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Discrete Dislocation Dynamics Simulation of Polycrystalline Materials: Grain Boundary Sliding and Grain Size Effects

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The classical discrete dislocation dynamics (DDD) approach has been extended to model plasticity in a polycrystalline material. The model incorporates grain boundary sliding, and emission, absorption and transmission of lattice dislocations at the grain boundary. Grain boundary sliding is modeled by the emission of grain boundary dislocations from sources placed in the grain boundary, and the subsequent glide of these dislocations along the grain boundary plane. These mechanisms compete to relax the local stress field, elevating the role that the grain boundary plays beyond simply blocking dislocation slip. Using this model, we demonstrate that the mechanical response of polycrystals can be modified as these mechanisms act synergistically to account for the grain microstructure, the dislocation dynamics, and the grain boundary structure. The present model is used to study the effects of the polycrystalline grain size on the mechanical response.