Agilent Nano Indenter G200

Data Sheet

Precise mechanical testing in the micro to "sub-nano" range of loads and displacements

Features and Benefits

- Accurate, repeatable results compliant with ISO 14577 standard
- Electromagnetic actuation allows unparalleled dynamic range in force and displacement
- Flexible, upgradeable nanoindentation instrument can be configured for repeatable specific applications or a variety of new applications
- Dynamic properties characterization via continuous measurement of stiffness by indentation depth
- Outstanding software with real-time experimental control, easy test protocol development, and precision drift compensation

Applications

- Semiconductor, thin films, MEMs (wafer applications)
- Hard coatings, DLC films
- Composite materials, fibers, polymers
- Metals, ceramics
- Biomaterials, biology

Overview

The culmination of decades of research and development, the Agilent Nano Indenter G200 is the world's most accurate, flexible, and user-friendly instrument for nanoscale mechanical testing. Electromagnetic actuation allows the Nano Indenter G200 to achieve unparalleled dynamic range in force and displacement.

The Nano Indenter G200 enables users to measure Young's modulus and hardness in compliance with ISO 14577. The G200 also enables measurement of deformation over six orders of magnitude (from nanometers to millimeters). Furthermore, a variety of options can be added to accommodate applications testing needs. The capabilities of the G200 can be extended to facilitate frequency-specific testing, quantitative scratch and wear testing, integrated probe-based imaging, high-temperature testing, expanded load capacity up to 10 N, and customizable test protocols.

With the Nano Indenter G200, users are able to quantify the relationship between structure, properties, and performance of their materials quickly and easily with minimal sample preparation. The user-friendly design of the G200 simplifies training requirements — standard tests can be run on the same day the instrument is installed. Every

G200 is backed by highly responsive Agilent Technologies customer service personnel. Knowledgeable and experienced regional applications engineers are available to guide users through more advanced testing, provide outstanding technical support, and offer unmatched applications expertise.

Advanced Design

All nanoindentation experiments rely on the accuracy of the fundamental load and the displacement data, requiring the highest precision control of load applied to the sample. The Nano Indenter G200 is powered by electromagnetic actuation-based force transducers to ensure precise measurements. The instrument's unique design avoids lateral displacement artifacts, while software compensates fully for any drift in force.

Among the many benefits of the Nano Indenter G200 design are convenient access to the entire sample tray, excellent sample positioning accuracy, easy viewing of the sample position and the sample work area, and simplicity in sample height adjustment to speed test throughput. A modular controller design is optimized for future upgrading. In addition, the G200 conforms to ISO 14577 to ensure data integrity, gives users the ability to program experiments with each force transducer and switch between them at any time, and has an optimized lateral footprint to conserve lab space

Dynamic Contact Module (DCM) Option

The Nano Indenter G200 standard configuration utilizes the Agilent XP indentation head, which delivers <0.01 nm displacement resolution and >500 µm maximum indentation depth. To extend the range of load-displacement experimentation to the surface contact level, the G200 can be equipped with the Agilent

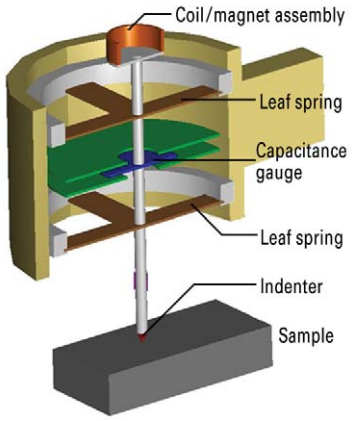

Figure 1. Schematic diagram of the actuating and sensing mechanisms of the Nano Indenter G200.

Dynamic Contact Module (DCM) option. With this option, researchers can study not only the first few nanometers of an indentation into the surface of a material, but even the pre-contact mechanics.

The DCM is a fully dynamic indentation head for ultra-low-load (10 mN max load) mechanical properties characterization. At this scale, the noise level of the indentation system also must be optimized to enhance its actual displacement measurement capability. Using standard methods, the displacement resolution of the DCM is determined to be 0.0002 nm (0.2 picometers). The sensor has a motion of 15 µm. More importantly, real-world testing shows that the noise levels are typically less than an angstrom, ensuring the best resolution of any indenter on the market today. The DCM has the lowest noise floor of any instrument of its type.

Continuous Stiffness Measurement (CSM) Option

In conventional quasi-static indentation testing, the stiffness of contact is determined by analyzing the force vs. displacement curve during unloading. This depth-sensing method provides a single measurement for the given indentation depth. The Agilent Continuous Stiffness Measurement (CSM) technique, which is compatible with both the XP and the DCM indentation heads, satisfies application requirements that must take into account dynamic effects, such as strain rate and frequency.

The CSM option offers a means of separating the in-phase and out-of-phase components of the load-displacement history. This separation provides an accurate measurement of the location of initial surface contact and continuous measurement of contact stiffness as a function of depth or frequency, thus eliminating the need for unloading cycles. Since the contact stiffness is determined directly, no assumptions (such as mechanical equilibrium) are required to correct for elasticity.

This makes CSM a powerful tool not only for stiff materials such as metals, alloys, and ceramics but also for time-dependent materials like polymers, structural composites, and biomedical materials.

The state-of-the-art CSM option provides the only means available to both fully characterize dynamic properties in the nanometer range and accurately characterize viscoelastic materials providing values such as storage modulus. Indentation tests using CSM can be controlled with a constant strain rate, a critical test

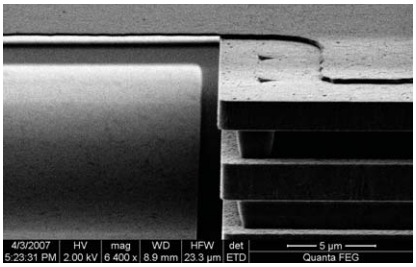

Figure 2. This SEM image shows indents made at the base of a cantilever beam. The Nano Indenter G200 is uniquely suited for testing both MEMS and component materials for two reasons. First, the actuating and sensing mechanisms allow an unparalleled combination of range and resolution. Second, the controlling software is test-method based — there is no configuration or calibration of hardware.

parameter for material systems such as pure metals or low-melting-point alloys, and polymer films and film / substrate systems. This level of control is not possible with the conventional method.

Lateral Force Measurement (LFM) Option

There are several additional performance-extending Nano Indenter G200 options available for use with the standard XP indentation head. The Agilent Lateral Force Measurement (LFM) option provides three-dimensional quantitative analysis for scratch testing, wear testing, and MEMS probing. This option enables force detection in the X and Y directions to examine shear forces. Tribological studies benefit greatly from the LFM option for determination of the critical load and coefficient of friction over the scratch length.

High Load Option

The capabilities of the Nano Indenter G200 can also be enhanced via the Agilent High Load option. Designed for use with the standard XP indentation head, this option expands the load capabilities of the Nano Indenter G200 up to 10 N of force, allowing the complete mechanical characterization of ceramics, bulk metals, and composites. The High Load option has been engineered to avoid sacrificing the instrument's load and displacement resolutions at low forces while seamlessly engaging at the point in the test protocol when extra force is required.

Heating Stage Option

This option, which is compatible with the standard XP indentation head, facilitates the study of materials of interest as they are heated from room temperature to as high as 350°C. To ensure reliable data, the system's software compensates for drift associated with heating.

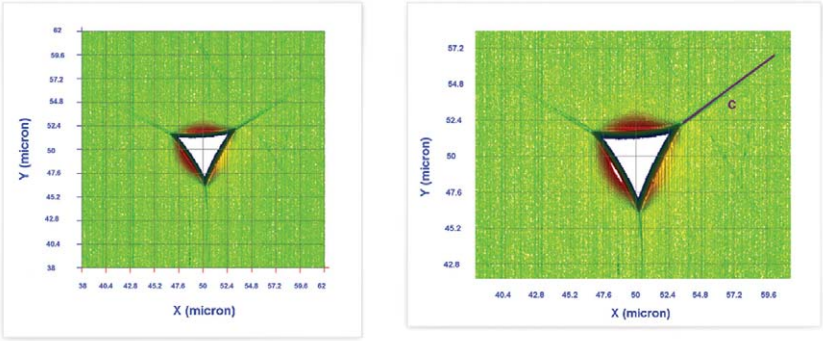

Figure 3. Fracture toughness by Nanoindentation. Left image: A 24 x 24 µm scan of a 1200 nm deep indent in silica. Crack features accentuated. Right image: An enlarged image of the indent taken straight from the NanoSuite 5.0 review page.

New Enhanced NanoSuite 5.0 Professional Software

Every Nano Indenter G200 comes with the Agilent NanoSuite 5.0 Professional software package. NanoSuite 5.0 lets users run tests and manage data with unprecedented ease. Through the elegant and intuitive interface, users can set up and run indentation experiments quickly — changing test parameters as often as desired — with just a few clicks.

Advanced features such as enhanced imaging capabilities (including profile cross-sectional imaging, real-time adjustment of scanning parameters, polynomial distortion or leveling correction, and plane-fit leveling), survey scanning of areas up to 500 µm x 500 µm, and new test method development help researchers get from testing to results in record time. A NanoSuite method is a software file that contains the protocol for performing a test, analyzing the data, and generating an easy-to-read printed report. For example, one NanoSuite method may contain instructions to execute tests and report results in compliance with ISO 14577, the international standard for indentation testing, whereas a different NanoSuite method would be used to perform a controlled scratch test and report relevant results.

NanoVision Software Option

The Agilent NanoVision option for the Nano Indenter G200 is used to probe the surface of a sample, generating a 3D map of the surface. Backed by decades of nanomechanical testing experience, the NanoVision nanomechanical microscopy option delivers quantitative imaging by coupling a linear electromagnetic actuation-based indentation head with a closed-loop nanopositioning stage. NanoVision allows users to create quantitative high-resolution images using a Nano Indenter G200, target indentation test sites with nanometer-scale precision, and examine residual impressions in order to quantify material response phenomena such as pile-up, deformed volume, and fracture toughness. This option also lets users target and characterize individual phases of complex materials.

Nanoindentation instruments from Agilent Technologies conform to the ISO 14577 standard, delivering confidence in test accuracy and repeatability. These state-of-the-art solutions ensure reliable, high-precision measurement of nanomechanical properties for research and industry.

Agilent Nano Indenter G200 Specifications

Standard XP Indentation Head	
Displacement resolution	<0.01 nm
Total indenter travel	1.5 mm
Maximum indentation depth	>500 µm
Load application	Coil / magnet assembly
Displacement measurement	Capacitance gauge
Loading capability	
Maximum load (standard)	500 mN
Maximum load with DCM option	10 mN
Maximum load with High Load option	10 N
Load resolution	50 nN
Contact force	<1.0 µN
Load frame stiffness	~5 x 10^6 N/m
Indentation placement	
Useable surface area	100 mm x 100 mm
Position control	Automated remote with mouse
Positioning accuracy	1 µm
Microscope	
Video screen	25x (x objective mag.)
Objective	10x and 40x

DCM Indentation Head Option	
Displacement resolution	0.0002 nm
Maximum indentation depth	>15 µm
Loading column mass	<100 mg
Load application	Coil / magnet assembly
Displacement measurement	Capacitance gauge
Typical leaf spring stiffness	~100 N/m
Typical damping coefficient	0.02 Ns/m
Typical resonant frequency	180 Hz
Loading capability	
Maximum load	10 mN (1 gm)
Load resolution	1 nN (0.1 µgm)

LFM Option	
Maximum lateral force	>250 mN
Lateral resolution	<2 µN
Maximum scratch distance	>100 mm
Scratch speed	100 nm/s up to 2 mm/s

High Load Option	
Maximum force	10 N
Load resolution	≤1 mN
Maximum indentation depth	≥500 µm
Displacement resolution	0.01 nm
Frame stiffness	≥5 x 10^6 N/m

NanoVision Option	
X-Y scan range	100 µm x 100 µm
Z scan range	Indentation head dependent
Positioning accuracy	≤2 nm
Resonant frequency	>120 Hz

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