seminar

SEMTE

Soft Solids, Small Scales, and Stability

School for Engineering of Matter, Transport and Energy

abstract

Soft solids get their low modulus from low bond density, whether that arises from low-energy bonds over tens of nanometer scales (elastomers) or high-energy bonds over tens of microns (foam-like, vertically aligned carbon nanotubes). However, this is only a small part of the length-scale-dependent microstructural variation that makes measuring and understanding the mechanical properties of soft solids both interesting and challenging. This talk exemplifies the variety that is encountered in the study of soft solid materials through exploration of two very different materials systems: vertically aligned carbon nanotubes (VACNTs) and polymer gels. Both exhibit unique, instability-driven mechanical responses that require non-linearities in each material's constitutive response. In the case of VACNTs, we find that their unusual, sequential folding behavior upon application of a uniaxial load can be described with an intensive, material instability within the non-linear constitutive response. In the other example, triblock copolymer gels provide a model system for a developing, needle-based characterization technique, Cavitation Rheology (CR). Void growth instability at the tip of the pressurized needle embedded within the gel correlates with modulus, making CR a promising technique for in vivo measurement. The development of CR is based on previous work describing general void growth in soft solids as a mechanism for failure in rubbers and pressure sensitive adhesives. CR provides two distinct additions to this conversation: first, a new set of boundary conditions as a result of the pressurizing syringe (and key to describing the experimentally observed instability), and second, control of initial void size and location. Drawing upon expertise gained from these two studies, I also propose the exploration of "soft solid dynamics" for the development of osmotically responsive, soft, cellular materials.

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biosketch

Dr. Shelby Hutchens began her career in chemical engineering at Oklahoma State, obtaining her B.S. in 2004. She went on to acquire her M.S. and Ph.D. from the California Institute of Technology in 2006 and 2011, respectively, finishing her thesis under Prof. Julia R. Greer. For her thesis research on the experimental characterization and simulation of vertically aligned carbon nanotubes under uniaxial compression, Dr. Hutchens received the Demetriades-Tsafka-Kokkalis Prise for best thesis in "Nanotechnology and Related Fields" at Caltech as well as the prestigious International Quadrant Award presented in Zurich, Switzerland. Additionally, she has four first author publications, was the recipient of the Gordon and Betty Moore Teaching and Research Fellowship at Caltech, and has been selected on multiple occasions to participate in highly regarded professional development and research workshops. Currently, she works as a postdoctoral researcher in the Polymer Science and Engineering Department at the University of Massachusetts Amherst with Prof. Alfred Crosby. Her research interests lie in the exploration and mechanical characterization of small-scale soft solids for a variety of technologies, including the development of soft actuators for biomedical and advanced manufacturing applications.

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