APCOM & ISCM
11-14th December, 2013, Singapore

FTMP-based Simulation and Continuum Description of Discrete Dislocation System

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This study proposes a method for a continuum description of discrete dislocation systems based on Field Theory of Multiscale Plasticity (FTMP). Dislocations are linear defects generally extended in 3D space in complex manners: They can bend, mutually tangle, multiply, annihilate and even yield topological changes (e.g., junction formations). Those pieces of information are discrete in nature and, at the same time, include complicated spatial information. FTMP-based incompatibility representation of the 3D dislocation system enables us to express not only the density-related information (i.e., change in the total length) but also those about the configurational changes such as rigid-body translations, local bowing-out and pinning-unpinning behaviors, including their directionalities, which are absent in the conventional dislocation density-based representation. The associated energy flow is also examined in detail based on the flow-evolutionary perspectives that relates the spatio-temporal fluctuation in the elastic strain energy with the incompatibility field.

Keywords: Field theory, Dislocation, Discrete dislocation dynamics, Incompatibility tensor, Continuum mechanics, Crystalline plasticity