

# JOM



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## About the Cover

From "Toward Closing a Loophole: Recovering Rare Earth Elements from Uranium Metallurgical Process Tailings," by James Vaughan et al., shown is the Mary Kathleen open pit in Queensland, Australia. Rare earth elements (REE) are required for use in high-tech components and primary production is necessary to meet the demand. Reprocessing legacy metallurgical tailings is advantageous as the material has already been mined, beneficiated, upgraded and contained in a single location. The Mary Kathleen uranium process tailings provide an opportunity for this, with tailings classified as one of the world's 25 highest-grade REE deposits. Photo courtesy of Antony van der Ent, a coauthor on the paper.



## January 2021 Guest Editors

### Advances in the Circular Economy of Lanthanides

*Recycling and Environmental Technologies Committee; Process Technology and Modeling Committee; Energy Conversion and Storage Committee*

Fiseha Tesfaye, Abo Akademi University  
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### Augmenting Physics-based Models in ICME with Machine Learning and Uncertainty Quantification

*Invited*

Somnath Ghosh, Johns Hopkins University  
David McDowell, Georgia Tech  
James Saal, Citrine Informatics

### In Situ Synchrotron and Neutron Characterization of Additively Manufactured Alloys

*Advanced Characterization Committee, Testing, and Simulation Committee*

Fan Zhang, National Institute of Standards and Technology  
Dhriti Bhattacharyya, Australian Nuclear Science and Technology Organization  
Lianyi Chen, University of Wisconsin-Madison

### Silicon Production, Refining, Properties, and Photovoltaics

*Recycling and Environmental Technologies Committee; Materials Characterization Committee*

Shadia Ikhmayies, Al Isra University

### Sintering of Oxides and Concentrates

*Pyrometallurgy Committee*

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M Akbar Rhamdhani, Swinburne University of Technology

### Zinc Oxide Nanotechnology

*Materials Characterization Committee*  
Shadia Ikhmayies, Al Isra University

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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.

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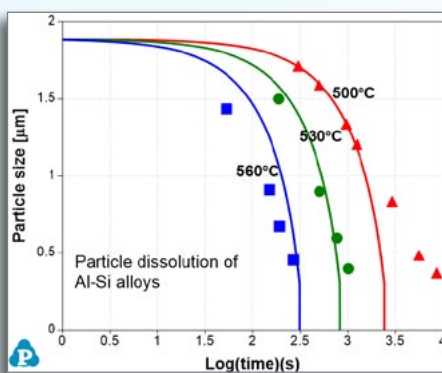
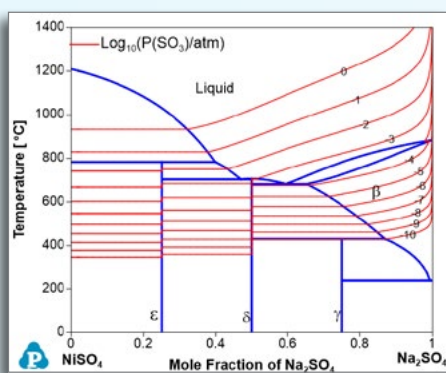
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# in the final analysis

*“As we care about more of humanity, we’re apt to mistake the harms around us for signs of how low the world has sunk rather than how high our standards have risen.”*

—Steven Pinker, *Enlightenment Now: The Case for Reason, Science, Humanism, and Progress*

# JOM

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In October 2020, the World Economic Forum convened the Jobs Reset Summit. The thesis of this virtual meeting (is there any other kind of meeting these days?): “After years of growing income inequality, concerns about technology-driven displacement of jobs, and rising societal discord globally, the combined health and economic shocks of 2020 have put economies into freefall, disrupted labour markets, and fully revealed the inadequacies of our social contracts. As we emerge from the crisis, we can proactively shape more inclusive, fair, and sustainable economies, organizations, societies, and workplaces. To do so, we must mobilize the best human capabilities, technologies, innovative policies, and market forces.”

As you might anticipate, driving the reset in jobs are robotics and artificial intelligence (AI). One of the summit participants, Hiroshi Tasaki, honorary professor at the Graduate School of Tama University, wrote that a “serious unemployment issue created by the Fourth Industrial Revolution is the prospect of many workers previously engaged in the knowledge economy losing their jobs to rapidly developing AI.” Let’s define terms: What’s the Fourth Industrial Revolution? Explains Klaus Schwab, founder and executive chairman of World Economic Forum, “The First Industrial Revolution used water and steam power to mechanize production. The Second used electric power to create mass production. The Third used electronics and information technology to automate production. Now a Fourth Industrial Revolution is building on the Third, the digital revolution that has been occurring since the middle of the last century. It is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres.”

If you are looking for evidence of the Fourth Industrial Revolution in application, it sounds a lot like what has been occurring within TMS. Consider, for example, our government-funded studies, including the latest—2020’s *Accelerating the Broad Implementation of Verification & Validation in Computational Models of the Mechanics of Materials and Structures*. Our family of studies has helped set some of the parameters for how the Fourth Industrial Revolution is presenting within the materials community.

Within TMS, let’s circle the First World Congress on Artificial Intelligence in Materials and Manufacturing, which will debut April 3–6, 2022, in Pittsburgh, Pennsylvania. It is chaired by Taylor Sparks of the University of Utah and is sponsored, within TMS, by the Materials Processing & Manufacturing Division, the Integrated Computational Materials Engineering Committee, and the new Artificial Intelligence Subcommittee of the Materials Innovation Committee. The new event will include programming on intelligent/robotic manufacturing, machine learning and deep learning, computer vision, autonomous materials research, AI-assisted development of new materials and alloys, human-AI collaboration, and organizational impacts of AI. I’m intrigued.

While these developments in AI and the Fourth Industrial Revolution are exciting, Prof. Tasaka sees deep workforce challenges: “Many of those to be thrown out of work are people engaged in jobs that depend on the application of professional knowledge and judgement based on logical thinking—two skills in which AI has an overwhelming advantage. Lawyers, accountants, doctors, pharmacists, and other professions are no exception.” The STEM-minded might infer that this extends to materials scientists and engineers as well. That would be a bitterly ironic scenario for a materials community moving us apace in the new direction.

While I am neither a scholar nor a deep thinker (readers know that), I have a more optimistic perspective that the trajectory of our technology is ever upward. There are always bumps, but our innovations invariably lead to improved and more widely shared standards of living and quality of life. There’s no artificiality about it.



James J. Robinson  
Executive Director

@JJRoTMS

*“If you are looking for evidence of the Fourth Industrial Revolution in application, it sounds a lot like what has been occurring within TMS.”*



## TMS Member Receives ABET Honor; Congressional Fellow Update; Welcome New Members



**Jeffrey Fergus**

### Jeffrey Fergus Named ABET Fellow

Jeffrey Fergus, associate dean for undergraduate studies and program assessment and professor of materials engineering in the Samuel Ginn College of Engineering at Auburn University, was chosen as one of four 2020 ABET Fellows. As noted in his citation, Fergus was selected “for leadership ensuring high-quality training of Program Evaluators and Team Chairs, a smooth transition to the new engineering criteria, and laying the foundation for virtual visits within the EAC.” Fergus was honored at the virtual 2020 ABET Awards Celebration in October 2020.

Fergus has held a number of roles within ABET since 2003, most recently as Engineering Accreditation

Commission (EAC) Chair. The EAC is one of four ABET commissions responsible for reviewing educational programs and making accreditation decisions for each program. His additional roles within ABET include Program Evaluator, EAC vice chair of operations, and EAC Executive Committee member, for both TMS and ABET.

As a TMS member for more than 30 years, he has been a past chair and member of the Accreditation and Professional Registration Committees, was the first chair of the Professional Development Committee, and was a Board Director for Professional Development.



**Megan Malara**

### TMS/MRS Congressional Fellow Accepts Placement

Megan Malara, 2020–2021 TMS/MRS Congressional Science and Engineering Fellow, is bringing her background in biology, biomaterials, and materials science to the office of U.S. Senator Sherrod Brown (D-OH). Malara began her one-year term as a special legislative assistance on Capitol Hill in September 2020, after a two-week science policy orientation and several rounds of interviews with multiple offices to find the best fit. Activities in this role with Senator Brown’s office may include conducting legislative work, assisting in congressional hearings, or preparing briefs and writing speeches.

As a graduate student, Malara attended Material Advantage Congressional Visit Days, where she learned more about the role that scientists can play in advocating

for and influencing policy. “Scientists have a duty to the public to inform decisions made by policymakers,” she said. She continued her interests as a community team leader for a political campaign where she trained and organized volunteers to engage with the public on policy-related issues. Influenced by her Rust Belt upbringing, Malara has policy interests in translating research to manufacturing jobs, increasing opportunities for education, and improving public confidence in science.

For a listing of past Fellows and their *JOM* articles highlighting what they learned through the program, visit [www.tms.org/PGA](http://www.tms.org/PGA) and click the link for TMS/MRS Congressional Science and Engineering Fellowship.

### member news

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



## TMS Welcomes New Members

**The TMS Board of Directors approved professional membership for the following individuals at its October 2020 meeting. Please join us in congratulating and welcoming them to all the privileges and benefits of TMS membership.**

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Ali, Zeeshan; National University of Sciences and Technology, Pakistan	Bodnar, Richard L.; SSAB, United States	Das, Piyush K.; Veer Surendra Sai University, India
Altin, Serdar; Inonu University, Turkey	Borunda, Adan; Advanced Material Research Center, Mexico	Das, Satyabrata; Council of Scientific & Industrial Research - Advanced Materials and Processes Research Institute, India
Amaechi, Ifeanyichukwu; Institut National de la Recherche Scientifique, Canada	Braun, Paul V.; University of Illinois, United States	Dash, Khushbu; Indian Institute of Technology Madras, India
Anderson, Magnus J.; United Kingdom	Bridge, John; University of Washington, United States	De Avila Ribas, Morgana; MacDermid Alpha Electronic Solutions, Japan
Ashiri, Rouholah; Islamic Azad University, Islamic Republic of Iran	Buterbaugh, Chris P.; United States	Decock, Jeroen; Umicore NV, Belgium
Assadian, Mahtab; Callaghan Innovation, New Zealand	Cai, Qingan; University of California, Riverside, United States	Devanshu, Ambrish; KIET Group of Institutions, India
Aworinde, Abraham K.; Covenant University, Nigeria	Chan, Alvaro; Workstrings International, United States	Dhall, Shivani; D.A.V. College, India
Bae, Douglas; Arconic, United States	Chen, Shuonan; University of California, Riverside, United States	Dhokey, Narendra B.; College of Engineering, India
Bagheri, Ramin; Gam Afarin Wheel Co., Islamic Republic of Iran	Cheng, Kai-Yuan; United States	Dutta Majumdar, Jyotsna; Indian Institute of Technology, India
	Cheung, Noe; University of Campinas, Brazil	
	Choudhary, Renu; Ames Laboratory, United States	

Economy, Jessica; Boise State University, United States	Habib, Khaled J.; Materials Science Laboratory, Kuwait	Jagatramka, Ritesh; United States
Efremenko, Vasily Georgijevich; Priazovskiy State Technical University, Ukraine	Hadi, Syamsul; State Polytechnic of Malang, Indonesia	Javad, Sofia; Pakistan
El-Hussiny, Naglaa A.; Central Metallurgical Research and Development Institute, Egypt	Hagisawa, Takehito; The Japan Steel Works, Japan	Jeon, Junmo; Aalto University, Finland
Emerson, Thomas; United Kingdom	Hahn, Gail; Boeing Company, United States	Johnson-Glauch, Nicole; California Polytechnic State University San Luis Obispo, United States
Fagiha, Hamza A.; Illinois Institute of Technology, United States	Haraldsson, Joakim; Linköping University, Sweden	Julian, Nicholas H.; University of California, Los Angeles, United States
Fechine, Pierre; Universidade Federal do Ceará, Brazil	Harris Odum, Nicole L.; AM/NS Calvert, United States	Jungjohann, Katherine; Sandia National Laboratories, United States
Finkelstein, Ryan D.; Wyman Gordan Forgings Inc., United States	Hassan, Hala Abd El-Hakim; Ain Shams University, Egypt	Junjie, Shi; China
Flores, Brandon; Mexico	Hernandez, Javier; Universidad de Sonora, Mexico	Kairy, Prattay Deepta; University of Utah, United States
Gezicioglu, Yavuz; United States	Hernandez-Negrete, Ofelia; Universidad de Sonora, Mexico	Kajikawa, Koji; Japan Steel Works M&E Inc., Japan
Ghosh, Suddhodhan; Gautschi Engineering GmbH, Austria	Hestad, Samantha; Amptek, United States	Kamble, Deepak; Leibniz Institute for Solid State and Materials Research, Germany
Ghosh, Sumit; University of Oulu, Finland	Heulens, Jeroen; Umicore, Belgium	Kar, Amlan; Indian School of Mines, India
Giarmas, Vaggelis; Alumil SA, Greece	Hoeger, Leah; Luvata Appleton LLC, United States	Karade, Sukhdeo Rao; Council of Scientific & Industrial Research-Central Building Research Institute, India
Gogusetti, Renuka; United States	Hug, Eric; CRISMAT Laboratory, France	Karimi, Roshanak; Foolad Mehr Sahand, Islamic Republic of Iran
Golen, Erin; Association for Iron & Steel, United States	Hussain, Syed Rizwan; National University of Sciences and Technology, Pakistan	Kaushik, Pallava; ArcelorMittal Global R&D, United States
Gomez, Andrea; United States	Iglesias, Roberto; University of Oviedo, Spain	Kavanlouei, Majid; Urmia University, Islamic Republic of Iran
Gorley, Michael; United States	Iliukha, Nickolai H.; Kyiv University, Ukraine	Kennedy, John Rory; Idaho National Laboratory, United States
Greene, Rawley B.; United States	Imroze, Fiheon; Indian Institute of Technology Madras, India	Khan, Gobinda Gopal; Tripura University, India
Gruber, Georg; BSH Home Appliances, Germany	Iqbal, Khurram; Institute of Business Management, Pakistan	Khan, Kunwar Laiq; KIET, India
Gubicza, Jeno; Eotvos Lorand University, Hungary	Ishikawa, Hiroki; Idemitsu Kosan, Japan	Khurram, Yaqoob; National University of Science and Technology, Pakistan
Gunasegaram, Dayalan R.; Commonwealth Scientific and Industrial Research Organisation, Australia	Islam, Mohammad; King Saud University, United States	Kirik, Ihsan; Bingol University, Turkey
Gutierrez-Castaneda, Emmanuel J.; Universidad Autónoma de San Luis Potosi, Mexico	Iyen, Cookey; Federal University Wukari, Nigeria	
Habib, Khaled; Materials Science and Photo Electronics Lab, Kuwait	Jagarlaqudi, Krishna S.; Lam Research, India	



Kober, Edward; Los Alamos National Laboratory, United States	Lillard, Jennifer; University of Akron, United States	Moelnaas, Haavard; Elkem ASA, United States
Koppad, Praveennath G.; Dayananda Sagar College of Engineering, India	Liu, Yu-chen; National Cheng Kung University, Taiwan	Mogaddas, Ehsan; Mobarake Steel Co., Islamic Republic of Iran
Koskelo, Aaron; Los Alamos National Laboratory, United States	Liu, Jiawei; Chongqing University, China	Momeni, Amir; Hamedan University of Technology, Islamic Republic of Iran
Kostrzyhev, Andrii G.; University of Wollongong, Australia	Lliukha, Nickolay G.; Kyiv Politechnical University	Monsegue, Niven; Federal-Mogul Corporation, United States
Krishnaswamy, Nagarajan; Commarin Petroleum Inc., Canada	Longo, Francisco G.; FL&A, Dominican Republic	Moser, Newell; National Institute of Standards and Technology, United States
Kuang, Huilin; United States	Lu, Matthew Y.; United States	Motshwawedi, Saasebeng S.; South Africa
Kulkarni, Ajit; Indian Institute of Technology Bombay, India	Ma, Chi; United States	Muhammad, Adeel; Pakistan
Kumar, Atul; Defence Metallurgical Research Laboratory, India	Makaya, Advenit; European Space Agency, Japan	Murden, Patrick; United Kingdom
Kumar, Deepak; Indian Institute of Science, Bengaluru, India	Malathi, Madhurai; National Metallurgical Laboratory, India	Mustapha, Kabiru; Kwara State University, Nigeria
Kumar, Kaushlendra; Defence Metallurgical Research Laboratory, India	Mandal, Arup Kumar; Indian Institute of Technology (Banaras Hindu University), Varanasi, India	Na, Noori; United States
Kuo, Dong-Hau; National Taiwan University of Science and Technology, Taiwan	Manivasagam, Geetha; Vellore Institute of Technology, India	Nassar, Eman Ebrahim; Higher Technological Institute, Egypt
Kurniawan, Denni; Universiti Teknologi Brunei, Brunei Darussalam	Manzoor, Faisal; University of Ulster, United Kingdom	Naushin, Nushrat; Khulna University of Engineering and Technology, Bangladesh
Kyung, Shik Oh; POSCO, North Korea	Marchel, Zeke S.; Oshkosh Corporation, United States	Nawaz, Muddasir; Qatar University, Pakistan
Lanje, Amrut Sadashiv; Dr. Babasaheb Ambedkar College of Arts, Commerce & Science, India	Maria Pillai, Nandhakumaran; Cosma Casting Michigan (Magna International), United States	Nayyeri, Mohammad Javad; Islamic Azad University, Islamic Republic of Iran
Lanza, Mark S.; Pacific Northwest National Laboratory, United States	Martinez, Dora I.; Universidad Autónoma de Nuevo León, Mexico	Nyamukapa, Tapiwa G.; University of Zimbabwe, Zimbabwe
Lavanya, S.; Indira Gandhi Center for Atomic Research, India	Matin, M.D.; Bangladesh University of Engineering and Technology, Bangladesh	Obara, Richard; Emerson Climate Technologies, United States
Le, Bryan T.; United States	Meisels, Aryeh P.; Aerojet Rocketdyne, United States	Obregon Machado, Javier E.; University of Illinois at Chicago, United States
Leopold, Leopold; ETH Zurich, Switzerland	Mhlanga, Cynthia; University of Zimbabwe, Zimbabwe	Osoaba, Lawrence O.; University of Lagos, Nigeria
Li, Yang; Chongqing University, China	Mihajlovic, Ivan; University of Belgrade, Serbia and Montenegro	Oster, Simon E.; United States
Liang, Wu; Chongqing University, China	Mir, Feroz; BGSB University, India	Ouyang, Jun; United States
	Mitchell, Jeremy N.; Los Alamos National Laboratory, United States	Owolabi, Oluwasegun B.; National Engineering Design Development Institute, Nigeria

Oyatogun, Grace Modupe; Obafemi Awolowo University, Nigeria	Rameshkumar, Santhosh; DRDO Young Scientist Laboratory, India	Selvam, Kannan; Laxmi Institute of Technology, India
Panda, Sujata; Rajiv Gandhi Institute for Steel Technology, India	Real-Ramirez, Cesar; Universidad Autonoma Metropolitana, Mexico	Sevik, Huseyin; Mersin University, Turkey
Parasumanna, Ajeet Babu Kumar; The Automotive Research Association of India, India	Reddy, Madhu; Raytheon Vision Systems, United States	Shalaan, El-sayed; King Abdulaziz University, Saudi Arabia
Park, Woonsup; Aerospace Corporation, United States	Redmond, Paul; Redmond Metallurgical Consulting, United States	Shankar, Vani; Indira Gandhi Centre for Atomic Research, India
Patel, Pranay M.; United States	Reidy, John P.; Desktop Metal Inc., United States	Sharma, Radheshyam; United States
Pathak, Ashish; Defence Metallurgical Research Laboratory, India	Reigel, Marissa M.; Savannah River National Laboratory, United States	Sharma, Pankaj; National Institute of Technical Teachers Training and Research, India
Perez, Antonino; CIMAV, Mexico	Reyes-Dominguez, Ivan A.; Universidad Autonoma de San Luis Potosi, Mexico	Sharma, S.C.; National Assessment and Accreditation Council, India
Phale, Prasad S.; The Automotive Research Association of India, India	Rodrigues Jr., Jose Antonio Miguel; Anglo American Brasil, Brazil	Sharma, Subhash; Centro de Nanociencias y Nanotecnología de las Universidad Nacional Autónoma de México, Mexico
Poddar, Vaishali Sushil; College of Engineering Pune, India	Rosales-Marin, Gilberto; Coordinación Académica Región Altiplano de la Universidad Autónoma de San Luis, Mexico	Sharma, Sumit Kumar; BIT Sindri, India
Poursaman, Samaneh; Aluminium Research Centre (Regal), Canada	Roy, Ankit; Lehigh University, United States	Sharma, Vinay K.; Nanyang Technological University, Singapore
Pownceby, Mark Ian; Commonwealth Scientific and Industrial Research Organisation, Australia	Ruckh, Elena; European Space Agency, Netherlands	Shekhar, Prabhanshu; United States
Prakash, Vikas; Washington State University, United States	Ruiz-Sanchez, Angel; Mexico	Shelyug, Anna; Institute of Solid State Chemistry, Russia
Prasad, Kartik; Defence Metallurgical Research Laboratory, India	Ruopp, Peter G.; PGRI, United States	Shi, Renhai; University of Science and Technology Beijing, China
Rachuri, Sharat Chandra; Defence Metallurgical Research Laboratory, India	Sabolsky, Edward M.; West Virginia University, United States	Shubrajit, Bhaumik; SRM Institute of Science and Technology, India
Rafailidis, Nikolaos; Alumil Group, Greece	Sahay, Satyam S.; John Deere, India	Shukla, Shivakant; Oak Ridge National Laboratory, United States
Ragavan, Ramakrishnan; India	Sahin, Gorkem; ETH, Switzerland	Sidorov, Valeriy; Ural State Pedagogical University, Russian Federation
Rai, Rajesh K.; MNIT, India	Salehi, Maryam; Iran University of Science and Technology, Islamic Republic of Iran	Singh, Garima; ROTOP Pharmaka, India
Rajendran, Venkatachalam; Dr. N.G.P. Arts and Science College, India	Samardzic, Veljko; New Jersey Institute of Technology, United States	Singh, Manjri; Council of Scientific & Industrial Research, India
Raji, Sadiq Abiola; Tshwane University of Technology, South Africa	Saturnus, Mariola; Silesian University of Technology, Poland	Singh, Sradhanjali; Council of Scientific & Industrial Research, India
	Satour, Ohsaki; Japan Steel Works M&E Inc., Japan	
	Schroeder, Tyler; United States	



Sisodia, Venu; Central University of Rajasthan, India	Agadi College of Engineering & Technology Lakshmeshwar, India	Williams, Adrienne D.; ADDee Technologies LLC, United States
Sivaswamy, Giribaskar; Advanced Forming Research Centre, University of Strathclyde, Glasgow, United Kingdom	Taunk, Manish; Indus International University, India	Williams, Kevin; Advanced Dynamics Corporation Ltd., Canada
Sreenarayanan, Sanjay; Lam Research, India	Teja, Surya B.; India	Wright, Ashleigh R.; North Carolina State University, United States
Sridhar, A.; Defence Met Research Laboratory, India	Tewari, Sudhir K.; GE Aviation, United States	Wu, Yipin; Keysight Technologies, United States
Srivastava, Anurag; Atal Bihari Vajpayee-Indian Institute of Information Technology and Management, India	Tiammar, Arif S.; PT Wanatiara Persada, Indonesia	Wu, Yiquan; Alfred University, United States
Su, Shei Sia; United States	Trebukhov, Sergey; Institute Metallurgy and Ore Beneficiation JSC, Kazakhstan	Xhanti, M.; Russia
Sun, Binhan; Max-Planck Institute, Germany	Turgut, Güven; Erzurum Technical University, Turkey	Yamanoglu, Ridvan; Kocaeli University, Turkey
Sun, Yaokun; United States	Uysal, Alper; Yildiz Technical University, Turkey	Yamanouchi, Takuya; Japan Steel Works M&E Inc., Japan
Sun, Yani; United States	Vamsi, K. V.; University of California, Santa Barbara, United States	Yanala, Srinivasa Reddy; Chaitanya Bharathi Institute of Tech, India
Szost, Blanka Angelika; University of Cambridge, Germany	Veerababu, R.; Defence Metallurgical Research Laboratory, India	Yao, Yao; Schlumberger, United States
Taheri, A. Karimi; Sharif University of Technology, Islamic Republic of Iran	Velazquez, Jesus M.; University of California, Davis, United States	Yoshiya, Masato; Osaka University, Japan
Tamang, Siddharth; Indian Institute of Technology Delhi, India	Venegas, Diego; Universidad del Bío-Bío, Chile	Youssif, Khalid; Aluminum Company of Egypt, Egypt
Tamimi, Saeed; Advanced Forming Research Centre, University of Strathclyde, United Kingdom	Venkatesh, Pavan Hanu; Bharat Heavy Electricals Limited, India	Zahoor, Mudasar; King Fahd University, Saudi Arabia
Tan, Danny; United States	Villarreal, Julian E.; United States	Zeka, Bastri
Tao, Chen; Chongqing University, China	Vishnumolakala, Krishna; United States	Zhang, Liangzhe; Stress Engineering Service Inc., United States
Tattimani, Mahantesh S.; Smt. Kamala & Sri Venkappa M.	Wakeford, Ryan; Terracon, United States	Zhang, Lin; University of Science & Technology Beijing, China
	Wang, Jun; Deakin University, Australia	Zhang, Shuye; Harbin Institute of Technology, China
	Wang, Tao; Rio Tinto, United States	
	Welch, Lynn; Kean Miller, United States	

***\*Membership grade recommendations are based on a review of credentials provided by the individuals. These credentials are taken on the honor system and not independently verified, except by exception.***



*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](mailto:kcalva@tms.org) for consideration.*

## ***In Case You Missed It:*** **Business News from the Field**

### **Aurcana to Restart Revenue-Virginus Mine**

**Vancouver, Canada:** Aurcana Silver Corporation plans to reopen the Revenue-Virginus Mine in Ouray, Colorado, by the spring of 2021. The site in the San Juan Mountains is home to one of the richest silver lodes in the world but has undergone several failed restarts since a fire closed its doors in 1916. In October 2020, Aurcana forecast six months to initial production and nine months to cash flow, based on a 2018 feasibility study.

### **Rainbow and Bosveld Partner in Rare Earths**

**Saint Peter Port, Guernsey:** Rainbow Rare Earths is partnering with Bosveld Phosphates to co-develop the Phalaborwa rare earths project in South Africa. The asset contains about 35 million tonnes of gypsum resulting from historic phosphate hard rock mining, containing rare earth elements with an estimated average in situ grade of 0.6% total rare earth oxides. Rainbow will pay Bosveld \$750,000 in cash and share in three equal tranches over 12 months. After a pre-feasibility study, Rainbow will hold 70% of the project and Bosveld the remaining 30%.

### **New Material for Protecting First Responders**

**Cambridge, Massachusetts, USA:** A research team developed a new material with the potential to greatly improve safety

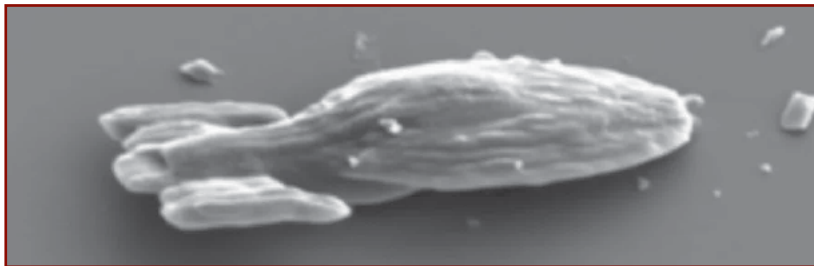
gear used by first responders and military personnel. Offering the bulletproof strength of Kevlar, the material is lightweight for mobility and has thermal protection for extreme temperatures. First author Grant M. Gonzalez, Harvard University, said the material's "long fibers could resist a mechanical impact while the pores would limit heat diffusion, thanks to a mix of order and disorder in its molecular structure and orientation." Harvard University led the research in collaboration with the U.S. Army Combat Capabilities Development Command Soldier Center and the U.S. Military Academy at West Point.

### **Self-healing Microstructures Strengthen Aluminum**

**Melbourne, Australia:** Monash University researchers demonstrated improvements in the fatigue life of high-strength aluminum alloys. The alloys are important for transportation applications because their lightness improves fuel efficiency, but their fatigue properties are poor compared to steel of similar strength. After demonstrating that the poor fatigue performance was caused by weak links, called precipitate free zones, the researchers were able to make aluminum alloy microstructures that can heal the weak links while in operation, a form of self-healing. The improvement in the lifetime of high-strength aluminum alloys could be 25 times compared to current state-of-the-art alloys.

### **New Institute Opens on Materials Discovery**

**San Diego, California, USA:** The Institute for Materials Discovery and Design (IMDD) opened in September 2020 at the University of California, San Diego (UCSD). The goal of the IMDD, a collaboration between UCSD's Jacobs School of Engineering and Division of Physical Sciences, is to leverage researchers' cross-disciplinary expertise to discover, design, and characterize advanced materials needed to address global challenges. This materials work has applications in energy and transportation systems; healthcare solutions; sustainability; and information technologies.



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**Leiden, The Netherlands:** Physicists at Leiden University applied 3D printing technology to develop a microswimmer in the shape of the *USS Voyager*, a starship from *Star Trek*. A platinum coating on the microswimmers reacts to a hydrogen peroxide solution to propel them through the liquid. The miniature *Voyager*, measuring 15 micrometers long, is part of research to understand how shape affects the motion and interactions of microswimmers. The research could have potential applications in developing new drug delivery vehicles. (Photo courtesy of Rachel Doherty and Samia Ohajji.)



## Showcasing the 2021 TMS Scholars

**Megan Enright**



This Class of 2021 TMS Scholars represent the bright future of the minerals, metals, and materials professions. From their testimonials, the TMS community has provided them with opportunities to grow and learn, to meet new people in their fields, and much-appreciated financial assistance which has allowed them to continue their studies and work in these fields.

In addition to the assistance with the cost of education, many of the scholarships awarded include travel grants to aid these students in attending highly regarded professional meetings. This allows

these students to begin connecting with professionals in their fields, expand their technical knowledge, and build their professional profile.

Several of these scholarships will be awarded during the TMS 2021 Annual Meeting & Exhibition (TMS2021) technical division functions. Be sure to support this promising group of scholars and congratulate them on all their achievements. Furthermore, various other awards and scholarships will be conferred at the TMS-AIME Awards Ceremony during TMS2021. Learn more about TMS2021 awards events at [www.tms.org/TMS2021](http://www.tms.org/TMS2021).



### Your Gift Can Support Students Like These

The scholarships featured in this article not only remove boundaries to education, but also support students in pursuing a deeper involvement in the greater materials community that can help open doors and build careers. And right now, students are facing unprecedented challenges to their career paths, making the assistance and assurance provided by these scholarships more important than ever.

All of the awards are made possible by the

TMS Foundation and its generous supporters. You can ensure that the good work of the Foundation continues by making a donation today. Visit [www.TMSFoundation.org/Contribute](http://www.TMSFoundation.org/Contribute) to make a one-time donation or set up a monthly gift. You can also send a check, payable to the TMS Foundation, to 5700 Corporate Drive Suite 750, Pittsburgh, PA 15237. For more information or to discuss donation options, contact TMS Foundation staff at [TMSFoundation@tms.org](mailto:TMSFoundation@tms.org).



Lily Turaski



Zachary Wolff

## TMS DIVISION AWARDS

*TMS division scholarships recipients will also receive a dollar-for-dollar scholarship match through the Battelle Matching Scholarship Program. This is made possible through the generous support of Battelle and its retired chief executive officer, Jeffrey Wadsworth. Additionally, students who receive a Battelle Matching Scholarship will be eligible for a Battelle Materials Graduate Student Award when they matriculate to a graduate school to continue studies in a materials-related field.*

### FUNCTIONAL MATERIALS DIVISION (FMD) GILBERT CHIN SCHOLARSHIP

*Awarded through the FMD and the TMS Foundation to sophomore or junior undergraduate students studying subjects related to synthesis and processing, structure, properties, and performance of electronic, photonic, magnetic, and superconducting materials, as well as materials used in packaging and interconnecting such materials in device structures.*

**Lily Turaski**  
*Georgia Institute of Technology (Georgia Tech)*

“TMS and Material Advantage have made an immense impact on my education and career path. I attended my first TMS annual meeting as a freshman. I loved learning about innovations and discoveries at the forefront of materials research and meeting fellow materials science and engineering students, professors, and industry professionals. That first experience cemented my love of materials science and ensured I would be a regular conference-goer,” Turaski said. “Since then, I have had the opportunity to present research posters, participate in the Undergraduate Speaking Contest, and enter the Material Bowl Competition. I have also been involved in the Material Advantage

chapter at Georgia Tech, where I am currently serving as vice president. I enjoy getting other students involved in Material Advantage and showing them the benefits of a professional society. I plan to attend graduate school and obtain a Ph.D. in materials science with a focus in electronic materials. I am so thankful that TMS, Battelle, and the Functional Materials Division are investing in students like me.”

### LIGHT METALS DIVISION (LMD) SCHOLARSHIP

*Awarded through the LMD and the TMS Foundation to outstanding sophomore or junior undergraduate students majoring in metallurgical and/or materials science and engineering with an emphasis on both traditional and emerging light metals.*

**Zachary Wolff**  
*University of Nevada, Reno*

“The TMS Foundation and Material Advantage have been imperative components to my academic career. TMS has kept me up-to-date on new events and opportunities occurring in the materials science and engineering field; one of which is the TMS Annual Meeting & Exhibition, where scientists and students alike are able to present their research and findings to the materials community. Material Advantage has provided a medium to communicate with our peers, allowing us to organize activities to explore various organizations and corporations,” Wolff said. “After I graduate, I would like to continue my education by obtaining a master’s degree, studying irradiated materials and radiation detection. Currently, I work for the Nevada National Security Site in hopes of attaining a full-time career as a materials engineer.”

**“I am so thankful that TMS, Battelle, and the Functional Materials Division are investing in students like me.”**

**—Lily Turaski**



## **MATERIALS PROCESSING & MANUFACTURING DIVISION (MPMD) SCHOLARSHIPS**

*Awarded through the MPMD and the TMS Foundation to sophomore or junior undergraduate students majoring in metallurgical and/or materials science and engineering, with an emphasis on manufacturing, integrating process control technology into manufacturing, and basic and applied research into key materials technologies that impact manufacturing processes.*

### **Alexander Goldman**

**University of Nevada, Reno**

“It is the personal connections and friends that I make through Material Advantage that I enjoy the most. Through having technical discussions with my peers and discussing career opportunities with my mentors, I have gained great confidence in beginning my research and choosing my path. Attending the TMS 2020 Annual Meeting & Exhibition was the most enjoyable experience I have had as an engineer. I was given countless opportunities to learn and engage with people from all backgrounds, which helped me find new interests and start relationships with incredibly bright and talented members of TMS. I will always be grateful for the help and guidance I have received from the kind community surrounding materials science and engineering,” Goldman stated. “I plan to research renewable energy in a materials science master’s program after I graduate in the spring. After I complete my academic

education, I hope to follow my dreams with a career in the aerospace sector. I have always loved anything that flies, and I cannot wait to contribute my exciting plans toward an even more exciting field!”

## **STRUCTURAL MATERIALS DIVISION (SMD) SCHOLARSHIPS**

*Awarded through the SMD and the TMS Foundation to sophomore or junior undergraduate students majoring in metallurgical and/or materials science and engineering with an emphasis on the science and engineering of load-bearing materials, including studies into the nature of a material’s physical properties based upon its microstructure and operating environment.*

### **Jadzia Graves**

**University of Idaho**

“It is a great honor to be recognized by TMS with the Structural Materials Division Scholarship for the second year. Being part of Material Advantage and TMS has given me a great opportunity to learn and grow as an engineering student and an individual. Receiving this scholarship will help me achieve my academic goals by allowing me to focus on my classes rather than my financial situation. I am extremely thankful for the opportunities that have given me the experiences necessary to qualify for this scholarship and hope to continue to further my experience in structural materials.”



**Alexander Goldman**



**Jadzia Graves**



## **Explore Opportunities with Material Advantage**

Material Advantage gives students access to technical resources, grant money, networking opportunities, and scholarships such as those highlighted in this article. For a single membership fee, the Material Advantage student program allows undergraduate and postgraduate students to benefit from membership in four materials-related societies—The American Ceramic Society (ACerS), the Association for Iron & Steel Technology (AIST), ASM International, and TMS.

**Visit [www.materialadvantage.org](http://www.materialadvantage.org) to explore all of the opportunities the program has to offer or join today.**

**“I will always be grateful for the help and guidance I have received from the kind community surrounding materials science and engineering.”**  
—Alexander Goldman



T.M. Kelsey Green



Justine Schulte

## SOCIETY AWARDS

### TMS INTERNATIONAL SYMPOSIUM ON SUPERALLOYS SCHOLARSHIP

*This award is for undergraduate and graduate students majoring in metallurgical and/or materials science and engineering with an emphasis on all aspects of the high-temperature, high-performance materials used in the gas turbine industry and all other applications. Awards are presented in conjunction with the Materials Science and Technology Conference or the International Symposium on Superalloys.*

#### T.M. Kelsey Green

*University of Michigan-Ann Arbor*

"I am greatly honored to receive the TMS International Symposium on Superalloys Scholarship. Receiving this scholarship underscores the importance and quality of my research on alloys for advanced nuclear applications and motivates me to continue my devotion to advancing the field. I am excited for the opportunity this scholarship provides, including the ability to continue my professional development via attendance and presentations at TMS conferences. After completing my Ph.D., I wish to continue developing my technical

skills as a materials scientist at a national laboratory. Throughout my career, I also aim to influence and develop energy policy."

#### Justine Schulte

*University of Virginia*

"I am incredibly honored to be one of the recipients of the TMS International Symposium on Superalloys Scholarship and I would like to express my thanks to the selection committee for their recognition. After graduating from the University of Virginia, I plan to pursue a higher degree in a materials science-related field," Schulte explained. "My Material Advantage membership has proved to be an invaluable tool during the process of applying to graduate programs, as it provides access to numerous materials science societies and opportunities to network with professionals in the field. This exposure to the different facets of the field has assisted me in exploring my interests and determining an area that truly speaks to me as a researcher. The resources generously provided by this scholarship will help support my undergraduate education, while yielding additional funds to pay for graduate school applications."

## Apply for a 2022 TMS Scholarship

If you are a full-time undergraduate or graduate student interested in financial assistance, early career recognition, and important opportunities for advancement through technical exchanges at the TMS Annual Meeting & Exhibition, consider applying for a 2022 TMS Scholarship.

Applicants must submit a completed TMS scholarship application, up to three recommendations, a personal statement, and a transcript with current GPA to Bryn Simpson, TMS Membership and Volunteerism Program Manager, at [bsimpson@tms.org](mailto:bsimpson@tms.org). **The deadline to apply for a 2022 award is March 15, 2021.**

Visit [awards.tms.org](https://awards.tms.org) to learn more about scholarship submission details and to access their application forms.



William Carpenter (right), South Dakota School of Mines & Technology, receives the Extraction & Processing Division Scholarship at the TMS 2020 Annual Meeting & Exhibition (TMS2020).







# TMS meeting headlines

Meeting dates and locations are current as of November 13.

For the most up-to-date list of TMS-sponsored events, visit [www.tms.org/Meetings](http://www.tms.org/Meetings).

## Other Meetings of Note

**11th International Conference on Molten Slags, Fluxes and Salts (MOLTEN 2021)**  
 February 21–25, 2021  
 Virtual Event

**Solidification Course 2021**  
 May 30–June 4, 2021  
 Villars-sur-Ollon, Switzerland

**European Metallurgical Conference (EMC 2021)**  
 June 27–30, 2021  
 Salzburg, Austria

**5th International Congress on 3D Materials Science (3DMS 2021)**  
 June 29–July 2, 2021  
 Washington, D.C., USA

**13th International Conference on the Technology of Plasticity (ICTP 2021)**  
 July 25–30, 2021  
 Columbus, Ohio, USA

**Liquid Metal Processing & Casting Conference (LMPC 2021)**  
 September 19–22, 2021  
 Philadelphia, Pennsylvania, USA

**TMS 2022 Annual Meeting & Exhibition (TMS2022)**  
 February 27–March 3, 2022  
 Anaheim, California, USA

**Additive Manufacturing Benchmarks 2022 (AM Bench 2022)**  
 August 15–18, 2022  
 Bethesda, Maryland, USA

## TMS2021

150<sup>th</sup> Annual Meeting & Exhibition

March 14–18, 2021

Orlando World Center Marriott  
 Orlando, Florida, USA

**Registration Now Open!**

[www.tms.org/TMS2021](http://www.tms.org/TMS2021)

- The TMS 2021 Annual Meeting & Exhibition (TMS2021) celebrates 150 years of bringing together engineers, scientists, business leaders, and other professionals in the minerals, metals, and materials fields for a comprehensive, cross-disciplinary exchange of technical knowledge. TMS2021 will include more than 85 symposia in 13 topic areas.
- The Fourth Summit on Diversity in the Minerals, Metals, and Materials Profession (DMMM4) and the Fifth International Symposium on Nickel and Cobalt (Ni-Co 2021) are two co-located events. Visit the TMS2021 website for information on registration, housing, and programming.



September 12–16, 2021

Seven Springs Mountain Resort  
 Seven Springs, Pennsylvania, USA

**Proceedings are Available Now!**  
[www.tms.org/Superalloys2021](http://www.tms.org/Superalloys2021)

- All accepted manuscripts are published in the *Superalloys 2020* proceedings publication. The proceedings access will be included in the registration fee.
- Learn about new technologies for lifecycle improvement of superalloys. Explore improvements in the processing and performance of existing materials and the development of new alloys.
- Register today and join the community for the longest-running symposium dedicated to superalloys.



September 19–23, 2021

Omni William Penn Hotel  
 Pittsburgh, Pennsylvania, USA

**Abstract Deadline: April 2, 2021**

[www.tms.org/MiNES2021](http://www.tms.org/MiNES2021)

- Materials in Nuclear Energy Systems (MiNES) 2021 will serve as the professional destination for the fission reactor materials community to share the latest research and developments specific to the field.
- The call for abstracts is open and considering submissions on the following topics: fundamental irradiation damage; evolution of material properties; integrated phenomena in reactor materials; advanced/novel materials; fuels and actinide materials; and nuclear fuel cycles.



October 17–21, 2021

Columbus, Ohio, USA

**Abstract Deadline: March 15, 2021**

[www.matscitech.org/MST21](http://www.matscitech.org/MST21)

- Materials Science & Technology 2021 (MS&T21) is the most comprehensive forum for materials science and engineering technologies, supported by three major materials organizations: The American Ceramic Society (ACerS), the Association for Iron & Steel Technology (AIST), and The Minerals, Metals & Materials Society (TMS).
- Abstracts are being accepted now on a variety of topics, including additive manufacturing, artificial intelligence, biomaterials, ceramic and glass materials, fundamentals and characterization, iron and steel, materials-environment interactions, modeling, nanomaterials, and others.



# call for papers

**JOM is seeking contributions on the following topics for 2021. For the full Editorial Calendar, along with author instructions, visit [www.tms.org/EditorialCalendar](http://www.tms.org/EditorialCalendar).**



## July 2021

### Manuscript Deadline: February 1, 2021

#### Topic: Machine Learning in Design, Synthesis, and Characterization of Composite Materials

**Scope:** Machine learning methods are enabling unprecedented advances in the area of composite materials. These methods are versatile in handling a large number of parameters and are helping in developing novel materials structures and compositions for the given application requirements. This topic is intended to cover all aspects of the application of machine learning methods to the field of composite materials, including design of microstructure, synthesis condition optimization, and evaluation of properties.

**Editors:** Nikhil Gupta, Simona Hunyadi Murph, and Ramasis Goswami

**Sponsor:** Composite Materials Committee

#### Topic: Nanomaterials and Composites for Energy Conversion and Storage

**Scope:** The emergence of nanostructured and composite materials has resulted in significant advancements in energy conversion and storage, such as fuel cells, photovoltaic cells, batteries, and supercapacitors. The topic scope includes the design and development of low-dimensional nanomaterials; photocatalysts and photoelectrochemical devices for solar fuel production; semiconductor nanomaterials for new-generation solar cells; computational nanomaterial science; and electrode nanomaterials for efficient energy storage systems including batteries and supercapacitors, etc.

**Editors:** Yu Lin Zhong, Soumendra Basu, and Ziqi Sun

**Sponsor:** Energy Committee and Energy Conversion and Storage Committee

#### Topic: Phase Transformations during Solid-phase Welding and Processing

**Scope:** Papers are invited covering phase transformations and interfacial phenomena during solid-phase welding and processing.

**Editors:** Piyush Upadhyay and Arun Devaraj

**Sponsor:** Shaping and Forming Committee

## August 2021

### Manuscript Deadline: March 1, 2021

#### Topic: Additive Manufacturing: Functionally Graded Alloys

**Scope:** Functionally graded metals, or “gradient alloys,” have the potential to add a completely new dimension to metal additive manufacturing by allowing the composition of near-net-shaped parts to be strategically controlled. Successful demonstrations of applications, challenges, and paths forward for the research area are reflected. Emerging metal additive manufacturing technologies that are more conducive to functionally grading metals can be discussed, along with comments about the intersection between metal printing and metal coating.

**Editors:** Somayeh Pasebani and Tom Stockman

**Sponsor:** Additive Manufacturing Committee

#### Topic: Defect and Phase Transformation Pathway Engineering for Desired Microstructures

**Scope:** Extended defects such as dislocations and internal interfaces have been frequently utilized to tune desired phases and optimize mechanical properties. This special topic aims to publish research that brings together state-of-the-art characterization tools and computational tools for the fundamental understanding of defect-microstructure interactions and the corresponding defect engineering strategies to design new microstructures, both homogeneous and heterogeneous / hierarchical for unprecedented properties.

**Editors:** Yufeng Zheng, Rongpei Shi, and Rajarshi Banerjee

**Sponsor:** Phase Transformations Committee

#### Topic: Multiscale Methods for Design of High Performance Coatings

**Scope:** This topic emphasizes new results in the development and application of multiscale techniques (both experimental and computational) toward the design of high-performance coatings. Particular applications of



interest include thermal barrier coatings, wear coatings, and coatings for extreme environments.

**Editors:** William J. Joost, R. Wesley Jackson, Mark Carroll, and Pantcho Stoyanov

**Sponsor:** ICME Committee

### September 2021

**Manuscript Deadline: April 1, 2021**

#### Topic: Computational Modeling in Pyrometallurgy

**Scope:** Pyrometallurgical furnace operations are typically very complex in nature and may involve tightly coupled interactions between phenomena from heat transfer, fluid flow, electromagnetics, thermochemistry, phase change, granular media, and more. Exacerbating the difficulties in understanding such phenomena are the extraordinary challenges inherent in performing measurements on pyrometallurgical processes (e.g., extreme conditions limit direct measurements). This topic

will aim to cover a variety of contemporary applications of computational modeling in pyrometallurgical science and engineering.

**Editors:** Quinn Reynolds and M. Akbar Rhamdhani

**Sponsor:** Pyrometallurgy Committee

#### Topic: Recovery, Sorting, and Processing of Secondary Aluminum

**Scope:** This topic covers recycling of aluminum and its alloys, with a specific focus on managing recovery, sorting, and processing for secondary aluminum production. This may include advances in sorting technologies, pre-treatment steps, and various re-melting techniques together with, or in addition to, recovery of by-products from these techniques. Also, holistic approaches for secondary aluminum production are welcomed.

**Editors:** Anne Kvithyld

**Sponsors:** Aluminum Committee and Recycling and Environmental Technologies Committee

## Contribute to *JOM*

Visit [jom.tms.org](http://jom.tms.org) to access author tools that will answer your questions during every step of the manuscript preparation process, from determining the appropriate technical topic for your paper to reading the final product on Springerlink.

**For further information on contributing to *JOM*, contact *JOM* Editor Maureen Byko at [mbyko@tms.org](mailto:mbyko@tms.org).**



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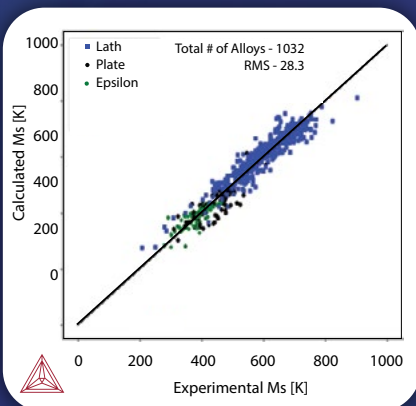
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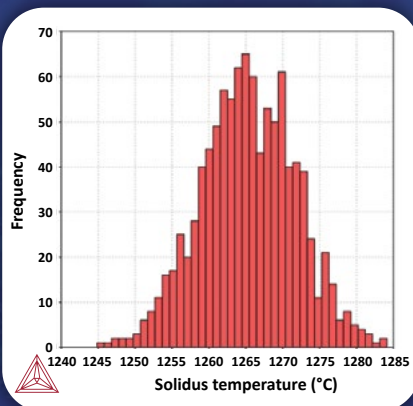
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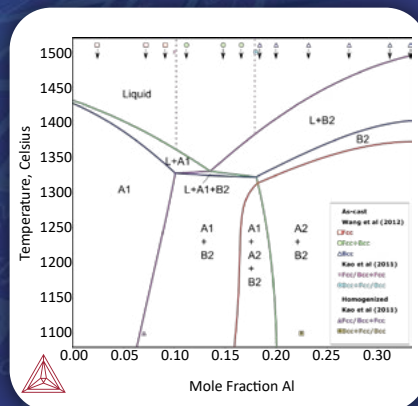
Comparison of calculated and experimental Ms temperatures for a wide range of steels

### Nickel



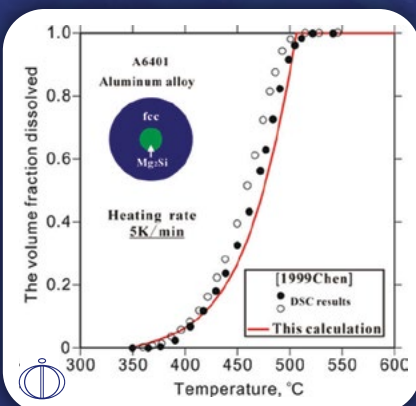
Variation in solidus temperature over 1000 compositions within alloy 718 specification

### High Entropy Alloys



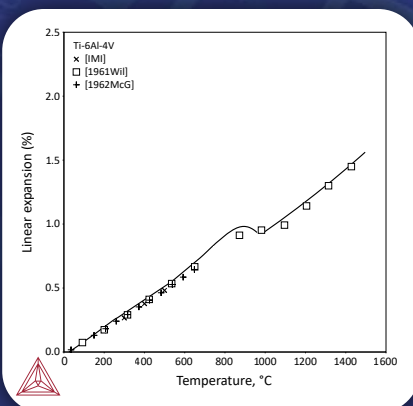
Calculated phase diagram along the composition line of CoCrFeNi-Al

### Al Alloys



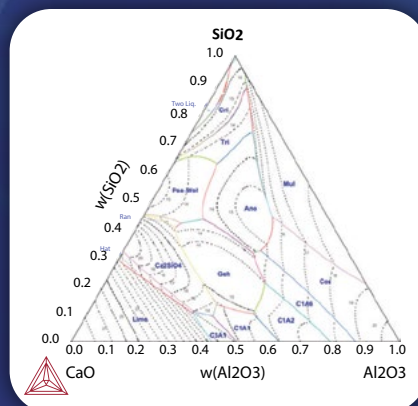
Dissolution of Mg<sub>2</sub>Si precipitate in Alloy A6401

### Ti and TiAl Alloys



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

### Oxides



Ternary liquidus projection in oxide systems