



**Mechanical
Engineering**

SEMINAR

The Science and Applications in Making Diamond Slippery, Non-Sticking, and Wear-Resistant

Professor Robert W. Carpick

**Mechanical Engineering & Applied Mechanics
University of Pennsylvania**

Friction, adhesion, and wear are crucial in applications from the macro to the nanoscale, but these effects are yet to be well-understood or controlled. Carbon-based films, including nanocrystalline diamond, are of interest because of their high strength, low friction, and stable surfaces. We use atomic force microscopy (AFM) and a range of surface science tools to determine nanoscale adhesion, friction, and wear as a function of surface atomic structure and environment. We present studies of diamond, where the final atomic layer is tailored. The surface atomic bonding configuration (including the carbon hybridization state) is determined by synchrotron-based X-ray absorption spectroscopy. Nanoscale adhesion and friction are directly affected by the nature of these bonds. Exposure to atomic hydrogen terminates the surface with a hydrogen monolayer, maximizes the pure diamond bonding character, and reduces friction and adhesion to the van der Waals limit (1,2). Photoemission electron microscopy (PEEM) is used to observe localized chemical changes in worn regions of samples, allowing us to show that passivation by adsorbates, not graphitization, is responsible for low friction and wear of diamond (3). Furthermore, we find that nanoscale AFM tips made out of diamond are far more wear-resistant than their conventional Si-based counterparts. This demonstrates the first practical implementation of diamond in a commercial microfabricated mechanical device.

Robert W. Carpick is an Associate Professor in the Dept of Mechanical Engineering and Applied Mechanics at UPenn. He moved to U. Penn in January 2007 after serving on the faculty for 7 years in the Engineering Physics Department at the Univ. of Wisconsin-Madison. In Sept, 2007, he was named as the UPenn Director of the Nanotechnology Institute (NTI), a multi-institutional entity funded by the Commonwealth of Pennsylvania that supports the commercialization of nanotechnology through industry-university partnerships. Prof. Carpick received his B.Sc. in Physics from the University of Toronto in 1991, and his M.A. and Ph.D. in Physics from the University of California at Berkeley in 1997 under the supervision of Dr. Miquel Salmeron. Prof. Carpick works at the intersection of mechanics, materials, and physics to conduct research into nanotribology (the atomic-scale origins of friction, adhesion, lubrication, and wear), nanomechanics, nanostructured materials, and scanning probe microscopy (SPM). His primary focus is on using SPM and other surface science and material characterization techniques to probe the fundamental nature of materials in contact, and to apply the results to nanotechnology applications. He currently serves on the Editorial Board of the journal Tribology Letters, and serves as a Board Member of the Solid Lubricants Division of the Society of Tribologists and Lubrication Engineers.



FRIDAY, Oct 10, 2008
11:00 am Seminar in 227 Mudd
12:00 pm Lunch in ME Lobby