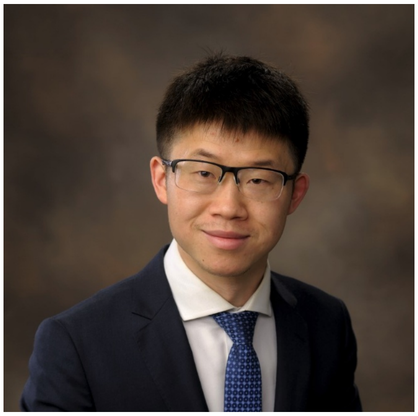
COLLEGE OF ENGINEERING
MECHANICAL ENGINEERING
UNIVERSITY OF MICHIGAN

A Mixed Diffusive-Sharp Interface Approach for Multi-Physics Modeling and its Application to Metal Additive Manufacturing

Jinhui Yan

Associate Professor

University of Illinois Urbana-Champaign



Tuesday, September 17th, 2024
4:00 PM to 5:00 PM
Room 2540 GGB

ME Seminar Link
Passcode: 340994

Add ME Seminar to Google Calendar

Abstract:

Interface-coupled multi-physics systems are ubiquitous in natural phenomena and engineering systems. They possess all the features of bulk-coupled multi-physics counterparts: physical coupling occurs through source terms or constitutive relations at every spatial point of the problem domain. Additionally, the physics coupling occurs through an idealized interface or a narrow buffer zone through boundary conditions. Metal additive manufacturing (AM) is such a challenging system. However, existing metal AM models have difficulty handling the laser-metal interaction and associated boundary conditions (BCs) that significantly influence printed part quality. This talk presents a mixed sharp-diffusive interface computational method to overcome these challenges in multi-physics simulations of metal AM processes. The framework consists of two components. The first is a mixed interface-capturing/interface-tracking multi-physics model to explicitly track the gas-metal interface topological changes without mesh motion or remeshing. The second is an enriched immersed boundary method (EIBM) to impose the critical Neumann BCs, which are enforced in a smeared manner in current AM models, on the gas-metal interface with strong property discontinuity.

I will demonstrate how the developed model elucidates the fundamental metal AM physics (e.g., melt pool dynamics, keyhole instability, and powder spattering) and predicts critical part quality-related quantities (e.g., defect and surface roughness). The proposed framework's accuracy is assessed by thoroughly comparing the simulated results against experimental measurements from NIST and Argonne National Laboratory using in-situ high-speed, high-energy x-ray imaging. I will also report other important quantities experiments cannot measure to show the framework's
predictive capability.

Bio:

Jinhui Yan is an associate professor in the Department of Civil and Environmental Engineering at the University of Illinois Urbana-Champaign. He obtained his B.S., MS, and Ph.D. from Wuhan University (2009), Peking University (2012), and University of California, San Diego (2016), respectively. After a two-year postdoc at Northwestern University, he joined the faculty of CEE@UIUC. His research group broadly works on computational mechanics and its scientific and engineering applications. His honors include the ASME Robert M. and Mary Haythornthwaite Young Investigator Award in 2018 and the Gallagher Young Investigator Medal from the U.S. Association for Computational Mechanics (UASCM) in 2023. The AM model developed by his research group won two prizes in the 2022 NIST AM benchmark modeling contests. His work also won the Best Paper in Manufacturing Technology from the Vertical Flight Society in 2024. He is a Levenick Teaching Fellow and often enters the list of excellent teachers ranked by the students at UIUC. He currently serves as the vice-chair of the computational fluid dynamics (CFD) and fluid-structure interaction (FSI) technical thrust of USACM and the Computational FSI committee of ASME.