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Plastic flow and lattice dynamics experiments on shock and ramp loaded solid-state samples at extreme pressures and strain rates[1]

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Experiments are being done on high power lasers, such as the Omega laser at LLE and the Janus and NIF lasers at LLNL, to probe the solid-state plastic response of materials to high pressure (50-500 GPa), and very high strain rate deformation (1.e6 - 1.e10 1/s). Two classes of experiments will be described. Dynamic Laue diffraction experiments with a time resolution of ∼0.1 ns have been developed to probe the microscopic lattice response of single crystal samples to a strong shock. In particular, the time scale for the onset of plasticity and the rate of the 1D to 3D lattice relaxation are a direct measure of how rapidly dislocations can be generated and transported on sub-nanosecond time scales (lattice kinetics). Macroscopic plastic flows at high pressure and strain rate can be generated that span a few tens of nanoseconds by using the Rayleigh-Taylor or Richtmyer-Meshkov fluid instabilities. Results from both classes of experiments will be compared with simulations using various models of flow stress (strength), a multi-scale model for bcc strength, and with analytic theory, where possible.

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