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From Dislocation Junctions to the Three Stages Curve

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The strain hardening matrix of fcc crystals can be obtained from crystallographic continuum models deriving from the Kocks-Mecking framework. DD simulations were used to compute the coefficients of the interaction matrix between slip systems and to extend an existing model for stages II and III in order to also include stage I. Other parameters of the model are the mean-free path of the dislocations and their critical annihilation distance by cross-slip, which can be estimated from various sources. The resulting constitutive formulation is inserted into a numerical crystalline model using a FE code, which is used here to test single crystal behavior. As a result, parameter-free deformation curves can be obtained for fcc crystals, which depend in a known manner on the nature of the material, the orientation of the crystal and temperature. This is illustrated by a comparison between aluminum and copper crystals initially oriented for easy glide at room temperature. In this type of modeling, the internal variables are average dislocation densities per slip system. Thus, although dislocation patterning is not accounted for, the traditional three-stage stress vs. strain behavior is fully recovered. The present results seem to indicate or confirm that, as long as there is no change in strain path, there is no need to account for dislocation patterning when modeling strain hardening properties up to the end of stage III. This statement raises a few interesting questions.

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