Examination of strain evolution in compressed micropillars by HR-EBSD

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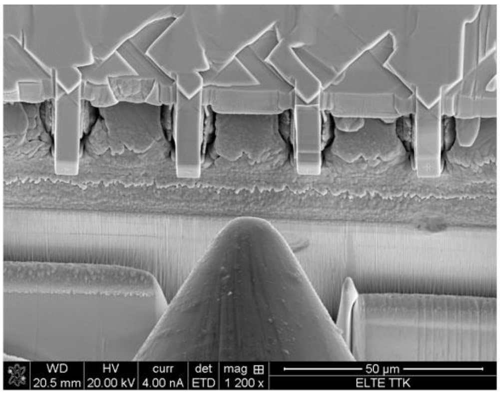
The understanding of the mechanisms occurring during plastic deformation of crystalline materials is in the focus of materials science research. In the last decade one of the remarkable results of plasticity was that plastic deformation of crystals becomes dramatically different when the sample size is reduced to the micron or submicron scale, compared to the behavior of bulk materials. This difference decisively influences today's industrial sectors with focus on miniaturization, as the size reduction effect is no longer negligible. Therefore the plastic behavior at the micrometer scale (in case of micropillars) is in the main focus of the presented work.

The aim of our research was to develop a focused ion beam (FIB) milling method to be able to produce micropillars in large numbers, which are also suitable for electron backscatter diffraction (EBSD) measurements. After the preparation phase of the copper single crystal sample, micropillars were formed on the surface, and then they were compressed to various deformation levels with a nanoindentation stage developed by the researchers at Eötvös Loránd University (ELTE). After compression the pillars were sliced up by FIB and the resulting new surfaces were measured with high resolution EBSD (HR-EBSD). The HR-EBSD technique is capable of mapping the strain field in the deformed sample caused by the dislocations, therefore we can examine the strains' magnitude and distribution evolving in the material after plastic deformation. After the HR-EBSD evaluation the slices were put together by a three dimensional (3D) reconstruction software to receive the 3D model of all the micropillars that were measured. These reconstructed models are shown and analyzed in more detail in the presentation.

The micropillars made by the FIB preparation (Fig.1/a) were successfully compressed and measured by EBSD. The high resolution EBSD maps show interesting features when the different components of the strain tensor elements are plotted, and it enables us to quantitatively characterize the microstructure. The experiments were conducted on differently oriented samples as well. The comparison of the results lead us to the possibility to map and reconstruct strain states in 3 dimensions (Fig.1/b), which is a fairly new approach in the experimental research of microdeformations.

a)



b)

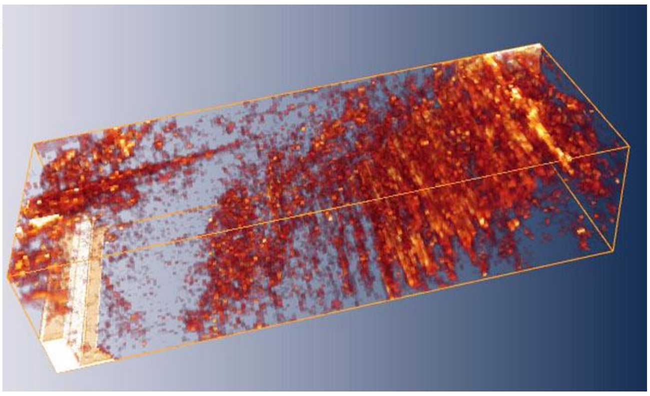


Fig.1. a) The prepared and compressed micropillars (initially 6 um × 6 um × 18 um sized) shown with the indenter head. b) The reconstructed micropillar model highlights the activated slip systems (after 2% deformation).