Simulating Size-Effects with Continuum Dislocation Dynamics

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ABSTRACT

Numerous experiments characterizing metal plasticity in micron-scale samples have revealed size-effects, where macroscopically well-defined materials properties appear to be dependent on the absolute sample size. It is now accepted that the majority of these size-effects are related to the discrete nature of plasticity on the micro-scale, which derives from the motion and interaction of dislocations.

The recently developed continuum dislocation dynamics (CDD) theory is a crystal plasticity law based on the averaged behaviour of dislocations [1]. A thermodynamically consistent constitutive theory for the average dislocation velocity entering the flow rule in CDD naturally leads to the occurrence of strain gradient dependent contributions to the critical resolved shear stress on the slip systems [2]. The internal length which enters is the average dislocation spacing, which is expected from experiments and theory. But CDD not only captures size-effects due to strain gradients but also those observed in nominally homogeneous deformations as the compression of micor-pillars as well as size effects related to the confinement of dislocations as observed in thin films.

In the current talk we shall present size-effects observed in numerical simulations of small scale tests employing a CDD-based crystal plasticity law. Examples include micro-compression tests, micro-bending and micro-torsion.

REFERENCES

[1] T. Hochrainer, S. Sandfeld, M. Zaiser and P. Gumbsch, 2014. Continuum dislocation dynamics: towards a physically theory of plasticity. *J. Mech. Phys. Solids*, Vol. 63, 167–178.

[2] T. Hochrainer, Thermodynamically consistent continuum dislocation dynamics, *J. Mech. Phys. Solids* , Vol. 88, 12-22 (2016)