UC RIVERSIDE | Mechanical Engineering

ME 250 SEMINAR

Thermal Transport in Electronics Cooling and Additive Manufacturing

Thermal transport is critical to a wide range of applications and I herein focus on electronics cooling and additive manufacturing with the objective of teaching select scientific challenges underlying practical engineering advancements.

Overheating cripples the operation of electronic devices. Interfaces limit heat transfer rates, whether they are at the perfect intersection of epitaxial films or at the imperfect junction between solids with mismatched topography. Understanding fundamental heat transfer processes at interfaces is thus key to understanding operating temperatures and optimizing thermal management strategies for electronics. Beta-gallium oxide (β-Ga2O3) is leading the way to thin and high-power electrical devices due to its ultrawide band gap, high breakdown field, and affordable grown-from-melt substrates. We studied heat transfer rates at metal/β-Ga2O3 interfaces and discovered that thermodynamically favorable oxidation of the metals at the β-Ga2O3 interface limits heat transfer rates. We have also made theoretical progress on modelling thermal transport at interfaces where intermediate layers are used to promote adhesion and transmission of heat.

In metals additive manufacturing heat is our friend because it is used to transform feedstock (e.g. powder or wire) into parts with incredible geometric flexibility. My focus is laser powder bed fusion where a rastering laser melts patterns into sequential layers of metal powder to build solid parts one layer at a time. Additive manufacturing is currently an open loop process where the power and velocity of the rastering laser beam are maintained constant throughout the build in an effort to deliver a consistent amount of energy to the powder. However, complex geometries (e.g. overhangs), hatch patterns, heat accumulation, and powder spatter can cause heat transfer variations throughout the build that yield defective parts. Process Monitoring and closed loop feedback are hence broadly viewed as essential to widescale adoption of additive manufacturing. In my lab we are developing a highspeed two-color thermal imaging approach to monitor the meltpool, and with collaborators creating machine learning algorithms to associate defects with meltpool behaviors. In parallel we are studying thermal transport in the powders themselves to better inform deterministic meltpool models.

THURSDAY, May 13, 2021 | ZOOM | 11:00 AM - 11:50 AM

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Jon received his Ph.D in Mechanical Engineering at the University of California, Berkeley where he investigated thermoelectricity in single molecule junctions, in an effort to learn more about electronic transport in molecular electronics and organic-inorganic hybrid materials. He received his B.S. in Mechanical Engineering at the University of Michigan, Ann Arbor in 2000 and an S.M. in Nuclear Engineering (2003) from MIT. Since his arrival at Carnegie Mellon in 2009, Jon has received the AFOSR Young Investigator Award (2011), NSF CAREER Award (2012), ARO Young Investigator Award (2014), ASME Bergles-Rohsenhow Young Investigator Award in Heat Transfer (2014), the Carnegie Mellon College of Engineering Outstanding Research Award (2016), and the Carnegie Mellon College of Engineering Outstanding Teaching Award (2019). In 2020-2021 he served as the College of Engineering's Interim Associate Dean for Diversity, Equity, and Inclusion.