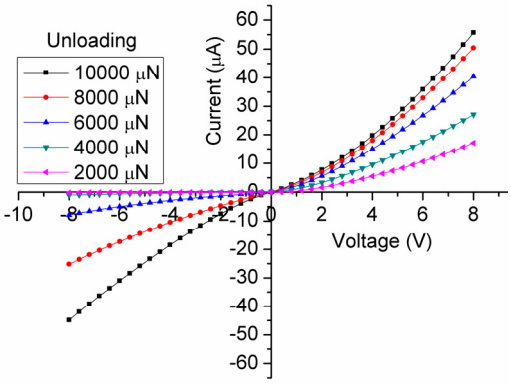
World Leader in Nanomechanical Test Instruments

Hysitron Incorporated

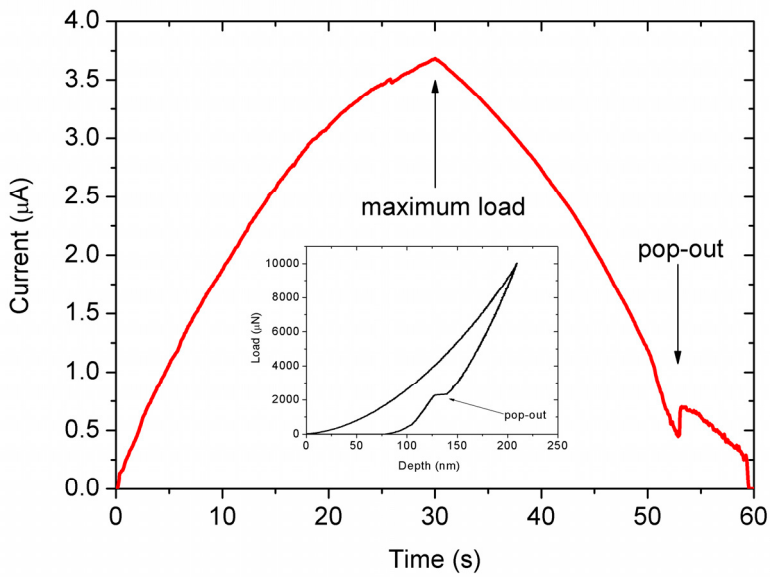
nanoECR™

Nanoscale Electrical and Mechanical Test Instrument

In recent years, there has been a rapid growth of research and applications utilizing nanomaterials and nanotechnology. This miniaturization of materials and devices has mandated a change in the way that materials are characterized. Nanoscale measurements are crucial to understanding these materials and allowing successful development and integration of these materials into real products. Hysitron is the world leader in nanomechanical test instruments and has developed numerous solutions for nanoscale mechanical testing. Hysitron is continuing the tradition of pioneering nanoscale characterization techniques with a novel nanoscale electrical measurement tool. nanoECR, a nanoscale Electrical Contact Resistance tool, provides a powerful solution for simultaneous, *in-situ* electrical and mechanical measurements. Correlation of multiple measurements from *in-situ* experiments increases the wealth of information obtained from nanoscale probe measurements.



*A series of Current-Voltage (I-V) curves obtained at different loads during a single indentation experiment.**



*Load-displacement data and the correlating current measurement from an indentation into Si showing the changes in resistivity during a phase transformation.**

Hardware

Transducer

nanoECR utilizes a new model of Hysitron's patented three-plate capacitive force and displacement transducer that has been modified to provide an electrical path from the tip to signal acquisition and measurement hardware, which allows measurement of electrical contact conditions. This transducer guarantees uncompromised mechanical testing by providing industry-leading force and displacement measurement capabilities. The electrical path is housed and shielded within the transducer and cabling to ensure that the mechanical and electrical testing is not affected by undesirable experimental conditions, such as attaching a wire to the tip or exposed wires that may be susceptible to extraneous signals.

Conductive Probes

Hysitron provides conductive Boron-doped diamond probes with a nominal resistivity of 3.3Ω-cm for standard mechanical and electrical testing. These conductive probes can be supplied in any of Hysitron's standard probe geometries or any custom geometry. In addition, conductive tip holders can be obtained that will allow users to mount their own conductive probes or coated materials for maximum versatility in defining the contacting materials to be studied.

Biasing Sample Stage
A biasing sample stage is utilized to apply a bias voltage or current to the sample, which drives the electric flow through the tip. The bias conditions are applied through a sourcemeter, which is remotely computer controlled through an easy-to-use flexible software interface.

Electrical Source and Meter
A Keithley voltage/current source and meter is utilized to apply a user-definable voltage or current through the sample stage and measure the resultant voltage or current. The sourcemeter has micro-Volt and pico-Amp resolution allowing application and measurement of low-voltage and low-current contacts. Point measurements or I-V curves can be automatically generated and measured through computer control of the sourcemeter.

Data Acquistion Card
A 100kHz data acquisition card is added in parallel to the current load-displacement data acquisition system to allow rapid data acquisition of electrical measurements with high time-resolution correlation of the load-displacement and current-voltage measurements. This additional data acquisition card allows input and time-based correlation to the load-displacement data of any analog signal from parallel measurements. The analysis software allows math operations on the analog signals to convert the input signals to meaningful quantities. In addition, the digital channels on the data acquisition card can be utilized to trigger other hardware or parallel measurements during the simultaneous electrical and mechanical measurements.

Software

Hysitron has developed proprietary software to provide user-friendly control and automation of the hardware for electrical measurements. Automated configuration of the electrical measurement hardware optimizes the measurement resolution for any magnitude of measured current or voltage. A versatile load-function editor allows single point or I-V curve measurements to be triggered and acquired at any point during an indentation loading function. In addition, the bias voltage or current or range of values used for an I-V sweep can be defined for each electrical measurement performed during the indentation test. Observation of test results can be quickly and easily observed through single or dual ordinate graphs with user-defined selection of load, displacement, current, voltage, time or other input signals as the plot data. This allows the user to quickly and easily observe the correlation of any number of measured signals. The TriboAnalysis software provides further analysis of nanoECR data for standard and customized data analysis.

Highlights

- Simultaneous, *in-situ* electrical and mechanical measurements.
- Time-based correlation of multiple measurements, including force, displacement, voltage and current.
- I-V measurements from nanoscale probe contacts during controlled load or displacement conditions.
- Conductive diamond probes provide optimized electrical and mechanical contacts.
- High resolution electrical sourcemeter provides low voltage/current measurements for nanoscale contacts.
- Extra data acquisition card allows input, control and acquisition of auxiliary parallel measurements.
- User-friendly software for control and observation of electrical test measurements.

Potential Applications

- Stress-induced phase transformations
- Oxide fracture
- MEMS contact resistance fatigue
- Nanoscale breakdown voltage
- Conductive polymers
- Piezo-electric material response
- Adhesion investigations

* Data courtesy of S.Ruffell, J.E.Bradby, M.Williams, Department of Electronic Materials Engineering, Research School of Physical Sciences and Engineering, Australian National University, Canberra, Australia

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