2021 UA TRICAMPUS MSE SPRING SEMINAR SERIES

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Design and Characterization of Nanostructured Materials for High-Strength Applications

Nanostructured materials, which are bulk metals and ceramics with grain sizes less than ~ 500 nm, are commonly used for many high-strength applications. Because a key microstructural feature of nanostructured materials is their high-volume fraction of grain boundaries, the development of new nanostructured materials is facilitated by enhancing one's ability to control and characterize grain boundary behavior. For years grain boundaries have been simply defined as 2D defects, but a more modern perspective considers grain boundaries as "phase-like" equilibrium structures that undergo first-order transitions. This new paradigm has been coined grain boundary complexion engineering and several case studies have demonstrated how complexions can be designed to improve material performance. I will start this talk by detailing a case study of my research where complexions were designed to improve fracture toughness of nanostructured boron suboxide for ballistic armor applications. I will demonstrate how we (1) tailored microstructures to promote crack deflection, (2) identified multiple grain boundary complexions in doped B6O using aberration-corrected scanning transmission electron microscopy (ac-STEM), (3) verified that the observed complexion types were thermodynamically stable using Density Functional Theory (DFT), and (4) discovered that the ordered complexion types toughened B6O using micro-cantilever beam testing. I will then describe a second case study where similar concepts and characterization techniques were used to engineer high entropy alloys that contain coherent ceramic phases in order to maximize hardness. Finally, I will conclude the talk by introducing the Lehigh Nano\Human Interface Initiative, which was created to accelerate scientific discovery of nanostructured materials by improving human-computer interactions with electron microscopes.

Dr. Chris Marvel is a Research Scientist in the Department of Materials Science and Engineering at Lehigh University and is currently the Associate Director of the Lehigh Presidential Nano\Human Interfaces Initiative. He received his bachelor's degree (2012) and PhD (2016) from Lehigh under the mentorship of Dr. Martin Harmer and studied thermal stability mechanisms of nanocrystalline metals and grain boundary complexions. In recent years Dr. Marvel has established a strong collaboration with the Army Research Laboratory (ARL) to synthesize nanocrystalline high entropy alloys and to design/characterize grain boundary phenomena in ultrahard ceramics. He was recently awarded the MEDE-MSA Research Fellowship to temporarily join Dr. Richard Todd's research group at the University of Oxford. Besides his academic work, Dr. Marvel just concluded a 3-year appointment in the ASM Emerging Professionals Committee, continues to serve on the Lehigh Valley ASM Executive Board, and works part time in the materials diagnostics company GrainBound LLC as the Chief Operations Officer.

Wednesday, February 17 - 2 pm CT

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