High-Resolution Reciprocal Space Mapping for Characterizing Deformation Structures

With high-angular resolution three-dimensional X-ray diffraction (3DXRD), quantitative information is gained about dislocation structures in individual grains in the bulk of a macroscopic specimen by acquiring reciprocal space maps. In high-resolution 3D reciprocal space maps of tensile-deformed copper, individual, almost dislocation-free subgrains are identified from high-intensity peaks and distinguished by their unique combination of orientation and elastic strain; dislocation walls manifest themselves as a smooth cloud of lower intensity. The elastic strain shows only minor variations within each subgrain, but larger variations between different subgrains. On average, subgrains experience backward strains, whereas dislocation walls are strained in a forward direction. Based on these observations the necessary revision of the classical composite model is outlined. Additionally, subgrain dynamics is followed in situ during varying loading conditions by reciprocal space mapping: during uninterrupted tensile deformation, formation of subgrains is observed concurrently with broadening of Bragg reflections shortly after the onset of plastic deformation. When the traction is terminated, stress relaxation occurs, but no changes in number, size and orientation of the subgrains are observed. The radial profile asymmetry becomes reversed, when pre-deformed specimens are deformed in tension along a perpendicular axis.

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