Carnegie Mellon
Materials Science and Engineering Seminar Series

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"On Wetting, Shape Memory Surfaces, Mechanics of Battery Electrodes, and Nanoindentation in Viscoelastic Solids"

Friday, October 2, 2009
10 A.M. Seminar in Baker Hall 136A

(1) *Is the lotus leaf truly superhydrophobic?*
This question was studied by observing water on lotus leaves and lotus-like surfaces at the micro- and macro-meter scales. Our work suggests that these surfaces can be either hydrophobic or hydrophilic. This finding may have significant ramifications on how to make and use "superhydrophobic" surfaces.

(2) *Shape memory surfaces*
Using micro- and nano-indentation techniques, we demonstrated the existence of shape memory and superelastic effects under complex loading conditions at the micro- and nano-meter scales. These effects form the basis for applying shape memory alloys as "self-healing" surfaces and "metallic-based adhesion" materials. The microscopic shape memory effect can also be exploited to create surfaces with reversible roughness and texture for applications such as friction control and information storage.

(3) *Understanding diffusion-induced-stresses in nanostructured materials for durable lithium ion batteries*
We examined the effects of surface tension and surface modulus on diffusion-induced stresses in spherical nano-particles. We showed that both the magnitude and distribution of stresses could be significantly affected by surface mechanics. In particular, a tensile state of stress ay be significantly reduced in magnitude or even be reverted to a state of compressive stress with decreasing particle radius. This reduction in tensile stress may be responsible for the observed resilience to fracture and decrepitation of nanostructured materials used in electrochemical energy storage.

(4) *Modeling instrumented indentation in linear viscoelastic solids*
Instrumented indentation is playing an important role in characterizing the small-scale mechanical properties of "soft" matters, such as polymers, composites, and biomaterials that exhibit viscoelastic behavior. Modeling of indentation in viscoelastic solids thus forms the basis for analyzing indentation experiments in these materials. We will examine the relationships between initial unloading slope, contact depth, and viscoelastic properties for various indentation conditions. We will then discuss several methods for obtaining viscoelastic properties, including relaxation modulus, creep compliance, and storage- and loss-modulus using quasi-static and dynamic indentation techniques.

These examples suggest a wide range of applications of nanostructured materials. They also illustrate the multidisciplinary nature of materials research.

Y.-T. Cheng received his B.S. (1982) in Physics/Math, M.S. (1983) and Ph.D. (1987) in Applied Physics from Caltech. He was with General Motors R&D Center from 1987 to 2008, most recently as a Technical Fellow and a Lab Group Manager responsible for engineered surfaces, tribology, and functional materials. In August 2008, he moved to the University of Kentucky as a professor of materials engineering. He has 28 US patents and over 100 publications in areas such as nanoindentation modeling and measurement of mechanical properties; growth, structure, and properties of nanostructured materials (e.g., amorphous materials, nano-composites, epitaxial single crystals, single crystal nanowires); microscopic shape memory and superelastic effects; superhydrophobic surfaces; magnetorheological fluids; ion-solid interactions and ion beam modification of materials; fuel cells and batteries; and environmentally friendly machining processes. He is a Fellow of the American Physical Society (APS) and a member of the Materials Research Society (MRS) and ASM International. Additional information may be found at: http://www.engr.uky.edu/~ycheng/.