Multiscale Modeling Abaqus


Multiscale Modeling Approaches for Composites outlines the fundamentals of common multiscale modeling techniques and provides detailed guidance for putting them into practice. Various homogenization methods are presented in a simple, didactic manner, with an array of numerical examples. The book starts by covering the theoretical underpinnings of tensors and continuum mechanics concepts, then passes to actual micromechanic techniques for composite media and laminate plates. In the last chapters the book covers advanced topics in homogenization, including Green’s tensor, Hashin-Shtrikman bounds, and special types of problems. All chapters feature comprehensive analytical and numerical examples (Python and ABAQUS scripts) to better illustrate the theory. Bridges theory and practice, providing step-by-step instructions for implementing multiscale modeling approaches for composites and the theoretical concepts behind them Covers boundary conditions, data-exchange between scales, the Hill-Mandel principle, average stress and strain theorems, and more Discusses how to obtain composite properties using different boundary conditions Includes access to a companion site, featuring the numerical examples, Python and ABACUS codes discussed in the book

Computational Modelling of Biomechanics and Biotribology in the Musculoskeletal System: Biomaterials and Tissues, Second Edition reviews how a wide range of materials are modeled and applied. Chapters cover basic concepts for modeling of biomechanics and biotribology, the fundamentals of computational modeling of biomechanics in the musculoskeletal system, finite element modeling in the musculoskeletal system, computational modeling from a cells and tissues perspective, and computational modeling of the biomechanics and biotribology interactions, looking at complex joint structures. This book is a comprehensive resource for professionals in the biomedical market, materials scientists and biomechanical engineers, and academics in related fields. This important new edition provides an up-to-date overview of the most recent research and developments involving hydroxyapatite as a key material in medicine and its application, including new content on novel technologies, biomorphic hydroxyapatite and more. Provides detailed, introductory coverage of modeling of cells and tissues, modeling of biomaterials and interfaces, biomechanics and biotribology Discusses applications of modeling for joint replacements and applications of computational modeling in tissue engineering Offers a holistic perspective, from cells and small ligaments to complex joint interactions

The book explores the effect of nanoscale matrix additives along the four levels of material formation, particle-resin interaction, the influence of nanoparticles on the processability of the polymer, the influence of nanoparticles on polymer curing and the influence of nanoparticles on the fiber plastic composite. Fiber-reinforced plastics have a significantly
higher lightweight construction potential in components with a primary single- or biaxial stress state compared to isotropic metals. At the same time, their insensitivity to corrosion and their advantageous fatigue properties can help to reduce maintenance costs. Due to their outstanding specific mechanical properties, they are among today's high-performance lightweight construction materials. These properties make them particularly attractive in the field of mobility. However, as soon as the matrix properties dominate the mechanical properties, e.g. in the case of fibre-parallel compressive strength, significant weaknesses become apparent in the mechanical properties. Here, one approach is to significantly increase the matrix properties through nanoscale ceramic additives and at the same time to guarantee the processability of the resin.

Microscale damage mechanism of the multi-layer composite laminates is one of the active areas of research. Micromechanics theory is extensively used for the prediction of elastic response and to perform damage analysis of unidirectional laminae via representative volume element (RVE). The present state of the art in the micromechanics theory is extended in this study for the damage analysis of the multi-fiber multi-layer laminates to capture the local damage mechanisms which include matrix failure, fiber-matrix debonding, fiber failure, and delamination. A multi-fiber multi-layer representative volume element (M2RVE) representing a multi-layer cross-ply laminate is developed. Each layer in the M2RVE is represented by a unit cube with multiple randomly distributed fibers of same diameter at specified angle ensuring specified volume fiber fraction. Periodic boundary conditions are applied to the all six M2RVE surfaces to model the directional periodicity. All the simulations are performed by using FE analysis code ABAQUS®. A maximum principal stress criterion is used for modeling fiber failure. Mohr-coulomb failure criterion is used for matrix failure and standard traction-separation law is used for fiber-matrix debonding and for modeling delamination between plies. Numerical results from the FE analysis are found to be in good agreement with the experimental data obtained. Note that this technique is valid for periodic structures. The periodic boundary condition is not a suitable assumption, especially in the regions of high gradients like free edges, interfaces, material discontinuities. The periodicity of simple unit cells is also unrealistic for non-uniform microstructures, due the presence of randomness, clustering or evolving micro-structural behavior. Consequently, this approach has limited utility in identifying local damage in real structural members. To address the limitations of the M2RVE, a micromacro multiscale scale multilevel model is proposed. The multilevel model is comprised of two levels, namely, microscale, and macroscale. The micro-macro model is an effective and computationally efficient technique for modeling the deformation and local damage in real composite structures.

This book provides an overview of multiscale approaches and homogenization procedures as well as damage evaluation and crack initiation, and addresses recent advances in the analysis and discretization of heterogeneous materials. It also highlights the state of the art in this research area with respect to different computational methods, software development and applications to engineering structures. The first part focuses on defects in composite materials including their numerical and experimental investigations; elastic as well as elastoplastic constitutive models are considered, where the modeling has been performed at macro- and micro levels. The second part is devoted to novel computational schemes applied on different scales and discusses the validation of numerical results. The third part discusses gradient enhanced modeling, in particular quasi-brittle and ductile damage, using the gradient enhanced approach. The final part addresses thermoplasticity, solid-liquid mixtures and ferroelectric models. The contents are based on the international workshop “Multiscale Modeling of Heterogeneous Structures” (MUMO 2016), held in Dubrovnik, Croatia in September 2016.

The rising demand to reduce fuel consumption and the continuous increase of materials and manufacturing costs has obliged aircraft manufacturers to boost the use of composite materials and to optimise the manufacturing methods. Foam core sandwich structures combine the advantages of high bending properties with low manufacturing costs when liquid composite processes are used. However, the use of foam core sandwich structures is not widespread in aircraft applications due to the better weight-specific performance of honeycomb cores and the susceptibility to impact loading. In this context, pin reinforcements are added to the foam core to improve its mechanical properties and its damage tolerance. This work contributes to the understanding of the mechanical behaviour of pin-reinforced foam core sandwich structures under static and impact loading. Ultrasonic scan and micro-computed tomography are used to identify the different damage modes. The effect of very low temperature on the damage behaviour under impact loading is investigated. An explicit simulation model to predict the impact response of pin-reinforced foam core sandwich structures is also proposed.

This volume collects selected papers presented at the Ninth International Workshop on Meshfree Methods held in Bonn, Germany in September 2017. They address various aspects of this very active research field and cover topics from applied mathematics, physics and engineering. The numerical treatment of partial differential equations with meshfree discretization techniques has been a very active research area in recent years. While the fundamental theory of meshfree methods has been developed and considerable advances of the various methods have been made, many challenges in the mathematical analysis and practical implementation of meshfree methods remain. This symposium aims to promote
collaboration among engineers, mathematicians, and computer scientists and industrial researchers to address the development, mathematical analysis, and application of meshfree and particle methods especially to multiscale phenomena. It continues the 2-year-cycled Workshops on Meshfree Methods for Partial Differential Equations.

A modified Weibull cumulative distribution function, which accounts for the effect of fiber length on the probability of failure, was used to characterize the variation in fiber tensile strength in a SCS-6/ TIMETAL 21S material system and was implemented within the framework of the NASA code MAC/GMC. A parametric study investigating the effect of repeating unit cell architecture and fiber strength distribution on the RUC-averaged ultimate composite strength and failure was performed. Multiscale progressive failure analyses of a tensile dogbone specimen were performed using FEAMAC/ ABAQUS to assess the effect of local variations in fiber strength on the global response. The effect of the RUC architecture, fiber strength distribution, and microscale/ macroscale discretization on the global response was determined. The methodology developed in this work for accounting for statistical variations in microscale properties that feed into macroscale progressive failure analyses can readily be applied to other composite material systems.

The papers in this volume deal with materials science, theoretical mechanics and experimental and computational techniques at multiple scales, providing a sound base and a framework for many applications which are hitherto treated in a phenomenological sense. The basic principles are formulated of multiscale modeling strategies towards modern complex multiphase materials subjected to various types of mechanical, thermal loadings and environmental effects. The focus is on problems where mechanics is highly coupled with other concurrent physical phenomena. Attention is also focused on the historical origins of multiscale modeling and foundations of continuum mechanics currently adopted to model non-classical continua with substructure, for which internal length scales play a crucial role.

This book gives a unified presentation of the research performed in the field of multiscale modelling in sheet metal forming over the course of more than thirty years by the members of six teams from internationally acclaimed universities. The first chapter is devoted to the presentation of some recent phenomenological yield criteria (BBC 2005 and BBC 2008) developed at the CERTETA center from the Technical University of Cluj-Napoca. An overview on the crystallographic texture and plastic anisotropy is presented in Chapter 2. Chapter 3 is dedicated to multiscale modelling of plastic anisotropy. The authors describe a new hierarchical multi-scale framework that allows taking into account the evolution of plastic anisotropy during sheet forming processes. Chapter 4 is focused on modelling the evolution of voids in porous metals with applications to forming limit curves and ductile fracture. The chapter details the steps needed for the development of dissipation functions and Gurson-type models for non-quadratic anisotropic plasticity criteria like BBC 2005 and those based on linear transformations. Chapter 5 describes advanced models for the prediction of forming limit curves developed by the authors. Chapter 6 is devoted to anisotropic damage in elasto-plastic materials with structural defects. Finally, Chapter 7 deals with modelling of the Portevin-Le Chatelier (PLC) effect. This volume contains contributions from leading researchers from the Technical University of Cluj-Napoca, Romania, the Catholic University of Leuven, Belgium, Clausthal University of Technology, Germany, Amirkabir University of Technology, Iran, the University of Bucharest, Romania, and the Institute of Mathematics of the Romanian Academy, Romania. It will prove useful to postgraduate students, researchers and engineers who are interested in the mechanical modeling and numerical simulation of sheet metal forming processes.

Multiscale Modeling of Additively Manufactured Metals: Application to Laser Powder Bed Fusion Process provides comprehensive coverage on the latest methodology in additive manufacturing (AM) modeling and simulation. Although there are extensive advances within the AM field, challenges to predictive theoretical and computational approaches still hinder the widespread adoption of AM. The book reviews metal additive materials and processes and discusses multiscale/multiphysics modeling strategies. In addition, coverage of modeling and simulation of AM process in order to understand the process-structure-property relationship is reviewed, along with the modeling of morphology evolution, phase transformation, and defect formation in AM parts. Residual stress, distortion, plasticity/damage in AM parts are also considered, with scales associated with the spatial, temporal and/or material domains reviewed. This book is useful for graduate students, engineers and professionals working on AM materials, equipment, process, development and modeling. Includes the fundamental principles of additive manufacturing modeling techniques Presents various modeling tools/software for AM modeling Discusses various design methods and how to optimize the AM process using these models

Recent interest in nanotechnology is challenging the community to analyse, develop and design nanometer to micrometer-sized devices for applications in new generations of computer, electronics, photonics and drug delivery systems. To successfully design and fabricate novel nanomaterials and nanosystems, we must necessarily bridge the gap in our understanding of mechanical properties and processes at length scales ranging from 100 nanometers (where atomistic simulations are currently possible) to a micron (where
continuum mechanics is experimentally validated). For this purpose the difficulties and complexity originate in the substantial differences in philosophy and viewpoints between conventional continuum mechanics and quantum theories. The challenge lies in how to establish the relationship between a continuum mechanical system and its atomistic counterpart in order to define continuum variables that are calculable within an atomic system.

Damage Modeling of Composite Structures: Strength, Fracture, and Finite Element Analysis provides readers with a fundamental overview of the mechanics of composite materials, along with an outline of an array of modeling and numerical techniques used to analyze damage, failure mechanisms and safety tolerance. Strength prediction and finite element analysis of laminated composite structures are both covered, as are modeling techniques for delaminated composites under compression and shear. Viscoelastic cohesive/friction coupled model and finite element analysis for delamination analysis of composites under shear and for laminates under low-velocity impact are all covered at length. A concluding chapter discusses multiscale damage models and finite element analysis of composite structures. Integrates intralaminar damage and interlaminar delamination under different load patterns, covering intralaminar damage constitutive models, failure criteria, damage evolution laws, and virtual crack closure techniques. Discusses numerical techniques for progressive failure analysis and modeling, as well as numerical convergence and mesh sensitivity, thus allowing for more accurate modeling. Features models and methods that can be seamlessly extended to analyze failure mechanisms and safety tolerance of composites under more complex loads, and in more extreme environments. Demonstrates applications of damage models and numerical methods.

The 5th International Congress on Design and Modeling of Mechanical Systems (CMSM) was held in Djerba, Tunisia on March 25-27, 2013 and followed four previous successful editions, which brought together international experts in the fields of design and modeling of mechanical systems, thus contributing to the exchange of information and skills and leading to a considerable progress in research among the participating teams. The fifth edition of the congress (CMSM ?2013), organized by the Unit of Mechanics, Modeling and Manufacturing (U2MP) of the National School of Engineers of Sfax, Tunisia, the Mechanical Engineering Laboratory (MBL) of the National School of Engineers of Monastir, Tunisia and the Mechanics Laboratory of Sousse (LMS) of the National School of Engineers of Sousse, Tunisia, saw a significant increase of the international participation. This edition brought together nearly 300 attendees who exposed their work on the following topics: mechatronics and robotics, dynamics of mechanical systems, fluid structure interaction and vibroacoustics, modeling and analysis of materials and structures, design and manufacturing of mechanical systems. This book is the proceedings of CMSM ?2013 and contains a careful selection of high quality contributions, which were exposed during various sessions of the congress. The original articles presented here provide an overview of recent research advancements accomplished in the field mechanical engineering.

The aim of the book is to provide engineers with a practical guide to Finite Element Modelling (FEM) in Abaqus CAE software. The guide is in the form of step-by-step procedures concerning yarns, woven fabric and knitted fabrics modelling, as well as their contact with skin so that the simulation of haptic perception between textiles and skin can be

This book brings together a diverse compilation of inter-disciplinary chapters on fundamental aspects of carbon fiber composite materials and multi-functional composite structures: including synthesis, characterization, and evaluation from the nano-structure to structure meters in length. The content and focus of contributions under the umbrella of structural integrity of composite materials embraces topics at the forefront of composite materials science and technology, the disciplines of mechanics, and development of a new predictive design methodology for the safe operation of engineering structures from cradle to grave. Multi-authored papers on multi-scale modelling of problems in material design and predicting the safe performance of engineering structure illustrate the inter-disciplinary nature of the subject. The book examines topics such as Stochastic micro-mechanics theory and application for advanced composite systems. Construction of the evaluation process for structural integrity of material and structure. Nano- and meso-mechanics modelling of structure evolution during the accumulation of damage. Statistical meso-mechanics of composite materials. Hierarchical analysis including "age-aware," high-fidelity simulation and virtual mechanical testing of composite structures right up to the point of failure. The volume is ideal for scientists, engineers, and students interested in carbon fiber composite materials, and other composite material systems.

Stochastic-based, discrete-event progressive damage simulations of ceramic-matrix composite and polymer matrix composite material structures have been enabled through the development of a unique multiscale modeling tool. This effort involves coupling three independently developed software programs: (1) the Micromechanics Analysis Code with
Generalized Method of Cells (MAC/GMC), (2) the Ceramics Analysis and Reliability Evaluation of Structures Life Prediction Program (CARES/Life), and (3) the Abaqus finite element analysis (FEA) program. MAC/GMC contributes multiscale modeling capabilities and micromechanics relations to determine stresses and deformations at the microscale of the composite material repeating unit cell (RUC). CARES/Life contributes statistical multiaxial failure criteria that can be applied to the individual brittle-material constituents of the RUC. Abaqus is used at the global scale to model the overall composite structure. An Abaqus user-defined material (UMAT) interface, referred to here as "FEAMAC/CARES," was developed that enables MAC/GMC and CARES/Life to operate seamlessly with the Abaqus FEA code. For each FEAMAC/CARES simulation trial, the stochastic nature of brittle material strength results in random, discrete damage events, which incrementally progress and lead to ultimate structural failure. This report describes the FEAMAC/CARES methodology and discusses examples that illustrate the performance of the tool. A comprehensive example problem, simulating the progressive damage of laminated ceramic matrix composites under various off-axis loading conditions and including a double notched tensile specimen geometry, is described in a separate report. Nemeth, Noel N. and Bednarcyk, Brett A. and Pineda, Evan J. and Walton, Owen J. and Arnold, Steven M. Glenn Research Center STOCHASTIC PROCESSES; MICROCRACKS; SIMULATION; CERAMIC MATRIX COMPOSITES; POLYMER MATRIX COMPOSITES; FINITE ELEMENT METHOD; MICROMECHANICS; SOFTWARE DEVELOPMENT TOOLS; SOFTWARE ENGINEERING; DAMAGE; BRITTLE MATERIALS; COMPOSITE STRUCTURES; CRACK INITIATION; CRACK PROPAGATION; FRACTURE MECHANICS; PROBABILITY THEORY; STRESS-STRAIN RELATIONSHIPS; STRUCTURAL ANALYSIS

The broaching process remains an essential machining process when manufacturing fir tree slots in turbine disks for aircraft engines. The cost- and time-intensive experiment-based approach restricts the application of alternative cutting tool materials when broaching nickel-based alloys. Given the accuracy and computation time, the developed model-based multiscale approach presents great advantages in prediction of the broaching process and thus can accelerate the development process.

Multiscale Approaches for Composites outlines the fundamental theory behind the most commonly-used multiscale techniques and also provides detailed methodology for putting these techniques into practice. Various homogenization methods are presented in a simple and didactic manner and an array of numerical examples are provided alongside them illustrating the use of the discussed approaches. The book is divided into three sections, the first of which covers the theoretical underpinnings of tensors and continuum mechanics concepts such as both Voigt and Reuss bounds. The second part moves into actual micromechanics techniques for composite media covering mean-field methods, periodic homogenization, and more. The book concludes with a final section paying attention to advanced topics in homogenization and features chapters on Green's tensor, Hashin-Shtrikman bounds, special mean-field type problems, among others. All chapters feature simple analytical and numerical examples (Python and ABAQUS scripts) to better illustrate the discussed theoretical aspects. Bridges theory and practice by providing both step-by-step instructions for implementing a range of multiscale modeling approaches for composites as well as the theoretical concepts behind doing so Covers boundary conditions, data-exchange between scales, the Hill-Mandel principle, average stress and strain theorems, and more Discusses how to obtain composite properties using different boundary conditions

Today, multi-functional materials such as piezoelectric/ferroelectric ceramics, magneto-strictive and shape memory alloys are gaining increasing applications as sensors, actuators or smart composite materials systems for emerging high tech areas. The stable performance and reliability of these smart components under complex service loads is of paramount practical importance. However, most multi-functional materials suffer from various mechanical and/or electro-magnetical degradation mechanisms as fatigue, damage and fracture. Therefore, this exciting topic has become a challenge to intensive international research, provoking the interdisciplinary approach between solid mechanics, materials science and physics. This book summarizes the outcome of the above mentioned IUTAM-symposium, assembling contributions by leading scientists in this area. Particularly, the following topics have been addressed: (1) Development of computational methods for coupled electromechanical field analysis, especially extended, adaptive and multi-level finite elements. (2) Constitutive modeling of non-linear smart material behavior with coupled electric, magnetic, thermal and mechanical fields, primarily based on micro-mechanical models. (3) Investigations of fracture and fatigue in piezoelectric and ferroelectric ceramics by means of process zone modeling, phase field simulation and configurational mechanics. (4) Reliability and durability of sensors and actuators under in service loading by alternating mechanical, electrical and thermal fields. (5) Experimental methods to measure fracture strength and to investigate fatigue crack growth in ferroelectric materials under electromechanical loading. (6) New ferroelectric materials, compounds and composites with enhanced strain capabilities.

'Metal-Matrix Composites' are being used or considered for use in a variety of applications in the automotive, aerospace and sporting goods industries. This book contains sixteen
This unique volume presents the state of the art in the field of multiscale modeling in solid mechanics, with particular emphasis on computational approaches. For the first time, contributions from both leading experts in the field and younger promising researchers are combined to give a comprehensive description of the recently proposed techniques and the engineering problems tackled using these techniques. The book begins with a detailed introduction to the theories on which different multiscale approaches are based, with regards to linear homogenization as well as various nonlinear approaches. It then presents advanced applications of multiscale approaches applied to nonlinear mechanical problems. Finally, the novel topic of materials with self-similar structure is discussed.

Nowadays, it is quite easy to see various applications of fibrous composites, functionally graded materials, laminated composite, nano-structured reinforcement, morphing composites, in many engineering fields, such as aerospace, mechanical, naval and civil engineering. The increase in the use of composite structures in different engineering practices justify the present international meeting where researchers from every part of the globe can share and discuss the recent advancements regarding the use of standard structural components within advanced applications such as buckling, vibrations, repair, reinforcements, concrete, composite laminated materials and more recent metamaterials. For this reason, the establishment of this 19th edition of International Conference on Composite Structures has appeared appropriate to continue what has been begun during the previous editions. ICCS wants to be an occasion for many researchers from each part of the globe to meet and discuss about the recent advancements regarding the use of composite structures, sandwich panels, nanotechnology, bio-composites, delamination and fracture, experimental methods, manufacturing and other countless topics that have filled many sessions during this conference. As a proof of this event, which has taken place in Porto (Portugal), selected plenary and keynote lectures have been collected in the present book.

Sustainable Composites for Aerospace Applications presents innovative advances in the fabrication, characterization and applications of LDH polymer nanocomposites. It covers fundamental structural and chemical knowledge and explores various properties and characterization techniques, including microscopic, spectroscopic and mechanical behaviors. Users will find a strong focus on the potential applications of LDH polymer nanocomposites, such as in energy, electronics, electromagnetic shielding, biomedical, agricultural, food packaging and water purification functions. This book provides comprehensive coverage of cutting-edge research in the field of LDH polymer nanocomposites and future applications, and is an essential read for all academics, researchers, engineers and students working in this area. Presents fundamental knowledge of LDH polymer nanocomposites, including chemical composition, structural features and fabrication techniques Provides an analytical overview of the different types of characterization techniques and technologies Contains extensive reviews on cutting-edge research for future applications in a variety of industries

This book contains the proceedings of the IUTAM Symposium on Multiscale Modeling and Uncertainty Quantification of Materials and Structures that was held at Santorini, Greece, September 9 – 11, 2013. It consists of 20 chapters which are divided in five thematic topics: Damage and fracture, homogenization, inverse problems--identification, multiscale stochastic mechanics and stochastic dynamics. Over the last few years, the intense research activity at micro scale and nano scale reflected the need to account for disparate levels of uncertainty from various sources and across scales. As even over-refined deterministic approaches are not able to account for this issue, an efficient blending of stochastic and multiscale methodologies is required to provide a rational framework for the analysis and design of materials and structures. The purpose of this IUTAM Symposium was to promote achievements in uncertainty quantification combined with multiscale modeling and to encourage research and development in this growing field with the aim of improving the safety and reliability of engineered materials and structures. Special emphasis was placed on multiscale material modeling and simulation as well as on the multiscale analysis and uncertainty quantification of fracture mechanics of heterogeneous media. The homogenization of two-phase random media was also thoroughly examined in several presentations. Various topics of multiscale stochastic mechanics, such as identification of material models, scale coupling, modeling of random microstructures, analysis of CNT-reinforced composites and stochastic finite elements, have been analyzed and discussed. A large number of papers were finally devoted to innovative methods in stochastic dynamics.

This book presents current spatial and temporal multiscaling approaches of materials modeling. Recent results demonstrate the deduction of macroscopic properties at the device and
component level by simulating structures and materials sequentially on atomic, micro- and mesostructural scales. The book covers precipitation strengthening and fracture processes in metallic alloys, materials that exhibit ferroelectric and magnetoelectric properties as well as biological, metal-ceramic and polymer composites. The progress which has been achieved documents the current state of art in multiscale materials modelling (MMM) on the route to full multi-scaling. Contents: Part I: Multi-time-scale and multi-length-scale simulations of precipitation and strengthening effects Linking nanoscale and macroscale Multiscale simulations on the coarsening of Cu-rich precipitates in 3-Fe using kinetic Monte Carlo, Molecular Dynamics, and Phase-Field simulations Multiscale modeling predictions of age hardening curves in Al-Cu alloys Kinetic Monte Carlo modeling of shear-coupled motion of grain boundaries Product Properties of a two-phase magneto-electric composite Part II: Multiscale simulations of plastic deformation and fracture Niobium/alumina bicrystal interface fracture Atomistically informed crystal plasticity model for body-centred cubic iron FE2AT finite element informed atomistic simulations Multiscale fatigue crack growth modeling for welded stiffened panels Molecular dynamics study on low temperature brittleness in tungsten single crystals Multi scale cellular automata and finite element based model for cold deformation and annealing of a ferrite-pearlitic microstructure Multiscale simulation of the mechanical behavior of nanoparticle-modified polyamide composites Part III: Multiscale simulations of biological and bio-inspired materials, bio-sensors and composites Multiscale Modeling of Nano-Biosensors Finite strain compressive behaviour of CNT/epoxy nanocomposites Peptide?zinc oxide interaction

The topic of dynamic models tends to be splintered across various disciplines, making it difficult to uniformly study the subject. Moreover, the models have a variety of representations, from traditional mathematical notations to diagrammatic and immersive depictions. Collecting all of these expressions of dynamic models, the Handbook of Dynamic System Modeling explores a panoply of different types of modeling methods available for dynamical systems. Featuring an interdisciplinary, balanced approach, the handbook focuses on both generalized dynamic knowledge and specific models. It first introduces the general concepts, representations, and philosophy of dynamic models, followed by a section on modeling methodologies that explains how to portray designed models on a computer. After addressing scale, heterogeneity, and composition issues, the book covers specific model types that are often characterized by specific visual- or text-based grammars. It concludes with case studies that employ two well-known commercial packages to construct, simulate, and analyze dynamic models. A complete guide to the fundamentals, types, and applications of dynamic models, this handbook shows how systems function and are represented over time and space and illustrates how to select a particular model based on a specific area of interest.

A mesh objective crack band model is implemented in the generalized method of cells (GMC) micromechanics model to predict failure of a composite repeating unit cell (RUC). The micromechanics calculations are achieved using the MAC/GMC core engine within the ImMAC suite of micromechanics codes, developed at the NASA Glenn Research Center. The microscale RUC is linked to a macroscale Abaqus/Standard finite element model using the FEAMAC multiscale framework (included in the ImMAC suite). The effects of the relationship between the characteristic length of the finite element and the size of the microscale RUC on the total energy dissipation of the multiscale model are investigated. A simple 2-D composite square subjected to uniaxial tension is used to demonstrate the effects of scaling the dimensions of the RUC such that the length of the sides of the RUC are equal to the characteristic length of the finite element. These results are compared to simulations where the size of the RUC is fixed, independent of the element size. Simulations are carried out for a variety of mesh densities and element shapes, including square and triangular. Results indicate that a consistent size and shape must be used to yield preserve energy dissipation across the scales.

Clay–Polymer Nanocomposites is a complete summary of the existing knowledge on this topic, from the basic concepts of synthesis and design to their applications in timely topics such as high-performance composites, environment, and energy issues. This book covers many aspects of synthesis such as in-situ polymerization within the interlamellar spacing of the clays or by reaction of pristine or pre-modified clays with reactive polymers and prepolymer. Indeed, nanocomposites can be prepared at industrial scale by melt mixing. Regardless the synthesis method, much is said in this book about the importance of the clay pre-modification step, which is demonstrated to be effective, on many occasions, in obtaining exfoliated nanocomposites. Clay–Polymer Nanocomposites reports the background to numerous characterization methods including solid state NMR, neutron scattering, diffraction and vibrational techniques as well as surface analytical methods, namely XPS, inverse gas chromatography and nitrogen adsorption to probe surface composition, wetting and textural/structural properties. Although not described in dedicated chapters, numerous X-ray diffraction patterns of clay–polymer nanocomposites and reference materials are displayed to account for the effects of intercalation and exfoliations of layered aluminosilicates. Finally, multiscale molecular simulation protocols are presenting for predicting morphologies and properties of nanostructured polymer systems with industrial relevance. As far as applications are concerned, Clay–Polymer Nanocomposites examines structural composites such as clay–epoxy and clay–biopolymers, the use of clay–polymer nanocomposites as reactive nanocomposite fillers, catalytic clay-(conductive) polymers and similar
nanocomposites for the uptake of hazardous compounds or for controlled drug release, antibacterial applications, energy storage, and more. The most comprehensive coverage of the state of the art in clay–polymer nanocomposites, from synthesis and design to opportunities and applications Covers the various methods of characterization of clay–polymer nanocomposites - including spectroscopy, thermal analyses, and X-ray diffraction Includes a discussion of a range of application areas, including biomedicine, energy storage, biofouling resistance, and more

Presenting a state-of-the-art overview of theoretical and computational models that link characteristic biomechanical phenomena, this book provides guidelines and examples for creating multiscale models in representative systems and organisms. It develops the reader's understanding of and intuition for multiscale phenomena in biomechanics and mechanobiology, and introduces a mathematical framework and computational techniques paramount to creating predictive multiscale models. Biomechanics involves the study of the interactions of physical forces with biological systems at all scales – including molecular, cellular, tissue and organ scales. The emerging field of mechanobiology focuses on the way that cells produce and respond to mechanical forces – bridging the science of mechanics with the disciplines of genetics and molecular biology. Linking disparate spatial and temporal scales using computational techniques is emerging as a key concept in investigating some of the complex problems underlying these disciplines. Providing an invaluable field manual for graduate students and researchers of theoretical and computational modelling in biology, this book is also intended for readers interested in biomedical engineering, applied mechanics and mathematical biology.

Composites materials have aroused a great interest over the last few decades. Several applications of fibrous composites, functionally graded materials, laminated composites, nano-structured reinforcements, morphing structures, can be found in many engineering fields, such as aerospace, mechanical, naval and civil engineering. The necessity of lightweight structures, smart and adaptive systems, high-level strength, have led both the academic research and the manufacturing development to a recurring employment of these materials. Many journal papers and technical notes have been published extensively over the last seventy years in international scientific journals of different engineering fields. For this reason, the establishment of this second edition of Mechanics of Composites International Conference has appeared appropriate to continue what has been begun during the first edition occurred in 2014 at Stony Brook University (USA). MECHCOMP wants to be an occasion for many researchers from each part of the globe to meet and discuss about the recent advancements regarding the use of composite structures. As a proof of this event, which has taken place in Porto (Portugal), selected plenary and key-note lectures have been collected in the present book.

The 3rd edition of this popular textbook covers current topics in all areas of casting solidification. Partial differential equations and numerical analysis are used extensively throughout the text, with numerous calculation examples, to help the reader in achieving a working knowledge of computational solidification modeling. The features of this new edition include: • new chapters on semi-solid and metal matrix composites solidification • a significantly extended treatment of multiscale modeling of solidification and its applications to commercial alloys • a survey of new topics such as solidification of multicomponent alloys and molecular dynamic modeling • new theories, including a theory on oxide bi-films in the treatment of shrinkage problems • an in-depth treatment of the theoretical aspects of the solidification of the most important commercial alloys including steel, cast iron, aluminum-silicon eutectics, and superalloys • updated tables of material constants.

A weave reinforced composite material with a thermoplastic matrix is investigated by using a multiscale chain to predict the macroscopic material behavior. A large-strain framework for constitutive modeling with focus on material non-linearities, i.e. plasticity and damage is defined. The ability of the geometric and constitutive models to predict the deformation and failure behavior is demonstrated by means of selected examples.

Multi-scale modelling of composites is a very relevant topic in composites science. This is illustrated by the numerous sessions in the recent European and International Conferences on Composite Materials, but also by the fast developments in multi-scale modelling software tools, developed by large industrial players such as Siemens (Virtual Material Characterization toolkit and MultiMechanics virtual testing software), MSC/e-Xstream (Digitmat software), Simulia (micromechanics plug-in in Abaqus), HyperSizer (Multi-scale design of composites), Altair (Altair Multiscale Designer) This book is intended to be an ideal reference on the latest advances in multi-scale modelling of fibre-reinforced polymer composites, that is accessible for both (young) researchers and end users of modelling software. We target three main groups: This book aims at a complete introduction and overview of the state-of-the-art in multi-scale modelling of composites in three axes: . ranging from prediction of homogenized elastic properties to nonlinear material behaviour . ranging
from geometrical models for random packing of unidirectional fibres over meso-scale geometries for textile composites to orientation tensors for short fibre composites. ranging from damage modelling of unidirectionally reinforced composites over textile composites to short fibre-reinforced composites. The book covers the three most important scales in multi-scale modelling of composites: (i) micro-scale, (ii) meso-scale and (iii) macro-scale. The nano-scale and related atomistic and molecular modelling approaches are deliberately excluded, since the book wants to focus on continuum mechanics and there are already a lot of dedicated books about polymer nanocomposites. A strong focus is put on physics-based damage modelling, in the sense that the chapters devote attention to modelling the different damage mechanisms (matrix cracking, fibre/matrix debonding, delamination, fibre fracture,) in such a way that the underlying physics of the initiation and growth of these damage modes is respected. The book also gives room to not only discuss the finite element based approaches for multi-scale modelling, but also much faster methods that are popular in industrial software, such as Mean Field Homogenization methods (based on Mori-Tanaka and Eshelby solutions) and variational methods (shear lag theory and more advanced theories). Since the book targets a wide audience, the focus is put on the most common numerical approaches that are used in multi-scale modelling. Very specialized numerical methods like peridynamics modelling, Material Point Method, eXtended Finite Element Method (XFEM), isogeometric analysis, SPH (Smoothed Particle Hydrodynamics), are excluded. Outline of the book The book is divided in three large parts, well balanced with each a similar number of chapters: Part I deals with all "ingredients" to start with multi-scale modelling, limited to elastic property prediction. This typically includes: (i) setting up your geometrical model at micro- or meso-scale (definition of Representative Volume Element (RVE) or Repeating Unit Cell (RUC)), (ii) definition of periodic boundary conditions, (iii) homogenization of the elastic properties, starting from the elastic properties of the constituents, (iv) importance of statistical representation of geometry and stochastic nature of fibre architecture. This should bring all readers at the same level of principles and terminology for multi-scale modelling. Advanced users could eventually skip this first part. Part II deals with nonlinear multi-scale modelling. We build further upon the ingredients from Part I, but now add all kinds of nonlineairities to the simulation at micro- or meso-scale (matrix cracking, delamination, fibre/matrix debonding, delamination, fibre failure, visco-elasto-plasticity-damage of the polymer matrix,.) Not only finite element based techniques are covered, but also much faster inclusion methods (Mori-Tanaka, Eshelby,.) and variational methods. Part III deals with the laminate scale or macro-scale, where all these multi-scale modelling tools are applied for macro-scale ply-based modelling and virtual testing of laminates (in static loading, but also sometimes for prediction of fatigue, post-impact strength,). In all three parts, the main three types of fibre reinforcement are covered (unidirectionally reinforced composites, textile composites and short fibre composites). The chapters are written by leading authorities from academia, and each chapter gives a self-contained overview of a specific topic, covering the state-of-the-art and future research challenges. All software users, R&D people and researchers that have some knowledge in general continuum mechanics modelling of composites, but have never worked in the field of multi-scale modelling,. this book should also provide a strong theoretical background to the end users of commercial multi-scale modelling tools, and warn them for the pitfalls and difficulties in obtaining results with such software,. for advanced users and researchers in multi-scale modelling, the book will still be of much value, because almost nobody will cover in his/her own research the complete field of knowledge that is described in this book.

A material's various properties is based on its microscopic and nanoscale structures. This book provides an overview of recent advances in computational methods for linking phenomena in systems that span large ranges of time and spatial scales. Particular attention is given to predicting macroscopic properties based on subscale behaviors. Given the book's extensive coverage of multi-scale methods for modeling both metallic and geologic materials, it will be an invaluable reading for graduate students, scientists, and practitioners alike.

Nanotechnology is a progressive research and development topic with large amounts of venture capital and government funding being invested worldwide. Nano mechanics, in particular, is the study and characterization of the mechanical behaviour of individual atoms, systems and structures in response to various types of forces and loading conditions. This text, written by respected researchers in the field, informs researchers and practitioners about the fundamental concepts in nano mechanics and materials, focusing on their modelling via multiple scale methods and techniques. The book systematically covers the theory behind multi-particle and nanoscale systems, introduces multiple scale methods, and finally looks at contemporary applications in nano-structured and bio-inspired materials.

This book presents the state-of-the-art in multiscale modeling and simulation techniques for composite materials and structures. It focuses on the structural and functional properties of engineering composites and the sustainable high performance of components and structures. The multiscale techniques can be also applied to nanocomposites which are important application areas in nanotechnology. There are few books available on this topic.
The papers in this proceeding are a collection of the works presented at the IUTAM symposium-Marrakech 2002 (October 20-25) which brought together scientists from various countries. These papers cover contemporary topics in multiscale modeling and characterization of materials behavior of engineering materials. They were selected to focus on topics related to deformation and failure in metals, alloys, intermetallics and polymers including: experimental techniques, deformation and failure mechanisms, dislocation-based modelling, microscopic-macroscopic averaging schemes, application to forming processes and to phase transformation, localization and failure phenomena, and computational advances. Key areas that are covered by some of the papers include modeling of material deformation at various scales. At the atomistic scale, results from MD simulations pertaining to deformation mechanisms in nano-crystalline materials as well as dislocation-defect interactions are presented. Advances in modeling of deformation in metals using discrete dislocation analyses are also presented, providing an insight into this emerging scientific technique that can be used to model deformation at the microscale. These papers address current engineering problems, including deformation of thin films, dislocation behavior and strength during nanoindentation, strength in metal matrix composites, dislocation-crack interaction, development of textures in polycrystals, and problems involving twining and shape memory behavior. On Behalf of the organizing committee, I would like to thank Professor P.