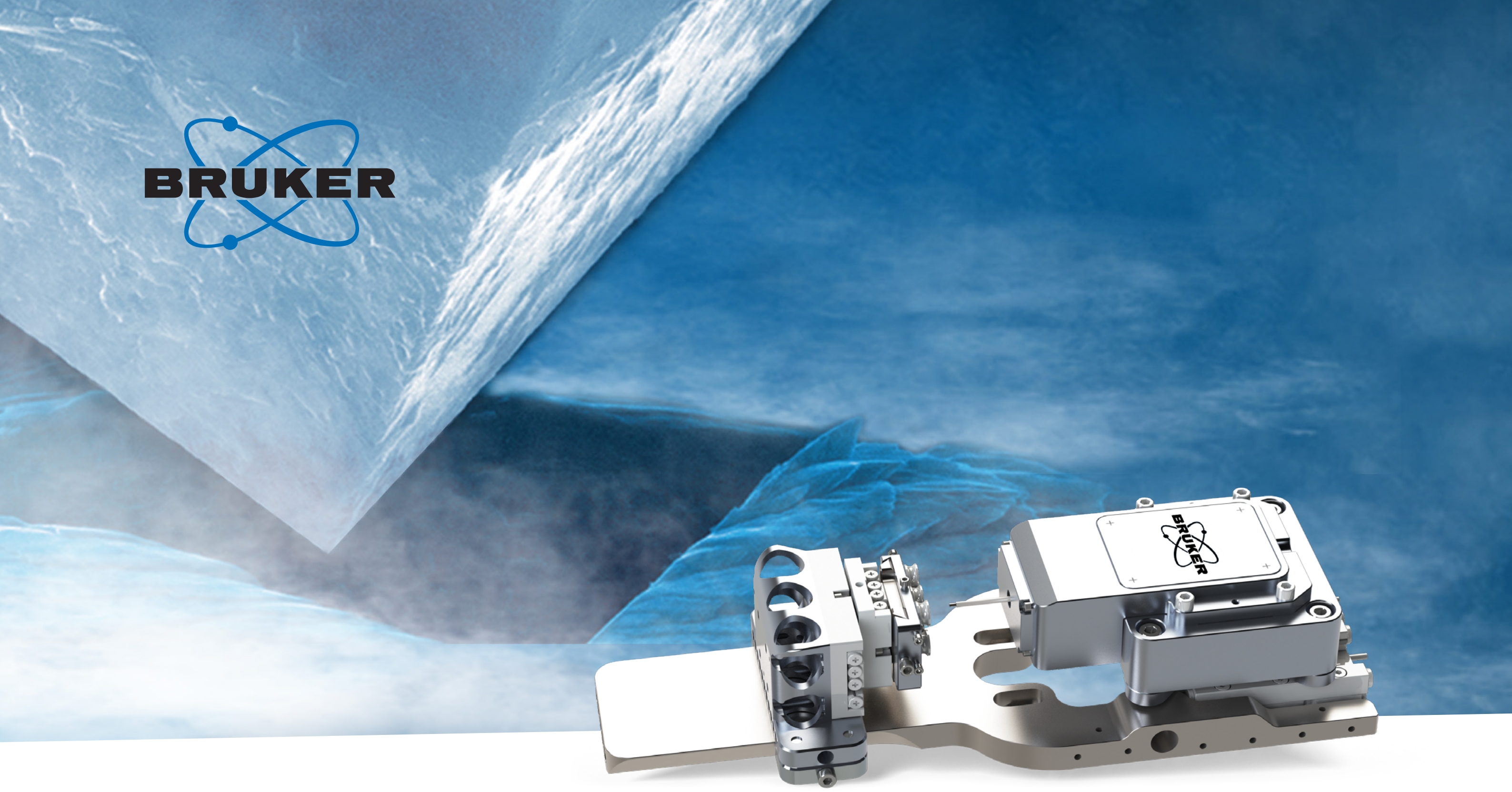

SEM PicoIndenter Series

PI Cryo for Hysitron PI 89

In-Situ SEM Nanomechanics at Cryogenic Temperatures

Bruker's new PI Cryo environmental stage extends quantitative in-situ nanomechanical testing capabilities of the PI 89 SEM PicoIndenter down to -130°C and below. Now with its combination of cryogenic and high temperature options, PI 89 can accurately perform mechanical characterization, including indentation, cantilever bending, and pillar or particle compression, of small-scale samples from one temperature extreme to the other. Since the deformation mechanisms and properties of materials can change dramatically as a function of temperature, this increased capability helps provide critical data for designing new structural materials that operate in extreme conditions.

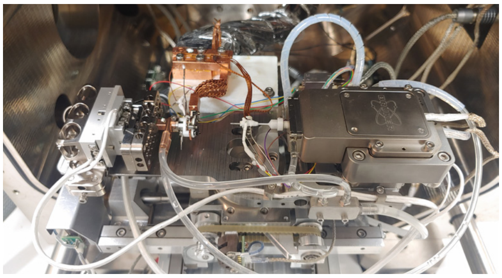

FIGURE 1

Hysitron PI 89 equipped with PI Cryo inside a SEM chamber.

PI Cryo Features

- Proprietary stage design enables reliable in-situ mechanical testing down to -130°C
- Cryostat and copper braids ensure isothermal testing conditions
- Feedback-controlled heaters deliver precise intermediate temperature control to both tip and sample
- Thermal breaks prevent leakage into the transducer and stages while maintaining cooling power for regions of interest
- Full compatibility with Hysitron XPM provides comprehensive quantitative nanomechanical property maps and property distribution statistics in a record amount of time
- Rapid setpoint stabilization enables high-throughput variable temperature cryogenic testing

Test Case: Steel Sample at Cryogenic Temperatures

Nitronic 50 stainless steel is an austenitic stainless steel with a blend of strength and corrosion resistance that is higher than stainless steel grades 316, 316/316L, 317, and 317/317L. It is known to have good ductility and impact resistance at cryogenic temperatures.

Cryogenic pillar tests indicate that Nitronic 50 retains good ductility all the way down to -140°C as indicated by the high plastic strain achieved in the post mortem image. The yield strength increased by about a factor of 2 over the same temperature range, which compares well with H/3 conversion of nanoindentation on the same material done with the Hysitron TI 980 TriboIndenter cryo option. However, the added benefit of in-situ testing allows for visualization of the deformation mechanisms, in this case slip bands, during and after the test.

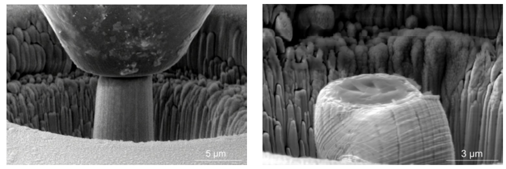

FIGURE 2

A flat punch tip aligned with a Nitronic 50 pillar for testing at -140°C (left) and postmortem image of Nitronic 50 pillar test performed at -140°C (right).

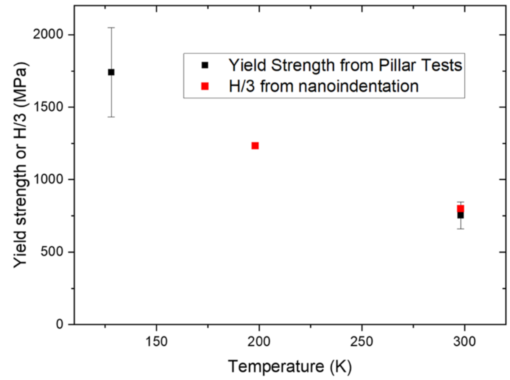

FIGURE 3

Comparison of yield strength from pillar tests and H/3 hardness conversion for Nitronic 50.

Applications

Materials properties (e.g., yield strength, elastic modulus, and fatigue characteristics) can change significantly at cryogenic temperatures, most prominently for ductile-to-brittle transitions. Such changes must be well-characterized to enable the development of new materials, and design of robust components for the chemical industry, cryogenic fuels, aerospace, refrigeration, food and beverage, and automotive markets.

Materials suitable for cryogenic applications include:

- Austenitic stainless steels
- Aluminum alloys
- Copper alloys
- Niobium
- Titanium

PI Cryo Specifications

Minimum temperature	-130°C and below
Maximum temperature*	50°C
Temperature stability	<1°C
Drift rate	<2 nm/sec
Maximum load	3.5 N
Maximum displacement	150 µm

*800°C and 1000°C options are available separately.

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