Pile-up of dislocations in DP steels

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Introduction and aim of the project

Dual Phase (DP) steels consist of a ferritic matrix containing a hard martensitic second phase in the form of islands. The aim of the project is to understand the interplay between the microstructure of DP steels and their mechanical properties, in particular the effect of grain size on strain hardening.

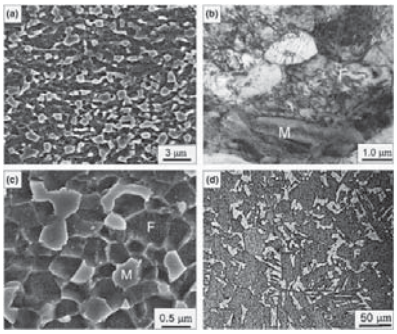


Figure 1: Microstructures of DP steels (From K.-T. Park et al., Scripta Materialia 51 (2004), 909-913).

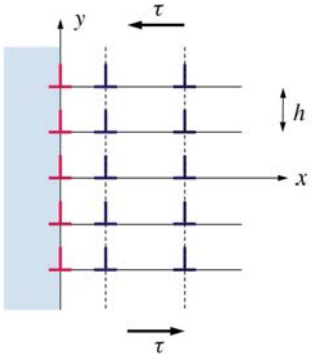
GOAL: To develop a physically based macroscopic model of DP steel, starting from a purely atomistic one, in a rigorous way.

Approach

This problem has a multi-scale nature and the focus of my research will be the micro-meso upscaling, i.e., the derivation of a model for the dislocation density starting from a purely discrete model of the pile-up of dislocations at a grain boundary.

Micro-Model: An Idealised Pile-Up

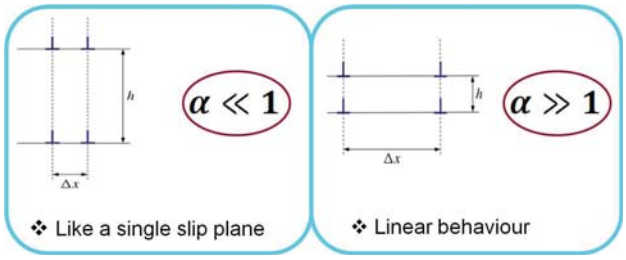
We model the dislocation pile-up in the ferrite grains adjacent to martensite as follows (see [1]):



- Impenetrable barrier
- Infinite wall
- Parallel & equidistant slip planes
- Applied shear stress

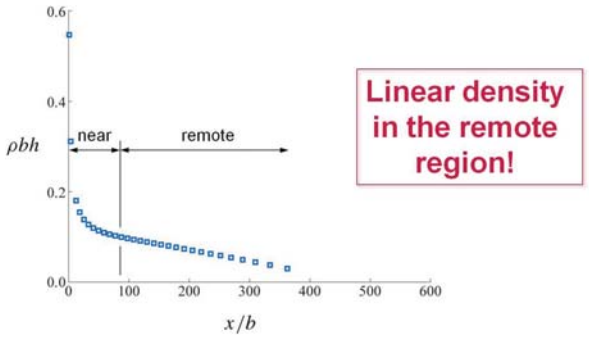
We use as a key parameter the ratio $\alpha := \frac{\Delta x}{h}$ and we analyse the cases $\alpha \ll 1$ (close to the obstacle), $\alpha \simeq 1$ (critical case) and $\alpha \gg 1$ (remote region) separately.

First Step: Heuristics



Results

Preliminary computations for the case $\alpha \gg 1$ suggest that the density of dislocations is linear in x, in agreement with the numerical results in [2]:



We also have results for the transition region, where we derived an ODE for the dislocation density.

Future Plans

Provide a characterization of the dislocation density over the whole pile-up region. Next, consider the case of multiple slip systems and the more ambitious case of moving dislocations.

References

[1] A. Roy, R.H.J. Peerlings, M.G.D. Geers and Y. Kasyanyuk (2008). *Mat. Sci. Eng. A-Struct.* **486**, 653–661.

[2] T.W.J. de Geus, R.H.J. Peerlings and C.B. Hirschberger. In preparation.