SURFACE STRESS IN METALS INDUCED BY ORGANIC MONOLAYER FILMS

Srinivasan Chandrasekar, Purdue University, IN, USA
chandy@purdue.edu
Debapriya Pinaki Mohanty, Purdue University, IN, USA
Tatsuya Sugihara, Department of Mechanical Engineering, Osaka University, Osaka, Japan
Anirudh Udupa, Purdue University, IN, USA
James B Mann, Purdue University, IN, USA
Ronald Latanision, Exponent Inc; and Massachusetts Institute of Technology, MA, USA

Key Words: surface stress, metals, adsorbate films, plasticity, fracture

Adsorbed films on metal surfaces can trigger large-scale phenomena such as fracture and changes in surface plasticity. More recently, we have observed local embrittlement at the surface in large-strain deformation of metals triggered by nanometer-scale films. Some of these phenomena at least appear to be related to changes in surface stress (not surface energy) induced by the films. We use a macroscale cantilever-deflection technique to measure surface stress produced by organic monolayer films. Monomolecular films of the alkanoic acid family, with hydrocarbon chain lengths in range of 3 to 18, are deposited onto thin aluminum and copper foils (substrates) by molecular self-assembly. Each foil, with thickness of 0.1 to 0.25 mm and lengths of 20 to 80 mm, and clamped at one end, is immersed in an organic solvent containing the molecules, for the self-assembly. As the molecule adsorbs onto one side of the substrate, the cantilevered foil deflects due to a change in surface stress induced by the film. The surface stress is estimated from *in situ* measurements of the cantilever-tip deflection, using Stoney's equation. The measured surface stress is quite large, and tensile, in the range of 3 to 35 N/m. This corresponds to conventional engineering stress values on the order of a few GPa, though very local. Interestingly, the stress is found to be strongly dependent on the molecule chain length, increasing with increasing chain length. The rate of cantilever deflection is also used to characterize adsorption kinetics. Implications of the results for environment assisted cracking and material removal processes for metals are discussed.