Keysight Technologies
Nano Indenter G200

Precise mechanical testing for micro-to-nano range of loads and displacements.

Data Sheet

KEYSIGHT TECHNOLOGIES

Overview

The culmination of decades of research and development, the Keysight Technologies, Inc. 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. Furthermore, Keysight's innovative Express Test option, an award-winning technology that allows the world's fastest nanoindentation for mechanical-properties mapping, is compatible with all G200 indentation DCMII and XP heads, and stages.

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). Modular options can be added to accommodate a variety of applications. 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 10N, 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 Keysight 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.

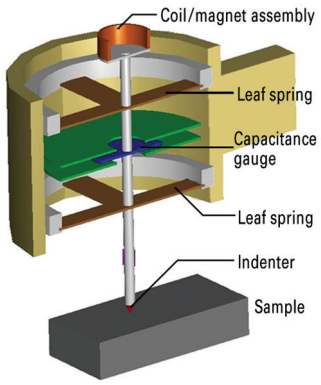


Figure 1. Schematic diagram of the actuating and sensing mechanisms of the Nano Indenter G200.

Features and benefits

- Award-winning, high-speed Express Test option compatible with all G200 indentation DCMII and XP heads, and stages
- Simple determination of indenter area function and frame stiffness
- Accurate, repeatable results compliant with ISO 14577 standard
- Electromagnetic actuation allows unparalleled dynamic range in force and displacement
- Configurable for optimized routine testing or new applications
- Modular options for imaging scratch, high-temperature, and dynamic testing
- 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
- Lead-free solder
- Biomaterials, biological and artificial tissue

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.

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. The modular controller design is optimized for future upgrades. 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.

Enhanced Dynamic Contact Module II (DCM II) Option

The Nano Indenter G200 standard configuration utilizes the Keysight 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 enhanced Keysight Dynamic Contact Module II (DCM II) option. This option offers all of the impressive performance afforded by Keysight's original DCM option as well as several new advantages, including 3x higher loading capability (30mN max load), easy tip exchange for quick removal and installation of application-specific tips, and a full 70 µm range of indenter travel.

With the DCM II 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. At this scale, the noise level of the indentation system is optimized to enhance its actual displacement measurement capability. Using standard methods, the displacement resolution of the DCM II is 0.0002 nm (0.2 picometers). Even more important, 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 II 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 Keysight Continuous Stiffness Measurement (CSM) technique, which is compatible with both the XP and the DCM II 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. The 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.

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 complex modulus. Indentation tests using CSM can be controlled with a constant strain rate, a critical test parameter for material systems such as pure metals or low-melting-point alloys, and polymer films and film/substrate systems.

Award-Winning Express Test Option

A recent recipient of the prestigious R&D 100 Award, Keysight's Express Test option allows up to 100 indents to be performed at 100 different surface sites in 100 seconds. Express Test, the world's fastest means of performing instrumented indentation for mechanical-properties mapping at the nanoscale, is compatible with all G200 indentation heads and stages!

Designed exclusively for use with the G200, Keysight's highly versatile, easy-to-use Express Test methods are ideal for applications that involve metals, glasses, ceramics, structural polymers, thin films, and low-k materials. With Keysight NanoSuite > 6.2 software, users can automatically generate histograms and 3D mechanical-properties maps. Graphs and supporting data are easily exported to Microsoft Excel.

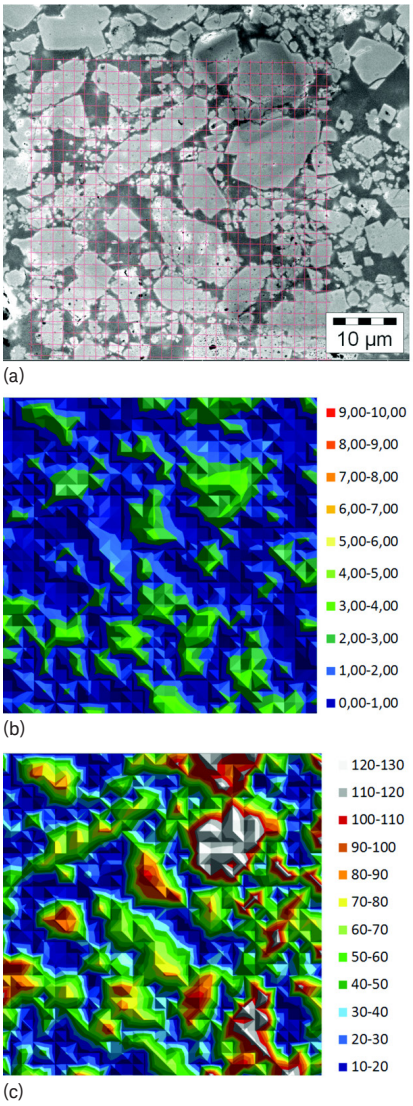


Figure 2. Lithium-ion battery cathode, (a) DCM Express Test Nanoindentation Grid. (b) DCM Express Test Hardness [GPa]. (c) DCM Express Test Modulus [GPa] calculated at depth 100 nm.

Laser heated tip and stage option

Keysight has developed a new G200 system solution that makes use of a stage and sample heated by a precise high-power diode laser. Advantages include the ability to measure various nanomechanical properties at precisely controlled temperatures and to test a wide range of samples under highly dynamic temperature conditions. To ensure reliable data, the system minimizes drift associated with heating by using a heated tip and the laser as a heating source. The G200 also gives users the option to purge samples with various gases to avoid contamination and oxidation.

Figure 3. Keysight G200 Laser Heater System.

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 Keysight 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.

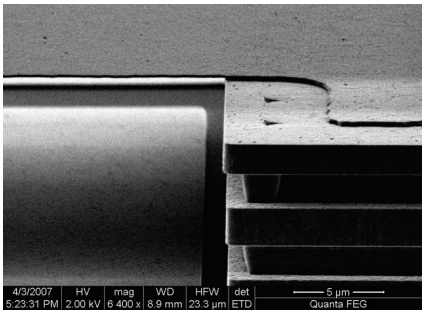


Figure 4. This SEM image shows indents made at the base of a cantilever beam. The Nano Indenter G200 is uniquely suited for testing both MEMS and component materials for two reasons. First, the actuating and sensing mechanisms allow an unparalleled combination of range and resolution. Second, the controlling software is test-method based – there is no configuration or calibration of hardware.

High Load Option

The capabilities of the Nano Indenter G200 can also be enhanced via the Keysight 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 10N 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.

NanoVision Option

The Keysight 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.

Enhanced NanoSuite Professional Software

Every Nano Indenter G200 comes with Keysight NanoSuite Professional software, a premium-performance package that gives researchers in scientific and industrial settings an unprecedented combination of speed, flexibility, and ease of use. NanoSuite offers a variety of prewritten test methods, including an exclusive nanoindentation technique for making substrate-independent measurements of thin film materials, several novel techniques for testing polymers, and improved scratch test methods. Keysight's field-proven method for testing in compliance with ISO 14577, the international standard for indentation testing, is provided as well.

NanoSuite includes a fully integrated tool that greatly simplifies the determination of indenter area function and load-frame stiffness. Once a rather involved and time-consuming endeavor, this process now requires only a couple of mouse-clicks within the NanoSuite > 6.2 program. Prewritten methods for testing gels (DCM II indentation head and CSM option required) and for measuring strain-rate sensitivity (XP indentation head and CSM option required).

Additional new capabilities allow a standard batch of tests comprising 25 or more samples to be set up in 5 minutes or less, 2D and 3D graphs and histograms to be plotted on-screen and exported directly to Microsoft Excel while preserving all labels and scales, and sample files to be organized by project and subproject. NanoSuite > 6.2 also provides Microsoft Windows 7 (32-bit) compliance for current systems and a convenient PDF printer to replace hardware printers.

As in the package's previous iteration, an intuitive interface allows users to set up and run experiments quickly — changing test parameters as often as desired — with just a few clicks. NanoSuite > 6.2 offers support of small force/displacement measurements, surface topology, stiffness mapping, scratch tests, and more. Versatile imaging capabilities, a survey scanning option, and streamlined test method development help researchers get from testing to results in record time.

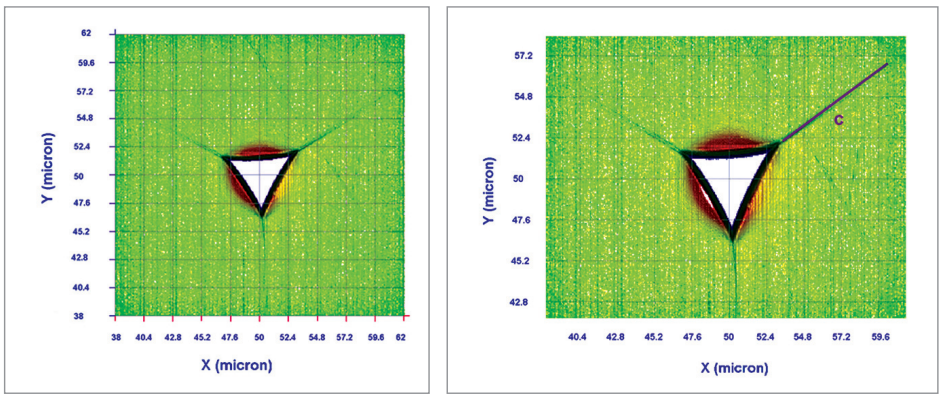


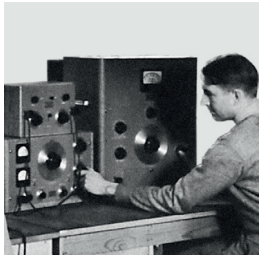
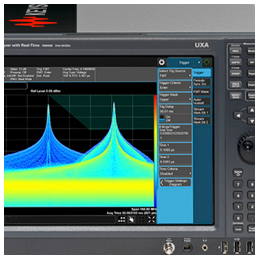
Figure 5. Fracture toughness by Nanoindentation. Left image: A 24 x 24µm scan of a 1200nm deep indent in silica. Crack features accentuated. Right image: An enlarged image of the indent taken straight from the NanoSuite 6.2 review page.

Keysight 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 II option	30 mN
Maximum load with High Load option	10 N
Load resolution	50 nN
Contact force	< 1.0 µN
Load frame stiffness	~5 x 106 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 II Indentation Head Option	
Displacement resolution	0.0002 nm (0.2 picometers)
Range of indenter travel	70 µm
Loading column mass	< 150 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	120 Hz
Lateral stiffness	80,000 N/m
Loading capability	
Maximum load	30 mN (13 gm)
Load resolution	3 nN (0.3 µgm)
Express Test Option	
Time per indentation	Standard < 5.0 sec
LFM Option	
Maximum lateral force	> 250 mN
Lateral resolution	< 2 µN
Maximum scratch distance	> 100mm
Scratch speed	100 nm/s up to 2 mm/s
High Load Option	
Maximum force	10 N
Load resolution	50 nN
Maximum indentation depth	≥ 500 µm
Displacement resolution	0.01 nm
Frame stiffness	≥ 5 x 106 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

Nanoindentation instruments from Keysight Technologies conform to the ISO 14577 standard (Metallic materials — Instrumented indentation test for hardness and materials parameters), 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.

Evolving Since 1939

Our unique combination of hardware, software, services, and people can help you reach your next breakthrough. We are unlocking the future of technology.
From Hewlett-Packard to Agilent to Keysight.


Nano Mechanical Systems from Keysight Technologies

Keysight Technologies, the premier measurement company, offers high-precision, modular nano-measurement solutions for research, industry, and education. Exceptional worldwide support is provided by experienced application scientists and technical service personnel. Keysight's leading-edge R&D laboratories ensure the continued, timely introduction and optimization of innovative, easy-to-use nanomechanical system technologies.

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