SSNN 12P **INDENTATION AND PLASTIC PROPERTIES OF MgO SINGLE CRYSTALS IN NANO AND SUBMICROVOLUMES**

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The strength and plastic properties of MgO single crystals have been thoroughly studied in microvolumes [1–3]. However, it has been proved on various materials that a reduction in the characteristic dimensions of an object or structure element to $R \leq 1$ μm (at least one of the three dimensions) leads to a substantial change in its mechanical properties. Particularly strong size effects (Indentation Size Effect) occur when $R \leq 100$ nm; at $R \leq 10$ nm their behavior can radically change again [4]. For this reason, the mechanical parameters of solids on the nanoscale cannot be obtained by simple extrapolation from macro or microregions; this problem requires new research, and it is the aim of this work.

Mechanical properties were studied by the dynamic indentation method using a Nanotester-PMT3-NI–02 device equipped with a Berkovich indenter. The tests were conducted in a load range of P_{max}= 3–900 mN. The following results were obtained. Young modulus values vary with changing load; however, they fluctuate around E = 250 GPa at almost all applied loads. Dependences *H(P)* demonstrate ISE. Starting from a load of P_{max}= 40 mN, the hardness value increases with decreasing load and reaches a value of 12.8 GPa at P_{max}= 3 mN. As the load increases to 40 GPa, the hardness values slightly fluctuate around H = 8 GPa. At the highest load of 900 mN, the hardness value slightly decreases. The effect is most probably attributed to the cracking around indentations even at the loading stage.

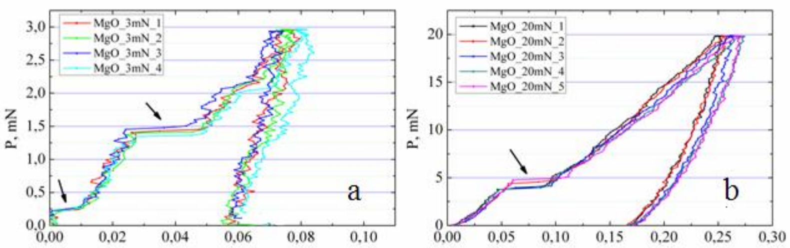

Fig. 1. MgO, (001). Loading–unloading curves $P(h)$ obtained at different peak loads, P_{max} = (a) 3 and (b) 20 mN. The arrows show the pop-in effects under loading.

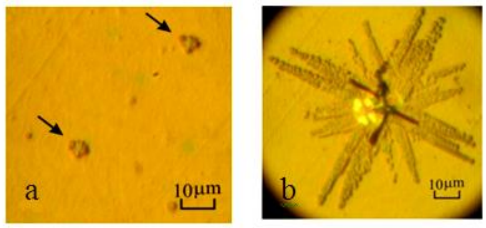

Fig. 2. MgO, (001). Dislocation rosettes near indentations. P = (a) 3 (shown by arrows) and (b) 900 mN.

The *P(h)* loading–unloading curves show three typical 'pop-in' effects in respective load ranges at $P_{max} \approx$ (i) 0.2–0.3, (ii) 1.0–1.5, and (iii) 5.0 mN (Fig. 1). All the three 'pop-in' effects are attributed to the nucleation of dislocations during nanoindentation (Fig. 2a). In accordance with this, the hardness values decrease. The dislocation structure becomes more complicated with a further increase in load. Dislocation reproduction, activation of all sliding systems and, as a result, interactions and intensive intersections of dislocations take place in the indentation neigbourhood (Fig. 2b). The above evolution of plastic deformation was confirmed by detailed analysis of the images of the dislocation structures near indentations.

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