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Assessment of X-ray diffraction and crystal plasticity lattice strain evolutions under biaxial loading

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Abstract

A methodology to simulate X-ray diffraction lattice strains using crystal plasticity, replicating in-situ synchrotron experimental measurements during the deformation of a low-carbon steel, has been developed. Uniquely, the model calculated lattice strains for full Debye-Scherrer diffraction rings, providing the in-plane lattice strain distributions determined from crystal plasticity. Thus, a direct method of comparison between experimental and crystal plasticity results becomes possible. The model considered two forms of hardening whilst subjecting the material to two dissimilar proportional strain-paths; uniaxial and balanced biaxial deformation. Both deformation paths showed influence on resulting lattice strain distributions which were also found to depend upon texture. Biaxial straining led to a stronger dependence on the material's hardening behaviour and this was attributed to the higher rate of work hardening seen under biaxial compared to uniaxial straining. However, biaxial deformation showed quite isotropic lattice strains distribution, irrespective of initial texture or hardening. Quantitatively, good agreement between the computed and experimentally determined lattice strain distributions was obtained for each strain path. This success demonstrates the possibility of calibrating crystal plasticity model parameters using such methodologies, or simply to provide insight into the governing mechanisms in polycrystal deformation.

Keywords: Lattice strain distribution; crystal plasticity; X-ray diffraction; texture, hardening