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ADVANCED MATERIALS & PROCESSES

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SUSTAINABLE COMPOSITES FOR AUTOMOTIVE

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DEVELOPING SUSTAINABLE COMPOSITES FOR AUTOMOTIVE APPLICATIONS

Sabah Javaid and Surojit Gupta

Automotive manufacturers are making significant investments in the design and development of bioplastics and biocomposites-based components.

On the Cover:

Substituting biomass for fossil fuel-based precursors in plastics manufacturing holds promise for achieving sustainability goals. Courtesy of Dreamstime/Candy1812.

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AEROMAT 2022 SUMMARY

Jeff Grabowski and Eli Ross

AeroMat's successful return to in-person meetings featured keynotes and programming on next-generation materials, and for the first time, was co-located with AeroTech.

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The latest news about ASM members, chapters, events, awards, conferences, affiliates, and other Society activities.

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3D PRINTSHOP

Researchers are looking at ways to improve additive manufacturing processes by controlling heat and modifying inks.

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PASSING THE GREEN TORCH

Decades ago, my dad, a civil engineer, was involved in the development of solar paneled huts that protected water pumps in our hometown and kept them from freezing. He passed away recently, and in going through memorabilia, my sisters and I were reminded that a perk of our dad's job when we were kids was being invited to enjoy the beautiful great outdoors—hiking, boating, and fishing—with other engineers' families at Camp Muskingum in Ohio. After one excursion in the 1970s, we found ourselves on the cover of *Ohio Engineer* magazine. Those trips helped build our appreciation for nature and were reassurances that the engineering community valued, protected, and reveled in it as well.

In recent years, my dad had been very intrigued by electric vehicle (EV) technology and the ecological promise it holds. He just missed seeing the late April release of "Lightning," Ford's first all-electric F-150. But I know he would have enjoyed the articles in this issue focused on sustainability in the auto industry.

Myself in center with sister and dad on *Ohio Engineer* cover.

One article provides a summary from key thinkers in the area of sustainable materials for EVs, based on a webinar jointly presented by ASM International and the Materials Research Society. Much of the webinar discussion centered around materials and recycling issues for EV batteries. In addition to those challenges, speaker Kristin Persson from the University of California, Berkeley reported that charging stations are not well maintained or properly policed. Sometimes a charger is not operational. Other times, a car is parked in front of one for longer than the allotted time, with no ticketing or fines. These basic logistical challenges need to be worked out before we will see a large growth in EV adopters.

A different angle on sustainability in the automotive sector is presented in the lead article. Researchers from the University of North Dakota discuss the increasing use of bioplastics in auto parts as a means to reduce greenhouse gas emissions. Yet, they conclude, more needs to be done on the cost considerations side to make them viable.

In other environmental news, protocols around steel production are getting a refresh as the industry looks for greener processes. The World Steel Association reports that in 2020, every metric ton of steel produced emitted almost twice that much carbon dioxide (1.8 tons) into the atmosphere. An encouraging case study from Uddeholm shows how their new sustainable process for tool steel production reduced 90% of the company's CO_2 emissions. Results worthy of emblazonment.

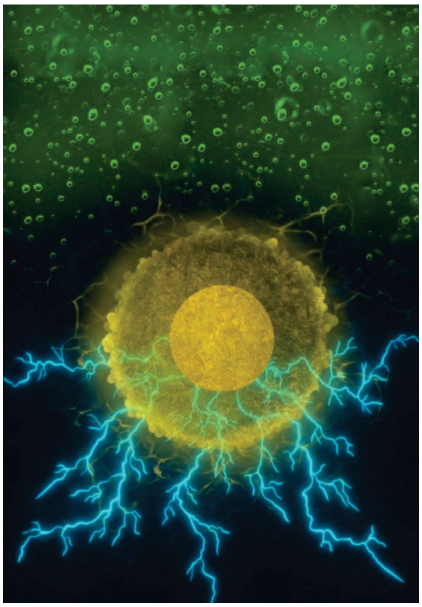
ASM members who wish to discuss these green topics in greater detail can look to the recently formed Sustainable Materials Engineering Technical Committee, chaired by John Wolodko, FASM, of the University of Alberta. Let us know if you'd like to be involved.

There is so much human potential to solve ecological issues with materials science. It will be fascinating to see what today's and tomorrow's engineers can do—across the globe or in their own hometowns—to carry on the work of all those who came before.

Joanne Miller

joanne.miller@asminternational.org

RESEARCH TRACKS



Alcohol, shown as green droplets (top), interacts with curcumin-enveloped gold nanoparticles to efficiently yield energy, depicted as white sparks (bottom).

TASTY TURMERIC FORTIFIES FUEL CELLS

A team from Clemson University's Nanomaterials Institute (CNI), South Carolina, and Sri Sathya Sai Institute of Higher Learning in India found a way to combine curcumin, the substance in turmeric, with gold nanoparticles to create an electrode that requires significantly less energy to convert ethanol into electricity versus other methods. Although more testing is needed, the discovery is another step toward replacing hydrogen as a fuel cell feedstock. The team focused on the fuel cell's anode, where the ethanol is oxidized, and selected gold as the catalyst.

Rather than using conducting polymers or metal-organic frameworks to deposit gold on the electrode's surface, researchers used curcumin due to its structural uniqueness. Curcumin is applied to decorate the gold nanoparticles in order to stabilize them, forming a porous network around them. The team deposited the curcumin gold nanoparticles on the surface of the electrode at 100x lower electric current than in previous studies. "Without this curcumin coating, the performance is poor," says Apparao Rao, CNI's founding director. "We need this coating to stabilize and create a porous environment around the nanoparticles, and then they do a super job with alcohol oxidation. The next step is to scale the process up and work with an industrial collaborator who can actually make the fuel cells and build stacks of fuel cells for real applications." *clemson.edu.*

SUPER SPEEDY GLASS PRINTING

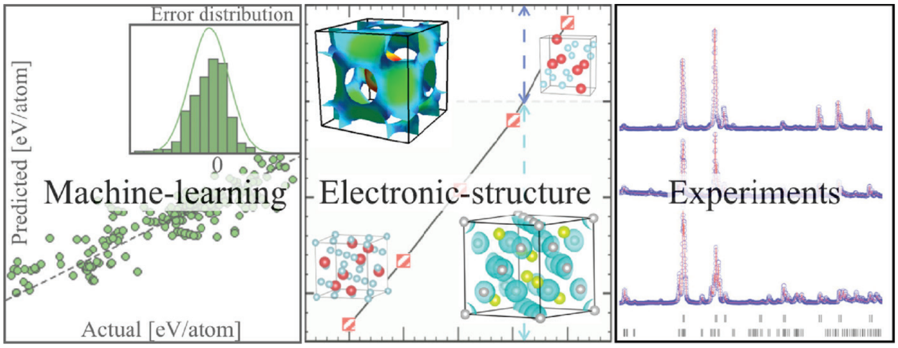
Researchers at Lawrence Livermore National Laboratory (LLNL) and the University of California, Berkeley are using a new 3D printing method to make microscopic objects out of silica glass in mere seconds. The process employs a laser-based volumetric additive manufacturing (VAM) approach, an emerging technology in near-instant 3D printing. The computed axial lithography (CAL) technology developed by LLNL and UC Berkeley is similar to computed tomography imaging. CAL works by computing projections from several angles through a digital model of a target object, optimizing these projections, and then delivering them into a rotating volume of photosensitive resin using a digital light projector. Over time, the projected light patterns reconstruct a 3D light dose distribution in the material, curing the object at points exceeding a light threshold while the vat of resin spins. After the fully formed object materializes, the vat is drained to retrieve the part.

The process combines a microscale VAM technique called micro-CAL, which uses a laser instead of an LED source, with a nanocomposite glass resin developed by the German company Glassomer and the University of Freiburg. Using the new approach, the team created glass objects with complex microstructures, exhibiting a surface roughness of just 6 nm and features down to 50 µm. Researchers say the benefit of VAM for micro-optics is that it can produce extremely smooth surfaces without layering artifacts, resulting in faster printing without additional post-processing time. Applications could include micro-optics in high-quality cameras, consumer electronics, biomedical imaging, chemical sensors, virtual reality headsets, advanced microscopes, microfluidics with challenging 3D geometries, and more.

Caitlyn Cook, a polymer engineer in LLNL's materials engineering division, says she and her team will further tune the resolution of VAM and the doses required for a variable range of resolutions and print speeds. In addition, the team is conducting a feasibility study to advance the VAM glass printing efforts for larger optics. "Cracking problems typically arise in larger prints due to shrinkage stresses," says Cook. "Our teams at LLNL are developing custom formulations to produce larger optics and glass printed parts that will not crack during the debinding and sintering processes." *llnl.com.*

Microscopic object made of silica glass using volumetric additive manufacturing.

MACHINE LEARNING | AI



A new machine learning model uses regression learning to assess the phase stability of various rare earth compounds. Courtesy of Ames Laboratory.

MACHINE LEARNING AIDS RARE EARTHS RESEARCH

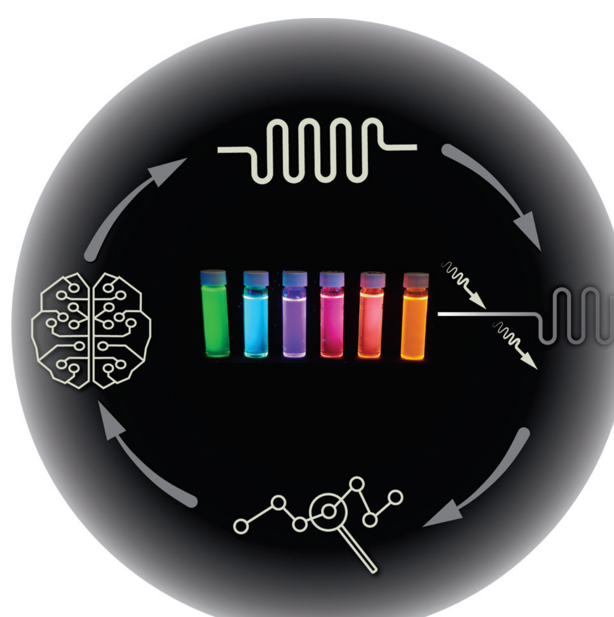
Scientists at the DOE's Ames Laboratory and Texas A&M University trained a machine learning (ML) model to determine the stability of rare earth compounds. The team used the upgraded Ames Laboratory Rare Earth database (RIC 2.0) and high-throughput density functional theory (DFT) to build the foundation for their model. High-throughput screening allows researchers to test hundreds of models quickly, while DFT is a quantum mechanical method used to investigate thermodynamic and electronic properties. Based on this collection of information, the new ML model uses regression learning to assess the phase stability of different compounds.

Ames scientist Prashant Singh says the material analysis relies on a discrete feedback loop in which the AI/ML model is updated using the new DFT database, which is based on real-time structural and phase information obtained from the experiments. The process ensures that information is carried from one step to the next and reduces the chance of making mistakes. Project supervisor Yaroslav Mudryk notes that the framework was designed to explore rare earth compounds due to their technological importance, but its application is not limited to rare earths research. The same approach could be used to train an ML model to predict magnetic properties of compounds, develop new process controls for manufacturing, and optimize mechanical behaviors. *ameslab.gov.*

SELF-DRIVING LAB STUDIES NANOCRYSTALS

A research team from North Carolina State University and the University at Buffalo developed a "self-driving lab" that uses artificial intelligence (AI) and fluidic systems to gain knowledge regarding metal halide perovskite (MHP) nanocrystals. These nanocrystals are an emerging class of semiconductor materials that have potential for use in printed photonic devices and energy technologies due to their solution processability, unique size, and composition-tunable properties. They are highly efficient, optically active materials that are under consideration for use in next-generation LEDs. Because they can be made using solution processing, they also have the potential to be made in a cost-effective way.

Doping the material with varying levels of manganese can change its optical and electronic properties, such as the wavelength of light emitted, and also introduce magnetic properties. Especially noteworthy is that the new system does all of this autonomously. Specifically, its AI algorithm selects and runs its own experiments: Results from each experiment inform which experiment it will run next—and it keeps going until it understands which mechanisms control the MHP's various properties. "In other words, we can get the information we need to engineer a material in hours instead of months," says NC State associate professor Milad Abolhasani. While the work demonstrated in this research focuses on MHP nanocrystals, the system could also be used to characterize other nanomaterials that are made using solution processes, including a wide variety of metallic and semiconductor nanomaterials. *ncsu.edu.*



A new self-driving lab is using AI and fluidic systems to study MHP nanocrystals. Courtesy of Milad Abolhasani.

PROCESS TECHNOLOGY

ACRC is now well established at UCI, joining its other materials research centers.

NEW ACRC FOUNDRY AND LABS

The University of California, Irvine (UCI), completed construction of a state-of-the-art metal processing facility for the Advanced Casting Research Center (ACRC) and opened the doors in March. The new foundry and lab include a high-tech vacuum melting system, complete Spectro lab for chemical analysis, digital image correlation system, an Olympus microscopy suite, x-ray computed tomography, a laser powder bed fusion system, and more.

Alan Luo, Director of Lightweight Materials and Manufacturing Research Lab at The Ohio State University who attended the opening, comments, “The new ACRC facility has the state-of-the-art equipment and lab space for research and development in advanced metal casting and digital manufacturing. It’s a one-of-its-kind center in the United States for fostering industry-academia collaboration, which is indispensable for the metals and manufacturing sectors in the nation.” *acrc.manufacturing.uci.edu.*

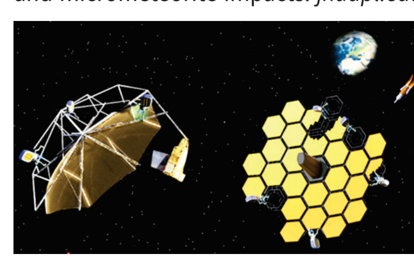
MANUFACTURING IN SPACE

In late 2021, DARPA launched its Novel Orbital and Moon Manufacturing, Materials and Mass-efficient Design (NOM4D, pronounced “nomad”) program to develop foundational materials, processes, and designs needed to manufacture large, precise, and resilient systems in space. Specifically, the program focuses on the design of space-based systems too large to be built on Earth and launched. These structures will have features that enable them to withstand maneuvers, thermal cycles, and physical damage typical of space and lunar environments. With a history of successful DARPA collaborations, the Johns Hopkins Applied Physics Laboratory (APL) in Laurel, Md., was chosen to evaluate the operational potential of future adaptive, large-scale, space-based manufacturing.

To address the wide-ranging technical challenges presented by NOM4D, the APL assembled a team of scientists and engineers with deep expertise in materials science, physics, lunar geology, optical sensing, power systems, spacecraft engineering, cislunar space, and more. A successful NOM4D program would truly mark a paradigm shift in manufacturing space structures. Space-based fabrication would leverage native cislunar materials mined and processed in space whenever possible, incorporating advanced materials and components developed on and transported from Earth when necessary.

NOM4D’s goal of pioneering off-Earth manufacturing maximizes stability, agility, resiliency, and adaptability of space systems. In three 18-month phases, the program will tackle increasingly challenging concepts. Phase 1 calls for materials and designs that meet stringent structural efficiency targets. Phase 2 will focus on risk reduction and technical maturation. Phase 3 calls for a leap in precision to enable infrared reflective structures that can be used in a segmented long-wave infrared telescope.

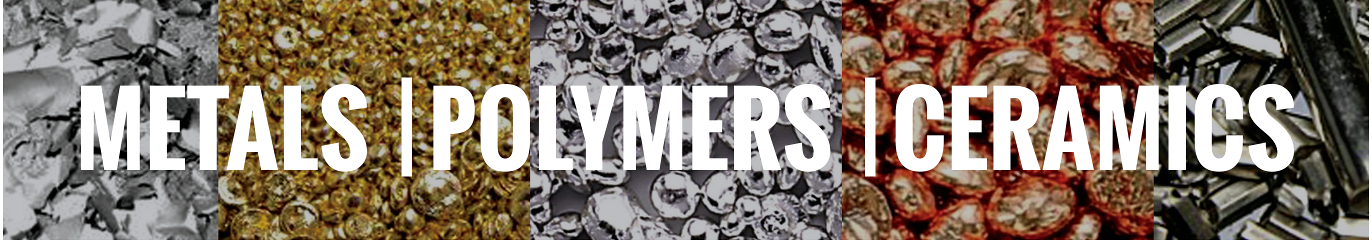
Ground-based fabrication of subscale exemplar structures—as opposed to the full structures—will be used to validate advanced NOM4D materials, manufacturing capabilities, and design concepts. Importantly, technologies must be designed to survive and maintain precise operation during potentially destructive events, such as lunar storms and micrometeorite impacts. *jhuapl.edu.*



NOM4D-enabled future concept. Courtesy of Johns Hopkins APL.

BRIEF

Wauseon Machine and Manufacturing Inc., Wauseon, Ohio, a provider of robotics automation, tube fabrication equipment, and build-to-print precision machined parts, acquired **McAlister Design and Automation LLC,** Greenville, S.C., a leading robotics systems integrator. McAlister’s four facilities total 48,000 sq. ft., adding significantly more capacity for automation projects. *wauseonmachine.com.*



Doctoral student William Trehern operating a vacuum arc melter—a synthesis method commonly used to create high-purity alloys of various compositions. Courtesy of Texas A&M Engineering.

ALLOY DISCOVERY

Using an Artificial Intelligence Materials Selection framework (AIMS), researchers from Texas A&M University, College Station, have discovered a new shape memory alloy. The shape memory alloy showed the highest efficiency during operation achieved thus far for nickel-titanium-based materials. In addition, the researchers' data-driven framework offers proof of concept for future materials development. The shape memory alloy found during the study using AIMS was predicted and proven to achieve the narrowest hysteresis ever recorded. Essentially, the material showed the lowest energy loss when converting thermal energy to mechanical work. The material showcased high efficiency when subject to thermal cycling due to its extremely small transformation temperature window. It also exhibited excellent cyclic stability under repeated actuation.

Typical shape memory alloys are nickel-titanium-copper compositions. These alloys normally have titanium equal to 50% and form a single-phase material. Using machine learning, the researchers predicted a different composition with titanium equal to 47% and copper equal to 21%. While this composition is in the two-phase region and forms particles, they help enhance the material's properties, the researchers explain. In particular, this high-efficiency shape memory alloy lends itself to thermal energy harvesting, which requires materials that can capture waste energy produced by machines and put it to use, and thermal energy storage, which is used for cooling electronic devices. More notably, the AIMS framework offers the opportunity to use machine-learning techniques in materials science. The researchers see potential to discover more shape memory alloy chemistries with desired characteristics for various other applications. *tamu.edu.*

NEW 2D MATERIALS

Researchers from Tulane University, New Orleans, developed a new family of 2D materials with promising applications, including in advanced electronics and high-capacity batteries. The name of the new family of 2D materials is transition metal carbo-chalcogenides, or TMCC. It combines the characteristics of two families of 2D materials—transition metal carbides and transition metal dichalcogenides. The latter is a large family of materials that has been explored extensively and found to be very promising, especially for electrochemical energy storage and conversion. However, one downside is their low electrical conductivity and stability. Conversely, transition metal carbides are excellent electrical conductors with much more powerful conductivity. Merging the two families into one is anticipated to have great potential for many applications such as batteries and supercapacitors, catalysis, sensors, and electronics.

"We used an electrochemical-assisted exfoliation process by inserting lithium ions in-between the layers of bulk transition metals carbo-chalcogenides followed by agitation in water," explains researcher Ahmad

Michael Naguib, professor at Tulane, is an expert in two-dimensional material and electrochemical energy storage. Courtesy of Paula Burch-Celentano.

BRIEF

LIFT, a national manufacturing innovation institute based in Detroit, granted a "U LIFT Challenge" project award to the **University of Central Florida,** Orlando, to further explore metallic alloys used in additive manufacturing (AM). Researchers will establish thermokinetic criteria to determine printability and buildability of metallic alloys for powder bed fusion AM. *www.lift.technology.*

Majed. Unlike other exotic nanomaterials, he continues, the process of making these 2D TMCC nanomaterials is simple and scalable. *tulane.edu.*

BREAKING DOWN PLASTIC

In a world's first, a team of researchers from Northwestern University, Evanston, Ill., successfully used metal-organic frameworks (MOFs) to break down polyester-based plastic into its component parts. In addition to demonstrating that MOFs are a stable and selective catalyst, an important bonus of the new process is that one of the resulting component parts, terephthalic acid, is a chemical used to produce plastic. In this way, the method eliminates the need to utilize expensive, energy-intensive production to separate xylenes. "We can do a lot better than starting from scratch when making plastic bottles," says scientist Omar Farha. "Our process is much cleaner."

For the experimental catalyst, the researchers chose a zirconium-based MOF called UiO-66 because it is easy to make, scalable, and inexpensive. The team used what plastic they had on hand—water bottles that colleagues in the lab had discarded. They chopped them up, heated the plastic, and then applied the catalyst.

"The MOF performed even better than we anticipated," according to Farha. "We found the catalyst to be very selective and robust. Neither the color of the plastic bottle or the different plastic the bottle caps were made from affected the efficiency of the catalyst. And the method doesn't require organic solvents, which is a plus." According to the researchers, the work helps address long-standing challenges associated with plastic waste and opens up new areas and applications for MOFs. *northwestern.edu.*

With Northwestern's unique degradation process using MOFs, more plastic bottles can be made into new ones instead of ending up in a landfill.

TESTING | CHARACTERIZATION

University of Oklahoma graduate student Sergio Chacon helps undergraduate researcher Rachel Penner set up perovskite solar cell measurements.

SOLAR CELLS FOR SPACE

A collaborative research team led by the University of Oklahoma, Norman, developed optimal conditions for testing perovskite solar cells for space applications. Perovskite solar cells are creating excitement in the photovoltaics community due to their rapidly increasing performance and their high tolerance to radiation. These properties suggest they could be used to provide power for space satellites and spacecrafts. The team measured the solar cells' radiation hardness under different conditions. Using lower-energy particles, specifically protons, researchers confirmed that perovskites are radiation hard and that when damaged, they heal quickly.

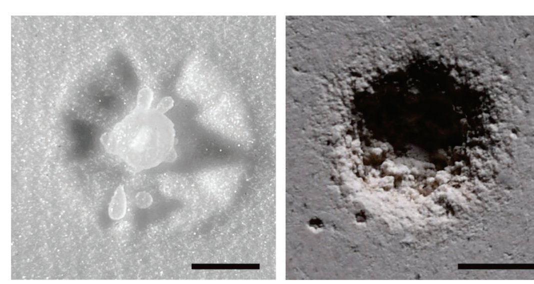
One area of application for the new protocol includes investigating perovskites' use in permanent installations on the moon, specifically in whether lightweight flexible perovskites could be sent into space folded up and successfully deployed there, or even made on the moon. Future research could explore the utility of perovskite solar cells for space missions to planets like Jupiter that have an intense radiation environment or for satellite missions in polar orbits with high radiation levels. *ou.edu.*

STUDYING DROPLET IMPACTS

A new discovery about liquid droplets and their affect on hard surfaces could help engineers design better, more erosion-resistant materials. Using a newly developed technique, researchers from the University of Minnesota Twin Cities were able to measure hidden quantities such as the shear stress and pressure created by the impact of liquid droplets on surfaces, a phenomenon that has only ever been studied visually.

Previously, droplet impact has only been analyzed visually using high-speed cameras. The researchers' new technique, called high-speed stress microscopy, provides a more quantitative way to study this phenomenon by directly measuring the force, stress, and pressure underneath liquid drops as they hit surfaces. The researchers found that the force exerted by a droplet actually spreads out with the impacting drop—instead of being concentrated in the center of the droplet—and the speed at which the droplet spreads out exceeds the speed of sound at short times, creating a shock wave across the surface. Each droplet behaves like a small bomb, releasing its impact energy explosively and giving it the force necessary to erode surfaces over time.

The research could help engineers design more erosion-resistant surfaces for applications that must weather outdoor elements. Next, the team plans to study how different textures and materials change the amount of force created by liquid droplets. *twin-cities.umn.edu.*



The image shows the impact liquid droplets can make on a granular, sandy surface (left) versus a hard, plaster surface (right). Courtesy of Cheng Research Group, University of Minnesota.

BRIEFS

Zeiss held a ribbon cutting on April 7 at its **Zeiss Microscopy Customer Center Bay Area** (ZMCC BA) in the company's new high-tech building designed for customer and employee collaboration in Dublin, Calif. The ZMCC BA houses electron, light, and x-ray microscopes that are supported by resident application experts in life science, materials research, and electronics segments. *zeiss.com.*

Leica Microsystems will partner with **Imperial College London** to set up a dedicated imaging hub at the university, which will be equipped with advanced confocal and widefield microscopy systems. The hub will serve as a microscopy knowledge center in optical precision imaging for scientists and researchers, and will also create a space for joint research projects between the two organizations. *leica-microsystems.com.*

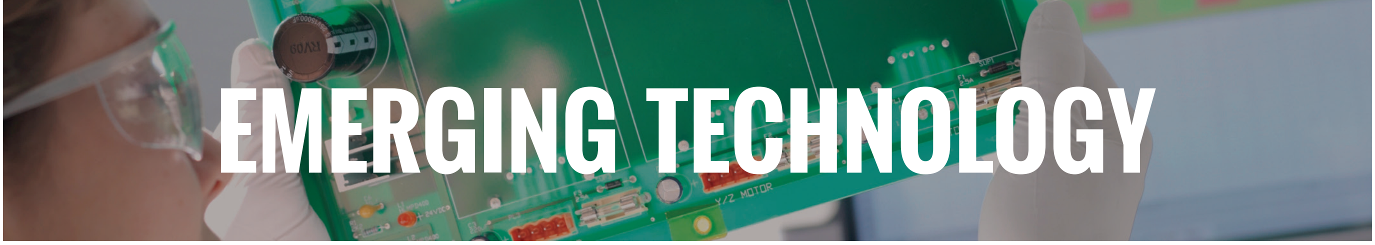
ALLOYS FOR AIRCRAFT

Scientists studying aluminum alloys at the atomic level found patterns that will help improve their structure. Researchers from the Belgorod State University and the Skolkovo Institute of Science and Technology (Skoltech) studied aluminum alloys used in aircraft structures. They say these alloys have a wealth of advantages, such as small weight and resistance to wear and fracture at elevated temperatures, as well as cyclic and shock loads. The findings will be useful for developing new alloys for modern aircraft, according to the researchers.

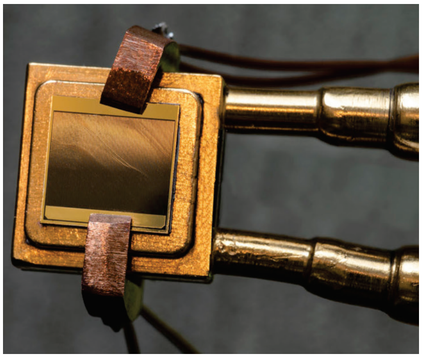
The work focused on the aluminum, copper, magnesium, silver (Al-Cu-Mg-Ag) system used for wing and fuselage skin. Al-Cu-Mg-Ag alloying helps obtain high heat resistance alloys, but the evolution of the alloy's structure and mechanical properties in various thermal or thermomechanical treatment modes and operating conditions is still not well understood.

Working with the Al-Cu-Mg-Ag system, scientists observed the formation of dispersed particles with a thickness of only a few nanometers, making the alloys much stronger despite their small size. "In addition," explains Skoltech researcher Anton Boev, "the particles turned out to be coherent and fit well into the aluminum matrix, like pieces of a puzzle, although with slight distortions in their atomic structure. Also, we found that the particles' structure and, therefore, the heat-treated alloy's mechanical behavior change according to a certain pattern." The combination of mechanical properties obtained by the team will help extend the lifetime of aircraft structures made from these materials. *www.bsu.edu.ru/en, www.skoltech.ru/en.*

Courtesy of Pixabay/CC0 Public Domain.



EMERGING TECHNOLOGY



A TPV cell (size 1 x 1 cm) mounted on a heat sink is designed to measure the cell's efficiency. Courtesy of Felice Frankel.

STATIONARY HEAT ENGINE

A research team designed a heat engine with no moving parts in a collaboration between engineers at MIT, Cambridge, and the National Renewable Energy Laboratory in Golden, Colo. They demonstrated that the heat engine converts heat to electricity with over 40% efficiency—a performance better than that of traditional steam turbines. The engine is a thermophotovoltaic (TPV) cell that passively captures high-energy photons from a white-hot heat source and converts them into electricity. The team's design can generate electricity from a heat source of between 1900° to 2400°C, or up to about 4300°F.

The researchers plan to incorporate the TPV cell into a grid-scale thermal battery. The system would absorb excess energy from renewable sources such as the sun and store that energy in heavily insulated banks of hot graphite. When the energy is needed, such as on overcast days, TPV cells would convert the heat into electricity, then dispatch the energy to a power grid. With the new TPV cell, the team has now successfully demonstrated the main parts of the system in separate, small-scale experiments. They are now working to integrate the parts to demonstrate a fully operational system. From there, they hope to scale up the system to replace fossil-fuel-driven power plants and enable a fully decarbonized power grid, supplied entirely by renewable energy. *mit.edu, nrel.gov.*

RICE HUSK LEDs

Scientists from Japan's Hiroshima University created the world's first silicon quantum dot (SiQD) LED light using recycled rice husks. Searching for a scalable method to fabricate quantum dots, the researchers looked to agricultural waste. Milling rice to separate the grain from the husks produces about 100 million tons of rice husk waste globally each year. The new environmentally friendly, low-cost method transforms this waste into state-of-the-art light-emitting diodes.

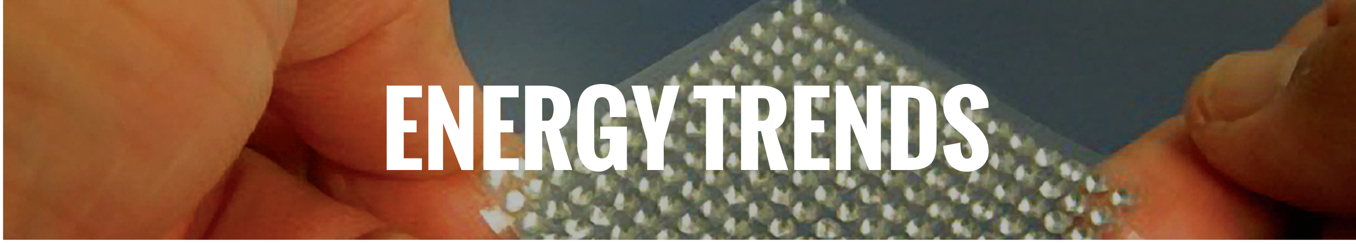
Nontoxic and abundant in nature, Si has photoluminescent properties, stemming from its microscopic quantum dot structures that serve as semiconductors. Waste rice husks, it turns out, are an excellent source of high-purity silica (SiO_2) and value-added Si powder. The team used a combination of milling, heat treatments, and chemical etching to process the rice husk silica. First, they milled rice husks and extracted SiO_2 powders by burning off organic compounds of the husks. Next, they heated the resulting silica powder in an electric furnace to obtain Si powders via a reduction reaction. Third, the purified Si powder product was further reduced to three nanometers in size by chemical etching. Finally, its surface was chemically functionalized for high chemical stability and high dispersivity in a solvent, producing SiQDs that luminesce in the orange-red range with efficiency of over 20%.

The scientists suggested that the method they developed could be applied to other plants, such as sugar cane bamboo, wheat, barley, or grasses that contain SiO_2. These natural products and their wastes might hold the potential to be transformed into nontoxic optoelectronic devices. The scientists would like to see commercialization of their ecofriendly approach to creating luminescent devices from rice husk waste. *www.hiroshima-u.ac.jp/en.*

Graphical depiction of the world's first LED light created from rice husks and chemically obtained products. Courtesy of ACS.

BRIEF

Researchers from the **University of Wuppertal** and the **University of Cologne** along with four other German universities and institutes developed a tandem solar cell that reaches 24% efficiency. This sets a new world record as the highest efficiency achieved so far with this particular combination of organic and perovskite-based absorbers. *www.uni-wuppertal.de.*



ENERGY TRENDS

Electric car lithium battery pack and power connections.

OPTIMIZED BATTERY RECYCLING

In a big step toward the electromobility society of the future, researchers from Chalmers University of Technology, Sweden, developed an optimized recycling process for electric vehicle (EV) batteries to make the recycling of electric car batteries easier, cheaper, and more environmentally friendly. As the use of EVs increases, recycling and recovery processes for their batteries and the critical raw metals used in production are becoming an increasingly important area of research. One method that currently attracts a lot of interest is a combination of thermal pretreatment and hydrometallurgy, in which aqueous chemistry is used to recover the metals. Several companies are developing systems that will use this combination, but the research team discovered that these companies use widely differing temperatures and times in their processes, and that there was a great need for a comparative study to determine the optimal thermal treatment and hydrometallurgical process for recycling lithium-ion batteries.

A key finding of the research was that the hydrometallurgical process can be carried out at room temperature. This is something that has not been previously tested but could yield major benefits in the form of reduced environmental impacts and battery recycling costs. The process can also be carried out significantly quicker than previously thought. “Our research can make a huge difference for developers in this area. In some cases, it can be as much as reducing the temperature from between 60 and 80°C down to room temperature, and from several hours to just 30 minutes,” according to the team.

The researchers also investigated how the different steps—thermal pretreatment and hydrometallurgy—are affected by each other. An important comparison was made between two different approaches to thermal pretreatment, incineration and pyrolysis. The latter is without oxygen and is considered more environmentally friendly, and the researchers determined that this produced the best results. *www.chalmers.se/en.*

LITHIUM-BATTERY INITIATIVE

A national workforce development strategy for lithium-battery manufacturing was announced by the DOE and will be launched in coordination with the U.S. Department of Labor and the AFL-CIO. As part of a $5 million investment, DOE will support up to five pilot training programs in energy and automotive communities and advance workforce partnerships between industry and labor for the domestic lithium battery supply chain. The announcement follows DOE’s recent release of two notices of intent authorized by the Bipartisan Infrastructure Law to provide $3 billion to support projects that bolster domestic battery manufacturing and recycling. The funding, rolling out in the coming months, will support battery-materials refining, which will bolster domestic refining capacity of minerals such as lithium, as well as production plants, battery cell and pack manufacturing facilities, and recycling facilities. *energy.gov.*

Through DOE funding, more ways to recycle lithium-ion battery packs are on the horizon.

BRIEF

Syrah Resources, Australia, is investing $176 million to expand its **Syrah Technologies** graphite processing facility located in Vidalia, La. The project adds 180,000 sq. ft. to the existing 50,000-sq.-ft. building, to support processing of natural graphite into active anode material (AAM) used in lithium-ion batteries for electric vehicles (EVs). The expansion follows an agreement with **Tesla** to supply natural graphite AAM for EV battery use. *syrahresources.com.*

DEVELOPING SUSTAINABLE COMPOSITES FOR AUTOMOTIVE APPLICATIONS

Sabah Javaid and Surojit Gupta*
University of North Dakota, Grand Forks

Automotive manufacturers are making significant investments in the design and development of bioplastics and biocomposites-based components.

*Member of ASM International

Substituting biomass for fossil fuel-based precursors in plastics manufacturing holds promise for achieving certain sustainability goals[1]. It is estimated that manufacturing plastics from biogenic resources could reduce greenhouse gas emissions by up to 225%[2]. Further, plastics that feature end-of-life biodegradability have potential to alleviate some of the environmental issues stemming from plastics use[2]. More specifically, bioplastics have emerged as a promising solution. They can be classified into three main categories: (a) bio-based and nonbiodegradable, (b) bio-based and biodegradable, and (c) petroleum-based and biodegradable (Fig. 1). Currently, global use of bioplastics is <1% of the annual plastics production of roughly 367 million tons. However, it is predicted that bioplastics production will increase from around 2.41 million tons in 2021 to approximately 7.59 million tons in 2026 (>2% of global plastics production)[3]. This article focuses on the potential of biomass and bioplastics in the automotive industry.

NATURAL FIBERS

Natural fibers such as bamboo, sisal, cotton, jute, kenaf, coir, industrial hemp, and banana have emerged as practical options for natural reinforcements in polymers[4]. Faruk et al. classify fibers according to the schematics in Fig. 1b[5]. Figure 2 shows density and tensile strength for several natural fibers[6]. The combination of low cost, high specific strength, low density, renewability, biodegradability, and good thermal properties make these fibers suitable for a variety of applications[7]. Regarding density, both flax and hemp are 40% lighter weight than glass fibers. Some disadvantages of natural fibers involve quality issues that are further compounded by weather, the hydrophilic nature of the fibers resulting in poor moisture resistance, low fire resistance, limitations on processing temperatures, residual smell, and price fluctuations due to harvesting variations[6,7]. Thus, manufacturers and end users must balance the advantages and disadvantages for large-scale use of these fibers. For example, high quality jute fibers are standardized as Tossa Grade D[7].

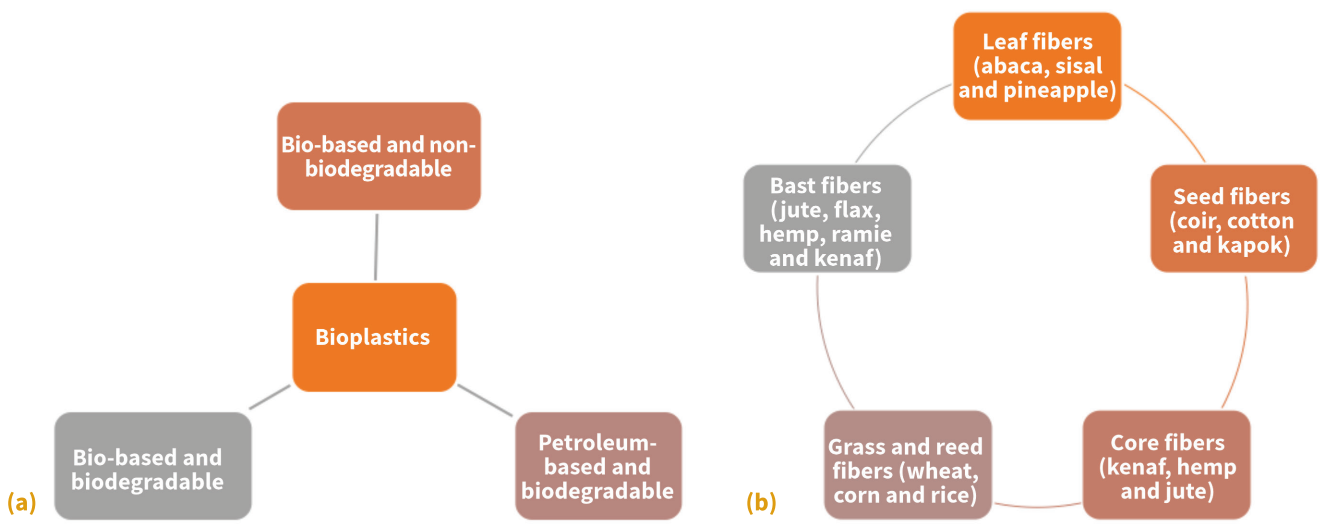


Fig. 1 — Different types of (a) bioplastics[2] and (b) fibers[5].

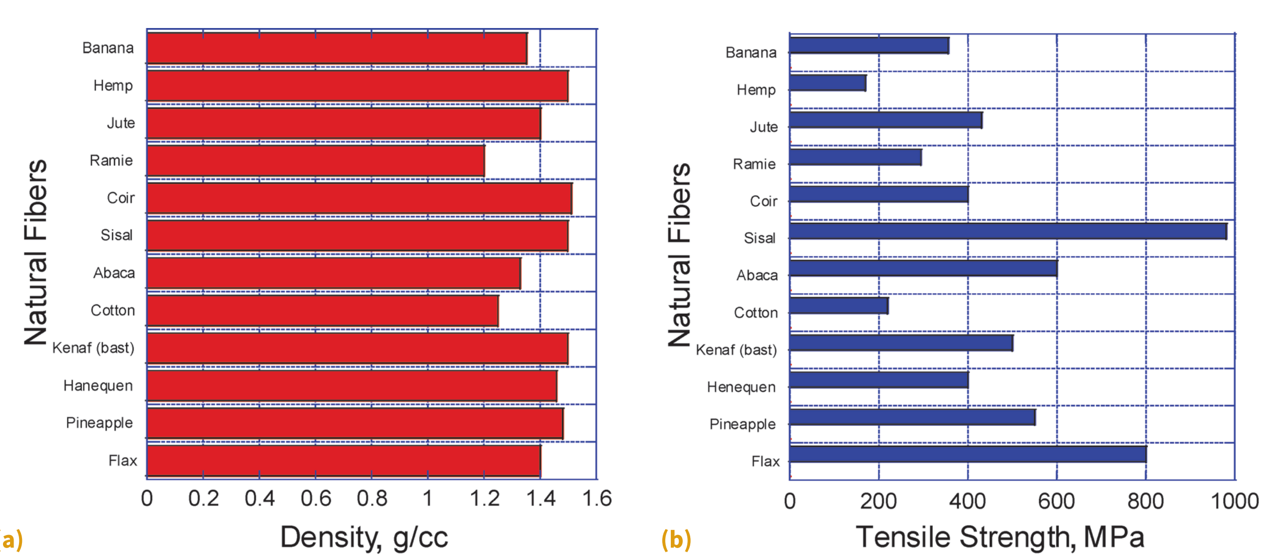


Fig. 2 — Plot of (a) density and (b) tensile strength of natural fibers. Lower limit is plotted from the reference. Data from Table 4, Ref. 6.

Bledzki et al. summarized that natural fibers blended with thermoplastics are well accepted in the automotive industry for use in door liners/panels, parcel shelves, and boot liners[7]. Some examples of fossil fuel-based thermoplastics include polyethylene (PE), polypropylene (PP), polystyrene (PS), and polyvinyl chloride (PVC). Examples of fossil-fuel based thermosets include epoxy, polyester, and vinyl ester. Most of the major car manufacturers including Audi (spare tire lining), BMW (door and head liner panels), Ford (boot liner), Saab (door panels), and Volkswagen (boot lid) have integrated biofibers in their product lists (see Table 6, Ref. 7).

By using natural fibers, it is possible to reduce vehicle weight by 34%[8]. As an external application, the 2018 Mercedes-Benz A-Class model uses a natural fiber mat coupled with a thermosetting bonding agent for a sliding sunroof, replacing the traditional sheet steel frame. In 2019, Porsche reported its 718 Cayman GT4 Clubsport as the world's first car to have exterior parts made of hemp and flax natural fiber-reinforced composites[8]. From these examples, the automotive industry appears to be a pioneer in the design and implementation of sustainable solutions. However, to create a truly sustainable composite system, it is also critical to design a sustainable matrix that can bind the natural fibers.

Porsche's 2019 718 Cayman GT4 Clubsport is the world's first car with exterior parts made of hemp and flax natural fiber-reinforced composites. Courtesy of Porsche.

GREEN BIOPLASTICS

Figure 3 summarizes different types of biodegradable and renewable bioplastics[9]. They can be derived by chemical processing, fermentation, and chemical modification of natural products. Polylactic acid (PLA), polyhydroxyalkanoates (PHAs), soy-based resins, and thermoplastic starch are some examples of promising biodegradable bioplastics. PLA is a renewable biopolymer that can be produced from corn and sugarcane[10]. It is one of the most studied sustainable polymers due to its many advantages such as processability, good mechanical properties, biodegradability, and biocompatibility[11]. Brittleness and low toughness are some of its limitations[10].

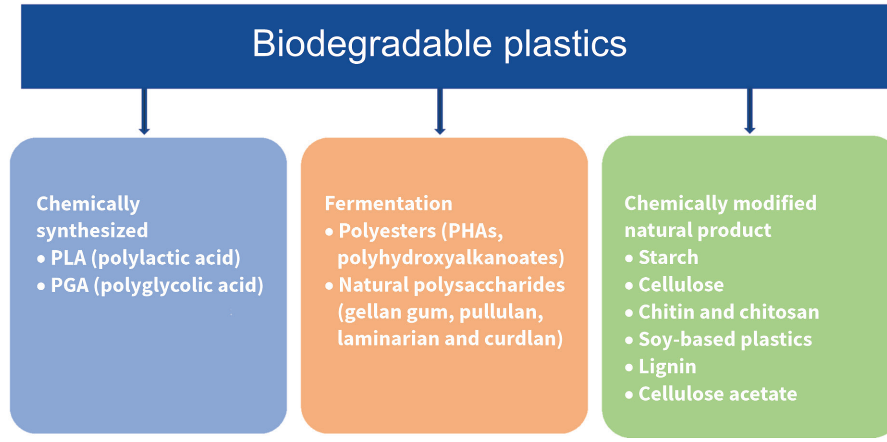


Fig. 3 — Different types of biodegradable plastics[9].

PHA biopolymers are naturally produced from different microorganisms[12]. Biocompatibility, biodegradability, and a thermoplastic type nature are unique attributes of PHAs[13]. Soybean oil-based triglyceride monomers such as maleinized hydroxylated soybean oil (HSO/M), maleinized soybean oil monoglyceride (SOMG/MA), and acrylated epoxidized soybean oil (AESO) are major components of molding resin and exhibit comparable properties to conventional polymers[14]. Starch is one of the abundant plant-based renewable polysaccharides that is completely biodegradable[15]. For example, thermoplastic starch (TPS) has applications for short life use such as food packaging[16].

AUTOMOTIVE BIOCOMPOSITES: A SHORT HISTORY

Figure 4 shows a timeline of automotive applications using bioplastics and biocomposites[17-19]. Henry Ford proposed the idea of using bio-based materials in the early 1930s[17]. These environmentally friendly materials enabled low emissions and lightweight car bodies, which spurred extensive research by Ford Motor Company. On August 13, 1941, at the annual Dearborn Days festival, the first car body made of soybean plastics was unveiled[17]. Soybean, hemp, wheat straw, flax, and ramie were claimed ingredients in the plastic panels, although the exact chemical composition is not available. Nevertheless, it was reported that the car body weight was just two thirds of a standard car of the time.

The "Soybean Car" was unveiled by Henry Ford on August 13, 1941, at Dearborn Days. The steel frame had 14 plastic panels attached to it, made of soybeans, wheat, hemp, flax, ramie, and other ingredients, according to one source. Lowell E. Overly, the car's chief creator, claims the formula was "…soybean fiber in a phenolic resin with formaldehyde used in the impregnation." Courtesy of The Henry Ford.

Research into plastic cars was stalled by World War II and war recovery efforts[17]. However, in recent years, several car companies have made significant investments in the design and development of bioplastics and biocomposites-based components (Fig. 4). In 2018, a group of researchers from Eindhoven University of Technology in the Netherlands designed a car completely made of biocomposites. The chassis was made of PLA and the car weighed just 360 kg (794 lb), roughly a quarter of the weight of a typical mid-size car.

CHALLENGES AND RECOMMENDATIONS

Some critical challenges facing the use of bioplastics include the following: low heat resistance; low strength (for example, starch is a hydrophilic additive that can weaken hydrophobic polymers); confusion between compostability and biodegradability (not all biodegradable materials are compostable); high cost (for example, PHA costs four times as much as conventional plastics); poor durability; and lack of awareness regarding best practices for disposal[20,21].

From an engineering perspective, it is possible to control strength and durability by focusing on microstructure and a design that incorporates additives such as plasticizers, multicomponent blends, and impact modifiers. Figure 5 shows the schematics of different types of microstructures that can be

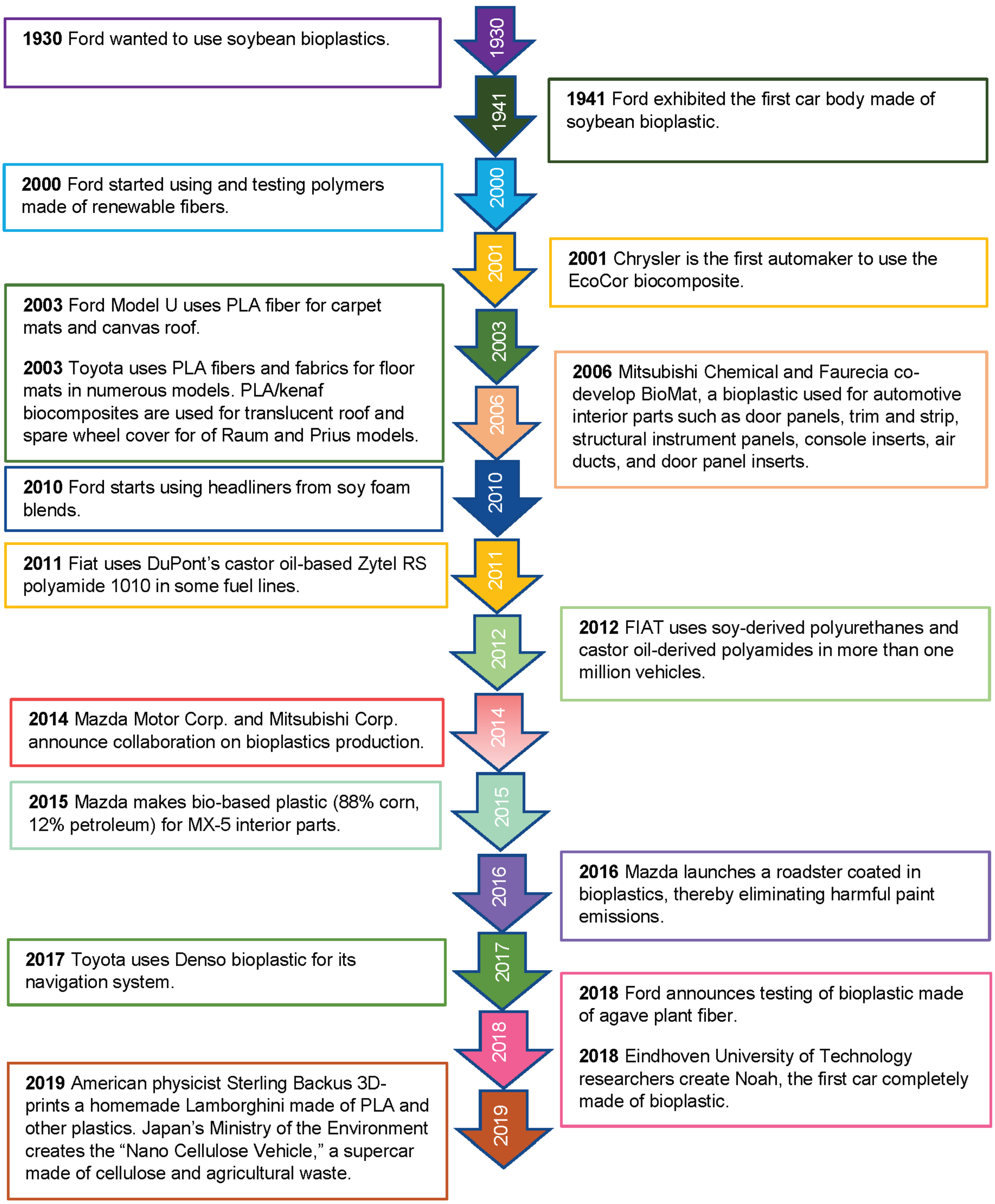


Fig. 4 — Application timeline for automotive bioplastics[17-19].

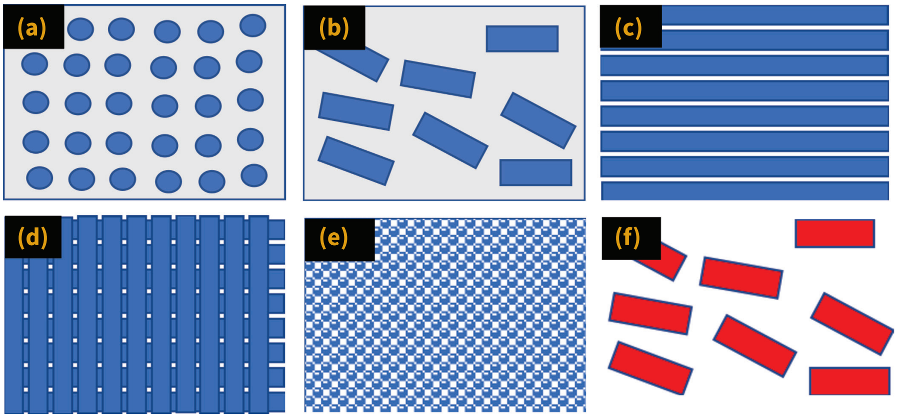


Fig. 5 — Schematics of different bioplastic microstructures reinforced with: (a) particulates; (b) short fibers; (c) continuous fibers; (d) multilayered structures with fibers reinforcing the matrix in longitudinal and transverse directions; (e) porous; and (f) a porous network reinforced with fibers.

attained by integrating particulates and fibers in the biopolymer matrix. For example, particles, short fibers, and continuous fibers can be integrated in the matrix (Fig. 5a-c). Multilayered structures can be created by stacking fibers in different orientations (Fig. 5d). In addition, it is also possible to tailor the porosity and design various types of derivatives based on the results (Fig. 5e-f).

Notta-Cuvier et al. used a tributyl citrate (TBC) plasticizer and halloysite nanotubes (HNTs) synergistically in the PLA matrix to enhance rigidity, strength, ductility, and toughness[22]. See Fig. 5a for an example of this type of microstructure. Abu Aldam et al. showed that with solvent casting, a PLA matrix can be reinforced with crystalline PHA—another example of the Fig. 5a microstructure[23]. Efendy et al. designed PLA composites by using discontinuous harakeke and hemp fibers[24] (Fig. 5b). They subsequently designed mats by alternating layers of PLA and PLA reinforced with up to 40 wt% fiber composites (Fig. 5d). They also proposed that a rule of mixtures calculation can be effective in predicting the strength of these composites.

Hinchcliffe et al. used continuous fiber strands of flax and jute to reinforce a PLA matrix[25] (Fig. 5c). This group observed enhanced 116%, 62%, 14%, and 10% for tensile strength, stiffness to weight, flexural specific strength, and rigidity to weight, respectively, as compared to PLA samples. Recently, Gupta et al. designed biofoams by using lignin and wheat straw (WS) as precursors. The team reports an ultimate compressive strength of lignin-50 wt% WS was ~20.4 MPa after pyrolysis at 300 °C[26] (Fig. 5e-f). Based on these research efforts, the future of bioplastics looks promising in spite of the remaining challenges.

ASTM D6400 is the standard for compostable bioplastics, although composting can be done at home or in an industrial setting. For example, PLA is compostable in an industrial setting compared to chitin and PHA, which are compostable under home conditions. A common misconception is that all biodegradable polymers are compostable under home conditions[20]. In order to develop better disposal practices for bioplastics, a public awareness campaign should be created to inform various stakeholders about disposal and composting from a circular economy perspective.

Further research regarding precursors should be explored to lower the cost of bioplastics. On average, 998 million Mt of agricultural waste are generated every year. This waste could potentially be used as a precursor for manufacturing PHA by optimizing fermentation conditions[12]. Further, engineering of blended designs that focus on binary and ternary blends is recommended to increase the performance of bioplastics[23]. Finally, although natural fiber use has reached maturity in industry, it could further benefit from strict quality standards. **~AM&P**

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SUSTAINABILITY AT UDDEHOLM: A STUDY IN PRODUCING CLIMATE-NEUTRAL TOOL STEEL

Fig. 1 — Uddeholm was founded in 1668 in a small rural town in Sweden.

Uddeholm devoted a week to study sustainable development opportunities, reducing their carbon emissions and analyzing ways to produce tool steels more sustainably.

Robert Gustafsson and Berne Högman
Uddeholm, Hagfors, Sweden

The endeavor to achieve a sustainable society is part of Uddeholm's business, believing that new technical innovations will play a major role in many of the global environmental challenges that lie ahead. The great challenge is to make sure that the company's profitability is the result of striking a long-term balance between social, environmental, and financial interests.

More than ten years ago, Uddeholm proactively converted from oil to natural gas, which plays an important role in the transition toward a renewable future (Fig. 1). Uddeholm only uses fossil-free electricity. In addition, the company's products consist of up to 85 to 98% recycled materials. These are some of the many measures already taken toward a more sustainable future.

CLIMATE NEUTRAL WEEK

Sustainability has long been an important key factor for Uddeholm. Years of research and development have put the company at the forefront of sustainable tool steel production, and they decided to push this concept further. In the middle of December 2021 they ran a week-long trial of producing climate-neutral tool steel to show that the impossible is possible. The week resulted in a reduction of up to 90% of Uddeholm's fossil CO_2 emissions.

The following steps were taken to achieve climate-neutral tool steel.

Step 1: Start with a sustainable foundation. Sustainability is not a new concept to Uddeholm. Since the 1960s, they have been using an electric arc furnace (EAF) for the melting process, and have reduced fossil CO_2 emissions by 46% since 1990 (Fig. 2). Today they use 100% fossil-free energy sources and products are made of 85 to 98% recycled material.

Step 2: Make real changes. During the Climate Neutral Week, the company replaced liquefied natural gas (LNG) with fossil-free liquefied biomethane gas (LBG), and all internal transportation ran on fossil-free electricity or 100% share of HVO100 (biodiesel). These measures led to a significant reduction of up to 90% of fossil CO_2 emissions.

Step 3: Climate compensation. The remaining 10% of emissions consist of carbon in scrap metal and graphite electrodes used for the melting process at the EAF. As of today, there are no fossil-free replacements. The company compensates for this 10% with Gold Standard certificates in accordance with the United Nations sustainability goals.

FUTURE OUTLOOK

Work is already in progress to analyze and quantify the carbon footprint for each of the company's products. The purpose of this work is to monitor the areas where the steel manufacturer can contribute the most to reducing the carbon footprint. This analysis describes what activities should be done first in order to have the greatest effect, and also in what direction they should move to develop more sustainable tool steels that meet customer demands.

Fig. 2 — Since the 1960s Uddeholm has used an electric arc furnace for its melting process, and reduced fossil CO_2 emissions by 46% since 1990.

These studies identify indirect greenhouse gas emissions in the upstream supply chain of the purchased materials, direct emissions from processes and the production of the tool steels, and downstream on the treatment of waste and wastewater.

Carbon reporting generally follows the GHG (Green House Gas) Protocol, which divides emissions into three scopes as shown in Fig. 3. While Scope 1 and 2 emissions are compulsory to report, Scope 3 emissions are voluntary and the most challenging to monitor.

Scope 1 greenhouse gas emissions are emissions that come directly from a company and its controlled entities. Companies interested in reducing their Scope 1 emissions tend to focus on improving their energy efficiency and transitioning their transportation fleet toward electric vehicles. Uddeholm is already using 100% fossil-free electricity and over 50% of Uddeholm's internal transports are fossil-free.

Scope 2 greenhouse gas emissions are emissions that come indirectly from

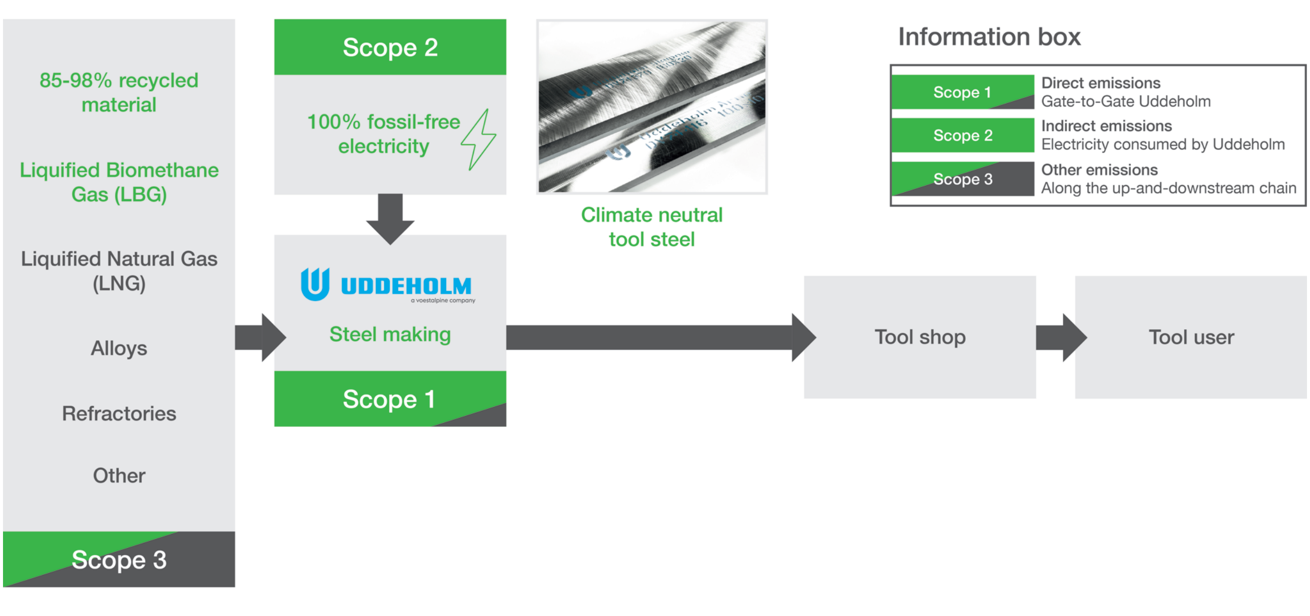

Fig. 3 — The company followed the Green House Gas Protocol, which divides emissions into three scopes.

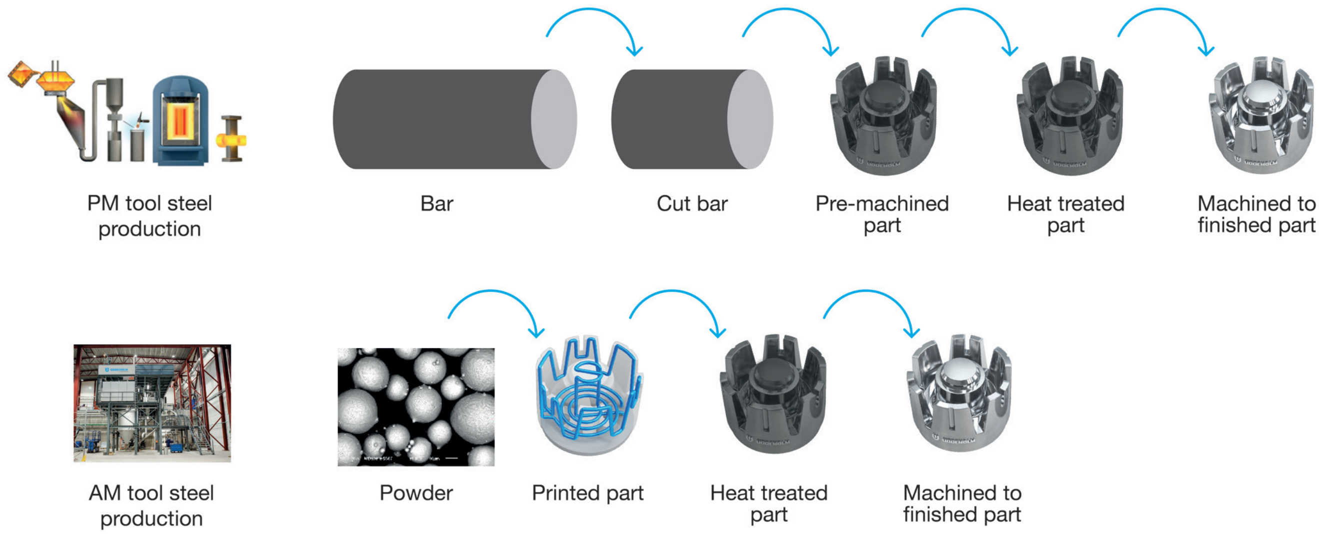

Fig. 4 — Traditional powder tool steel production versus additive manufacturing tool steel production.

the generation of purchased energy from a utility provider. For most companies, electricity consumption is their one and only source of Scope 2 emissions. Companies intent on reducing their Scope 2 emissions tend to purchase their energy from utility providers with clean energy options, as well as purchasing carbon offsets. Today, Uddeholm products comprise 85 to 98% recycled material, LNG is being replaced with fossil-free LBG.

Scope 3 emissions are all indirect emissions not included in Scope 2 that occur in the value chain of the reporting company, including both upstream and downstream emissions. In other words, emissions linked to the company's operations, according to the GHG Protocol. As previously mentioned, during Climate Neutral Week, Uddeholm replaced LNG with fossil-free LBG, and the goal is to replace up to 30% of today's annual volume of LNG with fossil-free LBG, starting in April 2022.

Uddeholm is looking into many things to be even more sustainable. Additive manufacturing (AM) technology is one area that is developing quite fast and will most likely be more sustainable than traditional tool making. The value chain is shorter and reduces the waste of material and energy needed to produce the finished part (Fig. 4). It also allows more freedom of design, which will optimize the need of material for the tool function. This can be by conformal cooling channels that make the tool more efficient, increase tool life, and reduce scrap rates. AM also opens up more possibilities to combine materials and repair tools, ensuring a more efficient usage of raw materials in the tool.

The flexibility of AM could also be a better alternative to traditional manufacturing of tool steels from a sustainability perspective. The majority of active tool inserts today can fit into a 3D printer. This means that a printer cannot only reduce the traditional extensive dimensional steel bar program, but also print any desired shape within this size. Today the printing cost is often higher than traditional tool making, but with higher demands on reducing carbon footprint and lead times, AM technology will be a more competitive and sustainable alternative for tool making in the near future. **~AM&P**

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SUSTAINABLE MATERIALS FOR ELECTRIC VEHICLES: WEBINAR ROUNDUP

A webinar collaboration between ASM International and the Materials Research Society in 2021 brought together a panel of speakers to discuss the challenges and opportunities on the horizon as electric vehicle designers and manufacturers search for materials with sustainability characteristics.

Electric vehicles (EVs) are dominating the technology news today as we look to a future with less dependence on fossil fuels and a more sustainable technology. Materials are playing a critical role in the growth of electric vehicles, primarily for batteries and fuel cells, but also for other components. The widely used lithium-ion batteries in EVs are the subject of much research for greater efficiencies and energy densities. Fuel cells using hydrogen continue to be explored for larger electric vehicles such as trucks. In this development of existing and new materials, sustainability is an important consideration over the whole design, processing, and recycling cycle. The talks in this webinar cover various aspects of sustainable materials and their use for electric vehicles with a focus on batteries and fuel cells.

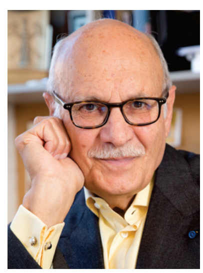
DIRAN APELIAN, FASM: HOST

Distinguished Professor, Department of Materials Science & Engineering, University of California (UCI), Irvine

Director, Advanced Casting Research Center, UCI

Provost Emeritus and Founding Director, Metal Processing, Worcester Polytechnic Institute, Mass.

Founding Editor, Journal of Sustainable Metallurgy



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Climate change is real. For thousands of years, the carbon dioxide levels in the Earth's atmosphere have been around 250 to 275 ppm (parts per million). In the last couple of decades, this value has risen to 475 ppm. The last five years have been the hottest five years on record. The factors that affect the production of carbon dioxide can be broadly classified into those that relate to housing, transportation, and manufacturing of goods.

The presentations by this webinar's three presenters highlight the effort to transition to sustainable energy in the area of mobility. Higher performing electric vehicles that are also affordable offer tremendous potential to mitigate global warming. The key to this effort is energy storage. In 2019, of all the energy used for mobility, only about one tenth of a terawatt hour was used by electric vehicles. To have one hundred percent electrification, this figure would need to increase by one hundred times. Storage also enables broad utilization of clean energy through better use of intermittent resources such as wind and solar.

These possibilities have raised palpable excitement about battery and battery materials, as evidenced by Gigafactories being built and planned globally. Even traditional car companies such as Volkswagen are electrifying a majority of their fleet.

KRISTIN PERSSON: PRESENTER

Professor, Department of Materials Science & Engineering, University of California, Berkeley

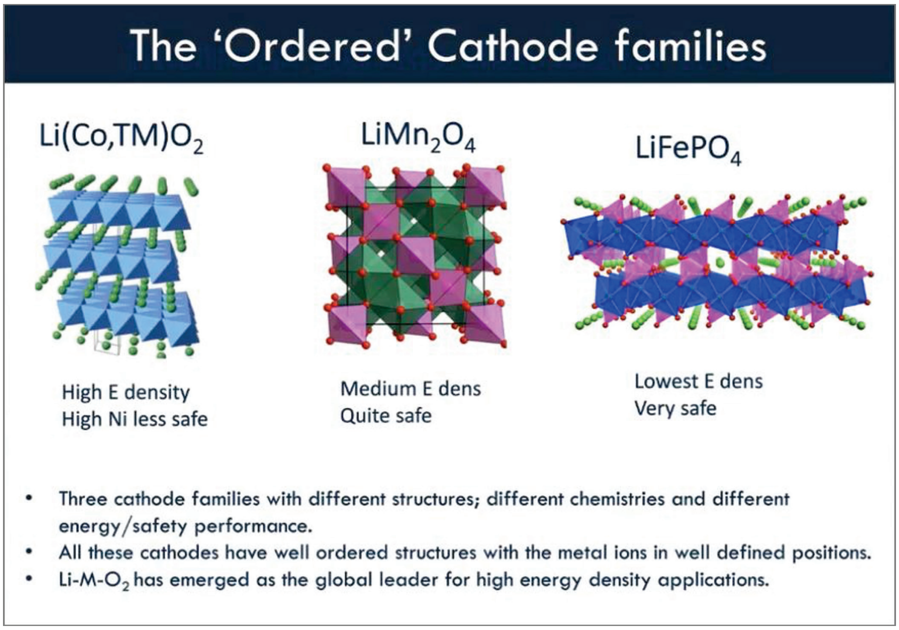
Director, Molecular Foundry, Lawrence Berkeley National Lab

Persson

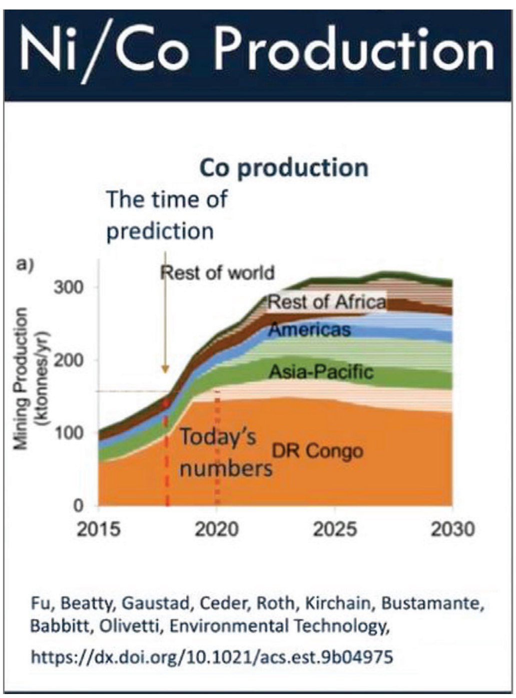
Battery Materials for Transportation: Challenges and Opportunities

The materials perspective of energy storage can be examined by understanding the chemical, structural, and thermodynamic challenges facing batteries.

In lithium batteries, as in other batteries, an active material is sandwiched between two electrodes. In the traditional lithium-ion battery, the electrolyte is a liquid that delivers and withdraws lithium ions during charging and discharging. In solid state batteries, the electrolyte is a solid. Both of these systems use high energy cathode materials belonging to three different structural families—namely those of lithium iron phosphate, lithium manganese spinel, and the layered family. Consequently, the challenges and the opportunities



Slide 1



Slide 2

in both the battery systems are largely convergent.

These families are said to be "ordered" which means that the lithium ions and transition metal ions sit in specific sites within them (Slide 1). Lithium iron phosphate has the lowest voltage and the lowest energy density, but is the safest. Lithium manganese spinel has a higher voltage but medium energy density. Layered cathodes—so named because of their distinct layered structure—have the highest energy density.

As the nickel content in these materials increases, they become less safe. However, they have emerged as a global leader because of their high energy density and because of the perception that safety can be engineered on the pack level of storage.

The safety concern for the layered family can be understood through the example of lithium cobalt oxide. The structure typically consists of alternating layers of cobalt and lithium interleaved with oxygen. As more and more lithium is pulled out during charging and discharging, the material becomes unstable—like a jenga tower—and finally collapses. Increasing the cobalt, nickel, and manganese content causes structural instabilities so that the cathode cannot be charged more than 70 or 80%. They also release oxygen at high charge, leading to porosity and cracking of the electrodes.

Yet, we can essentially only make layered materials with nickel and cobalt as active redox elements. All other transition metals will migrate upon delithiation, resulting in lower voltage and shutting down lithium migration.

This has a significant impact on the future of electric storage. Estimates of the electric storage capacity needed for 2022 range from 2 to 20 terawatt hours. Two terawatt hours is equivalent to approximately two million tons of nickel and cobalt, and 10 terawatt hours is correspondingly 10 million tons of nickel and cobalt.

As the diagram in Slide 2 shows, the cobalt production today is almost an order of magnitude less than needed. Therefore, new materials that perhaps use disorder to their advantage by keeping lithium diffusion pathways open need to be actively explored.

IRYNA V. ZENYUK: PRESENTER

Professor, Department of Chemical and Biomolecular Engineering, University of California, Irvine

Associate Director, National Fuel Cell Research Center

Zenyuk

Fuel Cell Electric Vehicles: Materials Needs for Deployment at Scale

Hydrogen can be a competitive energy source for this industry as it has a similar range to internal combustion engines, has quick refueling time, and produces zero emissions if extracted from clean sources. The gravimetric density of hydrogen is three times that of diesel, producing between 100 and 120 MJ/kg. The U.S. produces more than 10 million metric tons of hydrogen, but unfortunately, 99% of this is from fossil fuels with 95% generated through steam methane reforming. This emits carbon dioxide and is harmful to the environment.

If compressed hydrogen is used instead of diesel, there is no substantial reduction in the payload capacity of heavy duty trucks. However, a hydrogen fuel cell based system would take up significant space, reducing the available payload capacity from 50,000 to 35,850 lbs. Compressed hydrogen also takes 15 minutes for refueling, while a diesel truck only takes 5 minutes. Despite this, hydrogen is very suitable for heavy duty transportation as it enables carrying a large amount of fuel for long distance transportation. Trucks therefore can be driven for 700 miles on hydrogen without refueling. For this reason, Europe projects deployment of 1.7 million heavy duty vehicles by 2015 (Slide 3). Currently, the challenges are cost, durability, and the availability of refueling stations.

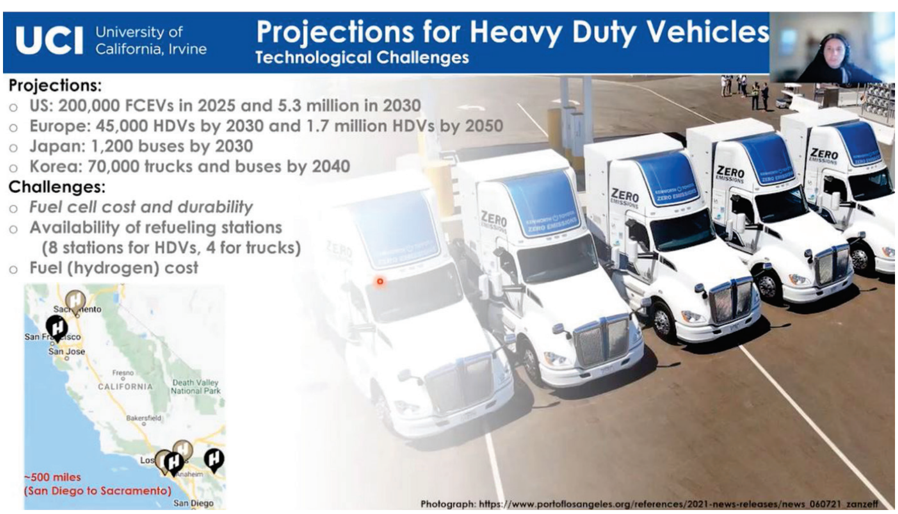
Ideally, a fuel cell system that uses hydrogen as a fuel for heavy duty transportation should be able to operate for 30,000 hours and cost around $60/kW in order to be competitive with diesel engines. One of the most expensive parts of this system is the platinum within the fuel cell. A standard heavy duty vehicle (HDV) would require about 156 g of platinum per vehicle. The projected demand for platinum to meet the target of 1.7 million HDVs in Europe by 2050 is 265 tons (Slide 4). Currently, global platinum production is at 200 metric tons. Therefore, the platinum target is achievable, but it would strain other sectors where the precious metal is used, such as jewelry. Recycling, therefore, is much needed.

The most expensive component of hydrogen fuel cells today is the platinum catalyst (up to 50 to 60%) and consequently many novel high activity catalysts are being developed—such as alloyed compositions, shape controlled, core shell, and nanostructured catalysts. It's still not clear how to integrate them with the rest of the fuel cell stack, as a continuing problem with these systems is that the ionomer layers tend to adsorb onto platinum. Because of this, the performance of these catalysts is much lower in actual fuel cells than predicted.

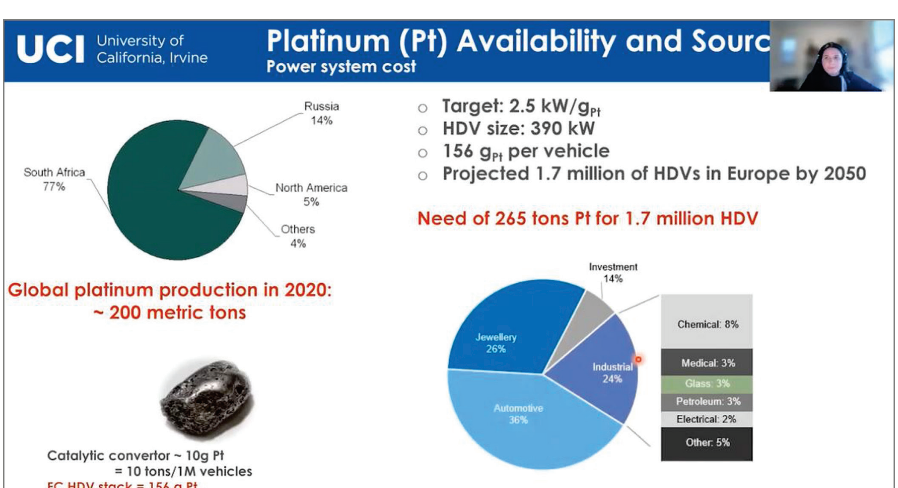
This presenter's group works on enabling several solutions to prevent this "ionomer poisoning." One of them is introducing an ionic liquid in between the catalyst and the ionomer which prevents the adsorption of SO_3 groups on the catalyst surface that results in much better durability in encapsulating platinum. Another approach is to introduce molecular modifiers such as poly melamine formaldehyde (PMF) into the catalyst, which improves activity and lowers the SO_3 poisoning on platinum. A third approach is to replace the current ionomer layers with novel compositions that have similar performance but are less susceptible to sulfonic acid poisoning.

Successive cycles of oxidation and reduction can also lead to the dissolution of platinum ions, which degrades the catalyst. Several material mechanisms such as Ostwald ripening, platinum band formation, agglomeration, and particle detachment have been shown to be responsible for this. Combating these phenomena requires both systems as well as materials solutions. For example, lowering the potential of the cell can slow down the degradation. Materials optimizations consider a tradeoff between activity and durability. These options include the introduction of ordered intermetallic alloys and doping of a third element to the platinum alloy nanoparticle—which forms a "skin layer" over the catalyst. Large nanoparticles have lower specific surface areas which can also reduce the degradation.

Fuel cells will be deployed mostly in the heavy duty transportation sector or in ships, trains, and aircraft. Currently, the challenges are with the cost and durability, with most of the static cost coming from platinum. So, by making sure that the fuel cells are more durable and by recycling platinum, the cost targets can be reached. Each time a new catalyst is introduced into the fuel cells, every other component has to be reevaluated and integrated well with that catalyst. That's why the problem is so challenging.



Slide 3



Slide 4

ERIC GRATZ: PRESENTER

CTO and Co-founder, Ascend Elements, formerly Battery Resourcers

Former Assistant Research Professor, Metal Processing Institute at Worcester Polytechnic Institute, Mass.

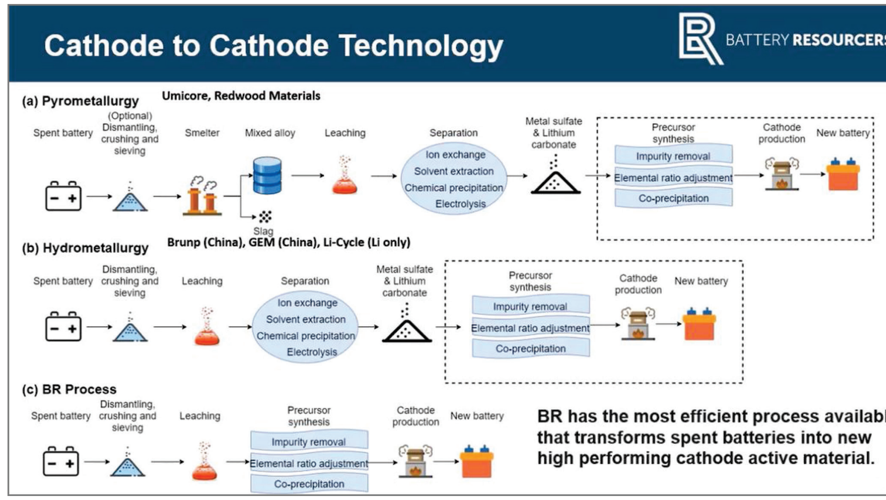
Gratz

High Performance Materials through Closed-Loop Recycling

There is a great need to discover the best recycling methods for making new cathode materials from spent lithium-ion batteries. It is driven by the growing use of lithium-ion batteries, which is putting pressure on existing supply chains.

For example, Europe currently has a capacity of 40 gigawatt hours, which is scheduled to increase to 512 gigawatt hours. This is bound to put immense strain on the supply of nickel, cobalt, lithium, etc. Ascend Elements, formerly known as Battery Resourcers, is closing the supply chain loop by recovering critical elements in used batteries and engineering new, sustainable cathode material to be returned to the battery supply chain. Cathode material is a higher-value, engineered material compared to metal salts, which are more of an unprocessed raw material.

Currently in North America, the largest recyclers such as Umicore and Redwoods Materials use a pyrometallurgical process to recycle spent batteries. Here a used battery is dismantled, crushed, and the resulting material is smelted to produce a nickel cobalt ore. When dissolved in acids, the nickel and cobalt turn into their respective sulfates while lithium changes into a carbonate. After purification, these materials are sent to a battery manufacturer to



Slide 5

be turned into cathodes. Other recyclers use a hydrometallurgical process that does not require smelting. With this method, the crushed battery materials are directly dissolved in an acid and the resulting sulfates and carbonates are separated by organic solvent extraction. Once purified, they are sent to a battery manufacturer as well.

Ascend Elements takes a different approach by converting the crushed battery materials to a nickel manganese cobalt (NMC) hydroxide which can be directly used in battery manufacturing, which makes it far more efficient than the previous two processes (Slide 5). If the elemental composition of the specific cathode does not match with the NMC hydroxide, additional sulfates or carbonates can be added to the mixture to reach the correct stoichiometry. This process eliminated the need for many intermediate steps and provides an advantage in that the recycling and manufacturing happens at one site, thereby saving costs and emissions involved in shipping.

This process also costs around 35% less than virgin raw materials, making it desirable for manufacturers. For comparison, pyrometallurgical processes cost 2% more than the original raw material. There is also an 87% reduction in the amount of carbon dioxide produced. These gains are significant as the cathode is the most expensive and carbon intense material in batteries.

The cathode materials produced at Ascend Elements have high purity and cycle life and are targeted at Tier I European and Asian suppliers. They are working on high nickel cathode material, single crystal materials, anode materials, and high purity graphite. **~AM&P**

Acknowledgments

The webinar was sponsored by Linde and UPC Marathon. Editorial assistance on this roundup article was provided by Vineeth Venugopal, postdoctoral researcher at MIT.

For more information: The recorded webinar from August 4, 2021, is available on demand on both the MRS and ASM websites at:

- https://mrs.digitellinc.com/mrs/sessions/32642/view
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AEROMAT 2022 SUMMARY: RESEARCH AND DEVELOPMENT ENABLING NEXT-GENERATION AEROSPACE MATERIALS

AeroMat's successful return to in-person meetings featured keynotes and programming on next-generation materials, and for the first time, was co-located with AeroTech.

Jeff Grabowski, QuesTek Innovations LLC, 2021 Conference Chair*

Eli Ross, Pratt & Whitney, 2022 Conference Chair*

The Pasadena Convention Center.

After two years in a virtual-only mode, ASM's AeroMat conference returned in March 2022 to in-person. Held in Pasadena, California, the 2022 edition represented the 33rd year of the preeminent conference focused on aerospace materials and processes. The attendance was roughly 55% of pre-COVID events, with more than 125 technical papers presented and over 20 exhibitors present. There was a noticeable buzz of energy across the technical sessions and exhibit hall, as people engaged in rich technical and business discussions with old colleagues, as well as making new contacts across the diverse attendees. The 2022 edition also marked the first ASM AeroMat co-located with SAE's annual AeroTech conference, adding to the programing with cross-registration privileges, relevant keynotes, panel discussions, and a broadened attendee base.

In addition to technical presentations covering a range of relevant topics, AeroMat also featured an education course on metal additive manufacturing, three keynote speakers representing Airbus, Constellium, and Howmet Aerospace, as well as a panel discussion. Two of the keynote addresses and the joint AeroMat-AeroTech panel discussion focused on the emergence of sustainability in the aerospace industry and the various ways materials can contribute to addressing this global challenge. This was a theme across many other technical presentations and discussion among attendees. Notably, these talks and discussions went beyond high-level goals and broad initiatives, instead digging deeper into current updates reporting on actual progress that companies are making and investing in a more sustainable future. In the technical sessions, global participants shared updates on traditional AeroMat topics such as additive manufacturing, welding, and high-temperature materials in addition to emerging areas such as residual stress and tribology.

The AeroMat organizing committee looks forward to future events that continue the tradition of gathering a diverse group of aerospace materials and industry experts together for information sharing and collective problem solving to address key challenges. The

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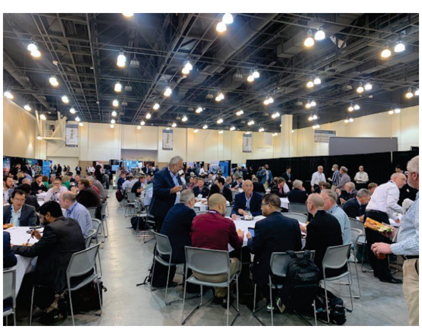
call for papers is open, so please join us at AeroMat 2023, planned for March 14-16 in Ft. Worth, Texas, where the theme is "Next-Generation Materials & Processes for Sustainability in Aerospace," again co-located with SAE's AeroTech conference. **~AM&P**

For more information: Kathy Murray, global conference manager, ASM International, 9639 Kinsman Rd., Materials Park, OH 44087, 440.671.3843, kathy.murray@asminternational.org, events@asminternational.org, aeromatevent.org.

Dr. Sylvain Henry gives a keynote address.



Attendees enjoy networking during lunch.

The panel discussion addressed "Sustainability, an Aerospace Imperative." (Panelists from left: Jacqueline Hardin, QuesTek Innovations; Bill Bihlman, Aerolytics; Christian Rückert, Airbus; Kay Blohowiak, Boeing; Graham Webb, Pratt & Whitney; Philippe Meyer, Novelis; Tammy Reeve, Patmos Engineering; Pascal Thalin, SAE International; and Sylvain Henry, Constellium.

Members of the AeroMat 2022 organizing committee after the traditional luncheon and conference review meeting.

AEROMAT 2023: CALL FOR PAPERS

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9:00–10:00 A.M.

DR. KATHRYN BEERS
Program Manager, Circular Economy
NIST

TUESDAY, SEPTEMBER 13

SUSTAINABLE MATERIALS AND PROCESS STRATEGIES FOR THE AIRCRAFT OF TOMORROW

3:00–4:00 P.M.

DR. KAY YOUNGDAHL BLOHOWIAK
Senior Technical Fellow
Boeing Research & Technology

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DR. JASON SEBASTIAN
President
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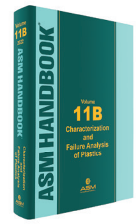

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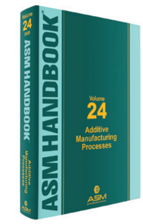

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Iron & Steel Castings Engineering Guide

By Jagan Nath
2021 • 368 pages
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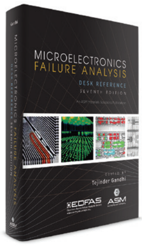
An accompanying guide to *Aluminum Castings Engineering Guide* (ASM International, 2018; see on page 6), it explains the interactions of product design, materials engineering, and process engineering practices.



Microelectronics Failure Analysis Desk Reference, Seventh Edition

Edited by Tejinder Gandhi
2019 • 705 pages
ASM Digital Library: $75 / ASM Member: $59
Free to EDFAS Members
EISBN: 978-1-62708-247-1
Print: $250/ ASM or EDFAS Member: $190
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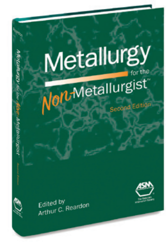

Metallurgy for the Non-Metallurgist™, Second Edition

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2011 • 526 pages
ASM Digital Library: $49 / ASM Member: $39
EISBN: 978-1-62708-261-7
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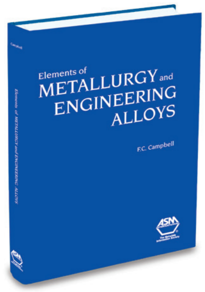
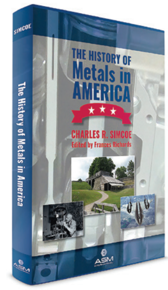
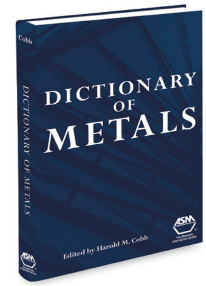


Elements of Metallurgy and Engineering Alloys gives a thorough presentation of physical and mechanical metallurgical concepts along with a practical survey of all important metals, their alloys, and their engineering properties. It covers basic metallurgy, metallic material selection, and application.



The History of Metals in America chronicles the development of metals as both an industrial activity and a science. Progress involving structural metals made possible the air, land, sea, and space travel of today, skyscrapers reaching over 100 stories high, and many other engineering accomplishments that continue to shape modern society.



Dictionary of Metals is the authoritative reference work for terms and definitions of metals and terms relating to metals. It also includes a considerable amount of history starting with the seven metals of antiquity. Each of the metallic elements has a discussion that includes the discoverer and date, the naming of the metal and its meaning, the major applications, the significance of the discovery, and physical properties.

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Print: $205 / ASM Member: $155
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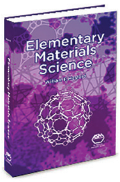
ASM Metals Reference Book, Third Edition
Edited by M.L. Bauccio • 1993 • 614 pages
Print: $185 / ASM Member: $140
ISBN: 978-0-87170-478-8
Product Code: 06118G

Dictionary of Metals
Edited by Harold M. Cobb • 2012 • 374 pages
Print: $175 / ASM Member: $130
ISBN: 978-1-61503-978-4
Product Code: 05359G



Elementary Materials Science
By William F. Hosford • 2013 • 188 pages
ASM Digital Library: $25 / ASM Member: $17
EISBN: 978-1-62708-283-9
Print: $90 / ASM Member: $70
ISBN: 978-1-62708-002-6
Product Code: 05373G

Elements of Metallurgy and Engineering Alloys
Edited by F.C. Campbell • 2008 • 672 pages
ASM Digital Library: $49 / ASM Member: $39
EISBN: 978-1-62708-251-8
Print: $175 / ASM Member: $130
ISBN: 978-0-87170-867-0
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Print: $125 / ASM Member: $95
ISBN: 978-1-62708-145-0
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Lightweight Materials: Understanding the Basics
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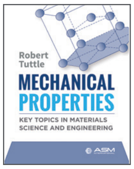

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2017 • 547 pages
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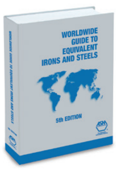
ISBN: 978-1-62708-137-5
Product Code: 06838G



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Advanced High-Strength Steels: Science, Technology and Applications
By Mahmoud Y. Demeri • 2013 • 312 pages
ASM Digital Library: $49 / ASM Member: $39
EISBN: 978-1-62708-279-2
Print: $185 / ASM Member: $140
ISBN: 978-1-62708-005-7
Product Code: 05370G

ASM Specialty Handbook® Cast Irons
Edited by J.R. Davis • 1996 • 494 pages
Print: $380 / ASM Member: $285
ISBN: 978-0-87170-564-8
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ASM Specialty Handbook® Carbon and Alloy Steels
Edited by J.R. Davis • 1996 • 731 pages
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Product Code: 06241G

Handbook of Residual Stress and Deformation of Steel
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Iron and Steel Castings Engineering Guide
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ISBN: 978-1-62708-330-0
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Stahlschlüssel (Key To Steel) 2019 Edition
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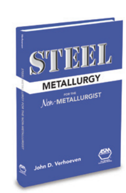
Product Code: 05231G

Steel Castings Handbook, Sixth Edition
Co-published by Steel Founders' Society of America and ASM International • 1995 • 472 pages
Print: $255 / ASM Member: $190
ISBN: 978-0-87170-556-3
Product Code: 06820G



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Price: Print: $135 / ASM Member: $100
ISBN: 978-0-87170-858-8
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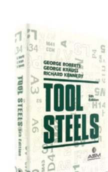
Print: $265 / ASM Member: $200
ISBN: 978-1-62708-083-5
Product Code: 05441G



Tool Steels, Fifth Edition
By G. Roberts, G. Krauss, and R. Kennedy • 1998 • 364 pages
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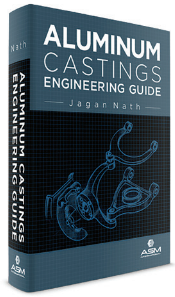
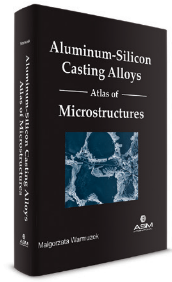
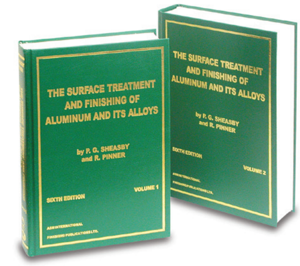
ISBN: 978-0-87170-599-0
Product Code: 06590G



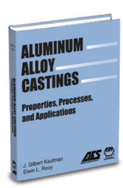
Aluminum Castings Engineering Guide is a practical guide to product and process engineering of various aluminum castings emphasizing process and material characteristics; product-process-alloy integration; manufacturing aspects of aluminum casting; product design features; tooling design, feeding and gating design; product quality needs and specifications.



Aluminum-Silicon Casting Alloys: Atlas of Microstructures provides engineers and researchers who work with aluminum castings with a practical and substantive tool for the visual analysis of the microscopic images of the microstructure of the aluminum casting alloys.



The Surface Treatment and Finishing of Aluminum and Its Alloys is a comprehensive review and guide to surface engineering — cleaning, finishing, and coating — of aluminum and its alloys. It covers anodizing and coloring treatments.



Aluminum Alloy Castings: Properties, Processes, and Applications
By J.G. Kaufman and E.L. Rooy • 2004 • 340 pages
Co-published by ASM International and the American Foundry Society.
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ISBN: 978-0-87170-803-8
Product Code: 05114G

Aluminum Castings Engineering Guide
By Jagan Nath • 2018 • 301 pages
ASM Digital Library: $75 / ASM Member: $59
EISBN: 978-1-62708-280-8
Print: $240/ ASM Member: $180
ISBN: 978-1-62708-205-1
Product Code: 06841G

Aluminum Extrusion Technology
By P.K. Saha • 2000 • 259 pages
Print: $230 / ASM Member: $175
ISBN: 978-0-87170-644-7
Product Code: 06826G

Aluminum-Silicon Casting Alloys: Atlas of Microfractographs
By Małgorzata Warmuzek • 2004 • 124 pages
Print: $140 / ASM Member: $105
ISBN: 978-1-87170-794-9
Product Code: 06993G

Aluminum-Silicon Casting Alloys: Atlas of Microstructures
By Małgorzata Warmuzek • 2016 • 186 pages
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Introduction to Aluminum Alloys and Tempers
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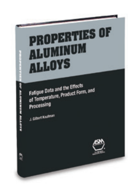

Properties of Aluminum Alloys: Fatigue Data and the Effects of Temperature, Product Form, and Processing
Edited by J.G. Kaufman • 2008 • 574 pages
Print: $285 / ASM Member: $215
ISBN: 978-0-87170-839-7
Product code: 05156G

Properties of Aluminum Alloys: Tensile, Creep, and Fatigue Data at High and Low Temperatures
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Print: $477 / ASM Member: $405
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Product Code: 06945G
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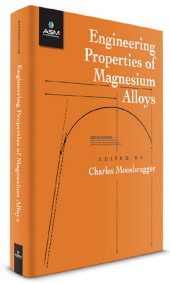

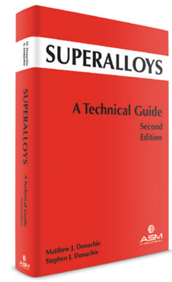

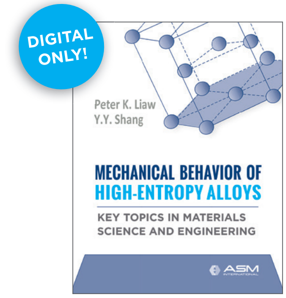

Engineering Properties of Magnesium Alloys is written for those engaged in the design process of material selection and material elimination. While focused on mechanical properties for structural design, the physical properties that are germane to corrosion behavior and electrical applications are represented.

Superalloys: A Technical Guide, Second Edition provides reliable and cost-effective means of achieving high operating temperature and stress conditions in aircraft and industrial gas turbines and in a wide variety of other applications, covering virtually all technical aspects related to the selection, processing, use, and analysis of superalloys.

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Edited by J.R. Davis • 1997 • 591 pages
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ISBN: 978-0-87170-596-9
Product Code: 06612G

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Edited by M. Avedesian and H. Baker • 1999 • 314 pages
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ISBN: 978-0-87170-657-7
Product Code: 06770G

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By K.A. Walsh • Edited by E.E. Vidal, A. Goldberg, E. Dalder, D.L. Olson, and B. Mishra • 2009 • 680 pages
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Engineering Properties of Magnesium Alloys
Edited by Charles Moosbrugger • 2017 • 184 pages
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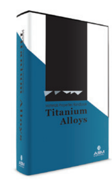
Product Code: 05920G



Materials Properties Handbook: Titanium Alloys
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By Peter K. Liaw • 2022 • 50 pages
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Product Code: 05603O

Superalloys: A Technical Guide, Second Edition
By M.J. Donachie and S.J. Donachie • 2002 • 439 pages
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EISBN: 978-1-62708-267-9
Print: $230 / ASM Member: $175
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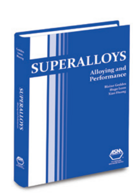
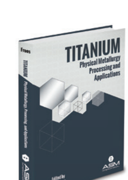
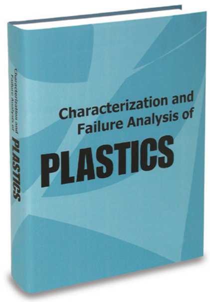


Superalloys: Alloying and Performance
Blaine Geddes, Hugo Leon, and Xiao Huang • 2010
176 pages
ASM Digital Library: $25 / ASM Member: $17
EISBN: 978-1-62708-313-3
Print: $120 / ASM Member: $90
ISBN: 978-1-61503-040-8
Product Code: 05300G

Titanium: A Technical Guide, Second Edition
By M.J. Donachie, Jr. • 2000 • 381 pages
ASM Digital Library: $49 / ASM Member: $39
EISBN: 978-1-62708-269-3
Print: $230 / ASM Member: $175
ISBN: 978-0-87170-686-7
Product Code: 06112G



Titanium: Physical Metallurgy, Processing, and Applications
By F.H. Froes • 2015 • 404 pages
ASM Digital Library: $49 / ASM Member: $39
EISBN: 978-1-62708-318-8
Print: $205 / ASM Member: $155
ISBN: 978-1-62708-079-8
Product Code: 05448G



Characterization and Failure Analysis of Plastics covers the performance of plastics and how it is characterized during design, property testing, and failure analysis. Selected by *Choice* magazine for its excellence in scholarship and presentation, the significance of its contribution to the field, and value, as an important treatment of the subject.

Microelectronics Failure Analysis Desk Reference, Seventh Edition will help engineers improve their ability to verify, isolate, uncover, and identify the root cause of failures. Prepared by a team of experts, this updated reference offers the latest information on advanced failure analysis tools and techniques, illustrated with numerous real-life examples.

STEM-in-SEM: Introduction to Scanning Transmission Electron Microscopy for Microelectronics Failure Analysis explains how SEMs equipped with transmission electron detectors, besides producing higher-resolution images, reveal additional details such as diffraction patterns, grain texture, sample thickness, and subsurface defects.

PLASTICS, COMPOSITES, AND CERAMICS

Characterization and Failure Analysis of Plastics
2003 • 482 pages
ASM Digital Library: $75 / ASM Member: $59
EISBN: 978-1-62708-281-5
Print: $270 / ASM Member: $205
ISBN: 978-0-87170-789-5
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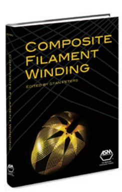

Composite Filament Winding
Edited by S.T. Peters • 2011 • 174 pages
Print: $185 / ASM Member: $140
ISBN: 978-1-61503-722-3
Product Code: 05286G

Engineered Materials Handbook® Volume 2: Engineering Plastics
1988 • 883 pages
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1991 • 1217 pages
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Optical Microscopy of Fiber-Reinforced Composites
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ISBN: 978-1-61503-044-6
Product Code: 05303G

Structural Composite Materials
By F.C. Campbell • 2010 • 630 pages
ASM Digital Library: $49/ ASM Member: $39
EISBN: 978-1-62708-314-0
Print: $185 / ASM Member: $140
ISBN: 978-1-61503-037-8
Product Code: 05287G

MICROELECTRONICS FAILURE ANALYSIS

ISTFA™ 2021 Proceedings from the 47th International Symposium for Testing and Failure Analysis
2021 • 461 pages
Print: $185 / ASM or EDFAS Member: $140
ISBN: 978-1-62708-419-2
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Edited by Tejinder Gandhi • 2019 • 705 pages
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ISBN: 978-1-62708-239-6
Product Code: 09111G

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STEM-in-SEM: Introduction to Scanning Transmission Electron Microscopy for Microelectronics Failure Analysis
By Jason D. Holm, Benjamin W. Caplins • 2020 • 33 pages
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EISBN: 978-1-62708-292-1

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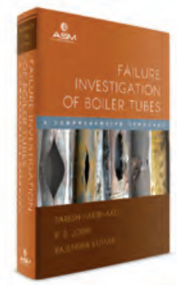

Failure Investigation of Boiler Tubes: A Comprehensive Approach covers properties and selection of materials for boiler tubes, damage mechanisms responsible for failure of boiler tubes, and characterization techniques employed for investigating failures of boiler tubes in thermal power plants and utility boilers of industrial/commercial/institutional boilers.

How to Organize and Run a Failure Investigation outlines a proven, systematic approach to failure investigation. It explains the relationship between various failure sources and the organization and conduct of the investigation.

Decoding Mechanical Failures introduces how to examine the fractures of broken steel parts and diagnose their failure modes. Covering all mechanical failure modes, it includes numerous case studies to increase the depth of understanding.

FAILURE ANALYSIS

Failure Analysis of Heat Treated Steel Components
Edited by L.C.F. Canale, R.A. Mesquita, and G.E. Totten • 2008 • 652 pages
ASM Digital Library: $49 / ASM Member: $39
EISBN: 978-1-62708-284-6
Print: $230 / ASM Member: $175
ISBN: 978-0-87170-868-7
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Failure Investigation of Boiler Tubes: A Comprehensive Approach
By Paresh Haribhakti, P.B. Joshi, and Rajendra Kumar • 2018 • 436 pages
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How to Organize and Run a Failure Investigation
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EISBN: 978-1-62708-281-5
Print: $185 / ASM Member: $140
ISBN: 978-0-87170-811-3
Product Code: 05118G

Life Lessons of a Failure Analyst
By McIntyre R. Louthan, Jr. • 2016 • 202 pages
Print: $30 / ASM Member: $25
ISBN: 978-1-62708-110-8
Product Code: 05921G

Systems Failure Analysis
By Joseph Berk • 2009 • 214 pages
ASM Digital Library: $25 / ASM Member: $17
EISBN: 978-1-62708-268-6
Print: $135 / ASM Member: $100
ISBN: 978-1-61503-012-5
Product Code: 05278G

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Understanding How Components Fail, Third Edition
By Donald J. Wulpi • Edited by Brett Miller • 2013 • 310 pages
ASM Digital Library: $49 / ASM Member: $39
EISBN: 978-1-62708-270-9
Print: $220 / ASM Member: $165
ISBN: 978-1-62708-014-9
Product Code: 05363G

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Atlas of Fatigue Curves
Edited by H.E. Boyer • 1986 • 518 pages • 500+ fatigue curves
Print: $340 / ASM Member: $255
ISBN: 978-0-87170-214-2
Product Code: 06156G

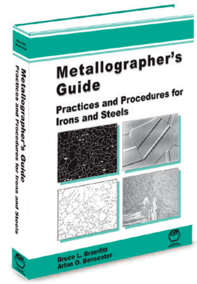
Decoding Mechanical Failures: The Definitive Guide to Interpreting Fractures
By Shane Turcott
Print: $95
ISBN: 978-17771576-0-9
Product code: 05933G

Fatigue and Fracture: Understanding the Basics
Edited by F.C. Campbell • 2012 • 698 pages
ASM Digital Library: $49 / ASM Member: $39
EISBN: 978-1-62708-303-4
Print: $205 / ASM Member: $155
ISBN: 978-1-61503-976-0
Product Code: 05361G

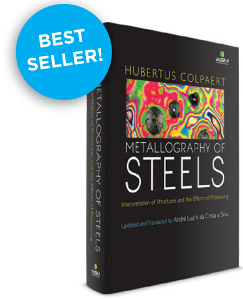
Fractography Poster
By Mohan D. Chaudhari
Print: $55 / ASM Member: $40
Product Code: 06568G

Mechanics and Mechanisms of Fracture: An Introduction
By A.F. Liu • 2005 • 458 pages
ASM Digital Library: $49 / ASM Member: $39
EISBN: 978-1-62708-309-6
Print: $185 / ASM Member: $140
ISBN: 978-0-87170-802-1
Product Code: 06954G

Crystalline Imperfections: Key Topics in Materials Science and Engineering deals with the practical aspects of compositional and structural imperfections, how they are controlled, and how they influence material properties and behaviors.



Metallographer's Guide: Practices and Procedures for Irons and Steels covers important metallurgical concepts related to the microstructures of irons and steels. It includes more than 500 representative microstructures and how they can be altered by heat treatment and other means.



Metallography of Steels: Interpretation of Structure and the Effects of Processing is a combination of a metallographic atlas for steels and cast irons and an introductory textbook covering the fundamentals of phase transformations and heat treatment of these materials.

Atlas of Stress-Strain Curves, Second Edition
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Print: $385 / ASM Member: $290
ISBN: 978-0-87170-739-0
Product Code: 06825G

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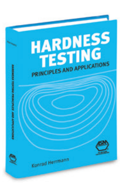
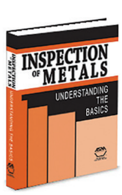
Crystalline Imperfections: Key Topics in Materials Science and Engineering
By Yip-Wah Chung • 2021 • 32 pages
ASM Digital Library: $9
EISBN: 978-1-62708-389-8
Product Code: 05602O



Hardness Testing: Principles and Applications
Edited by Konrad Herrmann, et al. • 2011 • 262 pages
Print: $175 / ASM Member: $130
ISBN: 978-1-61503-832-9
Product Code: 05331G



Inspection of Metals: Understanding the Basics
Edited by F.C. Campbell • 2013 • 487 pages
ASM Digital Library: $49 / ASM Member: $39
EISBN: 978-1-62708-305-8
Print: $205 / ASM Member: $155
ISBN: 978-1-62708-000-2
Product Code: 05372G

Light Microscopy of Carbon Steels
By L.E. Samuels • 1999 • 502 pages
ASM Digital Library: $75 / ASM Member: $59
EISBN: 978-1-62708-291-4
Print: $260 / ASM Member: $195
ISBN: 978-0-87170-655-3
Product Code: 06656G

Metallographic Etching, Second Edition
By G. Petzow • 1999 • 240 pages
Print: $140 / ASM Member: $105
ISBN: 978-0-87170-633-1
Product Code: 06670G

Metallographer's Guide: Practices and Procedures for Irons and Steels
By B.L. Bramfitt and A.O. Benscoter • 2002 • 354 pages
ASM Digital Library: $75 / ASM Member: $59
EISBN: 978-1-62708-258-7
Print: $285 / ASM Member: $215
ISBN: 978-0-87170-748-2
Product Code: 06040G

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Metallography of Steels: Interpretation of Structure and the Effects of Processing
By Hubertus Colpaert
Updated and translated by André Luiz V. da Costa e Silva • 2018 • 699 pages
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EISBN: 978-1-62708-259-4
Print: $250 / ASM Member: $190
ISBN: 978-1-62708-148-1
Product Code: 05922G

Metallographic Polishing by Mechanical Methods, Fourth Edition
By L.E. Samuels • 2003 • 345 pages
Print: $175 / ASM Member: $130
ISBN: 978-0-87170-779-6
Product Code: 06964G

Metallography: Principles and Practice
By G. Vander Voort • 1984 • 752 pages
ASM Digital Library: $49 / ASM Member: $39
EISBN: 978-1-62708-260-0
Print: $195 / ASM Member: $145
ISBN: 978-0-87170-672-0
Product Code: 06785G

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By L. Cartz • 1995 • 229 pages
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ISBN: 978-0-87170-517-4
Product Code: 06390G

Optical Microscopy of Fiber-Reinforced Composites
By Brian S. Hayes and Luther M. Gammon • 2010 • 284 pages
Print: $195 / ASM Member: $145
ISBN: 978-1-61503-044-6
Product Code: 05303G

Tensile Testing, Second Edition
Edited by J.R. Davis • 2004 • 283 pages
Print: $150 / ASM Member: $115
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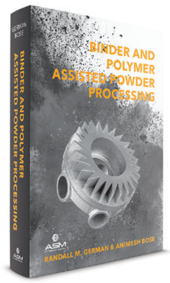
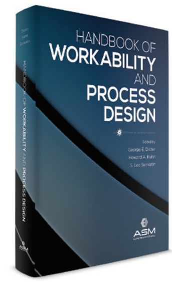
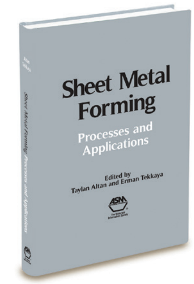


Binder and Polymer Assisted Powder Processing focuses on the basic principles and options available for the application of polymers and natural organics to powder processing. It links the material, powder characteristics, forming process, and product attributes together to give the first unified treatment on polymer assisted powder processing.



Handbook of Workability and Process Design describes the underlying concepts and practical methods for effective design, evaluation, and optimization of bulk working operations such as forging, rolling, and extrusion.



Sheet Metal Forming: Processes and Applications is a practical and comprehensive reference gives the latest developments on the design of sheet forming operations, equipment, tooling, and process modeling. Individual chapters cover all major sheet forming processes such as blanking, bending, deep drawing, and more.

MANUFACTURING AND DESIGN

ASM Specialty Handbook® Tool Materials
Edited by J.R. Davis • 1995 • 501 pages
Print: $380 / ASM Member: $285
ISBN: 978-0-87170-545-7
Product Code: 06506G

Binder and Polymer Assisted Powder Processing
By Randall M. German and Animesh Bose • 2020 • 300 pages
ASM Digital Library: $75 / ASM Member: $59
EISBN: 978-1-62708-319-5
Print: $240 / ASM Member: $180
ISBN: 978-1-62708-275-4
Product Code: 05929G

Cold and Hot Forging: Fundamentals and Applications
Edited by T. Altan, G. Ngaile and G. Shen • 2005 • 341 pages
ASM Digital Library: $49 / ASM Member: $39
EISBN: 978-1-62708-300-3
Print: $230 / ASM Member: $175
ISBN: 978-0-87170-805-2
Product Code: 05104G

Extrusion, Second Edition
Edited by M. Bauser, G. Sauer, and K. Siegert • 2006 • 608 pages
Print: $285 / ASM Member: $215
ISBN: 978-0-87170-837-3
Product Code: 06998G

Gear Materials, Properties, and Manufacture
Edited by J.R. Davis • 2005 • 339 pages
Print: $205 / ASM Member: $155
ISBN: 978-0-87170-815-1
Product Code: 05125G

Handbook of Workability and Process Design
Edited by G.E. Dieter, H.A. Kuhn, and S.L. Semiatin • 2003 • 414 pages
Print: $270 / ASM Member: $205
ISBN: 978-0-87170-778-9
Product Code: 06701G

Metals Fabrication: Understanding the Basics
By F.C. Campbell • 2013 • 439 pages
ASM Digital Library: $49 / ASM Member: $39
EISBN: 978-1-62708-308-9
Print: $205 / ASM Member: $155
IBSN: 978-1-62708-018-7
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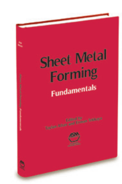

Sheet Metal Forming: Fundamentals
Edited by Taylan Altan and A. Erman Tekkaya
2012 • 314 pages
ASM Digital Library: $49 / ASM Member: $39
EISBN: 978-1-62708-316-4
Print: $230 / ASM Member: $175
ISBN: 978-1-61503-842-8
Product Code: 05340G

Sheet Metal Forming: Processes and Applications
Edited by Taylan Altan and A. Erman Tekkaya • 2012 • 382 pages
ASM Digital Library: $49 / ASM Member: $39
EISBN: 978-1-62708-317-1
Print: $230 / ASM Member: $175
ISBN: 978-1-61503-844-2
Product Code: 05350G

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By M.M. Schwartz • 2003 • 421 pages
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Product Code: 06955G

Joining: Understanding the Basics
Edited by F.C. Campbell • 2011 • 346 pages
ASM Digital Library: $49 / ASM Member: $39
EISBN: 978-1-62708-306-5
Print: $205 / ASM Member: $155
ISBN: 978-1-61503-825-1
Product Code: 05329G

Principles of Brazing
By David M. Jacobson and Giles Humpston • 2005 • 268 pages
Print: $185 / ASM Member: $140
ISBN: 978-0-87170-812-0
Product Code: 05123G

Principles of Soldering
By Giles Humpston and David M. Jacobson • 2004 • 271 pages
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1997 • 417 pages
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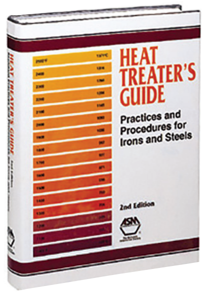

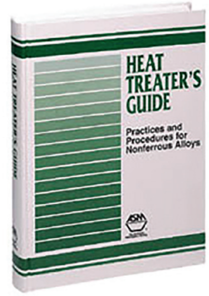

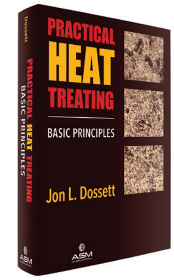

Heat Treater's Guide: Practices and Procedures for Irons and Steels, Second Edition provides hundreds of data sheets for heat treating of carbon and alloy steels, tool steels, stainless steels, and cast irons. Each data sheet gives the chemical composition of the alloy, a listing of similar U.S. and foreign alloys, its characteristics, and the recommended heat treating procedure.

Heat Treater's Guide: Practices and Procedures for Nonferrous Alloys provides quick access to recommended heat treating information for hundreds of nonferrous alloys, plus composition, trade names, common names, specifications (both U.S. and foreign), available product forms, and typical applications. Information is presented by alloy group in the datasheet format.

Practical Heat Treating: Basic Principles describes the basic principles of heat-treating technology in clear, concise, and practical terms for students, emerging professionals, production personnel, and manufacturing or design engineers. It details many practical implications of heat treatment in terms of material and process selection and structure and property development with insights on doing it right or more reliably.

Atlas of Time-Temperature Diagrams for Irons and Steels
Edited by G. Vander Voort • 1991 • 804 pages • 1839 diagrams
Print: $340 / ASM Member: $255
ISBN: 978-0-87170-415-3
Product Code: 06150G

Atlas of Time-Temperature Diagrams for Nonferrous Alloys
Edited by G. Vander Voort • 1991 • 474 pages • 500 diagrams
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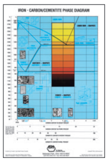
Elements of Induction Heating: Design, Control, and Applications
By S. Zinn, S.L. Semiatin • 1988 • 335 pages
Print: $120 / ASM Member: $90
ISBN: 978-0-87170-308-8
Product Code: 06522G



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Product Code: 06400G

Heat Treater's Guide: Practices and Procedures for Nonferrous Alloys
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Print: $385 / ASM Member: $290
ISBN: 978-0-87170-565-5
Product Code: 06325G

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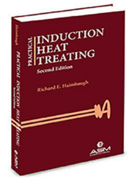
Print: $690 / ASM Member: $520
Product Code: 06489G

Heat Treatment of Gears: A Practical Guide for Engineers
By A.K. Rakhit • 2000 • 209 pages
Print: $185 / ASM Member: $140
ISBN: 978-0-87170-694-2
Product Code: 06732G

NEW!
Practical Heat Treating: Basic Principles
By Jon L. Dossett • 2020 • 404 pages
ASM Digital Library: $75 / ASM Member: $59
EISBN: 978-1-62708-326-3
Print: $240 / ASM Member $180
ISBN: 978-1-62708-324-9
Product Code: 05931G



Practical Induction Heat Treating, Second Edition
By R.E. Haimbaugh • 2015 • 365 pages
ASM Digital Library: $49 / ASM Member: $39
EISBN: 978-1-62708-311-9
Print: $230 / ASM Member: $175
ISBN: 978-1-62708-089-7
Product Code: 05505G

SteCal® 3.0 (CD + Booklet)
By P. Tarin and J. Pérez • 2004 • Microsoft Windows format
CD-ROM: $447 / ASM Member: $335
ISBN: 978-0-87170-796-3
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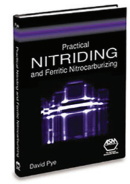
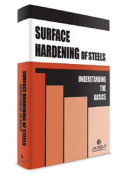
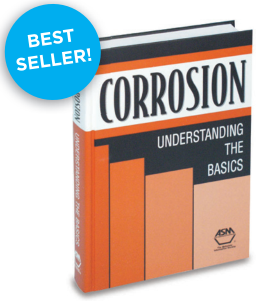


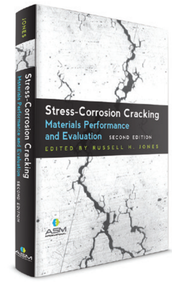
Practical Nitriding and Ferritic Nitrocarburizing
By David Pye • 2003 • 256 pages
Print: $230 / ASM Member: $175
ISBN: 978-0-87170-791-8
Product Code: 06950G



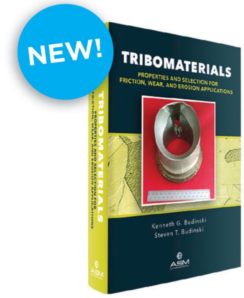
Surface Hardening of Steels: Understanding the Basics
Edited by J.R. Davis • 2002 • 364 pages
Print: $160 / ASM Member: $120
ISBN: 978-0-87170-764-2
Product Code: 06952G



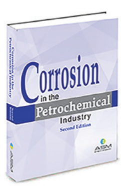
Corrosion: Understanding the Basics uses a "how to" approach to understanding and solving the problems of corrosion of structural materials. Written for those with limited technical background. It provides more experienced engineers with a useful overview of the principles of corrosion and can be used as a general guide for developing a corrosion-control program.



Stress-Corrosion Cracking: Materials Performance and Evaluation, Second Edition 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; and for the failure analyst to help determine if SCC played a role in a failure under investigation.



Tribomaterials: Properties and Selection for Friction, Wear, and Erosion Applications helps readers reduce the unwanted costs and ramifications of friction, wear, and erosion by recommending engineering materials that have proven to be successful. Recommendations include which tool materials work best, the most abrasion-resistant plastics, where ceramics should be used, and where lubrication and coatings fit.



Corrosion in the Petrochemical Industry, Second Edition
Edited by Victoria Burt • 2015 • 426 pages
ASM Digital Library: $49 / ASM Member: $39
EISBN: 978-1-62708-282-2
Print: $240 / ASM Member: $180
ISBN: 978-1-62708-094-1
Product Code: 05503G

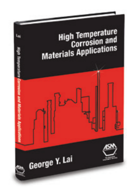
Corrosion of Aluminum and Aluminum Alloys
Edited by J.R. Davis • 1999 • 313 pages
ASM Digital Library: $49 / ASM Member: $39
EISBN: 978-1-62708-299-0
Print: $185 / ASM Member: $140
ISBN: 978-0-87170-629-4
Product Code: 06787G

BEST SELLER
Corrosion: Understanding the Basics
Edited by J.R. Davis • 2000 • 563 pages
ASM Digital Library: $75 / ASM Member: $59
EISBN: 978-1-62708-250-1
Print: $250 / ASM Member: $190
ISBN: 978-0-87170-641-6
Product Code: 06691G

Fundamentals of Electrochemical Corrosion
By E.E. Stansbury and R.A. Buchanan • 2000 • 487 pages
ASM Digital Library: $49 / ASM Member: $39
EISBN: 978-1-62708-302-7
Print: $175 / ASM Member: $130
ISBN: 978-0-87170-676-8
Product Code: 06594G

Handbook of Corrosion Data, Second Edition
Edited by B. Craig and D. Anderson • 1995 • 998 pages
Print: $340 / ASM Member: $255
ISBN: 978-0-87170-518-1
Product Code: 06407G

High Pressure Cold Spray: Principles and Applications
Edited by C.M. Kay and J. Karthikeyan • 2016 • 324 pages
ASM Digital Library: $49 / ASM Member: $39
EISBN: 978-1-62708-285-3
Print: $220 / ASM Member: $165
ISBN: 978-1-62708-096-5
Product Code: 05446G



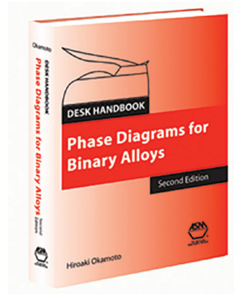
High-Temperature Corrosion and Materials Applications
By George Y. Lai • 2007 • 480 pages
ASM Digital Library: $49 / ASM Member: $39
EISBN: 978-1-62708-304-1
Print: $260 / ASM Member: $195
ISBN: 978-0-87170-853-3
Product Code: 05208G

Stress-Corrosion Cracking: Materials Performance and Evaluation, Second Edition
Edited by Russell H. Jones • 2016 • 473 pages
ASM Digital Library: $75 / ASM Member: $59
EISBN: 978-1-62708-266-2
Print: $250 / ASM Member: $190
ISBN: 978-1-62708-118-4
Product Code: 05509G

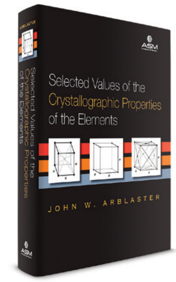
Surface Engineering for Corrosion and Wear Resistance
Edited by J.R. Davis • 2001 • 279 pages
ASM Digital Library: $25 / ASM Member: $17
EISBN: 978-1-62708-315-7
Print: $120 / ASM Member: $90
ISBN: 978-0-87170-700-0
Product Code: 06835G
Co-published by IOM Communications and ASM International.

NEW!
Tribomaterials: Properties and Selection for Friction, Wear, and Erosion Applications
By Kenneth G. Budinski and Steven T. Budinski • 2021 • 477 pages
ASM Digital Library: $75 / ASM Member: $59
EISBN: 978-1-62708-323-2
Print: $240 / ASM Member $180
ISBN: 978-1-62708-321-8
Product Code: 05930G

Binary Alloy Phase Diagrams, Second Edition contains 4,700 binary alloy phase diagrams in a 3-volume set. It includes atomic/weight % compositions, solubilities, stable/metastable phases, discrepancies in reported values, and uncertainties in experimental/calculated data.



Desk Handbook: Phase Diagrams for Binary Alloys, Second Edition provides nearly 2,500 binary alloy phase diagrams (one "best" diagram selected per system) and associated crystal structure data. It includes an "Introduction to Alloy Phase Diagrams" and an explanation of "Impossible and Improbable Forms of Binary Phase Diagrams."



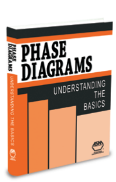
Selected Values of the Crystallographic Properties of the Elements presents a unique and comprehensive review of the crystallographic properties of all the elements and will be a valuable resource for metallurgists and crytallographers.

Binary Alloy Phase Diagrams, Second Edition
Edited by T.B. Massalski, H. Okamoto, P.R. Subramanian, and L. Kacprzak • 1990 • 3589 pages (3-Volume Set)
Print: $1980 / ASM Member: $1485
ISBN: 978-0-87170-403-0
Product Code: 57718G

Desk Handbook: Phase Diagrams for Binary Alloys, Second Edition
By Hiroaki Okamoto • 2010 • 855 pages
Print: $395 / ASM Member: $295
ISBN: 978-1-61503-046-0
Product Code: 57751G

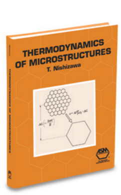
Handbook of Ternary Alloy Phase Diagrams 10-Volume Set
Edited by Pierre Villars, Alan Prince, and Hiroaki Okamoto • 1995
Print: $10,780 / ASM Member: $8085
ISBN: 978-0-87170-525-9
Product Code: 57706G

Pearson's Desk Edition (2-Volume Set)
Edited by Pierre Villars • 1997
Print: $1045 / ASM Member: $935
ISBN: 978-0-87170-603-4
Product Code: 57763G



Phase Diagrams: Understanding the Basics
Edited by F.C. Campbell • 2012 • 470 pages
ASM Digital Library: $49 / ASM Member: $39
EISBN: 978-1-62708-310-2
Print: $205 / ASM Member: $155
ISBN: 978-1-61503-835-0
Product Code: 05342G

Selected Values of the Crystallographic Properties of the Elements
By John W. Arblaster • 2018 • 684 pages
Print: $295 / ASM Member: $220
ISBN: 978-1-62708-154-2
Product Code: 05244G



Thermodynamics of Microstructures
By Taiji Nishizawa, translated by Kiyohito Ishida
2008 • 308 pages
Print: $230 / ASM Member: $175
ISBN: 978-0-87170-716-1
Product Code: 05232G

ASM Materials Platform for Data Science (MPDS)
The world's largest and most comprehensive repository of inorganic materials data comprised of phase diagrams, crystal structures, and properties. Utilizing concise searching technology, over 1 million experimental and calculated data properties are organized in an intuitive and customizable tool that allows users to dive deep into materials information not found anywhere else in a single resource.

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Edited by Pierre Villars and Karin Cenzual
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440.338.5409 | onlineDBsales@asminternational.org

ASM Alloy Phase Diagram Database™
A fully searchable database containing over 40,300 binary and ternary alloy phase diagrams, each with their associated crystal and reaction data. Also includes all inorganic systems. The APD Center places the full breath and scope of available data on binary and ternary phase diagrams right on your desktop to assist with troubleshooting, manufacturing control, and the development of new materials.

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ASMNEWS

BOARD NOMINEES ANNOUNCED

Goyal for Senior VP; Manjooran for VP; Kuli for Treasurer; Black, Carlone, and McDonald for Trustees

The ASM Nominating Committee, chaired by Dr. Diana A. Lados, FASM, announces the nominees for ASM senior vice president and vice president for 2022-2023 and three members of the Board of Trustees for 2022-2025.

In accordance with the ASM Constitution, these nominees will be voted on at the ASM Annual Society Meeting on September 12. Once elected, the senior vice president will automatically become ASM president for 2023-2024.

In accordance with Article IV, Section 5 of the ASM Constitution, the ASM Board of Trustees has also announced its nominee, John C. Kuli, for a third one-year term as ASM Treasurer for 2022-2023.

Officers and members of the Board who will continue in office for 2022-2023 include: Dr. David B. Williams, FASM, who will become president in September; Dr. Judith A. Todd, FASM, who will serve as immediate past president; and trustees Burak Akyuz, Dr. Elizabeth Hoffman, FASM, Dr. Ann Bolcavage, FASM, Dr. U. Kamachi Mudali, FASM, and Dr. James E. Saal. The remaining Trustee term for Dr. Navin Manjooran, FASM, will be filled by the Board in accordance with the ASM Constitution, Article III, Section 7, Filling Vacancies.

Retiring from the Board at this year's Annual Society Meeting will be immediate past president Ms. Diana Essock, FASM, and trustees Dr. Toni Marechaux, FASM, Dr. Priti Wanjara, FASM, and Prof. Ji-Cheng (JC) Zhao, FASM.

About the President-Elect and Board Nominees

Williams

Dr. David B. Williams, FASM
President-Elect

David B. Williams was dean of engineering at The Ohio State University from 2011-2021. He led 1000 faculty and staff who educated 10,000 students with a $310 million budget, including $150 million in research. He was board chair of the Transportation Research Center and the Metro STEM School and was on the boards of The Ohio Aerospace Institute and Lightweight Innovations for Tomorrow (LIFT), part of the National Network for Manufacturing Innovation. Williams represented OSU on the Business Higher Education Forum and the Council on Competitiveness. He is senior fellow of the Council and was on the board of One Columbus, responsible for Central Ohio's economic development for nine years.

Williams served on the ASM International Board of Trustees (2014-2017) and was elected vice president in 2021. He was president of the University of Alabama in Huntsville from 2007-2011. He served on the boards of the Tennessee Valley Corridor and the Alabama Business Council. Before Huntsville, Williams was vice president of research at Lehigh University and was chair of the MS&E department and director of the Electron Microscopy Laboratory.

Williams holds B.A., M.A., Ph.D., and Sc.D. degrees from Cambridge University. He is a (co-) author/editor of 13 textbooks and conference proceedings and (co-) author of 450 publications on electron microscopy of materials. He has given 300 invited talks in 30 countries and is a fellow of eight international professional societies in materials, microscopy, and aerospace.

Goyal

Mr. Pradeep Goyal, FASM
Nominee for Senior Vice President

Pradeep Goyal grew up in Mumbai and completed his B Tech in metallurgical engineering at IIT Kanpur in 1978, graduating with the first rank. He was awarded a silver medal by the President of India. IIM awarded him the Best Metallurgist of the year. He completed his masters in metallurgy at MIT in 1980 with a research assistantship. After three years at Air Products and Chemicals Inc., he returned to India in 1983 to start his company Pradeep Metals Ltd. He is the chairman and managing director.

In This Issue

Submit news of ASM and its members, chapters, and affiliate societies to Joanne Miller, editor, ASM News | ASM International
9639 Kinsman Road | Materials Park, OH 44073 | P 440.338.5455 | F 440.338.4634 | E joanne.miller@asminternational.org
Contact ASM International at 9639 Kinsman Road, Materials Park, OH 44073 | P 440.338.5151 or 800.336.5152 (toll free in U.S. and Canada) | F 440.338.4634 | E MemberServiceCenter@asminternational.org | W asminternational.org

Goyal has served ASM as chair of the India Chapter (2002-2005) and trustee of ASM International (2005-2008). He was recognized as a FASM in 2015, Fellow of Alpha Sigma Mu in 2017, and awarded Distinguished Life Membership in 2021. He has organized and chaired five major materials science events and helped the India Chapter build an office and training center in Mumbai. He serves on the boards of many corporations, including UPL Ltd., the fourth largest agrichemicals company in the world. He is a member of the Technology Development Board of India, member of the board of Indian Institute of Technology, Kanpur, IIT Bombay Research Park, and National Institute of Advanced Manufacturing Technologies.

He is conducting research on a novel manufacturing process to manufacture steel using microwaves and holds several patents for process development work using microwaves. He has served as the past president of Rotary Club of Mumbai South (2004-2005) and past assistant governor of Rotary International District 3141 (2009-2010). He is currently the chair of Ekal Abhiyan Trust, an NGO that runs over 80,000 single teacher schools in the remote tribal areas of India, providing primary education to 2.2 million children up to third grade.


Manjooran

Dr. Navin J. Manjooran, FASM

Nominee for Vice President

Navin Manjooran currently serves as the chairman of Solve, a technology and research services company addressing energy, industry, medical, and infrastructure challenges. Over the past decade, Manjooran was on the global leadership team of Siemens AG with oversight for international collaborations, advanced technologies, and innovation.

Since 2010, Manjooran has served as an adjunct professor in materials science and engineering at Virginia Tech University and is a board member of the U.S. Technology Advisory Group. He taught multiple courses and co-organized 32 international symposia for the National Institute of Technology (India), University of Florida, Virginia Tech, and various professional societies including ASM International, ACerS, AIST, ASME, IEEE, and TMS.

Manjooran also serves as chair of the advisory board for the materials science and engineering department at the University of Florida. He has also served on the Virginia Tech University Board of Visitors, University of Chicago Board of Trustees, and Virginia Tech Capital Campaign.

He holds a B.S. in metallurgical engineering from the National Institute of Technology (India), an M.S. in materials science and engineering from the University of Florida, and a Ph.D. in materials science and engineering from Virginia Tech. He also has an MBA from the Booth School of Business at the University of Chicago.

Manjooran has been awarded 12 patents, edited 12 books, and delivered more than 100 presentations/publications at national and international events. His awards include: Outstanding University of Florida Alumni (MSE), Outstanding Indian American (Engineering) Award, Distinguished Virginia Tech (VT) Alumnus, TMS Young Leader Award, VT Outstanding Leader Award, VT Paul Torgersen Doctoral Research Excellence Award, VT Outstanding Service Commendation Award, VT Outstanding Student Award, NITW Sri Kabadi Subalu Medal, and the NITW Alumni Association Gold Medal.


Kuli

Mr. John C. Kuli, Jr.

Nominee for Treasurer

John C. Kuli, Jr., is technology and innovation lead for operations within the Performance Alloys & Composites Division of Materion. His present role is focused on optimization of alloy chemistries for improved properties and purchase of new equipment to drive new product growth. During his 30-year career with Materion, he has specialized in optimization of molten metal processing techniques, robust casting mold design and manufacture, and hot working process improvements for the manufacture of copper, nickel, and aluminum-base alloys. He is a co-inventor of Materion's new high conductivity copper QMet 200 and QMet 300 alloys and holds patents in aluminum processing and nickel-base alloy development.

Kuli earned a B.S. in metallurgical engineering from the University of Pittsburgh, where he was awarded both ASM and Alcoa scholarships. He began his engineering career with Alcoa (Arconic) where he specialized in equipment and process optimization for semicontinuous casting of high strength 7XXX aluminum alloys. Kuli joined Brush Wellman in 1986 focusing on casting of lean beryllium-copper alloys including installation of a horizontal continuous caster for thin strip. He then worked for Wagstaff as a customer service engineer and regional sales manager, installing and commissioning aluminum billet and ingot casting systems. Kuli returned to Materion in 1996 as a technical manager to optimize the design, installation, and production start-up of a new melt and cast shop supporting Materion's 1996-1998 Coiled Strip Mill Expansion Project.

Kuli is a 41-year member of ASM International and has always been involved with his local ASM Chapter (Pittsburgh, Toledo, Cincinnati, and Cleveland). He currently serves on the ASM Technical Books Committee and is membership chair of the Cleveland Chapter. He is also active in the American Foundry Society, NADCA, and Wire Association International.

Black

Dr. Amber N. Black

Nominee for Trustee

Amber N. Black is a research and development engineer for Los Alamos National Laboratory (LANL), where she has worked for the past five years. During that time, she has been a part of Sigma division, the laboratory's manufacturing science division as part of the Welding and Joining team. She is the subject matter expert on high energy density welding and electron beam additive manufacturing. She has worked with lasers and electron beams for over 15 years, using them to weld, cut, drill, braze, engrave, coat, and for various research processing methods. Black is the principal investigator for a number of high priority projects and the author of numerous reports and presentations, which are instrumental to supporting stockpile stewardship and modernization as part of LANL's mission. Prior to joining LANL she worked as a Welding Applications Engineer for PTR – Precision Technologies, where she developed welds for customers with aerospace, defense, automotive, research, and industrial applications.

She has been a member of the materials science community for 17 years. Black became an ASM member while an undergraduate at the University of Connecticut, where she began honing her leadership skills as the president of the Material Advantage Chapter. She was an ASM International student board member in 2008-2009. Black also volunteers for the American Welding Society and the International Institute of Welding. In these positions she has been instrumental in standards development, co-authored handbook chapters, and acted as chair for several committees and subcommittees.

Black holds a B.S. from the University of Connecticut and a Ph.D. from the Pennsylvania State University.

Carlone

Dr. Pierpaolo Carlone

Nominee for Trustee

Pierpaolo Carlone is professor of manufacturing technologies and systems at the department of industrial engineering of the University of Salerno (Italy). He is the head of the composite materials lab and of the metrology lab. He serves as member of both the doctoral council in industrial engineering and the didactic council in mechanical and management engineering. As an educator, Carlone has supervised more than 230 project reports, master theses, Ph.D. theses, and post-docs. He served as external evaluator and member of the jury for numerous Ph.D. candidates.

Carlone's research activities are focused on advanced and lightweight materials processing, in particular fiber reinforced polymer matrix composites, solid-state welding, and heat treatment. He has authored more than 120 papers published in high reputation journals, conference proceedings, book chapters, and one book. Additionally, he has authored two patent inventions on nonmetallic materials treatment. Carlone serves as referee and editorial board member for various scientific journals. He has delivered approximately 50 plenary/keynote/invited lectures and seminars. He has coordinated research projects on materials characterization, manufacturing, and treatment, funded by government or private entities. He also coordinates collaborative research activities on materials science and engineering with several academic and industrial organizations worldwide.

He is a member of the Italy-Switzerland Chapter of ASM International. He participates in the ASM Award Selection Committees, the *JMEP* Editorial Board Committee, and the ASM Technical Books Committee and he received the ASM-IIM Visiting Lectureship Award in 2018. Carlone is member of the Italian Association for Manufacturing and director of the European Scientific Association for Material Forming where he is in charge of promoting international cooperation and formulating new initiatives. He also leads the future vision and activities working group of the Association.

McDonald

Dr. André McDonald, FASM

Nominee for Trustee

André McDonald is currently a professor in the department of mechanical engineering and also serves as associate vice president (strategic research initiatives and performance) at the University of Alberta. He received his BSME in 2001 and his MSME in 2002 from the City College of New York. He was awarded his Ph.D. from the University of Toronto in 2007 under a collaborative research program with the National Research Council Canada in Boucherville, Quebec.

McDonald has nearly 20 years of experience in the fabrication, development, and performance assessment of thermal and cold spray coatings. He has published a textbook on the practical design of thermo-fluid systems, a manual for thermal spraying for the oil and gas industry, several book chapters on thermal spray coatings, and numerous industry reports.

He has received several awards including the Jules Stachiewicz Medal from the Canadian Society for Mechanical Engineering for heat transfer, Fellow of The Institute of Materials, Minerals and Mining, Fellow of ASM, Fellow of The Institution of Mechanical Engineers, the Mentorship Award from the Faculty of Engineering (University of Alberta), and the Association of Professional Engineers and Geoscientists of Alberta's Early Accomplishment Award. He holds Professional Engineer licenses in Canada (Alberta) and the United States (California) and is a registered Chartered Engineer in the United Kingdom.

McDonald was chair of the Natural Science and Engineering Research Council Scholarships and Fellowships Selection Committee – Civil and Mechanical Engineering and is currently the lead editor of the *Journal of Thermal Spray Technology,* chair of the Canadian Cold Spray Alliance, and immediate past president of the ASM Thermal Spray Society board. He currently leads the Experiential Learning in Innovation, Technology, and Entrepreneurship Program for Black Youth.

Official ASM Annual Society Meeting Notice

The Annual Society Meeting of members of ASM International will be held on:

Monday, September 12 - 4:00 - 5:00 p.m.

The purpose of the ASM Annual Society Meeting is the election of officers for the 2022-2023 term and transaction of other Society business.

ASM Nominations

The ASM International Constitution provides that members of the Society may submit additional nominations after the Nominating Committee has made its official report. Article IV, Section 6, of the ASM Constitution reads: "After publication of the Nominating Committee's report on nominees, and the Board report on its nominee for Treasurer per the Rules for Government, and at any time prior to July 15 of the same year, additional nominations for any or all of the vacancies may be made in writing to the Executive Director at Headquarters. Such nominations must be signed by at least twenty-five individual Professional or Chapter Members. Such nominees shall be processed by the Executive Director for compliance with Section 4 of this Article. This shall be the only way in which additional nominations may be made. The membership of ASM International shall be duly notified in a regular publication of such additional nominations."

LECTURERS ANNOUNCED

ASM is excited to announce in-person lectures are back for 2022. This year's lineup includes presentation of the Alpha Sigma Mu Lecture and the 2020 and 2022 Edward DeMille Campbell Memorial Lectures, which are scheduled for presentation at IMAT'22 in New Orleans this September. Additionally, the 2022 ASM/TMS Distinguished Lecture in Materials and Society is scheduled for presentation at MS&T in Pittsburgh this October. Details including lecturer, abstract, date, location, and time of each is as follows:

2022 Alpha Sigma Mu Lecture

Monday, September 12 | 3:00 – 4:00 p.m.
IMAT, New Orleans


Furrer

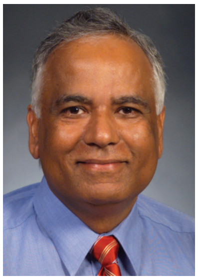
Dr. David Furrer, FASM
Senior Fellow, Discipline Lead, Materials & Processes Engineering
Pratt & Whitney, East Hartford, Conn.

"Industry 4.0 and ICME: The Evolution and Revolution of Materials Science and Engineering"

Materials science and engineering is a critical engineering discipline that supports the design, development, and realization of some of the world's most complex and useful products. Materials science and engineering has and continues to evolve from a completely empirical discipline of making, breaking, and analyzing to one of understanding of fundamental, underlying physics-based behavioral mechanisms that can be controlled and optimized to produce new and more advanced capabilities. Computational methods are leading to further integration of materials design and optimization within component and system design activities as envisioned by the various integrated computational materials engineering initiatives. Materials definitions are also advancing through the use of computational models and associated key chemical and structural parameters along with their accompanied variability for any given pedigree and their associated quality control system. Materials descriptions are evolving toward model-based definitions that support the statistical-based material understanding and control. The establishment and linkage of materials and manufacturing process data capture, analysis, and curation with physics-based behavioral models is providing a path toward probabilistic materials science and engineering. This is allowing for component location-specific properties rather than a simple, single empirically driven component minimum value. Revolutionary component design and structural analysis workflows are leading to the use of location-specific material property values with associated probabilities based on optimized manufacturing process paths and model-based material definitions.

2020 Edward DeMille Campbell Memorial Lecture

Tuesday, September 13 | 9:00 – 10:00 a.m.
IMAT, New Orleans



Singh

Dr. Mrityunjay Singh, FASM
Chief Scientist, Ohio Aerospace Institute, Cleveland

"Additive Manufacturing: Disrupting Global Supply Chains and Enabling Sustainable Development"

The integration of new materials and innovative manufacturing technologies into product supply chains is critically needed to address human and societal needs and to promote sustainable development and economic competitiveness. Recently, there has been tremendous growth in the additive manufacturing (AM) landscape with the introduction of high-end machines suitable for industrial applications. In addition, availability of desktop 3D printers as well as open source printers and platforms have also facilitated the large-scale growth of distributed manufacturing. The paradigm shift in thinking, where one can turn their design into product on demand, is leading to new business models and challenging traditional models of product development and distribution.

In this presentation, an overview of different AM technologies will be provided along with technical challenges and opportunities. Various examples of materials (polymers, ceramics, metals, hybrids, and multi-material systems) and structures achieved from utilizing a wide variety of additive manufacturing approaches will be provided. Technical challenges and opportunities for the use of additive manufacturing as a powerful enabler for sustainable development and a disruptive technological threat to global supply chains for different materials and systems will be presented.

2022 Edward DeMille Campbell Memorial Lecture

Tuesday, September 13 | 10:30 – 11:30 a.m.
IMAT, New Orleans

Fraser

Dr. Hamish L. Fraser, FASM
Ohio Regents Eminent Scholar and Professor, Center for the Accelerated Maturation of Materials, MSE, The Ohio State University, Columbus

"Modern Physical Metallurgy: Importance, Use of New Tools, and How to Finance the Metallic Materials Enterprise"

Physical metallurgy has been a subject of study for a considerable period of time, and as advances have been achieved, major contributions have been made to systems and components in a wide variety of technological areas. In the age of one and two-dimensional materials, device materials, and the like, there appears to be a somewhat reduced interest in physical metallurgy if funding numbers are used as a gauge. This lecture will review the importance of physical metallurgy in the modern day and will show how new tools, both computational and experimental, have contributed to a major increase in our understanding of metallic materials. The ways and means of financing research and development of new metallic materials will be discussed, involving a comparison of funding opportunities in the U.S. versus other developed nations, such as in Europe.

2022 ASM/TMS Distinguished Lectureship in Materials and Society

Tuesday, October 11 | at MS&T in Pittsburgh

Anderson

Dr. Iver E. Anderson, FASM
Senior Metallurgist, Ames Laboratory, Iowa

"Materials Research on Clean Energy: For the Sake of Our Grandchildren"

To attack and, hopefully, to reverse greenhouse gas (GHG) growth, the critical but formidable goal of net zero GHG emissions by 2050 must be reached. This will require major efforts from across society, especially a "leap of faith" by all the world's economies. From the latest IPCC report, it is becoming increasingly apparent that we must do this for the health and well-being of our own children and grandchildren, if we want to help them avoid predictable climate disasters. Therefore, we professionals in the materials science and engineering community must make our best efforts to work on important GHG emission challenges to make the economic leap to green technologies more pragmatic and palatable. Recent analysis shows that there are huge market opportunities that can arrive with clean energy transitions, particularly if several key materials technology barriers are overcome. With solutions to these critical materials problems resulting from research that is supported by enlightened governments and industry leaders, a new global energy economy can emerge quite naturally. The new sustainable economy has the potential to create millions of excellent jobs across a host of new supply chains, along with many more generations of smiling grandchildren.

ASM Student Board Members for 2022-2023 Announced

The ASM Board of Trustees values the insights, ideas, and participation of Material Advantage students. The Student Board Member program provides the opportunity to attend four board meetings where the students will meet and work with leading technical professionals and gain leadership skills that will benefit them throughout their career. The next deadline for submissions is April 1, 2023. Details can be found on the ASM website.

Berez

Jaime Berez

Georgia Institute of Technology

Jaime Berez is a Ph.D. student in the G.W. Woodruff School of Mechanical Engineering at the Georgia Institute of Technology in Atlanta. He earned a B.S. in mechanical engineering from the University of Maryland in 2018, where he participated in his school's SAE Collegiate Design Series' racing team and held internships in the aerospace and automotive industries. His current research focuses on in-process and materials/mechanical qualification of metal additive manufacturing methods. Berez is passionate about equitable and student-centered engineering education and believes that ASM's informational content is a great fit for the engineering classroom, where it can help produce more capable and prepared engineers.

Hamilton

Ashlie A. Hamilton

University of Minnesota – Twin Cities

Ashlie Hamilton is an undergraduate student at the University of Minnesota - Twin Cities pursuing a bachelor's degree in materials science and engineering. She is currently a research assistant in Professor Nathan Mara's lab at the University of Minnesota. Previously, she participated in the MRSEC Research Experiences for Undergraduates (REU) program at the University of Illinois Urbana-Champaign working with Professor Pinshane Huang. Hamilton has been the secretary of the Tau Beta Sigma Honorary Band Sorority for the last two years. Additionally, she is an active participant in the local Material Advantage Chapter.

Hudak

Nicole M. Hudak

The Ohio State University

Nicole Hudak is a second-year student at The Ohio State University. Her first experience studying materials was at the 2019 ASM Eisenman Materials Camp and since then it has been an easy decision to major in materials science and engineering. This summer, Hudak will be furthering her materials education by working at Oatey Co. as a quality engineering intern and she will be returning to the 2022 ASM Eisenman Materials Camp as a junior mentor. She is excited to share the passion she found at that camp with others in the field and help pave the way for younger generations of students to come.

FROM THE PRESIDENT'S DESK

Chapters and Members

Todd

As the flowers burst into bloom and winter turns into spring, the last month has been a wonderful time to reunite with friends and colleagues not seen since the beginning of COVID. I was fortunate to attend in-person meetings of the Philadelphia and Penn State chapters and to meet members of the Los Angeles Chapter virtually. The Liberty Bell Chapter held their Officers Night meeting at the historic Joseph Ambler Inn, a must visit if you are in the King of Prussia area. Surrounded by beautifully restored buildings dating from 1734, their gift of the chapter's souvenir Liberty Bell—the original was commissioned in 1751—was even more meaningful.

Following a tour of the production facility, the Penn State chapter held its meeting at the Axemann Brewery and Tap Room in the former Cerro Metal Factory, Titan Energy Park, Bellefonte, Pa. Encouraged by the unusually warm weather, members then gathered to relax and network on the deck overlooking the trout stream. The air was filled with renewed energy as students, faculty, and industry members mingled for the first time in two years. See the Chapters in the News section of this issue for photos from my Pennsylvania visits.

Memories of my days as an officer (1980s) came flooding back when I met with the Executive Committee of the Los Angeles Chapter. We reminisced about common acquaintances, discussed changing member demographics and work environments, and looked to the post-COVID future.

All three chapters have strong and dedicated leadership and I was impressed with their balance of senior, mid-career, and emerging professionals. Opportunities for increasing membership through in-person, remote, and hybrid meetings was a unifying theme. As geographically dispersed chapters are challenged by meeting locations, Philadelphia decided to invest in computer technology and a Zoom upgrade so they could reach out via ASM Connect to all interested ASM members. Returning to in-person education with downloadable content from online courses was also a high priority, as was a return to student recognition and scholarship award events. We look forward to hearing more about the success of these ventures at Leadership Days.

On May 2, Vice President Dave Williams and I, together with Past President Ravi Ravindran and Trustees Navin Manjooran and Kamachi Mudali, will attend the virtual inauguration of ASM's latest Material Advantage Chapter at VIT Bhopal University. Incoming ASM Senior Vice President Pradeep Goyal will give the Chief Guest address. Our chapters in India are flourishing and we are delighted to welcome such an enthusiastic group of students and faculty to the ASM family.

In closing, I am delighted to recognize the incoming 2022-2023 ASM Board officers-elect and trustees-elect. Joining the Board will be Senior Vice President-elect Mr. Pradeep Goyal, chairman, Pradeep Metals Ltd. India; Vice President-elect Dr. Navin Manjooran, chairman, Solve Technology and Research Inc.; Trustees-elect Dr. Amber Black, Los Alamos National Laboratory; Professor Pierpaolo Carlone, University of Salerno, Italy; Professor André McDonald, University of Alberta, Canada; and Student Trustees-elect Jaime Berez (Ph.D. Georgia Tech); Ashlie Hamilton (undergraduate, University of Minnesota); and Nicole Hudak (undergraduate, The Ohio State University). Full details of these candidates can be found on page 49 of this issue. I look forward to seeing you all at the strategic planning meeting in June.

ASM President Judith A. Todd, FASM
judith.todd@asminternational.org

Members of the Philadelphia Chapter during ASM Presidential visit in March.

Nominations Sought for 2023 ASM/TMS Distinguished Lectureship in Materials & Society

Nominations are currently being taken for the ASM/TMS Distinguished Lectureship in Materials & Society. The lecture was established in 1971 and is jointly sponsored by The Minerals, Metals & Materials Society (TMS) and ASM International. The topic of the lecture shall fall within these objectives:

- To clarify the role of materials science and engineering in technology and in society in its broadest sense.
- To present an evaluation of progress made in developing new technology for the ever-changing needs of technology and society.
- To define new frontiers for materials science and engineering.

Qualifications of the lecturer include:

- A person experienced in national or industrial policymaking in the field of materials science and engineering.
- An eminent individual who has an overview of technology and society in which technology and society are affected by development in materials science and engineering.
- A person associated with government, industry, research, or education.

Nominations may be proposed by any member of either Society. **Submit your nominations by September 1 for consideration.** Recommendations should be submitted to the headquarters of either Society.

View sample forms, rules, and past recipients at asminternational.org/membership/awards/nominate. To nominate someone for any of these awards, contact christine.hoover@asminternational.org for a unique nomination link. You may also contact Deborah Hixon at TMS Headquarters, hixon@tms.org.

VISIT THE CAREER HUB

Matching job seekers to employers just got easier with ASM International's CareerHub. After logging on to the ASM website, job seekers can upload a resume and do searches on hiring companies for free. Advanced searching allows filtering based on various aspects of materials science, e.g., R&D, failure analysis, lab environment, and manufacturing. Employers and suppliers can easily post jobs and set up pre-screen criteria to gain access to highly qualified, professional job seekers around the globe. For more information, visit the CareerHub site. http://careercenter.asminternational.org/.

EXECUTIVE DIRECTOR CORNER

My First Few Months: Meeting Our Community and Developing Context

Robert

Here we are in late spring, and I am wrapping up my initial deep dive into the People, Programs, and Financials that serve as the backbone of ASM International. A mentor from my manufacturing workforce policy days used to say that understanding a community's context will help you design better solutions for its stakeholders. I fully agree, and I've learned to seek context whenever I explore a new industry or field. Looking for context is about understanding the historical roots of a community, its values, its passionate advocates, its current areas of focus, and what impact the community wants to achieve. I've developed a good base of understanding in these first few months of serving ASM International; a good base from which to grow.

With Diana Lados and J.C. Zhao at TMS meeting in Anaheim in March.

As a highly people-oriented leader, I've focused in these early months on getting to know the ASM International staff and officers, to build strong relationships, and to clarify priorities. I've also met with each Board Trustee to learn more about their perspectives and ideas. I've joined many Committee, Council, and Task Force calls, as well as meeting with our Affiliate Society presidents, and several of our past presidents. I continue to be tremendously enthusiastic about the wealth of talent and commitment surrounding our organization. Many thanks to those of you who sent welcoming wishes to me as I settled in!

I've initiated my learning journey surrounding our programs and collaborations by engaging with our partners and my peers at sister societies, and by attending events. What a welcome change it is to see people in person again; a thought that is echoed by many of you! I've held introductory conversations with Jim Robinson, TMS; with Colin Church, IOM3; with Raman Venkatesh, SAE International; and with Mark Mecklenborg, ACerS. I'm exploring the Material Advantage program, where four societies including ASM International partner on a fully dimensional student membership package, and I'm gaining knowledge of our first-year AeroMat and AeroTech (SAE International) co-location in Pasadena, Calif., which both partners agree we will repeat next year. Working together, we can accomplish so much more for the materials science community, by aligning our distinctive offerings and expertise.

In April, I attended the Pittsburgh "Golden Triangle" Chapter of ASM International for Young Members' Night at

Dinner with event organizer Nisrit Pandy and vice chair Thomas Wingens at Pittsburgh Chapter meeting.

Onsite at AeroMat in Pasadena.

the invitation of chapter vice chair Thomas Wingens, and member Nisrit Pandey. There was so much energy in that room! The first week in May, attended my first international event organized by ASM International, in partnership with the German Welding Society (DVS), ITSC 2022 in Vienna, and I joined the Thermal Spray Society (TSS) for their Board meeting. In mid-May as I write this, I'm gearing up for the SMST 2022 show in San Diego.

The third leg of my framework, Financials, I approached almost immediately by working with our volunteer and executive staff leadership to prepare the 2022 Annual Operating Plan for review and approval by the Board of Trustees in mid-January. I met with chairs of the Finance and Investment Committees to better understand our financial position from their points of view, and I monitor our monthly financials with our Chief Financial Officer and our Board Officers. ASM International is very strong financially, and at the same time, we are facing financial pressures brought on by the pandemic, the Russian invasion of Ukraine, and by the supply chain and economic disruptions that are a result. These pressures are part of the dynamic landscape of today's world, they are inevitable, and faced by people and organizations globally. These pressures have been building for some time, and they played a crucial factor in my decision to come to ASM International to serve as executive director: We are on a strategically sound pathway to grow our digital services, including the Data Ecosystem, a gateway to serving materials scientists, and those needing materials solutions, worldwide. I am committed to continuing to develop the financial plan to success.

TSS board meeting in Vienna (from left), back row: Komal Laul, Thomas Klassen, Robert Vassen, Daniel Tejero Martin, and Daniel Sordelet; front row: Rogerio Lima, Sandy Robert, Kelly Thomas, Bill Lenling, André McDonald, and Ryan Milosh. Others joined the meeting virtually.

Over the next few months, the Board and I will work on updating our strategic plan and clarifying priorities for our journey ahead. I look forward to welcoming the new Officers and Board Trustees, who you can read about in this issue, and to meeting more of you as I continue my travels and outreach.

Sending best wishes from the Dome.

Sandy Robert, CAE
Executive Director, ASM International
sandy.robert@asminternational.org

FROM THE FOUNDATION

Master Teachers in the Making

McDonald and Lundy attended Master Teacher Training at ASM Headquarters, April 23-24.

Teachers have experienced quite a roller coaster ride since March 2020. Those of us working as Master Teachers through the ASM Materials Education Foundation are really looking forward to returning to in-person Materials Camps this summer. There is nothing like the excitement teachers feel when they learn to do those new labs and see how they can engage their students in new ways.

This year is particularly special for me, after being a Master Teacher for more than 10 years. One of my former students, now a colleague, is training to become a Master Teacher. Two years ago, I accepted a new position in my school district as an instructional coach to other teachers, making use of my experience teaching teachers. Leaving my materials science class was easier knowing that my former chemistry student was now a chemistry teacher and would take over the materials science classes.

After teaching materials science for four years and attending the ASM Materials Camp, Matt Lundy is now training to become a Master Teacher himself. I am so thrilled to be able to see this process cascade down. In addition, we now have a student who is looking forward to being a chemistry teacher in the future—another Master Teacher in the making!

The ASM Materials Camp program has changed my teaching, my career, and impacted my students in many ways. I will continue to do my part to provide that positive impact on other teachers. Thank you for your assistance in continuing this program so that many more teachers—and ultimately our students—can benefit.

Gissel McDonald
ASM Master Teacher
ASM Materials Education Foundation

ASM-IIM ACCEPTING NOMINATIONS FOR LECTURESHIP AWARDS

ASM-IIM Visiting Lectureship Award in India

Every year, many members of ASM International who study or work outside of India make brief personal visits to India. The visiting lectureship brings together such qualified visitors and the appropriate organizations in India and provides an honorarium for travel within India. This cooperative program of ASM and the Indian Institute of Materials (IIM) is intended to promote international cooperation and provide a useful service to ASM members.

ASM-IIM North American Visiting Lectureship

Following the success of the ASM-IIM Visiting Lectureship program, ASM and IIM jointly established and funded a new ASM-IIM program in 2013. The lectureship provides an honorarium of $2000 for qualified IIM members to travel to the United States and Canada.

Nomination deadline is June 15. Access a sample form, rules, and request a unique nomination link at asminternational.org/membership/awards/nominate.

IMS
International Metallographic Society
ASM INTERNATIONAL

International Metallographic Contest at IMAT

Deadline: September 2

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, will be held at IMAT 2022 in New Orleans, September 12-15. Six different classes of competition—including a new video class—cover all fields of optical and electron microscopy:

Class 1: Light Microscopy—All Materials

Class 2: Electron Microscopy—All Materials

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

Class 4: Artistic Microscopy (Color)—All Materials

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

Class 6: Video Entry—Topic of Choice involving defined problem (Undergraduate Students Only)

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 asminternational.org/web/ims/membership/imc or contact IMC chair, Ellen Rabenberg, at ellen.m.rabenberg@nasa.gov.

Seeking Nominations for Thermal Spray Hall of Fame

The Thermal Spray Hall of Fame, established in 1993 by the Thermal Spray Society of ASM International, recognizes and honors outstanding leaders who have made significant contributions to the science, technology, practice, education, management, and advancement of thermal spray. For a copy of the rules, nomination link request, and list of previous recipients, visit tss.asminternational.org or contact maryanne.jerson@asminternational.org. Nominations are due **September 30.**

ASM Digital Short Course: Vacuum Heat Treating Additively Manufactured Parts

Photo courtesy of Solar Atmospheres Inc.

ASM is offering a new digital short course that teaches various vacuum heat treating processes for additively manufactured parts.

This short course focuses on annealing and stress relieving, solid-solution annealing, and solution treating and aging. It addresses several practical concerns involved in using vacuum heat treatment, including temperature measurement, unvented cavities, loose powder, and direct contact of metals in the high-temperature vacuum. Sintering and evaporation of metals in vacuum furnaces is also discussed.

Students move at their own pace in this self-guided digital course aided by helpful visuals, narrated animations, and interactive quizzes. For more information, visit https://bit.ly/380GBMv.

EMERGING PROFESSIONALS

2022–2023 EPC Webinars Announced

Ho Lun Chan, Alexandra Merkouriou, Jeffrey Bunn, and Brittnee A. Mound-Watson

The ASM Emerging Professionals Committee (EPC) proudly announces our first year of webinars. The primary audiences are MSE students, early-career engineers, engineers from other countries, women and ethnic minority professionals, and ASM volunteers.

In recent years, ASM International has seen a steady diversification of membership demographics, especially among the emerging professional category, as well as the growing number of volunteers for local colleges and K-12 institutions. With this trend in mind, the EPC created the following list of topics hoping to spark more engagement:

1. "Get Involved as an ASM Student Member & Volunteer"—Shruti Dubey, IIT Kanpur, and David Scannapiec, Case Western Reserve University
2. "The Unexpected Versatility of Scanning Electron Microscopy for Outreach in Materials Science"—Abigail Carbone, Stanford University
3. "Women in Materials Engineering"—TBD
4. "Your Story as an Indian Student and Engineer in Materials Engineering"—TBD
5. "Launching Your First Career from a Conference Exhibit"—Kenneth Hirscht and Michael Kloesel, The Lunar Partners Group

Webinars 1, 2, and 5 will be prerecorded and uploaded to the ASM International YouTube channel for members to access. A discussion post will also be available for each webinar in ASM Connect to allow audience members to ask questions. Webinars 3 and 4 will consist of live discussion with more information to follow. Stay tuned for future webinar topics.

The EPC has a strong desire to connect and build relationships with students and local ASM Chapters, and to connect emerging professionals, students, and volunteers to resources to help them succeed. In you are interested in joining the EPC, apply by March 2023. Information about the application process is on the ASM International website.

VOLUNTEERISM COMMITTEE

Profile of a Volunteer

Lucas Equeter, Junior Lecturer, Machine Design and Production Engineering Unit, University of Mons, Belgium

Equeter

Some moments in life are pivotal. In Belgium, Lucas Equeter grew up immersed in STEM, with his mom teaching high school physics and his dad an electronics technician. While studying at the University of Mons, he was interested in computer engineering—but fascinated by a materials science lesson on the behavior of materials depending on composition and temperature, and how that affected the sinking of the Titanic. "All of a sudden, I realized it all had a down-to-earth application," recalls Equeter. "Then after my first lesson in theoretical mechanics, I was hooked and picked mechanical engineering with a focus on design and production."

Equeter is now a junior lecturer and researcher at University of Mons, where he completed his Ph.D. in 2020 on the optimal replacement of cutting tools in turning. He first learned about ASM in 2019 when a colleague suggested presenting his work at MS&T in Portland, Oregon. "He even helped me convince my supervisor. A few months later, I was presenting my latest experimental results and getting to know ASM."

Beyond ASM handbooks, Lucas finds great value in discussing technical subjects with the vast ASM community. He decided to give back by volunteering as chair of the ASM LGBTQ+ subcommittee. "I think many extremely talented young people from any minority are underrepresented in STEM, partly due to a lack of role models. We can empower people and show it's possible. We also owe it to the field. Diverse societies perform better."

Lucas considers discussions with other members as one of ASM's greatest riches. "The in-person exchanges helped me gain perspective on my thesis, and though I have not been a regular on ASM Connect, you may see more of me there!"

His volunteering only takes a few hours per month, so Lucas encourages others to get involved. "Giving back has to do with a sense of purpose, with an opportunity to reflect on your own practices and see the bigger picture. And just making the effort to understand each other's point of view has a positive effect on the community."

THE FACE OF MATERIALS ENGINEERING

*This profile series features members from around the world at all stages in their careers. Here we speak with **Ellen Wright,** senior staff consultant at Engineering Systems Inc., Kansas City.*

Wright

What does your typical workday look like?

No two days are the same! I get to wear many hats in my job and work in many different environments, including in laboratories, on-site where incidents/accidents occur, in manufacturing and storage facilities, in a variety of offices, and when requested, as an expert witness in the court of law. The dynamic nature of my job is exciting and I am continuously learning.

What part of your job do you like most?

My favorite part of my job is working with my colleagues. Growing up, I preferred individual over group assignments, but I have found exactly the opposite to be true in my career at ESi. I love working on multidisciplinary teams and learning technical, professional, and business skills by interacting with and purposefully observing others.

What is your engineering background?

I hold a B.S. in metallurgical and materials engineering with a minor in biotechnical engineering and life sciences and a Ph.D. in metallurgical and materials engineering from the Colorado School of Mines. I am a licensed professional engineer in metallurgical and materials engineering. At ESi, I specialize in failure analysis and prevention, fractography, and characterization of materials. It is rewarding to apply engineering fundamentals to investigate and prevent industrially relevant problems.

What attracted you to engineering?

I enjoy the hands-on nature of engineering and working in a field that requires me to bring my brain to work. I am fortunate that my career constantly challenges me both technically and interpersonally.

Best career advice, given or received:

Take time for yourself to know exactly who you are and who you want to become. Then be honest and deliberate in your actions. Build your team, embrace the things that make you feel like the best version of yourself, and pursue challenges and opportunities that best utilize and grow your individual strengths.

Hobbies?

Skiing, hiking, reading, and cooking.

Last book read?

"A Gentleman in Moscow" by Amor Towles.

Favorite motto:

Forewarned is forearmed.

Tell us about your involvement with ASM International, why are you a member?

I became part of the ASM community by attending conferences and chapter meetings and presenting my graduate research as a student. After graduate school, I served on the Emerging Professionals Committee (EPC), and in 2019, I had the honor of being on the Nominating Committee. Currently, I am a member of the Failure Analysis Society (FAS) and serve on the FAS Programming Committee. I am a member of ASM for a variety of reasons, including the opportunities ASM provides for professional development. I believe in the power of networking through ASM; many of my most important professional relationships and friendships were formed through ASM involvement.

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

CHAPTERS IN THE NEWS

ASM President Visits Liberty Bell Chapter

On March 17, ASM President Judith Todd, FASM, visited the Liberty Bell Chapter for the annual Officers Night meeting. This year it was held at the quaint and historic Joseph Ambler Inn near King of Prussia, Pa.

Philadelphia Chapter chair Spencer Freund presents the Liberty Bell to President Judith Todd, FASM. Let freedom ring!

Penn State Hosts ASM President

ASM President Judith Todd, FASM, visited the Penn State Chapter this spring for a tour and meeting at the Axemann Brewery and Tap Room, which formerly served as the Cerro Metal Factory in Bellefonte, Pa.

Members of the Penn State Chapter relax at the Axemann Brewery after a tour and talk.

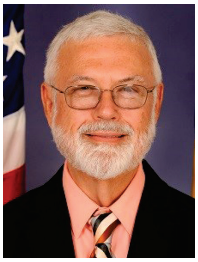
MEMBERS IN THE NEWS

Pathak Nominated for Evaluation Board

Pathak

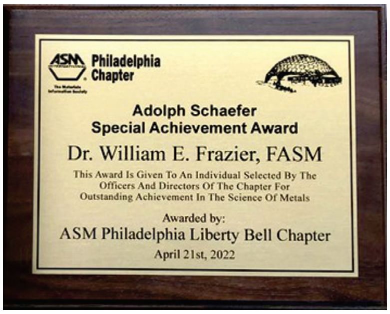
Udayan Pathak, FASM, chair of ASM International's Pune Chapter, was nominated as an expert member on the Performance Appraisal Board (PAB) of the Council of Scientific & Industrial Research, Central Mechanical Engineering Research Institute (CSIR-CMERI). CSIR is a network of 37 national research labs and 39 outreach centers, three innovation complexes, and five units with a pan-India presence, under the Department of Science & Technology, Government of India. The Prime Minister of India serves as president of the governing body. As a PAB member, Pathak will review and appraise the performance of the labs over the past five years. He will then inform the advisory board and governing body of the lab about the outcome of his review and suggest remedial measures to improve performance. Pathak is the first ASM member to be nominated for this prestigious board under the Government of India.

Frazier Honored by Philadelphia Chapter



Frazier

William E. Frazier, FASM, was presented with a special honor at the April 21 meeting of the ASM Philadelphia Chapter. He received the Adolph Schaefer Award for "Outstanding Achievement in the Science of Metals." Frazier served as ASM President from 2016-2017. He is a Navy executive with nearly 40 years of experience in naval aviation materials science and engineering and is now president and principal consultant of Pilgrim Consulting LLC. Frazier also serves as editor of the *Journal of Materials Engineering and Performance.* His award was conferred following a technical talk entitled "Philadelphia Naval Shipyard: Past, Present, and Future," presented by Philip M. Dehennis, the division head for quality assurance, metallurgy, and inspection at the Naval Foundry and Propeller Center in Philadelphia.



Singh Receives Award from UMBC

Singh

N.B. Singh, FASM, was honored during the University of Maryland Baltimore County's (UMBC) 2022 Presidential Faculty and Staff Award ceremony on April 6. The university awarded the UMBC's 2022 Research Faculty Excellence Award to Prof. Singh, of the department of chemistry and biochemistry, computer science, and electrical engineering for the recognition of excellence in research and contributions in teaching and mentoring. Singh is a previous recipient of ASM's Engineering Materials Award for the "Development of Material for the Acousto-Optic Tunable Filter based Hyperspectral Imager for Homeland Defense Applications." On hand for the April ceremony was UMBC President Dr. Freeman Hrabowski who is retiring in June.

UMBC provost Philip Rous congratulates awardee N.B. Singh (right).

Lampman Retires from ASM

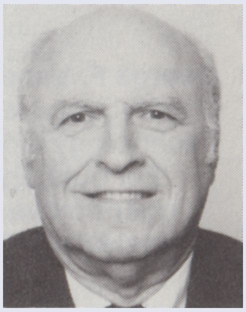
Lampman

Steve Lampman, senior content developer, is retiring from ASM International on June 10 after a long publishing career at the society that began in May 1988. For more than three decades, he has served as editor of the *ASM Handbook* series working with authors, volume editors, division editors, and reviewers. Lampman has been the authority on ASM technical content assets, making major contributions to all *ASM Handbook* volumes published since the late 1980s, and essentially driving several ASM technical books and data compilations. He also served as staff liaison to the ASM Handbook Committee. In 2016, Lampman was recognized as a Fellow of Alpha Sigma Mu at a ceremony held in Salt Lake City. Alpha Sigma Mu is the international professional honor society dedicated to encouraging and recognizing excellence in the materials engineering field.

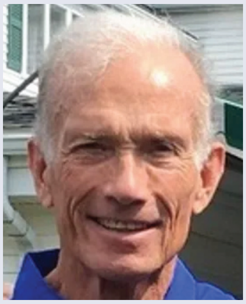
IN MEMORIAM


Loton

Brian T. Loton AC, from Melbourne, Australia, died on March 29 at age 92. The Distinguished Life Member of ASM International was born on May 17, 1929, in Perth. He received a degree in metallurgical engineering from Melbourne University in 1953. He was BHP director and CEO in 1984 and then its deputy chairman in 1991. He was appointed chairman the next year and held the position until retiring in 1997. Loton was president of the Australian Mining Industry Council in 1983-1984. He also served as president of the Business Council of Australia and as vice chairman of the Iron and Steel Institute. He was a fellow of the Australian Institute of Mining, an honorary fellow of the Institute of Engineers Australia, and a counselor of the U.S. Conference Board. Loton derived much satisfaction from his career and professional life, and always spoke highly of his international peers and associated organizations around the world.


Schwartz

Melvin "Mel" Schwartz, FASM, 92, of Charlottesville, Va., passed away on February 15. Born in Philadelphia, he was an ASM Life Member. Schwartz became an ASM Fellow in 1990 and was cited "for significant contributions and production innovations in the brazing and welding of aircraft structures and engine cases, and leadership in metal matrix composites and inertia welding of titanium rings for helicopters." He served as chief of materials and processes at Sikorsky Aircraft, United Technologies Corp., in Stratford, Conn. Schwartz authored the ASM technical book, *Brazing,* now in a second edition.


Soderberg

David C. "Suds" Soderberg of Duxbury, Mass., passed away at age 70 in his home on February 11. He was born in Worcester, Mass., on May 6, 1951. Soderberg graduated from Burncoat High School in 1969, Worcester Industrial Technical Institute in 1972, and WPI School of Industrial Management in 1981. He worked in the field of metallurgy for 49 years. Soderberg was a member of the ASM Central Massachusetts Chapter and served on its executive committee 2002-2021.

ADVANCED MATERIALS & PROCESSES

EDITORIAL PREVIEW

JULY/AUGUST 2022

Metal Additive Manufacturing

Highlighting:
- Directed Energy Deposition
- 3D Printing for Automotive
- IMAT Show Preview

Advertising Bonus and Distribution:
- Signet Ad Study
- Show issue for IMAT 2022 and the Thermal Spray & Surface Engineering Forum & Expo 2022
- IMAT: September 12-15, New Orleans
- TSS Forum: September 13-14, New Orleans

Special Supplements:
- *International Thermal Spray and Surface Engineering* newsletter covering coatings in the aerospace and defense industries, along with TSS news and initiatives.
- *HTPro* newsletter covering heat treating technology, processes, materials, and equipment, along with Heat Treating Society news and initiatives.

Advertising closes June 20

SEPTEMBER 2022

Nondestructive Testing and Failure Analysis

Highlighting:
- Mechanisms of Metallurgical Failure
- Terahertz Wave Diagnostics
- ISTFA Show Preview

Advertising Bonus and Distribution:
- ISTFA: November 13-17, Pasadena

Advertising closes August 8

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AD INDEX

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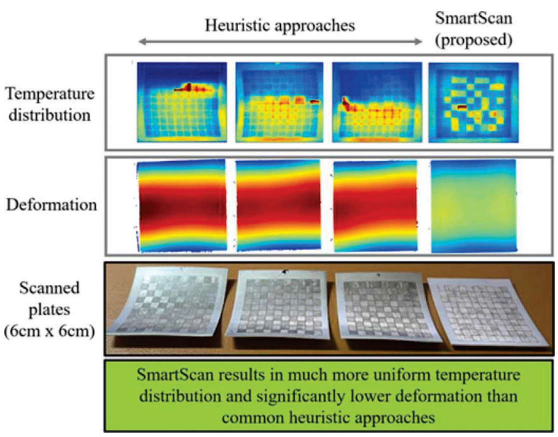
3D PRINTSHOP



Thermal-model-based software directs printer lasers to reduce warpage. Courtesy of University of Michigan.

SOFTWARE REDUCES HEAT BUILDUP IN PRINTERS

New software developed at the University of Michigan reduces harmful heat buildup in laser powder bed fusion printers. The printers use a laser to fuse layers of powdered metal or plastic together. But the laser's heat can build up in the delicate parts being printed, causing deformation and other defects.

Called SmartScan, the software demonstrated a 41% improvement in heat distribution and a 47% reduction in deformations in a recent study. It's also likely to speed the manufacturing process in two ways: by reducing the need for printers to slow down to help with cooling, and by significantly reducing heat-caused defects that must be corrected after printing.

"This problem gets even more serious for parts with really thin features," says Chinedum Okwudire, U-M associate professor of mechanical engineering. "The heat doesn't have a lot of room to spread, so you need to be smart about how you move the laser around, otherwise your part will deform in really weird ways."

The researchers plan to further improve the software by factoring the fusing of metal or plastic powder into their thermal modeling, as well as enabling active updating of a scan sequence during printing based on real-time observed temperature measurements using an infrared camera. *umich.edu.*

LIQUID METAL MICROGEL INKS FOR 'SMART' CLOTHES

Researchers are developing an electrically conductive ink made of liquid metal droplets that can be printed onto a variety of fabrics. The team from Zhejiang University in China believe this is a cost-effective way to print intricate, flexible, and durable circuits that can monitor posture, communicate with smart devices, and manage body temperature.

Conventional electronics are rigid and unable to withstand the twisting and stretching motions that clothing undergoes during typical daily activities. Because of their fluid nature and excellent conductivity, gallium-based liquid metals (LMs) are promising materials for flexible electronics. However, LMs don't stick well to fabrics, and their large surface tension causes them to ball up during 3D printing, rather than form continuous circuits. Yong He and colleagues wanted to develop a new type of conductive ink that could be 3D printed directly onto clothing in complex patterns.

To make their ink, the researchers mixed LM and alginate, a polymer derived from algae. Stirring the solution and removing the excess liquid resulted in LM microdroplets coated with an alginate microgel shell. The ink was very thick until it was squeezed through a nozzle for 3D printing, which broke hydrogen bonds in the microgel and made it more fluid. After the ink reached the fabric surface, the hydrogen bonds reformed, causing the printed pattern to maintain its shape.

The team 3D printed the new ink onto a variety of surfaces, including paper, polyester fabrics, nonwoven fabrics, and acrylic-based tape. Although the printed patterns were not initially conductive, the researchers activated them by stretching, pressing, or freezing, which ruptured the dried alginate networks to connect the LM microdroplets.

After activation, the printed circuits had excellent electrical conductivity and strain sensing properties. In addition, applying a small voltage to the ends of the circuit caused it to heat up, even in very cold temperatures. *www.zju.edu.cn/english.*

BRIEF

In a paper published by **Florida State University,** researchers describe how to improve 3D printing by teaching machines to learn from each other. The researchers connected different printers on a cloud platform, and then had the machines share data about accurate processing, which decreased the time needed to prepare and calibrate them. *eng.famu.fsu.edu.*

Interconnected 3D printers collaborate to share data to achieve 'group intelligence.' Courtesy of M. Wallheiser/FAMU-FSU Engineering.

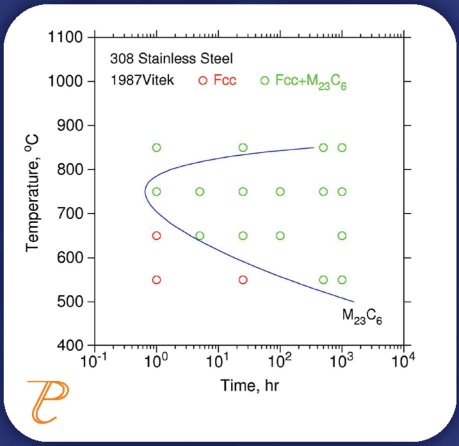
Thermo-Calc Software

Empowering Metallurgists, Process Engineers and Researchers

What if the materials data you need doesn't exist?

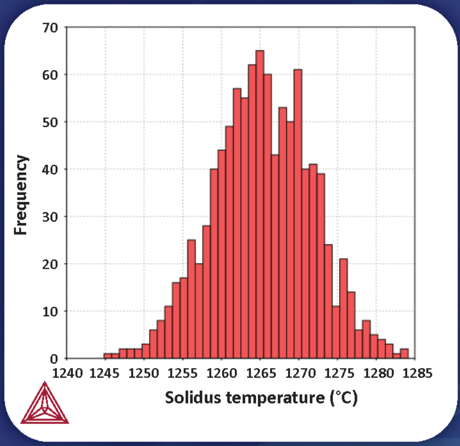
Gain insight into materials processing

Precipitation



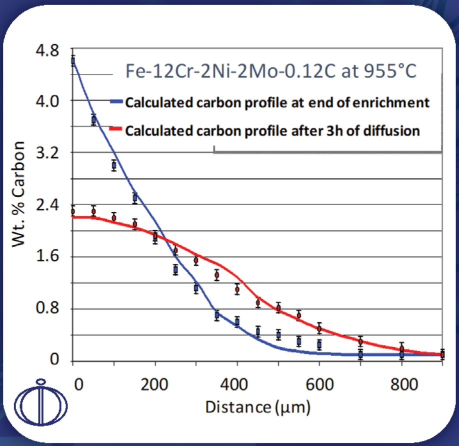
Time temperature precipitation of $M_{23}C_6$ in 308 stainless steel

Solidification



Solidus variation within Alloy 718 specification (Gaussian, n=1000)

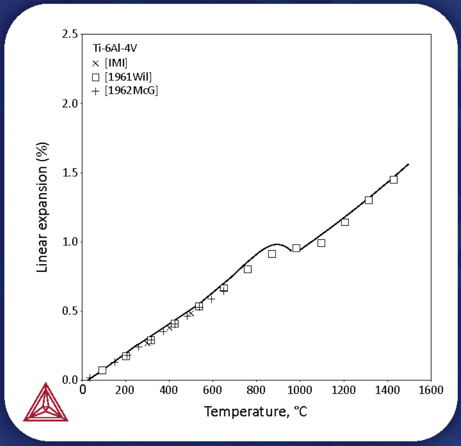
Diffusion



Carbon diffusion profile near surface during carburization of a martensitic stainless steel

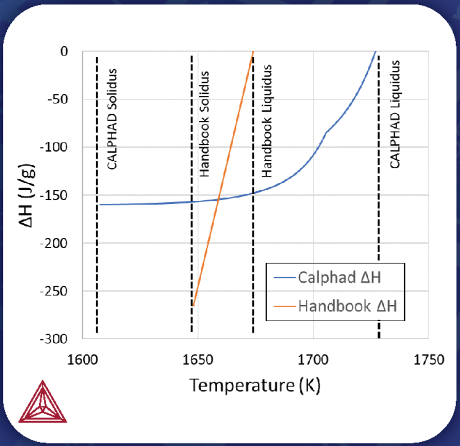
Predict a wide range of materials property data

Thermophysical Data



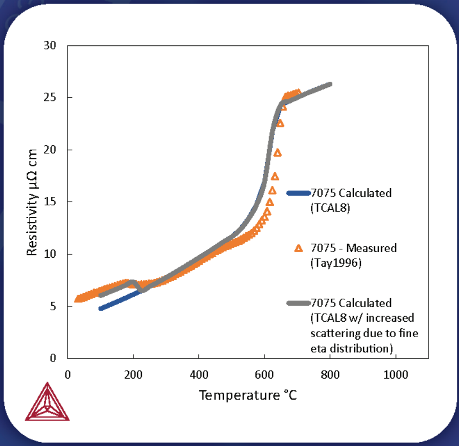
Linear expansion vs temperature for Ti-6Al-4V

Thermodynamic Properties



Calculated latent heat compared to handbook values for a specific 316L stainless steel chemistry

Electrical Resistivity



Calculated electrical resistivity of aluminum alloy 7075

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