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PII: S0142-1123(18)30411-0
DOI: https://doi.org/10.1016/j.ijfatigue.2018.08.027
Reference: JIJF 4823

To appear in: *International Journal of Fatigue*

Received Date: 6 June 2018
Revised Date: 8 August 2018
Accepted Date: 16 August 2018

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Abstract

To predict the cyclic plasticity behavior of polycrystalline copper on the micro scale for fully reversed torsion, a model, which expresses back stress in an Armstrong-Frederick form, is developed. The model parameters are size dependent and correlate with the critical density of geometrically necessary dislocations (GNDs). For monotonic loading, the flow stress satisfies the parabolic Taylor relation, and a mathematical equation is derived that expresses the flow stress as the superposition of internal variables, such as back stress and yield stress. With this new expression of flow stress, the parameters for the saturated value of back stress are found to relate to GNDs. Although the flow stress is dominated by the dislocation pile-up under fully reversed torsion loading, the parameters do not change with the overall dislocation density but remain constant. It is assumed that the critical GND density is determined by the strain range, and related to level of dislocation pile-up. Moreover, our model is verified by simulation, and satisfactory results are obtained for facts such as strength increase, cyclic hardening, the Bauschinger effect, and plasticity recovery.

Keywords: Size effect; Geometrically necessary dislocation; Statistically stored dislocation; Cyclic plasticity; Cyclic hardening; Bauschinger effect