HAZEN LECTURE SEMINAR SERIES

On the Design of Complex Solid-Solution Alloys

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Duane D. Johnson is F. Wendell Miller Professor of Materials Science & Engineering at Iowa State University (h-index 46+; 250 + publications, APS Fellow, 2003) and a leading expert in materials theory and computational materials science, with focus on electronic-structure-based method for quantitative prediction of stability, properties, thermodynamics, and transformations in alloys (e.g., chemically complex alloys, like high-entropy alloys) and energy-conversion materials. He has multiple patent applications/patents, and open-source codes, such as generalized solid-solid nudged-elastic band methods for determining transformation pathways. He served 6+ years as Chief Research Officer of Ames Laboratory overseeing the full ($47M) R&D portfolio with 375 people. At the University of Illinois, he was the Ivan Racheff Professor of Metallurgy (1997-2010) and served as the Director of the NSF-funded Materials Computation Center (2000-2010). Prior to this he was Senior Member of Technical Staff at Sandia National Laboratories, California (1988-1997), NRC Post-doctoral Fellow at the Naval Research Laboratory (1987-1988), and Post-doctoral Fellow at University of Bristol (1985-1986).

High-entropy alloys, a near-equiaxial subset of complex solid-solution alloys (CSAs), exhibit remarkable high-temperature mechanical strength, toughness and oxidation resistance in harsh environments. Nonetheless, from an alloy design perspective, CSAs offer a much larger and fertile design space to control/tune stability and properties, especially in various extreme environments. I introduce the concept (dispel myths) of “high-entropy alloys” and showcase a quantitative theory-guide design to combinatorial synthesis experiment and characterization, offering an integrated validation and design approach. I then outline areas of application for designed CSAs and their controlling mechanisms – from high-temperature mechanical behavior, oxidation resistance (with co-design, self-healing coatings), high-temperature thermoelectric properties, radiation resistance, hydrogen-embrittlement resistance, or cryogenic-enhanced strength.