

Viscous relaxation of dislocation sub-structure evolution

Citation for published version (APA):

Yalcinkaya, T., Brekelmans, W. A. M., & Geers, M. G. D. (2009). *Viscous relaxation of dislocation sub-structure evolution*. Poster session presented at Mate Poster Award 2009 : 14th Annual Poster Contest.

Document status and date:

Published: 01/01/2009

Document Version:

Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

[Link to publication](#)

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

www.tue.nl/taverne

Take down policy

If you believe that this document breaches copyright please contact us at:

openaccess@tue.nl

providing details and we will investigate your claim.

Viscous Relaxation of Dislocation Sub-Structure Evolution

Tuncay Yalcinkaya,
W.A.M. Brekelmans,
M.G.D. Geers



The aim of the project

The aim of the project is to model the plastic anisotropy induced by the strain path changes in BCC metals. We follow three main modeling steps (Figure 1) in order to obtain a physically based multi-scale constitutive model. We started with the

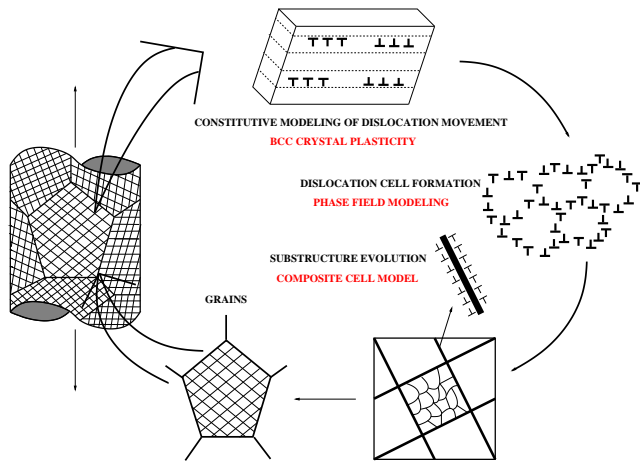
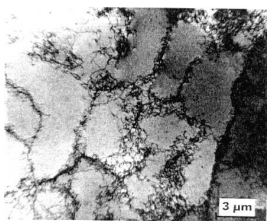


Fig. 1 Bridging between micro, meso and macro levels.

implementation of a **crystal plasticity** framework [1]. Then a **composite cell model** [2] was developed for the evolution of dislocation cells and the induced anisotropy. Now we are developing a method to predict the dislocation slip patterning.

Dislocation patterning



Dislocation patterning refers to the formation of regions of high and low dislocation densities. It is new a challenge to develop computational tools which can predict the emergence and the evolution of the dislocation sub-structures. Presented model, based on the relaxation of non-convex energies offers a new solution technique.

Field model - Non-convex SGCP

We solve the following system of equations with FEM,

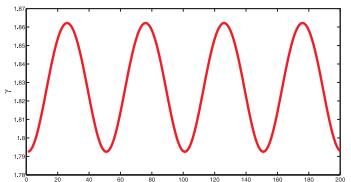
$$\begin{aligned} \frac{\partial \sigma}{\partial x} &= 0 \\ \dot{\gamma} - \dot{\gamma}_0 \left(\frac{\sigma^{\text{dis}}}{s} \right) \text{sign}(\sigma^{\text{dis}}) &= 0 \end{aligned} \quad (1)$$

where, σ^{dis} consists of stresses which are thermodynamically conjugate to variables γ , $\nabla\gamma$ and ε^e ,

$$\sigma^{\text{dis}} = \hat{\sigma}^{\text{dis}} \left(\frac{\partial \psi}{\partial \varepsilon^e}, \frac{\partial \psi}{\partial \gamma}, \frac{\partial \psi}{\partial \nabla \gamma} \right) \quad (2)$$

Free energy

Additional to convex parts ($\psi_e, \psi_{\nabla\gamma}$), a non-convex (ψ_γ) contribution of free energy enters the formulation via (2) and results in a **rate dependent non convex strain gradient crystal plasticity framework** which can model the formation and evolution of dislocation microstructures (right).



Spinodal decomposition of slip

Non-convexity in the free energy (ψ_γ) triggers the patterning between the spinodal points (Figure 2), however causes instability which results in mesh dependent behavior and an ill-posed BVP. The viscous effects and $\psi_{\nabla\gamma}$ part stabilizes the solution.

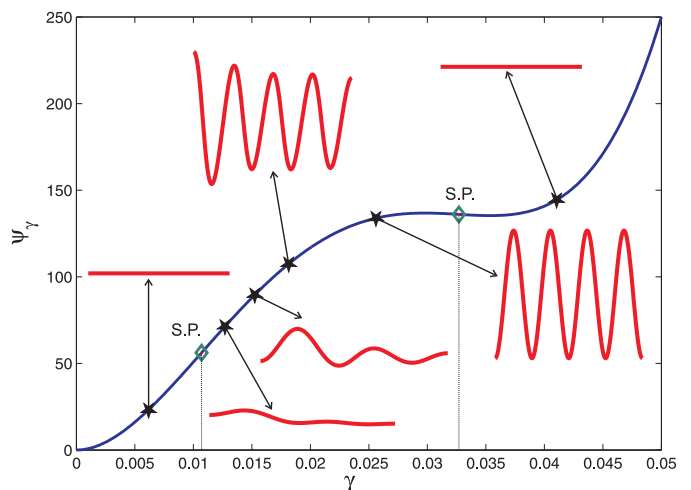
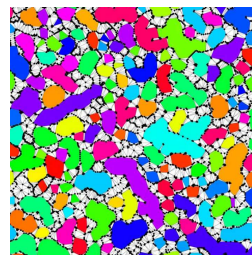


Fig. 2 Patterning of plastic slip between spinodal points.

Outlook



The current work is concentrated on the comparison of the presented model with different approaches. The next step is the multi-dimensional implementation of the model in order to have a more physical base for comparisons with experiments.

References:

- [1] YALCINKAYA T. , BREKELMANS W. A. M. , GEERS M. G. D.: *MSMSE. 16 2008 085007*
- [2] YALCINKAYA T. , BREKELMANS W. A. M. , GEERS M. G. D.: *MSMSE. 17 2009 064008*