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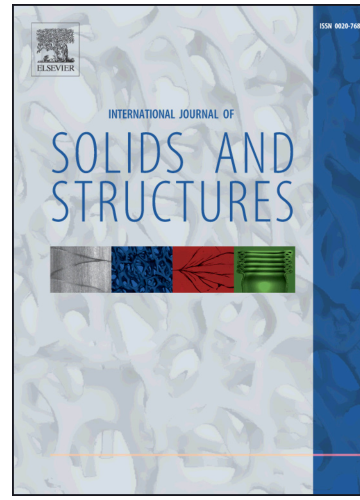

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A stochastic crystal plasticity model with size-dependent and intermittent strain bursts characteristics at micron scale

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Abstract: Size effect and strain bursts are widely observed in the plastic deformation of micron-sized single crystals. In this paper, a stochastic crystal plasticity model is established by importing these two dislocation-source-controlled characteristics into the conventional crystal plasticity theory. The plastic strain is composed of a series of strain bursts instead of formulated as a continuous function. The size of each strain burst follows a power-law distribution function and the rate of strain bursts is determined by a constitutive equation. On the other hand, size effect is accounted for by dislocation-source-controlled slip resistance. The effective dislocation source length is derived as a function of sample size by a statistical analysis and experimental data. Uniaxial compression of single crystal Ni micron-sized pillars, with diameters ranging from 5 to 40 μm, are investigated by the model. The results show that this model well captures the significant features of plastic deformation at micron scale: 1) Strain bursts are strongly affected by sample size. For large pillars (e.g. 40 μm), the stress-strain curves are almost continuous and predictable. But as sample size decreases, strain bursts become more and more evident and the stress-strain curves are unpredictable. 2) The yield strength increases significantly as sample size decreases. For diameter larger than 40 μm, the strengthening effect still exists but is not evident anymore. All these results match well with the experimental observations.

Keywords: Strain burst; Size effect; Single crystal metal; Plasticity; Micropillar; Continuum model

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