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WEAR OF SILICON AND CARBON-BASED NANOSCALE ASPERITIES

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ABSTRACT

Wear at the nanoscale is a key limitation of conventional silicon and silicon nitride atomic force microscope (AFM) probe tips. Tip degradation and contamination induced by tip-sample interactions can result in decreased resolution and uncertainty in AFM measurements. Prediction and control of the wear behavior is challenging since there is no rigorous theory for the wear of a <100 nm asperity. However, ultrananocrystalline diamond (UNCD) and diamond-like carbon (DLC) are potentially ideal materials for AFM probe applications because of their high stiffness and hardness, low surface roughness, low macroscale friction coefficient and wear, and chemical inertness. The nanoscale adhesion and wear behavior of UNCD, DLC, silicon, and silicon nitride AFM probes have been characterized through systematic AFM wear tests and characterization of the corresponding nanoscale modification of the tips through transmission electron microscopy (TEM) imaging, AFM-based adhesion measurements, and AFM-based blind reconstruction of the tip shape. Our results demonstrate that significant reductions in the nanoscale wear can be achieved through the use of these carbon-based materials. We will discuss how the nanoscale wear behavior of the tips can be linked to their intrinsic materials properties through consideration of the mechanics and physics of nanoscale contacts.

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