UNIVERSITÄT PADERBORN
Die Universität der Informationsgesellschaft

LTM
Lehrstuhl für Technische Mechanik

26. Workshop
Composite Forschung in der Mechanik
6. Forum Metallplastizität
11. und 12. Dezember 2013
Paderborn, Liborianum

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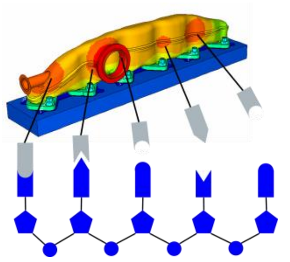

GRADUATE SCHOOL 1483
Process Chains in Production:
Interaction, Modelling and Assessment of Process Zones

DFG Sonderforschungsbereich
Transregio 30

26. Workshop Composite Forschung / 6. Forum Metallplastizität / Funktional gradierte Strukturen

Vorwort

Wie in den Jahren 2009 und 2011 führen die AG Composite aus Paderborn und Karlsruhe, das Graduiertenkolleg des SFB/TR 30 der Universitäten Kassel, Dortmund und Paderborn sowie das Graduiertenkolleg 1483 der Universität Karlsruhe jetzt zum dritten Mal einen gemeinsamen Workshop zu Werkstoffuntersuchungen durch. Dazu waren auch in diesem Jahr Wissenschaftler aus verschiedenen Bereichen aufgefordert, ihre Erkenntnisse über aktuelle Fragestellungen zu Metallen und Kunststoffen unter Berücksichtigung der Mehrskaligkeit vorzustellen. Im Vordergrund stehen wie in den Vorjahren Entwicklungen der experimentellen Charakterisierung, der mathematischen Modellierung und der Simulation zur Beschreibung, Bewertung und Optimierung von Bauteilzuständen in verketteten Fertigungsprozessen.

Gemeinsame Workshops mit Wissenschaftlern verschiedener Fachrichtungen haben in der Vergangenheit in Paderborn zu spannenden und aufschlussreichen Diskussionen geführt, auf die wir uns auf Grund der interessanten eingereichten Beiträge auch in diesem Jahr freuen dürfen.

T. Böhlke, O. Wünsch, V. Schulze, B. Nestler, R. Mahnken

Ermöglicht durch die freundliche Unterstützung
des DFG-Sonderforschungsbereichs
Transregio 30

26. Workshop Composite Forschung / 6. Forum Metallplastizität

Ein gemeinsamer Workshop des DFG Graduiertenkollegs 1483

und des DFG Sonderforschungsbereiches Transregio 30

Programm

Mittwoch, 11. Dezember 2013

9:00 Eröffnung

Experiments and Processes
Chairman: O. Wünsch

09:05-09:35 **C. Cheng, R. Mahnken:** Macroscopic and mesoscopic modelling based on the concept of generalized stresses for cutting simulation

09:35-10:05 **R. Ostwald; M. Tiffe; T. Bartel; A. Zabel; A. Menzel, D. Biermann:** Efficient assessment of in-process phase-transformations – application to machining processes

10:05-10:35 **O.Viun, F. Labesse-Jied, R. Moutou-Pitti, Y. Mezouar, V. Loboda, Y. Lapusta:** Modeling of active piezoelectric composite structures with cracks.

10:35-11:00 Kaffeepause

Experiments and Processes
Chairman: O. Wünsch

11:00-11:30 **A. Wibbeke, V. Schöppner:** Graded structures in films

11:30-12:00 **M. Schaper :** In-situ Characterization of metallic materials using digital image correlation

12:10 Gruppenfoto

12:30-13:45 Mittagessen

Plasticity and Phase transformation
Chairman R. Ostwald

14:15-14:45 **D. Schneider, O. Tschukin, A. Choudhury, M. Selzer, B. Nestler:** phase-field modelling of stress evolution in heterogeneous structures

14:45-15:15 **A. Kumar, M. Rajdip, B. Nestler:** Theoretical and numerical study of eutectoid transformation in diffusion controlled regime

15:15-15:45 Kaffeepause

Plasticity and Phase transformation
Chairman R. Ostwald

15:45-16:15 **K.-U. Widany, R. Mahnken:** Approximation of the dual problem for error estimation in elasto-plasticity

16:15-16:45 **C. Dammann, R. Mahnken:** On the simulation of strain induced anisotropy for polymers

16:45-17:15 **Y. Lapusta, M. K.-Marchant, N. Zalachas, F. Labesse-Jied, N. Gippius**: Finite element modelling of bi-material structures based on hydrogels

19:00 Abendessen im Liborianum

Donnerstag, 12. Dezember 2013

Multi-Scale and Homogenisation
Chairman: Y. Lapusta

09:00-09:30 **J.-W. Simon, B. Stier, S. Reese:** Multiscale Modeling of fiber reinforced laminated composites

09:30-10:00 **F.Rieger, T.Böhlke***:* Two-Scale Modeling of Dual-Phase Steels

10:00-10:30 **S. Schmitt, K. Schulz, P. Gumbsch:** From discrete dislocations towards a dislocation density based continuum formulation for plasticity

10:30-11:00 Kaffeepause

Multi-Scale and Homogenisation
Chairman: Y. Lapusta

11:00-11:30 **R. Glüge, J. Kalisch**: An interface orientation distribution based approach to analytical homogenization

11:30-12:00 **M. Lobos, T. Böhlke:** Representation of Hashin-Strikman Bounds of textured cubic crystal aggregates with application in material design

12:30 Abschlussworte

12:30-13:30 Mittagessen

ABSTRACTS

MACROSCOPIC AND MESOSCOPIC MODELING BASED ON THE CONCPET OF GENERALIZED STRESSES FOR CUTTING SIMULATION

C. Cheng[1], M. Düsing[1], R.Mahnken[1], I.M.Ivanov[2], E.Uhlmann[2]
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Abstract

Based on the concept of generalized stresses that proposed by GURTIN [1] and FORESTet al.[2] macro- and meso-scopic modelling have been made. For the macroscopic modelling we developed a multi-mechanism model for strainrate- and temperaturedependent asymmetric plastic material behavior accompanied by phase transformation with consideration of the Trip-strain [3]. Furthermore, we extend the multi-mechanism model with the gradient of phase fraction, which as an extra degree of freedom considered is. For mesoscopic modelling a phase field model is implemented for describing the phase transformations. Under the special consideration of the cutting process we have a martensite-austenite-martensite transformation. A generalized principle of virtual power is postulated involving generalized stresses and used to derive the constitutive equations for both modelling. In the examples parameters of the multi-mechanism model related to the visco-plasticity with SD-effect and the Trip-strain are identified for the material DIN 100Cr6. At last, a cutting simulation for testing the multi-mechanism model and a phase-transformation simulation are shown.

Literatur

[1] Gurtin, M. E.: Generalized Ginzburg-Landau and Cahn-Hilliard equations based on a micro force balance. Physica D 92 (1996) 3 - 4, S. 178 - 192.

[2] Forest, S.; Ammar, K.; Appolaire, B.: Micromorphic vs. Phase-Field Approaches for gradient Viscoplasticity and Phase Transformations. Lecture Notes in Applied and Computational Mechanics 59 (2011), S. 69 - 88.

[3] Mahnken, R.; Wolff, M, Cheng, C.: A multi-mechanism model for cutting simulations combining visco-plastic asymmetry and phase transformation, Int. J. Solids Struct. DOI: 10.1016/j.ijsolstr.2013.05.008, 2013.

ON THE SIMULATION OF STRAIN INDUCED ANISOTROPY FOR POLYMERS

Christian Dammann, Rolf Mahnken

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Abstract

The alignment of polymer chains is a well known microstructural evolution effect due to straining of polymers. This has a drastic influence on the macroscopic properties of the initially isotropic material, such as apronounced strength in the loading direction of stretched films. For modeling the effect of strain induced anisotropy a macroscopic constitutive model is presented. As a key idea, weighting functions are introduced to represent a strain-softening/hardening-effect to account for induced anisotropy. These weighting functions represent the ratio between the total strain rate (representing the actual loading direction) and a structural tensor (representing the stretched polymer chains). In this way, material parameters are used as a sum of weighted direction related quantities. In the finite element examples we simulate the cold-forming of amorphous thermoplastic films below the glass transition temperature subjected to different re-loading directions.

AN INTERFACE ORIENTATION DISTRIBUTION BASED APPROACH TO ANALYTICAL HOMOGENIZATION

Rainer Glüge, Jan Kalisch

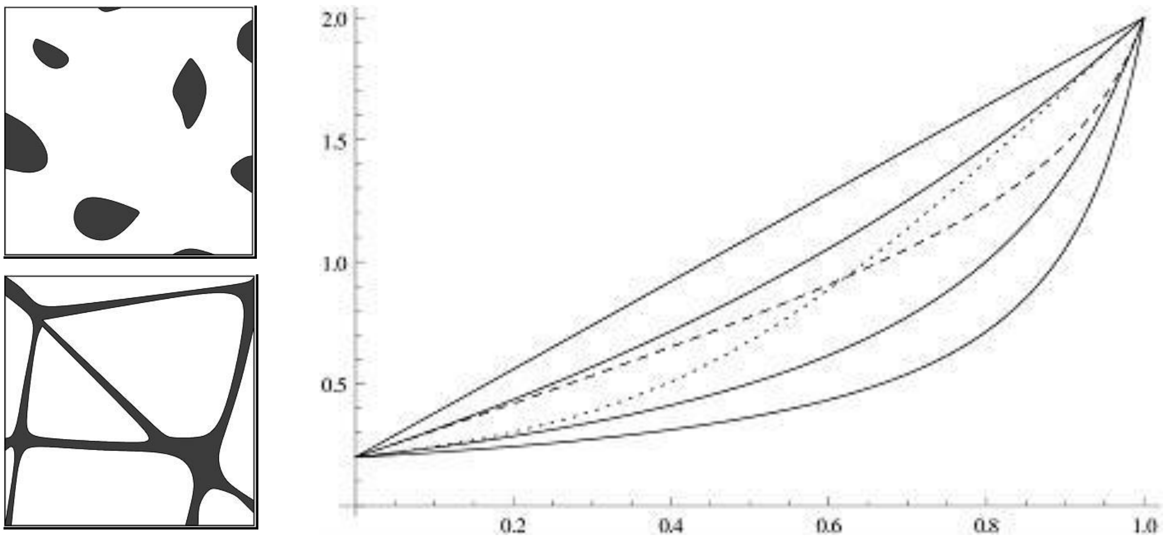
Universität Magdeburg, Institut für Mechanik

Abstract

Most analytical homogenization approaches for linear elasticity take into account either pure phase volume fractions, or rest on the Eshelby solution of an ellipsoidal inclusion in an infinite matrix, as it is the case for the self consistent scheme. At extremal volume fractions, the self consistent approach coincides up to first order with the Hashin-Shtrikman bound that gives the lower slope. This is due to the fact that the phase with the smaller volume fraction is considered the inclusion phase, which results in a minimal change of the stiffness at extremal volume fractions.

Different behaviors are obtained with other reference solutions. Specifically, we employ a laminate-based approach. Averaging over an isotropic interface orientation distribution with two isotropic phases, a homogenization scheme with properties converse to the self consistent approach is obtained. This behavior is readily explained by the different premise of the underlying reference solution, for which no matrix-inclusion structure is presumed.

The new approach complements the self-consistent approach. It allows for a better approximation of the elastic properties of materials with no matrix-inclusion structure, and of microstructures with a lower volume fraction of the matrix phase.



Extremal matrix-inclusion microstructures, where the smaller phase is either the matrix or the inclusion phase (left). An example for the resulting shear modulus as a function of the phase volume fraction (right, usual bounds correspond to the solid lines, self consistent approach to the dotted line, new approach to the dashed line)

THEORETICAL AND NUMERICAL STUDY OF EUTECTOID TRANSFORMATION IN DIFFUSION-CONTROLLED REGIME

Kumar Ankit, Rajdip Mukherjee, Britta Nestler

Institute of Materials and Processes, Karlsruhe University of Applied Sciences

Abstract

Non co-operative growth mode in eutectoid transformation for low carbon steel containing pre-existing cementite particle yields a microstructure known as divorced pearlite which is easily machinable compared to its lamellar counterpart obtained from co-operative growth mode. We perform a parametric study for both the modes using a multiphase-field model, which is based on grand-potential formulation [1] and integrated with CALPHAD database. First, we validate the present model by simulating a pearlite lamella and comparing the growth rates with the Jackson-Hunt-type calculation extended for eutectoid transformation by accounting for diffusion in austenite as well as in ferrite [2]. Then, we use the validated model to study the microstructure evolution of austenitic matrix with pre-existing cementite particles and report the non co-operative growth mode which is obtained for smaller particle spacing. We also observe intermediate regimes characterized by coarsening and dragging of cementite particles during the temporal evolution.

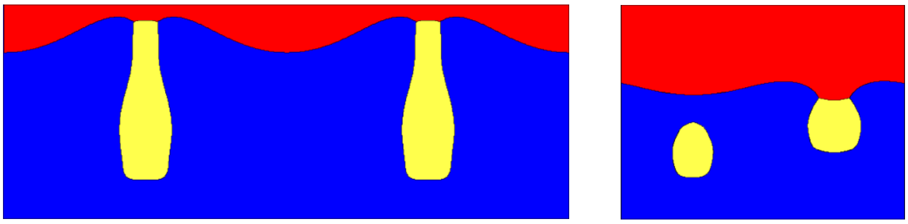


Fig. 1 Phase-field simulation of lamellar (left) and divorced pearlite (right).

Literature

[1] A. Choudhury and B. Nestler, “Grand-potential formulation for multicomponent phase transformations combined with thin-interface asymptotics of the double-obstacle potential”, Physical Review E, Volume 85, February 2012, 021602.

[2] K. Ankit, A. Choudhury, C. Qin, S. Schulz, M. McDaniel and B. Nestler, “Theoretical and numerical study of lamellar eutectoid growth influenced by volume diffusion”, Acta Materialia, Volume 61, Issue 11, June 2013, Pages 4245–4253.

FINITE ELEMENT MODELING OF BI-MATERIAL STRUCTURES BASED ON HYDROGELS

Yuri Lapusta[3], M. Marchant[1], N Zalachas[1], F. Labesse-Jied[2], N. Gippius[1]

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[3] French Institute of Advanced Mechanics, Institut Pascal / UBP / IFMA / CNRS / Clermont Université, BP 265, 63175 Aubière CEDEX, France.

Abstract

In this work, we discuss the mechanical behavior of some bi-material structures using a pH-sensitive hydrogel as their functional part. Such devices can find interesting applications in microsystems as sensors and actuators. For example, a hydrogel grating on a substrate can be used for pH-sensing due to its coupled mechanical and photonic behavior. Also, a hydrogel ring bonded between two rigid plates can act as actuator and move the liquid enclosed in the ring, changing the curvature of a liquid microlens. In both examples, the constrained hydrogel swells or shrinks as pH changes. Finite element modeling of such systems is discussed. To describe the large deformation behavior of the hydrogel components, a recently developed theory [1] which was implemented into the Finite Element software Abaqus as a subroutine UHYPER is employed. We use this subroutine to analyze numerically the coupled behavior of the above mentioned bi-material structures based on hydrogels. It is shown that the large deformation of the gel can significantly influence the functionality of such bi-material systems.

Acknowledgements: The support from the French program investissement d'avenir managed by the National Research Agency (ANR), the European Commission (Auvergne FEDER funds) and the Region Auvergne in the framework of the LabEx IMobS3 (ANR-10-LABX-16-01) is gratefully acknowledged. The authors also gratefully acknowledge the Transversal Program of the Pascal Institute, Division "Materials and Multiscale Modeling".

Literature

[1] R. Marcombe, S. Q. Cai, W. Hong, X. H. Zhao, Y. Lapusta and Z.G. Suo, "A theory of constrained swelling of a pH-sensitive hydrogel", Soft Matter 6, 784-793 (2010).

REPRESENTATION OF HASHIN-SHTRIKMAN BOUNDS OF TEXTURED CUBIC CRYSTALL AGGREGATES WITH APPLICATION IN MATERIALS DESIGN

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Institute of Engineering Mechanics – Chair of Continuum Mechanics
Karlsruhe Institute of Technology (KIT)

Abstract

The Hashin-Shtrikman bounds of aggregates of cubic crystals are explicitly represented in terms of tensorial texture coefficients. The formula is valid for arbitrary crystallographic textures and isotropic two-point statistics. The isotropy of the two-point statistics implies that the grain shape is isotropic on average. The new explicit representation has the advantage that the set of energetically admissible crystallographic textures and corresponding effective linear elastic properties can be directly determined and analyzed based on minimum principles of the elastic strain energy density. It is shown that all energetically admissible textures with maximum anisotropy have an effective elastic behavior with cubic sample symmetry. Furthermore, it is proven, that there exist texture states without maximum anisotropy which have the extremal elastic properties peculiar to states with maximum anisotropy. This is an important result for the design of elastic material properties.

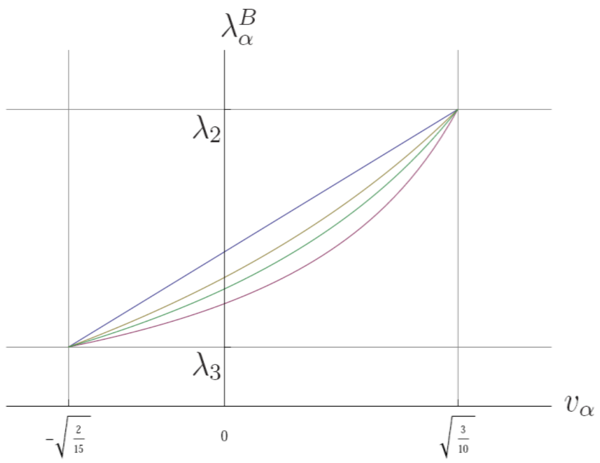

Fig. 1: Exact eigenvalues λ_α^B of the bounds over the texture eigenvalues v_α within the energetically admissible interval for cubic materials with eigenvalues $\lambda_3 < \lambda_2$: Voigt in blue, Reuss in red, upper and lower Hashin-Shtrikman in yellow and green

Literatur

[1] Hashin, Z. and Shtrikman, S., “A variational approach to the theory of the elastic behaviour of polycrystals”, J. Mech. Phys. Solids, 10:343-352, 1962.

[2] Adams, B. L., Kalidindi, S. R. and Fullwood, D. T., “Microstructure sensitive design for performance optimization”, Butterworth-Heinemann, 2012.

EFFICIENT ASSESSMENT OF IN-PROCESS PHASE-TRANSFORMATIONS – APPLICATION TO MACHINING PROCESSES

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Abstract

We present an efficient finite element based scheme for the prediction of process properties, especially regarding the material condition of the workpiece surface after machining. To this end we use a database generated with the help of a micro-mechanically motivated material model that allows the simulation of temperature-dependent interactions between phase transformations and plasticity. Based on this pre-computed phase database, an efficient post-processing scheme is applied to a macroscopic thermo-mechanically coupled finite element simulation of the machining process. In this work, the modelling technique is applied to the martensitic part of a functionally graded workpiece which is produced by thermo-mechanically controlled forging processes.

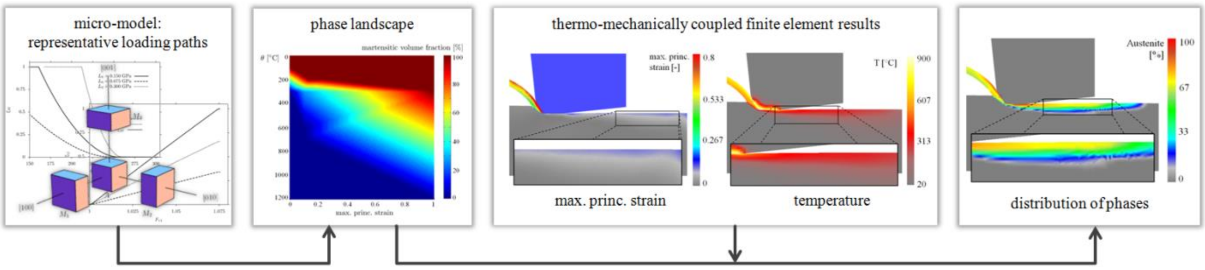

Fig. 1: Post-processing based assessment of in-process phase-transformations

We compare the results obtained for both a new tool and a worn tool and we show that the presented technique facilitates the efficient assessment of in-process phase-transformations that occur during the machining process.

Literatur

[1] R. Ostwald, M. Tiffe, T. Bartel, A. Zabel, A. Menzel, D. Biermann: “Towards the Multi-Scale Simulation of Martensitic Phase-Transformations: An Efficient Post-Processing Approach Applied to Turning Processes”, submitted for publication, 2013

TWO-SCALE MODELING OF DUAL-PHASE STEELS

F.Rieger, T.Böhlke

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Abstract

Dual-phase steels (DP) are nowadays widely used for automotive applications, e.g. due to their weight reduction potential and good formability. For example crash-relevant structural parts are deep-drawn from dual-phase sheet steels. The advantageous attributes are mainly generated by the highly nonlinear interactions of the composite like microstructure, consisting of a ductile ferritic matrix and hard martensitic inclusions.

For industrial structural part simulations, the microscopic behavior is modeled using a semi-analytical nonlinear homogenization scheme of Hashin-Shtrikman type on the integration point level of finite element simulations. The representative volume element consists of one single martensitic phase and several ferrite phases that are described by individual geometric parameters based on experimental electronic backscatter diffraction data.

During the production process, the austenite-martensite phase transformation leads to an inhomogeneous material state within DP. This corresponds to macroscopic continuous yielding and high initial strain hardening of DP. In this work, the heterogeneous initial material state is modeled by adjusting the initial average dislocation density in each ferrite grain based on the martensite coverage.

The ferrite deformation spreads from the grain and phase boundaries into the grain interior until the whole grain is saturated with dislocations and the ferrite-ferrite grain boundaries are no particular obstacles to dislocation movement any more. The pile-up of dislocations at ferrite-ferrite grain boundaries and ferrite-martensite phase boundaries gives rise to back stresses. By using the martensite coverage for each individual ferrite grain, a main effect of the spatial constituent arrangement is reproduced.

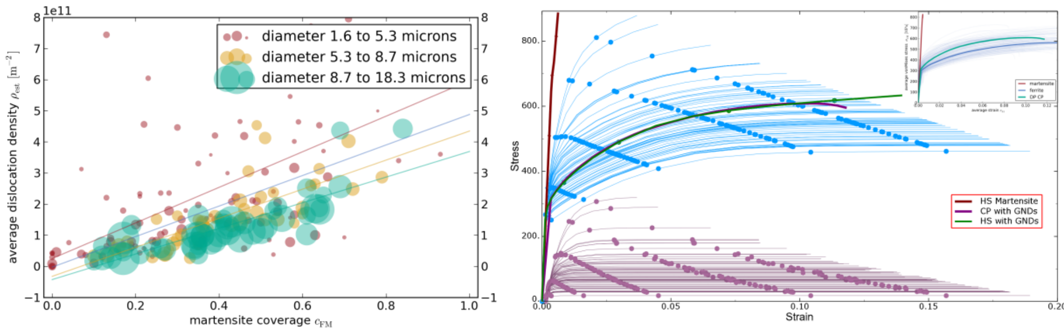

Abb. 1 Initial dislocation density distribution and RVE results comparison

Literatur

[1] Ramazani, A., and K. Mukherjee. "Quantification of the Effect of Transformation-Induced Geometrically Necessary Dislocations on the Flow-Curve Modelling of Dual-Phase Steels.", International Journal of Plasticity 43, 2012

[2] Carvalho-Resende, T., S. Bouvier, F. Abed-Meraim, T. Balan and S.-S. Sablin, "Dislocation-Based Model for the Prediction of the Behavior of B.c.c. Materials - Grain Size and Strain Path Effects.", International Journal of Plasticity 47, 2013

IN-SITU CHARACTERIZATION OF METALLIC MATERIALS USING DIGITAL IMAGE CORRELATION

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Abstract

New physically based models describing the behavior of metallic materials in various situations e.g. plastic deformation, failure or phase transformation require for new in-situ techniques analyzing the microstructural behavior in these situations. Therefore, this presentation illustrates how in-situ experiments can be carried out by combining mechanical testing facilities for experiments under tension, compression and bending loads with light and electron optical techniques, e.g. scanning and transmission electron microscopy [1-3]. During the in-situ experiments both the macroscopic using the force and displacement signal as well as the microscopic material behavior using the digital image correlation is recorded. This provides the opportunity of determining the material behavior on a wide range of scales. The ramifications of the results determinable via in-situ experiments will be discussed with respect to the applicability to industrial processes.

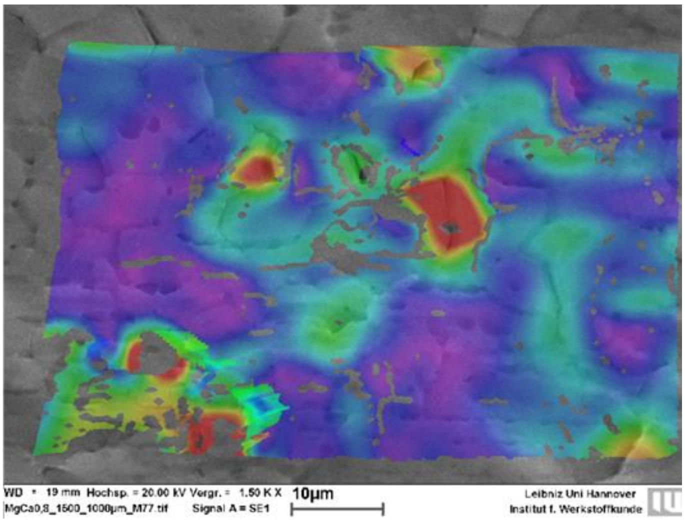

Figure 1: Measurement of local strain by use of digital image correlation

[1] M. A. Haque, M. T. A. Saif, Experimental Mechanics 2002, 42, 123.
[2] M.T. Malachevsky, C.A. D'Ovidio, Superconductor Science and Technology 2005, 18, 289.
[3] M.J. Holzweissig, D. Canadinc, H.J. Maier, Materials Characterization 2012, 65, 100.

FROM DISCRETE DISLOCATIONS TOWARDS A DISLOCATION DENSITY BASED CONTINUUM FORMULATION FOR PLASTICITY

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Abstract

Material modeling has become an important aspect in optimizing material properties and industrial processes. The information gained on small scales has to be linked to larger scales in order to reduce computational effort compared to discrete dislocation simulations by sustaining accuracy of predictions.

In the context of plasticity, dislocation motion plays an important role. The main task is the question of homogenization, i.e. the meaningful averaging of dislocations in a given volume. Major advances have been archived by generalizing the concept of Kröner's classical dislocation density theory, [1], and the introduction of a formulation for the evolution of curved dislocations. The Continuum Dislocation Dynamics theory, [2], allows maintaining information about the orientation and curvature of dislocations while averaging over a given volume.

Based upon this concept, we focus on the analysis of the internal stress fields due to the dislocation configuration for the correct evolution of the dislocation density and introduce further aspects of homogenization to move towards a continuum formulation. The problem of a meaningful representation of dislocation interaction stresses in a continuum model will be addressed.

Literatur

[1] Kröner, E.: “Kontinuumstheorie der Versetzungen und Eigenspannungen”. Heidelberg: Springer-Verlag, 1958.

[2] Hochrainer, T.; Zaiser, M.; Gumbsch, P.: “A three-dimensional continuum theory of dislocation systems: kinematics and mean-field formulation”. In: Phil. Mag. 87 (2007), S. 1261-1282.

PHASE-FIELD MODELLING OF STRESS EVOLUTION IN HETERO-GENEOUS STRUCTURES

***Daniel Schneider*[1], *Oleg Tschukin*[2], *Abhik Choudhury*[3], *Michael Selzer*[2], *Britta Nestler*[1,2]**

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Abstract

Computational models based on the phase-field method typically operate on a mesoscopic length scale resolving structural changes of the material and provide valuable information about microstructure and mechanical property relations. An accurate calculation of the stresses and mechanical energy at the transition region is therefore indispensable. We derive a quantitative phase-field elasticity model based on force balance and Hadamard jump condition at the interface.

Comparing the simulated stress profiles in a plate with a round inclusion under hydrostatic tension with the theoretical predicted stress fields, we show the quantitative characteristics of the model. In order to validate the elastic contribution to the driving force of the phase transition, we demonstrate the absence of excess energy in one dimensional equilibrium condition of serial and parallel material chain.

MULTISCALE MODELING OF FIBER REINFORCED LAMINATED COMPOSITES

J.-W. Simon, B. Stier, S. Reese

Institute of Applied Mechanics, RWTH Aachen University

Abstract

In many technical applications fiber reinforced composites are gaining importance due to their very high Young's modulus and low density. These are particularly leveraged in thin structures of lightweight constructions. The composites examined in this paper consist of multiple layers, each of which is composed of a woven fabric, with two families of fibers, embedded in a matrix material. In order to describe realistically the material behavior of such composites, a slightly modified version of the micro-mechanically motivated material model proposed by Reese [1] is used.

Structural collapse in fiber composite structures can possibly be caused by different damage modes: matrix transverse cracking, fiber fracture, or delamination. Including delamination into the computation of composite structures requires the definition of an appropriate criterion for its onset as well as the prediction of its growth after an initial crack has evolved. In the present work, however, the focus lies on the prediction of the onset of delamination by using stress-strength relationships as suggested by Ye [2].

On the one hand, the use of a fully three-dimensional material model strongly suggests using solid elements. On the other hand, shell elements should usually be preferred due to the application in thin shell-like structures. Hence, a solid-shell element is applied here, which was presented by Schwarze and Reese [3] combining the advantages of both solid elements and shell elements at the same time. This solid-shell formulation utilizes a reduced integration scheme within the shell plane using one integration point, whereas a full integration is used in thickness direction. Thus, an arbitrary number of integration points can be chosen over the shell thickness. Thereby, different fiber orientations of the layers can be taken into account easily, since the material parameters can be defined for each integration point separately.

References

[1] S. Reese: Meso-macro modelling of fiber-reinforced rubber-like composites exhibiting large elastoplastic deformation. International Journal of Solids and Structures, Vol. 40, pp. 951–980, 2003.

[2] Ye, L., "Role of matrix resin in delamination onset and growth in composite laminates". Composite Science Technology, Vol. 33 (4), pp. 257–277, 1988.

[3] Schwarze, M., Reese S., "A reduced integration solid-shell finite element based on the EAS and the ANS concept - large deformation problems". International Journal for Numerical Methods in Engineering, 85, 289–329, 2011.

MODELING OF ACTIVE PIEZOELECTRIC COMPOSITE STRUCTURES WITH CRACKS

O. Viun[1], Labesse-Jied F.[2], Moutou-Pitti R.[3], Mezouar Y.[5], Loboda V.[4], Lapusta Y.[5]

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Abstract

High performance, flexibility and durability are some major properties of the piezoelectric fiber macro composite actuators. These devices, able to couple efficiently electrical and mechanical fields, can find interesting applications in robotics and aircraft industry. For example, in a two link flexible robot arms, active patches can be introduced like a sensor and an actuator. They are used in a feedback control for rigid body motion. Also, MFC can be used in a hybrid control strategy in order to control the slow and fast subsystems and hence to stabilize the whole system. The performance of such systems can be strongly affected by the integrity of interfaces between their constituents. Problem of interface cracks are therefore very important in such applications.

In this work, a smart system composed of an aluminum beam with two MFC patches is analysed. The influence of defects like cracks is studied. First, a crack is introduced between MFC and the aluminum beam, and the influence of this crack on the amplitude of beam is studied. Further, a crack in a fixed part of the beam is analysed. The J-integral and stress intensity factors are found numerically. It was found that the influence of this crack on the amplitude of beam is small. The results of modeling by finite element method (FEM) were compared with experiment results [1] and good coincidences were obtained.

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GRADED STRUCTURES IN FILMS

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Abstract

Components with graded structures have modified properties in spatial direction. One way to produce a graded structure in a polymer film is the local irradiation cross-linking. Here primarily the radiation dose determined the desired properties. By crosslinking a network is formed that prevents the fluidity of the polymer. In this way, the elastic modulus can be increased at temperatures above the crystalline melting point and the thermal expansion coefficient decreases [1]. Here one radiation-crosslinkable polyethylene film (BorPEX ME 2592) was irradiated under local shielding. In a subsequent and a constant wall thickness distribution can be generated.

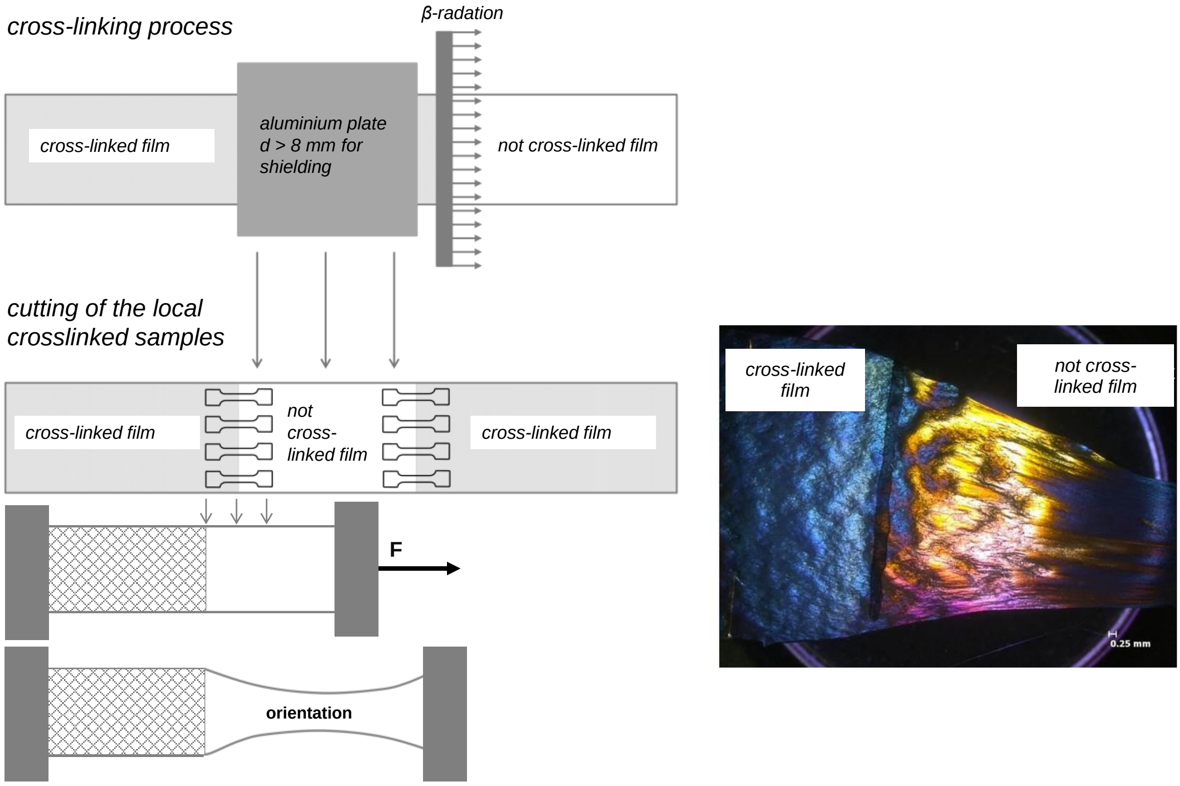

Fig. 1 Principle of the local cross-linking process

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APPROXIMATION OF THE DUAL PROBLEM FOR ERROR ESTIMATION IN ELASTO-PLASTICITY

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Abstract

In numerical simulations with the finite element method the dependency on the mesh - and for time-dependent problems on the time discretization – arises. Adaptive refinements in space (and time) based on goal-oriented error estimation [1] become more and more popular for finite element analyses to balance computational effort and accuracy of the solution. The introduction of a goal quantity of interest defines a dual problem which has to be solved to estimate the error w.r.t it.

Often such procedures are based on a space-time Galerkin framework for instationary problems [2]. Discretization results in systems of equations in which the unknowns are nodal values. Contrary, in current finite element implementations for path-dependent problems some quantities storing information about the path-dependence are located at the integration points of the finite elements [3], e.g. plastic strains etc.

In this contribution we propose an approach for the approximation of the dual problem which mainly maintains the structure of current finite element implementations for path-dependent problems. An application example is given for an elasto-plastic problem.

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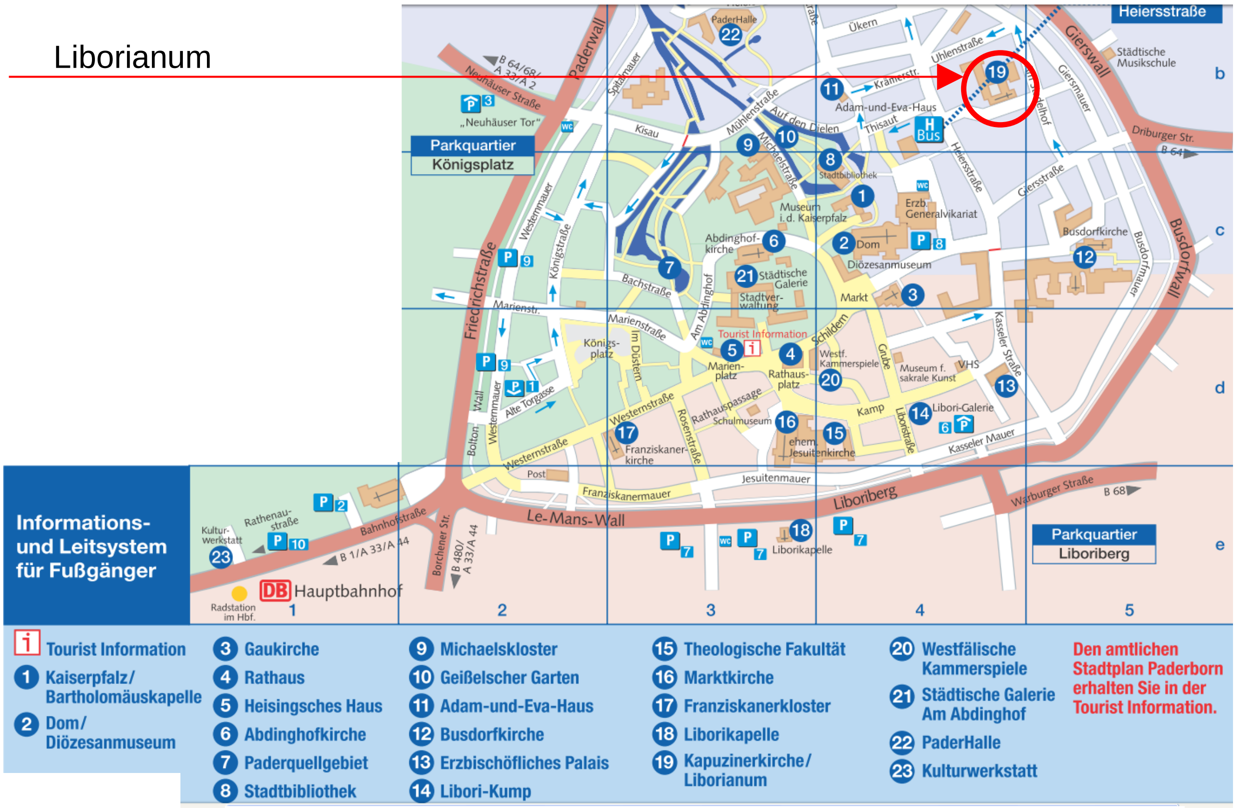

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