Study of the effects of geometrically necessary dislocations and boundary conditions on size effects in a higher-order crystal plasticity model

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ABSTRACT

In this work a higher-order crystal plasticity model is used to study size effects that appear in sub-micron indentations and in the compression of nano-pillars. These size effects are normally associated to the presence of geometrically necessary dislocations (GNDs). Hardening mechanisms in crystal plasticity model can be phenomenologically associated to them by different models. In this work two possibilities are explored: energetic hardening, where density of GNDs contribute to the free energy of the material, and dissipative hardening, where only the rate of the density of GNDs are considered. As higher-order stresses are considered in the model, higher-order boundary conditions must be applied. These conditions are related to the flux of GNDs through the boundary.

In simulations considering indentation, a wedge indenter is used. If symmetry around the axis of the indenter tip is taken, higher-order boundary conditions must be considered throughout the symmetry plane. It is shown that these boundary conditions have a strong effect on results, changing the distribution of GNDs and the magnitude of the size effect. As lattice rotation distribution shows a discontinuity at the symmetry, it is also investigated how these rotations interfere or relate with boundary conditions. Also, in general, hardening associated to dissipation is larger than hardening associated to free energy. Finally, it is explored if the crystal plasticity model proposed is able to capture the changes in the failure of nano-pillars with size.

REFERENCES

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