Nanotribology and Surface Properties

Accurate adhesion/friction measurements at the nanoscale are needed in microelectromechanical systems (MEMS) and nanoelectromechanical systems (NEMS) devices. Lubrication by molecular assemblies at nanometer dimension is required to control the surface properties of device components and ensure durability. The magnetic storage industry also needs control of friction via lubrication in the push towards 1 Terabit/in^2 areal density and a fast data transfer rate. The head-disk interface space is shrinking to 3.5 nm, with a head speed of 40 m/s. Occasional contacts between the head and disk will test the strength and robustness of the carbon overcoat and lubricant layers which are continuously being reduced in thickness.

Stephen Hsu

Significant progress has been achieved in two areas: measurements for adhesion, friction, and lubrication at the nanoscale and establishing test methods relevant to magnetic hard disk performance (with input from the National Storage Industry Consortium.)

The nanofriction measurement activity aims to develop a constitutive equation for nanofriction to include surface force components and material characteristics. We set up a novel, multiscale friction apparatus, developed jointly with Hysitron, allowing friction measurements across nm to mm scales. Figure 1 shows friction data from a diamond tip sliding on silica for different tip sizes (tip radius). The coefficient of friction values show significant dependence on tip size. Future work in nanofriction comparing results among different scales will provide an understanding of how the scale affects frictional forces.

We continue to work with our external academic partners (UC Berkeley, UC Davis, and Ohio State) under the NIST Nanotechnology Extramural Initiative. This collaboration focuses on the development of friction measurement by three approaches: MEMS devices, AFM-based methods, and a novel ultra-high vacuum method. Results thus far have revealed that meniscus forces and electrostatic forces exert a significant effect on nanofriction. We are now quantifying these effects.

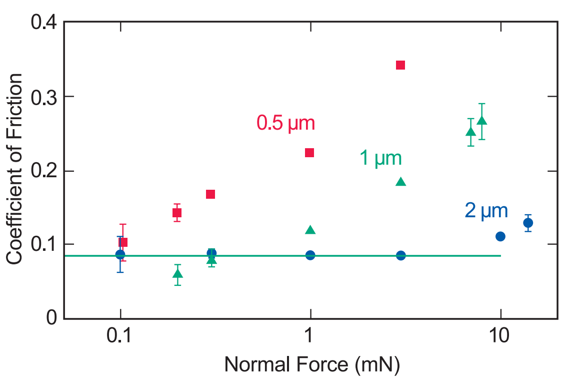

Figure 1: *Effect of tip sizes on friction.*

Significant progress has been made in establishing test methods for assessing the performance of the carbon overcoat and lubricant layers in magnetic head/disk interfaces. A high speed impact test was developed to simulate the occasional high-speed impacts that occur between the head and the disk media under the ramp-load and unload operating conditions. As the magnetic spacing continues to shrink, this type of contact could lead to data loss. In our test, a 1000 nm ridge is artificially created on a disk, and a ruby ball is used to collide with the ridge at 20 m/s. The impact force and the deformation are measured using an acoustic sensor. Recent improvements in the impact height control were achieved by installing capacitance probes to control the location and positioning of the ruby ball in the z direction. Crater imaging was also improved by using a new dual white light interferometer microscope. (See Figure 2.) Results show that the performance ranking of lubricants and overcoats agrees with field experience.

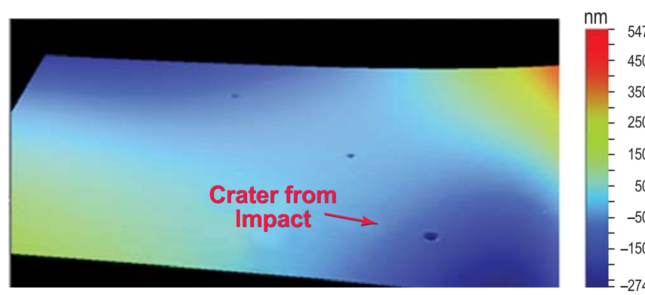

Figure 2: *Microscopic image of impact craters.*

A finite element model was developed last year to describe the stress distribution in the carbon overcoat/lubricant multilayer films. Recently, the model was improved by incorporating brittle fracture criteria for the carbon overcoat. This refinement allows the determination of the threshold stress level where data loss may occur.

Contributors and Collaborators

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