

performech™

Advanced Control Module for TS, TI and PI Series Instruments

Hysitron's new *performech* control module greatly advances the precision of feedback-controlled nanomechanical testing. The *performech* advanced control module allows Hysitron instrumentation to operate quantitatively with unparalleled performance and accuracy at a length scale only previously imagined. The *performech* offers a <30 nN normal force noise floor and the ability to capture data at acquisition rates up to 38 kHz. Lateral (scratch) force and displacement measurement sensitivity is also greatly enhanced with low noise floors of <3.5 μN and <2 nm, respectively.

Hysitron's patented *in-situ* Scanning Probe Microscopy (SPM) imaging capability is mandatory for surface structure identification and precise test placement. The *performech*'s industry-leading sensitivity allows SPM imaging contact forces as low as 70 nN, which is ideally suited for imaging soft materials and intricate surface structures.

Superior Feedback Control

The *performech*'s high-speed digital feedback during nanoindentation allows



Figure 1. The *performech* advanced control module.

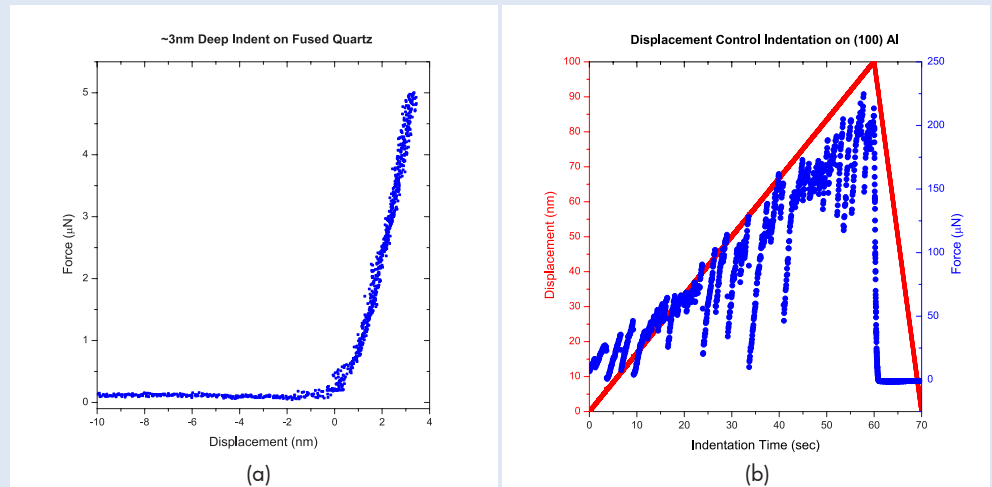


Figure 2. *Performech* data showing: a) A ~ 3 nm deep indent performed on fused quartz showing the low noise floor of the *performech* advanced control module. b) Displacement controlled nanoindentation test on (100) Al showing substantial dislocation activity through the loading cycle, made possible by the 78 kHz feedback loop rate of the *performech*.

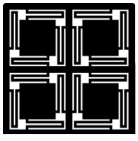
for superior control of both indenter-specimen contact forces and indenter displacements. Traditional Proportional Integral Derivative (PID) control algorithms do not work well over a wide range of materials due to the rapidly changing contact stiffness that occurs during nanoindentation. Hysitron has made great strides in going beyond textbook PID control by implementing controls more appropriate for the physics of the Hysitron transducer as well as the evolving indenter-specimen contact. This provides feedback control for the nanoindentation process that accurately reproduces the request of the user. All feedback-control functionalities are carried out by the dedicated digital-signal processor (DSP) and field-programmable gate-array (FPGA) embedded *performech* controller. The FPGA and parallel data acquisition architecture enables high sampling rate

($\sim 80,000$ samples/sec) at 24 bit resolution for 24 channels simultaneously.

Hysitron offers both load and displacement control feedback modes for precise control during nanoindentation. Force and displacement feedback controlled nanoindentation tests are superior methods to analyze the creep and stress relaxation of nanomaterials. The 78 kHz feedback loop rate of the *performech* advanced control module assures that the system can effectively respond to fast transient events such as dislocation nucleation, fracture, and thin film delamination.

Enhanced Technology

The *performech* is an advanced control module, incorporating a DSP with FPGA architecture and USB 2.0 connectivity. Compared to Hysitron's standard control system, the



performech controller offers an order of magnitude faster feedback (78 kHz feedback loop rate vs. 3 kHz) while also achieving substantially higher digital resolution (24 bit A/D converters vs. 16 bit), a substantially lower system noise floor (<30 nN), and user-definable data acquisition rates up to 38 kHz.

Modular Design

The *performech* advanced control module has an easy-to-upgrade architecture allowing users to add technique-specific cards to support the full suite of Hysitron testing techniques. This all-in-one control system is capable of controlling every Hysitron transducer, head, and scanner with increased accuracy and sensitivity. In combination with the **TI 900 TriboIndenter®**, the *performech* supports optional dual-head system functionality, providing the capability to operate one of Hysitron's industry-leading capacitive transducers (1D, 2D, **nanoDMA®**, **nanoECR®**) capable of *in-situ* SPM imaging, with one of Hysitron's higher load heads (**3D OmniProbe™** or **MultiRange NanoProbe™**) for true sub-nanometer to micrometer scale connectivity.

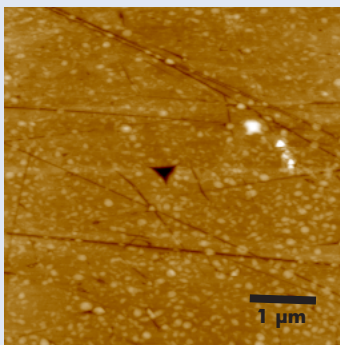


Figure 3. *In-situ* SPM image of an indenter taken with an imaging force of **70 nN**.

HIGHLIGHTS

- Digital Signal Processor (DSP) plus Field Programmable Gate Array (FPGA) architecture with USB 2.0 connectivity
- Dual head testing capability allowing seamless operation between any combination of Hysitron capacitive transducers and high load heads (on the **TI 900 TriboIndenter** systems)
- Completely software controlled operation eliminating the need for manual switching of front panel gains, tare values, etc. on the transducer control unit
- Industry leading sensitivity, enabling ultra small-volume materials characterization and ultra soft materials characterization
- Faster feedback: 26× faster than the conventional Hysitron control system
- Ultra fast, user-definable data acquisition rates up to 38 kHz
- Ultra low contact force SPM imaging. The new control system allows imaging forces as low as 70 nN, which is ideally suited for soft materials research
- New **TriboScan™** v.9 software package with enhanced testing routines and functionality
- Modular design. Fully upgradeable to enable researchers to grow with their research. Additional capabilities can be added to the controller to support current and future upgrade options
- Easy integration to existing **TS 70 TriboScope®**, **TI 700 Ubi™**, and **TI 900 TriboIndenter** systems

SPECIFICATIONS

PERFORMECH ARCHITECTURE

- Embedded DSP and dedicated FPGA for each bank of ADC and DAC (~80,000/sec simultaneous sampling rate) for parallel operation
- 78 kHz internal digital feedback loop rate
- Auxilliary digital I/O lines, DAC's, and ADC's for interfacing with external devices
- Integrated SPM imaging control capability (for **TI 700 Ubi** and **TI 900 TriboIndenter** systems)

PERFORMANCE SPECIFICATIONS

NORMAL FORCE

- Resolution: <1 nN
- Noise Floor: <30 nN
- Imaging Contact Force: ≤70 nN

NORMAL DISPLACEMENT

- Resolution: <0.02 nm
- Noise Floor: <0.2 nm
- Drift: <0.05 nm/sec

LATERAL FORCE

- Resolution: <50 nN
- Noise Floor: <3.5 μN

LATERAL DISPLACEMENT

- Resolution: <0.02 nm
- Noise Floor: <2 nm
- Drift: <0.05 nm/sec

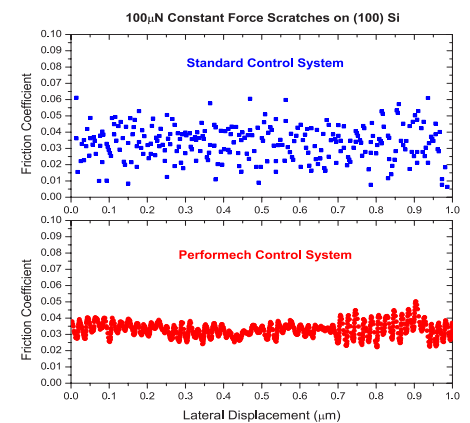


Figure 4. The improved lateral-noise performance of the *performech* control module shows nanoscale tribological phenomena on (100) Si not distinguishable using the standard control system.