PI 88 SEM PicoIndenter®

The PI 88 SEM PicoIndenter is Hysitron’s most advanced in-situ mechanical testing instrument for the SEM. This stage mounted instrument provides quantitative micro- and nanoscale mechanical property measurements such as hardness, elastic modulus, fracture toughness, and yield stress, which are synchronized with high resolution SEM imaging to allow researchers to directly observe the deformation of advanced materials in real-time. The highly modular instrument design also delivers unprecedented flexibility to upgrade to any of the advanced testing modules such as 800°C tip and sample heating, extended range load cell, tilt and rotation sample positioning, electrical biasing, and more.

Applications of In-Situ Scratch Testing

- **Films & Coatings** – Measure scratch resistance, coefficient of friction, film-substrate adhesion, and correlate lateral force data to real-time SEM imaging to determine failure mode (cohesive vs. adhesive, delamination, buckling, spallation, peripheral fracture, etc.).
- **Structures** – Apply shear forces to pillars, solder bumps, beams, MEMS devices, and oriented crystalline materials to provide another dimension to your understanding of failure and deformation.
- **Particle-Substrate Interaction** – Quantify the friction between a single micro- or nanoparticle and the supporting substrate, and observe the damage initiation and wear processes on both sides of the sliding contact.
- **Atmospheric Control** – The vacuum environment of the SEM minimizes the influence of surface water layers and oxidation on frictional measurements while ESEM allows for the in-situ characterization of tribological processes across a wide range of controlled conditions.

Specifications

- Maximum Lateral Actuation Distance: >30 µm
- Maximum Lateral Force: >30 mN
- Lateral Force Noise Floor: <3 µN
Case Study: Low-k Dielectric Film Failure

In this study, a PI 88 SEM PicoIndenter equipped with the nanoScratch module and a diamond cube-corner probe was used to perform constant normal displacement and ramping normal force scratch tests in an effort to quantify the performance of a low-k film on a silicon substrate under sliding conditions. Figure 3 shows an SEM image of scratch tests where the normal displacement was held at a maximum of 750 nm, while the sample was moved laterally at a rate of 500 nm/s.

Clear evidence of adhesive failure is shown in the image, which happens in a very periodic manner. These delamination events are also followed by spallation of the delaminated material as evidenced by the residual material that has been ejected from the scratch path. Figure 4 plots the normal displacement and lateral force versus time from one of these tests. The lateral force data clearly shows many large, periodic load drops that can be easily correlated to the corresponding delamination and spallation events shown in the static, post-test SEM image.

As the reported data shows, the PI 88 SEM PicoIndenter equipped with the nanoScratch module delivers quantitative nanoscale mechanical data in both the normal and lateral loading directions. By coupling this multidimensional testing capability with high resolution SEM imaging, even the most transient events can now be captured and fully quantified. The in-situ nanoScratch module for the PI 88 represents a major step forward in the characterization of nanoscale wear processes for a wide variety of materials such as protective coatings like diamond like carbon (DLC), sliding components like bearings or MEMS devices, or for interpreting the performance of constituent thin film layers of electronic devices such as low-k dielectric films.