Following deformation mechanisms in nanocrystalline Ni using *in situ* Synchrotron techniques and Automated Crystal Orientation and phase Mapping (ACOM)

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A prerequisite to exploit the unique mechanical properties of nanocrystalline (nc) materials is a thorough understanding of the underlying deformation mechanisms. *In situ* characterization is necessary in order to (i) detect reversible mechanisms and (ii) separate and ascribe the active mechanism to the respective strain regime. Therefore *in situ* compression tests are conducted on nc Ni specimens using high energy synchrotron X-ray diffraction (XRD) with a fast area detector that allows for continuous recording of complete Debye-Scherrer rings.

The XRD results of the initial and the final state after deformation are compared and verified with the Nanomegas Automated Crystal Orientation and phase Mapping (ACOM) solution (ASTAR) [1, 2] operating on a Tecnai F20 in µP-STEM mode. The µP-STEM mode opens the possibility to obtain orientation maps with nanometer resolution and also to acquire (fast) STEM reference images of the area of interest. After the acquisition of the orientation maps, data processing was done using the Mtex Toolbox, which was modified and extended for a quantitative grain size and texture analysis [3]. It enables good identification of the crystallographic orientation of all grains and sub-grains and the detection of all twin boundaries.

Both the in-situ XRD and the ACOM results (Figure 1) were analyzed quantitatively to determine the orientation dependent grain size and the texture development during straining (Figure 2 and 3) as well as lattice and micro strain in case of in-situ XRD. The two different techniques show an excellent agreement indicating the reliability of the analysis techniques.

Based on the unique in-situ XRD setup the deformation behavior of nc Ni was determined to be a distinct sequence of elastic grain interaction, grain boundary sliding, grain rotation, dislocation activity and grain growth. The succession of the different deformation mechanisms leads to a specific in-plane texture observed both by XRD and ACOM.

References:

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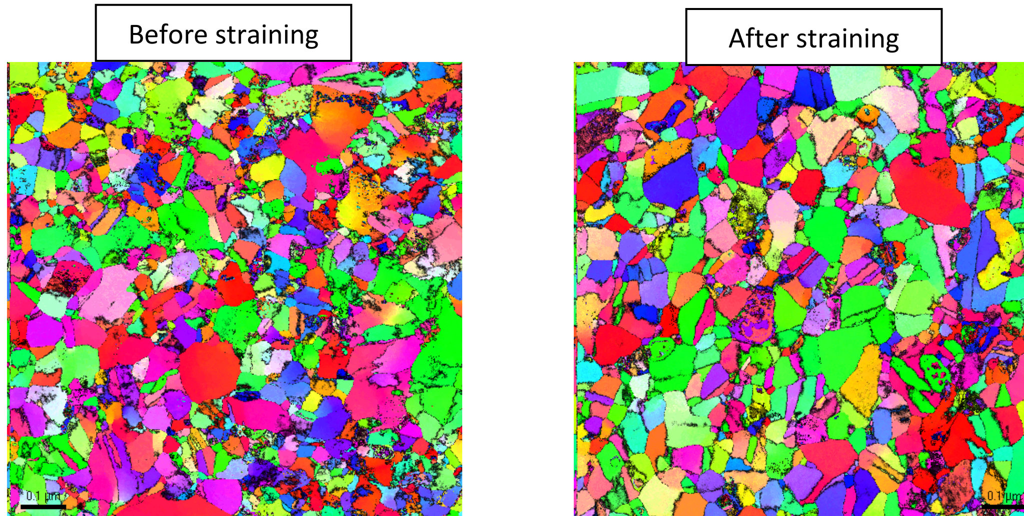

Figure 1: *orientation maps (x-direction) of the nc Ni before and after the in-situ straining*

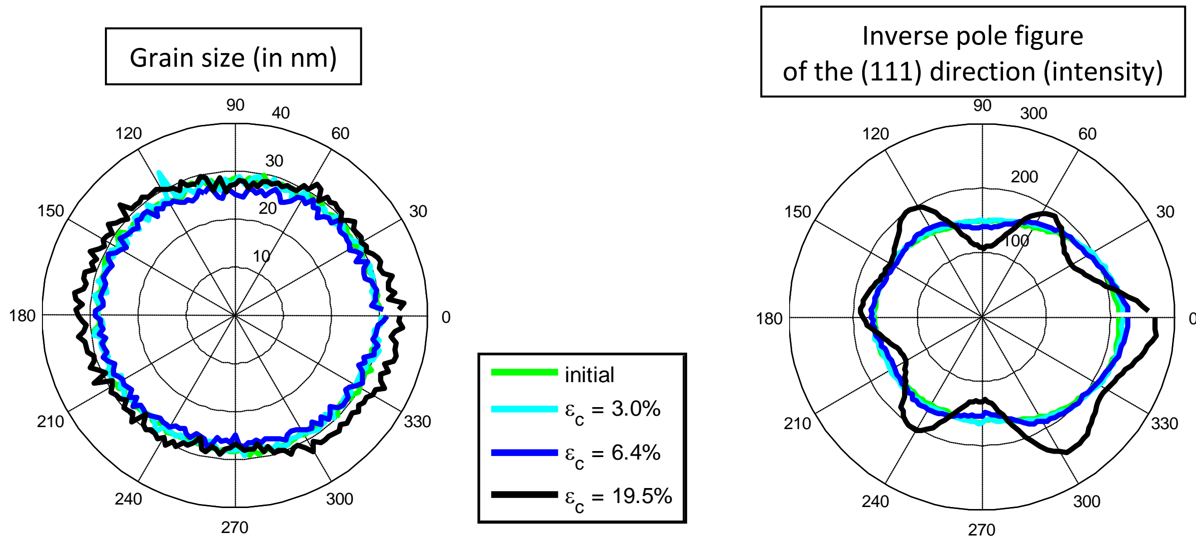

Figure 2: *in-situ XRD data show the grain size and texture development in different states of the straining.*

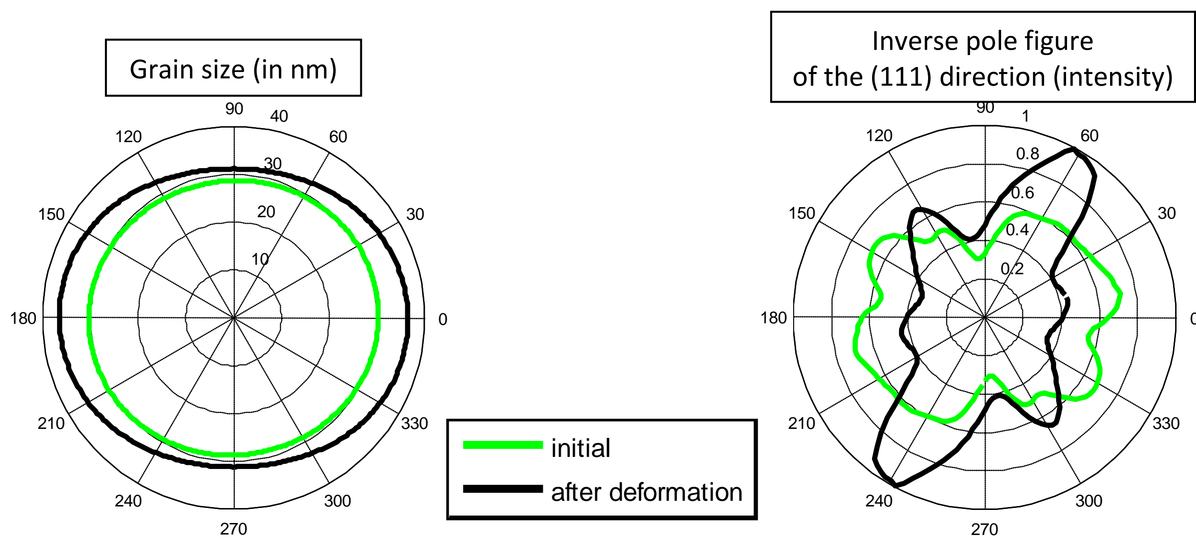

Figure 3: *ACOM data processed with a modified Mtex to reveal the grain size and texture development between initial and final state.*