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Watch and Learn: Anniversary Keynote Presentations Now Available

Kelly Zappas

In honor of the 150th anniversary of TMS and the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME), TMS has made a series of recorded talks available from the TMS 2021 Virtual Annual Meeting & Exhibition (TMS2021 Virtual), held March 15–18, 2021. Selected by the TMS technical divisions as Anniversary Keynote Presentations, these noteworthy talks can now be viewed through the TMS website. No log-in is required to view them.

Gain a sneak preview of each talk through this article and view the full presentations at **www.tms.org/AnniversaryKeynotes**.

Extraction & Processing Division

"Materials Innovations Towards Decarbonization of Industrial Processes"

Elsa Olivetti

Presenter: Elsa Olivetti, Massachusetts Institute of Technology

This invited presentation was delivered at Design and Manufacturing Approaches for the Next Generation of Sustainable Materials, the 2021 Student-Led Symposium, which was organized by a team of students from the Colorado School of Mines.

Olivetti discusses work focusing on strategies to mitigate greenhouse gas emissions in materials-related industries and looks at resource use and the complexity of that process.

"Because materials don't exist in isolation—they're part of complex networks—we need to think about the various scales at which we develop these materials in order to understand their environmental impact and to help mitigate that impact," said Olivetti.

This presentation focuses on the significant challenge of reducing the burden of materials production, reviews recent progress in understanding the potential for decarbonization in the materials production sector, and describes where and how the material science community can have significant impact.

"Establishing a Domestic Cobalt Supply Chain: Unlocking Challenging Feedstocks"

Frank Santaguida

Presenter: Frank Santaguida, First Cobalt Corporation

This talk was presented at the plenary session for the 5th International Symposium on Nickel and Cobalt (Nickel-Cobalt 2021), a special event held in conjunction with TMS2021 Virtual.

Cobalt is deemed a critical mineral in the United States and Canada due to its use in power and energy generation and its availability within the global supply chain.

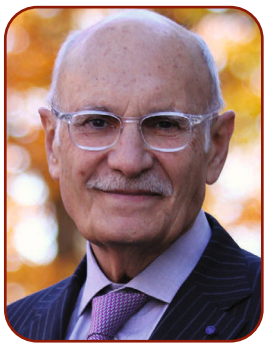
"Cobalt ranks highly along with the rare earth element metals," said Santaguida. "This talk highlights why cobalt ranks so highly and what is being done to address this criticality, specifically the supply risks in North America."

His talk looks at the availability of resources around the world and the challenges this poses to the supply chain. Though he admits that North America is likely about five years away from decreasing its dependance on cobalt imports, his presentation ends on a high note.

"The message I'd like to leave everyone with is positive. Changes are happening to establish a domestic cobalt supply chain that will be needed to sustain the electric vehicle market," he said. While there are some barriers that impede the timeline, he says, "These barriers are not walls."

Functional Materials Division

"Current Perspectives in High-Entropy Alloys"



Diran Apelian

Presenter: Diran Apelian, University of California, Irvine

Co-Authors: Benjamin Macdonald, Cheng Zhang, and Enrique Lavernia, University of Califonia, Irvine

"We shouldn't think of HEAs as a materials class but rather the paradigm by which we can design materials—a new design approach," Apelian says in this keynote presentation from the High Entropy Alloys IX: Alloy Development and Properties symposium at TMS2021 Virtual. In this talk, he discusses how the field of high-entropy alloys (HEAs) has evolved, examines specific systems and mechanistic opportunities, and looks at future directions for HEA research.

Since the first use of the term "high-entropy alloy" in 2004, there has been an explosion in the field, he says. And for good reason. Apelian points out the many structural as well as functional uses. "When you look at a list of the applications, you can see its almost universal application."

Two key research directions include the critical evaluation of the impact of atomic scale compositional fluctuations on alloy properties, and integrated computational materials engineering approach to developing refractory based HEAs with optimal mechanical behavior at elevated temperatures. This presentation seeks to establish the state of the art in both of these areas.

"Designing Electrode Architectures across Length Scales: Some Lessons Learned from Li-ion and 'Beyond Li' Chemistries"

Sarbajit Banerjee

Presenter: Sarbajit Banerjee, Texas A&M University

"We're in the midst of an unprecedented change in paradigm as far as energy is concerned," said Banerjee in this keynote talk from the symposium, Advanced Materials for Energy Conversion and Storage VII. "A big part of this puzzle is going to be energy storage."

Despite a large push for energy storage technologies, he pointed out, we've only had a four-fold improvement in energy density over the last 160 years. So, what are the bottlenecks preventing us from accessing some of the theoretical capacity for materials? Banerjee argues that this is a multiscale challenge, and it requires understanding of the entire range of phenomena.

"The moral of the story is the urgent need to bridge scales starting from understanding atomistic phenomena all the way to mesoscale phenomena and then to electrode-level phenomena," said Banerjee, whose talk discusses efforts to develop an Angstrom-level view of diffusion pathways using a combination of single-crystal X-ray diffraction and density functional theory calculations.

Light Metals Division

"Evolution of Alloy Design, Its Science/Instruments Base, Tech Transfer Routes, and Market Pull, 1921–2021"

Raymond Decker

Presenter: Raymond Decker, University of Michigan

This talk was delivered at TMS2021 Virtual as part of the TMS Light Metals Division symposium, Greater Than the Sum of Its Parts—Concurrent Alloy Design and Processing Science, which was held in honor of Raymond Decker's 90th birthday. In this presentation, Decker, who has been a member of TMS for 70 years, looks back at a century of evolution in alloy design and application, from 1921 to 2021.

Six successful case histories of alloy design and applications are presented, from the Inconel Alloy 600 in 1921 to maraging stainless steel for additive manufacturing at QuesTek in 2021 using integrated computational materials engineering (ICME). Drawing on his extensive experience, Decker offers a closer look at each example and looks at trends that have developed in the field during that time.

After looking at a century of examples, Decker states, "The best in alloy design is yet to come." He closes the talk by offering his own recipe for alloy design and applications.

Light Metals Division

"Near Net Manufacturing of Light Metal Alloys"

Mark Easton

Presenter: Mark Easton, RMIT University

In this talk, which was delivered at the TMS Light Metals Division Awards Ceremony & Special Lecture at TMS2021 Virtual, Easton discussed research that has been a theme throughout his career.

He began by defining near net shape manufacturing as a term given to processes that aim for the initial fabrication of a component to be close in size and shape to the finished product. This approach, he explained, reduces production costs and times associated with finishing steps and is particularly appealing for component manufacturing for high-value materials.

He spoke about challenges to the process and also how some of the themes of this research can travel from one manufacturing technology to the next.

"Near net shape manufacturing is continuing to evolve from more traditional methods such as casting to more modern methods such as additive manufacturing," he said. Many of the challenges, such as microstructure control and defect formation, remain the same, but approaches used in more traditional technologies to dealing with these issues can also be used in additive manufacturing.

Materials Processing & Manufacturing Division

"The High Entropy Alloy Space Is Not as Big as We Think It Is"

Raymundo Arroyave

Presenter: Raymundo Arroyave, Texas A&M University

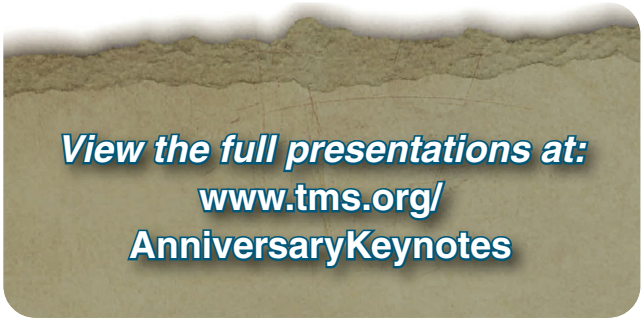
Co-Author: Tanner Kirk, Texas A&M University

How big is the available, feasible alloy space in high-entropy alloys (HEAs)? That is the question this invited talk from the Computational Thermodynamics and Kinetics symposium at TMS2021 Virtual sets out to answer.

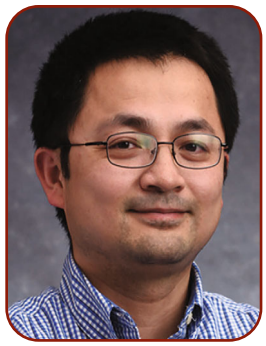
Arroyave presents recent investigations suggesting that, while big, the feasible HEA space in any given sub-sector (e.g., face-centered cubic HEAs, refractory HEAs, etc.) is severely constrained by typical alloy design considerations.

Combining CALPHAD, physics-based models, machine learning, and search/optimization algorithms, Arroyave presents a more nuanced view of the HEA space.

Ultimately, Arroyave concludes, the answer to his initial question is, "Not as large as we thought it would be."



"Applying Additive Manufacturing Itself as a High-throughput Tool to Accelerate Heat Treatment Design of Additively Manufactured Alloys"



Wei Xiong

Presenter: Wei Xiong, University of Pittsburgh

Co-Authors: Yunhao Zhao, Noah Sargent, and Kun Li, University of Pittsburgh

"Additive Manufacturing (AM) has become a very popular processing technique," Xiong says in this invited talk from the symposium, Additive Manufacturing: Solid-State Phase Transformations and Microstructural Evolution. "However, right now, we still have a limited understanding of processing-structure-property relationship in many of the AM processes."

As a result, he says, we have limited choices of new alloys or customized alloys for AM itself. "Therefore, this is a giant push for us to study this."

In thinking about how to accelerate the design of AM, Xiong's group looked at high-throughput computation with machine learning. This presentation looks at their research, which developed a gradient temperature heat treatment on a bar shape Inconel 718 alloy sample prepared by the laser powder bed fusion.

"I hope that with the community developing such strong interest, eventually we can develop more and more robust, high-throughput experiments to serve the purpose of alloy manufacturing design," he concludes.

Structural Materials Division

"Beyond Superalloys: An Efficient Strategy for Assessing Environmental Resistance"

Bruce Pint

Presenter: Bruce Pint, Oak Ridge National Laboratory

As part of the symposium, Materials for High Temperature Applications: Next Generation Superalloys and Beyond, Pint's talk looks at the interest in developing new materials with higher temperature capabilities to improve cycle efficiency and thereby, reduce fuel consumption and greenhouse gas emissions. He begins by discussing oxidation resistance and how not much has changed since 2004.

"Oxidation issues have become more important and harder to ignore," he said. "It's a foolish strategy to think that a practical high-temperature material will be developed without inherent oxidation resistance."

For refractory metals, high entropy alloys, and other candidates, embrittlement also is a concern for long-term performance. Examples are provided of assessments that include a variety of conventional and experimental alloys in environments simulating turbine exhaust and supercritical CO_2.

"The Role of Fracture in the Reduction of Iron Ore with Hydrogen"

Dierk Raabe

Presenter: Dierk Raabe, Max-Planck Institute

This invited presentation was delivered as part of 100 Years and Still Cracking: A Griffith Fracture Symposium at TMS2021 Virtual. Raabe opens his talk with some numbers: globally, we produce two billion tonnes of metallic products a year, consuming about 8% of global energy and accounting for about 30% of all industrial greenhouse gas emissions. On the other hand, the global market for materials products is about 3,000 billion euros per year.

The question Raabe's presentation poses is this: Can this market be turned into a circular/sustainable one?

This talk looks particularly at steel. While its products are a sustainability enabler (lightweight cars, wind farms, magnets), its production is not. Iron is typically reduced from ore using carbon, but this presentation looks at emission reductions that can be achieved by using hydrogen as a reductant instead. This lecture reports on recent progress in this research field, presenting results of a multi-scale structure and composition analysis of iron reduced from hematite with pure H_2.