Abstract Submitted
for the DPP12 Meeting of
The American Physical Society

Theory of Strength and High-Rate Plasticity in BCC Metals Laser-Driven to High Pressures[1] ROBERT E. RUDD, N.R. BARTON, R.M. CAVALLO, J.A. HAWRELIAK, B.R. MADDOX, H.-S. PARK, S.T. PRISBREY, B.A. REMINGTON, Lawrence Livermore National Laboratory, A.J. COMLEY, AWE and Lawrence Livermore National Laboratory, P.W. ROSS, N. BRICKNER, National Security Techologies — High-rate plastic deformation is the subject of increasing experimental activity. High energy laser platforms such as those at the National Ignition Facility and the Laboratory for Laser Energetics offer the possibility to study plasticity at extremely high rates in shock waves and, importantly, in non-shock ramp-compression waves. Here we describe the theory of high-rate deformation of metals and how high energy lasers can be, and are, used to study the mechanical strength of materials under extreme conditions. Specifically, we describe how LLNL's multiscale strength model has been used to interpret the microscopic plastic flow in laser-driven Rayleigh-Taylor strength experiments, and how molecular dynamics (MD) and plasticity theory have been used to help understand in-situ diffraction based strength experiments for tantalum. The multiscale model provides information about the dislocation flow associated with plasticity and makes predictions that are compared with the experimental in-situ radiography of the Rayleigh-Taylor growth rate. We also use multi-million atom MD simulations inform the analytic theory of 1D to 3D plastic relaxation and compare to diffraction.

[1]This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

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Date submitted: 23 Jul 2012 Electronic form version 1.4