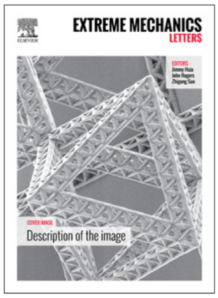
Accepted Manuscript



Non-Schmid effects and finite wavelength instabilities in single crystal metals

Hossein Salahshoor, Raj Kumar Pal, Julian J. Rimoli

PII: S2352-4316(17)30202-X
DOI: https://doi.org/10.1016/j.eml.2017.12.010
Reference: EML 339

To appear in: *Extreme Mechanics Letters*

Received date : 7 November 2017
Revised date : 22 December 2017
Accepted date : 29 December 2017

Please cite this article as: H. Salahshoor, R.K. Pal, J.J. Rimoli, Non-Schmid effects and finite wavelength instabilities in single crystal metals, *Extreme Mechanics Letters* (2018), https://doi.org/10.1016/j.eml.2017.12.010

Non-Schmid effects and finite wavelength instabilities in single crystal metals

Hossein Salahshoor, Raj Kumar Pal, Julian J. Rimoli*

270 Ferst Drive, Department of Aerospace Engineering,
Georgia Institute of Technology,
Atlanta, GA 30332-0150

Abstract

A long standing postulate in crystal plasticity of metals, known as Schmid law, states that yielding commences once the resolved shear stress on a slip plane reaches a critical value. While non-Schmid effects have previously been reported experimentally (mostly in alloys) and in molecular-dynamics simulations, we examine the validity of this assumption through phonon stability analysis. We subject four distinct single crystal metals to a combined shear-hydrostatic deformation and identify the onset of plasticity with the onset of an instability. We find significant shear-normal coupling in single crystal metals, reflecting non-Schmid effects in defect nucleation. Also, it is a widespread assumption in the literature [1, 2] that the instabilities in single crystal metals are of long wavelength. In contrast, we show that short wavelength instabilities are abundant. Our results illustrate the potential pitfalls of relying on the widely used elastic stability analysis for investigating defect nucleation.

Keywords: lattice instability, finite wavelength, dislocation nucleation, non-Schmid effects, homogenization

When a perfect single crystal is subjected to a deformation such that the energy at a lattice site exceeds the Pierels energy barrier, dislocations are nucleated there and move towards the boundary[3]. Dislocation nucleation in a perfect crystal can be identified with the onset of an instability under appropriate loading conditions, which breaks the local translation symmetry. Thus studying lattice instabilities provide fundamental insights into the mechanics of defect nucleation in single crystals, which is identified with the onset of plasticity. This article investigates two important aspects of the nature of defect nucleation in metallic crystals: I) Schmid Law; II) the type of instabilities.

Schmid law in crystal plasticity, which governs dislocation motion [4, 5, 6], was proposed by Boas and Schmid in 1934. It states that glide on a given slip system commences when its resolved shear stress reaches a critical value [7, 6].

*Corresponding author