The Department of Mechanical Engineering/College of Engineering and Applied Sciences
Stony Brook University

Mechanical Engineering Seminar

Robert Carpick

Associate Professor

Department of Mechanical Engineering and Applied Mechanics
University of Pennsylvania

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

Friday, November 14, 2008, 2:00 PM, Room 301 Engineering Building

Abstract

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.

(1) A. V. Sumant et al., Adv. Mater. 17, 1039 (2005)
(2) A. V. Sumant et al., Phys. Rev. B 76, 235429 (2007)
(3) A.R. Konicek et al., Phys. Rev. Lett., 100, 235502 (2008)

Biography

Robert W. Carpick is an Associate Professor in the Department of Mechanical Engineering and Applied Mechanics at the University of Pennsylvania. He holds a secondary appointment in the Department of Materials Science and Engineering, and is a member of the Physics Graduate Group. He was previously on the faculty of the Engineering Physics Department at the University of Wisconsin-Madison for 7 years. Prof. Carpick works at the intersection of mechanics, materials, and physics to conduct research in nanotribology (the atomic-scale origins of friction, adhesion, lubrication, and wear), nanomechanics, nanostructured materials, and scanning probe microscopy (SPM). 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, and spent two years as a postdoctoral appointee at Sandia National Laboratory in the Surface and Interface Science Department, and then the Biomolecular Materials and Interfaces Department. He is the Director of the Nanotechnology Institute (NTI) at the University of Pennsylvania, which supports the commercialization of nanotechnology through industry-university partnerships, and 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. He was the recipient of a CAREER Award from the National Science Foundation in 2001, and was named Outstanding New Mechanics Educator by the American Society for Engineering Education in 2003. He has taught several invited short courses on nanomechanics and scanning probe microscopy, and is the author of over 50 peer-reviewed publications.

Directions: Please refer to website: http://www.sunysb.edu or call Melissa Castelbuono at 631-632-8300 for more information. Check http://me.eng.sunysb.edu for any changes to location or time.

STONY BROOK UNIVERSITY