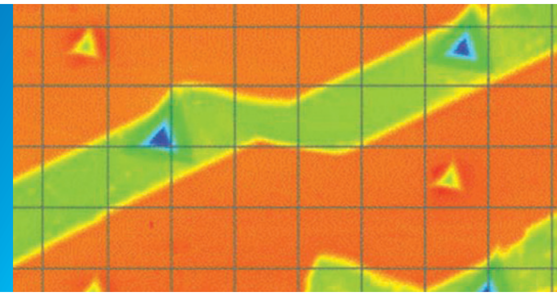
Laser Heated Tip and High Temperature Stage for Nano Indenter® G200



Overview

The Nano Indenter® G200 system is an accurate, flexible, user-friendly instrument for nanoscale mechanical testing. The system measures Young's modulus and hardness, including measurement of deformation over six orders of magnitude, from nanometers to millimeters. Modular options on the Nano Indenter G200 system accommodate a variety of applications including high-temperature testing. A laser heated tip and high temperature stage gives users the ability to measure various nanomechanical properties at precisely controlled temperatures. A high-power diode laser can heat the tip and sample to the same temperature, allowing the Nano Indenter G200 system to test a wide range of samples under highly dynamic temperature conditions. To ensure accurate data, the system minimizes drift associated with heating by using a heated tip and the 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.

Features and Benefits

- Temperatures up to 500°C
- Fast heating and cooling
- Minimal thermal drift
- User-friendly interface for complete NanoSuite software integration
- Option to purge samples with various gases to avoid contamination and oxidation
- Dynamic measurements enabled by Continuous Stiffness Measurement (CSM) option

Advanced Laser Heating

Conventional heaters heat both the substrate and the instrument, often leading to excessive thermal drift, thereby compromising the accuracy of nanoindentation results. The Nano Indenter G200 heater avoids thermal drift by employing a diode laser with an adjustable spot size, to match the heat-generating area in the heater precisely to the substrate size. The energy is then transferred directly to the substrate via a light fiber and optical components included in the sample

Figure 1. The Nano Indenter G200 Laser Heater System

holder. In addition, the Nano Indenter G200 uses function-optimized materials that reduce the thermal drift of the system.

The Nano Indenter G200 system's substrate holder provides high mechanical and temperature stability. To ensure easy and convenient operation, the transparent plate underneath the sample contains a built-in thermocouple. For additional accuracy (e.g., for nanoindentation applications involving thick polymer samples), users can mount a thermocouple to the sample surface.

Laser-Heated Tip

The laser-heated indenter tip for the Nano Indenter G200 system is designed to prevent disturbance of the substrate temperature during measurement—a consideration that is critical for working with materials that have poor thermal conductivity or mechanical properties that are strongly affected by temperature. Because the tip is heated by a small laser via a thin optical fiber through the hollow shaft of the indenter head, the tip and sample are kept at the same temperature, allowing users to perform highly precise high-temperature CSM as well.

Standard diamond tips provide superior hardness and low wear, ideal for hard coated samples. Sapphire tips, which are chemically inert and can be used in air for most metallic materials, are also offered for standard heating experiments.

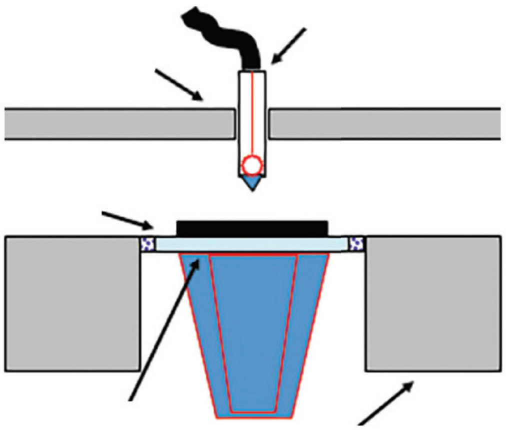


Figure 2. Diagram of the tip heater

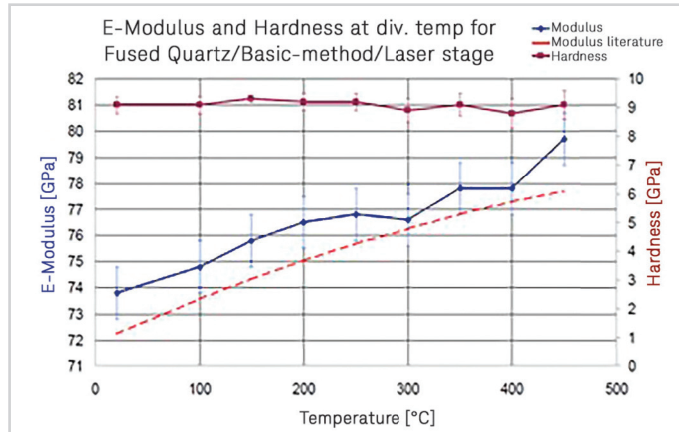


Figure 3. Elastic modulus and hardness of fused quartz, determined over temperature range from room temperature to 450°C

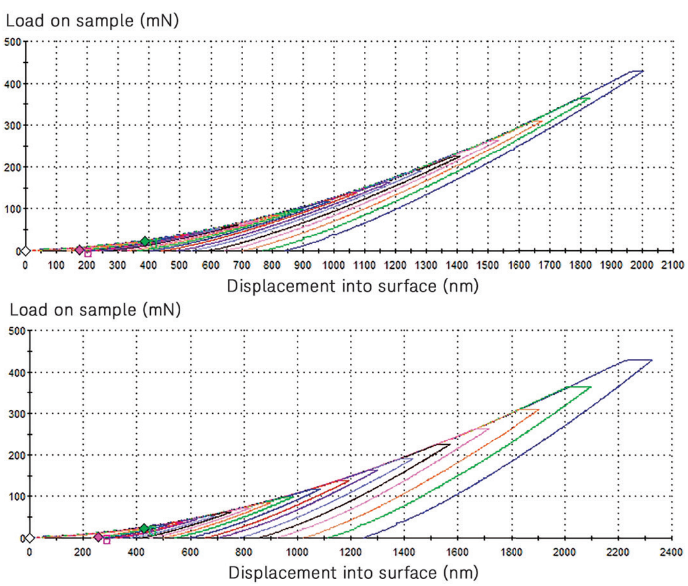
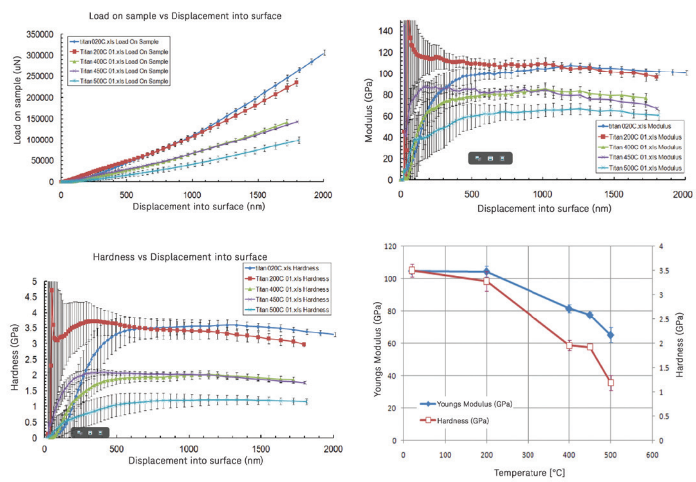


Figure 4. Nanoindentation displacement versus load curves for fused silica at 27 °C (top) and 500 °C (bottom)



Temperature (°C)	Young's modulus (GPa)	Hardness (GPa) σ
20	104.6±1.5	3.5+0.1
200	104.3±3.3	3.3+0.2
400	81.5±2.6	2.0+0.1
450	77.6±1.9	1.9+0.1
500	65.2±4.4	1.2+0.2

Figure 5. Displacement versus load measurements of titanium samples at temperatures ranging from 20°C to 500°C, and resulting determinations of temperature-dependent Young's modulus and hardness values. Depth-dependent measurements utilize CSM option

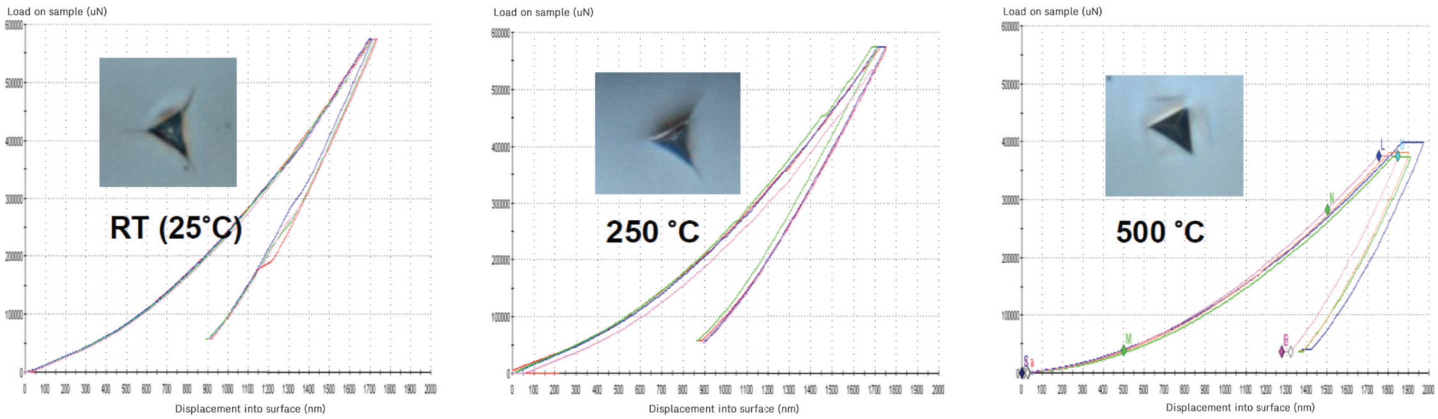


Figure 6. Displacement versus load curves for silicon over temperature range from room temperature to 500°C, showing temperature dependence of brittle to ductile transition.

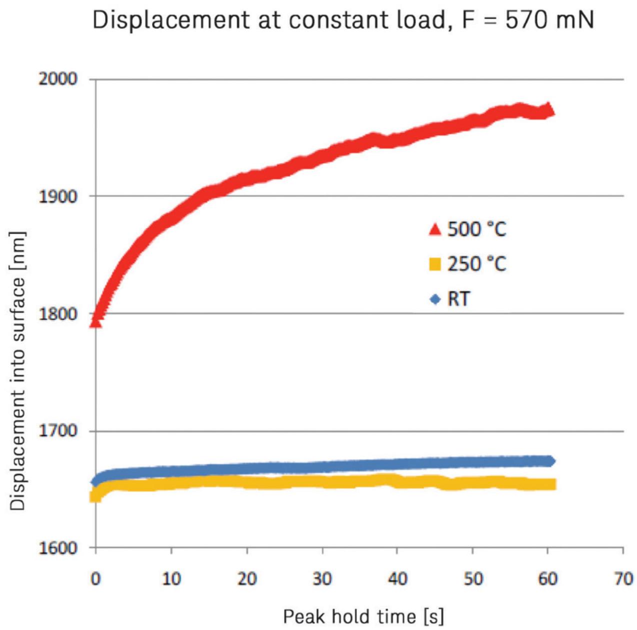


Figure 7. Displacement at constant load, F = 570mN, for at room temperature, 250°C and 500°C.

Laser Heater Specifications

Temperature range: RT to 500C for stage and indenter tip (temperature limit imposed by tip material)

Wavelength: 940nm for 40W laser diode, 808nm for 4W tip laser diode

Heating and cooling rates: 20 to 25C /sec

Cooling: Circulating bath chiller

Maximum substrate size: 12mm (length) x 12mm (width) x 3mm (thickness)

Light fiber (tip heating): 125µm diameter; 1m length

Heatable indenter tips: Various geometries for diamond, sapphire and conical cubic boron nitride

KLA SUPPORT
Maintaining system productivity is an integral part of KLA'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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