LSU | College of Engineering
Department of
Mechanical & Industrial Engineering

The Robert W. Courter Seminar Series

3:00-4:00pm, Friday, March 8, 2019
1263 Patrick F Taylor Hall

Mechanics-guided Deterministic 3D Assembly

by Yonggang Huang*

Northwestern University

Complex three-dimensional (3D) structures in biology (e.g., cytoskeletal webs, neural circuits, and vasculature networks) form naturally to provide essential functions in even the most basic forms of life. Compelling opportunities exist for analogous 3D architectures in human-made devices, but design options are constrained by existing capabilities in materials growth and assembly. We report routes to previously inaccessible classes of 3D constructs in advanced materials, including device-grade silicon. The schemes involve geometric transformation of 2D micro/nanostructures into extended 3D layouts by compressive buckling. Designs inspired by kirigami/origami and/or releasable multilayers enable the formation of mesostructures with a broad variety of 3D geometries, either with hollow or dense distributions. Demonstrations include experimental and theoretical studies of more than 100 representative geometries, from single and multiple helices, toroids, and conical spirals to structures that resemble spherical baskets, cars, houses, cuboid cages, starbursts, flowers, scaffolds, each with single- and/or multiple-level configurations. Morphable 3D mesostructures whose geometries can be elastically altered can be further achieved via nonlinear mechanical buckling, by deforming the elastomer platforms in different time sequences. We further introduce concepts in physical transfer, patterned photopolymerization and non-linear plasticity to enable integration of 3D mesostructures onto nearly any class of substrate, with additional capabilities in access to fully or partially free-standing forms, all via mechanisms quantitatively described by theoretical modeling. Compatibility with the well-established technologies available in semiconductor industries suggests a broad range of application opportunities. Illustrations of these ideas include their use in building 3D structures as radio frequency devices for adaptive electromagnetic properties, as open-architecture electronic scaffolds for formation of dorsal root ganglion (DRG) neural networks, as ultra-stretchable interconnects for soft electronics and as catalyst supports for propulsive systems in 3D micro-swimmers with geometrically controlled dynamics.

* Yonggang Huang is the Walter P. Murphy Professor of Mechanical Engineering, Civil and Environmental Engineering, and Materials Science and Engineering at Northwestern University. He is interested in mechanics of stretchable and flexible electronics, and mechanically guided deterministic 3D assembly. He is a member of the US National Academy of Engineering, a member of European Academy of Sciences and Arts, a foreign member of Academia Europaea, and a foreign member of Chinese Academy of Sciences. His research awards since 2013 include the Drucker Medal (2013) and Nadai Medal (2016)from the American Society of Mechanical Engineers (ASME); Prager Medal (2017) from the Society of Engineering Sciences; and Bazant Medal (2018) from the American Society of Civil Engineers. He is a Highly Cited Researcher in Engineering (2009), in Materials Science (since 2014), and in Physics (since 2018). He has received teaching and undergraduate advising awards from University of Arizona, University of Illinois at Urbana-Champaign; and Northwestern University.