Micro Materials
Excellence in Nanomechanics

User case study

National Centre for Nuclear Research (Poland)

Overview

AT NCBJ, the nanoindentation technique is utilized to measure materials' hardness and Young's modulus as a function of indentation depth to understand irradiation effects. Measurements are performed using the NanoTest Vantage systems manufactured by Micro Materials Ltd enabling nano- and micro-mechanical studies in the load ranges 0.1-500 mN and 0.3 – 20 N, respectively. A high-temperature chamber allows conducting measurements from RT up to 750 °C under a controlled atmosphere. The systems are equipped with Atomic Force Microscopes (AFM), optical microscopes, and piezo-stage tools to visualize imprints after the indentation.

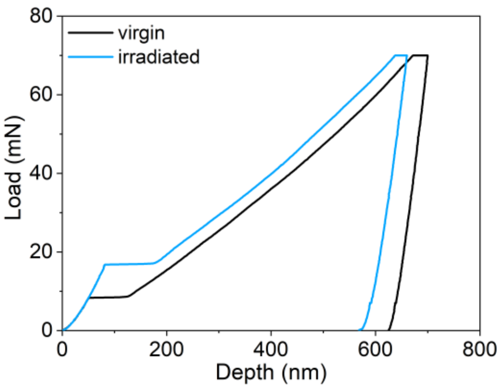


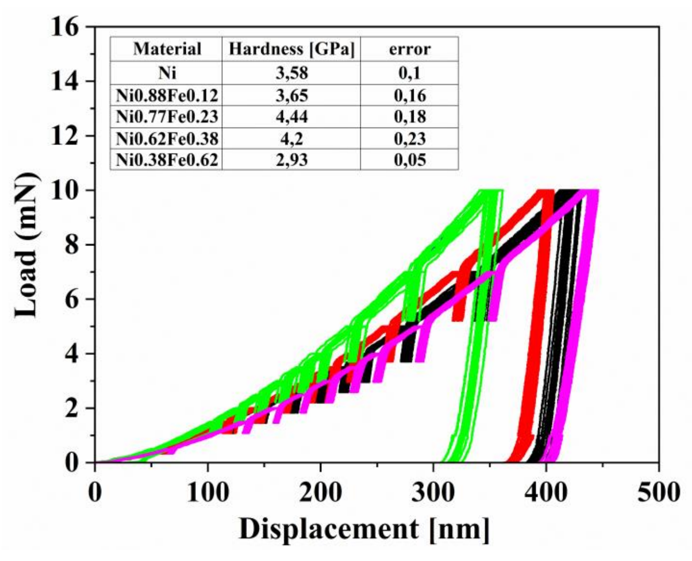
Fig. 1. Load-displacement curves on virgin and ion-irradiated material showing the effect of radiation damage

NCBJ NanoTest platform configuration

- Berkovich, Vickers, Cube Corner, Conical indenters
- HT measurements with diamond (up to 450°C) and cBN (up to 750°C) indenter measurements under controlled argon atmosphere
- Coupled Atomic Force Microscope
- SPM-nanopositioning stage
- Optical microscope (up to 40x mag.)
- Covers range forces from 0.1 mN to 20 N
- Load or depth-controlled mode
- Partial unloading experiments

Partial load/unload experiments

Nanoindentation tests are carried out in Load Partial Unload (LPU) mode. This procedure is used to obtain a hardness response for different-sized indents in the same spot. In this experiment, the force is increased to the maximum global force in a series of force-increasing and partial force removal increments. In our experimental set-up, we typically increased force from 0.5 mN to a maximum 10 mN every 0.5 mN up to 4 mN and then at 5, 7, and 10 mN. At each maximum local force, the load is held constant for 2 s and then reduced to 30% of the max. force before reloading to the next force increment.



Material	Hardness [GPa]	error
Ni	3,58	0,1
Ni0.88Fe0.12	3,65	0,16
Ni0.77Fe0.23	4,44	0,18
Ni0.62Fe0.38	4,2	0,23
Ni0.38Fe0.62	2,93	0,05

Figure 2. Load-displacement curves obtained during multicycle indentation of the irradiated single crystal alloys.

The described experimental procedure resulted in recording indentation depths between approx. 70 to 450 nm, depending on the specimen type. Each measurement is repeated 16 times with 50 microns spacing between the indents. All the indents are made by using a loading/unloading rate of 0.5 mN/sec. The dwell period for drift data correction is set to 60 secs.

User Profile

National Centre for Nuclear Research is the largest research institute in Poland. We employ over 1000 physicists, engineers and technicians. Our research staff includes about 70 Professors and holders of the Dr. Hab., Post-doctoral-degree, as well as over 120 PhDs. Established in 2011, merging the former Institute of Atomic Energy POLATOM and the former Andrzej Sołtan Institute for Nuclear Studies, both dating back to 1955, NCBJ's pure/applied research profile combines nuclear energy studies (nuclear power safety, research reactor technologies, medical applications etc.) and various fields of physics (mainly elementary particles, nuclear physics, hot plasma physics and astrophysics). The Centre is also the operator of the only nuclear reactor in Poland (MARIA) with experience of running several previous research reactors and critical assemblies). POLATOM is developing new methods of producing radioisotopes and new pharmaceutical forms of medicines. We are conducting studies on new nuclear reactors technologies, including new materials and investigations of hot plasmas from the point of view of their possible future applications in thermonuclear power industry. We cooperate with leading research institutes on each continent (including CERN, the largest scientific lab in the world), and our Professors hold positions in managing bodies of many international research organizations. We participate in global enterprises and research projects in many areas.

Figure 3. NCBJ NanoTest platform.

Highlights from the user

- Low thermal drift during high temperature measurement
- Quick and simple indenter mounting
- Intuitive software
- Excellent sensitivity in low load regime

Quote from the user

"Unprecedented accuracy of the measurements in the equipment load range"

References

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