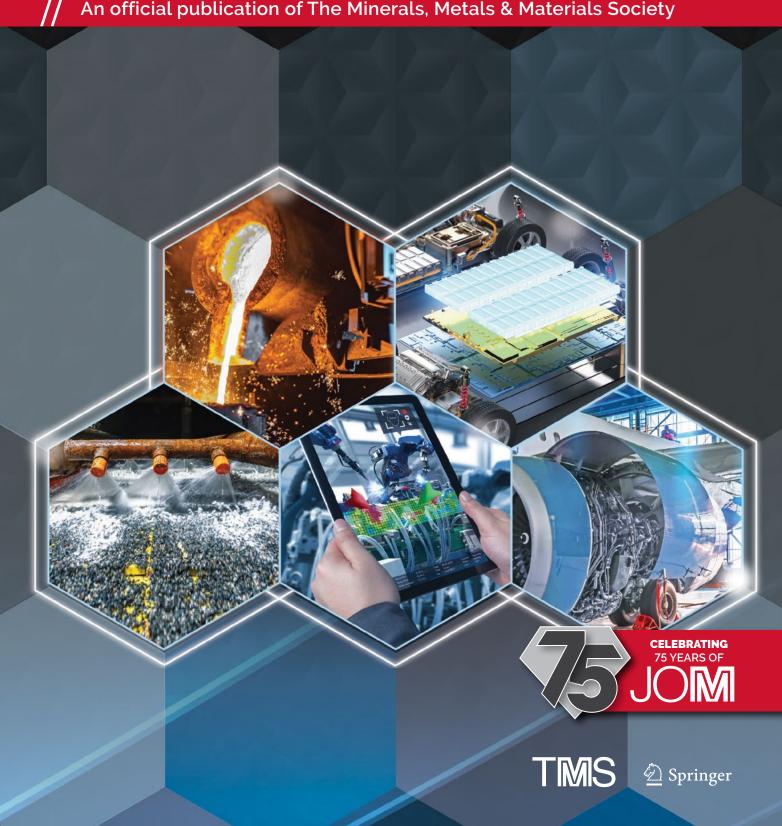


NOVEMBER 2024 www.tms.org/JOM

An official publication of The Minerals, Metals & Materials Society



TMS GRADUATE STUDENT PROGRAM

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> -Cynthia Rodenkirchen, 2024 International Symposium on Superalloys Graduate Scholarship Recipient



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November 2024 Guest Editors

Advanced Materials for Extreme Environments

Refractory Metals & Materials Committee Gaoyuan Ouyang, Ames National Laboratory; Andrew Kustas, Sandia National Laboratories

Thermodynamic and Process Modeling Tools for Material Production Processes

Process Technology and Modeling Committee

Adamantia Lazou, National Technical University of Athens;

Alexandra Anderson, RHI Magnesita; Samuel Wagstaff, Oculatus Consulting;

Gwen Bracker, DLR Institute of Materials Physics in Space

About the Cover

The five cover images represent the five technical divisions of The Minerals, Metals & Materials Society: Extraction & Processing, Functional Materials, Light Metals, Materials Processing & Manufacturing, and Structural Materials. In representing the five technical divisions, JOM: The Journal balances the interests of its members and authors in the monthly topics and articles it publishes.

About JOM:

The scope of JOM (ISSN 1047-4838) encompasses publicizing news about TMS and its members and stakeholder communities and publishing high-quality 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 application of materials.

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IN THE FINAL ANALYSIS



"Constructive dialogue is the bedrock of effective boardroom discourse. Directors can foster this dialogue by asking clarifying questions, encouraging healthy debate, and acknowledging the value of different perspectives."

—Hendrith Vanlon Smith Jr., Board Room Blitz: Mastering the Art of Corporate Governancey

Board service is an exceptional and particularly generous expression of a member's commitment to an organization. I've observed such commitment manifested beneficially within TMS time and again over decades. Do the best board members possess a secret sauce? I can't define what that is, but I can conjecture as to several essential ingredients: Prepared, measured and rational, clear and coherent with one's viewpoint, encouraging of others to express alternative viewpoints, attentive, mindful of mission and practicality, respectful, and able to see beyond today.

With enough secret-sauce board members, a board can effectively set strategic direction for an organization, articulate a vision, show leadership, put systems into place that ensure purposeful governance and accountability, engage in wise delegation of authority, create an environment of innovation, oversee resources and finances, behave legally and ethically, and—most importantly—properly serve the organization's owners. For a nonprofit professional society such as TMS, the owners are not shareholders as in the business world but the actual members themselves.

Speaking of members serving on boards of directors, . . . TMS is presently encouraging and accepting self-nominations by TMS members who seek to fill opening positions on the TMS Board of Directors. Through a deliberative process, the TMS Board is developing a slate of promising candidates for endorsement by the membership. For the period that begins with the conclusion of TMS2026 and ends with the conclusion of TMS2029, seven candidates will be presented to the membership for election to the Board of Directors. The positions are

- Presidential Rotation
- Financial Planning Officer
- Content Director
- Professional Development Director
- Public and Governmental Affairs Director
- Extraction & Processing Division Director
- Functional Materials Division Director

From October 1, 2024, through January 15, 2025, the Society will accept self-nominations for all but the final two positions (Technical Division Vice Chairs are automatically added to the slate of candidates). The slate to be presented to the membership will be determined at TMS2025, with the TMS Nominating Committee giving the Board advice on developing the slate. It is a competitive process.

While our cohort of incoming Board members varies in number from year to year (2, 5, or 7), the number of members on the Board remains constant: 14. In this way, the composition of each year's Board varies sometimes a bit and sometimes a lot from that of the previous year and that of the coming year. No two Boards are exactly alike. Variety in the composition of each TMS Board of Directors is constant. Also constant is the excellence of the volunteers who give so much of their time, intellect, and passion to serve on it.

Perhaps you are ready to share some of your secret sauce with TMS leadership and be part of a future TMS Board's blend of seasoned continuity and fresh energy. Interested? Tell Google, "tms board of directors nomination" and the resulting link will reveal all.



James J. Robinson

Executive Director



encouraging
and accepting
self-nominations
by TMS members
who seek to fill
opening positions
on the TMS Board
of Directors."

JOM TECHNICAL TOPICS



Find peer-reviewed technical articles covering the full range of minerals, metals, and materials science and engineering in the November issue of *JOM*: The Journal. Each issue features several technical topics presenting a series of related articles compiled by guest editors. A preview of November technical topics and articles is listed below. TMS members can log in to www.tms.org/Journals for full access to technical articles from *JOM*: The Journal and additional TMS journals.

Below is a sample of articles that will appear in the November issue, based on information available at press time. For the most up-to-date article listing, visit www.tms.org/JOM.

NOVEMBER 2024

Advanced Materials for Extreme Environments

Editors: Gaoyuan Ouyang, Ames National Laboratory; Andrew Kustas, Sandia National Laboratories Sponsor: Refractory Metals & Materials Committee

"Effect of Cooling Rate on the Solidification Behavior of GH415." **Yue Chen**, et al.

"Oxidation Behaviour of Fe-28Al-5Si at.% Alloyed with Ti and Mo," **Adam Hotař**, et al.

"Investigations on the Cr Phase Solubility Increasing and Dynamic Recrystallization Induced by Adiabatic Shearing in Cu-15Cr In-Situ Composite," **Shuangjun Yang**, et al.

"Ablation Resistance of ZrB2-SiC-Si Composite Coatings Applied on Graphite Substrate by Spark Plasma Sintering," **Mehran Jaberi Zamharir**, et al.

"Effect of Stabilization Heat Treatment Time on the Microstructures and Tensile Properties of Inconel 706 Alloy," **Lei Gao**, et al.

"Preparation of Novel (Hf_{0.2}Nb_{0.2}Ta_{0.2}Ti_{0.2}W_{0.2}) B2 High-Entropy Boride Ceramics," **Boyu Ni**, et al.

"Influence of g-C3N4 on Phase Evolution and Microstructural Modifications in Spark Plasma Sintered TiB2-based Ceramics," **Milad Sakkaki**, et al.

"The Formation of γ -Denuded Zone and the Effect on the Properties of Inconel 740H Welded Joint After Creep at 750°C," **Renyuan Zhou**, et al.

"Investigation of Mechanical Properties and Wear Behavior of Nickel-Based Superalloys Synthesized by Powder Metallurgy," **Geetika K. Salwan**, et al.

"Effects of Hot Isostatic Pressing on the Microstructure and Mechanical Properties of K418 Alloys Fabricated by Selective Laser Melting," **Xiaoxuan Zhang**, et al.

"Review of Solid State Consolidation Processing Techniques of ODS Steels (Hot Extrusion, Hot Isostatic Pressing, Spark Plasma Sintering, and Stir Friction Consolidation): Resulting Microstructures and Mechanical Properties," **Matthew DeJong**, et al.

"Strength Behavior of Niobium-Based Refractory Systems," **Krishna Prasad Joshi**, et al.

"A Review of Multiphysics Coupling Mechanical Behavior of Coated-Titanium Heterogeneous Wing for Re-entry Hypersonic Vehicle," **Fei Liu**, et al.

"Effect of Bonding Temperature on the Interfacial Microstructure and Mechanical Properties of W/Steel Joints Diffusion Bonded with a CoFeNi Interlayer," Chunyan Wang, et al.

"Exploration of Microstructural and Physical Characteristics in a Newly Formulated Ceramic Utilizing Kaolin and Waste MgO–C Refractory Bricks," **Sabrina Ladjama**, et al.

Thermodynamic and Process Modeling Tools for Material Production Processes

Editors: Adamantia Lazou, National Technical University of Athens; Alexandra Anderson, RHI Magnesita; Samuel Wagstaff, Oculatus Consulting; Gwen Bracker, DLR Institute of Materials Physics in Space Sponsor: Process Technology and Modeling Committee

"Capturing the Interaction Between Mold Flux and Different Steel Compositions During Industrial-Scale Continuous Casting Trials," P.P. Sahoo, et al.

"Experimental and Simulation Study of Babbitt Alloy/Steel Composite in Swing Cold Metal Transfer (CMT) Welding Under Different Heat Input," Chenkang Fan, et al.

"Leaching Kinetics of Limonite-Type Laterite Nickel Ore from Ammonium Hydrogen Sulfate Solution at Atmospheric Pressure," Yi Wang, et al.

"Numerical Simulation of Inclusion Collision Growth and Removal in a Tundish with Intermittent Induction Heating," Bin Yang

"Study on the Evolution of Inclusions in Ce-Modified M50NiL Steel Through the CALPHAD Approach and a Novel Inclusion Prediction Condition," **Xiaoqiang Wang**

"Numerical Simulation and Sensitivity Evaluation of Process Parameters for AC-HVAF Spraying 3D Model," Chang Li, et al.

"Exploring the Potential of B₂O₃ and SiO₃ to Dissolve MgAl₂O₄ from Experiment and AIMD Simulation," Yiyu Xiao, et al.

"Influence of Solutal Marangoni Effect on Droplet Behavior in Metal-Slag Emulsion System: A Numerical Study," Mingming Li, et al.

"An Online Visualization Model of the Slag Crust Thickness on the Copper Staves of the Blast Furnace," Dongliang Liu, et al.

"Hot Deformation Behavior and Dynamic Recrystallization Mechanism of Fe-18.2Mn-0.52C Twinning-Induced Plasticity Steel," Kairui Xue, et al.

"Stability of Crystalline Compounds in Slag Systems Mainly Composed of Li₂O-SiO₂-CaO-MnO₂," D.A. de Abreu, et al.

"Timed Thermodynamic Process Model Applied to Submerged Arc Welding Modified by Aluminium-Assisted Metal Powder Alloying," Theresa Coetsee. et al.

"Numerical Simulation of Stress and Temperature Fields in Laser Alloyed FeMnSiCrNi Shape Memory Alloy Coatings on 316 Stainless Steel," Yubin Sun, et al.

"Thermodynamic Modeling of Ilmenite Smelting and Impurity Distribution," Elmira Moosavi-Khoonsari, et al.

"Mitigating Cathode Corrosion in Aluminum Reduction Cells Using a VOF-Electric Model," Min Zhang, et al.

"Optimizing CZ Silicon Crystal Growth: Algorithmic Approach for Defect Minimization," Amir Reza, et al.

"Phase Diagram of CaO-Al₂O₃-VOx Slag System Under Reducing Atmosphere," Chengjun Liu, et al.

View More Technical Articles

JOM regularly publishes additional articles that fit within the scope of the journal, but not within the scope of a particular technical topic. Read these in the "Technical Articles" section of JOM on Springer.



JOM: The Magazine, Vol. 76, No. 11, 2024 https://doi.org/10.1007/s11837-024-06918-3 © 2024 The Minerals, Metals & Materials Society

Introducing the 2025 TMS SCHOLARS

Kaitlin Calva



Support my education. Achieve my career goals. Pursue my dreams.

These themes, woven throughout the personal, touching stories told in the next few pages by the 2025 Class of TMS Scholars themselves, remind us just how important these awards and programs are for the next generation. They serve as a common thread tying together the promise of today's students and the success and innovation of tomorrow's materials science and engineering minds.

With a monetary scholarship, these awards help ease the heavy financial lift that comes with attending college or university for many. An added travel stipend further reduces barriers to education, enabling recipients to attend Society meetings that may otherwise be inaccessible. These vital benefits make a real, immediate impact in the lives of students.

Perhaps even more valuable, though, are the intangible benefits that accompany each scholarship. Society meetings offer students a venue to present their work, network with their peers, and broaden their technical knowledge. The ability to accept their awards in person at highly regarded technical meetings, like the TMS Annual Meeting, provides students with the rare chance to establish connections with potential mentors, or even future employers. Such careerbuilding experiences can often provide recipients with

a boost in confidence that confirms their beliefs—that they *are* supported in their education; that they *can* achieve their career goals; and, most importantly, that they *can* realize their dreams.

Many of the scholarships described in this article will be presented during technical division functions held at the TMS 2025 Annual Meeting & Exhibition (TMS2025). The awards and lecture portions of division luncheons are open to all TMS2025 attendees, so be sure to support the 2025 scholars and congratulate them in person. Other awards and scholarships will be conferred at the TMS-AIME Awards Ceremony, which is open to all meeting attendees. TMS2025 will be held March 23–27, 2025, in Las Vegas, Nevada, USA. Learn more about the special events, networking opportunities, and registration at www.tms.org/TMS2025.

A GIFT FOR THE FUTURE



Each scholarship highlighted in this article is made possible through donations from individuals who believe in the mission of the TMS Foundation. Please consider joining them to ensure that the TMS Foundation can continue supporting the minerals, metals, and materials community in strong and impactful ways—with scholarships, awards, and

leadership development for every stage of the academic and professional career. Donate by **December 31**, **2024**, to be included in the TMS Foundation's 2024 year-end appeal.

Visit www.TMSFoundation.org/Contribute to make a one-time donation or set up a monthly gift. You can also make a contribution by check, made payable to the TMS Foundation and mailed to TMS, 5700 Corporate Drive Suite 750, Pittsburgh, PA, 15237. For more information or to discuss a donation personally, please contact TMS Foundation staff at TMSFoundation@tms.org.

DIVISION AWARDS

TMS division scholarship recipients will also receive a dollar-for-dollar scholarship match through the Battelle Matching Scholarship Program, 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 should they matriculate to graduate studies in a materials-related field.

EXTRACTION & PROCESSING DIVISION (EPD) SCHOLARSHIP

Awarded through the EPD and the TMS Foundation to sophomore or junior undergraduate students majoring in the extracting and processing of minerals, metals, and materials.



Paul Odewale Federal University of Technology Akure

"TMS and Material Advantage have played a major part in helping expand my knowledge of the processing of minerals, materials, and metals through access to their journals and

networking platforms. I am incredibly humbled to have been chosen to receive the EPD Scholarship. It will lighten my financial burden and help cover my research expenses, allowing me to spend more of my time studying. Upon completing my degree, I plan to pursue a Ph.D. and an industry career researching the utility of machine learning on the engineering of quantum materials at the nanoscale to enhance their properties for energy applications. Thanks to TMS, I am one step closer to my goal."

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.



Brooke Lastinger University of Florida

"I have always believed the biggest disservice you can do to yourself is to stop learning, which is why being a part of TMS has proven to be a crucial aspect of my undergraduate experience. TMS

has enriched my education by providing me with an avenue to explore and network within the field. The generosity and devotion of the TMS Foundation, the FMD, Jeffrey Wadsworth, and Battelle is an act I will remember through my lifetime and hope to be a part of in the future."

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.



Alya Zaleha Rasjid Sultan Ageng Tirtayasa University

"Receiving this award and being a part of TMS and the TMS Foundation is a great honor that recognizes my dedication to advancing materials science. It encourages me to keep

learning and innovating. I'm inspired to contribute more to the field and support future generations of scientists and engineers."

MATERIALS PROCESSING & MANUFACTURING DIVISION (MPMD) **SCHOLARSHIP**

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.



Jocelyn Hess University of Tennessee

"The generosity of TMS will go a long way towards furthering my education. It allows me to pursue my dreams of getting a Ph.D. with the goal of professorship."

"Thanks to TMS, I am one step closer to my goal." -Paul Odewale

STRUCTURAL MATERIALS DIVISION (SMD) **SCHOLARSHIP**

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.



Kevin Ram University of California, Berkeley, U.S. Air Force, Lawrence Livermore National Laboratory

"It's an honor and privilege to be recognized by TMS for the SMD Scholarship. TMS has provided me with

an invaluable opportunity to connect professionally and build relationships with researchers in the field. I look forward to pursuing graduate studies in a similar field in support of my long-term career goals."

SOCIETY AWARDS

TMS INTERNATIONAL SYMPOSIUM ON SUPERALLOYS SCHOLARSHIP

This award is for 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 & Technology Conference and the International Symposium on Superalloys.



Rafael Rodriguez University of Pittsburgh

"To receive the TMS International Symposium on Superalloys Scholarships is a great honor. I am deeply grateful to both TMS and Material Advantage for providing

a platform that encourages and supports young researchers in the field of superalloys. Thank you for this recognition which I received with the commitment to continue striving for excellence and contribute to the development of new superalloys."

APPLY FOR A 2026 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 2026 TMS Scholarship.

The deadline to apply for the 2026 cycle of TMS scholarships—March 15, 2025—will be here before you know it, so start working on your application materials now. Prospective scholars must use the official online form to submit their application and supporting documents before this deadline. Visit www.tms.org/Awards to learn more.

KAUFMAN CALPHAD SCHOLARSHIP

This scholarship is awarded to an undergraduate student majoring in metallurgical engineering, materials science and engineering, or minerals processing/extraction programs. The scholarship is established to recognize the memory of Dr. Larry Kaufman for his contributions to computational thermodynamics and its applications. It is supported by CALPHAD Inc. and the TMS Foundation.



Megan Nash Clemson University

"I am extremely grateful to receive the Kaufman CALPHAD Scholarship for 2025. I am very dedicated to my studies in the field of materials science and cannot wait to continue growing my

education with further graduate studies. Thank you to the TMS Foundation and its generous supporters for granting me the ability to continue pursuing education in a field that I love."

"Thank you to the TMS Foundation and its generous supporters for granting me the ability to continue pursuing education in a field that I love."

-Megan Nash

TMS BEST PAPER CONTEST

This award recognizes student essays on global or national issues as well as technical research papers relating to any field of metallurgy or materials science.

BEST PAPER AWARD - FIRST PLACE GRADUATE



Hugh Shortt University of Tennessee-Knoxville Paper: "Low-Cycle-Fatigue Study of a Strong and Ductile Medium Entropy Alloy"

"This award is a great honor, in part because it represents the culmination

of several people's collaboration and diligent cross examination of a complex topic on a complex material with large implications for fatigue material candidates in the near future. TMS has been an integral part of bringing collaborative efforts and people from across different industries and universities together to bring the research to its current state."

BEST PAPER AWARD - SECOND PLACE GRADUATE



Olajesu Olanrewaju **Iowa State University** Paper: "Studying the Local Deformation Behavior of Tantalum using High throughput Spherical Nanoindentation"

"I feel highly honored to be recognized for this award by TMS-one

of the biggest and most well-known associations in the materials science and engineering field. TMS and Material Advantage provide me with the opportunities to be engrafted into a professional society and a wealth of resources with excellent researchers. I would like to sincerely appreciate my advisor, Dr. Sid Pathak, and collaborators on the NSF-DMREF team for their invaluable support and guidance in my research. This award is a harbinger for more awards and reputation in the field of materials science and engineering."

BEST PAPER AWARD - FIRST PLACE UNDERGRADUATE



Sarah Cole **Boise State University** Paper: "Establishing a Domestic HALEU Supply Chain: A Policy Analysis on the Nuclear Fuel Cycle"

"Earning the TMS Undergraduate Best Paper Award inspires me to

continue my research journey in nuclear energy. After graduating with my bachelor's degree in materials science and engineering from Boise State University, I plan to complete a Ph.D. in nuclear engineering and will pursue my passion for nuclear energy policy in Washington, D.C."

BEST PAPER AWARD - SECOND PLACE UNDERGRADUATE



Christian Álvaro Mendoza Ramos AIMET (Asociación de Ingenieros Metalúrgicos de Bolivia) Paper: "Recovery of Antimony from Refinery Slag of Unified Mining Company"

"This award represents a milestone in my professional journey, recognizing the dedication and passion I've invested into it. TMS's support is invaluable to me to contribute to and innovate in my research."

"Thanks to the generosity of the TMS Foundation. I find myself one step closer to my goal as I graduate from Boise State University this year."

-Sarah Cole

ACTA MATERIALIA AWARDS

ACTA MATERIALIA UNDERGRADUATE SCHOLARSHIP

Supported by the generosity of Acta Materialia Inc. and issued under the TMS Foundation, this scholarship is available to undergraduate students majoring in metallurgical engineering, materials science and engineering, or to undergraduate students with a significant interest in the materials area.



Sarah Cole **Boise State University**

"Earning the TMS Acta Materialia Inc. Undergraduate Scholarship supports my dreams to earn a bachelor's degree in materials science and engineering. Thanks to the generosity of the TMS

Foundation, I find myself one step closer to my goal as I graduate from Boise State University this year. Next, I plan to complete a Ph.D. in materials science and engineering with a research concentration in ceramic nuclear fuels and aim to pursue my passion for nuclear energy policy in Washington, D.C."



Austin Davis Arizona State University

"It is an honor to accept this award, and I will make the most of it by striving to excel in my studies and research. This award will help propel me through the last year of my undergraduate

degree and support me as I prepare to enter graduate school to continue my studies. I can't express enough gratitude to Acta Materialia Inc. for their support. Thank you!"

AIME AWARDS

AIME HENRY DEWITT SMITH SCHOLARSHIP

This scholarship is awarded to graduate students majoring in mineral, metal, and/or materials engineering. The award aims to advance the mineral industries by assisting students in the pursuit of graduate education in mining, metallurgical, materials, or petroleum-related disciplines.



Hang Yuan **Northeastern University**

"I would like to express my sincere gratitude to TMS and Material Advantage for awarding me the Henry deWitt Smith Scholarship. I have been a Material Advantage member since my

first year of Ph.D. studies, and this valuable experience has enabled me and my chapter to organize various professional development, technical, and educational events that have significantly enhanced my career skills and interactions with peers. Upon completing my degree, I am eager to continue my work in the R&D of metallic and ceramic materials, whether in industry or academia."



Karthikeyan Hariharan The Ohio State University

"I am really honored to receive this award as it recognizes my efforts as a graduate student. I have been involved with the Material Advantage program and TMS since my undergraduate days

and it has shaped me as an individual. I hope to repay my gratitude to TMS by continuing my involvement with the organization and contributing to the materials and corrosion community as a future academic."

Kaitlin Calva is an independent contractor providing writing support for TMS and JOM: The Magazine.

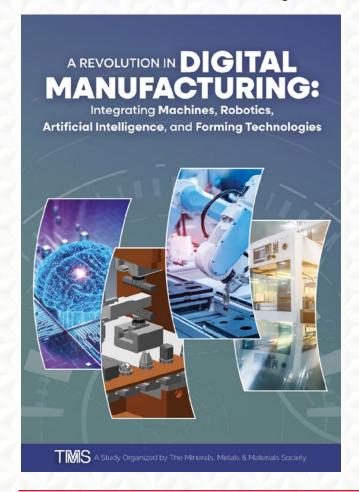
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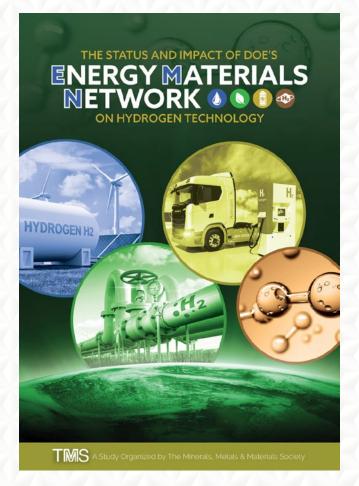
Learn more about scholarships, travel grants, contests, and membership options for graduate and undergraduate students—including the new TMS Graduate Student Membership program—at www.tms.org/Students.

DIGITAL MANUFACTURING AND HYDROGEN TECHNOLOGY HIGHLIGHTED IN RECENT TMS STUDIES

Kelly Zappas

TMS regularly convenes respected technical experts and leaders from the minerals, metals, and materials communities to develop influential technology accelerator studies and reports. In the past six months, TMS has released two new studies: *A Revolution in Digital Manufacturing: Integrating Machines, Robotics, Artificial Intelligence, and Forming Technologies* and *The Status and Impact of DOE's Energy Materials Network (EMN) on Hydrogen Technology*. Both studies are now available for free download through the TMS website at www.tms.org/Studies.





A REVOLUTION IN DIGITAL MANUFACTURING:

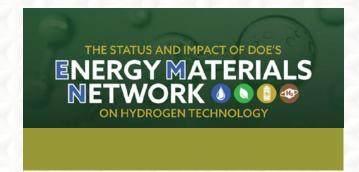
Integrating Machines, Robotics,
Artificial Intelligence, and Forming Technologies

This study identifies and prioritizes the acceleration and widespread development and adoption of metamorphic manufacturing (also known as robotic blacksmithing) within the U.S. manufacturing enterprise. It was funded by the Office of Naval Research.

The report identifies unique needs and key enablers that will support integration of robotics, machines, and computation/artificial intelligence (AI) for metamorphic manufacturing. It also provides detailed recommendations and activities that will result in dramatic progress in the development of metamorphic manufacturing equipment suites and enable the initial fabrication of complex demonstration parts.

The following study team members developed the report:

- Glenn Daehn, Study Chair, The Ohio State University
- Tony Schmitz, Study Co-Chair, University of Tennessee and Oak Ridge National Laboratory
- Daniel Braley, Boeing
- David Bourne, Carnegie Mellon University
- Jeffrey Burdick, U.S. Army CCDC Ground Vehicle Systems Center (GVSC)
- Mark Carroll, Honeywell Aerospace
- Vic Castillo, Lawrence Livermore National Laboratory
- Wei Chen, Northwestern University
- Robert Gao, Case Western Reserve University
- **Joseph Giampapa**, ARM Institute
- Michael Kirka, Oak Ridge National Laboratory
- Chinedum Okwudire, University of Michigan
- Babak Raeisinia, Machina Labs



This study focuses on the development of the novel materials needed to support a clean hydrogen energy ecosystem. In June 2024, TMS released the final report, developed by an expert study team to examine the status, impact, and future opportunities of hydrogen technology for the U.S. Department of Energy's (DOE) Energy Materials Network (EMN) and the EMN's four hydrogen-related consortia. This science and technology accelerator study was funded by the Hydrogen and Fuel Cell Technology Office (DOE-EERE-HFTO) via the Pacific Northwest National Laboratory (PNNL).

The report includes an overview of recent developments and achievements in hydrogen technology, an examination of how the EMN is driving innovation and progress in the field, and insights into emerging trends and research opportunities shaping the future of materials development for hydrogen technologies.

The following study team members developed the report:

- Kathy Ayers, Nel Hydrogen
- Jack Brouwer, University of California, Irvine
- Nemanja Danilovic, Electric Hydrogen
- Jay Keller, Zero Carbon Energy Solutions
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TMS Welcomes New Members in May and August 2024

The TMS Board of Directors approved professional membership for the following individuals at its May and August 2024 meetings. Please join us in congratulating and welcoming them to all the privileges and benefits of TMS membership.

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www.extractionmeeting.org/Extraction2025



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