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Magnetic Soft Composites with Integrated Multiphysics Responses

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ABSTRACT:

Magnetic soft composites are a type of stimuli-responsive materials that can generate large deformation and locomotion under external magnetic fields. They have recently attracted great interest due to the increasing demand for programmable materials that can be easily controlled to achieve complex functionalities for untethered morphing and reconfigurable structures. In particular, these composites are considered to be competitive candidates for developing soft robots as biomedical devices for drug delivery and minimally invasive surgeries for two major reasons: the magnetic untethered control (1) offers a safe and effective operation method for biomedical applications, which typically require remote actuation in enclosed and confined spaces; and (2) separates the power source and controller from the device, making miniaturized robots possible. However, it is still a great challenge to design and fabricate high performance multifunctional magnetic soft composites for advanced engineering applications, due to the lack of design guidance on materials, fabrication, and stimulation control. In this talk, a mechanics-guided methodology is first introduced to achieve structures with precise actuation control for multifunctionality of magnetic soft composites. This methodology is then used to guide the design for a few novel applications, including symmetry-breaking actuation for soft robots, magnetic shape memory polymers for untethered shape morphing and locking, and magnetic origami robots for functional deformation and locomotion. At the end of this talk, future directions in fundamental research and novel applications of magnetic soft composites will be discussed.

BIOGRAPHY:

Ruike Renee Zhao is an Assistant Professor of Mechanical Engineering, Terman faculty fellow, and Gabilan faculty fellow at Stanford University. Renee received her BS degree from Xi'an Jiaotong University in 2012, and her MS and PhD degrees from Brown University in 2014 and 2016, respectively. She was a postdoc associate at MIT during 2016-2018 prior to her appointment as an Assistant Professor in the Department of Mechanical and Aerospace Engineering at The Ohio State University from 2018 to 2021. Renee's research concerns the development of stimuli-responsive soft composites for multifunctional robotic systems with integrated shape-changing, assembling, sensing, and navigation. By combining mechanics, polymer engineering, and advanced material manufacturing techniques, the functional soft composites enable applications in soft robotics, miniaturized biomedical devices, flexible electronics, deployable and morphing structures. Renee is a recipient of the ASME Journal of Applied Mechanics award (2021), the NSF Career Award (2020), and the ASME Haythornthwaite Research Initiation Award (2018).