Nano-meter scale contact deformation and friction of solid surfaces

Kyung-Suk Kim, Professor
Division of Engineering
Brown university
Providence, RI 02912

Abstract

At small length scales, adhesion and surface roughness play significant roles in mechanics of solid surface contacts. In single asperity contacts, friction experiments with atomic force microscopes and a surface force apparatus have indicated that the single asperity friction stress depends on the scale of contact size at a certain range of the scale. In that range the friction stress is supposed to be inversely proportional to one half power of the contact radius. However, our recent experiments show that the power is larger than 0.6 and it is believed that the larger power comes from a scale dependence of undulating atomic-scale roughness in addition to the scale dependence of adhesive slip instabilities. For such phenomena Mindlin's classical solution of partial contact slip becomes more valid than cohesive zone solutions of partial contact slip. The cohesive zone solution gives the scale dependence power of one half. In this presentation, scale dependence of nanometer scale surface plastic deformation caused by solid surface contact is also analyzed using atomistics and dislocation theories. The theoretical prediction of the evolution of near-surface dislocations under surface contact is verified with a chemical etching experiment. These scale dependent phenomena are found to be useful and important for analyzing and designing solid surface suspension and imprinting at the nanometer scale.

Keynote presentation for Mindlin's 100^{th} year birthday symposium.