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Evolution of Plastic and Elastic Shock Waves on the Ultrafast Time Scale in a Face Centered Cubic Metal JONATHAN CROWHURST, MICHAEL ARMSTRONG, KIMBERLY KNIGHT, JOSEPH ZAUG, ELAINE BEHYMER, Lawrence Livermore National Laboratory — We characterize the deformation of pure aluminum in the first few hundred picoseconds subsequent to a dynamic load, at peak stresses up to 44 GPa and strain rates of in excess of 10^{10} s^{-1}. For strong shocks we obtain stresses, strain rates and plastic rise times. At peak stresses below 30 GPa, prior to the onset of plasticity we observe elastic stresses that are nearly ten times larger than those observed in traditional (longer time scale) shock compression experiments. We show that in the strong shock regime plastic rise times are very short ($< \sim 30$ ps) and spatial rises are less than ~ 300 nm. We show that our data are consistent with a simple power law dependence of strain rate on shock stress established at much lower strain rates; thus verifying this dependence over an additional 3 orders of magnitude in the strain rate. Together with the consistency of our strong shock data with the known shock adiabat of aluminum we conclude that the dynamic behavior of even very thin films (~ 1 μm) is indistinguishable from the bulk material, but below the strong shock threshold, time and hence length scale become critically important. This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract No. DE-AC52-07NA27344.

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