MATERIALS ENGINEERING
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"Continuum Dislocation Dynamics Modeling of Mesoscale Crystal Plasticity at Finite Deformation"

By

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ABSTRACT

Over the past two decades, there have been renewed interests in using continuum models of dislocations to predict the plastic strength of metals from the basic dislocation properties. Such interests have been motivated by the unique self-organized dislocation microstructures that develop during the deformation of metals and the need to understand their origin and connection with strength of metals. In this respect, discrete dislocation dynamics is a valuable tool for studying systems of dislocations. However, due to the computational cost of discrete simulations, the study of dislocation systems at large scales becomes infeasible, and consequently, continuum models must be introduced. This talk focuses on the theoretical development of a model that utilizes a vector-density based representation of dislocation dynamics on the mesoscale, accounting for large crystal deformations. The relevant driving forces and transport equations for the model and its numerical solution are discussed. In the development of this model, a deficit of the current continuum models of dislocation was realized because only line information of the dislocation structures is utilized, even though the dislocations networks found in experiments contain both line and point information. To resolve this, we introduce more information about the dislocation network in the form of a junction point density using graph-theoretic ideas. The motion of the junction points produces a mechanism of increasing the line length of dislocations, which shows up as a new term in the vector-density based model's transport equations. Transport equations for junction point density, driving forces on the junction points, and the constitutive closure of the equations are discussed for the junction point density.

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