New nanocrystalline diamond probes overcome wear

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Researchers at the McCormick School of Engineering and Applied Science at Northwestern University have developed, characterized, and modeled a new kind of probe used in atomic force microscopy (AFM), which images, measures, and manipulates matter at the nanoscale.

Using diamond, researchers made a much more durable probe than the commercially available silicon nitride probes, which are typically used in AFM to gather information from a material, but can wear down after several uses.

Horacio Espinosa, James and Nancy Farley Professor of Manufacturing and Entrepreneurship, and his graduate student Ravi Agrawal have shown that diamond atomic force microscopy probes are 10 times more durable than silicon nitride probes.

Their results were recently published in the Journal of Applied Physics.

"It is well-known that diamond should perform much better than other probe materials," says Espinosa. "However, rigorous quantification of wear and the development of models with predictive capabilities have remained elusive. It was exciting to discover that diamond probes are an order of magnitude more wear resistant than silicon nitride probes and that a single model can predict wear for both materials."

In the study, wear tests were performed using AFM probes made from different materials — silicon nitride, ultrananocrystalline diamond (UNCD) and nitrogen-doped UNCD — by scanning them across a hard UNCD substrate. Argonne National Laboratory, where UNCD was originally invented, also supported this work by providing nitrogen-doped UNCD. Probes were made in house and also provided by Advanced Diamond Technologies, Inc. (ADT).

"It took quite an effort to develop UNCD into a sharp tip. We needed to optimize the initial stages of diamond growth to form nanometer structures with consistent results. It is really nice to find that this work paid off to demonstrate that UNCD probes are quite wear resistant, which we predicted," said Nicolaie Moldovan, a former research professor at Northwestern University involved in the fabrication of the UNCD probes. Moldovan is now a microfabrication expert at Advanced Diamond Technologies, Inc.

In addition to characterizing the probe, researchers also created a model that can predict how a probe tip will wear.

"The development of a general model with predictive capabilities is a major milestone. This effort also provided insight into how the interfacial adhesion between the probe and substrate relates to the wear resistance of AFM probes," says Agrawal.

Neil Kane, president of ADT, said, "The results reported in this investigation are impressive in showing the improvement in wear resistance of diamond probes. This work in part inspired the development of our commercially available NaDiaProbes®."

The paper, authored by Agrawal, Moldovan, and Espinosa, was also selected for the October 5, 2009 issue of the *Virtual Journal of* Nanoscale *Science and Technology* (www.vjnano.org).

Source: Northwestern University