Strain localization and dynamic recrystallization in polycrystalline metals: thermodynamic theory and simulation framework - COMPLAS 2019

Charles K. C. Lieou*[†], Hashem M. Mourad[†] and Curt A. Bronkhorst[†,††]

[†] Theoretical Division, Los Alamos National Laboratory
Los Alamos, NM 87545, USA
Email: clieou@lanl.gov

[††] Department of Engineering Physics, University of Wisconsin-Madison
Madison, WI 53706, USA
Email: cbronkhorst@wisc.edu - Web page:
https://directory.engr.wisc.edu/ep/Faculty/Bronkhorst_Curt/

ABSTRACT

We describe a theoretical and computational framework for adiabatic shear banding (ASB) and dynamic recrystallization (DRX) in polycrystalline materials. The Langer-Bouchbinder-Lookman (LBL) thermodynamic theory of polycrystalline plasticity [1,2], which we recently reformulated [3] to describe DRX via the inclusion of the grain boundary density or the grain size as an internal state variable, provides a convenient and self-consistent way to represent the viscoplastic and thermal behavior of the material, with minimal ad-hoc assumptions regarding the initiation of yielding or onset of shear banding. We implement the LBL-DRX theory in conjunction with a finite-element computational framework [4]. Favorable comparison to experimental measurements on a top-hat AISI 316L stainless steel sample compressed with a split-Hopkinson pressure bar suggests the accuracy and usefulness of the LBL-DRX framework, and demonstrates the crucial role of DRX in strain localization.

REFERENCES

[1] J.S. Langer, E. Bouchbinder and T. Lookman, "Thermodynamic theory of dislocation-mediated plasticity", *Acta Materialia*, **58**, 3718-3732 (2010).

[2] J.S. Langer, "Statistical thermodynamics of strain hardening in polycrystalline solids", *Phys. Rev. E* **92**, 032125 (2015).

[3] C..K.C. Lieou and C. Bronkhorst, "Dynamic recrystallization in adiabatic shear banding: Effective-temperature model and comparison to experiments in ultrafine-grained titanium", Int. J. Plasticity, **111**, 107-121 (2018).