seminario

STUDIES OF SMALL SCALE PLASTICITY

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We present a higher-order Strain Gradient Crystal Plasticity (SGCP) theory in which, for each glide, three dissipative length scales enter the model through the definition of an effective slip rate. Such a plasticity measure depends on the crystallographic projections of the plastic strain gradient rate and governs the isotropic hardening function. Also, the theory is characterised by a non-standard free energy involving a higher-order term called the defect energy, that is a function of Nye's dislocation density tensor and allows for the inclusion of energetic material length scales.

By focusing on a crystalline strip sheared between two bodies impenetrable to dislocations, we show which size effects the model can predict. In particular, we focus on the strengthening and increase in strain hardening accompanied with diminishing size, and on their relation both with dissipative and energetic material length scales and with single-slip and multi-slip behaviours.

By exploiting a Γ-convergence technique, we find an analytic solution in the "isotropic limit" of the crystal model, where any direction is assumed to be a possible slip system. This, supported by many simulations, shows that the phenomenologicalmodel of strain gradient plasticity which better approximates the crystal one is that constitutively involving the dissipation due to the plastic spin. The material parameter governing such a dissipation is identified by means of the comparison with the analytic integration of the balance equations obtained from the minimisation of the "isotropic" Γ-limit.

Finally, we present the results of a comparison between SGCP and discrete Dislocation Dynamics (DD). The DD results show a very large latent hardening size effect that, to be described by SGCP, requires a further gradient extension, affecting the standard latent hardening model conventionally employed in crystal plasticity. The resulting, quite complex, flow theory of SGCP has been implemented into finite elements in order to identify its material parameters on the basis of the pseudo-experimental results obtained from the DD simulations.

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