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2D Mesoscale Simulations of Quasielastic Reloading and Unloading in Shock Compressed Aluminum[1]

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2D mesoscale simulations of planar shock compression, followed by either reloading or unloading, are presented that predict quasi-elastic (QE) response observed experimentally in shocked polycrystalline aluminum. The representative volume element (RVE) of the plate impact experiments included a realistic representation of a grain ensemble with apparent heterogeneities in the polycrystalline sample. Simulations were carried out using a 2D updated Lagrangian finite element code ISP-TROTP incorporating elastic-plastic deformation in grain interior and contact/cohesive methodology to analyze finite strength grain boundaries. Local heterogeneous response was quantified by calculating appropriate material variables along in-situ Lagrangian tracer lines and comparing the temporal variation of their mean values with results from 2D continuum simulations. Simulations were carried out by varying a large number of individual heterogeneities to predict QE response on reloading and unloading from shock state. The heterogeneities important for simulating the QE response identified from these simulations were: hardened grain boundaries, hard inclusions, and micro-porosity. It is shown that the shock-deformed state of polycrystalline aluminum in the presence of these effects is strongly heterogeneous with considerable variations in lateral stresses. This distributed stress state unloads the shear stress from flow stress causing QE response on reloading as well as unloading. The simulated velocity profiles and calculated shear strength and shear stresses for a representative reloading and unloading experimental configuration were found to agree well with the reported experimental data. Work supported by DOE.

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