

JOM THE MAGAZINE

APRIL 2024


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ABOUT THE COVER



This month's issue of *JOM: The Magazine* introduces our 2024 TMS President Srini Chada, who officially became president at the TMS 2024 Annual Meeting & Exhibition (TMS2024) in Orlando in March. In the cover photo, Chada examines a complex printed circuit board for defects at the General Dynamics Mission System's Component and Materials Lab. Chada is Manager PM&P at General Dynamics Mission Systems. You can read his introduction, in his own words, beginning on page 8. This month's cover was designed by David Rasel, TMS Senior Manager, Brand and Digital Assets.



Access Technical Journal Articles

TMS members receive free electronic access to the full library of TMS journals, including JOM. Technical articles published in JOM: The Journal are available on the Springer website. TMS members should log in at www.tms.org/Journals to ensure free access.

About JOM: The Magazine:

This print publication is excerpted from the publication of record, *JOM*, which includes both The Magazine and The Journal sections. *JOM: The Magazine* includes news and insights about TMS, its members, and the professions it serves. To access the publication of record, visit www.tms.org/JOM.

About TMS:

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

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IN THE FINAL ANALYSIS

"If the beat gets to the audience, and the message touches them, you've got a hit."

—Casey Kasem

Casey Kasem occupies a secure point in the pop culture firmament for two momentous contributions. First, he was the original and long-running voice actor for Shaggy from the cartoon series *Scooby-Doo, Where Are You!* Second, for almost 20 years he hosted syndicated radio staple *American Top 40*, counting down the Billboard Top 40 pop songs of the week. During the Spotify-free 1970s, I tuned to Kasem on many a weekend morning, loving some songs, hating others, and being ambivalent about most. While Kasem was far too schmaltzy for high-school me, *American Top 40* was irresistible as I loved music, lists, and countdowns. Still do.

I love materials, too. Fast-forwarding 50 years, a modern list that I thoroughly savor is the annual countdown of the past year's most downloaded papers from TMS journals. It is compiled not by Billboard but by Springer Nature, with which TMS publishes six journals. Unlike Impact Factor, which focuses on paper citations, downloads reflect interest for a topic. Here's what intrigued our community in 2023 as found in the TMS Top 10 Journal Download Chart:

10. 6,167 Downloads: **"Recent Progress in Titanium Extraction and Recycling"** by Osamu Takeda and two others from 2020's *Metallurgical and Materials Transactions B*. This is down from No. 6 in 2022 and No. 4 in 2021.
9. 6,459 Downloads: **"Lithium: Sources, Production, Uses, and Recovery Outlook"** by Laura Talens Peiró and two others from 2013's *JOM*. This is down from No. 1 in 2022 and No. 1 in 2021.
8. 6,465 Downloads: **"Carbon Footprint and Energy Transformation Analysis of Steel Produced via a Direct Reduction Plant with an Integrated Electric Melting Unit"** by Julian Suer and two others from 2022's *Journal of Sustainable Metallurgy*.
7. 6,851 Downloads: **"Synthesis of Fe₃O₄ Nanoparticles with Different Shapes Through a Co-Precipitation Method and Their Application"** by Muneer M. Ba-Abbad and four others from 2022's *JOM*.
6. 7,232 Downloads: **"Perspectives on the Impact of Machine Learning, Deep Learning, and Artificial Intelligence on Materials, Processes, and Structures Engineering"** by Dennis M. Dimiduk and two others from 2018's *Integrating Materials and Manufacturing Innovation*. This is down from No. 3 in 2022 and No. 3 in 2021.
5. 7,449 Downloads: **"The Twelve Principles of Circular Hydrometallurgy"** by Koen Binnemans and Peter Tom Jones in 2023's *Journal of Sustainable Metallurgy*.
4. 8,155 Downloads: **"Manufacturing Processes for Permanent Magnets: Part I—Sintering and Casting"** by Jun Cui and 11 others in 2022's *JOM*. This is down from No. 2 in 2022.
3. 8,297 Downloads: **"Graphene Properties, Synthesis and Applications: A Review"** by Akanksha R. Urade and two others in 2023's *JOM*.
2. 10,370 Downloads: **"Artificial Meat Industry: Production Methodology, Challenges, and Future"** by Tarun Mateti and two others in 2022's *JOM*.
1. 14,407 Downloads: **"REE Recovery from End-of-Life NdFeB Permanent Magnet Scrap: A Critical Review"** by Yongxiang Yang and ten others in 2017's *Journal of Sustainable Metallurgy*. This is up from No. 4 in 2022 and No. 5 in 2021.

So, what are we gravitating toward? Primary metals production, recycling, energy, critical materials, artificial intelligence, emergent materials . . . sounds a lot like an everyday playlist at TMS.



James J. Robinson
Executive Director



James Robinson

"A modern list that I thoroughly savor is the annual countdown of the past year's most downloaded papers from TMS journals."

Find peer-reviewed technical articles covering the full range of minerals, metals, and materials science and engineering in the April issue of *JOM: The Journal*. Each issue features several technical topics presenting a series of related articles compiled by guest editors. A preview of April technical topics and articles are 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 April issue, based on information available at press time. For the most up-to-date article listing, visit www.tms.org/JOM.



Fiseha Tesfaye

JOM welcomes **Fiseha Tesfaye** to the editorial team joining Victoria Miller as an Associate Editor. As a former *JOM* Advisor for the Recycling & Environmental Technologies Committee, Tesfaye brings strong subject matter expertise and TMS volunteer experience to his work with the journal.

// APRIL 2024

Innovations in Forming Technologies for Light Alloys

Editor: Dmitry Eskin, Brunel University London

Sponsor: Aluminum Committee

"Fabrication of Gasar Porous Mg Agx ($x = 0.5, 17.57$) Alloys Via the Metal-H Eutectic Directional Solidification Process," **Fei Bao**, et al.

"Dimensional Accuracy Enhancement in Hydroforming of Tubular Components with Rectangular Cross-Sections," **Xiao-Lei Cui**, et al.

"The Influence of Y and Er on the Grain Structure and Superplasticity of Al-Cu-Mg-Based Alloys," **A.V. Mikhaylovskaya**, et al.

"Defect Formation in Different Characteristic Areas During Variable-Curvature Shell Room-Temperature Stamping of Cast-Rolled AZ31 Alloy," **Wenxing Zheng**, et al.

"Microstructure, Texture, and Mechanical Properties of Mg-Gd-Y-Zr Alloy Prepared by Rotating Backward Extrusion Process," **Mengxian Zhang**, et al.

"Effect of a Large Height-to-Diameter Ratio Upsetting-Extrusion Process on the Microstructure and Mechanical Properties of Mg-Gd-Y-Zn-Zr Alloys," **Weidong Qiao**, et al.

"Simultaneous Enhancement of Strength and Ductility in AM60 Tubes Using a Novel Approach of Modified Tube Cyclic Expansion Extrusion," **M. Aali Majidabad**, et al.

"Evolution of Texture and Mechanical Anisotropy of Mg-13Gd-4Y-2Zn-0.5Zr Sheet Produced by Rotary Forward Extrusion," **Zhaocan Li**, et al.

"Effect of Multi-pass Deformation on Microstructure Evolution of Spark Plasma Sintered Ti-6Al-4V Alloy," **Xueyan Dai**, et al.

Materials Research Needs for Development of Technical Standards in Additive Manufacturing

Editor: Mark R. Stoudt, National Institute of Standards and Technology;

Thomas P. Battle, Extractive Metallurgy Consultant; and **David L. Bourell**, University of Texas at Austin

Sponsor: Additive Manufacturing Committee

"Materials Research Needs for Development of Technical Standards in Additive Manufacturing," **Mark Stoudt**, et al.

"Providing a Rigorous Benchmark Measurement Foundation for Modeling-Informed Qualification and Certification of Metal Additive Manufactured Components," **Lyle Levine**, et al.

"Toward a Standard Data Architecture for Additive Manufacturing," **Shengyen Li**, et al.

"Scientific Foundations and Approaches for Qualification of Additively Manufactured Structural Components," **Sharlotte L.B. Kramer**, et al.

"Standardization Gaps in Powder Feedstock Characterization and Establishing Acceptability for Reuse in Additive Manufacturing," **Tyler LeBrun**

TMS MEMBER NEWS

Share the Good News!

Contact Kelly Zappas, *JOM: The Magazine* editor, at kzappas@tms.org to share your professional accomplishments. Please note that only news submitted by current TMS members will be considered.

Suresh Receives National Medal of Science

Congratulations are in order for TMS member **Subra Suresh**, one of nine 2023 recipients of the National Medal of Science. The highest recognition in the U.S. for scientists and engineers, the award was bestowed by U.S. President Joe Biden at the White House on October 24, 2023.

Since joining TMS in 1983, Suresh has been an active member of the Structural Materials Division (SMD). He has earned several of the Society's pinnacle awards, including the 2000 Fellow Award, the 2011 TMS/ASM Joint Distinguished Lectureship in Materials and Society Award, and the 2012 Institute of Metals/Robert Franklin Mehl Award. Additionally, Suresh has gained accolades for his innovative work from a number of organizations around the world. He is one of just a few individuals who have been elected to all three U.S. National Academies—Sciences, Engineering, and Medicine.

Suresh is currently professor at large in the Brown University School of Engineering and is the Vannevar Bush Professor Emeritus in the Department of Materials Science and Engineering at the Massachusetts Institute of Technology. Notably, he is the former director of the National Science Foundation and has served as president of Carnegie Mellon University and Nanyang Technological University in Singapore.

Suresh's citation reads: "For pioneering research across engineering, physical sciences, and life sciences. A transformative educator, he has advanced the study of material science and its application to other disciplines. His commitment to research and collaboration across borders has demonstrated how science can forge understanding and cooperation among people and nations."



Subra Suresh received the National Medal of Science, the nation's highest scientific honor, from U.S. President Joe Biden in October 2023. (Photo credit: Ryan K. Morris and the National Science & Technology Medals Foundation.)

Llorca Receives Spanish National Research Award



TMS member **Javier Llorca** has been honored with the 2023 Leonardo Torres Quevedo National Research Award in Engineering and Architecture by the Ministry of Science and Innovation of Spain. Llorca is currently the scientific director and leader of the bio/chemo/mechanics of materials research group

at IMDEA Materials Institute and a full professor at the Technical University of Madrid.

Spanish Minister of Science and Innovation Diana Morant announced the 2023 National Research Awards in September 2023. Llorca's citation reads: "For the pioneering nature and leadership of his research in the field of computational materials engineering, highlighting his contributions to development of novel multi-scale modeling strategies that have had a great

impact on different industrial sectors."

Since becoming a TMS member in 2014, Llorca has been actively involved in two signature TMS events as a member of the Organizing Committee or International Advisory Committee: the World Congress on Integrated Computational Materials Engineering and the International Congress on 3D Materials Science. In 2019 he received the TMS Structural Materials Division's (SMD) *JOM* Best Paper Award and in 2023 the SMD Distinguished Scientist/Engineer Award.

He has previously held positions as a visiting professor at Brown University, Indian Institute of Science, Shanghai Jiatong University, Central South University, and Yanshan University.

Llorca is considered by many to be among the fathers of computational materials engineering and is a highly cited researcher in the field of structural materials engineering, with more than 21,000 citations on his 350 publications to date.

Rodriguez Named HENAAC Scientist of the Year

TMS member Sal Rodriguez was named the 2023 Scientist of the Year from Great Minds in STEM (GMIS) during their annual Hispanic Engineer National Achievement Awards Conference (HENAAC). Rodriguez is currently a principal member of the technical staff in the Advanced Nuclear Concepts Group at Sandia National Laboratories and an associate professor at the University of New Mexico's (UNM) Nuclear Engineering Department.

Scientist and/or Engineer of the Year is not awarded annually, but only when the selection committee identifies a candidate from one of the professional awards categories whose achievements merit elevation to one of these special honors. Bestowed for both exemplary leadership and scientific achievement, this award recognizes individuals who "are meeting the demands of today's rapidly advancing technology and dynamic economic environment."

Among the attributes mentioned in Rodriguez's award citation, it is noted that: "His research resulted in many game-changing advances for modeling fluid dynamics, swirl, and turbulent flows which resulted in multiple patents and patents pending, including one for more efficient wind turbine blades that use turbulators and dimples for increased wind energy output."

Since joining TMS in 2022, Rodriguez has been active in the Functional Materials Division. He also participated

in the 3rd World Congress on High Entropy Alloys in 2023 as both a presenter and a session chair.



TMS member Sal Rodriguez, named the 2023 HENAAC Scientist of the Year, is shown here with a dimpled rocket that he helped to create. Photo credit: Sandia National Laboratories/photo by Jennifer Plante.

TMS at PRICM11

TMS members **George "Rusty" Gray III**, Los Alamos National Laboratory (LANL), and current TMS Functional Materials Division Chair **Saryu Fensin**, LANL, represented the Society at the 11th Pacific Rim International Conference on Advanced Materials and Processing (PRICM11) in November 2023. This long-standing event is jointly organized by the Chinese Society for Metals (CSM), the Japan Institute of Metals and Materials (JIM), the Korean Institute of Metals and

Materials (KIM), Materials Australia (MA), and TMS, and is hosted alternately among these five sponsoring organizations. The 2023 iteration was hosted by KIM and held in Jeju, South Korea.

For more than 30 years, PRICM has served as an international stage for the dissemination of current and emerging materials and processing knowledge. In the Society's non-hosting years, TMS members contribute to the planning and implementation of technical programming through the TMS Organizing Committee and the International Advisory Board. Onsite at PRICM11, Gray served as the TMS in-country representative while Fensin participated as one of the TMS organizing committee appointees. Gray was also honored as one of the three plenary speakers for the conference, presenting a talk entitled, "Dynamic Behavior of Additively Manufactured Materials."

In addition to the programming efforts of Gray and Fensin, the following TMS members were involved in PRICM11: **Nikhilesh Chawla**, Purdue University; **Paul R. Ohodnicki Jr.**, University of Pittsburgh; **Elizabeth A. Holm**, University of Michigan; 2022 TMS President **W. Jud Ready**, Georgia Institute of Technology; and **Dan J. Thoma**, University of Wisconsin-Madison.

Although details for the next PRICM conference have not yet been announced, you can explore additional TMS events at www.tms.org/Meetings.



George "Rusty" Gray and Saryu Fensin represented TMS at PRICM 11 in Jeju, South Korea.

A Tribute to Professor Emeritus Thorvald Abel Engh



Thorvald Abel Engh passed away on December 22, 2023, two weeks before his 90th birthday. Thorvald was an active TMS member for 50 years. He presented many insightful papers and assisted in TMS short courses on aluminum refining. At the TMS 2017 Annual Meeting & Exhibition,

he and Christian Simensen were honored for their technical contributions in a special Light Metals Division symposium, The Science of Melt Refining.

Thorvald began his studies at the Norwegian Institute of Technology (now the Norwegian University of Science and Technology, NTNU) in Trondheim, Norway, receiving a master's degree in physics in 1958. He worked for five years as an associate engineer for process control at an IBM Laboratory before returning to Trondheim and earning his Ph.D. in chemical engineering in 1966. As a lecturer in the Chemical Engineering Department, Thorvald received a travel scholarship which enabled him to work with John F. Elliott at the Massachusetts Institute of Technology (MIT). In 1970 he worked at the Metallurgical Research Plant in Luleå, Sweden, and later that year became a lecturer in the Department of Ferrous Metallurgy at the Royal Institute of Technology in Stockholm, Sweden. In 1971 he became an associate professor of metallurgical engineering at NTNU and remained on the faculty until his retirement as emeritus professor in 2004.

While on sabbatical leaves throughout his career, Thorvald worked with Carnegie Mellon University and the Alcoa R&D Center, both in Pittsburgh, Pennsylvania; the University of Melbourne in Australia; Drexel University in Philadelphia, Pennsylvania; and the Research Institute for Advanced Materials Processing, Tohoku University, in Sendai, Japan.

Thorvald began in the theoretical sciences of physics and mathematics, but after working in industry decided to apply his skills to solving practical problems, for which he brought an intense desire to know and understand. In his modelling of metallurgical processes, he did not resort to computers to solve complex differential equations. Instead, he produced exact mathematical solutions. Sometimes his mathematical analyses produced important dimensionless numbers, which characterized the kinetics of the process.

Thorvald always had a unique way of seeing things and his viewpoint was usually insightful. He had a lively sense of humor and a sharp wit. We will miss our many interesting and useful conversations with Thorvald, but we will not miss his knowledge. His last act, and gift to us, was to detail his life's research. He also convinced 20 colleagues to contribute their knowledge to his book, *Principles of Metal Refining and Recycling*. Read it for yourself, and you will soon feel the force and depth of his unique personality and come away with a deeper understanding of metal refining and recycling.

*Contributed by **Geoffrey K. Sigworth**, a consultant with GKS Engineering Services and a TMS member since 1981, and **Anne Kvithyld**, a research scientist with SINTEF and a TMS member since 2002.*

In Memoriam

TMS offers its condolences to the families, friends, and colleagues of the following members:


Rodney "Rod" R. Boyer, known to many in the community as the "Ti Guy," passed away on November 16, 2023. Throughout the course of his career, Boyer consulted for NASA, Lockheed Martin, and TIMET. A TMS member since 1977, Boyer was always active in the Structural Materials Division's Titanium Committee, serving as the committee's secretary, vice chair, and chair in the 1990s. In 2020 he received the Society's highest honor, the Fellow Award, "for exemplary and sustained leadership in the growth of understanding and application of Ti alloys in commercial aircraft. For exceptional service to our profession." Recently, the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) captured an interview with Boyer for its Oral Histories project, which can be found at www.tms.org/OurHistory. Boyer earned the "Ti

Guy" nickname due to his significant contributions to the titanium research and the aerospace industry. He has given more than 300 technical presentations around the world and co-edited more than seven books, most notably *Titanium Alloys Metals Properties Handbook*.

John Edward Litz passed away on December 28, 2023. Specializing in developing processes for the recovery of metals from ores, concentrates, and recyclable materials, Litz was active in the TMS Extraction & Processing Division since joining TMS in 1992. Throughout his career, he worked at mining camps in Colorado and New York. Litz spent the latter part of his career self-employed as a metallurgical engineer at his company, J.E. Litz & Associates LLC.

2024 TMS PRESIDENT SRINI CHADA: TMS—MY HOME SOCIETY

SRINI CHADA



Srini Chada examines a complex printed circuit board for defects at the General Dynamics Mission System's Component and Materials Lab.

“During my tenure, I will strive to make TMS the Home Society of every member and contribute to its prosperity with a clear eye toward future technologies, while staying grounded in the fundamental principles of materials science.”

What does the word 'Home' mean to you? What sort of emotions and memories does it evoke? I will share my thoughts through my life's journey, starting with my life in India where I was born and raised before emigrating to my adopted home, the United States of America, in pursuit of higher education.

In the early years, Home was where, in my mother's lap, I learnt the alphabet, nursery rhymes, and arithmetic. It was where my father introduced me to the beauty of geometry and intricacies of English poetry. Later, in my hometown, the Jesuit brothers with their 'tough love' approach laid a solid foundation of English grammar, physics, chemistry, and calculus. Next came Karnataka Regional Engineering College (KREC) and the journey to a place of learning 1000 miles away from family. KREC was my home for the next four years and where, with the help of brilliant and unyielding professors and the friendships I forged, I not only grew academically but as an individual.

My pursuit of higher education next brought me to Marquette University in Milwaukee. Although I did not know it then, the United States would become the place I would meet my life partner, Susan, and our beautiful daughter, Rachel, and finally be my home for the rest of my life.

During graduate school at Marquette, my professor and advisor, Dr. Raymond Fournelle, was instrumental in my growth both as a materials science engineer and as a person. I attended my first TMS meeting with Dr. Fournelle in 1988, and this was the start of my decades-long relationship with TMS. As a graduate student, I truly benefited from the wisdom and interaction with the researchers from academia, national labs, and industry that I met at TMS conferences. Several of these scholars were generous both with their time and counsel, going above and beyond to send me paper copies of publications through snail mail and corresponding with me via email and phone. Apart from being the home of my scientific pursuit, TMS is where I made life-long friends, a few of them past TMS presidents.

Home is where you are encouraged with no reservations or judgement. It is where you feel at ease and comfortable in your own skin, rubbing shoulders with people of like minds but with diverse backgrounds. Home is where you are truly yourself, with no pretense or false humility. Home is where you belong, where your accomplishments are cherished, and where shortcomings are forgiven and then forgotten.

This is, in essence, why I feel TMS is my Home Society, and I am sure it is for many of you. As the next president of TMS, I will work to grow our membership by encouraging student members, first-time attendees, and occasional participants to join and swell our ranks. I want them all to experience first-hand what I have gained in the past three-and-a-half decades as a TMS member. Additionally, I want to continue to promote the TMS Diversity, Equity, Inclusion, and Accessibility (DEIA) initiatives that have been successfully implemented by my predecessors, as they reflect the ethos of TMS as a society of the present and future. TMS is and should remain a place where no walls or divisions exist based on country, gender, race, creed, or choice. I am proud to be part of a group that unequivocally expresses its opposition against any form of discrimination. This is yet another reason that I am proud to say that TMS is my Home Society.

The setbacks our world experienced due to COVID-19 still echo through disruptions to supply-chain and in-person interactions. Thanks to diligent leadership, TMS dug deep and survived. Mitigating measures are now paying dividends, as conference attendance is once again rising. However, virtual meetings and electronic media will remain tools we can effectively use in conjunction with traditional conferences and meetings. This will not only sustain us through the next global pandemic but will keep us current with advances in communication technology.

As you all know, artificial intelligence (AI) is a disruptive technology making giant strides. However, the promise of AI and fundamental metallurgy and materials science are not mutually exclusive. On the contrary, the future lies in the hands of people who can use a strong scientific foundation to improve AI by engineering newer materials and generating accurate predictive models. Without a strong foundation and a sound understanding of materials and fundamental phenomenon, relying solely on AI may be problematic. Blind reliance on AI technology will remove the scientific checks and balances necessary for maintaining a healthy and stable society. Hence, I will continue to support the ideas that past presidents have implemented to inculcate fundamental metallurgical principles in TMS programs.

For years, TMS has been successful in attracting various industries to exhibit at the Annual and MS&T conferences to encourage participation and generate revenue. However, only a small percentage of these industry exhibit participants actively partake in the technical symposia. Additionally, the

industry personnel who are active members and who regularly attend conferences are few when compared to academics and researchers from national laboratories. As an industry professional, I personally have benefited from TMS activities. Therefore, I will continue to actively promote collaboration among industry, academia, and national laboratories through workshops and symposia. As additive manufacturing is gaining steam, we can translate the ideas from academia and national labs into practical solutions from the industrial arena. This is a golden opportunity for TMS. I will endeavor to enhance industry participation in programs that promote collaboration with academia and provide material solutions for the future benefit of humankind.

Finally, TMS has a history of collaborating and co-organizing with other materials-related societies, such as ACerS and MetSoc; however, there is still room for TMS to expand its membership by collaborating with smaller dedicated niche societies. These

societies have a strong industry following as they address practical and technical topics that solve problems faced in the industry. TMS, with its strong programming presence and technical offerings, can add value to these societies and in turn benefit from their partnership by increasing our membership and collocation of conferences.

In closing, I am grateful and thrilled to be chosen as president of my Home Society, TMS. A home which has contributed to my growth as a materials science engineer and as a human being in innumerable ways. During my tenure, I will strive to make TMS the Home Society of every member and contribute to its prosperity with a clear eye toward future technologies, while staying grounded in the fundamental principles of materials science.

Editor's Note: This article is based on the speech Chada delivered at the TMS 2024 Annual Meeting & Exhibition in Orlando, Florida, when he was installed as the 2024 TMS President in March.

Meet the 2024 TMS Board of Directors

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JOM: The Magazine Talks with SLADE GARDNER of Big Metal Additive

Kelly Zappas



Slade Gardner is president and founder of Big Metal Additive (BMA), a company advancing large-scale metal hybrid additive manufacturing. He was the invited speaker at the Light Metals Division Luncheon at the TMS 2023 Annual Meeting & Exhibition, where he delivered the talk, "Rewriting Design, Cost, and Schedule Paradigms for Satellites with Aluminum Hybrid Additive Manufacturing."

This month, *JOM: The Magazine* talks with Slade Gardner about his company, Big Metal Additive, which has used metal hybrid additive manufacturing technology in projects ranging from unmanned underwater vehicles to satellites made of additive-produced parts.



Could you briefly describe your background and career path? How did you end up in your current role at Big Metal Additive?

Gardner: Ever since my Ph.D. work at Virginia Tech, I was fascinated with materials processing. While many of my peers were studying structure-property relationships, my dissertation was focused on process-structure-property relationships of advanced materials. The 'how' was just as important as the 'what.'

My first job was with Amoco Carbon Fibers, and in less than a year, my manager had me running engineering production orders in the factories. The immense responsibility of 'performing experiments' to trouble shoot manufacturing processes with the company's critical money-making infrastructure was not only thrilling, but also confirmed that the closer that I could connect development to product delivery, the more professionally satisfied I would be.

My next move was to Lockheed Martin Skunk Works® where I found endless appreciation of working on the most advanced platforms for the most important customers: warriors who defend our nation. Fortune favors the bold, and when the group leader of a special advanced manufacturing team asked me to research the use of carbon nanotubes as a structural material for next-generation air/space vehicles, I scoped a project to invent a new composition of matter and a synthetic method enabling additive manufacturing of

nanotube structures. Over the next decade, I built my own development portfolio focused on large-scale AM (additive manufacturing) of polymers, composites, nanomaterials, and other advanced materials. Our group was the first to demonstrate large-scale extruder-based composite additive manufacturing. As part of Skunk Works®, our work was done quietly so it was left to other organizations who extended our work to capture the fame and recognition. After a decade of working on aircraft, I transferred to Lockheed Martin Space Systems Company, where I could apply the maturing manufacturing portfolio to space vehicles. Most importantly, we had matured wire-based metal AM sufficiently for producing satellite propellant tanks. I led the development effort, produced the first tank, and gained advocacy from stakeholders in Propulsion Engineering and Production. Years of work followed, and the team brought large-scale wire AM into the factory and qualified 46-inch-diameter satellite propellant tanks.

I found fulfillment with transition of AM to qualified manufacturing and product acceptance. The particular wire AM method we used had poor production

This article is part of an occasional feature series in which *JOM: The Magazine* talks with industry leaders about technology developments and current issues. To suggest a candidate for a future issue, contact Kelly Zappas, *JOM: The Magazine* editor, at kzappas@tms.org.

metrics for cost, speed, rate, and product acceptance, but I saw incredible potential with large-scale AM. I quit my job and founded Big Metal Additive (BMA) to solve the issues of large-scale AM, serve a wide range of customers, and re-define AM as an industrial manufacturing process for factory scale-up.



What is Big Metal Additive doing that's unique?

Gardner: When I founded the company, my goals were to solve issues of size, surface finish, and dimensional control with metal AM. I knew success required that the process was affordable and the products were acceptable—truly meaning there was a clear path to product qualification and acceptance. Every decision was guided by priorities using established industrial materials, processes, practices, and equipment. It sounds strange to say the uniqueness of the company is predicated on the commonality of every element, but that is the truth. So many of our competitors try to blend invention into their manufacturing path. My philosophy was that nothing should be invented; existing knowledge, industrial practices, and familiar components should be used and levered. Although a unique feature for BMA is the incorporation of multi-axis computer numerical



Early stages of manufacturing a cryogenic tank with integral cooling passages.

control (CNC) machining into the AM process, we blend mature manufacturing capabilities, springboarding to a powerful result. We machine as we build and it makes all the difference. BMA can trim, surface machine, and re-establish datum every layer of the additive build. This gives our products superior mechanical properties, dimensional control, and complexity of product. Because our metal deposition is based on gas metal arc welding (GMAW), we lean on more than 60 years of manufacturing heritage, acceptance criteria, workforce training, inspection methods, equipment development, scientific literature, and worldwide trust of critical structure produced with the method. Every day, we drive over bridges in cars, trusting our lives to both, which have been produced and accepted with GMAW manufacturing. Oh yeah, and our machines are bigger than most. Our goal is not to be the biggest, just to be the best, highest quality products that meet customer requirements and expectations.



You started your talk at TMS2023 by saying that your company makes impossible parts. What does that mean?

Gardner: There are impossible designs and there are impossible schedules. An impossible design might be an incredibly complex geometry like the topology optimized airframe structure that we produced for an Air Force project or it might be the cryogenic tank with optimized cooling channels built into the tank walls we produced for a NASA project. These products extend the imagination of our customers and present opportunities to optimize for assembly, integration, thermal performance, mass/mass distribution, or contained volume. We have courageous, creative, commercial customers pushing boundaries on their product designs to challenge our shared purview of achieving the impossible. This is not only incredibly



This optimized lightweight airframe structure has interior and exterior machined surfaces. Photos provided by Big Metal Additive.



Parts 8 ft tall can be produced on this large BMA machine with a work table 12 ft x 12 ft.

rewarding for me, but it keeps the best of the best interested in working at BMA.

An impossible schedule is another animal altogether. Think of a 12-inch diameter stainless steel valve for a critical application with a 50-week lead time. Plant operations, ships, or submarines are held hostage to these schedule limitations. BMA can produce such an article in a quarter of the time, reducing delivery schedules for pressure vessels, valves, fittings, and other industrial components. Customers appreciate the reduced lead time and are willing to trade higher cost for faster delivery. Keeping their operations and their business moving forward is more important than saving a fraction of cost with months of delay.



What benefits and challenges does your AM process have compared to more traditional production methods?

Gardner: We are growing to a factory of 100 machines. Our AM process is flexible. We can produce a different product on each machine, or we can load the same Digital Production File on every machine and provide surge manufacturing. Wise customers are recognizing the power of having their products in digital inventory. A qualified 155mm artillery round would bring that product into digital inventory and dedicated production with every one of the 100 machines yielding thousands of rounds per day. When the surge manufacturing need was satisfied, the machines would be loaded with new files and other products would be produced.

The challenges we face are that strategy and wisdom do not always prevail. Many decisions are based on cost alone and do not account for schedule or availability

or future orders. The U.S. manufacturing landscape is a testament to this with so many businesses lost over the past few decades because customers would rather send work to competitor countries to save a few bucks.



At TMS2023, your talk—delivered at the Light Metals Division Luncheon—focused on aluminum. Do you work with other materials as well?

Gardner: We started with one material, and it was aluminum. With startup success and business growth, we have expanded into other materials. We respond to customer demand, bringing materials through development and into qualification with business engagement. Our materials portfolio now includes steel, stainless steel, ultra-high strength steel, Inconel, copper-nickel and other nickel alloys. Importantly, we begin with certified wire feedstock materials and qualify the process and resultant materials we offer for customer applications.



What's the next challenge ahead for Big Metal Additive?

Gardner: The next challenge ahead for BMA is a giant leap in growth. As we qualify first articles for customers and create digital inventories, we also prepare for assembling factory lines of machines. We are planning that factory expansion to accommodate a variety of customer parts from a range of different materials. Our growth to a factory of 100 machines will likely occur in groups of ten machines at a time. I mentioned a characteristic lead time of 50 weeks we routinely hear from customers for supply-chain-challenged parts. Because our manufacturing philosophy is based on existing and accepted industrial components, we could stand up a factory line of ten machines in less than 50 weeks. Often, we can scale equipment and produce a customer component in less time than they currently wait for traditional product supply times.



Is there anything else you'd like to add?

Gardner: It's important to know that getting a part into digital inventory is a journey that begins with a prototype that solves challenges and proves feasibility. The next step is a 'first article' that includes creation of a Technical Data Package and then qualifies the part. The result is a digital inventory and readiness for production. All previous process, material, and equipment qualifications are valid for new products, so customers can build on the momentum. A digital inventory can be a cost savings, a schedule savings, or part of a strategic plan. It really is the next big discriminator in manufacturing supply.

CELEBRATING SERVICE WITH A GIFT TO THE TMS FOUNDATION

Kaitlin Calva



Every gift is a celebration.

Last year, the TMS Foundation saw an increase in tribute gifts, which are celebrations in the most obvious way, honoring mentors or colleagues who have so selflessly changed lives. By generously sharing their time, talents, and friendships, they have ensured that the minerals, metals, and materials science and engineering professions will endure. One way that their students and friends have found to repay this service is through a donation, formally recognizing the relationship that helped shape them into the professionals and leaders they are today.

All donations to the TMS Foundation are celebrations, though, not just those which name a particular honoree. Every gift speaks volumes—that the donor believes so strongly in the future of our professions they are willing to make a financial contribution. That they have seen the good work of the Foundation and want to aid in providing scholarships, leadership awards, and grants to the next generation of TMS members. And this service to the future is truly worth celebrating.

In 2023, the TMS Foundation made strides toward achieving the focus goals set forth by the Board of Trustees several years ago. Fifteen additional individuals attended the TMS 2023 Annual Meeting & Exhibition (TMS2023) thanks to expansion of both the Young Leaders Professional Development Awards and TMS Family Care Grants programs made possible by donations from previous years. This puts the

Foundation halfway toward its goal of doubling the Young Leaders Professional Development Awards (currently 15 awards are available, with a final goal of 20) and one-third of the way toward the goal of doubling the TMS Family Care Grants (currently 30 grants are available, with a final goal of 40 grants).

TMS members kept the momentum going with their gifts in 2023, raising a total of \$189,599 from 232 individuals over the course of the year. Twenty-four of those donors made their first gift to the Foundation in 2023. Of the total amount, \$169,298 was raised from October through December during the year-end appeal campaign.

The 2023 Annual Giving Honor Roll and Lifetime Giving Honorable Societies listed on the following pages recognize those donors who so generously gave their support in the past year. Additionally, you will see tribute gifts included on the Honor Roll, calling out the role models who have made all the difference in our members' lives. You can also view the Honor Roll online at www.TMSFoundation.org/HonorRolls.

To earn a spot on the 2024 Honor Roll, make a donation at www.TMSFoundation.org/Contribute.

For additional donation options, visit www.TMSFoundation.org, or to discuss your donation personally, contact Adrienne Carolla, TMS Deputy Executive Director, at 724-814-3180 or acarolla@tms.org.

Thank You to Our 2023 Donors



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2023 Annual Giving Honor Roll *(List updated annually)*

The TMS Foundation offers its sincere thanks to all of the donors listed below. Together, these individual contributions will help to shape the future of the minerals, metals, and materials professions.

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In Honor of Walt Milligan: *"For setting me on a great professional path. Your teaching and mentorship has been essential in my career."*

In Honor of Robert O. Ritchie: *"For all the mentorship you've provided over the years."*

In Honor of Calvin White: *"For the education you provided me in mechanical behavior—an education that I use every day of my life."*

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2023 Annual Giving Honor Roll *(Cont.)*

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Donors gather at the 2023 TMS Foundation Donor Appreciation Dinner, held during the TMS 2023 Annual Meeting & Exhibition in San Diego, California.

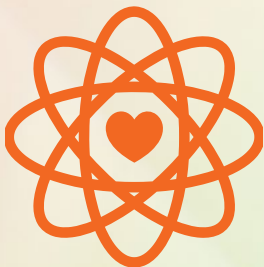
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Kaitlin Calva is an independent contractor providing writing support for TMS and JOM: The Magazine.



It's Easy! Make a Tribute Gift

Continue the spirit of giving by making your next gift to the TMS Foundation in honor or memory of a mentor, colleague, or friend.

Begin your donation using the standard contribution form at www.tms.org/Contribute. Check the "dedicate this gift" box in the Tribute Option section of the form, fill out the relevant fields, and complete the remainder of the donation form. It's that easy!

Cross-Disciplinary Learning and Collaboration: A Preview of the TMS Specialty Congress 2024

Megan Enright

2nd World Congress on
ARTIFICIAL INTELLIGENCE
IN MATERIALS & MANUFACTURING
AIM
2024

Symposium on
**DIGITAL & ROBOTIC
FORMING 2024**

ACCELERATING DISCOVERY
FOR MECHANICAL BEHAVIOR
OF MATERIALS 2024

TMS SPECIALTY CONGRESS 2024

The TMS Specialty Congress 2024 is planned for June 16–20, 2024, at the Cleveland Hilton in Cleveland, Ohio, USA. This inaugural installment of the conference series will feature the following three co-located events: the 2nd World Congress on Artificial Intelligence in Materials and Manufacturing (AIM 2024), Digital and Robotic Forming 2024, and Accelerating Discovery for Mechanical Behavior of Materials 2024. As an exciting addition to the TMS annual event portfolio, this meeting will feature technical talks by experts in the field, multidisciplinary networking opportunities, social and professional development events, and more. Read on to learn more about this conference.

TECHNICAL PROGRAM FEATURES

The 2nd World Congress on Artificial Intelligence in Materials and Manufacturing (AIM 2024)

AIM 2024 is the second event of its kind and will address the key issues and identify future pathways in artificial intelligence (AI) implementation in materials science and engineering and related manufacturing processes. The specific technical topics for AIM 2024 will include:

- AI Application to Non-Destructive Evaluation (NDE & Data)
- Bridging Length Scales (from Laboratory to Manufacturing)
- Data Management: Curation, Collection, and Verification
- High-Throughput Synthesis & Characterization
- Image Processing
- Large Language Models (LLMs) for Materials
- Machine Learning Algorithm Development for Materials Science
- Machine Learning/Deep Learning Applied to Manufacturing Process Optimization
- Machine Learning/Deep Learning Applied to Discovery of Materials
- Robotics & Automation

Learn more about the specific features of AIM 2024 at www.tms.org/AIM2024.

Digital and Robotic Forming 2024

Digital and Robotic Forming 2024 is a new TMS event exploring numerically controlled forming methodologies that include robotics, machine learning, and/or combinations of manufacturing practices and their application to forming techniques, processing science, and the way materials are made. This event will cover:

- Artificial Intelligence/Machine Learning in Robotic Forming
- Fundamentals of Incremental Forming
- Hybrid Processes (e.g., Stamping & Robotic Forming, Robotic Forming & Stretch Forming)
- ICME in Support of Forming Operations
- ICME-Based Design in Robotics
- In-Situ, In-Operando, and Post-Mortem Characterization (Temperature, Strain, Microstructure)
- Industry Application on Infrastructure (includes: Marine, Defense, Automotive, Aerospace, Medical, Large-Scale Energy, Construction, Architecture)
- Methods for 3D/4D Processes
- Robotics: Enabling and Application
- Robotic Forming on Non-Metals
- Tools: Computational and Control

Learn more at www.tms.org/RoboticForming2024.

Accelerating Discovery for Mechanical Behavior of Materials 2024

Accelerating Discovery for Mechanical Behavior of Materials 2024 is another brand new TMS event. It will encompass cutting-edge research and development efforts surrounding mechanical behavior over a wide range of material types, with an emphasis on the underlying microstructural causes.

This meeting will highlight the different techniques and methodologies that research groups are developing to understand the multi-scale mechanisms used to explore mechanical behavior in microstructurally and compositionally complex alloys.

The Accelerating Discovery for Mechanical Behavior of Materials 2024 event will include coverage of the following specific technical topics:

- Accelerated Approaches
- Design
- Machine Learning
- In-Situ and In-Process of Extreme Environments
- Mechanics of Novel Materials

Discover more details about Accelerating Discovery for Mechanical Behavior of Materials 2024 at www.tms.org/MechanicalBehavior2024.

EXHIBIT AT TMS SPECIALTY CONGRESS 2024

A fresh approach to topic-focused events, the TMS Specialty Congress gives you small-event access to your specific customer base, while also enabling you to expand your reach into aligned materials communities through cross-disciplinary events and interactions. For more details and to reserve your exhibit space, visit the Exhibitor and Sponsor page at www.tms.org/SpecialtyCongress2024. Act now, space is limited!

PLENARY AND KEYNOTE SPEAKERS

The TMS Specialty Congress 2024 will feature four all-conference plenary presentations from experts. These leaders in the field will set the tone for this robust technical program. The plenary speakers will include **Chris Eberl**, Fraunhofer Institute; **Ian Foster**, Argonne National Laboratory and the University of Chicago; **Emily Molstad**, VALIS Insights; and **Charles Ward**, Air Force Research Laboratory (retired).

Each co-located meeting will also feature keynote presentations and a number of invited speakers. For Digital and Robotic Forming 2024, **David Furrer**, Pratt & Whitney, will deliver the keynote talk. **Markus Buehler**, Massachusetts Institute of Technology, is the keynote speaker for Accelerating Discovery for Mechanical Behavior of Materials 2024.



Pictured left to right: **Chris Eberl**, Fraunhofer Institute; **Ian Foster**, Argonne National Laboratory and the University of Chicago; **Emily Molstad**, VALIS Insights; **Charles Ward**, Air Force Research Laboratory (retired); **David Furrer**, Pratt & Whitney; and **Markus Buehler**, Massachusetts Institute of Technology

PUBLICATION OPPORTUNITIES

In lieu of traditional conference proceedings, each co-located meeting will be publishing a topical collection dedicated to their event in a TMS journal. Only submissions from participants will be considered for each of these collections. Submissions will go through the journals' standard peer review process.

AIM 2024: AIM 2024 participants are encouraged to submit their work to *Integrating Materials and Manufacturing Innovation*. Submissions are due by August 31, 2024.

Digital and Robotic Forming 2024: *Integrating Materials and Manufacturing Innovation* will also be publishing the topical collection for Digital and Robotic Forming 2024. Submissions are due by August 31, 2024.

Accelerating Discovery for Mechanical Behavior of Materials 2024: *JOM* will be publishing the topical collection for this meeting. Participants should submit by September 1, 2024.

PROFESSIONAL DEVELOPMENT

In addition to the robust technical program, the TMS Specialty Congress 2024 will feature a professional development short course for an additional fee at registration. The **Handling Your Materials Data for Maximum Impact Using the FAIR Data Principles** course will be offered on Sunday, June 16, 2024, from 1:00 p.m. to 5:30 p.m. at the Cleveland Hilton. Expert instructors will introduce the concepts of the FAIR Data Principles (Findability, Accessibility, Interoperability, and Reusability) for materials scientists and engineers and instruct data generators and users on how to implement these principles in their everyday handling of data to maximize their impact.

Attendees will gain a practical working knowledge for materials data generators for how best to handle, curate, and manage materials and manufacturing related data to allow for maximum impact and/or community uptake of the data, while also establishing a working knowledge of some key data platforms available to materials data generators and users.

This course will be taught by lead instructor **Charles Ward**, Air Force Research Laboratory (retired), and additional instructors **David Elbert**, Johns Hopkins University, and **Matthew Jacobsen**, Air Force Research Laboratory.

To secure your place for this course, be sure to select it when registering for the congress.



Pictured left to right: **Charles Ward**, Air Force Research Laboratory (retired); **David Elbert**, Johns Hopkins University; and **Matthew Jacobsen**, Air Force Research Laboratory

NETWORKING AND SOCIAL EVENTS

The TMS Specialty Congress 2024 will have several networking opportunities and social events that will provide attendees with a chance to informally discuss the latest developments in the field, while also making valuable professional connections. Get to know potential collaborators, mentors, and colleagues by attending these events.

Sunday Night Welcome Reception: Introduce yourself to fellow attendees and exhibitors who you will see throughout the week. Light refreshments will be served.

Tuesday Night Poster Session and Reception: Explore the latest research on display at the poster session and enjoy refreshments while talking with presenters.

Extended Networking Breaks: Network with speakers, program officers, participants, and more at the informal networking discussions to be held during the extended breaks throughout the meeting.

Congress Luncheons: Attending the congress luncheon(s) will provide an opportunity to continue to meet and network with attendees. All full-congress registrants receive one ticket to the luncheon of their choice in their registration fee. If you would like to attend additional luncheons, tickets may be purchased during registration. The congress luncheons are:

- **Monday, June 17:**
Digital and Robotic Forming 2024
- **Tuesday, June 18:**
Accelerating Discovery for Mechanical Behavior of Materials 2024
- **Wednesday, June 19:**
AIM 2024

REGISTER BY APRIL 30 AND SAVE

The TMS Specialty Congress 2024 provides a unique opportunity to explore your technical interest in a focused, small event environment, while also having access to cross-disciplinary learning and collaboration opportunities with aligned materials communities. This synergistic event will attract leaders from across industries and locations to collaborate, network, and connect under one roof.

When you register by the **April 30, 2024**, discount deadline, you will save considerably on your registration fee. Register today at www.tms.org/SpecialtyCongress2024.

BOOK YOUR ROOM TODAY

The TMS Specialty Congress 2024 will take place at the Cleveland Hilton in Cleveland, Ohio. A block of rooms has been reserved at the Cleveland Hilton at a special rate for your convenience. In addition to saving you time and money, staying at the congress location will give you convenient access to technical session rooms and social functions, allowing plenty of informal networking opportunities with your colleagues. To take advantage of this special rate, accommodations must be secured by **May 24, 2024**. Book your room today at www.tms.org/SpecialtyCongress2024

SAVE THE DATE

Save the date for these upcoming iterations of the TMS Specialty Congress series.

**TMS SPECIALTY
CONGRESS 2025**

JUNE 15–19, 2025
Anaheim Marriott
Anaheim, California, USA

**TMS SPECIALTY
CONGRESS 2026**

JUNE 21–25, 2026
Anaheim Marriott
Anaheim, California, USA

www.tms.org/SpecialtyCongress

TMS MEETING HEADLINES

Meeting information is current as of January 31, 2024. For the most recent updates on TMS-sponsored events, visit www.tms.org/Meetings.

TMS Specialty Congress 2024



June 16–20, 2024
Cleveland, Ohio,
USA

Discount Registration Deadline: April 30, 2024

"Who should be attending and participating in the TMS Specialty Congress? I really see it as people who are at the forefront of our field, are pushing in new directions, and are studying very innovative new topics," said Tim Rupert, TMS Programming Director and member of the TMS Specialty Congress 2024 Steering Committee.

www.tms.org/SpecialtyCongress2024

15th International Symposium on Superalloys (Superalloys 2024)



September 8–12, 2024
Champion, Pennsylvania,
USA

Discount Registration Deadline: July 31, 2024

The 15th International Symposium on Superalloys aims to highlight advances in superalloy technologies for the sustainable future. These technologies have enabled enhanced fundamental understanding of the material behavior and helped to improve the processing and performance of existing materials while accelerating the development of new alloys.

www.tms.org/Superalloys2024

TMS Fall Meeting 2024 at Materials Science & Technology (MS&T24)



October 6–9, 2024
Pittsburgh, Pennsylvania,
USA

Abstract Submission Deadline: May 1, 2024

TMS Fall 2024 presents robust programming, networking and social activities, and professional development events tailored to TMS member interests within the broader structure of the MS&T conference series, giving attendees an opportunity to experience both their TMS community and the resources of all the MS&T partnering societies.

www.tms.org/TMSFall2024

OTHER MEETINGS OF NOTE



TMS 2025 Annual Meeting & Exhibition (TMS2025)

March 23–27, 2025
Las Vegas, Nevada, USA

www.tms.org/TMS2025



TMS Specialty Congress 2025

June 15–19, 2025
Anaheim, California, USA

www.tms.org/SpecialtyCongress2025



Extraction 2025 Meeting & Exhibition (Extraction 2025)

November 16–20, 2025
Phoenix, Arizona, USA

www.extractionmeeting.org/Extraction2025

CO-SPONSORED MEETINGS

Offshore Technology Conference 2024

May 6–9, 2024
Houston, Texas, USA
Co-sponsored by TMS

4th International Symposium on Electrometallurgy - part of the 63rd Conference of Metallurgists (COM 2024)

August 19–22, 2024
Halifax, Nova Scotia, Canada
Co-organized by TMS

Solidification and Casting of Aluminium Alloys: From Basics to Technology

September 2–6, 2024
Brunel University, London, United Kingdom
Co-sponsored by TMS

EXHIBIT OPPORTUNITIES

TMS SPECIALTY CONGRESS 2024

JUNE 16-20, 2024

Cleveland Hilton

Cleveland, Ohio, USA

#TMSSpecialtyCongress

The TMS Specialty Congress series convenes multiple specialty meetings under one roof, giving you three shows for the price of one! For attendees and exhibitors alike, that means more opportunities and less travel. The inaugural TMS Specialty Congress in 2024 will showcase some of the hottest topics in materials science within three co-located technical meetings:



WHO YOU WILL MEET

The TMS Specialty Congress 2024 is projected to attract approximately 500 attendees, with 40 to 50% traveling from outside the United States. Based on experience with smaller specialty meetings, we are expecting to welcome the following types of professionals to this new and larger event:

INDUSTRIES

Aerospace, architecture, automotive, construction, defense, large-scale energy, marine, and medical

ORGANIZATIONS

Industrial R&D laboratories, metal producers and OEMs, government and non-profit laboratories, university-based research laboratories

ATTENDEES

Metallurgists, R&D engineers, principal engineers, staff and senior scientists, data specialists, group leaders, university faculty and researchers, graduate students, and early-career professionals

THE FUTURE OF YOUR TEAM IS HERE

Specialty Congress offers opportunities for companies to introduce themselves to the top emerging professionals in the field of materials science and engineering. An exhibit display showing all your company has to offer can help you recruit the best and brightest!

INTERESTED IN EXHIBITING? TAKE THE NEXT STEP

Talk to a member of the TMS Sales Team to learn how Specialty Congress can be an efficient and effective way to meet new customers and collaboration partners. Contact the TMS Sales Team at sales@tms.org or by calling 1-724-814-3140.

BECOME A FOUNDING SUPPORTER

Since this is the inaugural Specialty Congress, all exhibitors and sponsors for 2024 will receive the designation of "Founding Supporter" for future annual iterations—that will mean special recognition and priority bookings for future events!

THE WORLD COMES HERE.
TMS 2025
154th Annual Meeting & Exhibition

March 23–27, 2025

MGM Grand Las Vegas Hotel & Casino
Las Vegas, Nevada, USA

#TMSAnnualMeeting | www.tms.org/TMS2025



**SEE YOU IN
LAS VEGAS
FOR
TMS2025!**

JOIN US NEXT YEAR

For the first time in 30 years, the TMS Annual Meeting & Exhibition is headed to Las Vegas, Nevada. The event has already attracted 120 symposium proposals, promising a strong technical program and demonstrating high interest in our new location.

HOUSING IS NOW OPEN

Reserve your room today at the MGM Grand Las Vegas Hotel & Casino, the headquarters hotel for TMS2025.

MARK YOUR CALENDAR

May 2024: Call for Abstracts Opens
October 2024: Registration Opens
March 23–27: Conference Dates





SUBMIT AN ABSTRACT

ABSTRACTS DUE: NOVEMBER 1, 2024

NOVEMBER 16-20, 2025

Sheraton Grand at Wild Horse Pass
Phoenix, Arizona, USA | #ExtractionMeeting

FEATURING:



**DON'T MISS YOUR OPPORTUNITY TO
SHARE YOUR WORK**
with the global extractive metallurgy community.

ORGANIZING SOCIETIES:



For more details and to submit your abstract visit:
www.extractionmeeting.org/2025