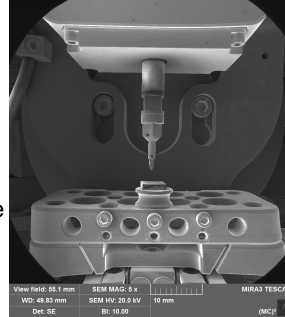
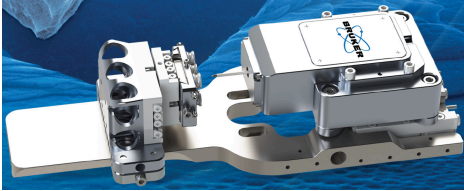


# Bruker/Hysitron PI 89 SEM PicoIndenter

- A Nanomechanical Test Instrument in (MC)2

The PI 89 PicoIndenter makes it possible to perform nanomechanical testing while simultaneously imaging in a scanning electron microscope (SEM). It comes with a low load (maximum indent 10mN / tensile 10mN) extended range (xR) transducer and a high load (maximum indent 500mN / tensile 100mN) xR transducer. Displacement along indentation axis is from 1nm to 150um. Load or displacement-controlled testing modes enable indentation, compression, tension, fatigue, creep or bending tests. Berkovich probe, flat-end probe, and cono-spherical probe are available for different types of testings. A diamond gripper to grab dog-bone sample for direct-pull test is made by focused ion beam (FIB). With in-situ heating elements applied to the probe and the sample, indentation at a temperature up to 800°C is achievable. A unique tilt-rotation stage make sample orientation flexible and especially good for in-situ electron backscatter diffraction (EBSD) measurement.

## Indenter Setup



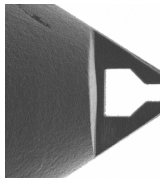
- The PI 89 PicoIndenter is interfaced with the Tescan MIRA SEM in MC2.
- Both transducer and a sliding stage mount are attached to an horizontal adapter plate.
- Before each test, a low load or high load transducer should be installed on the adapter plate first, then carefully screw a selected probe onto a threaded post that is sticking out from the transducer.
- Next, sample stub is fixed to a sample stage, then attach the sample stage onto the stage mount.
- Manually slide the stage mount on the adapter plate to adjust to a close but safe distance between the probe and the sample surface.
- All the above procedures are done on a bench top outside SEM.
- Once the adapter plate with both transducer and sample stage/mount secured, it can now be easily installed on the SEM stage.
- Connect cables, power on controllers, start PC and TriboScan software and proceed to SEM operations.

## Transducers

- Vacuum-compatible low load extended range (LL xR) transducer: maximum 15mN indent / 14mN tensile.
- Vacuum-compatible high load extended range (HL xR) transducer: maximum 500mN indent / 100mN tensile.
- Maximum displacement along indentation axis (y direction): 150um.

## Probes

- Conductive Berkovich, cube corner (<50nm radius of curvature), cono-spherical (tip radius <1um), flat end (1um, 5um, 20um radius) probes are available for different applications needs.
- A conductive Berkovich probe for heating test only.
- Probes for PI 89 and PI 95 can be shared between the two PicoIndenter and the LL xR and HL xR transducers on PI 89.
- A conductive diamond gripper (as shown on the right) is available.

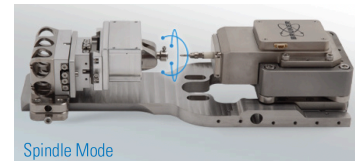
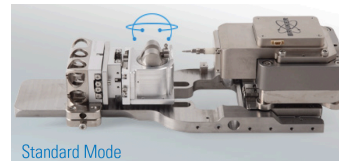


## Sample

- Sample with flat and smooth surface is ideal for nano mechanical measurement.
- A conductive sample is preferred, otherwise coating with Au or Carbon is recommended to avoid charging problem during SEM imaging.

## Stages

- A regular sample stage can hold up to 6 sample stubs. Sample positioning range: 12mm (z axis along electron beam) x 26mm(x) x 29mm(y indentation axis). Encoded with 1 nm resolution that enables indentation within nanocrystalline grains.
- Rotation/Tilt stage (maximum 400mN) has two configurations: standard mode and spindle mode that is good for EBSD.
- Tilt range 180° / Tilt accuracy <0.33°; Rotation range 180° / Rotation accuracy: <0.12°.



## In Situ Testing Modes in SEM

- **Indentation:** Usually a Berkovich probe is used to indent with either load or displacement control to measure modulus and hardness on a location of interest on the sample.
- **Compression:** Usually a cono-spherical or flat end probe is used to compress a micro pillar made by focused ion beam (FIB).
- **Direct Pull:** Usually a dog bone sample is firstly made by FIB. The sample size could be small enough to include individual microstructural features, such as single grains, grain boundaries, heat affected zones, and surface treatment zones. Make sure the sample size will fit the gripper.
- **Automated mechanical mapping (XPM)** with z >1 mm x >1 mm range from multiple locations.
- A variety of standard load functions are available or a user can design your own load function by using the TriboScan control software.

## In-situ Heating

- In-situ heating elements to probe and sample, indentation at temperature up to 800°C.
- Tip and sample heating with independent controls.
- A chiller will circulate cooling water through the system.

## Software and Data Analysis

- TriboScan software for stage and probe control and data acquisition. Real-time plotting of force vs. displacement and control variable vs. time.
- SEM video correlation: facilitates time synchronization between force-displacement curve and corresponding SEM video.
- Tribo iQ data analysis software based on OriginPro 2020 64bit.