Nanotribology, Nanomechanics and Materials Characterization Studies Using Scanning Probe Microscopy

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At most solid-solid interfaces of technological relevance, contact occurs at numerous asperities. A sharp atomic/friction force microscope (AFM/FFM) tip sliding on a surface simulates just one such contact. However, asperities come in all shapes and sizes which can be simulated using tips of different shapes and sizes. AFM/FFM techniques are commonly used for tribological studies of engineering surfaces at scales ranging from atomic- to microscales. Studies include surface characterization, adhesion, friction, scratching/wear, boundary lubrication, and surface potential and capacitance mapping[1-5]. AFMs and their modifications are also used for nanomechanical characterization, which includes measurement and analysis of hardness, elastic modulus and viscoelastic properties, and in-situ localized deformation studies. State-of-the-art contact mechanics models have been developed and are used to analyze dry and wet contacting interfaces. Experimental data exhibit scale effects in adhesion, friction, wear, and mechanical properties, and a comprehensive model for scale effects due to adhesion/deformation and meniscus effects has been developed. Generally, coefficients of friction and wear rates on micro- and nanoscales are smaller, whereas hardness is greater. Therefore, micro/nanotribological studies may help define the regimes for ultra-low friction and near zero wear. New lubrication strategies such as the use of self-assembled monolayers promise to be very versatile and effective at these scales.

These fundamental nanotribological studies provide insight to molecular origins of interfacial phenomena including adhesion, friction, wear and lubrication. These studies are needed to study interfacial phenomena in micro- and nano structures used in magnetic storage systems, micro/nanoelectromechanical systems (MEMS/NEMS), BioMEMS/NEMS, and other industrial applications. Friction and wear of lightly loaded micro/nano components are highly dependent on the surface interactions (few atomic layers). Nanotribological and nanomechanics studies are also valuable in the fundamental understanding of interfacial phenomena in macrostructures to provide a bridge between science and engineering. This talk will present an overview of nanotribological and nanomechanics studies and their applications.

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