11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

ANALYSIS OF THE STOCHASTICS OF INTERACTING DISLOCATION DENSITIES BY DISCRETE DISLOCATION DYNAMICS

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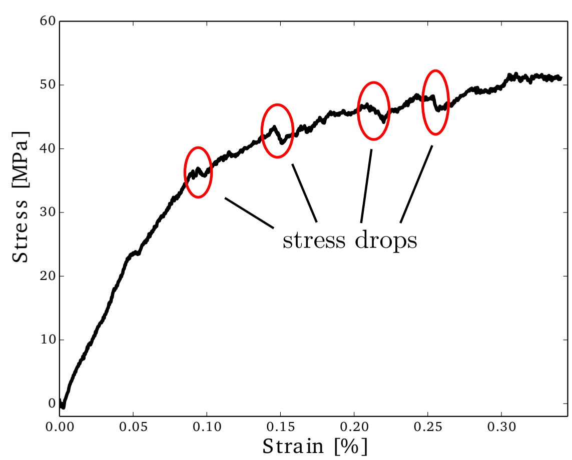
Key words: *Dislocation Dynamics, Microstructure, Topology, Statistics*

The mechanical response of metallic structures on the micro scale exhibits a strong size dependence of the flow stress due to the topology of the underlying dislocation structure and interaction of mobile dislocations with the dimensional constraint of the sample [1]. Using discrete dislocation dynamics (DDD) [2, 3] as a tool for investigating the evolution of dislocation ensembles, statistical data on dislocation evolution, junction formation and dislocation multiplication are extracted. This information is important for the development of continuum theories to include those observations even after averaging and homogenization approaches.

It is generally accepted, that the variation in flow stress and hardening depends on

(a) [100] tensile strained dislocation network



(b) Corresponding stress-strain curve with stress drops

aspect ratio, initial dislocation density and source distribution as well as crystallographic

orientation [4, 5]. It is important to note that the ratio average dislocation spacing over smallest outer dimension determines the behavior, e.g small samples with a high density behave similar to large samples with low dislocation density. For large ratios the deformation mechanisms are geometrical constraints of dislocation motion and reduction of the mobile dislocation density, which is leading to dislocation activation on secondary and tertiary planes with lower Schmid factors [6].
By simulating micropillar structures in the micrometer and sub-micrometer regime with DDD under uniaxial loading conditions (uniaxial compression or tension [7, 8], Fig. 1a) we address this complex problem. Correlations between stress drop events with dislocation bursts, junction formation, cross slip events, dislocation multiplication as well as dislocation interaction including second generation sources [9] and dislocation multiplication by glissile reactions are presented. From this a dislocation density measure for the rate of occurrence of the above mentioned mechanisms can be derived.

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