EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

	Experiment title: Strain mapping of disordered metallic materials during nano-indentation using in-situ nano-diffraction	**Experiment number**: MA/2281
Beamline: ID11	**Date of experiment**: from: 21.10.2014 to: 26.10.2014	**Date of report**: 31.08.2015 *Received at ESRF:*
Shifts: 15	**Local contact(s)**: Andrea Bernasconi	

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Report:

The proposed work aimed to studying the deformation processes in Zr-based amorphous materials, insitu in transmission mode, subjected to controlled deformation using a nanoindenter. We combined nanomechanical testing technique, that provided high resolution load and displacement data (in orders of micro-newtons and sub-nanometer range), with high spatial resolution structural information obtained from nanometer sized X-ray beam to probe the deformed volume in these materials. This combination of techniques, which provides direct experimental data on strain fields created beneath this indenter, offers a wide scientific community very powerful tool for the delineation of composition-structure-property relationships, and hence contribute to material discovery and property optimization.

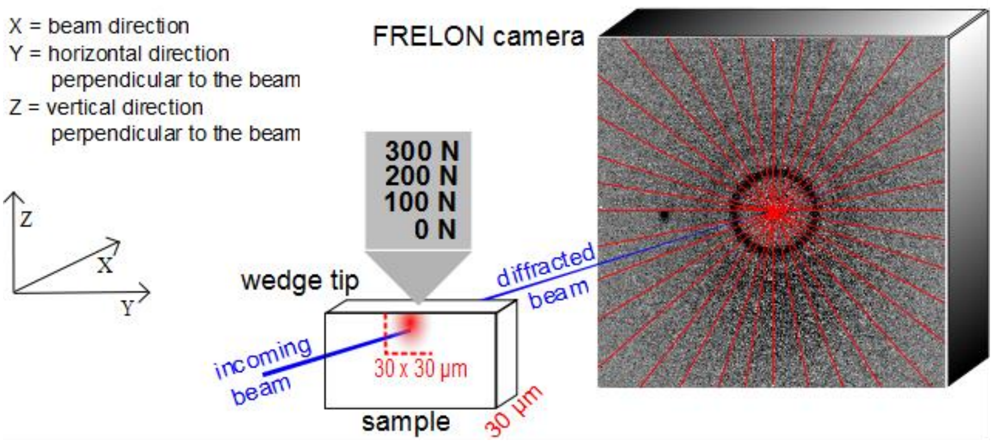
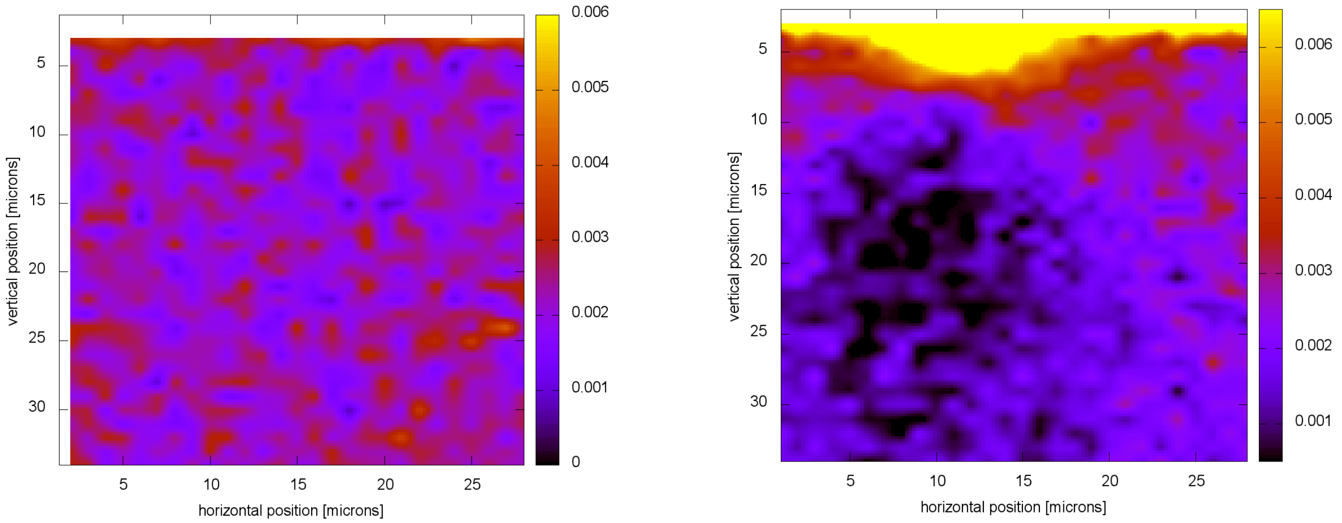


Figure 1: Schematic view of the X-ray nanodiffraction experiment. In the projection on detector a real diffraction pattern obtained during measurement is displayed. Red lines show the areas for caking.

Spatially resolved X-ray diffraction scans were performed during the indentation using a nanometer sized monochromatic photon beam with energy 65.435 keV and size 500 × 500 nm^2 (width × height). The size of the sample area scanned was 30 × 30 μm^2 situated right beneath the indenter diamond tip. The scanning experiments were realized by translating the whole nanoindenter set-up with the sample-holder in Y and Z directions lying in the plane perpendicular to the incoming X-ray beam, see *Figure 1*, with well-defined steps with resolution of 1 micron. XRD patterns were collected in transmission mode by a FRELON camera with pixel size of 50 x 50 µm. One diffraction pattern was collected for 30 seconds, the total time of the measurement was 8.5 hours. After every completed X-ray scan the applied load was increased by about 100 mN keeping the tip permanently touching the sample at the same position. In this way we covered forces from 0 to 300 mN.



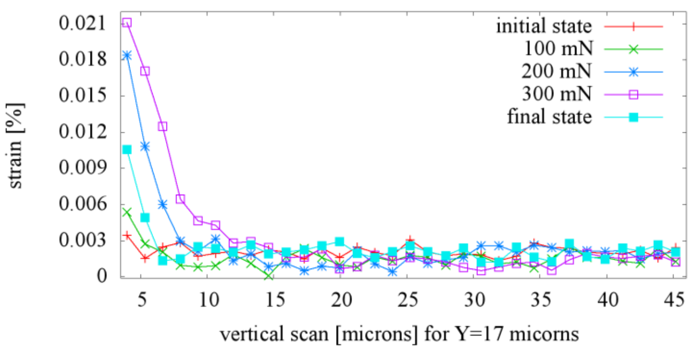


Figure 2:
2D maps of the strain for load: 0 N – left and 300 mN – right, obtained from diffraction data in the area of 30 µm × 30 µm beneath the indenter-diamond-tip in the deformed volume of the $Zr_{53}Cu_{18.7}Ni_{12}Al_{16.3}$.

Figure 3:
Position dependence of the strains. Plot was taken from Y=17 µm in the Figure 2.

From the calculation of the deformation tensor, values for normal-(ε_{11} and ε_{22}) and shear-(γ) components were obtained. The deformation is given by the magnitude of deformation tensor. 2D maps for load 0 mN and 300 mN are displayed in *Figure 2*. One can clearly identify not only the position of the elastic deformation field but also the shape of the elastic deformation during the indentation. The centre of the strain field is localized at Y = 12 µm (horizontal position in our coordinated system, *Figure 1*). One can see that the impacted area around the centre of deformation is continuously growing with increasing of load. This behaviour is demonstrated for each measured load in the *Figure 3*.

References:

[1] Michalikova J., Michalik S., Bednarcik J., Hvidos P.,Alfeld M.,Franz H., Key Engineering Materials Vol. 662 (2015) pp 51-54.