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Analysis of deformation-induced intragranular orientation spread in IF-steel by a combination of 3DXRD and crystal plasticity

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The lattice rotation and intragranular orientation spread of individual grains in IF steel during 9% tensile elongation have been monitored by 3DXRD. At first the lattice rotations from the initial undeformed orientation to the average final orientation of the deformed grains were determined. Subsequently the shapes of the reflection spots from selected individual grains were investigated to analyse the intragranular orientation spread.

Grains of similar orientation clearly exhibited different average rotations and also developed orientation spreads of different magnitudes. The variations in average rotations were compared to predictions based on standard crystal plasticity models, in particular the Taylor ambiguity was considered. The observed differences between the grains are well beyond these standard predictions.

Inverse polycrystal plasticity analysis was employed to determine the major slip systems in each grain. The analysis assumed axisymmetrical tensile strain while enforcing the experimentally determined average rotation of the grain. As in the standard polycrystal plasticity models the solution with minimum internal work was selected to find the identity as well as the activity of the slip systems which are responsible for the average rotation of the grain.

Several hypotheses about the slip system variations leading to the intragranular orientation spread were tested, including intragranular variations in the tensile strain and different relative activities of the slip systems deduced for the average rotation. In order to evaluate these hypotheses diffraction spots corresponding to the expected orientation spread were simulated and compared with the experimentally observed spots.

In this way we have shown that the dominant trend in the observed orientation spread can be explained by relative variations of the activities of the most active slip systems. The implications in terms of inter- and intragranular variations in the strain tensor and therefore the character of grain interactions are discussed.