APRIL 2017 | VOL 175 | NO 3

ADVANCED MATERIALS & PROCESSES

AN ASM INTERNATIONAL PUBLICATION

MATERIALS SPECIFICATION

SIX SIGMA ENABLES MATERIALS SELECTION

P.16

22 CAREERS IN MATERIALS ENGINEERING

26 ANTIBACTERIAL MATERIALS

39 ASM STRATEGIC PLAN

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SIX SIGMA PROCESS STREAMLINES MATERIALS SELECTION

Karteek Kesavamatham

Using a six sigma, statistics-based approach for selecting materials offers a unique way to compare different options for use in various applications.

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Taking a six sigma approach involves a commitment to decision-making based on data and statistics rather than anecdotal evidence and assumptions.

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PUTTING WELDS TO THE TEST

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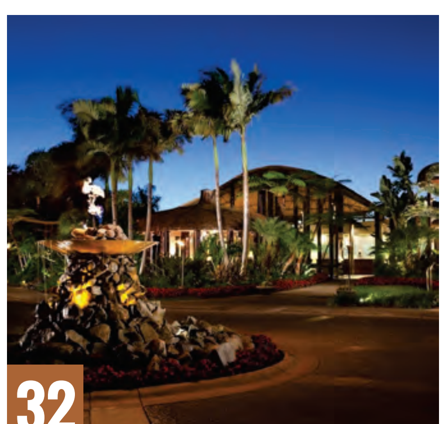

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ASM NEWS

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

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ASM INTERNATIONAL

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

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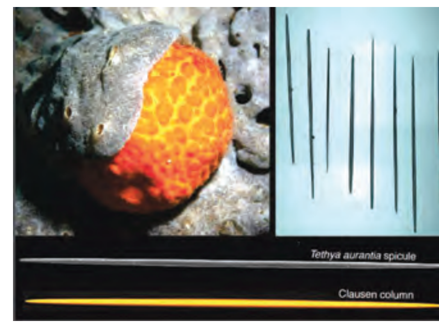
NATURE SPRINGS INTO MATERIALS INNOVATIONS

Spring has finally arrived and the daffodils are up again, swaying in the breeze and bobbing their pretty heads. If this sounds corny to you, it can only mean one thing: You've never slogged through the monotony of a gray Cleveland winter. Nature is inspiring in so many surprising and unusual ways, including a multitude of concepts that have a direct impact on materials science. In fact, every issue of *AM&P* includes a few instances of awe-inspiring biomimicry. Following is a snapshot of some of the most interesting materials developments blooming in labs this season:

- *Orange puffball sea sponges (pictured):* Using structural mechanics models and data from obscure math journals, researchers at Brown University found that these sponges have tiny structural rods with the perfect shape to resist buckling. This natural form could be used as a blueprint for delicate man-made structures like bicycle spokes and arterial stents.



Orange puff all sea sponge bodies feature tiny structural rods that resist buckling. Courtesy of Brown University.

- *Moth eyes:* The technology that enables a new NASA-developed camera to create images of astronomical objects with far greater sensitivity than previously possible was inspired by a moth's eye. These insect eyes contain fine arrays of tiny, tapered cylindrical protuberances whose job is to reduce reflection for nocturnal navigation. The same concept is being applied to NASA's far-infrared absorber in the new camera system.
- *Bone tissue:* For the first time, biomedical engineers at the University of New South Wales have woven a smart fabric that mimics the complex properties of periosteum. Researchers are now ready to produce fabric prototypes for a range of advanced functional materials, with applications such as protective suits that stiffen under high impact for skiers, racecar drivers, and astronauts.
- *Brown recluse webs:* New research at the University of Oxford shows that brown recluse spiders use a unique micro-looping technique to make their threads stronger than that of any other spider. Unlike other spiders, who produce round ribbons of thread, recluse silk is thin and flat. This structural difference is key to the thread's strength, in addition to tiny loops or knots the spider adds for even greater stability. This spider sense is now being transferred to synthetic fibers.
- *Algae armor:* Chemists at Johannes Gutenberg University Mainz are working on a coating to prevent seawater fouling, inspired by a chemical defense mechanism in algae that uses metabolic products to prevent other organisms from attaching to them. The nontoxic coating could replace copper-base biocides, which are poisonous, accumulate in the environment, and lead to resistance.

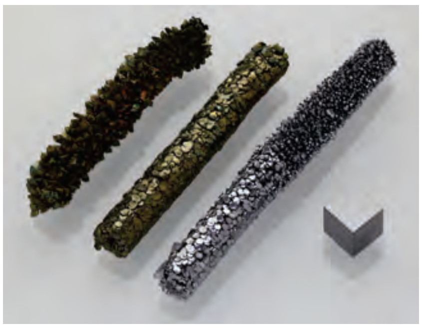
These are just a handful of recent materials developments inspired by nature. If you are working on any biomimetic projects, we'd like to hear about them. In the meantime, we hope your spring is off to a productive start.

F. Richards

frances.richards@asminternational.org

MARKET SPOTLIGHT

2016 COMMODITIES REVIEW: A MIXED BAG



Crystal bar vanadium showing different textures and surface oxidation; 3N5-pure cube for comparison. Courtesy of wikipedia.org/Alchemist-hp.

It was a mixed year for commodities in 2016, according to analysts at Roskill Information Services, London. Major trends included debt reduction by large public mining companies, adjustment to China's slowing economy, and market reactions to the growing public sentiment against "business as usual"—including the European referendum vote and the U.S. presidential election. Prices for a number of commodities were at several-year lows as 2016 began. But by mid-year, increases were seen in aluminum, crude steel, iron ore, and across a range of minor metals and industrial minerals, say analysts.

Moving into 2017, stability appears to be the key aim of the major miners. For steel alloys in particular, the outlook for 2017 is positive, with vanadium feedstock availability set to be tight amid growing buzz around vanadium redox batteries (VRBs). The year started with vanadium prices at a considerable low, with ferrovanadium prices having dropped from over $22/kg at the start of 2015 to below $14/kg by the end of the year. In 2016, prices slowly recovered, reaching over $20/kg by November. Most market participants expect prices to continue to improve during 2017, with vanadium demand from the steel sector forecast to grow at a steady rate and the availability of feedstock expected to remain tight.

Regarding chromium, it has been a difficult time for chromite and ferrochrome producers, say analysts. Demand for stainless steel recovered after the global economic downturn, and so did prices during 2010-2012. After this period, falling production costs coupled with oversupply and relatively sluggish demand caused prices to stagnate and then fall. By Q1 2016, prices were at six-year lows. However, in the second half of 2016, a dramatic recovery occurred and by Q3, chrome ore prices had recovered to their highest levels since the global downturn. In 2017, it is forecast that ferrochrome prices will remain strong in Q1 and possibly Q2.

The molybdenum market showed a strong recovery in 2016, with U.S. ferromolybdenum prices increasing from a low of $6.14/lb in January to a peak of $9.39/lb in June. However, in the second half of 2016, poor demand from downstream industries led to U.S. ferromolybdenum prices tailing off, averaging $9.04/lb in Q3 and forecast to average $8.20/lb in Q4 2016. The strong recovery in pricing has been led by better than anticipated stainless steel production in China, with the international Stainless Steel Forum reporting a 4.1% year-on-year increase in global output and a 7.9% increase in Chinese output in the first half of 2016. The recovery in crude oil prices also supported increased production and exploratory drilling in North America, which contributed to marginally increased demand for molybdenum-bearing steels. *For more information, visit roskill.com.*

FEEDBACK

BETHLEHEM STEEL POSTMORTEM

I read the article on the decline of the U.S. steel industry with great interest ["Metallurgy Lane," November/December 2016]. In early 1973, I interviewed at Homer Research Laboratory after returning from Army Reserve training in the Ordnance Corps at Aberdeen Proving Ground. My master's thesis advisor at MIT, Professor John Elliott, helped me set this up. The lab was a really busy place and the cafeteria had a great view of the valley and big mill below. Nothing came of my visit, but I did find out that new hires were getting about a month of vacation, since the union had negotiated that for the hourly men.

Fast forward to the mid-1980s when I was working for Air Products outside of Allentown. I needed to get some tensile bond testing (ASTM C633) done for developmental thermal spray coatings and Homer Lab had the test machines to do it. I was shocked when I got there. The formerly bustling cafeteria and labs were nearly deserted. Our metallographer at Air Products had worked at Homer Lab and he believed there were two main reasons for Bethlehem Steel's fall:

- Licensing technology to the Japanese that they exploited better than Bethlehem did.
- Allowing non-inventors in the chain of command to add their own names to an engineer's patent application. There was a company limit on the total number of names per patent, so if too many of the brass climbed on board, the real inventor was bumped. This somehow reduced innovation.

I wonder if other ASM members could confirm this or weigh in on Bethlehem's demise with more information and opinions.

Robert Miller

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

OMG!
OUTRAGEOUS MATERIALS GOODNESS

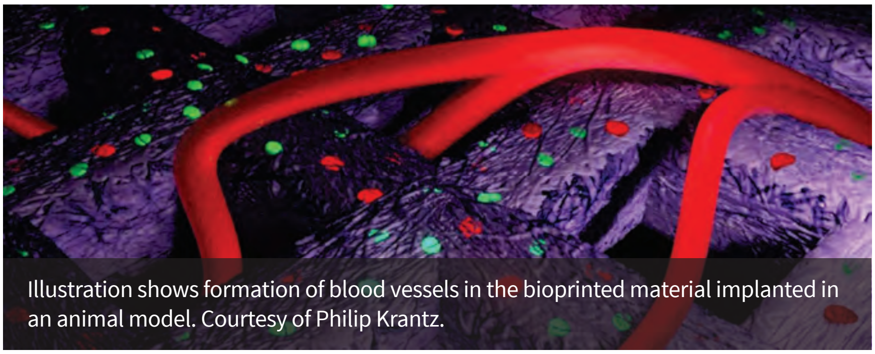


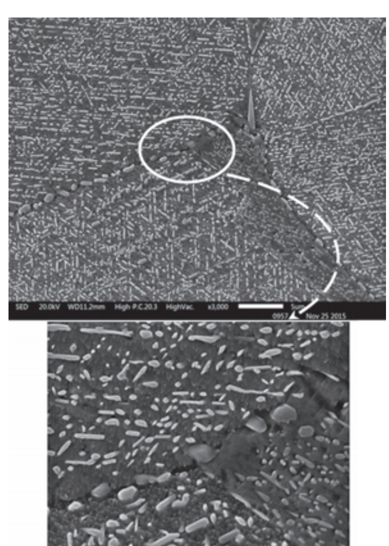
Illustration shows formation of blood vessels in the bioprinted material implanted in an animal model. Courtesy of Philip Krantz.

BIOPRINTING SPURS CARTILAGE CREATION

Using 3D bioprinting, researchers at Chalmers University of Technology and Sahlgrenska Academy, both in Sweden, successfully facilitated growth of human cartilage cells in an animal model. “This is the first time anyone has printed human-derived cartilage cells, implanted them in an animal model, and induced them to grow,” says Paul Gatenholm, professor of biopolymer technology at Chalmers. First, researchers printed a hydrogel of nanocellulose mixed with human-derived cartilage cells. Immediately after printing, the construct was implanted in mice. The team reports three positive results of the animal study: Human cartilage tissue grew in the animal model; blood vessels formed between the materials (vascularization); and neocartilage formed and multiplied via the human stem cells. *www.chalmers.se/en.*

NEW COPPER-BASE ALLOY IS VERY ATTRACTIVE

A team from Materion Corp., Cleveland, recently discovered a copper-base alloy system that exhibits magnetic behavior. The alloy—a quaternary mixture of copper with nickel, tin, and manganese—holds promise for applications requiring magnetic performance along with conductivity and formability. Copper alloys are characteristically nonmagnetic and transparent to magnetic fields, and also exhibit very low permeability, particularly when iron impurities are absent. This magnetic transparency favors use in electrical systems and magnetic sensing equipment such as directional drilling sensors for oil and gas. In contrast, the new alloy system shows potent age hardenability with the ability to modify magnetic properties by controlling the age hardening reaction. The alloy family includes strength combinations up to 1170 MPa (170 ksi) and a variety of magnetic hysteresis loop behaviors describing magnetic moment at saturation up to 1.4 emu and tailorable levels of remanence, coercivity, and permeability. Controlled supersaturation of Ni, Mn, and Sn produces precipitates during heat treatment, which allows the alloy to be magnetically switched on or off while modulating strength and ductility. *For more information: Michael Gedeon, mgedeon@materion.com.*



In a newly discovered copper-base alloy system, the precipitation reaction is key to tailoring strength and magnetics.

SPINNING A STURDIER WEB

New research shows that brown recluse spiders use a unique micro-looping technique to make their threads stronger than that of any other spider. The study was produced by scientists from the University of Oxford, UK, and the College of William & Mary, Williamsburg, Va. From observing the arachnid, the team discovered that unlike other spiders, who produce round ribbons of thread, recluse silk is thin and flat. This structural difference is key to the thread’s strength, providing the flexibility needed to prevent premature breakage and withstand the knots created during spinning that give each strand additional strength. The ribbon shape adds the flexibility needed to prevent premature failure, so that all the micro-loops give additional strength to the strand. By using computer simulations to apply this technique to synthetic fibers, the team was able to test and prove that adding even a single loop significantly enhances material strength. *www.ox.ac.uk, wm.edu.*

The brown recluse’s spinning technique could inspire tougher materials and textiles.

Are you working with or have you discovered a material or its properties that exhibit OMG - Outrageous Materials Goodness?
Send your submissions to Frances Richards at frances.richards@asminternational.org.

METALS | POLYMERS | CERAMICS

High performance materials and structures are needed for safe and affordable next-generation exploration systems such as transit vehicles, habitats, and power systems. Courtesy of NASA.

NASA LAUNCHES TECHNOLOGY INSTITUTES

NASA, Washington, selected proposals for the creation of two multidisciplinary, university-led research institutes that will develop technologies critical to Earth-independent space exploration missions. The Institute for Ultra-Strong Composites by Computational Design (US-COMP) is comprised of university faculty, industrial partners, and the U.S. Air Force Research Lab. It aims to develop and deploy carbon nanotube-based, ultra-high strength, lightweight aerospace structural materials for exploration applications such as next-generation transit vehicles, habitats, and power systems. These materials—which must be lighter and stronger than those currently used in even the most advanced systems—could support an array of applications on this planet as well. The Center for the Utilization of Biological Engineering in Space (CUBES) will advance research into a multi-function, multi-organism, bio-manufacturing system to produce fuel, materials, pharmaceuticals, and food, eliminating the need for resupply missions from Earth. Each institute will each receive up to $15 million from NASA's Space Technology Mission Directorate over a five-year period. *nasa.gov/spacetech.*

CERAMIC MANUFACTURING METHOD ROCKS EFFICIENCY

Materials scientists at ETH Zurich, Switzerland, developed a new cold sintering method of manufacturing ceramics inspired by the geological process that creates limestone. To create the ceramic, the scientists added water to a calcium carbonate nanopowder then compacted it at room temperature for just an hour—an approach far more energy efficient than typical firing processes, which require temperatures well above 1000°C. "Our work is the first evidence that a piece of ceramic material can be manufactured at room temperature in such a short amount of time and with relatively low pressures," says André Studart, professor of complex materials. So far, the scientists have produced material samples about the size of a quarter using a conventional hydraulic press, while larger workpieces require more pressure. Tests show that the new material can withstand about

BRIEFS

Bonnell Aluminum, Newnan, Ga., a subsidiary of **Tredegar Corp.,** Richmond, Va., acquired **Futura Industries Corp.,** Clearfield, Utah, for approximately $92 million. Futura designs and manufactures extruded aluminum products as well as OEM components for applications such as truck grills and solar panels. Futura will operate as a division of Bonnell. *bonlalum.com.*

Ryerson Holding Corp., Chicago, a distributor and value-added processor of industrial metals, acquired **Guy Metals Inc.,** Hammond, Wis., a metal service center. Guy Metals processes stainless and nickel alloy products including its trademarked "Pit Free Dairy" and "Super4" finishes used in food, dairy, pharmaceutical, and beverage applications. *ryerson.com.*

Zekelman Industries, Chicago, acquired **American Tube Manufacturing Inc.,** Birmingham, Ala. The deal expands the structural tubing market presence of Zekelman and its Atlas Tube operating division into the southeastern U.S. *zekelman.com.*

Ceramic sample compacted at room temperature. Courtesy of ETH Zurich/ Peter Rüegg.

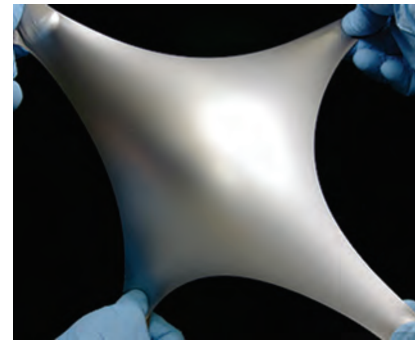
10 times as much force as concrete before failure, and is just as hard to deform as stone or concrete.

The cold sintering process could be a boon in the quest for carbon neutrality. Captured carbon dioxide could be used to produce the calcium carbonate nanopowder, and the ceramics produced could serve as substitutes for cement-based materials, which currently require energy-intensive production methods that generate large amounts of CO_2. *www.ethz.ch/en.*

NEW COMPOSITE IS A STRETCH

Researchers at Carnegie Mellon University, Pittsburgh, developed an electrically insulating rubber material that exhibits an unprecedented combination of thermal conductivity and elasticity. The key ingredient in the new composite—nicknamed "thubber"—is a suspension of nontoxic, liquid metal microdroplets. The liquid state allows the metal to deform with the surrounding rubber at room temperature. When the rubber is pre-stretched, the droplets form elongated pathways that are efficient for heat travel. To demonstrate these findings, the team mounted an LED light onto a strip of the material to create a safety lamp worn around a jogger's leg. The "thubber" dissipated the heat from the LED, which would have otherwise burned the jogger.

"Until now, high power devices have had to be affixed to rigid, inflexible mounts that were the only technology able to dissipate heat efficiently," explains Jonathan Malen, associate professor of mechanical engineering. The new material's combination of high thermal conductivity and elasticity—it can stretch to six times its initial length—is critical in applications such as wearable computing and soft robotics. Advanced manufacturing, energy, and transportation are other areas where stretchable electronic material could have an impact. *cmu.edu.*



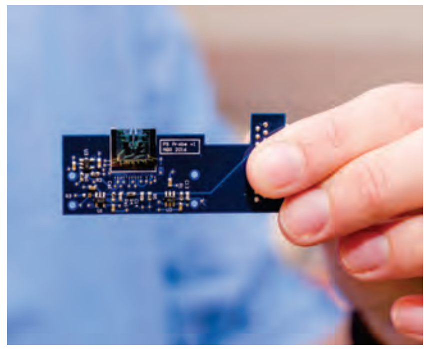
A new material called "thubber" exhibits both thermal conductivity and elasticity.

TESTING | CHARACTERIZATION

TINY MICROSCOPE TAPS POTENTIAL OF MEMS

Researchers at The University of Texas at Dallas created a prototype of a tiny atomic force microscope (AFM) on a chip using microelectromechanical systems (MEMS) technology commonly found in smartphone accelerometers and gyroscopes. The prototype 1-cm^2 AFM is attached to a printed circuit board about half the size of a credit card and operates in "tapping mode"—a tiny cantilever with a sharp tip oscillates up and down, scanning across a material's surface. While the amplitude of the oscillation wants to change with the sample's topography, the device maintains it, creating feedback that translates into a nanoscale image. This method prevents damage to the device and sample, which can occur in other AFM methods where constant contact occurs between the tip and surface.

Conventional AFMs are much larger, requiring lasers and other bulky components, and cost between $30,000 for educational versions to more than $500,000 for laboratory units. Because MEMS can be mass produced, the entire miniature AFM system could cost only a few thousand dollars. Developers foresee demand across a range of applications. For example, the semiconductor industry could use the tiny AFM to detect micro-faults on silicon wafer surfaces before shipment. *utdallas.edu.*



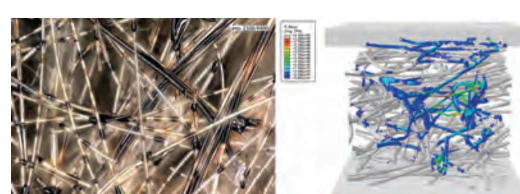
A new MEMS-based atomic force microscope is just 1 cm^2 in size (top center). Here it is attached to a small printed circuit board that contains circuitry, sensors, and other miniaturized components that control the movement and other aspects of the device. Courtesy of UT Dallas.

SIMULATION SEES DECADES INTO THE FUTURE

Scientists at Sandia National Laboratory, Albuquerque, N.M., are advancing quantitative prediction capabilities for brittle components to ensure they remain fully functional over a 30-year lifespan. Using a combination of experimental materials data and computer modeling, the Brittle Materials Assurance Prediction Program (BritMAPP) examines stress and loading, fracture mechanics, and the relationship between material properties and structure. BritMAPP researchers are currently analyzing glass-to-metal seals, which are vital to sending electrical signals through hermetic systems. While accurate qualitative predictions can be made about the performance of these seals, the next step is to validate lifetime predictions.

"If component designers just want to know, is Design A better than Design B, I can tell you that quickly," explains researcher Brenton Elisberg. "If you want to know more specifically if and when Design A is going to fail, then that's when we run a more complex

Brenton Elisberg, left, and Ryan Jamison look through a piece of cracked laminate glass, an example of how brittle materials can fail. Courtesy of Randy Montoya.



To show how simulation-based engineering can assist manufacturers, Purdue demonstrated to Knauf Insulation how mechanical loads are transmitted in porous glass fiber materials.

BRIEFS

Bruker, Billerica, Mass., acquired **Hysitron Inc.,** Minneapolis, a manufacturer of nanomechanical test instrumentation. The acquisition complements Bruker's existing portfolio of atomic force microscopes, surface profilometers, and tribology and mechanical testing systems. *bruker.com.*

Purdue University, West Lafayette, Ind., launched The Indiana Consortium for Simulation-Based Engineering of Materials and Structures (ICSEMS), comprised of engineering faculty and facilities. The consortium offers partnerships with Indiana-based manufacturers, providing technical expertise and infrastructure for computer modeling—specifically for stress and deformation analysis, fatigue and fracture, shape optimization, and materials selection. ICSEMS also offers education and training for the engineering workforce and a platform for running open-source simulation software. *purdue.edu.*

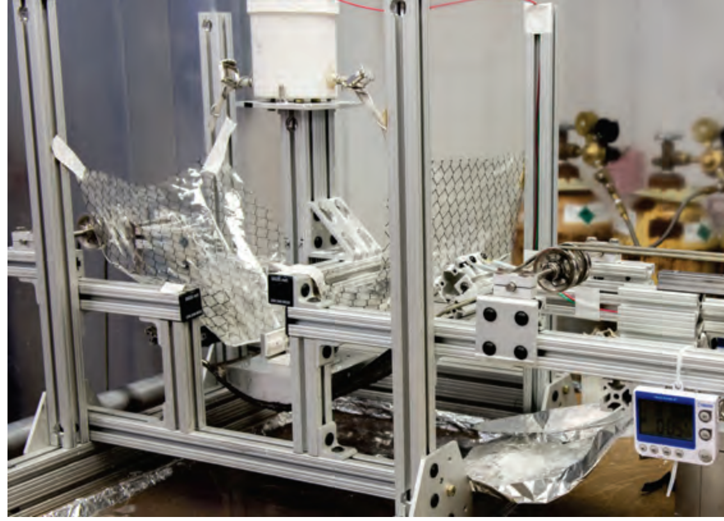
simulation." Due to more sophisticated modeling and ever-improving supercomputers, the team is on the way to doing just that. Elisberg recently ran hundreds of processors for 72 hours to simulate an extensive series of thermal test cycles—a feat that would have been impossible just two years ago. *sandia.gov.*

WHO'S THE THINNEST OF THEM ALL?

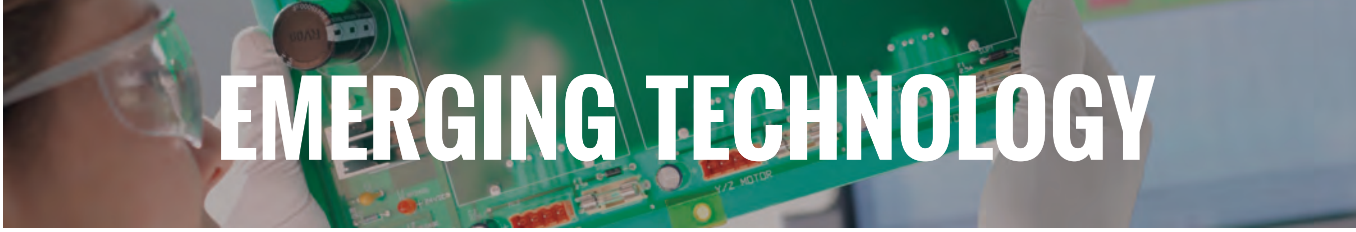
Scientists at NASA's Goddard Space Flight Center, Greenbelt, Md., created and proved for the first time a technique for manufacturing high-resolution, x-ray mirrors using single-crystal silicon. The development points to lightweight, super-thin mirrors that offer significantly larger collection areas and dramatically improved resolution over traditional mirrors—all at a reduced cost.

To create the mirrors, which must be curved and nested inside a canister-like assembly to collect highly energetic x-ray photons, astrophysicist William Zhang and his team heat a block of silicon and cut it to shape with a band saw. After its surface is ground and refined with machining tools and chemical methods, a substrate a fraction of an inch thick is sliced off. The surface is polished, and individual segments are coated with iridium to improve reflectance. Unlike typical optics materials that suffer from high internal stress when cut or shaped—especially as they become thinner—single-crystal silicon's lattice structure prevents it from deforming, and it is inexpensive and abundantly available, thanks to the semiconductor industry.

Zhang and his team are perfecting techniques for aligning and bonding 6000 mirror segments to form meta-shells to be integrated into a mirror assembly; their goal is to create six meta-shells and automate the alignment process. *nasa.gov.*



Scientist Will Zhang created a manufacturing facility to build a new-fangled x-ray optic made of silicon. Image shows the buffing machine used o remove imperfections from the mirror's surface. Courtesy of NASA/W. Hrybyk.



EMERGING TECHNOLOGY

T. rex tooth and an electron microscope image of the tooth enamel. Courtesy of Kotov Lab, University of Michigan.

TOOTH-INSPIRED MATERIAL TAKES THE SHAKE

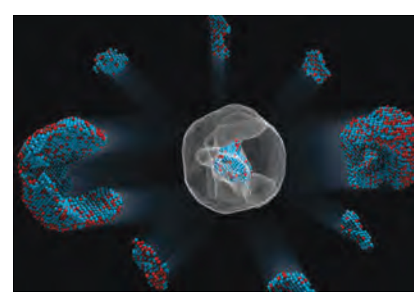
Researchers at the University of Michigan, Ann Arbor, designed a rigid material with exceptional vibration absorption capabilities modeled after tooth enamel. Enamel can withstand decades of impact due to its structure: columns of ceramic crystals infiltrated with a matrix of proteins set into a protective coating. When the stiff nanoscale columns bend under stress and press against the soft polymer surrounding them, friction occurs, and the large contact area dissipates energy that would otherwise be damaging. To recreate this structure, researchers grew zinc oxide nanowires on a chip then poured on layers of polymer. With each layer, the chip was spun to spread the polymer, then baked. It took 40 layers to build up a single micrometer of synthetic enamel, and to further increase the material's thickness, the whole process was repeated up to 20 times. The painstaking layering ensures that surfaces are perfectly mated—even nanoscale gaps between the polymer and ceramic reduce friction intensity.

Computer modeling confirms that vibrational forces are diffused through the polymer and column interaction, and the synthetic enamel prevents damage almost as well as real tooth enamel. "Artificial enamel is better than solid commercial and experimental materials that are aimed at the same vibration damping," explains Nicholas Kotov, professor of chemical engineering. "It's lighter, more effective, and perhaps less expensive." Kotov believes the material could be deployed in airplanes and other environments in which vibrations are inescapable. *umich.edu.*

3D ATOM MAP REVEALS BOUNDARY ISSUES

Using advanced electron microscopy and powerful reconstruction algorithms, physicists at the University of California, Los Angeles mapped the coordinates of more than 23,000 individual atoms in an iron-platinum nanoparticle. The team identified and located more than 6500 iron and 16,600 platinum atoms in the particle and determined that the atoms are arranged in nine grains, each of which contains different ratios of iron and platinum atoms. They also showed that atoms closer to the interior of the grains are more regularly arranged than those near the surfaces and that the grain boundaries are more disordered. When researchers fed the coordinates into quantum mechanics calculations, they observed abrupt changes in magnetic properties at the grain boundaries.

"Understanding the 3D structures of grain boundaries is a major challenge in materials science because they strongly influence the properties of materials," explains Jianwei "John" Miao, professor of physics and astronomy. "Now we are able to address this challenge by precisely mapping out the 3D atomic positions at the grain boundaries for the first time." The work makes significant advances in characterization capabilities and the understanding of structure-property relationships, and could find broad application in materials science as well as physics, chemistry, and nanotechnology. *ucla.edu.*



Identification of the precise 3D coordinates of iron, shown in red, and platinum atoms in an iron-platinum nanoparticle. Courtesy of Colin Ophus and Florian Nickel.

BRIEF

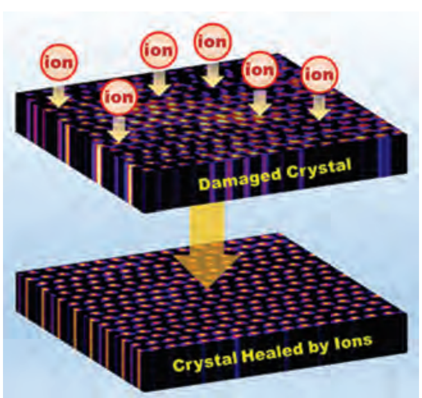
The Sir Henry Royce Institute for Advanced Materials, UK, received a government grant of £128 million (approximately $156 million) to support precision equipment and construction of state-of-the-art facilities, including a new hub at **The University of Manchester.** The institute will explore nine key areas grouped into four themes—energy, engineering, and functional and soft materials—and focus on the commercialization of fundamental advanced materials research. *www.royce.ac.uk.*

Illustration of the Henry Royce Institute. Courtesy of NBBJ and Vyonyx.

PROCESS TECHNOLOGY

HIGH-ENERGY HEALING

Scientists from Oak Ridge National Laboratory, Tenn., and the University of Tennessee, Knoxville, discovered that blasting silicon carbide with high-energy ions did not damage the material, but repaired preexisting defects in its atomic structure instead. The bombardment caused local heating along the ion path, resulting in a significant reduction in structural disorder at the microscopic and atomic scales. Typically, exposure of a material to energetic particles, such as ions or neutrons, creates defects as the incoming ions penetrate the material and knock its atoms out of position in the crystal structure. In this case, however, experimentation and atomistic simulations revealed that incoming high-energy ions lost energy not by colliding with the atoms themselves, but by transferring energy to the electrons in the atomic structure.

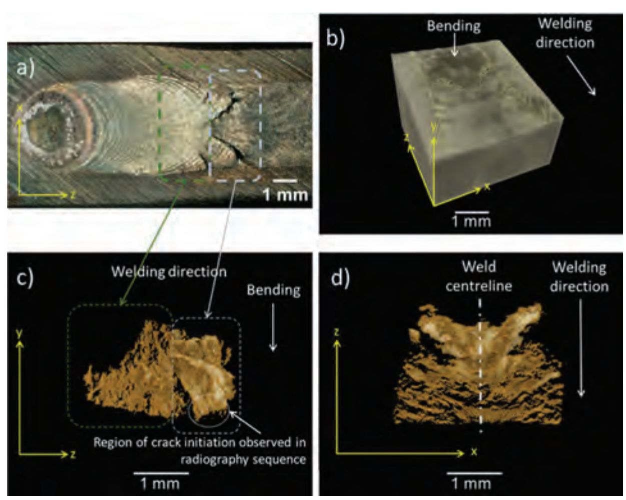


In this projected electron microscopy image, the previously damaged crystal (smeared spots in top slab) is bombarded with high-energy ions. Surprisingly, this process restores structural order (ordered bright spots in bottom slab) by annealing. Courtesy of ORNL.

Harnessing the thermally activated healing process could lead to in-operando repair of radiation damage in silicon carbide components used in nuclear and space applications. The discovery could also be applied to defects created by implantation doping during the fabrication of advanced electronic materials. Finally, the fundamental understanding of this energy transfer could contribute to improved performance predictions for materials exposed to high-energy ions during the manufacture of electronic devices and engineered nanostructures. *ornl.gov, utk.edu.*

WELDING FAILURE PROCESS OBSERVED

Researchers at the University of Leicester, UK, discovered the process by which solidification cracking occurs during steel welding. Using a synchrotron x-ray beamline at the European Synchrotron Radiation Facility, the scientists witnessed that cracks grow by linking microporosities in the meshing zone in the solidifying weld pool. It is the first time solidification crack formation was observed in real time.



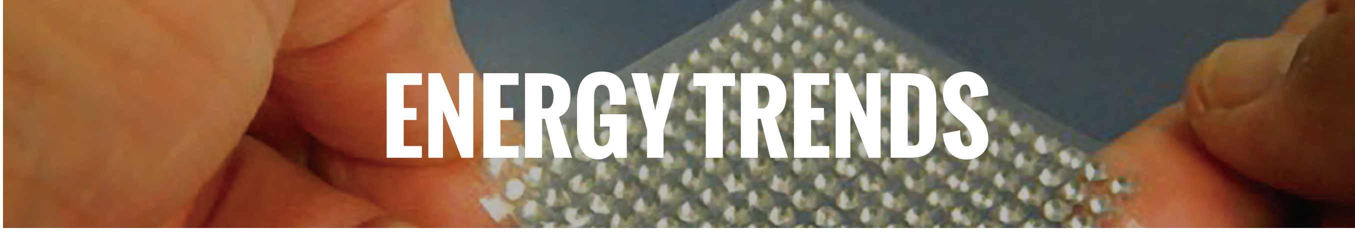
3D tomographic reconstruction and characterization of weld solidification cracks, showing: (a) macrograph of the sample weld containing solidification cracks, (b) 3D reconstruction of the crack containing volume, (c) Y-Z plane 2D view of the solidification crack network, and (d) weld centerline and welding direction. Courtesy of University of Leicester.

"Solidification/hot cracking is the most common failure mode during metal processing—such as welding, casting, and metal additive manufacturing," explains engineering professor Hong Dong. Insight into the process could lead to improvements in the shipbuilding, pipeline, automotive, aerospace, defense, and construction industries. *le.ac.uk.*

BRIEFS

The Industry Development Board of the **Metal Powder Industries Federation,** Princeton, N.J., redesigned the PickPM.com website to showcase technical data, application case studies, and white papers, along with additional resources. The site presents a case for why component engineers should opt for powder metallurgy over other metal forming solutions. *mpif.org.*

Air Products, Allentown, Pa., installed an advanced nitrogen supply sytem at **Boeing's** new 777X Composite Wing Center in Everett, Wash., for the world's largest autoclave. The system includes three 15,000-gallon liquid tanks and a steam sparged water bath vaporization system used to create the inert atmosphere and rapid pressure necessary to form and cure carbon fiber composite wings for the new 777X commercial jetliners. This is the third major autoclave project Air Products has completed with Boeing in the past three years. *airproducts.com/aerospace, boeing.com.*



ENERGY TRENDS

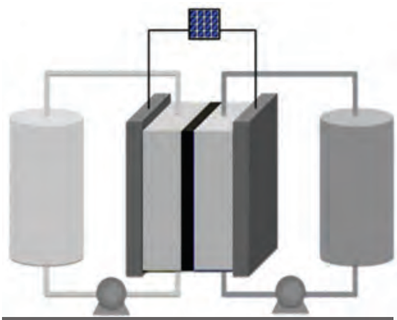


Diagram of a redox flow battery. Courtesy of Sharmila Samaroo.

GRID STORAGE BATTERY HAS GOOD CHEMISTRY

Chemists from The University of Utah, Salt Lake City, and University of Michigan, Ann Arbor, developed a charge-storing molecule 1000 times more stable than current compounds, paving the way toward a better redox flow battery. In this type of battery, anolytes and catholytes in solution are housed in two storage tanks separated by a central set of inert electrodes. As the solutions flow past the electrodes, they store or release charge. Because molecules that can store more charge tend to be less stable, choosing compounds for these batteries has been a challenge. Current redox flow batteries incorporate costly—and potentially toxic—vanadium.

To design and test other potential electrolyte molecules, the researchers enlisted a computational method common in pharmaceutical development that uses the structural features of a molecule to predict its properties. They found that a candidate compound decomposed when two molecules interacted with each other, but by tuning a factor describing the height of a certain molecular component, they could place a "deflector shield" around the candidate molecule: This shield prevents the interaction and increases stability. The team's most promising anolyte is based on the organic molecule pyridinium. While other compounds exhibit longer half-lives, this anolyte provides the best combination of stability and redox potential, which is directly related to energy storage capability. The team is working to identify a catholyte to pair with this and future molecules. *utah.edu, umich.edu.*

CLEAR IMPROVEMENT IN SOLAR CELL WINDOWS

Researchers at the University of Minnesota, Minneapolis, and University of Milano-Bicocca, Italy, developed a new method for creating photovoltaic windows using silicon. Instead of typical substances like indium, lead, or cadmium—which are either rare or potentially toxic—the team embedded silicon nanoparticles into luminescent solar concentrators (LSCs). LSCs on a window trap the useful frequencies of sunlight and concentrate them to the edges where solar cells hidden in the window frame capture the energy. While silicon is abundant in the environment and nontoxic, it does not emit light in its conventional bulk form. The researchers solved this problem by shrinking the silicon crystals to a few nanometers. At this size, silicon's properties change and it becomes an efficient light emitter that does not reabsorb its own luminescence.

The silicon nanoparticles—each containing fewer than 2000 atoms—are produced using a plasma reactor and formed into a powder, which is then used to make an ink-like solution. The solution is embedded in a polymer, which can be turned into a sheet of flexible plastic material or used as a thin film surface coating. The silicon particles are nearly perfectly compatible with the industrial process for producing the polymer LSCs, which can capture more than 5% of the sun's energy at unprecedented low costs. *twin-cities.umn.edu, www.unimib.it.*

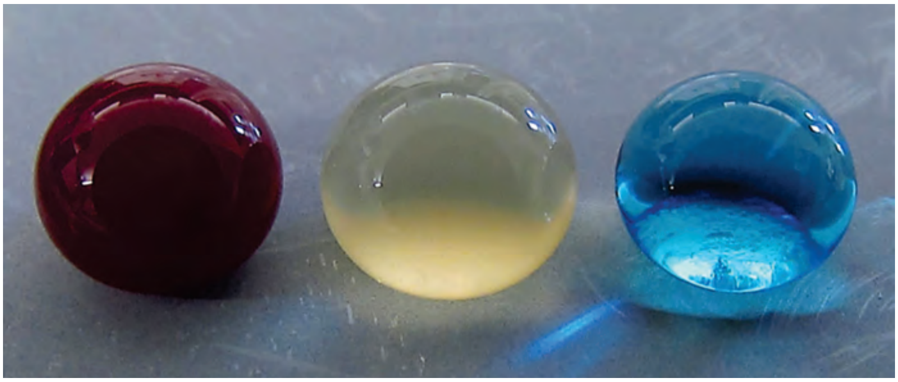
Samantha Ehrenberg uses a plasma reactor to create silicon nanoparticles for use in luminescent solar concentrators. Courtesy of Patrick O'Leary.

BRIEF

Ulsan National Institute of Science and Technology (UNIST), South Korea, secured $5 billion in research funding over three years from **Korea Electric Power Corp.** and **Korea East-West Power Co. Ltd.** to develop cost-efficient, high-stability batteries that store and produce electricity using seawater. *www.unist.ac.kr.*

Seawater battery pack developed at UNIST.

SURFACE ENGINEERING



From left, blood, plasma, and water droplets beading on a superomniphobic surface. CSU researchers created a superhemophobic titanium surface, repellent to blood, with potential applications in biocompatible medical devices.

SNEAKY SURFACE BAMBOOZLES BLOOD

Engineers at Colorado State University (CSU), Fort Collins, developed a specially grown, superhemophobic titanium surface that is extremely repellent to blood. The material could form the basis for medical implants with a lower risk of blood clotting—a complication that can ultimately lead to heart attacks, embolisms, or rejection by the body. Experiments on the titanium surfaces showed very low levels of platelet adhesion, a biological process that leads to clotting. After analyzing different textures and chemistries, and comparing the extent of platelet adhesion and activation, researchers determined that fluorinated nanotubes offer the best protection.

Biomedical scientists often use materials that are "philic" (with affinity) to blood to make them biologically compatible. In a counterintuitive twist, the CSU researchers created a surface so repellent that it can actually trick blood into believing it's not even there. "The reason blood clots is because it finds cells in the blood to go to and attach," explains Ketul Popat, associate professor of mechanical engineering and biomedical engineering. "If we can design materials where blood barely contacts the surface, there is virtually no chance of clotting." The researchers plan to continue examining other clotting factors and eventually test actual medical devices. *colostate.edu.*

BIO-INSPIRED COATING KEEPS IT CLEAN

Chemists at Johannes Gutenberg University Mainz (JGU), Germany, developed a protective coating containing cerium dioxide nanoparticles to prevent seawater fouling including the growth of bacteria, algae, or mollusks on marine vessels and structures. The coating is inspired by a chemical defense mechanism in algae, which uses its own secondary metabolic products to blockade receptors in other small marine organisms, preventing the other organisms from attaching to them by suppressing biofilm creation. The nontoxic, affordable, algae-inspired coating could replace currently used copper-base biocides, which are poisonous, accumulate in the environment, and lead to resistance.

To test the new coating, antifouling paints with and without cerium dioxide nanoparticles were applied to stainless steel plates. The painted plates, along with controls, were attached statically to a boat bridge with direct exposure to fresh water. After 52 days, the plates without cerium dioxide nanoparticles showed heavy fouling, but the plate with cerium dioxide coating did not. In addition to benefitting the shipping industry, which loses $200 billion a year to damage associated with fouling, cerium dioxide coatings could prove revolutionary anywhere undesirable biofilms can be found—from catheters to roof coverings to food packaging. *www.uni-mainz.de/eng.*

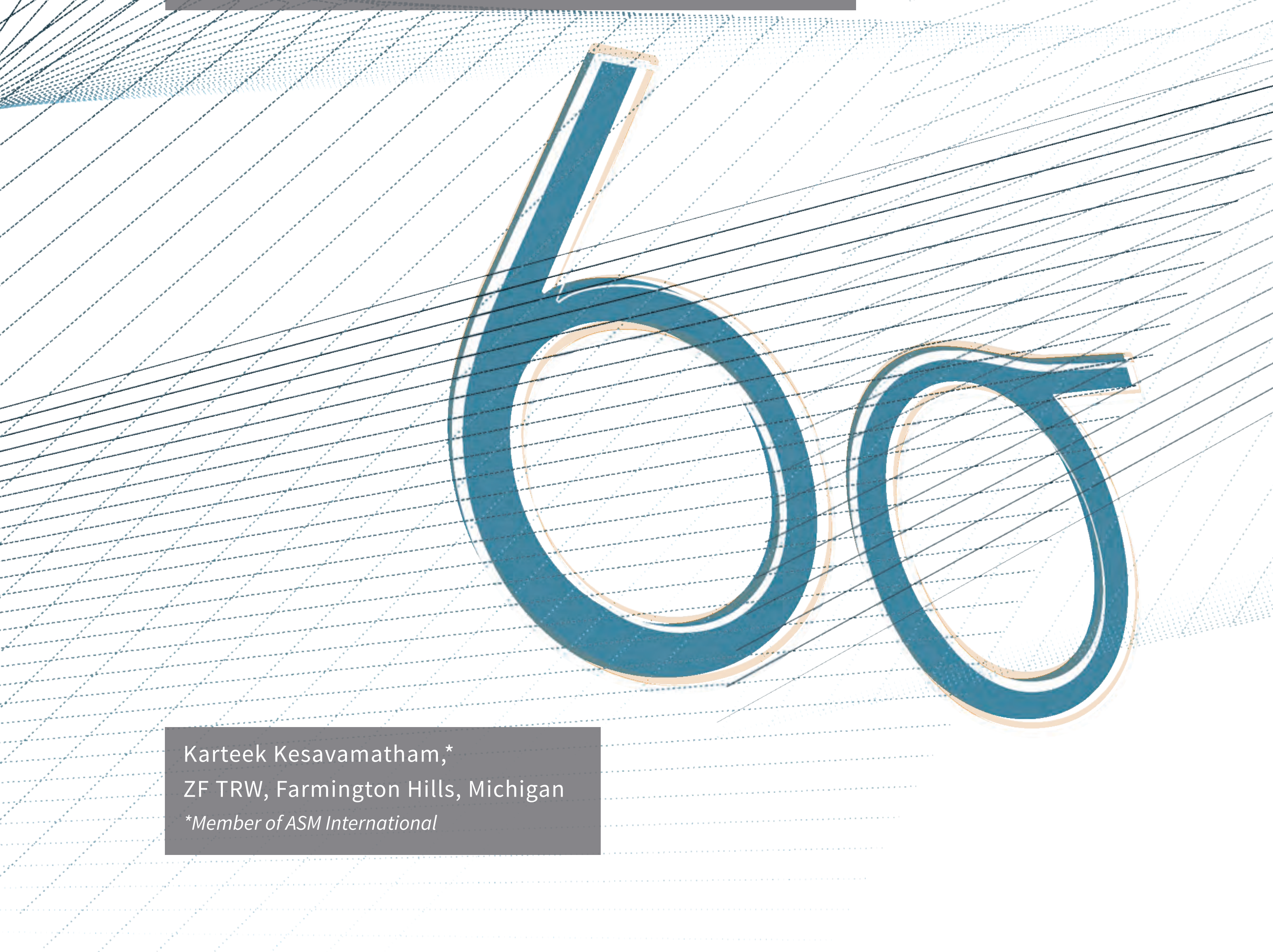
Illustration of the mode of action of bioinspired underwater paints: Like the natural enzyme vanadium bromoperoxidase, cerium dioxide nanoparticles act as a catalyst for the formation of hypobromous acid from bromide ions (contained in sea water) and small amounts of hydrogen peroxide that are formed upon exposure to sunlight, yielding reduced biofilm formation. Courtesy of Tremel Research Group/JGU.

BRIEF

Axalta Coating Systems, Philadelphia, a global supplier of liquid and powder coatings, will acquire **Century Industrial Coatings,** Jacksonville, Texas, a manufacturer of high performance industrial coatings for structural steel, oil and gas, rail cars, and other OEM applications. Terms were not disclosed. *axaltacs.com.*

SIX SIGMA PROCESS STREAMLINES MATERIALS SELECTION

Using a six sigma, statistics-based approach for selecting materials offers a unique way to compare different options for use in various applications.



Karteek Kesavamatham,*
ZF TRW, Farmington Hills, Michigan
**Member of ASM International*

Key factors to consider when selecting a new material for an application include a clear understanding of component and application requirements and component design aspects. This requires input from customer application experts and designers, which enhances the success of the materials selection process.

MATERIALS SELECTION PROCESS TEMPLATE

A template for the materials selection process is created by condensing the overall process. The template is a high-level flow chart designed to align with business goals and depict the involvement of different areas of the organization. It also identifies places where statistical tools are used in the selection process and exactly when each tool can be used. Figure 1 shows an example of a materials selection process flow chart.

VOICE OF CUSTOMER (VOC)

The VOC exercise is conducted to understand key application and component requirements. The first step is to create a customer selection matrix that represents all organizational functions related to producing the component. Customer selection segments/functions include mechanical, service, and product engineering; quality control; manufacturing; reliability; marketing and sales, purchasing; and supplier quality based on organization type and size.

After creating the customer selection matrix, a questionnaire related to component details is developed for use in interviewing each stakeholder (VOC interview). Interviews are conducted to obtain critical information and requirements from each organizational function. VOC addresses:

- Implications for customers
- Limitations associated with material search or change
- Customer needs and requirements
- Properties (e.g., mechanical) and service temperature capabilities
- Production limits such as design, assembly, and component manufacturing
- Durability requirements such as containment and component life
- Physical requirements such as weight, appearance, surface finish, and material consistency
- Current product strengths and weaknesses
- Product cost and performance tradeoffs

This information forms the technical requirements for the new material search initiative[1]. Interview responses are compiled and clarified to create key material requirements, which serve as input for a critical parameter tree (CPT). The voice of business is understood at this stage.

Key requirements derived from the VOC are translated into the CPT[5], which identifies application requirements and outlines measurable properties that are important to the material selection. CPT branches are straight and interact with each other. These interacting branches between critical measures provide key input for the materials selection requirements and technical specifications. Figure 2 shows a CPT used to select a material

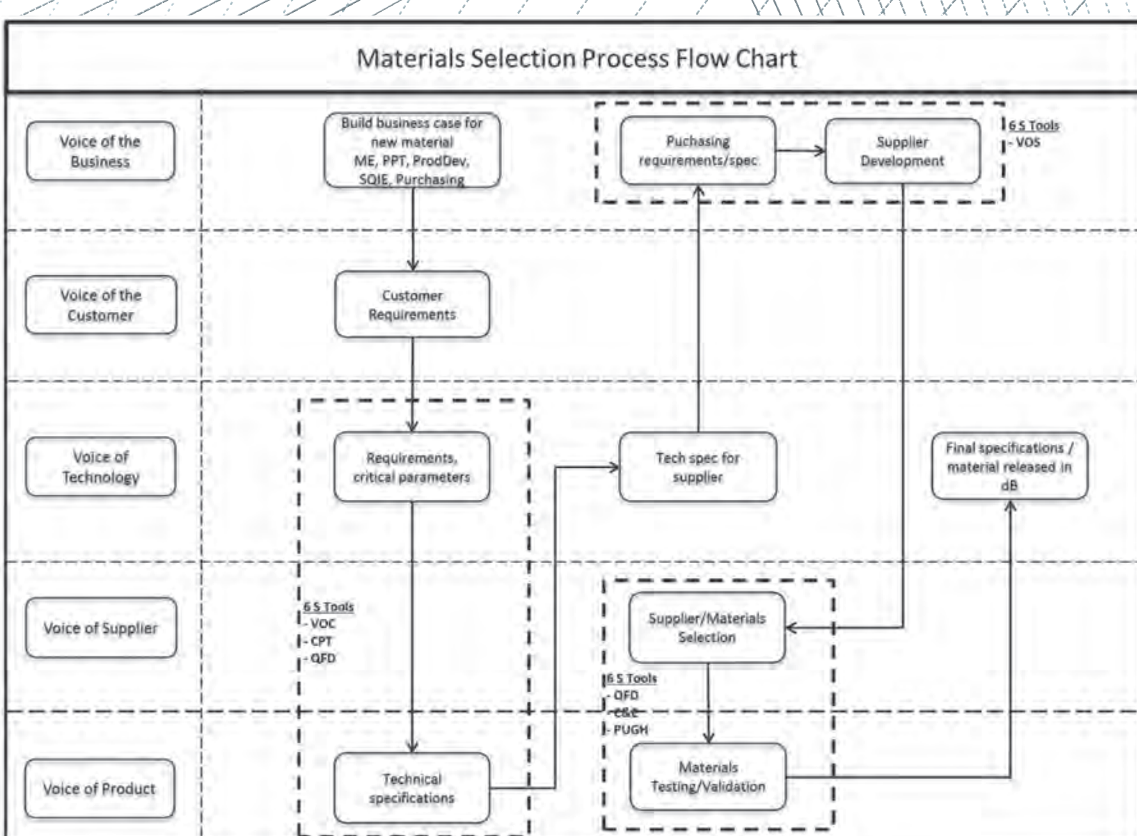


Fig. 1 – Selection process template for materials.

for a low-cost turbocharger compressor housing.

The top parameters on the CPT indicate key requirements formulated from VOC interviews. Second-level parameters are properties and aspects associated with the material, process, cost, and quality, which are key measures defined for the future materials that enable comparing different materials. These measures are narrowed down based on application requirements, which in turn are submitted to suppliers as technical specification requirements.

TECHNICAL SPECIFICATIONS

The technical specifications prescribe component operating conditions and performance requirements to materials suppliers to help them meet minimum property requirements when selecting an alternative material for the application or component. Nondisclosure agreements are required from suppliers before mutually sharing information.

VOICE OF SUPPLIER (VOS)

A potential supplier list is created from existing suppliers, purchasing department suggestions, and internet-based research. After submitting a technical specification and request for quotation (RFQ) to suppliers, VOS is conducted to understand supplier capabilities to deliver a strong candidate material(s) and correct manufacturing process[2]. The technical specification and CPT are used in interviewing and capturing supplier voices and the materials they offer. The questionnaire includes a purpose, objective, and interview guide. The VOS document completely outlines each supplier's capability to provide the correct material, with specific requirements including:

- Material options and availability
- Mechanical and physical properties and service temperature capability
- Material and manufacturing cost
- Manufacturing options (manufacturing steps)
- Production limits (e.g., design, assembly, and component manufacturing)
- Durability requirements (life of the material)

Supplier interviews and input from the supplier's engineering departments result in a list of material possibilities for the component or application.

QUALITY FUNCTION DEPLOYMENT (QFD)

The methodology of QFD[4] as a tool for new product development is useful in concept engineering. The QFD exercise is aimed at understanding how

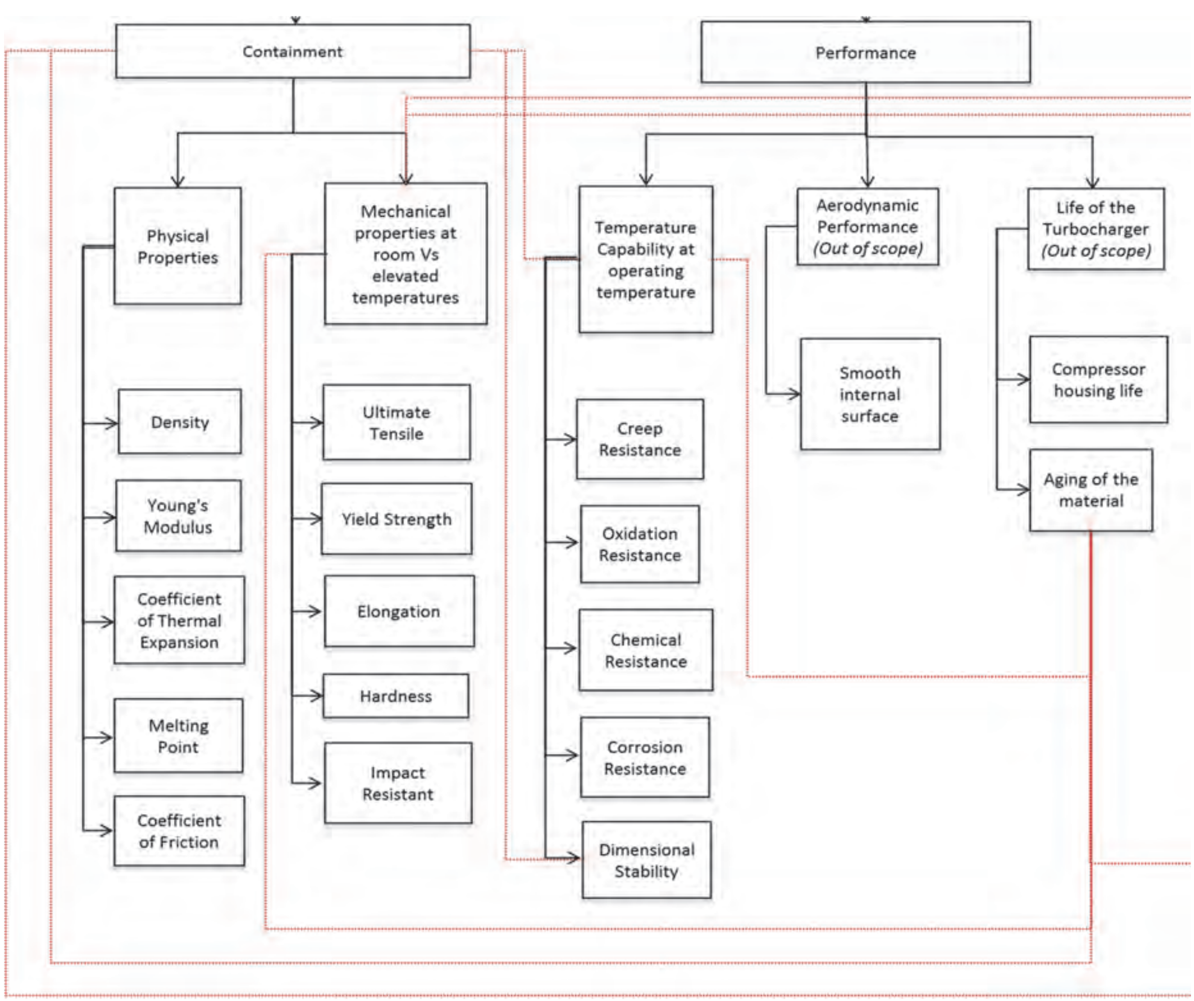


Fig. 2 – Section of a critical parameter tree.

VOC/customer requirements deploy throughout and establish quality measures for the requirements mentioned previously. QFD helps to graphically clarify objectives, interactions, and links derived from CPT. It documents decisions made in early stages of concept selection. QFD lists customer requirements/VOC and determines prioritization. It also identifies functional product requirements, derives relationships between VOCs and requirements, calculates priorities for requirements, and identifies technical correlations to determine the benchmark (technical requirements in this case).

QFD sets targets for functional product requirements (new materials considered in this case) based on technical requirements from the VOC. The vertical columns on the left of the QFD (Fig. 3) show various requirement levels. The blue level requirement is the final goal of material selection. The red level customer requirements show the attributes of the application/product/design. The black level customer requirements show the relevant properties for the red level requirements, and importance ratings (between 1 and 10) are given for the black level requirements to formulate a customer's priority of properties. The horizontal row shows "critical to quality" measures, which are the material's physical and mechanical properties rated by 0, 1, 3, and 9 to create a wide spread of properties for comparison. Out-of-scope aspects of the selection process can be rated with low scoring, and need not be evaluated during material comparison rating.

The QFDs in Figs. 3 and 4 are separated for ease of viewing in the article. In general, a QFD is one matrix with all the details. Based on the QFD matrix, the benchmark section (Fig. 4) shows a comparison of materials against technical requirements or current performance. By this stage of the process, all information about material choices has been evaluated, material properties provided by the supplier are verified by in-house testing, and material concept

				Critical to Quality Measures																	
Blue Level Customer Requiremen	Red Level Customer Requirement	Black Level Customer Requirements	Importance Rating (In the Eyes of the Customer from 1-10 with 10 being most important)	Density	Young's modulus	Coefficient of thermal expansion	Melting point	Coefficient of Friction	Ultimate tensile strength (Mpa min)	Yield strength	Elongation (%)	Hardness (HB)	Impact resistance	Creep resistacne	Chemical and corrosion resistance	Surface finish measurement	Material cost	Material recycling cost	Number of steps in fabrication	Fabrication equipment cost	Time consumption for manufacturin
		Direction	(+ or -)																		
Material Selection	Containment	Physical properties	8	9	9	9	9	9	1	1	1	1	3	1	0	3	1	1	1	1	1
		Mechanical properties at elevated temperature	10	1	3	1	9	3	9	9	9	9	9	9	3	0	1	1	1	1	1
	Performance	Aerodynamic performance	9	0	0	1	3	1	0	0	3	0	0	3	3	9	1	1	1	1	1
		Life of the turbocharger	5	3	3	3	3	3	3	3	3	3	9	9	9	0	1	1	1	1	1
	Assembly	Resistance to loading	8	1	3	3	3	1	9	9	9	3	3	9	3	1	1	1	1	1	1
		Resistance to wear	2	3	3	3	9	0	9	9	9	9	3	9	9	1	1	1	1	1	1
		Ease in assembly	3	1	1	3	1	3	1	1	3	3	3	1	3	3	1	1	3	3	3
		Service of the turbocharger	1	1	1	3	3	3	1	1	3	3	3	3	3	3	1	3	1	3	1
	Cost	Base material cost	7	1	1	1	3	3	3	3	3	3	3	3	3	3	9	9	3	3	3
		Manufacturing Process	7	3	1	3	3	3	3	3	3	3	3	1	3	9	9	9	9	9	9
		Recycling of the material	1	1	1	1	3	3	3	3	3	3	3	3	3	1	9	9	0	0	0
		Manufacturing lead time (development cost)	4	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	9	3	9
	Quality	Quality control of the supplier	7	1	1	1	1	1	3	3	3	3	3	3	3	3	9	1	9	9	3
		Rating Importance Score		151	173	184	304	198	273	273	308	233	267	318	222	245	244	190	235	213	193
		Current Performance / "Us Now"																			
		Competitor 1 Performance																			
		Competitor 2 Performance																			
		Competitor 3 Performance																			
		Units																			
		Target Performance																			
		Ratio - Competitor / US																			
		Technical Importance Rating																			
		Company Weighted Importance Rating (Rating Importance Score * Ratio)		151	173	184	304	198	273	273	308	233	267	318	222	245	244	190	235	213	193
		% of Total (Use as customer importance in QFD 2)		4	4	4	7	5	6	6	7	6	6	8	5	6	6	4	6	5	5

Fig. 3 – Quality function deployment (QFD) template showing various levels of requirements and critical measures.

Rating Importance Score	318	308	304	245	273	273	267	244	222	235	233	213	198	193	190	184	173	151
Current Performance / Sand cast Al alloy		3.0	660		260	186	55.0		2		60					22	71	2.6 8
Supplier 1 - Material Option 1		3.5	576		317	170	56.0		2		75					21	71	2.6 3
Supplier 1 - Material Option 2		3.5	568		324	165	47.0		2		80					21	71	2.7 1
Supplier 2 - Material Option 1		2.4	282		245		55.0		4							25	17	1.6 2
Supplier 2 - Material Option 2		3.0	275		210		52.0		4							20	13	1.4 9
Supplier 3 - Material Option 1		3.0	280		195		53.0		4							19	15	1.6 5
Supplier 4 - Material Option 1		3.0	510		240	160	48.0		2		70					26	45	1.8 1
Units		%	°C		Mpa	Mp a	kJ/m2(charpy un-notched)		Rati ng		BH N					µm/m per °C @ 23 C	Gp a	gm/ cc
Target Performance		3.0	660		260	186	9.0		5		60					22	71	2.6 8

Fig. 4 – Benchmark section of QFD.

selections are narrowed down to four or five choices.

MAKING SELECTIONS

Materials concept selection. All materials information and relevant properties from suppliers and in-house testing data are collected and loaded into the QFD benchmark section of the matrix to compare properties and rate key properties to be input into both the PUGH matrix and cause and effects (C&E) matrix.

PUGH concept selection. The PUGH matrix[6] is constructed using the current material grade or current technical requirement as the datum point. Key measures or properties of the materials selected are compared against the datum. Scoring is performed based on materials properties evaluation, rated as "+" indicating better than the current datum, "S" meaning similar to datum, and "-" meaning worse than datum. After the PUGH matrix is populated based on the criteria, ranking for each material choice is derived for a concept

Criteria/Concept	Concept						
	Datum						
	Current Choice	Supplier 1 - Material 1	Supplier 1 - Material 2	Supplier 2 - Material 1	Supplier 2 - Material 2	Supplier 3 - Material 1	Supplier 4 - Material 1
Elongation x Tensile Stregth at room temperature	S	+	+	-	S	-	S
Elongation x Tensile Stregth at 220°C	S	+	+	-	-	-	S
Melting Point	S	S	S	-	-	-	S
Tensile Strength	S	+	+	S	-	-	S
Tensile Strength @ 220°C	S	-	+	-	-	-	-
Impact Stregth	S	S	-	S	S	S	-
Corrosion Resistance	S	S	S	+	-	-	+
Coefficient of Thermal Expansion	S	S	S	+	+	+	+
Young's Modulus	S	S	S	-	-	-	-
Young's Modulus @ 220°C	S	+	+	-	-	-	-
Density	S	S	S	+	+	+	+
Surface Finish	S	+	+	+	+	+	+
Aging	S	S	S	-	-	-	-
Materials Cost	S	+	+	+	+	+	+
Total Σ +	0	6	7	5	4	4	5
Total Σ –	0	1	1	7	8	9	5
Total Σ S	14	7	6	2	2	1	4
Total	0	5	6	-2	-4	-5	0
Rank	3	2	1	5	6	7	3

Fig. 5 – PUGH concept selection matrix.

	Customer: ______	Rating of Importance to Customer (low 1- high 10)	10	9	8	1	5	4	3	3	6	2	
			1	2	3	5	7	8	9	10	11	12	
	Process Sub Step (if applicable)	Inputs	(Elongation x Tensile Stregth) at room temperature	(Elongationx Tensile Stregth) at high temperature	Tensile Strength	Corrosion Resistance	Coefficient of themal expansion	Young's Modulus	Density	Surface Finish	Aging	Materials Cost	Total
1		Current Performance	3	3	9	3	3	9	1	1	3	1	209
2		Supplier 1 - Material 1	9	9	9	3	3	9	1	3	3	3	333
3		Supplier 1 - Material 2	9	9	9	3	3	9	1	3	3	3	333
4		Supplier 2 - Material 1	3	1	9	9	3	1	9	9	1	9	217
5		Supplier 2 - Material 2	3	1	3	9	3	1	9	9	1	9	169
6		Supplier 3 - Material 1	3	1	3	9	1	1	9	9	1	9	159
7		Supplier 4 - Material 1	3	3	9	3	3	3	3	3	3	3	201
Total			330	243	408	39	95	132	99	111	90	74	

Fig. 6 – C&E concept selection matrix.

selection. An example of a PUGH matrix is shown in Fig. 5.

Cause & Effects (C&E) concept selection. The C&E matrix[7] is also constructed using the data and information from the supplier and in-house testing. Key process inputs are used to create an importance rating. Scoring is based on materials properties evaluation. The resulting concept selection matrix for current performance compared with new materials is given by the C&E matrix. The criteria for each material choice are rated on a scale of 1 to 10 based on importance to the customer. Each material concept is rated using 0, 1, 3, and 9, with 9 showing a strong correlation. The matrix displays total scoring for each material concept based on which selection can be made.

At this point, concept selection can be narrowed down based on rankings and ratings from PUGH and C&E matrices. An example of a C&E matrix is shown in Fig. 6.

SUMMARY

Using a six sigma, statistics-based approach for selecting materials offers a unique way to compare different options for use in various applications. The materials selection template is used to identify the optimal process and supplier. The statistical tools are fairly easy to use and provide a clear picture of how to capture the correct voices within a business to create the key requirements a material must meet. CPT and QFD tools lay out critical-to-quality measures translated as material properties linked to key requirements. QFD provides the first point of differentiation between materials, and benchmarks current performance and current requirements. PUGH and C&E matrices evaluate material choices and define clear ranking between materials. At this point, materials can be selected based on the final ranking defined by PUGH and C&E. The material selection process template also identifies critical points where these statistical tools should be used. This type of selection process is both quick and effective. **~AM&P**

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References

1. M.F. Ashby and K. Johnson, *Materials and Design, the Art and Science of Materials Selection in Product Design*, Butterworth-Heinemann Ed., Oxford, UK, 2002.

2. K.G. Swift and J.D. Booker, *Manufacturing Process Selection Handbook*, Butterworth-Heinemann Ed., Oxford, UK, 2013.

3. T. Pyzdek and P. Keller, *The Six Sigma Handbook*, McGraw-Hill, 3rd Ed., 2010.

4. G.L. Duffy and J.W. Moran, *Quality Function Deployment*, Am. Soc. for Quality, 2010, http://asq.org/quality-press/display-item=E1382.

5. *Critical to Quality – CTQ*, iSixSigma, http://www.isixsigma.com/dictionary/critical-to-quality-ctq/.

6. *PUGH Decision Matrix*, Am. Soc. for Quality, http://asq.org/learn-about-quality/decision-making-tools/overview/decision matrix.

7. R. Pereira, Cause & Effect Matrix, Gemba Academy, 2007, <blog.gemba-academy.com/2007/06/11/need-help-making-decisions/>.

LEADERSHIP ROLES FOR MATERIALS ENGINEERS STEADILY EVOLVING: ARE YOU READY?

Today's materials engineering leadership role is expected to expand and have a greater impact on evolving the organizational, technological, and strategic initiatives of original equipment manufacturers.

Satyam S. Sahay, FASM, John Deere Technology Center India, Pune*

The number of materials engineers is not expected to significantly grow in the future, but their influence on the way materials are selected, used, sourced, and manufactured in a company will undergo a structural shift with considerable business impact. Further, the scope of materials engineering leadership will broaden from component and subsystem level work to influence on product, strategy, and business goals. This evolution together with technology megatrends such as materials analytics, modeling, optimization, and Industry 4.0 (IoT) will significantly transform the conventional view of the materials engineering function as a quality sub-function—with emphasis on experience and experiments.

CURRENT STATE

Direct material cost is the highest cost item for an original equipment manufacturer (OEM) of automotive, agricultural, and construction equipment. Four significant OEM materials decisions include:

1. Materials research (introduction of new materials or process)
2. Materials selection for a component or assembly
3. Materials processing
4. Materials sourcing

However, only one of these decisions is driven by materials engineering in OEMs (Table 1). Unfortunately, the role of materials engineering is reactionary in many of these decisions, i.e., fixing wrong materials decisions made by other functions. Even the introduction of new materials or processes, which is typically performed by materials engineering, requires synergy and maturity of design, supply management, manufacturing, and quality functions for transitioning to business.

Traditionally, the OEM materials engineering function has 4E characteristics: (1) expertise and experience based decisions, (2) experiment based decisions, (3) emergency problem solving, and (4) external supplier dependency. Most materials engineering decisions are derived from functional experience plus laboratory and shop-floor experiments. Materials engineers are continually "putting out fires" on product issues in the field or at the customer (failure analysis) and on the manufacturing line due to this reactionary approach. Many of these issues are attributed to decisions made at an earlier stage of design, manufacturing, and procurement without appropriate materials engineering input. With today's increased emphasis on outsourcing, there is greater dependence on external suppliers for many key materials processes and workflow decisions, resulting in a loss of important OEM competencies and skillsets. Further, materials engineering functions operate primarily at the component or subsystem level, resulting in limited influence and impact.

IMMENSE POSSIBILITIES AND BUSINESS IMPACT

New skillsets and an encouraging environment provide an unprecedented opportunity for materials engineering

TABLE 1 – KEY OEM MATERIALS DECISIONS AND RESPONSIBLE FUNCTIONS

Key materials engineering decisions	Function driving decision
Materials research	Materials engineering
Materials selection	Design function
Materials processing	Manufacturing engineering
Materials sourcing	Supply management function

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leadership to have an impact on all four OEM materials related decisions. Some possibilities and real examples follow.

Materials research. Generally, the OEM materials engineering R&D team is responsible for identifying appropriate opportunities to introduce new materials and processes to the organization. The challenge is to identify newly mature technologies and specific components and processes that could impart business value. Mere generic identification of technology trends, e.g., nanomaterials, additive manufacturing (AM), or lightweighting, is not sufficient for successful adoption by the organization. For example, although AM is near the required maturity level for business implementation, the challenge lies in specific organizational opportunities where it can be successfully implemented with sufficient value. Even at current manufacturing cost levels, AM has been successfully leveraged in low-volume, high-performance critical aerospace components that cannot be produced using traditional manufacturing methods. Other AM applications include low-volume production parts made without investing in tooling costs, producing agriculture machinery parts, rapid prototyping in product development, and making tool fixtures.

Another factor to consider before adopting new materials or processing technology is the simultaneous maturity of all associated functions[1]. Bottlenecks for technology adoption many times are due to functions other than materials engineering. For example, adopting nanobainitic steel (a steel with extraordinary strength and ductility) requires a designer's acceptance for a specific application, a structural analyst's acceptance in terms of materials properties and failure criteria, acceptance of materials standards and quality criteria, the OEM's ability to form and handle this high strength material, and possibly the most difficult aspect of ensuring a supply chain to scale up the use of the special material at an acceptable cost (Fig. 1).

Similarly, adopting adhesives to replace welded structures requires changes in the OEM manufacturing line with guidelines for failure criteria and analytical procedures. Structural applications of carbon fiber-reinforced composites include high-end sports cars, boats, and aerospace components. Carbon-fiber composites are also used in agriculture machinery, such as self-propelled sprayers with higher boom width. The lightweight structure results in significant weight reduction, enabling a 25% increase in sprayer tank capacity, which enhances productivity. High customer value justifies the use of this expensive material.

Product engineering. Emergence of integrated computational materials engineering (ICME) provides opportunities for the materials engineering function to have an impact on OEM product development. ICME is a computational framework that integrates design, materials, and manufacturing during product development and creates value at their point of juncture (Fig. 2). Value creation arises from engineering realization through an accelerated development cycle and/or reduced product cost[2].

ICME has been leveraged for functional design of specific alloy grades and functional coatings, as well as design optimization. The approach can be leveraged at multiple scales including efficient design of specific components. Figure 3 shows an integrated ICME framework, where design, process, and product verification phases are coupled to realize an optimal, robust component[3]. In the framework, design and FEA steps are combined with the correct tooling and process for the purpose of optimization, which significantly reduces the design-FEA iteration cycle and enables optimal product design. Further, cost and performance are incorporated for a holistic design to evaluate multiple materials and design concepts. Instead of the prevalent heuristic approach, the framework also provides opportunities for rational materials and process selection for a specific component, resulting in significant cost and weight reductions in castings, welded fabrications, and heat treated components. For example, Fig. 4 shows a tractor production part optimized through this approach, with ubstantial cost reductions and attractive ROI.

Further, ICME predicts and includes effects of the manufacturing process (e.g., residual stress from carburizing or shot peening) in the design stage for optimal, robust components

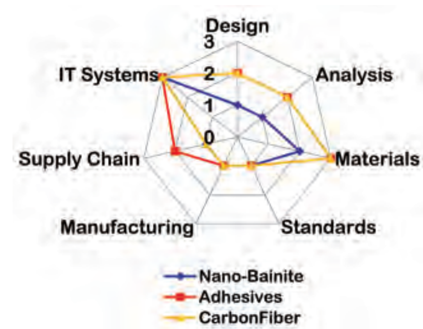

Fig. 1 — Multifunctional maturity is required to successfully adopt new materials and processes.

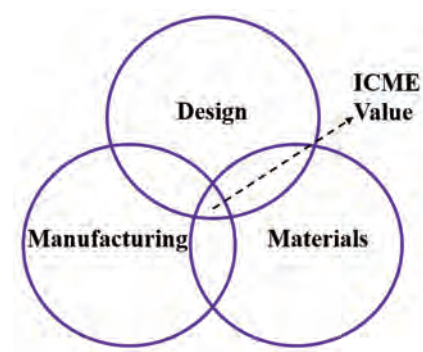

Fig. 2 — ICME value creation at the junction of design, materials, and manufacturing through a computational framework.

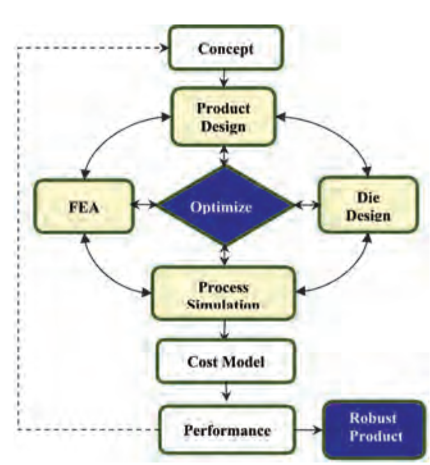

Fig. 3 — Integrated framework for design optimization including simultaneous materials and manufacturing considerations[3].

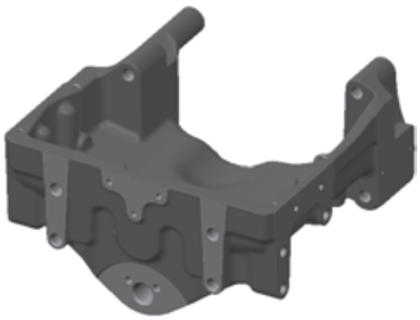

Fig. 4 — Production part for a tractor developed through design optimization and rational materials selection.

(Fig. 5). Considering the improvement in fatigue life due to residual compressive stress, this active feedback approach in the design phase could result in weight reduction of 12% for a carburized shaft and 5-8% for a shot peened shaft[4]. Another example of product impact is the development of a sugarcane harvester from system level modeling of wear mechanisms, understanding of a materials wear map, and machine-crop interactions[5]. This industry-leading innovation is expected to significantly reduce wear on the harvester cutting blades—the second highest operating expense after fuel costs[6].

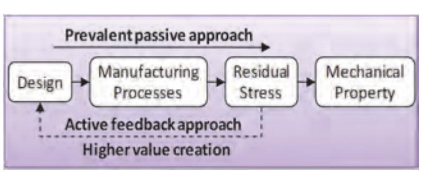

Fig. 5 — Active feedback loop for anticipating and incorporating manufacturing-induced changes in the design process for robust, optimal products[4].

Other possible impacts of product engineering include rationalizing materials grades and thicknesses and developing specific ground level application maps for materials, processes, and treatments. These solutions must be deployed appropriately in the product development cycle, PLM tool sets, standards, and designer guidelines so that manufacturing can be systematically scaled up to create significant value.

Manufacturing operations. A significant amount of material, process, production, and quality data is generated in modern manufacturing operations, which are primarily used for process audits and troubleshooting specific batches with quality issues. These rich data sets can be better used to generate insights for process optimization to improve manufacturing efficiency and product quality for overall reduction in operating costs (Fig. 6).

Big data, data analytics, and data-based modeling approaches (neural network, principal component analysis, and other advanced statistical methods) are emerging to analyze manufacturing operations. The effectiveness of this approach is described in the literature[7], where manufacturing data together with domain understanding are synthesized with physics and data-based modeling approaches to generate insight for process optimization and control. This work results in tangible business value in terms of enhanced operational productivity, proactive furnace maintenance, recipe rationalization, and operational cost reduction.

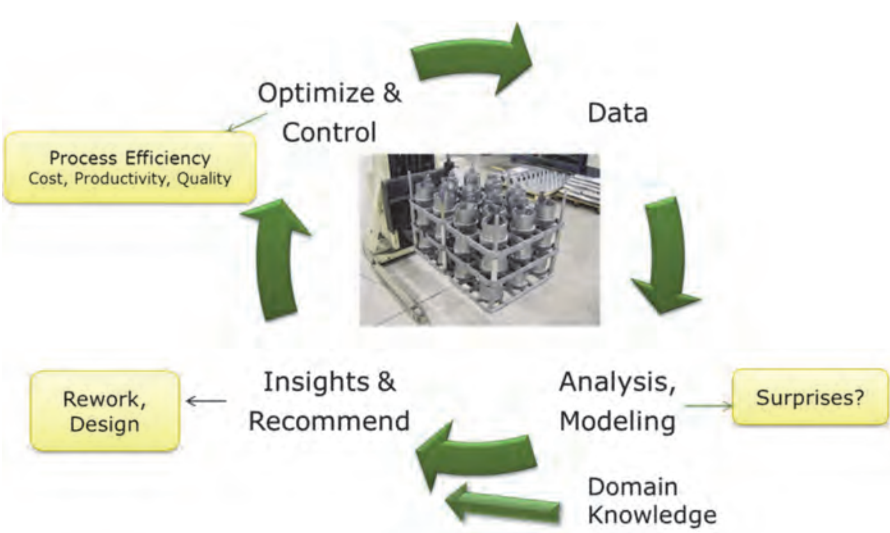

Fig. 6 — Approach to process analytics, integrated modeling (data and physics based), and optimization for industrial processes[7].

Further, the emergence of Industry 4.0 can have a significant impact on materials processing operations such as heat treatment[8] and foundry operations. The most significant difference would be a mindset change in considering the heat treating process as part of the connected production operation instead of the prevalent silo view. A connected gearmaking process is illustrated in Fig. 7.

Heat treating data, which is typically used for quality audit purposes, would be leveraged to provide part-level data-sharing for improved pre- or post- operations. Transferring specific data (e.g., chemistry data from the steel mill and casting) could provide better control of reheating, annealing, and carburizing operations, which in turn would help mitigate or manage distortion in these precision components. Also, identifying the location of specific components in batch type operations would help to design better recipes for machining and finishing operations. Such individualized solutions at the part level would bring transformational change to quality control at the product level. One of the biggest changes in the heat treating operation is recipe management, which is now heuristically driven. The large amount of production and quality data and their mathematical models would help in developing self-learning and self-evolving heat treating recipes, suiting current production and quality needs with due consideration of current furnace health and operating conditions. When aligned with the overall Industry 4.0 vision, these changes would also make heat treating operationally efficient with robust quality products.

Supply management. Materials engineering could play a significant role by providing strategic input to the materials-sourcing and supply-management function. In multinational companies with global operations and multiple product platforms, the supply chain network is very complex. Materials engineering could strategically support the standards group in rationalizing material grades to be used for all products. In addition, by identifying equivalent local grades at key supply chain nodes, substantial cost reduction can be achieved without incurring special grade material cost. Further, advanced analytics can identify similar parts, comparing specific costs and detecting cost-outliers with structural reduction in direct materials cost.

Another issue is that commodity prices of different materials undergo significant price fluctuations. For example, during the past decade the price of nickel (a key element of drivetrain steel grades) nearly tripled and then fell back to lower levels. Materials engineers could create dynamic preferred materials grades with criterion on material cost cutoffs to trigger alternate grades during a high commodity-price cycle, acting as a safeguard against commodity pricing swings. Multifunctional synergy among supply management, IT, and materials engineering for a strategic shift in data- and knowledge-based sourcing strategy could unlock unprecedented OEM business value.

DEVELOPING FUTURE TALENT

As mentioned previously, future materials engineering teams can significantly influence and impact OEM business results. However, different competencies and skillsets must be developed. There is a significant shortage of skilled engineers in conventional areas (materials selection, physical and mechanical metallurgy, casting and solidification, heat treating, powder metallurgy, ferrous and nonferrous metals, polymers and elastomers, composites, and special materials), which are needed for successful OEMs. These foundational capabilities must be revisited with respect to new perspectives of analytics, modeling, optimization, IoT, and Industry 4.0 framework. Also, a solid understanding of the business value chain, product, and associated functional influence is necessary to be successful in a leadership role. Such a skillset transformation (Fig. 8) would make materials engineering more contemporary and exciting, and help with effective management of functional knowledge with an enhanced impact on the organization.

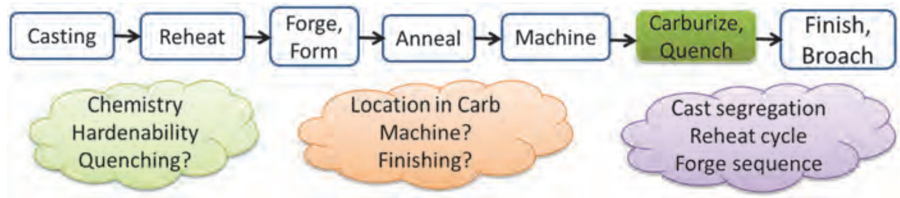

Fig. 7 — Process chain for gearmaking, also showing the way heat treating operations are integrated into the chain[8].

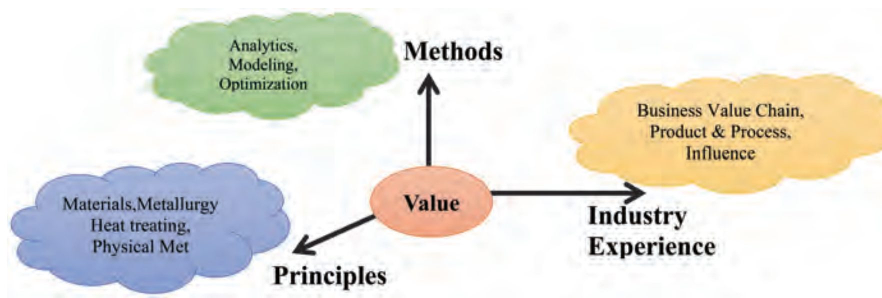

Fig. 8 — Modern materials engineering competencies needed to be successful within an OEM.

SUMMARY

The materials engineering leadership role within OEMs is expected to transform into a role of influencer for materials research, product engineering, manufacturing, and supply chain. This requires new skillsets and competencies regarding analytics, modeling, and optimization, which would supplement the conventional approach of experiments and experiential problem solving. Leadership focus should aim for proactive identification of opportunities to bring structural changes in the way materials are selected, specified, used, manufactured, and sourced within OEMs, which will have an unprecedented impact on business. **~AM&P**

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References

1. J.D. Evans and R.O. Johnson, Tools for Managing Early-Stage Business Model Innovation, *Res. Tech. Mgmt.*, Sep-Oct, p 52, 2013.

2. M.F. Horstemeyer and S.S. Sahay, Defining ICME, *ICME: Industrial Applications*, M.F. Horstemeyer (ed.), (in preparation).

3. S.S. Sahay and M. El-Zein, Technology Vision: Residual Stress Engineering for Leaner, Greener And Safer Design, *Surf. Eng.*, 27, p 77-79, 2011.

4. S.S. Sahay, *ASM Handbook,* Volume 4D, *Heat Treatment of Gears*, p 204-218, ASM International, 2014.

5. G. Mohapatra and S.S. Sahay, *ASM Handbook*, Volume 18, *Friction, Lubrication and Wear Technology,* ASM International, (in press).

6. J.P. Scrivner, et al., Dual Function Basecutters, U.S. Patent Application Publication No. US 2016/0073580 A1, March 17, 2016.

7. S.S. Sahay, Analytics, Modeling and Optimization of Industrial Heat Treating Processes, *Adv. Matls. & Proc.*, Vol 172, No. 3, p 44-47, 2014.

8. S.S. Sahay, Industry 4.0 Meets Heat Treating, *Adv. Matls. & Proc.*, Vol 174, No. 10, p 59-61, 2016.

A NEW INTERNATIONAL STANDARD FOR TESTING ANTIBACTERIAL EFFECTS

Development of international antibacterial standards will greatly benefit societ by helping industry produce goods with better antibacterial, anti-biofilm, an anti-biofouling properties.

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Chamaecyparis obtusa, a type of cypress known as *hinoki* in its native Japan, is prized for the quality of its wood. Since ancient times, hinoki has been the preferred building material for architectural structures of all sizes, including the iconic pagodas in Nara, Japan, still standing after 1300 years. Hinoki is naturally resistant to decay because it contains aromatic compounds that defend the wood—and anything nearby—from insects, microorganisms, and toxins. Russian biochemist Boris P. Tokin spent decades in the early 1900s investigating the nature of these fragrant plant-based chemicals, for which he coined the term *phytoncide,* meaning "exterminated by the plant." Researchers later determined that some of these compounds are produced continuously without provocation, while others, namely *phytoalexins,* are synthesized in response to pathogenic attacks. What we now know about phytoalexins may help explain hinoki's extraordinary longevity: Studies show these phytoalexins can puncture the cell walls of invasive microorganisms, disrupt their metabolism, and even prevent reproduction.

Fig. 1 – The five-story pagoda on the grounds of the historic Horyuji Temple in Nara, Japan, is among the oldest wooden structures in existence, dating back more than 1300 years. The resilience of this ancient building lies in the material from which it is constructed, a type of cypress with a natural defense system that repels insects, withstands toxins, and keeps harmful bacteria and fungi in check. Courtesy of Urabe Research Laboratory, Japan, www.uraken.net.

ANTIBACTERIAL EFFECTS AND KOHKIN

In Japan, where hinoki originates, the term *Kohkin* can be used to describe the enduring protection provided by phytoalexins and phytoncides, particularly their antibacterial action. It may also be used in a more technical sense in reference to the suppression and control of bacterial growth as it applies to manufactured products. Here, however, the term takes on a much more specific meaning. Kohkin is unique in that it does not require the killing or complete elimination of microorganisms as do other classifications of sanitization (Table 1). What it implies is a more natural state of balance between harmful and healthy bacteria. For Japanese consumers, this distinction has strong appeal and product marketers have been quick to take advantage of it.

Recognizing the potential for abuse and a subsequent market crisis, not to mention intractable product liability issues, the Society of International Sustaining Growth for Antimicrobial Articles (SIAA) created an international test standard, ISO 22196[2],

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TABLE 1 - ANTIBACTERIAL EFFECTS AND THEIR DEFINITIONS[1]

Technical term	Definitio
Kohkin	Inhibition of bacterial growth on product surfaces.
Sterilization	Broad killing of microorganisms.
Pasteurization	Killing of microorganisms such as bacteria and viruses.
Disinfection	Killing/elimination of all pathogenic microorganisms.
Eradication	Elimination of microorganisms from a certain substance or limited space.

to scientifically verify product marketing claims in regard to the Kohkin effect. SIAA's role in maintaining the integrity of Kohkin products is shown in Fig. 2, while the test procedure for measuring antibacterial effectiveness is presented in Fig. 3.

The accepted process for measuring the Kohkin effect, often called the "film covering method," is so named because test samples are coated with a bacterial solution and covered with a polymer film. Samples are incubated for 24 hours at 35°C, then bathed in sterilized water to create a suspension that is further diluted by a controlled amount. To determine the number of viable bacteria, lab technicians spread a small amount of the dilution across the surface of an agar medium, letting it incubate as before. The number of colonies that form per unit area is then used to quantify the antibacterial properties of the test material or treatment[4].

BIOFILMS: A STICKY SITUATION

Although the ISO 22196 test procedure is useful, and perhaps the only international standard that measures the antibacterial effect of materials, it sheds only a limited amount of light on the interactions between materials and bacterial growth. For example, it cannot fully answer why material surfaces would lose their Kohkin (antibacterial) effect over time or why different environments would cause the antibacterial properties of a material to change. Nor can it explain the many surface effects where bacteria play a dominant role but do not act alone. Such is the case with a phenomenon known as "stickiness" that has plagued mankind for millennia.

Stickiness is a surface property stemming from the development of films due to bacterial activity. The formation and growth of such films is illustrated in Fig. 4. Organic compounds that inevitably accumulate on material surfaces are a target for bacteria, which make their way to the nutritional source through a process called chemotaxis (Fig. 4-1). When the amount of bacteria in a given region reaches a certain level (Fig. 4-2), the organisms simultaneously excrete polysaccharide, producing a film consisting of bacteria, exopolymeric substanes (EPS), and water (Fig. 4-3). Although "biofilms" are mostly water, the presence of EPS—a combination of polysaccharides, proteins, lipids, and nucleic acids—makes them sticky.

This stickiness is behind some of the most pervasive and costly problems in industry, including corrosion and the formation of scale on the inner walls of pipes. It also has a significant impact on the cost of healthcare because it makes bacteria more difficult to control. Bacteria encased in a biofilm typically have

Fig. 2 – SIAA, an industry association, serves as a resource for product manufacturers, testing institutions, government and consumer organizations, and suppliers of antimicrobial, fungicidal, and antibacterial agents, helping them maintain test standards for antimicrobial effectiveness and classification[3].

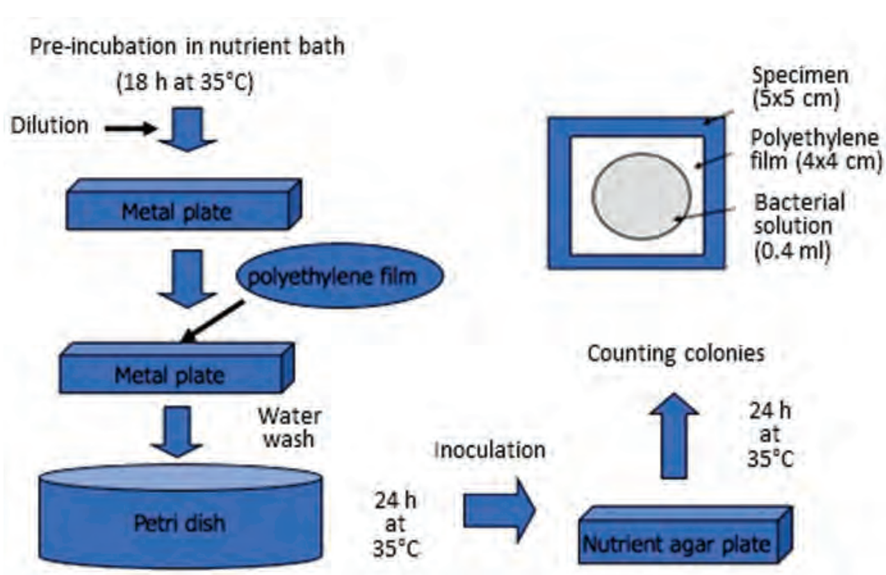

Fig. 3 – The ISO 22196 test procedure, shown in schematic form, employs a process called the "film covering method" that measures the antibacterial or Kohkin effectiveness of material surfaces and treatments.

a strong resistance to biocides and antibiotics that would otherwise easily kill them. Despite the many problems attributed to biofilms, there are instances where film development can have a positive effect. For example, biofilms on fish reefs and seaweed beds provide protection from environmental threats.

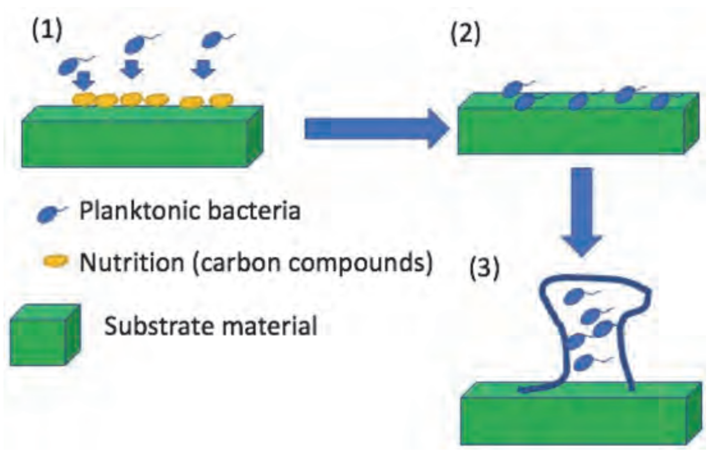

Fig. 4 – Bacteria drawn to organic compounds on material surfaces produce biofilms by excreting polysaccharides when present in sufficient numbe s.

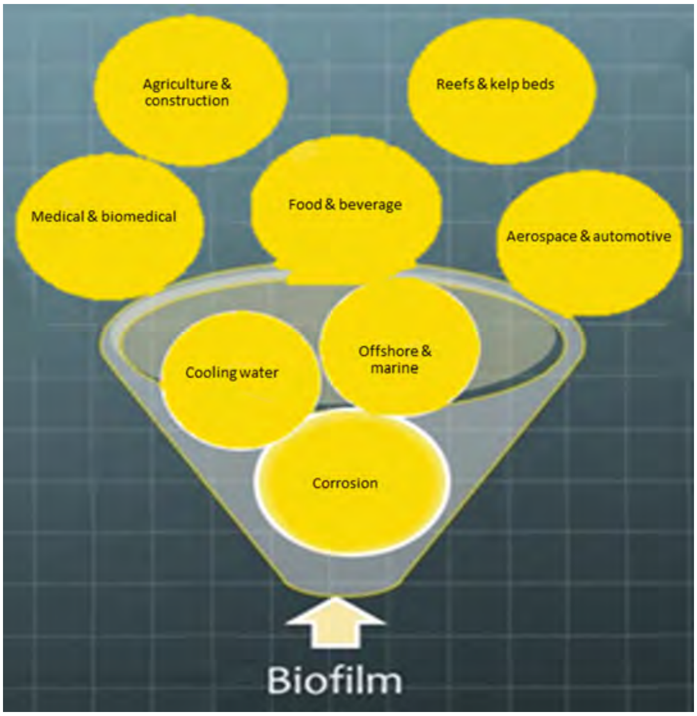

Fig. 5 – Biofilms are implicated in numerous problems plaguing industry and society in general. They can also be employed for good, however, to protect beneficial microorganisms such as those found on coral reefs and kelp beds.

Whether the goal is to prevent or promote biofilm growth, the market potential for materials that do one or the other is huge with numerous applications (Fig. 5). The development path for such materials, however, is currently impeded by a lack of standards for measuring a material's ability to control biofilm formation and growth. Although a few test standards associated with biofilms exist, as noted in Table 2, they do not apply to the rigorous R&D that would be required to bring anti-biofilm materials to market.

SETTING A NEW STANDARD

A few years ago, a standards committee organized by SIAA set out to address the need for an anti-biofilm test standard. Its two-fold objective was to better understand the biofilm formation process as it relates to materials and gain proficiency with test methods that can reliably measure the degree of fouling associated with biofilm growth.

The combination of process knowledge and evaluation expertise is essential to the development of new anti-biofilm and anti-biofouling materials, as well as any standard that would apply (Fig. 6). Such knowledge and know-how is indeed evident in a key background document describing a series of investigations undertaken by Kanematsu et al.[5-7] Several concepts in the emerging standard are based on this work, although the standard promises to be more universal and would apply to any organization in any market.

At the time of this writing, the committee is engaging in full-scale research to finalize the first draft of the proposal. The goal is to produce a standard that can be used not only by engineers in industry, but also by testing organizations and academic researchers.

TABLE 2 - ASTM STANDARDS RELATED TO BIOFILMS

Standards	Purposes	Sources
E2562	Biofilm formation and quantification (continuous flow reactors)	www.astm.org/Standards/E2562.htm
E2871	Evaluating disinfectant efficacy (single tube method)	www.astm.org/Standards/E2871.htm
E2196	Biofilm formation and quantification (rotating disk reactors)	www.astm.org/Standards/E2196.htm
E2647	Biofilm formation and quantification (drip flow reactors)	www.astm.org/Standards/E2647.htm
E2799	Evaluating disinfectant efficacy (MBEC assay)	www.astm.org/Standards/E2799.htm

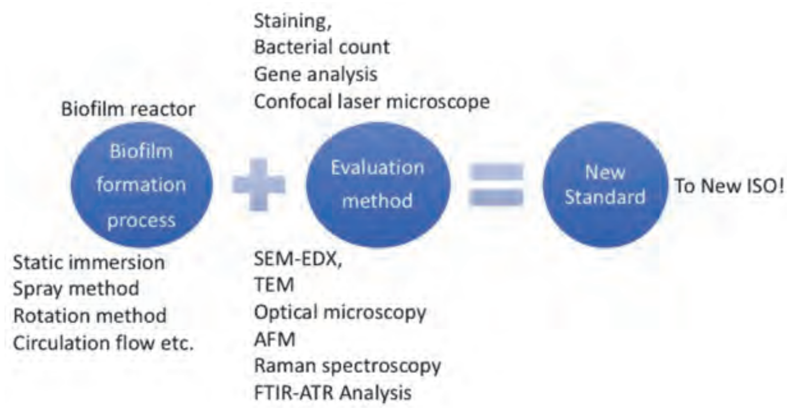

Fig. 6 – An emerging test standard that conveys a deep understanding of biofilm formation and characterization is expected to aid in the development of new anti-biofilm and anti-biofouling materials.

In November, the authors plan to hold an international workshop in Nara, Japan, where experts will discuss the new proposal and finalize a draft. The historic pagodas standing outside will silently attest to the importance of this work.~**AM&P**

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References

1. E.B. Coy, Measurement of Transient Heat Flux and Surface Temperature Using Embedded Temperature Sensors, *J. Thermophys. Heat Transfer,* Vol 24, No. 1, 2010.

2. SIAA web page: What is SIAA? http://www.kohkin.net/en_index/en_siaa.html.

3. SIAA web page: What is Kohkin? http://www.kohkin.net/en_index/en_antibiotic.html.

4. ISO 22196, Measurement of Antibacterial Activity on Plastics and Other Nonporous Surfaces, http://www.iso.org/iso/catalogue_detail.htm?csnumber=54431, 2011.

5. H. Kanematsu, H. Ikigai, and M. Yoshitake, Evaluation of Various Metallic Coatings on Steel to Mitigate Biofilm Formation, *Int. J. Mol. Sci.,* Vol 10(2), p 559-571, 2009.

6 H. Kanematsu and M. Yoshitake, Nanocomposite Coating for Antibacterial Purposes, Handbook of Nanoceramic and Nanocomposite Coatings and Materials, p 498-513. Elsevier: Oxford, UK, 2015.

7. H. Kanematsu and D.M. Barry, Biofilm and Materials Science. Springer, 2015.

TECHNICAL SPOTLIGHT

PUTTING WELDS TO THE TEST

Advanced instrumentation combined with effective test procedures gives manufacturers an edge in measuring and analyzing welds.

If it wasn't for metal welds, our world would literally fall apart. Yet most people are largely unaware of the incalculable load and responsibility that welds bear for our safety, satisfaction, and well-being. Nor are they likely to appreciate the high cost of weld failures and the relentless pursuit to improve the tools and techniques available to industry to measure the strength and longevity of metal welds. *Advanced Materials & Processes* spoke with Keith Thompson, product manager of microanalysis for Thermo Fisher Scientific, who not only understands the need for better tools and methods, but is working with others to do something about it.

AM&P: Can you discuss the importance of measuring metal welds and the implications for industry?

KT: Welds can be the weakest point in fabricated metal structures. And the welding process itself can degrade the properties of metals and alloys due to microstructural changes caused by the heating and cooling cycle. It is quite common for manufacturers to conduct hundreds of tests on weld development, using optical microscopes, for example, to check welds for cracking, porosity, and general integrity. In addition, air testers and dyed water tests are used to probe for leaks, while mechanical pull tests are used to measure weld strength. But if the tests detect only symptoms and not the cause, which is often the case, welds that pass inspection at the factory may still fail earlier than expected in the field.

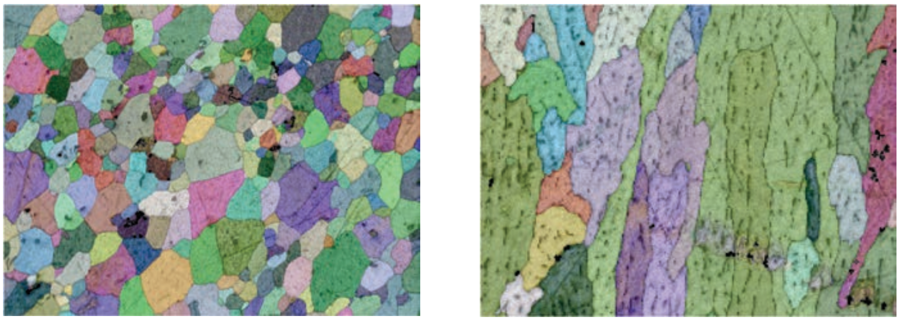
AM&P: What are some of the challenges manufacturers face in their weld testing processes?

KT: Many manufacturers conduct lifetime tests by running products until failure. Automakers, for example, will drive test vehicles in different environments and under a variety of conditions until a part fails. Then they take the part and spend months trying to improve it before running additional tests, then repeat the process. This kind of symptomatically driven "make it and break it" development process can take two to five years to wring out a design—an unacceptably long time, especially in the highly competitive automotive market.

In order to minimize tradeoffs between time-to-market and product reliability, safety, and service life, industry as a whole is investing heavily in developing analytical instrumentation technology and test procedures that more directly and reliably expose root causes of failures. These efforts are paying off. In the case of metal welds, manufacturers now have access to powerful imaging techniques such as electron backscatter diffraction (EBSD), meaning they no longer have to wait for parts to fall off test vehicles or develop discernible cracks to begin fixing them. Instead, they just need to put a weld sample under a scanning electron microscope and look for telltale microstructural changes.

AM&P: Could you give us an example of a microstructural change caused by welding?

KT: Grains in metals tend to be nonpreferential in shape and direction, which is why metals are isotropic by nature, exhibiting properties that are the same in any direction. Now if I join two pieces of metal with a weld bead that goes from left to right, the grains along the weld are likely to become larger, possibly more elliptical in shape, and aligned to the right (Fig. 1a and 1b). The resulting structure might be stronger in the direction of the weld, but weaker laterally. I can confirm this using EBSD on a weld sample by applying a force in



(a) (b)

Fig. 1 – EBSD Euler maps reveal microstructural changes in aluminum caused by welding. Note the differences in grain size and orientation between (a) the bulk material and (b) that in the weld region.

the lateral direction and examining the grains to see if they buckle.

Insights obtained at the microstructural level are particularly helpful in the strategically important area of lightweighting. Aluminum is a very light material, but it lacks the strength of iron. To make up for that, manufacturers often add strengthening elements, such as manganese or copper. These impurity atoms are mobile, though, and may be driven away from weld joints by the heat of the process. As a result, the aluminum in the vicinity of the weld joint may revert to its original weaker state. Manufacturers can screen for that as well, however, using EDS (energy-dispersive x-ray spectroscopy) in conjunction with EBSD to simultaneously examine the microstructure and chemical composition of the weld joint. The concentration of the impurity elements in the area of the weld, revealed by EDS, is an indicator of the joint's relative strength.

AM&P: What can be done to make advanced weld testing more accessible to industry?

KT: Like anything new, it starts with education. Industry, academia, and professional organizations need to work together to train both the current and future workforce, teaching engineers and technicians how to use new analytical tools and how to develop and implement best practices for weld test procedures. This, in fact, is the goal of a joint effort between Thermo Fisher and the University of Wisconsin, in which some of our applications scientists are working with undergraduate MSE students analyzing aluminum welds and developing test protocols. Under the direction of Sindo Kou, professor of materials science and engineering at the UW-Madison College of Engineering, and with the help of our scientists, students are getting hands-on experience with the latest EDS and EBSD technology while developing real-life materials analysis project management skills.

Sindo Kou, professor of materials science and engineering at the University of Wisconsin-Madison College of Engineering.

Over the course of the project, which spans the 2016-2017 academic year, students will have analyzed multiple sample preparation techniques, experimentally determining which is most effective. Each sample undergoes the same test. The student selects a point in the weld area and makes 3000 consecutive acquisitions, using an automated sequencer that varies the beam current and measurement duration. The goal is to determine the ideal sample preparation technique and the settings or patterns that achieve the highest level of measurement success with the shortest acquisition times.

AM&P: What is driving the need to develop and disseminate best practices for using advanced equipment?

KT: Not long ago, the majority of materials scientists in industry had a Ph.D. and years of training on sophisticated equipment that they alone used. Today, however, companies want more of their employees to be able to operate advanced instrumentation and they want it to be relatively easy. As a result, makers of scientific instruments are expected to provide not only highly automated equipment that tunes and calibrates itself, but also application processes and workflows that nearly anyone can put to use. **~AM&P**

For more information: Keith Thompson is product manager of microanalysis, Thermo Fisher Scientific Inc., 525 Verona Rd., Madison, WI 53711, 608.276.5603, keith.thompson@thermofisher.com, www.thermofisher.com/pathfinder.

Thompson

MAY 16 & 17

SMST2017

PARADISE POINT | SAN DIEGO, CA, USA

SHAPE MEMORY AND SUPERELASTIC TECHNOLOGIES CONFERENCE AND EXPOSITION

The International Conference on Shape Memory and Superelastic Technologies (SMST), a biennial forum for the engineered materials community, will be held at the Paradise Point Resort & Spa in San Diego from May 15-19. The conference is intended to facilitate the spread of knowledge on accepted practices, recent discoveries, and emerging trends in the manufacture and application of shape memory alloys (SMAs) and devices.

SMST 2017 will deliver nearly 120 presentations organized in nine technical tracks. Leading experts in the field will address a wide range of topics across the process-structure-property-performance continuum and delve into applications where SMAs typically shine, including actuation, damping, caloric, and medical devices. SMST presenters will also introduce new manufacturing, measurement, and modeling techniques, along with optimization strategies.

In addition to an expanded technical program, SMST 2017 offers an optional one-day workshop for anyone seeking a comprehensive introduction to Nitinol. Other conference highlights include a design contest and poster session. The design challenge, sponsored by the Consortium for the Advancement of Shape Memory Alloy Research and Technology (CASMART), will feature projects by students who have been working in teams since September 2016 on either a medical or space application.

SMST attendees will have the opportunity to meet with nearly two dozen companies active in the shape memory market. The exposition opens during a reception held the first evening and remains open throughout the next day. For more information, visit asminternational.org/web/smst2017.

TECHNICAL PROGRAM TRACKS

- **Designing Next Generation Shape Memory Materials and Forms: Beyond Nitinol**
  Chair: Othmane Benafan
- **Material and Device Testing**
  Chair: Neil Morgan
- **Mechanics of Shape Memory Materials: Modeling Meets Experiments**
  Chair: Harshad Paranjape
- **Microstructure Characterizations of Shape Memory Materials**
  Chair: Sam Daly
- **Production, Processing, and Standards**
  Chair: Aaron Stebner
- **Shape Memory Actuators, Caloric, and Superelastic Damping Devices**
  Chair: Tad Calkins
- **Shape Memory and Superelastic Medical Devices**
  Chair: Jeremy Schaefer
- **SMA Failure Analysis and Modeling**
  Chair: Mitch Mitchell
- **Surface Engineering and Corrosion**
  Chair: Christine Trépanier

KEYNOTE SESSIONS

Design of Supercompatible Shape Memory Alloys

Richard D. James
University of Minnesota

Supercompatibile SMAs can be optimized for low thermal hysteresis with multi-million cycle repeatability of full transformation under high-stress superelastic cycling. James will review alloy design by supercompatibility and how it relates to other alloy optimization procedures based on the manipulation of precipitates.

Breakthroughs and Misfortunes in the Maturing of NiTi Medical Device Development

Brian Berg
Boston Scientific

Medical device engineers have methodical perseverance, learning from limitations and mistakes to create better devices. Berg will review real-life examples where breakthroughs in manufacturing, testing, deployment, and in vivo use grew from failure.

Challenges towards Successful Integration and Test of SMA Aerospace Applications

James H. Mabe
Boeing Research and Technology

Boeing's successful flight tests in 2005 of Variable Geometry Chevrons on a 777 and the 2012 Adaptive Trailing Edge on a 737 clearly demonstrated a high technology readiness level for SMA actuator systems. Mabe will discuss the engineering, integration, and program challenges, and how the flight test team overcame them.

NiTi Alloys for Structural and Tribological Applications: The Other Side of Superelastics

Christopher Dellacorte
NASA Glenn Research Center

Nickel-rich alloys have been shown to be amenable to advanced powder metallurgy processing, leading to a new class of structural materials suited for challenging tribological applications. Dellacorte will introduce this new family of dimensionally stable yet highly elastic materials and show how NASA is putting them to work.

Control Property and Behavior of Nano-Structured Niti SMAs by Grain Size Engineering

Qingping Sun
Hong Kong Univ. of Science and Technology

Grain size engineering holds promise as a method for improving the performance of shape memory alloys. Sun will report on recent experimental and theoretical findings that shed new light on the relationship between grain size and the thermal, mechanical, cyclic, and fatigue properties of NiTi SMAs.

NITINOL EDUCATION WORKSHOP

Monday, May 15 • 9:00 a.m. – 5:00 p.m.

Organized by Alan R. Pelton, Ph.D., G.RAU Inc.

SMST 2017 will conduct an all-day workshop on May 15, giving participants a thorough introduction to SMST materials, devices, and applications. Subject matter experts from leading organizations will cover a wide range of topics from the physics of SMST materials to the design and production of actuators and medical devices.

Topics & Instructors:

- Intro to Shape Memory and Superelasticity, Neil Morgan, Advanti
- Intro to Shape Memory Actuators, Othmane Benafan, NASA Glenn Research Center
- Intro to Medical Devices, Brian Berg, Boston Scientific
- Intro to Fatigue, Scott Robertson, Fathom Engineering
- Intro to Corrosion and Biocompatibility, Katie Miyashiro, Nitinol Devices & Components

ASMNEWS

INTERNATIONAL METALLOGRAPHIC CONTEST: FIRST TIME AT MS&T

Deadline: September 26

The International Metallographic Contest (IMC), an annual contest cosponsored by the International Metallographic Society (IMS) and ASM International to advance the science of microstructural analysis, is heading to MS&T this year. In celebration of its 50th anniversary, IMS is taking the IMC to Pittsburgh, October 8-12, to share the excitement of the contest with all MS&T attendees. Five different classes of competition cover all fields of optical and electron microscopy:

Class 1: Optical Microscopy—All Materials

Class 2: Electron Microscopy—All Materials

Class 3: Student Entries—All Materials (Undergraduate or Graduate Students Only)

Class 4: Artistic Microscopy (Color)—All Materials

Class 5: Artistic Microscopy (Black & White)—All Materials

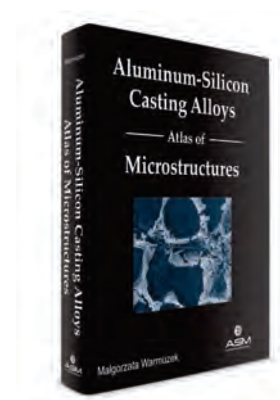
Best-In-Show receives the most prestigious award available in the field of metallography, the Jacquet-Lucas Award, which includes a cash prize of $3000. For a complete description of the rules, tips for creating a winning entry, and judging guidelines, visit metallography.net.

In addition, IMS will hold a special full-day symposium at MS&T17 celebrating 50 years of metallography and materials characterization. The symposium will honor past recipients of the Henry Clifton Sorby Award, IMS Buehler Technical Paper of Merit Award, and Jacquet-Lucas Award.

IMC 2016 poster display.

ASM PUBLISHES TWO NEW TECHNICAL BOOKS

Aluminum-Silicon Casting Alloys: Atlas of Microstructures



"Aluminum-Silicon Casting Alloys: Atlas of Microstructures" by Małgorzata Warmuzek is a practical tool for visually analyzing microscopic images of the microstructure of aluminum casting alloys, as examined during routine laboratory procedures. The gallery of microstructure images presented in this atlas has been selected and systematically arranged with two main goals in mind:

- To help the reader who has an image of an alloy microstructure identify the examined alloy in a gallery of standard casting Al-Si alloys
- To help the reader identify the typical microstructure of an alloy based on its estimated cooling rate

For more information, visit asminternational.org/alsicasting.

ASMNEWS

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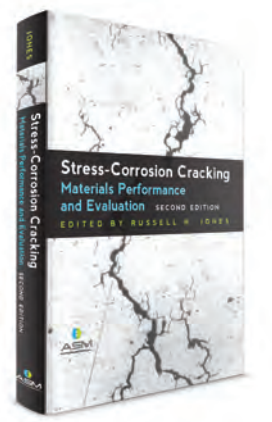
ASM INTERNATIONAL

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

Stress-Corrosion Cracking: Materials Performance and Evaluation, Second Edition

This new second edition, edited by Russell H. Jones, serves as a go-to reference on the complex subject of stress corrosion cracking (SCC), offering information to help metallurgists, materials scientists, and designers determine whether SCC will be an issue for their design or application. The book is also useful for failure analysts, to help determine if SCC played a role in a failure under investigation.



Research conducted over the last 20 years warranted new coverage on crack tip chemistry analysis and modeling, SCC of low strength steels in alcohol, SCC in new high strength steels, new data in SCC of stainless steels and nickel-base alloys, SCC of copper alloys in potable water, and hydrogen induced cracking of aluminum alloys. Additional case studies and a section on high strength, low alloy steels were added. An appendix of relevant standards pertaining to SCC is also included. For more information, visit asminternational.org/stresscc.

CANADA COUNCIL AWARD NOMINATIONS DUE APRIL 30

ASM's Canada Council is seeking nominations for its 2017 awards program. These prestigious awards include:

G. MacDonald Young Award–The ASM Canada Council established this award in 1988 to recognize distinguished and significant contributions by an ASM member in Canada. This award consists of a plaque and a piece of Canadian native soapstone sculpture. The 2016 recipient was Alex P. Varro, Thuro Inc., Calgary, Alberta.

M. Brian Ives Lectureship–This award was established in 1971 by the ASM Canada Council to identify a distinguished lecturer who will present a technical talk at a regular monthly meeting of each Canadian ASM Chapter who elects to participate. The winner receives a $1000 honorarium and travels to each ASM Canada Chapter throughout the year to give their presentation with expenses covered by the ASM Canada Council. The 2016 recipient was Lukas Bichler, University of British Columbia, Kelowna.

John Convey Innovation Awards–In 1977, the Canada Council created a new award to recognize sustaining member companies that contribute to development of the Canadian materials engineering industry. The award considers a new product and/or service directed at the Canadian or international marketplace. Two awards are presented each year, one to a company with annual sales in excess of $5 million, and the other to a company with annual sales below $5 million. The 2016 recipient was Erhan Ulvan, Acuren Group Inc., Eastern Canada.

Award rules, past recipients, and sample nomination forms can be found at asminternational.org/membership/awards/nominate. To nominate someone, contact christine.hoover@asminternational.org for a unique nomination link.

VOLUNTEERISM COMMITTEE

Profile of a Volunteer

Tom Steigauf, Principal Materials Engineer, Medtronic


Steigauf

Tom Steigauf grew up in St. Paul, Minnesota. Discovering that he liked working on cars more than going to St. Thomas College, he transferred to the University of Minnesota and studied metallurgical engineering. Before graduating in 1981, he joined the ASM Minnesota Chapter. "Honestly, it was selfishness," he laughs. "I was young and it was a place to generate contacts." That eventually led to jobs with Crane Engineering as a technical expert doing things he'd never done before, like going to accident scenes and testifying in court cases—and with Honeywell, making ring laser gyros for aircraft.

Steigauf now works in research and material-related product issues for Medtronic in Minneapolis, a medical device company that makes products such as drug pumps for people with chronic pain. Over the years, he has served on the ASM board, marketed ASM courses to raise funds, helps organize a yearly seminar, and helps run an ASM summer camp for high school students at the University of Minnesota. The camp is in high demand, attracting nearly 100 applicants, including many girls, for 35 spots.

Sitting on the sidelines of ASM for a number of years, Steigauf was finally encouraged by a senior member to get more involved. "I got dragged in by an older gentleman who said, 'Here, you're doing this!' I discovered that it's true: You get out what you put into it."

"What hooks you into ASM is making a difference," he says. "You see kids light up. They may not become engineers, but we keep them in math and science. We get them to feel comfortable with themselves. We tell them, 'We're all geeks. Use the cards you're dealt and find a career you're happy with!'" Steigauf encourages others to choose one chapter activity and volunteer with ASM. "Stick your toe in. You'll find it's fun, and you'll develop skills you didn't know you had."

EMERGING PROFESSIONALS

Rotational Engineering Programs

Joe DeGenova, Loop Program Metallurgist, Ellwood Group Inc.

DeGenova

Today, the process of fabricating engineered products relies on materials engineers with knowledge of multiple processes and materials. Traditionally, this knowledge is accumulated through multiple years on the job, and often after serving multiple roles within a company.

While a college education provides students with access to fundamentals, the detailed work of a full-time job comes through years of practice and execution. Rotational programs are ideal for exposing young professionals to a company's entire product line in a short time. Although the approaches to rotation time and structure vary from company to company, the final product is fairly consistent—a young professional who is well-versed in the technical aspects of a company's products, processes, and people.

Those who enter into rotational programs will graduate with exposure to diverse technical knowledge that takes many engineers years to experience. In a short time, young professionals learn the technical aspects of a company or division, become competent enough to complete projects, hand those over, and begin anew. Having a more intimate knowledge of a company's products from inception to final application allows a materials engineer to be more forward-thinking in their approach to problem-solving upon graduation.

Additionally, the contacts and relationships one obtains during a rotational program are invaluable. When technical questions arise, a rotational program graduate has a vast network of intercompany contacts with whom to consult. While creating this network, individuals also have ample opportunity to develop critical soft skills not widely taught in college. Learning details of a different technical background with a new group of people every several months necessitates development of advanced communications skills and increased workplace agility. As a result, rotational program graduates gain excellent communications skills crucial to the success of future achievements.

Rotational programs are not for everyone. Individuals must be willing to move frequently and learn an entire business. Regardless, those who graduate will be well prepared to take on the challenges of a permanent role. The exposure to multiple technical experiences and soft skills provides an excellent opportunity to succeed as an engineer in today's increasingly demanding manufacturing environment.

WOMEN IN ENGINEERING

*This profile series introduces leading materials scientists from around the world who happen to be females. Here we speak with **Beth Matlock,** senior materials engineer at Technology for Energy Corp. (TEC).*

Matlock

What does your typical workday look like?

My day starts early. I spend the quieter moments tying up loose ends, planning my day, and performing tasks that require extra concentration. I have technical responsibility for TEC's materials testing lab. We are in the process of introducing MAX, a new, portable x-ray diffraction system. I spend part of my time making sure that MAX meets or exceeds the technical specifications, but the majority of the day is spent working with our accredited services lab. There's never a dull moment reviewing jobs, instructing lab personnel, and discussing results with customers. Happily, I'm part of a great team, which makes my job much easier. Since we use and manufacture x-ray producing equipment, we have a state-regulated radiation safety program. As radiation safety officer, I have the opportunity to teach and maintain radiation safety at TEC. Luckily, the safety systems in place minimize any radiation exposure to our employees and customers.

What part of your job do you like most?

I have the best job in the world. I continue to learn and grow. I have the chance to solve problems, provide baselines, and compare different processes for our customers. There's often an interesting story behind the parts that come into our lab. Working with my customers and coworkers feeds my extroverted nature. There's enough challenges with finding a unique approach to solving a problem that the job is never dull. There's also the reward of persevering until a project is successfully completed. We see enough variety in our lab that we don't get bored with routines.

What is your engineering background?

My degrees are in materials engineering and materials science. I started my career working for a metallurgical and x-ray lab on the NCSU campus. After graduation, I went to work for B&W's Lynchburg Research Center (LRC). At LRC, I performed applied research on B_4C, x-ray diffraction pole figures on Zircaloy, and failure analysis on nuclear components. I left the nuclear industry to join TEC. At TEC, I've returned to my first love—x-ray diffraction, which we use to measure residual stress and retained austenite.

Did you ever consider doing something besides engineering?

I started my education with medical school in mind. I actually wanted to become a large-animal vet, but settled for the medical option. While at NCSU, I was "discovered" by a metallurgist who offered me a job on campus working in an x-ray diffraction lab. This opportunity changed my life. I quickly realized I loved x-ray diffraction. Also, scholarships were available to female engineering students that were absent in the biology/zoology programs. It did not take long for me to change my major. After graduating in materials engineering, I never thought twice about applying to medical school. The opportunities I've had through an engineering career have allowed me to purchase a farm with horses, cows, and chickens. When I'm not pursuing engineering tasks, I spend my time developing my animal husbandry dreams.

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

I would first do a sanity check to see what the young person's perception is of science and engineering and find out more about their interest in the field. Then I'd do everything possible to support and encourage them to follow their dreams. Engineering is a dynamic field and we need bright minds to build on the foundations established by the giants that have gone before us. I was raised with the belief that if I wanted something strong enough, and was willing to work for it, that I would be able to accomplish anything.

Hobbies?

In my spare time, I run a beef cattle operation and I'm a church pianist.

Last book read?

"The Eighty-Dollar Champion" by Elizabeth Letts.

Do you know someone who should be featured in an upcoming Women in Engineering profile? Contact Vicki Burt at vicki.burt@asminternational.org.

MD CORNER

Committee Participation Primer

Mahoney

Spring is a time of renewal and ASM embraces both the season and our own ASM Renewal by refreshing our volunteer base and renewing committee participation as a vital process within our organization. ASM's appreciation for our volunteers is deep and heartfelt. We realize you give of your time, money, and talent for our organization, so we thought it might be a good idea to let everyone know that our volunteers are carefully chosen to help make ASM *THE* premier organization for materials scientists, engineers, and technicians. We're thankful for the dedicated professionals who are advancing ASM's Renewal along with all of us here at the Dome.

Participation on committees enables professional growth for individual volunteers. Development of leadership skills and connectivity with other ASM professionals can lead to future business relationships. To keep our committees functioning and viable, a clearly defined process takes place through which we select committee volunteers. We encourage our membership to understand and engage in that process.

If you are interested in volunteering, visit our website and click on the Volunteer Interest Form: asminternational.org/membership/volunteering/volunteer-interest-form. ASM follows a March to September timeline in preparing and setting our committees, including reviews and recommendations by staff liaisons, the vice president, and the full board. Once selected, committee members begin their terms on September 1 and participate in initial face-to-face meetings at MS&T in the fall.

Today, ASM's website lists 30 Society committees, five technical committees, and 38 Affiliate committees. With such numbers, not all of our committees are fully functional or provide significant added value to the membership. This spring, the vice president and I will carefully inspect the committee reviews and conduct an Affiliate Summit. Under the ASM Renewal, these events will take a fresh look at ASM committees as well as resolve the relationship between our committees and current board task forces. Some consolidations and integrations may occur.

Thank you for your feedback, guidance, and support for the ASM Renewal.

William T. Mahoney, ASM Managing Director
bill.mahoney@asminternational.org

ASM PROGRESS REPORT: STRATEGIC PLAN HIGHLIGHTS FOR 2017 AND BEYOND

William E. Frazier, FASM, ASM President

Frederick E. Schmidt, FASM, ASM Vice President

William Mahoney, ASM Managing Director

In June 2016, 50 members of ASM were called together to help chart ASM's strategic path forward. This article shares key results of that meeting, which define the overall direction of ASM International for the next several years. To read the plan in full, visit www.asminternational.org/about/strategicplan.

ASM International is a society of professionals who have come together to accomplish great works for the common good that cannot be achieved independently. The maximum value ASM can bring to its members and society can be achieved by working at the intersection of design/engineering, manufacturing, and materials (Fig. 1).

Shared values of transparency, integrity, technical excellence, diversity, and constancy of purpose are the great enablers. Our Society's future is very bright and is well defined by our mission and vision statements as well as our core values:

Mission: ASM International benefits the materials community by providing scientific, engineering, and technical knowledge, education, networking, and professional development.

Vision: To be the leading resource for the advancement of materials knowledge in education, industry, and society.

Core Values:

- Exceptional member/customer service and input
- Stewardship of finances
- Transparency
- Integrity in all operations
- Benefits of diverse worldwide community of volunteers
- Continuous improvement and an adaptable and flexible organization
- Importance of education, experience, and lifelong learning

THREE CRITICAL AREAS

Three critical areas in which ASM must excel in order to ensure our success and growth include technical excellence, increased membership, and strategic partnerships/collaborations. ASM's plan systematically addresses these in a carefully thought out, time-phased manner. Table 1 provides the summary results of the strategic planning process. For each of the critical areas identified, big hairy audacious goals (BHAGs) were agreed upon. Objectives were defined in order to overcome the challenges associated with achieving these goals. Finally, action plans were developed.

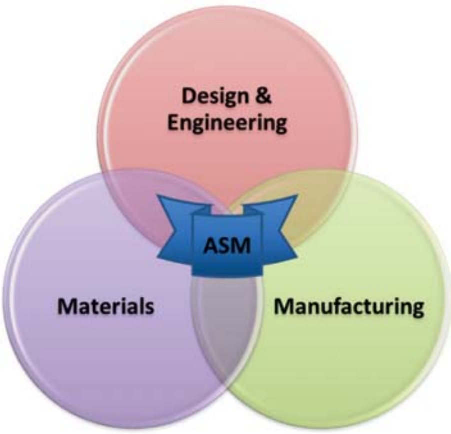


Fig. 1 – ASM binds, connects, and enables materials design, engineering, and manufacturing.

OPERATING PLAN DETAILS

The ASM Operating Plan defines the time-phased approach to implementing the Strategic Plan. An intensive period of remediation, reconstruction, and gradual but continuous improvement began for ASM in 2016. New corporate-experienced management team members joined

TABLE 1 - SUMMARY RESULTS OF STRATEGIC PLANNING PROCESS

	Membership	Technical Excellence	Strategic Collaborations and Partnerships
BHAG	ASM membership is the obvious choice for anyone interested in materials.	ASM will be the recognized world leader for materials information.	ASM will expand its strategic partnerships and collaborations in order to provide enhanced value.
Objectives	• Enhance full-paid and student membership • Enhance membership diversity • Enhance member engagement	• Increase the speed and volume of content creation and its dissemination • Establish ASM as the "thought leader" in emerging engineered materials • Enhance content accessibility • Facilitate member-to-member technical interactions	• Increase partnerships with manufacturing institutes • Increase partnerships with other materials data providers • Increase education courses offered with partner Societies
Action Plans	We will: 1. Provide enhanced resources of value to students transitioning into the work place and existing working professionals. 2. Unlock the value of ASM content and redesign the website for usability and access. 3. Expand and strengthen the technical content offered by ASM. 4. Create a tailored membership model to encourage non-material professional participation. 5. Improve ASM brand identity and awareness.	We will: 1. Develop a new, sustainable business model for technical product creation and delivery. 2. Implement streamlined content management and delivery infrastructure and processes. 3. Establish a (Wiki-like) member driven content creation and review process. 4. Publish authoritative technical reports (biannually) on emerging technologies. 5. Implement tools that members use to connect, collaborate and share real world advice with peers.	We will: 1. Engage with the national network of manufacturing institutes in order to provide value added content. 2. Assess the needs of our potential strategic partners in order to build win-win relationships. 3. Partner with key sources of materials data. 4. Evaluate business models for providing open source materials data.

ASM and began the process of reinvigorating ASM as the world's leading association serving the materials industry. That transformational process carries the title "The ASM Renewal."

The ASM Renewal will require a span of approximately three years to accomplish. The first 18-24 months will focus on improving the merchantability and market access of ASM's current materials information products and services, while the first two phases of a digital transformation/content enrichment program are executed. The second phase should see ASM perfecting the use of its new digital platform and predominantly electronic publishing model, which will continue during the third phase of this project. To deliver new products and services, along with new primarily digital forms of its traditional products and services, cleanup of prior crisis conditions will occur in 2017 and initial stabilization will be achieved. 2018 will see an extension of stability as well as modest growth. 2019 should begin to see consistent growth, but no breakthroughs or dramatic upticks. Accelerating growth will become realistic in 2020 and beyond. Nevertheless, by the end of 2019—when The ASM Renewal is complete—ASM should be positioned as the best option for professional development for materials scientists, engineers, and technicians, as well as the most comprehensive and competitive materials technology information services available.

The digital transformation/content enrichment program includes three areas of investment and deployment: web and content reengineering; deploying a new customer relationship management (CRM) system and integrated association management system, to replace our current obsolete system; and upgrading and migrating our underlying IT infrastructure to the cloud. In successive phases, these investments and deployment are expected to improve our transactional capability and reliability, support and services levels, and the discoverability, searchability, and electronic utility of ASM's materials content.

Front row, from left: Bill Mahoney, Ellen Cerreta, Craig Clauser, Jon D. Tirpak, William E. Frazier, Frederick E. Schmidt, Rachael Stewart, Kathryn Dannemann.
Back row, from left: Swetha Barkam, T.S. Sudarshan, Larry D. Hanke, Roger A. Jones, John Wolodko, Sudipta Seal, Allison Fraser.

SUMMARY

ASM has set aggressive but achievable strategic goals and objectives based on enhancing membership, improving technical excellence, and establishing strategic collaborations/partnerships. ASM will focus at the intersection of design/engineering, manufacturing, and materials in order to provide maximum membership value. Importantly, the necessary leadership and resources are in place to tackle the hard work ahead. Further steps are being taken in order to ensure we achieve our vision state. Four trustee-led task forces have been established to explore the following critical areas in depth: education, committee structure, digital workforce, and enhancing student membership. We wish to greatly expand our educational offerings in community colleges and chapters. We also wish to organize our committees to better facilitate the generation and delivery of content. In addition, we recognize that ASM must deliver digital content in the manner desired by tomorrow's workforce. Lastly, we recognize that students are the seed corn from which our Society will prosper and that we must cultivate and engage them. For more information and to view a PowerPoint about ASM's strategic and operating plans, visit www.asminternational.org/about/strategicplan.

CHAPTERS IN THE NEWS

Pittsburgh Hosts Young Members' Night

From left, Zhimin Sun, Chase Royer, Katerina Kimes, Taylor Russo, Shuchen Cong, Christine Rooney, Heather Bowman, Rafael Giacomin, Betsy Clark, and Bennet Monnie.

On February 16, the Pittsburgh Chapter hosted its 31st annual Young Members' Night at the University of Pittsburgh (Pitt) University Club. Students from Carnegie Mellon University (CMU), University of Pittsburgh, and Robert Morris University, along with participants in industry, organized this event. Farzin Fatollah-Fard of CMU presented on his dissertation topic, "The Electrochemical Production of Titanium by the MER Process," followed by a poster competition, awards ceremony, a guest speech by Richard J. Lee (CEO of RJ Lee Group), and door prizes.

Undergraduate poster winners were Colleen Hilla, Heather Bowman, and Katerina Kimes. Graduate poster winners included Ross Cunningham, Isha Kashyap, and Shivram Sridhar. David Ott and Eamonn Hughes won the Outstanding College Seniors award, Yushuan Peng won the PCEAS junior award, and Guarav Balakrishnan won the PCEAS sophomore award. Sponsors included Arconic, Allied High Tech Products Inc., American Stress Technologies, ATI, Elliott Group, The Perryman Co., Product Evaluation Systems Inc., Westmoreland Mechanical Testing and Research Inc., and Carpenter Technology Corp., Latrobe Specialty Metals.

From left, scholarship winners Eamonn Hughes, David Ott, Guarav Balakrishnan, and Yushuan Peng, along with Pittsburgh Chapter member Allan Hutt.

Northwestern PA Chapter Hosts Student Night

One of the crankshafts p oduced by Ellwood Crankshaft G oup (ECG).

The Northwestern PA Chapter held a successful student night at Penn State Behrend in February. The presentation, "Continuous Grain Flow (CGF) Forging of Diesel Engine Crankshafts: Development and Startup of the World's Largest Crankshaft Forging Press," was given by Manas Shirgaokar, director of forging technology and Sharon Operations for Ellwood Crankshaft Group. Approximately 40 students attended the event.

Manas Shirgaokar, left, receives a certificate of appreciation from Chetan P. Nikhare of Penn State.

MEMBERS IN THE NEWS

Samal and Shields Named APMI Fellows

APMI International's most prestigious award recognizes members for their significant contributions to the goals, purpose, and mission of the organization as well as for a high level of expertise in the technology, practice, or business of the powder metallurgy (PM) industry. The 2017 Fellow Award recipients, **Prasan Samal** and **John Shields, FASM,** will receive elevation to Fellow status at the Powdermet2017 conference in Las Vegas on June 14.


Samal

Prasan Samal, North American Hoganas Inc., Hollsopple, Pa., retired, is one of the leading experts in the stainless steel powder industry. Collaborating with several PM parts producers, he helped develop and qualify many stainless steel components for use in automotive exhaust systems. Other R&D achievements include optimizing sintering parameters for stainless steel to enhance dimensional accuracy, machinability, weldability and corrosion resistance; refinement of dispersion strengthened copper; and electrolytic iron refinement.


Shields

John Shields, PentaMet Associates LLC, has been a leading expert on molybdenum and its associated metals for more than three decades. He is noted for alloy research and development, along with a critical and analytical approach to problem solving. He has worked with NASA to develop materials for space shuttles, refined sintered tungsten ingots to increase tungsten sheet yields, and led a team to bring a novel thermal management system for galvanic corrosion resistance to market.

Sargent STEPs Ahead

Binky Sargent of Kennametal Inc. received honors at the fifth annual Women in Manufacturing STEP (Science, Technology, Engineering and Production) Ahead Awards presented by The Manufacturing Institute. The awards honor women who have demonstrated excellence and leadership in their careers and represent all levels of the manufacturing industry, from the factory floor to the C-suite. Sargent is the manager of Kennametal's material analysis team located in Latrobe, Pa. She joined Kennametal in 1997 where she began her career as an engineer in the company's carbide process development group. She is an active mentor for STEM programs and is a champion for the company's local high school manufacturing outreach programs.

Hemker, Manuel, Howarter, Arroyave Join TMS Board

The Minerals, Metals & Materials Society (TMS) installed new officers during its 2017 Annual Meeting & Exhibition in San Diego. Among the new TMS Board of Directors are the following ASM members: **Kevin J. Hemker, FASM,** professor of mechanical engineering at Johns Hopkins University, will serve as 2017 vice president; **Michele V. Manuel,** MSE professor at the University of Florida, will serve as content development and dissemination director/chair; **John A. Howarter,** assistant MSE professor at Purdue University, will serve as public and governmental affairs director/chair; and **Raymundo Arroyave,** associate MSE professor at Texas A&M University, will serve as functional materials division chair.

IN MEMORIAM


Simcoe

Charles Robert Simcoe passed away on February 25 at age 93. He was a Navy veteran of World War II, serving as a welder on the USS White Marsh (LSD-8) during the invasions at Saipan, Peleliu, Lye, Luzon, and Okinawa. After the war, Simcoe studied metallurgical engineering, graduating from Purdue University in 1950. He worked as a research metallurgist studying zirconium, titanium, alloy steels, copper, aluminum, and special materials. After retirement, he took a position with the University of Buffalo teaching metallurgy. When he retired from teaching, he continued his research and writing. Beginning in January 2014, Simcoe authored nearly 40 articles during his popular "Metallurgy Lane" series published in *AM&P.* A book based on this series will be published by ASM later this year. Simcoe was a Life Member of ASM, first joining in 1950. Purdue University named him Alumnus of the Year in 2014.


French

Peter Michael French passed away on January 9 at age 81. He was born in Yorkshire, England, and received both his bachelors and masters of science degrees in metallurgy from Leeds University. French spent his early career working for the UK Atomic Energy Authority. In 1967, he was recruited by Westinghouse and brought his family to the United States. They traveled to America aboard the Queen Elizabeth 2, arriving in New York City and settling in Oakmont, Pa. French worked for Westinghouse the rest of his career, starting in the advanced reactors division in Cheswick, Pa., and eventually working his way into management including his position as manager of business development–advanced power systems division. In 1976, the entire family celebrated becoming naturalized U.S. citizens. French completed his career at the Savannah River Project where he worked for 13 years before retiring. He also helped found the International Metallographic Society (IMS), serving as vice president from 1977-1979 and as president from 1979-1981.


Geary

Arthur R. Geary Jr. passed away on February 9 at age 82. After serving in the U.S. Air Force, he worked for Pratt & Whitney Aircraft for 34 years. Geary then started his own business upon retirement, Metallography Consulting Services, and continued to work and travel until his illness a few weeks ago. Geary joined ASM in 1949 and was a Life Member. He was also active in the International Metallographic Society (IMS) and ASM Thermal Spray Society (TSS). From 2000-2005, he served on the TSS Recommended Practices Committee and the Recommended Practices Subcommittee on Metallography.

ADVANCED MATERIALS & PROCESSES

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MAY/JUNE 2017

Materials for Automotive/ Energy/Power Generation

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- Advanced High-Strength Steels
- ITSC Show Preview

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JULY/AUGUST 2017

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STRESS RELIEF

FIFTY SHADES OF SPIDER SILK

In March, Bolt Threads of Emeryville, Calif., debuted its first attempt at commercial apparel production—a necktie made of 100% synthetic spider silk. The company was founded based on curiosity about natural spider silk and the idea of engineering novel protein materials. During its R&D phase, the Bolt team developed a way to closely mimic silk created in nature, with the goal of pioneering more sustainable and nontoxic processes for mass textile production. At the 2017 South by Southwest Festival held last month in Austin, Texas, the company announced a limited edition tie, reportedly the first synthetic spider silk product ever available for purchase. The unisex tie, made by humans using the company's proprietary technology, is the culmination of seven years of research and design. Fifty neckties were sold on the company's website via a lottery, which ran from March 11-14. Lucky winners were able to purchase a tie for $314. *boltthreads.com.*

The world's first 100% synthetic spider silk tie. Courtesy of Bolt Threads.

Courtesy of Business Wire.

PAINT CAN MOSAIC SETS WORLD RECORD

PPG Comex, Mexico City, and its network of over 750 paint dealers, recently collaborated in Acapulco, Mexico, to achieve the Guinness World Records title for the largest mosaic in the world created with paint cans. The artwork included 4900 cans of Comex paint, which is now being donated to help beautify spaces in needy areas of Mexico.

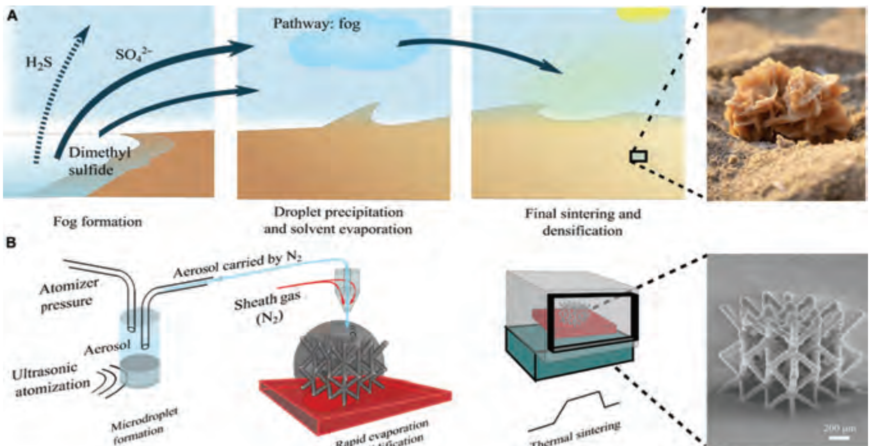
Plastic and visual artist Triana Parera created the design concept, along with graphic designer and illustrator Jimena Montemayor, who is known in Mexico as JIMO. The mosaic was created using the company's Vinimex Total paint in eight colors, covering an area of approximately 538 square feet (50 square meters). *ppg.com, guinnessworldrecords.com.*

DECORATING GOES DIGITAL

Changing paint color may soon be as simple as pressing a button, due to a newly developed digital ceramic panel developed by Italian scientists. Using innovative photonics technology, the luminous electronic tile project—Lumentile—combines the simplicity of a plain ceramic tile with the complexity of sophisticated touchscreen technology, creating a light source with unprecedented interaction. This lighting project is reportedly the first to embed electronics into ceramics or glass for a large-scale application. With the ability to play videos or display images, tiles allow users to turn a wall into a large cinematic screen, where each individual unit acts as a set of pixels of the overall display. A combination of ceramic, glass, and organic electronics, the digital tile includes structural materials, solid-state light sources, and electronic chips that can be controlled by a central computer, smartphone, or tablet. Each tile has its own internal power source and can be switched off so that silver, black, or white is the default setting. In 2016, Lumentile received a grant of more than $2.6 million from Horizon 2020 via the Photonics Public Private Partnership. The project is scaling up for mass production by the end of 2020. *www.lumentile-project.eu.*

Lumentile ceramic tile.

3D PRINTSHOP



3D printing method inspired by a weather phenomenon produces strain resistant materials similar in structure to bone and wood.

AEROSOL PRINTER TURNED FOG MACHINE YIELDS BIO-LIKE MATERIALS

Researchers at Washington State University (WSU), Pullman, have adapted an aerosol jet printing technique to produce free-form hierarchical structures similar to natural materials such as bone, hair, and wood. The adaptation is inspired by a weather phenomenon called “desert roses” that produces crystalline structures. In rare instances, sulfide evaporants from seawater are carried by a fog mist over hot dry deserts and deposited on sandy surfaces, causing intricate formations of gypsum or barite to grow.

Instead of sulfides driven by desert winds, however, WSU researchers use nitrogen gas to propel silver nanoparticles to a hot substrate, where they form 3D lattices that extend over multiple length scales. The resulting materials have a high strength-to-density ratio over a wide range of densities, occupying a previously unrealized area on the Ashby chart. To see how the process works, visit *https://youtu.be/a0Oa_JjNCTI.*

ONE METAL, MULTIPLE PROPERTIES

Inconel 718, a nickel-chromium-base superalloy, is a preferred material for high temperature, high pressure applications and use in corrosive environments. It is also the focus of a joint project between St. Petersburg Polytechnic University, Russia, and Delft University of Technology, the Netherlands, in which researchers are using selective laser melting (SLM) to create 3D structures with the properties of two metals—in this case, two grades of Inconel. The dual nature of the monolithic samples is the result of a gradient microstructure achieved during the build. Researchers have shown that by varying laser energy, they can control microstructure formation—and thus the grade of Inconel—throughout the sample. With this technology, specific properties can essentially be assigned to specific areas of a part, optimizing performance with fewer constraints. *www.english.spbstu.ru.*

FIRST SUCCESSFUL BNNT COMPOSITE PRINT

Researchers at the Deakin University Institute for Frontier Materials (IFM), Australia, achieved a milestone by successfully printing a cube-shaped sample from a boron nitride nanotube/titanium (BNNT) composite. BNNTs have a structure similar to carbon nanotubes that makes them ultralight and super strong, but they are much more heat resistant. They also have better electrical and piezoelectric properties, are more chemically stable, and unlike carbon nanotubes, they can be made transparent or dyed various colors. The problem with BNNTs is that they are difficult to produce in volume, rendering them impractical for commercial use. IFM researchers believe they can overcome this limitation with a scalable additive process compatible with standard equipment. They now plan to build a pilot plant where they expect to produce BNNTs in kilogram quantities. *www.deakin.edu.au.*

A cube made of boron nitride and titanium is the first 3D structure successfully printed from a BNNT composite.

Variations in the microstructure of a test sample made using SLM correspond to different grades of Inconel 718 achieved by controlling laser energy and scan rate during the build.