PLASTICITY IN NANOSCALE FRICTION: STATIC AND DYNAMIC

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In classical macroscopic friction bulk plasticity has an important role, but in most experimental investigations of nanoscale single asperity sliding it is absent, with purely interface slip the dominant factor. This is primarily because techniques such as AFM and SFA have very limited dynamic range of stiffness measurement and contact stress. The connection between nanoscale studies and macroscopic friction systems is thus problematic. Explaining the phenomenon of static friction is also difficult. This talk will describe the use of a new 2-D nanoindentation system to investigate the initial stages of lateral deformation of contacts[1].
We show that static friction depends on indent sink-in arising from the combination of lateral and normal stresses. Material H/E ratio affects the evolution of contact area. As lateral strain increases the limit of junction growth is reached, and the onset of full sliding is controlled by interface friction and tip geometry, broadly in agreement with classical models. If sufficiently small normal loads and smooth tips are used the purely interface sliding and largely wear-free friction seen in AFM and SFA can be observed. A model using H/E ratio, tip geometry and interface strength can distinguish the pathways of initial sliding and transition between modes of behaviour. It may also be applied to multi-asperity contacts and friction of rough surfaces.
In these experiments the dominant energy dissipation mechanism, as soon as there is steady sliding, is interface slip rather than bulk plastic flow. We comment on the significance for classical models of friction and wear. The mechanisms of frictional energy dissipation and the distinction between constitutive and local atomistic models will be discussed.

1. Brazil, O., Pethica, J.B. & Pharr, G.M., *Proc. R. Soc. A* (2021)0502. https://doi.org/10.1098/rspa.2021.0502