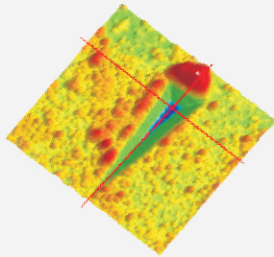




Apex - Nano & Micro Indenter & Scratcher

Industry-Leading Sensitivity, Unmatched Performance and Versatility



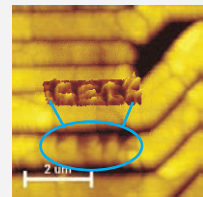
Nano scratch at increasing load



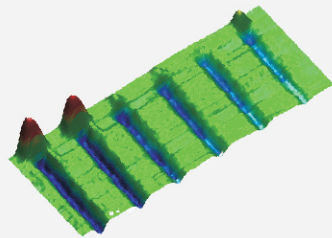
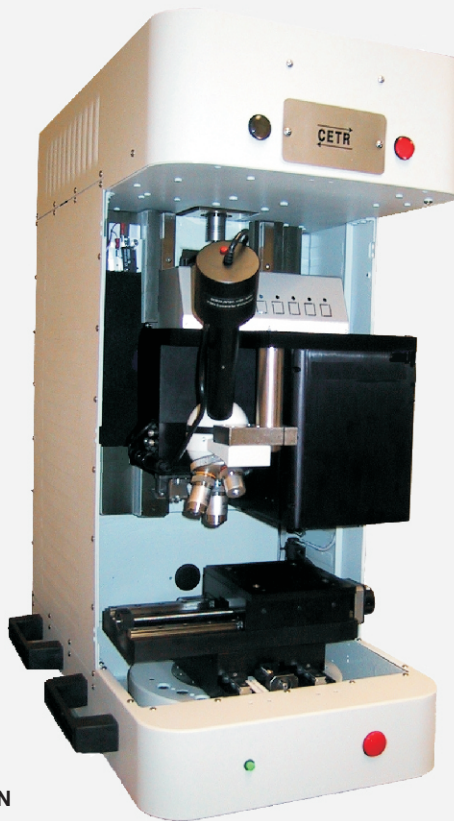
Letter "H" by multiple indents



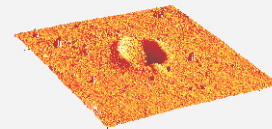
Side view during Nano Indentation



CETR-logo on a 1 um wire by 52 indents



DLC coating scratched with Berkovich tip at loads 60, 40, 20 μN



Nano indent

- | | | | |
|---------------|-----------------|-------------------|------------------|
| Nano Hardness | Young's Modulus | Von Mises Stress | Micro Hardness |
| Nano Wear | Nano Fatigue | Hardness vs Depth | Scratch Hardness |
| Nano Friction | Tensile Stress | Modulus vs Depth | Scratch Adhesion |

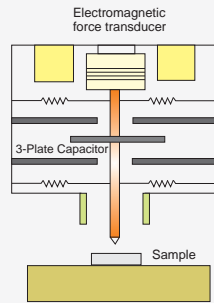
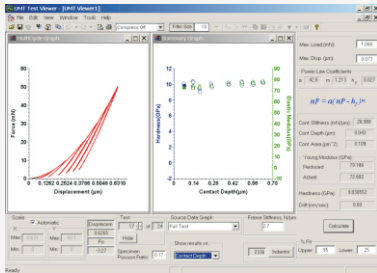
Nano Module NH-3

With the progress of nanotechnology and development of thin films (solar cells, cvd, pvd, DLC, MEMS, etc.) nano-mechanical tests have become standard. They improve on the traditional tests by being done at low loads and shallow depths with very sharp tips, high spatial resolution and in-situ precise load-displacement data.

Nano Indentation - Single/multiple indents per the ISO 14577 to measure hardness, Young's modulus, tensile and von Mises stresses, contact stiffness, etc. of thin films, thick coatings and bulk materials.

Nano Scratch at constant, increasing and user-defined programmable load to evaluate scratch hardness and scratch adhesion of thin films, thick coatings and bulk materials.

Dynamic indentation (with vibrating tip) to measure depth-dependent loss and storage moduli.

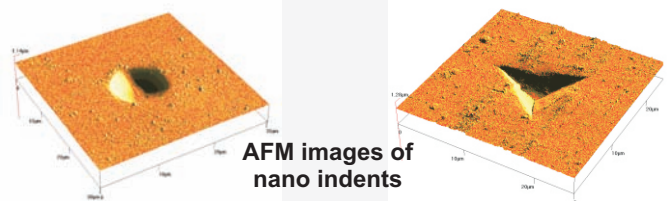


Multiple loading-partial unloading cycle

NH-3 setup schematic

Features of NH-3

- Electromagnetic force transducer.
- 3-plate capacitance sensor to measure displacement with ultra high accuracy.
- Berkovich, spherical, cube corner, etc. indenter tip geometries.
- Mapping of unlimited number of indents.
- In-line imaging options (AFM recommended).
- High throughput and repeatability.
- Optional advanced in-situ sensors.
- Thermal & acoustic enclosure, vibration isolation table.
- ASTM, DIN and ISO compliant.



AFM images of nano indents

Micro Module MH-2

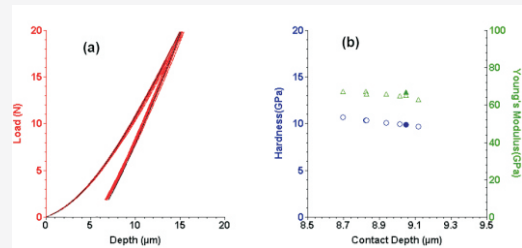
Micro-mechanical tests have been used to measure mechanical properties of coatings or bulk materials. Instrumented micro-mechanical test improves on the traditional ones by providing in-situ load-displacement data and by using advanced signals like acoustic emission, ECR, friction, etc. for more comprehensive characterization.

Instrumented Micro Indentation - per the ISO 14577 on macro-scale (for loads greater than 2 N) and micro-scale (loads under 2 N) to calculate hardness, Young's modulus, tensile and von Mises stresses, contact stiffness, etc. of coatings and bulk materials.

Traditional Vickers and Knoop micro-hardness per the ASTM E384-99.

Micro Scratch at constant, increasing and user-defined programmable load to evaluate scratch hardness and scratch adhesion of coatings.

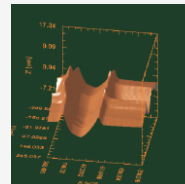
Dynamic indentation (with vibrating tip) to measure depth dependent loss and storage moduli.



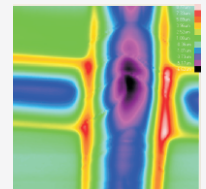
Load-unload curves at multiple positions

Features of MH-2

- Electromagnetic force transducer.
- 3-plate capacitance sensor to measure displacement with ultra high accuracy.
- Vickers, Rockwell, Knoop, spherical, etc. indenter tip geometries.
- Mapping of unlimited number of indents.
- In-line imaging options (3D profiler recommended).
- High throughput and repeatability.
- Optional advanced in-situ sensors.
- User definable analysis algorithm or models to calculate material properties.
- ASTM, DIN and ISO compliant.



3D Profilometer images of a cross scratch



Advanced In-situ Sensors

AE

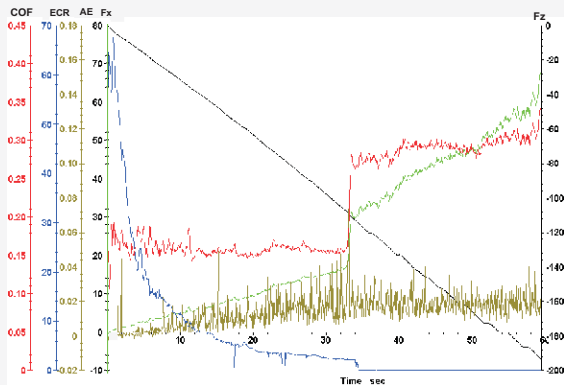
The high-frequency acoustic emission sensor detects the crack initiation and propagation in the hard and metallic coatings.

COF

When the coating breaks or when the indenter digs deep in the coating the friction changes. Coefficient of friction (static and dynamic) is automatically calculated.

ECR

The electrical contact resistance changes as a conductive tip digs deeper into the coating.



DLC coating scratch data monitored with advanced sensors.

Software Capabilities

Apex comes with Windows-based software package for fast data acquisition and detailed data analysis.

•Data monitoring, recording and motion control - Real time DAS up to **200 kHz**

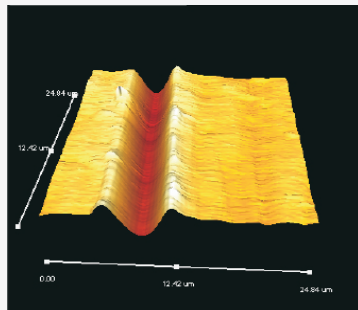
- Programmable load, displacement, velocity and motion control routines.
- Automated multi-channel data acquisition recording and display.
- Intuitive, flexible & powerful programmable test recipes.
- Unlimited test duration.

•Data presentation - Powerful statistical analysis software "Viewer" to view and edit the data.

- Automated stress-strain and force-displacement analysis.
- The raw & processed data can be exported to ASCII & Excel.
- Calculator for Hertzian contacts for different geometries.
- Fast Fourier transform and power spectrum calculation.
- User-defined analysis algorithm for modeling.
- Presentation grade images, graph and report generation.
- Extensive library of standards for calculating material properties.

In-line Imaging

Advanced in-situ and in-line imaging options. The images are generated automatically after the test without removing the sample from the tool.



AFM - Scanning ranges from 50 x 50 x 3 μm up to 180 x 180 x 14 μm

3D profilometer- Scanning ranges from 10 x 10 x 10 μm up to 500 x 500 x 500 μm.

High Magnification microscope - With revolving head and multiple objectives.

Medium Magnification Microscope - For in-situ imaging and precise positioning; both top and side views.

Instrument Highlights

•**Modular design** enables micro and nano modules to be interchangeable in less than 5 minutes.

•Combination of electromagnetic force transducer and 3-plate capacitance sensor to provide industry leading stability and accuracy.

•**Multiple in-situ sensors** (acoustic, electrical resistance, friction, temperature, humidity, velocities, etc.).

•Proprietary advanced **servo control** of loads, speeds and positions.

•**In-line nano and micro imaging** without removing the sample.

•Fast effective real-time data monitoring, recording and a powerful **statistical analysis software**.

•Optional **environmental chambers**.

•Automated handling of multiple small and large samples.



Apex Technical Specifications

Parameter	Nano (NH-3)	Micro (MH-2)
Load Range Resolution	up to 500 mN 0.03 µN	up to 20 N 0.1 mN
Friction Range Resolution	up to 100 mN 3 µN	up to 10 N 0.2 mN
Depth Range Resolution	200 µm 0.02 nm	500 µm 0.1 nm
XY Stage Range Resolution	120 x 120 mm 0.1 µm	120 x 120 mm 0.1 µm
Optical Microscope	from 10x to 2500x	from 10x to 2500x
Scratch Speed Length Depth	1 µm/s to 10 mm/s 1 µm to 100 mm 1 nm to 200 µm	1 µm/s to 10 mm/s 1 µm to 100 mm 10 nm to 500 µm

Specifications may be subject to change, please contact CETR for updates

Apex Three Head Positions

- Left Mechanical (easily interchangeable micro and nano heads).
- Middle Revolving-head microscope (up to 4 easily interchangeable objectives).
- Right Imaging (easily interchangeable AFM and 3-D profiler).

Applications

Wear-resistant coatings
TiN, TiC, DLC, WC
Cutting tools

Semiconductors
Low K materials
Interconnects
Passivation layers

Biomedical
Tablets and pills
Implants and Tissues

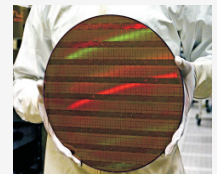
Thin films
CVD/PVD coatings
Solar cells, MEMS, fuel cells

Optical components
Window Glass
Lenses
Optical coatings

Decorative coatings

Hard disk industry
Disk and head overcoats
DLC coatings

Automotive & Aerospace
Paints and intermediate layers
Windows
Engine components



ASTM / DIN / ISO Standards

Apex is Compliant with multiple standards.

- ASTM E2546 New standard practice for nano indentation
- ISO 14577 Instrumented indentation for hardness
- ASTM C1624 Standard method for adhesion and mechanical failure of ceramic coatings
- ISO 20502 Standard test for fine ceramic scratching
- ASTM D7187 Scratch behavior of paints

and many more

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