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Dislocation mechanics based constitutive equation descriptions for copper and iron in high rate deformation tests RONALD ARMSTRONG, WERNER ARNOLD, MBDA-TDW Schrobenhausen, FRANK ZERILLI, NSWC-IHD Retired — Different constitutive equations apply for the loading rate dependence of shock-induced plastic deformations in copper as compared with high rate shockless deformations in isentropic compression experiments (ICEs). In the shock case, the rate dependence is attributed to thermally-activated generation of a nanoscale dislocation structure at the propagating front. Exceptionally high shear-induced dislocation densities are produced. In high rate ICE-type shockless loading, different dislocation dynamics apply for mobile dislocations activated from within the originally-resident density. The lower density necessitates a higher dislocation velocity and, thus, a much higher drag-controlled flow stress is needed to sustain even lower strain rates than apply for shocks. A quasi-ICE strength result for copper is near to the theoretical limit. For iron, shock-induced plate impact results show competition at the Hugoniot elastic limit between different grain-size-dependent slip and deformation twinning stresses. The follow-on plastic strain rate is controlled by generation of a grain-size-independent nanoscale deformation twinning structure, consistent with dislocation mechanics considerations.

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