

TEM-NanoIndenter™

TEM holders for in situ Nanoindentation



The TEM-NanoIndenter system provides a unique opportunity to image the nanoindentation process in real time using TEM as well as to acquire the force-displacement and force-time data. It is designed to perform in situ analysis of the mechanical properties of nanomaterials. The concept of the TEM-NanoIndenter is to combine the power of high-resolution electron microscopy (HRTEM), utilized to monitor deformations, with precise measurements of the forces and stresses imposed on the nanostructure. This system has a miniaturized force sensor device designed to operate inside the TEM.

The standard TEM-NanoIndenter system includes a side entry TEM holder with a built-in Nanoindentation device, an electronics control system and a PC with the data acquisition software.

Such system offers the following advantages:

- Quantitative low load nanomechanical testing based on capacitive measurements
- Load-displacement, load-time curves acquisition during Nanoindentation
- Live TEM imaging of diamond probe geometry and actual contact area
- Sub-nanometer control of sample alignment and positioning with sub-nanometer accuracy
- High resolution imaging of both sample and diamond probes
- The compact design of the Nanoindentation head and low-noise electronics based on SPM technology



(Left) TEM image of a nanowire bent with the Indenter tip, the bending force is recorded during this experiment.

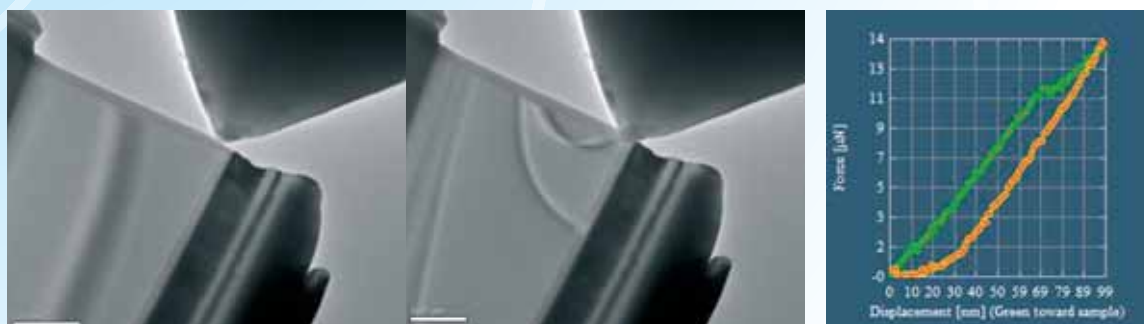
(Middle) In situ fracture experiment for semiconductor section.

(Right) TEM image of the indented plug after the Indentation cycle in TEM.

TEM-NanoIndenter™

Suggested Applications

- In situ force measurements in TEM
- Characterization of mechanical properties of thin films and nanostructures
- Nanomanipulation and nanomechanics at the sub-nanometer scale
- Analysis of elastic, plastic material-deformation and related phenomena, including dislocation propagation, and grain boundaries migration
- Imaging and observation of the stress/strain-induced structural changes
- Performing EM controlled Nanoindentation experiments
- Quantitative analysis of Nanoindentation data



(Left, Middle) TEM images of a layered FIB section before and after contact with the Indenter diamond tip.
(Right) An example of the Force-displacement plot recorded during the Indentation cycle.

SPECIFICATIONS

Working load range	0-1000 μN	Force sensitivity	0.3 μN
Sample size – standard grid	$\varnothing = 3 \text{ mm}$	Sample size – wire diameter	0.25 mm
Scanning range	25 $\mu\text{m} \times 25 \mu\text{m}$	Z-range	2.5 μm
Rough motion range (X,Y)	(2mm, 2 mm)	Rough motion range (Z)	2 mm
Piezo resolution X, Y	0.2 $\text{\AA}$		
Piezo resolution Z	0.025 $\text{\AA}$		

Operation mode: contact

Tip apex diameter: < 50-100 nm (Ultra sharp diamond tips, < 20-30 nm, are available)

Tip geometries: Conical, Berkovich, Vickers

Holders fit in all TEM models with analytical pole pieces

Note that specifications are subject to change, due to continuing improvements.

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I N S T R U M E N T S

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