MCEN GRADUATE SEMINAR

Influence of Surface Tension on Deformation of Compliant Solids

Anand Jagota
Department of Chemical and Biomolecular Engineering
Lehigh University
E-mail: anj6@lehigh.edu

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Abstract:
For conventional stiff solids, by which we mean materials with Young's modulus greater than a few mega-Pascals, surface tension is a weak force in the sense that the deformation it drives is negligible except at length scales of a few nanometers or smaller. However, surface tension becomes an important, sometimes dominant, influence on the deformation of compliant solids – those with Young's modulus less than a few mega-Pascals. We will describe briefly some recent demonstrations of deformation in compliant solids where surface tension plays an important role and discuss in more detail two examples:

(a) Flattening of an undulating surface due to its tension
(b) The role played by surface tension on the deformation due to a liquid drop

In the first example, we show that a hydrogel replica of a rippled surface has significantly attenuated amplitude. Reduction in ripple amplitude can be modeled as deformation driven by the tendency of surface tension to flatten curved surfaces. Motivated by experimentally observed, time-dependent deformation, we develop an idea proposed by Mullins to show that a difference in surface tension and surface energy generates a chemical potential that can drive time-dependent mass transport.

In the second example, we show that a liquid drop placed on a compliant substrate causes it to deform and, in general, equilibrium shapes must satisfy conditions of both configurational and static equilibrium. We study experimentally the deformation of elastomeric film due to a water droplet. For sufficiently thin films, the equilibrium shape of the bulge is governed by balance of surface tensions, which is different from Young's equation.

Biographical Sketch

Anand Jagota is professor of chemical engineering and director of the bioengineering program at Lehigh. His research interests are in biomaterials, biomechanics, and nanobiotechnology. His group works on properties, processing, and modeling of DNA interactions with nanomaterials, specifically on its hybrids with carbon nanotubes. He also has interests in nanomechanics, biomechanics, adhesion and friction. In another active project, his group works on biomimetic fibrillar interfaces with enhanced adhesion, friction, and compliance achieved by design of near-surface architecture. Currently, Jagota's lab is engaged in research projects in solution-based processing of carbon nanotubes, the biomimetics of fibrillar adhesion, and adhesion and mechanical properties.