Carnegie Mellon
Materials Science and Engineering Seminar Series

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Gaithersburg, MD

"Not Your Father's Hardness Test: Nanoindentation of Brittle Materials"

Friday, February 17, 2005
10:30 A.M. Refreshments, 11:00 A.M. Seminar
Singleton Room, Roberts Engineering Hall (REH)

Brittle materials are used in a wide variety of advanced technologies based on nano-scale structures: microelectronic, photonic, magnetic storage and micro-electromechanical systems. In many cases, optimizing the desired functional characteristics of such materials is in conflict with their role as structural elements in the intended application. Thus, in order to optimize manufacturing yield and operational reliability of advanced devices, or even make materials selections, measurement of the mechanical properties of brittle materials at ultra-small scales is crucial. Instrumented indentation testing (IIT, "nanoindentation") provides a way of measuring mechanical properties at the nano-scale—although the methodologies have developed considerably from their origins in the traditional hardness test: Modern instrumentation and techniques now allow routine measurement of elastic and plastic properties as a function of depth beneath a material surface with nm resolution. More recent developments are extending these techniques to measure viscous and creep properties in ductile materials and fracture and densification properties in brittle materials and foams. After some historical context, this presentation will provide an overview of nanoindentation behavior of metals, ceramics and polymers. This will be followed by presentation of recently-developed methods to determine the toughness and deformation characteristics of organosilicate nanoporous low-*k* dielectric films and macroporous three-dimensionally ordered silica foams. A feature of the toughness measurements is the use of cube-corner probes to extend indentation cracking into the nano-scale. The presentation will conclude by considering what it means to be brittle.

Robert Cook received a B.Sc.(Hons I) in Physics from Monash University, Melbourne, Australia in 1981 and a Ph.D. in Physics from the University of New South Wales, Sydney, Australia in 1986, spending time as a Guest Researcher at NIST in 1982 and 1984. In 1985 he joined the Physical Sciences department of IBM Research, Yorktown Heights, New York, first as a post-doctoral researcher and then as a research staff member and for a time as a senior manager. From 1998-2004 he was an Associate Professor and then a Professor of Materials Science at the University of Minnesota, working after that as an independent consultant on ceramic and dielectric reliability. In 2005 he joined the Ceramics Division of the National Institute of Standards and Technology (NIST), Gaithersburg, Maryland as Project Leader of Surface and Interfacial Nanomechanics. His research interests center on mechanics and mechanical properties of materials, especially fracture.