

NANOINDENTATION HARDNESS TESTING

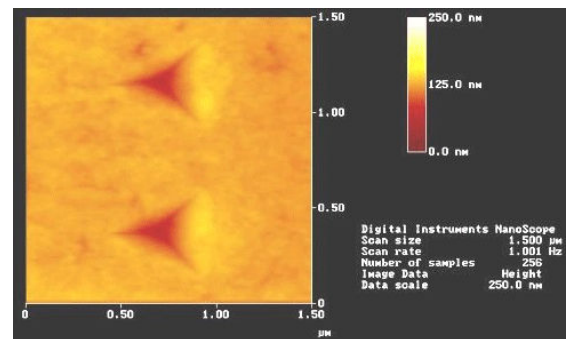
DESCRIPTION OF TECHNIQUE

Nanoindenting is a new method to characterize material mechanical properties on a very small scale. Features less than 100 nm across, as well as thin films less than 5 nm thick, can be evaluated. Test methods include indentation for comparative and quantitative hardness determination and scratching for evaluation of wear resistance and thin film adhesion.

Nanoindenting is performed in conjunction with atomic force microscopy (AFM). The area for testing is located by AFM imaging, and indentations and scratching marks are imaged by AFM after testing. A three-sided, pyramid-shaped diamond probe tip is typically used to indent, scratch and image the sample.

For indentation, the probe is forced into the surface at a selected rate and to a selected maximum force. In scratching, the probe is dragged across the sample surface. The force, rate, length and angle of the scratch is controlled.

Imaging is performed in situ using the probe in intermittent contact (tapping mode) AFM. The depth of the indentation is measured from the AFM image to evaluate hardness. A force-displacement curve obtained during indentation also provides indications of the sample material's mechanical and physical properties.



AFM Images of Two Impressions in a Polymer

ANALYTICAL INFORMATION

Nanoindentation - Indentation forces ranging from 1 μ N to 100 mN can be made to measure material hardness. Indentation depth or area is inversely proportional to hardness. Force displacement curves obtained during the indentation process indicate hardness and elastic modulus properties.

Scratching - Patterns scribed in the sample surface show the potential for spalling or delamination of thin films.

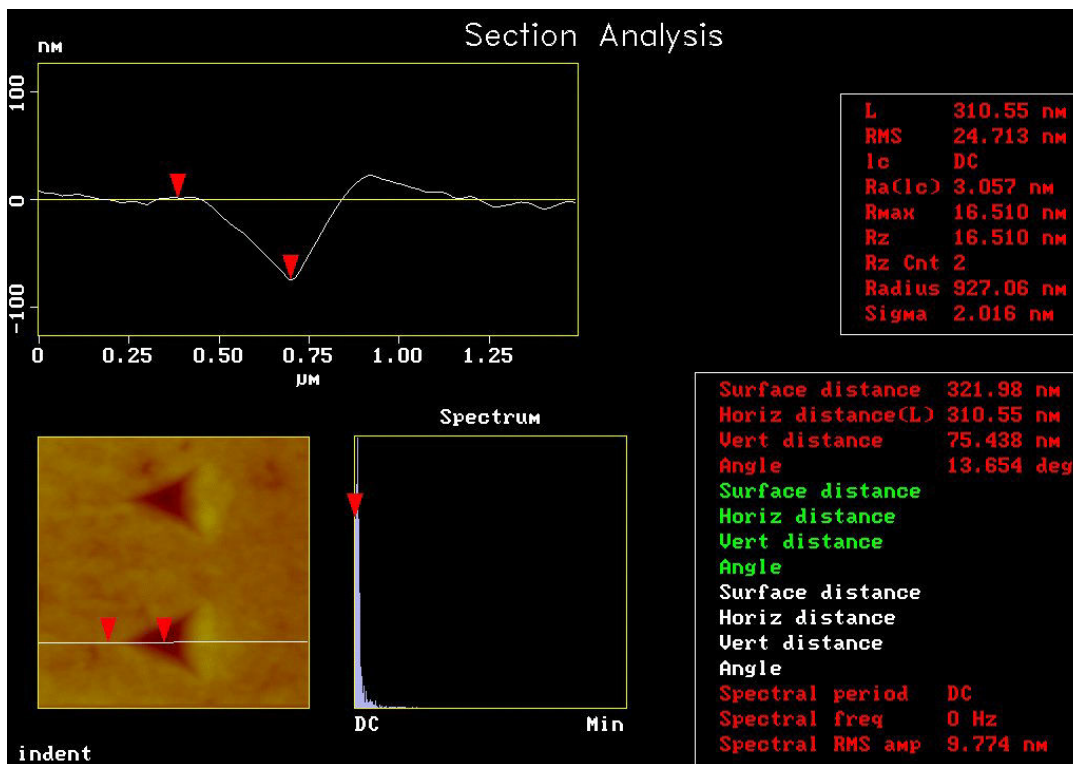
Wear Testing - The diamond probe tip is repeatedly scanned over the same sample surface area at a selected force. Wear durability is measured by the material lost from the tested surface. Depth of material loss is measured by AFM imaging after testing.

TYPICAL APPLICATIONS

- Hardness measurements for submicron-size features
- Thin film adhesion evaluation
- Coating wear durability evaluation
- Elastic modulus comparisons for thin films

SAMPLE REQUIREMENTS

Samples up to 8 in. (200 mm) across and 1 in. (25 mm) thick can be fixtured and tested in some instruments. Larger samples can be fixtured for access to limited surface areas. The sample surface must have a smooth finish for uniform indentation and to allow AFM imaging for indentation depth. The required finish depends on the material and the test force.



AFM Section Analysis for Nanoindentation Hardness