibers." *For more information: Luis Fernando Velásquez-García, 617.253.0573, lfvelasq@mit.edu, web.mit.edu.*



A scanning electron micrograph of the new microfiber emitters, showing arrays of rectangular columns etched into their sides.

Optimize Furnace Performance

with Expert Advice and Resources

1. Finding Leaks in Your Vacuum Furnace – Part I

2. A Daily Checklist for Preventative Maintenance

3. PID Tuning as First Step for Preparing for TUS and SAT

1 When it comes to finding leaks in your furnace, it can be a true art form. One of our most common customer questions concerns how to find a leak using a helium mass spectrometer. Which is why, in this video and during Ipsen U, we show attendees first-hand how to perform a leak check using a helium mass spectrometer, including how to calibrate the helium mass spectrometer and how not to flood the system with helium.

An essential part of the leak check process is knowing which parts of the furnace should be checked for leaks, starting with the …

Watch the video on finding leaks in your furnace:
bit.ly/Optimize-FindingLeaks

2 When working with furnace equipment, it is essential to extend the life of your vacuum furnace as long as possible. An effective method for doing so is to adhere to a carefully scheduled preventative maintenance plan.

However, one of the hardest things to know (and keep track of) are all the furnace components you need to review on a regular and/or periodic basis. In an effort to help with this, we have provided a few basic checklists that are grouped by the frequency in which certain preventative maintenance tasks should be ...

See the full article for all of the items you should include on your checklist:
bit.ly/Optimize-DailyChecklist

3 In the complex world of heat treatment, nothing is more important than validating your equipment to ensure uniformity, reliability and repeatability. An important part of validating your equipment is performing surveys, such as Temperature Uniformity Surveys (TUS) and System Accuracy Tests (SAT). However, in order to correctly perform such surveys, you must know how to properly configure your equipment.

The first order of business: PID Tuning. A proportional-integral-derivative (PID) controller is used to help ensure the temperature of the furnace during a heating cycle stays ...

Read the full article and discover how to tune your PID controller:
bit.ly/Optimize-PIDTuning

For more resources, visit www.IpsenHarold.com

Ipsen

BERYLLIUM OPTICS ENABLE ADVANCED SPACE TELESCOPES

Beryllium won a lengthy competition as the material of choice for the mirrors on the James Webb Space Telescope, set to launch in 2018.

Don Hashiguchi, FASM*
Materion Corp.
Elmore, Ohio

James Marder, FASM*
Thermacore Inc.
Rostraver, Pa.

Roger Paquin*
Advanced Materials Consultant
Grantham, N.H.

*Member of ASM International

Launching objects into earth's orbit is enormously expensive, so every pound removed saves significant cost. When considering materials for the James Webb Space Telescope (JWST), a lengthy competition took place to determine the best choices and beryllium was ultimately specified for the mirrors. This article documents the developmental history leading up to that decision. It took decades of improvements to make Be—in particular O-30 atomized powder/hot isostatically pressed (HIP'd) components—homogeneous, isotropic, polishable, thermally and dimensionally stable, and above all, predictable.

BERYLLIUM PROPERTIES: IDEAL FOR SPACE

The most obvious requirements for space optics include low mass, high stiffness, predictable contraction when cooled to cryogenic temperatures, and the ability to be polished to a highly reflective surface. These characteristics were recognized and discussed as design parameters as early as 1966 by Barnes[1], while limitations of the available vacuum hot pressed (VHP) Be were also detailed. A decade later, after numerous telescopes with Be mirrors were already in orbit, hot isostatic pressing was advocated for Be optics and an evaluation of HIP'd Be material in comparison with VHP'd Be from the same powder was published[2]. The new material was found to be superior and therefore meets the specifications for infrared mirrors.

Low thermal expansion glass, such as the ULE fused silica (Corning's Code 7972 Ultra Low Expansion Glass) selected for the Hubble Space Telescope primary mirror, meets several of the material criteria very reliably—but not as well as O-30 Be, which was developed specifically for satellite mirrors. Table 1 compares the important properties of O-30 Be, ULE, aluminum, and magnesium.

In order to minimize mass, using a low density material is an obvious first step: The density of ULE is slightly less than that of Al. However, conventional mirror materials such as ULE and Al are much heavier than Be, which is 31% lighter than Al and 18% lighter than ULE. Magnesium is 6% lighter than Be. Yet another factor is stiffness, or modulus of elasticity, which is equally important because it measures how well a material resists deformation under load. Beryllium is 400% stiffer than both Al and ULE and 670% stiffer than Mg. Specific stiffness—the ratio of modulus to density—determines the engineering efficiency of a material, and it is clear that Be is more than five times better than the other materials in this regard.

Specific stiffness measures how well a structure maintains its shape in the face of forces such as gravity, launch, or maneuvering g's. After a mirror is polished to its desired shape—or *optical figure*—on earth at 1 g, it changes figure in the 0-g orbital environment. This "gravity release" causes only a slight figure change, but with very lightweight mirrors these changes, measured in fractions of wavelengths of light, can be enough to substantially distort the image. Grinding and polishing the mirror on earth to what will become the correct figure in space is called *null figuring,* which is much easier with a material featuring a high specific stiffness because the distortions are so much smaller. Surprisingly, steel, Al, Ni alloys, and Ti alloys all have similar ratios to Mg and ULE, while the specific stiffness of Be surpasses all of these, as shown in Table 1.

Historically, Be was not considered an ideal optical material[1]. However, due to its significant weight and stiffness advantages, a concentrated development effort worked to overcome its limitations. During the 1980s, the Strategic Defense Initiative emphasized the need for extremely lightweight, high performance surveillance satellites. It was during the "Star Wars" initiative that the shortcomings of Be as a mirror material were generally recognized and possible solutions imagined. Designers of satellite mirrors and structures constantly thought about how to save even a single pound. Beryllium affords these designers the opportunity to potentially save hundreds of pounds.

BERYLLIUM SPACE TELESCOPE HISTORY

The reflecting mirrors that act as the compound eyes of the James Webb Space Telescope are among the most precise and complex space optics ever fabricated. Essential to the telescope's performance are the characteristics of 18 adjustable segments that make up the 6.5-m primary reflector. Specifying Be broke new ground in high performance space optical materials development, and was a significant departure from the glass Hubble Space Telescope primary mirror that preceded the JWST. However, even during the 1970s, many space telescopes featured Be optics. These early mirrors cleared the path to the improved polishability and stability of the JWST.

TABLE 1–ROOM TEMPERATURE PROPERTIES OF MIRROR MATERIALS

Property	Symbol	Units	O-30 Be	ULE	6061 Al	Mg
Density	ρ	g/cm^3	1.85	2.21	2.70	1.74
Modulus	E	GPa	303	68	68	45
Specific stiffness	E/ρ	$10^6 m^2/s^2$	163	30	25	26
Coeff. of thermal expansion	α	$10^{-6}/K$	11.4	0.03	22.5	24.8
Thermal conductivity	k	W/m•K	208	1.3	167	156

Space telescopes serve many purposes, ranging from weather and astronomical exploration to communications and a variety of scientific and military applications. Increasing demand for higher resolution, lighter weight, and greater dimensional stability has driven the choice of many systems to Be, but with increased emphasis on dimensional stability and polishability.

Beryllium use for light, stiff, low moment of inertia applications during and after WWII show that it could be the right material for mirrors and structures in the new field of space technology. One of the earliest applications of Be mirrors in space was the Multi-Spectral Scanner for the Landsat earth imaging satellite in which the S-200E grade was used. The earliest applications were electroless nickel plated because uncoated S-200E could not be polished to the required finish. The first of these Landsat satellites was launched in 1972. Later versions include the Thematic Mapper instrument, which used S-200F, an improved version of S-200E. An SEM micrograph of the powder and an optical micrograph of consolidated S-200F are shown in Figs. 1 and 2, featuring an oxide content of approximately 1% BeO.

Another early space optical application was VISSR, the Visible Infrared Spin Scan Radiometer on the GOES, Geostationary Operational Environmental Satellite[3]. The scan mirror was particularly critical in this application, and any bending as the mirror reversed direction would have distorted the image. The extremely low moment of inertia Be scan mirror provided the required image stability, whereas conventional materials could not. The three mirrors for the early VISSR telescopes were plated with electroless nickel for polishability[4]. The first of these satellites was launched in 1974 and GOES satellites are still produced and launched. The VISSR instrument was replaced by a multispectral scanner that continues to use lightweight Be mirrors, with improved Be grades specified as they became available.

One of the first space telescopes to use an engineered grade of Be was IRAS, the InfraRed Astronomical Satellite, launched in 1983. It had a 60-cm primary mirror of I-70A Be and was polished bare, without a Ni coating. IRAS was one of the first athermalized telescopes where all components, including the mirrors and structure, were made of Be. This ensured that the entire assembly contracted uniformly to the 10K operating temperature. The coefficient of thermal expansion of Be at that temperature is virtually zero, which guarantees dimensional stability with any minor temperature variations. The IRAS primary mirror did, however, exhibit significant thermal figure distortion at the cryogenic temperature, but that distortion only minimally affected measurements at the shortest wavelength of 12μm. At longer wavelengths, the telescope was diffraction limited.

The successor to IRAS was the Shuttle InfraRed Telescope Facility, SIRTF, now designated Spitzer Space Telescope, one of NASA's four great

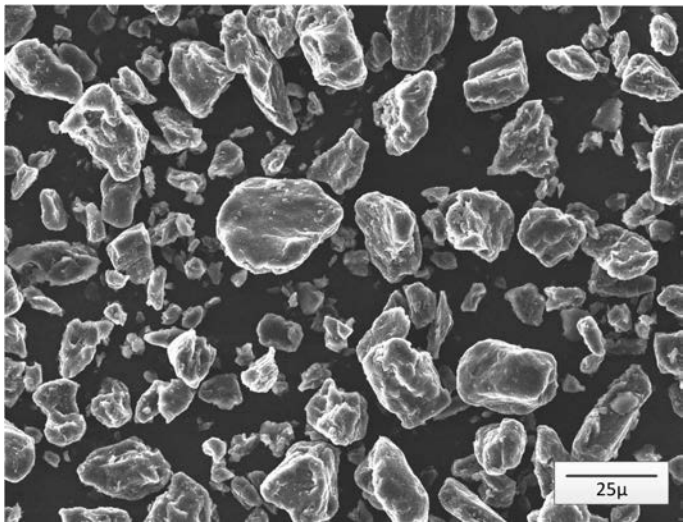


Fig. 1 — 500× SEM photomicrograph of S-200F grade blocky shaped beryllium powder produced by impact grinding. All images courtesy of Materion except 5 and 6.

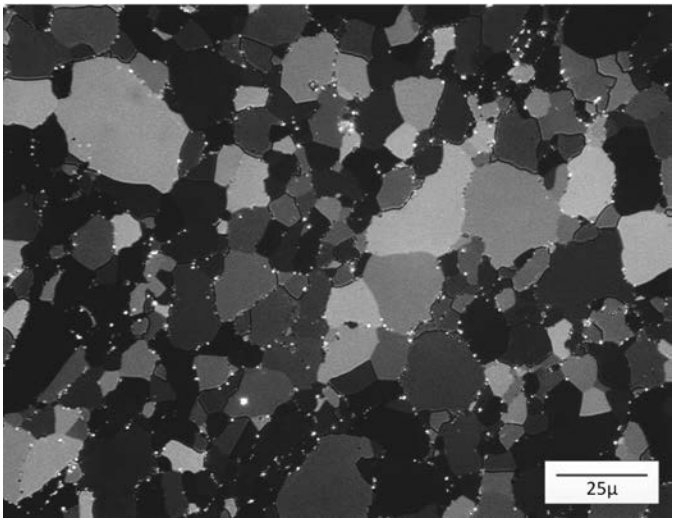


Fig. 2 — Polarized light photomicrograph of S-200F grade beryllium.

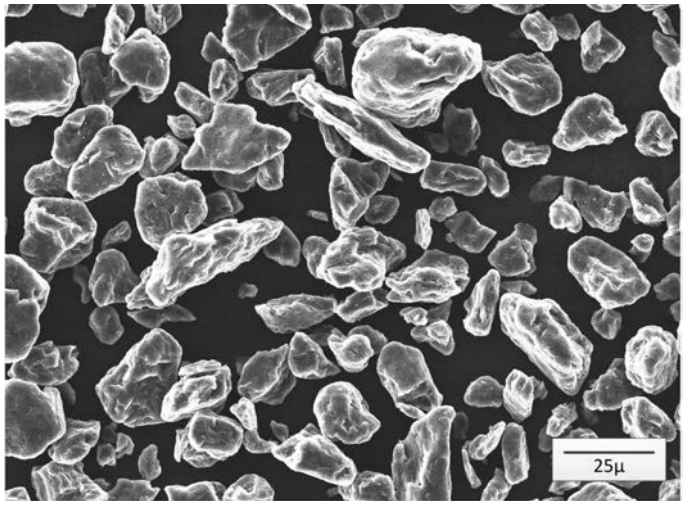


Fig. 3 — SEM photomicrograph of I-70 grade beryllium powder produced to a higher purity in comparison to S-200F grade that improved the ability to produce a polished mirror surface. Powder is produced by impact grinding.

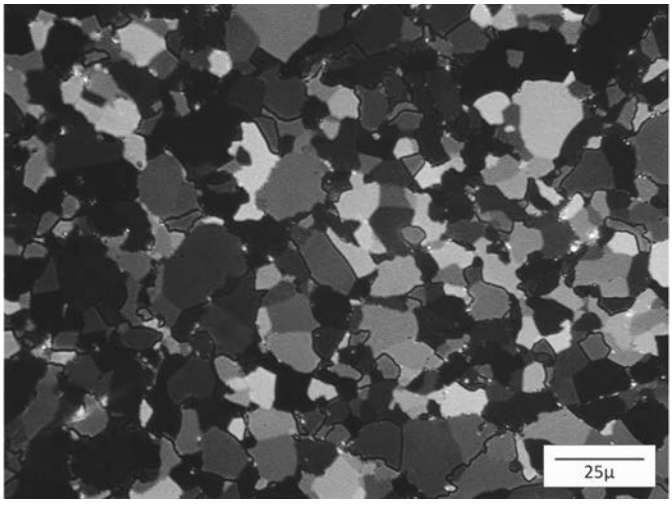


Fig. 4 — Polarized light photomicrograph of I-70H grade of beryllium consolidated by HIP. Higher purity input powder in comparison to S-200F is illustrated by fewer white oxide particles.

observatories. With its 85-cm diameter, bare polished primary mirror made of HIP consolidated I-70 Be (I-70H), this all-Be telescope operates at 5.5K. An SEM and associated light micrograph of I-70H are shown in Figs. 3 and 4. The telescope shown in Fig. 5 is the prototype being tested at Jet Propulsion Laboratory[5]. The excellent surface finish and optical figure obtained, as well as the insignificant thermal dimensional instability observed when tested at 10K, were a direct result of the improved material quality achieved by the HIP process. Because the optical figure of the primary mirror was tested at cryogenic temperatures, the correction to the small figure error was polished into the surface in a process called cryo null figuring. While neither the scatter nor optical figure of this telescope would be acceptable for a diffraction limited visible wavelength system, it exceeded specifications for the mid and far infrared wavelengths being observed.

The low oxide content and residual inhomogeneity found in I-70H (0.7% BeO) needed to be reduced even further before Be could become a viable candidate for JWST mirrors, because they operate at much shorter wavelengths. The next step—development of spherical Be powder consolidated by HIP—provided the ultimate material for the JWST mirrors. Four mirrors are used in the JWST, including the 18 segment 6.5-m primary, 738-mm secondary, 738 x 517-mm tertiary, and a 172.5-mm fast steering mirror to stabilize the image. All mirrors are gold-coated for enhanced infrared reflectance. Figure 6 shows the finished mirrors and the complete JWST[6].

Each of the 18 primary mirror segments (plus spares) measures 1.3 m and weighs approximately 40 kg (88 lb). Segments were polished to a surface figure accuracy of 24.2 nm rms and include

Fig. 5 — Prototype SIRTF telescope undergoing random vibration testing[5].

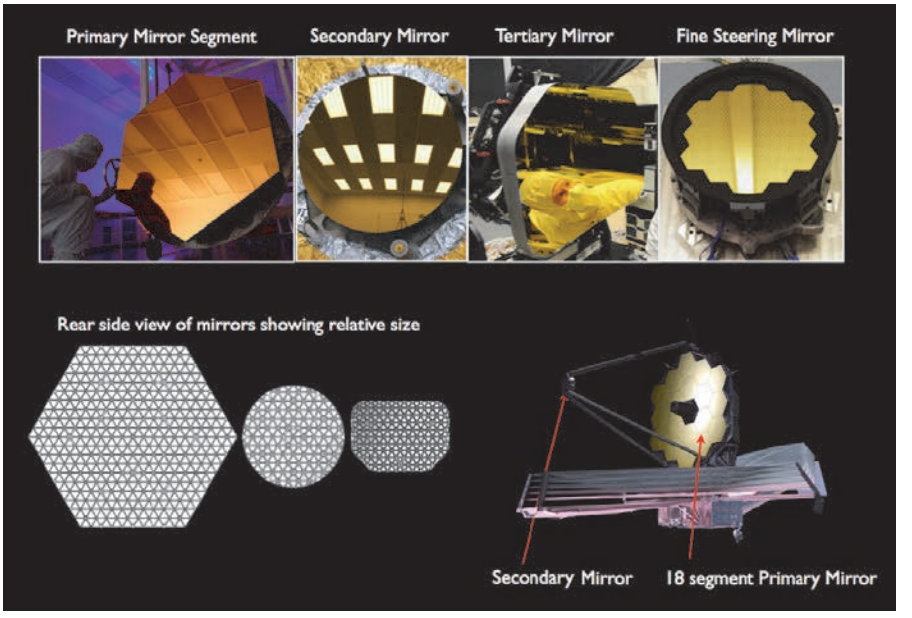


Fig. 6 — James Webb Space Telescope and its mirrors[6]. Bottom right shows an artist's conception of the telescope optics with 18 primary mirror segments. On the bottom row are the three different mirror segments as seen from the rear showing the honeycomb structure that makes them both light and stiff.

a vacuum deposited gold coating, 1000 Å thick. The convex secondary mirror, though much more difficult to polish and measure, has a similar figure accuracy.

BERYLLIUM POWDER: HISTORICAL DEVELOPMENT

Beryllium processing traditionally starts with vacuum melting and casting as part of the refining process. Vacuum melting removes residual magnesium and oxides that might be carried over from the reduction of beryllium hydroxide into metallic Be. Newly refined as well as recycled Be are input to the vacuum casting step. Statically cast beryllium features a typical ingot structure, with large columnar grains growing inward from the ingot wall and residual porosity toward the center. This results in property anisotropy, difficulty in machining, and overall poor properties. However, machining the ingot into chips prior to powder processing helps improve properties.

Powder metallurgy was used in the late 1940s to produce fine grained, nearly random-structured material. The more random grain and crystal orientation improves isotropy, particularly the coefficient of thermal expansion, while the finer grain size also improves mechanical properties. In the 1940s and 50s, beryllium powder was produced by two different processes—ball and attrition milling. Ball milling uses a rotating canister filled with chips and grinding media generally made of hardened steel. Beryllium was crushed and sheared into fine powder flakes, but this was a costly batch operation and resulted in iron contamination from the grinding media. Attrition milling was a continuous process in which beryllium chip was fed into a device similar to old flour mills. The chip passed between rotating and stationary beryllium plates and was sheared into powder particles. The weakest orientation of the Be crystal is the basal plane and this process produced powder particles with a slight flake-like structure by fracture on the basal plane.

Impact grinding to produce beryllium powder was introduced as a production process in the late 1970s and uses high velocity gas to propel Be chips against a Be target. The air is dried, and then cools as it expands from the nozzle. The impact shatters the chips into powder particles, which exhibit a blockier shape than ball or attrition milled powder. This process was also semi-continuous because oversized powder particles could be separated by air elutriation and fed back into the impact stream. This process improvement reduced iron and oxygen contamination, and produced a powder shape less related to the crystal structure than other processes. This was important during vibratory loading of containers in preparation for consolidation into a solid. The flat surfaces of flakes are all basal planes. When flakes are loaded into a press to consolidate them, they can stack up like a deck of cards or sheets of mica, with large regions having the same crystal orientation. Each of these regions behaves differently than adjoining regions with different orientations. When the solid, polished mirror cools, the difference between regions gives the surface an orange-peel appearance, which means that each region is reflecting a beam of light at a slightly different angle, scattering the beam rather than reflecting it in one uniform direction. Each time the mirror is warmed and cooled, these regions actually deform one another slightly. Scattering is unpredictable and changes on each cooling cycle. Therefore, additional polishing is not a solution.

The process that made the most sense for making powder was inert gas atomization, developed in the late 1980s for beryllium. A stream of liquid metal is blasted into small droplets by

a stream of gas in a two-story chamber, resulting in spherical particles. Helium, argon, and ultimately nitrogen were all used as atomization gases. An SEM micrograph of atomized Be powder is shown in Fig. 7.

Spherical particles pack together with no relation to crystal orientation. Because each particle is randomly oriented, no large regions can develop. Properties level themselves out, leading to an essentially uniform surface. In conjunction with HIP consolidation, this results in a predictable mirror with equal thermal contraction in all directions. In addition, oxide particles degrade the performance of a mirror because each oxide particle acts as a separate scattering source. Therefore, lower oxide translates into improved optical performance. The solid optical blanks made from the atomized optical grade of beryllium powder, O-30, have less than 0.35% beryllium oxide. Recall that I-70A and S-200F have 0.7% and 1% oxide respectively. Atomized powder is therefore an excellent choice for a mirror material[7].

Once the powder is made, it is compacted into a solid. Historically, powder was vacuum hot pressed into solid cylinders ranging from roughly 8 to 72 inches in diameter. Aerospace components requiring the highest level of stiffness to density were made from these cylinders. For example, the Space Shuttle umbilical doors were machined from large-diameter hot pressed cylinders, as were the window frame, brakes, and navigation base. The Advanced Inertial Reference Spheres (AIRS) of the Peacekeeper ICBM (intercontinental ballistic missile) were likewise machined from vacuum hot pressed beryllium. This hot pressing method leaves less than 0.5% voids, but does not totally eliminate them. For the JWST Telescope, all voids had to be eliminated, leading to use of hot isostatic pressing (HIP)[2].

Although HIP was developed by Battelle at its Columbus, Ohio, headquarters in the 1940s for cladding nuclear reactor fuel rods, its uses have greatly expanded to include casting densification, powder consolidation, and diffusion bonding. In HIP, powder is poured into a metal can that is evacuated and sealed. This is then placed into the HIP unit, which is pressurized with argon and heated. A typical pressure compressing the can and its contents is 15,000 to 30,000 psi and temperatures to 2000°C can be applied. The solid that emerges after the can is removed is completely free of voids. Another advantage of HIP is that the pressure is applied in all directions so it maintains the non-directionality of the final product better than uniaxial vacuum hot pressing. The microstructure of consolidated O-30 is shown in Fig. 8.

Technologists who worked on mirrors in the 1960s reported that beryllium atomization trials were unsuccessful. In particular, very high oxide levels resulted. Much effort was spent making certain that the new atomizer was airtight to control the oxygen level. HIP'ing beryllium powder had also been tried, but failed because voids were formed when

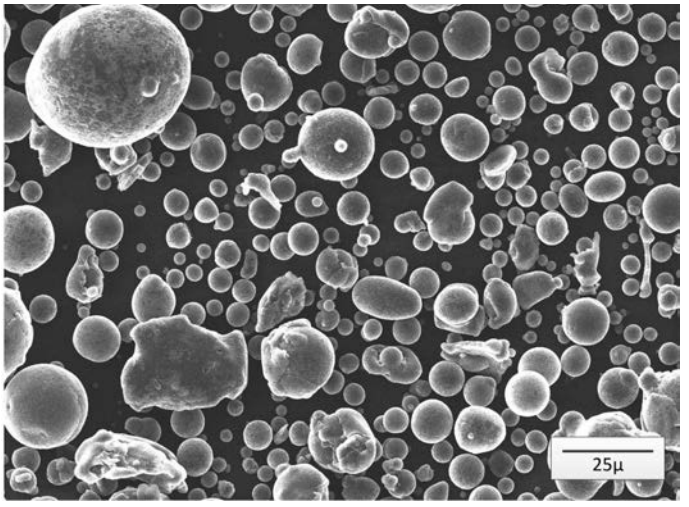


Fig. 7 — SEM photomicrograph of inert gas atomized O-30 grade Be powder.

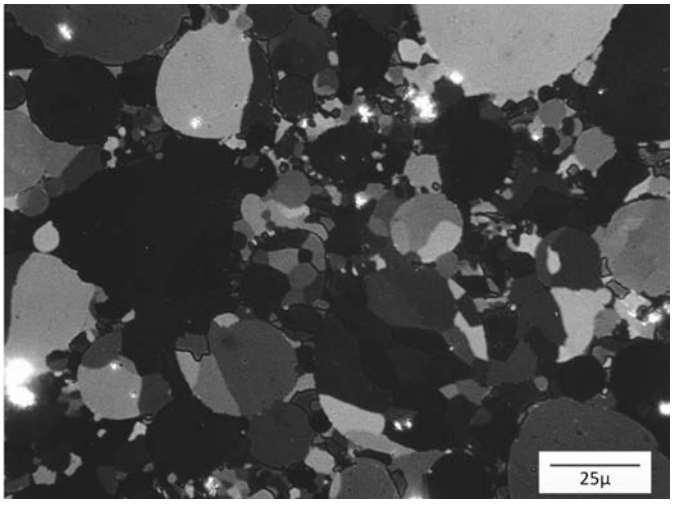


Fig. 8 — Polarized light photomicrograph of O-30 H grade beryllium consolidated by HIP from inert gas atomized beryllium powder. Spherical prior particle boundaries containing multiple grains per particle are evident.

the solid mirror blanks were heat treated, which was referred to as "HIP disease." When O-30 was developed, it was recognized that water molecules entrained on the surface of powder particles were the cause of HIP disease, now called "thermally induced porosity." The process was further developed to eliminate the water molecules and therefore the disease.

The James Webb Space Telescope is scheduled for launch in 2018. It is expected to provide as dramatic an improvement over the Hubble as the Hubble did over previous observatories. The evolution of beryllium as the optical material will provide a substantial contribution to the success of the new telescope.**~AM&P**

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TECHNICAL SPOTLIGHT

TESTING INORGANIC AND ORGANIC MATERIALS WITH A NEW ION SOURCE

A new monatomic and gas cluster ion source for XPS instruments uses both Ar^+ and Ar_n^+ (n>1000) gas cluster sputtering to clean surfaces and create depth profiles for a growing class of advanced materials.

A common technique called depth profiling uses x-ray photoelectron spectroscopy (XPS) to evaluate layered materials using ion etching. However, before testing can even begin, samples that arrive at the laboratory often need to be cleaned of contamination. Most XPS instruments include an ion gun that produces monatomic argon ions (Ar^+). This gun works particularly well for most inorganic materials, keeping the chemical structure intact as layers are removed by ion bombardment. However, other classes of materials, such as polymers, biomaterials, and even some metal oxides, can be damaged by interaction with the ion beam, changing the material's chemistry and distorting test data.

To enable cleaning or depth profiling of these types of materials, an ion source that sputters the sample surface using large, singly-charged gas clusters was developed. The new monatomic and gas cluster ion source (MAGCIS) for Thermo Scientific XPS instruments uses both Ar^+ and Ar_n^+ (n>1000) gas cluster sputtering, enabling surface cleaning and depth profiling of a growing class of advanced materials that include both hardened inorganic and softer organic materials.

Complex, multilayered materials are increasingly used in a wide range of products and devices. These materials were traditionally based around metallic or oxide layers. However, with today's drive toward lightweight and less expensive components, polymer-based materials are becoming more common, particularly in areas such as display technologies, biomedical devices, and energy generation. Understanding the interaction of these layers with each other and the environment is a crucial part of the development cycle. Because these interaction zones are typically just a few nm thick, understanding their chemistry requires techniques that are especially surface sensitive and can profile through the material to access subsurface interfaces.

XPS is one such technique. It is very surface sensitive, the sampling depth is generally less than 10 nm, and it provides quantitative chemical information. To probe subsurface layers, an XPS system is usually fitted with an ion gun that produces monatomic argon ions to remove material from the surface. This works particularly well for inorganic materials. A range of beam energies are usually available, typically from a few hundred eV up to a few keV, giving operators a choice of etch rates depending on the thickness of the layers to be analyzed. Spectroscopy helps with material removal by ion milling to generate a depth profile, typically displayed as atomic concentration, which shows the variation in the chemistry with depth into the surface. Depths up to a few microns can be investigated using this approach.

This method has been available for many years. However, it is particularly unsuccessful with polymeric systems, which tend to be chemically modified by interaction with the ion beam. This chemistry change affects the spectra obtained during the depth profile experiment because they no longer represent the original material. To allow depth profiling of the increasing number of polymer-based systems, gas cluster ion sources have been developed.

The key to minimizing damage to a polymer system during depth profiling is to reduce the energy going into the surface. With a monatomic beam, any energy not used to eject material from the surface generally penetrates into the surface, breaking bonds and damaging the remaining material. This damage is typically just greater than the XPS information depth, so spectra become representative of the damaged surface rather than the real surface.

It is possible to reduce the damage zone by reducing the beam energy, but below a threshold of roughly 50 eV, it no longer has an effect on the surface. This threshold can be negated by making the projectile much heavier: By using a weakly bound cluster of several thousand gas atoms, material can still be removed, and the beam energy can spread across the whole cluster. Upon impact, the cluster removes surface material, but also breaks apart, minimizing penetration of the projectile into the surface, and instead disperses the energy in the beam laterally. By having such a low energy per atom, damage to the remaining surface is substantially reduced, so the resultant spectra represent the sample's actual chemistry.

PROFILING ORGANIC FIELD EFFECT TRANSISTORS

The trend toward thin, low cost, flexible electronic systems has led to the design of many organic microelectronic components, including field effect transistors (FETs). Early organic FET designs were based on aromatic organic semiconducting materials, while recent developments explore organometallic species, which potentially offer greater

performance. Copper phthalocyanine (CuPc) is of significant interest as an organometallic semiconductor and is the basis for the device under study.

Using a depth profiling technique, XPS can monitor the composition of a coated or layered material to greater depths (hundreds of nm or even µm scales). Traditional ion sputtering depth profiling techniques cause significant damage to the subsurface of "soft" organic materials, which is visible in XPS data as a loss of structure and chemical information. The new MAGCIS source addresses this problem. The gentle, shallow sputtering from argon cluster ions does not cause subsurface damage, so XPS data preserve chemical state information throughout the entire profile. MAGCIS can also generate traditional monatomic ion beams for profiling inorganic materials, so it is possible to profile through an organic layer with the cluster ions, then switch to monatomic ions to profile into a harder substrate.

The K-Alpha⁺ XPS instrument, fitted with the MAGCIS cluster ion source, was used to acquire depth profiles from the CuPc FET, and was profiled with 4 keV argon cluster ions, with an average cluster size of 2000. The source was then switched to monatomic ion generation to profile through the SiO_2 isolation layer into the silicon substrate. The two profiles were combined to produce a single depth profile through the entire organometallic/inorganic stack.

In this analysis, the spectra are similar, but the device sample has more hydrocarbon signal from surface contaminants at 285 eV. This confirms that the surface chemistry of the organic layer approximates CuPc. MAGCIS cluster ion sputtering successfully removed material without causing subsurface damage, so the XPS spectrum resembles a pure material. This is a primary strength of the cluster ion technique, which allows depth profile analysis of organic materials without visible damage in XPS data. The spectral quantification in Table 1 confirms that the exposed CuPc is an excellent match to the expected composition.

By sputtering through the CuPc with cluster ions, and through the SiO_2 with monatomic ions, building up a profile of the entire device stack is possible (Fig. 2).

CLEANING METAL OXIDES

The benefits of cluster ion sources are not limited to depth profiling experiments; they can also be useful for more routine analysis. For example, accurately quantifying the chemical compositions of metal oxide samples with XPS can be hindered by adventitious carbon contamination, typically present on the surface. Gas cluster ions do not penetrate the oxide surface, preserving chemical state information while still cleaning contamination from a sample. With the ability to provide both cluster ions and monatomic ions, the MAGCIS source offers versatility and convenience for a range of sample types.

The K-Alpha⁺ XPS instrument was used to acquire spectra from a sample of tantalum pentoxide. Spectra were taken at three different areas following different cleaning processes. In the first area, spectra were taken in an as-received state with no cleaning performed; in the second position, the sample was sputtered with 200-eV monatomic ions before analysis; and at the third position, the sample was analyzed following sputtering with single-ion argon clusters. For this experiment, cluster beam energy was 4 keV with a cluster size of 1000 atoms. Survey spectra (wide scans covering the entire elemental range) were also collected from uncleansed areas, as well as the area that had been sputtered with the cluster ion beam.

TABLE 1–QUANTIFICATION OF MAGCIS-CLEANED CuPc

	Expected atomic %	Observed atomic %
C	78.0	78.6
N	19.5	19.4
Cu	2.4	1.9

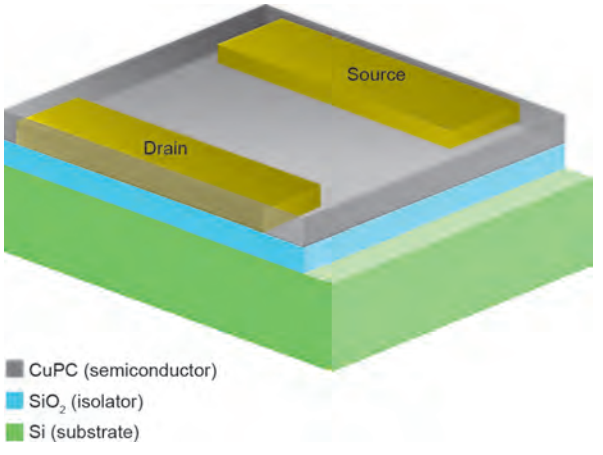

Fig. 1 — Schematic of copper phthalocyanine (CuPc) organic FET.

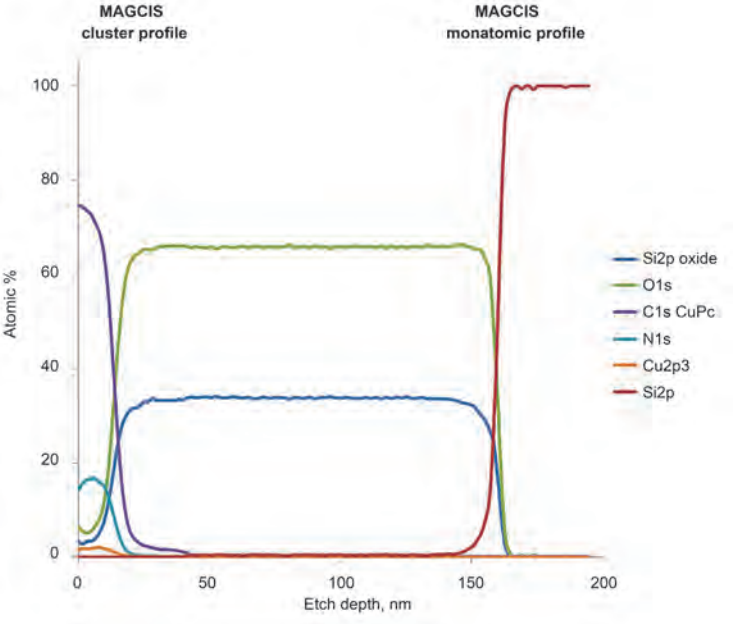

Fig. 2 — MAGCIS profile of organic FET.

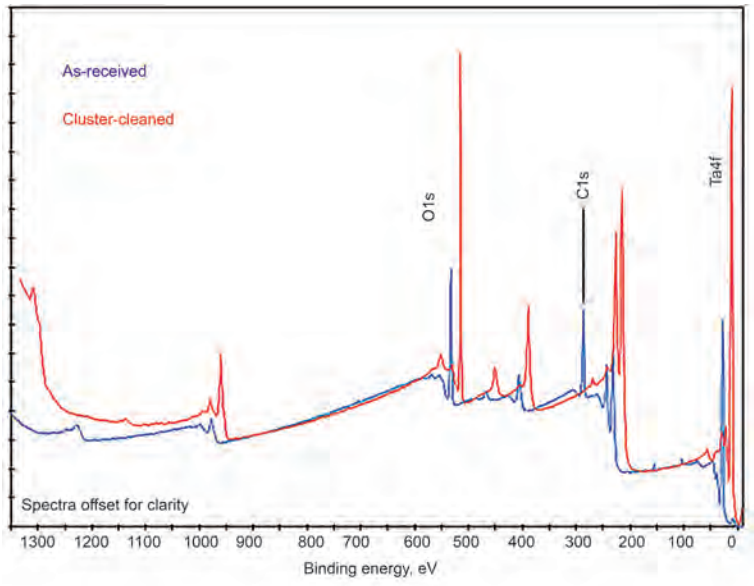

Fig. 3 — Comparison of XPS survey spectra before and after argon cluster ion cleaning.

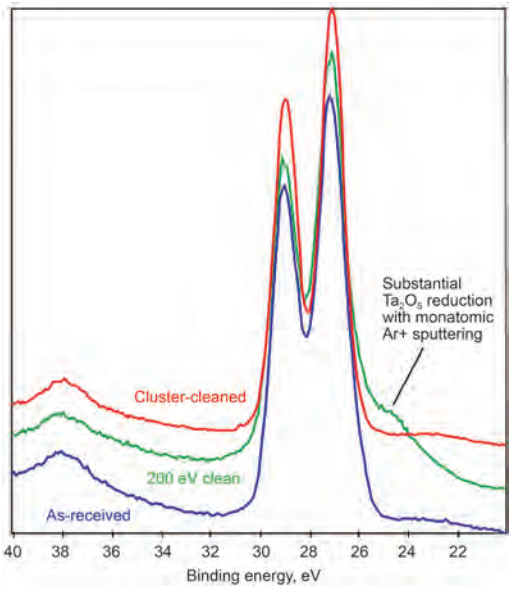

Fig. 4 — Comparison of Ta 4f spectra for monatomic Ar^+ and argon cluster ion sputter-cleaning of Ta_2O_5.

TABLE 2–ATOMIC CONCENTRATIONS BEFORE AND AFTER CLUSTER-CLEANING

Name	As-received atomic %	After cluster cleaning atomic %
C	50.7	0
O	33.7	71.8
Ta	11.8	28.2
Si	3.8	0

TABLE 3–RELATIVE INTENSITIES OF TA 4F OXIDE AND REDUCED COMPONENTS BEFORE AND AFTER SPUTTER-CLEANING

Cleaning method	Ta 4f oxide	Ta 4f reduced
None	100	-
Cluster ions	100	-
200eV monatomic	70.4	29.6

A comparison of the XPS survey spectrum taken from the Ta_2O_5 sample in its as-received state and cluster-cleaned state is shown in Fig. 4. Although the two spectra are similar, the as-received spectrum shows noticeable carbon contamination on the surface, evidenced by the large peak at 285 eV. After the sample was cleaned using the argon cluster beam, contamination is greatly reduced. Quantifying the spectrum shows that the surface is Ta_2O_5.

Table 2 shows atomic concentrations for the two spectra shown in Fig. 3. It is apparent that after cluster-cleaning, surface contamination was removed.

Figure 4 compares Ta 4f spectra from the three areas on the surface—as-received, after a 200-eV monatomic ion clean, and after cluster ion cleaning. The monatomic ion beam cleaned surface shows clear signs of reduction, as seen by the shoulder on the low binding energy side of the doublet, compared to the as-received spectrum. This corresponds to approximately 30% of the surface being reduced due to ion-induced chemical changes. A 200-eV monatomic ion beam provides low beam energy, yet still causes reduction. Using more common monatomic ion beam energies, such as 1000 eV, would cause considerably more damage. The cluster-cleaned surface does not display this reduction, ensuring that the stoichiometry of the surface is preserved following carbon removal. Surface compositions are shown in Table 3.

Even using low-energy monatomic Ar^+ ion sputter-cleaning causes a significant amount of Ta_2O_5 reduction, proving cluster ions can be vital in metal oxide analysis. Gas cluster ion beams are proven to successfully clean inorganic samples without any visible signs of oxide reduction and without inducing chemical changes to the surface being measured.

SUMMARY

The utility of cluster ion beams for XPS analysis is just beginning to be explored, making a range of materials accessible that previously could not be analyzed. When combined with a monatomic source, these cluster ion beams will become an essential tool for any materials analysis laboratory. **~AM&P**

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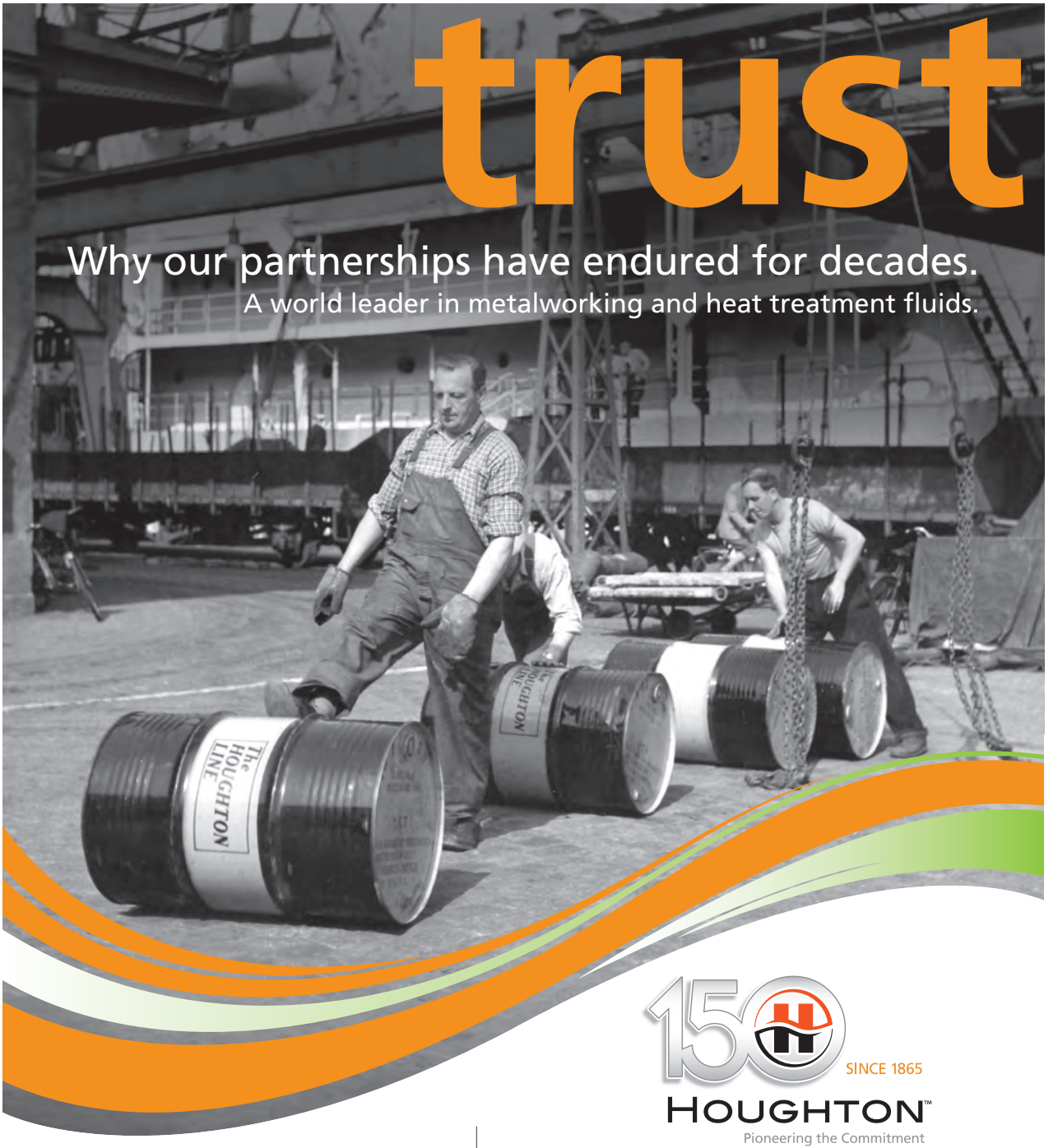

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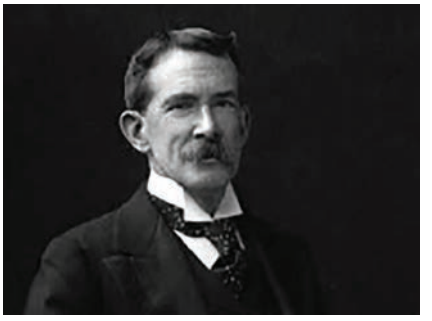
PIONEERS IN METALS RESEARCH–PART I

STEEL PIONEER HENRY MARION HOWE WAS AN INDUSTRIALIST, SCIENTIST, TEACHER, WRITER, AND LIFELONG RESEARCHER.

While Henry Marion Howe wrote his first textbook in 1893 about every aspect of steel known at the time, he is perhaps best known for teaching metallography to many of the students who would go on to develop modern physical metallurgy. He first taught at the Massachusetts Institute of Technology after a brief career in industrial metallurgy. He later accepted a professorship at Columbia University as the first professor of metallurgy in the School of Mining Engineering in 1897.

Howe was born in 1848 to parents who were well known in Boston's intellectual circles. His father, Samuel Howe, was a physician who became the first director of the Perkins School for the Blind. His mother, Julia Ward Howe, was a poet and an ardent supporter of civic causes, in high demand as a lecturer in the women's suffrage movement. She was also famous as the author of the Civil War song, "The Battle Hymn of the Republic." Henry Marion Howe brought his intellectual passion to the field of metallurgy.

His father had many connections after serving in the Greek army during the war with the Turks, so Henry received his early education from European tutors who taught him both French and German. He attended high school at the famous Latin School in Boston and enrolled at Harvard, where he graduated in 1869. Much to his family's dismay, he then studied mining engineering at the recently founded MIT, graduating in 1872. As part of his student training, he worked for a year at the Albany and Rensselaer Iron and Steel Co. in Troy, N.Y., on the Bessemer steel process.



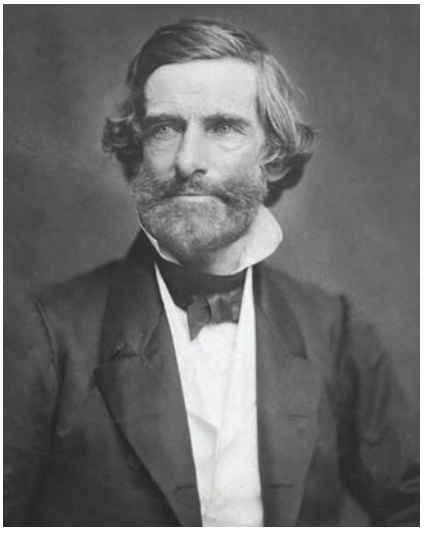
Henry Marion Howe.

Here he came in contact with Alexander Holley, who was building a steel industry with this new process.

Upon graduation from MIT, Howe accepted a job as superintendent of the new Bessemer plant of the Joliet Iron and Steel Co. in Illinois. He stayed only one year and then accepted a job in Pittsburgh at the Blair Iron and Steel Co. After one year in this position, he returned to Boston to spend time writing. In 1877, Howe entered an entirely new field when he went to Chile to oversee the copper mining operations of a wealthy Boston family. Returning to the U.S. in 1879, he supervised the construction of copper smelters in Canada and New Jersey. He then became manager of a copper smelting company in Pima, Arizona. After one year he again returned to Boston, ending his career as an industrial metallurgist. Howe set up a consulting practice and began teaching at MIT.

THE MAKING OF STEEL

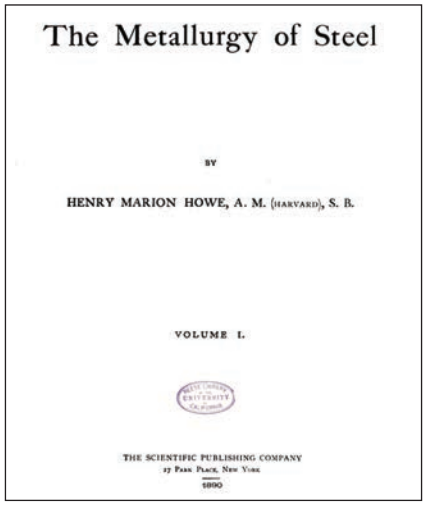
Over the next several years, Howe worked on his first major book, *The Making of Steel,* published in 1893. This book established his reputation throughout the industrial world as a leading metals engineer. Howe surveyed all of the published literature on steel from the U.S., England, France, Germany, and Russia. He covered steelmaking processes in the bulk of the text and included very little on what is now called physical metallurgy. He also covered the known information on alloys, including chromium, manganese, nickel, and tungsten. Much of it was about



Samuel Howe, Henry's father.

Julia Ward Howe, Henry's mother.

ASM's Henry Marion Howe Medal, established in 1923.



The Metallurgy of Steel

BY

HENRY MARION HOWE, A. M. (HARVARD), S. B.

VOLUME I.

THE SCIENTIFIC PUBLISHING COMPANY
27 PARK PLACE, NEW YORK
1890

First page of *The Metallurgy of Steel,* published in 1890.

Green Peace home in Bedford Hills, New York. Courtesy of digital.library.upenn.edu/women/richards/howe/howe-l.html.

the mechanical properties achieved with small amounts of alloy additions. In most instances, he found very little difference between these alloys and plain carbon steel. This was to be expected because the major effect of alloys in steel does not alter the hardness.

He also included extensive information on chromium in steel. Based on chemical analysis, he concluded that most "chromium steel" actually contained little or no chromium, which he blamed on poor workmanship. He cited the Eads Bridge across the Mississippi that was supposed to be made of crucible steel containing chromium. However, chemists found little or no chromium in the steel. Recent studies of the Eads Bridge steel found 0.60% chromium with about the same percentage of carbon. Because this steel was made by the crucible process in 100-lb batches, the chromium could have varied wildly. He finally concluded that there was evidence that chromium could increase the depth of hardening in large parts, in amounts of 2%. Here he had the secret of alloy steels—that they have the ability to increase what we now call hardenability. However, neither Howe nor anyone else followed up on this important concept, which would not be resolved until the 1930s.

TEACHING AT COLUMBIA

Howe joined the Columbia School of Mines in 1897 as the first professor of metallurgy. While there, he did his major work in teaching the new field of metallography and wrote *Metallurgical Laboratory Notes* and two more major books, *Iron, Steel, and Other Alloys* in 1903 and *The Metallography of Steel and Cast Iron* in 1916. He retired in 1913 at age 65 and moved into his second home called Green Peace in Bedford Hills, N.Y. His home was equipped with a full laboratory where he continued his research. With the U.S. entry into World War I, Howe came out of retirement and volunteered his services to the federal government. He served as a consultant to the National Bureau of Standards and the U.S. Bureau of Mines and was appointed to the National Research Council.

Throughout his career, Howe was active in technical organizations. He joined the newly founded American Institute of Mining Engineers in 1871, along with Alexander Holley, while a student in Troy, N.Y. He was elected president of that society in 1893. He was also very active in organizations working on material standards and joined the International Society for Testing Materials. Later, he was a founder of the American Society for Testing Materials and served as president from 1909 to 1911. Howe also joined the new Steel Treaters Club (later ASM International) when it was formed in 1913.

HOWE'S LEGACY

Howe's reputation developed due to his trio of books on steel. His major legacy, however, is based on his metallography courses, which attracted students from across the country. Edgar Bain and Earl Smith from Ohio State, Samuel Hoyt from Minnesota, Charles Fulton from the South Dakota School of Mines, Joseph Emmons from Cleveland, and many others who would go on to teach the subject or conduct major steel research. Among his many honors is the Henry Marion Howe Medal, established in 1923 by ASM for his lifetime contributions to steel metallurgy. The Howe Memorial Lecture was also established in 1923 by the Association for Iron & Steel Technology.

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

save the date

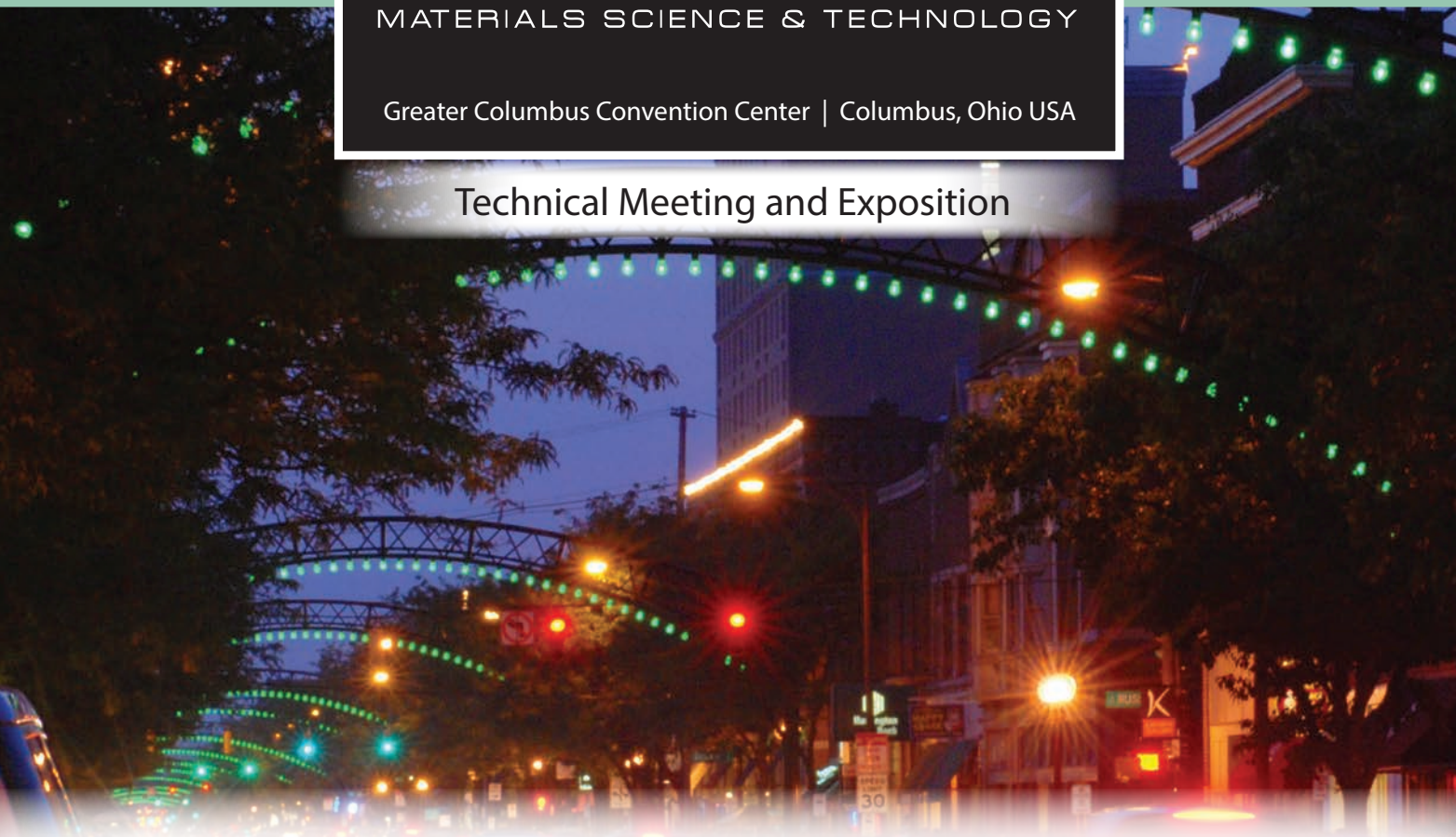
October 4 – 8, 2015

MS&T15

MATERIALS SCIENCE & TECHNOLOGY

Greater Columbus Convention Center | Columbus, Ohio USA

Technical Meeting and Exposition



The technical program covers:

- Biomaterials
- Ceramic and Glass Materials
- Electronic and Magnetic Materials
- Energy Issues
- Fundamentals and Characterization
- Iron and Steel
- Materials – Environment Interactions
- Materials Performance
- Nanomaterials
- Processing and Product Manufacturing

matscitech.org

Organized by:

The American Ceramic Society www.ceramics.org

AIST Association for Iron & Steel Technology

ASM International

TMS The Minerals, Metals & Materials Society

Sponsored by:

NACE International The Corrosion Society

MATERIALS SCIENCE & TECHNOLOGY 2015

October 4–8 • Greater Columbus Convention Center, Columbus, Ohio

Organizers: The American Ceramic Society www.ceramics.org; AIST Association for Iron & Steel Technology; ASM International; TMS

Co-Sponsor: NACE International

The MS&T partnership brings together scientists, engineers, students, suppliers, and other professionals to discuss current research and technical applications, and to shape the future of materials science and technology. In addition to the four organizing societies, NACE International will co-sponsor MS&T15.

PLENARY LECTURES

Tuesday, October 6
8:00–10:40 a.m.
ACerS Edward Orton Jr. Memorial Lecture

"Space: The Materials Frontier"

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

Space environments place tremendous demands on materials that must perform with exceptional reliability to realize the goals of robotic or human space exploration missions. Materials are subjected to extremes of temperature, pressure, radiation, and mechanical loads during all phases of use, including takeoff and ascent, exposure to space or entry into an atmosphere, and operation in a planetary atmosphere. Space materials must be robust and enable the formation of lightweight structures or components that perform the required functions; materials that perform multiple functions are of particular interest. This talk will review the unique challenges for materials in space and some of the specific material capabilities that will be needed for future exploration missions. A detailed description of needs and trends in thermal protection materials and systems will complete the talk.

AIST Adolf Martens Memorial Steel Lecture

"A Complete Theory for Martensitic Transformations"

Harry Bhadeshia, FRS FREng FNAE, Tata Steel Professor of Metallurgy and director, SKF Steel Technology Centre, University of Cambridge, UK

The crystallographic theory of martensitic transformations is so well tested and tried that it does not require attention. However, the response of the transformation to variables such as stress, elastic and plastic strain, mechanical stabilization, austenite grain size effects, austenite grain shape effects, crystallographic texture, and stimuli such as magnetic and electrical fields has only recently been expressed quantitatively. Bhadeshia will demonstrate the "complete theory" that permits quantitative prediction of the effect of all of these variables on martensitic transformations in steels. Further, he will show that the martensite transformation is rightly classified as the most understood of all solid-state phase changes in steels.

ASM/TMS Joint Distinguished Lecture in Materials and Society

"What is a Splendid Leader?"

Vincent J. Russo, FASM, Executive Director, Aeronautical Systems Center (ASC), Wright-Patterson AFB, Ohio (Retired)

The desirability for leaders of major organizations to possess an engineering education seems to be growing daily. But unfortunately, the vast majority of engineers are seldom trained to be effective leaders. This talk is structured to help engineers understand a leadership framework that can be applied to every level of an organization. The framework is identified in the following four pillars: Behavior Realities; Leadership Tenets; Essence of Leaders; and Life Balance. The talk will explain the four pillars and offer tools for use by potential and current leaders. Leadership can be learned; it just takes dedication, study, and hard work. A full treatment of leading technical organizations can be found in the book *The Splendid Leader.*

Designed by internationally recognized architect Peter Eisenman, the Greater Columbus Convention Center is home to this year's Materials Science and Technology Conference and Exhibition, October 4–8.

Columbus skyline with Ohio State Fair. Courtesy of Randall L. Schieber.

TECHNICAL PROGRAM

MS&T15 focuses on 12 major themes covering the breadth of materials science and engineering. These include additive manufacturing; biomaterials; ceramic and glass materials; electronic and magnetic materials; energy; fundamentals, characterization, and computational modeling; green manufacturing technology; iron and steel (ferrous alloys); materials-environment interactions; nanomaterials; processing and manufacturing; and special topics.

EDUCATION COURSES

Saturday, October 3
Microstructures 101 and Beyond
8:30 a.m.–4:30 p.m.

Do you interpret microstructures on a regular basis for quality control, failure analysis, or research? Are you curious about what the structures mean that you have been seeing all these years or is metallography a new field for you? If so, this course is for you.

Introduction to Two and Three-Component Phase Diagrams
9:00 a.m.–5:00 p.m.

This one-day course will introduce attendees to phase diagrams with two and three components. A basic understanding of chemistry is assumed. Topics covered will begin with the underpinnings of a two-component phase diagram and end with complex crystallization in ternary systems.

Sunday, October 4
Advanced High-Strength Steels
8:30 a.m.–4:30 p.m.

Based on the book with the same name, this course is a comprehensive review of the science, technology, and applications of Advanced High-Strength Steels (AHSS). *Advanced High-Strength Steels: Science, Technology, and Applications* is included when taking this course.

Robotics for the Thermal Spray Industry
8:30 a.m.–4:30 p.m.

The creation of a basic robot program for thermal spraying involves a number of rudimentary robotic concepts. These will be explained in some detail in order to move to the more complicated topic of process and path programming.

Understanding Why Ceramics Fail and Designing for Safety
8:00 a.m.–4:30 p.m.
Course details coming soon.

Additive Manufacturing Materials and Processes Workshop
1:00–5:30 p.m.

The purpose of this workshop is to familiarize participants with current additive manufacturing (AM) processes; current AM practices for metals, polymers, and ceramics; modeling of AM processes, microstructural evolution, and service properties; and current challenges and research opportunities.

Introduction to Materials Informatics with Open Source Tools
1:00–4:30 p.m.

Microstructure informatics is an emerging suite of advanced statistical tools and data science methods tailored specifically to the quantification of the hierarchical internal structure (also called microstructure) and the extraction of process-structure-property (PSP) relationships in materials science.

Thursday, October 8 and Friday, October 9
Sintering of Ceramics Short Course
9:00 a.m.–4:30 p.m. and
9:00 a.m.–2:30 p.m.

This course follows key topics in the textbook *Sintering of Ceramics* by M.N. Rahaman, CRC Press, and will be supplemented by detailed case studies of the sintering of specific ceramics and systems.

SPECIAL ACTIVITIES

Welcome Reception
Sunday, October 4
6:00–7:30 p.m.

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

Monday, October 5
Experience Columbus—Information on Columbus Attractions ($15 per person)
9:00–11:00 a.m.

Join the staff of Experience Columbus who will provide information on local activities, sites, and other opportunities for self-guided tours in Columbus. Information on the city's CBUS program will be provided as well as assistance in getting your day planned and started. If you have time to explore Columbus, plan to attend. Coffee and light pastries will be provided. Separate registration is required.

ACerS 117th Annual Meeting
1:00–2:00 p.m.

Watch newly elected officers take their positions as the Annual Membership Meeting is held. All ACerS members and guests are welcome.

ASM Leadership Awards Luncheon
11:30 a.m.–1:00 p.m.

ASM's organizational unit awards as well as awards and scholarships of the ASM Materials Education Foundation will be presented. ASM's incoming Committee/Council chairs will also be recognized for their leadership. ASM Committee and Council members meeting during MS&T, and awardees, will receive an invitation to attend. Others may purchase tickets via meeting registration.

ASM Alpha Sigma Mu Lecture
2:30–4:00 p.m.

Siegfried Hecker, FASM, Stanford University, Calif., will speak about "Metallurgy and Nuclear Diplomacy."

ASM 102nd Annual Business Meeting
4:00–5:00 p.m.

Attend ASM's annual meeting where officers will be elected for the 2015–2016 term and other ASM business will be transacted. ASM members and guests are welcome.

Women in Materials Science and Engineering Reception
5:30–6:30 p.m.

Enjoy the chance to network with professionals and peers over light appetizers while relaxing after a day of sessions.

ACerS 117th Annual Honors and Awards Banquet
7:30–10:00 p.m.

Enjoy dinner, conversation, and the presentation of Society awards. Purchase tickets for $90 via meeting registration.

ASM Canada Council Suite
9:00 p.m.–1:00 a.m.

Tuesday, October 6
ASM Geodesic Dome Design Competition "Domesday"
10:15 a.m.–1:30 p.m.

Can these domes take the weight? Visit the exhibit hall for the display, judging, and selection of winners at the second ASM Geodesic Dome Design Competition. To register as a contestant and for more information, go to asminternational.org/domes.

Ceramic Mug Drop Contest
11:15 a.m.–12:15 p.m.

Mugs fabricated by students from ceramic raw materials are judged on aesthetics and breaking thresholds. The mug with the highest successful drop distance wins.

Ceramic Disc Golf Contest
12:30–1:30 p.m.

This student-initiated contest is sure to draw a crowd! Students create discs from ceramic or glass materials to meet certain specifications, and the discs are thrown into a regulation disc golf basket. Each disc will be judged based on farthest distance achieved and artistic merit (aesthetics).

Plenary Lectures
8:00–10:40 a.m.
See full description on page 37.

Tasting Tour of German Village ($49 per person)
10:00 a.m.–1:00 p.m.

Wear comfortable shoes for this walking and tasting tour through German Village, a vibrant and historic neighborhood located just south of downtown Columbus. During this tour, you will be immersed in the heritage and old world architecture of this charming village and will taste what makes this area unique. Separate registration is required.

ACerS Frontiers of Science and Society—Rustum Roy Lecture
1:00–2:00 p.m.

EXHIBITOR LIST

Booth	Company
725	AdValue Technology
632	Advanced Abrasives Corp.
417	Agilent Technologies
719	Aldrich Materials Science
619	Alfred University (CACT)
604	Allied High Tech
706	American Stress Technologies
620	Angstrom Scientific
809	Anton Paar USA
621	Applied Test Systems
633	Beckman Coulter Canada Ltd.
425	Buehler
518	California Nanotechnologies
705	Carl Zeiss Microscopy LLC
531	Centorr Vacuum Industries
533	CM Furnaces
709	CompuTherm
720	CVD Equipment Corp.
820	Dr. Fritsch Powder Shaping Technology
629	Ebatco
516	EDAX Inc.
742	EMSL Analytical Inc.
808	Extrel
527	FEI
432	Fritsch Milling and Sizing
613	Gasbarre Products Inc. (PTX)
626	Goodfellow Cambridge
512	Granta Design
816	Harper International

Booth	Company
625	Hitachi High Tech America
817	HORIBA Scientific
612	Hysitron
810	International Centre for Diffraction Data (ICDD)
605	JEOL
824	KEYENCE Corp.
419	Keysight Technologies
806	Lake Shore Cryotronics
504	Leco Corp.
407	Linseis
611	Maney Publishing
713	Metal Samples
717	Metcut Research
643	Metkon Instruments Inc.
721	Micromeritics Instrument
405	MTI Corp.
431	MTS Systems Corp.
737	Nabertherm Inc.
813	Nanovea
704	Netzsch Instruments
812	NETZSCH Premier Technologies LLC
537	NIST
637	NSL Analytical Services
519	Nutonian
718	Olympus
711	Ophir-Spiricon LLC
617	Oxford Instruments
821	Panalytical

Booth	Company
631	Photron USA Inc.
732	PREMIER Lab Supply Inc.
805	Proto Mfg. Ltd.
609	Pulstec USA Inc.
510	Renishaw
804	Rigaku
628	SCHOTT North America Inc.
712	Sente Software
825	Setaram Inc.
744	Simpleware Ltd.
545	Spectro
509	Springer
708	Struers
627	TA Instruments
716	TEC (Technology for Energy Group)
424	Tekna Plasma Systems Inc.
505	Tescan
521	Thermcraft
727	Thermo Scientific
520	Thermo-Calc
736	Thinky USA Inc.
630	UES Inc.
517	Union Process
543	United Testing System Inc.
733	Unitron Ltd.
616	Verder Scientific Carbolite
807	Wiley
513	ZIRCAR Ceramics

**Exhibitor list current as of July 17.*

MS&T Young Professionals Reception
4:30–6:00 p.m.

Attend this reception to meet and network with fellow young professionals.

MS&T15 Exhibit Happy Hour Reception
4:00–6:00 p.m.

Network with colleagues and build relationships with qualified attendees, buyers, and prospects.

ASM Awards Dinner
7:15–9:30 p.m.

Join ASM in celebrating the wonderful accomplishments of this year's award recipients and the 2015 Class of Fellows. Tickets, which include the President's Reception following the dinner, can be purchased via the registration form.

Wednesday, October 7
Edward DeMille Campbell Memorial Lecture
12:45–1:45 p.m.

This lecture, "A Correlative Six-Dimensional Study of Phase Separation at the Subnano-Nanoscale of Nickel-Aluminum Alloys," will be presented by Prof. David N. Seidman, FASM.

EXHIBITION

MS&T15 brings together professionals from virtually every field of materials science—metals, polymers, ceramics, and composites. Almost every industry is represented including automotive, aerospace, instrumentation, medical, oilfield, and energy. Reach potential customers from all markets in a single venue. There is also a Professional Recruitment & Career Pavilion with access to seasoned veterans, young professionals, and graduate or post-doc candidates, all primed for the job market.

EXHIBIT DATES AND HOURS*

Monday, October 5
4:30–6:00 p.m.
Opening Reception NEW!—
5:00–6:00 p.m.

Tuesday, October 6
10:00 a.m.–6:00 p.m.
Refreshment Break—10:30 a.m.
Poster Session—11:00 a.m.–12:00 p.m.
Lunch—12:00–2:00 p.m.
Happy Hour Reception—4:00–6:00 p.m.

Wednesday, October 7
9:30 a.m.–2:00 p.m.
Lunch—12:00–2:00 p.m.

**Times are tentative and subject to change*

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That's how you'll feel at goodfellowusa.com

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- Ceramics
- Polymers
- Compounds
- Composites
- Intermetallics
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ASM HEAT TREATING SOCIETY CONFERENCE AND EXHIBITION

October 20–22 • Cobo Center, Detroit

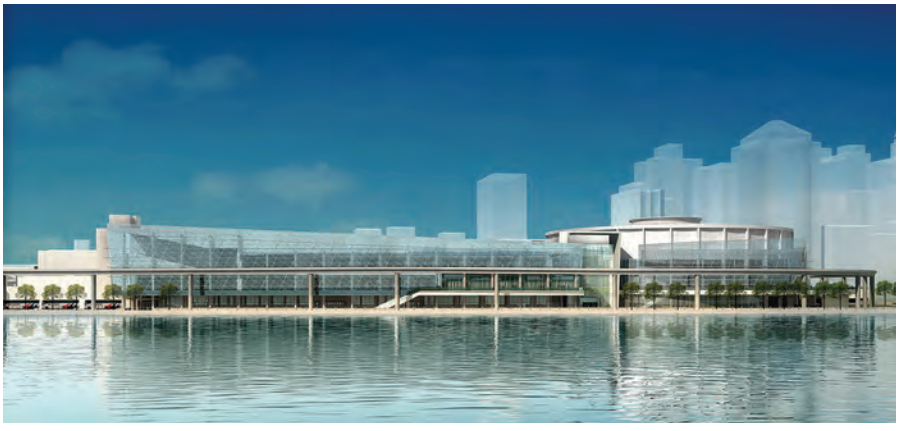
CORPORATE SPONSORS:

SPONSORS:

MEDIA PARTNER:

Don't miss the 28th ASM Heat Treating Society Conference and Exhibition—Heat Treat 2015. The ASM Heat Treating Society and the American Gear Manufacturers Association once again partner to create an exciting mix of education, technology, networking, and exposition opportunities. The event includes more than 130 technical sessions; a special keynote presentation about the LIFT consortium; a panel session featuring "New Directions and Opportunities in Heat Treating;" and a robust exhibit showcasing more than 275 vendors. As a bonus, attendees will have access to drive technology vendors participating in Gear Expo 2015; a new applied technology track, which will provide valuable training to heat treat personnel including shop floor, metal processing, machine shop, and quality assurance personnel, as well as heat treating operators, managers, and technicians; and much more! Heat Treat 2015 also features a free student program this year. College students studying materials science and engineering will receive complimentary registration.

Detroit skyline.



Cobo Center is situated along Jefferson and Washington avenues in downtown Detroit. It is home to this year's Heat Treating Society Conference and Exhibition, October 20–22.

TECHNICAL PROGRAM

The Heat Treat 2015 technical program features sessions on advanced processes; quenching and cooling methods; processes and applications; light metals; applied energy; advances in heat treating; microstructure development and atmosphere technology; and much more.

Special Keynote Presentation
Wednesday, October 21
11:45 a.m.–12:45 p.m.

LIFT Consortium (Lightweight Innovations for Tomorrow)

Presented by Dr. Alan Taub, LIFT Chief Technical Officer

Alan Taub joined the faculty of Materials Science and Engineering at the University of Michigan in 2012. In this role, Taub conducts research in advanced materials and processing.

Master Series

Attend the Master Series with three intriguing lectures on "Martens & Osmond: Hardenite Past & Future," "Bainite and the Bainite Controversy," and "Holloman and Jaffe on Tempering."

EXHIBITOR LIST

Booth	Company
204	Abbott Furnace Co.
542	Across USA Inc.
210	Advanced Energy
627	AFC-Holcroft
235	AFFRI Inc.
655	Aichelin Heat Treatment Systems Inc.
434	Air Liquide Industrial US
508	Air Products and Chemicals Inc.
512	Airflow Sciences Corp.
733	Ajax Tocco
553	Alcon/Cast Alloy
516	Allegheny Alloys
115	Allied High Tech Products
716	Ametek
711	Atmosphere Engineering Co.
237	Avion Manufacturing Co.
137	Bay Composites Inc.
334	Bodycote
449	BTU International Inc.
347	Busch Vacuum Pumps and Systems
526	C&L Development Corp.
433	C.I. Hayes
605	Can-Eng Furnaces International Ltd.
242	Carlisle Carbon Group
106	Castalloy
522	Clemex Technologies Inc.
227	Cleveland Electric Labs
614	CMI Industry Americas
332	Coherent Inc.
453	Connert Industrial Solutions LLC
105	Contour Hardening Inc.
236	Control Concepts Inc.
518	Cooley Wire Products
532	CoorsTek Technical Ceramics
838	Cornerstone Systems Inc.
208	Criterion NDT
744	Custom Electric Mfg.
616	Daniels Fans North America
620	Dante Software
726	Datapaq Inc.
547	Denton TSI
621	DF Fan Services Inc.
536	DIAS Infrared Corp.
534	DixiTech CNC
349	Dowa THT America Inc.
415	Dry Coolers Inc.
420	ECM USA Inc.
214	Edwards Vacuum
232	EFD Induction
318	Elmet Technologies Inc.
612	Ernst US
217	Eurotherm by Schneider Electric
722	Flame Treating Systems Inc.
316	Fluxtrol Inc.
129	Friedr. Lohmann GmbH
501	Furnace Control Corp.
439	Furnace Parts LLC
109	Furnaces, Ovens & Bath Inc.
610	G.N.R. S.R.L.
513	Garden City Fan/Flaktwoods
517	Gear Solutions
321	GeoCorp Inc.
652	GH Induction Atmospheres LLC
320	G-M Enterprises
552	Graphite Machining Inc.
228	Graphite Metallizing Corp.
220	Guntner US LLC
215	H.C. Starck
549	Harry Major Machine
223	Hauck Manufacturing Co.
149	Heat Treating Services Unlimited Inc.
601	Heatbath/Park Metallurgical Corp.
226	HEESS GmbH & Co. KG
328	Herakles (Safran Group)
146	Hind High Vacuum Company (Pvt.) Ltd.
426	Houghton International
148	Idemitsu Lubricants America
443	Induction Tooling Inc.
303	Inductoheat Inc.
120	Industrial Heating
116	Industrial Heating Equipment Assoc.
622	INEX Inc.
739	Inland Vacuum Industries Inc.
335	Innova Techno Products (P) Ltd.
243	Interpower Induction USA
701	Ipsen Inc.
433	J.L. Becker Co.
343	Jackson Transformer Co.
633	Jensen Industries Inc.
753	Jiangsu Fengdong Thermal Technology Co. Ltd.
538	Johnstone Co. Inc.
111	KGO GmbH
732	Kowalski Heat Treating Co.
642	Kurt J. Lesker Co.
216	Lapmaster International LLC
514	Laserline Inc.
326	LECO Corp.
519	Lindberg/MPH
248	Linde LLC
515	LumaSense Technologies
501	Marathon Monitors Inc.
346	Material Interface Inc.
133	McDanel Advanced CeramicTechnologies
649	McLaughlin Services LLC
246	Measuring Instruments/Beijing Dragon Electronics Co.
126	Mersen USA Greenville-MI Corp.
122	Metal Treating Institute
704	Metallurgical High Vacuum Corp.
117	Mitutoyo America Corp.
637	Nabertherm Inc.
528	Neftec Corp.
452	Nitrex
511	Nitrex Metal Inc.
132	North American Cronite
142	NOXMAT GMBH
247	NWL Inc.
119	Oerlikon Leybold Vacuum
211	Park Thermal International
742	Phase II
238	Phoenix TM
110	Power Parts International
608	Praxair Inc.
619	Preco Inc.
353	Premier Furnace Specialists/ BeaverMatic Inc.
118	Procedyne Corp.
127	Proceq USA Inc.
501	Process-Electronic GmbH
143	Pro-Tech Co. Inc.
543	Protection Controls Inc.
229	Proton OnSite
303	PV/T
249	Pyradia
233	Qual-Fab Inc.
303	Radyne
728	Raytek Corp.
520	Rock Valley Oil & Chemical Co.
421	Rohde GmbH
507	Rolled Alloys
139	Sandvik Heating Technology USA
636	SBS Corp.
352	Scientific Forming Technologies Corp.
527	Seco/Warwick
219	Selas Heat Technology
121	Sente Software Ltd.
338	SGL Group - The Carbon Co.
639	Shijiazhuang Zhongqing Import & Export Co. Ltd.
123	Siemens Industry Inc.
736	Signature Vacuum Systems Inc.
433	Sinterite
738	Solar Atmospheres
743	Solar Manufacturing
348	South-Tek Systems
611	Struers Inc.
537	Sun-Tec Corp.
727	Super Systems Inc.
403	Surface Combustion Inc.
617	TE Wire & Cable
643	Tech Induction
222	Televac
205	Tenaxol Technologies Inc.
409	Tenova Core
147	The Furnace Belt Company Ltd.
342	Thermal Care Inc.
303	Thermatool Corp.
128	Thermcraft Inc.
333	Thermo Transfer Inc.
423	Thermo-Calc Software
438	Throughput|Bluestreak
339	Tinius Olsen
310	Toyo Tanso USA
244	Toyo-Ro American Inc.
310	Toyo-Ro Industries Co. Ltd.
501	United Process Controls
606	Vac Aero International Inc.
455	Verder Scientific Inc.
124	W.S. Tyler
653	Warner Power
501	Waukee Engineering Co. Inc.
327	Wellman Furnaces Inc.
623	Williams Industrial Service
419	WS Thermal Process Technology Inc.
521	Yokogawa Corp. of America
144	YRC Freight Inc.
707	Zijiang Furnace (Nanjing) Co. Ltd
432	Zircar Refractory Composites Inc.

**Exhibitor list current as of July 17.*

SCHEDULE-AT-A-GLANCE

Monday, October 19

HTS Education Course: Quenching Technology
8:00 a.m.–12:00 p.m.

This half-day session will cover the areas of quenching including selection of quench oils, measuring of quench speed and quenchant performance, and other related topics. In addition, the importance of maintenance and control will be addressed in the following areas of measurement—safety, performance, oxidation, and operational.

HTS Education Course: Heat Treatment of Aluminum
8:00 a.m.–4:30 p.m.

This full-day session is designed to provide a combination of practical and theoretical elements of heat treatment processes for aluminum and aluminum alloys used specifically in the automotive industry. Basic principles as well as specific heat treating practices for both wrought and cast alloys will be covered.

Ford Rouge Tour
1:00–5:00 p.m.

Join fellow attendees in a tour of an actual Ford factory and immerse in the past, present, and future of American automobile manufacturing. *USA Today* recently named this Ford plant "one of the Top 10 places to be inspired by innovation." Separate pre-registration is required, and round-trip transportation will be provided.

Registration Open
4:00–7:00 p.m.

Tuesday, October 20

Registration Open
7:00 a.m.–5:30 p.m.

Technical Sessions
8:00–10:00 a.m.

Break
10:00–10:30 a.m.

Technical Sessions
10:30 a.m.–12:00 p.m.

Lunch
12:00–1:00 p.m.

Technical Sessions
1:00–3:00 p.m.

Break
3:00–3:30 p.m.

Aerial view of the Ford River Rouge plant (circa 1927). Courtesy of the Library of Congress.

Master Series Session
3:30–4:30 p.m.

Wednesday, October 21

Registration Open
7:00 a.m.–6:00 p.m.

Students/Young Professionals Breakfast
7:00–8:00 a.m.

Special Panel Session featuring "New Directions and Opportunities in Heat Treating"
9:00–11:30 a.m.

See what the industry may look like in 2040 as heat treating industry leaders present their views of the future directions for the industry. Discussions will include new technology needs and availability as well as potentially disruptive technologies.

Exhibits Open
9:00 a.m.–6:00 p.m.

Break
10:00–10:30 a.m.

Plenary Session (Heat Treat speaker—Solutions Center)
11:45 a.m.–12:45 p.m.

Lunch on the Show Floor
12:45–1:45 p.m.

HTS General Membership Meeting (Solutions Center)
12:45–1:45 p.m.

Technical Sessions
1:45–3:05 p.m.

Break
3:00–3:30 p.m.

Master Series Session
3:30–4:30 p.m.

Master Series Reception
4:30–5:00 p.m.

Networking Reception and Students/Young Professionals Mixer
5:00–6:00 p.m.

Special Event (Offsite)
7:00–10:00 p.m.

Thursday, October 22

Registration Open
7:00 a.m.–4:00 p.m.

Technical Sessions
8:00–9:40 a.m.

AGMA/HTS Education Course: Heat Treatment of Gears
8:00 a.m.–4:30 p.m.

Due to their unique contribution to the operation of so many machines and mechanical devices, gears have received special attention from the technical community for more than two millennia. New developments in gear technology, particularly from the materials and heat treatment perspectives, will be discussed with regard to improved gear performance.

Exhibits Open
9:00 a.m.–5:00 p.m.

Break
9:30–10:00 a.m.

Master Series Session (followed by Awards Announcements)
10:00–11:30 a.m.

Lunch/AGMA Plenary Speaker
11:30 a.m.–1:00 p.m.

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DID AL GORE INVENT THE TITANIUM SIX FOUR?

In response to the April "Metallurgy Lane" article by Charles Simcoe, *Titanium Part II*, Stanley Abkowitz, FASM, compiled this letter with some differing historical evidence, based on a monograph he wrote that included a detailed discussion of the patent office proceedings that resulted in the Ti-6Al-4V alloy patent.

Several years ago, I authored a monograph titled "The Emergence of the Titanium Industry and the Development of the Ti-6Al-4V Alloy." This was produced at the request of John Monsees, then director of the International Titanium Association. Many of the facts reported in Part II of the "Metallurgy Lane" series covering titanium are in direct conflict with my monograph. Published in 1999, the monograph addresses what I consider to be misinformation included in the April article, particularly on page 35.

The monograph tells of the broadly announced development of the Ti-6Al-4V alloy in an official Army press release in May 1954 based on my internal work during 1951-1954 on alloys for armor applications. This work was accomplished internally at the Arsenal Laboratory and it explains the part played by Armour Research Foundation (ARF) in this work. ARF was mentioned in the press release as furnishing material to the Army-developed specification for the new 6Al-4V alloy. This was an intentional effort to credit the government contracted funding with bearing some payoff, particularly in light of the disappointing technical results coming at that time. I thank my two mentors, Leonard Jaffe, chief of the Physical Metallurgy Branch, and Abe Hurlich, chief of the Armor Branch, for their guidance in my Watertown program.

The monograph explains the suggestion from Watertown to include the Ti-6Al-4V alloy into Nate Promisel's MAB Ti sheet rolling program. This is documented with correspondence between then Lt. Harris Burte of AFML and myself.

Lockheed Martin U-2S. Courtesy of Lockheed Skunk Works.

It also explains the circumstances that led to the Air Force contract to purchase 100-lb ingots to supply engine builders with test material for high temperature properties evaluation. This resulted from the new information supplied by the Arsenal to the Air Force.

The April article refers to an ARF patent, but there never was an ARF patent. As explained in my monograph, an ARF interference patent application was denied by the court in view of the earlier Battelle (Rem-Cru) broad range patent. Furthermore, in the Watertown patent application, the Arsenal did not request a delay for security as Simcoe implies. The delay request came much later from the Secretary of the Army in October 1957 (almost three years after the filing date) and was approved by the patent office in December 1957. The original documents are fully illustrated in the monograph.

Further, the April article never referenced the interference suit of ARF vs. Crucible Steel. Chapter 12 of the monograph explains how the ARF broad range patent application could not overcome the broad range patent of Crucible and that neither showed a Ti-6Al-4V alloy in their early reduction to practice. Although the Battelle/Crucible patent permitted Crucible to negotiate license agreements with some U.S. and foreign suppliers, when the Army patent was finally issued, it eliminated any future Ti-6Al-4V license opportunities. This nevertheless permitted a period of time for some to believe that Crucible was the inventor of Ti-6Al-4V. Chapter 15 of the monograph details the Five Year Proceedings with the Army application in the patent office freezer.

Simcoe's article refers to the Rem-Cru suit against the government and then interprets the outcome as leaving the Ti-6Al-4V alloy invention "unsettled." My monograph details the complete legal deliberations in Chapter 13.

The determination here was *dismissal* by the judge, based on the fact that the alloy under discussion was already well known and in production prior to any alloy suggested or invented by Crucible. Rather than "leaving the invention of the Ti-6Al-4V unsettled" as concluded in the article, the patent granted to Watertown Arsenal (No. 2,906,654) was indeed a composition patent, and not a process patent as implied. This too is well documented in the monograph and includes data derived from arc melted ingots produced for Watertown by purchase orders to National Research Corp. in Cambridge, Mass.

This confused history evolved as a result of the widespread announcement of the Watertown development in 1954 followed by five years of quiet regarding any government patent application. During that quiet time, Ti-6Al-4V production and application grew tremendously, boosted by immediate use in the J-57 engine for the highly secret U-2 spy plane. Because there was no word regarding any government patent application, both Battelle (Rem-Cru) and ARF thought they may have fallen upon rights to this valuable alloy. Both claimed ternary alloys of Ti-Al-V and each tried to reach back to earliest conception. Their competing conception dates were close and neither had produced an alloy containing 6Al-4V. The earlier work and patent application at Watertown displayed data that any higher Al would not produce the required ductility for the application, and any higher V would not offer the necessary weldability; lower content of either would not achieve optimum strength. Original data from the patent application is reported in the monograph.

The failure to mention the U-2 project and the related Pratt & Whitney J-57 engine that enabled its success is a major oversight. Chapter 8 of the monograph—A Short Drive to East Hartford, Connecticut—tells of the top secret program funded by the CIA to Lockheed and onto P&W for a new jet engine that could reach the high altitude required for the U-2 designed by Kelly Johnson at the Lockheed Skunk Works. This endeavor was a top priority and also top secret. In 1953, I was instructed to visit P&W to present our complete results on Ti-6Al-4V alloy and to indicate that we had ordered production ingots of this alloy from Mallory Sharon and Titanium Metals Corp. and that a mil spec had been prepared. It was the J-57 that made the U-2 possible and it was the Ti-6Al-4V alloy that made the J-57 possible. That interesting U-2 story still has segments that remain secret to this day.

In my research for further facts after my startling visit to P&W, I determined that a top secret program had existed involving President Dwight Eisenhower, president James Killian of MIT, president Edwin Land of Polaroid, and CIA director Allen Dulles along with Lockheed Skunk Works director Kelly Johnson and P&W. This working group was called the Killian Panel. It was the Lockheed design that required an improved J-57 engine to achieve the altitude necessary to meet the mission requirements that would allow Land's cameras to photograph the ground below. And it was the prompt switch at P&W to Ti-6Al-4V alloy for key components that permitted the first real test flight in August 1955 and the first flyover of the Soviet Union in 1956.

This historical note helped me to better understand why I was instructed to visit P&W and present the data personally, while GE, GM-Allison, Boeing, Lockheed, and others got to review the detailed Ti-6Al-4V data from the Metallurgical Advisory Committee on Titanium (MACT) report P-13. This relayed the technical information in response to their direct letter inquiries prompted by the press release. I drafted the response to all of these inquiries, which are also documented in the monograph.

Now comes the difficult part of my comments on the history presented in the April article—the Hickey letter, which Simcoe describes as "the final word." The reader is not told that this letter was written in 1987, well over 30 years after the invention at Watertown, yet 12 years before my monograph was published. I researched this letter as well, but out of respect for Hal Kessler did not address it in the 1999 monograph. I will now explain its occurrence. I called Charlie Hickey and asked how he could say to Kessler that he was the inventor. Hickey apologized and explained as follows: In the course of presenting a technical paper at a Titanium Development Association meeting (now ITA) at Annapolis, Md., in 1987, Hickey credited Watertown Arsenal and myself as the inventor of the Ti-6Al-4V alloy. This resulted in a letter to Hickey from Kessler claiming that ARF and Harold Kessler invented the Ti-6Al-4V alloy. Hickey said he avoided responding to the letter and to repeat phone calls from Kessler because the occurrence was so many years before he or his current colleagues were at the Arsenal and much was still under security classification. With the calls demanding a response becoming bothersome, Hickey said he went to his boss and asked what he should do. His boss replied, "Tell the pest what he wants to hear and get him off your back!" On Kessler's next call, Hickey did just that and then got the unexpected request to put it in writing.

Even the three-sentence Hickey response (which exists with my monograph files) does not resemble the description presented in the article stating that "he (Kessler) was indeed the inventor" of the alloy. The brief Hickey letter vaguely referred to the developers as Watertown and ARF and references a later contract initiated in July 1953 and completed in August 1955 from work directed by Don McPherson. The letter does not even mention Kessler or include the words "indeed" or "inventor."

The JOM Monograph entitled "The Emergence of the Titanium Industry and the Development of the Ti-6Al-4V Alloy—Collections and Recollections" is available from ITA for $10 per copy, reduced from $45. However, I will personally cover the costs for the first 50 requests. To obtain a free copy, call ITA at 303.404.2221.

*—Stanley Abkowitz, FASM**

*Abkowitz received the 1993 ASM William Hunt Eisenman Award and the ASM Distinguished Life Membership Award in 2005.

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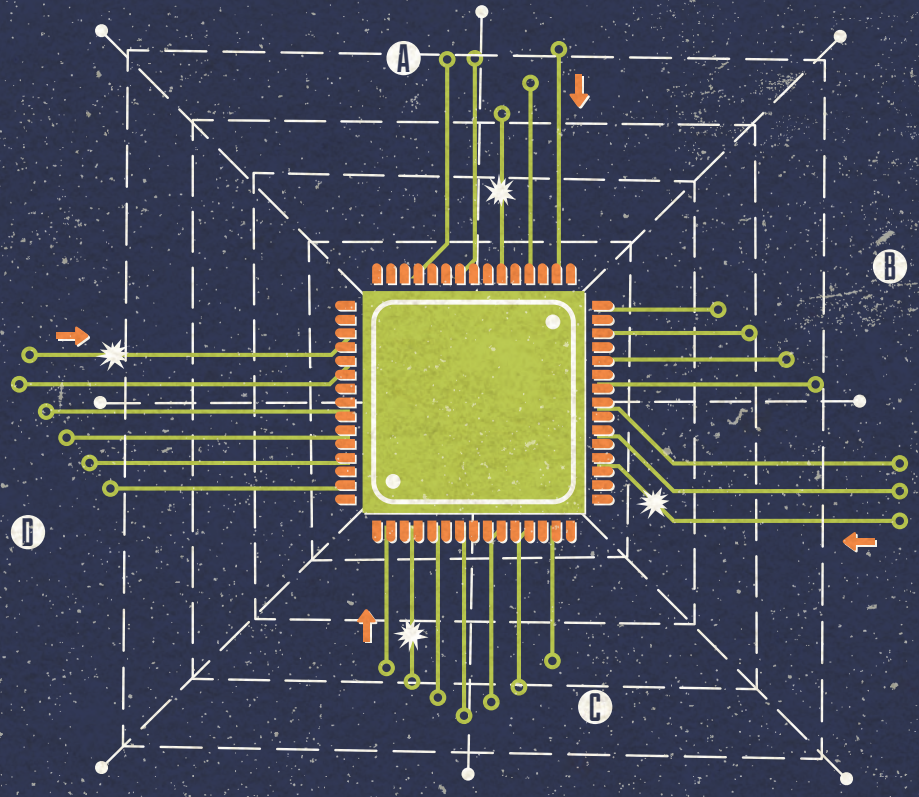

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ANNUAL REPORT 2014

MISSION

To excite young people in materials, science, and engineering careers.

Dear Friends:

Overall results achieved during 2014 were cause for celebration in the ASM Materials Education Foundation, so we are carrying the theme of "celebrating milestones" into this year's annual report. Further, 2014 marked the 15th anniversary of Materials Camps, as well as the launch of a new brand platform. We also accomplished—one year in advance—the "Pick Up the Pace" goal to expand our Materials Camp for Teachers program to 50 locations!

I attribute our success to several groups of people. First, I owe a debt of gratitude to our donors for sharing our vision to create a workforce that is skilled in science, technology, engineering, and mathematics through hands-on, discovery-based learning. Without you, the ASM Materials Education Foundation could not exist. In the past year, we have experienced continued growth and ongoing requests for camps, to which you have responded so generously.

I am also deeply grateful to our dynamic staff, the tireless efforts of our volunteers, and the Board of Trustees members who are passionate about exciting young people in STEM careers.

As we look ahead to the next 15 years, I thank you for believing in the ASM Materials Education Foundation and, more importantly, in the educators and students who are driven to succeed and inspire others.

With warm regards,

Nichol Campana

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2014 GEORGE A. ROBERTS AWARD

Mr. Michael B. Connelly, FASM

Michael B. Connelly is vice president of Casey Products Inc., Woodridge, Ill. His participation in ASM's educational programs began in 1973 when he attended Chicago Chapter courses in heat treating and metallography. Connelly officially joined ASM in 1979 while attending a new class at "the Dome" called "Practical Interpretation of Ferrous Microstructures." He then made the transition from student to instructor in 1990 when he began teaching an ASM course on the practical application of statistical process control in heat treating. This lead to volunteer work with various ASM education committees. In 2000, Connelly was asked if he would like to join a new endeavor with other ASM volunteers and create a camp to excite high school students about careers in materials science. That initiative became Materials Camp. For the past 15 years, Connelly has served as a mentor at the Eisenman Camp held every summer at ASM Headquarters. Connelly has also served on the ASM Materials Education Foundation Board of Trustees and is currently involved in the "Fabulous Furnace Team Project," which awards Materials Camp Master Teachers a furnace for their classroom.

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—Wendy Bramlett, Tuscaloosa Magnet Middle School, Alabama

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Dr. and Mrs. Charles A. Wert

2014 ASM FOUNDATION PACESETTER AWARD

NACE INTERNATIONAL

The NACE International Foundation is dedicated to preparing the next generation of professionals in science, technology, engineering, and mathematics (STEM), while addressing the rapidly declining workforce in the field of corrosion control and prevention. As a supporting organization of NACE International, the NACE Foundation strives to inspire future leaders who will protect people, assets, and the environment from the effects of corrosion.

In 2005, the NACE Foundation developed the cKit™, a corrosion toolkit with fun and challenging experiments that provide hands-on learning about the effects of corrosion. Since then, the NACE Foundation has distributed more than 7700 cKits across the United States and Canada to middle and high school teachers participating in ASM's Teacher Materials Camps. The NACE Foundation has also provided financial support for the program.

Corrosion pervades our communities and our everyday lives, with damages costing $1.8 trillion globally each year, $450 billion in the United States alone. As the number of students pursuing careers in science and engineering decreases, the ability to fulfill the increasing demand for corrosion prevention professionals is also diminishing. The NACE Foundation is committed to conquering this challenge by delivering groundbreaking programs and investing in scholarships, training, and workforce development.

ACTION IN EDUCATION COMMITTEE

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2014 STUDENT CHAPTER GRANT WINNERS

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Winner: University of Maryland
Title: "Novel PBA-Grafted Carbon Nanotube Soft Body Armor"

Second Prize: $1500 + $500 travel assistance
Winner: Michigan Technological University
Title: "A Redesign of the Tap Bit for ArcelorMittal's No. 7 Blast Furnace"

Third Prize: $1000 + $500 travel assistance
Winner: Northwestern University
Title: "Design of a Fatigue-Resistant Shape Memory Alloy for Artificial Heart Valve Frames"

2014 NATIONAL MERIT SCHOLAR

Kirin Naidu
Manheim Township High School, Lancaster, PA

2014 WILLIAM PARK WOODSIDE FOUNDER'S SCHOLARSHIP

Patrick Veloskey
University of Wisconsin-Madison

2014 THE LUCILLE AND CHARLES A. WERT SCHOLARSHIP

Anna Bretzke
Missouri University of Science & Technology

2014 GEORGE A. ROBERTS SCHOLARSHIPS

Katrina Boos
The Ohio State University

Taylor Brown
University of Alabama at Birmingham

Aliya Carter
University of Connecticut

Mary Cole
University of Akron

Rachel Sylvester
The Ohio State University





2014 WILLIAM & MARY DYRKACZ SCHOLARSHIPS

Thomas Chrobak
University of Wisconsin-Madison

Rachel Martin
University of Alabama at Birmingham

Jared Ottmann
University of Wisconsin-Madison

Michael Strand
University of Wisconsin-Madison




2014 LADISH CO. FOUNDATION SCHOLARSHIP

Elliott Busta
University of Wisconsin-Madison

DJ Murphy Devan
University of Wisconsin-Madison


2014 OUTSTANDING SCHOLAR AWARDS

Mayela Renata Aldaz Cervantes
University of Texas at El Paso

Margaux Balagna
University of Michigan

Natalie Briggs
University of Washington



2014 JOHN M. HANIAK SCHOLARSHIP

Ziyin Huang
Drexel University

2014 EDWARD J. DULIS SCHOLARSHIP

Alexandra Glover
Michigan Technological University

2014 KISHOR M. KULKARNI DISTINGUISHED HIGH SCHOOL TEACHER AWARD

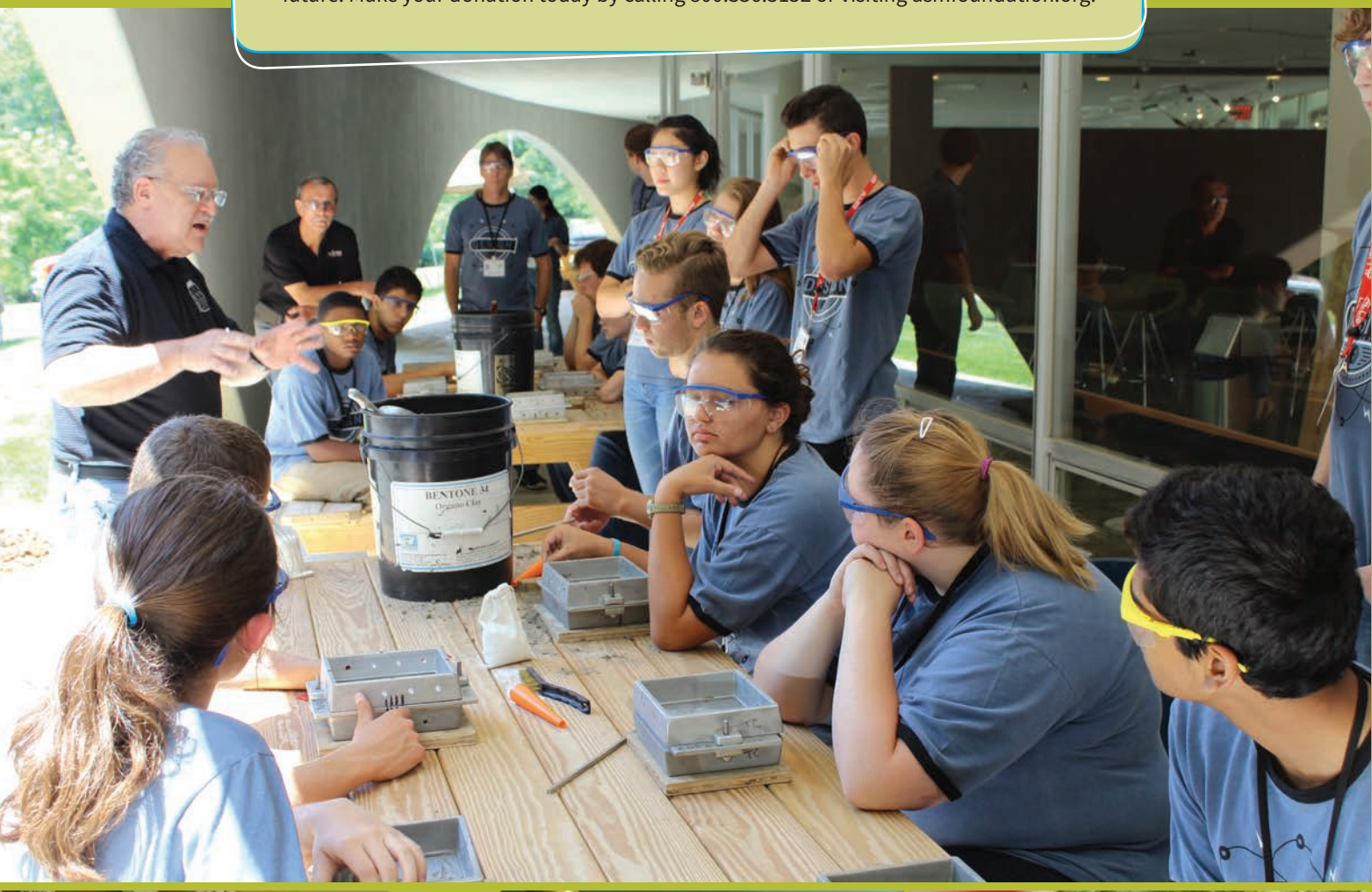
Brian Wright
Olympia High School

Having to finance my own tuition and living expenses throughout college has been challenging, but your generosity has made pursuing my goals much more manageable. I am completely committed to inspiring the future generation of scientists and engineers, and look forward to the day when I am the one receiving letters from students who are passionate about making our world even more amazing.

—Mayela Aldaz, University of Texas-El Paso, 2014 Outstanding Scholar

FOR MORE INFORMATION, PLEASE VISIT ASMFOUNDATION.ORG

Through your generous contributions we can continue to inspire and excite students to explore new worlds through hands-on discovery and to become materials pioneers of the future. Make your donation today by calling 800.336.5152 or visiting asmfoundation.org.



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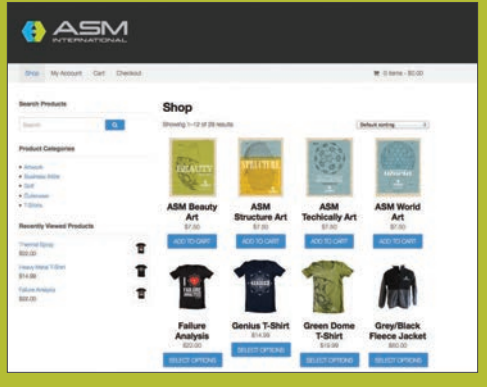


The new ASM Online Store has been reengineered for an easier navigation and shopping experience. The online store is open for business with a brand-new line of products and premium apparel that has you covered for any season!

ASMNEWS

ASM's 2015 Class of Fellows

In 1969, ASM established the Fellow of the Society honor to provide recognition to members for their distinguished contributions to materials science and engineering and to develop a broadly based forum of technical and professional leaders to serve as advisors to the Society. Following are the members recognized by their colleagues for 2015. Additional Fellows may be elected to this distinguished body in subsequent years. The solicited guidance, which the Fellows provide, will enhance the capability of ASM as a technical community of materials science and engineering professionals in the years ahead. Awards will be presented at ASM's annual Awards Dinner, Tuesday, October 6, in Columbus, Ohio, during Materials Science & Technology 2015.

Prof. Sean R. Agnew, FASM
Professor
University of Virginia, Charlottesville

For exemplary research and student-centered education focused on fundamental aspects of plastic deformation in ultra-light non-cubic alloys, including dislocation slip and twinning, and their relationships to fatigue and deformation processing.

Prof. Pranesh B. Aswath, FASM
Professor and Associate Dean
College of Engineering
University of Texas at Arlington

For significant contributions to the science of tribology through establishing fundamental relationships between lubricant additive chemistry, tribofilm formation, and friction and wear.

Mr. Victor K. Champagne, FASM
Leader of ARL Center for Cold Spray
U.S. Army Research Laboratory, Aberdeen, Md.

For serving as the international champion of cold spray technology through exemplary research, development, qualification, and persistent dedication toward transition and implementation throughout all sectors of industry and the Department of Defense.

Prof. Mark Robert De Guire, FASM
Associate Professor
Case School of Engineering
Case Western Reserve University, Cleveland

For significant contributions in the synthesis, processing, phase equilibria, defect structure, and characterization of functional ceramic films for electrical, magnetic, optical, and energy applications.

Dr. Robert L. Freed, FASM
Principal Consultant
DuPont Co., West Chester, Pa.

For significant contributions in metallurgy, hard materials, tribology, and wear control to solve complex industrial equipment and process issues leading to corporate global implementation.

Dr. Hamid Garmestani, FASM
Professor
Georgia Institute of Technology, Atlanta

For significant contributions in developing relationships between processing and microstructural control in crystalline materials, leading to materials design methodologies that address texture in a range of materials systems.

Dr. Frank W. Gayle, FASM
Deputy Director, AMNPO
NIST, Gaithersburg, Md.

For outstanding technical contributions and research management in materials measurement, applications, and manufacturing with significant contributions to light alloy metallurgy, quasicrystals, high temperature superconductivity, solder science, and structural integrity.

In This Issue

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'S 2015 CLASS OF FELLOWS

Mr. Pradeep Goyal, FASM
Chairman and Managing Director
Pradeep Metals Limited, India

For establishment of the internationally known Industrial Microwave Research Center in India, success in environmental and energy improvements in ore and petrochemical processing industries using new technologies, and work in steel production technologies and facilities.

Mr. William L. Hamm Jr., FASM
Director/Board Member
Materials Design Inc., Angel Fire, N.M.

For outstanding contributions to the safety, reliability, and performance of U.S. Navy nuclear submarines and aircraft carriers, and advancing the scientific and engineering technology for materials used in nuclear steam generators, reactor core internals, pressure vessels, and other components.

Prof. Jacob C. Huang, FASM
National Chair Professor and Sr. Vice President
National Sun Yat-Sen University, Taiwan

For outstanding contributions to the development of aluminum and magnesium alloys as well as thin-film metallic glasses, and excellent efforts to transfer technology to the optical and biomedical industries.

Mr. Donald F. Jordan, FASM
Vice President of R&D/Corporate Metallurgist
Solar Atmospheres, Souderton, Pa.

For sustained technical excellence in a career that includes development of wear and corrosion resistant materials for U.S. Navy submarines and outstanding leadership in the development and implementation of novel vacuum heat treatment technology for surface treatment of metals.

Prof. Vivekanand Kain, FASM
Outstanding Scientist
Bhabha Atomic Research Centre, India

For significant contributions focused on understanding and controlling corrosion in nuclear power plants, especially the corrosion of stainless steel and nickel and zirconium-based alloys.

Dr. Paul S. Korinko, FASM
Sr. Fellow Scientist
Savannah River National Laboratory,
Aiken, S.C.

For significant research on the effects of hydrogen isotopes on materials and the development of novel welding processes.

Dr. Xingbo Liu, FASM
Professor
West Virginia University, Morgantown

For significant contributions to the science and technology of high temperature materials used in energy production and conversion, including heat-resistant superalloys in ultra-supercritical power systems, high strength, corrosion-resistant nickel superalloys in ultra-deep wells, and anode/cathode materials in solid oxide fuel cells.

Dr. Benji Maruyama, FASM
Senior Materials Research Engineer
Air Force Research Laboratory, WPAFB, Ohio

For significant contributions in the science and engineering of carbon-based materials and composites, seminal work on carbon nanotube growth, and catalyzing progress in these communities.

Prof. Suveen N. Mathaudhu, FASM
Assistant Professor
University of California, Riverside

For scientific leadership, management, and advocacy of the U.S. Army materials research efforts, in particular the development and support of new advanced lightweight metals and bulk nanostructured materials.

Mr. Brett A. Miller, FASM
Technical Director
IMR Metallurgical Services, Louisville, Ky.

In recognition of a distinguished career of leadership and contribution to the field of failure analysis through lectures, publications, and mentoring of students and professionals.

Mr. Christopher J. Misorski, FASM
Technical Specialist – Materials
Mercury Marine, Fond du Lac, Wis.

For the invention and development of unique materials systems and applying expert knowledge in casting, solidification, physical metallurgy, and heat treatment to reduce the environmental impact of marine engines and vessels while enhancing manufacturability and product performance.

Dr. Thomas M. Moore, FASM
President
Waviks Inc., Dallas

For revolutionizing microelectronics and materials characterization industries through the development of in-situ transmission electron microscopy, sample preparation in the focused ion

beam, and phase inversion for delamination detection in scanning acoustic microscopy.

Dr. Joseph W. Newkirk, FASM
Associate Professor
Missouri University of Science and Technology, Rolla

For outstanding contributions in teaching, mentoring, professional service, and entrepreneurial research in alloy property development, particulate composites, powder metallurgy materials, and property assessment of powder metallurgy and metal injection molded parts.

Dr. Gankidi Madhusudhan Reddy, FASM
Scientist
Defense Metallurgical Research Lab, India

For outstanding contributions in welding science and technology with special emphasis on the development of solutions enabling fabrication of critical components used in defense and aerospace applications.

Prof. Federico Rosei, FASM
Professor and UNESCO Chair
INRS, Varennes, Canada

For sustained contributions to the synthesis and characterization of multifunctional materials through outstanding research in terms of output and impact and for exceptional mentoring activities.

Dr. Muthukumarasamy Sadayappan, FASM
Research Scientist
Canmet Materials, NRCAN, Canada

For significant contributions to the field of non-ferrous foundry metallurgy and solidification processing.

Dr. Judy Schneider, FASM
Professor
University of Alabama, Huntsville

For sustained influential and pioneering advancements in the field of advanced manufacturing processes, and mentoring and development of the next generation of engineers and professors.

Dr. Justin Schwartz, FASM
Kobe Steel Distinguished Professor and Department Head
North Carolina State University, Raleigh

For the advancement of high temperature superconductors and their applications as well as supporting the fledgling superconducting materials technology industrial base, and for advancing diversity in materials science and engineering.

Prof. Yongho Sohn, FASM
Professor
University of Central Florida, Orlando

For significant contributions to teaching and research in the fundamental understanding of multi-component diffusion kinetics, analysis and control of microstructures, phase transformations, and the application of advanced materials characterization techniques.

Mr. David B. Spenciner, FASM
Research Fellow
DePuy Synthes Mitek Sports Medicine, Raynham, Mass.

For distinguished contributions to orthopedic device testing and increasing clinical acumen within the sports medicine industry.

Prof. Chester J. Van Tyne, FASM
FIERF Professor
Colorado School of Mines, Golden

For significant contributions to understanding the effects of processing and microstructure on the plastic deformation behavior of steels and nickel-base alloys in metal forming manufacturing processes.

Prof. Petri Vuoristo, FASM
Professor
Tampere University of Technology, Finland

For continuous and dedicated contributions toward the advancement of thermal spray, cold spray, and laser cladding technologies worldwide through education and practice.

Mr. Zbigniew Zurecki, FASM
Senior Research Associate
Air Products & Chemicals Inc., Allentown, Pa.

For conceptualization and sustained development of cleaner, safer, and environmentally-friendlier alternatives to many conventional methods of processing metals resulting in improved product quality and increased productivity of industrial operations.

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.

Nomination Deadline for the 2016 Class of Fellows is Fast Approaching

The honor of Fellow of the Society was established to provide recognition to members for distinguished contributions in the field of materials science and engineering, and to develop a broadly based forum for technical and professional leaders to serve as advisors to the Society.

Criteria for the Fellow award include:

- Outstanding accomplishments in materials science or engineering
- Broad and productive achievement in production, manufacturing, management, design, development, research, or education
- Five years of current, continuous ASM membership

Deadline for nominations for the class of 2016 is November 30, 2015. Complete information including the rules, interpretive comments, and user-friendly online nomination forms are available on the ASM website at asminternational.org/membership/awards/asm-fellows or by contacting Christine Hoover at 440.338.5151, ext. 5509 or christine.hoover@asminternational.org.

ASM Indian Institute of Metals Announces Recipients of 2015 ASM/IIM Visiting Lecturer Program

The cooperative Visiting Lecturer program of ASM International and the Indian Institute of Metals (IIM) is pleased to announce the five distinguished individuals named to participate in the 2015 Visiting Lecturer program: **Prof. Mysore Dayananda, FASM,** Purdue University; **Mr. Michael Halbig,** NASA Glenn Research Center; **Prof. Vilupanur Ravi, FASM,** California State Polytechnic University; **Dr. Amit Shyam,** Oak Ridge National Laboratory; and **Prof. C. Saryanarayana, FASM,** University of Central Florida. The award includes an $800 honorarium to be used for travel expenses


Dayananda


Halbig


Ravi


Saryanarayana


Shyam

Seeking Nominations for 2016 ASM/TMS Distinguished Lectureship in Materials & Society

Qualifications of the lecturer include:

- An eminent individual who has an overall understanding of technology and society, and how both are affected by developments in materials science and engineering.
- Experienced in national or industrial policymaking in the field of materials science and engineering.
- Associated with government, industry, research, or education.

Nominations may be proposed by members of either Society. Submit nominations by **November 30.** For complete details, visit asminternational.org/membership/awards.

ASM held its first-ever Affiliate Summit on July 28 at the Dome, a highly successful meeting that will now become an annual event.

within India during the lecturer's visit and a certificate of recognition to be presented at the ASM Leadership Awards Luncheon scheduled for October 5 in Columbus, Ohio, during MS&T15.

ASM Affiliate Summit Debuts in July

ASM's inaugural Affiliate Summit was held at the Dome on July 28. The impetus for this initial meeting was born out of a need to bring our sister societies together to discuss what ASM can do for them, and to provide a forum for ASM staff to learn about what our affiliates need to be successful. Members of ASM's Lead Team gave presentations and Ross Brindle from Nexight Group facilitated a discussion on priorities for the affiliates in terms of service needs and business development. Attendees were highly engaged in the Summit and members of the various societies had the opportunity to meet each other for the first time and exchange ideas.

In attendance were leaders of the Heat Treating Society, Electronic Device Failure Analysis Society, International Metallographic Society, International Organization on Shape Memory and Superelastic Technologies, and Thermal Spray Society, as well as the Failure Analysis Committee, who has shown an interest in becoming part of the affiliate community in the future. For more information, contact sarina.pastoric@asminternational.org.

EDWARD DeMILLE CAMPBELL MEMORIAL LECTURE

New day announced for MS&T15

The Edward DeMille Campbell Memorial Lecture will be presented by **Prof. David N. Seidman, FASM.**

Wednesday, October 7, 12:45–1:45 p.m.

Greater Columbus Convention Center – Room D131

"A Correlative Six-Dimensional Study of Phase Separation at the Subnano-Nanoscale of Nickel-Aluminum Alloys"

See ASM News July/August issue for full abstract.

EMERGING PROFESSIONALS

EPC Announces Emerging Materials Professionals Symposium at MS&T

The Emerging Professionals Committee (EPC) is organizing the 8th annual "Perspectives for Emerging Materials Professionals" symposium at MS&T15 in Columbus, Ohio, October 4-8. The path to success in materials science and engineering (MSE) might not be clear for early professionals, while established professionals may have already figured it out. The symposium objective is to bring different generations of materials professionals together and pass down knowledge to emerging professionals.

A diverse group of speakers from academia, industry, and the national labs will share tips on professional development, ways to meet goals, the importance of diversity, emerging opportunities in computational modeling, and taking on management roles. ASM's incoming president, **Jon Tirpak, FASM,** will deliver the keynote presentation and highlight opportunities that exist for MSE professionals.

The symposium will also include an interactive panel discussion titled, "I Got My Degree, Now What?" Panelists include **Dianne Chong, FASM** (The Boeing Co., retired), **Melanie Cole** (U.S. Army Research Laboratory), **James Earthman** (University of California, Irvine), **Jack Hyzak** (Precision Castparts Corp.), and **Jon Tirpak, FASM** (FDMS/PROFAST/ASM International).

For more information or to get involved in future symposia, contact Khinlay Maung at kmaung@aicpcc.com or Rachel Bethancourt at rbethancourt@cherryaero.com.

EDITOR SPOTLIGHT

Prasan Samal and Joseph Newkirk

Prasan Samal and **Joseph Newkirk, FASM,** are recognized in this spotlight as volume editors of the revised *ASM Handbook*, Volume 7, *Powder Metallurgy*. Their dedication and commitment as volume editors were instrumental in developing this authoritative publication.

The 2015 edition of Volume 7 focuses more on conventional powder metal (PM) technology than the previous edition and captures advancements made in PM technology since the publication of the prior edition in 1998. The coeditors, with approval of the Handbook Committee, reorganized the volume along the lines of major PM material families. This is intended to simplify the understanding of process-property relationships within each material system. The new edition is divided into 19 sections, five that cover basic principles common to all PM materials (material standards, powder manufacture, powder characterization, compaction, and sintering), two devoted to full-density processing and metal injection molding, and the remaining 12 that cover the application of PM technology to individual PM material families.

Samal and Newkirk, using their extensive experience in the PM industry, were successful in recruiting highly recognized industry experts to head each section. The volume is comprised of more than 80 articles written by industry experts and will be a valuable resource for engineers involved in any aspect of the PM process or those who want to learn more about the process.

Do you have an idea for a book? Would you like to share your knowledge and expertise with the engineering community? ASM can help you in such an endeavor. Contact Karen Marken at 440.338.5151 ext. 5545 or karen.marken@asminternational.org to discuss your ideas.

Newkirk

Samal

UPCOMING *ASM HANDBOOK* EDITIONS: CALL FOR CONTRIBUTORS

The *ASM Handbook* series is internationally recognized as a standard reference in materials science and engineering, and ASM is seeking technical contributions for new editions of *ASM Handbook* Volumes 10, 17, and 18. If you are interested in revising *Handbook* articles in these volumes or contributing new articles or case studies, please contact the editors as follows:

- Email the editors (with Volume identified in subject line) at handbooks@asminternational.org.
- Complete an interest survey at www.research.net/s/ASMHandbooks.

Materials Characterization, *ASM Handbook*, Volume 10

Editors include **George Vander Voort, FASM,** Chair ASM Handbook Committee, and **Joseph Michaels,** Sandia National Labs, along with **Jeffrey Jansen,** Madison Group, and **Larry Hanke, FASM,** Materials Evaluation & Engineering Inc.

ASM Handbook Volume 10 is being updated for engineers and materials scientists who seek a guide on material characterization methods and information required to work effectively with analytical specialists in defining a test matrix, determining sampling procedures, and obtaining and interpreting data.

Editors are seeking contributors for all aspects of SEM and TEM imaging and analytical techniques, electron-probe microanalysis, atom probe, Auger electron spectroscopy, XPS, and more. Updated content and new application examples are also sought for other surface analysis methods, thermal analysis (DSC, TGA, DMA, TMA), x-ray spectroscopy, and x-ray and neutron diffraction.

Contributors are also needed to update existing articles on spectroscopy (optical emission, atomic absorption, infrared, Raman); mass and ion spectrometry (spark source, gas analysis, low-energy ion-scattering, Rutherford back scattering, gas, liquid and ion chromatography); and chemical analysis and separation techniques (spot tests, analytical chemistry, chromatography, electrochemical methods), and more.

Nondestructive Evaluation of Materials, *ASM Handbook*, Volume 17

Editors include **Aquil Ahmad,** Volume Chair, along with **Kevin Smith,** Pratt & Whitney; **Leonard Bond,** Iowa State; **Claudia Kropas Hughes,** Wright Patterson AFB; and **Steven Shepard,** Thermal Wave Imaging Inc.

ASM Handbook Volume 17 is being significantly updated with expanded coverage on signal processing, general material-state awareness (not just cracks), in-line process control, automation, and all levels of modeling and reliability analysis. New coverage, examples, and case studies are sought for all types of NDE methods, metallic and nonmetallic materials, and product-form applications. Major topics areas include visual and optical techniques; thermography; acoustic techniques; ultrasound; radiography; neutron inspection; nondestructive evaluation of manufactured products and components; and quantitative nondestructive evaluation and life assessment.

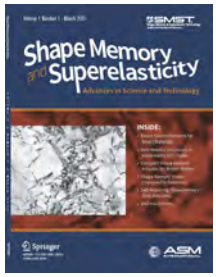
Friction, Lubrication, and Wear Technology, *ASM Handbook,* Volume 18

Editors include **George Totten, FASM,** Totten and Associates, and **Jeffrey Hawk, FASM,** U.S. Department of Energy, along with **Thomas Scharf,** University of North Texas; **Emile van der Heide**, University of Twente; **Hong Liang,** Texas A&M University; **Lim Seh Chun,** Singapore University of Technology & Design; **Christina Lim,** National University of Singapore; and **Bojan Podgornik,** Institute of Metals and Technology (Slovenia).

Tribology is a multidisciplinary field that includes diverse fields such as mechanical design, lubrication, contact mechanics, fluid dynamics, surface chemistry, solid-state physics, and materials science and engineering. *ASM Handbook,* Volume 18 is being updated as a basic resource on the physical fundamentals, testing and analysis, materials selection, and field diagnosis of tribology problems. Editors are seeking contributors for updated new and expanded coverage on solid friction; lubricants and lubrication; wear mechanics; wear testing and characterization; wear monitoring and diagnosis; friction and wear of components; friction and wear of materials; and surface treatments and coatings for friction and wear control.

Second Issue of Shape Memory Journal Now Online

The second issue of *Shape Memory and Superelasticity: Advances in Science and Technology* is now available online.



Shape Memory and Superelasticity is the official journal of The International Organization on Shape Memory and Superelastic Technologies, an affiliate society of ASM International. This new online quarterly journal is available free of charge for the first two years of publication and presents original papers on shape memory materials in physics, crystallography, materials science, thermomechanical testing, and more. It also covers uses in micromechanics, constitutive modelling, mathematics and microstructures, smart materials, and multiferroics. The first two issues are available at http://link.springer.com/journal/volumesAndIssues/40830.

Shape Memory and Superelasticity invites original peer-reviewed papers that focus on shape memory materials research with contributions from materials science, materials engineering, experimental and theoretical mechanics, mathematics, and physics. For more information, visit https://mc.manuscriptcentral.com/shapememory.

CHAPTER NEWS

Leadership Days Celebrates ASM's Chapter Network

Leadership Days 2015 took place July 16-19 in Cleveland, attended by 79 volunteer delegates representing 57 ASM Chapters from three countries. Volunteers attended various training sessions related to strengthening Chapter involvement in ASM's Strategic Plan. After a networking event on Thursday, attendees were welcomed on Friday morning by Chapter council chair Tom Ackerson and director of sales and marketing Skip Wolfe. Several sessions were presented with regard to operations and membership. Following a festive tour of Cleveland Whiskey, an awards presentation was held and 13 Chapters were recognized for achievements in membership retention and recruitment, student outreach, innovative programming, communications, and young professional engagement.

Leadership Days hosted 79 volunteer delegates from 57 ASM Chapters.

On Saturday, Chapter leaders attended various sessions related to programming, such as exploring new approaches, sharing ideas, and brainstorming creative topics for future meetings. Following these sessions, attendees were transported to ASM headquarters to experience the wonder of "Dinner Under the Dome" as a way to express gratitude to our Chapter leadership for all of their hard work. Guests were treated to an evening of food, music, and networking activities. Leadership Days came to a close Sunday morning with a breakfast and impromptu speech by ASM past president C. Ravi Ravindran.

ASM Congratulates Chapters on Outstanding Service

The ASM Chapter Council presented 13 Chapter awards at the Leadership Days Awards Dinner on July 17. Prior to the selection process, all Chapters had the opportunity to submit essays in a variety of categories in conjunction with the annual reporting process. Congratulations to this year's winners:

- **Membership retention & recruitment:** Chennai and Pune
- **Student outreach:** Quebec, Albuquerque, Hartford, and Pittsburgh
- **Innovative programming:** Chennai, Edmonton, Brandywine Valley, and Detroit
- **Communications:** Edmonton and Pittsburgh

We look forward to receiving your Chapter's submissions in 2016!

MEMBERS IN THE NEWS

Ilia Recognized for Outstanding Technical Paper

The Howard I. Sanderow Outstanding Technical Paper Award was presented to **Edmond Ilia, FASM,** chief metallurgist, Metaldyne Performance Group, Plymouth, Mich., for his paper, "The Effect of Copper Precipitation on Mechanical Properties at Operating Temperature of the Materials Used to Manufacture Powder Forged Connecting Rods." He was recognized during Powdermet2015 in San Diego. The award was established in 1993 to recognize authors of manuscripts for excellence in scientific and technical written communications.

Edmond Ilia (right) receives the Howard I. Sanderow Outstanding Technical Paper Award from James Trombino of the Metal Powder Industries Federation.

Vander Voort Teaches in Italy

George Vander Voort, FASM, gave the opening and closing keynote lectures at the Europena Conference on Heat Treatment 2015 and the 22nd IFHTSE Congress, "Heat

Los Angeles Chapter Presents Scholarships, Samples Spirits

At the recent Los Angeles Chapter Scholarship Golf Tournament, two scholarships were presented, including $2000 to Rukmini Ravi (left) of Chaffee College and $8000 to Stoney Middleton (right) of the University of California, Irvine.

Following a tour of the Greenbar Craft Distillery in Los Angeles (LA's first legal distillery to open since Prohibition), members of the Los Angeles Chapter sampled various spirits after learning about how the products are made using organic ingredients and sustainable practices and packaging.

Treatment and Surface Engineering from Tradition to Innovation," held in May in Venice, Italy. Other ASM speakers included **George Totten, FASM, D. Scott Mackenzie, FASM,** and **Derek Northwood, FASM.** The following week, Vander Voort presented four one-day seminars organized by Struers at the Association of Italian Metallurgists in Milan, RTM Breda test laboratory in Cormano, AQM laboratory and technical service center in Provaglio d'Iseo, and at Tenaris in Dalmine.

Vander Voort and his class at the RTM Breda test laboratory in Cormano, Italy.

Sahay Named John Deere Fellow

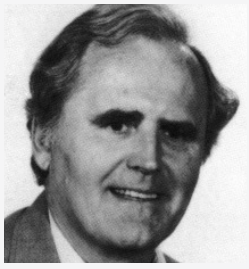
Satyam Sahay, FASM, is part of the inaugural class of four John Deere Fellows, selected for his exemplary knowledge leadership in materials engineering. The new distinction was created this year as the highest recognition of functional expertise within the company. Sahay co-leads the enterprise advanced materials engineering division and is based at the John Deere Technology Center India, in Pune.

Erdemir Receives Mayo D. Hersey Award

Ali Erdemir, FASM, recently received the American Society of Mechanical Engineers' (ASME) Mayo D. Hersey Award "in recognition of distinguished and continued contribution over a substantial period of time to the advancement of lubrication science and engineering." A scientist at the DOE's Argonne National Laboratory since 1987, Erdemir has dedicated nearly his entire career to reducing friction between moving parts. His discoveries of nearly frictionless carbon and superhard nanocomposite coatings, as well as a range of novel nanolubricants and lubrication additives, have been hailed as major breakthroughs in the field.

IN MEMORIAM

Richard C. Krutenat, Life Member, passed away on July 8 in Cocoa Beach, Fla. Born February 25, 1934, in Buffalo, N.Y., he earned a Ph.D. in metallurgy and materials science at Massachusetts Institute of Technology in 1965. He was employed by Pratt and Whitney Aircraft, Exxon Research and Engineering Co., and retired from Textron Systems Corp. in 1997. Krutenat joined ASM in 1960 and his most recent activity was with the Central Florida Chapter where he served as treasurer and program chairman until 2007.



Régis Pelloux, FASM, died July 10 at age 83. Pelloux was born in Passy, France, where he was educated before receiving a Jean Gaillard Fellowship to study at the Massachusetts Institute of Technology (MIT), where he earned an M.S. in 1956 and a Ph.D. in 1958. After completing his doctorate, he enrolled in the French Army and was stationed at the French Army Atomic Research Centre. In 1961, he was hired by Boeing Scientific Research Laboratories to work on difficult assignments related to turbine fracture. He joined the MIT faculty in 1968, in what is now the department of materials science and engineering, where he most recently served as professor emeritus. Pelloux was a researcher and educator in what was then a new and relatively small field—fatigue and fracture of engineering materials and structures. He worked closely with faculty in the departments of aeronautics and astronautics and mechanical engineering, consulted widely, and taught an unusually large course load until he retired in 1995. Pelloux received ASM's Albert Sauveur Achievement Award in 1995.

AEROMAT2016

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Call For Papers is Open

AeroMat is the premier aerospace materials conference in the world presented by top leaders in the aerospace materials field. It includes an exposition of aerospace products and services from over 80 companies and organizations.

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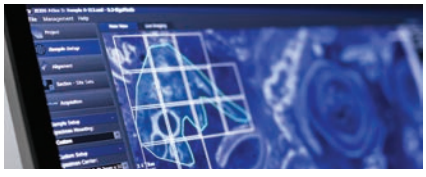
To exhibit or advertise at the show, contact Christina Sandoval at christina.sandoval@asminternational.org for more information.

PRODUCTS & LITERATURE

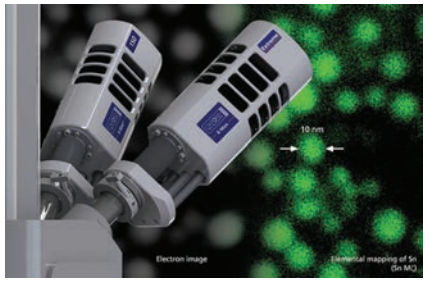
Hitachi High-Technologies Corp., Japan, announces the NX9000 real-time **3D analytical FIB 1-SEM 2 composite instrument.** Automatic repetition of FIB cross-section preparation and SEM observation provide a series of cross-sectional images enabling 3D structural analysis of a specified microscopic section. The SEM column and FIB column are arranged orthogonally rather than the usual diagonal configuration, which avoids issues that affected conventional FIB-SEM composite instruments, namely shrinking of cross-sectional SEM images and non-alignment of the visual field on recovery of an image series. *hitachi-hta.com.*



Carl Zeiss, Germany, introduces ZEISS Atlas 5, a **hardware and software package** that extends the capacity of ZEISS scanning electron microscopes (SEMs) and focused ion beam SEMs. Atlas 5 streamlines automatic image acquisition and enables efficient navigation and correlation of images from any source including light and x-ray microscopes. Taking full advantage of high throughput and automated large area imaging, users can acquire large sets of 2D or 3D nanoscale electron microscope images for hours, or even days, without operator supervision. Advanced preset and customizable protocols produce consistent and reproducible results. *zeiss.com.*

Leica Microsystems, Germany, launched the DM4 P **polarization microscope** for the investigation of crystalline structures such as minerals, plastics and polymers, drugs and pharmaceuticals, and pigments and cement. The microscope is fully coded and semi-automated and can be configured with either a transmitted light axis or an incident light axis (or both), which makes it a useful tool for polarization tasks. LED illumination lights samples homogeneously and at a constant color temperature at all microscope settings. *leica-microsystems.com/science-lab/polarization-contrast.*

Physik Instrumente (PI), Germany, introduces PInano, a **super resolution (SR) microscope stage series** available in two variations including high precision with piezoresistive position feedback sensors and high precision with high stability based on capacitive feedback sensors. High stability models are equipped with direct-measuring capacitive sensors. The large aperture accommodates microscopy accessories, such as slide holders and Petri dish holders. The recessed bottom slide mount allows full rotation of the turret, without in-and-out Z-motion. *physikinstrumente.com.*



Oxford Instruments, UK, launched X-Max Extreme, a **silicon drift detector** reported to be a breakthrough solution for ultrahigh resolution FEG and FIB-SEM applications. The EDS spatial resolution using X-Max Extreme approaches that of the SEM. The detector enables EDS data collection at very low kV (between 1-3 kV) and a very short working distance to provide elemental analysis under the conditions used to analyze nanomaterials and surfaces at the highest SEM resolution. It is based on a windowless 100 mm^2 detector—and uses a radical geometry to enable data acquisition under short working distances. *oxford-instruments.com.*

STRESS RELIEF

SAUTÉING IN SPACE

What would it be like to stir-fry in space? A bit messy, according to researchers at Cornell University, Ithaca, N.Y., who recently conducted the first partial gravity cooking on record. Postdoctoral research associates in the lab of associate professor Jean Hunter recently boarded a zero gravity G-Force 1 space simulator plane to test the effectiveness of a specially constructed space galley jointly designed with Makel Engineering, Chico, Calif.

Apollo Arquiza shows what the galley kitchen looks like in the zero gravity G-Force 1 space simulator plane.

In a series of four flights launched from Houston, the team tossed tofu and shredded potatoes into pans of sizzling oil and filmed the oil splatters as the plane climbed and dove in parabolic paths. Each cycle created a brief period of partial weightlessness, simulating conditions astronauts would face during extended stays on the moon or Mars. Strips of paper were positioned inside the galley fume hood, and the oil was dyed bright red in order to see and collect splatter patterns. Under reduced gravity conditions, food settled more slowly into the pan, and more oil appeared to fall outside of it. Oil droplets also traveled a greater distance from the pan than under Earth conditions—probably because it took longer for gravity to pull them down, say researchers.

The team collected 200 red-speckled strips that could contribute to understanding the science of space cuisine. They are now being analyzed to measure size distribution and distance traveled. Results will be used to create computer models that could be extrapolated for the design of future terrestrial and extraterrestrial cooking technology. *cornell.edu.*

An outline of Marilyn Monroe's iconic face appears on a clear, plastic film when a researcher fogs it with her breath.

USING MARILYN MONROE TO CATCH COUNTERFEIT DRUGS

Counterfeit drugs, which at best contain wrong doses and at worst are toxic, are thought to kill more than 700,000 people each year. While less than 1% percent of the U.S. pharmaceuticals market is believed to be counterfeit, it is a huge problem in the developing world where as much as one third of the available medicine is fake. To combat counterfeiting, researchers at University of Michigan, Ann Arbor, and in South Korea developed a way to make labels that change when you breathe on them, revealing a hidden image—in this instance, Marilyn Monroe.

The method requires access to sophisticated equipment that creates very tiny features, roughly 500 times smaller than the width of a human hair. Once the template is made, labels can be printed in large rolls at a cost of roughly one dollar per square inch, offering an affordable way to protect brand reputations and ensure consumer safety. *For more information: Nicholas Kotov, 734.763.8768, kotov@umich.edu, www.umich.edu.*

MOOD ICE CREAM CHANGES COLOR AS IT MELTS

Physicist Manuel Linares took a course in ice cream making, which included encouraging students to make a new flavor—so he decided to make one that changes color. The 37-year-old Spaniard studied physics and engineering before deciding to become a cook and was able to create the new ice cream called *Xamaleon*. The ice cream turns from blue to purple as it starts to melt. He is staying tight-lipped over the secret behind how the color change works in his recipe but notes, "As a physicist, I know that there are various possibilities that might work and I was delighted when I managed to crack it and create an ice cream that changes color." Further details will become available as soon as the patent process is complete.

A new kind of ice cream created by a physicist changes color as it melts.

ADVANCED MATERIALS & PROCESSES

EDITORIAL PREVIEW

OCTOBER 2015

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- Advanced Testing Methods Using XPS
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HTPro newsletter covering heat treating technology, processes, materials, and equipment, along with Heat Treating Society news and initiatives.

Bonus Distribution:

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- International Symposium for Testing & Failure Analysis
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NOVEMBER/DECEMBER 2015

Materials Testing & Characterization

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- Advances in Testing Equipment & Processes
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HTPro newsletter covering heat treating technology, processes, materials, and equipment, along with Heat Treating Society news and initiatives.

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AD INDEX

SUCCESS ANALYSIS

SPECIMEN: THE BRIGHT WORLD OF METALS

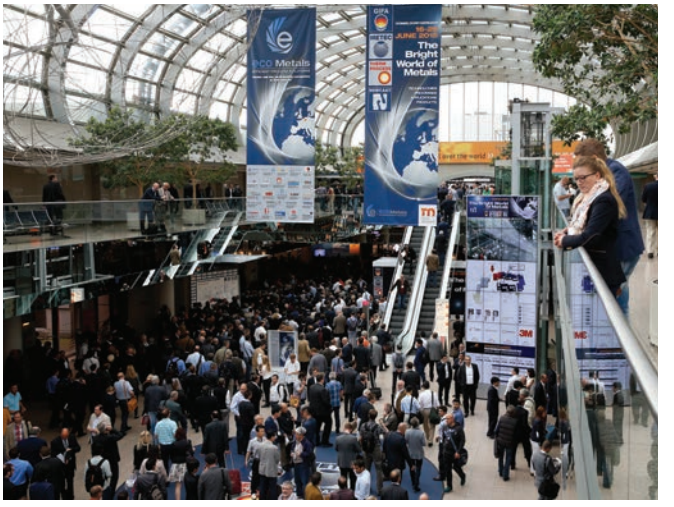
VITAL STATISTICS

The Bright World of Metals trade show quartet held in June in Düsseldorf, Germany, included the GIFA, Metec, ThermProcess, and NewCast exhibitions, featuring foundry, metallurgy, thermal processing, and casting technologies. More than 78,000 visitors from 120 countries attended the event, which included 2214 elaborate booths on display. The majority of international visitors were from India, Italy, Turkey, France, and China. Exhibitors, including several ASM members, reported many successful meetings and purchase orders with their specific target groups. At GIFA, these were experts from the ferrous and non-ferrous metal castings industries. At Metec and ThermProcess, most of the visitors are involved in iron and steel production, plant engineering and construction, equipment engineering, and tool making. NewCast attendees included experts from automotive and gear manufacturing.

SUCCESS FACTORS

In addition to block-long booths featuring fully functional machinery, private conference rooms, and catered meals, another unique aspect of the trade shows was the "ecoMetals Trail" featuring 24 companies with environmentally friendly approaches to energy and materials usage. Because casting, steel, and non-ferrous metal production are energy-intensive, technologies that contribute to resource efficiency and reduced CO_2 emissions are especially important. These companies were spread out throughout the four shows and booths were marked with special signs, while guided tours escorted visitors to each display for technology demonstrations. Several exhibitors showcased developments involving inorganically manufactured castings. For example, ASK Chemicals, Germany, highlighted its Inotec technology, which is suitable for aluminum and iron casting as well as nonferrous metal casting. The technology is useful for automotive applications such as manufacturing engine blocks and cylinder heads. Visitors were treated to small blue racing cars that were cast onsite to showcase the odor-free, environmentally friendly nature of the inorganic method.

Other companies on the tour featured technologies that focused on reducing energy consumption for compressed air needs, a 98% efficient distillation process that uses and recovers "clean" rolling oil used during aluminum production, and vertical molding machines that require one-third of the energy consumed by their horizontal counterparts. In addition, slag and sand reclamation systems for waste materials and overall improvements in control systems, servomotors, hydraulics, and drive technologies were highlighted throughout the tour with the ultimate goal of using energy and resources more efficiently and sustainably.



More than 78,000 visitors from 120 countries attended The Bright World of Metals.

This 50-ton induction furnace from ABP Induction shipped to Saudi Arabia immediately following ThermProcess.

This BMW concept car features several parts cast by Loramendi's electric vertical molding machine (powered by servomotors), which uses one-third less energy than those with traditional hydraulic units.

ABOUT THE INNOVATORS

The Bright World of Metals takes place every four years and is hosted by Messe Düsseldorf, an international trade show organizer spanning a range of industries from fashion and medicine to metallurgy and heat treating. Included among the U.S. contingent in the ThermProcess show were AFC-Holcroft, Ajax Tocco Magnethermic, Centorr Vacuum Industries, Dry Coolers, Fluxtrol, H.C. Starck, and Surface Combustion, along with the European arms of companies such as EFD Induction, Inductotherm Group, SECO/Warwick, and many others.

Contact Details

Messe Düsseldorf North America
150 N. Michigan Ave.
Chicago, IL 60601
312.781.5185, mdna.com

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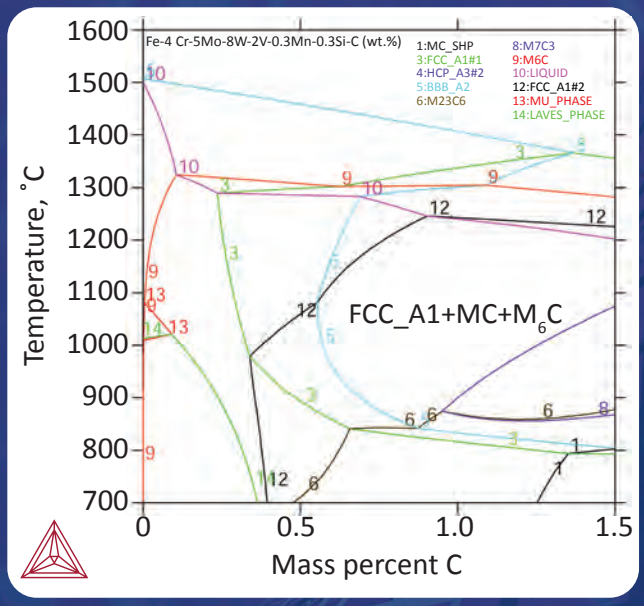

Calculation of an isopleth

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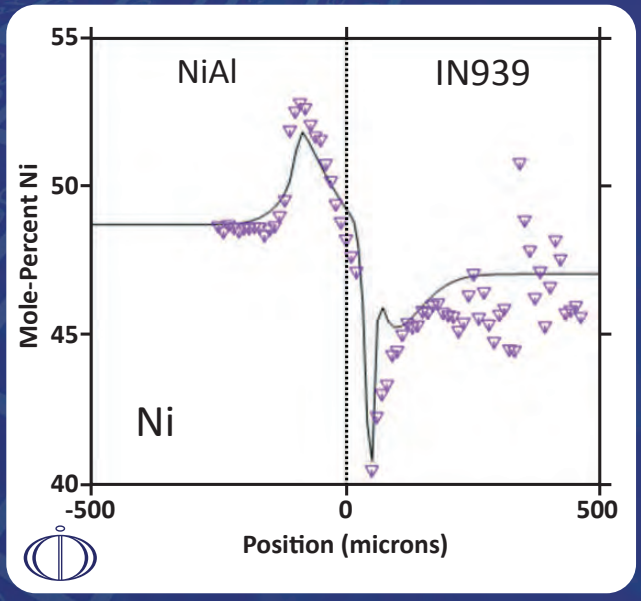
- ✓ **Shorten** development time and accelerate materials development while reducing risk
- ✓ **Improve** the quality and consistency of your products through deeper understanding of your materials and processes



Diffusion in ordered phases

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