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Scanning Probe Applications to the Adhesive, Tribological and Rheological Properties of Materials

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Scanning probes are finding expanding application to the local analysis of a broad range of materials properties. I will discuss studies of adhesion, tribology and rheology applied to a range of materials using Interfacial Force Microscopy (IFM), a scanning force-probe technique distinguished by its use of a quantitative and mechanically stable force-feedback sensor. This unique sensor enables the force to be recorded as two interfaces approach, make contact, deform and separate making possible an accurate evaluation of the development of the adhesive bond and its failure. Thus, the nature of the adhesive bond, e.g., van der Waals, electrostatic, covalent, etc., can be established and the total adhesive energy measured quantitatively. Lateral forces can also be measured enabling direct observation of the interfacial friction force as a function of the normal force. These advantages will be illustrated with examples involving: (1) the interaction of a tip and substrate functionalized with self-assembled monolayer films having various combinations of chemically distinct end groups, as well as the interaction involving polymer surfaces, (2) the viscous properties of adventitious water adsorbed on various tip and substrate materials and (3) a quantitative, local rheological analysis of an extreme example of a viscoelastic material. These examples clearly demonstrate the intimate relationship between interfacial bond strength and the mechanical properties of the contact in determining overall adhesive strength. In addition, they dramatically demonstrate the weak correlation between the maximum adhesive force upon contact separation (the so called "pull-off force") and the quantitative work of adhesion. The assumptions required to make this correlation strong are seldom valid in "real" contact situations. Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the U.S. Department of Energy's National Nuclear Security Administration under Contract DE-AC04-94AL85000.