

Beyond Hardness: Measuring Elastic and Dissipative Properties by Nanoindentation

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The nuclear materials community is frequently constrained by limited material availability and challenging experimental conditions. Advanced nanoindentation provides a powerful approach for characterizing mechanical behavior at the nanoscale while minimizing required sample volume. In this work, a single plutonium specimen is used to measure hardness, elastic modulus, and internal friction.

Unlike conventional microhardness testing, hardness is determined from the load–displacement response rather than optical measurement of the residual indent. Analysis of the elastic unloading segment of the curve further enables extraction of the elastic modulus. In addition, the nanoindenter is operated as a dynamic mechanical analyzer (nanoDMA) to measure frequency-dependent mechanical response, allowing quantification of dissipative behavior, or internal friction.

This approach enables characterization of bulk regions, small-scale microstructural features, and intermetallic phases within the same specimen, eliminating the need for multiple samples and extensive preparation for different testing platforms. Nanoindentation results are compared with bulk measurements obtained using complementary techniques, including microhardness testing and resonant ultrasound spectroscopy (RUS), to establish consistency across length scales.