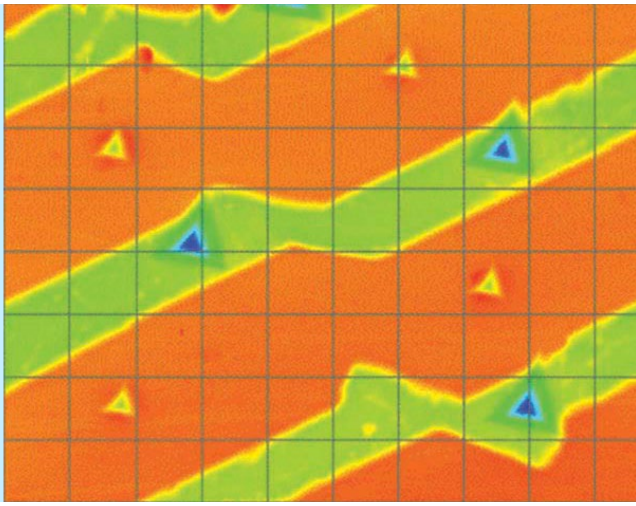
# Nano Indenter® G200

NANO-MECHANICAL TESTER



KLA-Tencor


# NANO INDENTER G200

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

The Nano Indenter® G200 system is an accurate, flexible, user-friendly instrument for nanoscale mechanical testing. The Nano Indenter G200 measures Young's modulus and hardness, including measurement of deformation over six orders of magnitude (from nanometers to millimeters). The system can also measure the complex modulus of polymers, gels and biological tissue as well as the creep response (strain rate sensitivity) of thin metallic films. Modular options can accommodate a variety of applications: frequency-specific testing, quantitative scratch and wear testing, integrated probe-based imaging, high-temperature testing, expanded load capacity up to 10N and custom test protocols.

**Features**

- Electromagnetic actuation for superior dynamic range in force and displacement
- Modular options for imaging scratches, high-temperature measurements, and dynamic testing
- Intuitive interface for quick test set up- calculation parameters can be changed with just a few mouse clicks
- Real-time experimental control, easy test protocol development and precise thermal drift compensation
- Award-winning, high-speed Express Test option
- Versatile imaging capabilities, survey scanning, and streamlined test method development for rapid results
- Simple determination of indenter area function and load frame stiffness

**Applications (Materials)**

- Semiconductor, thin films, MEMS (wafer applications)
- Hard coatings, including diamond-like carbon (DLC) films
- Composite materials, fibers, polymers
- Metals, ceramics
- Lead-free solder
- Biomaterials, biological and artificial tissue

**Advanced Design**

All nanoindentation measurements rely on the precision of the applied load and the accuracy of the displacement data. The Nano Indenter G200 is powered by electromagnetic 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, accurate sample positioning, easy viewing of the sample position and the sample work area, and simple sample height adjustment to speed test throughput. The modular controller design is optimized for upgrades. In addition, the G200 gives users the ability to program measurements with each force transducer and switch between them at any time. It has a small footprint to conserve lab space. The Nano Indenter G200 system conforms to ISO 14577 to ensure data integrity.

In its standard configuration the Nano Indenter G200 system utilizes the XP indentation head with a loading capability of 500mN, delivering < 0.01nm (10pm) displacement resolution and > 500µm maximum indentation depth.

The Nano Indenter G200 system provides a wide array of imaging capabilities, including profile cross-sectional imaging, real-time adjustment of scanning parameters, correction of polynomial distortion, simple or three-point leveling, and the choice of false-color palettes.

For scanning areas up to 500µm x 500µm, the Nano Indenter G200 offers a survey scanning mode. This mode is ideal for scratch and wear testing on large samples or for working with large, irregularly-shaped samples, large samples composed of heterogeneous materials, various metals, ceramics and hard coated materials. Flatness of travel is 100nm per 100µm (0.1%).

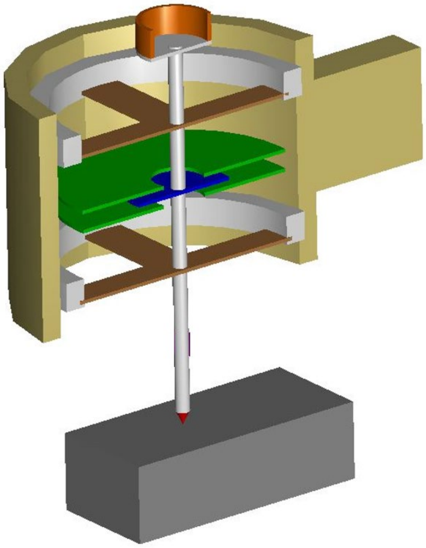


Figure 2. Schematic image of coil-magnet assembly and three-plate capacitors within indentor head.

**Data Acquisition, Recording and Control**

The fundamental data acquisition rate of the Nano Indenter G200 is 12.5kHz, and data are recorded at a rate up to 500Hz. Even at the system's highest recording rate, the G200 allows real-time experimental control based on any recorded or calculated data channel. This capability allows the user to plot nanomechanical properties in real time or respond quickly when a test sample fails.

**Enhanced Dynamic Contact Module II (DCM II) Option**

To extend the range of load-displacement measurements to the surface contact level, the Nano Indenter G200 system can be equipped with the enhanced Dynamic Contact Module II (DCM II) option. This option extends the maximum loading capability to 30mN and offers a full 70µm range of indenter travel with 0.2pm displacement resolution. Tip exchange is designed for quick removal and easy installation of a variety of application-specific tips. With the DCM II option, researchers can study not only the first few nanometers of indentation into the surface of a material, but also the pre-contact mechanics. Real-world testing shows that the G200 equipped with the DCM II option typically delivers noise levels less than 1Å, supporting high resolution measurements.

Figure 3. DCMII head with Berkovich tip installed.

## Continuous Stiffness Measurement (CSM) Option

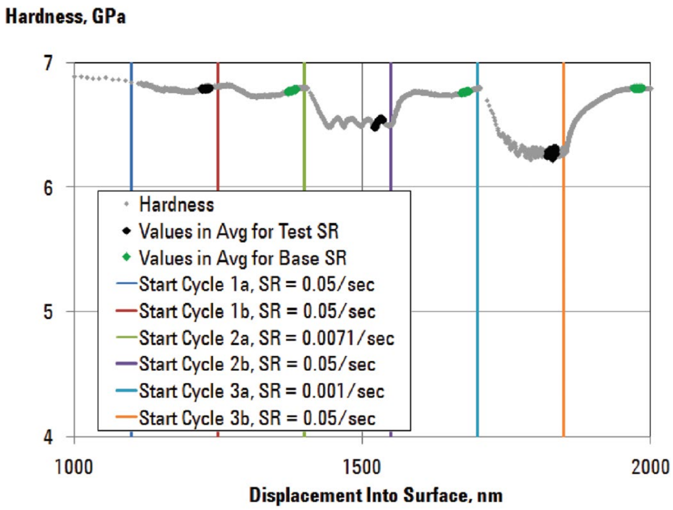



Figure 4. Strain Rate Sensitivity measurement using CSM module on G200.

In conventional quasi-static indentation testing, contact stiffness is determined by analyzing the force vs. displacement curve during unloading. This depth-sensing method provides a single measurement for a given indentation depth. The Continuous Stiffness Measurement (CSM) technique, 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. Phase separation enables accurate determination of the location of initial surface contact, and continuous measurement of contact stiffness as a function of depth or frequency, eliminating the need for unloading cycles.

The CSM option is applicable for not only stiff materials such as metals, alloys and ceramics, but also for materials with compliant material properties, such as polymers, structural composites and biomedical materials. The CSM option can fully characterize dynamic properties (e.g., strain rate sensitivity) in the nanometer range. It can also accurately characterize viscoelastic materials where there is a phase difference between stress and strain, providing values such as complex (dynamic) 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, polymer films and film/substrate systems.

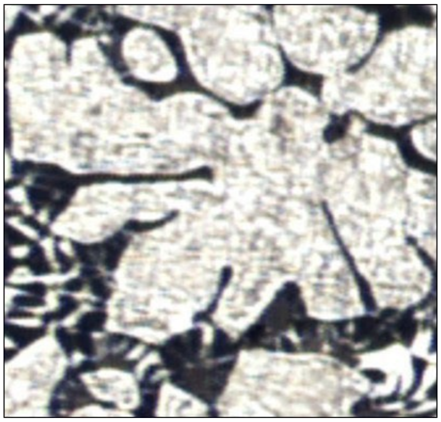


Figure 5. Microscopy image of a sample for high entropy alloy.

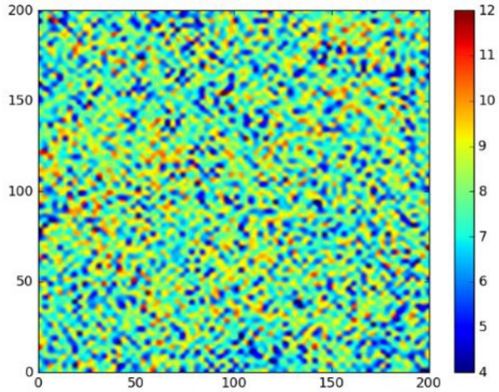



Figure 6. Hardness mapping using Express Test on high entropy alloy.

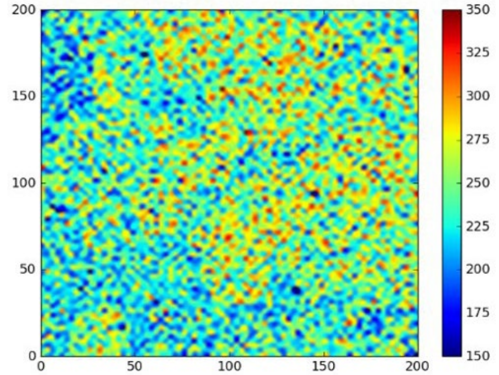



Figure 7. Modulus mapping using Express Test on high entropy alloy.

## Award-Winning Express Test Option

The Express Test option is a novel, fast way to conduct high-precision nanomechanical tests. A recipient of the R&D 100 Award, the Express Test option performs one complete indentation every second, meaning that 100 indentations can be performed at 100 different sites in 100 seconds. The Express Test option is compatible with all Nano Indenter G200 DCM II and XP indentation heads and all stages. Versatile, easy-to-use Express Test methods are ideal for applications involving metals, glasses, ceramics, structural polymers, thin films and low-k materials. One Express Test method for thin film measurements incorporates a thin-film model that automatically accounts for the substrates' influence on the measurement, allowing rapid, accurate measurement of Young's modulus.

Users can run multiple Express Test arrays on multiple samples in one batch, automatically generating histograms and 3D maps of mechanical properties. User-created 2D and 3D graphs can be exported to Microsoft Excel with plotting options intact.[1]

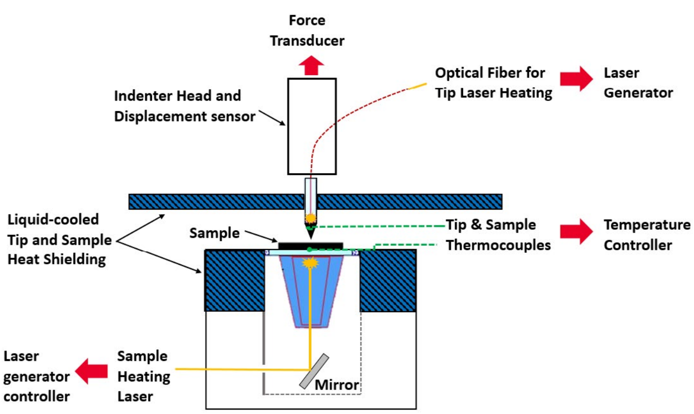



Figure 8. A schematic image of Laser Heater working mechanism for tip heating and sample heating.

## Laser-Heated Tip and Stage Option

Compatible with the standard XP indentation head, the Laser-Heated Tip and Stage option for the Nano Indenter G200 system uses a high-power diode laser to heat the tip and the sample to the same temperature. Advantages include the ability to measure various nanomechanical properties at precisely controlled temperatures or under highly dynamic temperature conditions. To ensure accurate data, the system minimizes drift associated with heating by using a heated tip, and by using a laser as a heating source (not resistive heating). The G200 also gives users the option to purge samples with various gases to avoid contamination and oxidation.

[1] Microsoft and Excel are registered trademarks of Microsoft Corporation.


Figure 9. Nano Indenter G200 Laser Heater System.

## Heating Stage Option

The Heating Stage 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 350C. To ensure reliable data, the system's software compensates for drift associated with heating.

## Lateral Force Measurement (LFM) Option

The Lateral Force Measurement (LFM) option provides three-dimensional quantitative analysis for scratch testing, wear testing and MEMS probing. This option enables shear force measurement in the X and Y directions. Tribological studies benefit greatly from the LFM option, for determination of the critical load and coefficient of friction over the scratch length.

### NanoVision Option

The NanoVision option features a closed-loop nanopositioning stage for high-resolution 3D imaging and precise targeting. NanoVision allows users to target indentation test sites with nanometer-scale precision, and characterize individual phases of complex materials. NanoVision users can also examine residual impressions to quantify material response phenomena such as pile-up, deformed volume and fracture toughness.

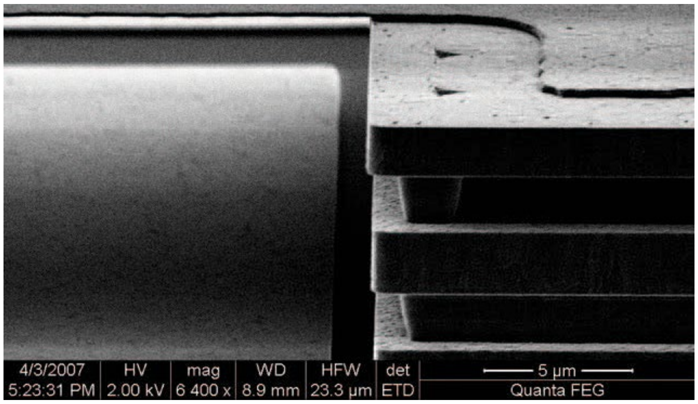



Figure 10. This SEM image shows indents made at the base of a cantilever beam. The Nano Indenter G200 is uniquely suited for testing both MEMS and component materials for two reasons. First, the actuating and sensing mechanisms allow an unparalleled combination of range and resolution. Second, the controlling software is test-method based — there is no configuration or calibration of hardware.

### High Load Option

Designed for use with the standard XP indentation head, the High Load option expands the load capabilities of the Nano Indenter G200 system up to 10N, allowing 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, and seamlessly engage at the point in the test protocol when extra force is required.

### NanoSuite® Software Versions

All Nano Indenter G200 systems are powered by standard NanoSuite Professional software. The NanoSuite Professional version gives users access to pre-written test methods, including methods that comply with ISO 14577 and methods that remove substrate-related artifacts from samples with thin-film materials. The NanoSuite Explorer version enables researchers to write their own NanoSuite methods using a simple protocol. With Simulation Mode, available with both NanoSuite Professional and NanoSuite Explorer software, users can write test methods, process and analyze data offline.[1]

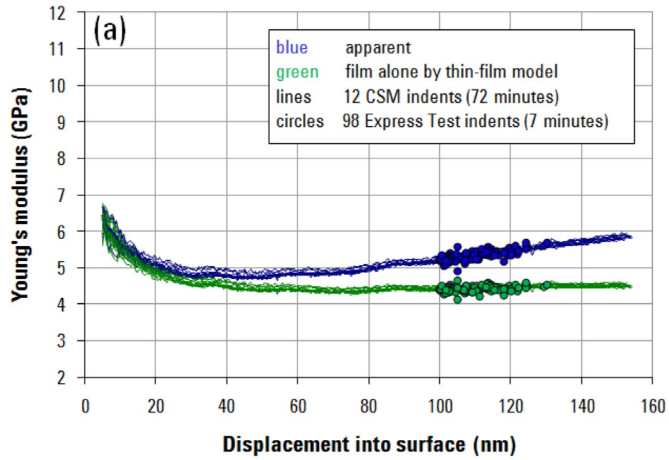



Figure 11. New test method for Express Test gives the substrate-independent Young's modulus of a 1000nm low-κ film on silicon by means of 98 indents performed in just 7 minutes (green circles).

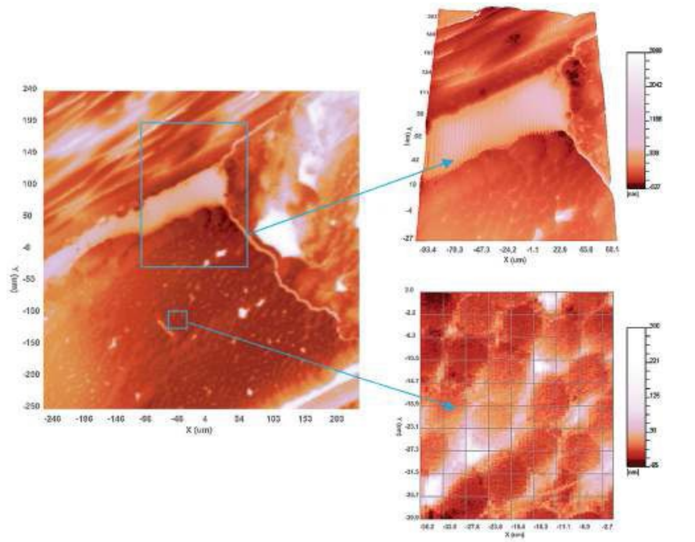


Figure 12. Left: 500 x 500µm scan of carbon fibers over 18µm of height deviation. Top right: 40µm scan of feature shown in 3D. Bottom right: 40µm scan of carbon fiber ends after polynomial leveling.

KLA-TENCOR SUPPORT
Maintaining system productivity is an integral part of KLA-Tencor's yield optimization solution. Efforts in this area include system maintenance, global supply chain management, cost reduction and obsolescence mitigation, system relocation, performance and productivity enhancements, and certified tool resale.



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