A QUANTITATIVE MULTISCALE APPROACH FOR THE CLIMB OF JOGGED DISLOCATIONS

P.-A. Geslin (pageslin@gmail.com), B. Appolaire, A. Finel
LEM, ONERA/CNRS, CHÂTILLON, FRANCE

INTRODUCTION

Mesoscopic approaches to dislocation climb such as dislocation dynamics [1, 2] or crystal plasticity approaches [3] are based on several assumptions:

(i) Elastic interactions between dislocations and vacancies are neglected.
(ii) Transient regime is neglected.
(iii) The dislocation is assumed to act as a perfect source/sink of vacancies (local equilibrium assumption).
(iv) Diffusion is considered to take place in a hollow cylinder.

Objective: Discuss theoretically assumptions (iii) and (iv)

ANALYTICAL SOLUTION FOR A JOGGED DISLOCATION

1. Assumptions:
   - Jogs separated by \( d_j \) are at local equilibrium with vacancies.
   - Different formation energies and diffusion coefficients in the dislocation core and in the bulk.
   - Energy barriers between the core and the bulk.

2. Stationary diffusion equations in the bulk and in the core:
   \[
   \frac{\partial^2 c_v}{\partial r^2} + \frac{1}{r} \frac{\partial c_v}{\partial r} + \frac{\partial^2 c_v}{\partial z^2} = 0 \\
   D_c \frac{\partial^2 c_c}{\partial z^2} = 0
   \]

3. We solve Eqs. (1-2) with \( \xi = D_c \tau_c/a \). The climb rate is obtained by integrating the incoming flux:
   \[
   v_1 = \ln \left( \frac{D_c \tau_c}{r_c} \right) + \frac{\xi}{1 + 4 \sum_{k=1}^{\infty} \frac{1}{\xi} \left( \frac{1 - H_k}{2 \xi} - \frac{1 - H_k}{2 \xi} \right)}
   \]

CONCLUSION

- Thorough analytical solution for the climb of a jogged dislocation.
- Assumption (iii) is shown to be valid only for high jog concentrations.
- Brings insights on the activation energy of climb.
- Quantitative upscaling to a phase-field model enabling large scale simulations.
- Collective climb simulations show that the cylindrical assumption (iv) systematically overestimates the climb rate.

PERSPECTIVES

- Investigate the influence of elastic interactions between vacancies and dislocations.
- Choose \( L \) for a regime limited by jog nucleation (higher stresses).
- Couple with a phase-field model for dislocation glide.

REFERENCES


 Upscaling to a continuous phase-field model [4]