Anton Paar

Instrumented Indentation Testers

Mechanical Characterization of Materials

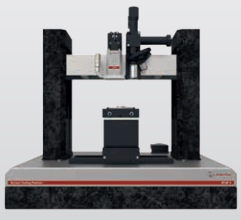
Applications

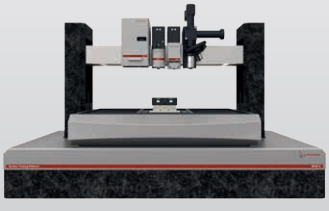
Anton Paar Instrumented Indentation Testers (IIT) measure a wide range of mechanical properties of materials ranging from the hardest diamond-like carbon (DLC) coating to the softest hydrogel. All indentation testers have a unique top-referencing design which provides the highest possible measurement stability and a fast cycle time.

High productivity and high throughput for both academic and industrial applications including:

- PVD/CVD coatings (TiN, TiCN, DLC)
- Thermal barrier coatings
- Metals and alloys
- Ceramics and composites
- Glasses
- Semiconductors
- Polymers (coatings, paints and bulk materials)
- Biomaterials (bones, cartilage, cornea, prostheses, stents, contact lenses, tissues and hydrogels)
- Pharmaceutical pills
- Cementitious materials (concrete, cement)

All materials tested represent a very wide range of industrial applications: cutting tools, automotive, electronics, biomedical, semi-conductors, polymers, optics, nuclear civil, MEMS and watch industries.





Solutions

The state-of-the-art design of Anton Paar Instrumented Indentation Testers provides the most accurate and efficient testing solution in a compact and modular format. When combined with other modules such as Micro/Nano Scratch Testers, the Nano Tribometer or imaging solutions (AFM, ConScan, In Situ Microscope), the testing platform can be tailored to the precise requirements of your application.

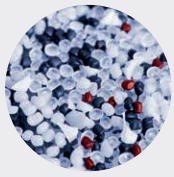
Measurement capabilities include the direct display of various properties:

- Hardness (H_{IT}) and Elastic Modulus (E_{IT})
- Indentation Creep (C_{IT}) and Indentation Relaxation (R_{IT})
- Creep compliance
- Elastic and plastic energies

Instrumented Indentation Testers are also used for various research studies:

- Viscoelastic properties
- Fracture toughness
- Stress-strain curves
- Strain hardening
- Fatigue testing

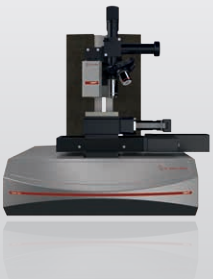
Bones

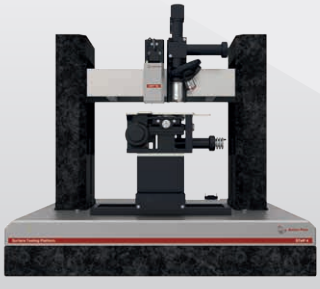


Polymers

Hydrogels

SOFT





Platform Concept

Anton Paar platforms represent a unique design for the best capabilities in nano and micro mechanical testing. All required functionalities for Instrumented Indentation Testing (IIT) are included.

Measurement Technologies

Indentation

Measuring Heads

MHT³
Microindentation Tester
Max Load: 30 N

NHT³
Nanoindentation Tester
Max Load: 500 mN

UNHT³
Ultra Nanoindentation Tester
Max Load: 100 mN

UNHT³ Bio
Bioindenter
Max Load: 20 mN

UNHT³ HT
High Temperature Ultra Nanoindentation
Max Load: 100 mN

Imaging Solution

VID
Optical Video Microscope

AFM
Atomic Force Microscope

COS
Conscan Confocal Microscope

IVID
In-situ Video Microscope

Platforms

TTX
Table Top

STeP 4
Surface Testing Platform

STeP 6
Surface Testing Platform

UNHT³ Bio, UNHT³ HT, glove box, vacuum and humidity chambers available on request

Platform Features

- Fully automated 3-axis motion control
- High positioning accuracy over a great length with a Surface Testing Platform (STeP 4 for max. 3 heads and STeP 6 for max. 4 heads)
- One-click synchronization of position from video microscope to indenter tip
- High modularity with reversibly exchangeable measuring heads
- Unique customized synthetic granite for enhanced vibration damping
- Integrated anti-vibration table
- Optional acoustic enclosure
- Customized platforms for glove box and vacuum chamber available

Scratch & Tribology

Measuring Heads

NST³
Nano Scratch Tester

MST³
Micro Scratch Tester

MCT³
Micro Combi Tester

NTR³
Nano Tribometer

For more information on these products, please request the Scratch or Tribology catalogue.

Typical configuration:
Surface Testing Platform with Micro Combi Tester + Nanoindentation + Atomic Force Microscope + Optical Video Microscope

Table Top Nanoindentation Tester

The most versatile nanoindenter for easy, fast and automated determination of Hardness and Elastic Modulus

- Compact and robust design for industrial environment
- Fully compliant with ISO 14577 and ASTM E2546
- Design with ultra low thermal expansion coefficient materials
- Highest nanoindenter frame stiffness (10^7 N/m)
- Fully compatible with liquid testing
- No thermal stabilization required before the first measurement
- Multiple choice of indenters

Optical microscope

with 4-position turret

Nanoindentation head

for measuring Hardness and Elastic Modulus

Precise X-Y positioning tables

Nanoindentation Tester (NHT^3)

The most versatile nanoindenter from low loads (0.1 mN) to high loads (500 mN), from shallow depths (less than 20 nm) to greater depths (more than 100 µm).

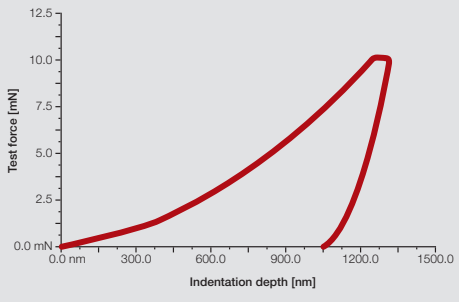
The unique design of the Nanoindentation Tester (NHT^3) is based on a Top Surface Referencing technique, which incorporates a reference ring that encompasses the indenter and provides a constant reference for the depth of penetration into the material compared to the sample surface.

This equipment is not only robust but also fast and easy-to-use for multiple advanced indentation modes: Continuous Multi Cycles (CMC), user-defined sequences, sinus mode (optional), advanced matrix and multi-sample protocols.

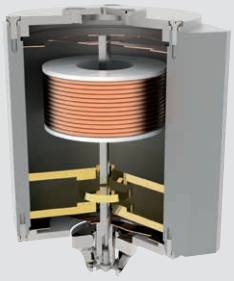
Features

- Most user-friendly nanoindenter with protective reference ring
- Highest throughput
- High load frame stiffness: 10^7 N/m for increased depth accuracy
- Frame with custom synthetic granite
- Feedback loop control of normal force
- Unique design with MACOR low thermal expansion coefficient material: < 10^{-6} / °C
- High thermal stability: raw data uncorrected thermal drift < 0.05 nm/sec
- Compatible with liquid testing
- Easy, safe and fast change of indenter tip
- Multiple objective video microscope for both pre- and post-test inspection

Force versus depth curve



NHT^3 head



Microindentation Tester (MHT^3)

The MHT^3 Microindentation Tester directly measures the Hardness and Elastic Modulus with high loads (10 N with Instrumented Indentation Testing, 30 N with Vickers Hardness).

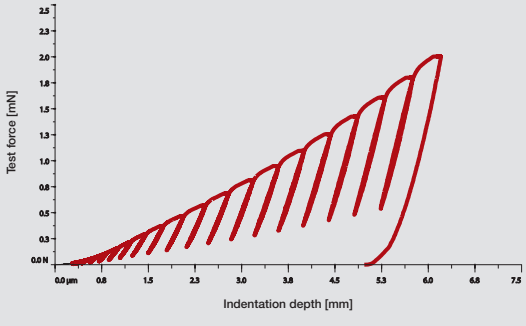
Since the Microindentation Tester not only measures the Hardness of materials but also the Elastic Modulus, it is more valuable than conventional micro hardness testers. It is applicable to many materials from bulk samples with rough surfaces to thin coatings. It features two independent sensors: one for force and one for depth.

The scratch option for microindentation also offers unique scratch testing features, including a patented Synchronized Panorama Mode from low loads (10 mN) to high loads (30 N) and wear testing capabilities.

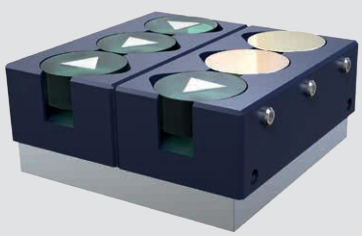
Features

- Maximum load up to 30 N with optical inspection for Vickers Hardness
- Determination of mechanical properties as function of depth with Continuous Multi-Cycle (CMC)
- Visual matrix of indentations: multi positioning of indents with video
- Calibrated Vickers indenter tip which can be recalibrated with reference sample
- Optional scratch testing with the Micro Combi Tester: Microindentation + Micro Scratch
- Top surface referencing fork for high stability

Continuous Multi-Cycle measurement



Multi-sample holder



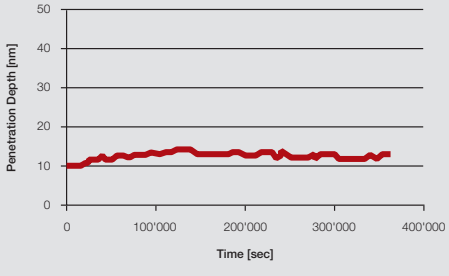
Ultra Nanoindentation Tester (UNHT^3)

The Ultra Nanoindentation Tester is uniquely configured as two parallel indenter columns. One acts as the indentation tip, the other has a large radius of curvature as a reference probe. Each indenter column has its own load cell. The columns are connected close to the sample surface with a differential capacitive sensor measuring the difference in the positions of the two tips. Therefore, the indentation tip is always actively referenced to a position on the sample surface.

Features

- Unique patented active top referencing (EP 1828744 and US 7,685,868)
- Reference has its own piezo actuator and load sensor; applies a very small feedback loop control load to the sample
- Unique materials design with no thermal expansion: ZeroDur® glass
- Highest thermal stability: raw drift rate of < 1 ppm/°C
- Highest possible frame stiffness: infinite frame stiffness (>> 10^8 N/m)
- Two independent depth and load sensors
- High resolution capacitive sensors for true depth and load control modes
- Ultra high resolution and very low noise floor:
  - Depth resolution: 0.003 nm, noise floor < 0.03 nm
  - Force resolution: 0.003 µN, noise floor < 0.1 µN
- Lowest drift rate (down to 10 fm/second)

Depth stability of UNHT^3 during a pause of 100 hours



UNHT^3 stability demonstration
Sample: bulk diamond
Normal force: 1 mN
Hold time = 360,000 seconds = 100 hours;
Creep/drift rate: ***2.1 x 10^{-6} nm/second***
Data courtesy of National Physical Laboratory (NPL), UK

Customer-specific Configurations

Bioindenter (UNHT^3 Bio) Nanoindentation Tester for Biomaterials

The Bioindenter is a new, unique device for measuring local mechanical properties of biological samples. It combines instrumented indentation (nanoindentation) with the requirements of testing of biological samples. The concept of Bioindenter is based on the successful Ultra Nanoindentation technology with extended travel range, improved force resolution and full compatibility of testing in fluids.

The Bioindenter includes a petri dish holder specially designed to accommodate many types of biological samples. The attached optical microscope is equipped with a turret with two long working distance objectives for observation of samples in liquids. Excellent thermal stability allows for easy characterization of time dependent properties such as creep or poroelasticity.

High Temperature Ultra Nanoindentation Tester (UNHT^3 HT)

Anton Paar is a pioneer in environmentally controlled, high temperature instrumented indentation with various solutions up to temperatures of 800 °C and down to -150 °C. The actuating system is based on the patented technology of the Ultra Nanoindentation Tester (UNHT^3) at room temperature.
Different components have been modified in order to sustain higher temperature testing: Thermal bridges are added to include a thermal barrier between the force and depth sensors and the heated sample; water circulation is included to provide cooling of the heated parts; a reflective mirror is installed to limit the heat on the parts exposed to the heating stage. In addition, a high vacuum chamber minimizes oxidation as well as heat loss from convection.

Specifications

	MHT³	NHT³	UNHT³	UNHT³ Bio**	UNHT³ HT**
Maximum indentation load [mN]	30,000	500	100	20	100
Load resolution [µN]	6	0.02	0.003	0.003	0.003
Load noise floor, rms [µN]*	250	1	0.1	0.04	0.1
Maximum indentation depth [µm]	1000	200	100	100	100
Depth resolution [nm]	0.03	0.01	0.003	0.003	0.003
Depth noise floor, rms [nm]*	1.5	0.3	0.03	0.05	0.03
Frame stiffness [N/m]	2×10^8	10^7	$> 10^8$	N/A	N/A
Options					
Sinus Mode	○	●	●	-	-
Liquid testing	●	●	●	-	-
Heating stage up to 100 °C	●	○	●	-	-
Heating stage up to 200 °C	●	○	● (with head cooling)	-	-
Heating stage up to 450 °C	●	○	○ (UNHT³ HT)	-	-
Petri dish holder	○	○	○	-	-

The raw acquisition rate of Indentation Testers is 192kHz, which is then decimated and filtered down to 400Hz maximum for display.

Additional options and accessories are available on specific request: Electrical Contact Resistance (ECR), cooling for low temperatures (-150 °C in vacuum), wafer holder, multiple sample holder, ...

** Noise floor value specified under ideal laboratory conditions and using an anti-vibration table.*

*** Customer-specific production; details on request*

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