STEVENS INSTITUTE of TECHNOLOGY
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STEVENS INSTITUTE OF TECHNOLOGY
DEPARTMENT OF MECHANICAL ENGINEERING

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Soft Materials Mechanics: Developing Multi-Scale Structure-Property-Performance Relationships

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To provide critical feedback in the materials design process detailed structure-property-performance relationships must be developed. Hence I am studying how the soft materials deform, flow or fracture under stress, interact with complex interfaces, and can be processed into products. These materials are used in many applications, such as elastomers for adhesives and automotive tires, polymer melts for manufacturing fibers, films, and composites, gels/hydrogels for bioimplants, tissue scaffolding, and food additives. In the first part of the presentation I will present results of an ongoing effort of developing a new characterization technique, cavitation rheology, for the measurement of mechanical properties on small length scales, e.g. 10 -1000 μm, at any arbitrary location within a functional soft material. The technique involves growing a cavity at the tip of a syringe needle and monitoring the pressure of the cavity at the onset of instability. This critical pressure, Pc, is directly related to the local elastic modulus, E, of the material. Using this technique we probe the molecular link between the elastic modulus and fracture strength of polyacrylamide hydrogels. Scaling theories are adapted to capture the observed transition from reversible to irreversible deformations as a function of polymer volume fraction. I will then discuss the role of topological patterns on soft materials surfaces towards altering and controlling the adhesion behavior. Conventional patterning methods, including photo and imprint lithography, are difficult to apply to nonplanar surfaces. Surface wrinkling induced by swelling of a soft substrate (polydimethylsiloxane elastomers) constrained by a stiff, thin surface layer (silicate) offers an attractive approach. Using this method, surface patterns of various length scales over a large area on curved geometries are obtained. A simple phenomenological model is proposed that describes the change of adhesion behavior as a function of wrinkle morphology. Our results provide a critical understanding toward tuning the adhesion behavior of nonplanar surfaces consisting of periodic topographic structures.

Dr. Santanu Kundu is a postdoctoral research associate working in the Sustainable Polymers Group (Polymers Division) at the National Institute of Standards and Technology (NIST). Dr. Kundu has received his PhD in Chemical Engineering from Clemson University. His PhD work, which linked flow, microstructure, and the processing of liquid crystalline carbonaceous materials, has been awarded the Best Dissertation in Carbon Science (2004-2006) by the Elsevier-Carbon journal. Before joining NIST, Dr. Kundu also completed a two year postdoc in the Polymer Science department at UMass-Amherst.

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