GAMM Seminar on Microstructures 2009
Regensburg, 16-17.01.2009

Friday, 16.01.2009

8:30	Registration (Mathematics Building, Room 104)
9:00	Opening
9:05	Paul Van Houtte *Hierarchical multi-level modelling of plastic anisotropy of textured polycrystalline materials*
9:50	Olga Dmitrieva and Patrick Dondl *Microstructure in shear deformed copper single crystals*
10:15	Julia Orlik *Homogenization for multi-scale periodic contact problems*
10:40	Coffee break
11:05	Petr Šittner *In-situ experimental characterisation of microstructure evolution in martensitically transforming materials*
11:50	Hanus Seiner *Introducing thermodynamic inequalities into theory of martensitic microstructure*
12:15	Bob Svendsen *Experimental investigation, modeling and simulation of microstructural development in aluminum alloys during extrusion*
12:40	Lunch break
14:00	Régis Monneau *Introduction to recent results on dislocation dynamics*
14:45	Hans-Dieter Alber *A model for plasticity with Hamilton-Jacobi equation via dislocation movement*
15:10	Ulisse Stefanelli *The WED formalism and microstructure evolution*
15:35	Thorsten Bartel *On relaxation-methods for solid-solid phase-transitions: micromechanical modelling, FE-application and discussion*
16:00	Coffee break
16:20	Dennis Kochmann *Modeling the time-continuous evolution of microstructures in finite plasticity*
16:45	Ilona Frankenreiter *A hybrid micro-macro model with FEM-resolved CODF-textures in finite plasticity*
17:10	Patrizio Neff *The Reissner-Mindlin model is the* Γ*-Limit of Cosserat elasticity*

17:35 Stefan Neukamm
Combining homogenization and variational dimension reduction to derive Γ-limits in nonlinear elasticity

18:00 Barbora Benešová
An energy-estimates based algorithm for rate-independent problems with applications to SMA

18:25 Closure of the afternoon program

18:30 Meeting of the GAMM Activity Group (members only)

20:00 Social dinner

Saturday, 17.01.2009

8:30 Martin Kruzik
A model of shape memory alloys accounting for plasticity

8:55 Sebastian Heinz
The evolution of laminates

9:20 Klaus Hackl
On various principles for inelastic evolution

9:45 Jörg Schröder
Statistically similar microstructures for multiscale simulations of two-phase steels

10:10 Coffee break

10:30 Ricardo H. Nochetto
Modeling, analysis and simulation of electrowetting on dielectric with contact line pinning

11:15 Adrien Petrov
On the error estimates for space-time discretizations of rate-independent processes

11:40 Andreas Melcher
A general phase-field model for polycrystals with elastic and micromagnetic contributions

12:05 Vladimír Lukeš
Homogenization and numerical modelling of the acoustic transmission on perforated interfaces

12:30 Concluding remarks

12:40 Lunch

Supported by: DFG through FOR 797 "Analysis and computation of microstructure in finite plasticity"; Universitätsstiftung Hans Vielberth; Universität Regensburg; Universität Bonn and GAMM.

GAMM Seminar on Microstructures 2009
Abstracts

A model for plasticity with Hamilton-Jacobi equation via dislocation movement

Hans-Dieter Alber
Fachbereich Mathematik
Technische Universität Darmstadt

In standard models of plasticity the evolution equation for the plastic strain tensor, the constitutive equations, consist of a system of ordinary differential equations in time. As a result, the plastic deformation behavior shown by these models is independent of the size and dimensions of the plastic body. This contradicts experimental results, which show that the plastic yield limit is higher for thin films than for solid bodies with non-small dimensions in all directions.
In this talk we present a model for plasticity, in which the evolution equation for the plastic strain tensor is a first order partial differential equation, a Hamilton-Jacobi transport equation. One expects that for such a model the plastic behavior depends on the dimensions of the body.
The model has two forms, a "conservation law form" and a "Hamilton-Jacobi form". In the conservation law form the evolution equations consist of a system of conservation laws, whose solution is the dislocation density. The dislocation density can be equal to a "Dirac distribution supported on a curve"; such a distribution solution models a line dislocation in the crystal. The formulation of the system is chosen such that such line dislocations move with driving force given by the Peach-Köhler force. However, the idea is to consider less singular solutions of this system; these solutions can have jumps, along which Rankine-Hugoniot conditions must be satisfied.
The conservation law form of the model can be readily transformed to an equivalent second form, the Hamilton-Jacobi form, where it takes the form of a standard crystallographic model, however with the right hand sides of the evolution equations for the strain tensor multiplied by the absolute value of the gradient of the internal variables. This is the form mentioned above, where the evolution equation is now a Hamilton-Jacobi transport equation.

On relaxation-methods for solid-solid phase-transitions: micromechanical modelling, FE-application and discussion

Thorsten Bartel
Fachgebiet Mechanik, insbesondere Maschinendynamik, Fakultät Maschinenbau
Universität Dortmund

No abstract.

An energy-estimates based algorithm for rate-independent problems with applications to SMA

Barbora Benešová
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Prague, Czech republic

This talk shall present how a well-known necessary condition, derived in the framework of rate-independent processes, namely the two-sided energy inequality, may be implemented into simulation algorithms. Such a implementation may lead to better computation results. We shall recall the derivation and present the selectivity of the condition in question. Moreover numerical examples, namely simulations of the behaviour of a SMA-specimen, shall be given. It will be demonstrated that in some cases the verification of this condition indeed leads to better computation results, in other however it will be shown that it is a too weak condition.

Microstructure in shear deformed copper single crystals

Olga Dmitrieva and Patrick Dondl
Max-Planck-Institute for Iron Research, Düsseldorf
and
Max-Planck-Institut für Mathematik in den Naturwissenschaften, Leipzig

We investigate the formation of microscopic patterns in a copper single crystal deformed in a shear experiment. Using high-resolution electron backscatter diffraction (EBSD) imaging, we find a band-like microstructure consisting of confined areas in the sample with rotated lattice. Digital image correlation (DIC) allows us to exactly determine the macroscopic state of deformation of the sample. This data can be used as a side condition to calculate the lamination parameters from the theory of kinematically compatible lamination of separate material regions, each deforming in single slip. The parameters given by the theory agree with the measured properties, i.e., a lattice rotation of 3 degrees and a lamination normal rotated 7 degrees counterclockwise from a $\langle 111 \rangle$ direction.

A hybrid micro-macro model with FEM-resolved CODF-textures in finite plasticity

Ilona Frankenreiter
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Universität Stuttgart

The lecture outlines recent developments towards an efficient theoretical and algorithmic modeling of evolving crystal orientation microstructures in finite plasticity of polycrystals. We construct a framework for the description of grain texture induced anisotropy in planar polycrystals based on a hybrid micromacro modeling. On the macroscopic side this concerns a purely phenomenological setting of anisotropic finite plasticity based on evolving structural tensors accounting for the deformation-induced macroscopic anisotropy. On the micro-mechanical side, the macro-model is linked with an accompanying microscopic plasticity model that accounts locally for microscopic structural changes in the form of grain re-orientations. The model-inherent scale bridging is accomplished by an evolving crystal orientation distribution function (CODF), which governs the evolution of the structural tensors. The evolution of the CODF is determined by a microstructural balance equation. Here, we discuss an efficient numerical implementation of evolving CODFs by a distinct finite element method (FEM) which discretizes the orientation space. The new approach is compared with the known entropy method and selected exact solutions. The new model provides an efficient and computationally handable two–scale approach for the prediction of the complex microstructures evolution in polycrystals. The capability of the proposed method is demonstrated by means of representative numerical examples. This is joint work with D. Rosato and C. Miehe

On various principles for inelastic evolution

Klaus Hackl
Lehrstuhl für Allgemeine Mechanik
Ruhr-Universität Bochum

We study the evolution of systems described by internal variables. After the introduction of thermodynamic forces and fluxes various variational formulations are introduced which allow to specify the the fluxes as function of the forces. These principles are related to each other. Several cases are shown where the principles lead to the same evolution equations for the internal variables. However, also counter-examples are reported where such an equivalence is not valid. Different application will be given and the relationship to the theory of configurational forces will be highlighted.

K. Hackl, F.D. Fischer. On the relation between the principle of maximum dissipation and inelastic evolution given by dissipation potentials. Proc. Roy. Soc. London A, 464: 117132, 2008.

The evolution of laminates

Sebastian Heinz
Weierstrass Institute for Applied Analysis and Stochastics
Berlin

We study the evolution of microstructure in finite plasticity. In order to prescribe the mathematical model, we use an energetic formulation in the context of general standard materials. The deformations with small energy are expected to show microstructure, because of a lack of convexity in the model.
Our idea is to incorporate information on the microstructure into the inner variable. As a first step, we shall allow the inner variable to take values in the set of first-order laminates. Since the set of all first-order laminates does not wear the structure of a vector space, we will treat it as a metric space rather than a subset of a Banach space. The main concern of the talk will be to show how to transfer concepts of (reflexive) Banach spaces to metric spaces. In particular, we are interested in Sobolev spaces in a metric framework and the corresponding compact-embedding theorems.
This is joint work with Klaus Hackl and Alexander Mielke.

Modeling the time-continuous evolution of microstructures in finite plasticity

Dennis Kochmann
Lehrstuhl für Allgemeine Mechanik
Ruhr-Universität Bochum

Plastic deformation of crystalline solids very often gives rise to the formation of material microstructures experimentally visible as dislocation patterns. These microstructures are not inherent to the material but occur as a result of deformation. Modeling a physically deformed crystal in finite plsticity in terms of its displacement field a set of internal variables which capture the microstructural characteristics, we employ energy principles to analyze the microstructure initiation and subsequent evolution via standard minimum principles. In particular, for non-quasiconvex energy potentials the minimizers are no longer continuous deformation fields but small-scale fluctuations related to probability distributions of deformation gradients to be calculated via energy relaxation. We review the variational concepts of the underlying energy principles for inelastic materials. Central to this framework is a Lagrange functional consisting of the sum of elastic power and dissipation due to changes of the internal state of the material. For compuation of the relaxed quantities, we assume first- and second-order laminate microstructures. Based on this approach, we present explicit time-evolution equations for volume fractions and internal variables, then outline a numerical scheme by means of which the microstructure evolution can be computed, and show numerical results for particular examples in single- and multi-slip plasticity.

A model of shape memory alloys accounting for plasticity

Martin Kruzik
Institute of Information Theory and Automation of the ASCR

We formulate a model of phase transformation in shape memory alloys including cyclic plasticity effects. The sketch of a proof of a solution will be shown.

Homogenization and numerical modelling of the acoustic transmission on perforated interfaces.

Vladimír Lukeš
University of West Bohemia,
Pilsen, Czech Republic

The presentation will explain how the acoustic transmission through perforated interface can be treated using asymptotic analysis. The homogenized transmission conditions are imposed on an interface plane separating two halfspaces occupied by the acoustic medium. The conditions were obtained recently as the two-scale homogenization limit of the Helmholtz equation involved in the standard acoustic problem. This is imposed a the layer which embeds a sieve-like obstacle with periodic structure. The limit model is featured by the acoustic pressure discontinuity, whereas the acoustic momentum is continuous. The homogenized impedance coefficients depending on the so-called microscopic problems; these are imposed in the reference computational cell, Y embedding the obstacle.
This homogenization approach allows for an efficient treatment of arbitrary complicated perforation designs of perforations. For certain type of non-planar perforations (obstacles) the transversal acoustic transmission induces surface waves propagating along the perforation. It was observed that by changing the microstructure, i.e. the geometry of the perforation, the impedance properties of the layer can be modified to a great extent. In the talk the key assumptions and homogenization steps will be mentioned, then using some numerical examples we illustrate properties of the homogenized transmission conditions. Namely the influence of the thickness layer and of the representative cell Y definition will be discussed.
This is joint work with Eduard Rohan

A general phase-field model for polycrystals with elastic and micromagnetic contributions

Andreas Melcher
Institut für angewandte Forschung
Hochschule Karlsruhe Technik und Wirtschaft

A phase-field model coupled with elastic and micromagnetic contributions is introduced to describe the time spatial evolution of a polycrystal under the influence of

strains and in the presence of a magnetic field. We introduce the model in terms of a general Ginzburg-Landau free energy functional and derive a coupled system of partial differential equations for the vector valued phase-field variables, for the displacement-field and for the spontaneous magnetisation. Applications of the model to cubic and tetragonal crystal symmetries of the polycrystal are discussed. Finally we give a short insight into the numerical implementation.
This is joint work with Britta Nestler

Introduction to recent results on dislocation dynamics

Régis Monneau
CERMICS - ENPC
Marne la Vallée, France

Dislocations are microscopic defects present in crystals that are one the main explanations of the plastic behaviour of metals. These defects can be seen as curves moving in crystallographic planes. The typical length of these defects is of the order of the micrometer. The normal velocity of these curves is proportional to one component of the stress in the material (called the resolved Peach-Koehler force). One important fact, is that every dislocation curve creates its own stress field. In the framework of linear elasticity, the total stress appears naturally to be the sum of the contributions created by each defect in the material.
We are interested in the collective behaviour of such defects and will present some homogenization results on this dynamics of defects. In other words, we will explain how to replace the microscopic dynamics, by an effective macroscopic dynamics at large scales. To be able to perform rigorously this homogenization, we restrict our study to a particular geometry where all dislocation curves are contained in a single slip plane and have the same nature (namely have the same Burgers vector). In this particular situation, we can develop nonlinear homogenization technics in the framework of viscosity solutions for nonlocal PDE's. As a result of this homogenization procedure, we can predict a viscoplastic law at the macroscopic level.
For some pedagogical reasons, we will illustrate this procedure in the particular case of the fully overdamped dynamics of particles with two-body interactions. We will also present some numerical simulations to compute the effective macroscopic dynamics.

The Reissner-Mindlin model is the Γ-limit of Cosserat elasticity

Patrizio Neff
Fachbereich Mathematik
TU Darmstadt

We show that the Reissner-Mindlin membrane-bending plate model can be exactly obtained as the rigorous Γ-limit for zero thickness of a linear isotropic Cosserat bulk model with symmetric curvature. For this result we use the natural nonlinear scaling for the displacements u and the linear scaling for the infinitesimal microrotations $\overline{A} \in \mathrm{so}(3)$. We also provide formal calculations for other combinations of scalings whereby be retrieve other plate models previously proposed in the literature by formal asymptotic methods as corresponding Γ-limits. No boundary conditions on the microrotations are prescribed.

Combining homogenization and variational dimension reduction to derive Γ-limits in nonlinear elasticity

Stefan Neukamm
Forschungseinheit M6
Technische Universität München

We study the low energy limit behavior of a (geometric nonlinear) hyperelastic composite material occupying a thin two-dimensional domain with cell periodic inhomogeneity when the thickness h and the size of the inhomogeneity ε simultaneously converge to zero. More precisely, we analyze the scaled elastic energy

$$E^{h,\varepsilon}(u) := \frac{1}{h^3} \int_{\Omega_h} W(\nabla u(x);\, \tfrac{x_1}{\varepsilon})\, dx$$

of a deformation $u : \Omega_h \to \mathbb{R}^2$ with $\Omega_h := (0,1) \times (-h, h)$ and an energy density $W(F; y)$ which is periodic in y and vanishing for $F \in SO(2)$.
Using the notion of Γ-convergence, we derive bending models by combining homogenization methods related to two-scale convergence and variational dimension reduction. It turns out that the structure of minimizing sequences depends on the coupling behavior between h and ε.

Modeling, analysis and simulation of electrowetting on dielectric with contact line pinning

Ricardo Nochetto
Department of Mathematics, University of Maryland
College Park, Maryland, USA

Electrowetting on dielectric (EWOD) refers to a parallel-plate micro-device that moves fluid droplets through electrically actuated surface tension effects. These devices have potential applications in biomedical 'lab-on-a-chip' devices (automated DNA testing, cell separation) and controlled micro-fluidic transport (e.g. mixing and concentration control). We model the fluid dynamics using Hele-Shaw type equations (in 2-D) with a focus on including the relevant boundary phenomena, such as viscous damping and contact line pinning (sticking of the interface). The latter leads to a variational inequality on the liquid-gas interface. We use mixed finite elements for space discretization and a semi-implicit time discretization of curvature based on an explicit representation of the interface. We analyze this approach, present simulations and compare them to experimental videos of EWOD driven droplets. These experiments exhibit droplet pinching and merging events and are reasonably captured by our approach. This is joint work with S. Walker, A. Bonito, and B. Shapiro.

Homogenization for multi-scale periodic contact problems

Julia Orlik
Fraunhofer ITWM, Abteilung SYS
Kaiserslautern

We consider an elastic body with a periodic microstructure and micro-rough boundary. The multiple frictional contact is considered inside the body between its microstructured components and outside at a part of its rough boundary. The size of the micro-peaks and -valleys at the rough boundary as well as the size of the microstructure is very small compared to the macrosize of the body. This makes a direct numerical computation of the contact elasticity problem too expensive. A small geometric parameters is introduced, which denotes the period of structure and thickness of the rough boundary layer. Physical contact parameters were scaled related to the micro-geometry. The asymptotic analysis and two-scale convergence were applied to the milti-scale contact problem. The overcoming to the limit in the contact frictional functional with respect to period of structure provides an equivalent elasto-plastic macroscopic behaviour of the body and the overcoming to the limit with respect to the rough boundary provides an effectiv macroscopic contact condition.

On the error estimates for space-time discretizations of rate-independent processes

Adrien Petrov
Weierstraß-Institut für Angewandte Analysis und Stochastik
Berlin

In this talk, we are interested in error estimates for space-time discretizations in the context of rate-independent processes. After introducing a semilinear problem, we discuss a fully-discrete approximation and provide a priori error estimates. In particular, an explicit space-time convergence rate is obtained for the isothermal Auricchio-Souza model for shape-memory alloys.

Statistically similar microstructures for multiscale simulations of two-phase steels

Jörg Schröder
Institut für Mechanik, Fakultät für Ingenieurwissenschaften
Universität Duisburg-Essen, Essen

In order to optimize stiffness while minimizing dead weight modern steels make use of multi-phase microstructures. A suitable numerical tool for the modeling of these materials is the FE^2-method since phenomena as macroscopic anisotropy or internal stress distributions are captured by taking into account the microstructural influences of individual phases. We first focus on the framework of a two-scale homogenization procedure, where the introduction of a representative volume element (RVE) reflects the real microstructure. The mechanical behavior of Dual-Phase (DP) steels (consisting of ferrite and martensite) is influenced by a microheterogeneous initial plastic strain distribution arising from a volumetric jump of martensite when transforming from austenite during the production process. We propose a method that incorporates these initial plastic strains into the FE^2-simulation in some sense. In order to increase efficiency of the FE^2-method we present in this contribution a procedure for the construction of statistically similar RVE's of less complexity, which cover some characteristic morphology parameters.
This is joint work with Daniel Balzani

Introducing thermodynamic inequalities into theory of martensitic microstructure

Hanus Seiner
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Academy of Sciences of the Czech Republic, Prague

Since the pioneering works of Ball and James in 1980's, the theoretical description of martensitic microstructures in shape memory alloys (SMAs) became a self-sustained branch of material science, combining advanced mathematics (calculus of variation), thermodynamics (systems with multi-well Helmholtz free energy) and engineering (systems with mechanical hysteresis). However, this theory, although well developed, is, nevertheless, not sufficiently supported by experimental observations. Especially our understanding of thermally induced microstructures in single crystals of SMAs is lacking. In the presented talk, the cases of microstructures unpredictable by the classical theories will be shown, whereto the possibility of extending this theory by involving the thermodynamic inequalities will be discussed. The problem will be illustrated on three different specific examples (all forming during the shape recovery process in single crystals of the Cu-Al-Ni alloy): 1.Interfacial microstructures with two intersecting habit planes (X-interfaces); 2.'Smooth' twinned-to-detwinned interfaces in martensite. 3. Non-classical interfaces with curved habit planes.

In-situ experimental characterisation of microstructure evolution in martensitically transforming materials

Petr Sittner
Fyzikalni ustav AVCR, v.v.i.
Praha, Czech Republic

Unique thermomechanical properties of shape memory alloys /SMA/ due to martensitic phase transformations are accompanied by reversible and irreversible evolution of microstructures. If we have more and better information about these microstructural changes we will be able to significantly improve the existing and even come up with completely new engineering applications of these exciting materials. This is why microstructural evolutions in SMAs are presently studied both experimentally and theoretically by many research teams worldwide.
In my talk, I will introduce and discuss the use of two innovative experimental methods (in situ neutron and X-ray diffraction and in-situ electric resistivity) elaborated in recent years at IP ASCR in Prague to the problems in mechanics (I) and material science/engineering (II) of SMAs.
Ad I) It will be discussed how we can recognize (with these two experimental methods and earlier developed micromechanics model) the activity of various deformation/transformation mechanisms (e.g. elastic deformation, phase transformation, twinning, dislocation plasticity) involved simultaneously during thermomechanical loadings of SMAs, particularly NiTi and Cu-based SMAs. The experimental methods in this case help to develop micromechanics models of SMAs or are used in SMA application oriented research.
Ad II) The two experimental methods have been applied to the investigation of physical processes taking place during nonconventional final thermomechanical treatment of NiTi by electric current /FTMT-EC/. This is a very recenty developed method of the final conditioning of NiTi filaments (i.e. material science/engineering problem). The heavily deformed (cold worked) NiTi wire with nanostructurized microstructure is heated by a very short pulse of electric current under external constraint. During few millisecond time period of the DC pulse, as the wire is exposed to high temperature and stress, the cold worked heavily dislocated microstructure transforms to a nanosized dislocation free microstructure in which it shows excellent functional properties – different, and in some respect much better, compared to that of the conventional NiTi wires. It will be discussed how the in situ diffraction and in-situ electric resistivity measurements have been beneficially used while developing the FTMT-EC method.

The WED formalism and microstructure evolution

Ulisse Stefanelli
IMATI - CNR
Pavia, Italy

I shall report on the use of so-called *weighted energy-dissipation* (WED) functionals for the description of dissipative evolution.
The WED functional approach has been originally advanced by A. Mielke and M. Ortiz as a suitable tool for describing effective problems related to microstructure evolution in the rate-independent context. Later on, S. Conti and M. Ortiz carried this program further to the rate-dependent realm by providing two specific examples of WED functionals relaxations arising in microstructure evolution.
I will comment on the underlying basic convergence issue and show applications to the aforementioned examples.
This research has been developed jointly with A. Mielke.

Experimental investigation, modeling and simulation of microstructural development in aluminum alloys during extrusion

Bob Svendsen
Institute of mechanics
Dortmund University of Technology

The purpose of this work is the characterization, modeling and simulation of microstructural development in aluminum alloys during extrusion processes. In particular, attention is focused on Al-Mg-Si alloys of the 6000 series. During extrusion, the dislocation and microstructural development is governed by recovery, whereas recrystallization and precipitate formation may take place during cooling. The material properties are strongly dependent on the resulting microstructure.
Using Electron Back Scattering Defraction (EBSD), one can experimentally characterize microstructural development in such alloys during extrusion. Characteristics here include for example grain size, grain shape, and grain misorientation. In addition, this method can be used to characterize the grain structure for the purpose of finite element simulations. Examples will be given.

Hierarchical Multi-Level Modelling of Plastic Anisotropy of Textured Polycrystalline Materials

Paul Van Houtte
Katholieke Universiteit Leuven, Departement MTM
Leuven, Belgium

Polycrystalline metals with a pronounced crystallographic texture feature anisotropic plastic behaviour. This should be taken into account in finite element (FE) simulations of metal forming processes, or in predictions of sheet formability. One of the ways to achieve this is the use of an anisotropic constitutive model described by an analytical expression (such as an anisotropic yield locus) which contains a certain number of parameters to be chosen in such way that the desired anisotropy is reproduced. It is possible to identify these parameters using mechanical test results. However, this method is not capable of reproducing the anisotropic material response for all stress states or strain rates which can be imagined. An alternative approach, called "hierarchical multilevel method", is to identify the parameters using a multilevel model. Such model would typically take the crystallographic slip in the individual grains of the material into account, and it needs a description of the microstructure. The simplest of these models, such as the Taylor theory, only need the orientation distribution function describing the texture. More sophisticated models such as the ALAMEL model [1] need more detailed information about the microstructure. In any case, such models could be used to predict the anisotropic response of the material for a large number of stress or strain modes, thus enabling the identification of the parameters of a sophisticated analytical constitutive model. The "Facet" method is a recent approach of this type [2]. It is based on an analytical expression of plastic potentials in strain rate space and/or stress space. The method has been designed to be used in combination with a multilevel model for the plastic deformation of the polycrystalline material. The parameters of the expressions for the plastic potentials are identified by fitting to the predictions of the multilevel models instead of being fitted to the results of mechanical tests. This formulation has the advantage that it automatically ensures convexity of the anisotropic yield loci. It can in principle be used with more advanced multilevel models than the Taylor theory, such as the ALAMEL model. In contrast to most existing methods, the new method can also be applied to materials with a stress differential effect, as those which have been prestrained [3]. Some results obtained through the Facet method will be shown.

[1] P. Van Houtte, S. Li, M. Seefeldt and L. Delannay: "Deformation texture prediction: from the Taylor model to the advanced Lamel model", Int. J. Plasticity 21 (2005) 589-624.
[2] Van Houtte, P., Yerra, S.K. and Van Bael, A., 2008. The Facet method: a hierarchical multilevel modelling scheme for anisotropic convex plastic potentials. Int. J. Plasticity 25 (2009) 332-360.
[3] Peeters, B. Kalidindi, S.R., Teodosiu, C., Van Houtte, P., Aernoudt, E. A theoretical investigation of the influence of dislocation sheets on evolution of yield surfaces in single-phase b.c.c. polycrystals, Journal of the Mechanics and Physics of Solids, 50, 2002, 783-807