Nanoindentation for Hardness and Elastic Modulus Measurements at Nanoscale

Nanoscience and nanotechnology accelerate the proliferation of novel materials and devices possessing small sizes and low dimensions such as nanomaterials and ultra thin films. Mechanical testing and characterization of these materials have exposed challenges to the traditional hardness and tensile testing and measurement tools. Nanoindentation, also referred to as instrumented or depth-sensing indentation, is a proven technology for measuring nanomechanical properties of materials and miniaturized devices. Both hardness and elastic modulus of a material can be precisely determined through analysis of a load-displacement curve generated by a single nanoindentation test using the well-established Oliver-Pharr method.

The nanoindenter equipped in Ebatco's Nano Analytical and Testing Laboratory (NAT Lab) is a full-feature, multi-technique nanomechanical and nanotribological test system. It performs closed-loop controlled nanoindentation tests with sub-nanometer and nanoNewton resolutions. Experiments can be conducted at room, elevated or reduced temperature, submerged in liquid, or under humidity control. The in-situ scanning probe microscopy (SPM) capability of the instrument enhances the nanoindentation function by enabling SPM imaging of the surface and positioning the indenter tip with nanometer precision over the feature to be studied. The materials that have been tested cover almost all man-made materials including alloys, ceramics, composites, glass, metals, polymers, steels. The applications of nanoindentation onto natural materials like wood, bamboo, geological samples, and biological samples such as bones, tooth, and arteries are increasing. Examples of material formats and devices that can be tested through nanoindentation include thin films, coatings, nanoparticles, nanowires, bulk material surfaces and interfaces, MEMS, and electronic and biomedical devices.

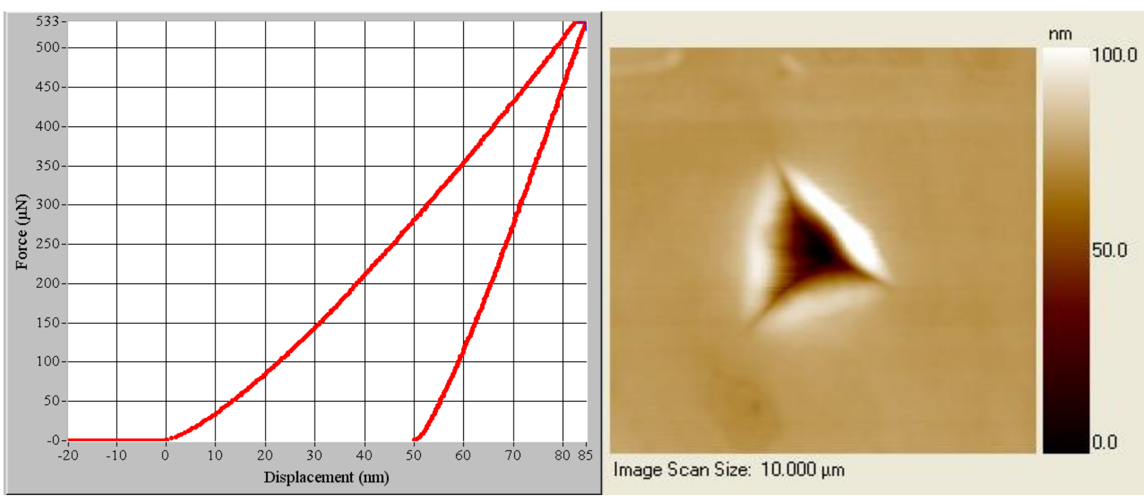

Figure 1. Load-displacement curve used for hardness and elastic modulus analysis (left) and an indent imaged through in-situ SPM imaging (right).

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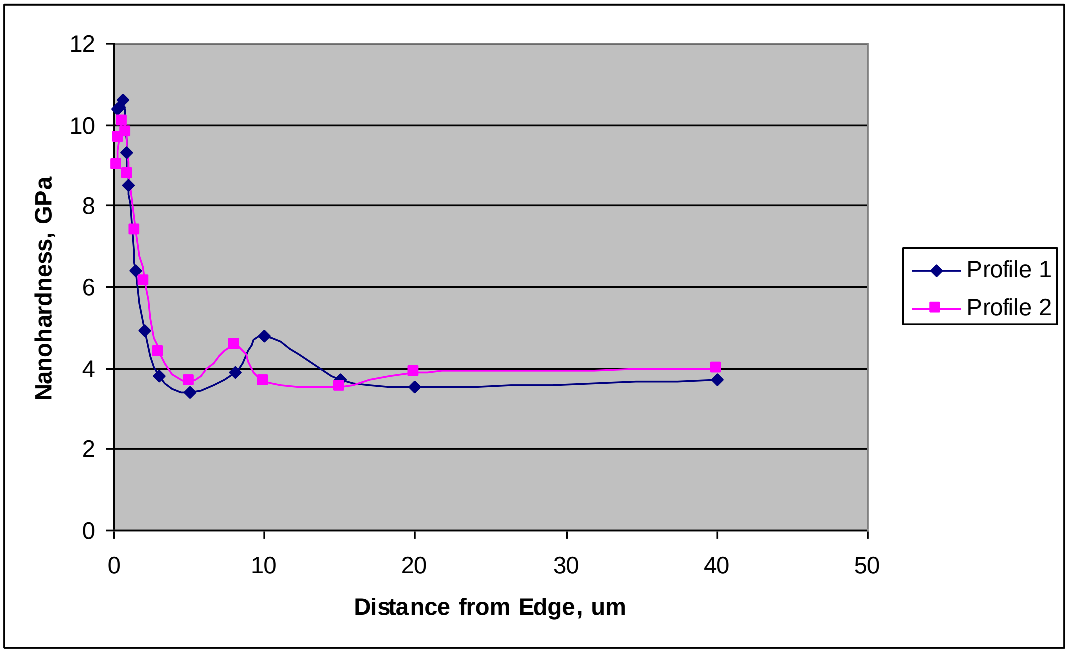

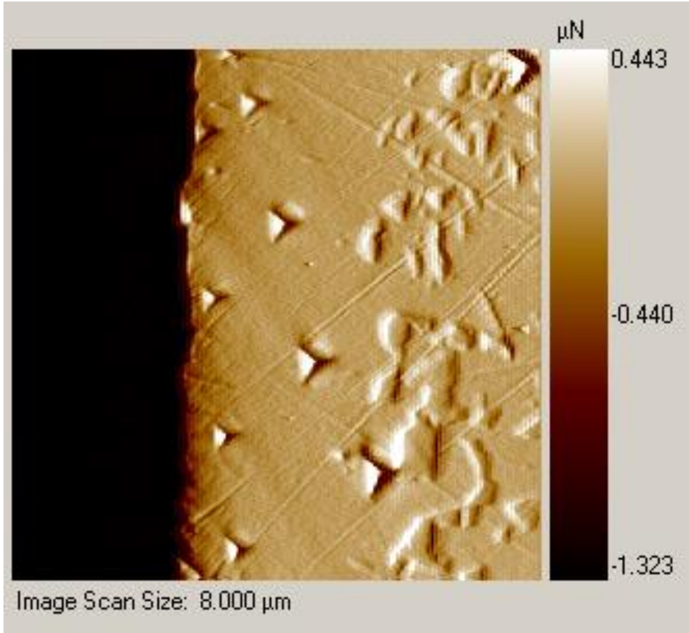

Figure 2. Nanohardness profile for a chemically treated titanium alloy (upper) and the tested surface with the indents imaged through in-situ SPM imaging (lower).