Feb 27, 2020

Soft Active Materials towards Soft Machines: Characterization, Design, and Functionalization

Ruobing Bai

Postdoctoral Fellow, Department of Mechanical and Civil Engineering, California Institute of Technology, Pasadena, CA

ABSTRACT:

Soft active materials, such as polymers, elastomers, and gels, are responsive to multiple stimuli, adaptable to and compatible with various environments, and form ideal candidates for human-machine interfaces. The multi-scale, multi-physics nonlinear interaction associated with these materials opens up not only new possibilities in application and development of emerging soft machines, but also interesting fundamental questions. In this talk, I will present a pathway from soft active materials towards soft machines through recent work on characterization, design, and functionalization of these materials, focusing on experimental results combined with theoretical analysis in a multi-disciplinary context. I will start with fatigue of hydrogels, i.e., failure in hydrogels under prolonged cyclic or static mechanical loads. Hydrogel fatigue lies at the interface of bonding chemistry, network topology, and dissipation mechanics, and forms a new lens to probe the molecular process and fracture under complex rheology. A design of flaw-insensitive hydrogel is then proposed to avoid fatigue crack growth through crack deflection. I will then utilize a synergy of chemistry, topology, and mechanics, and demonstrate the method to integrate hydrogels with other materials through designing strong adhesion at their interface. The design principle is capable of bonding various wet materials, in environments covering the full range of pH, without requiring special functional groups from the adherends. Finally, I will introduce a theoretical framework to predict photomechanical actuation of liquid crystal elastomers under both light illumination and mechanical load. Links to future experimental validation will be highlighted by the discovery of two generalized actuation modes, accompanied by formation of microscopic stripe domains and photomechanical phase transformation.

BIOGRAPHY:

Ruobing Bai is currently a postdoctoral fellow in the Department of Mechanical and Civil Engineering at California Institute of Technology. He received his B.S. in Theoretical and Applied Mechanics at Peking University in 2012, and his Ph.D. in Engineering Sciences under the program of Materials Science & Mechanical Engineering at Harvard University in May 2018. Afterwards, he worked as a postdoctoral fellow on research of photomechanical material systems in the Department of Mechanical and Civil Engineering at Caltech. His research interest lies in experiment and theory of soft active materials (hydrogels, liquid crystal elastomers, and biomaterials), large deformation, fracture, adhesion, and complex rheology of materials, as well as multiphysics and functionalities of materials combining mechanics, thermodynamics, chemistry, optics, and electromagnetism. Applications include soft actuators, sensors, biomimetic and biological materials for human health, human-machine interfaces, human augmentation, and biohybrid machines.