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Kavan Hazeli

Assistant Professor, Mechanical & Aerospace Engineering

The University of Alabama in Huntsville

Multifunctional Additively Manufactured Lattice Structures: Potential, Current Limitations, and Mechanics

Manufacturing multifunctional metals through the structural hierarchy (e.g., additively manufactured lattice structures or AMLS) is foreseen as one of the most promising directions of additive manufacturing (AM) as it can overcome the limitations of physical and mechanical properties of solid metallic materials that are imposed by the nature of their crystalline structure. AM techniques have revolutionized the manufacturing aspect of lattice structure materials by enabling a design that captures multiple functions through an intricate and complex structural hierarchy. AMLS made of superalloys and refractory alloys could provide remarkable e.g., yield strength, fatigue strength, and fracture toughness at elevated or cryogenic temperatures yet offsetting the high density of the base material. Empty spaces within AMLS enable controlled heat transfer, shock, and vibration energy management. Nevertheless, the effective mechanical properties of AMLS depend upon both the topology of the lattice structure and the base metallic material microstructure. Therefore, understanding the interplay between topology and microstructure under different loading conditions is necessary to maximize AMLS property for environment-specific applications. This talk focuses on the significance of understanding and quantifying the specific contribution of microstructure and topology on global behavior potentially leading to novel optimization capabilities. The discussed optimization approach accounts for scale separation and size effect that controls deformation mechanisms of AMLS to optimize macroscopic mechanical response under different loading conditions.

Dr. Kavan Hazeli is an assistant professor at the Mechanical & Aerospace Engineering Department at the University of Alabama in Huntsville. Kavan received his Ph.D. degree from the Mechanical Engineering and Mechanics Department at Drexel University in 2014. He completed his postdoctoral training in the summer of 2016 at Hopkins Extreme Materials Institute at Johns Hopkins University. His research lies at the intersection of manufacturing, materials science, and mechanics. Specifically, he uses combined experimental and modeling techniques to map processing-microstructure-property relationships in multifunctional materials made of superalloys and refractory alloys with macroscopic and microscopic hierarchical structures. Kavan is a recipient of 2020 NSF CAREER Award. His research effort is supported by a wide range of federal agencies including NASA, NSF, U.S. Army Space and Missile Defense Command, Department of Justice, Dynetics, and the US Air Force.

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