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ATHERMAL MECHANISMS OF SIZE-DEPENDENT CRYSTAL FLOW GLEANED FROM THREE-DIMENSIONAL DISCRETE DISLOCATION SIMULATIONS

***Satish I. Rao[2], Dennis M. Dimiduk[1], Triplicane A. Parthasarathy[2], Michael D. Uchic[1], Meijie Tang[3], and Chris Woodward[1]**

[1] Air Force research Laboratory, Materials and Manufacturing Directorate
AFRL/RXLM, Bldg. 655, 2230 10th Street, Wright-Patterson AFB, OH 45433-7817
dennis.dimiduk@wpafb.af.mil

[2] UES, Inc.
4401 Dayton-Xenia Road, Dayton, OH 45432-1894
satish.rao@wpafb.af.mil

[3] Lawrence Livermore National Laboratory,
P.O. Box 808
L-45 Livermore, CA 94551
tang7@llnl.gov

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ABSTRACT

Recent experimental studies discovered that micrometer-scale face-centered cubic crystals show strong strengthening effects, even at high initial dislocation densities [1,2]. The present studies examined the flow response of micron-scale single crystals using large-scale discrete dislocation simulation (DDS) in 3d. Uniaxial compression tests were simulated for cells ranging from 0.5-20 micrometers in edge length. Simulations were carried out for a range of initial dislocation densities, in the athermal limit and, for conditions that mimicked aspects of the experimental conditions [1, 3]. The study shows that two size-sensitive athermal hardening processes, beyond forest hardening, are *sufficient* to develop the dimensional scaling of the flow stress, stochastic stress variation, flow intermittency and, high initial strain-hardening rates, similar to experimental observations for various materials [4]. One mechanism, source-truncation hardening, is especially potent in micrometer-scale volumes. A second mechanism, termed exhaustion hardening, results from a break-down of the mean-field conditions for forest hardening in small volumes, thus biasing the statistics of ordinary dislocation processes.

E-mail: *SATISH.RAO@wpafb.af.mil*

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