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Ultra-high Angular Resolution 3DXRD for Observing Bulk Subgrains and their Dynamics

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A novel technique is presented that for the first time enables the direct investigation of the dynamics on the subgrain scale inside deeply embedded bulk grains. The technique is a variant of the 3DXRD technique [1] and is based on the setup for peak shape analysis developed previously [2]. By a unique optics at beam line 1-ID at the Advanced Photon Source (APS), an ultra-high angular resolution (≈0.003°) was achieved, with a vertically focused (full width at half maximum 25μm) hard X-ray beam (52keV). By using an area detector and rocking the sample around the axis perpendicular to the scattering plane a full 3 dimensional reciprocal space map of a diffraction peak is obtained.

At low angular resolution, diffraction peaks from individual grains in a deformed metal appear as smooth, broad, continuous distributions, both in the radial (2θ) and in the azimuthal directions. With the ultra high angular resolution this distribution breaks up into distinct spots superimposed on a cloud of low intensity. These spots are interpreted as coming from individual subgrains. The size of the entities giving rise to the distinct spots are (based on intensities) around 1 μm, which is consistent with the subgrain size found from transmission electron microscopy, thus supporting this interpretation. From the reciprocal space maps information about orientation and strain distribution of the subgrains can be gathered.

As this technique is non-destructive, it is possible to perform *in-situ* experiments, where either statistical properties or individual subgrains are followed during straining, hence giving a possibility to probe the dynamics on the subgrain scale. Such experiments will allow answering fundamental questions regarding structure formation processes during plastic deformation such as: Do subgrains exists during deformation or do they first appear when straining is stopped? How does the grain refinement process take place? How does the orientation distribution within the grain evolve during straining?

First static and dynamics results are presented demonstrating the strength of this novel technique. Further applications and experiments using the technique will be discussed.

1. H.F. Poulsen. *Crystall. Rev.* (2004) **10** , 29-43

2. W. Pantleon, H.F. Poulsen, J. Almer, U. Lienert. *Materials Science and Engineering A* (2004) **387-389,** 339-342

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