Abstract: At most solid-solid interfaces of technological relevance, contact occurs at numerous asperities. A sharp atomic 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 micrometer scales. Studies include surface characterization, adhesion, friction, scratching/wear, boundary lubrication, and electrical resistance, surface potential and capacitance mapping. 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.

Carbon nanotubes are being used for various nanotechnology applications. Mechanical strength of many of these devices critically relies on the nanotribology and nanomechanics of CNTs. Various investigations of adhesion, friction, wear and mechanics of MWNTs, SWNTs and MWNT arrays have been carried out. For bio/nanotechnology applications, it is important to investigate adhesion between biomolecules and silicon-based surfaces, chemical conjugation as well as surface patterning have been used. Friction and wear studies of biomolecules show that these act as a lubricant but exhibit some wear resistance. In the area of biometrics, surface roughness present on lotus and other leaves has been measured and the surface films are characterized to understand the mechanisms responsible for superhydrophobicity (high contact angle), self-cleaning and low adhesion. A model for surface-roughness-dependent contact angle has been developed and optimized distributions have been developed for superhydrophobic surfaces. Hierarchical structures of interest have been fabricated in the lab using various fabrication techniques and some of the surfaces show excellent performance superior to that of the lotus leaf.

These fundamental nanotribological studies provide insight to molecular origins of interfacial phenomena including adhesion, friction, wear and lubrication. 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.

Bio: Dr. Bharat Bhushan is an Ohio Eminent Scholar and The Howard D. Winbigler Professor in the Professor in the College of Engineering, and the Director of the Nanoprobe Laboratory for Bio- & Nanotechnology and Biomimetics (NLB) at the Ohio State University, Columbus, Ohio. He holds two M.S., a Ph.D. in mechanical engineering/mechatronics, an MBA, and three semi-Honorary and honorary doctorates. His research interests include fundamental studies with a focus on scanning probe techniques in the interdisciplinary areas of bio/nanotribology, bio/nanomechanics and bio/nanomaterials characterization, and applications to bio/nanotechnology and biomimetics. He has authored 6 scientific books, more than 90 handbook chapters, more than 700 scientific papers (h factor = 40+), and more than 60 scientific reports, edited more than 45 books, and holds 17 U.S. and foreign patents. He is co-editor of Springer NanoScience and Technology Series and Microsystem Technologies. He has organized various international conferences and workshops. He is the recipient of numerous prestigious awards and international fellowships including the Alexander von Humboldt Research Prize for Senior Scientists, Max Planck Foundation Research Award for Outstanding Foreign Scientists, and the Fulbright Senior Scholar Award. He is a member of various professional societies, including the International Academy of Engineering (Russia). He has previously worked for various research labs including IBM Almaden Research Center, San Jose, CA. He has held visiting professor appointments at University of California at Berkeley, University of Cambridge, UK, Technical University Vienna, Austria, University of Paris, Orsay, ETH Zurich and EPFL Lausanne.