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.

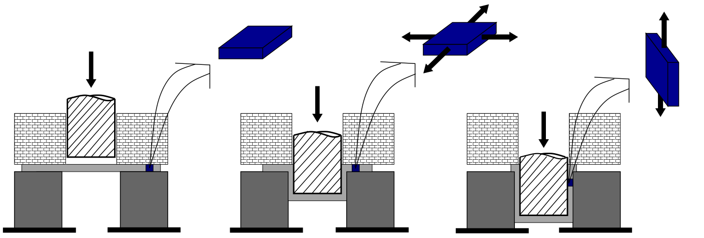
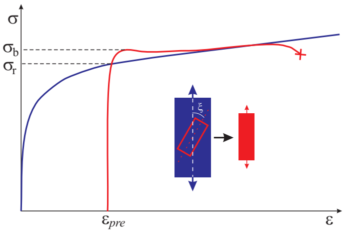


Fig. 1 *Strain path change during deep drawing process.*

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].

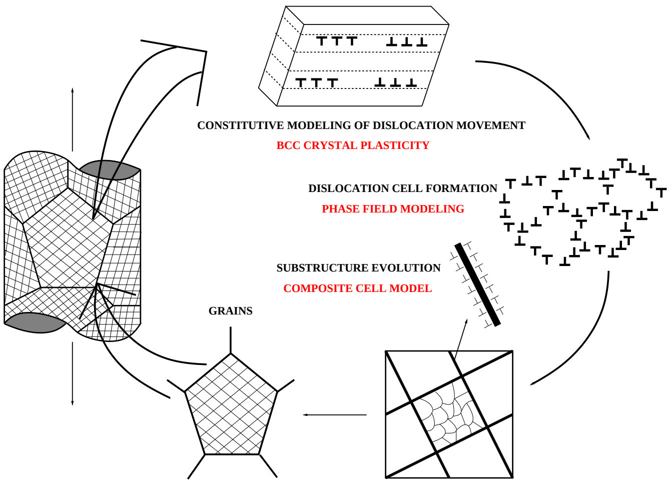
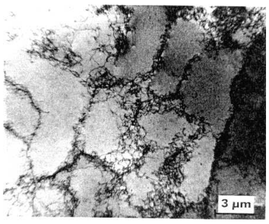


Fig. 2 *Global modeling strategy including the bridges between micro, meso and macro levels.*

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.

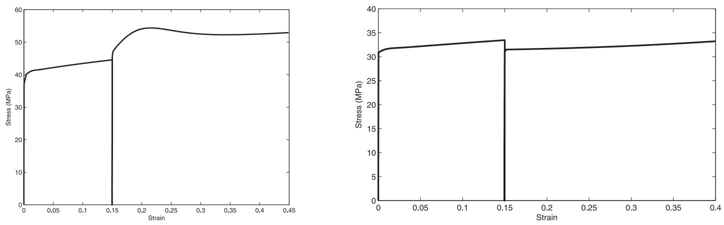
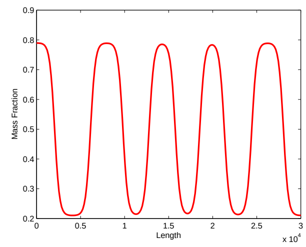


Fig. 3 *[001]-[111] cross test and Bauschinger simulations.*

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)