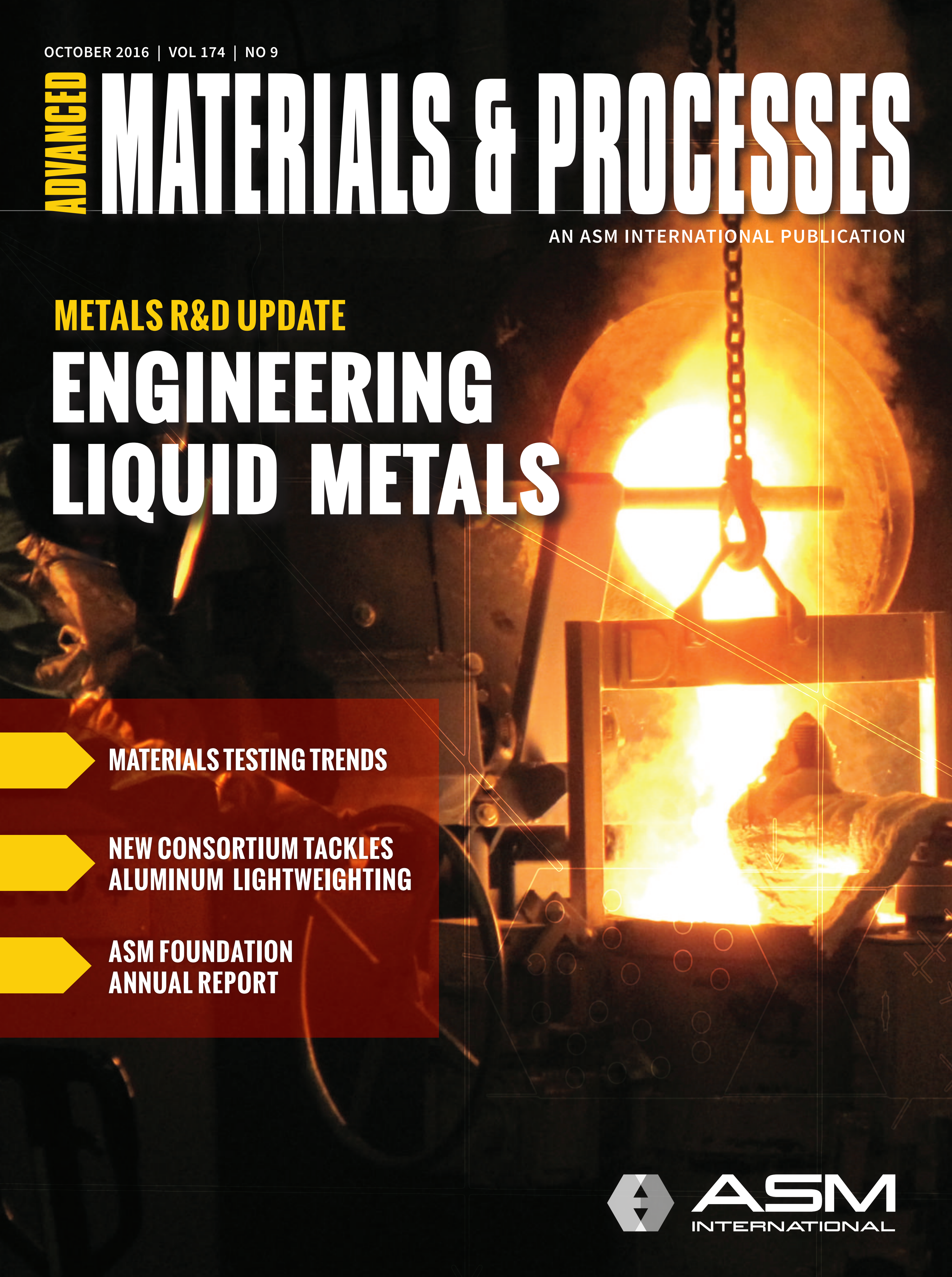
OCTOBER 2016 | VOL 174 | NO 9

ADVANCED MATERIALS & PROCESSES

AN ASM INTERNATIONAL PUBLICATION



METALS R&D UPDATE

ENGINEERING LIQUID METALS

- MATERIALS TESTING TRENDS
- NEW CONSORTIUM TACKLES ALUMINUM LIGHTWEIGHTING
- ASM FOUNDATION ANNUAL REPORT

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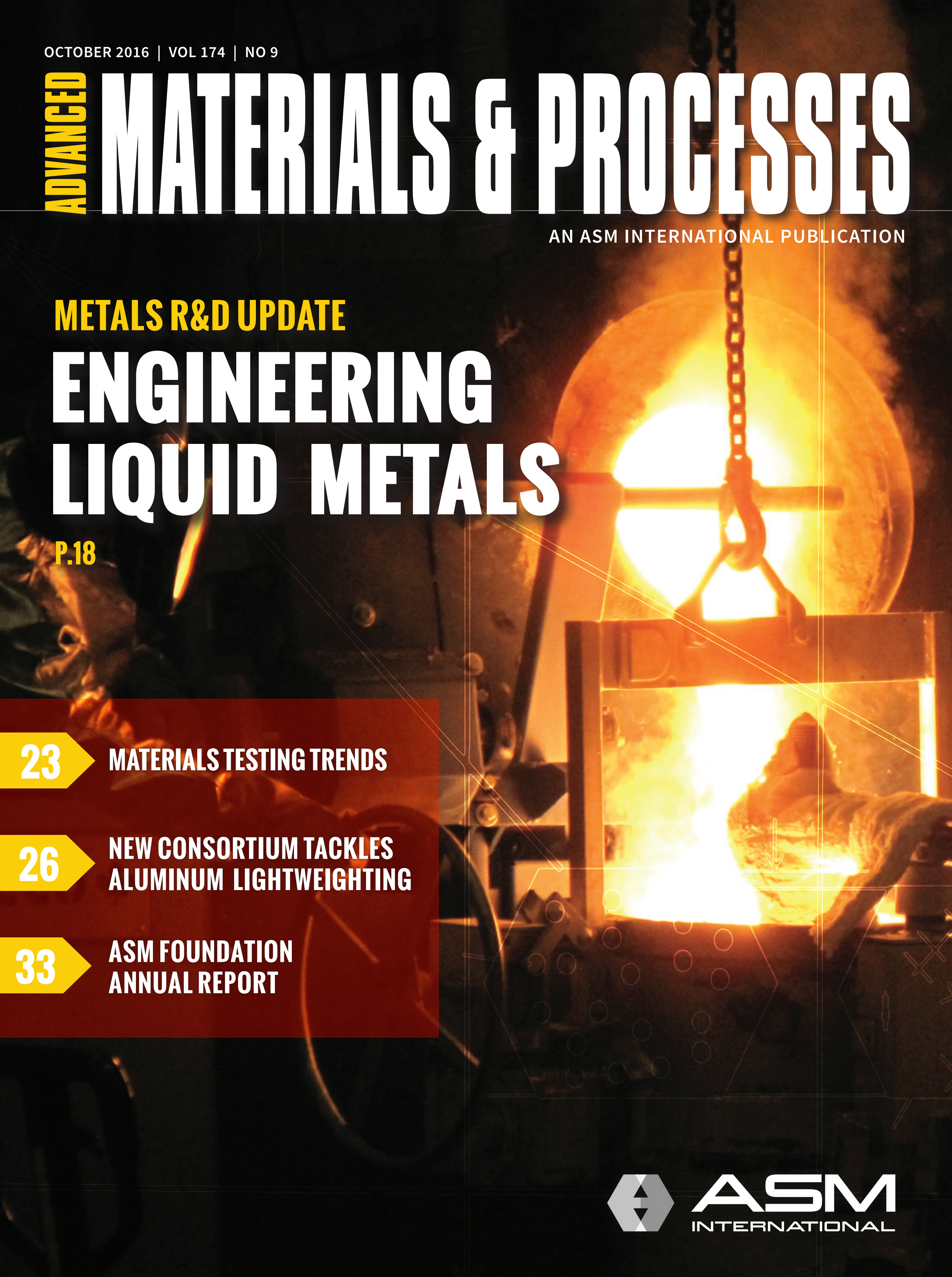

METALS R&D UPDATE

ENGINEERING LIQUID METALS

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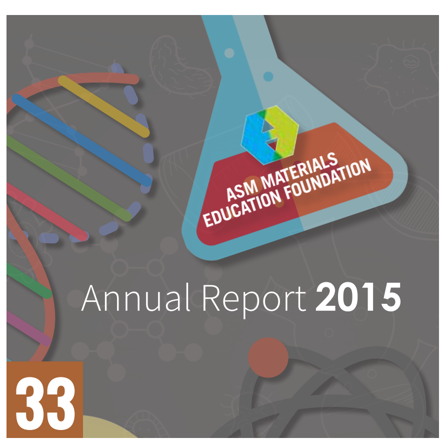
On the Cover:

Liquid metal during processing. Courtesy of CanmetMaterials, Natural Resources Canada.



ADVANCED MATERIALS & PROCESSES

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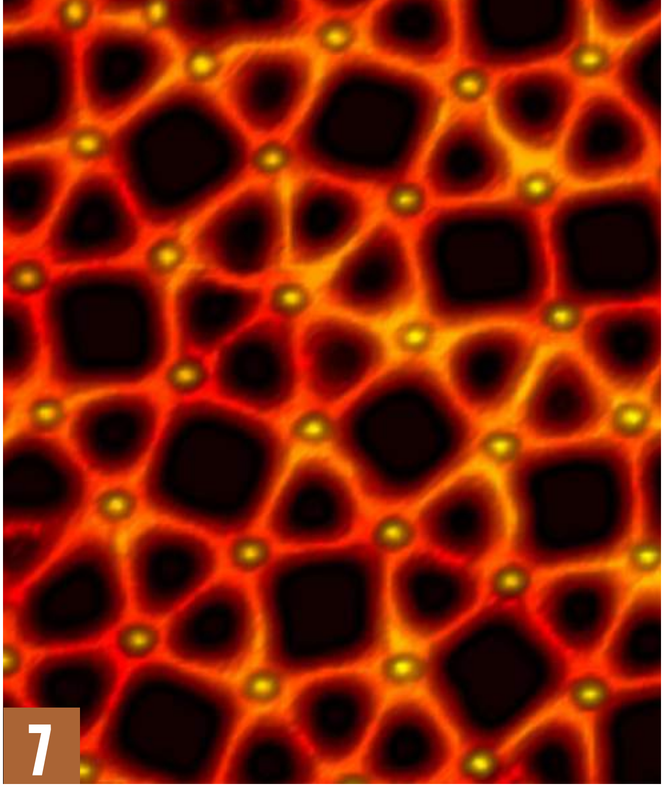
FEATURES



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TRENDS

INDUSTRY NEWS

DEPARTMENTS

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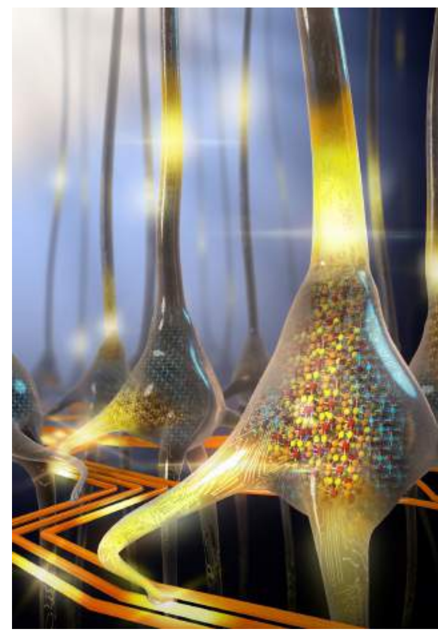
SERIOUS MATTERS

The best part about working on a science and engineering publication is the incredibly diverse array of press releases, news feeds, and video clips that pour into my inbox 24/7. Rest assured there is no shortage of scientific endeavors taking place around the world and elsewhere! During the past month, two news items were especially intriguing—and both are somewhat scary. One has to do with dark matter and the other involves gray matter.

Dark matter is defined as being an unidentified type of matter that makes up about 27% of the mass and energy of the universe not accounted for by ordinary matter, neutrinos or dark energy. It is also invisible because it doesn't emit or interact with electromagnetic radiation. On August 25, astronomers reported that the Dragonfly 44 galaxy—an *ultra diffuse galaxy* with the same mass as our dear Milky Way—may be almost entirely comprised of dark matter. Dragonfly 44 appears to have no stars and does not exhibit a traditional galactic structure. Now, numerous experiments are underway to detect dark matter particles through nongravitational methods. Just imagine the unusual material properties these particles could have once they are understood, and the impact this would have on materials science and engineering as we know it. I think this is fascinating to ponder, but not as daunting as the potential implications of developing artificial gray matter.



Artistic rendering of a population of stochastic phase-change neurons. Courtesy of IBM Research.

Although I have not yet seen it referred to as "gray matter," new results coming out of IBM Research in Switzerland seem mighty close to making the leap from materials research to actual artificial intelligence. (See p. 12). IBM scientists, inspired by how the human brain works, are using phase-change materials to create "randomly spiking artificial neurons" to pave the way to faster cognitive computing and improved analysis of big data. These neurons can perform "unsupervised learning at high speeds using very little energy" and they don't need coffee, bathroom breaks, sleep, or any HR benefits. I don't know about you, but I wasn't too worried about being replaced by a robot that handles manual labor tasks. But now that artificial intelligence is becoming closer to reality in a step-by-step fashion, it may be time for all of us to worry. I don't mean to sound alarmist, but as machines get better and smarter all the time, we do need to think about what humanity brings to the table in terms of employment skills.

One thing we can to do stay current and involved in our industries is to attend trade shows, learn about state-of-the-art research and best practices, and network with others in our fields to collaborate. To that end, we hope to see many of you in Salt Lake City later this month at MS&T16! And if you have thoughts to share on the dark or gray matters, we'd love to hear from you.

F. Richards

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MARKET SPOTLIGHT

MAGNESIUM MARKET SEES STEADY GROWTH

Global growth in the magnesium market is expected to average 3.4% per year reaching almost 1.2 Mt per year by 2020, according to a new report, "Magnesium Metal: Global Industry, Markets & Outlook, 12th Edition" from Roskill Information Services Ltd., London. Aluminum alloys and die casting are predicted to be the fastest growing markets, both at roughly 4% per year. However, the main factor affecting magnesium demand will likely be automobile use, due to both greater unit consumption and increased vehicle production. Development of magnesium metal with a dense uniform dispersion of silicon carbide nanoparticles could have significant long-term impact on demand. In addition, magnesium-ion rechargeable batteries that have twice the capacity and energy density of lithium ion batteries could also spur growth.

In the first quarter of 2016, a six-year decline in magnesium prices appears to have leveled out at $2000 per ton, based on production costs in China where nearly 80% of the world's magnesium is produced. As prices moved below this level at the end of 2015, resistance from producers coupled with firming coal prices and better than expected performance in the Chinese economy pushed the price of magnesium up by 11% in April 2016. The export price for Chinese magnesium is likely to stay in the $2000 to $2500/ton range for the remainder of this year.

Global magnesium consumption is estimated to have grown at an average annual rate of 1.6% from 2008 to 2015. This was after falling 7% in 2008 and 19% in 2009, and then recovering by 18% and 9% in the following two years. Growth was slow in 2012 and 2013, but rose to 8% in 2014 to a peak of almost 1 Mt. It then fell by 2% in 2015. Aluminum alloys containing on average 0.8% magnesium are widely used, with packaging, transport, and construction comprising the three leading industries for consumption.

Magnesium castings are used primarily by the automobile industry, but also in aerospace components, defense applications, and consumer goods such as cases for laptops, tablets, and mobile phones cases. The most widely used magnesium castings contain more than 90% Mg commonly alloyed with aluminum, although some castings are alloyed with rare earth elements to impart creep and corrosion resistance. *For more information, visit roskill.com.*

Magnesium castings are widely used in automotive and aerospace applications.

FEEDBACK

COMPOSITE DIE IDEA

I am a mechanical engineer with a master's degree in metallurgy, specialized in welding engineering. Upon retiring several years ago, I set up a website (www.welding-advisers.com) to provide open welding information, consultation, and a free monthly newsletter. Recently, I applied for a patent on a new method of constructing a composite die for forging and forming. I developed the patent to answer, among others, the following questions:

- Is it possible to build forging or forming dies in less time than with the usual way?
- Is it feasible not to be constrained by long lead times for tool steel blocks?
- Could a standard, in-stock tool steel shape be used to make different dies?
- Would simpler and cheaper hardened tool steels perform adequately for demanding dies?

I believe my idea would provide some practical benefits in the cost and time of building certain classes of dies. However, I have no real proof, as no hardware was ever built according to the principles I developed. I would like to share my idea with anyone in the industry who might be interested. A short note describing the essential aspects of the construction of such dies is available on my website at www.welding-advisers.com/Composite-Die-Description.html. I am very interested in receiving comments and feedback from readers who are curious about my idea.

Elia Levi
www.welding-advisers.com/contact.html

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

OMG!
OUTRAGEOUS MATERIALS GOODNESS


A new process to make carbon fiber uses less energy and is much more affordable than other methods.

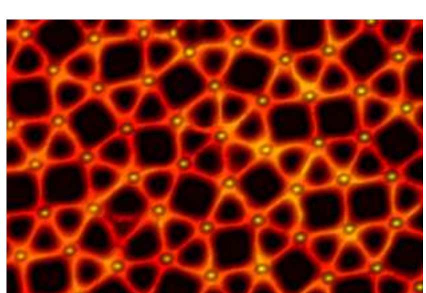
NEW CARBON FIBER SAVES MONEY AND ENERGY

LeMond Composites, Minneapolis, secured a licensing agreement with the DOE's Oak Ridge National Laboratory (ORNL), Tenn., to offer what is said to be an industry-disrupting carbon fiber to the transportation, renewable energy, and infrastructure markets. The breakthrough process, invented by LeMond CEO Connie Jackson and a research team at ORNL, will reduce carbon fiber production costs by more than 50% relative to the lowest cost industrial grade carbon fiber now available. The LeMond version features mechanical properties comparable to carbon fiber costing three times as much. This new method also reduces energy consumed during production by up to 60%. The innovative process will allow high volume, cost sensitive industries around the world to reap the benefits of carbon fiber composites at a fraction of the cost while incorporating chemistry geared toward recyclability, says Jackson. *www.lemond.cc.*

NOVEL MATERIALS FOR METAL-ORGANIC 2D QUASICRYSTALS

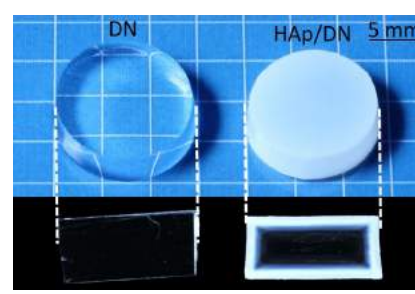
A group of scientists led by Professor Wilhelm Auwärter at TUM, Germany, in collaboration with Hong Kong University of Science and Technology, and the Spanish research institute IMDEA Nanoscience, developed a new basis for producing 2D quasicrystals, which could facilitate a better understanding of these peculiar patterns.

Researchers successfully linked europium with organic compounds, thereby constructing a 2D quasicrystal that has the potential to be extended into a 3D quasicrystal. They also thoroughly elucidated the new network geometry in unparalleled resolution using a scanning tunneling microscope and found a mosaic of four different basic elements comprising triangles and rectangles distributed irregularly on a substrate. Some of these basic elements assembled themselves to regular dodecagons that, however, cannot be mapped onto each other through parallel translation. The result is a complex pattern, a small work of art at the atomic level with dodecagonal symmetry. *For more information: Wilhelm Auwärter, wau@tum.de, +49 89 289-12399, www.tum.de.*


Scanning tunneling microscopic image of the quasicrystalline network built up with europium atoms linked with para-quaterphenyl-dicarbonitrile. Courtesy of J.I. Urgel/TUM.

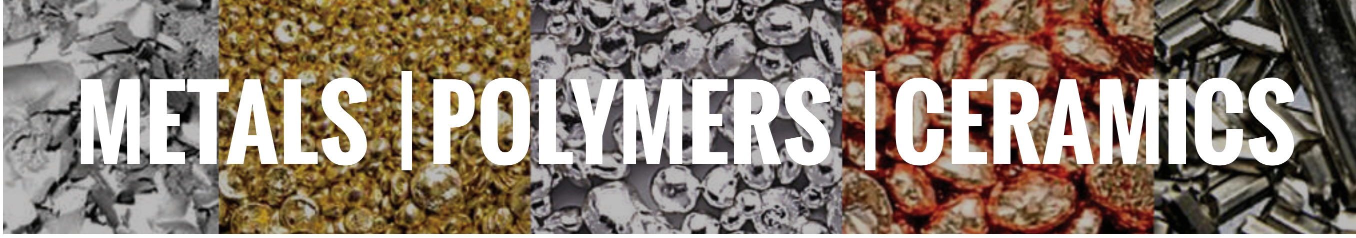
HYDROGEL MATERIAL SPURS BONE BONDING

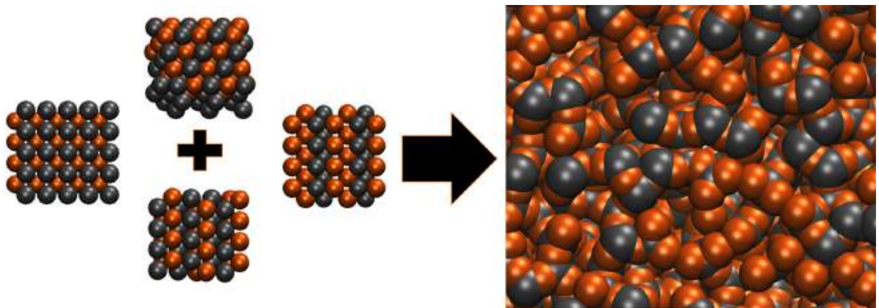
Researchers at Hokkaido University, Japan, developed a new kind of hydrogel that bonds spontaneously and strongly to defective or injured bones, suggesting potential use for treating joint damage. The group previously developed a tough, high-strength network gel called double-network gel (DN gel), which exhibits excellent performance such as low wear and inductive function for cartilage regeneration. However, as the gel's main component is water, it is difficult for it to bond with other surfaces—a major stumbling block in its practical application. Now, the team successfully added hydroxyapatite (HAp), the major inorganic component of bone, to the surface of DN gel by dipping it in calcium solution and phosphate solution. The HAp-coated DN gel (HAp/DN gel) was then transplanted into a defective rabbit bone. Four weeks later, the coated gel had securely bonded to the bone, while the non-coated gel had not bonded at all. Electron microscope analysis reveals that the newly formed bone component in the damaged area had penetrated into the gel surface and fused to it seamlessly. *www.oia.hokudai.ac.jp.*



DN gel (left) and newly developed HAp/DN gel (right) including cross-sectional views. Courtesy of T. Nonoyama and S. Wada, et al., *Advanced Materials,* May 17, 2016.

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.





When metal alloys are melted, the atoms lose their ordered structure and become amorphous, as seen above. Courtesy of the Vlassak Group/Harvard SEAS.

FINDING ALLOYS TO FORM BULK METALLIC GLASS

Researchers from the Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS), Cambridge, Mass., in collaboration with colleagues from Duke and Yale universities, recently developed a method to predict which alloys might form a bulk metallic glass. "For the first time, we've observed a strong correlation between the glass-forming ability of an alloy and properties that we can easily calculate ahead of time," says Joost J. Vlassak, a materials engineering professor at SEAS.

When metal alloys are melted, the atoms lose their ordered structure—although most will snap back to their rigid crystal structures when cooled. However, bulk metallic glasses, if cooled at certain rates, will retain the random amorphous structure even in the solid state. Yet some alloys have more options when it comes to their crystal structures. When these alloys are being cooled into solids, their atoms could crystallize in many different ways. "If a particular alloy composition exhibits many structurally different, stable or metastable crystal phases that have similar formation energies, these phases will compete against each other during solidification," explains Vlassak. "Essentially, the liquid becomes so confused, it remains amorphous as it solidifies."

"When you get a lot of structures forming next to one another that are different but still have similar internal energies, you get a sort of frustration as the material tries to crystalize," adds Eric Perim, a postdoctoral researcher at Duke. "The material can't decide which crystalline structure it wants to converge to, and a metallic glass emerges. What we created is basically a measure of that confusion." The team at Duke developed a database to simulate the hundreds of crystalline structures each alloy could potentially take. They created a program to analyze the various structures and compare the energy required to form them. Alloys that can form many different structures whose energy is similar are likely candidates to form a metallic glass. The teams at Harvard and Yale then verified the predictions experimentally. The new approach is able to predict the formation of known metallic glasses 73% of the time and has identified hundreds of new candidates for metallic glass made from simple, two-element alloys. Now that the researchers can predict good candidates for metallic glass, they can start looking for new material systems. *seas.harvard.edu.*

BRIEFS

A hydrolysis-resistant, bio-based polyamide, EcoPaXX, from **Royal DSM,** the Netherlands, was recently approved for use by a German car manufacturer. A thin-walled *T* connector for a coolant hose in this grade, Akulon PA66, is now available in two versions: HR-HG6 and HR-HG7, containing 30% and 35% glass fiber reinforcement, respectively. Both comply with OEM requirements for a high retention of flexural strength after immersion in the solution for 1000 hours at 135°C. Targeted applications include expansion tanks, air intake manifolds, oil pans with integrated cooling channels, and oil filter/cooler modules. *dsm.com.*

Hot rolled or hot forged bars of AUTO-Steel from **Advanced Materials Development (AMD) Corp.,** Canada, can be used in car and truck carburized powertrain and transmission components such as camshafts, gears, axles, and shafts. Carburized Grade1 features surface hardness of HRC 61-62 and core hardness of HRC 45-46. Grade2 is a medium carbon, deep nitriding composition suited for high precision components. After quenching and tempering, Grade3 features hardness of HRC 58-60 and UTS of 325-335 ksi. *info@amdoncorp.com.*

AUTOMOTIVE ALUMINUM RECYCLING GOING STRONG

New research from Worcester Polytechnic Institute's (WPI) Center for Resource Recovery and Recycling confirms an overall recycling rate of 91% for automotive aluminum in the U.S. The peer-reviewed study, funded by the Aluminum Association, examines how much aluminum used in the light-duty automotive sector is recovered and recycled from vehicles at end of life. The study, "Automotive Aluminum Recycling at End of Life: A Grave-to-Gate Analysis," provides a lifecycle evaluation, which begins the moment an automobile becomes obsolete and ends the moment the aluminum metal units are completely recycled and ready to be used as input material for new applications, including vehicles. Researchers attribute automotive aluminum's high recycling rate to its economic value, citing the "concerted effort to recover this valuable lightweight commodity from end-of-life vehicles." *drivealuminum.org.*

INJECTION MOLDING CREATES COMPLEX CERAMIC PARTS

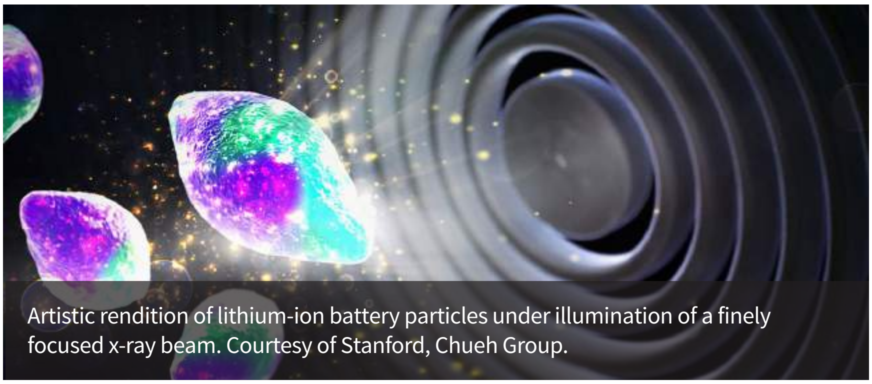
Scientific Ceramic Engineering, Spotsylvania, Va., licensed a Purdue University, West Lafayette, Ind., ceramic injection-molding technology that uses room temperature molding, low pressure machinery, and less toxic materials to produce stronger, faster, and less expensive complex ceramic parts for a multitude of industries. The innovation uses an injection molding technology to form high-temperature ceramic parts with complex dimensions by taking advantage of temperature flow properties of water-based ceramic suspensions. The molding technique enables ceramic materials to be machined with high precision and accuracy. The technology also provides consistent dimensions after sintering for reliable accuracy and improved strength and toughness for a stronger finished product, says CEO David Forster. *scientificcim.com.*

ALUMINUM FLIES HIGH IN AIRCRAFT

Aleris, Cleveland, signed a multiyear contract with Airbus, France, to supply aluminum plate and sheet to be used in the production of all Airbus aircraft programs. The contract starts in 2017 and also includes the supply of technically advanced wing skin material. The agreement includes not only aluminum plate and sheet used in applications including aircraft fuselage and wing structures, but also the supply of wing skins—a highly specialized product that requires additional processing and pre-machining. The contract includes the supply of material from the company's facilities in Koblenz, Germany, and Zhenjiang, China, the latter of which represents a $350 million greenfield project for Aleris. This facility was qualified by Airbus for the production of aerospace material in 2015. *aleris.com, airbus.com.*

Aleris signed a multiyear contract with Airbus to supply aluminum plate and sheet for use in all Airbus aircraft.

TESTING | CHARACTERIZATION



Artistic rendition of lithium-ion battery particles under illumination of a finely focused x-ray beam. Courtesy of Stanford, Chueh Group.

SCOPING OUT BATTERY PERFORMACE WITH X-RAYS

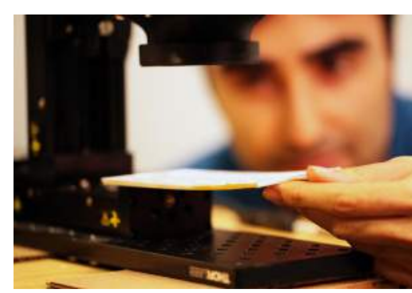
An x-ray microscopy technique developed at the DOE's Lawrence Berkeley National Laboratory, Calif., improves scientists' ability to image nanoscale changes inside the lithium-ion battery particles that make up electrodes. The new method uses soft x-rays to image micron-sized lithium iron phosphate particles as they charge and discharge in a liquid electrolyte, chronicling the evolution of the particles' chemical composition and reaction rates in real-time. Among other findings, researchers discovered that when positively charged lithium ions embed in the electrode's surface during charging, they rarely do so uniformly, especially as a battery ages—a phenomenon that likely curbs battery performance over time.

The imaging technique was implemented at the Lab's Advanced Light Source, at two beamlines that offer high-performance scanning transmission x-ray microscopy (STXM), in which an extremely bright x-ray beam is focused onto a small spot. Previously, transmission electron microscopy (TEM) has been used to study working batteries at the nanoscale, but STXM can image a larger field of view and thicker materials than TEM, and it provides very high chemical specificity. Researchers are now working on new x-ray microscopes that would improve the platform's spatial resolution by a factor of 10. *lbl.gov.*

A TERAHERTZ LOOK INTO A CLOSED BOOK

Researchers from Massachusetts Institute of Technology, Cambridge, and Georgia Tech, Atlanta, designed an imaging system that can read a closed book using terahertz radiation. The team uses a standard terahertz camera to emit ultrashort bursts of radiation at a stack of papers. A built-in sensor then detects and analyzes the radiation's reflections. The researchers' algorithm can determine the distance from the camera to each of the top 20 pages in a stack and correctly identify letters printed on the first nine sheets.

To determine the distance to each sheet, the camera's sensors locate the margins of the 20-µm-deep air pocket between each page, and then calculate the difference between the time radiation is emitted toward, and received back from, these boundaries—similar to a submarine using sonar. The system distinguishes between ink and blank paper by reading how the different chemicals absorb different radiation frequencies. Finally, the algorithm filters out competing noise. In addition to perusing rare books too fragile to flip through, the system could be used to analyze any materials organized in thin



Researchers at MIT and Georgia Tech are designing an imaging system that can read closed books. Courtesy of Barmak Heshmat.

BRIEFS

Xinghang Zhang, a professor in the School of Materials Engineering at **Purdue University,** West Lafayette, Ind., received a $450,000 grant from the **DOE's Office of Basic Energy Sciences** for work on metal characterization. Zhang will serve as the primary investigator for a three-year research project, "Deformation Mechanisms of Nanotwinned Aluminum and Binary Aluminum Alloys," using transmission electron microscopy to examine aluminum's atomic structure. *purdue.edu.*

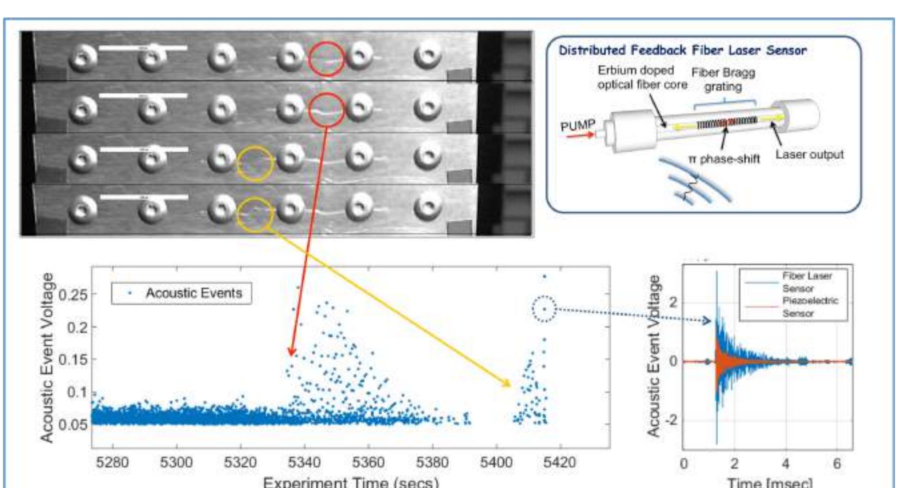
The in-house service lab at **Nanomechanics Inc.,** Oak Ridge, Tenn., now offers nanoscale indentation and nanomechanical testing for research and industrial applications, in addition to scratch testing, hardness and modulus measurements, and property mapping. Analytical lab services for small-scale mechanical testing are also available, including nondestructive mechanical property measurements, testing consulting, research collaboration, and nanoindentation testing reference materials. *nanomechanicsinc.com.*

layers, such as coatings on machine parts or pharmaceuticals. *mit.edu, gatech.edu.*

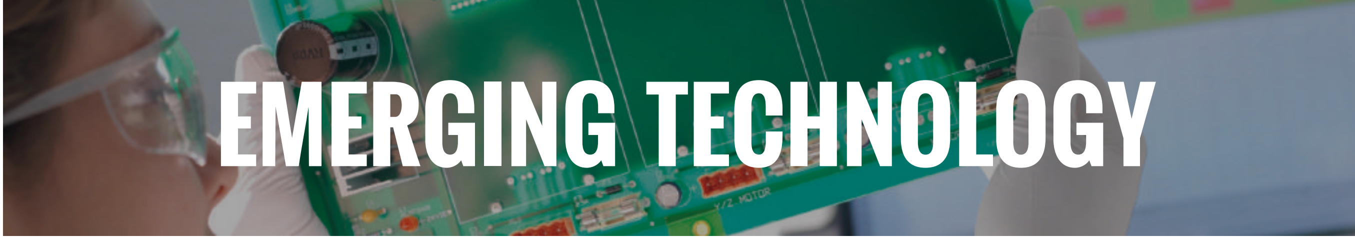
FIBER LASER SENSOR LISTENS FOR FRACTURES

For the first time, scientists at the U.S. Naval Research Laboratory (NRL), Washington, used a distributed feedback fiber laser acoustic emission sensor to detect acoustic emission from cracks in riveted lap joints. The sensor, integrated into a shallow groove in the lap joint, consists of a single fiber, about the width of a human hair. Researchers installed the sensors in a series of riveted aluminum lap joints and measured acoustic emission over a bandwidth of 0.5 MHz generated during a two-hour accelerated fatigue test. Measurements were also taken with an equivalent electrical sensor. The embedded sensors resolved low-level acoustic events generated by periodic fretting from the riveted joint in addition to acoustic emissions from crack formation. Time-lapse imagery of the lap joint correlated the observed fracture with the measured signals.

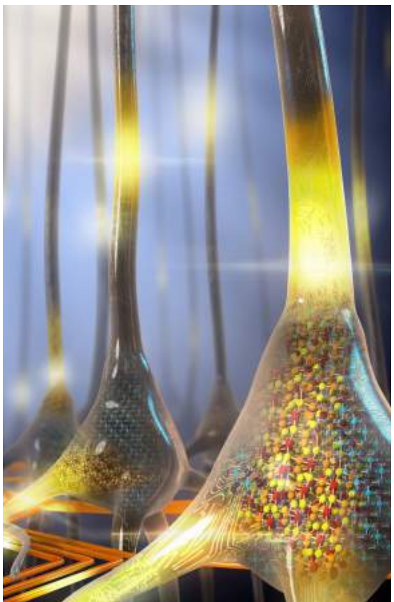
The fiber laser sensor has acoustic sensitivity comparable to, or greater than, that achieved by existing electrical sensors, and its laboratory performance is unmatched by any other intrinsic optical fiber sensor. It can measure compromising impacts as well as cracks, and could integrate with existing fiber optic strain and temperature sensing systems. In addition to military applications, the sensor could be used for continuous monitoring of buildings and bridges. *nrl.navy.mil.*



Initiation and growth of cracks between rivets in a lap joint (top left). A fiber laser sensor (top right) measures acoustic emission signals generated by the cracks and software records them as acoustic events. A typical event is shown in lower right plot. Amplitude of the AE events as a function of time is shown in lower left plot. Courtesy of NRL.



EMERGING TECHNOLOGY



Artistic rendering of a population of stochastic phase-change neurons. Courtesy of IBM Research.

PHASE-CHANGE MATERIAL MIMICS THE BRAIN

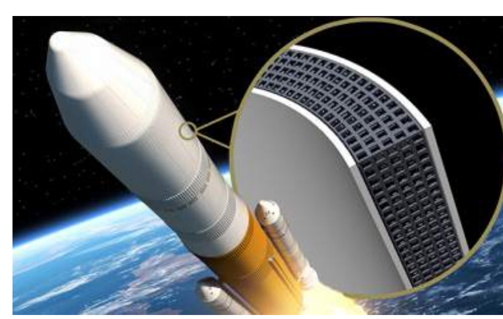
Inspired by brain function, scientists at IBM Research, Switzerland, used phase-change materials to create randomly spiking artificial neurons, paving the way to faster cognitive computing and improved analysis of big data for the Internet of Things. The materials, including germanium antimony telluride, exhibit two stable states—amorphous and crystalline. When the IBM team applied a series of electrical pulses to the artificial neurons, the material progressively crystallized, causing neurons to fire. Just like synapses and neurons in the brain, these artificial neurons function in an analog rather than digital way.

The artificial neurons "can perform various computational primitives such as data-correlation detection and unsupervised learning at high speeds using very little energy," explains IBM Fellow Evangelos Eleftherio. They can sustain billions of switching cycles—multiple years of operation—at an update frequency of 100 Hz, and on average, each update requires less than 5 pJ of energy and less than 120 μW of power. While even a single neuron can be used to detect patterns and discover correlations in real-time streams of event-based data—analyzing financial transactions or social media trends, for example—IBM scientists have demonstrated that hundreds of neurons can be organized into populations. For instance, the neurons could be configured for neuromorphic coprocessors with co-located memory and processing units. *ibm.com.*

3D-PRINTED GRID ABSORBS BAD VIBES

Researchers at ETH Zurich, Switzerland, developed a lattice structure capable of absorbing a wide range of vibrations while also serving as a load-bearing component. In the past, engineers have used soft materials to absorb vibrations in machines, vehicles, and aircraft that increase fatigue damage and make environments jarring and loud. Unlike these soft materials, however, the rigid lattice could be used to construct structural components, such as airplane rotors and helicopter propellers. Also, the lattice can be designed to absorb oscillations of a few hundred to tens of thousands of Hertz—a much broader range than soft materials can handle—including audible vibrations, which are the most undesirable.

The plastic grid, fabricated by 3D printing, has a lattice spacing of roughly 3.5 mm and is embedded with steel cubes slightly smaller than dice that act as resonators. Instead of vibrations traveling through the whole structure, they are trapped by the steel cubes and inner plastic grid rods. Widespread use of the lattice is limited by its material properties, which do not yet match those of components manufactured by traditional methods. Further, 3D printing technology is primarily geared toward small-scale production. Eventually, however, applications could include wind turbine rotors, vehicle and aircraft construction, and even rockets. *www.ethz.ch.*



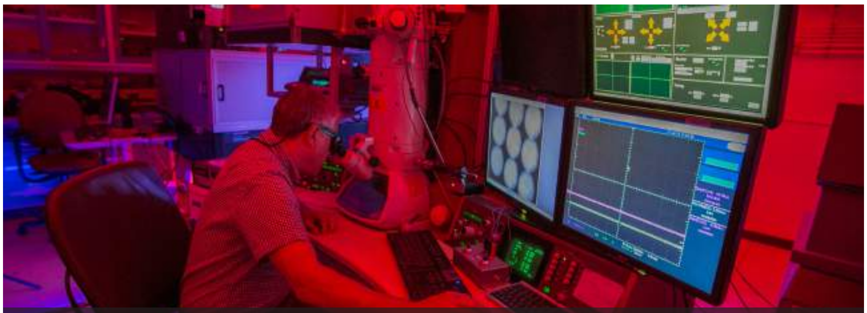
Vibration-absorbing lattice, which could eventually be used in rockets. Courtesy of 3Dsculptor/Shutterstock/Jung-Chew Tse.

BRIEF

Under a new agreement between **Oddello Industries LLC,** Morristown, Tenn., and **Oak Ridge National Laboratory** (ORNL), Tenn., a process developed at ORNL for large-scale recovery of rare earth magnets from used computer hard drives will undergo industrial testing as part of the DOE's Critical Materials Institute. The process recovers the magnets intact, enabling direct reuse by hard drive manufacturers or in motor assemblies. Magnets can also be resized or reshaped for alternate uses or processed back to rare earth metal. *ornl.gov.*

Model of a punching device to be tested for recovering magnet assemblies.

PROCESS TECHNOLOGY



Joseph McKeown uses LLNL's DTEM to investigate rapid alloy solidification. Courtesy of Julie Russell/LLNL.

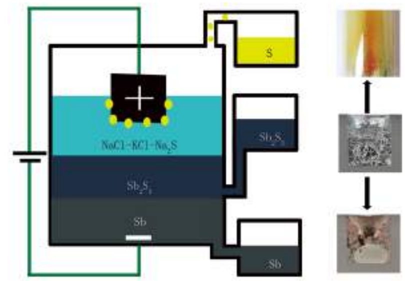
IMAGING ALUMINUM ALLOY SOLIDIFICATION

Engineers at the University of Pittsburgh are focusing the power of a dynamic transmission electron microscope (DTEM) on rapid solidification of aluminum alloys associated with laser or electron beam processing technologies. Unlike a traditional transmission electron microscope, the DTEM at Lawrence Livermore National Laboratory (LLNL), Calif., uses lasers to achieve high time resolution, allowing researchers to see how a chemical reaction, structural deformation, or phase transformation takes place with an unprecedented combination of spatial and temporal resolution—in nanometers and nanoseconds.

"DTEM allows you to see the interface between the solid and liquid during rapid solidification," says Joe McKeown, an LLNL materials scientist. "We can image this process as it's moving rapidly, and from that we can measure just how fast it's going. There's no other technique to do that." Previously, these transformations could only be simulated on a computer. McKeown said the data collected from the study, funded by a three-year, $500,000 grant from the National Science Foundation, could improve predictive capabilities for metal additive manufacturing and validate existing computer models. *pitt.edu, llnl.gov.*

SURPRISE! BATTERY MAKES 99.9% PURE METAL

While attempting to develop new electrochemistry for a battery, researchers at Massachusetts Institute of Technology (MIT), Cambridge, instead discovered an innovative method for producing antimony. During experiments with all-liquid, high temperature storage batteries, composed of layers of molten metals or salts, researchers placed a second electrolyte—in this case, antimony sulfide—between the positive and negative electrodes. When they attempted to charge the battery, liquid antimony was produced instead. Antimony sulfide is a good conductor of electrons and normally would not allow for electrolysis, which demands an ionic conductor. However, electrolysis was facilitated by adding an ionic conductor layer on top of the molten semiconductor.



Electrolysis of a molten semiconductor. Courtesy of the researchers.

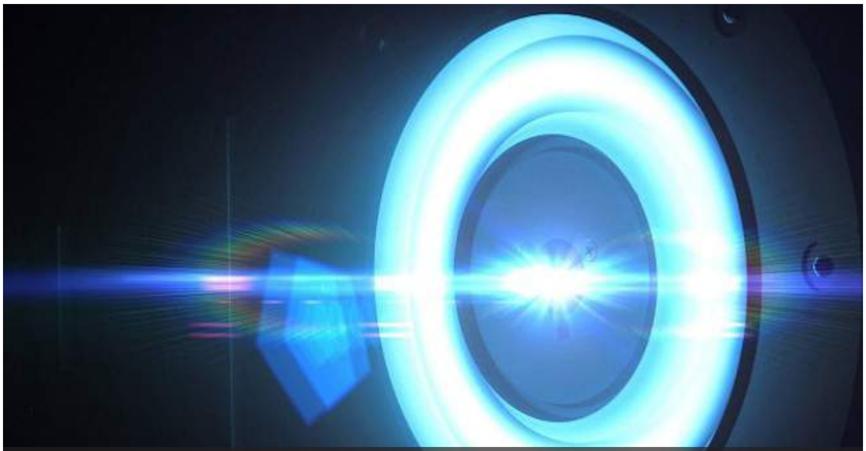
The process formed a pool of 99.9% pure antimony at the bottom of the cell, while pure sulfur gas pooled at the top, where it could be easily collected. In typical smelting processes, sulfur gas bonds with oxygen in the air to form sulfur dioxide—the major cause of acid rain—requiring subsequent scrubbing. As a single-step continuous process, electrolysis is much more efficient than traditional heat-based smelting, and if used to produce other common industrial metals such as copper, nickel, or steel, could dramatically lower metal prices and reduce air pollution and greenhouse gas emissions. *mit.edu.*

BRIEFS

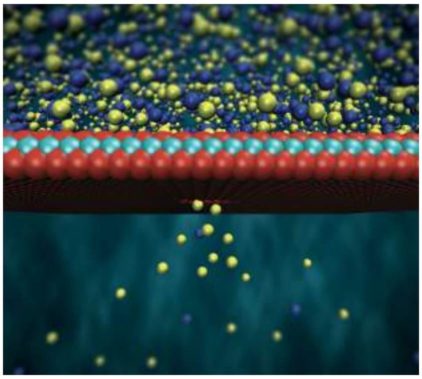
Kobelco Aluminum Products & Extrusions Inc., Japan, a subsidiary of **Kobe Steel Ltd.,** broke ground on its production facility in Bowling Green, Ky., where the company will manufacture aluminum bumper and car frame material for the U.S. automotive industry. Fabrication will begin in late 2017, with melting to extrusion processes coming online in late 2018. *kobelcocm-global.com.*

The Shagang Group, China, signed a licensing agreement with **Castrip LLC,** Charlotte, N.C., to use Castrip technology in conjunction with existing steelmaking furnaces for casting and finishing high strength, thin gauge sheet, with widths to 1600 mm and gauges from 0.7-1.9 mm. Estimated annual capacity is 500,000 tons per line, and hot commissioning of the new facility is scheduled for late 2017. The Castrip process will reduce energy use and emissions in the casting and rolling process. *sha-steel.com/eng, castrip.com.*

ENERGY TRENDS



SunCell produces energy by converting the hydrogen element in water-based solid fuel through a chemical reaction that produces a type of gas plasma energy.



A three-atoms-thick molybdenum selective membrane. Courtesy of Steven Duensing/National Center for Supercomputing Applications, University of Illinois, Urbana-Champaign.

CLEAN, GREEN ELECTRIC POWER ON THE HORIZON

Brilliant Light Power Inc., Cranbury, N.J., continuously generated over a million watts of power from a new primary source until the cell vaporized due to the intense heat. The power released by the conversion of hydrogen atoms from water molecules into a lower energy form called Hydrino or dark matter is manifest as brilliant-light emitting plasma. Within the plasma, the light is essentially all high-energy and exists in the extreme ultraviolet spectrum.

Using four methodologies, validators have confirmed over a million watts of plasma power developed by BrLP's SunCell at power gains of over 100 times the power to ignite the Hydrino reaction, and at power densities higher than any previously known energy source. The safe, nonpolluting power-producing system catalytically converts the hydrogen of the H_2O-based solid fuel into a non-polluting product, Hydrino, by allowing the electrons to fall to smaller radii around the nucleus. The energy release is over 200 times that of burning the equivalent amount of hydrogen with oxygen. Due to this extraordinary energy release, H_2O may serve as the source of hydrogen fuel to form Hydrinos and oxygen. *For more information: Lynn Kline, 609.490.1090 ext. 125, lkline@brilliantlightpower.com, brilliantlightpower.com.*

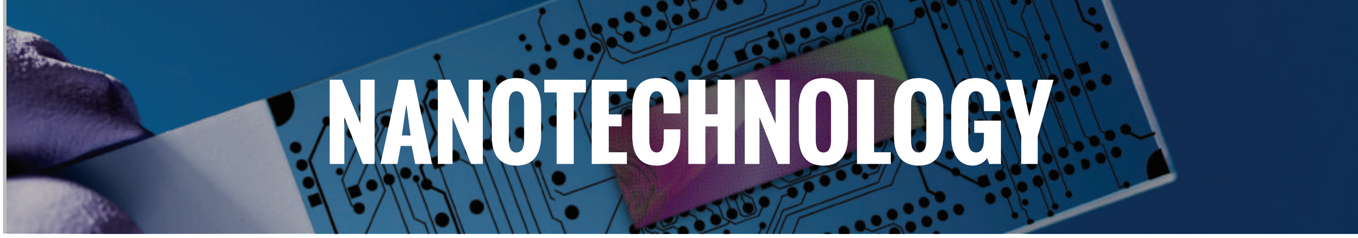
NEW FORM OF HYDROPOWER

Proponents of clean energy will soon have a new source to add to their existing array of solar, wind, and hydropower: osmotic power. Or more specifically, energy generated by a natural phenomenon occurring when fresh water comes into contact with seawater through a membrane. Researchers at Ecole Polytechnique Fédérale de Lausanne's Laboratory of Nanoscale Biology, Switzerland, developed an osmotic power generation system that delivers unprecedented yields. Their innovation lies in a three-atoms-thick membrane used to separate the two fluids.

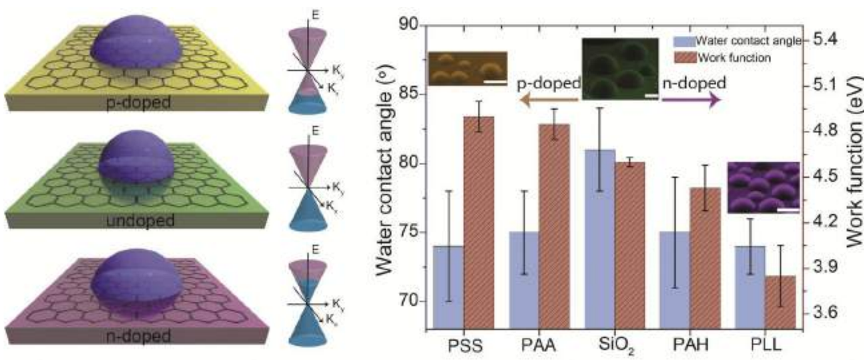
The concept is fairly simple. A semipermeable membrane separates two fluids with different salt concentrations. Salt ions travel through the membrane until the salt concentrations in the two fluids reach equilibrium. If the system is used with seawater and fresh water, salt ions in the seawater pass through the membrane into the fresh water until both fluids have the same salt concentration. Because an ion is simply an atom with an electrical charge, the movement of the salt ions can be harnessed to generate electricity. *www.epfl.ch.*

BRIEF

Researchers at the **Langevin Institute, ESPCI Paris,** and the **French National Center for Scientific Research,** recently discovered that a special class of materials called *hyperuniform materials* can be both dense and transparent. Their work demonstrates a new way to control light and could lead to novel materials for many light-based applications including solar photovoltaics. These novel materials can be made of plastic or glass that contains light-scattering particles spaced in a disordered, but not completely random, pattern. *www.institut-langevin.espci.fr/home?lang=en, www.espci.fr/en, www.cnrs.fr/index.php.*



NANOTECHNOLOGY



Doping-induced tunable wetting of graphene. Courtesy of University of Illinois.

TUNABLE WETTING AND ADHESION OF GRAPHENE

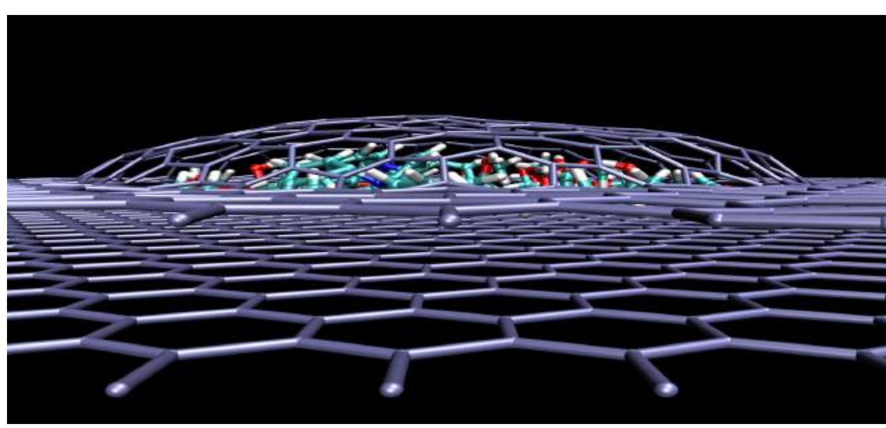
Researchers from the University of Illinois at Urbana-Champaign have demonstrated doping-induced tunable wetting and adhesion of graphene, revealing new opportunities for advanced coating materials and transducers.

"Our study shows for the first time that graphene demonstrates tunable wettability—switchable hydrophobic and hydrophilic behavior—when its electron density is changed by subsurface charged polymers and metals (a.k.a. doping)," explains SungWoo Nam, an assistant professor. "This finding sheds lights on previous unclear links between quantum-level charge transfer and macroscopic surface wettability for graphene. This opens new doors of possibility for tunable surface coating and electrowetting displays without continuous external electric current supply, which will translate into significant energy savings." *For more information: SungWoo Nam, swnam@illinois.edu, mechanical.illinois.edu.*

2D MATERIALS CREATED IN GRAPHENE PRESSURE COOKER

A graphene hydraulic nanopress is now capable of creating new 2D materials by exerting immense pressure on compounds sealed between layers of graphene. New findings reveal that sealing molecules between two atomically thin sheets of graphene creates extreme pressure on the molecules to modify their state, converting them to new crystals, according to a University of Manchester research group, UK, led by Professor Rahul Nair. The results demonstrate novel methods for creating versatile 2D materials, which have unique properties and benefits suited to a wide range of applications.

The graphene nanopress is made possible due to the material's unique properties. Graphene is stronger than diamond, which allows the extreme amount of pressure to be exerted on trapped molecules without breaking the graphene layers. The two stacked layers also create a self-sealing envelope around the trapped molecules to contain them. Molecules enclosed



Graphene hydraulic press.

BRIEFS

The **Congressional Research Service** prepared a policy primer on nanotechnology, which covers federal research and development, U.S. competitiveness, environmental, health, and safety concerns, nanomanufacturing, and public awareness. *https://fas.org/sgp/crs/misc/RL34511.pdf.*

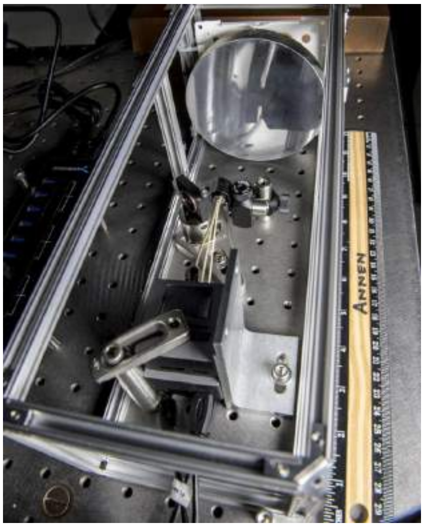
Federal agencies participating in the **National Nanotechnology Initiative** released a white paper describing the collective federal vision for the emerging and innovative solutions needed to realize the Nanotechnology-Inspired Grand Challenge for Future Computing. *www.nano.gov/sites/default/files/pub_resource/federal-vision-for-nanotech-inspired-future-computing-grand-challenge.pdf.*

between two layers of graphene experience pressures equivalent of 10,000 times the air pressure in a bicycle tire. *For more information: Rahul Nair, rahul@manchester.ac.uk, www.manchester.ac.uk.*

CNT MIRRORS FOR NASA TELESCOPE

A lightweight telescope that a team of NASA scientists and engineers is developing specifically for CubeSat scientific investigations could become the first to carry a mirror made of carbon nanotubes in an epoxy resin. Led by Theodor Kostiuk, a scientist at NASA's Goddard Space Flight Center in Greenbelt, Md., the technology development is aimed at giving the scientific community a compact, reproducible, and relatively inexpensive telescope that would fit easily inside a CubeSat. Individual CubeSats measure just 4 in. per side.

With funding from Goddard's internal R&D program, the team created a laboratory optical bench made up of three miniaturized spectrometers optimized for the ultraviolet, visible, and near-infrared wavelengths. Spectrometers are connected via fiber optic cables to the focused beam of a 3-in.-diameter carbon-nanotube mirror. The team is using the new bench to test the telescope's overall design. *For more information: Theodor Kostiuk, 301.286.8431, theodor.kostiuk-1@nasa.gov, www.nasa.gov/goddard.*



This laboratory breadboard is being used to test a conceptual telescope for CubeSat missions. Courtesy of NASA/W. Hrybyk.

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I certify that the statements made by me above are correct and complete.
Scott D. Henry
Publisher

ENGINEERING LIQUID METALS TO MANUFACTURE QUALITY COMPONENTS

Engineering molten alloys to change their solidification process improves part integrity and alloy microstructure, leading to better component performance.

Frank Czerwinski

CanmetMaterials, Natural Resources Canada

Hamilton, Ontario

Many factors must be considered when selecting a manufacturing technique to fabricate commercial components for large-scale production, such as in the automotive industry (Fig. 1). Two issues of utmost importance are part quality and cost. During part design, many manufacturing choices are available. The majority are associated with either net shape forming directly from the liquid state or those involving complex multistep operations involving a wrought path with additional hot and cold forming, machining, and other shaping processes following casting. Conventional casting offers limited part quality at relatively low cost. By comparison, solid state forming generally provides better properties at substantially higher cost. Work is being done to improve casting quality and to reduce solid state processing cost. However, novel technology that combines the best features of both processes might offer the ultimate solution—the highest properties achievable in wrought products at the low cost and simplicity of casting (Fig. 2).

Fig. 1 — Clamp area of 1200-ton, high-pressure die casting machine used for industrial-size trials at CanmetMaterials facility.

LIQUID METAL ENGINEERING

Liquid metal engineering is gaining attention as a new technology for large-scale production. The technique involves a variety of physical and chemical treatments of molten metal to influence solidification. A simplified approach limits the phenomenon to single-phase molten alloys above the liquidus line. However, it should generally cover manipulating liquid alloys coexisting with a solid phase, as is the case at temperatures in the liquidus-solidus region of the particular phase diagram[1]. Current techniques include melt filtering, rotary degassing, and various stirring/shearing/agitation methods using ultrasound, electromagnetic, magneto-hydrodynamic, and mechanical means (e.g., reciprocating injection screw and various types of mixers). For example, ultrahigh shear mixing/de-agglomeration solutions used in the food and cosmetic industries are also being tested with metals. Developing molten alloys with specific temperatures and chemistries to generate thixotropic morphologies is also being explored. A generation of unique alloys and composites made by mixing thixotropic slurries instead of molten alloys offers another opportunity[2].

Characteristics of two-phase slurries are affected by the deformation history of the material in the solid state prior to melting as it occurs during a stress-induced melt activation (SIMA) process, which demonstrates process complexity. The liquid alloy treatment can occur either at the stage of raw material generation for further processing, as in semisolid technologies, or directly prior to casting into net shape components. The overall objective at the stage of raw material generation might be limited to alloy microstructure. However, during forming of net shape components, it must cover both alloy microstructure and component integrity. The opposite approach of manipulating liquid to generate foamed materials instead of high-integrity structures is also of engineering and commercial interest[3].

Liquid metal engineering is applicable to all alloys although current research is focused on aluminum and magnesium due to their lower melting temperatures, and, therefore, less challenging designs of processing hardware. Note that the term liquid metal engineering has also been used for decades by the U.S. Atomic Energy Commission for development and non-nuclear testing of liquid-metal reactor components, covering totally different processes and materials from those described here.

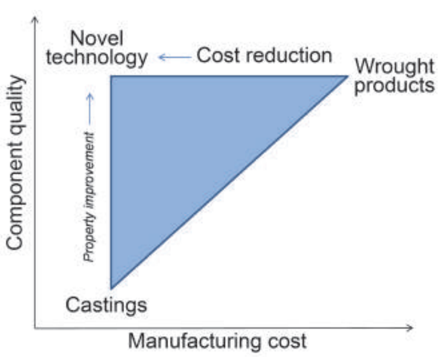

Fig. 2 — Cost-quality relationships for components manufactured through casting and through solid state wrought path. Anticipated location of the novel technology indicated for comparison.

SEMISOLID STATE TECHNOLOGIES

Invented in the early 1970s, semisolid processing was initially seen as a technology capable of manufacturing

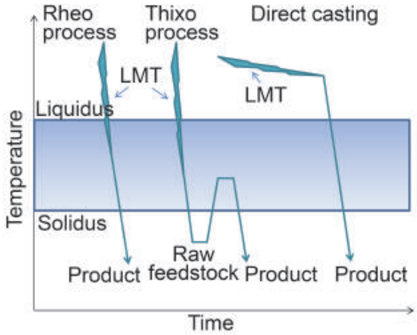

Fig. 3 — Concept of liquid metal treatments during rheoforming, thixoforming, and liquid base forming. LMT: Liquid metal treatment before transferring into die/mold for net shape forming.

net shape components with properties substantially better than those in castings. The primary objective of engineering liquid metal within all semisolid technologies is to generate thixotropic structures through nucleation of globular forms instead of dendritic ones during solidification. The former improves flow during net shape forming and provides other benefits[4]. In contrast to dendritic forms, thixotropic mixtures serve as deformable semi-cohesive spheroidal solids saturated with liquid, where an applied macroscopic stress is supported by both solid and liquid phases. This deformation behavior is unique for thixotropic structures. Alloys with dendritic features cannot be deformed by grain rearrangement due to significant geometric interference of complex solid features, leading to high flow resistance.

The initial approach of semisolid processing focused on rheocasting, where the molten alloy treatment during cooling to the liquidus-solidus range caused transformation from dendritic to globular morphologies. Several liquid metal treatments were introduced as the technology progressed. Semisolid processing was later dominated by thixoforming (thixocasting, thixoforging), where thixotropic raw material produced during the first stage was subsequently reheated to the semisolid range and subjected to net shape forming. However, thixocasting soon lost its advantage due to excessive cost, and today's semisolid processing is again dominated by rheo routes.

Treatment starts within a single-phase liquid and continues during coexistence of a two-phase thixotropic slurry (Fig. 3). As a result, only a portion of metal remains liquid and requires attention at the time of net shape forming. The solid fraction range that enables processing was defined between 5% and 60%. The upper limit is considered the content above which the alloy freezes, so it cannot flow into the mold cavity. However, with the invention of semisolid extrusion molding, the upper limit was substantially raised to over 85%, meaning that only a small fraction of liquid metal remained at the time of net shape forming[5].

The thixoforming path involves partial remelting of the previously solidified thixotropic alloy, creating a fraction of fresh liquid within the solid, which adds complexity. The chemical composition of the liquid fraction in the semisolid state differs from that measured for the bulk alloy, and the differences grow with decreasing temperature (Fig. 4a). The overall alloy chemistry should be specifically designed for this purpose to take advantage of having melts with two different compositions, i.e., an initial one and another at the forming stage. The lack of specifically designed alloys is one obstacle limiting commercialization of semisolid processing.

NEAR-LIQUIDUS PROCESSING

Temperature and time are essential parameters of liquid metal engineering. Initially, globular structure formation was explained as the need to break up dendrites during the freezing process either using mechanical stirring or other forms of agitation. The fragments of dendrites within the melt volume serve as nuclei of new grains that transform into spheroids. However, experimental evidence made this mechanism questionable. Direct observations of the solidification of transparent liquids with metal-like crystallization characteristics and numerical modeling suggest that globular crystals form through direct nucleation from a liquid instead of from fragments of broken dendrites.

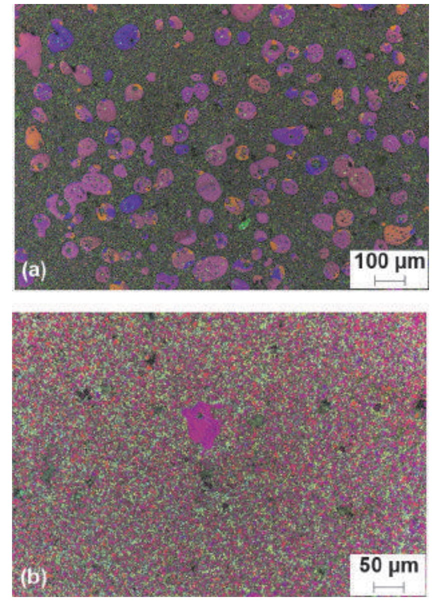

Fig. 4 — Features of microstructure obtained after liquid metal treatment: (a) semisolid processing with globular morphology of primary solid; (b) near liquidus processing; fine microstructure with a single globule of primary solid seen in the center. Material: Mg-9%Al-1%Zn magnesium alloy. Color etching reveals approximate grain orientations.

In general, the morphology of a solid in a two-phase mixture of solid and liquid is controlled by cooling or convection, or a combination of both. However, the particular role in generating globular forms is associated with melt temperature[6]. Generally, lowering the casting pouring temperature promotes formation of equiaxed solidification morphologies. In particular, when superheating is sufficiently low, the entire melt is undercooled and copious heterogeneous nucleation occurs throughout. This leads to complete elimination of the columnar zone in the casting and to formation of fine equiaxed grains in the entire volume. Executing temperature control imposed by the near liquidus concept is challenging for certain hardware and larger alloy volumes. A combination of melt shearing and precise temperature control in the near liquidus range conducted within the processing machinery leads to an ultrafine structure of magnesium alloys and a superior combination of strength and ductility (Fig. 4b).

Experiments show the need for a better understanding of thixotropic structure formation by pointing out the importance of time over melt temperature during processing, emphasizing the importance of melting kinetics[7]. The use of high-purity aluminum and a binary Al-Si eutectic alloy show that the possibility of forming thixotropic structures in materials with no practical freezing range is at odds with the conventional requirement of the freezing range by inspecting the liquid fraction versus temperature curve defined as the processing window. Results suggest that time sensitivity depends on alloy mass, heat flux, and phase transformation temperature.

CONVENTIONAL CASTING AND ALLOY DEVELOPMENT

Substantial advantages are expected using liquid metal engineering on casting alloys with temperatures exceeding the liquidus. However, progress over the past few decades in casting hardware and auxiliaries (particularly high-pressure die casting) was not accompanied by understanding and exploring opportunities created by engineering liquid metal. Therefore, there is renewed interest in the processing side of die casting, especially in controlling the nature of molten metal supplied to the shot sleeve of the machine. Recently, high integrity castings, where net shape parts have negligible porosity after solidification became of interest. Better quality components with higher strength lead to potential savings due to component size reduction for a given application, resulting in lower material and energy consumption and a smaller machine to manufacture it, which translates to lower capital investment.

Recent alloy development shows that alloying aluminum with elements having high melting points (e.g., V, Zr, Cr, Ti or Mo) generates extremely coarse compounds that degrade alloy properties in the as-cast state, and require long, costly post-casting homogenization. In some cases, even a long heat treatment is not effective. Moreover, to homogenize the molten alloy, high overheating and long holding times are required, leading to losses of more volatile constituents. Therefore, it is believed that intensive mechanical shearing/de-agglomeration not only homogenizes the chemical composition, but also refines alloying compounds of complex chemistry that control alloy properties during service. The melt treatment during alloy generation should offer benefits including reducing the overheating temperature required during melting, reducing the required holding time in the molten state, and reducing holding times during post-cast heat treatment. In some cases, heat treatment is eliminated, thus improving the energy efficiency of the entire process.

BENEFITS OF CONTROLLED NUCLEATION

During solidification, the homogeneous nucleation, occurring randomly in the bulk of the liquid, is always kinetically less favorable than heterogeneous nucleation, taking place on preferential nucleation sites. The heterogeneous nucleation can be further enhanced by providing substrates for easy nucleation described as nucleation potency. The latter term is defined as the crystallographic lattice mismatching between materials of the substrate and nuclei. An epitaxial nucleation model assumes that heterogeneous formation of the solid phase on a potent (small lattice misfit) substrate occurs by epitaxial growth of the transient solid phase on the substrate surface under critical undercooling. This mechanism is being explored to improve alloy properties through grain refinement. After a nucleus is formed, solidification enters the stage of growth. For decades, there has been a discussion to determine which of two stages, nucleation or growth, exerts a larger effect on the casting structure. There is a merit in the recent tendency towards emphasizing the paramount role of nucleation. However, to take full advantage of solidification, both stages, nucleation and growth, should be understood and explored.

Metallic oxides present in molten alloys have a particular role in grain refinement. During melting, pouring,

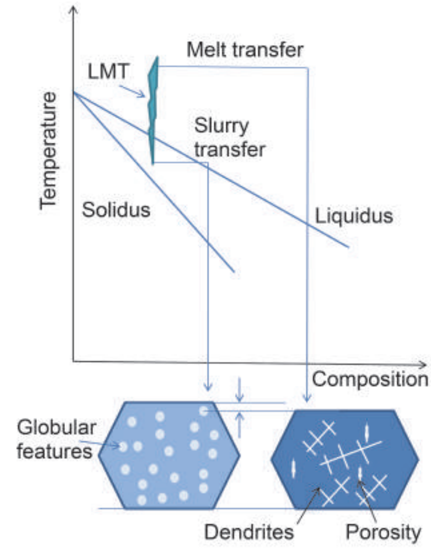

Fig. 5 — Schematic emphasizes component integrity and alloy microstructure; (left) semisolid forming with globular morphology, high integrity, and better net shape dimensions; (right) forming from overheated melt with dendritic morphology, porosity, and larger shrinkage.

and transfer processes, oxide formed on the free surface is entrained into the alloy volume due to melt turbulence. When an oxidized surface is folded over onto itself and entrained into the bulk liquid, a double oxide-film defect is formed with characteristic features of unbonded oxide surfaces separated by a gas. Entrained oxides and other defects preclude the production of high integrity parts.

Liquid metal engineering not only eliminates the harmful effect of oxide inclusions, but also serves as an effective grain refiner. For example, deliberately dispersed oxide film on molten Mg alloys using intensive melt shearing functions as endogenous particles for effective grain refinement. For the Mg-9Al-1Zn alloy, microscopic analysis of oxide extracted from molten alloy reveals submicron-sized MgO particles resulting from forced breakup of the oxide films. High-resolution microscopy reveals good lattice matching between MgO and the αMg matrix[8]. It is concluded from this work that intensive melt shearing disperses oxide films and oxide particles at a level that results in a slow rate of agglomeration, which enables casting and solidification to proceed with the grain refining effect.

IMPROVING QUALITY THROUGH PART INTEGRITY

Internal component integrity and alloy microstructure—factors that affect part performance—must be characterized to assess the influence of liquid metal treatment on component properties (Fig. 5). The transition from casting a liquid alloy into semisolid state reduces liquid content, resulting in reduced solidification shrinkage. In addition, the thixotropic nature of the slurry improves flow during filling of the die cavity, which reduces defects, especially for parts with intricate shapes and complex filling paths. Both factors have a positive effect on part quality. At the same time, the reduced temperature of the semisolid slurry can lead to premature freezing, preventing complete part cavity filling—a negative factor.

The effect of processing temperature on alloy microstructure is not straightforward. Alloy microstructure consists of phases with specific sizes and morphologies, and replacing dendritic forms with globular forms does not universally exert a positive influence on properties. In fact, the presence of coarse globules of the primary solid can reduce strength. Also, the liquid phase that solidifies at the end of the process is highly enriched in alloying elements, which can be brittle and therefore lead to a reduction of overall ductility. In contrast, microstructure refinement achieved by melt engineering has a positive effect on part properties for all solidification morphologies including dendritic, globular, and equiaxed.

CONCLUSION

There is a continual quest for novel technology that can be applied to large-scale production of high-performance net shape components. Techniques based on net shape forming from the liquid state either directly, such as high-pressure die casting, or exploring semisolid processing concepts offer advantages in terms of manufacturing simplicity, cost, and energy consumption compared with current complex processes based on solid state forming. Engineering molten alloys to influence their solidification process, which leads to improved component performance by improving part integrity and alloy microstructure, looks promising. However, more research is required to better understand the technology.

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TECHNICAL SPOTLIGHT

TESTING TRENDS: MEASURING TOMORROW'S STRUCTURAL MATERIALS

The materials testing industry must follow market trends, keeping up with both increased use of nonmetallic materials in fields formerly dominated by metals, as well as new and challenging metal alloys.

During the past several decades, metals were the most commonly used engineering material. However, in recent years the metals industry has faced increasing competition. Strengths of other material groups—such as plastics and composites—are threatening metal use in certain manufacturing environments. The most prevalent examples are seen in the automotive and aerospace industries where the principal volume is for sheet material.

Today, many cars feature body panels produced from plastics, which are not structural and therefore do not require the advantageous properties of metallic materials. Most importantly, plastics are considerably less dense than their metal counterparts, which means vehicle mass can be decreased by using plastics instead of metallic materials. This may be a fairly easy swap for cer-tain nonstructural components and sec-tions, but structural areas have different requirements.

In addition, composite use is becoming more widespread in the pro-duction of higher-end vehicles. In these applications, the high strength of com-posite materials and the ability to place this strength in a specific axis make them extremely effective at reducing overall vehicle mass. Fortunately for the metals industry, the composites manufacturing process is relatively expensive compared

Today's nonstructural automotive body panels are often made of plastics to save weight.

to the ability to press and form metal panels. Composites and metals are very different in terms of mechanical behavior. A simple example of this is how they react to a bump or knock. A metal panel may receive an obvious dent that can be easily knocked back into shape with no effect on its properties. However, a composite material will spring back to shape, but it is still susceptible to sustaining internal damage despite no external evidence of injury.

Similarly, in the aerospace industry, airplanes were traditionally manufactured with metallic materials. In 2009, Boeing released what is touted to be the most fuel efficient modern airliner. The airplane is predominantly produced from carbon fiber reinforced composite materials, whose strength to weight ratio is extremely advantageous. In the past, metals—mainly aluminum alloys—comprised more than 50% of the total aircraft structure. In the Boeing 787 Dreamliner, this was reduced to 20% of the overall structure. This trend toward lower metal use appears to be continuing.

Use of carbon fiber reinforced composite materials continues to make headway in the aerospace industry.

Axial and transverse clip-on extensometer.

METALS TECHNOLOGY MAKING GAINS

Although significant weight benefits can be achieved by using composites or plastics in certain applications, recent developments in metals technology are keeping the industry competitive. The biggest names in the metals industry have completed significant research and development aimed at creating considerably stronger materials across all the industries they serve. In the case of aluminum, this is spurring even more competition. Aluminum is now being used more often than ever before in the structural areas of vehicles with premium high strength 5000 and 6000 series alloys providing impressive strength to weight ratios. These developments are what enabled Ford to make its famous switch to aluminum for the F-150 pickup truck, which significantly reduced weight and boosted gas mileage.

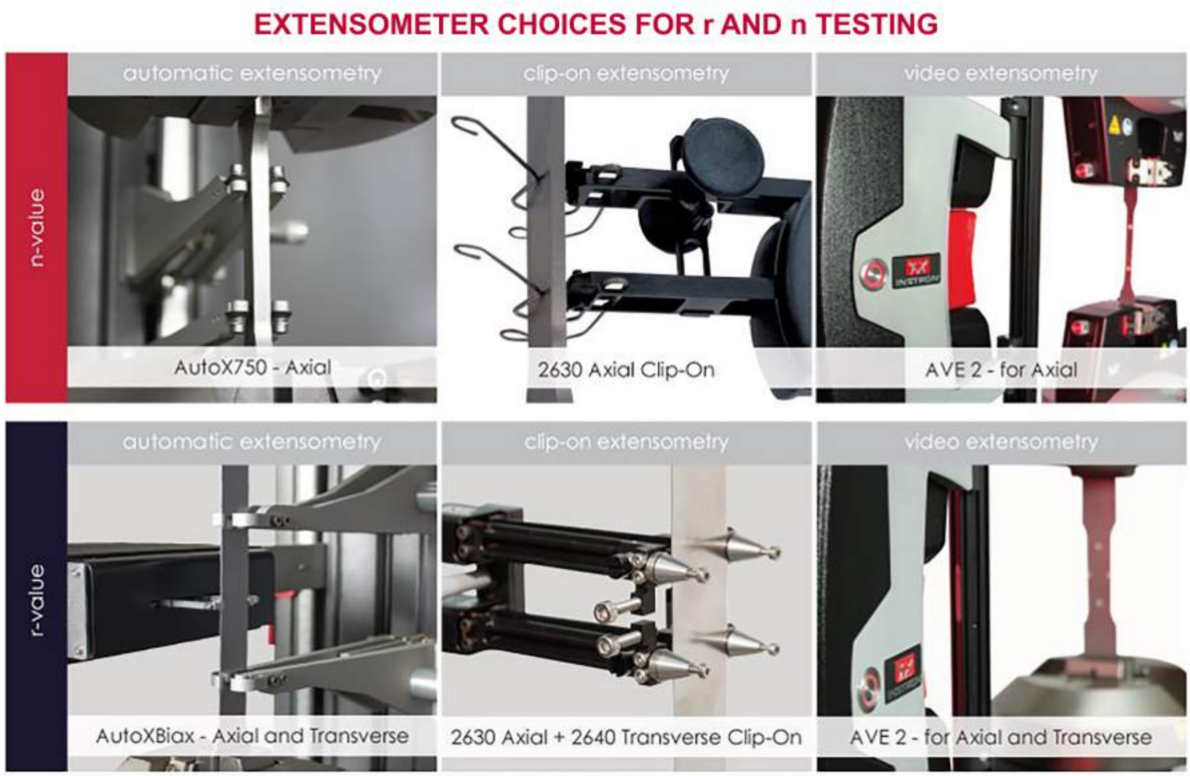
Traditionally, steel was the chief material used to build automobiles because vehicle weight was not as much of a concern in the past—so alloyed materials were rarely used due to their expense. Additionally, the strength and formability of steel was highly desirable. A new generation of high strength steels is being developed and produced to maintain the automotive industry's demand for steel and to compete against aluminum. For example, Arcelor Mittal is investing one third of all research and development funds into its automotive steels stating, "Innovations include high strength steels and advanced high strength steels with high mechanical properties enabling large energy absorption, and electrical steels with low loss and high permeability, which are used in hybrid and electrical vehicles."

Despite these efforts, automotive companies are working with aluminum producers to increase aluminum use in production. New aluminum alloys have many advantageous material properties such as low density, extreme formability, corrosion resistance, and comparable strength to steels.

TESTING KEEPS PACE WITH MATERIALS R&D

Metals producers are working closely with automotive manufactur-

Axial and transverse automatic extensometer.



Extensometer styles include automatic, clip-on, and video versions designed to meet the needs of a wide range of materials testing applications.

ers to shape trends and changes within the industry, directly impacting the future of structural materials. As with all research and development, considerable testing must prove that the end product is high quality, suitable for the intended application, and able to be produced with repeatable results.

One testing issue involves the material's relative strength. Weaker materials typically form much more easily without crack formation. As the material fails, the break is quite ductile and does not release much energy. As material strength increases, failures are much more severe and occur faster, thus releasing more energy. These more aggressive failure conditions can cause damage to testing equipment such as extensometers. Traditional clip-on, contact-based transverse extensometers are difficult to install on specimens consistently and are especially susceptible to damage during specimen failure.

For example, when testing advanced high strength steels, the plastic strain ratio (r-value) must be determined because it is a key indicator of the material's forming performance. To measure the r-value of high strength steel and ensure the equipment will not be damaged, Instron designed the AutoXBiax automatic contacting extensometer, which can be automatically removed before failure. The AutoXBiax uses a robust optical read head design to keep the device accurate and operational regardless of how violent the failure is. An Advanced Video Extensometer 2 (AVE 2) is also available, which uses a high-resolution camera to measure strain, meaning that nothing has contact with the specimen and the device cannot be damaged by specimen failure. Because the extensometer does not need to touch the specimen, the device can also be used with a temperature chamber, providing reliable r-value results at low or high temperatures.

Determining the n-value is important as well. The strain hardening exponent *n* is a measure of the response of metallic materials after cold working. After metals have reached their elastic limit and plastically deform, they experience strain hardening, which can increase the strength within the final product application. Metals with a high-strain hardening exponent will achieve increasing strength with a small amount of axial strain, whereas a material with a low-strain hardening exponent will experience high axial strain with little increase in strength. To determine n-value automatically, the axial strain needs to be accurately measured with an extensometer.

CONCLUSION

It is imperative that the materials testing industry follow these market trends. By 2035, there will be an increase in use of nonmetallic materials in applications formerly dominated by metals. However, metals producers will continue to make strides in developing new alloys to compete, namely aluminum and advanced high strength steels. These new metals will be even stronger and more difficult to test than today's materials, demanding that testing equipment manufacturers work with the metals industry to ensure they can meet the new challenges. **~AM&P**

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COLLABORATIVE APPROACH TACKLES ALUMINUM LIGHTWEIGHTING CHALLENGES

The National Research Council of Canada has teamed up with industrial partners to investigate the challenges of aluminum lightweighting—and their systematic approach is generating impressive results.

As demand for lightweight components continues to grow, organizations around the globe are developing innovative steel, aluminum, and composite solutions. Each of these solutions must meet rigorous technical specifications while remaining cost effective. The National Research Council of Canada (NRC) is no exception to this trend, but its approach includes partners in order to tackle the challenges of lightweighting using aluminum. The group's collaborative method is unique and is generating impressive results.

The NRC first became involved in aluminum research and development because Canada is the world's third largest aluminum producer and the center hoped to capitalize on this capability to transform manufacturing. The Aluminum Valley, a 500-km region around Saguenay, Québec, is the country's hotbed for primary and secondary enterprises in this sector. It is host to Rio Tinto and boasts 42 finished product manufacturers and four semi-finished ones, seven recycling organizations, and 44 equipment suppliers and specialized service providers. In 2000, the Canadian government decided to invest in the NRC Aluminum Technology Center at the heart of this cluster.

The state-of-the-art building houses approximately 40 NRC experts on the University of Quebec at Chicoutimi (UQAC) campus, in close proximity to the UQAC Centre for Aluminum Research, the province of Quebec's Centre for Aluminum R&D, and Rio Tinto's Research Arvida Centre. NRC supports the industry by addressing the technical challenges related to developing lightweight aluminum components and providing innovative R&D services and solutions not available elsewhere. In 2013, the Council launched *Lightweighting of Ground Transportation Vehicles (LGTV)* activities, which brought together experts from the Aluminum Technology Center as well as teams from across NRC. LGTV assists Canadian and international companies developing aluminum lightweighting solutions for cars, trucks, buses, and railcars.

"By focusing on the challenges of integrating aluminum in a new generation of vehicles, we've been able to more rapidly deepen our knowledge base in aluminum applications for the transportation sector, while building closer ties with industry and aligning our efforts with the needs of our clients," says LGTV leader Mélissa Després. The team quickly realized that in terms of aluminum components, the most pressing challenges were not unique to any given company, and that major gains could be made if resources and solutions were pooled together.

ALTec was born out of this solution and is the brainchild of senior project manager Marie-Christine Gagnon. It

The Aluminium Technology Centre in Saguenay, Quebec, Canada.

High velocity oxygen fuel coated sample for strip draw test used to evaluate tribological performance.

enables the industrial R&D group and its members to share the risks and rewards of aluminum component development and testing. "The major advantages of putting ALTec in place is that it enables a project-based approach that directly responds to industry needs, combined with an emphasis on clear communication with members to rapidly integrate the advances in their product lines," says Gagnon.

For an affordable cost, members participate in projects designed to respond to specific challenges. Project outputs are communicated via confidential webinars and technical briefs, and members are able to implement the new technologies. Established in 2015 with seven members and two sponsors, the group now has 18 members including companies such as Ford Motor Co., PPG Industries, Centerline, and others with whom projects are designed. Eight major partners including Rio Tinto, Prima, the Aluminum Association of Canada, and others provide additional funding and input into the consortium's overall direction and goals. In total, ALTec represents nearly $3.5 million dollars in R&D investment per year.

TABLE 1 — PROJECT COVERAGE FOCUS

	Project Coverage Areas		
	Manufacturing of advanced aluminum components	**Assembly of aluminum and multi-material components**	**Durability and performance evaluation and solutions**
Key topics covered	Warm and hot forming of aluminum sheet alloys at high production rates	Durable structural adhesive joints of minimally pretreated multi-material structures	In-service stress corrosion cracking: Evaluation of high strength aluminum alloys
	Heating coatings for multifunctional intelligent molds	Al/steel friction stir welding process optimization and robotic solutions	Mitigating galvanic corrosion of aluminum in dissimilar material assemblies
	Tribological coatings for multifunctional intelligent molds	Weldability of Al alloys	
	Design and production of large hollow extrusions		
	Vacuum-assisted high pressure die casting of hollow aluminum structural nodes		

PROJECT COVERAGE AREAS

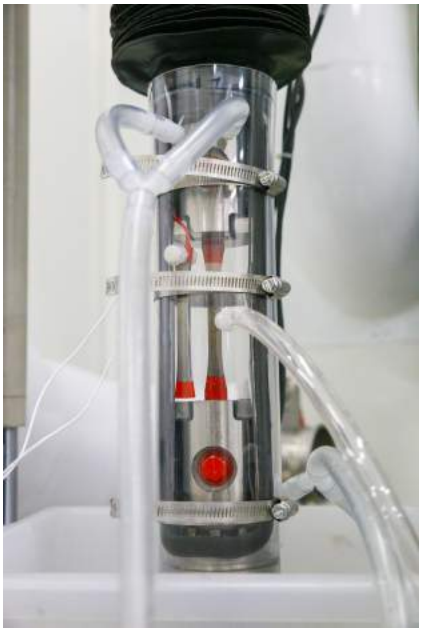
Approximately 10 projects have been initiated based on the needs expressed by members. From a technical standpoint, the projects fall under three areas, each led by an NRC expert. These include manufacturing of advanced aluminum components, assembly of aluminum and multi-material components, and durability and performance evaluation and solutions.

"Increasing the productivity of forming processes such as extrusion, stamping, and die casting is our objective," says ALTec manufacturing expert Jean Savoie. "We're helping members develop new alloys and processes suitable for rapid production of structural parts by hot stamping, assisting them in extruding profiles with various thicknesses, and developing new core technologies for high integrity casting, as well as intelligent dies for forming. The last 10 years have seen a growing emphasis on rapid, flexible processes that will reduce the weight and cost of components while accelerating their path to market. We think this can be achieved through better modeling and simulation of forming processes, and we measure our success by the quality of the first prototypes that come out of these optimized processes."

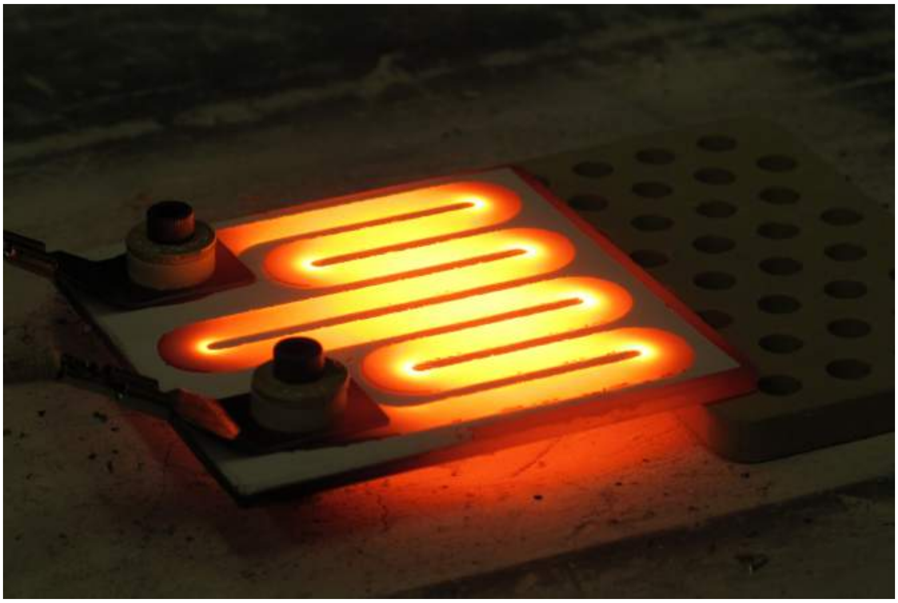
On the assembly side, mechanical fastening of aluminum to high strength or stainless steel is being displaced by friction stir welding (FSW), adhesive bonding, and resistance spot welding. Research is focused on finding the best approach from a corrosion standpoint. FSW is extremely promising, especially if it can be made linear—the main challenge is large loads that result in high robot payloads in an industry seeking to minimize these payloads.

To address this issue, a novel C-frame type robot is being designed to minimize lateral loads and increase forging loads. Looking ahead, it is clear that engineers wonder which welding or joining technique is the most appropriate for a given application, a question that is becoming more difficult

Painted aluminum samples exposed to in-service conditions for determination of chipping and blistering resistance.



Fatigue-corrosion cell designed for in-situ electrochemical monitoring of crack initiation and propagation.



Plasma deposited heater in operation at 600°C.

to answer as the spectrum of options continues to grow. Fatigue design, data, and life evaluation are thought to be important aspects in order to answer these questions.

Corrosion is not a new problem in the transportation industry. However, the recent use of multi-material structures designed to reduce vehicle weight comes with its share of new challenges, particularly in terms of galvanic corrosion, stress corrosion cracking, and filiform corrosion. To address this, ALTec is banking on a strategy that marries in-service data, laboratory exposure, and digital simulation to test new products and solutions. It has already recreated the effects of 150,000 km in-service field use in an accelerated process that takes just four days to execute in the lab environment.

MEMBER TESTIMONIES

Verbom is an aluminum component manufacturer as well as tool and die systems supplier who joined ALTec to better meet the needs of its automotive clients such as Tesla. "We know that the clock is ticking for OEMs, that corporate average fuel economy standards are getting exponentially stricter each year, and that vehicle manufacturers are all looking to win the lightweighting race. Innovation is what attracted us to ALTec, as well as the leverage we get from working as a group." says Nicolas Bombardier, director of R&D at Verbom. "We brought in a structural piece from a client that was impossible to produce through a conventional drawing process, to explore if hot stamping could be an answer. Because it is a structural piece, the alloy's mechanical properties and its thermal treatment are of utmost importance. In a short time span, ALTec has already helped us simulate the process and produce a few prototypes. We're also benefitting from the project to develop heating coatings for intelligent molds, which are extremely useful for die casting and extrusion."

Rio Tinto, a major materials supplier who is both a partner and member of the initiative, is leveraging ALTec's research in assembly, specifically when it comes to the weldability of new aluminum alloys. Joseph Langlais, R&D casting manager and Jerome Fourmann, technical services manager, agree that "NRC's expertise and access to cutting-edge measuring and characterization equipment allowed us to increase our skill base and understanding of the in-service behavior of aluminum alloys designed for the automotive sector. It's an added asset we use to quickly respond to client needs and it supports our market consolidation and development activities in this field."

Prevost, a member who manufactures motor coaches and recreational vehicles, is benefitting from projects in both assembly and durability. "The National Research Council helped us validate and understand corrosion's effects on the assembly of dissimilar metals. Concrete results, supported by clear explanations, have enabled us to develop new, lighter, and less costly designs while minimizing the risks identified at the start of the project," says mechanical product expert David Croteau.

OEMs seem to appreciate the collaborative model where they not only tackle the technical challenges of aluminum lightweighting, but also look at cost reductions in integrating these materials in the finished product, with the lowest risk possible. From the perspective of material producers, they want to be sure their materials have all the properties that Tier 1 and Tier 2 suppliers are looking for. ALTec enables its members to learn from others in the field in a confidential, precompetitive environment. Each member brings their pain points to the group and appreciates working hand-in-hand with NRC and other members to find innovative solutions.

LOOKING AHEAD

ALTec is not alone in the National Research Council's portfolio of lightweighting R&D, which runs the gamut of materials science. NRC experts across Canada are working on composites and biocomposites for the automotive and aerospace sectors, as well as polymers, composites, and ceramics for security applications. Because finished products often integrate solutions spanning several material types, NRC is increasing cross pollination between its experts to maximize results in multi-material assembly projects.

The group hopes to expand its reach both inside and outside Canada, especially in view of maximizing the country's supply chain from smelters to the final product. If it can help its members bring cutting edge aluminum lightweighting innovation to global markets while bridging the gap between university research and the factory floor, it will have achieved excellent mileage. **~AM&P**

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CANFSA: EXPLORING THE PHYSICAL METALLURGY OF NON-FERROUS ALLOYS

A unique collaboration brings together university and industry stakeholders to conduct basic and applied physical metallurgy research on non-ferrous structural alloys.

Peter Collins, Iowa State University, Ames

Amy Clarke, Robert Field, FASM,* Stephen Midson,* and Michael Kaufman, FASM**

Colorado School of Mines, Golden

Members, students, faculty, and guests attending the fall 2015 CANFSA IAB meeting at the Colorado School of Mines.

The Center for Advanced Non-Ferrous Structural Alloys (CANFSA) is a National Science Foundation industry/university cooperative research center that focuses on the physical metallurgy of non-ferrous engineering alloys and systems. It was created based on the historical decline in physical metallurgy research funding, which has resulted in a dramatic decrease in the number of students pursuing a career in this field. This trend has greatly reduced the synergies that previously existed between faculty, students, and the non-ferrous industries, and has potentially weakened the U.S. dominance of industries that rely on these interactions.

Jointly located at the Colorado School of Mines (CSM) and Iowa State University (ISU), along with an affiliate site at the University of North Texas (UNT), CANFSA was established in 2011 and recently transitioned into its second five-year phase. The center aims to:

- Become the premier location for research in non-ferrous structural alloys
- Bring together university and industry researchers to conduct basic and applied physical metallurgy research on non-ferrous structural alloys
- Combine computational modeling, processing, and state-of-the-art characterization methods to address projects of interest to industrial members
- Train students to become critical players in industries that develop or use non-ferrous alloys

This article provides a brief overview of CANFSA, summarizes current research efforts, and describes the types of industry-university interactions within CANFSA.

*Member of ASM International

CANFSA STRUCTURE

CANFSA is led by director Michael Kaufman, a professor at CSM, and two site directors, Peter Collins and Amy Clarke, associate professors at ISU and CSM, respectively. The directors and center are supported by the NSF-appointed center evaluator, David Meyer.

CANFSA's target members include organizations that research, produce, process, or use non-ferrous structural alloys. It is a member-driven organization, with participants consisting of large corporations, small businesses, government laboratories, and one trade association. At present, CANFSA has the following 14 members: Air Force Research Laboratory, Army Research Laboratory, Allegheny Technologies Inc. (ATI), Boeing, Embraer SA, GE Aviation, Honeywell International Inc., Los Alamos National Laboratory, National Aeronautics and Space Administration (NASA), North American Die Casting Association, Queen City Forging Co., Thermo-Calc Software Inc., Triumph Group Inc., and Weber Metals Inc. Each member has a seat on the industrial advisory board (IAB), which provides guidance to student projects and oversight of the overall research agenda. Two levels of membership are available within CANFSA—full or associate—with the latter available to organizations with less than 500 employees.

The managing director, Steve Midson (research professor, CSM), focuses on event planning, communications, procurement of external research grants, marketing, recruitment of new members, and reporting and other administrative functions.

CURRENT PROJECTS

As shown in Fig. 1, current annual funding for CANFSA is more than \$1.8 million, which originates from three sources including membership dues, National Science Foundation funds, and external, leveraged projects funded outside of CANFSA.

There are 17 ongoing research projects within CANFSA, which are divided into three thrust areas—light-

TABLE 1 — ONGOING CANFSA PROJECTS

Focus area	Project title
Lightweight non-ferrous alloys	Effects of Strain Variations on Aging Response & Corrosion Properties of 3rd Generation Al-Li Alloys
	High Temperature Stability and Mechanical Properties of Micro-eutectics in Bulk Solidified Al-Fe-Si-V and Related Alloys
	Damage Tolerance/Accumulation in Ultra Fine Grained Magnesium Alloys
High performance non-ferrous alloys	Engineering Fine Scale α-Precipitation for High Strength β-Ti Alloys
	Low-Level Hydrogen Effects on Toughness in Titanium Alloys
	Measurement and Modeling of Anisotropy in Ti-6Al-4V Forgings
	Mechanism of Dwell Fatigue Crack Initiation in Ti-7Al Under Biaxial Tension-Tension Loads
	High Temperature Titanium Alloys
	Effect of Grain Size and Precipitate Volume Fraction on Creep and Fatigue in Nickel Alloys
	Characterization of Microstructure Evolution in Nickel-Titanium-Hafnium Intermetallics for Bearing Applications
	Understanding Strengthening of an Aerospace Niobium-Hafnium-Titanium Alloy
	Atomic Ordering in Alloy 690 and its Effect on Long-Term Structural Stability and Stress Corrosion Cracking Susceptibility
Advanced alloys and processes	Collaboration to Accelerate the Discovery of New Alloys for Additive Manufacturing
	PVD Coatings Applied to Die Steel for Lube-Free Die Casting
	Multilayer PVD Coatings for Service Life Extension of Components Used in Aerospace and Manufacturing
	Effects of Thermal Processing Variations on Microstructure and High Cycle Fatigue of Beta-STOA Ti-6Al-4V
	Understanding the Physical Metallurgy of a New Nickel-Based Alloy with a Low Coefficient of Thermal Expansion

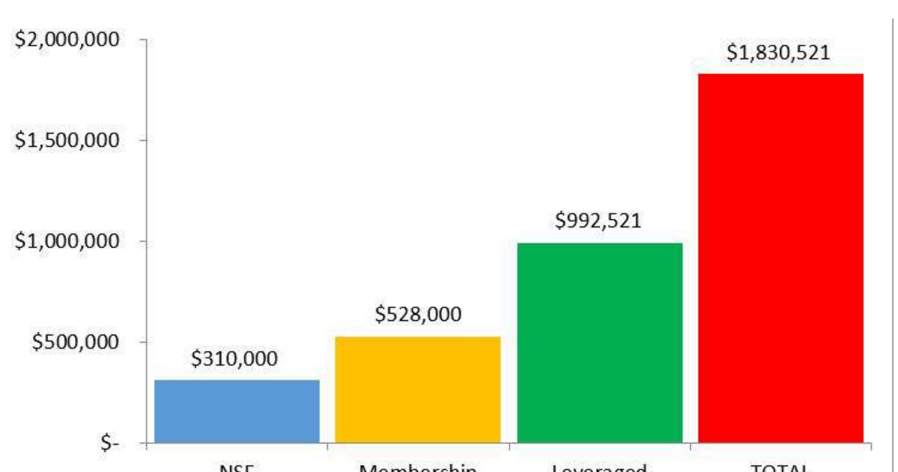

Fig. 1 — CANFSA annual funding effective April 1, 2016.

weight non-ferrous alloys, high performance non-ferrous alloys, and advanced alloys and processes. Current project titles are listed in Table 1.

NEW PROJECT SELECTION

It is common for universities to conduct research that is poorly aligned with industry needs, largely because faculty are unaware of the economic, infrastructural, or pragmatic technical requirements of industry. Thus, it is imperative that members within a consortium such as CANFSA play a pivotal role in project definition, selection, and execution. As shown in the schematic in Fig. 2, CANFSA provides its members with a number of opportunities to influence the direction of center-funded research projects, including setting objectives, participating in strategic planning, defining technology needs by providing project ideas and proposals, and voting on projects that will be undertaken.

CANFSA has developed a comprehensive, multimonth process for selecting new projects, which it has implemented during the past two years. The procedure consists of the following steps:

1. Ideas for new projects, including a title and short description, are submitted by faculty and members.
2. Ideas are distributed to IAB members who rate each topic, and the list is then narrowed to the top 10-14.
3. Members and faculty then discuss each of the ideas in a videoconference. Ideas might be combined, and if they are sufficiently vetted, they will be carried forward.
4. During the videoconference, each idea is assigned industrial and faculty champions who produce a project outline to be presented at the fall IAB meeting.
5. At the IAB meeting, a structured review process solicits further input from members, who ultimately vote to define project priority. Full members receive 30 votes while associate members get 10 votes to distribute among different projects.
6. Projects with the highest votes are then selected as research topics for incoming students depending on available funding levels and student interests.

Since implementing this process in 2014, 81% of new projects selected originated from ideas initially suggested by member organizations—a testament to the member-driven nature of the center.

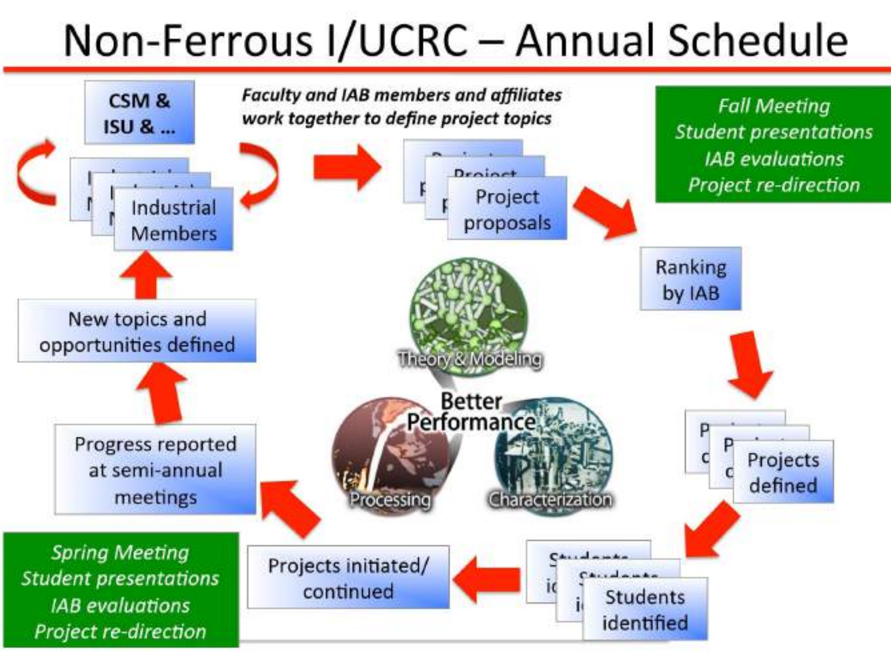

Fig. 2 — Operational practices for CANFSA.

CENTER-MEMBER COMMUNICATION

Formal communication between universities and members is critical to the success of CANFSA. This dialogue is accomplished in several ways.

IAB meetings: CANFSA hosts two semi-annual IAB meetings where students present research results. Typically, about 50 people attend these meetings, which are invaluable for providing personal interactions and networking among participants. Organizations interested in joining CANFSA are welcome to attend one IAB meeting as a guest.

Videoconference series: CANFSA also hosts two videoconference series per year—spaced between the semi-annual IAB meetings. Accordingly, students present project updates to members four times per year. Videoconferences provide an important opportunity for transferring information and enable an essentially unlimited number of employees from each member organization to access research results and provide students with project guidance. For example, one member organization recently had more than 20 employees from across multiple divisions in several states participate in one or more of the sessions.

Project mentoring: Project mentoring is another important communication tool between students and members. As such, at least one "industrial mentor" from a member organization is identified for each project. Industrial mentors frequently interact with students and faculty to provide industrial perspectives and research guidance. Written guidelines help define the project mentor role. **~AM&P**

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ASM MATERIALS EDUCATION FOUNDATION

Annual Report **2015**

Mission

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

Dear friends:

The ASM Materials Education Foundation knows that donors have a choice when it comes to charitable giving and we are extremely grateful that you have chosen to place your financial support behind our mission. Therefore, we are dedicating this year's theme to **YOU**, the donors! We are working in harmony with you to "*Inspire the future together*."

Building on last year's accomplishments, the Foundation is making changes aimed at creating new initiatives to continue fulfilling our mission, increase operational efficiency, and expand our organizational capacity.

These growth initiatives are intended to:

- Expand our menu of programs to more effectively excite young people to pursue careers in STEM fields.
- Deliver a greater degree of service to our donors and members.
- Increase visibility through use of the internet.

These dynamic achievements are being fueled by our talented, smart, and dedicated donors, partners, and Board of Trustees. **YOU** make it possible to provide quality programs for teachers and students and, like us, you believe in encouraging the next generation of materials scientists and engineers.

Thank you for your trust, generous support, and commitment, which enables today's youth to flourish and inspire others. We couldn't do it without you.

With gratitude,

Michol Campana

ASM Materials Education Foundation 2015 Board of Trustees

Dear Champions of the ASM Materials Education Foundation,

As my two-year term comes to a close as chairman of the ASM Materials Education Foundation, I wanted to thank you for the opportunity to serve the Foundation and the Society. These last two years have been an exciting time and one that I think has effected important changes in both our board and our mission. It was a great privilege to be part of it and to serve with such wonderful people on the board, executive team, staff, and at ASM International.

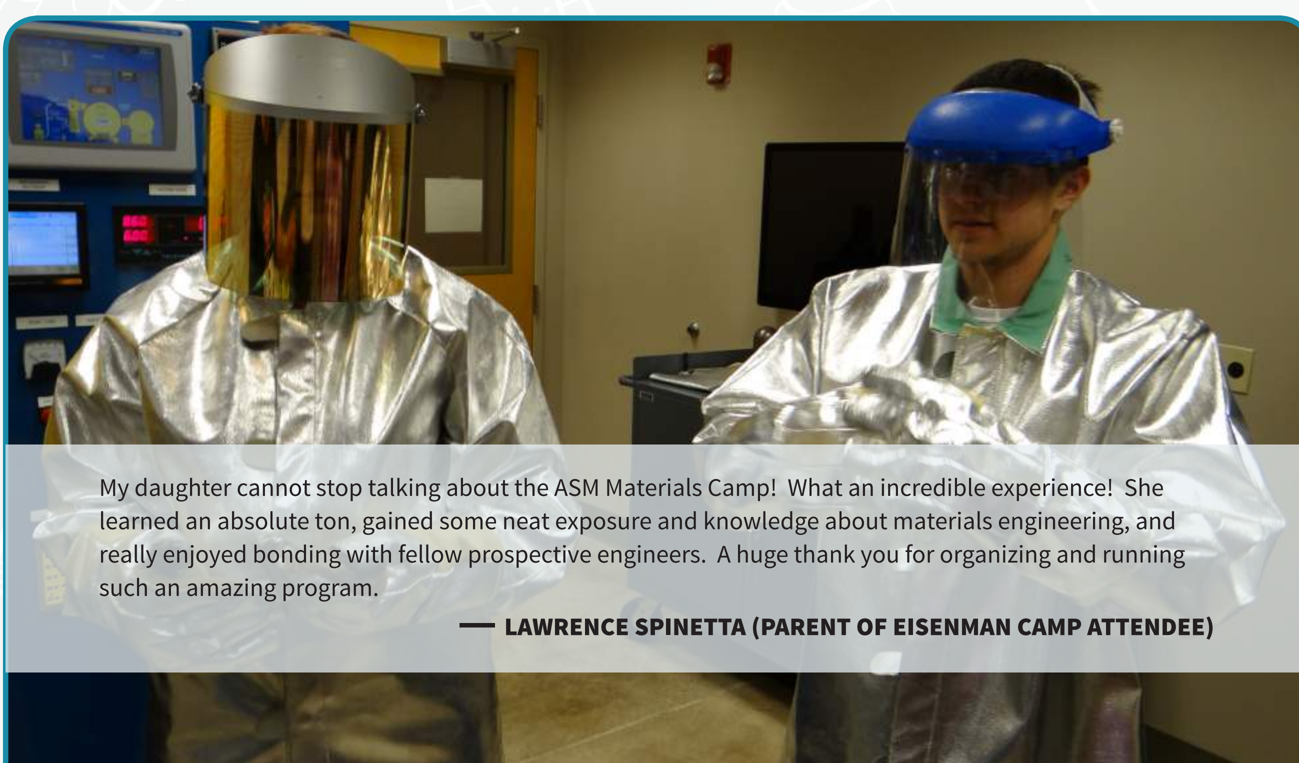
So what is new? Our board has diversified. We have younger members, more females, and colleagues with backgrounds beyond materials and who bring new perspectives to our mission of exciting young people about STEM careers. Even so, we have more work to do, particularly with regard to racial diversity.

Our programs have also become more diverse, consistent with our updated strategic plan. Our mission has grown from scholarships and camps to a much broader focus—all aimed at exciting young people about science, engineering, and materials. Your Foundation has incubated four new business units that will be important to increasing our impact on the ASM and STEM communities. One of these is an afterschool science program for middle school students that is run in cooperation with area museums—with a goal of exciting this age group about STEM and materials before they enter high school. For older students, our second business unit is a community college program designed to bring skilled technologists into the workforce. We have provided an initial round of scholarships to these deserving students. Another new initiative involves distance learning for teachers. Along with Temple University, we have invested in a website aimed at teaching science in an exciting and innovative way. This program expands our reach to schools everywhere, reaching beyond those served by our 40+ teacher camps. The curriculum covers not only coursework for pre-college common core standards, but also next-generation science standards. Finally, we are beginning to pursue how to excite younger students at an earlier age, namely fourth grade and younger when the desire for STEM education is more formative to their career choices.

We are excited by the potential of these new initiatives and realize that we may fail at some while succeeding at others. In any event, we are pursuing constructive change to enhance the scope of our goals and impact, so we can meet our mission more fully and at a lower cost.

We are sincerely grateful to all who have helped make this possible, particularly our ASM membership, ASM board, Foundation board, and executive leadership—and our wonderful donors that come from both inside and outside the materials community. It has been a pleasure working with you.

—Dr. David B. Spencer



My daughter cannot stop talking about the ASM Materials Camp! What an incredible experience! She learned an absolute ton, gained some neat exposure and knowledge about materials engineering, and really enjoyed bonding with fellow prospective engineers. A huge thank you for organizing and running such an amazing program.

— LAWRENCE SPINETTA (PARENT OF EISENMAN CAMP ATTENDEE)

REVENUE

2015 CONTRIBUTIONS

Titanium $10,000+
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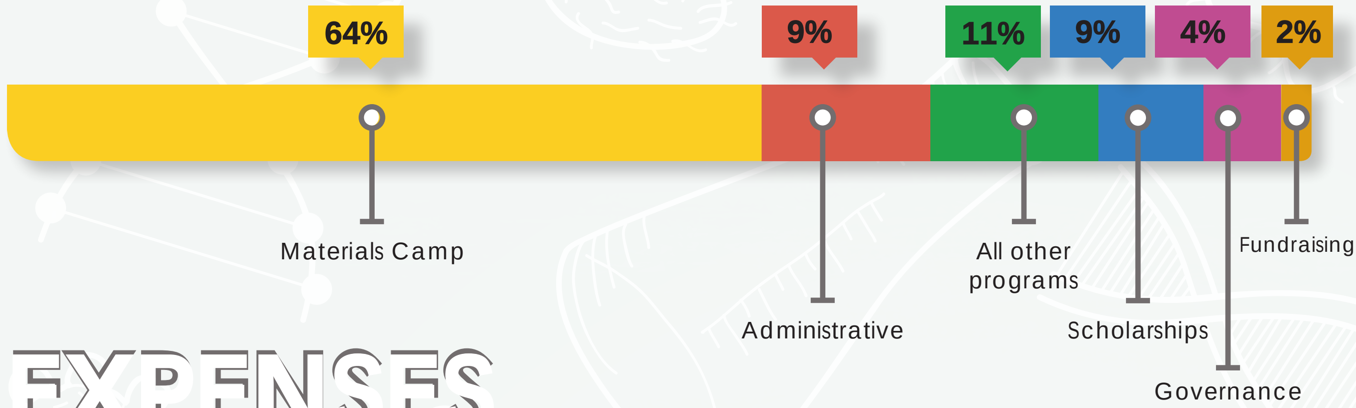
Foulds, Jude R.
Gaw, William D.



EXPENSES

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Harper, Sheila I.
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Elliott, Daniel S.
Elsey, James

Thank you for this opportunity to continue my education in science. I so appreciate the Foundation funding my participation. I have doubled the number of hands-on activities for my students in this one week of excellent presentations! Thank you for the materials and the plethora of ideas.

— **TEACHER PARTICIPANT, KANSAS CITY, MO**

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Wilhelmi, George F.
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Williams, Heidi
Wilt, Dale
Witham, John P.
Wood, Elizabeth
Wright, Kenton B.
Yamada, Yoshiro
Yasinskiy, Alexey
Yokota, Hideo
Young, Barbara

2015 GEORGE A. ROBERTS AWARD

Ashok K. Khare

Ashok K. Khare is president, Ash Khare Consulting LLC. He is a metallurgical engineer and his education includes B.Sc., B.Tech., and M.S. degrees. He has served as an active member and volunteer on numerous ASM International committees since 1977. Over the past 16 years, Khare has been an integral part of the ASM Materials Education Foundation's growth strategy and has made significant contributions with regard to governance, nominating, awards, fundraising, and the Foundation Pillars Society. He also served as a valued member of the ASM Materials Education Foundation's board of trustees from 2001 to 2015. Khare received the ASM Fellow award in 1983, Allan Ray Putnam Service Award in 1990, and the ASM Honorary Life Member award in 2007. In addition, he is a Life Member of the National Academy of Sciences in India.

PILLARS SOCIETY

The Pillars Society honors individuals who support the ASM Materials Education Foundation through charitable bequests, life income gifts, and trusts. The program was established as a way to thank those who have recognized the future needs of the Foundation in their personal estate plans. Membership into the Society is open to any member who confirms a bequest or other form of planned gift to the Foundation.

The name ASM Pillars Society is based upon the symbol of the Foundation, representing the four Pillars of our purpose:

- Education
- Knowledge
- Leadership
- Service

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Dr. and Mrs. Charles A. Wert

2015 KISHOR M. KULKARNI HIGH SCHOOL TEACHER OF THE YEAR

Jim Curiel

An instructor and chair of Materials Science, Engineering, and Technology at Don Bosco Technical Institute, California.

REMEMBERING ROBERT D. HALVERSTADT

We lost a cherished friend, leader, and champion of the ASM community in 2015 with the passing of board member Robert D. Halverstadt. Bob served the Foundation with distinction in his role as a Trustee since 2007 and has our profound gratitude and appreciation for his support and remarkable influence. His vision and leadership will have a lasting effect and we will be forever grateful for his service and dedication.

ASM CHAPTER PARTNERS

ASM Chapters play a key role in the growth and expansion of ASM Foundation programs. Through volunteerism, organization, and hosting of a Materials Camp, as well as providing a network of speakers and mentors, the ASM membership contributes to educational outreach within the organization.

ASM Akron
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ASM Ontario
ASM Oregon
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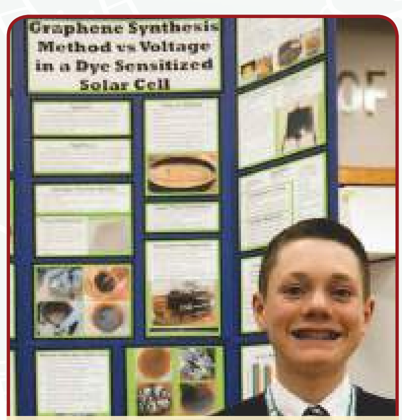
ASM Peoria
ASM Philadelphia
ASM Pittsburgh Golden Triangle
ASM Puget Sound
ASM Pune
ASM Quad Cities USA
ASM Rhode Island
ASM Saginaw
ASM South Central Pennsylvania
ASM Twin Tier
ASM Utah
ASM Warren
ASM West Michigan

DAVID JIMENEZ

"Most Outstanding Exhibit in Materials Science"
Washington State Science & Engineering Fair
Sunnyside, WA



DAN AVILA

"Most Outstanding Exhibit in Materials Science"
Washington State Science & Engineering Fair
Sunnyside, WA

SCIENCE & ENGINEERING FAIRS

The ASM Foundation in partnership with Intel has participated, since 2001, in presenting one "Most Outstanding Exhibit in Materials Science" award at approximately 500 regional science & engineering fairs throughout the world.

"I would like to thank you for selecting my project for your ASM Materials Education Foundation Award at the Central New Mexico Research Challenge. Your support has helped me win 1st place in the Engineering category and the Grande Award at the State Science Fair. I had a really fun time sharing my project with the judges and I hope to see you again with a 3D printer next year!"

—ZACHARY FITZGERALD, ALBUQUERQUE, NM

"I wish to thank you immensely for the prize you gave for my project, 'The search for the Most Effective Ice Melt'. Your encouragement has already sparked ideas for another science fair. Thank you!"

—REBECCA RAMTHUN, BOZRAH, CT

"I would like to thank you and the ASM Materials Education Foundation for recognizing my science fair project. I truly appreciate receiving the award of the Most Outstanding Exhibit in Materials Science and the medallion. I have never received a science medallion before. It really makes you feel good when someone recognizes your hard work and efforts."

—JUSTIN TODD, SAN DIEGO, CA

The camp was an amazing experience, helping me to better appreciate and grow in the sciences. I am so thankful for all of the wonderful opportunities that you were able to provide to me during my time at the camp and I can absolutely guarantee that the knowledge I gained will greatly influence my engineering pursuit at Virginia Tech.

—DOMINIC ANGELO, MURRYSVILLE, PA

ACTION IN EDUCATION COMMITTEE

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Brian Wright
Corey Zirker

"LIVING IN A MATERIAL WORLD" K-12 TEACHER GRANTS

Twenty $500 grants awarded to K-12 teachers to develop and implement science activities in their classrooms.

Winning Proposals

1. **Characterization Using Visible Spectroscopy,** David Benedetto, Winchester High School, Massachusetts (Grades 10-12)
2. **How Do You Use The Computer Interface To Effectively Teach Material Science?** Etzel Brower, Egg Harbor Township High School, New Jersey (Grades 9-12)
3. **Smart World Materials,** Loris Chen, Michigan, Dwight D. Eisenhower Middle School, New Jersey (Grade 8)
4. **The Great Tower Challenge,** Karen Cobb, James Tillman Elementary, Florida (Grades K-5)
5. **The Chemistry of Materials,** Brooke Detty, Zane Trace Middle School, Ohio (Grade 7)
6. **Materials Science in Engineering,** Merle Green, Resurrection College Prep, Illinois (Grades 9-12)
7. **How can students create plastic without using petroleum based materials?** Meghan Hess-Shamdasani, South Tech Academy, Florida (Grades 9-12)
8. **Materials Science,** Eileen Hite, St. Clement of Rome, Louisiana (Grades 5-7)
9. **Additive Manufacturing Filament Testing and Evaluating,** Bill Hughes, Park Forest Middle School, Pennsylvania (Grades 6-8)
10. **Chemistry of Materials Course,** Ginger Keeton, Dixon High School, Missouri (Grades 10-12)
11. **Furnace for High School Materials Science Classes,** Jenifer Lawrie, Webb School of Knoxville, Tennessee (Grade 11-12)
12. **Glass Inquiry: Now You See It, Now You Don't,** Nancy Manikas, Webb School of Knoxville, Tennessee (Grades 11-12)
13. **Introducing a new course "Material Science and Engineering,"** Hanan Mogawer, The Prout School, Rhode Island (Grades 10-12)
14. **Pre-College Science Institute Robotics Program,** Alice Myles, Fisk University, Tennessee (Grades K-6)
15. **Chemical Reactions!: The Soda and Mentos Phenomenon,** Jill Reed, Philipsburg-Osceola Middle School, Pennsylvania (Grade 6)
16. **Electromagnets,** Dale Rundgren, Mt. Olive Lutheran School, Kansas (Grade 5-8)
17. **A GIANT Polymer Periodic Table Project,** Jennifer Sherburn, Hesperia High School, Michigan (Grades 10-12)
18. **Scientists in Residence,** Karen Stringer, Highline School district Residential Program, Washington (Grades 9-12)
19. **Mobile Materials Lab,** Lisa Wininger, Plainwell Middle School STEM Academy, Michigan (Grades 6-7)
20. **Pixel Power,** Teresa Zimmer, Cherokee Elementary School, Alabama (Grade 3-5)

EISENMAN MATERIALS CAMP BENEFACTORS

Permanently Endowed Student Scholarships

Air Products Inc.
Doug Allan, FASM, and the Dave Fallen Memorial
John and Marian Andrews
Wendy Asphahani
Bruce E. and Marilyn L. Boardman
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John and Nancy Pridgeon
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R.P. Simmons Family Foundation
Bruce and Marilyn Boardman
Paul and Frances Huber
Donald and Eileen Muzyka

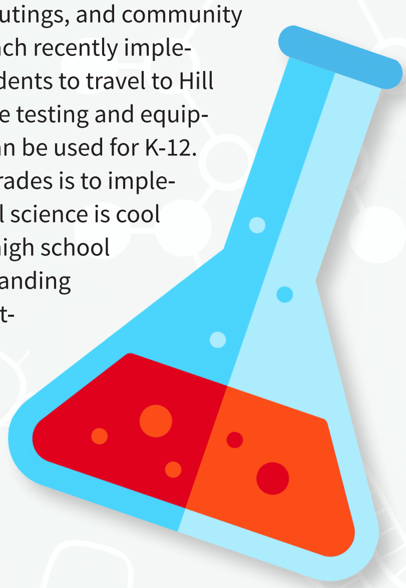
STUDENT CHAPTER GRANTS

This program launched in 2001 and supports Material Advantage student chapters' K-12 outreach activities that align and advance the Foundation's mission. Since inception, 72 grants have been awarded.

Five grants awarded in 2015 to:

- Colorado School of Mines
- Virginia Tech
- Rensselaer Polytechnic Institute
- University of Texas at El Paso
- Auburn University

The goal of CSMMAC outreach is to introduce students and the general public to metallurgy and materials science and engineering through demonstrations, interactive discussion, and tours of metallurgy departments. Demonstrations are held at elementary and high school science days, college outings, and community festivals. A new approach recently implemented allows the students to travel to Hill Hall and experience live testing and equipment use. All demos can be used for K-12. The goal for younger grades is to implement a "wow" material science is cool factor, while the later high school classes emphasize expanding vocabulary and navigating interest towards college and career opportunities.



2015 UNDERGRADUATE DESIGN COMPETITION

Design … a critical component to revitalize engineering in materials education.

- **First Prize:** $2,000 + $500 travel assistance + $500 to the department for support of future design teams

  Winner: California State Polytechnic University-Pomona

  Title: "Design of Diffusion Coatings: Effect of Process Control on Microstructural Evolution"
- **Second Prize:** $1,500 + $500 travel assistance

  Winner: Carnegie Mellon University

  Title: "Recycling of Specialty Metal Plant By-Products"
- **Third Prize:** $1,000 + $500 travel assistance

  Winner: Michigan Technological University

  Title: "E357 Alloy Design To Increase Elongation and Maintain Strength"

2015 NATIONAL MERIT SCHOLAR

The ASM Materials Education Foundation has been participating in the National Merit Scholarship Program since 1964. The National Merit Scholarship Corporation is a not-for-profit organization with a portion of its scholarship activities underwritten by some 500 independent corporate, college, and foundation sponsors like the ASM Foundation.

Nicholas Han
Westview High School

Eagle Crest high school materials program at a Colorado School of Mines outreach event.

2015 UNDERGRADUATE SCHOLARSHIP PROGRAM

19 scholarships totaling $110,000

WILLIAM PARK WOODSIDE FOUNDER'S SCHOLARSHIP

1 **Anna Bretzke**
Missouri University of Science & Technology

THE LUCILLE AND CHARLES A. WERT SCHOLARSHIP

2 **John Coffey**
The Ohio State University

GEORGE A. ROBERTS SCHOLARSHIPS

3 **Mary Cole**
University of Akron

4 **Ziyin Huang**
Drexel University

5 **Colin Lunstrum**
University of Idaho

6 **Rachel Sylvester**
The Ohio State University

7 **Cyrus Thompson**
University of Wisconsin-Madison

WILLIAM & MARY DYRKACZ SCHOLARSHIPS

8 **Taylor Brown**
University of Alabama at Birmingham

9 **Katrina Catledge**
Wright State University

10 **Nathaniel Griffen**
Missouri University of Science & Technology

11 **Zach Jensen**
University of Wisconsin-Madison

DAVID J. CHELLMAN SCHOLARSHIP

12 **Peter Barber**
LeTourneau University

LADISH CO. FOUNDATION SCHOLARSHIP

13 **Misty Pulcine**
University of Wisconsin-Madison

14 **Allison Weber**
University of Wisconsin-Madison

OUTSTANDING SCHOLAR AWARDS

15 **Allison Fraser**
Lehigh University

16 **Alexander Lark**
University of Utah

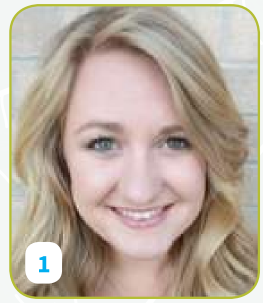
17 **Theresa Saenz**
Purdue University-West Lafayette

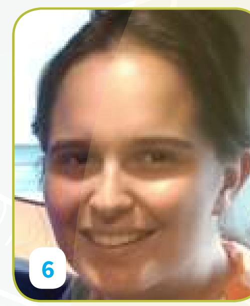
EDWARD J. DULIS SCHOLARSHIP

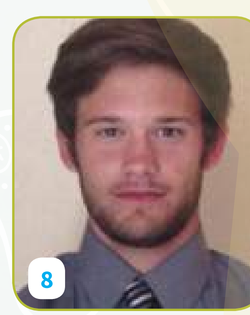
18 **Daniel Balder**
University of Minnesota

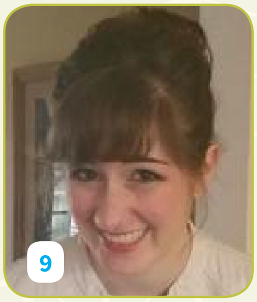
JOHN M. HANIAK SCHOLARSHIP

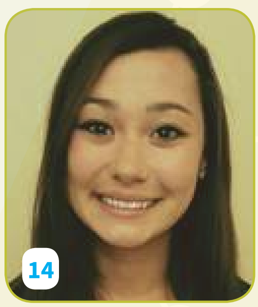
19 **Alexander Hall**
Pennsylvania State University

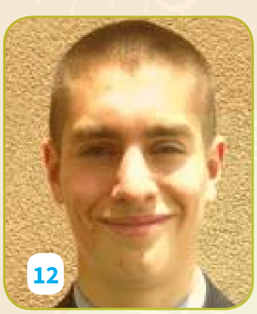












"Promoting the future of materials science is something I am very passionate about. ASM does such a great job of putting money from generous donors to use. I can't count the number of times I have heard incoming students say that they became interested in materials engineering after attending the materials camp sponsored by the ASM Foundation. I am so honored to have been selected to receive this scholarship and could not be more grateful for your generosity and commitment to the future of materials science and engineering. I am proud to be a part of such a supportive and intelligent network of people and hope to someday be able to help support up and coming engineers in return for all that ASM has already done for me."

—ANNA BRETZKE

"With the help of the ASM Materials Education Foundation Outstanding Scholar Award, I will be able to continue my education at Lehigh in a fulfilling and rigorous department that will prepare me for the metallurgy industry. By continuing my education with the help of such scholarships, I will be able to contribute my skills to the metallurgical field upon graduation and make a difference in the world. Without your support, this would not be possible, so I wish to sincerely thank you for helping to make my dreams a reality."

—ALLISON FRASER

ASMNEWS

ASM MATERIALS EDUCATION FOUNDATION ANNOUNCES 2016 SCHOLARSHIP WINNERS

William Park Woodside Founder's Scholarship

The William Park Woodside Founder's Scholarship was established in 1996, by a gift from Mrs. Sue Woodside Shulec in honor of her grandfather. William Park Woodside founded our Society as the Steel Treaters Club more than 100 years ago and later served as president of ASM. The scholarship was established to support an ASM student member studying materials science and engineering at the junior or senior level who demonstrates strength in leadership, character, and academics. Tuition of up to $10,000 for one academic year and a certificate of recognition are awarded to the recipient.

Katerina Kimes

University of Pittsburgh

Since declaring her major, Kimes' passion for materials science and engineering has led her to pursue hands-on opportunities, with summers spent as an intern cladding metals at All-Clad Metalcrafters and as a researcher focusing on functional materials at the University of Pittsburgh. She has gained an understanding of how important materials are to everyday life and wants to share this knowledge with others, which is what encouraged her to become secretary for her school's Material Advantage chapter.

The Lucille and Charles A. Wert Scholarship

The Lucille and Charles A. Wert Scholarship was established in 2006 through a generous bequest by the couple. It serves as an expression of their commitment to education and the materials science and engineering community. Tuition of up to $10,000 for the academic year is awarded through this scholarship.

Mystee Pulcine

University of Wisconsin-Madison

Life has taken Pulcine many places, but none quite so thrilling as the past four years. She has been given once-in-a-lifetime opportunities such as interning at NASA Langley researching boron nitrite nanotubes and working in Professor Perepezko's high temperature materials lab exploring grain growth and nucleation. She also served as vice president of the American Foundry Society student chapter at UW. Through these experiences, her dedication to the field of materials science has only solidified.

George A. Roberts Scholarships

The George A. Roberts Scholarships were established in 1995 through a generous contribution from Dr. George A. Roberts, FASM, past president and retired CEO of Teledyne, to the ASM Foundation as an expression of his commitment to education and the materials science and engineering community. Scholarships are awarded to outstanding undergraduate members of ASM at the junior or senior level who demonstrate exemplary academic and personal achievements, and interest and potential in metallurgy or materials science and engineering. Five scholars will receive a certificate and check for $6000 toward educational expenses for one academic year.

Victoria Christensen

Pennsylvania State University

Christensen strives to research high-performance polymers for clean water applications based on her experiences as a research fellow for PPG industries and a research intern at GE Oil & Gas. "I wouldn't be as dedicated to my future as a materials scientist if it weren't for my amazing teachers who encouraged me every step of the way," she says.

In This Issue

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

HIGHLIGHTS SCHOLARSHIP WINNERS

Jacob Cordell
Pennsylvania State University

With research interests in photovoltaics, Cordell focuses his work on reducing the cost of solar power and increasing efficiency of solar devices. His recent projects involved developing characterization tools at the National Renewable Energy Laboratory to expedite the discovery of photovoltaic absorbers and analyzing tin sulfide at Penn State as one of these new absorber materials.

Ann Graff
The Ohio State University

Graff has enjoyed several experiences with biomaterials research, involving biosensing nanofibers and working with human gingival tissue and dental implants. She learned so much in her first year of materials-specific classes and looks forward to more focused classes. “I love that you could do anything in materials science,” she says, “but I see myself working to improve prosthetics or implants.”

Elliot Smith
University of Alabama-Tuscaloosa

Smith interrupted his sophomore year to begin a three-semester co-op with Nucor Steel. His first semester involved learning about melting, rolling, and finishing plate processes. In his second term, he worked in the hot mill, testing descale nozzle sprays and conducting research on scale growth. His summer involved testing the physical limits of temper mill passing on different steel grades.

Robert Seivert
South Dakota School of Mines & Technology

“I had always been interested in new materials development, but it was the engaging and enthusiastic professors who sold me on metallurgy,” says Seivert. He has since completed two internships with a leading steel manufacturer and is vice president of his Material Advantage chapter. He plans to work in commercial materials manufacturing where he can help create advanced materials for everyday use.

William & Mary Dyrkacz Scholarships

The William & Mary Dyrkacz Scholarships were established in 2011 through a generous contribution from the couple to the ASM Foundation. Dyrkacz, an ASM Fellow, remembered the scholarships he received while an undergraduate at Carnegie Tech from 1939-1942. Scholarships are awarded to outstanding undergraduate members of ASM at the junior or senior level who demonstrate exemplary academic and personal achievements, and interest and potential in metallurgy or materials science and engineering. Four scholars will receive a certificate and check for $6000 toward educational expenses for one academic year.

Dan Balder
University of Minnesota

Completing an associate’s degree in nanoscience technology showed Balder “that in order to move technology forward, it is necessary to understand the materials that make up the world around us.” He is now an undergraduate senior studying materials engineering and chemistry. He spent the past three summers as an intern at a printed electronics company where he worked on improving characterization methods for metal-based inks.

Tina Berthiaume
Iowa State University

By including a biomedical engineering minor, Berthiaume is able to see how engineering is involved with trying to advance materials integration within the body. Her goal is to use her education to assist in the advancements of metals in the medical industry. “Materials are the baseline for almost anything, but the biomedical industry is what intrigues me the most,” she says.

Gregory Mulderink
Northwestern University

Mulderink began early in his sophomore year with a simple desire to investigate electronic materials of all kinds, which then developed into his current work with fabricating novel 2D nanoelectronic semiconducting materials. His summer was spent working on large-scale fabrication of 2D boron and he is now president of Northwestern’s Material Advantage chapter.

Ross Snyder

University of Missouri-Kansas City

Snyder's room has always been adorned with Lego creations, but it was not until college that he discovered materials science. While interning with Harley Davidson, he witnessed fascinating reactions in manufacturing between the building blocks of materials science. In May 2017, Snyder will graduate with a degree in mechanical engineering and his dream of metallurgy in sight.

David J. Chellman Scholarship

The David J. Chellman Scholarship was established in 2014 by Mrs. Arline Denny in honor of her husband, a long-standing Senior Technical Fellow with Lockheed Martin Corp. and ASM Life Member who enthusiastically served on the AeroMat Conference Organizing Committee for more than 25 years. The scholarship is an expression of his commitment to education and the materials science and engineering community. Tuition of $2500 for the academic year is awarded through this scholarship.

Rachel Weckselblatt

Lehigh University

Immediately after her first year in college, Weckselblatt got involved with research in 3D printing of metal clay bone implants, and the following summer in performing XRD for thermoelectric materials research. This past summer, she worked at a naval nuclear laboratory supporting the U.S. Navy. Working toward a minor in nanotechnology has really helped her appreciate the correlation between structure and material properties.

Ladish Co. Foundation Scholarship

Established in 2011, the Ladish Co. Foundation Scholarship is awarded to an outstanding undergraduate member of ASM who has demonstrated exemplary academic and personal achievements as well as interest and potential in metallurgy or materials science and engineering. (Student must be a Wisconsin resident and must attend a Wisconsin university to qualify.) Two scholars were selected this year, and each will receive a certificate and check for $2500 toward educational expenses for one academic year.

Zach Jensen

University of Wisconsin-Madison

Performing computational research in the Informatics Skunkworks group introduced Jensen to coding and methods of machine learning for materials research. The past two summers, he increased his experimental capabilities working as an R&D intern at Federal Mogul and as a summer researcher at Oak Ridge National Laboratory investigating solid oxide fuel cell electrolytes. "Understanding both theory and experimental methods is very important for computational science," he says.

Matthew Austin

University of Wisconsin-Madison

Originally a biomedical engineering major, Austin switched to materials science during his sophomore year due to his interest in the molecular structure of different materials, as covered in a chemistry class. During a co-op with Bemis Co., a global supplier of flexible packaging, he honed his professional skills and gained a greater understanding of what it means to be an engineer working in industry.

Outstanding Scholar Awards

The Outstanding Scholar Awards were established to recognize students who demonstrate exemplary academic and personal achievements as well as interest and potential in metallurgy or materials science and engineering. The awards are funded by the ASM Materials Education Foundation. Three $2000 awards are presented each year.

Harlan Grossman

Rensselaer Polytechnic Institute

Since learning about carbon allotropes in high school chemistry, Grossman's passion for materials science has only intensified. This interest led him to electrochemical research of cobalt and an internship at GE Aviation where he worked on projects ranging from dust ingestion to failure analysis. He aspires to a career in the aviation industry.

Joseph Ogea, Jr.
Virginia Polytechnic Institute & State University

After being accepted at Virginia Tech, Ogea attended the school's Foundry Institute for Research and Education open house. As he stepped onto the foundry floor, he was greeted by the hum of the induction furnace and whir of slurry tank motors. The physicality, intensity, and technology all rolled into one was incredible. After taking a foundry class, he was hooked.

Hannah Woods
Purdue University

One highlight of Woods' experiences thus far has been her internship in the Advanced Materials and Processing Branch at NASA Langley Research Center, where she worked on synthesis of novel high performance polymers. She also enjoys her roles as president of the Purdue American Chemical Society, and as public relations director for her Material Advantage chapter.

Edward J. Dulis Scholarship

The Edward J. Dulis Scholarship was established in 2003 and is awarded to an outstanding undergraduate member of ASM at the junior or senior level who demonstrates exemplary academic and personal achievements, as well as interest and potential in metallurgy or materials science and engineering. One scholar will receive a certificate and check for $1500 toward educational expenses for one academic year.

Keith Coffman
Georgia Institute of Technology

Already a veteran in the lab, Coffman's projects have included reducing the cost and complexity of applying the displacive compensation of porosity process to produce a fully dense ZrC/W composite with complex shapes, and contributing to research on aqueous Li-ion batteries by developing anodes, electrolytes, and fabrication techniques to increase operation voltage.

Robert Wesolowski named 2016 Kishor M. Kulkarni Distinguished High School Teacher

The Teacher Award Committee of the ASM Materials Education Foundation is proud to announce the selection of Robert Wesolowski of Saint Joseph High School, Pittsburgh, as recipient of the 2016 Kishor M. Kulkarni Distinguished High School Teacher Award.

The award, $2000 plus $500 toward travel to MS&T, was established in 2007 through a generous donation by Dr. Kishor M. Kulkarni, past trustee of ASM International, and his family to recognize the accomplishments of one U.S. high school science teacher who demonstrates a significant and sustained impact on pre-college age students. The award will be presented on October 24 at the ASM Leadership Awards Luncheon at MS&T16 in Salt Lake City.

Wesolowski maintains a strong personal commitment to improving STEM education within the Western Pennsylvania region. For 14 years, he coordinated a materials science teacher internship program at Carnegie Mellon University (CMU), and for six years he coordinated and presented at a teacher camp at CMU. He also authored "Science and Technology through Materials" curriculum with CMU, which was implemented in September 2011 throughout Pittsburgh Public Schools.

"Bob is a dynamic instructor who gives students many opportunities with hands-on learning, which generates excitement and interest in our students. He has a talent for engaging students in compelling discussions, motivating them to be inquisitive and think outside the box. Bob is about sharing resources, knowledge, and experiences with his students so they remain actively engaged in the learning process."

—Kimberly Minick, assistant principal,
Saint Joseph High School

2016 Undergraduate Design Competition Winners Announced

The ASM Materials Education Foundation and Design Competition Committee are pleased to announce the winners of the 2016 Undergraduate Design Competition. First prize goes to **California State Polytechnic University, Pomona** for "Design and Selection of Salts and Containment Materials for Concentrated Solar Power Generation." Team members include Obed Villalpando, Jason Wang, Jared Logier, Blake Morris, and faculty advisor Vilupanur Ravi, FASM. The team will receive $2000, $500 travel assistance for MS&T16, and $500 to the department to support future design teams.

Second prize goes to **Northwestern University** for "PH Austenitic TRIP Stainless Steel for Additive Manufacturing." Team members include Woo Hyun Chae, Nathaniel Gilbert, Yongwook Oh, Sarah Rappaport, Christina Robinson, Ryan Weidinger, and faculty advisor Gregory Olson, FASM. The team will receive $1500 and $500 travel assistance for MS&T16. Third prize goes to **Missouri University of Science & Technology** for "Reduction of the Adhesion of Fayalite Bearing Scale (Silicon Streak Scale) in CSP Steel Mill Production." Team members include Adam Schmitz, Mark Emmendorfer, Charles Campbell, Cameron Rudolph, and faculty adviser Mark Schlesinger. The team will receive $1000 and $500 travel assistance for MS&T16. Winners will be recognized on October 24 at the ASM Leadership Awards Luncheon at MS&T16 in Salt Lake City. To view abstracts of the winning projects, visit asmfoundation.org.

William T. Mahoney Named ASM Managing Director

With approval of the ASM Board of Trustees, ASM is pleased to announce the selection of William T. (Bill) Mahoney as ASM Managing Director. The appointment follows an extensive search led by the board-appointed Executive Search Committee with the assistance of Dise & Company, an executive search firm. Mahoney's appointment is effective immediately.

Mahoney most recently served as CEO of the South Carolina Research Authority (SCRA), from August 2005 to March 2016. SCRA is a non-stock, tax-exempt applied R&D corporation, which operates under a public charter from the state of South Carolina. Under his leadership, SCRA's annual revenues from its applied research and commercialization services operations grew from $74M to over $455M. In the decades prior to joining SCRA, Mahoney led a variety of companies that commercialized innovative solutions in telecommunications, electronic publishing, automatic remote monitoring, and other emerging applied systems markets, leading directly to IPO's or strategic acquisitions.

In addition to company leadership roles, Mahoney held a non-voting seat as secretary of the SCRA board and served as chairman of SCRA's applied R&D affiliate, Advanced Technology International Inc. He currently serves as chairman of tech startups STEM Premier and Carbon Conversions Inc. and is a board member of the National Defense Industrial Association, National Energy Marketers Association, and Fuel Cell and Hydrogen Energy Association. On a state and local level, he serves or has served on the boards of the SC Hydrogen and Fuel Cell Alliance, Midland Technical College Foundation, and SC Economics. Mahoney is a Harvard graduate and former member of both the Harvard Crew and U.S. National Rowing Team. He and his wife, Paula, have been married for 37 years and have two sons. A formal announcement will be made on October 24 during the ASM Annual Business Meeting at MS&T16 in Salt Lake City.

Jacquet-Lucas Award for Excellence in Metallography

The ASM Metallographic Award was established in 1946 for the best entry in the annual ASM metallographic competition. In 1958, it became known as the Francis F. Lucas Metallographic Award and has been endowed since that date by Adolph I. Buehler. In 1972, ASM joined with The International Metallographic Society (IMS) in sponsoring the Pierre Jacquet Gold Medal and the Francis F. Lucas Award for Excellence in Metallography. This award has been endowed by Buehler Ltd. since 1976.

The 2016 recipients of the Jacquet-Lucas Award are **Vikas Sinha, Adam Pilchak, Reji John, FASM, Sushant Jha, James Larsen, FASM,** and **William J. Porter, III,** for their entry entitled "Quantitative Characterization of Fracture Features in Titanium Alloys." Sinha works as a scientist at UES Inc., Dayton, Ohio, and is an onsite scientist at the Air Force Research Laboratory, Materials and Manufacturing Directorate, Wright-Patterson Air Force Base (WPAFB). Pilchak is senior research materials engineer, research lead metallic materials and processes team, Metals Branch Structural Materials Division, Materials and Manufacturing Directorate, Air Force Research Laboratory, Air Force Material Command, WPAFB. John is the research lead for metals probabilistic performance prediction research team in the Metals Branch, Structural Materials Division, Materials and Manufacturing Directorate, Air Force Research Laboratory, WPAFB. Jha is a senior research engineer, Universal Tech-

Sinha

Pilchak

John

Jha

Larsen

Porter

nology Corp., Dayton, Ohio. Larsen is the senior scientist for structural materials life prediction, Materials and Manufacturing Directorate, Air Force Research Laboratory, WPAFB.

Canada Council Awards

ASM Canada Council will present their awards during ASM's Leadership Awards Luncheon on Monday, October 24, in Salt Lake City, during MS&T16. Congratulations to the following Canadian award recipients:

ASM Canada Council
M. Brian Ives Lecture
Lukas Bichler
Associate Professor
University of British Columbia
School of Engineering
Kelowna, BC

ASM Canada Council
G. MacDonald Young Award
Alex P. Varro
CEO
Thuro Inc.
Calgary, AB

ASM Canada Council
John Convey Innovation Award
Erhan Ulvan
Acuren Group Inc.
Oakville, ON

Nomination Deadline for the 2017 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 2017 is **November 30, 2016.** For complete information including the rules, interpretive comments, and and to request a unique link for an online nomination form, visit asminternational.org/membership/awards/asm-fellows or contact Christine Hoover at 440.338.5151, ext. 5509, christine.hoover@asminternational.org.

Seeking Applicants for SMST Fellowship

The International Organization on Shape Memory & Superelastic Technologies (SMST), an affiliate society of ASM International, is seeking applications for the 2017 SMST Fellowship. The intent of the fellowship is to provide a current use gift to a deserving graduate student(s) with the purpose of initiating interest in a unique path of research for shape memory materials such as Nitinol. The award, which is financially supported in 2017 by Edwards LifeSciences, includes a stipend up to $50,000. The recipient will present research results at the 2019 SMST Conference to be held in Constance, Germany. Application deadline is **January 9, 2017.** For more information, visit http://bit.ly/29pjIkD or contact sarina.pastoric@asminternational.org.

Seeking Nominations for Thermal Spray Hall of Fame: Deadline Extended

The Thermal Spray Hall of Fame, established in 1993 by the Thermal Spray Society of ASM International, recognizes and honors outstanding leaders who have made significant contributions to the science, technology, practice, education, management, and advancement of thermal spray. For a copy of the rules, nomination form, and list of previous recipients, visit tss.asminternational.org or contact joanne.miller@asminternational.org. Nomination deadline extended to **November 14.**

HTS AWARD DEADLINES

ASM HTS/Bodycote "Best Paper in Heat Treating" Contest

The ASM Heat Treating Society established the Best Paper in Heat Treating Award in 1997 to recognize a paper that represents advancement in heat treating technology, promotes heat treating in a substantial way, or represents a clear advancement in managing the business of heat treating. The award, endowed by **Bodycote Thermal Process-North America,** is open to all students, in full time or part-time education, at universities (or their equivalent) or colleges. Students who have graduated within the past three years and whose paper describes work completed while an undergraduate or post graduate student are also eligible. The winner will receive a plaque and a check for $2500. Paper submission deadline is **March 1, 2017.**

Nominations Sought for George H. Bodeen Heat Treating Achievement Award

ASM's Heat Treating Society (HTS) is currently seeking nominations for the George H. Bodeen Heat Treating Achievement Award, which recognizes distinguished and significant contributions to the field of heat treating through leadership, management, or engineering development of substantial commercial impact. Deadline for nominations is **February 1, 2017.**

ASM HTS/Surface Combustion Emerging Leader Award

The ASM HTS/Surface Combustion Emerging Leader Award recognizes an outstanding early-to-midcareer heat treating professional whose accomplishments exhibit exceptional achievements in the heat treating industry. The award was created in recognition of Surface Combustions' 100 Year Anniversary in 2015. The winning young professional will best exemplify the ethics, education, ingenuity, and future leadership of our industry. Deadline for nominations is **April 1, 2017**.

For nomination rules and forms for all three awards, visit hts.asminternational.org and click on Membership & Networking and Society Awards. For more information, contact Joanne Miller at 440.338.5151 ext. 5513 or joanne.miller@asminternational.org.

IMS Salutes Corporate Sponsors

The International Metallographic Society (IMS) relies on corporate financial support to maintain its excellent awards program. IMS extends sincere appreciation to the following companies for their support.

IMS Benefactors: Buehler and Precision Surfaces International

IMS Patrons: Allied High Tech Products Inc. and Struers Inc.

IMS Associates: Carl Zeiss Microscopy LLC, Evans Analytical Group, Hoeganaes Corp., Metkon Instruments Inc., MetLab Corp., PACE Technologies Corp., and Ted Pella Inc.

IMS Sponsors: IMR Test Labs, Leco Corp., Nikon Metrology Inc., and Scot Forge Co.

WOMEN IN ENGINEERING

*This new profile series introduces leading materials scientists from around the world who happen to be females. Here we speak with **Judith A. Todd,** head of the engineering science and mechanics (ESM) department, P.B. Breneman Chair, and professor of engineering science and mechanics at Penn State.*

What does your typical workday look like?

While there is no typical workday, they are all equally exciting. Research is the norm for all students and faculty in the department, so we are continually developing proposals and new educational initiatives to support the research. Recent examples include: additive manufacturing of metals and 3D bioprinting of cartilage, bone, and pancreas, with a new, college-wide master's degree; growth of our Center for Nanotechnology Education and Utilization, which provides education at all levels and has workforce development programs in 16 U.S. states and Puerto Rico; establishment of a Center for Neural Engineering emphasizing infant brain diseases in Uganda (our global partners) and with a new M.D./Ph.D. degree program; and development of new, biodegradable self-healing polymers based on proteomic sequencing of squid ring teeth.

What's been your biggest technical challenge?

Keeping up with my research students as my administrative load limits the time available for research.

What part of your job do you like most?

My favorite part is the people and the research. I enjoy one-on-one interactions with students at all levels, inspiring all to be the best they can be, and then escaping to conduct research with my group. What greater privilege is there than to facilitate and encourage students to accomplish beyond their expectations, faculty to make breakthroughs in their research, and staff who make everything occur seamlessly.

What is your engineering background?

My B.A., M.A., and Ph.D. degrees are in materials science from Cambridge University, England. I was fortunate to be able to define my own Ph.D. topic, which involved a year's fieldwork in the Ethiopian bush studying the 2000-year-old bloomery iron (solid state reduction) process, which was still practiced in 1972. My thesis contains one of the last ethnographic records, with metallurgical analyses, of the manufacture of iron tools and products by the bloomery process. Upon completion, I conducted post-doctoral research programs in advanced fracture mechanics, aluminum hydride, and the design of low alloy steels for coal gasification and liquefaction vessels.

What are you working on now?

My current research relates to laser-sustained nitrogen and argon plasmas and their interactions with metals, particularly titanium and its alloys. The potential for developing hard nitride coatings is being explored.

How many people do you work with?

Within the department, I work with a faculty and staff of 60 people, approximately 35 visiting scholars per year, and a student body of up to 320 undergraduates and graduate students. However, as ESM teaches all the service mechanics courses across several colleges, we teach mechanics to approximately 4400 students per year. Our research activities involve extensive collaborations with Penn State's Research Institutes and Colleges, and with numerous universities across the globe. It is becoming increasingly important for students to have international experiences that will prepare them to address the grand challenges facing our global society.

If a young person approached you for career advice about pursuing engineering, what would you tell them?

An engineering background provides a very strong foundation for whichever career you decide to pursue. Engineering is not just a pathway to industry or academia, it underpins the professions (medicine, business, law, and entrepreneurship), leadership positions in government, humanitarian organizations, entertainment, and public service. We need to see more engineering students entering the fields of politics and public policy too.

Hobbies?

Reading, hiking, and archaeometry.

Last book read?

"The Warmth of Other Suns: The Epic Story of America's Great Migration," by Isabel Wilkerson.

ASM's Women in Materials Engineering Committee is actively seeking candidates for award nominations. Contact vicki.burt@asminternational.org.

VOLUNTEERISM COMMITTEE

Profile of a Volunteer

Ben Rasmussen,
Manufacturing Engineer, Caterpillar Inc.—Sumter Hydraulics

Volunteers can make a serious impact—especially when they have the audacity to tackle larger projects. When Ben Rasmussen was in high school and looking for an Eagle Scout service project, he chose a challenging one: Design and build a bridge, earthen ramps, and retaining walls in a forest preserve area to allow for removal of invasive species. It's not something just any Scout could do. But it fit him well. He still likes to take on big challenges and use his gifts to serve others in meaningful ways.

Rasmussen knew he wanted to be an engineer and found his way into materials science at the University of Illinois at Urbana-Champaign. Graduating in 2010, he was hired at Caterpillar's tech center in Peoria, Ill. Next, he spent two years working for Caterpillar in Mississippi as a remanufacturing engineer in metallurgical lab infrastructure and salvage processes. Two years ago, he began a new role in Caterpillar's Sumter, N.C., hydraulics facility. He shifted from R&D into the fast-paced job of supporting needs in a hydraulic cylinder manufacturing shop.

During college, Rasmussen joined his school's Materials Advantage chapter and later the Peoria Chapter. "I was somewhat active but not in leadership until I was asked to take on additional roles. That really spurred my involvement," he recalls. He became active on the national Emerging Professionals Committee. The group targets his own demographic—recently out of college and beginning a career. "We identify their needs and are the voice of younger members," he explains.

After his three-year committee term, Rasmussen has now joined a cause near and dear to his heart—the national Volunteerism Committee. "It's at the root of everything that keeps ASM going. We make sure volunteers are recognized and appreciated," he says. "This has a global impact on the entire organization."

CHAPTERS IN THE NEWS

Leadership Days Celebrates ASM's Chapter Network

Leadership Days 2016 was held during August in Cleveland, attended by 59 volunteer delegates representing 40 Chapters from four countries. Volunteers attended various training sessions related to strengthening Chapter involvement, membership, and alignment with the ASM Strategic Plan. Following these sessions, attendees were transported to ASM Headquarters to experience the wonder of "Dinner Under the Dome." This event gave Chapter leadership a proper thank you for all of their hard work. Everyone left the event feeling truly appreciated and energized to begin the 2016-2017 Chapter year.

Student delegates are a vital component of ASM's membership.

Attendees were treated to tours of ASM's newly renovated teaching labs.

From left, Peggy Jones, FASM, William Frazier, FASM, Jon Tirpak, FASM, and J.P. Singh next to a display of William Park Woodside's handmade tools, which were recently moved from Detroit to ASM Headquarters.

Leadership Days hosted 59 volunteer delegates from 40 ASM Chapters.

India Chapters Growing Strong

During Leadership Days 2016, ASM's India Chapter Council reported that their five chapters are experiencing significant growth:

- **Bangalore** – from 32 to 64 members
- **Chennai** – from 36 to 90 members
- **Gujaret** – from 15 to 46 members
- **India** – from 74 to 100 members
- **Pune** – from 90 to 110 members

Congratulations, ASM India!

Material Advantage Chapters of Excellence

Every year, ASM administers the Chapters of Excellence competition on behalf of the Material Advantage Student Program. The following Chapters were selected based on excellence in programming, career development, service, social activities, chapter management, and report quality. All winners will be recognized at the Student Awards Ceremony at MS&T16.

Most Outstanding Chapter ($750 award and certificate): Rensselaer Polytechnic Institute

Chapters of Excellence ($450 award and certificate):

- Suez University
- Iowa State University
- University of Illinois at Urbana-Champaign
- Colorado School of Mines
- Missouri University of Science and Technology

Runner-Up (certificate of achievement): Virginia Tech

Official ASM Annual Business Meeting Notice

The Annual Business Meeting of members of ASM International will be held in conjunction with MS&T16 on:

Monday, October 24
4:00 - 5:00 p.m.
Salt Palace Convention Center, Salt Lake City

The purpose of the ASM Annual Business Meeting is the election of officers for the 2016-17 term and transaction of other Society business.

MEMBERS IN THE NEWS

Wang Achieves Named Professorship

On August 26, the Purdue University Board of Trustees approved **Haiyan Wang** as the Basil S. Turner Professor of Engineering. Wang is a joint professor of materials engineering and electrical and computer engineering who came to Purdue in August from Texas A&M University where she served as a professor of electrical and computer engineering since 2006. From 2013-15, she also served as a program director at the U.S. National Science Foundation. In addition, Wang was on staff at Los Alamos National Laboratory, first as a postdoctoral fellow and later as a technical staff member, from 2003-2006. Her research interests include electronic materials and nanoscale processing and characterization of oxide and nitride-based thin films.

Suresh Rides in Driverless Car

Subra Suresh, FASM, president of Carnegie Mellon University joined Pittsburgh Mayor Bill Peduto in September for the first official ride in an Uber self-driving car. The inaugural ride began at City Hall for a loop around the downtown area. The commercial application of autonomous driving has drawn national attention in recent days, highlighting the formative role Carnegie Mellon research has played in this field for more than 30 years.

IN MEMORIAM

Donald J. Wulpi, FASM, passed away September 4 at age 92. Born in Oak Park, Ill., he was a World War II veteran and worked as a metallurgical engineer with International Harvester for 30 years, retiring in 1980. During his career, Wulpi made a name for himself as a specialist in failure analysis of metals. He taught classes and wrote books on the subject through ASM International, which were also used as college textbooks. "Understanding How Components Fail," now in its third edition, continues to sell briskly. After retiring, he started his own metallurgical consulting business specializing in failure analysis and was called as an expert witness in court cases worldwide. Wulpi received his Fellow Award as part of the Fellow Inaugural Convocation and Rededication of Metals Park. There were 200 members in the first class of Fellows, and the convocation took place at the Dome on October 18, 1970, when Allan Ray Putnam was managing director.

Joseph Frank Nachman passed away on July 27 at age 98. He graduated from the University of Toledo in 1940. He worked as a chemist at the Interlake Iron Corp. and was then appointed powder chemist at the Indiana Ordnance Works of the U.S. Army. Before enlisting in the Navy, Nachman was employed as a metallurgical chemist for the Electric Auto Lite Co. In 1943, he was assigned to the Ordnance Investigation Laboratory in Maryland, where he was engaged in R&D on the use of cavity charges. As a result, he developed the "linear cavity charge calculator" for use by bomb disposal personnel. For this work, he received a Special Letter and Medal of Commendation from the Chief of the Navy Bureau of Ordnance. After the war, Nachman earned a master's degree in metallurgical engineering from The Ohio State University and joined the U.S. Naval Ordnance Laboratory in Silver Spring, Md., working on magnetic and high temperature alloys. He was appointed manager of alloy development at the University of Denver Research Institute in 1956 where he directed R&D. In 1963, he joined Atomics Intl. in Canoga Park, Calif., where he served as group leader for development of nuclear fuel element and rocket materials. In 1966, he joined Solar Turbines in San Diego as chief of applied sciences where he worked until his retirement in 1981 and then served as a metallurgical consultant for several years. Nachman was a Life Member of ASM, joining in 1948.

Kiyoshi Funatani, FASM, passed away August 12 at age 82. Born in 1933 in Japan, he attended school in both Japan and China. He graduated from Nagoya Institute of Technology and joined Toyota in 1955. In 1990, he joined the Japan Fine Ceramics Center. Funatani was a strong supporter of ASM's Heat Treating Society, helped organized some of the early Heat Treat conferences, and served on the board from 1996-2000. He became an ASM Fellow in 1999 and was also an ASM Life member. In addition, he was very involved with the IFHTSE, serving on the executive committee from 2000-2015. He co-edited the "Handbook of Metallurgical Process Design" and "Handbook of Mechanical Alloy Design" and was a contributing author to the "Handbook of Residual Stress and Deformation of Steel." Funatani was envied for his restless enthusiasm in heat treatment technology despite his age. He was continuously evaluating developments in this field and always had a strong personal opinion, which he liked to share in his presentations.

Raymond DeWitt Daniels passed away on May 8 at age 88. He earned B.S. and M.S. degrees in physics and a Ph.D. in physical metallurgy from Case Institute of Technology in Cleveland. In 1958, he accepted a faculty position at the University of Oklahoma (OU). His colleagues remember him as a true gentleman, good natured with a cheerful smile. Many of them remember seeing him in the hallways wearing a bow tie and pocket protector. For years, he and his students worked with support from Tinker Air Force Base on issues associated with rapid startup of jet engines on B52 bombers. Daniels also served as director of the School of Chemical Engineering & Materials Science and Director of the Office of Research Administration at OU. In the early 1990s, he became involved in international engineering education. Working through the U.S. Agency for International Development, he led an effort by OU, the University of Michigan, and Case Western Reserve University to establish a graduate program in petroleum and petrochemical engineering at Chulalongkorn University in Thailand. That effort was so successful it resulted in an invitation from the White House to make a presentation regarding making the project a model for similar initiatives. He continued with this project until his retirement in 1998. Daniels was a Life Member of ASM, joining in 1955.

ADVANCED MATERIALS & PROCESSES

EDITORIAL PREVIEW

NOVEMBER/DECEMBER 2016

Materials Testing & Characterization

Highlighting:

- Emerging Testing Techniques
- Advances in Atom Probe Tomography
- Characterization of Biomaterials

Special Supplements:

- *International Thermal Spray & Surface Engineering* newsletter covering emerging technologies in the thermal spray industry.
- *HTPro* newsletter covering heat treating technology, processes, materials, and equipment, along with Heat Treating Society news and initiatives.

Advertising closes October 5

JANUARY 2017

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STRESS RELIEF

PRINT ME A ROBOT

Even a novice can design and build a customized walking robot using a 3D printer and off-the-shelf servo motors with the help of a new design tool developed by Disney Research and Carnegie Mellon University, Pittsburgh. Users can specify the shape, size, and number of legs for the robotic creature, using intuitive editing tools to interactively explore design alternatives. The system also ensures that the resulting design is capable of moving as desired and not falling down; it even enables the user to alter the creature's gait as desired. The design interface features two viewports—one that enables editing of the robot's structure and motion and a second that displays how those changes would likely alter the robot's behavior. Users can load an initial, skeletal description of the robot and the system creates an initial geometry and places a motor at each joint position. Users can then edit the robot's structure, adding or removing motors, or adjusting their position and orientation. *cmu.edu, disneyresearch.com.*

Digital designs for robotic creatures are shown on the left and physical prototypes produced via 3D printing on the right.

Detail photo of the foot of a gecko used for research at the University of Akron.

GECKO-INSPIRED LINGERIE

Kellie K Apparel has a mission to reinvent the strapless bra. The new lingerie is the brainchild of Anthony Roy, a robotics engineer from California Institute of Technology, Pasadena. Roy designed the bra for his girlfriend (now wife) using his engineering and robotics background.

He first developed a prototype using GeckTeck, a biocompatible, silicone-based material that achieves superior frictional adhesion using the same physical properties geckos use to cling to almost any surface. The material is designed so that it makes intimate contact with even the most sensitive skin without irritation. Such close contact creates an intermolecular attraction known as Van Der Waals forces that, on a micro level, keeps the lining close to the skin while still being comfortable to wear. *kelliekapparel.com.*

3D PRINTING MODERN ART

Stratasys Ltd., Minneapolis, announced that the San Francisco Museum of Modern Art has acquired the much-acclaimed "Gemini" chaise designed by Professor Neri Oxman for its permanent collection. Gemini is a semi-enclosed, stimulation-free environment designed to enhance vocal vibrations, which are thought to be healing, throughout the body. A biologically inspired, 3D-printed skin lines the beautiful wooden chassis.

The chaise includes 44 different material properties in varying shades of yellows and oranges with differing transparencies and rigidities, all produced simultaneously in a single print process. The materials, shapes, and surfaces of the 3D-printed skin enable a unique vibrational acoustic effect for a quiet, calming environment. According to Naomi Kaempfer, creative director of art fashion design at Stratasys, the trend for museums adopting 3D-printed design affirms the longevity of 3D printing as an artistic medium and reflects a wider movement of artists celebrating the unique capabilities made possible with this technology. *stratasys.com.*

Gemini acoustic chaise features an inner lining made of 44 composite materials using Stratasys' unique color, multimaterial 3D printing technology. Courtesy of Michel Figuet.

3D PRINTSHOP

PRINTED COMPONENT ACES FLIGHT TEST

Naval Air Systems Command, Patuxent River, Md., completed its first successful flight test of a safety-critical aircraft component produced by additive manufacturing (AM). The component, a titanium link and fitting assembly 3D printed at Naval Air Warfare Center Aircraft Division, Lakehurst, N.J., is one of four that secure a V-22's engine nacelle to the primary wing structure. It will remain on the test aircraft—an MV-22B Osprey—for continued evaluation. Prior to this flight, multiple V-22 components built at Lakehurst and at Penn State Applied Research Laboratory, Arlington, Va., were tested at Patuxent.

"AM is a game changer," says Liz McMichael, AM Integrated Product Team lead. "We'll be working with V-22 to go from this first flight demonstration to a formal configuration change to use these parts on any V-22 aircraft." McMichael and her team have identified six safety-critical parts they plan to build and test over the next year for three U.S. Marine Corps rotorcraft platforms including the V-22, H-1, and CH-53K. Three of the parts will be made out of titanium, while the other three will be stainless steel. Naval aviation has employed additive manufacturing as a prototyping tool since the early 1990s and has recently begun printing non-flight-critical parts and tools. *navy.mil.*

An MV-22B Osprey equipped with a 3D-printed titanium link and fitting inside an engine nacelle maintains a hover during a July 29 demonstration at Patuxent River Naval Air Station, Md. Images courtesy of U.S. Navy.

Aviation mechanic Cody Schwarz works to install the 3D-printed link and fitting on the MV-22B Osprey engine nacelle.

GUINNESS RECORD HOLDER HEADS TO BOEING

A trim-and-drill tool, developed by researchers at the DOE's Oak Ridge National Laboratory (ORNL), Tenn., was named the largest solid 3D-printed item by Guinness World Records. Measuring 17.5 x 5.5 x 1.5 ft and weighing approx. 1650 lb, the tool will be tested for use in building the Boeing 777X passenger jet. "The more expensive metallic tooling option we currently use comes from a supplier and typically takes three months to manufacture using conventional techniques," says Leo Christodoulou, Boeing's director of structures and materials. The new tool was printed on ORNL's Big Area Additive Manufacturing machine in just 30 hours using carbon fiber and ABS thermoplastic composite materials. After ORNL completes verification testing, Boeing plans to use the record-setting trim-and-drill tool in its new St. Louis production facility to secure the jet's composite wing skin for drilling and machining before assembly, providing feedback to ORNL on the tool's performance along the way. *ornl.gov.*

Official measurement of the 3D-printed trim tool co-developed by ORNL and Boeing exceeded the required minimum size to achieve the Guinness World Records title of largest solid 3D-printed item.

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