WIDE DYNAMIC RANGE 2-D NANOINDENTATION: FRICTION AND PARTIAL SLIP AT CONTACTS

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A new nanomechanical testing system is described. It provides the same force controlled displacement sensing capability as nanoindentation, but now with two completely separated orthogonal axes. Load modulation enables direct determination of contact area and stiffness, both lateral and vertical, along with energy losses from the phase shifts. Two features in particular, wide dynamic ranges of several orders of magnitude of stiffness and a very high degree of mechanical separation (low crosstalk) between the axes, distinguish the technique from AFM. AFM is one of the few techniques to date to investigate tribological single asperity contacts but its mechanical limitations make it difficult to discern the underlying mechanisms.

With this new technique, the evolution of a contact under 2-D stresses from deformation-free atomistic scale to initial plasticity along with the associated changes in geometry, can be monitored. Results will be presented showing that unlike in elastic contacts, Mindlin partial slip does not occur immediately under lateral stress in plastically deformed contacts. The evolution of contact area in the initial stages of sliding in the presence of plastic flow will be described, and resembles the predictions of classical Tabor and Johnson models. It will be shown that energy dissipation measured from phase shift of a modulating signal is largely due to interfacial friction rather than volumetric deformation. Prospects for further studies using both shear and normal loading will be discussed.