

In-situ SPM Imaging

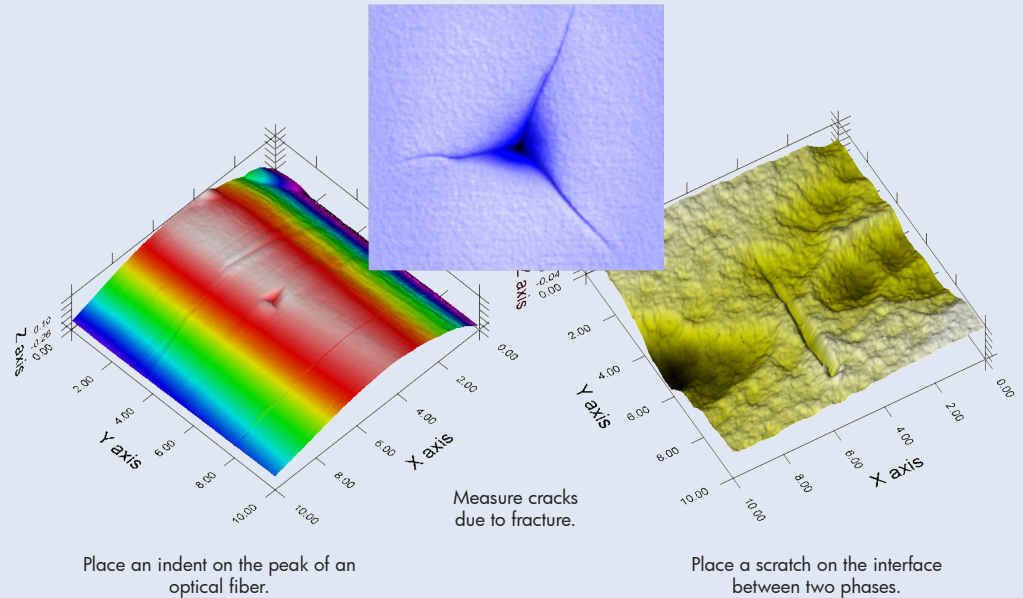
For Superior Nanomechanical Testing Results

Introduction

All of Hysitron's nanomechanical testing platforms are capable of *in-situ* Scanning Probe Microscopy (SPM) imaging. This technique provides high-resolution SPM images at the location of the test by imaging with the same probe that performs the nanomechanical testing. This provides fundamental information regarding the surface topography of the test location and the resulting test deformation which would be unavailable without the image resolution offered by *in-situ* imaging. Hysitron's probe-scanning system allows imaging of any location on large samples or imaging of multiple samples without necessitating user intervention.

Probe Placement

Precise positioning of the indentation probe is required in order to obtain reliable and repeatable data from nanomechanical tests. *In-situ* imaging is an indispensable technique for determining that the probe is placed at the desired location on the sample. With *in-situ* imaging it is possible to position the indenter probe with better than ten-nanometer resolution. This is particularly useful in interfacial studies or in testing nonhomogeneous samples such as multiphase materials. Without the information provided by *in-situ* imaging, the user cannot be guaranteed that the test is placed within the desired region. Even homogenous materials typically possess features such as surface roughness that must



be avoided in order to eliminate testing anomalies. *In-situ* SPM imaging facilitates precise positioning of the probe for the most accurate test results possible.

Imaging of Deformation

In-situ imaging can provide a wealth of information concerning the results of a test. When coupled with the corresponding load-displacement data, *in-situ* imaging can give insight into the deformation incurred during the test. Material property measurements, such as those for fracture toughness and yield strength, rely on information that can only be obtained from images that possess the resolution that this method can provide.

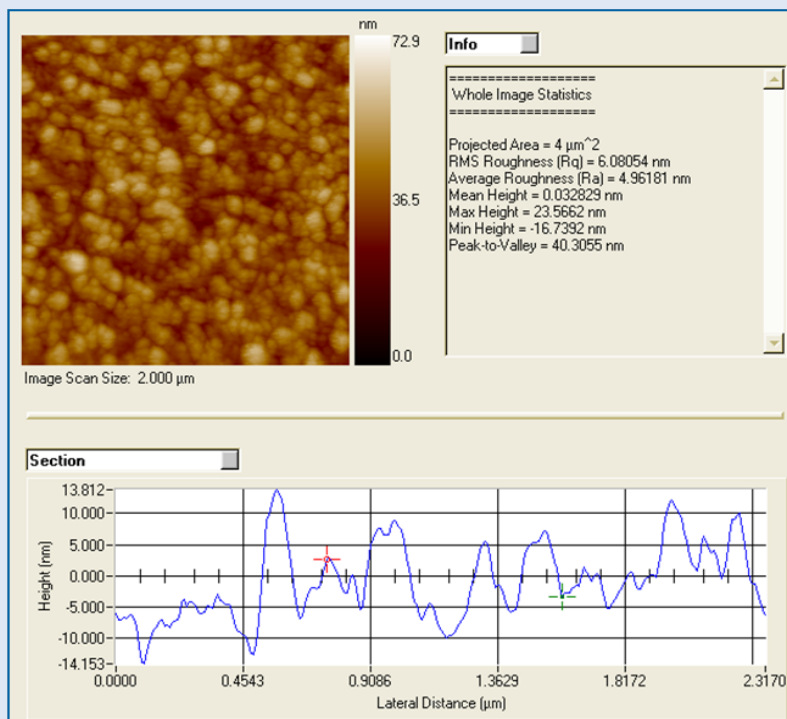
While subsequent *ex-situ* SPM imaging could provide similar information, it is difficult and time-consuming to locate the site of the test. Also, deformation created in some materials, such as viscoelastic materials, recovers with time. In these cases the time elapsed between testing and imaging must be minimized. With *in-situ* imaging it is possible to acquire images seconds after completing a test, offering the most accurate representation of the real deformation. Further, with repeated imaging of the test location, the recovery process can be documented. Observation of the mode and extent of recovery can provide the information necessary for future product development.

ScanningWear[™]

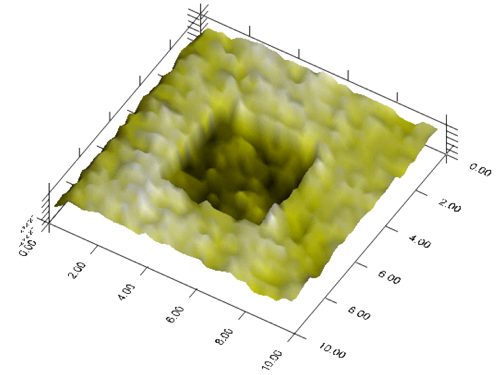
ScanningWear utilizes the synergy between the *in-situ* imaging and nanomechanical characterization to provide quantitative wear testing. By applying a load to the indenter tip as it is imaging the material surface, the surface is worn due to the applied stress under the tip. This allows simulation of point contact or asperity wear and is suitable for a wide array of applications, from CMP to the paint industry. By obtaining images of the surface before and after the scanning wear test is performed, a wear volume can be quantified by calculating the volume of material removed. A multitude of tip geometries are available to allow accurate simulation of the wear mechanisms in any application.

Image Analysis

Hysitron provides an exclusive offline image analysis software package, **TriboView[™]**, for quantitative analysis of *in-situ* SPM images. **TriboView** also provides advanced image viewing capabilities, such as 3D rendering, as seen in the above ScanningWear image. **TriboView** offers analysis options such as roughness analysis and section profiles, as demonstrated below on a PVD tungsten film. The **TriboView** package has been designed to offer the user straightforward access to useful information for understanding and interpreting nanomechanical testing results.



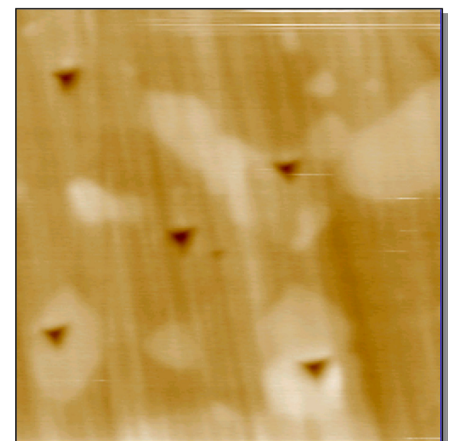
TriboView roughness analysis and section profile of an *in-situ* SPM image of a tungsten film.



ScanningWear of a DLC Film.

HIGHLIGHTS

- Exclusive probe-scanning technique on Hysitron's instruments
- Enables probe placement within ten nanometers of desired test location
- Eliminates blind testing of multi-phase materials or interfaces
- Allows quantification of deformation features necessary for determination of material properties
- Quantitative offline image analysis software available



Selective testing of individual phases in a multi-phase material.