# MESO SCALE FRICTION

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Perhaps the most remarkable result concerning friction is that the shear force required to slide is proportional to the normal force and independent of the contact area. This result, established a long time ago by Amontons and Coulomb for macroscale contact, has recently been confirmed at much smaller scales by experiments using an Atomic Force Microscope (AFM) [1], but for very different reasons. However, there is a crucial difference between the two scales. Macroscopic (actually microscopic) friction with contact regions on the order of tens of micrometers results in a frictional stress of about 0.001 μ (where μ is the shear modulus). Friction at this scale is governed by plastic deformation of asperities as suggested by the Bowden and Tabor model [2]. On the other hand, the AFM measurements, with contact regions under a few nanometers, indicate that the frictional stress is about 0.02 μ, almost equal to the shear strength of the material. This suggests an adhesive type of failure. As a result, it appears that while the frictional stress is independent of the contact area, it is indeed different at the different scales, with clearly different mechanisms operating at the two extremes.

Due to their relatively large surface areas and low actuation forces, a major concern in the development of reliable MEMS and NEMS devices is friction. Contact radii of MEMS and NEMS devices are expected to range from $10^{-8}<a<10^{-5}$m. This regime, which lies between the limits of single asperity and macroscopic contact, has yet to be explored because the apparati used to characterize friction at these limits do not operate between them.

This presentation describes the development of a new device, the Mesoscale Friction Tester (MFT), which will address this need. By making use of a range of sensor beam thicknesses, the MFT is capable of performing friction studies with contact radii that range from 10 nm to 10 μm and contact forces from μN to mN. This is beyond the force range of the AFM and the Interfacial Force Microscope (IFM) [3] but below that of the Surface Force Apparatus (SFA) [4]. Some initial data for tungsten on mica indicates that the transition from single asperity contact to macro scale contact is quite narrow.

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