CRYSTAL PLASTICITY MODELLING OF REAL AND SYNTHETIC POLYCRYSTALLINE MICROSTRUCTURES

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A Discrete Slip Plane model has been developed to account for the heterogeneity of plastic deformation at the subgrain scale, as well as for nonstandard, highly orientation-dependent plastic mechanisms facilitated by the substructure of some of the phases of interest. The model is founded on the concept that individual, atomic slip planes have a different likelihood of becoming active due to the presence of dislocation sources and obstacles on them. It hence considers the discrete slip on each of them and assumes it to depend on the ratio of the resolved shear stress and a slip resistance which is sampled from a statistical distribution which takes into account the presence of sources and obstacles [1]. The model has been validated against micro-tensile tests on advanced high strength steel samples which have locally been thinned to a few micron, so that their microstructure is practically uniform through the thickness. This allows us to construct finite element models which capture the full, three-dimensional microstructure of the region of interest in great detail and without the usual uncertainty on the subsurface microstructure [2]. A very good agreement between the experimental and numerical slip patterns is observed. Simulations of three-dimensional representative volume elements of the material allow us to understand particular features of its macroscopic response, such as e.g. the very steep initial hardening observed for martensite. References [1] J. Wijnen, R.H.J. Peerlings, J.P.M. Hoefnagels, M.G.D. Geers, A discrete slip plane model for simulating heterogeneous plastic deformation in single crystals. International Journal of Solids and Structures, 228, 111094, 2021. [2] T. Vermeij, J. Wijnen, R.H.J. Peerlings, M.G.D. Geers, J.P.M. Hoefnagels, A quasi-2D integrated experimental-numerical approach to high-fidelity mechanical analysis of metallic microstructures. Acta Materialia, 264, 119551, 2024.