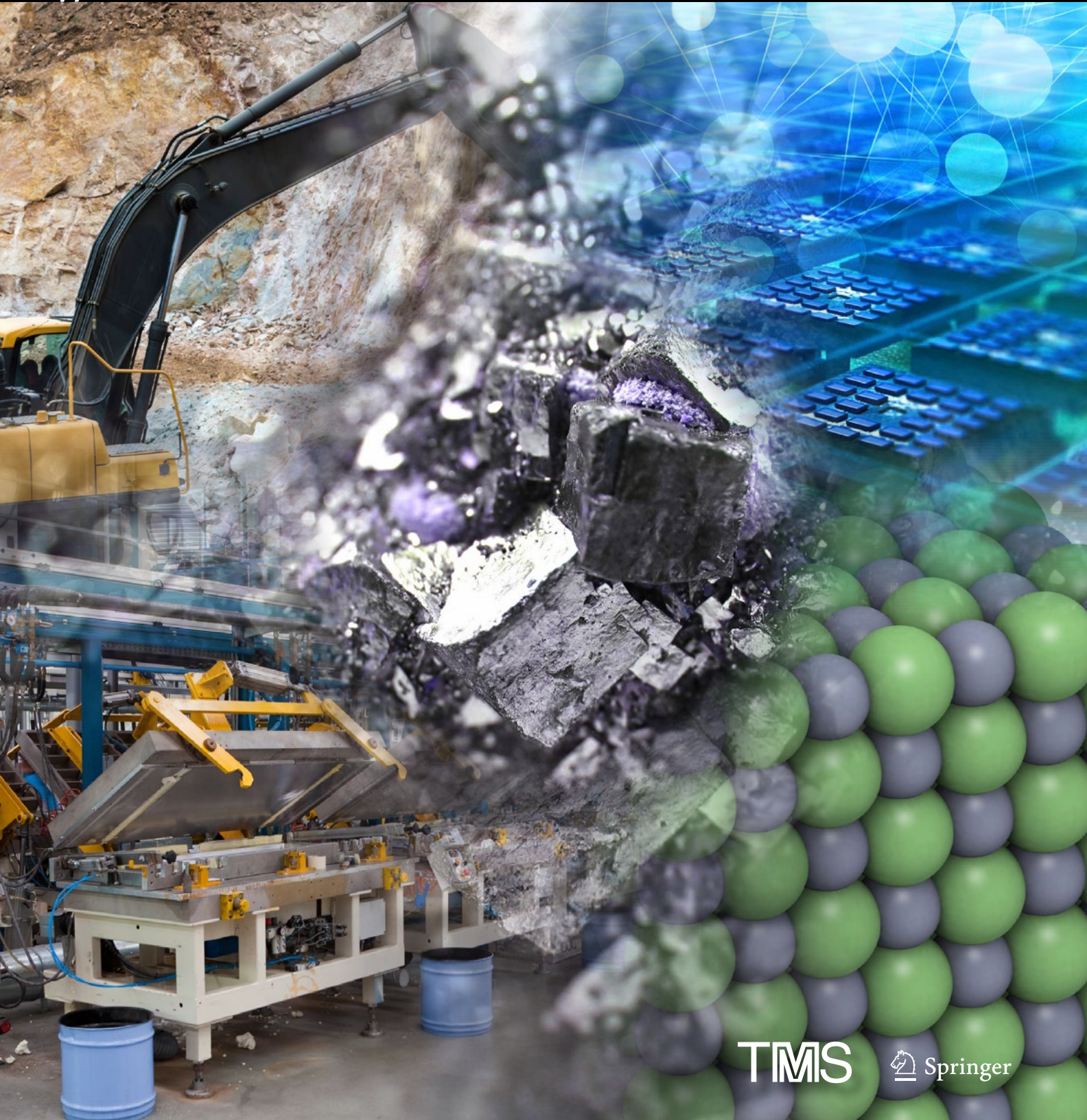


JOM

AUGUST 2023
www.tms.org/JOM

An official publication of The Minerals, Metals & Materials Society



TMS

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153rd Annual Meeting & Exhibition

MARCH 3–7, 2024

HYATT REGENCY ORLANDO | ORLANDO, FLORIDA, USA

#TMSAnnualMeeting | www.tms.org/TMS2024



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at the Hyatt Regency Orlando resort for the meeting that brings the global minerals, metals, and materials communities together.

This is a new venue for TMS, and the resort will be the location for all TMS2024 programming and events. Plan to stay at the headquarters hotel for easy access to activities, five on-site restaurants, and a number of additional amenities.

MARK YOUR CALENDAR WITH THESE KEY DATES

October 2023: Registration Opens | **February 6, 2024:** Housing Deadline
March 3–7, 2024: Conference Dates

SEE YOU IN ORLANDO!

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GUEST EDITORS

August 2023 Guest Editors

Advances in Grain Refinement during Solidification

Solidification Committee

Catherine Tonry, University of Greenwich, and Kara LuitJohan,
 Los Alamos National Laboratory

Solid-state Processing of Light Alloys

Aluminum Committee

Dmitry Eskin, Brunel University London

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.

Publishing Information:

JOM is an official publication of The Minerals, Metals & Materials Society and is owned by the Society. TMS has granted Springer the exclusive right and license to produce, publish, archive, translate, and sell *JOM* throughout the world. Publication Frequency: 12 issues per year. Springer, 1 New York Plaza, Suite 4600, New York, NY 10004-1562, USA
JOM articles from 1949 to the present are archived at
<https://link.springer.com/journal/11837/volumes-and-issues>

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IN THE FINAL ANALYSIS

JOM
THE MAGAZINE

"I am really proud to call this my home society. I will be supporting TMS meetings in the future and will commit to doing my part to create a more welcoming environment in all activities I participate in."

—TMS Member Raymundo Arroyave

The above is an excerpt from a LinkedIn posting made by Dr. Arroyave in response to a public statement issued by TMS President Brad Boyce and myself in late May 2023. The focus of our statement? The efficacy of holding conferences in the state of Florida. Why was it necessary to issue a statement about holding meetings in Florida? It has been a frequent and successful venue for the Society. What changed? The answer is in our statement's first paragraph: "We are distressed to see the recent actions by the Florida state government that effectively unwinds decades of the state's progress in areas associated with diversity, equity, and inclusion. . . . The affronts to Black, Hispanic and Latino/Latina, LGBTQ+, and other marginalized groups are well documented by U.S. news organizations."

Florida has been adding laws since 2022 that do not track with Goal 1 of the TMS Aspires Strategic Plan: "TMS aspires to be a highly inclusive society where all materials students and professionals feel welcome, and diversity is celebrated." Some TMS members ask about TMS2024 in Orlando, will I be welcome and safe or discriminated against and harassed? Trepidations are also expressed by those not worried for themselves but who have concerns for the well-being of others.

What can TMS do beyond offering expressions of empathy? We begin by acknowledging what we cannot do. TMS does not have the resources, voice, or standing to sway Florida's government. Even mighty Disney—a corporate colossus with a strong DEI agenda, staggering influence, and an enormous economic footprint in Florida—finds itself in a grinding legal conflict with the state because it gave voice to concerns about the new DEI restrictions. Disney World is Florida's largest employer and comprises a physical infrastructure the size of San Francisco. There is no putting that oversize load on the back of a tractor trailer and moving it to Virginia. Similarly, TMS has binding contracts with hotels in Orlando for three annual meetings in the 2020s. Exiting those contracts would bankrupt TMS. Was that careless planning? No. We are always cautious with the endless considerations that go into selecting meeting sites, but it is exceptionally difficult to know, seven or more years in advance when contracts are negotiated, which sites will be safe harbors and which will devolve into treacherous shoals.

Knowing our disadvantages, what are our advantages? Beyond TMS2024 delivering the materials event experience to which we have all become accustomed, there are many aspects of the venue that work in our favor. While Orlando is in Florida, the culture of the city is not the same as that of the state. Built on the business of hospitality, Orlando scores 100 out of 100 on the Human Rights Campaign's Municipal Equality Index. The city's visitors' bureau, VisitOrlando, says that the city "strives to be the nation's most inclusive travel destination, welcoming people from all over the planet to enjoy everything we have to offer regardless of their gender, ethnicity, sexual orientation or life stage."

Similarly, our TMS2024 host headquarters hotel/conference facility—the Hyatt Regency Orlando—has a like commitment from the corporate side: "Our purpose to care for people so they can be their best every day only has meaning because we care for everyone with no exceptions. Guests. Colleagues. Suppliers. Owners. And all others." The entirety of TMS2024 will be housed and conducted within this single venue located on the aptly named International Drive.

Our Society, our host city, and our host hotel are aligned to deliver a safe, comfortable, convenient, inclusive, and welcoming TMS2024 while enabling us to continue advancing the minerals, metals, and materials community. TMS exists to bring people together, and we will continue working hard to do that very thing.

Volume 75

Number 8

August 2023



James J. Robinson
Executive Director

[@JJRoTMS](https://twitter.com/JJRoTMS)

"Our Society, our host city, and our host hotel are aligned to deliver a safe, comfortable, convenient, inclusive, and welcoming TMS2024."

JOM TECHNICAL TOPICS

JOM
THE MAGAZINE

JOM: The Journal includes peer-reviewed technical articles covering the full range of minerals, metals, and materials. TMS members receive free electronic access to the full library of TMS journals, including *JOM*. For the full Editorial Calendar, visit www.tms.org/EditorialCalendar.

Review the technical topics included in the current issue of *JOM*: The Journal here, and then go to www.tms.org/JOM to log in for access to technical journal articles on the Springer website.

// AUGUST 2023

Advances in Grain Refinement during Solidification

Scope: Grain refinement is a proven technique for improving the strength and plasticity of alloys. This special topic focuses on recent developments of methods and techniques for achieving grain refinement prior to and during solidification. These include mechanical methods such as ultrasonic treatment, electromagnetic processing, and high shear melt processing as well as other novel techniques for improving the effect of grain refiners.

Editors: Catherine Tonry, University of Greenwich, and Kara LuitJohan, Los Alamos National Laboratory

Sponsor: Solidification Committee

Solid-state Processing of Light Alloys

Scope: Solid-state processing of light alloys encompasses a wide range of technologies aimed at forming semi-finished and final products without involving melting, remelting, or casting. This special topic covers advances in fundamental, applied, and numerical research and technology development, which results in the significantly improved properties and performance of light-alloy products. The targeted processes include (but are not limited to): rolling, extrusion, stamping, forging, sintering, and thermo-mechanical processing of aluminum, magnesium, and titanium.

Editor: Dmitry Eskin, Brunel University London

Sponsor: Aluminum Committee

Contribute to *JOM*: The Journal



Visit www.tms.org/JOM to access author tools that will answer your questions during every step of the manuscript preparation process, from determining the appropriate technical topic for your paper to reading the final product on SpringerLink.

For further information on contributing to *JOM*, contact *JOM* Editor Maureen Byko at mbyko@tms.org.

JOM: The Journal 2024–2025 Editorial Calendar Is Open for Submissions

Maureen Byko
and Kelly Markel

The 2024–2025 editorial calendar for *JOM: The Journal* is open for submissions. With 42 special topics scheduled from January 2024 through March 2025, the calendar offers potential authors a wealth of subject areas to host their work. And if none of those subject areas are a good fit, the popular “Technical Articles” sections will be returning for a second year to accommodate manuscripts that meet *JOM*'s scope, but not necessarily the scope of any planned topics.

We at *JOM* look forward to collaborating with and supporting our volunteers in another successful publishing year.

JOM



Introducing Publications Managing Editor Kelly Markel

Have a question about publishing in *JOM: The Journal*? Kelly Markel, the new Publications Managing Editor, is here to help. Markel was promoted to the position in June 2023, after working across the six TMS journals for more than three years. Her wide-ranging publications experience will benefit *JOM* volunteers, including authors and guest editors who might have questions about matters such as submitting manuscripts, navigating Editorial Manager, organizing special topics, and more.

You can reach her by email at kmarkel@tms.org and by phone at 724-814-3108.



JOM Editorial Calendar Highlights

The *JOM* Editorial Calendar typically includes special topics planned by TMS technical committees, manuscript collections from symposia and conference organizers, and occasional special topics developed by individual TMS members. Technical Committee contributions, however, are essential to the success of the journal. At the time this article was published, 32 committees had planned topics for the coming year—a strong representation of the interests of TMS members, its committees, and the five technical divisions into which the committees are organized. The following topics are some examples from committees within each division. View the full calendar at www.tms.org/EditorialCalendar to search by topic, committee sponsor, or guest editor name.

Extraction & Processing Division

- **Recent Developments on Metals and Energy Extraction from Waste Streams:** Recycling and Environmental Technologies Committee and Energy Committee
- **Sustainable Recovery of Refractory and Photovoltaic Metals:** Hydrometallurgy and Electrometallurgy Committee

Functional Materials Division

- **Advanced Functional and Structural Thin Films and Coatings:** Thin Films and Interfaces Committee
- **Advances in Biomaterials and Materials for Biomedical Applications:** Biomaterials Committee

Light Metals Division

- **Advanced Techniques for Investigating Twinning in Magnesium Alloys:** Magnesium Committee
- **Aluminum: Eliminating GHG Emissions:** Aluminum Committee

Materials Processing & Manufacturing Division

- **Advanced Characterization of Additively Manufactured Materials:** Additive Manufacturing Committee
- **Deformation-Assisted Pathways to Microstructural Manipulation:** Phase Transformations Committee and Shaping and Forming Committee

Structural Materials Division

- **Future Manufacturing Empowered by Nanomaterials:** Nanomaterials Committee
- **Thermo-mechanical Processing of Steels for Sustainable Energy Utilization:** Steels Committee

How to Publish in JOM

Visit the **Editorial Calendar** (www.tms.org/EditorialCalendar), where you can view the full calendar and search by keyword for a topic that fits your expertise. The topic's "Details" page offers the full scope and other useful information. If no topics are appropriate, plan to submit as a Technical Article.

Next, prepare your manuscript according to the **JOM Instructions for Authors** found at www.tms.org/AuthorTools. And finally, submit your manuscript through **Editorial Manager** at www.editorialmanager.com/jomj.

New Topics Invited for 2024-2025

Although the 2024-2025 Editorial Calendar offers a bounty of relevant, timely topics, there is always room for more. *JOM* is seeking TMS members to organize collections of four to six articles, particularly in emerging and developing research areas. Consider developing a topic around your own work and inviting colleagues and other prominent researchers in this area to contribute.

Please keep the following in mind when planning a new topic:

- All *JOM* submissions must have two reviews before a decision can be entered.
- Topic organizers can submit their own work, but the review and decision process must be handled by another expert in the subject area.
- New topics should not conflict with any on the existing editorial calendar.
- Topics should be submitted via www.tms.org/TopicSubmission. This form includes the submission deadline for each month to help you set a realistic publication target.

Become a JOM Peer Reviewer

Get a look at current work in your field while sharing your expertise with the materials community by becoming a peer reviewer. *JOM* is seeking reviewers who:

- Have published articles in their specialty areas
- Are currently practicing in the area(s) they want to review
- Have experience reviewing scientific manuscripts

If you are interested in becoming a peer reviewer, please send a brief description of your experience as a reviewer, along with a CV, to Kelly Markel, TMS Publications Managing Editor at kmarkel@tms.org.

TMS Welcomes New Members

Jillian Schultz

The TMS Board of Directors approved professional membership for the following individuals at its May 2023 meeting. Please join us in congratulating and welcoming them to all the privileges and benefits of TMS membership.

Approved May 2023

Acar, Sevket; Acar Consulting, LLC, United States

Al-Omari, Imaddin; Sultan Qaboos University, Oman

An, Ke; Oak Ridge National Laboratory, United States

Antrekowitsch, Juergen; Montanuniversitat Leoben, Austria

Barker, Erin; Pacific Northwest National Laboratory, United States

Beaudoin, Armand; University of Illinois, United States

Beeler, Benjamin; North Carolina State University, United States

Brinson, L. Catherine; Duke University, United States

Cao, Changyong; Case Western Reserve University, United States

Chang, Chih-Hung; Oregon State University, United States

Chen, Bilin; Indiana University/Big River Steel, United States

Cherukara, Mathew; Argonne National Laboratory, United States

Courtenay, John; MQP Ltd, United Kingdom

Das, Sazol; Novelis, United States

Dos Santos, Jorge; Pacific Northwest National Laboratory, United States

Dux, Tiffany; Howmet Aerospace, United States

Echlin, McLean; University of California, Santa Barbara, United States

Edmondson, Philip; University of Manchester, United Kingdom

Euh, Kwangjun; Korea Institute of Industrial Technology, Korea, South

Fecher, Jonas; Heraeus Precious Metals, Germany

Gerard, Celine; Pprime Institute CNRS Ensma, France

Gill, Simerjeet; Brookhaven National Laboratory, United States

Golumbskie, William; Naval Surface Warfare Center Carderock Division, United States

Gopalan, Srikanth; Boston University, United States

Gussev, Maxim; Oak Ridge National Laboratory, United States

Habel, Ulrike; MTU Aero Engines AG, Germany

Harder, Ross; Argonne National Laboratory, United States

Hassan, Suleiman; Nigerian Institute of Mining and Geosciences, Nigeria

Hung, Chang-Yu; National Energy Technology Laboratory, United States

Hurley, David; Idaho National Laboratory, United States

Jacobs, Tevis; University of Pittsburgh, United States

Jain, Anubhav; Lawrence Berkeley National Laboratory, United States

Jeldi, Arun; Lite Magnesium Products Inc, United States

Jiang, Chao; Idaho National Laboratory, United States

Jyothi, Rajesh Kumar; Korea Institute of Geoscience & Mineral Resources, Korea, South

Kang, Daehoon; Novelis, United States

Khafizov, Marat; Ohio State University, United States

Komarasamy, Mageshwari; Pacific Northwest National Laboratory, United States	Nagahama, Daisuke; Honda R&D Co., Ltd, Japan	Sokolov, Mikhail; Oak Ridge National Laboratory, United States
Kudzal, Andelle; Naval Surface Warfare Center Carderock Division, United States	Najmaei, Sina; U.S. Army Research Laboratory, United States	Son, Hyeon-Taek; Korea Institute of Industrial Technology, Korea, South
Le Brun, Pierre; Constellium Technology Center (C-Tec), France	Nelson, Andrew; Oak Ridge National Laboratory, United States	Stockinger, Martin; Montanuniversitat Leoben, Austria
Lee, Kee-Ahn; Inha University, Korea, South	Niu, Xiaoping; Magna Cosma Promateck Research Center, Canada	Sulejmanovic, Dino; Oak Ridge National Laboratory, United States
Lee, Hyo-Soo; Korea Institute of Industrial Technology, Korea, South	Ossa, Alex; Universidad Eafit, Colombia	Svensson, Ann Mari; Norwegian University of Science and Technology, Norway
Legzdina, Daira; Honeywell Aerospace, United States	Paranthaman, Mariappan; Oak Ridge National Laboratory, United States	Swanson, Alan; ATI Specialty Materials, United States
Li, Yi; Shenyang National Laboratory for Materials Science, China	Park, Jaihyun; Research Institute of Industrial Science and Technology, Korea, South	Tabor, Christopher; U.S. Air Force Research Laboratory, United States
Lim, Hyun Kyu; Korea Institute of Industrial Technology, Korea, South	Perez, Camilo; Rhi Us Ltd., United States	Tower, Eric; Pyrotek, United States
Lolla, Tapasvi; Electric Power Research Institute, United States	Pownceby, Mark; Commonwealth Scientific and Industrial Research Organization, Australia	Tucker, Melinda; Netzsch Instruments North America LLC, United States
Love, Corey; U.S. Naval Research Laboratory, United States	Provatas, Nikolas; McGill University, Canada	Usatiuk, Alexander; Mag Specialties Inc., United States
Martin, Wendy; Special Melted Products Ltd, United Kingdom	Rai, Beena; Tata Consultancy Services, United States	Vendette, Hugues; Aluminair Inc., Canada
Martinez, Ramon; Los Alamos National Laboratory, United States	Roberts, Scott; Sandia National Laboratories, United States	Vivek, Anupam; Ohio State University, United States
Marx, Michael; Saarland University, Germany	Rose, Scott; Boeing Company, United States	Wang, Weiling; Northeastern University, China
McIntyre, Daryl; Special Melted Products Ltd, United Kingdom	Ross, Kenneth; Pacific Northwest National Laboratory, United States	Wegner, Matthias; Heraeus Precious Metals, Germany
Meher, Subhashish; Idaho National Laboratory, United States	Sankar, Jagannathan; North Carolina A&T State University, United States	Widgeon Paisner, Scarlett; Los Alamos National Laboratory, United States
Meredig, Bryce; Citrine Informatics, United States	Sauber, Maziar; CanmetMINING, Canada	Wilson, David; United States
Misra, Devesh; University of Texas at El Paso, United States	Scarsella, Alessio; Metso Outotec, Germany	Winter, Ian; Sandia National Laboratories, United States
Mori, Hisashi; Railway Technical Research Institute, Japan	Shao, Lin; Texas A&M University, United States	Yamanaka, Akinori; Tokyo University of Agriculture and Technology, Japan
Msomi, Velaphi; Cape Peninsula University of Technology, South Africa	Shingledecker, John; Electric Power Research Institute, United States	Yin, Fei; Wuhan University of Technology, China
		Zhu, Miao-yong; Northeastern University, China

TMS MEETING HEADLINES

Meeting dates and locations are current as of June 1, 2023.

For the most recent updates on TMS-sponsored events, visit www.tms.org/Meetings.



TMS Fall Meeting 2023 @ Materials Science & Technology (MS&T23)

October 1–4, 2023
Columbus, Ohio, USA

Discount Registration Deadline:
September 7, 2023

The TMS Fall 2023 technical program will address structure, properties, processing, and performance across the materials community. Its exhibition showcases a wide variety of equipment and services to the automotive, aerospace, instrumentation, medical, oilfield, and energy industries.

www.tms.org/TMSFall2023



3rd World Congress on High Entropy Alloys (HEA 2023)

November 12–15, 2023
Pittsburgh, Pennsylvania, USA

Discount Registration Deadline:
September 27, 2023

HEA 2023 will feature highly focused technical talks on topics that include, but are not limited to, fundamental theory of alloy design, computational modeling and simulation, properties, processing, and applications of high entropy alloys.

www.tms.org/HEA2023



TMS 2024 Annual Meeting & Exhibition (TMS2024)

March 3–7, 2024
Orlando, Florida, USA

Make Plans to Attend

The TMS Annual Meeting & Exhibition will be held under one roof at the Hyatt Regency Orlando. Join your colleagues from around the world for five days of technical programming, networking activities, award ceremonies, exhibit events, and more.

www.tms.org/TMS2024



TMS Specialty Congress 2024

June 16–20, 2024
Cleveland, Ohio, USA

Abstract Submission Deadline:
October 30, 2023

The TMS Specialty Congress will feature three co-located events: the 2nd World Congress on Artificial Intelligence in Materials & Manufacturing 2024, the Symposium on Digital & Robotic Forming 2024, and Accelerating Discovery for Mechanical Behavior for Materials 2024.

www.tms.org/SpecialtyCongress/2024

Other Meetings of Note



The 15th International Symposium on Superalloys (Superalloys 2024)

September 8–12, 2024
Champion, Pennsylvania, USA

www.tms.org/Superalloys2024



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/SpecialtyCongress/2025



Extraction 2025 Meeting & Exhibition (Extraction 2025)

November 16–20, 2025
Phoenix, Arizona, USA

www.extractionmeeting.org/Extraction2025

10th International Symposium on Lead and Zinc Processing (PbZn2023)

October 18–20, 2023
Changsha, China

Co-sponsored by TMS

OTC Brasil 2023

October 24–26, 2023
Rio de Janeiro, Brazil

Co-sponsored by TMS

11th Pacific Rim International Conference on Advanced Materials and Processing

November 19–23, 2023
Jeju, South Korea

Co-sponsored by TMS

Materials in Nuclear Energy Systems (MINES 2023)

December 10–14, 2023
New Orleans, Louisiana, USA

Co-sponsored by TMS

WHERE MATERIALS PEOPLE

COLLABORATE

TMS makes a global community of materials professionals accessible to you. Connect in person at TMS events or reach out virtually to begin building or growing your network of international colleagues and experts.



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TMS

MEMBERSHIP

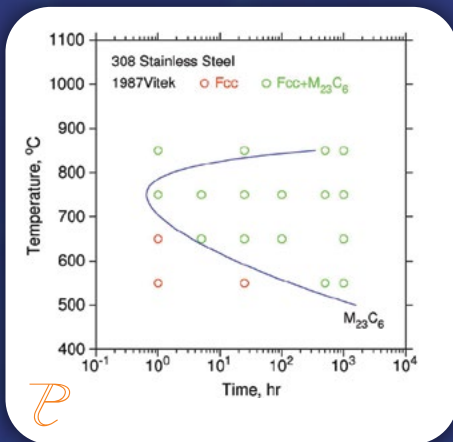
Thermo-Calc Software

Empowering Metallurgists, Process Engineers and Researchers

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

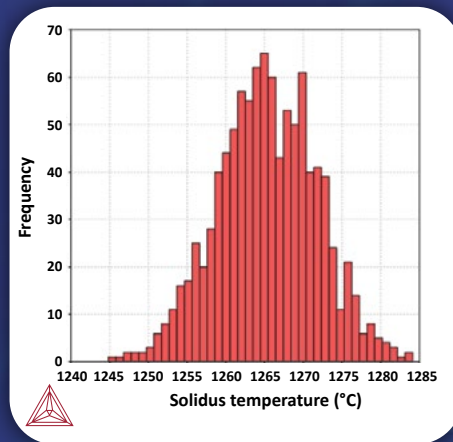
Gain insight into materials processing

Precipitation



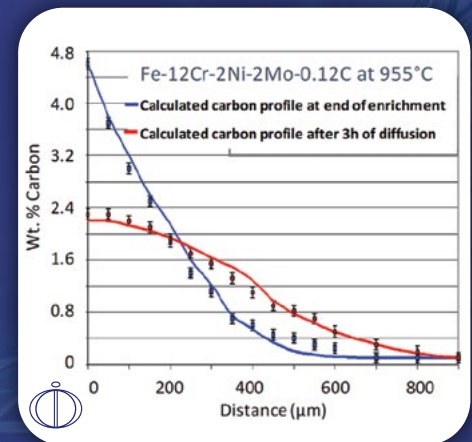
Time temperature precipitation of $M_{23}C_6$ in 308 stainless steel

Solidification



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

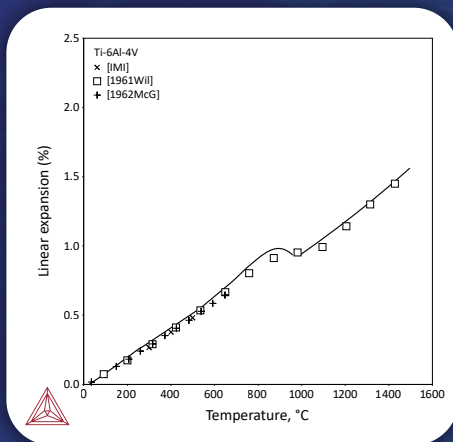
Diffusion



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

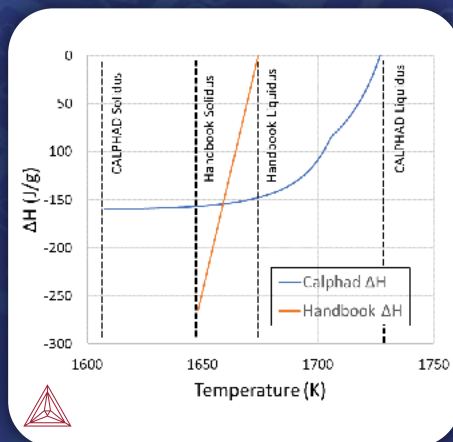
Predict a wide range of materials property data

Thermophysical Data



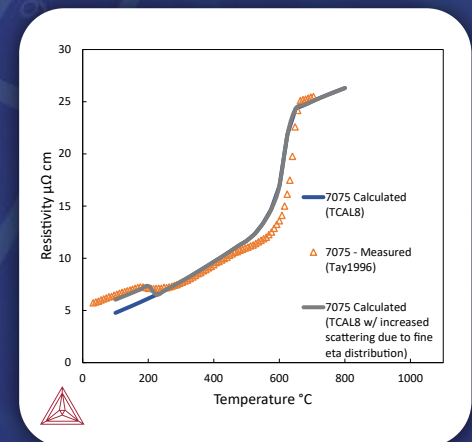
Linear expansion vs temperature for Ti-6Al-4V

Thermodynamic Properties



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

Electrical Resistivity



Calculated electrical resistivity of aluminum alloy 7075