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Morphable 3D Mesostructures and Microelectronic Devices by Multistable Buckling Mechanics

Yihui Zhang

Associate Professor,
Department of Engineering Mechanics,
Tsinghua University,
Beijing, China

ABSTRACT:

Three-dimensional (3D) structures capable of reversible transformations in their geometrical layouts have important applications across a broad range of areas. Most morphable 3D systems rely on concepts inspired by origami/kirigami or techniques of 3D printing with responsive materials, sometimes referred to as 4D printing. The development of schemes that can simultaneously apply across a wide range of size scales and with classes of advanced materials found in state-of-the-art microsystem technologies remains a grand challenge. This talk introduces a set of concepts for morphable 3D mesostructures in diverse materials (e.g., device-grade silicon, metals and polymers) and fully formed planar devices, including integrated electronic systems with high performance capabilities, spanning length scales from micrometers to millimeters. The approaches rely on elastomer platforms deformed in different time sequences to elastically alter, with engineering control, the 3D geometries of supported mesostructures via controlled processes of non-linear mechanical buckling. Comprehensive studies of multi-stability and corresponding energy landscapes in this context establish general design strategies. Demonstrations include experimental and theoretical investigations of over 20 examples, including mesostructures that can be reshaped between different generalized and recognizable geometries as well as those that can morph into three or more distinct states. Two functionally reconfigurable microelectronic devices, including an adaptive radio frequency circuit and a concealable electromagnetic device, provide examples of these concepts.

BIOGRAPHY:

Yihui Zhang is an Associate Professor of Engineering Mechanics at Tsinghua University. He received his Ph.D. in engineering mechanics from Tsinghua University in 2011. Then he worked as a Postdoctoral Fellow from 2011 to 2014 and as a Research Assistant Professor from 2014 to 2015, both at Northwestern University. He joined the Department of Engineering Mechanics at Tsinghua University in 2015, and was tenured in 2018. His research interests include mechanically guided 3D assembly, soft composite materials and stretchable electronics. He has published more than 80 peer-reviewed journal papers, including 2 in Science, 11 in Nature sister journals, 2 in Science Advances, 4 in PNAS and 8 in JMPS. His recent awards include ASME Sia Nemat-Nasser Early Career Award (2018), Society of Engineering Science's Young Investigator Medal (2018), Eshelby Mechanics Award for Young Faculty (2017), ASME Melville Medal (2017), Journal of Applied Mechanics Award (2017), MIT Technology Review's 35 Innovators Under 35 (TR35 Award) (2016), and Qiu Shi Outstanding Young Scholar Award (2016). He is an associate editor of the Journal of Applied Mechanics (ASME Transactions), and serves on the editorial board of several academic journals including Proceedings of the Royal Society A and npj Flexible Electronics.