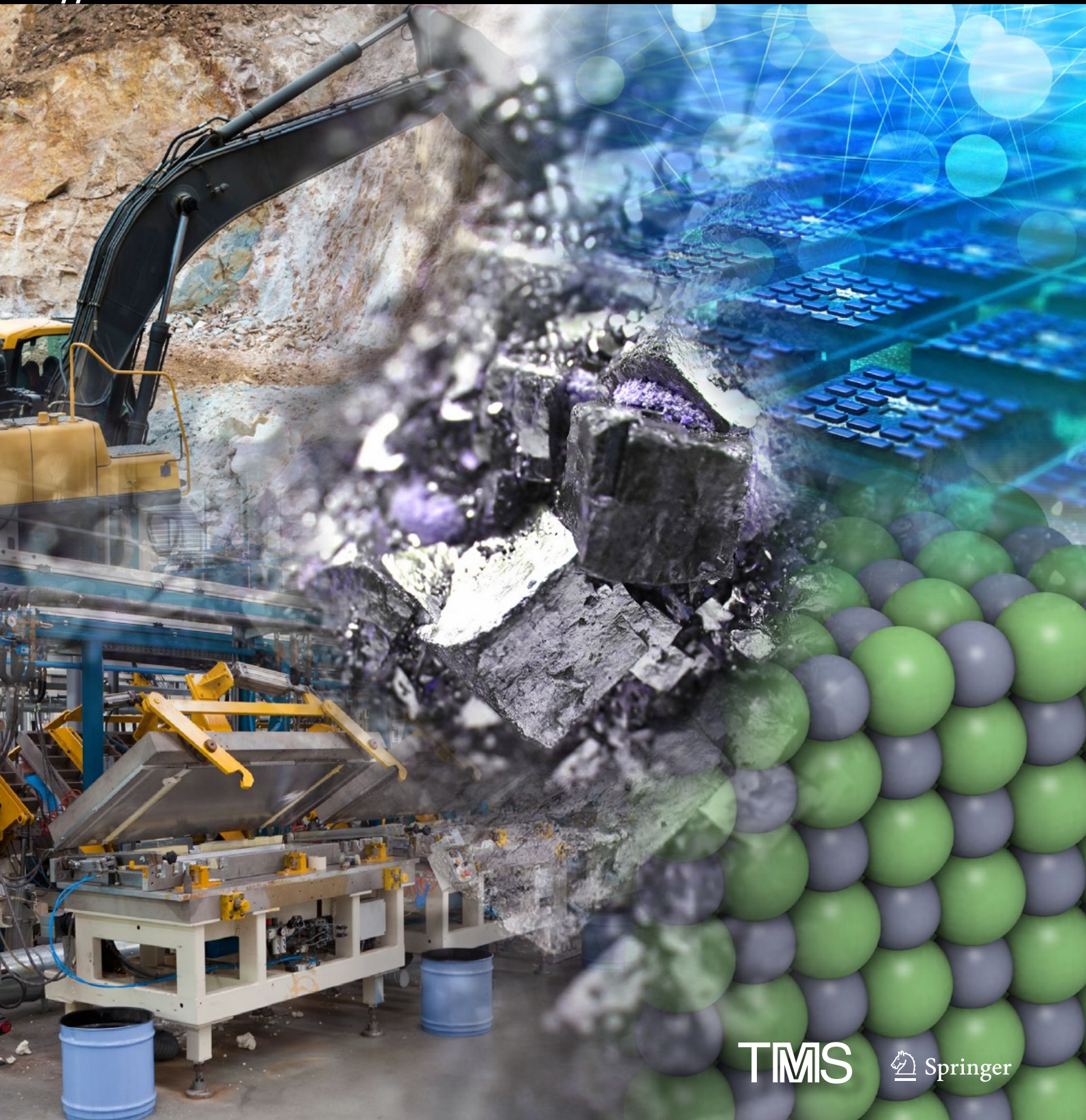


JOM

MAY 2023

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An official publication of The Minerals, Metals & Materials Society



TMS

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May 2023 Guest Editors

Heterostructured Materials: A Fast Emerging Materials Field

Mechanical Behavior of Materials Committee

Yuntian Zhu, City University of Hong Kong; Enrique Lavernia, University of California, Irvine;
 and Xiaolei Wu, State Institute of Mechanics

High-Temperature Phases and Processes for Enabling Cleaner Production of Metals and Energy

*Recycling and Environmental Technologies Committee, Energy Committee, and Process Technology
 and Modeling Committee*

Fiseha Tesfaye, Abo Akademi University; Joseph Hamuyuni, Metso Outotec;
 Hong Peng, University of Queensland; Chukwunwike O. Iloeje, Argonne National Laboratory;
 and Dirk Verhulst, Devv

Process Intensification in Hydro- and Electrometallurgy

Hydrometallurgy and Electrometallurgy Committee

Kerstin Forsberg, KTH Royal Institute of Technology,
 and Athanasios Karamalidis, Penn State University

Reducing CO₂ Emissions from Bauxite to Aluminum Reduction

Aluminum Committee

Jayson Tessier, Alcoa

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

"Some folks back home decided they wanted a law passed | So they called their local Congressman, and he said | You're right, there oughta be a law. | Then he sat down | And wrote me out and introduced me to Congress. | And I became a bill, and I'll remain a bill | Until they decide to make me a law."

—*"I'm Just a Bill"* by Dave Frishberg

Schoolhouse Rock is celebrating its fiftieth anniversary this year. Some readers are now going to have "Conjunction Junction" stuck in their heads for the next 30 minutes. You're welcome! For those not in the know, *Schoolhouse Rock* was nothing less than a lightning strike of educational ingenuity. Using a short, catchy song and accompanying cartoon, each installment engagingly imprinted on kids (and, I suspect, many adults). We learned sometimes difficult concepts from grammar, multiplication, America, science, money, and the environment. For many of us, countless segments have lingered a lifetime. "I'm Just a Bill" is one of my favorites as it engagingly explains the long path of how a bill can successfully become a law in the United States. As a person who is supposed to be conversational on all aspects of TMS governance, I often wish that I could muster the conciseness and clarity of "I'm Just a Bill" to easily dispel the mysteries of TMS governance apparatuses for staff and volunteers alike.

If I could sing, write music and lyrics, play guitar, and possess cartooning talent, I would create my own series: *Mineral Metal Material Rocks*. The first episode would be, "I'm Just a Board Nominee," and it would explain how a TMS member is elected to serve on the Board of Directors. TikTok would love it, and we would soon have TMS "governance challenges" going viral. Tempting, but I should stick to wordsmithing.

So, about the selection of new Board members. . . . It is important to recognize that there are two key governing forces at work in the selection of directors. The first is governance requirements imposed by the TMS Bylaws. The second is procedures developed by the Board of Directors to satisfy the bylaws requirements.

The bylaws specify that the Board is to consist of 13-15 members serving three-year terms. Qualifications to serve? Be a TMS member for at least three years prior to being elected as director. All directors must be approved for service by the TMS membership via the presentation of a slate of candidates assembled by the Board of Directors. If the membership does nothing in response to the slate, the nominees on the slate are automatically elected. Alternatively, 25 members can advance a separate candidate for one of the opening positions and require that an election be held.

The Board of Directors cannot supersede the bylaws, so they must devise compliant implementation procedures. So, the Board has determined that 14 is the optimum number of Board members. They have also determined that outside of individuals in the Presidential Cycle, all Board members must serve as chair of a functional committee or technical division. There are no at-large members.

What about that slate of candidates; how is it developed? Two ways: First, each technical division council elects a candidate to lead the division, The Board automatically adds that candidate to the slate. Second, the Board appoints the Nominating Committee to review incoming nomination packages that are submitted for all other Board positions. Any member in good standing can submit a nomination package. The Nominating Committee identifies who they believe to be the best suited candidate from among the nominees and gives a recommendation to the Board. The Board of Directors considers the recommendations and then decides whether to add those nominees to the slate or make changes. From there, it's up to the membership as to what happens next.

While the process can look daunting, it is rich in onramps for engaging as a candidate and for being heard as a member. Plus, it's a lot easier to understand than how a bill becomes a law!

Volume 75

Number 5

May 2023



James J. Robinson
 Executive Director

[@JJRoTMS](#)

"The Board of Directors cannot supersede the bylaws, so they must devise compliant implementation procedures."

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.

MAY 2023

Heterostructured Materials: A Fast Emerging Materials Field

Scope: Heterostructured materials are characterized by large differences (>100%) in mechanical properties among heterostructured zones. The large mechanical incompatibility leads to strong inter-zone interactive coupling, which produces a superior combination of strength and ductility that are deemed impossible according to conventional understanding in materials science and textbooks.

Editors: Yuntian Zhu, City University of Hong Kong; Enrique Lavernia, University of California, Irvine; and Xiaolei Wu, State Institute of Mechanics
Sponsor: Mechanical Behavior of Materials Committee

High-Temperature Phases and Processes for Enabling Cleaner Production of Metals and Energy

Scope: This special topic on thermodynamics and modeling of high-temperature phases and processes promotes the advancement of environmentally friendly and economic production of metals and renewable energy technologies. Areas of particular interest include off-gas treatments, corrosion control and sustainable operation of plants, energy efficiency, increased extraction and recovery, etc. pertaining to the metals and renewable energy industries.

Editors: Fiseha Tesfaye, Abo Akademi University; Joseph Hamuyuni, Metso Outotec; Hong Peng, University of Queensland; Chukwunwike O. Iloeje, Argonne National Laboratory; and Dirk Verhulst, Dev
Sponsor: Recycling and Environmental Technologies Committee, Energy Committee, and Process Technology and Modeling Committee

Process Intensification in Hydro- and Electrometallurgy

Scope: Process Intensification (PI) aims at improved efficiency; lower energy consumption, cost, and environmental impact by introducing enhanced and novel technology; and process concepts, placing PI in the core of sustainable process engineering. This topic seeks to advance the understanding and application of, for example, multifunctional reactors and hybrid separations, supercritical fluid extraction, alternative energy sources like microwave-assisted extractive metallurgy, new equipment, and plant design concepts for process intensification.

Editors: Kerstin Forsberg, KTH Royal Institute of Technology, and Athanasios Karamalidis, Penn State University
Sponsor: Hydrometallurgy and Electrometallurgy Committee

Reducing CO₂ Emissions from Bauxite to Aluminum Reduction

Scope: Primary aluminum producers are under pressure to reduce their CO₂ emissions from bauxite mining to aluminum reduction. Many primary producers are now offering low-carbon aluminum products to downstream processes. This will remain a high priority over the next decades to reach zero net carbon emissions. This topic seeks to present novel technologies or operational improvements aiming to reduce CO₂ emissions related to bauxite mining, alumina refining and aluminum reduction.

Editor: Jayson Tessier, Alcoa
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.



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.

Six TMS Members Elected to NAE



This year, six TMS members were elected to the U.S. National Academy of Engineering (NAE). Election to the NAE is among the highest professional

distinctions for engineers and recognizes those who have made outstanding contributions to "engineering research, practice, or education, including, where appropriate, significant contributions to the engineering literature" and to "the pioneering of new and developing fields of technology, making major advancements in the traditional fields of engineering, or developing/implementing innovative approaches to engineering education."

This NAE class will be inducted during the NAE Annual Meeting in October 2023. Join us in congratulating the TMS members who are among the newly elected 106 new members and 18 international members.



Robert D. Caligiuri, corporate vice president and principal engineer in the Materials and Corrosion Engineering Department at Exponent, was elected "for contributions to understanding failure mechanisms in engineering materials, especially in metals at very high strain rates." Caligiuri has been a TMS member since 1972.



David U. Furrer, senior fellow discipline lead in the Materials and Processes Department at Pratt & Whitney, was elected "for development and industrial implementation of computational modeling tools enabling efficient material/process/product design

of legacy and emerging aerospace alloys." A TMS member since 1988, Furrer has served on several TMS committees, including the Integrated Computational Materials Engineering Committee, the High

Temperature Materials Committee, and as a member of the *Integrating Materials and Manufacturing Innovation* Board of Reviewers. Furrer is a recipient of the 2019 TMS Materials Processing & Manufacturing Division Distinguished Scientist/Engineer Award and is a member of the 2023 class of TMS Fellows. Furrer will give a keynote presentation at the upcoming Superalloy 718 & Derivatives 2023 conference, scheduled for May 14–17, 2023, in Pittsburgh, Pennsylvania, USA.



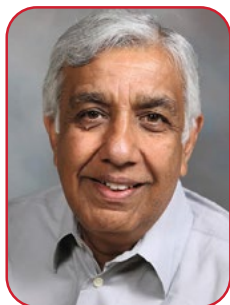
Carlos G. Levi, Mehribian Distinguished Professor in the Materials Department at the University of California, Santa Barbara, was elected "for contributions to understanding and development of high-temperature engineered surfaces and multilayers used in advanced gas

turbine engines." A TMS member since 1982, Levi has served on many TMS committees including the Public and Governmental Affairs Committee, the Composite Materials Committee, and the Solidification Committee. Levi also previously served as a member of the TMS Board of Directors and was the recipient of the 2014 Morris Cohen Award.



Alan Luo, professor in the Department of Materials Science and Engineering at the Ohio State University, was elected "for implementation of lightweight aluminum, magnesium, and titanium materials and advanced manufacturing processes for automotive applications." A TMS member since 1999,

Luo has served on a multitude of TMS committees including the Aluminum Committee, the Titanium Committee, and as a previous member of the TMS Board of Directors. He is a recipient of the 2013 Brimacombe Medal, the 2020 TMS Light Metals Division Distinguished Service Award, the 2021 Bruce Chalmers Award, and the 2023 Research to Industrial Practice Award, and he is a member of the 2023 class of TMS Fellows.



Anil Sachdev, principal technical fellow and lab group manager at General Motors, was elected "for the research, development, and commercialization of lightweight materials to improve vehicle fuel economy." A TMS member since 1992, Sachdev has served on several TMS committees including the Shaping and

Forming Committee, the Magnesium Committee, and the Ferrous Metallurgy Committee. Sachdev is a member of the 2022 class of TMS Fellows.



Ji-Cheng (JC) Zhao, Department Chair and Minta Martin Professor of Engineering in the Department of Materials Science and Engineering at the University of Maryland, was elected "for contributions to computational alloy design, integrated computational materials engineering, and high-throughput methods

used in industrial products." A TMS member since 1993, Zhao has served on various TMS committees, including the Alloy Phases Committee; the Advanced Characterization, Testing, and Simulation Committee; and the High Temperature Alloys Committee. Zhao is a recipient of the 2021 William Hume-Rothery Award and is a member of the 2023 class of TMS Fellows.

TMS Members Receive AAAS Fellow Distinction

Congratulations to the following TMS members who were honored by the American Association for the Advancement of Science (AAAS) as 2022 Fellows. According to AAAS, this distinction "honors members whose efforts on behalf of the advancement of science or its applications in service to society have distinguished them among their peers and colleagues." The 505 members of this class of fellows were elected in October 2022.

Section on Engineering

Carol A. Handwerker, Purdue University
TMS member since 1983

John H. Perepezko, University of Wisconsin-Madison
TMS member since 1975

Kristin Aslaug Persson, University of California, Berkeley
TMS member since 2006

Julie M. Schoenung, University of California, Irvine
TMS member since 2003

Section on Industrial Science & Technology

Ji-Cheng (JC) Zhao, University of Maryland
TMS member since 1993

If you know of any other TMS members who received this distinction in 2022, please contact Kelly Zappas, *JOM: The Magazine* editor, at kzappas@tms.org.

Marie Charpagne Awarded NSF CAREER Award



Marie Charpagne, materials science and engineering assistant professor, Grainger College of Engineering, University of Illinois Urbana-Champaign, was awarded a U.S. National Science Foundation (NSF) Faculty Early Career Development Program (CAREER) Award in December 2022. She was selected as

a recipient of this award for her work in additive manufacturing of metallic materials. Her project will explore the basic science of controlling the composition and arrangement of metals, at the atomic

scale, through thermal treatments after printing to obtain uniform mechanical properties throughout a 3D printed part. In addition, through educational and outreach activities, this research is intended to increase awareness of and participation in additive manufacturing in underrepresented communities.

A TMS member since 2016, Charpagne has served on a number of TMS committees including the High Temperature Alloys Committee; the Advanced Characterization, Testing, and Simulation Committee; and the Refractory Metals and Materials Committee. She was also a member of the organizing committee for the 6th International Congress on 3D Materials Science (3DMS 2022). *(Photo Credit: University of Illinois Urbana-Champaign)*

In Memorium

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

David Duquette

James L. Kirby

2022 Peer Reviewers: We Thank You!

JOM extends a heartfelt thank-you to all volunteers who completed peer reviews in 2022. We know our reviewers have busy lives and that making time for service to the community can be a challenge. The audience and authors of *JOM* are indebted to these reviewers who so generously shared their knowledge and time to ensure that only the highest quality articles are published. The full list of 2022 reviewers follows.

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TMS MEETING HEADLINES

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THE MAGAZINE

Meeting dates and locations are current as of February 23, 2023. For the most recent updates on TMS-sponsored events, visit www.tms.org/Meetings.



Superalloy 718 & Derivatives 2023

May 14–17, 2023

Pittsburgh,
Pennsylvania, USA

Join Your Colleagues

Superalloy 718 & Derivatives attendees will gain networking opportunities across industries, forge new connections for future collaborations, and learn about the latest developments in alloys, processes, applications, and modeling.

www.tms.org/Superalloy718-2023



7th World Congress on Integrated Computational Materials Engineering (ICME 2023)

May 21–25, 2023

Orlando, Florida, USA

Make Plans to Attend

ICME 2023 is the recognized hub of interaction among software developers and process engineers along the entire production chain, as well as for materials scientists and engineers developing new materials.

www.tms.org/ICME2023



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

October 1–4, 2023

Columbus, Ohio, USA

Housing Deadline: September 7, 2023

The TMS Fall Meeting will offer TMS members a chance to connect at a large-scale, multidisciplinary meeting—MS&T23—that will feature 25 symposia organized by TMS technical committees.

www.tms.org/TMSFall2023



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

November 12–15, 2023

Pittsburgh,
Pennsylvania, USA

Abstract Deadline: June 16, 2023

HEA 2023 will feature highly focused technical talks on topics that include fundamental theory of alloy design, computational modeling and simulation, properties, processing, and applications of high entropy alloys.

www.tms.org/HEA2023

Other Meetings of Note



11th Pacific Rim International Conference on Advanced Materials and Processing (PRICM11)

November 19–23, 2023
Jeju, South Korea

www.pricm11.org



TMS 2024 Annual Meeting & Exhibition (TMS2024)

March 3–7, 2024
Orlando, Florida,
USA

www.tms.org/TMS2024



TMS Specialty Congress 2024

June 16–20, 2024
Cleveland, Ohio,
USA

www.tms.org/SpecialtyCongress/2024



15th International Symposium on Superalloys (Superalloys 2024)

September 8–12, 2024
Champion, Pennsylvania,
USA

www.tms.org/Superalloys2024

European Metallurgical Conference (EMC 2023)

June 11–14, 2023
Düsseldorf, Germany
Co-sponsored by TMS

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

Materials in Nuclear Energy Systems (MiNES 2023)

December 10–14, 2023
New Orleans, Louisiana, USA
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Cleveland Hilton | Cleveland, Ohio, USA

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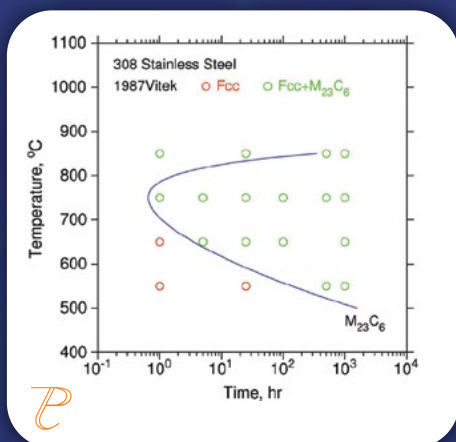
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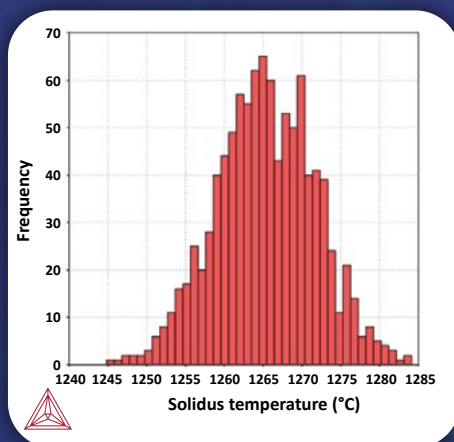
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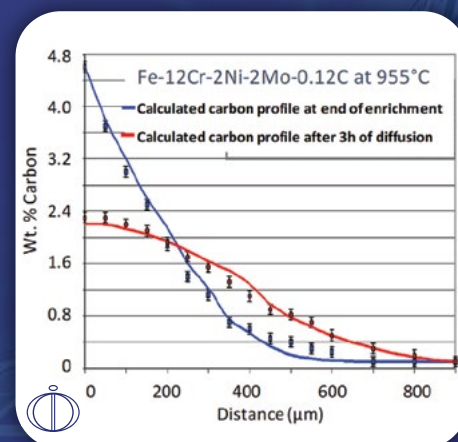
Time temperature precipitation of $M_{23}C_6$ in 308 stainless steel

Solidification



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

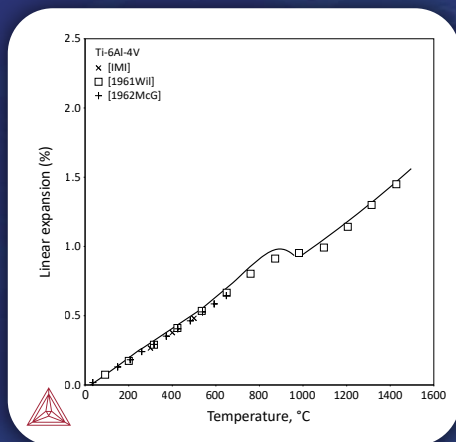
Diffusion



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

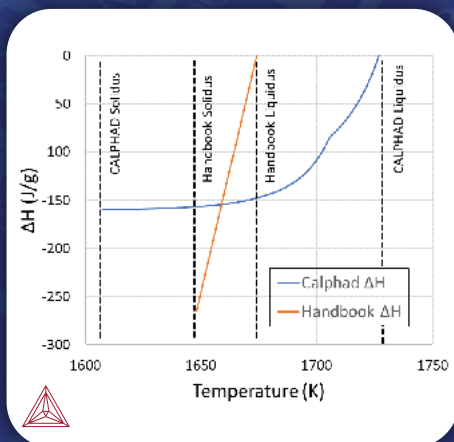
Predict a wide range of materials property data

Thermophysical Data



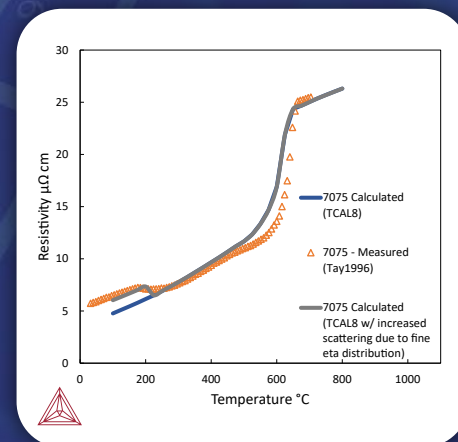
Linear expansion vs temperature for Ti-6Al-4V

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