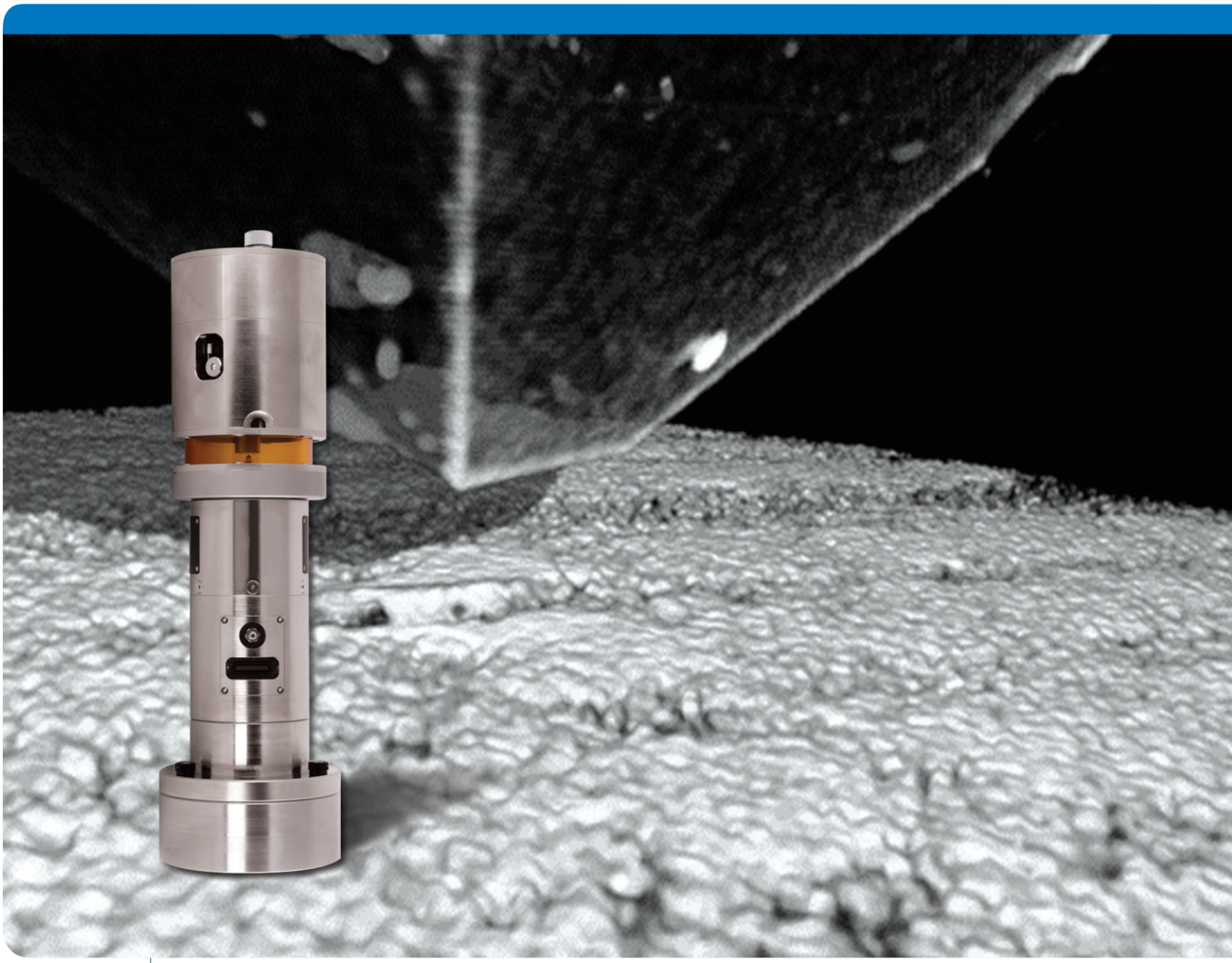


Hysitron IntraSpect 360

- In-Situ Mechanical Characterization
  for X-Ray Microscopes and Synchrotron Beamlines

Innovation with Integrity

Tribology & Mechanical Testing

Hysitron IntraSpect 360

Quantitative Mechanical Property Characterization

Bruker's Hysitron® IntraSpect™ 360 brings quantitative mechanical property characterization to X-Ray microscopes (XRM) and beamlines. This unique system can be used to perform a variety of mechanical tests such as indentation, compression, fatigue, and bending, which can then be correlated to 2D or 3D images from the host microscope.

Cutting-Edge Technology for Maximum Capability

The IntraSpect 360 utilizes a unique piezoelectric load cell combined with exclusive three-plate capacitive transducer technology. This arrangement delivers a significant increase in the available displacement range while maintaining an ultra-low noise floor. This exclusive design results in very little heat generation, which offers unparalleled stability while in contact with a sample. This is extremely important during the imaging process for computed tomography studies (µCT) where data acquisition can be lengthy. Tests as long as 168 hours have been reliably performed in combination with Hysitron's reference frequency correction technique. The system also includes Bruker's Performech® Advanced Control Module and TriboScan™ software for precision, feedback-controlled nanomechanical testing and automated data analysis.

Advanced Testing Capabilities with Precise Control

- High bandwidth, closed-loop feedback control system with advanced PID control algorithms
- Conducts tests in either load-controlled or displacement-controlled modes
- Provides accurate control over applied stress or strain conditions
- Supports a wide variety of testing modes, such as indentation, compression, bending, and fatigue
- Complements the diverse assortment of materials that are often analyzed using XRMs, including minerals, microelectronic packages, composites, and biological materials

Proprietary Design for Ultimate Performance

- Seamless 360° X-Ray transparent viewing window for gap-free 3D imaging
- Industry-leading transducer technology with unsurpassed levels of stability

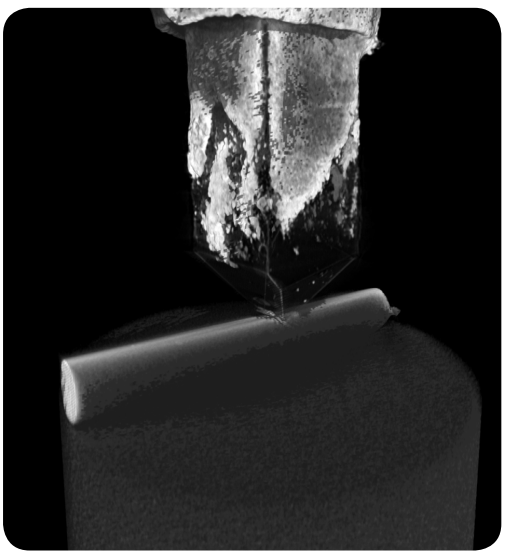


Figure 1: Low-magnification image of a wedge probe indenting a Nitinol wire.

Leverage Your 3D Imaging Capabilities

Case Study:

Indentation of Southern Yellow Pine

Fibrous materials, including natural and manufactured wood products, possess a complex microstructure that requires advanced techniques for effective characterization. As a result, nano- and microscale indentation testing has proven to be a preferred technique for evaluating both local mechanical and bulk structural properties of such materials. However, the deformation mechanics can be difficult to understand given the competition between material plasticity and bending in the coarser microstructural components. To help clarify these mechanics, an in-situ indentation testing was performed on Southern Yellow Pine using the IntraSpect 360 at beamline 2-BM-A at the Advanced Photon Source at Argonne National Laboratory, which allowed for direct observation of the deformation through X-Ray imaging.

Figure 2 shows a series of image slices acquired during the indentation test. The test was performed in a stepwise fashion to a maximum load of 4.5 N, pausing for three minutes at five evenly spaced intervals to acquire X-Ray tomograms of the deformation. Since the experiments can be quite lengthy (minutes-to-hours), nanoDynamic™ mode was used to superimpose a 12 nm, 100 Hz oscillation on top of the applied quasi-static force. This can be used for compensation of thermal drift or as a continuous measurement of the mechanical properties throughout the test. Figure 3 shows the resulting load-displacement data, along with the measured hardness values during the hold segments. Hardness decreases of 15-20% were observed during the hold segments, indicating a substantial amount of relaxation. The images collected at these intervals show the unique deformation response of the wood microstructure as the two fibers directly below the indenter barrel significantly under the concentrated stress, while fibers at the periphery of the contact buckle. Such observation of the microstructural response would not have been possible with ex-situ indentation techniques.

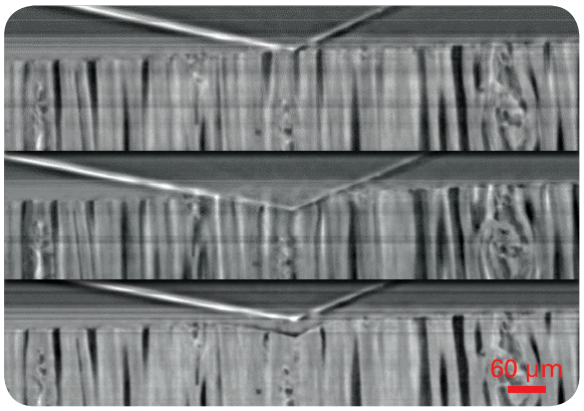


Figure 2: A series of 2D image slices acquired during an indentation test on Southern Yellow Pine. The load was applied normal to the transverse plane while deformation was observed on a longitudinal plane.

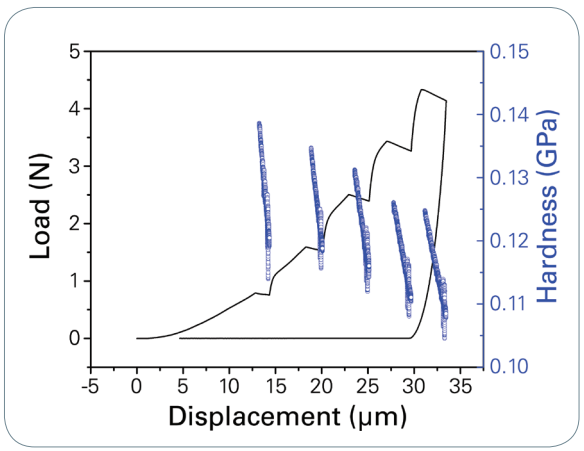


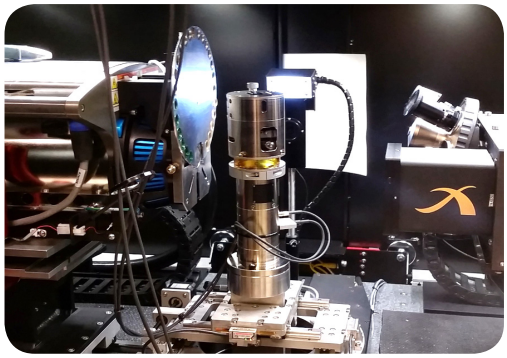
Figure 3: The load-displacement data resulting from the in-situ indentation test on Southern Yellow Pine.

This research used resources of the Advanced Photon Source, a U.S. Department of Energy (DOE) Office of Science User Facility operated for the DOE Office of Science by Argonne National Laboratory under Contract No. DE-AC02-06CH11357.

The Southern Yellow Pine sample was provided by the USDA Forest Service, Forest Products Laboratory.

IntraSpect 360 Features

- Seamless, 360° X-Ray transparent viewing window for gap-free 3D imaging
- X-Ray microscope (XRM) and beamline compatibility
- Ultra-stable piezoelectric load cell design with capacitive sensing
- Load or displacement-controlled testing modes for nanoindentation, compression, bending, and fatigue tests
- Performech Advanced Control Module with 78 kHz feedback rate and data acquisition up to 39 kHz to capture transient events, such as fracture initiation



Hysitron IntraSpect 360 Specifications

Normal Loading	Maximum Force: 10 N Load Noise Floor: ≤70 µN
Normal Displacement	Maximum Displacement: >80 µm Displacement Noise Floor: ≤0.5 nm
Testing Modes	Nanoindentation; Compression; Bending; Fatigue

Performech Advanced Control Module Specifications

Maximum Data Acquisition Rate	39 kHz
Feedback Loop Rate	78 kHz

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