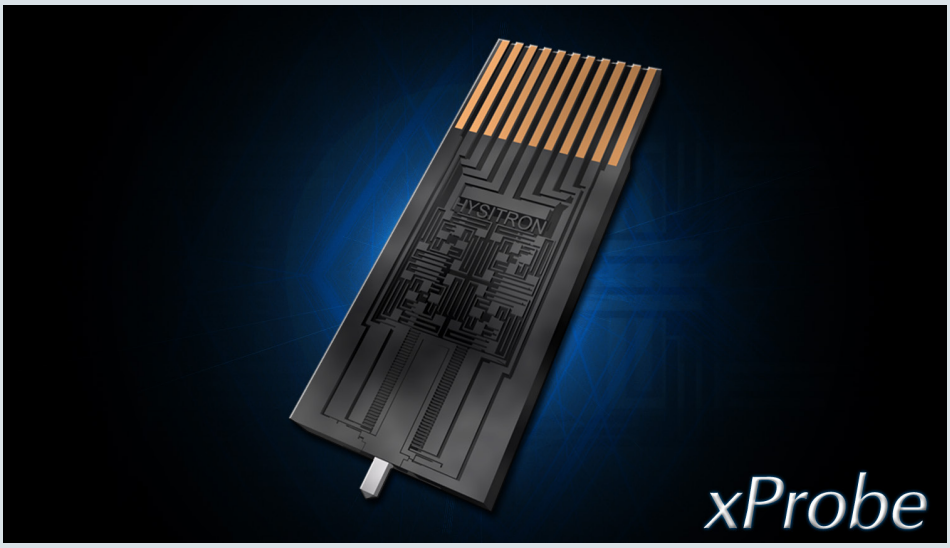
UPGRADE OPTIONS

xProbe

MEMS Technology For Quantitative Nanomechanical Measurement at Scales Previously Unimaginable



Hysitron continues its tradition of pioneering nanoscale characterization solutions through the introduction of the MEMS-based **xProbe**. **xProbe** extends the capabilities of the Hysitron **TriboIndenter**® down to angstrom scale, retaining the highly sensitive, stable, and accurate characteristics long associated with Hysitron's proprietary electrostatic actuation technology. This breakthrough device allows quantitative nanomechanical measurement of thinnest films, smallest features, and softest materials.

Noise, Sensitivity, & Feedback

Designed using Hysitron's expertise in electrostatic actuation and capacitive sensing combined with the latest MEMS fabrication technologies, the **xProbe** achieves load and displacement noise and sensitivity levels characteristic of AFMs while retaining the quantitative measurement and SPM imaging capabilities traditionally associated with Hysitron's nanoindentation instruments. The transducer's high axial stiffness increase its mechanical bandwidth by an order of magnitude, dramatically improving feedback response time and enabling access to high strain rates. Powered by Hysitron's ***performech***® controller, **xProbe** sets the standard on the forefront of small-scale quantitative mechanical measurement.

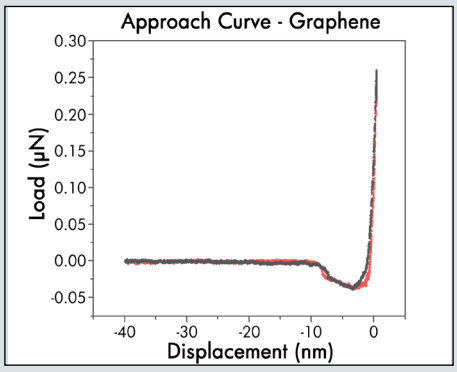


Figure 1. Force vs. displacement showing probe approach toward smooth graphene surface. Surface attractive forces of <50 nN are measured easily, and exceptional feedback control prevents "snap to contact" behavior usually observed in such an experiment.

HIGHLIGHTS

- Combines high resolution SPM imaging with highly sensitive, direct mechanical measurement
- Quantitative measurement of mechanical properties on films as thin as a few nanometers
- In-situ SPM imaging with nanonewton range contact forces minimizes disturbance to the surface during imaging, faithfully rendering images of soft samples and resolving angstrom scale features
- Probes engineered and fabricated specifically for nanoindentation measurement, enabling reliable geometric calibration and accurate test results
- Rapid mechanical and electronic response provides exceptional feedback control and allow high strain rate indentation testing

APPLICATIONS

- Quantitative mechanical characterization of very thin films
- Mechanical properties of soft materials at small scale
- Measurement of surface interaction forces
- Low contact force SPM imaging
- Measurement of nano-scale features and structures
- Nanoscale mechanical testing at strain rates spanning several orders of magnitude

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Low Force Imaging on Graphene

Unparalleled sensitivity enables high resolution imaging with nanonewton level contact forces. The **xProbe** has the sensitivity to clearly resolve angstrom scale step heights of graphene monolayers.

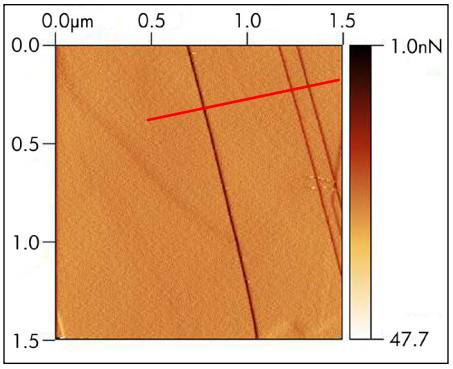

Figure 2a. SPM image of stacked layers of graphene clearly showing the edge of each layer.

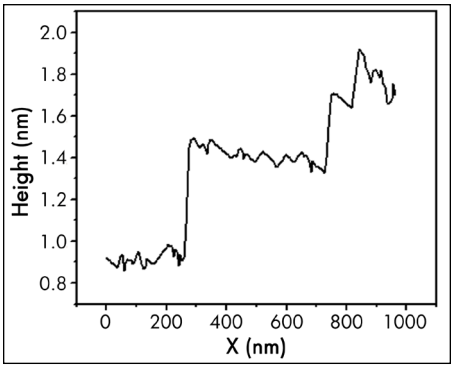

Figure 2b. Line profile across image in 2a showing individual sub-nanometer atomic steps.

Delamination of Graphene Monolayers

The **xProbe** enables scratch testing of monolayer films with high resolution in-situ SPM imaging to observe the deformation.

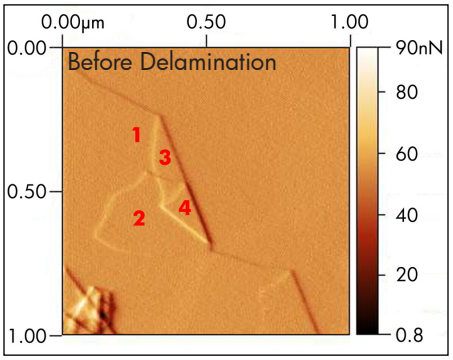

Figure 3a. High resolution SPM image of folded graphene sheets imaged at 5 nN using Hysitron's xProbe.

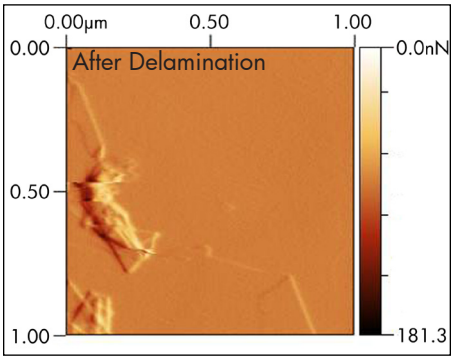

Figure 3b. 10 µN horizontal scratch across the folded monolayer sheets of graphene showing delamination and tearing of the film.

High Strain Rate Indentation

The advanced design of the MEMS-based **xProbe** along with the high bandwidth electronics of the ***performech***® control module combine to produce a system capable of performing indentation tests as fast as 8 ms, allowing access to strain rates far beyond the abilities of current indentation instruments.

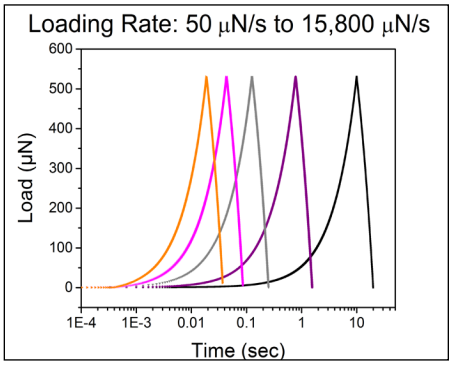

Figure 4a. With load-unload times down to 8ms, the fast response of the xProbe unlocks the ability to do high strain rate experiments.

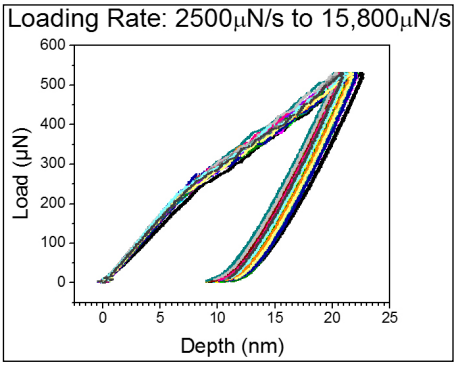

Figure 4b. Load-displacement curves for indentations at load rates spanning 3 orders of magnitude on single crystal iridium demonstrating (as expected) no strain rate dependence.

Specifications

- Load Noise Floor: <2 nN
- Displacement Noise Floor: <0.020 nm
- Displacement Resolution: <0.006 nm