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Compression dynamics and lattice kinetics in laser driven shocks of BCC metals using dynamic Laue diffraction[1]

CHRISTOPHER WEHRENBERG, Lawrence Livermore National Laboratory

Laue diffraction experiments were used to directly observe the strain relaxation process in Ta shock compressed along the [001] direction. The unit cell aspect ratio was measured from Laue patterns at times ranging 0.1 to 1.6 ns relative to the shock wave entering the Ta sample. For 50 GPa shocks, the aspect ratio increases asymptotically to a value of 0.95 over the course of $\sim$ 1 ns. The 1 ns time scale is on the order of predictions of the relaxation time scale made using the Livermore multiscale strength model [Rudd, R SCCM 2011]. In contrast, ultra-fast (less than 10 ps) relaxation times are expected above the homogeneous nucleation threshold. Consistent with this behavior, Ta subjected to shocks at 90 GPa relaxes faster than the resolution of the diffraction experiments (approximately 150 ps). As the relaxation time will be dependent on the dislocation density, one can infer a dislocation density behind the 50 GPa shock front. Dislocation densities estimated in this manner agree with in an order of magnitude both with predictions by the multiscale model and with residual dislocation densities observed in post-mortem samples.

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