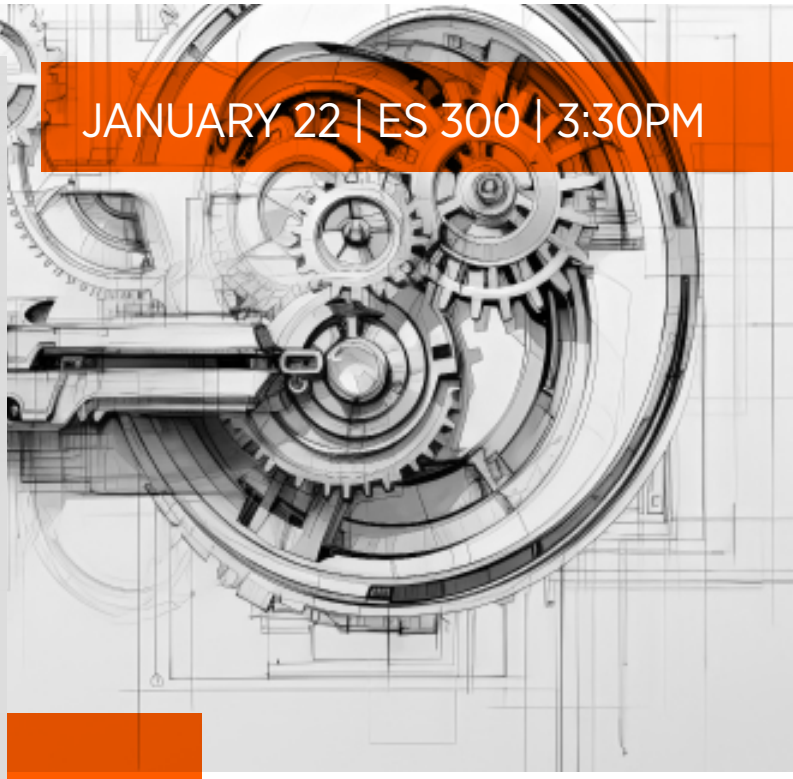
SCHOOL OF
MECHANICAL AND AEROSPACE ENGINEERING
College of Engineering, Architecture and Technology

MAE SEMINAR SERIES

Advanced Metal Additive Manufacturing: From Combinatorial Materials Design to Structural and Functional Applications



JANUARY 22 | ES 300 | 3:30PM

TUSHAR BORKAR, PH.D

Additive manufacturing (AM) has evolved from a rapid prototyping tool into a powerful platform for designing materials, microstructures, and components with site-specific properties that are difficult or impossible to achieve through conventional manufacturing routes. This seminar will present recent advances in laser- and arc-based metal additive manufacturing, emphasizing how controlled compositional design, in situ reactions, and hybrid AM–deformation pathways can be leveraged to tailor microstructure, mechanical performance, and functional properties. The talk will begin with laser-deposited metal-matrix composites, highlighting in situ phase formation in Ni–Ti–C systems where tailored TiC and graphitic phases form complex three-dimensional networks that deliver exceptional tribological performance. The role of reactive processing will then be discussed through in situ nitridation during laser deposition of Ti–Mo alloys, demonstrating how nitrogen alters solidification pathways, phase stability, and hardness while retaining the desirable ductility of β-Ti matrices. Next, a combinatorial additive manufacturing approach will be introduced to rapidly assess composition–microstructure–property relationships in complex, concentrated, and high-entropy alloys. Compositionally graded Al–Cr–Cu–Fe–Ni alloys exhibit systematic transitions in crystal structure, hardness, and magnetic behavior, underscoring AM's ability to accelerate alloy discovery and functional tuning. The concept of functional grading will then be extended to biomedical applications, where laser-deposited stiffness-graded titanium alloys enable fracture fixation implants with reduced stress shielding by matching elastic modulus to that of bone. The seminar will conclude with industrially relevant hybrid manufacturing strategies that combine AM with forging and repair operations. Results from hot-deformation studies on wire-arc additively manufactured Inconel 718 preforms will illustrate how post-deposition forging can eliminate anisotropy and refine the grain structure through controlled dynamic recrystallization. Finally, direct energy deposition–based repair of forging dies will be presented as a sustainable solution to extend tooling life, with insights into interfacial microstructure, mechanical performance, and alloy selection for repair applications. Collectively, these case studies demonstrate how additive manufacturing, when integrated with materials science principles and conventional processing, can enable next-generation structural, functional, and industrial components across aerospace, biomedical, and defense sectors.



ABSTRACT

Dr. Tushar Borkar is a Professor in the Department of Mechanical Engineering at Cleveland State University, where he leads a research program in advanced manufacturing, metal additive manufacturing, and forging science. His research focuses on process–structure–property relationships in additively manufactured and forged metals, hybrid additive–forging pathways, tooling and die repair, and digital qualification frameworks for aerospace and defense applications. The development of new classes of materials, including advanced metal alloys and metal matrix composites, using novel processing tools such as additive manufacturing, forms a unifying theme across Dr. Borkar's research activities. His work integrates advanced processing with state-of-the-art characterization techniques to uncover the underlying mechanisms and phase transformations governing microstructural evolution and microstructure–property relationships in complex, multiphase, multicomponent material systems and composites.

Dr. Borkar earned his Ph.D. in Materials Science and Engineering from the University of North Texas and his M.S. in Mechanical and Aerospace Engineering from Oklahoma State University, where he is an alumnus of the OSU MAE program. He previously worked as a Post-Doctoral Researcher at the University of North Texas and joined Cleveland State University in 2015. Since then, he has published more than 80 peer-reviewed journal and conference papers and has secured multi-million-dollar research funding from the U.S. Department of Defense, national manufacturing institutes, and industry partners. His research emphasizes close collaboration with the aerospace, forging, and tooling industries, with a strong focus on scalable manufacturing, workforce development, and the rapid transition of advanced manufacturing technologies into production environments.