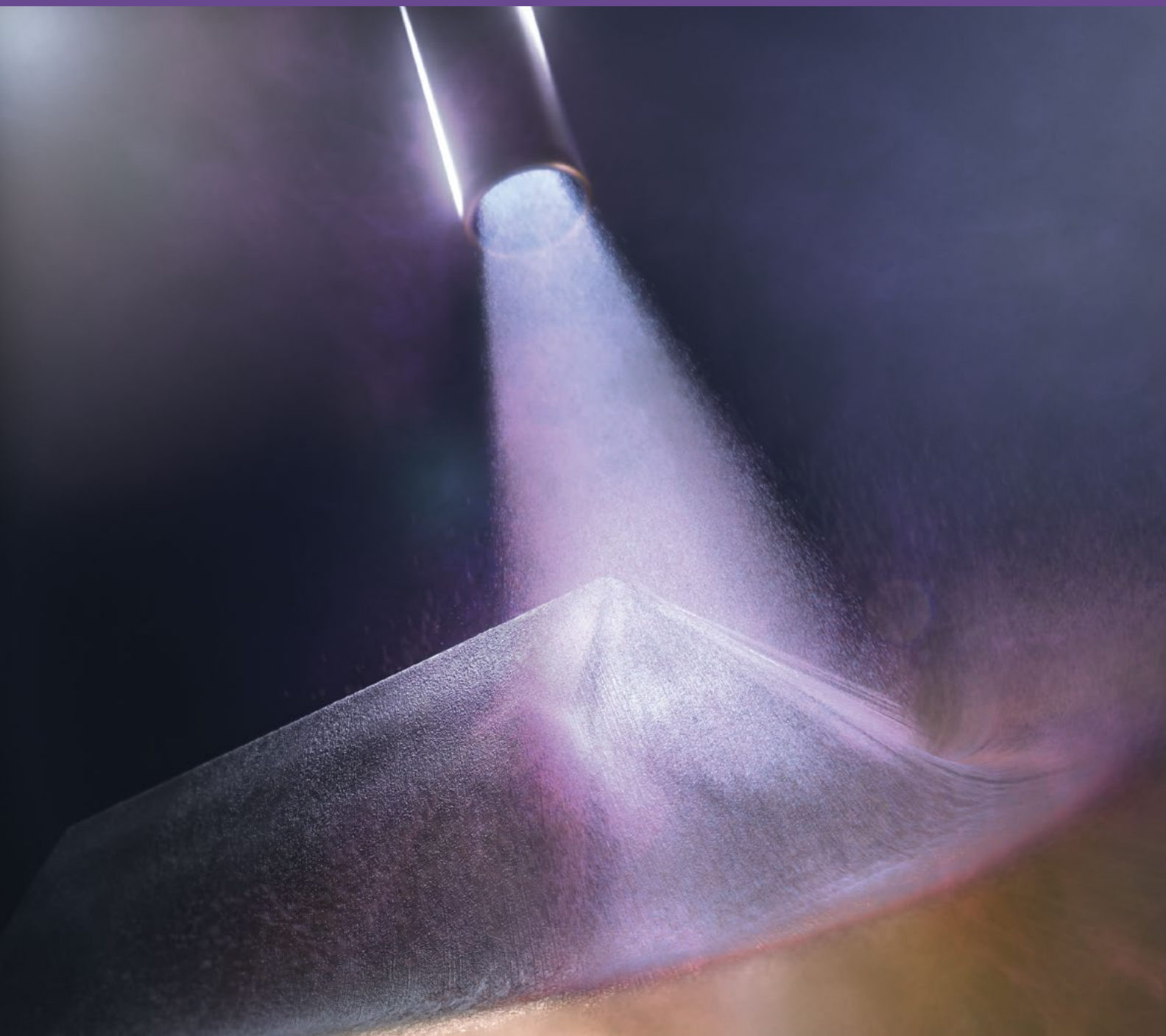
JOM

AUGUST 2020

jom.tms.org

An official publication of The Minerals, Metals & Materials Society



READ IT HERE FIRST: *JOM* Announces 2021 Editorial Calendar

TMS Springer

PLAN NOW TO EXHIBIT

ANNUAL MEETING
150th
TMS2021
SINCE 1871
AND EXHIBITION

MARCH 14-18, 2021 • ORLANDO WORLD CENTER MARRIOTT
ORLANDO, FLORIDA, USA
www.tms.org/TMS2021 • #TMSAnnualMeeting

The Exhibit Hall is Open March 15–17, 2021.

Get ready to make history at TMS's 150th Annual Meeting & Exhibition!

ACT NOW FOR A GREAT SPACE!

Booth package includes one full-conference registration and two exhibit-only registrations, inclusion in the TMS2021 Conference Guide, complimentary Wi-Fi in the Exhibit Hall, and so much more. Visit www.tms.org/TMS2021Exhibit to see all package details, view an interactive floorplan, and to book your booth today.

Booth Rate: $2,800 USD per 10'x10' booth (plus $150 USD per exposed corner)

TMS BLADESMITHING COMPETITION

BLADESMITHING IS BACK!

The TMS2021 will feature the popular Bladesmiting Competition, an even that always brings energy—and attendees—to the Exhibit Hall. Ask us about Bladesmithing sponsorship opportunities!

BOOK YOUR SPACE TODAY!

Don't miss this opportunity to be a part of another historic TMS Annual Meeting & Exhibition! Contact us to reserve your booth space today:

Gavin McAuliffe, TMS2021 Exhibit Manager • Corcoran Expositions Inc.
gavin@corcexpo.com • 1-312-265-9649

JOM table of contents

Volume 72
Number 8
August 2020

JOM: THE MAGAZINE

JOM: THE JOURNAL

Advanced Processing and Additive Manufacturing of Functional Magnetic Materials

Metal Matrix Composites: Analysis, Modeling, Observations and Interpretations

Metastable Phases and Phase Equilibria

Technical Articles

JOM

5700 Corporate Drive
Suite 750
Pittsburgh, PA 15237
USA

Phone: 1-724-776-9000
Web: jom.tms.org
E-Mail: jom@tms.org

TMS
Springer

About the Cover

From "Cold Spray Deposition of Thermoelectric Materials" by Alexander A. Baker et al., the cover shows a cold-spray chamber during deposition, with the nozzle at the top of the image and near-full density sample being fabricated in the center. Particles of the brittle thermoelectric Bi_2Te_3 are accelerated to more than 900 m/s in inert gas and directed onto a copper surface, laying down the strips that form the basis of a functioning thermoelectric generator to harvest waste heat. Image created by Jacob Long.

August 2020 Guest Editors

Advanced Processing and Additive Manufacturing of Functional Magnetic Materials
Magnetic Materials Committee
Scott McCall, Lawrence Livermore National Laboratory
Ikenna Nlebedim, Ames Laboratory

Metal Matrix Composites: Analysis, Modeling, Observations and Interpretations
Composite Materials Committee;
Mechanical Behavior of Materials Committee
T. S. Srivatsan, University of Akron
W. C. Harrigan Jr., Del West Engineering

Metastable Phases and Phase Equilibria
Phase Transformations Committee
Gregory Thompson, University of Alabama
Raj Banerjee, University of North Texas
Eric Lass, University of Tennessee, Knoxville
Bij-Na Kim, Carpenter Additive

About JOM:

The scope of *JOM* (ISSN 1047-4838) encompasses publicizing news about TMS and its members and stakeholder communities while publishing meaningful peer-reviewed materials science and engineering content. That content includes groundbreaking laboratory discoveries, the effective transition of science into technology, innovative industrial and manufacturing developments, resource and supply chain issues, improvement and innovation in processing and fabrication, and life-cycle and sustainability practices. In fulfilling this scope, *JOM* strives to balance the interests of the laboratory and the marketplace by reporting academic, industrial, and government-sponsored work from around the world.

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 applications 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, 233 Spring Street, New York, NY, 10013-1578, USA

JOM articles from 1949 to the present are archived at http://link.springer.com/journal/volumesAndIssues/11837.

Secure Copyright Permission:

Postmaster:

Send address changes to: *JOM*, Springer, 233 Spring Street, New York, NY 10013, USA. Periodicals postage paid at New York, NY and additional mailing offices.

JOM, Vol. 72, No. 8, 2020
https://doi.org/10.1007/s11837-020-04270-w

in the final analysis

"You have to do the right thing. . . .You may never know what results come from your action. But if you do nothing, there will be no result."

— Mohandas K. Gandhi

JOM
Volume 72
Number 8
August 2020

Although I was but a pre-teen in the 1960s, I vividly remember many images from the evening news as presented by Walter Cronkite, Frank Reynolds, David Brinkley, and others from a more dignified era of television reporting. They showed my wide eyes the Vietnam War, hippies vs. hardhats, the Cuban Missile Crisis, Nixon vs. Humphrey, the Beatles, the John F. Kennedy and Robert Kennedy assassinations, the moon landing, and more through the four channels received by the "rabbit ears" of our 16-inch black-and-white TV. Television news also made it plain that Black Americans were at a deep disadvantage: Civil rights demonstrations, protests against desegregation, the assassination of Martin Luther King Jr., housing discrimination, and burning city blocks. As a child, I wondered, why isn't everyone just treated equally? Half a century later, the same question painfully and depressingly persists.

The issue of social justice is electric and arcing in the United States, and TMS leadership believes it important to underscore our support of equity with meaningful words and actions. So, TMS President Tom Battle and I sent the following letter to TMS membership in June:

> We write to you in the wake of the killing of George Floyd and the subsequent protests. As leaders within The Minerals, Metals & Materials Society (TMS), we decry all forms of racism and discrimination and stand with those who are passionately and peacefully advocating for positive change.
>
> We want this to be more than a mere message of support, so we welcome your ideas for specific actions that TMS can take as we continue to seek to create a truly equitable community where all are treated with respect, and all can thrive. For ourselves, we plan to add social justice for black Americans and underrepresented groups to our advocacy position when TMS leadership travels to Washington, D.C., to advocate on behalf of materials science and engineering to federal officials and elected representatives. We will frame it as not only unjust but demeaning to the right of all people to seek a brighter future, such as the pursuit of professions in materials science and engineering as well as STEM.
>
> In 2016, TMS adopted a clear and unequivocal statement for our professional society on diversity:
>
> > *The Minerals, Metals & Materials Society (TMS) is committed to advancing diversity in the minerals, metals, and materials professions, and to promoting an inclusive professional culture that welcomes and engages all who seek to contribute to the field. TMS recognizes that a diverse minerals, metals, and materials workforce is critical to ensuring that all viewpoints, perspectives, and talents are brought to bear in addressing complex science and engineering challenges. To build and nurture this diverse professional community, TMS welcomes and actively engages the participation of underrepresented groups in all of its initiatives and endeavors.*
>
> Good words such as these can lead to good actions. In this regard, TMS has spent years making it a priority to "walk the talk." This is why the Society will host the 4th Diversity in the Minerals, Metals, and Materials Professions event at TMS2021, why we have a vibrant and long-standing Diversity, Equity, and Inclusion Committee with a Race & Ethnicity Working Group, why we are intolerant of any form of harassment in the Society, why we recognize accomplishments in diversity and inclusion with high-level awards, and why we are now actively reflecting on how to identify and conquer unconscious bias within the Society.
>
> We are committed to listening to the voices of those who are hurting and grieving, and we look forward to engaging with you in identifying actions we can take together in uniting around racial justice. As such, we encourage you to engage with our TMS Diversity, Equity, and Inclusion Committee and participate in our 4th Diversity in the Minerals, Metals, and Materials Professions event, which will be co-located with next March's 2021 TMS Annual Meeting and Exhibition.
>
> Speaking on behalf of the TMS Board of Directors and ourselves, we passionately believe that STEM professions and society in general are at their best when enriched by diversity, equity, and inclusion. The recent events in the U.S. remind us that there is still much more we all need to do to ensure a genuine embrace of equality for all.

We wrote in the spirit of doing the right thing, even though to "do the right thing" can be subject to the observer. What I see? Doing nothing works for no one.

James J. Robinson
Executive Director
@JJRofTMS

"TMS leadership believes it important to underscore our support of equity with meaningful words and actions."

JOM, Vol. 72, No. 8, 2020
https://doi.org/10.1007/s11837-020-04271-9

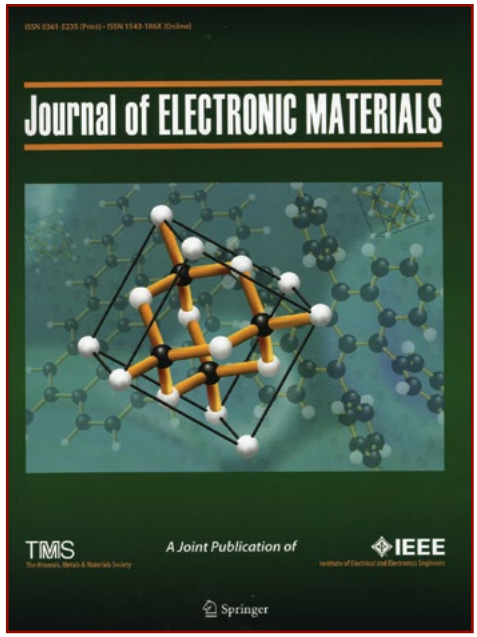
JOM themagazine

Journal of Electronic Materials Seeks Submissions for Two Topical Collections; TMS Member Receives Named Chair Appointment

member news

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

News on Two Topical Collections for the *Journal of Electronic Materials*



The *Journal of Electronic Materials* (*JEM*) is planning a new topical collection, **Carbon-Based Materials for Energy Storage**. Article submissions are due by **December 31, 2020**.

The collection will focus on and highlight recent progress on carbon-based materials for electrochemical energy storage and present a broad overview on new synthetic methods as well as novel characterization techniques revealing physiochemical mechanisms. It also aims to address how carbon materials are playing important roles in electrochemical storage systems as either active electrodes or conductive skeletons/layers.

Topics for this collection will include, but are not limited to:

- Carbon-based materials for electrochemical energy storage
- Synthesis methods for carbon materials for energy storage
- Characterization techniques for carbon-based energy storage
- Batteries and supercapacitors
- Modeling, simulation, and computation of carbon-based electrode materials

To submit your work, go to www.editorialmanager.com/jems and select article type "2020 Carbon Energy Storage." Author instructions and additional journal details are available at www.springer.com/11664.

The guest editors of this topical collection are: Xinhui Xia, Zhejiang University; Hui Xia, Nanjing University of Science and Technology; Faxiang Qin, Zhejiang University; and Xihong Lu, Sun Yat-Sen University.

Additionally, the submission deadline for *JEM*'s previously announced special topical collection, **Progress and Challenges with Stability, Sustainability, Toxicity, and Scalability of Perovskite Materials and Devices**, has been extended to **October 1, 2020**. While all perovskite-related contributions are welcome, the following areas are of special interest for this collection:

- Susceptibility to ambient environment resulting from insufficient encapsulation
- Material chemical stability due to inhibition of light-induced decomposition
- Energy losses in the bulk of the material, as well as the surface and interfaces
- Free exciton trapping and luminescence quenching
- Control of nucleation and rapid crystallization by modulating growth conditions
- New insight on structure–property–performance relationships
- Theoretical modelling, first-principles calculations, and machine learning discovery

Articles for this collection can also be submitted at www.editorialmanager.com/jems. Once there, select article type "2020 Perovskite Materials and Devices."

Andrea Hodge Begins USC Department Chair Appointment

Andrea Hodge has been appointed to a three-year term as the chair of the Mork Family Department of Chemical Engineering and Materials Science at the University of Southern California (USC). She is currently the vice provost for undergraduate programs at USC and the Arthur B. Freeman Professor of Chemical Engineering and Materials Science and Aerospace and Mechanical Engineering, in addition to serving as the co-director for the Core Center of Excellence in Nano Imaging. Her new role as department chair will begin on August 16, 2020.

A TMS member since 1998, Hodge is a recipient of the 2020 Julia and Johannes Weertman Educator Award "for her outstanding contributions to educating and mentoring students in materials science and engineering." In 2004, she received the Materials Processing & Manufacturing Division Young Leaders Professional Development.

Outside of TMS, several prestigious research awards have been conferred upon Hodge, including the National Science Foundation's CAREER Award, an Office of Naval Research (ONR) Young Investigator Program Award, and a Defense Advanced Research Projects Agency (DARPA) Young Faculty Award.

Andrea Hodge

In Memoriam: Kuang-Tsan "Kenneth" Chiang & Erhard Hornbogen

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

Kuang-Tsan "Kenneth" Chiang passed away on May 7, 2020, at the age of 69. A senior TMS member who joined in 1980, Chiang had worked as a materials science engineer and specialized in powder metallurgy and physical vapor deposition. Most recently, he worked as a senior research scientist at the Southwest Research Institute. After retiring, Chiang taught physics at Northwest Vista College. Throughout his career, he held positions at RCA, Lockheed Martin, the Rocketdyne Division of Rockwell International (which later became Boeing Rocketdyne), and Aerojet.

Chiang earned his bachelor's degree in physics from National Tsing Hua University in Taiwan. After serving as a second lieutenant in the army, he came to the United States in 1974 to earn his doctorate in from the University of Pittsburgh's Department of Physics and Astronomy. He also earned his M.S. in the management of technology from the University of Texas at San Antonio. In 2011, he became one of the first people from National Tsing Hua University or from Taiwan to be named an Associate Fellow of the American Institute of Aeronautics and Astronautics.

Erhard Hornbogen passed away at the age of 90 on April 16, 2020. A longtime TMS member, he is known for his research on understanding the design of superalloys, which provided the basis for the development of modern aircraft engines. Hornbogen earned his Ph.D. from the University of Clausthal in 1957, where his work as a research associate led to his 1956 discovery of the shape memory effect in Cu-based alloys.

His research career included positions at the University of Oxford; the Edgar C. Bain Laboratory for Fundamental Research (a U.S. Steel Corporation Institute); the Max Planck Institute for Metals Research; the Norwegian Central Institute for Applied Research; and the University of Goettingen. Additionally, Hornbogen participated in many extended research stays across the globe, including in the United States, France, and China. Hornbogen founded the Institue for Materials Research at Ruhr-University Bochum, serving as chair for Materials Science from 1968 until 1995.

Among many honors awarded to him over the years, Hornbogen received the 1979 TMS Institute of Metals/Robert Franklin Mehl Award.

JOM thanks Gunther Eggeler, Herbert Gleiter, and Easo George for thier contributions to Hornbogen's obituary.

Kuang-Tsan "Kenneth" Chiang

Erhard Hornbogen

JOM, Vol. 72, No. 8, 2020
https://doi.org/10.1007/s11837-020-04272-8

JOM themagazine

In Case You Missed It:

Business News from the Field

Do you have business or industry news of interest to the minerals, metals, and materials community? Submit your announcement or press release to Kaitlin Calva, JOM Magazine Managing Editor, at kcalva@tms.org for consideration.

New Exploration "Tastes" Groundwater

East Perth, Australia: The Minerals Research Institute of Western Australia published a report on the use of groundwater sampling to discover minerals through instruments that can "taste" the sediment. Researchers sampled known deposits of gold, uranium, and other minerals and recorded distinctive traces in the water resulting from the interaction of the ore systems. Exploration companies may be able to test for haloes of altered water chemistry in groundwater to locate underground ore deposits.

Rockcliff Unearths Copper and Zinc

Toronto, Ontario, Canada: Rockcliff Metals at Freebeth property in Manitoba found high-grade copper and zinc mineralization, including 5.28% copper equivalent over 2.3 meters and 4% copper equivalent over 4.7 meters. The drilling also identified a zone of high-grade copper and zinc mineralization in the Last Hurrah zone on the property, which Rockcliff described as a high-priority advanced exploration target. Additional Rockcliff projects in Manitoba include the Tower deposit and the Rail deposit.

Héricourt, France, and Paris, France: Gaussin Group and Total SA are jointly developing the world's first fully electric Aircraft Refueller Transporter, the ART Full Elec® Equipped with lithium-ion Saft batteries. A prototype will be stationed at an Airbus site in Toulouse that will be capable of towing two fuel tankers, with a fuel capacity of 30 tons each. Delivery is expected at the end of 2020. (Image courtesy of Total.)

Shell Sells Appalachian Asset

The Hague, Netherlands: Royal Dutch Shell plc reached a sales agreement with U.S. energy company National Fuel Gas Company and its subsidiaries, Seneca Resources Company LLC, National Fuel Gas Midstream Company LLC, and NFG Midstream Covington LLC, to sell its Appalachia shale gas position for $541 million. The transaction includes the transfer of ~450,000 net leasehold acres across Pennsylvania, with approximately 350 producing Marcellus and Utica wells in Tioga County and associated facilities. The current net production is ~250 million standard cubic feet per day. The transaction also includes the transfer of the Shell owned and operated midstream infrastructure.

Great Bear, First Nations Form Agreement

Red Lake, Ontario, Canada: Great Bear Resources inked an agreement with two of the area's Native communities, Wabauskang First Nation and Lac Seul First Nation, to establish a protocol of how they can communicate and engage with the exploration on their traditional territories. For two years, Great Bear has made numerous high-grade gold discoveries in its Dixie Project in the Red Lake mining district. As part of the process, 100,000 common shares in capital stock were issued to Lac Seul and Wabauskang to be equally divided between the two communities.

New Aluminum Alloy Developed

Evanston, Illinois, USA: High-performance materials manufacturer QuesTek Innovations LLC will develop a new 3D printer feedstock in collaboration with the German Aerospace Center (DLR). The new aluminum alloy will exhibit high strength at elevated temperatures between 200°C and 300°C. At this level of performance, the material will be able to replace titanium in some applications, making components and equipment lighter than before. Heinz Voggenreiter, director of the Institute of Materials Research at DLR, has deemed the material a type of "extraordinary printable alloy."

JOM, Vol. 72, No. 8, 2020
https://doi.org/10.1007/s11837-020-04273-7

New Editorial Calendar Builds on *JOM* Strengths

Maureen Byko and Justin Scott

Maureen Byko

Justin Scott

Introduction

During a *JOM* strategic planning session in early 2020 comprised of current and past guest editors, participants agreed that one of the journal's key strengths is its emphasis on special topics driven by volunteers. These special topics, collections of thematically connected papers, are developed primarily by members of TMS technical committees or their delegates. Thus, topics are as diverse as the TMS committees themselves and reflect a wide range of outputs from academia, government laboratories, and industry that span the five divisions of TMS. At the end of the volume year, readers will have been exposed to an extensive array of recent work in the minerals, metals, and materials communities, along with several new developments in areas closely related to their specialization.

JOM continues its tradition of diverse coverage in the coming year, centered on TMS member interests, with the new *JOM* Editorial Calendar. The 2021 calendar will explore materials research, development, and processing innovations all the way from extraction to recovery and recycling. In all, 40 special topics are planned.

Topic Highlights

Several upcoming topics look to expand frontiers in materials research and development and are slated to showcase advances in the application of emerging techniques in the community:

- Leveraging Materials in Topology Optimization
- Multiscale Methods for Design of High Performance Coatings
- Informatics-Enabled Design of Structural Materials

Energy research is also represented throughout the upcoming editorial calendar. Numerous topics can be found focusing on materials and processes for energy production, conversion, and storage. Papers are being solicited across a variety of areas including:

- Nanomaterials and Composites for Energy Conversion and Storage
- Powder Materials for Energy
- Materials for Small Nuclear Reactors and Micro Reactors, including Space Reactors
- Artificial Intelligence and Machine Learning in Energy Storage and Conversion Materials

Light metals and alloys are also a common theme throughout the upcoming editorial calendar with support from the Aluminum, Titanium, and Magnesium committees. For 2021, they are soliciting papers for topics that include the following:

- Advanced Casting and Melt Processing Technology for Light Alloys
- Developments in the Production of Magnesium Alloy Flat Products
- Impurity Control throughout the Primary Aluminum Production Chain
- Processing-Microstructure-Property Relationships in Additive Manufacturing of Ti Alloys

See the full calendar for all topics and their detailed scopes, organizers, and submission deadlines.

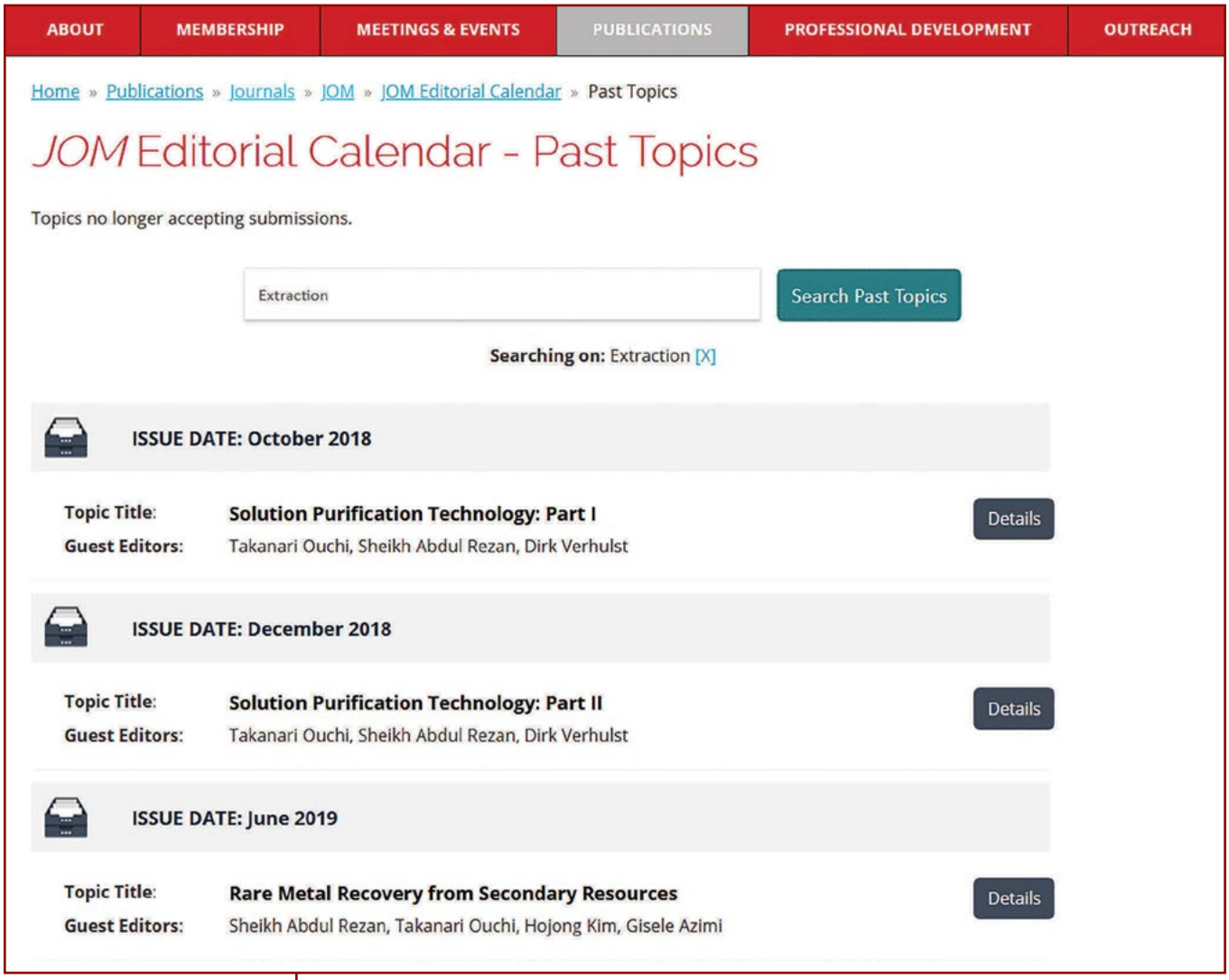


Figure 1. The *JOM* Past Topics archive is a searchable list of topics no longer accepting submissions, from January 2017 to the present.

Volunteer Support

Because *JOM* is a volunteer-driven publication, the editorial team continually seeks to improve that volunteer experience, providing tools and resources that authors, reviewers, and editors can access when they need it. This includes the regularly updated Editorial Calendar, which now also features access to a new, searchable *JOM* past topics archive that enables quick access to the full landscape of recently published topics (Figure 1). Access these topics by clicking the Past Topics Archive link at www.tms.org /EditorialCalendar.

Strategizing for the Future

The previously referenced ad hoc *JOM* Strategic Planning Committee, convened at the TMS 2020 Annual Meeting & Exhibition, is in the process of charting the course for *JOM* over the next three years. The participants offered a wealth of ideas to lay the groundwork for a journal that keeps pace with the needs of the materials community. They are currently working toward a suite of recommendations that will ensure *JOM* remains an impactful journal that continues to serve its diverse constituencies.

In the meantime, the *JOM* editorial team is pleased to present this 14-month editorial calendar, available now at jom .tms.org. Authors are invited contribute to the future of *JOM* by searching the calendar for a topic that aligns with their research interests, following the link to that topic, and submitting a manuscript.

Maureen Byko is the *JOM* Editor. Justin Scott is the *JOM* Principal Editor.

JOM, Vol. 72, No. 8, 2020
https://doi.org/10.1007/s11837-020-04274-6

Perspectives on the Pipeline: Progress through Internships and Research Programs

Amber Genau

Amber Genau

"Perspectives on the Pipeline: Progress through Internships and Research Programs" serves as an introduction to a thematic group of articles in the August 2020 issue of *JOM* covering education and research topics at universities and national laboratories. The article package is a feature series developed by the TMS Education Committee. For additional information, contact Kaitlin Calva, *JOM* Magazine Managing Editor, at kcalva@tms.org.

Do you remember your first breakthrough as a scientific researcher? It was probably small and may not have been a breakthrough to anyone but you. Perhaps it was finally mastering a tricky sample preparation, or getting a new experimental procedure to work, or uncovering an unexpected trend in some stubborn data. For me, that moment came as a young master's student, sitting front of a scanning electron microscope at Ames Laboratory, when I suddenly realized something crucial about the Al-Si powder particles I'd been staring at for months. I wanted to get up and dance around the room. Those moments of personal accomplishment and insight make the long hours of work worthwhile, and also send an important message to the young researcher: "You can do this. You are able to do science too."

For this reason and many others, immersive, hands-on experiences with research are one of the best ways to engage young people in the fields of science, technology, engineering, and math (STEM). The following three articles, developed as a project of the TMS Education Committee, describe programs which not only provide research internships to students at various levels, but specifically target underrepresented minority students. The goal of these programs is to increase the number and diversity of students in STEM education and STEM careers.

The problem of the "leaky pipeline" in STEM has been well-documented, as statistics show women and people of color leaving STEM at higher rates than their white, male counterparts at all points along the education and career path. In an attempt to address these disparities, each of the programs described in the following articles focuses on one or more of the critical "bridge periods" in students' educations: the transition from high school to college, from community college to a four-year institution, or from undergrad to graduate school. In each case, these are paid internships, making the experiences not only attractive but accessible to students from all backgrounds. These programs acknowledge that we have both a social and moral obligation to make STEM careers more accessible to groups who have traditionally been excluded, as well as the fact that demographic diversity is the best way to achieve cognitive diversity, and the massive challenges facing our research community will require the full breath of human experience to solve.

Read on to learn about the Minority Serving Institutions Partnership Program (MSIPP) at the U.S. Department of Energy's national labs, Purdue University's successful effort to incorporate community college students into a more traditional summer research experience program for undergraduates, and the University of Alabama at Birmingham's long-running summer internship program for high school and community college students. I hope these articles will inspire you to think about how you might get involved in these programs or ones like them at your institution—perhaps by encouraging a student you know to apply or hosting a student researcher in your lab—and open the doors for tomorrow's STEM professionals to experience that same thrill of discovery.

"…immersive, hands-on experiences with research are one of the best ways to engage young people in the fields of science, technology, engineering, and math."
—Amber Genau

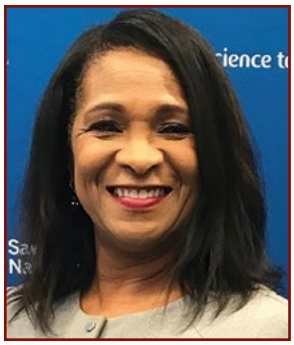
Amber Genau, an associate professor of materials science and engineering at the University of Alabama at Birmingham, is currently the chair of the TMS Education Committee and curated this article package.

JOM, Vol. 72, No. 8, 2020
https://doi.org/10.1007/s11837-020-04275-5

National Laboratories' Research Experience Opportunities for Diverse Scholars

Simona E. Hunyadi Murph and Vivian Holloway

Simona E. Hunyadi Murph



Vivian Holloway

The Positive Influence of National Labs

Education has been the foundation for advancement of civilizations since the beginning of time. It sparks curiosity, and curiosity drives discovery. Quality education is the combination of systematic theoretical instruction and enlightened experiences.

Colleges and universities are excellent student resources for generalized scientific academia and do an incredible job of specializing in scientific fields. As the world's undergraduate and graduate students continue to reach unprecedented levels of advanced academic theoretical education never thought possible centuries ago, these scholars must also be nurtured and inspired to think creatively in an applied environment. Graduate and undergraduate practicums available at U.S. national laboratories can supplement college and university programs, maximizing the growth of students in applied fields of science, technology, engineering, and mathematics (STEM) arenas. National laboratories' commitments to fostering and integrating underserved disciplines and populations can further ensure unparalleled advancements in scientific discovery.

Under the umbrella of the U.S. Department of Energy (DOE), 17 national laboratories located throughout the United States drive critical scientific and technological advances that solve the nation's strategic needs. These distinguished federal facilities are equipped with state-of-the-art equipment and facilities that enable the brightest scientific and engineering minds to develop and implement innovative ideas, ensuring America's homeland security and continued prosperity.

Myriad science and literacy programs, including internships, fellowships, outreach events, and trainings, are offered at national laboratories. These programs educate and inspire the next generation of trailblazers in scientific innovation and leadership. Through the complexities of undergraduate and graduate internships, national laboratories can achieve a level of scientific advancement that cannot flourish through academia alone. Internships are among the most advanced methods of applied education. National laboratory internships offer research experience in valuable, tangible, first-hand practical work, thus harnessing and complementing students' theoretical education and background from colleges and universities.

As national laboratories sponsor internships, they positively influence the development of a diverse scientific community that represents all facets of society, while focusing on a common vision of advancement in the STEM fields. The engagement of underrepresented groups in STEM education is a social and moral imperative. As we continue through the 21st century, it is essential to diversify our perspectives in STEM-related fields to ensure our progress toward solving many of mankind's scientific mysteries. National laboratory internship programs can focus students on underrepresented

"As national laboratories sponsor internships, they positively influence the development of a diverse scientific community that represents all facets of society…"
—Simona Murph and Vivian Holloway

segments of the scientific community at the early onset of applicants' undergraduate and graduate careers. This ensures cognitive stimulation in STEM and, through some programs, offers accessibility for minority populations to these sciences. Internship populations representing minorities will enhance the diversity of future scientific research in STEM fields for generations.

Creating Opportunities through the MSIPP

The Mission of the U.S. Department of Energy Office of Environmental Management (DOE-EM) is to complete the safe cleanup of the environmental legacy brought about from more than five decades of nuclear weapons development and government-sponsored nuclear energy research. The DOE-EM has recognized the potential and importance of providing project-based learning opportunities in the fields of STEM and mentoring underrepresented groups for some time.

In 2014, a groundbreaking initiative called the Minority Serving Institutions Partnership Program (MSIPP) was created. The MSIPP was designed to enhance and promote awareness and educational training opportunities for the next generation of diverse scientists and engineers by exposing them to research and development activities aligned to current and future missions of the DOE-EM. The MSIPP is managed by Savannah River National Laboratory (SRNL). An applied research and development laboratory at the DOE Savannah River Site (SRS), SRNL offers practical, high-value, cost-effective solutions to complex technical problems. It is also the lead national laboratory for the DOE-EM, whose mission is to address the nation's Cold War environmental legacy initiatives.

Academic institutions of higher education that enroll student populations with significant percentages of undergraduate and graduate minority students or postdoctoral researchers are qualified to participate in the MSIPP. Additionally, these minority-serving institutions must award bachelor's degrees in STEM disciplines, be an accredited postsecondary public or private institution, and be a nonprofit institution in order to be a part of the MSIPP.

Two different opportunities are available under MSIPP initiatives that create and foster a sustainable STEM pipeline, preparing a diverse workforce of world class talent. These are:

a) financial assistance through competitive research contract awards-based proposal submissions; through strategic partnerships between minority serving institutions and the DOE's national laboratories, faculty members can compete for funding to conduct R&D activities in relevant fields at their institutions that are aligned with DOE-EM mission; and
b) internship opportunities for graduate and undergraduate students in national laboratory settings that promote the education and development of the next generation workforce in critical STEM-related disciplines complementing current and future missions of DOE-EM and the national laboratories.

Internships through the MSIPP provide the unique opportunity to bridge the transition between undergraduate and graduate academia and the real-world applications required to make significant advances in scientific discovery. Qualified MSIPP graduate and undergraduate

Simona Murph (left) works with an intern as a part of the Minority Serving Institutions Partnership Program (MSIPP) at Savannah River National Laboratory.

"Through the combination of well-prepared undergraduates and graduates in academic settings and applied internships that spark creativity and discoveries, we will be well-equipped to provide the world its greatest advancements now and in the future."
—Simona Murph and Vivian Holloway

students are given the opportunity to complete summer internships under the direction of a host national laboratory.

Currently, six laboratories host MSIPP students. Through MSIPP internships, national laboratories facilitate creative scientific learning and trainings through project-focused educational environments. Interns can embrace and drive the direction of learning, while continuing to grow their creativity. These paid internships are performed at host laboratories, utilizing their facilities and equipment under the guidance of a senior research staff member. Interns can familiarize themselves with state-of-the-art instrumentation not readily available at traditional colleges and universities. These experiences also provide interns knowledge on the application of environmental and safety regulations that may not be as stringent in colleges and universities. National laboratories have some of the highest standards for environmental and safety regulations, offering a unique opportunity to instruct the next generation of scientists in proper safety and regulatory guidelines and protocols.

Since its inception, the MSIPP has supported and trained hundreds of graduate and undergraduate students through summer internships at national laboratories. These include SRNL, Argonne National Laboratory, Oak Ridge National Laboratory, Los Alamos National Laboratory, Idaho National Laboratory, and Pacific Northwest National Laboratory. Interns can also train with mentors and scientists at the headquarters offices of the DOE-EM in Washington, D.C. The sustainable MSIPP initiative has led to numerous successes for many young scholars, including postdoctoral opportunities, graduate school acceptances, technical manuscript publications, conference presentations, media outlet disseminations, and job offers at national laboratories and beyond.

Preparing for A Diverse Future

Education is a complex process in our ever-changing diverse global society. Continued advancements in the ability to create relationships among a vast array of traditionally underrepresented minority populations of the scientific community is essential to an influx of creativity, discovery, and advancement in STEM innovation. Through the combination of well-prepared undergraduates and graduates in academic settings and applied internships that spark creativity and discoveries, we will be well-equipped to provide the world its greatest advancements now and in the future.

If you are a graduate or undergraduate student interested in a MSIPP summer internship, feel free to explore https://www.srs.gov/general/srnl/msipp/internships.htm and learn how to apply.

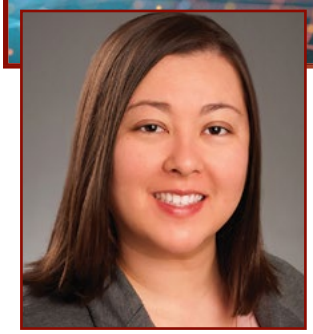
Simona E. Hunyadi Murph is a fellow scientist at Savannah River National Laboratory (SRNL) and the program manager for SRNL's Laboratory Directed Research and Development Program. She is also a special Government employee to the U.S. Department of Energy. A TMS member for many years, Murph has had an active role on several technical committees and is currently a representative for the Education Committee on the Functional Materials Division Council.

Vivian Holloway is the program manager for the U.S. Department of Energy-Office of Environmental Management's Minority Serving Institutions Partnership Program managed by SRNL. Holloway has held various positions of responsibilities in her 33 years at SRNL, including in management, chemical management, and environmental/regulartory compliance.

JOM, Vol. 72, No. 8, 2020
https://doi.org/10.1007/s11837-020-04276-4

Materials Research Experiences for Community College Students at Purdue University

Janelle P. Wharry, Timothy Pownell, Esteban Bautista, and Tanya Faltens


Janelle P. Wharry


Timothy Pownell


Esteban Bautista


Tanya Faltens

Closing the Research Gap

In the United States, more than 575,000 students are enrolled in engineering, engineering technology, computer science, mathematics, or natural science degree programs at public two-year colleges.[1] Upon matriculation, nearly 80% express an intention of transferring to a four-year institution, but ultimately, only 30% make the transfer.[1] Potential explanations for this gulf in transfer persistence are not well understood. However, two-year college or community college students have long been overlooked and underserved in discussions around science, technology, engineering, and math (STEM) research and engagement. As an initial step toward encouraging transfer persistence, Purdue University has stood up a summer research experience for community college students.

The concept of this research experience was motivated by the well-documented success of hands-on learning experiences and laboratories in enhancing community college student engagement.[2–7] This concept also extends the success of undergraduate-level research experiences to the community college level, as a means to encourage students to pursue post-baccalaureate studies in STEM fields.[8–14]

Success Stories at Purdue

The community college research experience pilot program was established in 2017 through the Network for Computational Nanotechnology (NCN)—a National Science Foundation (NSF) funded multi-institutional center led by Purdue University focused on developing modeling and simulation tools to predict multiscale behaviors of nanosystems. The pilot program integrated two-year college students in the existing formalized NCN Undergraduate Research Experience (URE), which had previously been open only to students from four-year colleges and universities.

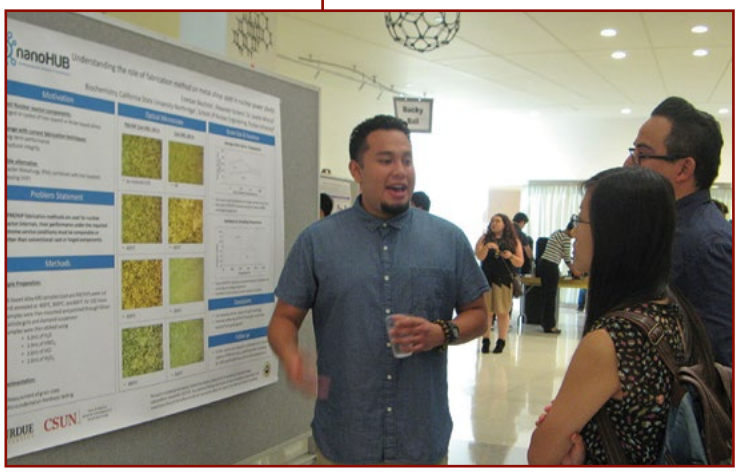
The NCN URE is a paid summer research program focusing on applying computational simulations and developing computational tools for physical processes, systems, and devices. The most unique feature of the NCN URE program is that the student-developed computational tools are published on nanoHUB.org, a cloud-based resource for interactive simulation tools that enable research and teaching across nanotechnology. The URE participants receive training on Jupyter Notebooks and Python, providing them with the necessary skills to build a nanoHUB tool. All URE students are paired with a faculty advisor and a graduate student mentor who define their research projects and provide day-to-day guidance. Students also participate in professional development workshops, attend research seminars, and engage in networking and social activities. At the conclusion of the program, students deliver poster presentations at the NCN URE research symposium.

Through the pilot program, five students from Pasadena City College (PCC) spent eight weeks conducting guided research at Purdue. During the pilot program, the PCC students explored scientific problems spanning a broad range of materials science topics. For example, one student developed the DualfoilUQ nanoHUB tool to improve uncertainty quantification for battery electrode material performance. Two students validated the mechanical properties of powder compacts for the Powder Compaction nanoHUB tool. Another student optimized plasma treatment process parameters on liquid crystal fiber wetting.

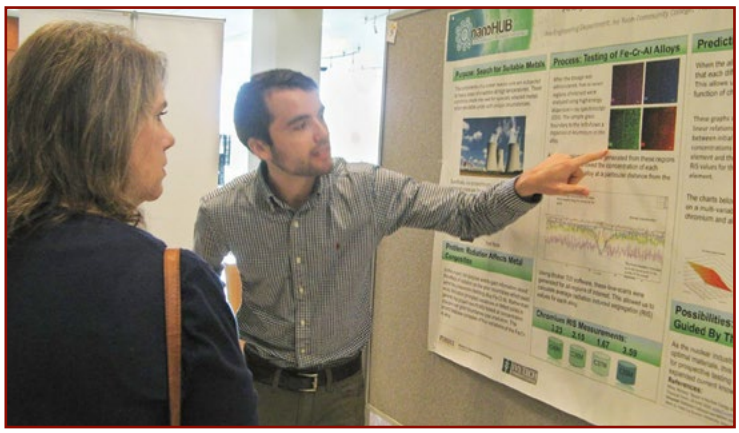
Esteban Bautista, a first-generation college graduate, participated in the pilot

program. During his NCN URE, Bautista investigated the long-term thermal aging of Inconel 625 and 690, comparing the performance of alloys fabricated by conventional forging to those fabricated by powder metallurgy with hot isostatic pressing (PM-HIP). By coupling his own experiments with data gathered from the archival literature, Bautista built a data-science tool on nanoHUB to predict the mechanical degradation of these alloys in nuclear power plant environments. Bautista's NCN URE research contributed to two peer-reviewed publications.[15–16] Following his research experience at Purdue, Bautista transferred to California State University, Northridge, where he has recently graduated with a degree in biochemistry. He will pursue his Ph.D. in chemistry at the University of California, Irvine beginning in the fall 2020.

Following on the success of the pilot program, research opportunities for two-year and community college students were formally integrated into the NCN URE program. Students were primarily recruited from Ivy Tech Community College of Indiana. Of the Ivy Tech students who transfer to four-year institutions, nearly 15% matriculate to Purdue, making the NCN URE partnership between Purdue and Ivy Tech a natural fit. Between three and five community college students participate in NCN URE each year. Students from Mt. San Antonio College and Skyline College in California and from Roxbury City College in Massachusetts have also participated in the program. To date, more than 15 students from two-year institutions have participated in the program.



a



b

Esteban Bautista (photo a) and Timothy Pownell (photo b) present their research posters at the Network for Computational Nanotechnology (NCN) Undergraduate Research Experience (URE) symposium at Purdue University.

Timothy Pownell is one such student who participated in NCN URE at Purdue in 2018 while he was enrolled at Ivy Tech. Pownell is a first-generation college student. His NCN URE project focused on the phenomenon of radiation-induced grain boundary segregation (RIS) in FeCrAl alloys, which are candidate alloys for accident-tolerant nuclear fuel claddings. Pownell analyzed composition maps previously acquired by transmission electron microscopy (TEM) with energy dispersive x-ray spectroscopy (EDX). Pownell built a nanoHUB tool that predicts RIS behavior from key parameters he identified, including grain size, irradiated microstructure, and irradiation conditions. This tool lays the foundation for a future machine learning program to predict RIS in FeCr alloys. Pownell returned to Purdue in 2019 for summer research and continues materials science research today. He has since transferred to Purdue, where he is pursuing a degree in mechanical engineering, and was selected for a summer internship at a brass foundry.

Lessons Learned

The program is formally evaluated using the Undergraduate Research Student Self-Assessment, administered anonymously through the Student Assessment of their Learning Gains website. Video interviews have also been conducted with pilot program participants approximately six months following the conclusion of their NCN URE.

Evaluations indicate that the NCN URE has enhanced self-efficacy in all

participating two-year college students. This is evidenced by a strengthened determination to attain higher education, an increased desire to transfer to a large research university, and an interest in continued pursuit of research. Students also consistently discuss a heightened confidence in their capabilities overall, their ability to be successful in unfamiliar or new situations, and their ability to achieve goals previously thought unattainable.

A challenge the community college students often cited, however, was difficulty in reconciling the scale of research conducted at a research-intensive institution. Prior to NCN URE, the students' exposure to research at the two-year college level involved seeing the scientific method through, from hypothesis to conclusion. But when they participated in NCN URE, their project was a small task within a larger research scope. This led to "cog in the wheel" feelings and some lack of ownership over their work. However, discussions with their faculty and graduate student mentors about the context of their NCN URE projects helped students understand the scale of federally funded research and improve their sense of accomplishment.

With proper research mentorship and project design, the Purdue NCN URE program enables community college students to improve their self-efficacy and gain research experience that influences their educational and career paths.

Acknowledgements

The NCN URE program was primarily supported by the Network for Computational Nanotechnology through National Science Foundation (NSF) award EEC-1227020. The student researchers highlighted in this article were also partially supported by NSF award DMR-1752636 and the US Department of Energy Office of Nuclear Energy contract DE-NE0008759.

End Notes

1. Current Term Enrollment Estimates: Fall 2019, National Student Clearinghourse, 2019. https://nscresearchcenter.org/wp-content/uploads/CTEE_Report_Fall_2019.pdf.
2. B.K. Townsend and K. Wilson, "A Hand Hold for A Little Bit: Factors Facilitating the Success of Community College Transfer Students to a Large Research University," *J. Coll. Stud. Dev.,* 47 (2006) 439–456.
3. P. Schuetz, "A Theory-Driven Model of Community College Student Engagement," *Community Coll. J. Res. Pract.*, 32 (2008) 305–324. doi:10.1080/10668920701884349.
4. V.B. Saenz, D. Hatch, B.E. Bukoski, S. Kim, K. Lee, and P. Valdez, "Community College Student Engagement Patterns: A Typology Revealed Through Exploratory Cluster Analysis," *Community Coll. Rev.*, 39 (2011) 235–267. doi:10.1177/0091552111416643.
5. V. Tinto and P. Russo, "Coordinated Studies Programs: Their Effect on Student Involvement at a Community College," *Community Coll. Rev.*, 22 (1994) 16–25.
6. T.H. Bers and K.E. Smith, "Persistence of Community College Students: The Influence of Student Intent and Academic and Social Integration," *Res. High. Educ.*, 32 (1991) 539–556.
7. S. Goldrick-Rab, "Challenges and Opportunities for Improving Community College Student Success," *Rev. Educ. Res.*, 80 (2010) 437–469. doi:10.3102/0034654310370163.
8. A.L. Zydney, J.S. Bennett, A. Shahid, and K.W. Bauer, "Impact of Undergraduate Research Experiences in Engineering," *J. Eng. Educ.*, 91 (2002) 151–157.
9. S. Kight, J.J. Gaynor, and S.D. Adams, "Undergraduate Research Communities: A Powerful Approach to Research Training," *J. Coll. Sci. Teach.*, 35 (2006) 34–39.
10. D.A. Sabatini, "Teaching and Research Synergism: The Undergraduate Research Experience," *J. Prof. Issues Eng. Educ. Pract.*, 123 (1997) 98–102.
11. D. Lopatto, "Undergraduate Research as a High-Impact Student Experience," *Peer Rev. Assoc. Am. Coll. Univ.,* 12 (2010) 27–30.
12. D. Lopatto, "Undergraduate Research Experiences Support Science Career Decisions and Active Learning," *Life Sci. Educ.,* 6 (2007) 297–306. doi:10.1187/cbe.07.
13. A.Q. Gates, P.J. Teller, A. Bernat, N. Delgado, and C.K. Della-Piana, "Meeting the Challenge of Expanding Participation in the Undergraduate Research Experience," *Am. Soc. Eng. Educ. Front. Educ. Conf.*, Tempe, AZ, 1998. doi:10.1109/FIE.1998.738588.
14. S.H. Russell, M.P. Hancock, and J. McCullough, "Benefits of Undergraduate Research Experiences," *Science*, 316 (2007) 548–549. doi:10.1126/science.1140384.
15. A.L. Bullens, E. Bautista, E.H. Jaye, N.L. Vas, N.B. Cain, K. Mao, D.W. Gandy, and J.P. Wharry, "Comparative Thermal Aging Effects on PM-HIP and Forged Inconel 690," *JOM*, 70 (2018) 2218–2223. doi:10.1007/s11837-018-2818-z.
16. E.M. Getto, B. Tobie, E. Bautista, A.L. Bullens, Z.T. Kroll, M.J. Pavel, K.S. Mao, D.W. Gandy, and J.P. Wharry, "Thermal Aging and Hall-Petch Relationship of PM-HIP and Wrought Alloy 625," *JOM*, 71 (2019) 2837–2845.

Janelle P. Wharry is an associate professor at Purdue University. A TMS member since 2009, she currently serves on the TMS Nanomechanical Materials Committee, Nuclear Materials Committee, and is the Structural Materials Division representative to the Education Committee.

Timothy Pownell is an undergraduate student at Purdue University. He was a participant in the Network for Computational Nanotechnology (NCN) Undergraduate Research Experience (URE) program at Purdue.

Esteban Bautista recently received his bachelor's degree from California State University, Northridge, and is pursuing his Ph.D. at the University of California, Irvine in fall 2020. He was a participant in the NCN URE program at Purdue.

Tanya Faltens is the educational content creation manager at the Network for Computational Nanotechnology at Purdue University. She has been a TMS member since 2017.

JOM, Vol. 72, No. 8, 2020
https://doi.org/10.1007/s11837-020-04277-3

Research as Equalizer: University Research Opportunities for Underserved Students

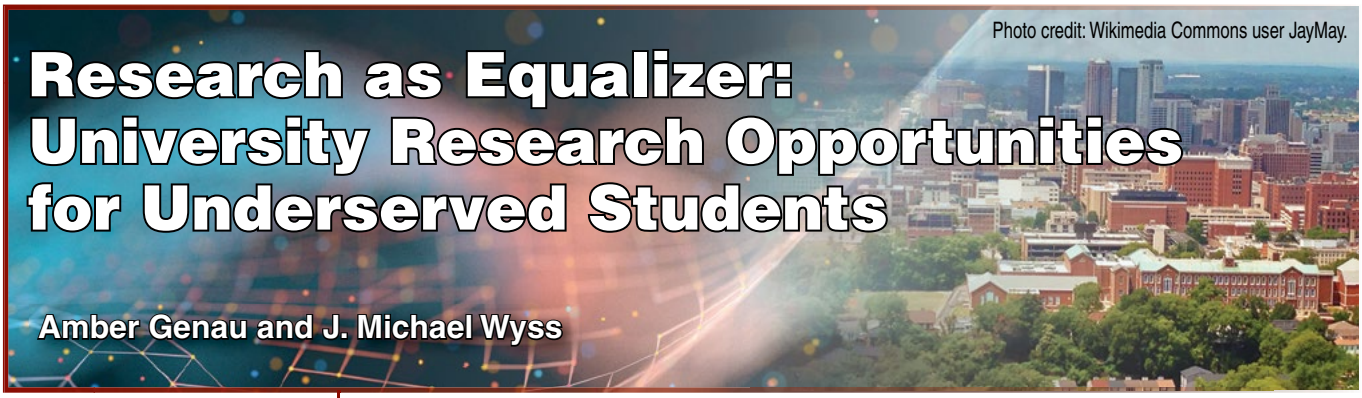


Photo credit: Wikimedia Commons user JayMay.

Amber Genau and J. Michael Wyss


Amber Genau


J. Michael Wyss

The Background on Birmingham

Universities, like people, are shaped by their surroundings. The University of Alabama at Birmingham (UAB) began as a medical school that evolved into a comprehensive university where over $600 million per year of extramural funding enables its investigators to conduct cutting-edge research in medicine, engineering, and other fields. Currently taking up 110 city blocks in the center of Alabama's largest metropolitan area, UAB is impacted by Birmingham's and Alabama's complicated history. Alabama is the sixth-poorest state in the U.S., with about 17% of Alabamians living below the federal poverty line. For Black and Hispanic residents, the poverty rate rises to more than 30%. African Americans make up 27% of the state population, 43% of the county in which Birmingham is located, and 73% of Birmingham itself. Growing up in the shadow of UAB are the children served by the Birmingham City School System, 98% of whom are Black or Hispanic, and nearly two-thirds of whom are economically disadvantaged. To most of those students, the activities inside the university often seem as distant and incomprehensible as the dark side of the moon. One group at UAB, however, is working diligently to change that.

CORD Can Make A Difference

The university's Center for Community OutReach Development (CORD) was founded in 1998 by UAB's then-president and a passionate professor of biochemistry out of a sense of responsibility and desire to give something back to the community. Its goal is to help students be engaged by and prepared for careers in science, technology, engineering and math (STEM), which form the bulwark of the 21st century economy. Today, CORD provides a variety of programs that impact ~65,000 students and ~3,000 teachers across Alabama.

One particularly successful and long-running activity has been CORD's summer research internships, which

Community college summer research interns studied the engineering aspects related to biomedical patient evacuation during their time in the University of Alabama at Birmingham's Center for Community OutReach Development (CORD).

bring high school and community college students to campus for an immersive experience of real scientific research. Over the years, more than 460 high school and community college students have participated in ten-week summer research experiences with UAB faculty. The CORD program actively recruits 15 to 20 top 11th grade students each year, many of whom are from the Birmingham City Schools, and around 20 additional students from the campuses of two area community colleges. By using its strong relationships with teachers to recruit the best and most promising individuals, including students who might not have previously considered entering a STEM career, CORD is able to maintain both extremely high standards and a focus on serving minority and underprivileged students. At least 70% of participants are minority students from the Birmingham City System, with the remaining 30% considered "privileged" students, coming mostly from schools in the wealthier suburbs. Using funding from the National Institutes of Health, National Science Foundation, and other grants, community college students receive a $5,000 stipend for their summer's work, while high school students receive $1,000.

About 60% of the Birmingham students are initially engaged in STEM through CORD's suite of programs for younger students. These programs are all linked to the curriculum of the students and since 2010, they have been linked to the engineering, cross-cutting concepts that have become a major element of the Next Generation Science Standards. In all of these programs, UAB researchers talk to students about their STEM careers. Especially helpful for these discussions are minority graduate students and postdocs who describe their work, causing the younger students to come to believe that they too could become STEM professionals.

In January, CORD starts to recruit faculty to serve as mentors, and then works carefully to match participants with research projects in their STEM area of interest. After a series of interviews, the final cohort of interns is selected. They are initially trained in topics like lab safety and research ethics both at their campuses in the spring and at UAB during the first week of the summer program. An important lesson that CORD learned was to try to ensure that the interns are trained in most of the regulatory programs required by the university, e.g., Institutional Review Board, Institutional Animal Care and Use Committee, Occupational Health and Safety. This allows the interns to very quickly begin to their research once at UAB. Lacking this, interns are often delayed one to three weeks in initiating their hands-on research.

> ***"By using its strong relationships with teachers...CORD is able to maintain both extremely high standards and a focus on serving minority and underprivileged students."***
> **—Amber Genau and J. Michael Wyss**

Throughout the summer, interns continue to meet regularly to present the research that they are conducting to each other, as well as to learn about topics like statistics and experimental design. A CORD staff member visits every intern's lab regularly, to make sure the student is progressing in their project and that they are engaged in real and meaningful tasks. An important requirement of the

Terry McCullough, a research intern through the CORD program, won a Best Presentation Award for his poster, based on work done in collaboration with his biomedical engineering mentor.

High school student and CORD program participant Kai Akinloye-Brown won the Most Promising Scientist Award for her project that studied biodegradable algae planters.

internship is that each student create and test their own hypothesis. Attendance requirements are strict: each student is given two vacations days for the entire summer and is expected to work in the lab about 40 hours per week. This means that students are sometimes faced with hard choices about participating in research at the expense of family vacations, sports practice, or band camp. At the end of the summer, all students present their work at UAB's Student Research Expo, which provides opportunities for both oral and poster presentations as faculty judges award various prizes.

"In the past 15 years, every high school intern has not only entered college after their senior year but also went on to graduate....Of the community college interns, about 70% come to UAB majoring in a STEM discipline."
—Amber Genau and J. Michael Wyss

Program Results

The proof of the efficacy of these programs is in the numbers. In the past 15 years, every high school intern has not only entered college after their senior year but also went on to graduate. Almost half of last summer's interns are headed to UAB this fall, many as members of the university's prestigious and competitive Science and Technology Honors Program. Of the community college interns, about 70% come to UAB majoring in a STEM discipline. About 90% of those students graduate in four years, with the rest finishing in five. Almost all of them then go on to graduate or professional school. About 20% of the interns become authors on journal articles based in part on their summer research. While the outstanding students are a major asset of the program, the dedicated research mentors are just as important. If mentors are not strongly committed to developing the next generation of STEM professionals, intern programs are unlikely to be successful.

Over the years, these internships, along with other CORD programs, have served as a recruiting tool for the university. More importantly, they serve UAB's mission of giving back to the community by reducing regional, racial, and gender disparities in STEM education and careers and building a strong, diverse science workforce, both locally and nationally. It is a mission that the students themselves are carrying on, with former interns now serving their communities as doctors, teachers, Ph.D. research scientists, and leaders in STEM outreach at other universities. To learn more about UAB's CORD programs, please visit https://www.uab.edu/cord/.

Amber Genau is an associate professor of materials science and engineering at the University of Alabama at Birmingham (UAB). She is currently the chair of the TMS Education Committee, vice chair of the Solidification Committee, and Material Advantage faculty advisor at UAB.

Michael Wyss is a professor of cell, developmental, and integrative biology, medicine, neurobiology, biology, and psychology, and has been the director of UAB's Center for Community OutReach Development (CORD) for the last 16 years.

JOM, Vol. 72, No. 8, 2020
https://doi.org/10.1007/s11837-020-04278-2

The Future of Materials Science in Academia: Landing Your First Faculty Position

V.M. Miller

V.M. Miller

Do You Have A Perspective to Share?

JOM: The Magazine is seeking case studies, member perspectives, and non-technical project overviews with strong industrial applications. To suggest an article idea, contact Kaitlin Calva, *JOM* Magazine Managing Editor, at kcalva@tms.org.

How to Get Started

Landing a first tenure-track faculty position is a monumental task. Even with strong mentorship, it can seem insurmountable. Universities routinely receive 150 to 500 applications for every open faculty position in materials science and related disciplines. While it would be impossible to put together a fully comprehensive guide, this article serves as an overview and resource for graduate students and postdoctoral researchers looking to apply for tenure-track faculty positions, primarily at research-focused institutions in materials science and engineering.

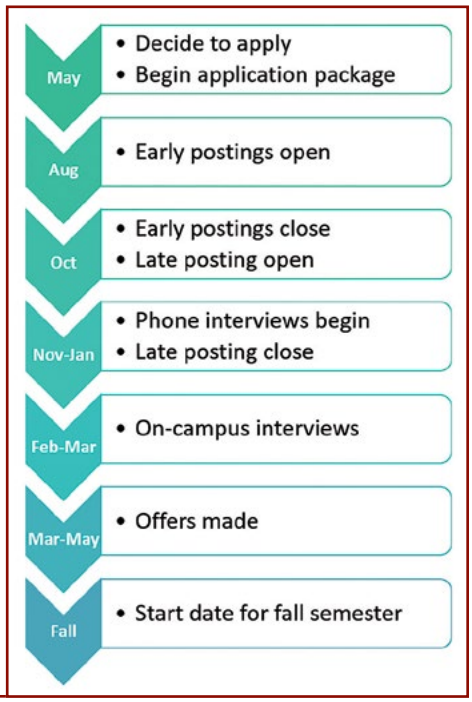


Figure 1. This graph depicts the timeline for a typical application and interview process, which begins as hundreds of applications get filtered down to approximately 10 to 15 by the search committee. Applicants are then invited to have a phone (or video conference) interview. The timing for phone interviews varies but is typically between November and February. From the phone interviews, approximately three applicants will be selected for on-campus interviews one to two months later. This sort of timeline would usually correspond to a start date for the following fall semester.

The application and interview process can take the better part of a year, so perhaps the first question you need to ask yourself is when do you apply? There is no hard and fast rule. A postdoc will almost never hurt and can be helpful in addressing areas of your *curriculum vitae* (CV) where you may be less competitive. However, getting an offer right out of school is not unheard of. The best advice will be to lean on your mentors—they will know if you are ready to apply or not.

The second question is where do you apply? The best option for most applicants is the middle ground. If you are preparing 30+ applications, you are unlikely to have time to customize all of them adequately, so they are not likely to be competitive. On the other hand, only applying to one or two schools *dramatically* reduces your chances.

Relatedly, do you apply solely to materials departments or could you be successful in another department? The answer will depend on your research direction and the research culture of the hiring department.

The path from application to accepting an offer is laid out in Figure 1. At most universities, faculty searches get posted online late in the summer or early in the fall. While there are posted deadlines, some universities start review immediately. As a result, it is better to submit applications early whenever possible.

The Application

The application packet is critical; it needs to be spectacular to make it through the first stage of winnowing the pile of applications down to a manageable volume. At this stage, one of the most important things for a successful application is to follow the format and content directions in the job posting. It is always advisable to mirror the language

"If a CV is a measure of how impactful you have been in the past, the research statement is an indicator of how impactful your research will be in the future."
—V.M. Miller

used in the posting.

For most universities, a complete application packet will have five components: a cover letter, the applicant's CV, a research statement, a teaching statement, and references to provide letters of recommendation. Each is described below, arguably in decreasing order of importance.

Curriculum Vitae

Having a complete and easy-to-interpret CV is critical. Publications and presentations illustrate at a glance how impactful you have been in your career to date. It is generally good practice to include hyperlinked DOIs whenever possible. While opinions vary on whether "in preparation" and "submitted" manuscripts should be included, one common rule of thumb is that you can include it with the disclaimer that copies are available upon request. For submitted manuscripts, it is inadvisable to list the journal to which it has been submitted before acceptance.

Research Statement

If a CV is a measure of how impactful you have been in the past, the research statement is an indicator of how impactful your research will be in the future. It needs to cover both the next five to ten years but also the arc of your whole career.

The research statement should begin with an over-arching theme of your future research program, followed by a brief description of roughly three research thrusts. One effective strategy is to frame the theme around one of the national or global research priorities to not only motivate your work but highlight which funding agency you would seek out to support this work. Ensure that the research thrusts all contribute to your theme, represent who you are as a researcher, and contain well-articulated research objectives outlining what new knowledge will result from the proposed research and why that is important.

Recommendation Letters

Recommendation letters for a faculty application have the same caveats as any other career stage: it is important to balance "name recognition" versus the quality of the letter that a person will write. Also, some people simply write better letters than others. To get perspective on this, it is important to lean on advisors and senior mentors. Think about which positive attributes about yourself that you want your letter writers to highlight. Make sure that your letter writers know and understand your goals and aspirations as a potential assistant professor.

Teaching Statement

For many research-intensive universities, the teaching statement will be significantly shorter than the research statement—a department's priorities can often be observed in the page limits for each component of the application. An excellent teaching statement cannot outweigh a subpar research statement; however, a bad teaching statement can ruin an otherwise good application.

This teaching statement should cover the broad theme of your teaching philosophy. This is an opportunity to reflect on issues you may have seen during your own coursework and propose solutions in a positive way, or perhaps to draw from peer-reviewed literature on effective pedagogy in engineering education. It also presents an opportunity to show interest in a particular department by referencing the course catalog to demonstrate how you might fit in with or help expand the existing curriculum.

Cover Letter

Like the teaching statement, it is important that a subpar cover letter does not deflate the rest of the application. This piece will be most heavily tailored to a given school; it *absolutely* should not read as a generic letter. Reference particular facilities or centers, what attracted you to the department, how you heard about the posting, or other non-generic information. How will your presence help to grow the department? How will this specific department improve your career? It is critical to cover both sides of the question to illustrate that the fit is correct.

Phone Interview

The next stage of the process is a phone or videoconference interview. These tend to be brief, but it is always advantageous to know in advance how long the interviewer(s) anticipate this will take—it can help to tune the length of verbal answers. The phone interview is typically

with part or all of the search committee. It is absolutely fine to ask who is expected to be in attendance, though last-minute changes are often inevitable.

One of the main objectives of the phone interview is to ensure that you can answer questions articulately when put on the spot. Written statements can be heavily coached or partially written by others; it is much harder to fake a phone interview.

The level of preparation expected on a phone interview is highly variable. In general, schools that provide a list of questions in advance tend to expect more preparation than schools that do not. Because of the variability, it is always important to prepare as much as reasonably possible. Ask a trusted friend or colleague to practice this portion with the same media that will be used for the interview to test your video or phone connection. Take your time and answer questions with a clear ending to avoid giving long-winded answers.

In-Person Interview

Regardless of career stage, these interviews are mentally, emotionally, and physically exhausting. However, if the school is a good fit, interviews are often fun! You get to spend one to two days talking about your past and future research with a group of people that hopes to work with you for the coming decades. One of the most important pieces of advice for this stage is to be yourself. You want a department to choose you based on your true qualities, rather than forcing yourself to fit into what you think they are looking for.

The interview has three primary components: the research talk, the vision talk, and individual or small group meetings with faculty. Additionally, there are nearly always meetings with the department head and the dean or another college-level administrator. You will typically get your itinerary a few days in advance—use this advance warning to thoroughly prepare and research the people you will be talking to.

Research Talk

Typically the first of the two presentations during an interview, the research talk is usually openly advertised to the department/center in which you are interviewing. This talk should be quite heavy on background and motivation; materials departments are especially diverse, so you do not want to lose the faculty who are in a different specialization area within the first few slides. The "pyramid theory" of giving a talk is helpful, as illustrated in Figure 2. The peak allows you to show that you are fully competent on the topic; if they want to push you further, they will have time in the question and answer section. And, by keeping the bulk of the talk broad enough that the majority of the audience understands, you can simultaneously demonstrate that you will be an effective teacher.

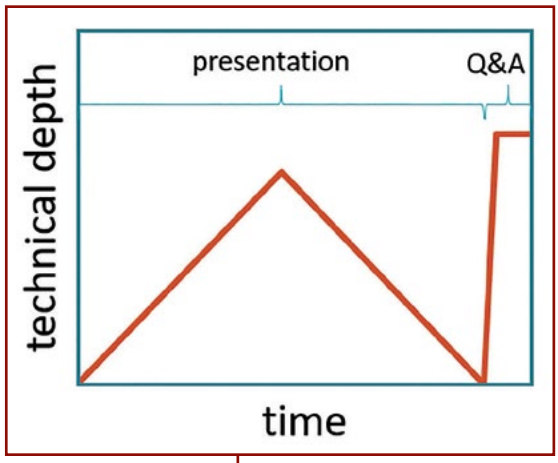


Figure 2. The "pyramid" structure of a technical talk starts with information so broad that anyone can understand it, builds to a peak of technical complexity that appeals to the subject matter experts briefly in the middle, then closes by generalizing your results back out to be broadly understood again.

Additionally, this research talk is an opportunity to illustrate how you think about problems as a scientist. You can motivate a problem showing the impact it will have on society, frame scientific objectives such that you show the impact it will have materials research, and illustrate that you can translate that opportunity into an effective research plan.

Vision Talk

Fundamentally, the vision talk speaks to who you are as researcher, as a teacher, and as a member of your scientific community. In the vision talk, you will address each of those three pillars in proportions that correspond to the priorities of the department. For a research-intensive university, this means you should spend 60 to 70% of the talk on research, roughly 20% on teaching, and roughly 10% on service.

One effective layout is to start with motivation for that research theme, segue to a brief five-minute summary of how your research to date fits that theme, then finally build to how that has prepared you to take on the new research programs that you propose. The longest portion of the talk will be a description of new research programs. The proposed research is in the near-term (the first proposal you would write or tasks for the first student), but it should be clear how this connects to your 30-year vision for your career.

> *"...you want to leave the impression that you are both a competent scientist with the ability to have a successful career* and *a pleasant person with whom to work."*
>
> **—V.M. Miller**

Meetings with Faculty and Administrators

Outside of the two seminars, the rest of the interview will be filled with back-to-back ~30-minute meetings. Like the rest of the application process, appropriate preparation is key (flashcards are a great way to study). During these meetings, you want to leave the impression that you are both a competent scientist with the ability to have a successful career *and* a pleasant person with whom to work.

Let the person you are meeting with lead the conversation if they want to but have a few planned points to prod them with if conversation is slow to start naturally. For someone in a research area close to yours, this is a good opportunity to demonstrate what you bring to the table as a future collaborator. Do not feel like each of these conversations needs to be perfectly unique; you will likely end up covering similar topics with a number of different people. This allows you to leave the department with a consistent message.

All meals during your interview are also likely to be with small groups of department faculty. There may also be social events in your schedule. It's important to be yourself and be friendly, but to remain professional. While it's reasonable to have an alcoholic beverage with dinner (or not!), absolutely do not over-indulge.

Meetings with administrators are slightly different. This is a unique opportunity to talk about the "big picture" vision for the department and the college. Based on these conversations, you can see if your vision for your own career is complementary to that of the institution. Most departments wrap up this interview with another meeting with the department head or a similar administrator to talk specifically about what would be needed in a competitive offer. Be prepared to talk about what research resources you need, including equipment and computational infrastructure. At this stage you probably do not need quotes, but it is helpful to have a ballpark price; the main goal is to convey that you have completed the forethought necessary to administer your research program. Additionally, be ready to talk about other concerns you have that might come up during the hiring process, such as a two-body problem if you are relocating with spouse or partner that also has a professional career.

Second Visit and Negotiation

More and more commonly, an applicant is offered a second visit to work out the details of what needs to be included in a competitive offer. The layout of a second visit varies, but it typically contains visits with faculty that you did not get to meet previously, laboratory tours, and often a real estate tour. While the second visit is typically less formal than the first, make no mistake: this is still an interview! Dress nicely, if less formally, and be professional to everyone that you meet with.

Discussion and negotiation of an offer takes place with the department head or department chair. The guiding principle is to ask for what you need to be successful. Do not tie your ego to inflating the number as much as possible, but also do not leave out equipment that you need because you are afraid of asking for too much. However, do build in some extra resources; budget for the full price of brand-new equipment, then get discounts from the manufacturer when you actually purchase it.

At this stage, everything is on the table: starting date, salary, years of student support, staff support, extra teaching relief, equipment, usage hours of shared equipment, etc. You have negotiating power for each of these things, but you need to decide which are most important to you. As with all negotiations, get the important commitments in writing; verbal agreements are subject to change if there is a shift in department priorities or the global economy. Get the negotiating done *before* you sign your offer; once you have signed, you have lost your negotiation power. Asking for more time (e.g., if you have an interview with another school scheduled) is fair but should be done carefully. While you can use competing offers as a point of negotiation, remember that the materials community is small; you do not want to develop a reputation for playing political games or leading schools on.

Once you have signed, celebrate! You are excited, the department is excited to have you, and an awful lot of stress evaporates!

V.M. Miller is an assistant professor in materials science and engineering at the University of Florida. She is an active member of several TMS technical and functional committees and received the 2018 TMS Light Metals Division Young Leaders Professional Development Award.

Acknowledgments

V.M. Miller would like to thank L. Rueschoff for substantial inspiration in writing this article.

JOM, Vol. 72, No. 8, 2020
https://doi.org/10.1007/s11837-020-04279-1

JOM themagazine

TMS meeting headlines

Meeting dates and locations are current as of June 23.
For the most up-to-date list of TMS-sponsored events, visit www.tms.org/Meetings.

Other Meetings of Note

The 11th International Conference on Molten Slags, Fluxes and Salts (MOLTEN 2021)
February 21–25, 2021
Seoul, South Korea

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

5th International Congress on 3D Materials Science (3DMS 2020)
June 29–July 2, 2021
Washington, D.C., USA

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

The 14th International Symposium on Superalloys (Superalloys 2021)
September 12–16, 2021
Seven Springs, Pennsylvania, USA

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

Materials in Nuclear Energy Systems (MiNES 2021)
September 19–23, 2021
Pittsburgh, Pennsylvania, USA

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

MS&T20
MATERIALS SCIENCE & TECHNOLOGY

October 4–8, 2020
David L. Lawrence Convention Center
Pittsburgh, Pennsylvania, USA
www.matscitech.org/MST20

- The Material Advantage Student Program offers $200 and $500 travel grants for individuals and Material Advantage chapters, respectively, to attend Materials Science & Technology 2020 (MS&T20). Awards will be distributed on a first-come, first-served basis. The deadline to apply is September 20, 2020.
- Excellent spots in the exhibit hall are still available that offer exposure to thousands of diverse attendees in virtually every field of materials science. Book your booth online today.

TMS2021
150th Annual Meeting & Exhibition

March 14–18, 2021
Orlando World Center Marriott
Orlando, Florida, USA
www.tms.org/TMS2021

- For 150 years, TMS has brought together minerals, metals, and materials scientists and engineers to discuss research, exchange ideas, and build relationships. Help us celebrate this milestone at the TMS 2021 Annual Meeting & Exhibition (TMS2021)!
- Two conferences will be co-located at TMS2021. Deepen your understanding of inclusion and equity in the workplace at Diversity in the Minerals, Metals, and Materials Professions 4 (DMMM4), and join engaging technical discussions at the 5th iteration of the International Symposium on Nickel and Cobalt (Ni-Co 2021).
- Book your hotel room now at the Orlando World Center Marriott and enjoy the convenience of staying at the conference venue.

TMS ICME
MANUFACTURING
DESIGN
MATERIALS

April 18–22, 2021
Hyatt Regency Lake Tahoe
Lake Tahoe, Nevada, USA
Abstract Submission Deadline:
September 11, 2020
www.tms.org/ICME2021

- Submit an abstract to the 6th World Congress on Integrated Computational Materials Engineering (ICME 2021), a congress that convenes leading researchers and practitioners of ICME to share the latest knowledge and advances in the discipline.
- Be a contributor to the only congress dedicated to bringing stakeholders together from across nations, disciplines, and organizations to focus on integration priorities and gaps. Don't miss this opportunity to share your work and help advance the field.

Mg 2021
12th International Conference on Magnesium Alloys and their Applications

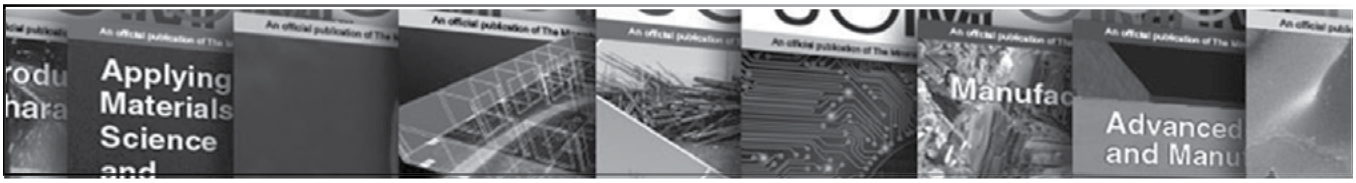
June 15–18, 2021
Hotel Omni Mont-Royal
Montreal, Canada
Abstract Submission Deadline:
September 15, 2020
www.tms.org/Mg2021

- The light metals community welcomes your contribution to the longest-running conference dedicated to the development of magnesium alloys. Submit an abstract to the 12th International Conference on Magnesium Alloys and their Applications (Mg 2021).
- A variety of sponsorship and tabletop exhibit opportunities are available to meet every budget. Visit the Exhibits & Sponsorship page of the Mg 2021 website for details.

JOM, Vol. 72, No. 8, 2020
https://doi.org/10.1007/s11837-020-04280-8

call for papers

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



February 2021
Manuscript Deadline: September 1, 2020

Topic: Advanced Coating and Thin Film Materials for Energy, Aerospace and Biological Applications

Scope: This special topic explores recent developments in advanced thin film and coating materials for energy, aerospace, and biological applications. Of particular interest are the following topics: novel coating and thin film materials and fabrication techniques, e.g., nanostructured coatings, functionally graded coatings; coating materials for energy production and energy conversion, e.g., thermal barrier coatings, coatings for solar cells, thin film materials for battery, environmental barrier coating, bio-inspired coating, and self-healing coating; and surfaces and coatings for biological and biomedical applications.
Editors: Jing Zhang, Yeon-Gil Jung, Albert Feuerstein, Li Li, and Raymond Sinatra
Sponsors: Surface Engineering Committee and Thin Films and Interfaces Committee

Topic: Characterization of Additive Manufactured Materials (By Invitation Only)

Scope: The field of additive manufacturing (AM), also referred to as 3D printing, has made great progress over the past few years. Significant research is being conducted in academe and in industry, opening new application areas, especially for rapid, custom manufacturing. Advances are being made in the development and production of certified feed powder materials, and new analytical techniques capable of characterizing end-use products. These advances are projected to yield superior and custom end-products.
Editors: Rajiv Soman, Yunus Eren Kalay, and Zhiwei Peng
Sponsor: Materials Characterization Committee

Topic: Impurity Control throughout the Primary Aluminum Production Chain

Scope: This topic covers the control of impurities (metallic and non-metallic) throughout the primary aluminum production chain, from bauxite to aluminum. Papers invited are those focusing on novel developments (underpinned by with new scientific and practical data) in managing detrimental and/or beneficial impurities in this value chain, including extraction and beneficiation of ores, alumina refining, electrode manufacturing and technologies, aluminum electrolytic reduction, and treatment prior to metal casting.
Editors: David S. Wong, Hong Peng, and Jayson Tessier
Sponsors: Aluminum Committee and Hydrometallurgy and Electrometallurgy Committee

Topic: Machine Learning and Other Emergent Paradigms in Computational Materials Research (By Invitation Only)

Scope: The field of computational materials science has been applying essential concepts of machine learning such as guessing and iteratively optimizing solutions, interpolating functions in high-dimensional space, and manipulating patterns in data, effectively since its inception. Recent developments in learning theory and practice, along with the proliferation of data and cheap computing, have resulted in promising new methods and enhanced embodiments of established techniques. This special topic comprises invited papers presented at the Computational Thermodynamics and Kinetics Symposium during the TMS 2020 Annual Meeting & Exhibition.
Editors: Jorge A. Muñoz, Sara Kadkhodaei, and James R. Morris
Sponsor: Invited

Topic: Materials for High Reliability Devices

Scope: This topic invites papers that are related to high reliability devices for autonomous car or wide bandgap applications. Materials that are used for energy conversion devices are also included.
Editors: Albert Wu and Babak Arfaei
Sponsor: Electronic Packaging and Interconnection Materials Committee

Topic: Thermodynamic Optimization of Critical Metals Processing and Recovery

Scope: This special topic invites research that applies thermodynamic optimization theory and techniques to minimizing industrial waste generation while increasing resource and energy efficiency in critical metals production from primary and secondary sources. Manuscripts that address topics in generalized theory, solution algorithms, specific materials processing units or whole production processes, as well as those that integrate experiments are welcome. Papers intended for a broad readership, including review papers, are especially encouraged
Editors: Chukwunwike Iloeje, Fiseha Tesfaye, and Allie Anderson
Sponsors: Process Technology and Modeling Committee and Recycling and Environmental Technologies Committee

March 2021
Manuscript Deadline: October 1, 2020

Topic: Additive Manufacturing: Searching for In-situ Signatures

Scope: While additive manufacturing processes are being optimized through modeling and experimentation, there remains a presence of stochastic anomalies which can adversely affect the quality of parts produced. If such anomalies go undetected, an unfit part may be mistakenly certified for use. Such instances reduce confidence in the use of additive manufacturing in structurally demanding applications. Manuscripts are solicited that seek to identify and characterize anomalous process behavior through analysis of in-situ monitoring data.
Editors: Tom Stockman and Somayeh Pasebani
Sponsor: Additive Manufacturing Committee

Topic: Leveraging Materials in Topology Optimization

Scope: Topology optimization is pushing the frontiers of material design by decoupling and independently optimizing material properties and functionality. Topology optimization offers a mathematical framework to determine the most efficient material layout for prescribed constraints and loading conditions. It offers a framework for accessing unexplored and previously unachievable areas of material-property space. This topic will feature several invited contributions from researchers and artists innovating methods and applications of design and topology optimization for materials.
Editor: Natasha Vermaak
Sponsor: Invited

Topic: Powder Materials for Energy

Scope: This topic will cover powder materials related to energy. It includes powder synthesis, forming (including additive manufacturing), sintering, and property evaluation. The topic intends to cover advances in theory, modeling, and computation while in parallel developing cutting-edge experimental techniques and approaches to understand and characterize powder materials in energy areas. Both theory and modeling and experimental efforts in powder materials synthesis, processing, characterization, and performance evaluation will be covered.
Editors: Kathy Lu and David Yan
Sponsor: Powder Materials Committee

TMS

Use Your TMS Membership to Access More High-Quality Journal Content!

Did you know that, as a TMS member, you have free electronic access to 26 materials-related technical journals?

Use your TMS membership to access current issues, as well as archived content, from all of the journals pictured on this page, as well as content from 20 additional journals published by Springer.

How?

To begin accessing your electronic subscriptions:

1) Go to **www.tms.org/Journals**
2) Log in using your TMS Username and Password
3) Select the TMS journal you'd like to read, and access your free journal content from SpringerLink

OR

4) Click on the "Additional Journals" link to select from a list of 20 additional Springer journals, which are all free to TMS members

Take full advantage of your TMS membership and explore all of these journals today.

www.tms.org/Journals

Thermo-Calc Software

Empowering Metallurgists, Process Engineers and Researchers

Do you rely on handbook data?
What if the materials data you need doesn't exist?

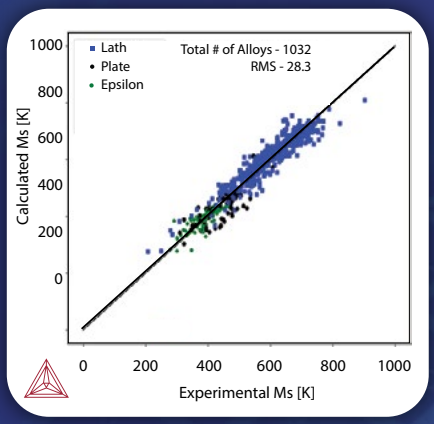
With Thermo-Calc you can:

- ✓ **Calculate** phase-based properties as a function of composition, temperature and time
- ✓ **Fill in** data gaps without resorting to costly, time-consuming experiments
- ✓ **Predict** how actual vs nominal chemistries will affect property data
- ✓ **Base Decisions** on scientifically supported models
- ✓ **Accelerate** materials development while reducing risk
- ✓ **Troubleshoot** issues during materials processing

Over 40 Thermodynamic and Kinetic Databases

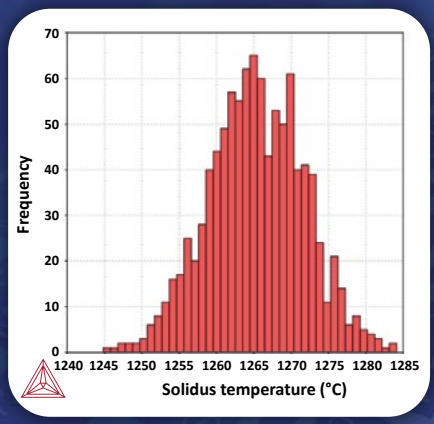
Choose from an extensive selection of thermodynamic and mobility databases in a range of materials, including:

Steel and Fe-Alloys



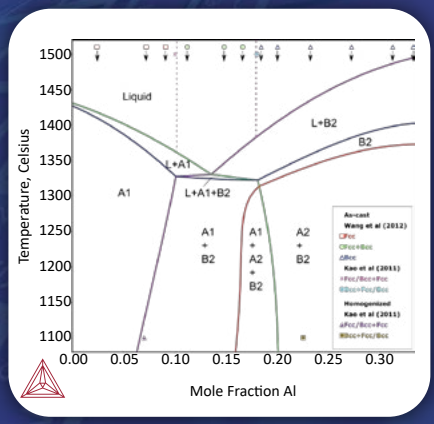
Comparison of calculated and experimental Ms temperatures for a wide range of steels

Nickel



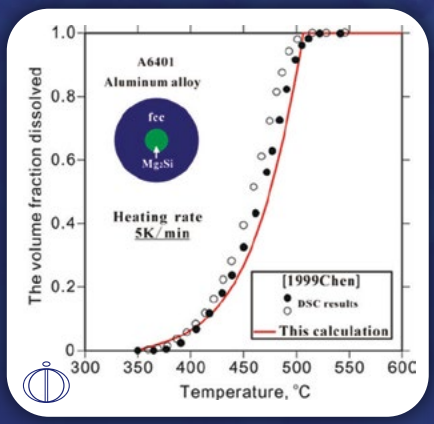
Variation in solidus temperature over 1000 compositions within alloy 718 specification

High Entropy Alloys



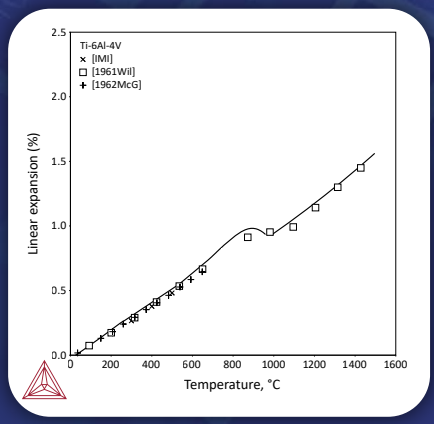
Calculated phase diagram along the composition line of CoCrFeNi-Al

Al Alloys



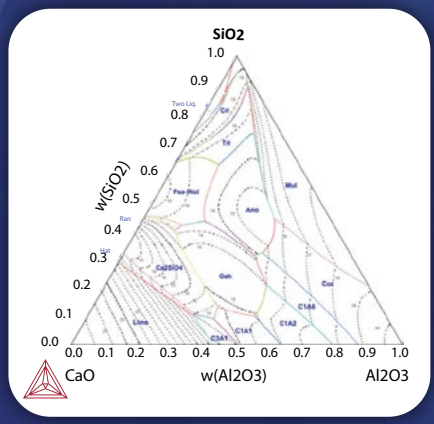
Dissolution of Mg2Si precipitate in Alloy A6401

Ti and TiAl Alloys



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

Oxides



Ternary liquidus projection in oxide systems

www.thermocalc.com

info@thermocalc.com