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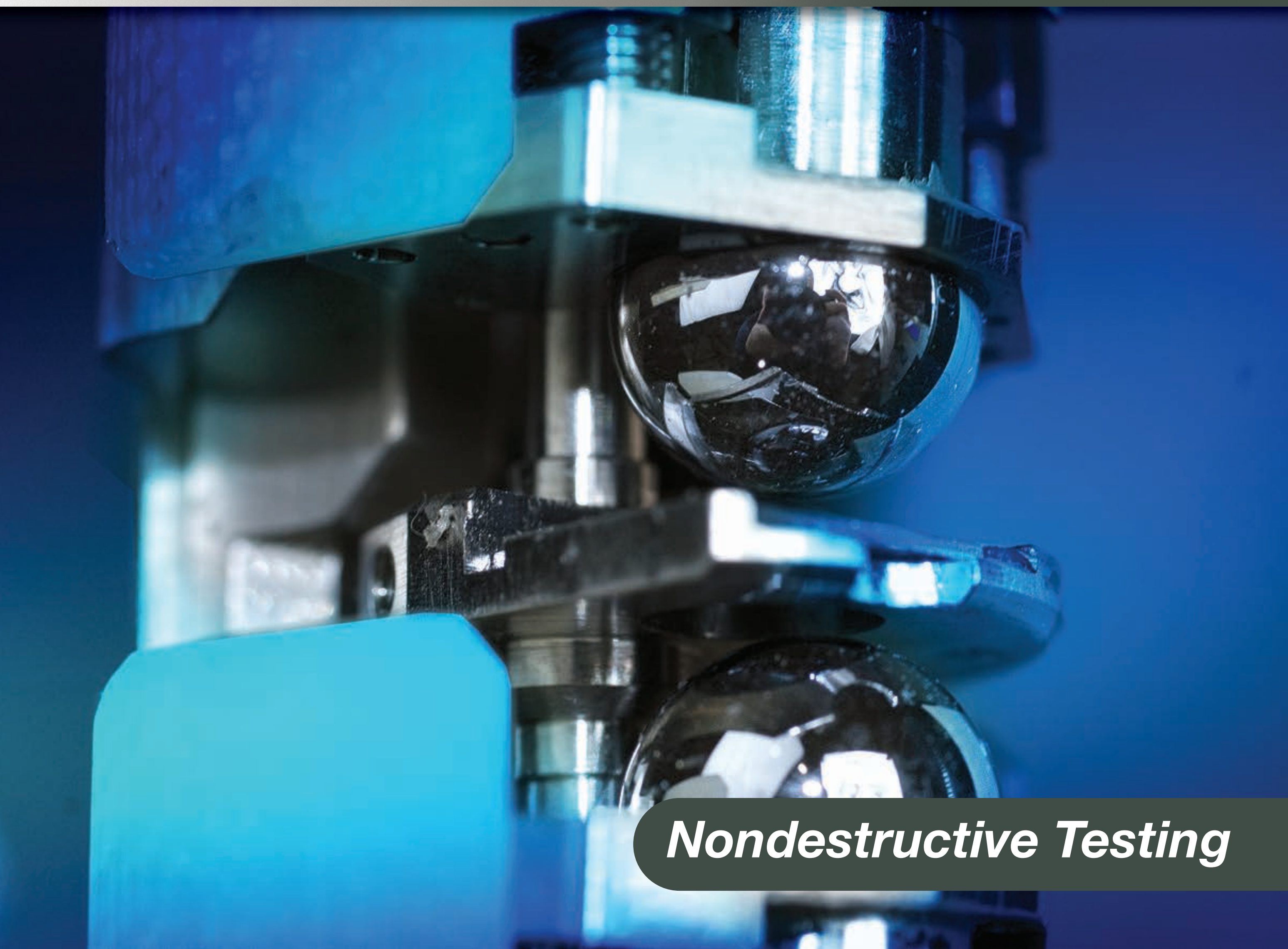

Nondestructive Testing

Resonant Ultrasound Spectroscopy •
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NDE Techniques for Semiconductors •

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ON THE COVER:
Continuous wave-THz spectroscopy system emitter and detector devices for semiconductor materials characterization. Dome-shaped emitters and detectors are mounted on thermally stable, optical stages that maintain THz alignment while measurements are taken at variable temperatures. Courtesy of Lake Shore Cryotronics Inc., lakeshore.com.

contents

DEPARTMENTS

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

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materials witness

Celebrating 101 years of materials milestones

When you hear the number 101, what's the first thing that comes to mind? For me, it's Dalmatians. But more importantly, it has been 101 years since the founding of the Steel Treaters Club, which eventually became ASM International. It's hard to believe it has been one year since ASM's 100th anniversary celebration, held last October in Montreal. Over the past year, ASM has undergone a branding makeover with a fresh, new logo, launched an updated website, released several new products and database updates, and continues to develop its Computational Materials Data Network, which aims to advance materials development and deployment by facilitating information sharing within the materials community. All of these efforts, and several others underway, could certainly be classified as sailing away from safe harbors. And that's exactly what makes it so exciting to be part of.

> ***"Twenty years from now you will be more disappointed by the things you didn't do than by the ones you did do. So throw off the bowlines. Sail away from the safe harbor. Catch the trade winds in your sails. Explore. Dream. Discover."***
>
> *—Attributed to Mark Twain*

Having ambitious plans in place is what keeps things fresh and inspiring. We know many of you are of the same persuasion, whether it's working on advanced battery designs, next-generation superalloys, specialized nanomaterials, or lightweight composites. All of these topics and many more will be discussed at MS&T14, coming up October 12-16 in Pittsburgh. Whether you attend as a presenter or a spectator, it makes no difference—you are likely to find inspiration and meaningful networking opportunities at every turn. From the opening plenary session, *Drivers for Advanced Manufacturing: Energy, Sustainability and Economics,* to educational short courses, intriguing lectures, and special events, there is truly something for every materials professional out there.

In other news, metallurgists the world over are now walking around with their shoulders back and their heads held a little higher, thanks to the new Apple Watch and iPhone models that debuted in September. Seriously, when is the last time you can remember a special shout-out to a *metallurgist* during a major product launch? For me, that answer is n-e-v-e-r. But that's exactly what Apple's senior VP of design Jony Ive did, gave credit to the company's metallurgists for custom alloys featured in the new watches: The Apple Sport model is made of a customized 7000 Series aluminum reportedly 60% stronger than standard alloys, while the fancier Apple Watch Edition cases are made of an 18-karat gold alloy developed to be twice as hard as standard gold. Yes, good times for materials scientists the world over.

Yet another glamorous area for materials experts involves sporting goods, which we will report on in a special summer issue next year. Just announced, Nanyang Technical University (NTU), Singapore, established an international consortium to develop innovative materials and processes for sports products. Besides NTU's Institute for Sports Research (ISR), the four founding members are all big industry players—Arkema, Chomarat, and Babolat (all of France) and bicycle manufacturer Topkey (of Taiwan). The consortium plans to develop new carbon composites materials, parts design methods, and manufacturing technology for products such as racquets and bicycle frames. It seems to be a golden era for materials scientists and engineers, and we hope to see you at MS&T!

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market

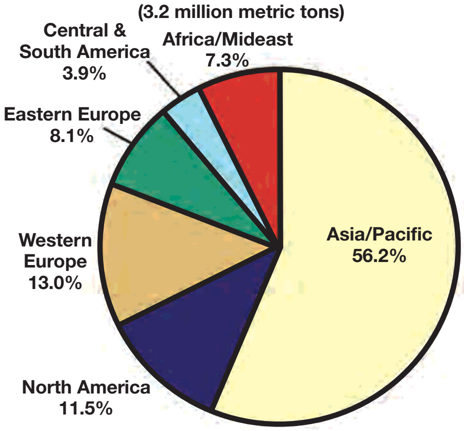
spotlight

Global demand for graphite to reach $30 billion in 2018

World demand for natural and synthetic graphite, including carbon fiber, is forecast to expand 5.8% per year to reach 4.2 million metric tons in 2018, with a market value of nearly $30 billion. Further, an overall strengthening of the global economy will bode well for all forms of graphite, say analysts at The Freedonia Group Inc., Cleveland, in their new study, *World Graphite (Natural, Synthetic & Carbon Fiber).* In particular, accelerating demand for steel and other metals will benefit synthetic graphite electrodes, which are essential for electric arc furnace steel production, as well as synthetic graphite powders and natural graphite used in other metallurgy applications.

Synthetic graphite demand is forecast to grow 5.7% annually to more than 2.8 million metric tons, valued at more than $25 billion. The increasing use of electric arc furnaces to produce steel in most parts of the world will boost sales of electrodes, the leading synthetic graphite product. The rise of advanced products such as graphene and fuel cells will boost demand for synthetic graphite as well.

World Graphite Demand by Region, 2013
(3.2 million metric tons)



Source: The Freedonia Group Inc.

Demand for carbon fiber is expected to grow at a double-digit annual pace as its use in aerospace, automotive, wind turbine, and other applications sharply increases, say analysts. Manufacturers are expected to incorporate greater amounts of carbon fiber into their products for weight reduction and improved strength. The cost of carbon fiber is expected to gradually decline due to technological innovation, which will further enhance its attractiveness to manufacturers. As a result, sales of carbon fiber will reach 120,000 metric tons by 2018, valued at $2.8 billion.

In the natural segment, flake graphite will continue to capture market share from amorphous graphite, as high-tech applications become more important and the availability of flake graphite greatly increases. Interest in flake graphite increased dramatically with the rise of lithium-ion batteries. For example, Tesla's new "Giga Factory" for lithium-ion batteries, due to begin U.S. production in 2017, is expected to significantly boost natural graphite demand. If run at full capacity, the plant will require about 100,000 metric tons of flake graphite annually.

Due to its large manufacturing economy, China is the leading consumer of synthetic and natural graphite, using nearly 1.1 million metric tons in 2013, one-third of global sales. Among other major consumers are the U.S., Japan, India, South Korea, Germany, and Russia. Carbon fiber demand is scattered among the developed economies of Western Europe, Japan, and the U.S., as well as China, although the U.S., Japan, and Germany are leading suppliers. *For more information, visit freedoniagroup.com.*

feedback

Celebrating cooperative engineering

The new "Metallurgy Lane" department does a nice job clearly explaining one historical advance at a time in a brief format that attracts busy metallurgists. As soon as *AM&P* arrives each month, this is what I look for and read while eating lunch at my desk. I recently wrote to the author, Charles Simcoe, praising his accounts and sending him some information where Canadian and U.S. engineering cooperate. One example is the Victoria Truss Bridge built in 1898 (27 spans of 70 m across the St. Lawrence at Montreal), which replaced a single track wrought iron bridge from 1859. With a design and Bessemer steel from Carnegie, Pittsburgh, the double track was built around the tube with advancing construction spans from both ends. The double track truss with external roadways on each side has four times the carrying capacity of the old bridge, but with only twice the weight. It still provides the critical link in transcontinental traffic for both Canadian National Railway and Via Rail passengers as well as commuter lines.

Hugh J. McQueen
Concordia University, Montreal

Victoria Truss Bridge, built in 1898. Courtesy of Hugh McQueen.

Pastimes should make Putin proud

I was reading the last few pages of an older edition of *AM&P* (July 2013) when I spotted the "Pastimes" item entitled *Respect the Metallurgist* by Jon Bryant from the July 1983 *Metal Progress*. Bryant laments the lack of a National Metallurgist Day. Turns out his wish has been answered, at least in Russia: Visit www.steelmaker.ru/en/node/1260. In part, the site proclaims, "Metallurgist Day was approved by the USSR government in 1957 and since that time, the third Sunday of July became a professional holiday for all employees of the industry. Metallurgy embraces the processes of obtaining metals from ores or other materials, changing the chemical ingredients, structure, and properties of metallic alloys, and shaping them. There would be no other industries without metallurgists."

Tony Wells
Australian Transport Safety Bureau

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

Buildings made of pistachio shells

Researchers in Iran used pistachio shells to produce a new type of nanocomposite with high tensile strength.

Researchers from Isfahan University of Technology, Iran, used pistachio shells to produce a nanocomposite with high tensile strength that could be used in the building industry. Iran is among the world's top pistachio producers, annually exporting thousands of tons to other countries. Easy access to shells as agricultural waste is a given. The structure of the shell and its components, specifically cellulose, make it an appropriate choice for composites production.

It is also resistant to humidity, loss of color, and various types of fungi and insects. Pistachio shell powder is used as filler in a heavy polyethylene matrix. The plastic wood composite is environmentally friendly, made from useless pieces of wood and recyclable plastic materials, and costs less to maintain than rough wood. Tensile strength increases 27% when the amount of nanoclay increases from zero to three weight sections, while it decreases 4% when the concentration reaches six weight sections. *www.iut.ac.ir/en.*

Green cement for the future

An EPFL-led consortium is developing a new blend of cement that promises to reduce the carbon footprint of concrete by up to 40%. Financial backing came from the Swiss Agency for Development to scale up efforts. Courtesy of Flickr/bnzai9.

A consortium led by the Swiss Federal Institute of Technology in Lausanne (EPFL), Switzerland, is developing a new blend of cement that promises to reduce the carbon footprint of concrete by up to 40%. Cement production is responsible for almost 10% of human CO_2 emissions. Nevertheless, it is one of the most sustainable construction materials. With partners from the Indian Institutes of Technology and universities in Cuba and Brazil, this new blend substitutes up to half of the usual Portland cement used to make concrete with highly abundant clay and limestone, promising to reduce cement-related CO_2.

As principle investigator Karen Scrivener explains, the strength of the combination of calcined clay and ground limestone, which the researchers call LC3 for Limestone Calcined clay Clinker Cement, lies in its chemistry. When used together, the aluminates from the calcined clay interact with the calcium carbonates from the limestone, leading to a less porous and stronger cement paste. In the past, these materials have been used individually to replace a small fraction of the cement, but together, they can replace up to half without altering the performance of the final product. *www.epfl.ch.*

Mixtapes make a comeback thanks to 3D printing

Back by popular demand, the MakerBot Mixtape is enjoying a resurgence—this 3D printed version of the iconic DIY music mixtape is available in different color combinations and offers a retro way to listen to your favorite music, but with a modern 3D printed twist. MakerBot, Brooklyn, N.Y., is known for its MakerBot Replicator desktop 3D printers. Now the musical endeavor combines modern 3D printing technology with the allure of something totally retro—a mixtape. The MakerBot Mixtape was one of the first items the company recreated through 3D printing and it is now producing a variety of color combinations to appeal to music lovers of all kinds, from rock and pop fans to those with a more classical leaning.

The MakerBot Mixtape is a retro way to listen to your favorite music with a modern 3D printed twist. Courtesy of Business Wire.

The redesigned MakerBot Mixtape is an all-new 3D printed cassette tape with an MP3 player embedded inside. With an improved user interface, the device offers drag and drop files just like a USB drive. It has 4 GB of storage to hold favorite tunes and playlists and will even store 3D printing STL files. *makerbot.com.*

briefs

A **QuesTek Innovations LLC Materials by Design,** Evanston, Ill., team accelerated the material development of M54 steel from a clean sheet design to a fully qualified, commercially available alloy in just six years, under a U.S. Navy Naval Air Systems Command (NAVAIR) Small Business Innovation Research funded project. Late last year, the Navy tested and qualified hook shank arresting gear components made from Ferrium M54 steel for the T-45 aircraft, in part because it provided more than twice the component life over the incumbent Hy-Tuf steel. Ferrium M54 benefits include superior strength and toughness, and resistance to fatigue and stress corrosion cracking. questek.com.

Armourglass, created by the **ArmourLite Watch Co.,** North Miami Beach, Fla., is a revolutionary shatterproof crystal that far surpasses the durability of traditional crystals, according to company sources. Most watch crystals have a glass strength of 700 Vickers while Armourglass has been tested to a hardness of 6000 Vickers. To match the Armourglass strength, the company developed special 316L stainless steel housings and mated the two with a custom rubber retaining ring that ensures superior shock resistance and watertight construction. armourlite.com.

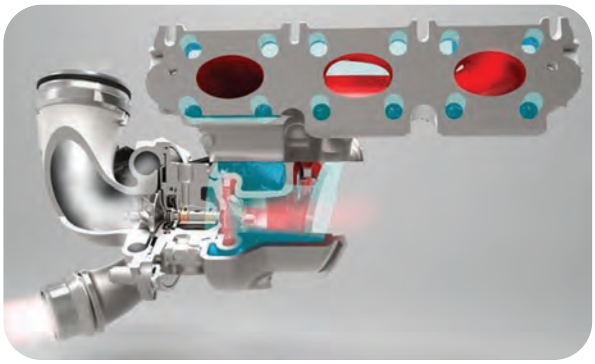
Overcoming magnesium barriers in aircraft interiors

For decades, magnesium has been banned from use on aircraft interiors due to the perceived threat of intense fire producing high heat and bright light. Although Mg alloys could reduce seat weight by 30%, this ban has hindered progress in designing lighter-weight structures. Bruce Gwynne, VP Divisional Strategic Development at Magnesium Elektron, UK, began pursuing magnesium use inside aircraft in 2006. He worked with Tim Marker of the FAA's William J. Hughes Technical Centre to undertake the many iterations of testing required to approve these new magnesium alloys. Initial tests compared the performance of full-scale seat models made of traditional magnesium to those made of the new alloys. After the new materials (including Elektron43) passed burn tests, the alloy structures were substantiated—including critical extra time before incapacitation on the survivability model—and the material was ready for the next phase.

The FAA has now released a report required to allow the new magnesium in the cabin under special condition approvals. A change to TSO C127a, which references SAE AS-8049 (the standard banning magnesium), will take more time, although the TSO modification is not required to move forward. *For more information: Steve Montisci +440.161.911.1220, magnesium-elektron.com.*

Aluminum turbochargers reduce vehicle weight

A modern turbocharged system is necessary to lower fuel consumption without sacrificing performance. Continental Automotive Systems, Germany, is pioneering innovative turbocharger technology. Developers have launched series production of the first car turbocharger with an aluminum turbine housing. The new turbocharger is making its debut in a demanding downsized application—a turbocharged three-cylinder engine with 1.5 l of cubic capacity and 100 kW of power.



The new turbocharger with aluminum housing by Continental is lighter and more economical than previous models. Courtesy of PRNewsFoto/Continental.

"The double-walled aluminum housing surrounds the hottest area with a cooling water jacket," says Wolfgang Breuer, head of the engine systems business unit. The coolant flowing through this jacket ensures that the external housing surface does not get hotter than 248°F and that the internal temperature does not exceed 662°F. At the same time, the dynamic response of the electric actuator at the wastegate ensures that the catalytic converter heats up quickly," adds Breuer. *continental-corporation.com.*

Studying nanoparticles that resemble stainless steel

Mathew M. Maye, associate professor of chemistry at Syracuse University, N.Y., was awarded a three-year, $360,000 grant from the National Science Foundation (NSF), Arlington, Va., supporting his ongoing work with metal stainless alloy nanostructures. The results of his work may impact gas storage, heterogeneous catalysis, and rechargeable lithium-ion batteries. Maye's approach is novel, in that he is attempting to chemically synthesize nanoparticle alloys that resemble steel and stainless steel.

"We're all aware of the basic properties of stainless steel," says Maye, citing shiny, rust-resistant kitchen metal surfaces as an example. "At the nanoscale, this rusting, or oxidation, is difficult to stop. By synthesizing stainless interfaces, we hope to better protect nanoparticles from oxidation."

Nanoparticles that contain iron cores and thin shells are used, the latter of which are made up of chromium, nickel, aluminum, or titanium. Maye developed the chemistry to produce these materials, which are then exposed to heat and oxygen, allowing for control of alloying and oxidation.

"Preliminary studies show that a nanometer-thin layer of oxide can be used to protect the nanoparticle, while providing a new mechanism to control nanoparticle structure and reactivity," he says. "As a result, we can make atomic to nanoscale voids, which are holes in the particle about the size of a molecule. These voids can be used to trap and store gas, such as carbon dioxide, and to serve as electrodes in lithium-ion batteries."

The goal of the NSF project is threefold: To develop "wet-chemical" synthesis strategies to prepare the alloy nanomaterials; to understand their oxidation and phase behavior; and to use such behavior to construct novel structures. *For more information: Mathew M. Maye, 315.443.2146, mmmaye@syr.edu, syr.edu.*

Creating safer materials to store industrial waste

A new material, being installed at a site in the Middle East, combines sodium bentonite clay and polymers to create a substance that can withstand industrial waste. Courtesy of CETCO.

University of Wisconsin-Madison researchers partnered with companies through the National Science Foundation's Grant Opportunities for Academic Liaison with Industry program to reinforce materials that house industrial waste by fusing them with polymers. Their starting point is sodium bentonite clay, which has proven reliable in a variety of environmental applications, essentially swelling and forming a seal when exposed to water or other liquids. But the clay sometimes fails to swell adequately when subjected to harsh conditions, such as the extreme pH levels of "red mud," the alkaline residue produced by aluminum extraction.

"You have to be able to store the waste into perpetuity—hundreds of acres of this liquid," says Craig H. Benson, professor of civil and environmental engineering. "Effective containment is part of the social contract these companies have with their community."

Benson and his colleagues spent the past five years experimenting with different ways to incorporate polymers into the bentonite clay. They eventually discovered that the best method was to let polymer molecules move around on the bentonite's surface, essentially finding a way into the flow path of the liquid as the clay swells up. The resulting material can withstand pH levels as low as 1 (highly acidic) and as high as 14 (highly basic) depending on the concentration of the substances involved. *For more information: Craig H. Benson, 608.262.7242, chbenson@wisc.edu, wisc.edu.*

industry news

TESTING CHARACTERIZATION

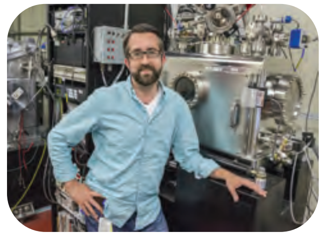
briefs

Junzhou Huang, a **University of Texas at Arlington** computer and data scientist, won a $250,000 **National Science Foundation** (NSF) grant to develop a scalable data-mining framework that will help manufacturers quickly discover desired materials for building their products. Huang will design scalable algorithms and a computational framework that can search unprecedented volumes of data detailing the complete set of genes present in numerous materials. He is teaming with the **Colorado School of Mines** on the research, funded by a total NSF award of $500,000 over three years. The grant is part of the national **Materials Genome Initiative.** uta.edu.

Laboratory Testing Inc., Hatfield, Pa., added moisture analysis to its extensive offering of materials testing services. The test is performed on a fully computerized Leco RC612 analyzer that reveals the percentage of moisture in a wide variety of inorganic materials, including welding flux, ores, ferroalloys, and chemical samples. Moisture Analysis is A2LA accredited to ISO 17025, and test procedures conform to AWS A4.4 M, MIL-E-23765/2E, and EB 4906 Rev A. labtesting.com.

Microscopy experiment breaks x-ray record

A record-setting x-ray microscopy experiment may have ushered in a new era for nanoscale imaging, according to researchers at the DOE's Lawrence Berkeley National Laboratory, Calif. The scientists used low energy or "soft" x-rays to image structures only five nm in size. This resolution, obtained at Berkeley Lab's Advanced Light Source (ALS), is reportedly the highest ever achieved with x-ray microscopy.



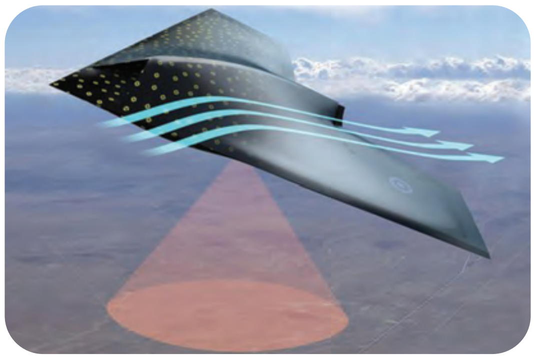
David Shapiro with the STXM instrument at ALS beamline 5.3.2.1. Courtesy of Roy Kaltschmidt.

Using ptychography, a coherent diffractive imaging technique based on high-performance scanning transmission x-ray microscopy (STXM), the team was able to map the chemical composition of lithium iron phosphate nanocrystals after partial dilithiation. Results yield important new insights into a material of high interest for electrochemical energy storage.

"We have developed diffractive imaging methods capable of achieving a spatial resolution that cannot be matched by conventional imaging schemes," says ALS physicist David Shapiro. "We are now entering a stage in which our x-ray microscopes are no longer limited by our optics and we can image at nearly the wavelength of our x-ray light." *lbl.gov.*

Spray-on sensors let airplanes feel damage

A unique system that allows airplanes to "feel" damage in a way similar to human skin is in development by British defense contractor BAE Systems. The technology works by covering the plane's body with tens of thousands of micro-sensors able to detect problems before they occur. The devices could measure wind speed, temperature, strain, and movement. Senior research scientist Lydia Hyde says the idea came to her while watching her tumble dryer, which uses a sensor to prevent overheating.



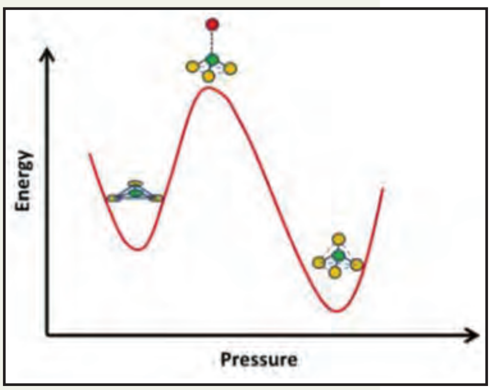
Sensors on military planes could warn engineers of potential problems. Courtesy of BAE Systems.

"Observing how a simple sensor can be used to stop a domestic appliance from overheating got me thinking about how this could be applied to my work and how we could replace bulky, expensive sensors with cheap, miniature, multi-functional ones," says Hyde. "This led to the idea that aircraft could be covered by thousands of these, creating a smart skin that can sense the world around them and detect stress, heat, or damage."

The sensors, possibly as small as dust particles and with their own power source, could even be sprayed onto aircraft like paint, according to BAE. *baesystems.com.*

Studying glass under stress

Glass has many applications that call for different properties, such as resistance to thermal shock or chemically harsh environments. Glassmakers commonly use additives such as boron oxide to tweak these properties by changing the atomic structure. Now researchers at the University of California, Davis, have captured atoms in borosilicate glass flipping from one structure



Researchers at UC Davis have for the first time captured atoms in borosilicate glass flipping from a flat triangular configuration with three oxygen atoms around one boron to a tetrahedron, via a pyramidal intermediate. Courtesy of UC Davis.

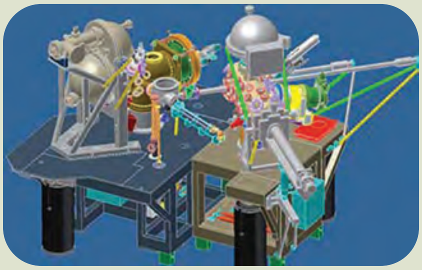
to another as it is placed under high pressure.

The new findings may have implications for understanding how glasses and similar amorphous materials respond at the atomic scale under stress, says materials science professor Sabyasachi Sen. Boron oxide is often added to glass to control a range of properties, including chemical durability, flow resistance, optical transparency, and thermal expansion. It is known that the structure around the boron atoms in borosilicate glass changes with pressure and temperature, switching from a flat triangular configuration with three oxygen atoms surrounding one boron atom to a four-sided tetrahedron, with four oxygen atoms surrounding one boron.

Previously, researchers could only study these structures in one state or the other, but not in transition. Sen and graduate student Trenton Edwards developed a probe that enables them to make nuclear magnetic resonance measurements of the environment of boron atoms in glass under pressures up to 2.5 GPa. They found that under pressure, the flat triangles of boron and three oxygen atoms first deform into a pyramid shape, with the boron atom pushed up. That may bring it close to another oxygen atom, and let the structure turn into a tetrahedron, with four oxygen atoms surrounding one boron.

Although glass is structurally isotropic and the stress on the glass is the same in all directions, the boron atoms respond by moving in one direction in relation to the rest of the structure. “This is an unexpected finding that may have far-reaching implications for understanding a wide range of stress-induced phenomena in amorphous materials,” notes Sen. *ucdavis.edu.*

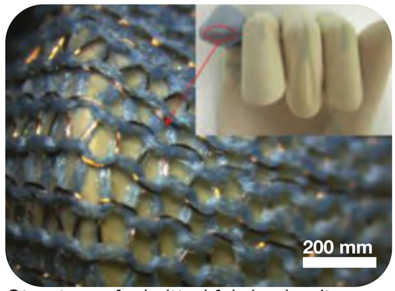
A super-advanced system for high-resolution imaging and spectroscopy, the first of its kind in the UK, will be installed at the **University of Bristol** thanks to a grant from the **Engineering and Physical Sciences Research Council.** The NanoESCA is an ultra-high vacuum photo electron emission microscopy system with state-of-the-art resolution for real-space and momentum-space imaging and spectroscopy. The new instrument will enable the electronic properties and chemical composition of thin layers of materials to be revealed and quantified by a nondestructive technique. The NanoESCA facility will be installed in the University of Bristol’s Centre for Nanoscience and Quantum Information in a dedicated ultra-quiet laboratory in 2015. www.bristol.ac.uk.



NanoESCA. Courtesy of University of Bristol.

Fabric circuit boards ready for wash and wear

Researchers at The Hong Kong Polytechnic University developed a computerized knitting technology that enables manufacturing of fabric circuit boards (FCBs), materials that can withstand harsh environments and keep performing. Making circuit boards that can handle more punishment than those currently available would allow for entirely new products such as shatter-proof phones, wearable devices embedded in clothing, and tougher police and military gear. The team combined electrically conductive fibrous metal materials with traditional fabric materials using the computer-based knitting technology. The result is a 3D material that can withstand stretching, being laundered in a washer and dryer, assault by a bullet (when under a bulletproof vest), and twisting over many cycles and for long time periods.



Structure of a knitted fabric circuit board. Courtesy of Proceedings of the Royal Society.

FCBs work by directing electricity from one part of the garment to another, offering mechanical support as they electrically connect discrete electronic components. They can also be designed as single, double, or multi-layered structures, mimicking traditional fabrics. To be used as wearable devices, they must offer low resistance to allow for reasonable comfort and be washable to allow for stain and odor removal. The Hong Kong team says their FCBs are ready for use in clothing items such as shirts and vests, which could be used as solar collectors or as multiple sensory devices to record the wearer's temperature, perspiration, and heart rate, for example. *www.polyu.edu.hk.*

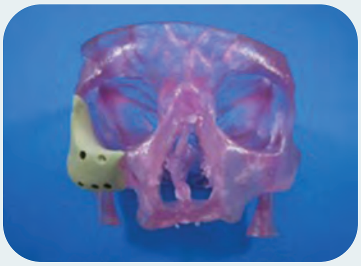
3D printing enters the cosmos

A custom 3D printer that enables fabrication of all the necessary tools and components required for a space mission will be sent to the International Space Station (ISS) aboard the SpaceX-4 resupply mission slated for late September. The printer was developed by Made In Space, Mountain View, Calif., which received a Small Business Innovation Research award as part of the 3D Printing In Zero-G Technology Demonstration program at NASA's Marshall Space Flight Center to develop the first 3D printer capable of working in microgravity. The new printer successfully completed all flight certification and acceptance testing in April 2014 at Marshall.

Mike Snyder and Jason Dunn of Made In Space assemble the 3D printer that will fly to the International Space Station. Courtesy of Made in Space.

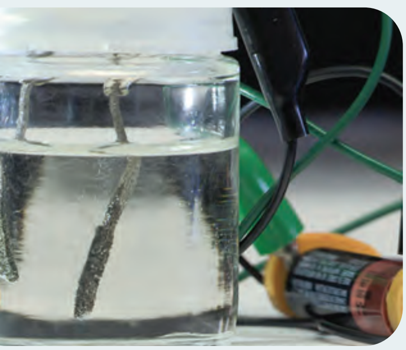
NASA engineers are hoping to demonstrate that a 3D printer can function as expected in space and print components with similar quality to those fabricated on earth. If successful, the achievement will be the first step toward establishing a working machine shop in space. The goal is to pave the way toward lower cost, lower risk, and more efficient missions on the ISS by creating tools and replacement parts on demand. Onboard manufacturing capabilities would be highly beneficial to long-term missions. The program is supported by the International Space Station Technology Development Office in Houston, as well as the Game Changing Development Program and the Advanced Human Exploration and Operations Mission Directorate at NASA headquarters in Washington. *madeinspace.us, nasa.gov.*

briefs



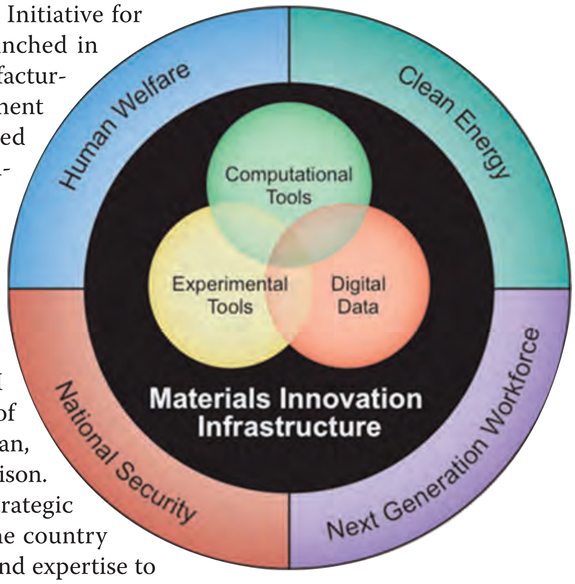
Oxford Performance Materials, South Windsor, Conn., received the first FDA clearance for a 3D printed polymeric implant for facial reconstruction. The OsteoFab Patient-Specific Facial Device is manufactured for individual patient anatomies using MRI or CT scans as templates. Implants are biocompatible, radiolucent, and similar to bone, including the ability to support bone attachments. oxfordpm.com.

Scientists at **Stanford University,** Calif., developed a low cost, emissions-free device that uses an ordinary AAA battery to produce hydrogen by water electrolysis. The hydrogen gas could be used to power fuel cells in zero-emissions vehicles, say researchers. The battery sends an electric current through two electrodes that split water into hydrogen and oxygen. Unlike other water splitters that use precious-metal catalysts, electrodes in the Stanford device are made of abundant nickel and iron. stanford.edu.



In the Stanford device, gas bubbles are produced by electrodes made of nickel and iron. Courtesy of Mark Shwartz.

Strategic approach to MGI advances materials research



Through the Materials Genome Initiative for Global Competitiveness (MGI), launched in 2011 under the U.S. Advanced Manufacturing Partnership, the federal government aims to double the pace of advanced materials discovery, innovation, manufacture, and commercialization. As the initiative marks its third year, experts at three leading universities are partnering on a unique effort to create synergy among materials researchers. The MGI Accelerator Network unites a team of leading MGI researchers at the Georgia Institute of Technology, the University of Michigan, and the University of Wisconsin-Madison.

One of the goals is to identify strategic ways in which researchers across the country might share resources, knowledge, and expertise to develop new materials quickly and efficiently. To improve understanding of MGI challenges and to help focus MGI-related research—which centers around building an innovation infrastructure of integrated experiments, computation, and digital data—members of the Accelerator Network are engaging thought leaders and stakeholders from academia, industry, and governmental agencies in the U.S. On June 5 and 6, the team hosted a workshop at Georgia Tech that drew more than 150 of these representatives, as well as speakers who are leading MGI efforts within U.S. industry, academia, and government. One of the workshop outcomes is a series of priorities that includes developing an inventory of MGI-related research and infrastructure.

"We want to get the most value out of what research is being planned and conducted," says John Allison, professor of materials science and engineering at the University of Michigan. "A comprehensive picture of these efforts, as well as the physical and cyber infrastructure that exists around the country, will allow materials researchers to form collaborations, identify fundamental engineering problems, share best practices and novel approaches, and support interdisciplinary communication among industry, academia, and government laboratories, and across geographical boundaries." *For more information: John Allison, 734.615.5150, johnea@umich.edu, umich.edu.*

3D printing project focuses on aerospace repairs

Optomec, Albuquerque, N.M., was awarded a major project from America Makes, the National Additive Manufacturing Innovation Institute, Youngstown, Ohio. The "Re-Born in the USA" project focuses on using additive manufacturing technology to repair aerospace metal components for the U.S. Air Force. The team led by Optomec will leverage the unique advantages of laser engineered net shaping (LENS) 3D metal printing technology, plus the expertise of some of the world's leading aerospace companies and industry organizations, to advance a reliable, cost-effective approach to replace conventional repair processes such as manual welding.

Optomec will lead a team of 23 partners, including GE Aviation, Lockheed Martin, United Technologies Research Center, and Rolls-Royce, as well as a group of technical experts serving as lead contributors, including EWI, Connecticut Center for Advanced Technology, TechSolve, the Pennsylvania State University Applied Research Lab, and Concurrent Technologies Corp. Unlike powder bed AM approaches, Optomec's LENS process can add metal onto an existing substrate of almost any 3D shape, making it well suited for repair operations. *americamakes.us, optomec.com.*

briefs

Alcoa Inc., Pittsburgh, will spend roughly $3 billion to acquire **Firth Rixson,** UK, a jet engine component company, in a deal expected to close later this year. Firth Rixson makes rings, forgings, and other metal products for aerospace and other industries. The high cost of producing aluminum and falling prices have pushed Alcoa toward more finished products that are used in aircraft, autos, and other goods. Aluminum prices have not recovered since the recession, so Alcoa has been idling smelters to reduce capacity and cut costs. The company also plans to spend $100 million to build a factory in Indiana to make nickel-based engine parts for commercial airliners. alcoa.com.

H.B. Fuller Co., St. Paul, Minn., signed an agreement to purchase **Tonsan Adhesive Inc.,** the largest independent engineering adhesives provider in China. Tonsan produces silicone, epoxy, anaerobic, and cyanoacrylate technologies. It develops, manufactures, and sells these engineering adhesives to key durable assembly markets, such as transportation, machinery, photovoltaic, electronics, and electrical appliances. H.B. Fuller's global infrastructure will enable the delivery of Tonsan's products around the world. hbfuller.com.

Automotive components manufacturer **Hatch Stamping Co.,** Chelsea, Mich., is planning a $17 million manufacturing facility in Portland, Tenn. The company will design and manufacture highly engineered metal stampings and assemblies in the 106,000-sq-ft manufacturing facility, producing auto parts for both the Southeast market and worldwide distribution. hatchstamping.com.

industry news

Energy Trends

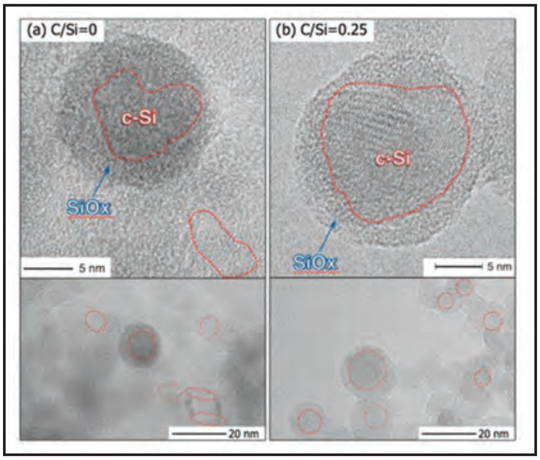
briefs

The U.S. Department of Energy selected a **University of Alabama** startup company for a $1.5 million award to refine an alternative material to extract uranium from the ocean. The company is developing an adsorbent, biodegradable material made from chitin, a compound found in shrimp shells, other crustaceans, and insects. Researchers developed transparent sheets, or mats, comprised of tiny chitin fibers, modified for the task. When suspended beneath the ocean's surface, the mats are designed to withdraw uranium. "Once you put it in the ocean, it will attract uranium like a magnet, and uranium will stick to it," says one researcher. ua.edu.

Alphabet Energy, Hayward, Calif., plans to sell a new type of material that can turn heat into electricity. Unlike previous thermoelectrics, the new material is plentiful, inexpensive, and nontoxic. The company is using tetrahedrite—an abundant, naturally occurring mineral that is also more efficient on average than existing thermoelectric materials. According to data released by Alphabet Energy, tetrahedrite costs about $4 per kg, whereas other thermoelectric materials cost between $24 and $146 per kg. The company is focusing on standalone generators but is also working with automotive companies to see if tetrahedrite can harness heat from car exhaust. alphabetenergy.com.

New process holds promise for Li-ion battery performance

The steadily growing Li-ion battery market continues its quest for increased battery capacity while maintaining a long recharging process. Structuring materials for electrodes at the nanometer length scale is an effective way to meet this demand; however, such nanomaterials need to be produced by high-throughput processing to transfer these technologies to industry.



High-resolution transmission electron microscopy images of the PS-PVD Si core and SiOx shell composites processed (a) without and (b) with a 1.1 slm methane (CH_4) gas addition.

A new approach by researchers at the National Institute for Materials Science, Japan, shows potential for producing nanosized, composite silicon-based powders for the negative electrodes within high-density Li-ion batteries. Researchers successfully produced nanocomposite SiO powders by plasma spray physical vapor deposition using low-cost metallurgical grade powders at high throughput. Using this method, they demonstrated a noticeable improvement in battery capacity cycle performance. *www.nims.go.jp/eng.*

The resilient electric grid is a self-healing technology that quickly recovers in the event that portions of Chicago's energy grid are lost for any reason.

Joining forces to protect Chicago's electric grid

ComEd, a unit of Exelon Corp., Chicago, will develop a deployment plan for American Superconductor's (AMSC), Devens, Mass., high-temperature superconductor technology to build a system to strengthen Chicago's electric grid. The resilient electric grid (REG) effort is part of the U.S. Department of Homeland Security (DHS) Science and Technology Directorate's work to secure the nation's electric power grids and improve resiliency against extreme weather, acts of terrorism, or other catastrophic events.

The REG is a self-healing system that provides resiliency in the event of any grid loss. Installation would be the first commercial application of this advanced technology in the U.S. "We believe that this system has the potential to play a significant role in protecting the infrastructure assets so vital to our electrical systems. Together with the leadership from DHS and ComEd, we believe AMSC is now in a position to offer this system solution to cities in America and around the world," says AMSC president and CEO Daniel P. McGahn. *comed.com, amsc.com.*

In a small lab at the **SLAC National Accelerator Laboratory,** a team of scientists from the **Stanford Institute for Materials and Energy Sciences (SIMES),** Calif., is making and testing new types of lithium-ion batteries. Their goal: Create a battery five times better than ones used today. SLAC lab director Yi Cui believes one key to creating a better battery is making the cathode of sulfur, instead of lithium-cobalt oxide. The team devised a yolk-shell design in which individual "nanonuggets" of sulfur are enclosed within a semi-porous shell that allows lithium ions to pass through but blocks the electrolyte. Making the shell somewhat larger than the nanoparticle allows the sulfur to swell and contract as it absorbs and releases lithium during charge/discharge cycles without dissolving. slac.stanford.edu.

Zhi Wei Seh assembles a prototype battery in SLAC's energy storage laboratory. Courtesy of SLAC.

Surface grooves on polymers enable waterproofing

Researchers from Kyoto University's Institute for Cell-Material Sciences (iCeMS), Japan, developed a unique way to waterproof new functionalized materials involved in gas storage and separation by adding exterior surface grooves. The materials, known as porous coordination polymers (PCPs), are hollow nanoscale, cagelike structures that can house molecules within their empty cavities. This behavior is particularly useful when selectively isolating chemicals of interest from mixtures such as gases, say researchers. However, one drawback of using PCPs involves their use in environments where water is abundant.

A bead of water sitting on top of water-resistant polymer crystals. Courtesy of Kyoto University.

"These materials are highly reactive with water, leading to their instability and subsequent decomposition," explains materials scientist Masakazu Higuchi. "In order to use them in real-life situations, we need to develop PCPs with the ability to keep water out while allowing organic molecules of interest in."

To do this, scientists designed grooves onto the exterior surface of the PCPs, thereby introducing a rough texture that effectively repels water. At the same time, organic substances can enter the PCPs based on size, demonstrating selectivity.

"Our method is the first to be conducted at the nanoscale, and serves as a simpler means to maintain functional properties of PCPs while preventing them from breaking down in the presence of water," notes iCeMS director and principal investigator Susumu Kitagawa. *www.icems.kyoto-u.ac.jp/e.*

Ultra-black coating holds promise for sensitive space instruments

A new super-black nanotechnology that aims to make spacecraft instruments more sensitive without enlarging their size is being tested on the International Space Station (ISS). The material is a highly uniform coating made of multi-walled carbon nanotubes. According to NASA scientists, the coating is especially promising as a technology to reduce stray light, which can overwhelm faint signals that sensitive detectors are supposed to retrieve. Ground-based laboratory testing proves that the coating absorbs 99.5% of the light in the ultraviolet and visible spectrum and 99.8% in the far-infrared bands. Instrument developers typically apply black paint on baffles and other instrument components to reduce errant light, but these techniques absorb only 90-96% of the light, says principal investigator John Hagopian.

The new coating's super-absorbency is based on the fact that the nanotubes are mostly empty space. However, the carbon atoms absorb the light and prevent it from reflecting off surfaces. Because only a tiny fraction of light reflects off the coating, sensitive detectors see the material as extremely black. The experiment, comprised of two trays containing two titanium discs coated with carbon nanotubes as well as other coating samples, are included on one of the new task boards for NASA's Robotic Refueling Mission (RRM)-Phase 2, which arrived at the ISS on August 12. Trays will be exposed to space for one year and then returned to Goddard Space Flight Center, Greenbelt, Md., for evaluation.

The experiment will be exposed to harsh radiation and other elements, including atomic oxygen that reacts with spacecraft materials and corrodes them. Determining whether or not the coating can withstand extreme environmental conditions will help further qualify the technology for potential use on space-based instruments. *nasa.gov.*

A new carbon-nanotube coating is one of several materials being tested on the ISS as part of the Materials Coating Experiment. The super-black material occupies the "D" slot on the sample tray. Courtesy of NASA/Bill Squicciarini.

briefs

LiquiGlide Inc., Cambridge, Mass., initiated international patent filings to protect the intellectual property (IP) of its liquid-impregnated surface technology. The international patent filing is directly related to U.S. Patent 8,574,704, granted to **Massachusetts Institute of Technology** (MIT), Cambridge. MIT holds two patents for the slippery coating technology with more than a dozen pending and LiquiGlide is the sole commercial entity with exclusive licensing rights. The 704 patent was granted in November 2013 and describes the company's method for creating permanently wet slippery surfaces by stably trapping liquids in a matrix of solid, micro-scale engineered features, reducing friction for viscous liquids moving across treated surfaces. liquiglide.com.

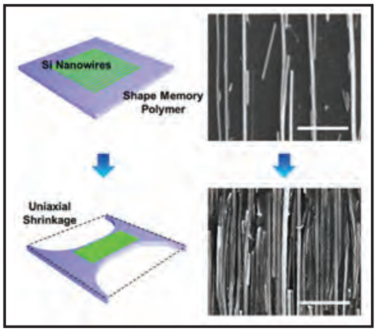
Aixtron SE, Germany, a semiconductor deposition equipment supplier, is working with **Fraunhofer IISB,** Germany, to develop 150 mm silicon carbide (SiC) epitaxy processes using the new Aixtron 8x150 mm G5WW vapor phase epitaxy system. The company's Planetary Reactor tool will be installed at the IISB cleanroom laboratory later this year. Fraunhofer has expertise in low-defect-density SiC epitaxial processes, critical for manufacturing high-voltage SiC devices. Special characterization techniques such as room temperature photoluminescence imaging and selective defect etching were developed and adapted to SiC material properties at its research facility. aixtron.com, www.iisb.fraunhofer.de.

industry news

NANOTECHNOLOGY

Shrinking plastic closes nanowire gap

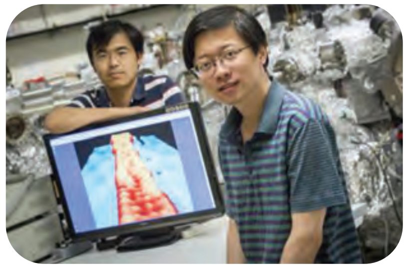
Engineers at the University of Illinois at Urbana-Champaign are using Shrinky Dinks—plastic that shrinks under high heat—to close the gap between nano-wires in an array to make them useful for high-performance electronics applications. Nanowires are placed on the Shrinky Dinks plastic just like any other substrate, and then shrunk to bring the wires much closer together. This enables creation of very dense arrays of nano-wires in a simple, flexible, and controllable process. The new method also brings the nanowires into alignment as they increase in density. Wires even more than 30° off-kilter can be brought into perfect alignment with their neighbors after shrinking. *For more information: SungWoo Nam, 217.300.0267, swnam@illinois.edu, illinois.edu.*



Plastic is clamped so it only shrinks in one direction. Courtesy of SungWoo Nam.

Graphene ribbons: Size matters

Using graphene ribbons of unimaginably small widths—just several atoms across—a group of researchers at the University of Wisconsin-Milwaukee (UWM) found a novel way to "tune" the wonder material, causing the extremely efficient conductor of electricity to act as a semiconductor. In principle, their method for producing these narrow ribbons and manipulating the ribbons' electrical conductivity could be used to produce nanodevices.



Yaoyi Li (foreground) and Mingxing Chen display an image of a ribbon of graphene 1 nm wide. Atoms are visible as bumps.

"Nano-ribbons are model systems for studying nanoscale effects in graphene, but obtaining a ribbon width below 10 nm and characterizing its electronic state is quite challenging," says postdoctoral researcher, Yaoyi Li. By imaging the ribbons with scanning tunneling microscopy, researchers confirmed how narrow the ribbon width must be to alter graphene's electrical properties, making it more tunable.

"We found the transition happens at three nanometers and the changes are abrupt," says Lian Li. *For more information: Lian Li, 414.229.5108, lianli@uwm.edu, uwm.edu.*

Mythical boron buckyball does exist

Researchers from Brown University, Providence, R.I., as well as Shanxi University and Tsinghua University, China, have shown that a cluster of 40 boron atoms forms a hollow molecular cage similar to a carbon buckyball. It is said to be the first experimental evidence that a boron cage structure—previously only a matter of speculation—does indeed exist.

Chemistry professor Lai-Sheng Wang and his research group showed earlier this year that clusters of 36 boron atoms form one-atom-thick disks, which might be stitched together to form an analog to graphene, dubbed borospherene. Boron clusters with 40 atoms are also abnormally stable compared to other boron clusters. Figuring out what that 40-atom cluster actually looks like required a combination of experimental work and modeling using high-powered supercomputers.The borospherene molecule is not quite as spherical as its carbon cousin. Rather than a series of five- and six-membered rings formed by carbon, borospherene consists of 48 triangles, four seven-sided rings, and two six-membered rings. Several atoms stick out, making the surface of borospherene somewhat less smooth than a buckyball. *For more information: Lai-Sheng Wang, 401.863.3389, lai-sheng_wang@brown.edu, brown.edu.*

Researchers show that clusters of 40 boron atoms form a molecular cage similar to the carbon buckyball. Courtesy of Wang lab/Brown University.

briefs

Scientists at **AMBER,** a materials science center based at **Trinity College Dublin,** Ireland, discovered a new material that could revolutionize information technology, computer processes, and data storage. The research group led by Michael Coey created a new alloy of manganese, ruthenium, and gallium, known as MRG. The alloy is a strange new magnet—internally it is as magnetic as the strongest magnets available, but from the outside it does not appear magnetic. The material (technically known as a *zero-moment half metal)* will initiate a completely new line of materials research and could open up numerous possibilities for electronics and information technology. www.tcd.ie.

Applied Materials Inc., Santa Clara, Calif., announced two new systems to help solve critical challenges in manufacturing high-performance, power-efficient 3D devices. The Applied Reflexion LK Prime CMP system provides superior wafer polishing performance with nanometer-level precision for FinFET and 3D NAND applications. The Applied Producer XP Precision CVD system solves demanding, fundamental deposition challenges presented by vertical 3D NAND architectures. These new CMP (chemical mechanical planarization) and CVD (chemical vapor deposition) tools directly address precision, materials, and defect issues, enabling 3D designs to reach high-volume manufacturing. appliedmaterials.com.

Resonant Ultrasound Spectroscopy Offers Unique Advantages as a **Nondestructive Test Method**

Haoqi Li
Fei Ren*
Temple University
Philadelphia

Resonant ultrasound spectroscopy is making headway as a fast and nondestructive measurement technique. Thanks to advances in computer technology, codes and software are now available for data reduction, analysis, and interpretation.

Resonant ultrasound spectroscopy (RUS) is an emerging ultrasonic measurement technique. By measuring the natural vibrational frequencies of test samples, RUS can determine the full set of elastic constants. For example, RUS can obtain Young's modulus, shear modulus, and Poisson's ratio for isotropic materials. By comparing the vibrational spectra of a test sample to those obtained from a standard, it is possible to infer the causes of the differences (if any) and detect various part defects, such as size variations, cracks, and pores.

RUS first appeared in the second half of the 20th century with its development fueled by advances in computing power. In 1964, Frasier and LeCraw performed one of the earliest RUS measurements on spheres of isotropic materials[1]. After this initial success, much improvement was made in the geophysics community, where RUS was used by Anderson and coworkers to measure the elastic properties of spherical lunar samples in the 1970s[2]. After the late 1980s, RUS was adapted by some physicists and materials scientists including Migliori and coworkers, who began to examine high-temperature superconducting materials[3]. Current research uses of RUS include a wide range of topics in physics, geophysics, and materials science, where elastic constants are being accurately measured on samples as small as 70 μg[4].

Industrial applications of RUS appeared around the beginning of the new millennium, used for quality control of manufactured parts. Among the first commercial RUS units in the U.S. were those made by Quatrosonics[5] in the 1990s based on technology developed at Los Alamos National Laboratory. However, due to the hardware and software complexity, commercial RUS units are still only available from a few sources[6,7].

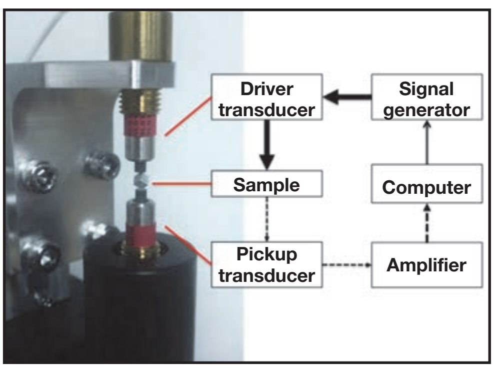


Fig. 1 — *Typical resonant ultrasound spectroscopy (RUS) measurement in a two-transducer setup.*

RUS is attractive because measurements are fast and nondestructive, and can also be automated. But data interpretation could be challenging due to the complicated nature of the theories. Thanks to advances in computer science and technology, codes and software are now available for data reduction and analysis, as well as interpretation.

Resonant ultrasound spectroscopy fundamentals

All RUS-related applications start with measuring the vibrational response of test samples when subjected to mechanical stimulation. For a piece of solid material, the natural mechanical vibrational frequencies (i.e., eigenfrequencies), which correspond to specific vibrational modes such as bending and torsion, are solely determined by the material's mass density, geometric parameters, and elastic constants. Because mass density and geometric factors are easy to obtain, if one could measure the natural vibrational frequencies of a test sample, its elastic constants could be back calculated—an inverse mathematical problem. In practice, due to the constraints of computing power, some simple geometry (such as spheres, cubes, and prismatic bars) is often used in actual measurements.

An example of measuring a cube sample using a two-probe RUS is shown in Fig. 1. The sample, approximately 2 mm wide on each side, is sandwiched between two piezoelectric transducers. One of the transducers (the driver transducer) is used to apply mechanical stimulation provided by a signal generator to the test sample; the other transducer (the pickup transducer) *listens* to the response from the sample and feeds it back to the data acquisition module. Input signals are usually a series of mechanical waves with a wide band of frequencies in the ultrasonic range (a few hundred kHz to MHz). Only those waves with frequencies matching the natural vibrational frequencies of the test sample can be detected by the pickup transducer. The resulting spec-

**Member of ASM International*

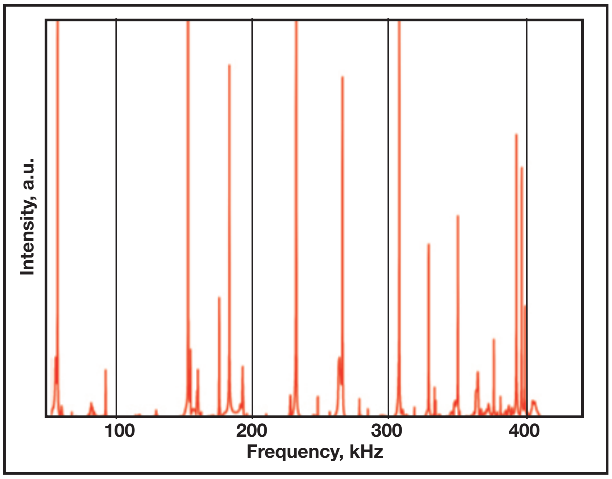


Fig. 2 — *Sample spectrum obtained from RUS measurement.*

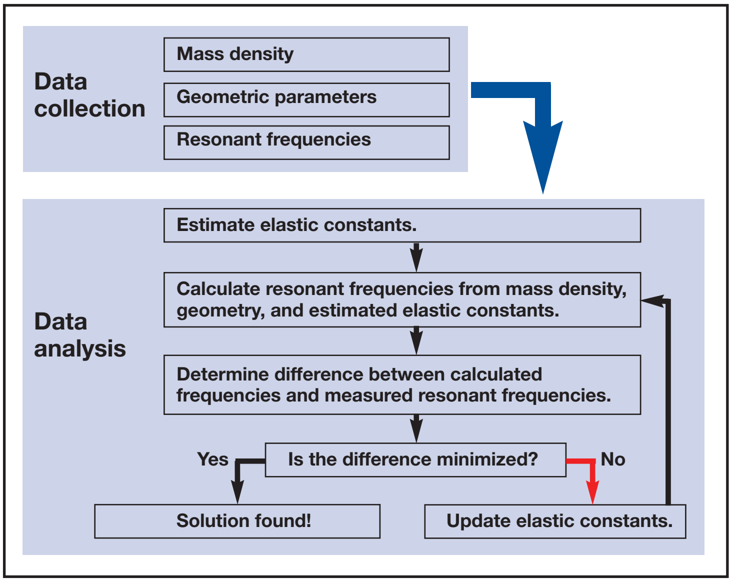


Fig. 3 — *Schematic of data collection and analysis steps involved in RUS.*

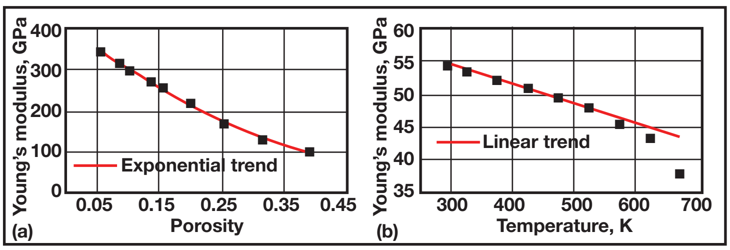


Fig. 4 — *RUS is used to determine (a) porosity effect on Young's modulus of alumina (after[10]), and (b) temperature effect on Young's modulus of PbTe-based thermoelectric materials (after[11]).*

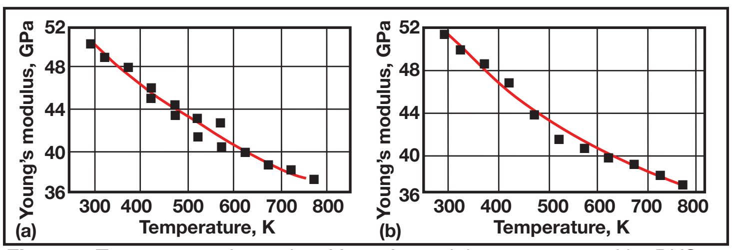


Fig. 5 — *Temperature dependent Young's modulus as measured by RUS reveals a diffusion controlled order-disorder phase change: (a) heating/cooling rate = 5 K/min, (b) heating/cooling rate = 2 K/min[12].*

tra are peaks at various frequencies as shown in Fig. 2. The positions of the peaks correspond to the eigenfrequencies of the test sample.

After collecting the resonant frequencies, determining the elastic constants involves a fairly complicated procedure. Because this is an inverse problem, one must first provide an initial "guess" regarding the unknown elastic constants from other means, such as existing knowledge of similar materials or theoretical modeling. Using these estimated elastic constants, along with sample geometry and mass density, the eigenfrequencies of the test sample can be estimated and compared to the measured data. If these two sets of frequencies are identical—or the difference is small enough—then the predicted values can be regarded as the sample's true elastic constants. Otherwise, the predicted values must be modified and the above steps repeated. This procedure usually requires a number of iterations and is affected by the quality of both the measured data and initial estimates.

A key step in this data analysis is to find an appropriate algorithm to modify the elastic constants based on differences between measured and calculated frequencies. This is often realized through computer codes and software. One common process is the Levenberg-Marquardt algorithm[8], which is a nonlinear least-squares scheme that uses Taylor's expansion to linearize the difference between measured and calculated frequencies. This data analysis procedure is illustrated in Fig. 3. RUS theories are explained further in a textbook by Migliori and Sarrao[9].

Resonant ultrasound spectroscopy research applications

As previously mentioned, RUS is used to measure the elastic constants of solid materials in various research areas including metals, alloys, ceramics, glasses, concretes, and rocks. Compared to many static testing methods, such as tensile and bending tests, RUS is nondestructive and can work with small samples. Compared to other ultrasonic techniques such as the pulse echo method, RUS features less preparation and faster sample installation.

Because elastic constants are influenced by other physical and chemical properties, RUS can be used to explore many related phenomena, including structural phase changes, superconducting transitions, magnetic transitions, and damage accumulation due to microcracking. For example, RUS is used to measure the influence of porosity on the elastic constants of alumina at different sintering stages. Young's modulus as a function of volume fraction porosity is shown in Fig. 4a[10]. This information can facilitate a deeper understanding of porosity evolution during sintering and its effect on mechanical properties—key aspects in the design and fabrication of engineering ceramics.

Further, RUS measurement can be made under some extreme conditions such as high and low temperatures. Figure 4b shows the measurement of Young's modulus of a PbTe-based thermoelectric material between room temperature and 673 K (400°C)[11]. In this case, Young's modulus initially decreased nearly linearly and then exhibited a rapid drop beyond 573 K (300°C) due to the creep of grain boundary phases. Because the target application for these thermoelectric materials is waste heat recovery, detection of the onset temperature of grain boundary sliding can help determine the safe operating temperature range, which in this case is up to 300°C.

Another example of applying RUS in materials research is shown in Fig. 5, where Young's modulus is again measured as a function of temperature[12]. In contrast to seeing a downward trend as shown in Fig. 4b, an upward trend is observed in the Young's modulus of a different PbTe-based thermoelectric material. The turning point around 523 K (250°C) in the curve indicates a change in bonding strength. Further analysis confirms the change is likely due to an order-disorder phase transformation: This transformation is controlled by the diffusion of doping elements such that when the heating/cooling rate is high, a hysteresis occurs (Fig. 5a), while no hysteresis is observed when the heating/cooling rate is reduced (Fig. 5b).

Resonant ultrasound spectroscopy industrial applications

In contrast to research uses of RUS that mainly focus on material property measurements, industrial applications primarily reside in nondestructive evaluation (NDE) of precision components. The basic configuration of an industrial RUS unit is similar to its research counterpart, although the sample stage and transducers may be modified to accommodate larger and more complicated parts. Figure 6 shows an example of a commercial RUS unit with integrated testing and online analysis capabilities.

A major difference between industrial and research applications involves data usage. Instead of calculating the elastic constants, measured ultrasonic spectra (Fig. 2) are directly used as input for analysis. Defects that result in variations in vibrational modes (eigenfrequencies) will lead to changes in RUS spectra. By comparing measured spectra with standards, it can be determined whether a part should be accepted or rejected, and potential defects in the bad parts can be explored.

A general guideline for using RUS to evaluate the integrity of metallic and nonmetallic (i.e., ceramics and composites) components is provided in ASTM standard E2001-98[13]. According to this standard, a *fingerprint*—usually a few characteristic resonant peaks—must first be established. Then, sorting criteria for acceptance/rejection should be determined. In practice, establishment of sorting criteria is often realized by examining a large number of good and bad parts and analyzing the data in a statistical manner. Typical criteria include the following aspects in measured spectra: *peak shifts,* or changes in peak positions; *peak splitting,* where a single peak splits into two or more due to symmetry imperfection; and a combination of peak shifts and splitting. Other considerations include changes in peak amplitudes, peak broadening, and phase changes[14].

Summary

Successful RUS applications include identifying various types of defects including cracks (on the order of millimeters or submillimeters), cavities, geometrical imperfections, compositional inhomogeneity, and hardness variations[13,14]. Compared to traditional NDE methods, such as dye penetration, magnetic particle method, and eddy current testing, RUS possesses some unique advantages. One is the ability to examine parts with both external and internal defects, compared to dye penetration and magnetic particle methods that can only be used to detect external defects. Another is the ability of RUS to evaluate both conducting and nonconducting components; in contrast, the eddy current method does not work with nonconducting materials. In addition, RUS measurements can be made very quickly (on the order of minutes or less) if a good testing procedure is developed.

Fig. 6 — *Commercial RUS unit. Courtesy of Magnaflux.*

Nevertheless, RUS has drawbacks. For example, it requires special equipment and software, which are not yet widely available. Further, establishing sorting criteria often involves extensive efforts in terms of testing and data analysis. Because it is an emerging technology, the learning curve for adapting RUS to existing industrial facilities may be steep. However, once these initial obstacles are cleared, RUS will serve as a fast and reliable NDE technique in many manufacturing settings. ❍

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Nondestructive Variable Temperature Materials Characterization for Semiconductor Research

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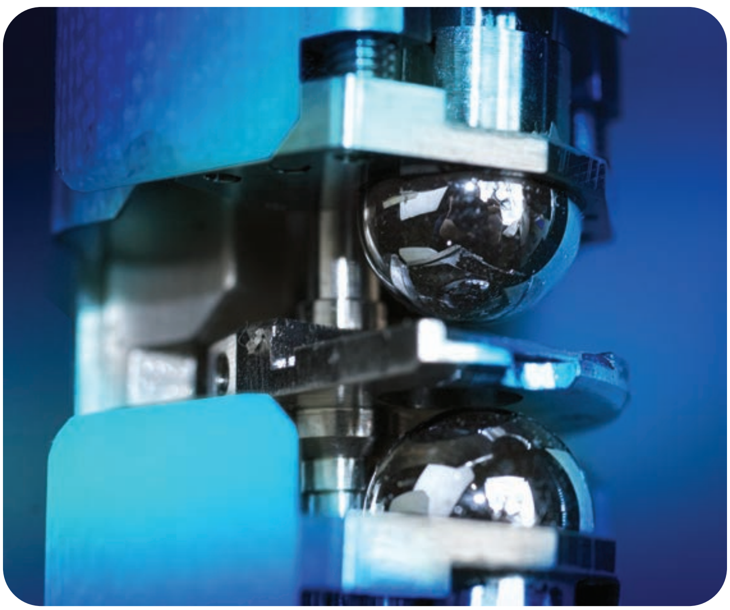
To meet the rigorous demands of next-generation computer technology, new approaches to nondestructive measurement for early stage, temperature dependent materials characterization are needed.

With the continuing demand for higher computing performance, significant research is being aimed at characterizing novel materials for semiconductor use. Characterization of carriers as well as unwanted impurities in materials will continue to be an important step in the development of next-generation semiconductor devices. Various measurement techniques for Hall conductivity, carrier concentration, and mobility measurements, as well as Raman and x-ray spectroscopy, help to understand these materials. However, many commercially available technologies offer limited utility because they do not account for material responses as a function of temperature, or their magnetic fields are fixed, so it is impossible to differentiate mobilities and carriers.

Many measurement platforms also do not allow for noninvasive characterization of wafer-scale materials or they require labor-intensive bonding and packaging, making them impractical in current semiconductor materials testing environments. New approaches to nondestructive measurement for early stage, temperature dependent materials characterization under high magnetic field, as well as device level, variable measurement testing will be explored, particularly as it relates to Hall analysis.



Continuous wave-THz spectroscopy system emitter and detector devices for semiconductor materials characterization.

Temperature and early-stage materials characterization

Analyzing at low temperatures is a common method for isolating specific material phenomena. Characterizing at variable temperatures can also yield important insights into underlying conductivity mechanisms. In particular, the cryogenic environment reduces the inherent noise of electronic materials, lessening its impact on measurements. Certain carrier transport properties are easier to detect at low temperatures as well.

In some semiconductor materials, free carriers can be "frozen out" at cryogenic temperatures while the intrinsic carrier concentration or activation energy can be determined from the temperature dependency of the carrier density. Knowing the material's mobility and temperature dependence can also help identify concentrations of impurities and gauge potential saturation transconductance.

Continuous wave terahertz

For more than 20 years, researchers have used terahertz frequency spectroscopy for materials characterization. The energy of terahertz waves is low enough to couple to the free carrier motion in semiconductors. As a noncontact, quasi-optical technique, terahertz spectroscopy is ideal for characterizing the conductivity of bulk semiconductors, ultrathin epilayers, and buried thin films in pre-device stage heterostructures.

Terahertz spectroscopy at cryogenic temperatures can expose properties not apparent at room temperature and allows carrier concentration and semiconductor mobility to be tuned. However, most commercially available THz systems lack the necessary cryogenic and magnetic environments required for targeted semiconductor materials research, and if they do have them, THz energy is usually generated outside the testing environment. With these optical cryostat-based systems, THz beams must pass through windows—reducing signal power and causing spectral distortion—and their optics are difficult to align, which can lead to repeatability issues.

However, all of this is changing with improvements in how THz energy is generated and applied to materials under test. Newer *con-*

tinuous wave (CW)-based THz spectroscopy systems place the optics inside the cryostat. CW-THz spectroscopy uses two distributive feedback lasers tuned to slightly different wavelengths. Mixing the light emitted by the lasers results in an intensity-modulated (with 0.2 to 1.5 THz modulation frequency) IR light source that is transmitted to fiber-coupled photomixer devices. Each photomixer contains a planar, broadband antenna patterned on an ultrafast photoconductive substrate and centered on a silicon dome lens. THz generation and detection is achieved with the IR light by modulating the conductance of the antenna with an integrated, semiconducting photoswitch. The cryogenically compatible THz emitters and detectors are contained in an insert that fits the narrow bore of a high-field magnet, in close proximity to tested materials. THz transmission spectra are acquired at temperatures from 5 to 300 K, and up to a 9 T magnetic field. Dome-shaped emitters and detectors are mounted on thermally stable, optical stages that maintain THz alignment while measurements are taken at variable temperatures.

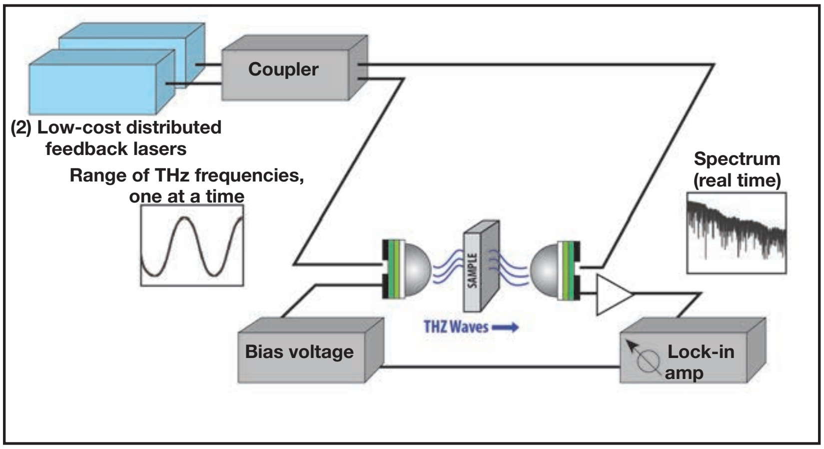


Fig. 1 — *Continuous wave-THz spectroscopy system.*

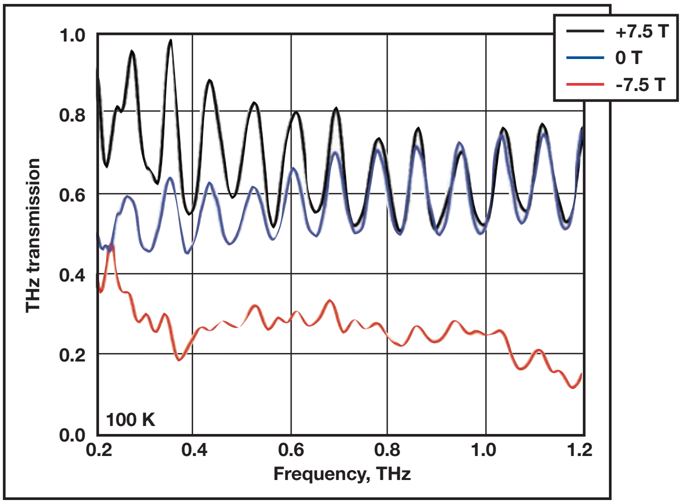


Fig. 2 — *Field dependent THz spectra of a B-doped silicon substrate.*

Case study: CW-THz magneto-spectroscopy

A researcher exploring new growth methods for a particular semiconductor already employs a host of conventional optical spectroscopy techniques to characterize materials, such as x-ray spectroscopy to gather information about crystal structure and UV-visible technologies to determine the band gap. THz characterization can augment the information derived by conventional optical measurements, particularly when trying to determine temperature-dependent conductivity.

Traditionally, by calculating the transmission and reflection from each interface of a wafer, the THz-frequency, complex-valued refractive index is extracted from the THz spectra of the material. The contribution of free carriers to the permittivity is then modeled with a simple but fairly accurate Drude model. However, in the absence of a magnetic field, extracting the electronic material parameters requires knowledge of both carrier type and band mass from other techniques.

Stimulating semiconductor materials at THz frequencies and in high field can reveal interesting properties that other techniques miss. For example, with InSb and other high-mobility materials, CW-THz magneto-spectroscopy can determine the cyclotron resonance condition in these materials. Band mass can be directly measured by mapping out the field dependence of the cyclotron resonance frequency shift while the resonance linewidth can provide an estimate of material mobility.

For many larger band mass carriers, where a THz-frequency cyclotron resonance condition cannot be easily met, THz magneto-spectroscopy can still reveal carrier type and mobility. Owing in part to the circularly polarized nature of CW-THz emission, electrons and holes behave differently in a magnetic field and result in an asymmetric (with field) permittivity of the material. As shown in Fig. 2, P-type silicon exhibits strong absorption in the THz band at negative fields and enhanced transmission at positive fields. Conversely, N-type materials show strong absorption at positive fields. Efforts are currently underway to develop a mobility extraction algorithm from field dependent CW-THz measurements.

Moving to the device stage

Nondestructive cryogenic testing can also play an important role later in the development cycle, such as when it is necessary to perform measurements on fabricated, on-wafer samples. Once research advances to the point of device construction, a cryogenic probe station enables multiple contact points for device biasing and signal measurement on a flexible, variable-temperature platform. The task of dicing fully fabricated wafers and bonding wire to the dissected piece for device characterization is no longer required, as in a conventional cryostat. Repositionable, micro-manipulated probes are used instead, eliminating the need for large, fixed-wire contacts and enabling multi-

Fig. 3 — *Three-terminal DC probing configuration for transistor measurements.*

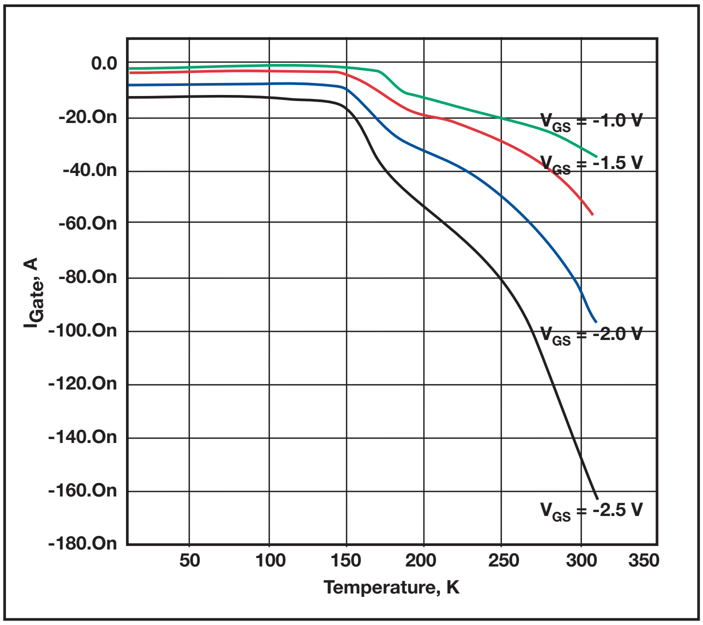


Fig. 4 — *Temperature-dependent pHEMT gate current during measurement of transfer curves (V_{DS} = 3 V).*

ple structures to be sampled on a wafer. In a probe station chamber, test structures can be tens of microns in size (such as for the high-speed pHEMT device measurement application described later in this article) or up to tens of millimeters in size for measuring Hall structures.

Measuring devices in the vacuum chamber of a probe station offer advantages as well. The variability in measurements caused by humidity, condensation, and other environmental factors can be eliminated. Electronic properties of some materials, such as organic semiconductors, can be significantly affected by surface contamination, and when measured under ambient conditions, electrochemical leakage currents can obscure sensitive current measurements. However, once the device is evacuated in a probe station, measurement conditions can be restored. Additional options are available in cryogenic probe stations for materials and devices where surface contamination must be avoided. For example, high-vacuum options are used to reduce the base pressure in the chamber; in the advanced stations, the sample stage can be maintained near room temperature during cool down of the radiation shields so that residual gases are cryopumped away from the sample space.

Also, when used in conjunction with sophisticated mobility spectrum analysis software tools, vertical magnetic field probe stations can be valuable for studying multilayer or multi-carrier semiconductor Hall samples (such as multiply doped materials and heterostructures) by segregating the mobility spectrum for each carrier species. By identifying individual carriers, users can verify doping effectiveness, correct for unwanted impurities during growth, and control quality during various manufacturing stages.

Case study: Cryogenic probing identifies off-state breakdown

Off-state breakdowns in *pseudomorphic high-electron-mobility transistor* (pHEMT) devices result from the complex interplay of material properties and device geometry. Because gate-drain breakdown limits the maximum power handling capability of these devices, this effect has been a topic of interest since the inception of pHEMT device architectures. Several physical mechanisms for the breakdown have been proposed and each has distinct temperature dependencies that can be used to discern the dominant mechanism in a given device architecture. Variable temperature, on-wafer, transport measurements were performed on a commercially available GaAs pHEMT used in RF applications.

Three distinct gate leakage regimes are identified in the temperature-dependent gate current for fixed source-gate voltages in Fig. 3. Above 210 K, the nonmonotonic temperature dependence of the gate current is indicative of a thermionic field emission mechanism. Below 150 K, the gate current is independent of temperature with a source-gate voltage dependence, which suggests the barrier conduction is dominated by tunneling transport. Between 150 and 210 K, the observed temperature dependence of the gate current indicates an intermediate breakdown mechanism, perhaps defect-assisted tunneling.

Conclusion

Semiconductor research is becoming increasingly important to the development of higher-performing electronics and computing technologies. Terahertz spectroscopy bypasses the limitations of other characterization techniques by enabling nondestructive measurement under variable temperature and high magnetic field conditions. It is in these environments that researchers can learn the most about novel materials. ❍

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Using **Digital Image Correlation** to Measure Full Field Strain

With new and advanced materials being developed continually, both research efforts and materials testing must adapt to keep up. Physical testing is not simply a matter of following a standard to collect data, but is a tool to analyze and optimize properties. Traditional strain measurement requirements involve characterizing axial strain at one gauge length in the center of the specimen. In some cases, transverse strain is also measured to determine Poisson's ratio, and strain gauges are used where it is difficult to use traditional extensometers.

However, existing strain measurement techniques do not offer enough information about how failures occur, so alternative methods are required. One technique involves using digital image correlation (DIC) to measure full field strain over the entire material surface. In addition to the strain map produced, virtual strain gauges and extensometers can be placed on the specimen after the test and replayed multiple times. Further, the technique can be used for almost any material; polymers, metals, composites, rubbers, foams, textiles, and other materials have been tested using DIC.

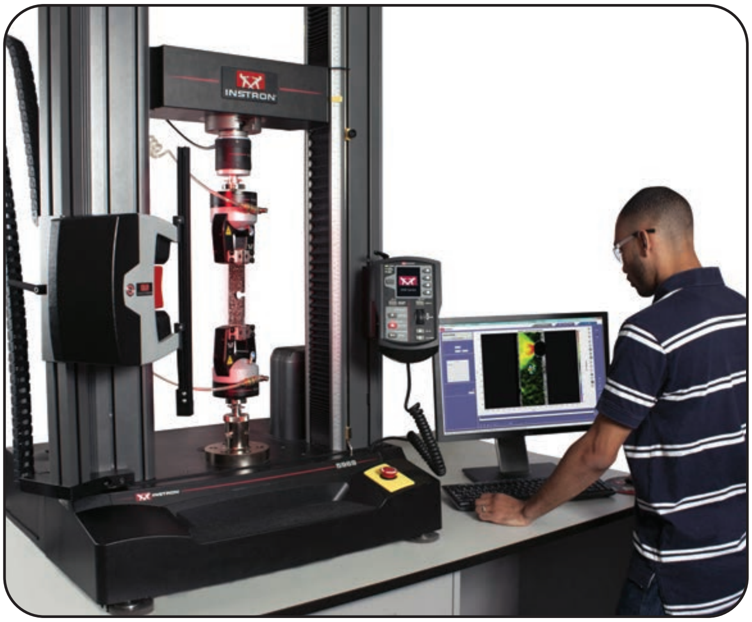

Fig. 1 — *Integrated digital image correlation (DIC) system.*

How digital image correlation works

Digital image correlation is a strain measurement technique that works by capturing a series of images throughout a test and analyzing them afterwards. A typical setup includes a camera system, lighting, and software package to control image capture and conduct post-test analysis. Recently, integrated DIC systems (Fig. 1), which use existing video extensometers, have been introduced to provide a streamlined package tailored to the materials testing market.

Pre-test samples are usually treated with a speckle pattern (Fig. 2) added by spraying, stamping, or sticking decals to their surfaces. In some cases, the sample's natural surface pattern is sufficient without the need to apply any additional marking. The number of images captured during a test depends on time, speed, and the sample itself, but 50 to 100 images are usually adequate. The first image—known as the *reference image*—is captured when there is no strain on the sample. The image is then split into small subsets and the patterns within each subset of subsequent images are compared to the reference image, and displacements are calculated from which a strain/displacement map is produced. Only one sample is required to determine axial and transverse strains and displacements, shear strain, and maximum and minimum normal strains.

Fig. 2 — *Typical speckle pattern applied to a test sample.*

These maps are similar to FEA-type images (Fig. 3), which leads to a very useful application for DIC—proving whether or not an FEA simulation is correct. In the past, engineers used simple test data from extensometers and strain gauges to verify predictions from an FEA simulation. With the new technique, subtle changes in a material that might be missed in a simulation can now be physically measured and identified, allowing operators to compare what they believe is happening to what is actually happening.

DIC software also allows the inclusion of virtual extensometers and strain gauges that can be placed anywhere on the sample. This enables analyzing the sample near failure points, so a position does not have to be selected before conducting the test. It also enables comparing existing data with new results.

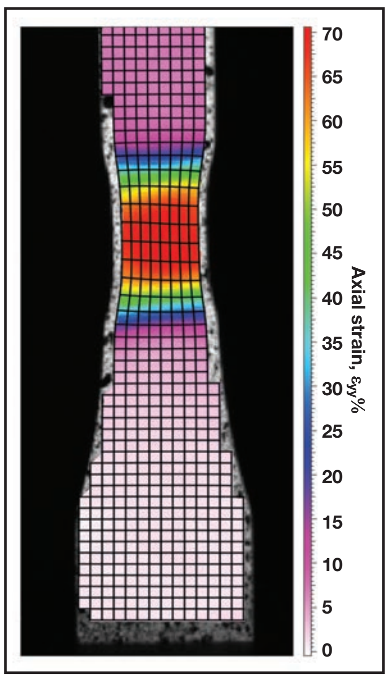

Fig. 3 — *Sample DIC strain map.*

DIC as a teaching tool and more

Having this type of visual method to observe material failure in action, as well as the capacity to analyze and reanalyze data, makes DIC a great teaching tool for materials science and engineering courses at the university level. A good example in metals testing is where strain can be seen as creating a “V” shape across the specimen, ultimately ending in a failure angled across the sample, as shown in Fig. 4. It is very difficult to see this strain buildup without a simulation, but DIC is measuring it from real specimens.

Once a strain map has been created, virtual extensometers and strain gauges can be added at different locations along the specimen to show how strain varies when it is measured either close to or away from the failure point. These results add to the teaching value by offering an easy-to-understand visual representation of how failures actually occur.

In addition to teaching, DIC can be used for test specimens and samples with nonuniform strain distribution throughout the material. In these cases, single extensometers and gauges do not provide much information about the test piece deformation and strain. For example, consider a tensile specimen containing a through-hole. The hole creates stress concentration, and therefore, produces a nonuniform strain pattern. While it might seem obvious that the strain is greater around the hole, DIC shows how strain forms and also allows measuring peak strain at the point of material failure. As shown in Fig. 5, axial strain builds to the left and right of the hole, and is at a minimum above and below the hole. With respect to shear strain, the map shows a varying positive-to-negative strain path around the hole.

DIC is unlikely to replace traditional extensometers or strain gauges in the short term, as these tools are required to meet current test standards. However, it is also a requirement of research departments and teaching universities to understand the complexities of modern materials. Digital image correlation is another tool to help accomplish this goal. ❍

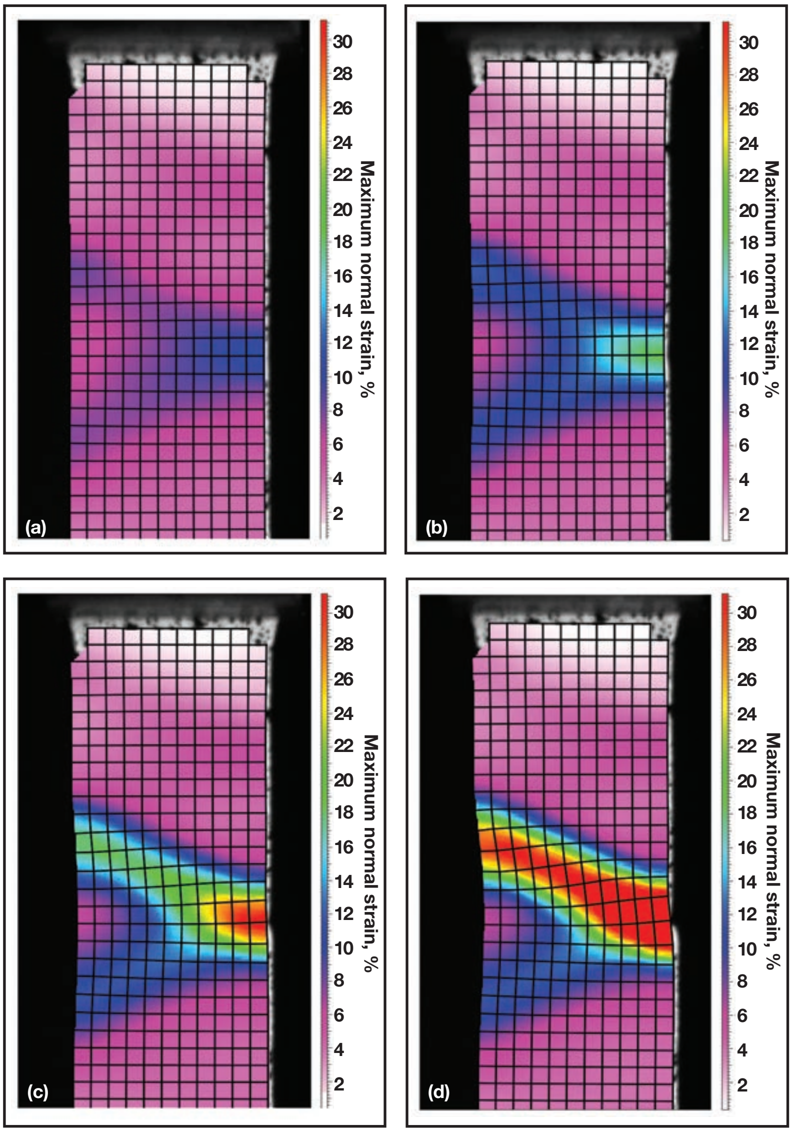

Fig. 4 — *DIC strain maps of a metal proceeding to failure.*

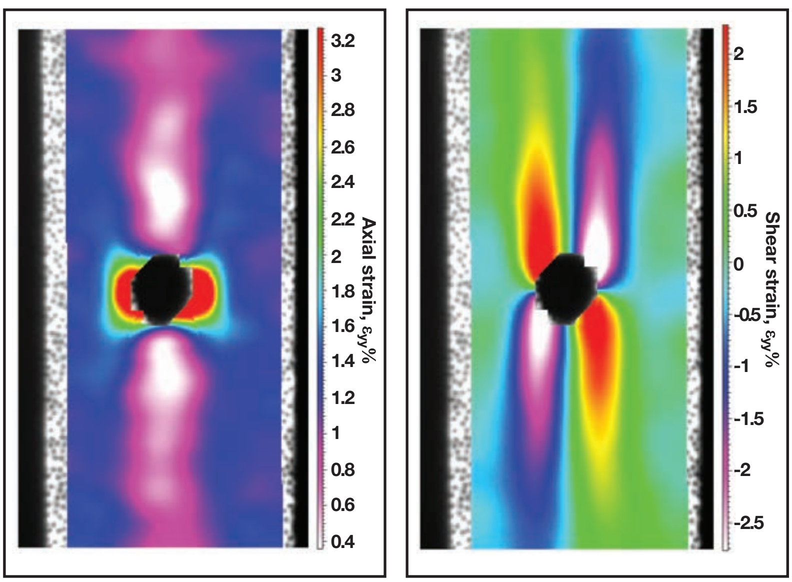

Fig. 5 — *Axial (left) and shear (right) DIC strain maps for a through-hole specimen.*

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Nondestructive Acoustic Cross-Sectioning Helps Pinpoint Part Failures

Physical cross-sectioning is commonly used on parts to reveal and study their internal features and defects. An alternative technology produces equivalent results and images for small parts without damaging them. Although physical cross-sectioning of parts is often standard practice, a newly developed acoustic cross-sectioning method can be useful in certain cases.

Acoustic microscopes routinely provide aerial (top view) planar acoustic images that offer nondestructive views into parts. These planar images are widely used to analyze part features and are an essential part of acoustically guided destructive physical analysis (AGDPA), which helps determine where physical sectioning should occur. If a small part has failed in service, planar acoustic imaging can pinpoint (in the *x-y* axes) the non-bond, delamination, or void that is occurring during production and causing the subsequent failure.

Q-BAM cross-sectioning method

A new method developed by Sonoscan Inc. called *Q-BAM cross-sectioning* goes a bit further. The part's planar image is examined to determine a useful cross-sectional view and a straight line is then drawn on the planar image to define the desired cross-section. Ultrasound is pulsed into the part by a scanning transducer and echoes are returned. Acoustic images are made from these echoes. In planar imaging, the transducer travels across the top surface of the part, pulsing thousands of times and receiving thousands of echoes per second. At the part's edge, the transducer moves fractionally along the length of the part, and scans back across its width.

In Q-BAM imaging, the transducer scans only the single straight line defined by the operator. On the first pass, it collects echoes from the deepest level of the part, Depth 1 in Fig. 1. This depth might be from 1.0 to 1.2 mm below the top surface of the part. The ultrasonic beam is focused on this depth during this scan. Ultrasound is also pulsed into the entire thickness of the part, but on this first scan, only the echoes (if any) from this single depth are collected and recorded.

Next, the ultrasonic beam focuses on a 0.8 to 1.0 mm depth, Depth 2 in Fig. 1, and the echoes are recorded. The cross-sectional image displays the voids present at this depth *and* that intersect the vertical plane defined by the line. The process continues until all depths have been scanned along the chosen line. In Depth 4, the cross-sectional image displays a horizontal line of some shade of gray, illustrating the material interface. The operator selects how many depths will be scanned, which can range from just a few to 100 or more.

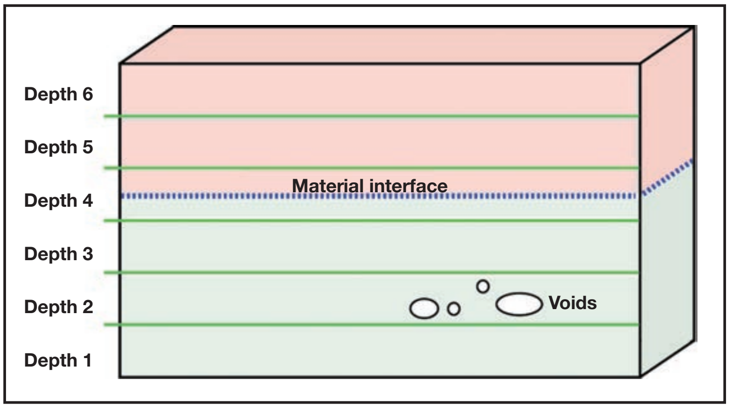

Fig. 1 — *Various sample depths are scanned by the transducer, starting at the bottom.*

Scanning part thicknesses

Some parts can be effectively cross-sectioned using a B-Scan imaging mode, where the entire thickness of the part is encompassed in a single scan. B-Scan works best when the beam is focused on a single depth of interest, whereas the Q-BAM image is focused on the entire part depth.

Nondestructive sectioning is performed by C-SAM acoustic microscopes and is just one of the microscope's many imaging modes. The tool employs a laterally scanning transducer that pulses ultrasound into the surface of the sample as it scans. The frequency of the ultrasound is typically between 15 and 230 MHz. The transducer, which may be moving laterally at a speed in excess of 1 m/s, sends a pulse of ultrasound into the sample and receives the return echoes thousands of times per second.

Ultrasound travels through materials such as ceramics, polymers, and metals at thousands of meters per second, enabling the transducer to collect a lot of data quickly. Return echoes only come from material interfaces. If the sample is a single homogeneous material without internal defects, no echoes will come from the bulk of the material, and the acoustic image will be entirely black. In contrast, a very strong echo will occur from the top surface of the part where it interfaces with the water that couples it to the transducer.

As another example, the material interface between a polymer and a metal will send back an echo with some sort of mid-range amplitude—the interface between these two solids will return 50% or another portion of the ultrasonic pulse. The percentage of the pulse reflected can be calculated from the density and speed of sound of the two materials, but it is never close to 100%. That degree of reflection (>99.99%) is reserved for solid-to-gap interfaces. An ultrasonic pulse striking a crack or delamination or process for creating a nondestructive cross-section differs chiefly in that the transducer does not scan the entire x-y area of the sample, but rather scans back and forth along the single straight line that sets the location for the vertical plane.

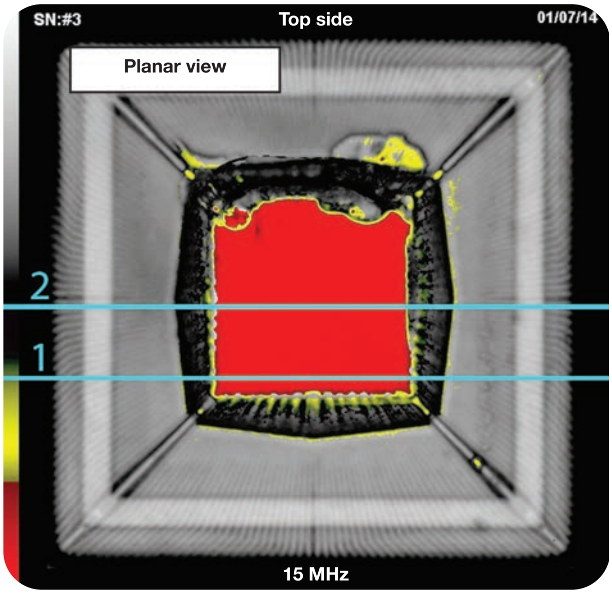

Fig. 2 — *Planar acoustic image looking down into a plastic-encapsulated integrated circuit. The two lines indicate the locations for cross-sectioning.*

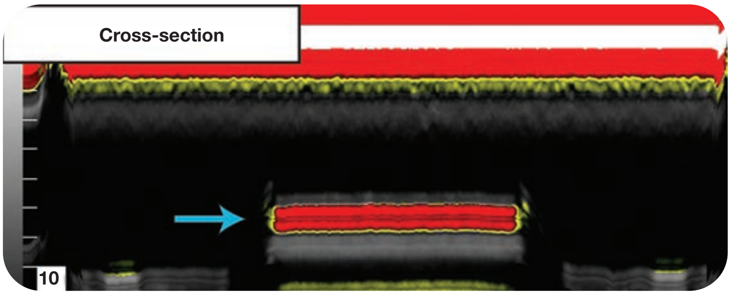

Fig. 3 — *Acoustic cross-section along line 1. The horizontal red line in the lower half of the image is the delamination that separates the die from the plastic encapsulant above it.*

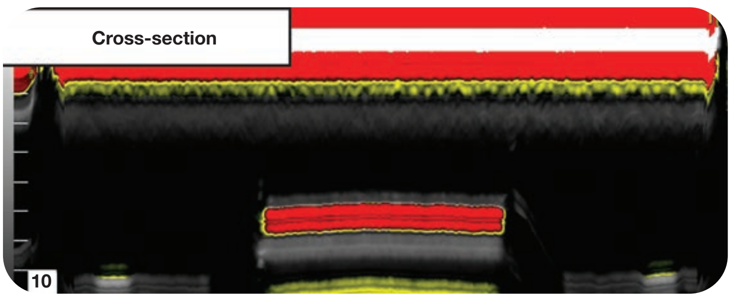

Fig. 4 — *Sectioning along line 2 suggests that the delamination is thickest over the center of the die.*

other gap-type defect will virtually all be reflected to the transducer and will produce a bright white pixel in the acoustic image. Bright white features indicate gap-type defects, whereas nongap features appear as shades of gray. Gaps are often pseudocolored red to make them stand out. No portion of the pulse crosses the defect (which has two interfaces) to go deeper into the sample.

The process described here illustrates how planar acoustic images are made. They usually display the internal features of the whole area of a sample, which might be anything from an electronics component to a medical package seal to a synthetic diamond cutting tool material. The

Integrated circuit case study

Figure 2 is a planar acoustic image of a plastic-encapsulated integrated circuit (IC). The fine lines radiating in all directions are metal lead frame fingers while the four heavier lines extending to each corner are tie bars. The red center marks the location of the silicon die; red (highest amplitude return echoes) indicates that the die is delaminated from the plastic encapsulation above it. The pale gray square near the outer ends of the lead fingers is tape that holds the lead fingers in place during IC package manufacturing. To learn more about the delamination, and perhaps to determine its cause, cross-sectional images were made along a line intersecting the die near its lower edge, and along a line at the center of the die.

The cross-sectional image made along the first line, near the edge of the die, is shown in Fig. 3. The strong red and white horizontal lines at the top indicate the interface between the plastic (solid) and the water (liquid) at the top surface of the IC package. Working downward from the surface, there are no echoes and no material interfaces until the horizontal red line (arrow) that marks the delamination between the die face and the plastic above it. Delamination extends along the entire width of the die and reflects >99.99% of the ultrasonic pulse.

Figure 4 is the cross-sectional view along the second line at the center of the die. In this vertical slice, the red delamination appears to be warped upward. But the red line only images the interface between the mold compound and the empty gap; ultrasound does not penetrate into the gap. The gap probably formed when the curing mold compound pulled away from the silicon and formed a shallow bubble that is thickest above the center of the die.

While most samples imaged by this method are flat, cylindrical samples can also be imaged by using a fixture that rotates them. The straight line that defines the vertical plane is drawn around the circumference of the cylinder at a given spot along its length. The transducer remains stationary just above the sample, and scans the deepest area of interest while the cylinder rotates through 360°. It then scans the next deepest level until the surface of the cylinder is reached.

Figure 5 shows the planar image (top) and cross-sectional image (bottom) of a plastic tube that is bonded by a polymer adhesive to a metal rod. In the planar image, the red-black features are bubbles in the adhesive. As part of the process modification, it was important to learn the depth at which the bubbles lay.

To create the Q-BAM image, the transducer scanned along the bottom edge of the planar image. The strong red line at the top of the cross-sectional image represents the interface between the plastic tube and the water couplant, Figs. 3 and 4. There is very little difference in acoustic properties between the tube and the adhesive, which is unusual. Both are whitish with gray horizontal features—and the dividing line between the tube and adhesive cannot be discerned. The black line at the bottom of the image is the surface of the metal rod, but the interface between the adhesive and plastic is hard to distinguish.

This test was looking for air bubbles that could reduce the strength of the adhesive in this critical application. The red-black features toward the bottom of the Q-BAM image are air bubbles. The interface between the adhesive and the plastic, although acoustically invisible, probably lies just above the bubbles.

An acoustic cross-sectional image generally does not display the texture or color of the materials as they would appear optically, but it has advantages (in addition to its nondestructive properties) over optical imaging. The very strong reflection of gap-type features is unchanged even if the gap is as thin as 0.01 µm. In physical cross-sections, such thin gaps may fill in with polishing material and become optically invisible.

Acoustic sectioning also permits meaningful analysis of internal features, which can then be used as a guide for subsequent physical sectioning. Instead of guessing the best location for sectioning, the acoustic (and planar) images show the precise location of internal features. If desired, a sequence of acoustic sections can be made along parallel surface lines to produce a slide show of internal features, including defects, from one end of the sample to the other.

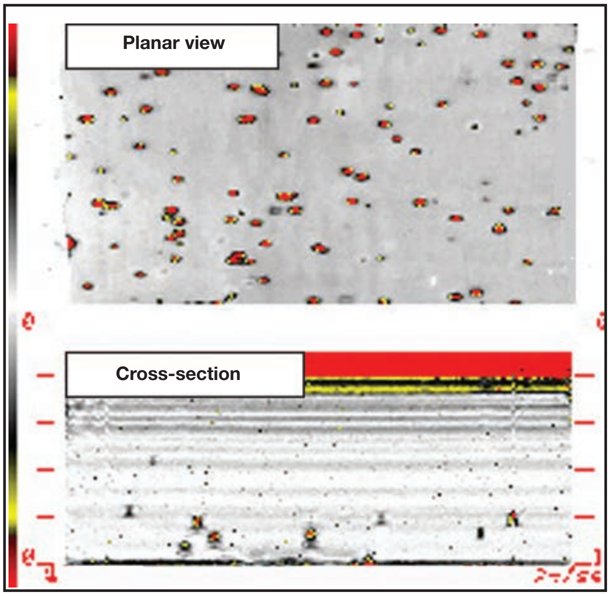

Fig. 5 — *Planar view (top) shows x-y locations of air bubbles in a polymer adhesive; cross-section (bottom) shows depths of bubbles in a line across the lower edge of the planar view.*

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I certify that the statements made by me above are correct and complete.

Scott D. Henry
Publisher

40th International Symposium for Testing and

Exploring the Many Facets of Failure Analysis

This year's technical program features 83 new and exciting presentations as well as additional poster presentations, a panel discussion, and four user groups. Technical symposia, seminars, short courses, and the largest equipment exposition in the industry make ISTFA the best place to learn, network, and further careers. Visit asminternational.org/content/Events/istfa for up-to-date information, technical programming, exposition details, and registration.

Keynote Session

The Speak & Spell:
The Birth of the Digital Signal Processor
Gene Frantz, Rice University

Gene Frantz is a professor at Rice University and also one of the original team members who developed the Speak & Spell toy in the mid-1970s. The toy was designed to be a simple educational product to help students learn to spell, but it had one problem standing in its way: It was impossible to create given the technology of the time. This talk will take us from the toy's difficult beginning to its successful conclusion. As usual, the effort was under-scoped—there were far more issues than the toy simply being impossible to develop.

Frantz became a professor after 39 years at Texas Instruments (TI) where he retired as principal fellow. For the last 30 years, he has applied his passion for finding new opportunities and creating new businesses using TI's digital signal processing (DSP) technology, and took a leadership role in starting businesses within the corporate structure.

Frantz is a Fellow of the IEEE, holds 48 patents in the areas of memories, speech, consumer products, and DSP, and has written more than 100 papers and articles. He is recognized as an industry expert and has been widely quoted in the media due to his tremendous knowledge and visionary view of DSP solutions.

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Downtown skyline and Buffalo Bayou, which stretches 52 miles through Houston, from the mouth of the Houston Ship Channel to the forests of Memorial Park. Courtesy of Greater Houston Convention and Visitors Bureau.

Technical Program At-a-Glance

Sunday, November 9

8:00 – 11:15 a.m.
Package and Physical Analysis Challenges
Session chairs: Jake E. Klein and Robert Champaign
8:00 a.m. – 12:15 p.m.
Electrical and Yield
Session chairs: Jenny Ma and Mayue Xie
8:00 a.m. – 4:15 p.m.
Fault Isolation
Session chairs: Susan Li and Gregory M. Johnson
1:15 – 6:30 p.m.
Microscopy
Session chairs: Carl Nail and Rose Ring
2:15 – 4:15 p.m.
Technology Specific FA
Session chairs: Jeremy A. Walraven and Chris Richardson

Monday, November 10

10:00 – 11:15 a.m.
Emerging Concepts and Techniques
Session chairs: Michael Bruce and Huimeng Wu
11:15 a.m. – 12:05 p.m.
Novel Research-Level Techniques and Concepts
Session chairs: Michael Bruce and Huimeng Wu
1:00 – 1:25 p.m.
Detecting Counterfeit Devices
Session chair: Zhigang Song
1:00 – 2:40 p.m.
3D Packages I
Session chairs: Frank Altmann and Yan Li
1:25 – 2:40 p.m.
Photon-Based Techniques I
Session chairs: Frank Zachariasse and Herve Deslandes
2:50 – 4:05 p.m.
Packaging and Assembly Analysis I
Session chair: Lihong Cao
Photon-based Techniques II
Session chairs: Frank Zachariasse and Herve Deslandes
4:05 – 6:00 p.m.
Contactless User Group

Tuesday, November 11

8:00 – 9:40 a.m.
3D Packages II
Session chairs: Frank Altmann and Yan Li
Microscopy I
Session chair: Carl Nail
9:55 a.m. – 12:00 p.m.
Electrical Characterization and Nanoprobing
Session chairs: Stefan B. Kaemmer and Izak Kapilevich
Packaging and Assembly Analysis II
Session chair: Lihong Cao
12:20 – 2:20 p.m.
Nanoprobing User Group
2:35 – 3:50 p.m.
Packaging and Assembly Analysis III
Session chair: Lihong Cao
2:35 – 4:40 p.m.
Case Studies and the Failure Analysis Process I
Session chairs: Zhigang Song and Peter Jacob

Education Short Courses

AS6171 Counterfeit Electronics Detection Test Techniques and Implementation
Saturday, November 8
8:30 a.m. – 12:30 p.m.
Instructor: Bhanu Sood

Fault Isolation
Saturday, November 8
8:30 a.m. – 4:30 p.m.
Instructor: David Vallett

Packaging FA
Saturday, November 8
8:30 a.m. – 4:30 p.m.
Instructor: Becky Holdford

November 9-13, 2014
Houston

Wednesday, November 12

8:00 – 9:00 a.m.
Fundamentals of Laser Signal Injection Microscopy
8:00 – 10:00 a.m.
Oil & Gas Microelectronics Failure Analysis: Methodologies and Selected Case Studies
10:15 a.m. – 12:15 p.m.
Panel Discussion
Session chair: Philippe Perdu
1:30 – 3:30 p.m.
Posters
Session chairs: Martin Versen and David Grosjean
3:30 – 4:20 p.m.
Circuit Edit
Session chairs: Dane Scott and Michael DiBattista
3:30 – 6:00 p.m.
Sample Preparation and Device Deprocessing I
Session chairs: Roger Alvis and Bryan Tracy
4:20 – 6:00 p.m.
Microscopy II
Session chair: Carl Nail

Thursday, November 13

8:00 – 9:40 a.m.
Case Studies and the Failure Analysis Process II
Session chairs: Zhigang Song and Peter Jacob
Sample Preparation and Device Deprocessing II
Session chairs: Roger Alvis and Bryan Tracy
9:50 – 11:30 a.m.
Defect Characterization and Metrology
Session chairs: Phil Kaszuba and Terence Kane
9:50 – 11:55 a.m.
Sample Preparation and Device Deprocessing III
Session chairs: Roger Alvis and Bryan Tracy
12:20 – 2:20 p.m.
Sample Prep User Group
2:30 – 3:45 p.m.
Sample Preparation and Device Deprocessing IV
Session chairs: Roger Alvis and Bryan Tracy
Software-based Techniques, Test, Diagnosis, and Yield
Session chairs: Geir Eide and Mark E. Kimball
3:45 – 5:45 p.m.
FIB User Group

EDFAS Photo Contest

The EDFAS Photo Contest is open to all members of the failure analysis community and is sponsored by the Membership Committee of the Electronic Device Failure Analysis Society. Images are judged on failure analysis relevance (35%), aesthetics (35%), and novelty of the technique or mechanism (30%). First place in each category receives a wall plaque and one-year complimentary EDFAS membership; second and third places in each category receive award certificates and one-year complimentary EDFAS memberships; and the top 10 entries in each category will be displayed at ISTFA 2014 in Houston.

Networking Opportunities

Monday Conference Social Event
Hilton Americas – Houston
7:00 – 9:00 p.m.

Tuesday Expo Networking Reception
5:00 – 6:00 p.m.

Wednesday EDFAS Membership Luncheon and Meeting
12:15 – 1:30 p.m.

Wednesday Dessert and Poster Reception
1:30 – 3:30 p.m.

Exhibition

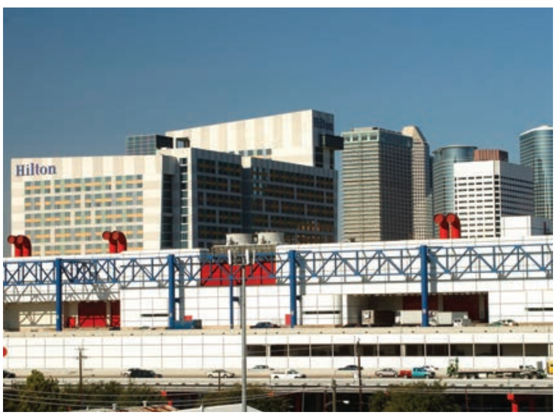
ISTFA is the only international venue devoted to the semiconductor, electronic sample preparation, and imaging markets. It attracts attendees from all major global geographic areas, offers a comprehensive practical and theoretical technical program that attracts the broadest mix of attendees, and continually expands topic areas to attract new and diverse audiences. ISTFA offers two full days of dedicated expo hours to make connections, build relationships, and generate sales.

Exhibitor List

Booth	Company
217	Asylum Research
308	Keysight Technologies
610	Agilent Technologies
309	Allied High Tech Products Inc.
220	Angstrom Scientific Inc.
616	Applied Beam
405	Bruker Optics
211	BSET EQ
621	CAMECA Instruments Inc.
524	Carl Zeiss Microscopy LLC
203	Checkpoint Technologies LLC
509	DCG Systems
526	Digit Concept
224	E.A. Fischione Instruments Inc.
607	Ebatco
724	EDAX Inc.
125	Electron Microscopy Sciences
304	Evans Analytical Group
608	EXpressLO LLC
209	FA Instruments Inc.
402	FEI Co.
518	Fraunhofer CAM
204	Gatan Inc.
103	Hamamatsu Corp.
310	HiLevel Technology Inc.
119	Hitachi High Technologies America Inc.
617	HORIBA Scientific
302	Hysitron Inc.
627	IR Labs
218	ibss Group Inc.
213	JEOL USA Inc.
619	JG & A Metrology Center
116	Keyence Corp.
521	LatticeGear LLC
417	Left Coast Instruments
609	Leica Microsystems

Booth	Company
504	Materials Analysis Technology Inc.
613	Meiji Techno America
117	Mentor Graphics
303	MultiProbe Inc.
421	Nanolab Technologies
612	Neocera LLC
118	Nisene Technology Group
625	NIST/CNST
113	Nordson DAGE
425	OKOS
616	Olympus
217	Oxford Instruments America
126	Precision Surfaces International
110	Quantum Focus Instruments
225	Quartz Imaging Corp.
419	RKD Engineering
505	Robson Technologies Inc.
516	SAMCO Inc.
424	SEMICAPS
725	Semitracks Inc.
527	Sonix
520	Sonoscan Inc.
316	SPI Supplies
519	Synopsys Inc.
127	Ted Pella Inc.
503	TeraView
325	Tescan USA Inc.
202	Trion Technology
109	ULTRA TEC Manufacturing Inc.
124	WinTech Nano-Technology Services Pte. Ltd.
327	XEI Scientific Inc.
502	YXLON Feinfocus
611	Zurich Instruments AG

Exhibitor list current as of August 27, 2014.



View of the George R. Brown Convention Center, Hilton Americas-Houston, and downtown skyline from Highway 59. Courtesy of Greater Houston Convention and Visitors Bureau.

Visit asminternational.org/content/Events/istfa for more information.

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- Sharpen your knowledge with practical and theoretical sessions, user groups, tutorials, and short courses. Paper presentations and posters also offer practical, hands-on education by peers that cannot be acquired in a book or found online.
- Listen to the keynote speaker, Gene Frantz, one of the original team members who developed the Speak & Spell™ toy in the mid-1970s, discuss how its development led to the birth of the digital signal processor.
- Make connections and build relationships within this vibrant community of international attendees who work on discrete components, dies, wafer fabrication, packages, board assembly, systems and more.

ISTFA features the largest exposition in the industry, with two full days of dedicated expo hours for unparalleled networking opportunities with industry influencers. Don't miss the Tools of the Trade Tour 2014 for select exhibitor previews of the latest technology and advancements on the show floor before the expo officially opens. Make sure to sign up for this popular tour when registering, before it fills up!

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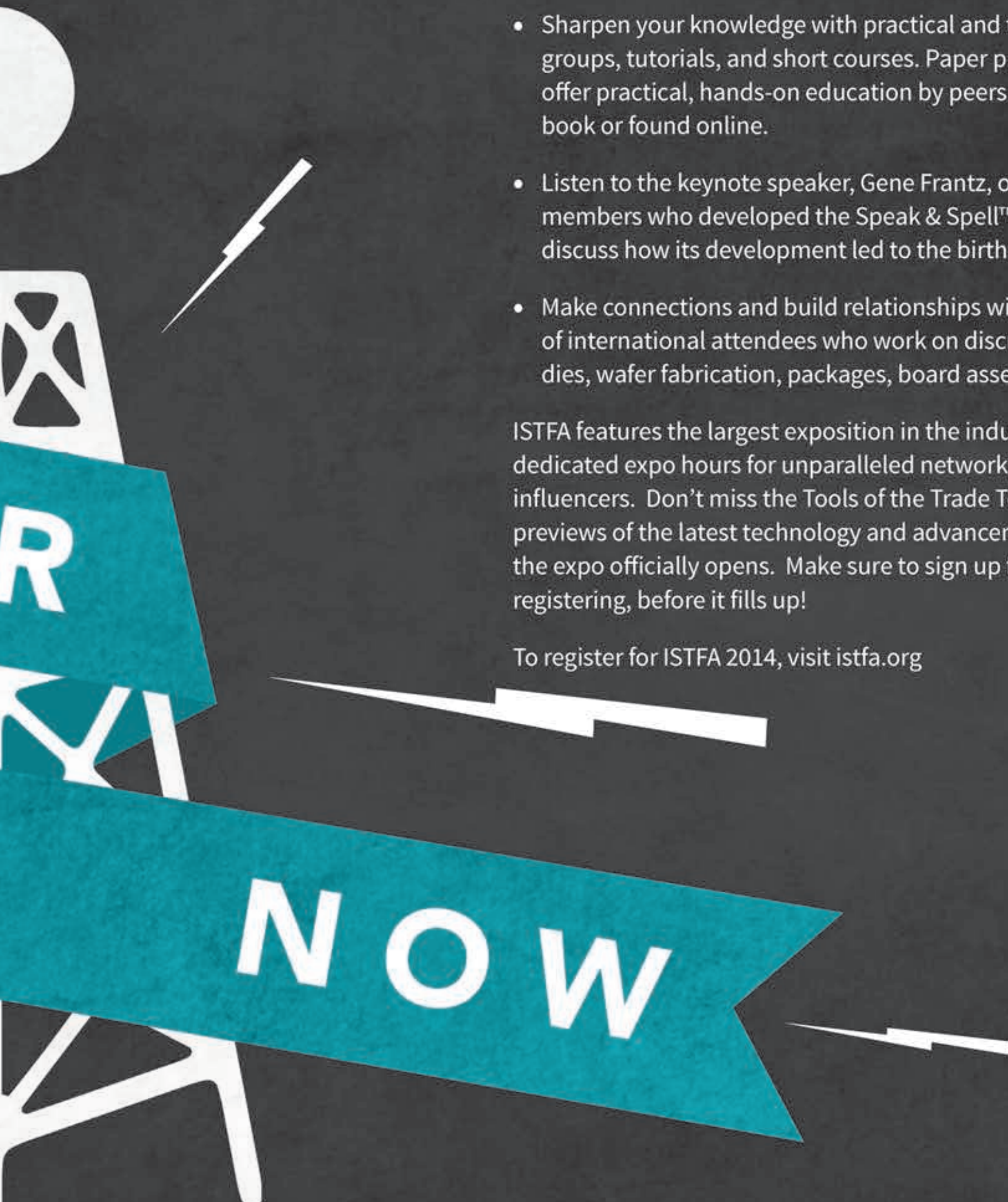

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Metallurgy Lane

Aluminum: The Light Metal—Part II

The cost of electric power is the biggest expense involved in aluminum production. Proximity to economical power sources determined the location of major aluminum reduction plants.

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

The Pittsburgh Reduction Co. signed the first industrial contract to take electricity from hydropower at Niagara Falls, N.Y., in 1893. A new aluminum processing plant was built there, which became operational in 1895. A second plant was constructed at the Falls in 1896, followed by a third plant—with its own electric power facility—in 1906. With steadily increasing production capacity and decreasing costs, the Pittsburgh Reduction Co. expanded rapidly throughout the 1890s. Production reached five million pounds in 1900, while the price decreased from 78 cents/lb for ingots in 1893 to 33 cents/lb in 1900.

The need for sheet, plate, wire, and other product forms meant installing equipment and hiring specialists to fabricate these products at the plant in New Kensington, Pa. When all the aluminum chemical reduction operations were moved to Niagara Falls under Charles Martin Hall, Arthur Vining Davis was put in charge of working aluminum into other products. This first decade of operations saw small annual losses in the early years and very modest profits at the end of the decade when pretax earnings reached $322,000.

At this critical time in the aluminum business, the Pittsburgh Reduction Co. lost its dynamic leader, Alfred E. Hunt. With his enthusiasm for the military, he led a company of men into the Spanish American War. He was posted to Puerto Rico where he contracted a tropical illness that took his life shortly after his return to the United States. Richard Mellon was appointed president to succeed Hunt, but day-to-day management tasks fell to Davis. The company continued to be controlled by Hall, Davis, the Mellons, and a small group of original investors. Hunt's family inherited his shares in the company and his son Roy joined the company upon college graduation. Roy became a key manager under Davis and played a significant role in the company's fortunes.

British WWI military recruiting poster features a Zeppelin above London at night. German Zeppelins represent the first major use of the precipitation hardening alloy Duralumin. Public domain image.

Liberty L-12 aircraft engine. Cast aluminum was used for its light weight. Courtesy of Stahlkocher/Wikimedia Commons.

Early aluminum applications

Aluminum production increased from five million pounds in 1900 to 35 million in 1909. A major application during this era was kitchenware, for which aluminum was best known by the American public. The Pittsburgh Reduction Co. acquired a kitchenware producer in 1901 when it went bankrupt due to owing a substantial bill for aluminum. This acquisition brought the company a pair of college students who had been selling pots and pans door-to-door with great success. A new company was organized to improve the quality and expand this effort. The resulting kitchenware became well known under the WearEver Cookware brand and continues to be widely sold today.

One of aluminum's early industrial uses was for cable to transmit high-voltage electric current over long distances. However, aluminum was not strong enough to carry its weight from tower to tower. The Pittsburgh Reduction Co. resolved this by adding a steel wire to the center of the cable. After 1910, a growing demand for aluminum came from the newly developing automobile industry. It was easier to manufacture customized bodies from ductile aluminum than steel. Yet this application, as with so many others, turned out to be short-lived because mass production required the lowest-cost material, steel. The market for aluminum cast parts was a substantial component of the early automobile industry, and a new casting process was developed in which molten aluminum was poured into water-cooled steel molds rather than into sand molds.

Raw materials

Expanded aluminum production after 1900 required the Pittsburgh Reduction Co. to seek both

WearEver aluminum cooking utensils were the Pittsburgh Reduction Company's first consumer products. Courtesy of wearever.com.

lower-cost raw materials and more economical electrical power. In addition, this search for backward integration was a necessary part of the company plan to exclude competition after the Hall patents expired in 1909. Electrical power was the costliest ingredient in aluminum production. By 1909, the company (renamed the Aluminum Company of America, or Alcoa for short) had secured water rights along the Little Tennessee River. They built dams, power plants, and a smelter around a small settlement they called Alcoa, Tenn.

Because the known reserves of domestic bauxite were inadequate, Alcoa searched overseas for all future supplies. Their largest investment was in the British and Dutch Guineas where vast reserves were located. The company also began producing a synthetic cryolite to replace the natural mineral, as the only available source of natural cryolite was in Greenland. The cryolite was used to dissolve alumina for the electrolytic processing to make aluminum metal.

World War I

Alcoa had fully integrated from mine to aluminum metal by the time of increased demand after 1910, especially with the start of World War I. They had also moved forward into production of many finished products. Alcoa became a major force in the worldwide aluminum industry. Although there were a number of competitors overseas, especially in France and Switzerland, Alcoa was protected by high tariffs during the prewar years and by wartime needs after 1915. The company sold its inventory of aluminum to the European powers allied against Germany in 1915 and 1916. Production was then purchased for U.S. defense use in the remaining years of the war. The bulk of all aluminum sold during this period went into munitions. As a powder, it was mixed with ammonium nitrate to form a high explosive. Other defense applications helped promote postwar uses for the metal, for example, specification of aluminum alloys for the Liberty engine used in most American aircraft built during the war.

Alcoa achieved pretax earnings of $4 to $6 million during each year between 1909, when the patents expired, and 1914. Earnings increased to $9 million in 1915, and then $25 million in 1916, $20 million in 1917, and $15 million in 1918. By 1919, Alcoa had corporate equity of $100 million, mainly from retained earnings. Of this equity, $60 million was earned during WWI. Alcoa's strong position in later years was a direct result of the enormous profits from the war.


The 1924 Studebaker Light Six, part of the Studebaker National Museum collection in South Bend, Ind., features an all-aluminum body. Public domain image.


Francis C. Frary, Alcoa's first director of research. His team developed numerous alloys that became basic structures for aircraft and industrial uses. Courtesy of electrochem.org.

Ongoing research

Numerous technical problems arose during the war years for which Alcoa was unprepared. Castings for the Liberty aircraft motor, engine pistons, and many other applications posed special problems throughout the aluminum foundry industry. The primary embarrassment for the company was its inability to produce the new German alloy called Duralumin. This alloy, which could be hardened by precipitation of a second phase, was used on all German Zeppelins built during the war. It was also being manufactured and used by France and Great Britain in limited aircraft applications.

The delay in undertaking research and development was due to Hall's reluctance to employ personnel trained in science, as this was his field of expertise and he jealously guarded it. After Hall died of leukemia in 1914 at the age of 51, management could now remedy this important deficiency. The man they hired was Francis C. Frary. He graduated in chemistry from the University of Minnesota and attended the University of Berlin for two years before receiving his doctorate from Minnesota. He taught there for several years and then moved on to perform research in industry. During the war, he went into the army to work in chemical warfare and joined Alcoa in 1919 as director of research. Frary continued to head research at Alcoa for the next 33 years, where he built one of the best laboratories in the country. In 1946, he received the Perkins Medal from the American Chemical Society, which Hall had received in 1912.

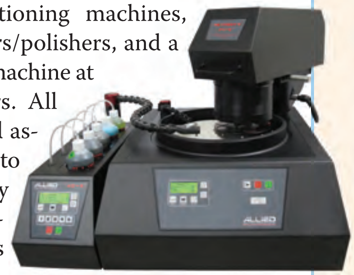
For more information:
Charles R. Simcoe can be reached at crsimcoe1@gmail.com.
For more metallurgical history, visit metals-history.blogspot.com.

2014 EXHIBITOR SHOWCASE

Visit these key exhibitors and more at MS&T14 in Hall A of the David L. Lawrence Convention Center in Pittsburgh.

See exhibition dates and times on next page.

Allied High Tech Products Inc.

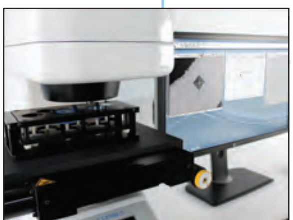


For over 31 years, Allied High Tech Products has provided quality products for metallographic sample preparation and analysis. Allied manufactures state-of-the-art equipment including sectioning machines, mounting systems, grinders/polishers, and a precision tabletop milling machine at its California headquarters. All design, manufacturing, and assembly takes place in-house to ensure the highest quality equipment is produced. Allied is a national Carl Zeiss Microscope dealer and carries a full line of hardness testers from Mitutoyo as well. Quality consumables are also available. Visit our website for more information, an online account for purchasing, or to download the current catalog. **alliedhightech.com**

Booth 415

Clemex Technologies Inc.

Clemex will attend MS&T, October 12-16 in Pittsburgh. Visit Booth 425 to see our new product solution for micro-hardness testing and other image analysis measurements. An innovative technique has been applied to the Clemex CMT.HD, allowing a seamless combination of micro-hardness testing with automated quantification of microscopic images such as grain size, phase area percentage, coating thickness, and more. For 25 years, Clemex has provided manufacturers and researchers with image analysis software and hardware to make quantification of microstructures less demanding and more effective. We specialize in automating the measurement of objects using digital images from microscopes and other precision optical devices. Contact us: 450.651.6573, info@clemex.com, **clemex.com/coating.**



Booth 425

Saudi Aramco

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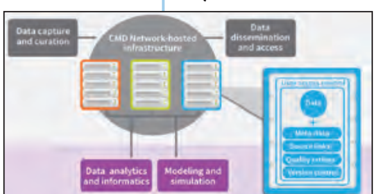
Booth 327

Computational Materials Data Network

The Computational Materials Data Network, founded by ASM International, supports and serves the materials community in its pursuit of the goals of the U.S. Materials Genome Initiative and the promise of ICME. Leveraging ASM's knowledge and experience in materials data, CMD Network is playing an integral role in multiple efforts where the data management standards of the future are being defined. Current development projects include the Structural Materials Data Demonstration Project, Materials Data Laboratory Pilot Project, and the Center for Hierarchical Materials Design. Visit our booth to see the latest demonstration databases and learn how the CMD Network can help you. **cmdnetwork.org.**



Booth 218

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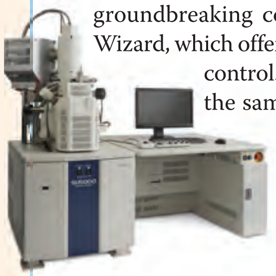
Booth 621

Hitachi High Technologies America Inc.

Visit Hitachi High Technologies America Inc. (Booth 318) to see the new SU5000 FE-SEM, equipped with Hitachi's groundbreaking computer-assisted technology, EM Wizard, which offers a new level of SEM operation and control. Expert or novice, the result is now the same: Highest quality nano-scale images at everyone's fingertips!



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hitachi-hta.com

Booth 318

Exhibition dates and times*

Tuesday, October 14

Show hours: 11 a.m. – 6 p.m.

Lunch: 12 – 2 p.m.

Poster session: 2 – 6 p.m.

Happy hour reception: 4 – 6 p.m.

Wednesday, October 15

Show hours: 9 a.m. – 2 p.m.

Poster session: 9:30 – 10:30 a.m.

Lunch: 12 – 2 p.m.

**Times are subject to change*

JEOL USA Inc.

JEOL is a world leader in electron optical instrumentation for scientific and industrial R&D. Core products include high resolution electron microscopes for materials, failure analysis, forensics, product inspection, nanotech, and semiconductor applications: SEMs and FE-SEMs for observation/analysis, TEMs for atomic-level imaging and high-speed mapping, surface analyzers for materials characterization, correlative microscopy solutions, specimen prep equipment, and other analytical instruments. JEOL is also well known for long-term applications and service expertise.

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Booth 501

Exhibition

MS&T14 brings together professionals from nearly every field of materials science: Metals, polymers, ceramics, and composites. Many industries are represented including automotive, aerospace, instrumentation, medical, oilfield, and energy. The exhibition at MS&T14 is a great opportunity to reach potential customers from all markets in a single venue.

Exhibitor List

Exhibitor	Booth
ACERS	106
Accutek Testing Laboratory	325
AdValue Technology LLC	405
Agilent Technologies	201
AIST	102
AK Steel	T8
Aldrich Materials Science	211
Alfred University	317
Allied High Tech Products Inc.	415
American Stress Technologies Inc.	502
Angstrom Scientific Inc.	326
Applied Test Systems Inc.	414
ArcelorMittal USA	T11
ASM	104
ASM	218
Beckman Coulter Life Sciences	410
Binder Inc.	217
Boise State University Materials Science & Engineering	214
Buehler	509
California Nanotechnologies Inc.	324
Carl Zeiss Microscopy LLC	401
Centorr Vacuum Industries Inc.	432
Ceramics Expo	624
Clemex Technologies	425
CM Furnaces Inc.	433
CompuTherm LLC	604
DTE Energy	T7
EA Fischione Instruments Inc.	205
Ebatco	319
EDAX Inc.	614
Electron Microscopy Sciences	310
EMSL Analytical Inc.	209
Extrel	615
FEI Co.	300
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Goodfellow Corp.	538
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ASM Materials Education Foundation
2014 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.

Patrick Veloskey
University of Wisconsin-Madison

Veloskey's inquisitive mind led him to the field of materials engineering. In class and at his co-op assignments, he asks questions. For example: What alloy is the metal? How will that affect machining? In the future, Veloskey wants to work with a materials engineering team to find the answers.

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.

Anna Bretzke
Missouri University of Science & Technology

Bretzke originally declared ceramic engineering as her major, but changed her mind after one week of working in a steel foundry. "As I stood on the melt deck and got to help charge, slag and tap a 700-pound induction furnace, I felt right at home, " says Bretzke.

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. Seven scholars were selected this year and will be presented with a certificate and check for $6000 toward educational expenses for one academic year.

Katrina Boos
The Ohio State University

"My foray into the engineering world was attending the 2010 ASM Eisenman Camp, an experience that convinced me to pursue materials engineering as a career," Boos recalls. "I'm blessed to have had the opportunity to pursue an engineering degree at a prestigious school with world-class researchers," says Boos.

Taylor Brown
University of Alabama at Birmingham

"My goal is to be hired by a steel company after graduation, so I can expand my potential and interest in metallurgy," says Brown. "After working in the field, I plan to return to school for a master's degree in materials science and engineering or business administration."

Aliya Carter
University of Connecticut

Carter worked as an intern at the Naval Undersea Warfare Center in Newport, R.I., and

...in this issue

Submit news of ASM and its members, chapters, and affiliate societies to
Joanne Miller, editor, *ASM News* | ASM International | 9639 Kinsman Road | Materials Park, OH 44073
P 440.338.5151 ext. 5662 | **F** 440.338.4634 | **E** joanne.miller@asminternational.org

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F 440.338.4634 | **E** MemberServiceCenter@asminternational.org | **W** asminternational.org

later obtained a research position at UConn studying nanomaterials. "The internship showed me what I could achieve by applying my math and science skills to real-world applications," she says.

Mary Cole
University of Akron

As a corrosion engineering co-op for BP America, Cole worked on a continuous improvement project to reduce the internal corrosion of pigging launchers and receivers for operations in Alaska. She has also volunteered at ASM Teachers Camps and the ASM Eisenman Camp, to "pay it forward."

Rachel Sylvester
The Ohio State University

After attending the ASM Eisenman Camp in 2010, Sylvester was hooked. She expanded her materials interests in college, and returns to ASM Materials Camps as a mentor during the summer. She would like to pursue a career in metals testing and consulting.

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, who was an ASM Fellow, remembered the scholarships he received when an undergraduate student 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 were selected this year and will be presented with a certificate and check for $6000 toward educational expenses for one academic year.

Thomas Chrobak
University of Wisconsin-Madison

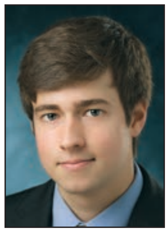
"I am most interested in advancing the materials industry to a more sustainable future," Chrobak says. "My ultimate professional goal is to work in the R&D sector of the steel industry to help make it even more efficient in terms of energy use and recyclability."

Rachel Martin
University of Alabama at Birmingham

"My goal is to pursue a career in a foundry environment as a metallurgist or in the quality control department," says Martin. As president of UAB's American Foundry Society student chapter, she has participated in "various casting and casting prep that has solidified my love of the metal industry."

Jared Ottmann
University of Wisconsin-Madison

"During an eight-month internship at Mercury Marine, I worked in the materials lab on projects including corrosion, failure analysis, and paint qualification," Ottmann says. "I really enjoyed the lab environment and was happy to be in a position that leveraged my problem-solving skills."



Michael Strand
University of Wisconsin-Madison

Every emerging technology has one limiting factor—the availability and understanding of new materials. Once Strand realized this, there was only one career choice for him—advanced materials. His work has focused on III-V semiconductors for photovoltaic applications, using x-ray diffraction to analyze InGaAs devices.

Outstanding Scholar Awards

The Outstanding Scholar Awards were established to recognize students who have demonstrated 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.

Mayela Renata Aldaz Cervantes
University of Texas at El Paso

Cervantes began her undergraduate studies in mechanical engineering, but switched to metallurgical and materials engineering after a summer in MIT's Department of Biological Engineering. Now her goals are to become a biomedical engineering researcher and a professor invested in minority outreach programs.

Margaux Balagna
University of Michigan

Balagna became fascinated by polymers while working in a pharmaceutical research lab. "After graduation, I'll be pursuing full-time jobs in the polymer science and chemistry field," she says. An entrepreneur at heart, Balagna wants to be in the forefront of commercializing innovations and discoveries in materials science.

Natalie Briggs
University of Washington

"I am prepared to delve deeper into the field of nanoscale optoelectronics, partially because of the overwhelming presence of electronics in society," says Briggs. "I hope to achieve a Ph.D. in materials science and a career at an R&D company that focuses on advanced electronic materials and devices."

Ladish Co. Foundation Scholarship

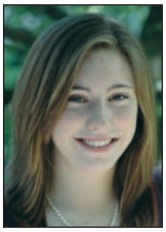
Established in 2011, the Ladish Co. Foundation Scholarship is awarded to an outstanding undergraduate member of ASM who has demonstrated exemplary academic and personal achievements as well as interest and potential in metallurgy or materials science and engineering. (Student must be a Wisconsin resident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

Elliott Busta
University of Wisconsin-Madison
Busta has become increasingly interested in rapid prototyping with metals and polymers. "I feel that rapid prototyping will eventually become as common as a paper printer in a household, and I aspire to be part of a team that makes them more advanced and economical," he says.

DJ Murphy Devan
University of Wisconsin-Madison
"I knew almost immediately upon entering the materials science and engineering department at UW-Madison that I wanted to be a metallurgical engineer," Devan says. "Ultimately, I hope my path leads to a career in aerospace or aeronautics and research into materials used in aircraft and spacecraft."

Edward J. Dulis Scholarship

The Edward J. Dulis Scholarship was established in 2003. It 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 was selected this year and will be presented with a certificate and a check for $1500 toward educational expenses for one academic year.



Alexandra Glover
Michigan Technological University
Glover has been fascinated by additive manufacturing technologies, or 3D printing, since her first two years at Michigan Tech. There she helped develop a material for open-source additive manufacturing systems using recycled polymer waste. She plans to work toward a Ph.D. in materials science and engineering.

John M. Haniak Scholarship

The John M. Haniak Scholarship was established in 2003. It 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 in metallurgy or materials science and engineering. One scholar was selected this year and will be presented with a certificate and check for $1500 toward educational expenses for one academic year.

Ziyin Huang
Drexel University
Huang chose materials science and engineering as his major "because materials engineering is essential for the development of new technologies." He is focused on materials for biomedical and electronic applications, and his work includes characterization of polymer crystallization at curved liquid-liquid interfaces and nanotube-induced flat interface polymer crystallization.

Official ASM Annual Business Meeting Notice

The Annual Business Meeting of members of ASM International will be held in conjunction with MS&T14 on:
Monday, October 13
4:00 – 5:00 p.m.
David L. Lawrence Convention Center, Pittsburgh
The purpose of the ASM Annual Business Meeting is the election of officers for the 2014-15 term and transaction of other Society business.

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. 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 2014 Recipient of the Jacquet-Lucas Award is **Thomas Nizolek,** a doctoral student at the University of California Santa Barbara, advised by Prof. Tresa Pollock, FASM, for his entry entitled: *Deformation of Bulk Metallic Nanolaminates.*

Nizolek received his B.S. in Materials Science and Engineering from Lehigh University in 2010 where he was a Dean's Scholar and an active member of the local chapter of ASM. During his undergraduate studies, he worked on a variety of research projects on topics including laminated steels, titanium nitride thin films, and titanium-tantalum shape memory alloys.

During the course of his Ph.D. research, Nizolek worked at Los Alamos National Laboratory as part of a team focused on improving the deformation processing and properties of bulk bimetallic nanolaminates. He is a previous Jacquet-Lucas recipient (2008), a Department of Defense NDSEG fellow, and a member of ASM since 2005.

ASM Nominating Committee and BOT **Nominations Due!**

ASM International is seeking a few good men and women to serve on the Nominating Committee and the Board of Trustees.

ASM Nominating Committee: The committee will select a nominee for 2015-2016 vice president (who will serve as president in 2016-2017) and three nominees for trustee. Candidates for the ASM Nominating Committee can only be proposed by a chapter through its executive committee, an ASM committee or council, or an affiliate society board. Nominations are due **December 15, 2014.**

ASM Board of Trustees: ASM chapters, committees, councils, affiliate societies, and individual members may submit candidates. The deadline for nominations is **March 15, 2015.**

For more information, contact Leslie Taylor at 440.338.5151, ext. 5500, leslie.taylor@asminternational.org. Or visit asminternational.org/about/governance/nominating-committee.

ASM MATERIALS EDUCATION FOUNDATION

Year in Review

Nichol Campana
Director of Development and Operations

The year 2014 has been a momentous one for the ASM Materials Education Foundation. This year marked the 15th anniversary of Materials Camps, we launched a new branding platform that includes fresh modern logos, piloted an after-school program called "Materials Matter," and accomplished—one year ahead of schedule—the Pick Up the Pace goal to expand the Materials Camp for Teachers program to 50 locations!

In accordance with our mission to excite young people in materials, science, and engineering careers, we awarded 18 scholarships to deserving students totaling $88,000.

It's a rare gift to love *what* you do and with *whom* you do it, and I'm grateful every day for the opportunity.

This has been a year of learning, both looking at the past and looking toward the future. As I complete my first year with this exceptional organization, I am humbled by the passion of the staff, enthusiasm of the volunteers, and commitment of our donors.

I would like to extend a special thank you to the staff: Pergentina (Jeane) Deatherage, Ginny Shirk, Veronica Becker, and Mary Anne Jerson. Their hard work and friendly service enables us to meet the needs and expectations of our supporters and participants. I would also like to thank the outstanding leadership of our Board of Directors and Executive Officers.

Lastly, I would like to express my gratitude to all of the volunteers who contribute to and participate in a multitude of committees and programs that review and help conduct the business of the Foundation.

As we approach the end of the year, I send my very best to each of you. I am proud to serve this organization and look forward to working with you in the coming year, and with your help, making ASM Materials Education Foundation the best it can be.

NOMINATIONS

Nomination Deadline for the 2015 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 are:

- 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 2015 is **November 30, 2014.**

Complete information including the rules, interpretive comments, and online nomination forms are available on the ASM website at: asminternational.org/membership/awards/asm-fellows, or by contacting Christine Hoover at 440.338.5151, ext. 5509, christine.hoover@asminternational.org.

Nominations Sought for ASM-IIM Visiting Lecturer for 2015

The cooperative Visiting Lecturer program of ASM International and the Indian Institute of Metals (IIM) is seeking lecturers for 2015. Criteria for the 2015 ASM-IIM Visiting Lecturers are as follows:

- ASM members who visit India
- Experience delivering technical presentations of interest to government, industrial, or academic organizations
- Able to lecture on current technological conditions in India
- Available between April 1 and December 31
- Definite travel plans to and from India using own funds

The award carries with it an $800 honorarium to be used for travel expenses within India during the lecturer's visit and a certificate of recognition to be presented at the ASM Leadership Awards Luncheon scheduled for October 2015 in Columbus, Ohio, during MS&T15. Deadline for application is **December 1.**

Nominations Sought for ASM-IIM North America Visiting Lecturer for 2015

The cooperative Visiting Lecturer program of ASM International and the Indian Institute of Metals (IIM) is seeking lecturers for 2015. Criteria for the 2015 ASM-IIM North America Visiting Lecturers are as follows:

- IIM Member currently residing In India
- Experience delivering technical presentations of interest to government, industrial, or academic organizations
- Available between June 1 and December 30

IIM provides $1000 and ASM will provide a matching award of $1000 for a total of $2000. The program honorarium is to be used for travel within the United States and/or Canada during the lecturer's visit and a certificate of recognition to be presented at the ASM Leadership Awards Luncheon scheduled for October 2015. Deadline for application is **December 1.**

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. The award is named in honor of George H. Bodeen, ASM President 1983, ASM Distinguished Life Member, FASM, and Founding President of the ASM Heat Treating Society. Rules for submitting nominations:

- Candidates may be submitted by any HTS member
- Nominations should clearly state the contributions the nominee has made to the field of heat treating and their commercial impact. Three support letters should be included with the nomination
- Nominations are eligible for three rounds of review. Awardees shall not be selected posthumously
- Deadline for nominations is **February 2, 2015**
- No more than one award every other year will be presented

For rules and nomination form, visit the Heat Treating Society Community website at hts.asminternational.org and click on Membership & Networking and Society Awards. For additional information or to submit a nomination, contact Joanne Miller at 440.338.5151, ext. 5513 or joanne.miller@asminternational.org.

Student Papers Sought for **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.

To view rules for eligibility and paper submission, visit hts.asminternational.org/portal/site/hts/HTS_Awards. Paper submission deadline is **December 12, 2014.** Send submissions to: Joanne Miller, ASM Heat Treating Society, 9639 Kinsman Rd., Materials Park, OH 44073; tel: 440.338.5151 ext. 5513; fax: 440.338.6614; joanne.miller@asminternational.org.

First **ASM HTS/Surface Combustion Emerging Leader Award** to Be Presented in 2015

The ASM HTS/Surface Combustion Emerging Leader Award was established in 2013 to recognize 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 Combustion's 100-year anniversary in 2015. It acknowledges an individual who sets the highest standards for the HTS and inspires others to dedicate themselves to the advancement and promotion of vacuum and atmosphere heat treating technologies. Rules for submitting nominations:

- Candidates must be a member and an active participant in ASM International and HTS.
- Nominees must be 40 years of age or younger and employed full time in the heat treating industry for a minimum of five years.
- Candidates must be submitted by an ASM International or HTS member.
- Three letters of recommendation must be submitted with the form. Nominations should clearly state the nominee's impact on the industry and/or service and dedication to the future of the HTS.
- The award shall be presented to one recipient every two years at the General Membership Meeting at the HTS Conference and Exposition.
- Recommendations must be submitted to ASM Headquarters no later than April 1 in the year in which the award is to be presented.
- The first award will be presented in 2015.
- Winner receives a plaque and $4000 cash award funded by Surface Combustion.

A selection committee consisting of five members will be appointed every two years by the HTS Awards and Nominations Committee. Three members of the selection committee will be appointed by Surface Combustion. The selection committee will submit a report for approval by the HTS Awards and Nominations Committee and the HTS Board, which shall include the rationale and documentation used for award selection.

For rules and nomination form, visit hts.asminternational.org and click on Membership & Networking and HT Awards.

ASM INTERNATIONAL | THE POWER OF ONE | Membership Drive

Looking for New Members: A Personal Perspective

Ash Khare, FASM
Honorary Life Member
and ASM President (2000)

Membership is the lifeblood of any organization and ASM is no different. Professional societies are always looking for the next group of individuals to join, contribute, and lead the future. Some members may only have enough time to enjoy the personal and professional benefits without any other involvement. That is also okay, as new members add to the collective knowledge of the group, thereby contributing like a rising tide raising all boats.

My personal involvement with membership development started in the early 1970s. ASM had launched a membership drive and during one of our chapter's executive committee meetings, the president of a local company complained how hard it was to get new members. We challenged each other to get one more member and the competition began. After five or six years and my signing more than 510 new members, we stopped counting.

There is no magic to getting new members: You simply have to ask. ASM sells itself, so it is just a matter of matching the prospective member's interest to one of ASM's many benefits. The basic benefit is that ASM provides a forum for exchange of ideas, which works on the local, national, and international level. Consider this: Two individuals meet at a street corner and exchange one dollar. Each came with a dollar and leaves with a dollar. Now if they exchange an idea—each leaves with two ideas. This is the essence of ASM membership.

During my membership efforts, we had a basic society with few specialized offerings compared to today where ASM has several affiliate societies within itself and the digital world at our fingertips. Surely we can find something that intrigues our prospects. Another bonus is that serving on national committees provides free leadership training.

I have gained a lot from my involvement with ASM, though many of my successes were not visible at the time I joined, more than 40 years ago. Good luck as you participate in "The Power of One" and please remember: You have to ask. Thank you for your efforts.

VOLUNTEERISM COMMITTEE

Profile of a Volunteer

Lindsay Golem
Student, Metallurgical Engineering
Missouri University of
Science & Technology

Lindsay Golem graduates in December 2014 with her undergraduate degree in metallurgical engineering—but is wise beyond her 22 years. "You can't solve problems by yourself," she reflects. "Wherever I end up going, I'll get involved in ASM. The network is huge...the resources, technology, and learning will all be beneficial."

A native of Texas, Golem decided on metallurgy after touring Missouri University of Science & Technology (MS&T) and visiting their foundry. "It was the coolest thing I'd seen," she recalls. "It was out of my comfort zone, beyond traditional engineering. It was the best decision I ever made."

Golem spent last summer as an intern at GE Aviation in Cincinnati where she learned how to process nickel-base alloys and titanium. She admired their Women in Technology network with its mission to help younger women early in their careers.

She prefers face-to-face communication over internet-based groups or social media. "I wish we had more chapter meetings with other groups. It's so valuable to interact with people, to hear inspiring stories about the industry," says Golem. She was impressed with the Ceramic Matrix Composite group at work when they eliminated useless meetings and reduced emails. "People would just walk down the hall to ask questions. It's more productive. Technology can be a crutch."

Being involved in the MS&T Material Advantage Chapter was a great experience for her. "Attending conferences was the most valuable to me because students interact with professionals to learn about options down the road," she notes.

Golem plans to earn an advanced degree and work in manufacturing, R&D, or with a technology group developing new alloys. "I like to be on the cutting edge of new technology. Maybe someday I'll manage a group where I can motivate and lead others."

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., Exponent Inc., Metallurgical Supply Co. Inc., Rolls-Royce Corp., and Struers Inc.

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Carl Zeiss MicroImaging LLC, Evans Analytical Group, Hoeganaes Corp., and Ted Pella Inc.

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

Canada Council Awards

ASM Canada Council will present their awards during ASM's Leadership Awards Luncheon on Monday, October 13, in Pittsburgh, during MS&T14. Congratulations to the following Canadian award recipients.

ASM Canada Council M. Brian Ives Lecture
Prof. Patricio F. Mendez
Weldco/Industry Chair in Welding and Joining
Director, Canadian Center for Welding and Joining
Edmonton, AB

ASM Canada Council G. MacDonald Young Award
Mr. John F. Clayton, FASM
Principal
FAMEX Engineering
Brampton, ON

ASM Canada Council John Convey Innovation Award
Dr. Glenn Byczynski
Technical Manager
Nemak, Windsor, ON

IN MEMORIAM

Sushama Rath (Sushie), wife of Dr. B.B. Rath, past president of ASM (2004-2005), passed away in her sleep on August 19. Mrs. Rath, with double master's degrees in English literature, was a member of the honor society Phi Beta Kappa, taught as a faculty at Washington State University and the University of Pittsburgh, and later served as the senior program analyst of the Northern Virginia community college system. She was a strong supporter of ASM International and its Education Foundation and was most creative as the first lady of the Society during 2004-2005. She was innovative in entertaining the wives of the Board of Trustees and leading members of the Society to create activities in collaboration with the ASM staff. She left requests to all friends of ASM to support the Foundation and freely provide voluntary service to the Society's missions and vision.

Word has been received at ASM Headquarters of the death of three members from the Central Massachusetts Chapter: **Leslie J. Dudley** and **Frederick Faulkner,** both of Worcester, and **James J. Pulaski** of Westborough.

For a list of upcoming ASM Training Courses, see our ad on the inside back cover of this issue.

Members in the News

Leadership Trio

ASM President Ravi Ravindran met with TMS President **Hani Henein** and Iron and Steel Society Past President **Alex McLean** over dinner to discuss the future of materials science and engineering on June 13 in Hamilton, Ontario, at Capri Ristorante.

Applied Process Takes on Majority Interest Partner

Effective August 13, Applied Process Inc. (AP) of Livonia, Mich., announced that it has taken on a majority interest equity partner, High Street Capital of Chicago. High Street is a private equity firm with a track record of partnering with, and growing, successful companies since 1997. The firm is investing in AP as they believe in its management, people, and business. **John R. (Chip) Keough,** AP's founder, stated, "My family and I will maintain a significant capital interest in the business. I will continue as a director and will be, as always, actively engaged in the growth of the business and the profitable conversion of components from one material/process combination to a better, faster, cheaper one."

Kumar Sridharan, FASM, Distinguished Research Professor in the Department of Engineering Physics and Materials Science and Engineering at the University of Wisconsin-Madison was nominated by the U.S. Department of Energy to represent the U.S. at an International Atomic Energy Agency conference held in Vienna, Austria, in June. At this meeting, delegates from seven member states discussed issues pertaining to implementation of high temperature materials for next-generation high temperature nuclear reactors.

CWRU Wins Grant to Improve Lifetime Performance of Ceramic Fuel Cells

Researchers at Case Western Reserve University (CWRU) received an $800,000 Department of Energy grant to study how to make solid oxide fuel cells last longer. **Mark DeGuire,** associate professor and project director, and **Arthur Heuer,** Distinguished University Professor and Kyocera Professor of Ceramics, will test small lab-scale fuel cells. The research will compare the performance of cells that have undergone accelerated aging to those that have performed up to 500 hours of use under normal conditions.

Marra Receives Rankin Award

Dr. James Marra, FASM, an investigator with the DOE's Office of Environmental Management's Savannah River National Laboratory, Aiken, S.C., was named the 2014 recipient of the D.T. Rankin Award for exemplary service to the Nuclear and Environmental Technology Division of the American Ceramic Society (ACerS). He received the award for his leadership within the division, professionalism, and participation in technical activities and innovation. He will be presented the award at the ACerS annual meeting in Pittsburgh in October.

ASM Chapter Honor Roll

The Volunteerism Committee is proud to announce an addition to the ASM Chapter Honor Roll. The **India Chapter** selected **Prem Kumar Aurora** as their nominee. Aurora has been an instrumental member in the Chapter for many years. His dedicated service and many contributions to the Chapter and ASM Community are to be commended.

ASM INTERNATIONAL | Emerging Professionals

What Oil & Gas Offers for Emerging Materials Professionals

Sai Prasanth Venkateswaran, BP

Ask a recently graduated materials science student, "What industry would you like to pursue?" Typical answers include silicon, magnetic, nano, fuel cells, and graphene. My answer was a little different—oil and gas—puzzling some of my friends who asked, "Why the traditional industry?" The energy industry, where I can learn scalability and complexity, was my interest, and the oil and gas industry fit in very well.

Every oil and gas development, pipeline, and refinery touches upon a multitude of challenging material requirements and environments. High temperatures, reactive fluids, and mechanical stresses all conspire to alter material behavior, and with it, performance. As a materials engineer, one is usually fighting against thermodynamics to ensure the material lasts for several decades of facility service or well life, without premature failures and in a cost-effective manner.

As a materials engineer, one is often involved in all aspects of project development, from wellbore to subsea to surface to pipeline. I am called upon to make and support technical and business decisions based on an understanding of risk. In addition, materials selection decisions necessitate a deep know-how of materials properties and a fundamental understanding of materials performance under different corrosive and challenging environments.

When defining and selecting materials, one must engage in developing material technologies to withstand the next frontier of harsh environments. We always strive to study and understand complex interactions of materials and environments on the atomic and nanoscale, and ultimately make better, more resilient materials for energy technology.

The convergence of forces, threats, and technology is creating a perfect environment for the next generation of young talent to exploit limitless opportunities in the oil and gas sector.

products & literature

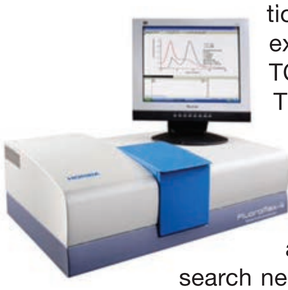
Thermo Scientific Inc., Madison, Wis., introduces Smart iTX, **a low-cost tool for high-quality ATR data collection.** The tool offers an improved optical design that maximizes its performance; maximum information and robust operation owing to the monolithic diamond crystal; interchangeable crystals including diamond, zinc selenide, and germanium for broader sample analysis capabilities; and an epoxy-free design that mitigates the risk of degradation when analyzing solvents. thermoscientific.com.

The Janis Research ultra-low temperature (ULT) group, Woburn, Mass., developed an enhanced **top-loading helium-3 cryostat** with sample in UHV environment—the model HE-3-TLSUHV-STM. A central UHV tube (32 mm diameter or larger) and gate valve provide top-loading access to the low temperature, high magnetic field region for sample and tip exchange. Vertical, horizontal, and 2D/3D vector field superconducting magnets are available and fully integrated. The system provides operating time of >80 hours at a base temperature of <300 mK (longer operating times are also possible by using additional He-3 gas). The system includes a mechanical heat switch for rapid precooling and cooled 4 K and 1.5 K radiation shutters for maximum hold time and minimum base temperature. janis.com.

Mettler-Toledo Inc., Columbus, Ohio, launched a **new guide on moisture and water content determination in plastics.** The *Moisture Guide for Plastics* presents the different methods of moisture and water content determination—loss of weight, chemical reaction, thermogravimetric, spectroscopic, and other types of analysis. The comprehensive guide reviews the advantages and disadvantages of the respective methods, offers tips and tricks to enhance the reliability and performance of measurements, and shows solutions to common challenges. mt.com.

FEI Co., Hillsboro, Ore., announces the Helios NanoLab G3 DualBeam **(FIB/SEM instruments),** extending the Helios family's offerings that feature excellent image contrast and resolution, while at the same time adding a user-friendly interface. The new Helios comes in two different workflow-specific configurations for materials science research: The CX configuration includes more versatile sample handling and positioning for fast and flexible analysis, sample preparation, and characterization. The UC configuration delivers super advanced imaging capabilities with increased sensitivity to surface detail and improved performance on soft, nonconductive, or beam-sensitive materials. fei.com/helios-g3.

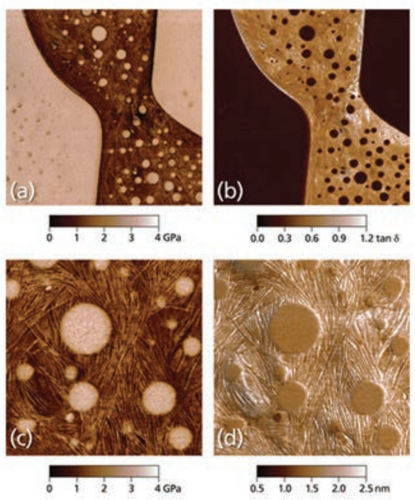
Horiba Scientific, Albany, N.Y., announces FluoroMax Plus, a user-friendly **benchtop spectrofluorometer.** The Plus model expands on the company's FluoroMax series with the option of a second detector and two-position grating turret, providing an extended range to 1650 nm, and TCSPC performance down to 25 ps. The higher sensitivity offered by FluoroMax Plus enables faster measurement of weaker and smaller samples. A broad range of gratings, detectors, and accessories are designed to fit numerous research needs, such as measuring solid and liquid samples, high throughput screening, cryogenic or elevated temperatures, absolute quantum yields, microliter volumes, and even micron-scale measurements with a fiber optic coupling to a microscope. fluorsolutions.com.



nPoint Inc., Middleton, Wis., introduces the NPZ100-403 nanopositioner, a piezo driven, **flexure-guided stage,** designed for high speed and nanometer precision. Fea-

turing a position noise of 0.5 nm with capacitive sensors and 3 nm with strain gauges, the system achieves high accuracy in advanced applications. This piezo stage can be paired with LC.400 series DSP controllers for closed-loop capability. It has a travel of 100 µm in the *z* axis and can also be used in *x* and *y* configurations. A resonant frequency of 1000 Hz enables fast scanning and settling times less than 3 ms. The stage has high stiffness for greater resonant frequencies, even with heavy loads. Applications include optical microscopy, lithography, nm-scale manipulation, metrology, materials testing, and optical fiber alignment. npoint.com.

Oxford Instruments Asylum Research, Santa Barbara, Calif., announces a powerful new **nanomechanical imaging technique,** AM-FM Viscoelastic Mapping Mode, for its entire line of Cypher and MFP-3D atomic force microscopes. The new mode lets users quickly and gently image viscoelastic properties including storage modulus and loss tangent with nanoscale spatial resolution. The imaging mode is suitable for quantitative nanomechanical measurements on materials such as polymers, composites, biomaterials, ceramics, and metals. One resonance is used for tapping mode imaging, also known as amplitude modulation (AM), while a higher resonance mode is operated in frequency modulation (FM). asylumresearch.com.



In a **new white paper,** Superior Technical Ceramics, St. Albans., Vt., outlines how ceria stabilized zirconia (CSZ) is more resistant to low-temperature degradation than yttria-stabilized tetragonal zirconia polycrystal (YTZP) and magnesia stabilized zirconia (MSZ). The key factor that separates CSZ from other zirconias is that there are no oxygen vacancies to make the tetragonal phase vulnerable in moist environments. No oxygen defects form in CSZ because the tetravalent cerium substitutes the Zr4+ ions directly. The paper also highlights the properties, specifications, and applications of CSZ and is available free of charge on the company's website. ceramics.net.

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editorial preview

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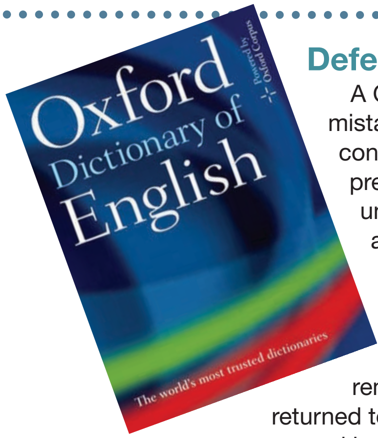
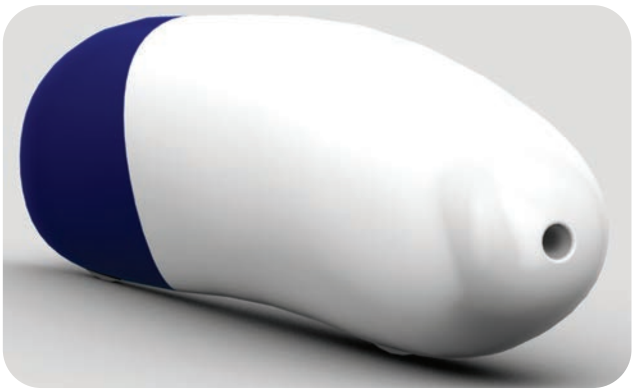
STRESS RELIEF

Defective dictionary definition



A Queensland University of Technology (QUT), Australia, physicist pointed out a 99-year-old mistake to one of the world's most authoritative dictionaries. Stephen Hughes sparked controversy over how a humble siphon works when he noticed an incorrect definition in the prestigious *Oxford English Dictionary.* In 2010, the eagle-eyed Hughes spotted the mistake, unnoticed for 99 years, which incorrectly described atmospheric pressure, rather than gravity, as the operating force in a siphon.

Hughes conducted an experiment in a hypobaric chamber, which simulates the effects of high altitude, at the Institute of Aviation Medicine at the Royal Australian Air Force's Base Edinburgh. A siphon 1.5 m high was set up in the chamber and when the pressure was reduced to an altitude of 40,000 ft, a waterfall appeared at the top, but the water flow remained nearly constant. At 41,000 ft, the siphon broke into two columns of water and, when returned to 40,000 ft, it reconnected as if nothing had happened. "The fact that the water level in the upper and lower buckets is constant indicates that atmospheric pressure is not pushing water into the siphon," explains Hughes. The dictionary corrected the error and removed the reference to atmospheric pressure after Hughes pointed it out. However, he said the new entry "unfortunately remains ambiguous." *For more information: Stephen Hughes, +617.3138.2327, sw.hughes@qut.edu.au, qut.edu.au.*



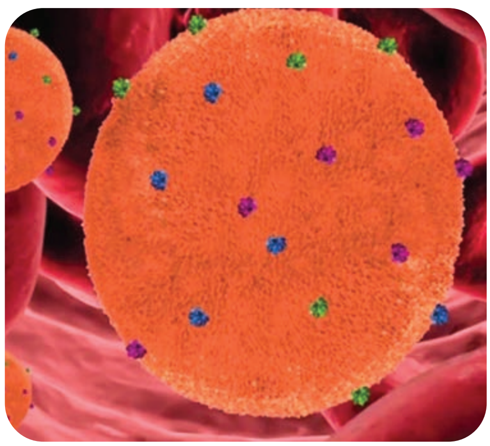
ARION1, which produces zero carbon emissions, weighs less than 55 lb, is 98.4% efficient, and will travel at almost double the current sprint cycling record.

It's a bird, it's a plane, it's a…bicycle!?

It's 40 times more aerodynamic than a Bugatti Veyron, has a top speed of 90 mph, generates enough power to light the average UK home—and is entirely pedal-powered. The ARION1 Velocipede is a *bicycle* that a team of UK engineering students believes will become the fastest human-powered vehicle in history. The University of Liverpool Velocipede Team (ULVT)—all members of the Institution of Mechanical Engineers—is hoping their design will smash the 83.13 mph record set in September 2013 by TU Delft and VU Amsterdam universities. ARION1 will be designed, manufactured, and ready to race by May 2015, and will attempt the record in September 2015 at the World Human Power Speed Challenge in Battle Mountain, Nev. *www.liv.ac.uk.*

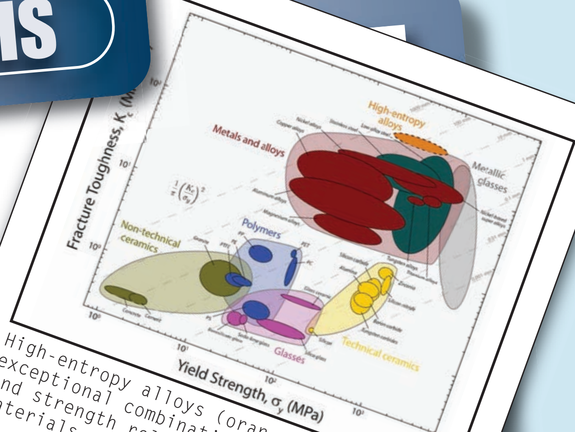
Nanosponges tackle superbugs

With support from the National Science Foundation, Liangfang Zhang and his team at the University of California San Diego (UCSD) created a nanosponge to combat drug-resistant infections, such as those caused by *Methicillin-resistant Staphylococcus aureus (MRSA).* The nanosponge, made from biocompatible, biodegradable polymer nanoparticles, is camouflaged with a red blood cell membrane. It circulates in the bloodstream, absorbing the toxins produced by infection. One red blood cell membrane can be used as a cloak for more than 3000 of these stealthy sponges. Once they are fully loaded with toxins, the nanosponges are safely eliminated by the liver. They are designed to work with any type of infection or poison that attacks the cellular membrane. Zhang is working closely with doctors and students at the UCSD Moores Cancer Center on this nano approach to tackling infections. He has been testing his approach on mice, with a nearly 100% success rate against staph infections. *For more information: Liangfang Zhang, 858.246.0999, zhang@ucsd.edu, ucsd.edu.*



A good disguise enables a nanosponge to soak up toxins from drug-resistant infections or poisons.

SUCCESS ANALYSIS



High-entropy alloys (orange) show an exceptional combination of toughness and strength relative to other materials. Courtesy of Ritchie group.

Specimen Name: High-Entropy Metallic Alloys

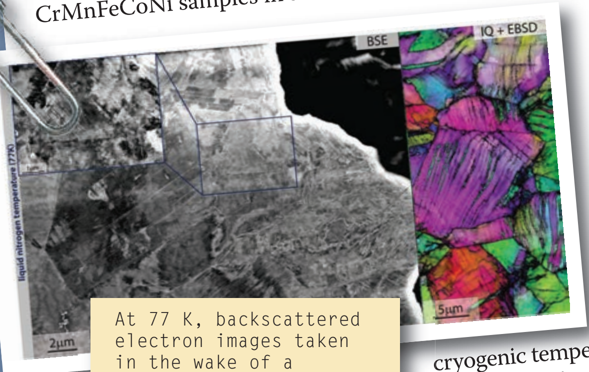
Vital Statistics:

New experiments involving *high-entropy alloys* have yielded a multiple-element material that tests as one of the toughest ever recorded, say researchers. In addition, the alloy's toughness—as well as its strength and ductility—improve at cryogenic temperatures. The new material was synthesized and tested at the DOE's Lawrence Berkeley and Oak Ridge National Laboratories (Berkeley Lab and ORNL).

"We examined CrMnFeCoNi, a high-entropy alloy that contains five major elements rather than one dominant one," says Robert Ritchie, a materials scientist at Berkeley Lab. "Our tests show that despite containing multiple elements with different crystal structures, this alloy crystallizes as a single phase, face-entered cubic solid with exceptional damage tolerance, tensile strength above one gigapascal, and fracture toughness values that are off the charts, exceeding that of virtually all other metallic alloys."

Success Factors:

Although high-entropy alloys have existed for more than a decade, their quality has only recently become adequate for scientific study, says Ritchie. Easo George, group leader of ORNL's Alloy Behavior and Design Group, and his team combined high-purity elemental starting materials with an arc-melting and drop-casting process to produce CrMnFeCoNi samples in sheets roughly 10 mm thick. After characterizing samples for tensile properties and microstructure, George sent them to Ritchie for fracture and toughness characterization.



At 77 K, backscattered electron images taken in the wake of a propagated crack exhibit formation of pronounced cell structures resulting from dislocation activity that includes deformation induced nano twinning.Courtesy of Ritchie group.

"High-entropy alloys do not derive their properties from a single dominant constituent or from a second phase," explains Ritchie. "The idea behind this concept is that configurational entropy increases with the number of alloying elements, counteracting the propensity for compound formation and stabilizing these alloys into a single phase like a pure metal."

Tensile strengths and fracture toughness values were measured for CrMnFeCoNi from room temperature down to 77 K. Recorded values are among the highest reported for any material. Results showing that these values increased along with ductility at cryogenic temperatures are a major departure from the vast majority of metallic alloys, which lose ductility and become more brittle at lower temperatures. Ritchie and George explain that the key to the alloy's cryogenic strength, ductility, and toughness is a phenomenon called *nano-twinning,* in which during deformation, atomic arrangements in adjacent crystalline regions form mirror images of one another.

About the Innovators:

Robert Ritchie is the corresponding author, along with Easo George, of a paper in *Science* describing this research, A Fracture Resistant High-Entropy Alloy for Cryogenic Applications.


Robert Ritchie, a senior faculty scientist with Berkeley Lab and UC Berkeley, is a recognized authority on the mechanical behavior of materials.

What's Next:

Ritchie notes that the mechanical properties of CrMnFeCoNi and other high-entropy alloys have yet to be optimized, as they have not been systematically studied yet. Large-scale studies are just beginning to take place. Regarding alloy development, one idea being tested out is removing just one or two elements at a time from the CrMnFeCoNi conglomerate and seeing how that affects the properties. Other researchers are looking at incorporating refractory metals such as Mo and W to see what happens. Although commercial applications may be at least a decade away from use as structural materials, Boeing is now conducting a large study focusing on the corrosion properties of these new and promising alloys.

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