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Dynamic Strength of Metals at High Pressure and Strain Rate

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A new approach to materials science at very high pressures and strain rates has been developed on the Omega laser, using a ramped plasma piston drive. A laser drives an ablative shock through a solid plastic reservoir where it unloads at the rear free surface, expands across a vacuum gap, and stagnates on the metal sample under study. This produces a gently increasing ram pressure, compressing the sample nearly isentropically. The peak pressure on the sample, diagnosed with VISAR measurements, can be varied by adjusting the laser energy and pulse length, gap size, and reservoir density, and obeys a simple scaling relation.[1] This has been demonstrated at OMEGA at pressures to 200 GPa in Al foils. In an important application, using in-flight x-ray radiography, the material strength of solid-state samples at high pressure can be inferred by measuring the reductions in the growth rates (stabilization) of Rayleigh-Taylor (RT) unstable interfaces. RT instability measurements of solid of Al-6061-T6 [2] and vanadium, at pressures of 20-100 GPa, and strain rates of 10^6 to 10^8 s^{-1}, show clear material strength effects. Modelling results for two constitutive strength models – Steinberg-Guinan and Preston-Tonks-Wallace, show enhanced dynamic strength that may be correlated with a high-strain-rate, phono-drag mechanism. Data, modeling details and future prospects for this project using the National Ignition Facility laser, will be presented. [1] J. Edwards et al., Phys. Rev. Lett., **92**, 075002 (2004). [2] K. T. Lorenz et al., Phys. Plasmas **12**, 056309 (2005). This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.