Multi-scale interfacial interaction

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Introduction

‘Tribology’ is the science of friction and wear. A fundamental understanding of macroscopic tribological processes requires investigations on a microscopic or even atomic scale. Physicists are using new and promising techniques - Atomic Force Microscopy and Molecular Dynamics - to study atomic-scale interfacial interactions. To bridge the gap between the atomic scale and the macroscopic tribology, a microtester is developed to simulate the local friction phenomena in a single asperity contact of a real surface.

The microtester

A sample plate is translated against a spherical tip (Fig. 1). Friction and normal forces on the tip are derived from the spring deflections, which are measured by focus-error-detection (FED) type optical heads. The normal load is controlled by feeding back optical head 1 to the piezo. Specific quality of the apparatus is the load range. Depending on the spring thickness, the normal load on the tip is varied between 10 μN - 100 mN. This way, an approach is made towards AFM.

Results

The microfriction of silicon depends on the normal load (Fig. 2a). Clearly, a transition from a low friction regime to a high friction regime appears. Contact mechanics indicate that this transition is the onset of yield in the top surface layers. Fig. 2b shows the plastic deformation of the silicon in the high friction regime. A similar transition is observed on stainless steel. These results are important for quantification of low friction and zero wear conditions.

Outlook

The use of several tip-sample material combinations must reveal material interactions and deformation mechanisms. Statistical or ranking methods are used to extrapolate the results to real rough surfaces. Nanotribology may explain atomic-scale interfacial phenomena.

Fig. 1 The microtester. Leaf-spring sizes: 2.5*1.5*0.03 and 4*1.5*0.03 mm

Fig. 2a Friction between polycrystal silicon and a diamond tip

Fig. 2b Wear track on silicon in the high friction regime (AFM)