

## Strain path dependency in BCC crystals

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# Strain Path Dependency in BCC Crystals

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## Introduction

Materials experience a complex deformation history during sheet metal forming processes (see Fig. 1), which usually is characterized by a non-uniform strain path.

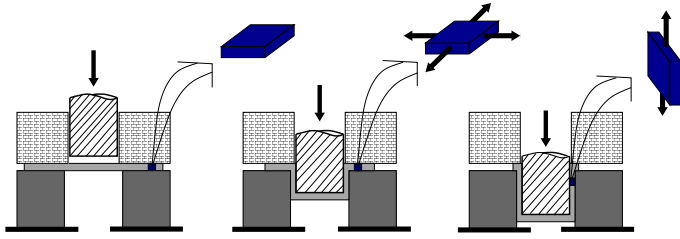
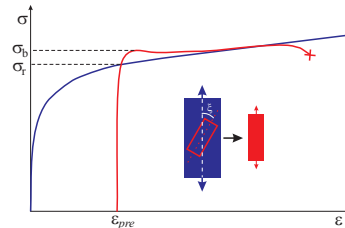


Fig. 1 Strain path change during deep drawing process.

## Objective

Changes in the strain path directions result in transient hardening and softening of the materials (right picture). The purpose of the present work is to develop a constitutive model which predicts the plastic anisotropy in BCC structured metals, by concentrating on the effect of the microstructure evolution during the non-uniform deformation history.



## Modeling strategy

The modeling starts with a proper description of dislocation movement. A **crystal plasticity** framework [1] is implemented and validated for this purpose. Evolution of the microstructure and its macroscopic effect on the material response is described by a **composite cell model** [2].

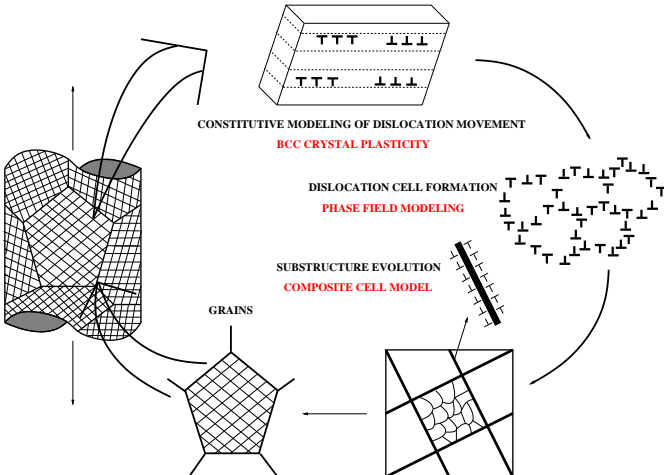
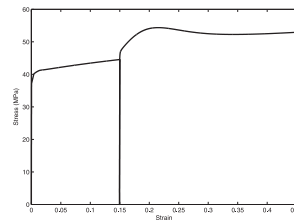
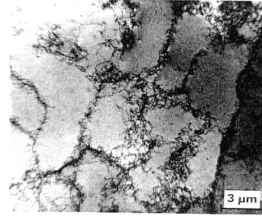


Fig. 2 Global modeling strategy including the bridges between micro, meso and macro levels.

## Composite cell model



Strain path change effects physically originate from a complex microstructure evolution (left picture). The present work deals with the contribution of the evolution of dislocation cell structures.

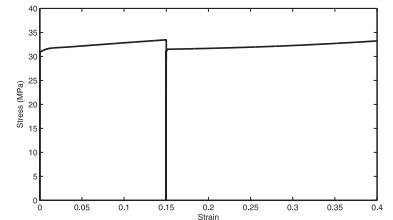
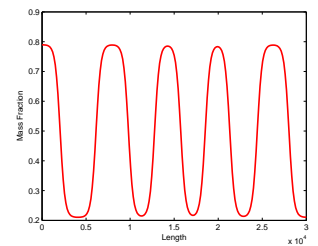


Fig. 3 [001]-[111] cross test and Bauschinger simulations.

Departing from an existing microstructure the evolution and the macroscopic response (see Fig. 3) are simulated. In order to make the loop (see Fig. 2) complete the formation of a dislocation substructure is being modeled by a **phase field approach**.

## Dislocation field model

It is assumed that the main reason of the formation of a two phase material is the non-convexity of the free energy. The figure at the right-hand side presents the 1D patterning of an initially random mass fraction according to the implemented phase field model.



A proper selection of the free energy expression, which reflects the dependency on the dislocation populations would result in a 2D dislocation substructure and corresponding internal stress fields.

## Current work

The current work is concentrated on the incorporation of a phase field model into the crystal plasticity framework. The identification of a non-convex configurational energy is the crucial point.

## References:

- [1] YALCINKAYA T. , BREKELMANS W. A. M. , GEERS M. G. D.: *BCC single crystal plasticity modeling and its experimental identification* (MSMSE. 16 2008 085007)
- [2] YALCINKAYA T. , BREKELMANS W. A. M. , GEERS M. G. D.: *A composite crystal plasticity model to describe strain path change effects in BCC structured metals* (to be submitted)