Nano-scratch & wear module with the NanoTest Vantage

Researchers interested in producing thin films and coatings (from a few nm to about 1 μm thick) for improved wear resistance in MEMS and general thin film applications need to optimise both the mechanical properties and tribological performance. Typically, this is done with a combination of indentation and scratch tests. Conventional scratch test conditions are not appropriate for these types of materials as they were developed for testing thicker coatings. Instead the Nano-Scratch & Wear module can provide what is needed.

How it works

The sample to be tested is moved perpendicular to the scratch probe whilst the contact is either held constant or ramped at a user-defined rate. Throughout the test the probe penetration depth and tangential (frictional) load are continuously monitored. Single and multi-pass tests are possible.

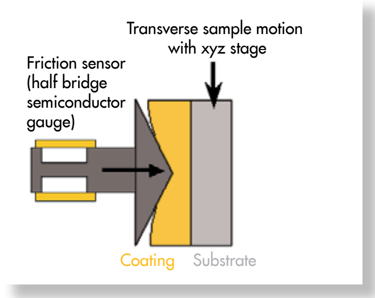


Figure 1 shows specifically targeted indents in gray cast iron

Important features of Nano-Scratch & Wear testing with the NanoTest Vantage

- High lateral stiffness: Horizontal loading mechanism with inherent high stiffness in "non-indenting" directions means that the same loading head used for nanoindentation may also be used for the Scratch & Wear module. Robustness of the loading mechanism means the scratch test results are highly reproducible.
- Multi-pass wear: Sliding/abrasive wear rates can be obtained. Multi-pass wear scratches are very sensitive to subtle differences in adhesion.
- Repetitive Nano-scratch procedure: Pre- and post-scratch scans mean precise identification of critical loads and failure mechanisms can be determined.
- Friction measurements: Capability to measure friction and wear reliably at 500 mN normal load
- Contact pressure measurements: Determination of contact pressure (scratch hardness)
- Scheduling: Fully automated – multiple experiments on multiple samples in a single automated schedule

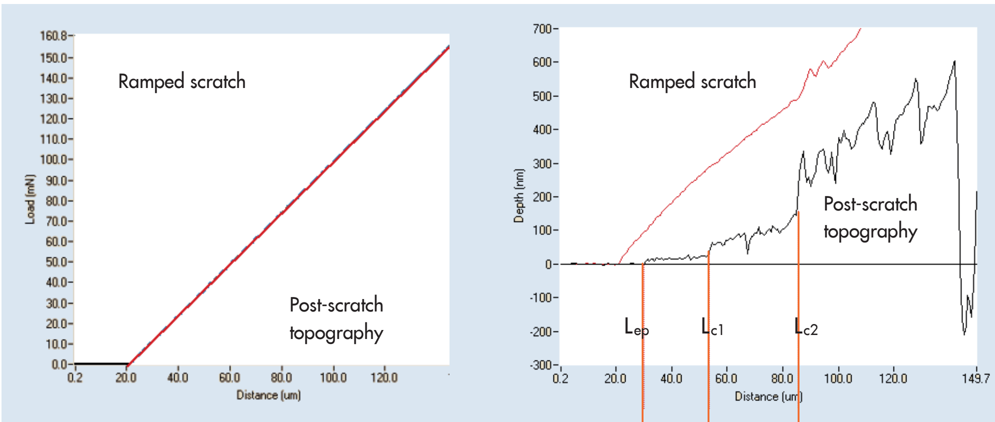
Figure 2: Ramped scratches to 500 mN show brittle fracture on 1.5 μm TiFeN film on Si. Data courtesy Dr V. Vishnyakov, Manchester Metropolitan University.

The Nano-Scratch & Wear module has found many applications in sectors as diverse as optical, microelectronics, polymers, biomaterials, and tribological coatings.

Multiple pass nano-scratch test of 60 nm ta-C film on Si wafer

Multi-pass test process

1. Initial topography scan
2. Ramped scratch
3. Final topography Scan
4. Software re-plots after compliance correction to show deformation only



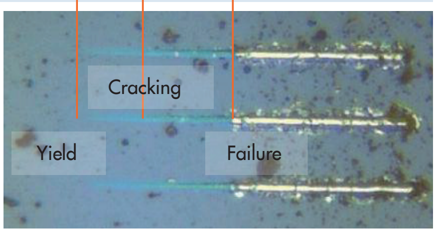


Figure 3 shows a three-scan scratch test with 3 μm end radius probe sc anning over a 150 μm track at a scan speed of 2 μm/s. In scan 2 after 20 μm the load is ramped at 2.5 mN/s. Three repeat tests were performed to test the reproducibility of scratch behaviour. The re-plot shown (top right) was from the second of these.

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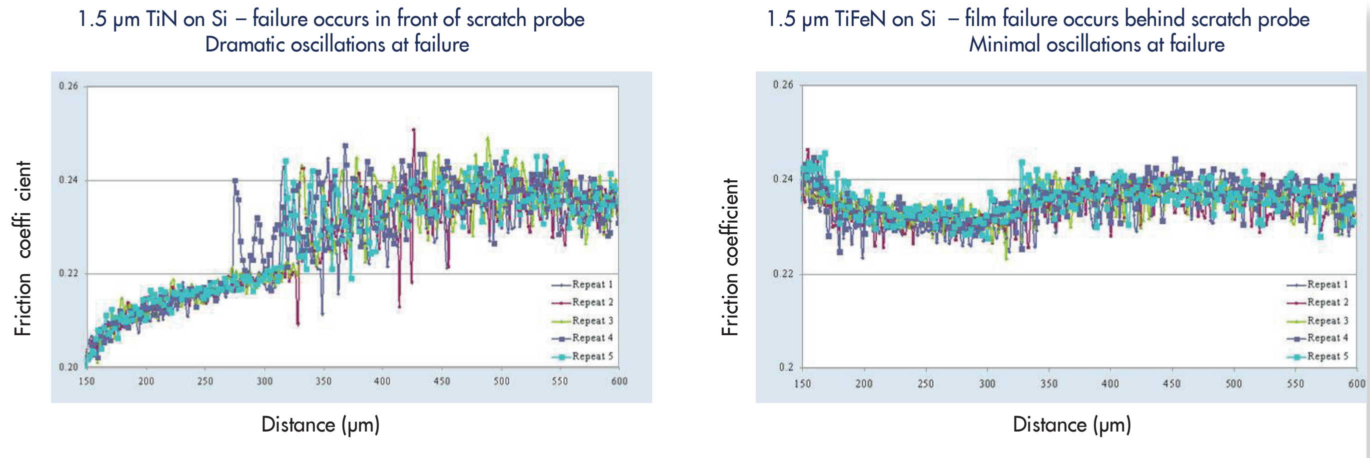
Nano-scratch & wear module with the NanoTest Vantage

High resolution friction measurements



Measurement of friction during scratch tests can provide valuable confirmatory information on the mechanism of film failure. Figure 4 shows optimisation by high frictional sensitivity scratch testing. The frictional signal is highly sensitive to the type of film failure that occurs. Th e test is also highly reproducible as shown by the virtual superposition of the friction data in the repeat tests at different locations on the coating surface.

NanoTest VANTAGE

Scratch & wear advantages

- Friction (tangential force) measurements as standard
- Critical load determination
- Multi-pass wear tests
- Fatigue and No. of cycles to failure
- On-load and off load (residual) depths
- Fully automated scheduling
- Contact pressure measurements
- Surface roughness (R_a, RMS, peak-to-valley)
- Smaller probes, lower scan rates and loads, more sensitive to variations across surfaces

Nano-wear testing

With its excellent long-term stability, the Scratch & Wear module can be used to study deformation processes where sub-critical loads can often be much more informative than single progressive load scratch tests.

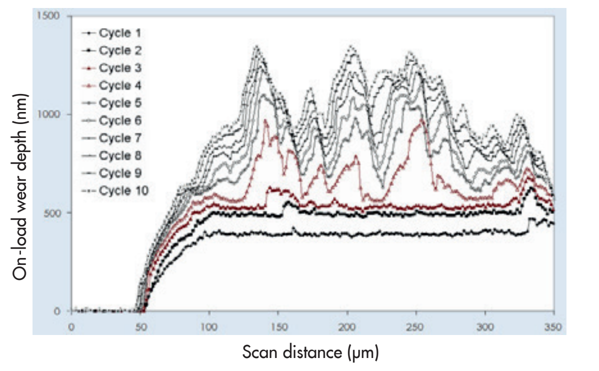


Figure 5 shows results of a Nano-wear test with 12 overlaid scratches (length 350 µm, scratch speed 10 µm/s, at a (sub-critical) load of 100 mN. Previous progressive load scratches revealed brittle fracture beginning at ~150 mN.

Ten wear cycles each had a load of 100 mN applied after 50 µm (rate 20 mN/s) which was held for the rest of the scan. Results showed deformation occurs initially at highly localised regions along the wear track (around 160 and 330 µm). This in situ test revealed that the wear rate was not constant and the onset of more marked deformation occurs during the 4th cycle.

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