

MultiRange NanoProbe™

Providing Nano-to-Micro Scale Connectivity

Hysitron's **MultiRange NanoProbe** bridges the gap between nano-indentation and microindentation testing. The **MultiRange NanoProbe** offers additional testing options to the **TI 900** series of instruments and increases the indentation force capabilities up to 10 N with displacements of up to 80 μm .

The increased normal force and displacement available with the **MultiRange NanoProbe** have been designed to accurately test very hard samples which require larger loads, as well as for fracturing films too thick for testing at nanoscale, or testing materials with high roughness. With indentation probes available in an array of geometries, the **MultiRange NanoProbe** is versatile enough to be used for most high force/high displacement testing regimes.

The **MultiRange NanoProbe** seamlessly picks up where the standard Hysitron transducer reaches its upper force or displacement limit providing users with an uninterrupted force testing range from a few micro Newtons up to several Newtons.

Hardware Design

The **MultiRange NanoProbe** utilizes a cutting-edge piezoelectric load cell in combination with Hysitron's trusted, proprietary capacitive sensor technology to provide unparalleled results with an ultra-low noise floor.

The unique arrangement of the piezoelectric actuator allows for a significant increase in the available forward displacement without the use of voice coils or permanent magnets which can produce additional noise.

The design of the **MultiRange NanoProbe** seamlessly incorporates sub- μN and sub-nm capacitive force and displacement sensors for unsurpassed performance. The over-damped loading system and high bandwidth allows for displacement rates up to 5 $\mu\text{m/s}$.

Driven with a dedicated **MultiRange NanoProbe** control unit, which is built upon Hysitron's trusted transducer controller, the **MultiRange NanoProbe** is reliable and easy to setup, calibrate and operate.



Figure 1. Photograph of **MultiRange NanoProbe** transducer head.

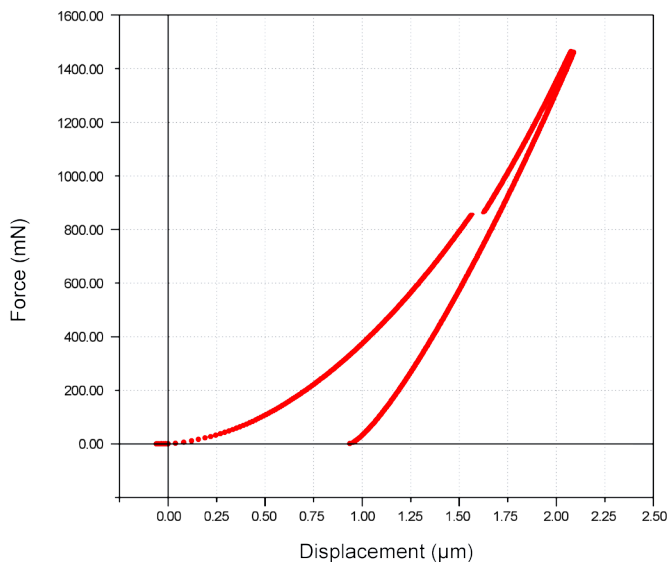


Figure 2. **MultiRange NanoProbe** indentation on hard film resulting in film delamination at approximately 850 mN of force.

Increased Control

The **MultiRange NanoProbe** system uses a high bandwidth, closed-loop feedback control system. The feedback control system uses advanced PID control algorithms that allow the system to be operated in either load or displacement control.

The addition of an adaptive gain control aids in PID gain adjustment in real-time over the duration of the test to produce the highest quality testing available over the range of the system.

Using the load control indentation testing in combination with the higher loads available with the **MultiRange NanoProbe** allows for creep testing of materials such as bulk polymers and alloys. Similarly, using the displacement controlled testing allows for stress-relaxation studies of materials that require a higher displacement than the standard transducer can offer.

The tunable design of the **MultiRange NanoProbe** provides the flexibility to select the maximum load of the transducer head from 500 mN up to 10 N thus expanding the current capabilities of the **TI 800** and **TI 900** series systems.

A vertical cross-sectional view of the **MultiRange NanoProbe** transducer is shown in figure 3 and illustrates the placement of the piezoelectric actuator and capacitive sensors.

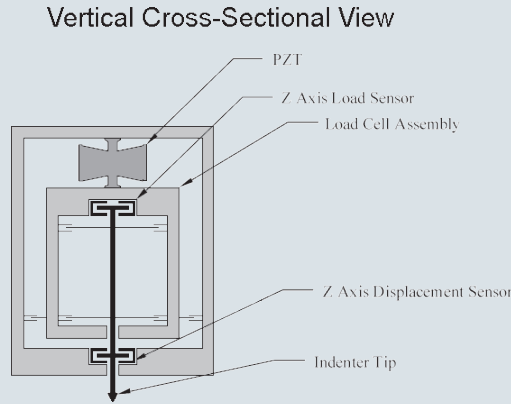


Figure 3. Schematic of **MultiRange NanoProbe** transducer head showing separate load and displacement control.

MultiRange NanoProbe Scratch Stage

The **MultiRange NanoProbe** may be used in combination with the High Load Scratch Option, which increases the capabilities of the **MultiRange NanoProbe** system to include lateral force measurements.

The High Load Scratch option offers multi-directional force and displacement sensing that allows for scratch testing to be performed and accurately measured in any direction over any length. The ability to perform lateral testing on a sample greatly increases the potential of the system by allowing for further fracture/delamination studies as well as coefficient of friction and profilometry measurements of samples.

The High Load Scratch option is machined from a single billet of 303 stainless steel to reduce the machine compliance of the system. Figure 4 shows the horizontal cross-sectional view of the High Load Scratch Option stage with the placement of the x/y-axis load sensors and design of the flexures.

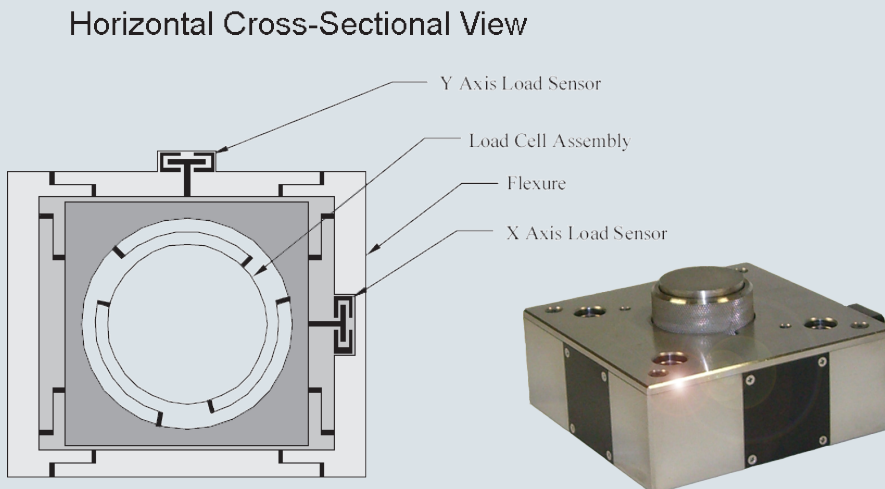


Figure 4. Schematic and photograph of High Load Scratch Option scratch stage assembly.

HIGHLIGHTS

MultiRange NanoProbe

- Operates in load or displacement control
- Unique piezo loading/capacitive sensing system offers superior stability and low thermal drift
- Tunable design provides flexibility for custom engineered maximum normal load

High Load Scratch Option

- Adds scratch testing to an existing **MultiRange NanoProbe** system
- Unique 3D force sensing design
- Increased scratch length and velocity for tribological studies

APPLICATIONS

MultiRange NanoProbe

- Fracture and delamination of hard films
- Creep analysis and stress relaxation
- Indentation testing on rough samples

High Load Scratch Option

- Mar resistance
- Friction and film delamination
- Profilometry measurements

SPECIFICATIONS

MultiRange NanoProbe

- Maximum normal force: 150mN-10N
- Normal force noise floor: 0.0007% of max load
- Maximum normal disp.: 80 μ m

High Load Scratch Option

- Maximum lateral force: 5 N
- Maximum lateral disp.: 160 μ m
- Lateral force noise floor: 40 μ N