University of Connecticut

ME Spring 2017 Seminar Series
MECHANICAL ENGINEERING

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Friday, January 20 • 2:30 PM – BPB, Rm. 130

Mechanics-guided, deterministic 3D assembly

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Abstract: Complex, three dimensional (3D) structures in biology (e.g. cytoskeletal webs, neural circuits, vasculature networks) form naturally to provide essential functions in even the most basic forms of life. Compelling opportunities exist for analogous 3D architectures in man-made devices, but design options are constrained by existing capabilities in materials growth and assembly. Here we report routes to previously inaccessible classes of 3D constructs in advanced materials, including device-grade silicon. The schemes involve geometric transformation of two dimensional (2D) micro/nanostructures into extended 3D layouts by compressive buckling. Demonstrations include experimental and theoretical studies of more than forty representative geometries, from single and multiple helices, toroids and conical spirals to structures that resemble spherical baskets, cuboid cages, starbursts, flowers, scaffolds, fences and frameworks, each with single and/or multiple level configurations.

Biographical Sketch: 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 has published 2 books and more than 500 journal papers, including multi-disciplinary journals Science (2006, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015) and Nature (2008, 2013, 2016). His recent research awards include the Larson Award in 2003, Melville Medal in 2004, Richards Award in 2010, Drucker Medal in 2013, and Nadai Medal in 2016, all from American Society of Mechanical Engineers (ASME); Young Investigator Medal in 2006 and Prager Medal in 2017 from the Society of Engineering Sciences; International Journal of Plasticity Medal in 2007; Guggenheim Fellowship from the John Simon Guggenheim Foundation in 2008; and ISI Highly Cited Researcher in Engineering in 2009 and ISI Highly Cited Researcher in Materials Science in 2014 and 2015. He is the Editor of Journal of Applied Mechanics (Transactions of ASME), a member of the Executive Committee of the ASME Applied Mechanics Division (Chair, 2019-2020), members of the Awards Committee and Nomination Committee of the Engineering Mechanics Institute of American Society of Civil Engineers, and was the President of the Society of Engineering Science in 2014.

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