

World Leader in Nanomechanical Test Instruments

Hysitron Incorporated



Feedback Control

Extend the Capabilities of Quasistatic Testing

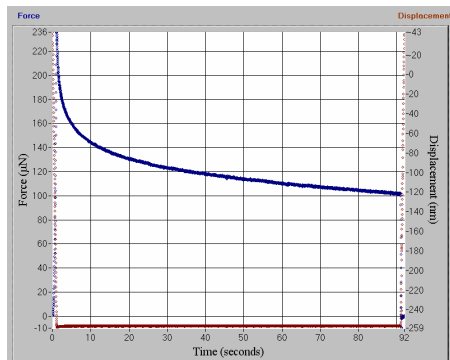
Introduction

Feedback control provides closed loop load and displacement control for Hysitron users who wish to extend the current capabilities of standard quasistatic testing. Closed loop control expands the scope of testing by offering improved control over the testing parameters, which provides superior results and opens the door for additional testing techniques.

Advanced Techniques

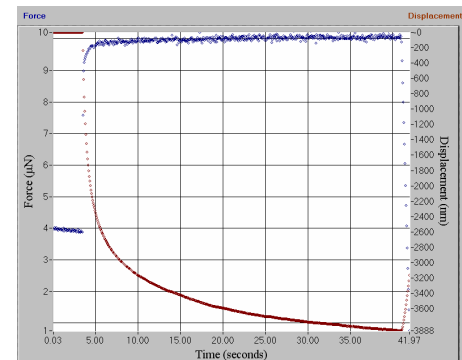
By providing augmented control of both the force and displacement, Hysitron has increased the performance of quasistatic testing for existing applications and opened the door for new measurement capabilities. Ultra-thin film and soft material applications will benefit most significantly from the advanced techniques made available by feedback control. Ultra-thin films require very small displacement indentations with a high degree of accuracy. Displacement control allows testing with true sub-nanometer control and observation of the displacement into the surface. Creep and stress relaxation measurements of viscoelastic materials are now made possible by operation in closed-loop load and displacement control. Soft material characterization is also improved by the capability to perform true constant strain rate experiments. Feedback-controlled tests begin with the probe out of contact with the surface, which allows observation of

Displacement Control



Displacement control test on LDPE shows stress relaxation behavior of the polymer.

Load Control



Load control test on a thin tribological coating shows creep behavior of the polymer film.

pre-contact probe-sample interaction forces as well as measurement of surface adhesion forces and surface energy. Calibration and measurement of other actuation devices, such as MEMS, is also enabled by providing the capability to perform blocked force calibration.

Tunable Control

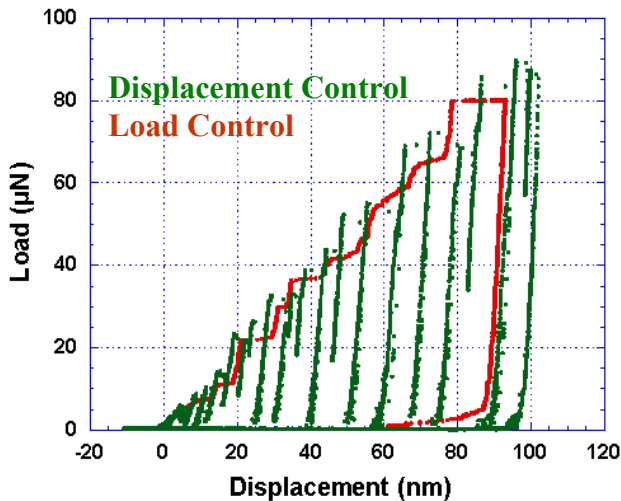
A software-driven feedback system has been developed that operates as a high-frequency feedback loop allowing true load and displacement control. The feedback control loop

operates at a greater frequency than the bandwidth of the transducer, rendering the digital signal utilized for actuation identical to an analog signal for the transducer. Tunable proportional-integral-derivative (PID) parameters provide the capability to tune the system to attain optimal feedback response during testing. An additional adaptive feedback term eliminates the necessity to retune the PID parameters due to different material responses by actively adapting to the material during testing.

...Making a Point in the Nanomechanical Community...

Displacement Control Benefits

- Stress-relaxation tests for investigation of viscoelastic properties of materials.
- Measure tip-sample attractive forces prior to contact and tip-sample adhesive forces during tip withdrawal.
- Eliminates snap-to-contact phenomenon that limits investigation of surface forces.
- Investigate material states missed by load control, such as those that occur during dislocation bursts or fracture.
- Limit total indentation depth to desired percentage of film thickness to avoid substrate effect on indentation data.
- Blocked force calibration of MEMS devices.



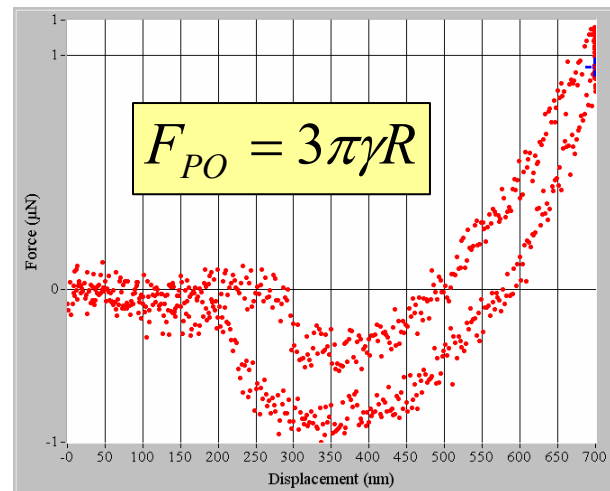
Comparison of load control and displacement controlled indents into single crystal Al, showing increased sensitivity of displacement control to material states.

Load Control Benefits

- Constant strain rate throughout loading for strain-rate dependent materials.
- Creep tests for investigation of time-dependent or viscoelastic properties of materials.
- Corrects for sample drift via bi-directional actuation capability.

Highlights

- Feedback control is available for all Hysitron nanomechanical testing instruments.
- Improved quasistatic testing performance for ultra-thin films and soft materials.
- Self-tuning adaptive control responds to variations in material stiffness.
- Provides superior force sensitivity for study of pre-contact tip-sample interaction.



Unaveraged displacement controlled test on PDMS showing sensitivity to pre-contact tip-sample interactions and the ability to measure pull-off forces.



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