seminar

"Materials Modeling and Experiments to Extend the Applicability of Advanced Manufacturing of Materials under Extreme Environments"

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abstract

For the last decade, advanced manufacturing processes are being applied to produce parts for use in extreme environments, especially for energy, nuclear, aerospace, and biomedical applications. A number of research groups have been investigating the applicability of direct metal deposition methods to build parts with oxide dispersion strengthened steels which is a strong candidate material for generation IV nuclear reactors. General Electric is making a large investment to 3-D printed jet engine parts. For the successful application of such advanced manufacturing processes, a good understanding of thermophysical and thermomechanical properties of materials prior to, during, and after manufacturing is indispensable. In the seminar, two major efforts will be presented to extend the applicability of advanced manufacturing through advances in the understanding of physical and transport phenomena in metals at high temperatures. First, a magnetohydrodynamic (MHD) model was developed to characterize the convection inside an electromagnetically levitated molten metal droplet. After first-ever quantitative experimental validation, the developed MHD model has been supporting the space experiments by providing the convection status during thermophysical property measurements and solidification of various metallic alloys. Second, a new noncontact method to measure the creep properties was developed and applied to materials for extreme environments. Using an electrostatic levitator at NASA Marshall Space Flight Center, a spherical, single-crystal niobium sample was rotated up to 5,000 Hz by a laser in a vacuum chamber. The constitutive parameters at 2,000 °C were determined by analyzing the deformation. The developed method was subsequently applied to several newly developed high temperature materials through funded collaborations with NASA, Aerojet Rocketdyne, General Electric, and the U.S. Air Force. These methods and tools are applicable to a broad range of other applications, including the additive manufacturing of high temperature aluminum-based alloys using laser engineered net shaping for next generation aerospace structural materials and highly porous medical implants with titanium alloys via cold gas dynamic spray.

biosketch

Dr. Lee is a research assistant professor in the Department of Mechanical and Industrial Engineering at the University of Massachusetts Amherst. He has been conducting multiple industry- and government-funded projects in the field of materials processing as PI and Co-I. Dr. Lee is the recipient of the Young Leader Professional Development Award in 2013 from The Minerals, Metals and Materials Society where he has been serving as a co-organizer and co-editor of the Materials Processing Fundamentals Symposium since 2014 and as a vice-chair of the Process Modeling and Technology Committee since 2017. Prior to joining the current institution, he had 4.5 years of industry experience and worked as a postdoctoral associate for Tufts University, Medford, MA. He earned his M.S. and Ph.D. in mechanical engineering from the University of Massachusetts Amherst and his B.S. in the same discipline from Inha University in Incheon, South Korea.

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