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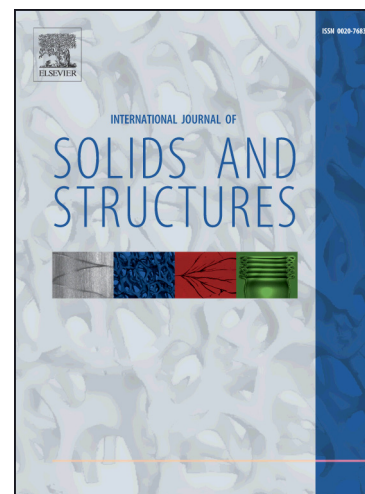
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A stochastic crystal plasticity model with size-dependent and intermittent strain bursts characteristics at micron scale

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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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