JOM

JULY 2019

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An official publication of The Minerals, Metals & Materials Society

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JOM | table of contents

Volume 71
Number 7
July 2019

JOM: THE MAGAZINE

JOM: THE JOURNAL

Second Phase Particles in Magnesium Alloys: Engineering for Properties and Performance

Composition-Processing-Microstructure-Property Relationships of Titanium Alloys: Part I

Urban Mining: Characterization and Recycling of Solid Wastes: Part I

Technical Articles

JOM

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About the Cover

Hard disk drives contain neodymium-iron-boron permanent magnets—a valuable source of rare earth elements (REEs). Thus, magnets from end-of-life consumer instruments should be considered as a potential source of REEs. Until now, however, there have been no commercial efforts to recover REEs from end-of-life products, especially from NdFeB magnets of hard disk drives. Read about an REE recovery method in "Microwave Exposure of Discarded Hard Disc Drive Magnets for Recovery of Rare Earth Values" by Himanshu Tanvar, Sonu Kumar, and Nikhil Dhawan.

July 2019 Guest Editors

Second Phase Particles in Magnesium Alloys: Engineering for Properties and Performance
Magnesium Committee
Victoria Miller, University of Florida
Petra Maier, Stralsund University of Applied Sciences

Composition-Processing-Microstructure-Property Relationships of Titanium Alloys: Part I
Titanium Committee
Ben Morrow, Los Alamos National Laboratory
Carl Boehlert, Michigan State University
Kayla L. Calvert, TIMET - HTL
Yufeng Zheng, Ohio State University
Peter Collins, Iowa State University

Urban Mining: Characterization and Recycling of Solid Wastes: Part I
Materials Characterization Committee and Recycling and Environmental Technologies Committee
Mingming Zhang, ArcelorMittal Global R&D
Bowen Li, Michigan Technological University

About JOM:

The scope of *JOM* (ISSN 1047-4838) encompasses publicizing news about TMS and its members and stakeholder communities while publishing meaningful peer-reviewed materials science and engineering content. That content includes groundbreaking laboratory discoveries, the effective transition of science into technology, innovative industrial and manufacturing developments, resource and supply chain issues, improvement and innovation in processing and fabrication, and life-cycle and sustainability practices. In fulfilling this scope, *JOM* strives to balance the interests of the laboratory and the marketplace by reporting academic, industrial, and government-sponsored work from around the world.

About TMS:

The Minerals, Metals & Materials Society (TMS) is a professional organization that encompasses the entire range of materials and engineering, from minerals processing and primary metals production to basic research and the advanced applications of materials.

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in the final analysis

JOM
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"If it's your job to eat a frog, it's best to do it first thing in the morning. And if it's your job to eat two frogs, it's best to eat the biggest one first."

—Mark Twain (attributed)

James J. Robinson
Executive Director

I love my job. It is full of opportunities to think and act strategically, to collaborate with brilliant professionals, to mentor some people and be mentored by others, and to make meaningful decisions. Plus, I get paid for something that I'd (almost) do for free. Best of all, I don't have to eat any frogs—literally or metaphorically. Alas, one thing that is not absent from the job is stress. There are challenging deadlines, brow-furrowing dilemmas, perplexing questions in need of sensible answers, and an endless must-do list. Such is the challenging and captivating lifestyle of an executive director.

Interestingly, I don't see executive director anywhere on a list of "33 high-paying jobs for people who don't like stress" as enumerated by *Business Insider's* Andy Kiersz. Mr. Kiersz created his ranking by pairing a stress-tolerance metric from the U.S. Department of Labor's occupational database with average annual salaries as compiled by the U.S. Bureau of Labor Statistics. Job stress is measured on a scale of 0-100; the higher the number, the greater the job stress. "Low stress" is 69 or less. High compensation is at least $75,000 per year. In reviewing the results, I see TMS members represented in 8 of the 33 low-stress, high-paying occupations, including the top and the bottom entries on the list. The pertinent rankings:

33. Environmental Scientists and Specialists (69 | $76,220)

30. Environmental Engineer (69 | $91,180)

20. Postsecondary Atmospheric, Earth, Marine, and Space Sciences Teachers (66 | $98,560)

16. Geoscientists (63 | $105,830)

10. Materials Engineers (61 | $98,610)

7. Chemical Engineers (61 | $112,430)

6. Physicists (61 | $123,080)

1. Materials Scientists (53 | $101,910)

"Does this mean that TMS members are all living large on Easy Street?"

Does this mean that TMS members are all living large on Easy Street? I suspect not. As context is everything, I clicked over to the Department of Labor's website to learn the stress rankings of some other occupations. Similar to materials engineers, here are a few occupations that also have stress scores of 61: solar photovoltaic installers, software developers, political scientists, and security guards. As for materials scientists, we find the following occupations having the same stress score of 53: computer numerically controlled machine tool programmers, electromechanical equipment assemblers, environmental restoration planners, and floor sanders and finishers.

Let's also look to the extremes: Only one position is rated at the maximum stress level of 100: Urologist. The site does not explain why, so I browsed to the publication *Trends in Urology & Men's Health* and the article "Stress and Burnout—Why are Urologists So Stressed?" by Ben Challacombe. He conjectures that the stress is because "urologists are getting busier and busier as the population ages and people become more demanding and less tolerant of benign conditions." The upside? Urologists have an average annual income of $200,890. Meanwhile, the occupation at the opposite end of the scale with a relatively stress-free score of 24 is . . . model. The catch? Models have an average annual salary of $23,770.

So, is there a meaning to all of this? Yes, I think: Recall the aphorism, "Choose a job you love, and you will never have to work a day in your life." My theory? TMS members generally find their work stresses a lot less acutely because they love their jobs. One additional bonus: No one has to eat a frog.

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Materials Explorers™ Offers New Content; TMS in Washington; Three TMS Members Serve ABET

member news

Share the good news about your professional accomplishments! Contact Kaitlin Calva, JOM Magazine Managing Editor, at kcalva@tms.org. Please note that only news submitted by current TMS members will be considered.

New *Materials Explorers*™ Topic Area Added

Materials Explorers™, TMS's educational outreach initiative for high school students, launched a new topic area, "Materials That Move Us," in March. Developed with support from Arconic Foundation, the "Materials That Move Us" collection uses examples from the transportation industry to explain science, technology, engineering, and math (STEM) concepts, including: Data Collection and Graphing; Measurement and Scale; Chemical and Physical Properties; and States of Matter. The update also includes a capstone project that encourages students to apply knowledge learned hrough the program to conceptualize and design their very own product.

"Programs such as *Materials Explorers*™ generate a real interest in STEM among young people," noted Suzanne van de Raadt, Vice President of Global Communications and Partnerships at Arconic Foundation. "Students can picture themselves as a scientist or engineer, and know that no career is barred to them. Arconic Foundation is happy to support a program that helps realize its mission of preparing tomorrow's workforce for successful, rewarding careers."

The "Materials That Move Us" curriculum, which includes class activities and questions for all four modules plus the capstone project and additional online resources, is available for free download under the Students section of the *Materials Explorers*™ website at www.materials-explorers.org.

The *Materials Explorers*™ program, launched in 2018, initially included eight distinct popular culture topic areas ranging from smartphones to superheroes, each with class activities for teachers, parents, and students. Another main component of the program is the volunteer structure, which brings TMS members into their local high schools to serve as real-life role models. "*Materials Explorers*™ presents STEM role models to students, especially those in underrepresented groups, who may have never considered a career in STEM," added James Robinson, TMS Executive Director. "This not only helps secure the future of the broad mateirals science and engineering field, but strengthens it by the inclusion of diverse perspectives and experiences."

If you are interested in bringing materials science and engineering to life for high school students in your local area, visit the Volunteers page at www.materials-explorers.org for more information, or contact TMS staff at materials-explorers@tms.org.

TMS Visits Congressional Leaders

TMS President James C. Foley traveled to Washington, D.C., on April 9 and 10, 2019, to represent TMS in meetings with staff members of Congressional leaders and committees, including representatives of the Research & Technology Subcommittee and the Energy Subcommittee of the U.S. House of Representatives Committee on Science, Space, and Technology, as well as the House Manufacturing Caucus. During the visit, Foley discussed legislative priorities that can impact the work of TMS members, specifically focusing on topics such as the Materials Genome Initiative, advanced manufacturing, metamorphic manufacturing, the Scientific Integrity Act of 2019, and U.S. Department of Energy Office of Science priorities.

Foley began his week in Washington by attending the National Academy of Engineering Convocation of Professional

Engineering Societies, which prepared representatives from a number of materials societies for their visits with government leaders, and the 16th Annual Engineering Public Policy Symposium.

"I was honored to represent TMS as one of the many societies in Washington, D.C., to impress upon our representatives how important science and engineering is to the well-being of our country," said Foley. "After the visit, I am even more sure that TMS is on the correct path with the Society's Strategic Plan."

(Learn more about TMS Aspires, the new TMS Strategic Plan, at www.tms.org/TMSAspires, or by reading the March 2019 *JOM* article, "New Strategic Plan Reveals TMS Aspirations.")

Just days before Foley's visit, 38 students and faculty members from 10 universities participated in the Material Advantage (MA) Congressional Visits Day (CVD) on April 1 and 2, 2019. The CVD is an annual event that gives students an opportunity to visit Washington, D.C., to educate Congressional decision makers about the importance of funding for basic science, engineering, and technology.

The 2019 CVD experience began with a reception that featured talks by: David Parkes, American Association for the Advancement of Science (AAAS); Kei Koizumi, AAAS; and Michele Bustamante, the 2018/2019 TMS/MRS Congressional Science & Engineering Fellow. Students were then provided with a chance to role-play in advance of their appointments with legislators and congressional staff on the following day.

David Bahr, Purdue University and past TMS Board of Directors member, and Iver Anderson, Ames Laboratory, Iowa State University, and TMS Fellow, helped coordinate the CVD, as they have for a number of years, and also conducted training on how to visit with legislators.

The 2019 Material Advantage Congressional Visits Day gave 38 students and faculty the opportunity to meet with their local legislators in Washington, D.C., in April.

TMS Members Begin New Roles with ABET

This year, three TMS members will move into top leadership positions for ABET, the organization that accredits college and university programs in the disciplines of applied and natural science, computing, engineering, and engineering technology at the associate, bachelor's, and master's degree levels.

In July, Jeffrey W. Fergus, associate dean for program assessment and graduate studies and professor of materials engineering at Auburn University, will begin a one-year term as the chair of ABET's Engineering Accreditation Commission (EAC). The EAC is one of four ABET Accreditation Commissions responsible for reviewing educational programs as well as making accreditation decisions on each program. He has also served ABET as a long-time program evaluator (PEV), EAC Executive Committee member, EAC vice chair operations, and facilitator for PEV Face-to-Face Training, where he helps in preparing volunteers for accreditation activities.

Fergus has also shared his expertise in his 30-year membership with TMS as a past Board Director for Professional Development, the first chair of the Professional Development Committee, and past chair and long-time member of the Accreditation and Professional Registration Committees.

In November, two additional TMS members will begin new positions on the ABET Board of Directors. Gillian Bond, professor emerita of materials and metallurgical engineering at New Mexico

Jeffrey W. Fergus

Gillian Bond *(Photo courtesy of ABET.)*

Dianne Chong *(Photo courtesy of ABET.)*

Institute of Mining and Technology and TMS member since 1984, will become the 2019–2020 ABET Secretary. Within ABET, Bond is a current member of the Global Council and has been a member of the EAC, EAC Executive Committee, and EAC Training Committee; a support facilitator for ABET's Program Evaluator Candidate Training; and a participant in EAC Readiness Reviews. Through TMS, Bond has been a PEV, is a past chair of the TMS Accreditation Committee, and has represented TMS on the ABET Board of Delegates. When Bond begins her appointment as secretary, Thomas Bieler, professor at Michigan State University, will become TMS's representative to the ABET Board of Delegates. Bieler is a PEV, past chair of the Accreditation Committee, and 2019 TMS Fellow.

Dianne Chong, retired vice president, Boeing Research & Technology, will become the 2019–2020 ABET President-Elect. In 2017, she was elected to both the National Academy of Engineering and the Washington State Academy of Science. Chong has been a TMS member since 1986.

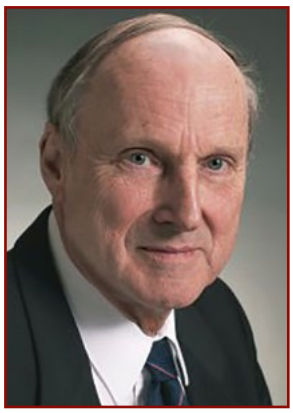
Ramana Reddy

Ramana Reddy Receives SEC Honors

TMS member Ramana Reddy, ACIPO endowed professor of metallurgy at the University of Alabama (UA), was awarded a 2019 Southeastern Conference (SEC) Faculty Achievement Awards in March. The awards program honors one educator from each of the 14 SEC universities annually, choosing individuals who have "excelled in teaching—particularly at the undergraduate level—and research." Reddy has also been head of the Department of Metallurgical and Materials Engineering and associate director for the Center for Green Manufacturing at UA.

In addition to serving on a variety of committees as a TMS member, Reddy has received several awards from the Society. In 2002, he gave a presentation at the TMS Annual Meeting & Exhibition as the Extraction & Processing Division (EPD) Distinguished Lecturer. He later received the EPD Science Award and EPD Distinguished Service Award, both in 2009; the Alexander Scott Distinguished Service Award in 2012; and was the first recipient of the renamed Julia and Johannes Weertman Educator Award in 2017.

In Memory of John Dutrizac



John Dutrizac

TMS extends its condolences to the family, colleagues, and friends of John E. Dutrizac, who passed away on April 1, 2019, at the age of 78. A longtime member of TMS, Dutrizac received his B.A.Sc. in metallurgical engineering in 1963 and Ph.D. in 1967 from the University of Toronto. After he graduated, Dutrizac briefly worked at Noranda Technology Centre before joining CANMET in 1968, where he worked as a research scientist studying hydrometallurgical problems until his retirement in 2008.

Throughout his career, Dutrizac received many awards and honors, including the 1992 TMS Extraction & Processing Division (EPD) Science Award and the 1998 James Douglas Gold Medal Award from the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME). Most notably, he served as the 1983–1984 President of the Metallurgy and Materials Society (MetSoc) of the Canadian Institute of Mining, Metallurgy, and Petroleum (CIM), and is known as the "father" of the Copper-Cobre conference series, of which TMS is a co-sponsor.

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JOM themagazine

In Case You Missed It:

Business News from the Field

Do you have business or industry news of interest to the minerals, metals, and materials community? Submit your announcement or press release to Kaitlin Calva, JOM Magazine Managing Editor, at kcalva@tms.org for consideration.

Tesla Predicts Shortage of EV Battery Minerals

Washington, D.C., USA: Representatives of electric vehicle (EV) producer Tesla Inc. recently addressed a conference of miners, regulators, and lawmakers on EV battery minerals. Tesla's global supply manager, Sarah Maryssael, explained that EV battery minerals like copper, cobalt, nickel, and lithium could soon be in shortage across the globe. Maryssael noted that Tesla will continue its increased focus on nickel as a part of CEO Elon Musk's plan to reduce cobalt usage in batteries, as some cobalt extraction techniques rely on controversial practices such as child labor.

Linde Starts New Air Separation Plant

Guildford, United Kingdom: Linde PLC, an industrial gas company, has launched a new air separation plant to support Samsung's operations at their display complex. This is the fourth such facility that Linde has launched at this complex. The air separation plant is expected to supply 700 tonnes per day of gaseous nitrogen to the facility, with the applications of cooling and purging manufacturing systems.

Kinshasa, Democratic Republic of Congo: Congolese Director General Ahmed Kalej Nkand announced in a statement that all mining subcontractors must comply with new regulations in order to perform subcontracting activities, including stipulations that subcontractors must be majority-owned by Congolese nationals. A regulatory body, known as the ARSP, will be responsible for identifying subcontractors and inspecting their ownership status before granting licenses. (Photo courtesy of Bloomberg.)

Toyota Announces Plans to Produce Crossover Vehicle

Cambridge, Ontario, Canada: Automaker Toyota Motor Corp. has announced plans to begin producing their Lexus NX crossover vehicle at their Cambridge plant. The plant, which currently produces the Lexus RX SUV and Toyota Corolla, will receive hundreds of millions of dollars in investment to enable production of the Lexus NX. Both gasoline and hybrid versions of the vehicle will be produced in the plant, with early 2022 as the target for beginning production.

Itaconix Receives Order for Bio-Based Detergent Polymer

London, United Kingdom: Specialty polymer manufacturer Itaconix PLC has reached a major milestone with the first European order for its bio-based detergent polymer. While neither the customer nor financial details were given at press time, the deal could mark a move away from phosphates for the industry. As phosphates are being phased out due to environmental concerns, companies are looking for more environmentally friendly alternatives for their detergents. Itaconix's bio-based polymers are derived from itaconic acid, a non-toxic organic acid.

Detroit Secures Land for Fiat Chrysler Plant

Detroit, Michigan, USA: The city of Detroit has officially acquired 208 of the 215 acres required for Fiat Chrysler Automobiles NV to build a new auto assembly plant, the first in nearly three decades for Detroit. The plant, which will build new three-row and electric vehicle versions of the Jeep Grand Cherokee, is part of a larger investment plan that could create 6,500 Fiat Chrysler jobs in the Detroit area.

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JOM 2020 EDITORIAL CALENDAR: More Options for Authors and Readers

Maureen Byko and Justin Scott

Maureen Byko

Justin Scott

The data is indisputable: more authors than ever are choosing *JOM* as their destination for publishing their work.

JOM announces its 2020 editorial calendar at a time of strong growth in submissions. The numbers have been climbing for several years and 2019 is on track to receive double the number of manuscripts for the volume year compared to 2017 (see Figure 1).

At the same time, author interest in citing *JOM* publications continues to rise, as illustrated by a steadily increasing Impact Factor in recent years. At press time for this issue, *JOM*'s Impact Factor was 2.145, a record high that attests to the hard work of the *JOM* advisors and guest editors in recent years.

Based on plans for 2020, these positive trends are likely to continue. Quality content representing a broad spectrum of minerals, metals and materials topics is again expected to be a hallmark of the upcoming volume year.

The new calendar features nearly 50 special topics to be published in 2020 and beyond. In keeping with *JOM*'s mission, this publishing plan represents the diverse interests of TMS's committees. In fact, in the next volume year, each of TMS's 34 committees—from Aluminum to Solidification to Thin Films and Interfaces—are represented as either a sponsor or co-sponsor of a special topic.

The full editorial calendar, along with information on upcoming deadlines and how to submit a manuscript, is available at www.tms.org/EditorialCalendar. To help authors find appropriate topics and ease the submission process, the website has been improved with input from authors, guest editors, and advisors prior to its recent debut in time for the *JOM* 2020 calendar. Authors can search the newly updated website by keyword, topic editor, publication deadline, and more. Each special topic's web page even has an option to save the topic deadline to one's

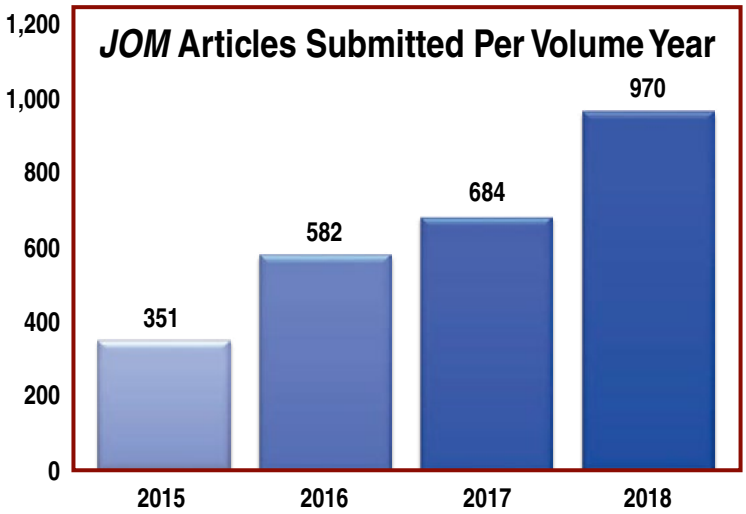

Figure 1. The number of articles submitted to *JOM* has been steadily climbing over the last several years, and is expected to continue growing throughout 2020.

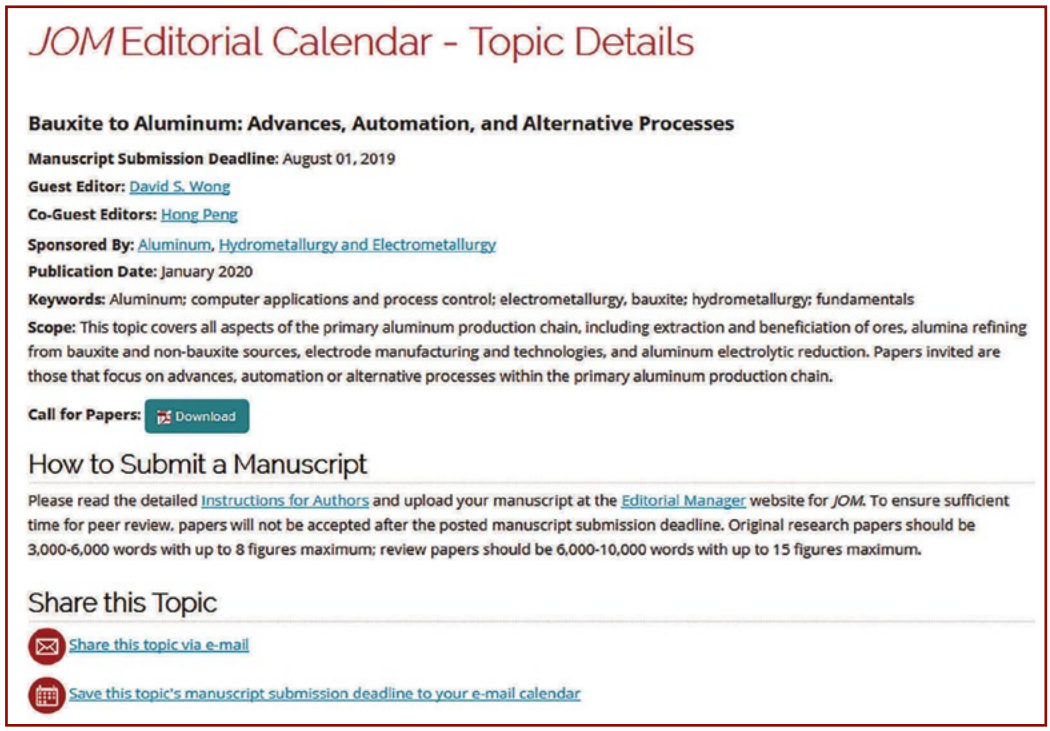

Figure 2. As displayed in this screenshot of a topic details page from the new *JOM* Editorial Calendar, the website includes new features that facilitate sharing the topic and setting reminders for topic deadlines. View the full calendar at www.tms.org/EditorialCalendar.

calendar so that you don't forget to submit a manuscript (Figure 2).

Coverage Highlights

Several committees and advisors have once again elected to feature papers on recent progress related to additive manufacturing. In the upcoming year, original research papers and reviews are being solicited in the following areas:

- Additive Manufacturing: Beyond the Beam Technology
- Additive Manufacturing: Validation and Control
- Advanced Processing and Additive Manufacturing of Functional Magnetic Materials
- Characterization of Additive Manufactured Materials
- ICME-Based Design and Optimization of Materials for Additive Manufacturing
- In Situ Synchrotron and Neutron Characterization of Additively Manufactured Alloys
- Solid Freeform Fabrication 2019

In addition, thorough coverage is planned for new developments and innovations across many established and emerging materials, including:

- Advancing Development and Application of Superalloys
- Aluminum and Magnesium: Casting Technology and Solidification
- Emerging Mechanisms for Enhanced Plasticity in Magnesium
- Graphene-based Composite Materials and Applications
- Quantum Materials for Energy-Efficient Computing

Many topics also welcome submissions focused on modeling and simulation, including:

- Advances in Surface Engineering
- Augmenting Physics-based Models in ICME with Machine Learning and Uncertainty Quantification
- Metal and Polymer Matrix Composites
- Thermodynamic Modeling of Sustainable Non-Ferrous Metals Production

For submission deadlines on these and other topics, visit the full editorial calendar at www.tms.org/EditorialCalendar. Manuscripts should be prepared according to the author instructions and can be uploaded to the Editorial Manager website at www.editorialmanager.com/JOMJ.

Any questions about publishing papers, developing special topics, or getting involved in *JOM* can be directed to *JOM*@tms.org.

Justin Scott is the *JOM* Principal Editor. Maureen Byko is the *JOM* Editor.

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TMS Presents the 2020 Board of Directors Nominees

Kelly Zappas

The individuals highlighted in the following pages have been nominated to fill the open Vice President/President/Past President position, or Presidential Rotation, as well as six additional positions on the TMS Board of Directors. The candidates, if elected by the TMS membership, will be installed at the conclusion of the TMS 2020 Annual Meeting & Exhibition, scheduled for February 23–27, 2020, in San Diego, California.

Additional nominations for these positions may be submitted for board consideration by any 25 TMS members by August 15, 2019. Nominations for qualified individuals should be sent to James J. Robinson, TMS Executive Director, at robinson@tms.org, and should include the nominee's name, biography, and written consent to serve if elected. If additional candidates are proposed, a majority vote of TMS members will determine who fills the position. If no new nominations are received, the individuals named in this article will be automatically elected on August 16, 2019.

Many board leaders began as members of a TMS technical committee. If you are aspiring to Society leadership, find out more about how you can get involved today by visiting the TMS Divisions & Committees web pages at www.tms.org/Committees to choose the technical committee that best matches your interests, and contact the chair about becoming a member. Committee membership is open exclusively to TMS members.

The nominees for the open positions on the 2020–2023 TMS Board of Directors are:

Vice President

Ellen Cerreta
Los Alamos National Laboratory

Ellen Cerreta is the deputy division leader for the Explosive Science and Shock Physics Division at Los Alamos National Laboratory (LANL). In this role, she works to implement strategy for the development and certification of high explosives (HE) for the stockpile which entails coordination over multiple organizations and programs within the lab. Cerreta also serves as HE safety program manager at LANL, requiring strong partnership across program and support organizations to enable compliant and safe, moderate, and high hazard operations. Since joining LANL, she has examined the correlation of microstructure to mechanical response of metals and alloys, with the support of the Office of Basic Energy Sciences, the Weapons Program, and Laboratory Directed Research and Development. Her research has had a focus on material behavior in dynamic loading environments. Cerreta is also an adjunct faculty member in The Institute of Shock Physics at Washington State University.

Cerreta earned her bachelor's degree in aerospace engineering from the University of Virginia and a master's and Ph.D. in materials science and engineering from Carnegie Mellon University. In 2006, she was the TMS Young Leaders International Scholar to the Japan Institute of Metals and Materials. In 2013, she was named a TMS Brimacombe Medalist. Most recently, in 2016, she became a Fellow of ASM International.

As a TMS member since 1997, Cerreta has co-organized several TMS symposia and has served as a member of the Mechanical Behavior of Materials and Titanium Committees. She has served on the TMS Board of Directors twice, first as Membership & Student Development Director and, most recently, as Structural Materials Division Director. She is the author or co-author of more than 100 peer-reviewed scientific articles and one book chapter.

Financial Planning Officer

Charles Ward

Air Force Research Laboratory's Materials and Manufacturing Directorate

Charles Ward is chief of the Manufacturing and Industrial Technologies Division at the U.S. Air Force Research Laboratory's Materials and Manufacturing Directorate, where he is responsible for executing a program valued at over $1.4 billion. He previously led the directorate's efforts in integrated computational materials science and engineering and was co-chair of the Materials Genome Initiative Subcommittee under the National Science and Technology Council.

His TMS activities include editor-in-chief of *Integrating Materials and Manufacturing Innovation*, past-chair and member of the Materials Innovation Committee, member of the Integrated Computational Materials Engineering (ICME), Accreditation, and Financial Planning Committees, and past Structural Materials Division representative to the Publications Coordination Committee (now the Content Development and Disseminations Committee). He currently represents TMS as a commissioner to ABET's Engineering Accreditation Commission.

His professional career has spanned 33 years, serving in several roles in research, engineering, and management. His research has focused on the microstructure-property relationships in titanium and titanium aluminide alloys. He has served as manager for the Air Force's basic research program in metals and as an engineer on the F-35 propulsion program. He also served as staff officer to the Assistant Secretary of the Air Force for Acquisition, as Air Force liaison for materials research and development in Europe, and as chief of the Metals, Ceramics, and Nondestructive Evaluation Division of the Materials and Manufacturing Directorate. He is also an adjunct faculty member in the materials engineering degree program at the University of Dayton and is a Fellow of ASM International.

Ward received his B.S. (1984), M.S. (1985), and Ph.D. (1992) in materials science and engineering from Carnegie Mellon University.

Content Development & Dissemination Director

Judy Schneider

University of Alabama in Huntsville

Judy Schneider is a professor in the Department of Mechanical and Aerospace Engineering at the University of Alabama in Huntsville. She received her B.S. in mechanical engineering from the University of Nebraska-Lincoln and her M.S. and Ph.D. in materials engineering from the University of California, Davis. Her research focuses on the behavior of structural materials under extreme environments imposed by either the processing conditions or subsequent operation.

As an active member of TMS since 2003, she has served on a number of technical and functional committees for the Society, most notably as the current vice chair of the Content Development & Dissemination Committee. In addition to her active research program, funded by NASA, the U.S. National Science Foundation, the U.S. Air Force Office of Scientific Research, and various industries, she was recognized with TMS's Structural Materials Division (SMD) Distinguished Service Award in 2015, was elected to the Acta Materialia Board of Governors as the TMS representative, and is a Fellow of ASM International. Schneider has served on the TMS Program Committee (2012 to 2014) and represented TMS to the Materials Science & Technology 2013 (MS&T13) and MS&T14 Conference Program Coordinating Committee, serving as chair for MS&T14.

In addition to her leadership roles for TMS committees, including technical committees in the SMD and Materials Processing & Manufacturing Division, she has also been *JOM* advisor for several committees, including her recent role with the Additive Manufacturing Committee.

The candidates, if elected by the TMS membership, will be installed at the conclusion of the TMS 2020 Annual Meeting & Exhibition, scheduled for February 23–27, 2020, in San Diego, California.

To learn more about the board nomination and selection process, visit www.tms.org/BoardNominations.

Professional Development Director

David L. Bourell

The University of Texas at Austin

David L. Bourell is the Temple Foundation Professor of Mechanical Engineering at The University of Texas at Austin. His areas of research include materials issues associated with laser sintering (LS) and particulate processing. Bourell holds nine primary patents and has published 250 papers in journals and conference proceedings, or as book chapters. He is a founding member of the ASTM F42 Technical Committee on Additive Manufacturing and currently serves on the ten-member ASTM/ISO Joint Group 51 on Terminology for Additive Manufacturing. Bourell is a Fellow of TMS and ASM International and a recipient of the TMS Materials Processing & Manufacturing Division Distinguished Scientist/Engineer Award. In 2017, he received the Society of Manufacturing Engineers Albert M. Sargent Progress Award for "significant accomplishments in the field of manufacturing processes."

Bourell has been an active member of TMS for more than 35 years. He was the charter faculty advisor for The University of Texas' TMS student chapter. Since 1982, he has consistently been a member or officer of at least one TMS technical or functional committee. Bourell is a current member of the Powder Materials, Professional Registration, and Additive Manufacturing (AM) Committees. He has completed officer rotations in all three committees, including as founding chair of the AM Committee, TMS's first technical committee to span three or more of the Society's five technical divisions. He is actively engaged in offering a popular, recurring workshop on additive manufacturing as part of the TMS Annual Meeting & Exhibition and Materials Science & Technology Conference, and is the lead editor for a special topic with *JOM*.

Bourell received his B.S. (1975) in mechanical engineering from Texas A&M Univeristy, and his M.S. (1976) and Ph.D. (1979) both in materials science and engineering from Stanford University.

Public & Governmental Affairs Director

Eric N. Brown

Los Alamos National Laboratory

Eric N. Brown is the division leader for the Explosive Science and Shock Physics Division at Los Alamos National Laboratory (LANL), where he oversees the research program on energetic materials and dynamic material response in support of national security. His research has spanned fracture and damage of complex heterogeneous polymers and polymer composites for energetic, reactive, and structural applications, including crystalline phase transitions, plasticity, dynamic loading conditions, and self-healing materials. Brown was a Director's Postdoctoral Fellow and technical staff member in the Materials Science and Technology Division at LANL, technical advisor for the Joint U.S. Department of Defense/Department of Energy Munitions Technology Program in the Office of the Under Secretary of Defense, and managed the Neutron Science and Technology Group in the Los Alamos Physics Division.

Brown is currently the vice chair of the TMS Public and Governmental Affairs Committee. He has participated in the TMS Mechanical Behavior of Materials Committee since 2006, served as the vice chair of the Content Development & Dissemination Committee (CDDC) from 2011 to 2014, and as the director/chair of the CDDC on the TMS Board of Directors from 2014 to 2017. He has been a key reader for *Metallurgical and Materials Transactions A* since 2007 and is the founding editor-in-chief of the *Journal of Dynamic Behavior of Materials*. He received the TMS Structural Materials Division Young Leaders Professional Development Award in 2007 and the TMS Brimacombe Medal in 2017, as well as awards from the American Society for Composites, U.S. Department of Energy National Nuclear Security Administration, LANL, Materials Research Society, Society for Experimental Mechanics, and the University of Illinois.

He received a B.S. in mechanical engineering in 1998 and a Ph.D. in theoretical and applied mechanics in 2003, both from the University of Illinois at Urbana-Champaign.

Extraction & Processing Division Chair

Christina Meskers
Umicore

Christina Meskers is senior manager, Open Innovation, at Umicore (Belgium), where she develops and implements the open innovation strategy and is responsible for the development, management, and governance of the network and global portfolio of programs in Recycling & Extractive Technologies. With more than 15 years of experience in the raw materials sector, her current focus is on the contribution of recycling and extractive technologies to the transition to sustainable cities and e-mobility.

Meskers graduated from Delft University of Technology with an M.Sc. (2004) in resource engineering and a Ph.D. (2008) in materials science and engineering, including stays at McGill University, the Norwegian University of Science and Technology, and the University of Melbourne.

Currently, Meskers serves on the industrial advisory boards of the Center for Resource Recycling and Recovery (CR3) and the Sustainable Materials (SuMa) and Sustainable and Innovative Resource Management (SINReM) international M.Sc. programs. She is vice-chair of EIT Raw Materials Innovation Hub West. The United Nations' International Resource Panel report, *Metal Recycling—Opportunities, Limits, Infrastructure* (2013) is a key publication that she co-authored. Meskers is co-recipient of the 2014 Ondernemers voor Ondernemers Award, and the 2013 Belgian Business Award for the Environment.

Her TMS activity started in 2007 with membership in the Recycling and Environmental Technologies and the Materials and Society Committees, and she later served on the Public & Governmental Affairs and Program Committees. She was lead organizer of Sustainable Materials Production & Recycling 2010 and of the last three installments of the REWAS symposium. In 2008, Meskers received the TMS Young Leaders Professional Development Award for the Extraction & Processing Division. Meskers is currently serving as the vice chair of the Extraction & Processing Division.

Functional Materials Division Chair

Paul R. Ohodnicki Jr.
National Energy Technology Laboratory

Paul R. Ohodnicki Jr. is a materials scientist and technical portfolio lead in the Functional Materials Team of the Materials Engineering & Manufacturing Directorate of the National Energy Technology Laboratory. He graduated from the University of Pittsburgh in 2005 with a B.Phil. in engineering physics and a B.A. in economics and subsequently earned his M.S. (2006) and Ph.D. (2008) in materials science and engineering from Carnegie Mellon University. He spent two years as a visiting research scientist at PPG Industries from 2008 to 2010 prior to joining the National Energy Technology Laboratory and the U.S. Department of Energy. He currently oversees projects spanning sensing and power electronics, with emphasis on advanced devices and enabling functional materials for photonic and wireless sensing as well as power magnetics component and materials design.

Ohodnicki has published more than 100 technical publications and holds more than 10 patents, with 15 additional patents under review. He also is the recipient of a number of awards and recognitions, including the Federal Employee Rookie of the Year Award (2012), Presidential Early Career Award in Science and Engineering (2016), and the Advanced Manufacturing and Materials Innovation Category Award for the Carnegie Science Center (2012, 2017, 2019). In 2017, he was a nominee for the Samuel J. Heyman service to America Medal.

Ohodnicki's involvement with TMS began as the recipient of the Young Leaders Professional Development Award for the Electronic, Magnetic & Photonic Materials (now Functional Materials) Division in 2010. Since then, he has organized more than 15 symposia for the TMS Annual Meeting & Exhibition and has served as the vice chair and chair of the Energy Conversion and Storage and the Magnetic Materials Committees as well as on numerous functional committees, including the Membership and Student Development and Young Professionals Committees. He is currently the vice chair of the TMS Functional Materials Division.

Get Involved in TMS

Behind every TMS meeting, publication, and initiative is a team of dedicated volunteers. TMS members have access to a broad range of volunteer opportunities to share their technical expertise, shape the future of materials science and engineering, and impact the wider world. Visit www.tms.org/Volunteer to find out more about how you can get involved.

2019 TMS Board of Directors

The current members of the TMS Board of Directors, installed at the conclusion of the TMS 2019 Annual Meeting & Exhibition in March, are as follows:

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Perspectives on Diversity

Megan J. Cordill

More than a decade ago, TMS established the Women in Materials Science and Engineering Committee as a forum to explore issues of concern to female scientists and engineers. Since then, TMS has led the way for other materials societies on diversity and inclusion initiatives within the STEM (sciences, technology, engineering, and math) fields, but has also expanded the scope of topics addressed by the group.

The newly named Diversity Committee has spearheaded events, initiatives, and policies to ensure that TMS is a fully representative materials society. We are now addressing other important matters that concern our lesbian, gay, bisexual, transgender, and queer/questioning (LGBTQ+) members and at the same time are exploring strategies to better support any members experiencing physical, mental, or emotional health concerns. The committee is also working toward providing mentoring opportunities to members representing racial and ethnic minorities as well as encouraging more engagement from our international members.

The four articles comprising the Perspectives on Diversity compilation in the July 2019 issue of *JOM* highlight our evolution from a female-specific group to a more well-rounded and inclusive committee. This collection of articles also provides a preview of the key issues and potential solutions that anyone can implement to impact both the TMS membership and our professions.

First, bias in the workplace will be addressed by Blythe Clark and Olivia Underwood. Their article, "Mitigating Implicit Bias as a Leader," provides current methods and recommendations for leaders to mitigate bias in order to encourage more diversity and inclusion in STEM.

Matthew Korey next provides a view on gender identities in STEM and what support systems are necessary to be one's true self by summarizing the LGBTQ+ branch of talks and activities from the TMS2019 diversity symposium in his article, "What's the T, Cis? Discussing Gender Identity and Sexual Orientation in TMS."

The third article, "The Elephant in the Room: Where is the Empathy in Science?" addresses how principle investigators, postdocs, and graduate students can take care of their mental health, something that is often overlooked by everyone regardless of identity. Jennifer Carter and Laura Bruckman detail steps that individuals can take to help themselves and those they may supervise with the mental health aspects of being in academia and to remove the stigma behind mental illness.

Finally, in "Promoting Positive Outcomes in K–12 Outreach through Design," Jessica Krogstad, Kaitlin Tyler, Nicole Johnson-Glauch, and Leon Dean describe the effectiveness of incorporating design elements into outreach camps as a means to build confidence in high-school women to study engineering or sciences to better supply the STEM pipeline.

It is intended that the information, insights, and guidance presented by these various authors on these topics will generate positive change within the diversity spectrum. Because understanding the humanity of our profession is, on many levels, as important as understanding the science.

Megan J. Cordill is a senior scientist with the Erich Schmid Institute of Materials Science of the Austrian Academy of Sciences and a lecturer with the Department of Materials Science of the Montanuniversität Leoben. She has been a TMS member since 2009 and is the current chair of the Diversity Committee.

Megan J. Cordill

"Perspectives on Diversity" serves as an introduction to a thematic group of articles in the July 2019 issue of *JOM* covering diversity and inclusion topics. The article package is the first feature series developed by the TMS Diversity Committee. For additional information, contact Kaitlin Calva, *JOM* Magazine Managing Editor, at kcalva@tms.org.

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Mitigating Implicit Bias as a Leader

Blythe G. Clark and Olivia D. Underwood

Blythe G. Clark

Olivia D. Underwood

Bias. It's a word that makes most of us squirm. Bias implies to us that we are "bad people" and are being accused of deliberately discriminating against others. Yet, if you ask a social scientist, you will find that it doesn't mean that at all; implicit bias is a neurologically based, energy-saving short cut.[1] Our brains apply mental models to make thousands of quick decisions every day: which brand of milk to buy at the store or when to turn the wheel to avoid a traffic accident. We form our implicit biases subconsciously over time, influenced by our upbringing, societal norms, and life experiences.

While benign in the above examples, when relied on for decisions regarding people, implicit bias can inadvertently cause us to exclude others, tune out their ideas, or under- or overestimate their abilities. When we interact with someone who doesn't "match" our mental model for that role, we unconsciously think of them as having lower potential; likewise when someone reflects our mental model, we give them more credit than is due.[2] In the workplace, we can even formalize our biases into preferred criteria for job candidates—criteria that are not critical for success in the job but mirror the skills or experiences of those that held the job in the past. As engineers and scientists, our value system is one of meritocracy, yet we cannot truly reach that ideal unless we commit to actively addressing, or mitigating, our biases, both individually and institutionally.

"We can significantly bolster our collective innovation, productivity, and sustained knowledge base by creating an inclusive culture where individuals feel they belong…"

—Blythe G. Clark and Olivia D. Underwood

Diversity, Engineering, and Inclusion

Engineering, as a discipline, has solved some of the world's most complex problems. These solutions often require the most creative, innovative approaches we can muster and for that, the overwhelming evidence shows that we need diverse teams with diverse thoughts: diversity of thought that comes not only from different educational backgrounds, but from different upbringings, different ethnicities, different genders, and different life experiences.[3–5]

There's a distinction, however, between simply inviting diversity to the table and taking full advantage of it by *including* diverse individuals and their ideas. Without acting to counter them, implicit biases serve as a barrier to inclusion. Left unmitigated, they can cause us to seek or integrate input only from a select few, to overlook the potential of others, and even to dismiss otherwise brilliant ideas. This, in turn, can cause diverse individuals to feel undervalued, dismissed, and excluded.

Take a moment to recall a time you felt like an outsider—perhaps even a childhood experience on the playground. Did you feel like your full self? Likely not. In fact, evidence shows that when we feel we don't belong, we are less creative, less engaged, and less likely to remain loyal to the organization.[6] Yet, the converse is also true: we can significantly bolster our collective innovation, productivity, and sustained knowledge base by creating an inclusive culture where individuals feel they belong, thus enabling engineering as a field to reach its full potential.

Admittedly, the idea of mitigating bias

can sound overwhelming. How can you possibly notice all of your biases and, even if you see them, what are you supposed to do about them? Luckily, there is an abundance of data on how to do this. In this article, we describe three of the most impactful and straightforward things you can do today to help mitigate bias: ensure rigor and consistency in people decisions, cultivate inclusion around you, and stay curious about diversity.

Ensure Rigor in People Decisions

One of the most effective ways to mitigate bias with hiring, performance evaluations, and promotions is to decide ahead of time—before we've begun to look over resumes or details—what criteria will directly measure excellence. Most of us have seen or heard of examples where someone didn't fit the mold: someone with seemingly low pedigree wildly exceeded everyone's expectations, or someone with all the pedigree in the world never lived up to expectations.

Deliberately defining and adhering to a structured approach prevents us from allowing our criteria to slide based on the candidates we see;[7] overweighing ancillary criteria that are not relevant to success in the role;[2] or being so impressed with one skill that we do not explicitly evaluate across all of the other criteria.[2] We recommend that you consider adopting the following tangible suggestions:

- When recruiting, ensure that your applicant pool reflects the diversity of availability. If it does not, reconsider where to target your talent searches, how the posting is worded, and how and where you are advertising the posting.[8]
- Be aware that women and minorities may have a tendency to self-select out of bidding if they don't match all of the listed criteria, whether required or desired.[9] It's best to list only the most important criteria in the posting.
- Create a rubric to avoid rushed decision processes or defaulting to a "gut reaction" that may in fact be aligned to stereotypes, and then justifying the decision based on plausible, but inherently biased, criteria.

"One of the most effective ways to mitigate bias with hiring, performance evaluations, and promotions is to decide ahead of time…what criteria will directly measure excellence."

—Blythe G. Clark and Olivia D. Underwood

- Avoid relying on indirect indicators (for example, pedigree) in evaluations. Seek direct evidence of excellence and recognize that attributes such as perseverance and grit may matter much more.[10, 11]
- Using "culture fit" as a criterion for selection can be a flag for bias. Essential attributes of the organization's culture must be explicitly defined prior to including fit as a criterion. Otherwise, determining "fit" may rely on a gut reaction triggered by implicit biases.
- With promotions and performance, recognize that there is more than one path to success. When evaluating others, question yourself if you note that you are turned off based on a career path that is non-traditional or that does not match the pattern you've been conditioned to look for.
- Regularly educate yourself and your decision-making teams on common biases. Many universities, for example, now provide bias education not only to faculty recruitment committees but also to tenure and promotion review committees each year.

Cultivate Inclusion on Your Teams

As with other diversity competencies, mentioning inclusion can draw blank stares. How do you do that—create more inclusion? Building inclusion boils down to some of the very things we value in others and that we know improve the performance of teams. While there are several references that go into this topic more deeply,[12, 13] we have put together the following list of actions that we can all commit to today:

- Disparaging comments from co-workers may seem like harmless banter, but in fact can erode confidence and aren't appropriate

"In order to continually realize innovation and impact, we must stay open to change. The day we stop learning and being curious about how to make our environment more inclusive is the day that our organizations become stagnant."

—Blythe G. Clark and Olivia D. Underwood

to establishing positive workplace dynamics.[14] Rather than dismiss these (for example, by saying or thinking, "Don't let it get to you"), articulate the impact of such comments and set expectations across the team to ensure that all team members feel valued and respected.

- Pay attention to meeting dynamics and be willing to intervene. Take notice when someone wants to contribute, and invite them to speak. Also, speak up when credit is being misattributed by saying something like: "That's a great idea, and it echoes what *so-and-so* suggested a minute ago."
- Evaluate who is on your "go-to" list and find opportunities for those without these experiences to take on new roles. Give them the training or tangible feedback needed to prepare them for success.
- Celebrate team success. One of the easiest things you can do to build inclusion and help everyone feel valued is to nurture a culture of recognizing each other for a job well done. Take the time to go out to lunch; celebrate a paper being published; or send a congratulatory e-mail to acknowledge the impact of new results.
- Finally, don't forget the little things, like introducing yourself to a new conference attendee; letting someone know when they give a nice talk; and introducing folks to each other when given the chance and "vouching" for them by explaining why the person is valuable (for example, you could say, "I'd like you to meet *so-and-so*, a talented and up-and-coming member of my team").

Remember that even small negative experiences build over time, and the cumulative impact can be just as painful as an acute experience of discrimination. When you do your part to build inclusion while pushing yourself to combat exclusionary actions[15] you may feel uncomfortable at first, but your teams will ultimately be much more engaged and productive as a result.

Leverage Your Inherent Scientific Curiosity

It's an interesting paradox that engineering and art are often considered so separately. By segregating these in our minds, we can fall into thinking that "squishy" concepts like diversity and inclusion are likely an art when the truth is, there is a lot of science behind these concepts. We have more data and evidence now than ever before on the concrete actions (such as those outlined in this article) and organizational approaches[16, 17] that have the most impact, and there are ample resources available to further our expertise in this area, just as with any other scientific discipline (see the Endnotes for an excellent reading list[18]).

In order to continually realize innovation and impact, we must stay open to change. The day we stop learning and being curious about how to make our environment more inclusive is the day that our organizations become stagnant. One foundational piece is understanding and celebrating different cultures, different races, different genders, and different world views.[19] As a starting point, try reaching out and networking with people who are "not like us." Doing so does two things: it challenges our assumptions about others in order to retrain our own biases, and it helps others feel included and valued for their differences.

Taking this advice is partly responsible for how we, as co-authors, became friends. Although we are both women in engineering, as we shared our experiences it was clear that the experience of a woman of color is very different than that of a white woman. We cannot assume we "know how it is" because we share one attribute. We

need to stay curious, ask each other about experiences, and educate ourselves on important topics as we move forward. As with all things new, it may feel awkward at first. For example, asking a transgender person if they have a preferred pronoun is not likely a skill we were taught early, but it can go a long way in making people who might otherwise feel excluded feel they are seen and valued for who they are.

We cannot reverse the adverse effects of implicit bias by being simply aware, but by thoughtfully assessing our work environment and everyday actions we can ensure we are including, respecting, and valuing the contributions of everyone.

Blythe G. Clark is an R&D department manager at Sandia National Laboratories and co-chair of the Sandia Women's Action Network. She has been an active member of TMS since 2003 and serves on the Advanced Characterization, Testing, and Simulation and Diversity Committees.

Olivia D. Underwood is a product realization team lead and principal member of technical staff at Sandia National Laboratories. Underwood has been an active member of TMS since 2013 and is a member of the Advanced Characterization, Testing, and Simulation Committee. She was the recipient of the 2019 Frank Crossley Diversity Award.

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What's the T, Cis? Discussing Gender Identity and Sexual Orientation

Matthew Korey

Matthew Korey

While TMS does not currently have metrics on how many of its members identify as lesbian, gay, bisexual, transgender, or any other identity under the queer umbrella (LGBTQ+), recent estimates suggest that anywhere from 3.0±0.5% of the U.S. population identifies as LGBTQ+.[1,2] Per the 2017 TMS Annual Report, if we apply these metrics to our Society we would anticipate anywhere from 325 to 455 LGBTQ+ members. Similarly, applying this same metric to attendance at the TMS 2019 Annual Meeting & Exhibition (TMS2019) would indicate 112 to 157 attendees identify this way. When expanded to the current population of the United States, similar estimates would indicate that five to eight million working Americans identify as LGBTQ+.

While it is possible for many LGBTQ+ people to hide their sexual orientation or gender identity in the workplace or other professional settings, such as a TMS annual meeting, many people cannot. This is because they physically wear their identity at work or at a conference, such as people who are mid-transition and people who identify outside of the gender binary (e.g., genderqueer).

As this information in the scientific literature is becoming more readily available, it is increasingly important for our discipline to continue to discuss methods to make our international meetings and individual workplaces more inclusive to people who identify as LGBTQ+. In October 2018, the TMS Board of Directors approved a new strategic plan—TMS Aspires. The primary goal of this plan, "TMS aspires to be a highly inclusive Society," creates the perfect opportunity to leverage this growing body of research on LGBTQ+ inclusion. (To learn more about this and other TMS strategic goals, visit www.tms.org/TMSAspires.)

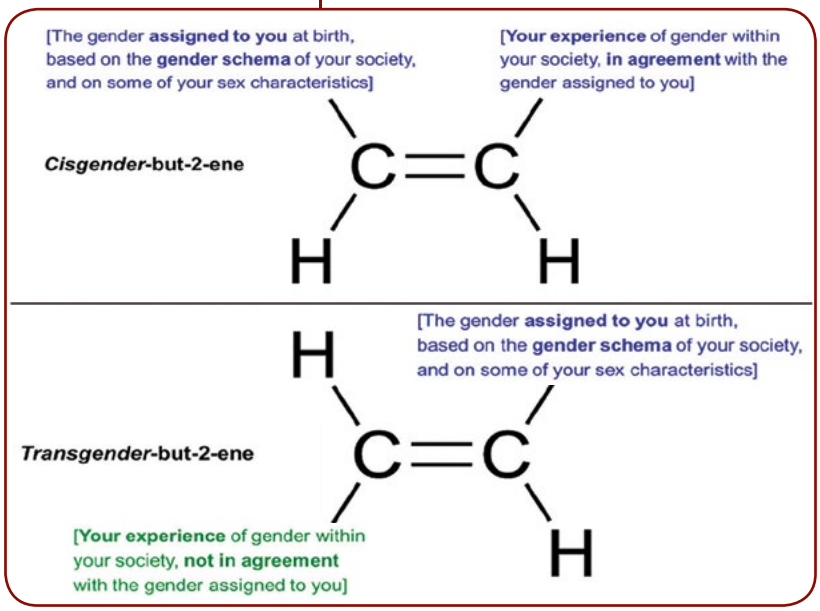

Figure 1. Using *cisgender*- and *transgender*-but-2-ene to explain gender identities.[3]

The TMS2019 Diversity Symposium

There was significant discussion of LGBTQ+ topics during the Diversity in STEM and Best Practices to Improve It symposium held at TMS2019. Three speakers gave descriptive, unique explanations of their experiences not only within TMS, but also within the discipline. Throughout the symposium, many different figures were used to help explain complex gender identities with which people identify to a materials science and engineering audience. One speaker used chemical bonds to illustrate the difference between *cisgender*, where one's experience of gender matches their assigned gender, and *transgender*, where

one's experience of gender does not match their assigned gender (see Figure 1).[3] To describe the absurdity of the concept of binary gender, the speaker parodied a phase diagram to help make their point that gender is not a binary (see Figure 2).[3]

One speaker addressed the needs of transgender individuals as outlined by Reisner et al. in a review of global transgender population health. The needs that act directly upon transgender individuals may be thought of in terms of broad categories—psychological, social, legal, and medical—though there are many external factors that affect whether an individual can meet those direct needs.[5] This interconnectivity of needs, known more generally as *intersectionality*, was addressed by many speakers during the diversity symposium. For transgender individuals, gender affirmation (a key indicator of their health) only happens when psychological, social, legal, and medical needs intersect positively (see Figure 3).[3]

Lessons Learned

The needs of LGBTQ+ individuals are not significantly different from other populations of people. Increasing the visibility and providing opportunities for LGBTQ+ people to connect to each other within our Society can help individuals feel more connected to TMS. However, making sure that transgender individuals have their basic needs met is an important aspect of inclusion within this complex community. TMS is striving to address these needs to ensure that the Society is inclusive of everyone.

In the last year, TMS Pride, a working group created within the TMS Diversity Committee, has begun increasing the availability of LGBTQ+ related programming and visibility throughout the Society, at the TMS Annual Meeting, and at other TMS-affiliated meetings. TMS Pride members have helped organize the TMS Diversity Breakfasts, led symposia, and hosted informal networking events during conferences. If you are interested in getting involved in this working group, please contact tmspride@tms.org for further information.

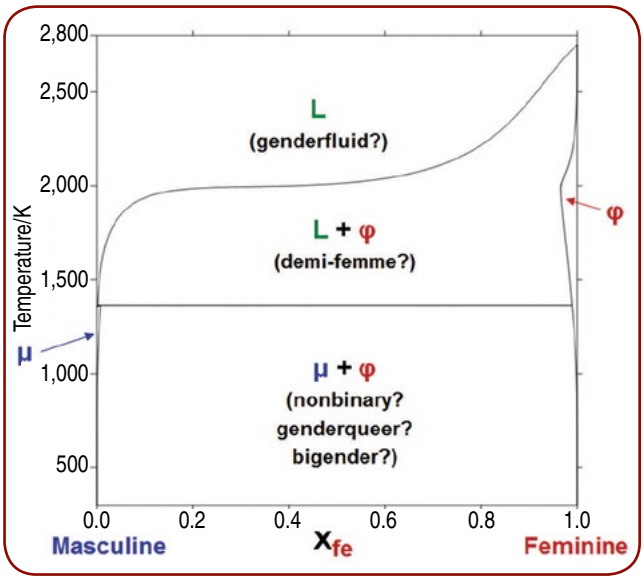

Figure 2. A parody of a phase diagram, used to describe the ways in which the notion of binary gender cannot adequately capture gender diversity. Presented in, "T Time: How to Welcome and Support People of All Genders," by KC Cunningham at TMS2019.[3] Adapted from "Calculated Cu-Nb Phase Diagram," by the U.K. National Physical Laboratory.[4]

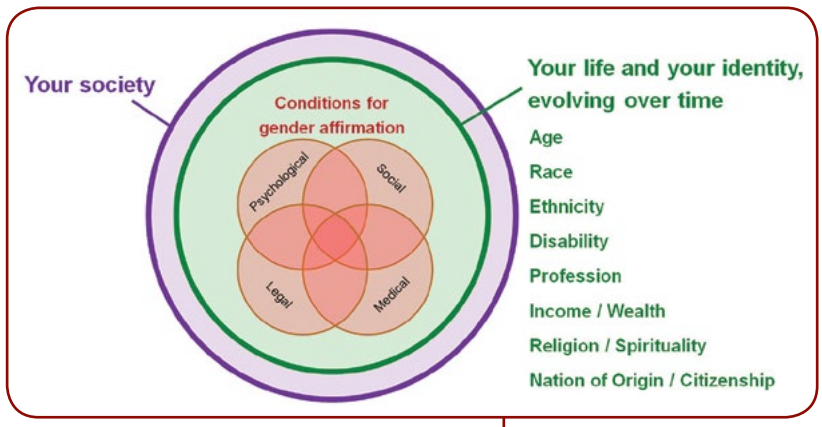

Figure 3: A visualization for how intersectionality can be used to understand the basic needs of transgender individuals.[3]

Matthew Korey is a National Science Foundation (NSF) Graduate Research Fellowship Program (GRFP) Fellow and graduate research assistant in materials engineering at Purdue University. Korey is an active member of the TMS Diversity Committee, was on the organizing committee for the 3rd Summit on Diversity in the Minerals, Metals, and Materials Professions, and is a founding member of TMS Pride.

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The Elephant in the Room: Where is the Empathy in Science?

Jennifer L.W. Carter and Laura S. Bruckman

Jennifer L.W. Carter

Laura S. Bruckman

A recent international study indicated that graduate students in science, technology, engineering, and math (STEM) fields are six times more likely than the general population to experience clinical symptoms of anxiety and depression.[1] Additionally, it has been shown that individuals who identify as a member of an underrepresented minority (e.g., race, gender identity, sexual orientation) in a STEM field are more likely to be afflicted by imposter syndrome.[2] It is our opinion that these disturbing trends are equally prevalent in the postdoctoral researcher community, since they are more often unseen by the university-industrial complex and more exposed to the stress of the funding mechanisms. The struggle with mental health issues during the Ph.D. process is so pervasive that the long-running Ph.D. comic strip continues to ring true (see Figure 1).[3]

The literature indicates that the interactions between students and their principal investigators (PIs) have a dramatic effect on their mental health. The value of the PI/early-career researcher relationship is well-known and is the reason why many universities/departments have onsite visits with potential graduate students.

It is not enough for PIs to just "point" early researchers to on-campus mental health services (many of which are maintained at a minimum of one certified staff member per 1,200 students). An overhaul in the tools and techniques at the disposal of the PI should have dramatic effects on the mental health of the students we teach and mentor. *Our goal with this article is to present tools and techniques that PIs (and their early-career researchers) can ask to implement at their institutions to promote an educational environment that enables both research advancements and the development of resilient individuals.*

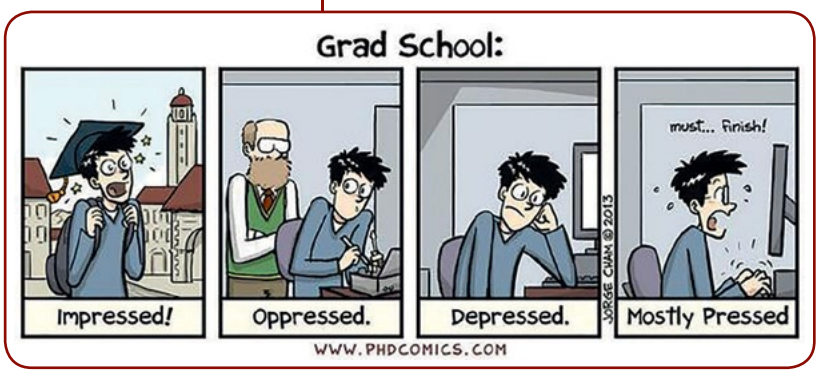

Figure 1. "Piled Higher and Deeper" by Jorge Cham (www.phdcomic.com) brings levity as it chronicles the universal struggles of graduate students and postdocs during their journey to become professionals in their field of choice.[3]

University

We can think of two things that universities should do to alleviate the mental health struggles of graduate students. First, they can provide effective methods for teaching faculty members how to mentor.[4] Most faculty did not go to graduate school or start their career with the objective of learning to mentor or teach. We also speculate that there is a large percentage of the faculty who potentially believe that mental health struggles are at best a taboo topic, or at worst are a generational product and not real ailments.

Universities need to change these mentalities by (1) allowing individuals to be vulnerable and forthright with their personal struggles, and (2) requiring consistent training to educate the educator. Mental health struggles are not a product of this generation, but being open about them is a healthy consequence of this generation.

Second, and more difficult, is that universities must acknowledge that the STEM graduate student population has changed dramatically, from predominantly single white male to a more diverse group of individuals. This diversity brings advantages for robust scientific discourse as well as a diverse set of challenges. For example,

some international students begin a graduate student program with a spouse who, based on visa restrictions, cannot work. If the graduate student stipend is designed under the assumption that graduate students can find housing-mates, this puts an unexpected financial burden on those who cannot follow this model. Therefore, an assessment of living salary for a particular location is not something that can be overlooked. Addressing how one university might tackle the unique challenges faced by their student populations on the topics of housing, food, and childcare insecurities will not likely lead to a "one-size-fits-all" approach. One example is the operation of university-sponsored food pantries to assist students dealing with food insecurity issues.

Departments

Departments should provide opportunities for early-career researchers to build a community during normal operating hours. A perceived healthy work-life balance promotes a more committed, healthy workforce.[1] The traditional method of hosting an after-hours happy hour is most accessible for conventional students (cis-gendered, white, single) and ignores the broader stressors on a diverse set of graduate students who are potentially struggling with housing/food insecurities, time commitments of parenthood, and/or have cultural issues surrounding alcohol consumption.

The Ohio State University's Department of Materials Science and Engineering does this well; they still have a traditional happy hour, but the department sponsors a during-office-hours doughnut hour on Friday mornings. The time was strategically selected to not overlap with the graduate classes, and the faculty and educational support staff make an effort to regularly attend the event.

Principal Investigator

The PI is at the front line of the professional and personal development of graduate students and other early-career professionals. While the PI cannot be expected to be a student's only support person, they should seek opportunities for professional development that provide them with the skills to be a successful mentor. A successful mentor is accessible to discussing problems, listens to concerns, and provides students with resources on mental health on campus without judgment.[5]

Faculty should also live a perceived healthy work-life balance. This could be as simple as adding the following statement to your e-mail signature: "My working week is likely different to yours. Please reply in your own time." Faculty could also facilitate the formation of "mentoring constellations" for each student.[4] These groups give students access to a broader community that can help them on their journey to becoming respected professionals. PIs can help normalize conversations about mental health by sharing a particular study such as the one referenced at the beginning of this article (or even this article) to start the discussion. This alleviates the need for faculty to share any mental health concerns of their own.

Students

To support your mental health needs, it is important to be honest with yourself. Find out what the university's policies are on sick leave and vacation time, and how your mentor may be expecting you to act in your own best interest.[6] Find a strong community of other students to participate in your constellation of mentors. For example, start or join a graduate materials society chapter at your university or become active in the graduate student governing board at your university. These organizations provide safety in numbers when requesting changes in university policy.

You must also learn to have what can often be difficult conversations with your mentor about what the expectations are during the graduate school experience to make sure you both have similar expectations. Finally, remember that you are not alone; Ph.D. comics is one of many tools at your disposal to find support during the universal struggles of graduate school. Successfully completing your Ph.D. program doesn't necessarily make you smarter than everyone else; it only means that you are more persistent in one aspect.

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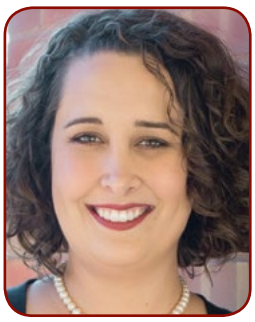
Promoting Positive Outcomes in K–12 Outreach through Design

Jessica Krogstad, Kaitlin Tyler, Nicole Johnson-Glauch, and Leon Dean

Jessica Krogstad



Kaitlin Tyler

Nicole Johnson-Glauch

Leon Dean

Summer outreach camps in engineering and science are common across the United States. The goal of these camps may vary—some provide an opportunity to compare different disciplines while others simply strive to provide tangible examples of what a career in science or engineering might look like—but almost all of these camps aim to encourage matriculation in a science or engineering program, and are often especially targeted at underrepresented populations. Women, in particular, remain underrepresented in STEM (science, technology, engineering, and math) fields despite the fact that they are now more equally represented amongst college educated adults.

Many have considered the causes of this so-called gender gap, identifying a complex array of social and cultural drivers that are not easily addressed by singular outreach experiences. However, these studies have also shown that a woman's confidence in her professional competency is critical to both selection and long-term retention in STEM fields and that experimental or project-based experiences with STEM are especially effective in boosting this confidence. This would suggest then, that summer outreach camps must do more than expose young women to STEM-related fields—they must convince them that they are capable of succeeding in STEM professions.

First, we must acknowledge that these are, in fact, different outcomes. Then we can consider how to go about achieving such a distinction. As an example, consider the plethora of online STEM outreach resources. A motivated camp coordinator could easily assemble a week's worth of activities from these resources and be quite confident that they have exposed their campers to some exciting STEM concepts. In fact, for several years this was the model that was

GLAM campers work together to design the most efficient and economic composite brick.

followed by GLAM, Girls Learning About Materials, a week-long summer camp for 10th through 12th grade high school women that operates under the umbrella of the Worldwide Youth Science and Engineering (WYSE) Camps at the University of Illinois at Urbana-Champaign (UIUC).

By all of our metrics, the campers responded favorably to this structure—they enjoyed individual activities, they had fun, and the majority of campers indicated that they would consider a STEM degree in their post-camp surveys. However, when we looked at their overall perceptions and comments from the same survey, we found remarks like this one: "*There was not much in the way of connecting things—we'd learn a cool thing, do a lab, and then move on to a completely unrelated subject.*"

In our efforts to expose them to the breadth of materials science and engineering—to show them all the cool things they could do in our field—we had created confusion about how all of these ideas could possibly be connected. And we found that the campers did not tend to contribute this confusion to the organization of the camp, rather they internalized it, thus reducing their perceived competency in materials science and engineering, and perhaps in STEM as a whole. Structure and organization can and do make a significant impact on the intended outcomes of the outreach camps.

This realization prompted us to restructure the entire GLAM camp, the details of which were published in 2017.[1] During this process, we drew motivation from the much broader body of engineering education literature emphasizing the use of design in undergraduate engineering curricula. Design is integral to engineering regardless of discipline—so much so that it's a tenant of the accreditation processes for all undergraduate engineering programs. Besides the direct translation to the engineering workplace, use of design thinking and design projects in undergraduate classrooms has been shown to promote higher order knowledge/skills transfer, creativity, self-motivation, and confidence. But the question remained whether this insight could be effectively applied to the much more compressed schedules common to K–12 outreach camps. And if so, would some approaches to incorporating design be more effective than others? After all, design may be common across engineering disciplines but there are still many ways to define design thinking or the design cycle.

GLAM campers demonstrate their prototype and explain the design to a member of the UIUC MatSE faculty during a poster session.

To explore this, we did more than just change our own camp; we implemented a two-phase study. First we compared outreach camps that intentionally incorporated some aspect of design to those that had no formal design component; then we studied four specific camps at UIUC, each of which used design in a different way over the course of the week-long camp. In this second phase, we attempted to correlate how design was introduced to the perceived outcomes of the camp for both the campers and coordinators.

In the first phase, we used a combination of pre- and post-camp surveys to compare design-incorporated versus design-absent camps. We found that all participants felt they understood what engineering was following the camp. The design-incorporated camps had a more positive perception of engineering following camp, while the design-absent camp showed a statistically significant decrease in interest in engineering (as derived from questions such as "I want to be an engineer when I grow up" or "I think engineering is interesting"). This was a more dramatic outcome than we had

"The breadth of, and within, STEM fields remains one of the biggest challenges for successfully developing, implementing, and even assessing outreach camps..."

—Jessica Krogstad, Kaitlin Tyler, Nicole Johnson-Glauch, and Leon Dean

expected, which prompted the more specific questions about how design was implemented in the second phase of the study.

The second phase compared four camps in the UIUC WYSE program, all targeted at 9th through 12th grade women. Girls Building Awesome Machines (GBAM) dedicated more than half of their camp time to a single, team-based design project that spanned the entire week—specifically to build a 3D printer. While GLAM also opted for a week-long, team-based design project, this was a smaller fraction of the total program relative to GBAM and did not predefine the final product. The Bioengineering Camp opted for a conceptual, team-based project, but no physical product was produced. Finally, the Aerospace Engineering (AeroE) Camp had many design projects throughout the week that were both team-based and individual projects.

The pre- and post-camper surveys included questions specific to design confidence and more general STEM confidence. From these surveys, GBAM, GLAM, and AeroE realized statistically significant increases in all design confidence questions following the camp. Moreover, these same camps all showed positive changes in responses to the question, "I believe I could be successful in a career in engineering/math/science." These are still very short-term perspectives, and much richer insight remains to be extracted from the coordinator interviews and video observations; however, they do suggest that when design is incorporated into outreach it can boost self-efficacy in STEM by providing opportunities for students to connect complex ideas, practice problem-solving, and improve their communication skills.

The breadth of, and within, STEM fields remains one of the biggest challenges for successfully developing, implementing, and even assessing outreach camps—especially when simply exposing students to STEM is likely insufficient to make a long-term impact on the workforce diversity of these fields. Our experience has demonstrated that thoughtful incorporation of design thinking and the design process can be used to boost positive outcomes across disciplines, by providing a unifying framework and boosting both self-confidence in and enthusiasm for STEM disciplines.

Jessica Krogstad is an assistant professor in the Department of Materials Science and Engineering at the University of Illinois at Urbana-Champaign and has been the faculty coordinator of GLAM since 2015. She has been a TMS member since 2008 and is an active member of the Diversity Committee.

Kaitlin Tyler is a Granta Education Fellow with Granta Design and was the GLAM graduate student coordinator from 2014 to 2017. Having been a Material Advantage member since 2014, she is currently transitioning to a professional TMS member.

Nicole Johnson-Glauch is a lecturer in the Materials Engineering Department at California Polytechnic State University. She was also the graduate student lab coordinator for GLAM from 2015 to 2017.

Leon Dean is a Ph.D. student in the Department of Materials Science and Engineering at the University of Illinois at Urbana-Champaign.

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TMS Welcomes New Members

The TMS Board of Directors approved professional membership for the following individuals at its June 2019 meeting. Please join us in congratulating and welcoming them to all the privileges and benefits of TMS membership.

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Acar, Handan; University of Oklahoma, United States

Adapa, Venkata Surya K; Delta Air Lines, United States

Agbenyegah, Gordon E. K.; University of Auckland, New Zealand

Agrawal, Richa; Naval Postgraduate School, United States

Agrawal, Vinamra; Auburn University, United States

Ahmad, Arsalan; Institute of Advanced Materials, Pakistan

Aindow, Tai-Tsui; University of Connecticut, United States

Akamatsu, Silvere; CNRS, France

Akdoãan, Vakur Ugur; Assan Aluminyum, Turkey

Akhtar, Shahid; Hydro Aluminium, Norway

Al Balushi, Omar A.; Sohar Aluminium, Oman

Al Jawi, Mohammad H.; Emirates Global Aluminium, United Arab Emirates

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Badaeva, Ekaterina A.; BR&T/ Boeing, United States

Badwe, Nilesh; Intel Corporation, United States

Bahl, Sumit; Oak Ridge National Laboratory, United States

Bai, Hao; University of Science and Technology Beijing, China

Baldinozzi, Gianguido; CNRS, University of Paris Saclay, France

Bale, Hrishikesh; Carl Zeiss Microscopy Inc., United States

Bang, Jung-Hwan; Korea Institute of Industrial Technology, South Korea

Banjab, Ali Jasim; Emirates Global Aluminium, United Arab Emirates

Bao, Yuping; University of Alabama, United States

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Barbati, Alexander; Desktop Metal, United States

Barela, Steven; Terves Inc., United States

Barrett, Christopher D.; Mississippi State University, United States

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Salonitis, Konstantinos; Cranfield University, United Kingdom

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Sangar, Dinesh; Sohar Aluminium, Oman

Sangjun, Park; Samsung Electronics, South Korea

Santangelo, Derek; Hatch, Canada

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Santra, Sangeeta; University of Oxford, United Kingdom

Sapochak, Linda; National Science Foundation, United States

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Sauvage, Xavier; Universite Rouen Normandie, France

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Schoeler, Simon; Leibniz University Hanover, Germany

Scholl, Sebastian; Dillinger Huettenwerke, Germany

Schrijvers, Dieuwertje; University of Bordeaux, France

Schuler, Thomas; CEA, France

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Shiratori, Seimei; Keio University, Japan

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Zou, Yu; University of Toronto, Canada

Zuo, Haibin; University of Science and Technology Beijing, China

Zweiacker, Kai W.; Empa, Switzerland

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JOM themagazine

TMS meeting headlines

View all upcoming meetings online at www.tms.org/Meetings.

Other Meetings of Note

TMS Metallurgical and Materials Engineering Professional Engineer (P.E.) Licensing Exam Review Course
August 14–17, 2019
Pittsburgh, Pennsylvania, USA

Copper 2019
August 18–21, 2019
Vancouver, Canada

19th International Conference on Environmental Degradation of Materials in Nuclear Power Systems–Water Reactors
August 18–22, 2019
Boston, Massachusetts, USA

The 10th Pacific Rim International Conference on Advanced Materials and Processing
August 18–22, 2019
Xi'an, China

11th International Conference on Porous Metals and Metallic Foams (MetFoam 2019)
August 20–23, 2019
Dearborn, Michigan, USA

TMS Industrial Aluminum Electrolysis Course (IAE 19)
November 10–14, 2019
Askar, Kingdom of Bahrain

TMS 2020 Annual Meeting and Exhibition (TMS2020)
February 23–27, 2020
San Diego, California, USA

LMPC 2019

September 8–11, 2019
University of Birmingham Edgbaston Park Hotel and Conference Centre
Birmingham, UK
Discount Registration Deadline: August 2, 2019
www.tms.org/LMPC2019

- The 2019 Liquid Metal Processing & Casting Conference (LMPC 2019) is a forum for the exchange of ideas in the fields of liquid metal casting, processing, and remelting.
- LMPC 2019 will include the topical area of liquid metal behavior in additive manufacturing processes.
- A blend of academic and industrial papers will be presented, encompassing advances in controls and process simulation, ingot defect formation and characterization studies, and more.

ANODE TECHNOLOGY for the Aluminum Industry Course

September 9–13, 2019
Hydro Aluminium AS Årdal
Årdal, Norway
www.tms.org/Anode2019

- Christopher Kuhnt, RAIN Carbon Inc., has joined four other instructors to teach the TMS Anode Technology for the Aluminum Industry Course. Learn more about each of these leading industry experts on the Instructors page of the course website.
- Improve efficiency and anode performance by taking this practical, operations-focused course. The TMS Anode Technology for the Aluminum Industry Course will present practical topics in the development of anodes, such as rodding and fume control.

MS&T19 MATERIALS SCIENCE & TECHNOLOGY

September 29–October 3, 2019
Oregon Convention Center
Portland, Oregon, USA
Late News Poster Session Abstract Deadline: August 1, 2019
www.matscitech.org

- A Late News Poster Session has been added to the program. To be considered for this session, submit your 150-word poster abstract by August 1, 2019.

ICTP 2020

July 26–31, 2020
The Ohio State University
Columbus, Ohio, USA
Abstract Submission Deadline: August 1, 2019
www.tms.org/ICTP2020

- The breadth of the metal forming community will convene at the 13th International Conference on the Technology of Plasticity (ICTP 2020).

SUPERALLOYS 2020

September 13–17, 2020
Seven Springs Mountain Resort
Seven Springs, Pennsylvania, USA
Abstract Submission Deadline: July 31, 2019
www.tms.org/Superalloys2020

- Technical topics for this symposium will include, but are not limited to: alloy development, processing, mechanical behavior, coatings, environmental effects, and technologies that contribute to improving the manufacturability, affordability, life prediction, and performance of superalloys.

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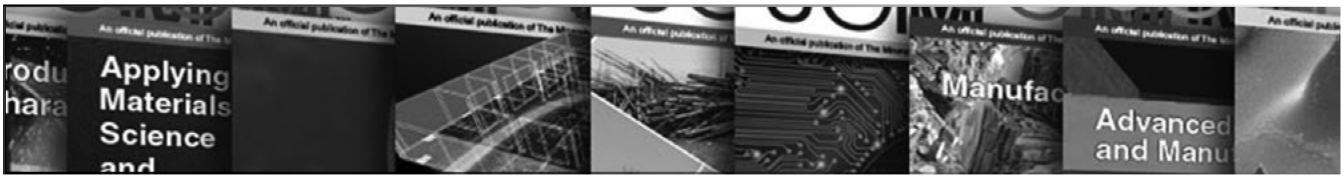
call for papers

***JOM* is seeking contributions on the following topics for 2020. For the full Editorial Calendar, along with author instructions, visit www.tms.org/EditorialCalendar.**



January 2020:

Manuscript Deadline: August 1, 2019

Topic: Design, Development, Manufacturing, and Applications of Refractory Metals and Materials

Scope: This topic encompasses the latest advances in the design, development, manufacturing, and applications of refractory materials, including metals, alloys, carbides, nitrides and borides, and more. Papers are invited on topics including experimental and theoretical research of the process-microstructure-property relationship in refractory metals and materials.

Guest Editors: Ravi Enneti and Chai Ren

Sponsors: Surface Engineering Committee and Steels Committee

Topic: ICME-Based Design and Optimization of Materials for Additive Manufacturing

Scope: Papers will be solicited in the following areas:

- Machine learning and artificial intelligence enabled additive manufacturing (AM) modeling techniques
- Modeling and simulation of AM process to understand the process-structure-property relationship
- Modeling of morphology evolution, phase transformation, and defect formation in AM parts
- Modeling of residual stress, distortion, plasticity/damage in AM parts
- Multiscale/multiphysics modeling strategies, including any or all of the scales associated with the spatial, temporal, and/or material domains
- CALPHAD (Calculation of Phase Diagrams)-based method for AM material informatics

Guest Editor: Jing Zhang

Sponsors: Additive Manufacturing Committee and ICME Committee

Topic: Advanced Characterization and Testing of Irradiated Materials

Scope: This topic focuses on the characterization and testing of radiation-affected materials through scanning and transmission electron microscopy, atom probe tomography, micro-mechanical testing, x-ray diffraction, etc.

Guest Editors: Dhriti Bhattacharyya, Fan Zhang, and Peter Hosemann

Sponsors: Advanced Characterization, Testing, and Simulation Committee and Nuclear Materials Committee

February 2020:

Manuscript Deadline: September 1, 2019

Topic: 7th European Conference on Renewable Energy Systems

Scope: This special topic will publish invited papers presented at the 7th European Conference on Renewable Energy Systems. The areas of coverage will include semiconducting materials, alloys, and composites in energy applications. In addition, submissions related to synthesis and characterization of materials for solar energy, wind energy, fuel cells, and energy storage materials are welcome.

Guest Editors: Shadia J. Ikhmayies and H. Hilal Kurt

Sponsors: Invited

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The TMS 2020 Annual Meeting & Exhibition (TMS2020) returns to San Diego—where it broke the TMS all-time attendance record in 2017. TMS2020 will feature two poster sessions, numerous networking opportunities, and lunch breaks for all attendees in the dynamic Exhibit Hall.

PbZn 9th International Symposium on Lead and Zinc Processing 2020

Additionally, TMS2020 will host the 9th International Symposium on Lead and Zinc Processing (PbZn 2020)—considered the leading technical forum of its kind!

EXHIBIT DETAILS
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- Access to the all-conference plenary session

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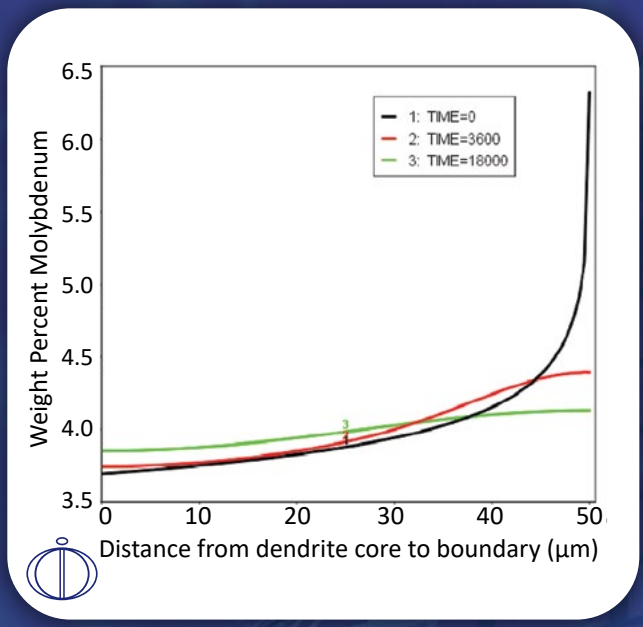

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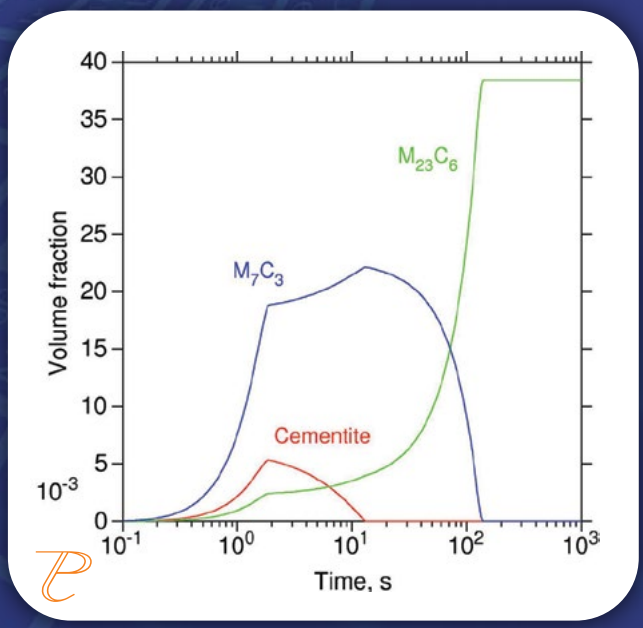

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