Finite Volume Micromechanics Of Heterogeneous Periodic Materials An Attractive Alternative To The Finite Element Based Homogenization Of Heterogeneous Media

In mining and mineral processing, compressive loading is often encountered during the comminution of ore bearing minerals and in the wear resistant materials used in the comminution circuit. A common thread joining many of the materials that are primarily used under compressive loading is the presence of a high modulus reinforcement, either fiber or particulate, embedded within a lower modulus matrix phase (i.e., a brittle heterogeneous material). Many of these heterogeneous materials are designed or manufactured such that an imperfect interface (i.e., an interface that provides less than complete coherency between the reinforcing phase and the matrix) exists between the reinforcing phase and the matrix (e.g., tough fiber-reinforced ceramics). To date, most research has focused on the response of these heterogeneous materials with imperfect interfaces to tensile loading; however, little is known about their response to compressive loading. The principal objective of this investigation is to develop a better understanding of the micromechanical behavior of these complex materials under compressive loading. Analytical solutions are reviewed and compared with finite element models for the simulation of heterogeneous materials with imperfect interfaces under compressive loading. This comparison shows that a nonlinear numerical approach (finite element method) is necessary to fully simulate the behavior of these materials. To validate the nonlinear model, laser moire experiments were conducted on a model heterogeneous material loaded under uniaxial and biaxial compression. In-plane displacements were measured and found to be in fundamental agreement with the nonlinear finite element model. Subsequently, finite element simulations were developed for a variety of heterogeneous materials with imperfect interfaces. Results show that deleterious tensile stress concentrations are primarily influenced by three factors: (i) the nature of the imperfect interface, (ii) the moduli mismatch between the reinforcement and matrix, and (iii) the volume fraction of the reinforcement. Finally, crack initiation experiments in laboratory models of a heterogeneous material with a frictional imperfect interface were conducted to substantiate the prior work using nonlinear finite element models. Experimental results correlate well with the numerically-predicted micromechanical behavior of a model heterogeneous system under uniaxial compressive loading.

The strength of metallic materials determines the usability and reliability of all the machines, tools and equipment around us. Yet, the question about which mechanisms control the strength and damage resistance of materials and how they can be optimised remains largely unanswered. How do real, heterogeneous ma- rials deform and fail? Why can a small modification of the microstructure increase the strength and damage resistance of materials manifold? How can the strength of heterogeneous materials be predicted? The purpose of this book is to present different experimental and computational analysis methods of micromechanics of damage and strength of materials and to demonstrate their applications to various micromechanical problems. This book summarizes at a glance some of the publications of the Computational Mechanics Group at the IMWF/MPA Stuttgart, dealing with atomistic, micro- and meso- chanical modelling and experimental analysis of strength and damage of metallic materials. In chapter 1, the micromechanisms of damage and fracture in different groups of materials are investigated experimentally, using direct observations and inverse analysis. The interaction of microstructural elements with the evolving damage is studied in these experiments. Chapter 2 presents different approaches to the - cromechanical simulation of composite materials: embedded unit cells, multiphase finite elements and multiparticle unit cells. Examples of the application of these models to the analysis of deformation and damage in different materials are given. Chapter 3 deals with the methods of numerical modelling of damage evolution and crack growth in heterogeneous materials.

This book contains fifteen papers based on the presentations made at the symposium on "Inelasticity and Micromechanics of Metal Matrix Composites" held at the University of Washington, USA, in mid-1994. The papers represent the most recent work conducted on inelasticity and micromechanics of metal matrix composites. The book is divided into two parts: Part I deals with the study of inelastic deformation in metal matrix composites, while Part II tackles the micromechanical aspects of metal matrix composites. The articles discuss different aspects of these two topics ranging from purely theoretical treatments to extensive experimental investigations. Many of the papers are by prominent researchers working in this area.

This book provides the fundamental basics for solving fluidstructure interaction problems, and describes different algorithmsand numerical methods used to solve problems where fluid andstructure can be weakly or strongly coupled. These approaches areillustrated with examples arising from industrial or academicapplications. Each of these approaches has its own performance andlimitations. Given the book's comprehensive coverage,engineers, graduate students and researchers involved in thesimulation of practical fluid structure interaction problems willfind this book extremely useful.

A Book in Honour of D. Roger J. Owen

Local and Nonlocal Micromechanics of Heterogeneous Materials

A Generalized Multiscale Analysis Approach

Eulerian Hydrocode Analysis of Reactive Micromechanics in the Shock Initiation of Heterogeneous Energetic Material

Micromechanics in Practice

Micromechanical Analysis and Multi-Scale Modeling Using the Voronoi Cell Finite Element Method

Here is an accurate and timely account of micromechanics, which spans materials science, mechanical engineering, applied mathematics, technical physics, geophysics, and biology. The book features rigorous and unified theoretical methods of applied mathematics and statistical physics in the material science of microheterogeneous media. Uniquely, it offers a useful demonstration of the systematic and fundamental research of the microstructure of the wide class of heterogeneous materials of natural and synthetic nature.

The book will concentrate on the application of micromechanics to the analysis of practical engineering problems. Both classical composites represented by carbon/carbon textile laminates and applications in Civil Engineering including asphalts and masonry structures will be considered. A common denominator of these considerably distinct material systems will be randomness of their internal structure. Also, owing to their complexity, all material systems will be studied on multiple scales. Since real engineering, rather than academic, problems are of the main interest, these scales will be treated independently from each other on the grounds of fully uncoupled multi-scale analysis. Attention will be limited to elastic and viscoelastic behaviour and to the linear heat transfer analysis. To achieve this, the book will address two different approaches to the homogenization of systems with random microstructures. In particular, classical averaging schemes based on the Eshelby solution of a solitary inclusion in an infinite medium represented by the Hashin-Shtrikman variational principles or by considerably simpler and more popular Mori-Tanaka method will be compared to detailed finite element simulations of a certain representative volume element (RVE) representing accommodated geometrical details of respective microstructures. These are derived by matching material statistics such as the one- and two-point probability functions of real and artificial microstructures. The latter one is termed the statistically equivalent periodic unit cell owing to the assumed periodic arrangement of reinforcements (carbon fibres, carbon fibre tows, stones or masonry bricks) in a certain matrix (carbon matrix, asphalt mastic, mortar). Other types of materials will be introduced in the form of exercises with emphases to the application of the Mori-Tanaka method in the framework of the previously mentioned uncoupled multi-scale analysis

This textbook demonstrates the application of the finite element philosophy to the solution of real-world problems and is aimed at graduate level students, but is also suitable for advanced undergraduate students. An essential part of an engineer's training is the development of the skills necessary to analyse and predict the behaviour of engineering systems under a wide range of potentially complex loading conditions. Only a small proportion of real-life problems can be solved analytically, and consequently, there arises the need to be able to use numerical methods capable of simulating real phenomena accurately. The finite element (FE) method is one such widely used numerical method. Finite Element Applications begins with demystifying the 'black box' of finite element solvers and progresses to addressing the different pillars that make up a robust finite element solution framework. These pillars include: domain creation, mesh generation and element formulations, boundary conditions, and material response considerations. Readers of this book will be equipped with the ability to develop models of real-world problems using industry-standard finite element packages.

The idea of this monograph is to present the latest results related to design and analysis of materials and engineering structures. The contributions cover the field of mechanical and civil engineering, ranging from automotive to dam design, transmission towers and up to machine design and exmaples taken from oil industry. Well known experts present their research on damage and fracture of material and structures, materials modelling and evaluation up to image processing and visualization for advanced analyses and evaluation

Micromechanics Modeling Methods and Simulations

Annual Report, 1989

Mechanics Down Under

Numerical Simulation

Overall Properties of Heterogeneous Materials

Annual Report

Toshio Mura has written extensively on micromechanics over the years, and in part due to his writings and many others in the field, micromechanics has gradually emerged as a recognized discipline in the study of mechanics of materials. The idea is to bring both the mechanics and physics on the micro scopic level to the macroscopic scale, so that the deformation and fracture processes of materials can be better understood. While much apparently remains to be done, this approach has already shed new light on certain selected topics and has proved to be fruitful. It is indeed a happy occasion to celebrate both Toshio's upcoming 65th birthday and the emergence of this young science at the same time. The volume contains thirty-seven original articles on the related topics of micromechanics and inhomogeneity; it is presented to Toshio by his friends, colleagues, and admirers as a wish for his good health and continuing pro ductivity. The contributors belong to both the applied mechanics and the materials communities, all with a common belief that micromechanics is an indispensable area of research. It is hoped that this somewhat balanced structure will make the volume more useful to a wider range of readers, and that in the meantime it will still reflect more or less the spectrum of Toshio's lifelong works. As Editors we have at the outset set the highest possible standards for the book, with a keen anticipation that the volume will be widely circulated for many years to come.

A comprehensive overview is given in this book towards a fundamental understanding of the micromechanics of the overall response and failure modes of advanced materials, such as ceramics and ceramic and other composites. These advanced materials have become the focus of systematic and extensive research in recent times. The book consists of two parts. The first part reviews solids with microdefects such as cavities, cracks, and inclusions, as well as elastic composites. To render the book self-contained, the second part focuses on the fundamentals of continuum mechanics, particularly linear elasticity which forms the basis for the development of small deformation micromechanics. In Part 1, a fundamental and general framework for quantitative, rigorous analysis of the overall response and failure modes of microstructurally heterogeneous solids is systematically developed. These expressions apply to broad classes of materials with inhomogeneities and defects. While for the most part, the general framework is set within linear elasticity, the results directly translate to heterogeneous solids with rate-dependent or rate-independent inelastic constituents. This application is specifically referred to in various chapters. The general exact correlations obtained between the overall properties and the microstructure are then used together with simple models, to develop techniques for direct quantitative evaluation of the overall response which is generally described in terms of instantaneous overall moduli or compliance. The correlations among the corresponding results for a variety of problems are examined in great detail. The bounds as well as the specific results, include new observations and original developments, as well as an in-depth account of the state of the art. Part 2 focuses on Elasticity. The section on variational methods includes some new elements which should prove useful for application to advanced modeling, as well as solutions of composites and related heterogeneous bodies. A brief modern version of elements in vector and tensor algebra is provided which is particularly tailored to provide a background for the rest of this book. The data contained in this volume as Part 1 includes new results on many basic issues in micromechanics, which will be helpful to graduate students and researchers involved with rigorous physically-based modeling of overall properties of heterogeneous solids.

This book is the first to apply the Spectral Finite Element Method (SFEM) to inhomogeneous and anisotropic structures in a unified and systematic manner. Readers will gain understanding of how to formulate Spectral Finite Element; learn about wave behaviour in inhomogeneous and anisotropic media; and, be able to design some diagnostic tools for monitoring the health of a structure. Tables, figures and graphs support the theory and case studies are included.

Attachment of dissimilar materials in engineering and surgical practice is a perennial challenge. Bimaterial attachment sites are common locations for injury, repeated injury, and mechanical failure. Nature presents several highly effective solutions to the challenge of bimaterial attachment that differ from those found in engineering practice. Structural Interfaces and Attachments in Biology describes the attachment of dissimilar materials from multiple perspectives. The text will simultaneously elucidate natural bimaterial attachments and outline engineering principles underlying successful attachments to the communities of tissue engineers and surgeons. Included an in-depth analysis of the biology of attachments in the body and mechanisms by which robust attachments are formed, a review of current concepts of attaching dissimilar materials in surgical practice and a discussion of bioengineering approaches that are currently being developed.

An Introduction to Computational Micromechanics

Micromechanics

Composite Materials and Structures in Aerospace Engineering

Micromechanics of Heterogeneous Materials Under Compressive Loading

Finite Volume Direct Averaging Micromechanics of Heterogeneous Media

Applied Rve Reconstruction and Homogenization of Heterogeneous Materials

The book contains state-of the-art reviews in the area of effective properties of heterogeneous materials - the classical field at interface of materials science and solid mechanics. The primary focus is on thermo-mechanical properties, materials science applications, as well as computational aspects and new opportunities provided by rapidly increasing computer powers. The reviews are at the level that is appropriate for a substantial community of researchers working in this field, both at universities and in the industry, and to graduate students. The book can be used as supplementary reading to graduate level courses.

In this second edition several new topics of technological interest have been added. These include: coupled mechanical and nonmechanical overall properties of heterogeneous piezoelectric materials, new upper and lower bounds for these coupled properties, a systematic comparison between the average-field theory and the results obtained using multi-scale perturbation theory, an account of the uniform-field theory, improveable bounds on overall moduli of heterogeneous materials which remain finite even when isolated cavities and rigid inclusions are present, and a brief account of a fundamental duality principle in anisotropic elasticity. In addition, better explanations of a number of topics are given, more recent references are added, the Subject Index has been expanded and printing and typographical errors have been corrected. The material is organized into two parts preceded by a précis. Part 1 consists of four chapters which are organized into fourteen sections and four appendixes. It deals with materials with microdefects such as cavities, cracks, and inclusions, as well as with elastic composites. Part 2 consists of two chapters which are divided into seven sections. It provides an introduction to the theory of linear elasticity, added to make the book self-contained, since linear elasticity serves as the basis of the development of small-deformation micromechanics. Part 2 mainly contains part of the lecture notes on elasticity which the first author wrote in the late 1960's. The material is mostly standard, given for background information.

Most materials used in contemporary life and industry are heterogeneous (composites) and multicomponent, possessing a rich and complex internal structure. This internal structure, or microstructure, plays a key role in understanding and controlling the continuum behavior, or macroscopic, of a wide variety of materials. The modeling process is a critical tool for scientists and engineers studying the analysis and experimentation for the micromechanics and behavior of these materials. "Heterogeneous Media" is a critical, in-depth edited survey of the major topics surrounding the modeling and analysis of problems in micromechanics of multicomponent systems, including conceptual and practical aspects. The goal of this extensive and comprehensive survey is to provide both specialists and nonspecialists with an authoritative and interdisciplinary perspective of current ideas and methods used for modeling heterogeneous materials behavior and their applications. Topics and Features: * all chapters use interdisciplinary modeling perspective for investigating heterogeneous media*Five chapters provide self-contained discussions, with background provided*Focuses only upon most important techniques and models, fully exploring micro-macro interconnections*extensive introductory survey chapter on micromechanics of heterogeneous media*microstructure characterization via statistical correlation functions*micro-scale deformation of pore space*wave fields and effective dynamical properties*modeling of the complex production technologies for composite materials The book is ideal for a general scientific and engineering audience needing an in-depth view and guide to current ideas, methods and

This book presents the most recent progress of fundamental nature made in the new developed field of micromechanics: transformation field analysis, variational bounds for nonlinear composites, higher-order gradients in micromechanical damage models, dynamics of composites, pattern based variational bounds.

The Toshio Mura 65th Anniversary Volume

Micromechanics of Composite Materials

Journal of Engineering Materials and Technology

Advances in Computational Plasticity

Introduction to Micromechanics and Nanomechanics

Proceedings of the IUTAM Symposium held in Beijing, China, June 27-30, 2005

Applied RVE Reconstruction and Homogenization of Heterogeneous Materials contains the basic principles underlying the main continuum mechanical partial differential equation models used in practice, together with numerical methods to approximately solve them. This book offers a unified presentation of continuum mechanical models and their discrete counterparts, providing a deeper understanding of the relationship between the main numerical methods, finite element methods, finite volume methods, and the advantages and shortcomings of each. In addition, the book shows, by way of Matlab code snippets, how to implement the methods described for all types of different problems, including linear and nonlinear and stationary and time dependent, also covering solids and fluids and the typical common finite element, finite volume, and time stepping methods. Presents a comprehensive approach for statistical RVE generation and homogenization of reconstructed RVE Creates a link between experimental and theoretical homogenization approaches Demonstrates how to extract statistical data from a different experimental approach Provides users with all they need to approximate higher order correlation functions

This dissertation research focuses on micromechanical modeling and simulations of two-phase heterogeneous materials exhibiting anisotropic and non-uniform microstructures with long-range spatial correlations. Completed work involves development of methodologies for realistic micromechanical analyses of materials using a combination of stereological techniques, two- and three-dimensional digital image processing, and finite element based modeling tools. The methodologies are developed via its applications to two technologically important material systems, namely, discontinuously reinforced aluminum composites containing silicon carbide particles as reinforcement, and boron modified titanium alloys containing in situ formed titanium boride whiskers. Microstructural attributes such as the shape, size, volume fraction, and spatial distribution of the reinforcement phase in these materials were incorporated in the models without any simplifying assumptions. Instrumented indentation was used to determine the constitutive properties of individual microstructural phases. Micromechanical analyses were performed using realistic 2D and 3D models and the results were compared with experimental data. Results indicated that 2D models fail to capture the deformation behavior of these materials and 3D analyses are required for realistic simulations. The effect of clustering of silicon carbide particles and associated porosity on the mechanical response of discontinuously reinforced aluminum composites was investigated using 3D models. Parametric studies were carried out using computer simulated microstructures incorporating realistic microstructural attributes. The intrinsic merit of this research is the development and integration of the required enabling techniques and methodologies for representation, modeling, and simulations of complex geometry of microstructures in two- and three-dimensional space facilitating better understanding of the effects of microstructural geometry on the mechanical behavior of materials.

With composites under increasing use in industry to replace traditional materials in components and structures, the modeling of composite performance, damage and failure has never been more important. Micromechanics of Composite Materials: A Generalized Multiscale Analysis Approach brings together comprehensive background information on the multiscale nature of the composite, constituent material behaviour, damage models and key techniques for multiscale modelling, as well as presenting the findings and methods, developed over a lifetime's research, of three leading experts in the field. The unified approach presented in the book for conducting multiscale analysis and design of conventional and smart composite materials is also applicable for structures with complete linear and nonlinear material behavior, with numerous applications provided to illustrate use. Modeling composite behaviour is a key challenge in research and industry; when done efficiently and reliably it can save money, decrease time to market with new innovations and prevent component failure. This book provides the tools and knowledge from leading micromechanics research, allowing researchers and senior engineers within academia and industry with to improve results and streamline development workflows. Brings together for the first time the findings of a lifetime's research in micromechanics by recognized leaders in the field Provides a comprehensive overview of all micromechanics formulations in use today and a unified approach that works for the multiscale analysis and design of multi-phased composite materials, considering both small strain and large strain formulations Combines otherwise disparate theory, code and techniques in a step-by-step manner for efficient and reliable modeling of composites

As multi-phase metal/alloy systems and polymer, ceramic, or metal matrix composite materials are increasingly being used in industry, the science and technology for these heterogeneous materials has advanced rapidly. By extending analytical and numerical models, engineers can analyze failure characteristics of the materials before they are integrated into the design process. Micromechanical Analysis and Multi-Scale Modeling Using the Voronoi Cell Finite Element Method addresses the key problem of multi-scale failure and deformation of materials that have complex microstructures. The book presents a comprehensive computational mechanics and materials science–based framework for multi-scale analysis. The focus is on micromechanical analysis using the Voronoi cell finite element method (VCFEM) developed by the author and his research group for the efficient and accurate modeling of materials with non-uniform heterogeneous microstructures. While the topics covered in the book encompass the macroscopic scale of structural components and the microscopic scale of constituent heterogeneities like inclusions or voids, the general framework may be extended to other scales as well. The book presents the major components of the multi-scale analysis framework in three parts. Dealing with multi-scale image analysis and characterization, the first part of the book covers 2D and 3D image-based microstructure generation and tessellation into Voronoi cells. The second part develops VCFEM for micromechanical stress and failure analysis, as well as thermal analysis, of extended microstructural regions. It examines a range of problems solved by VCFEM, from heat transfer and stress-strain analysis of elastic, elastic-plastic, and viscoplastic material microstructures to microstructural damage models including interfacial debonding and ductile failure. Establishing the multi-scale framework for heterogeneous materials with and without damage, the third part of the book discusses adaptive concurrent multi-scale analysis incorporating bottom-up and top-down modeling. Including numerical examples and a CD-ROM with VCFEM source codes and input/output files, this book is a valuable reference for researchers, engineers, and professionals involved with predicting the performance and failure of materials with structure-materials interactions.

Nonlinear Mesomechanics of Composites with Periodic Microstructure

Finite Element Applications

Micromechanics of Heterogeneous Materials

Realistic Micromechanical Modeling and Simulation of Two-phase Heterogeneous Materials

Atomistic and Continuum Modeling of Nanocrystalline Materials

Arbitrary Lagrangian Eulerian and Fluid-Structure Interaction

This volume contains the proceedings of the IUTAM Symposium on Mechanical Behavior and Micro-mechanics of Nanostructured Materials, held in Beijing on June 27-30, 2005. The proceedings consist of approximately 30 presentations. Nano-scale, micro-scale, theoretical, experimental and numerical aspects of the subjects are covered. A wide scope of research and progress are displayed. This is the first work in print on this particular subject.

This book presents a systematic treatise on micromechanics and nanomechanics, which encompasses many important research and development areas such as composite materials and homogenizations, mechanics of quantum dots, multiscale analysis and mechanics, defect mechanics of solids including fracture and dislocation mechanics, etc. In this second edition, some previous chapters are revised, and some new chapters added — crystal plasticity, multiscale crystal defect dynamics, quantum force and stress, micromechanics of metamaterials, and micromorphic theory. The book serves primarily as a graduate textbook and intended as a reference book for the next generation of scientists and engineers. It also has a unique pedagogical style that is specially suitable for self-study and self-learning for many researchers and professionals who do not have time attending classes and lectures.

This volume contains papers selected from the more than 120 contributions presented during the 4th international conference on Materials Structure & Micromechanics of Fracture (MSMF-4), in Brno, Czech Republic, June 23-25, 2004. The MSMF-4 conference successfully carried on the tradition of previous conferences. Nearly 150 scientists from 21 countries presented a variety of multiscale approaches to the modeling and testing of deformation and fracture processes in engineering materials. In collaboration with the International Advisory Board, the organizers also asked Prof. A. J. McEvily (University of Connecticut, USA), Prof. W. Dietzel (GKSS-Forschungszentrum Geesthacht GmbH, Germany), Prof. G. E. Beltz (University of Santa Barbara, California, USA) and Prof. T. Kitamura (Kyoto University, Japan) to prepare plenary key-note lectures. In addition, other leading scientists were asked to provide key-note lectures for each section. The resultant papers, ordered approximately in a sequence going from atomistic to mezoscopic to macroscopic, are presented in the first section of these proceedings. The contributed papers are similarly ordered in the second section.The main goal of the book was to demonstrate a variety of multiscale approaches, ranging from atomistic to macroscopic levels, and in this it succeeds admirably.

Composite structures are massively exploited in many engineering fields. For instance, the state-of-the-art civil aircraft (B787 and A350) are mostly made of composite materials. The design of composites leads to challenging tasks since those competencies that stemmed from the adoption of metallic materials are often inadequate for composites. Insights on many different disciplines and tight academic/industrial cooperation are required to fully exploit composite structure capabilities.

Spectral Finite Element Method

Micromechanics and Inhomogeneity

Multiscale Modeling in Biomechanics and Mechanobiology

Composite Materials

Computational Methods for Microstructure-Property Relationships

Effective Properties of Heterogeneous Materials

This book presents the micromechanics of random structure heterogeneous materials, a multidisciplinary research area that has experienced a revolutionary renascence at the overlap of various branches of materials science, mechanical engineering, applied mathematics, technical physics, geophysics, and biology. It demonstrates intriguing successes of unified rigorous theoretical methods of applied mathematics and statistical physics in material science of microheterogeneous media. The prediction of the behaviour of heterogeneous materials by the use of properties of constituents and their microstructure is a central problem of micromechanics. This book is the first in micromechanics where a successful effort of systematic and fundamental research of the microstructure of the wide class of heterogeneous materials of natural and synthetic nature is attempted. The uniqueness of the book lies in its development and expressive representation of statistical methods quantitatively describing random structures which are at most adopted for the forthcoming evaluation of a wide variety of macroscopic transport, electromagnetic, strength, and elastoplastic properties of heterogeneous materials.

This book presents the latest developments and applications of micromechanics and nanomechanics. It particularly focuses on some recent applications and impact areas of micromechanics and nanomechanics that have not been discussed in traditional micromechanics and nanomechanics books on metamaterials, micromechanics of ferroelectric/piezoelectric, electromagnetic materials, micromechanics of interface, size effects and strain gradient theories, computational and experimental nanomechanics, multiscale simulations and theories, soft matter composites, and computational homogenization theory. This book covers analytical, experimental, as well as computational and numerical approaches in depth.

In this, its second corrected printing, Zohdi and Wriggers' illuminating text presents a comprehensive introduction to the subject. The authors include in their scope basic homogenization theory, microstructural optimization and multifield analysis of heterogeneous materials. This volume is ideal for researchers and engineers, and can be used in a first-year course for graduate students with an interest in the computational micromechanical analysis of new materials.

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.

Micromechanics and Nanosimulation of Metals and Composites

Continuum Micromechanics

Multipole Expansion Approach

Inelasticity and Micromechanics of Metal Matrix Composites

Fatigue and Fracture

A Practical Guide to the FEM Process

Computational Methods for Microstructure-Property Relationships introduces state-of-the-art advances in computational modeling approaches for materials structure-property relations. Written with an approach that recognizes the necessity of the engineering computational mechanics framework, this volume provides balanced treatment of heterogeneous materials structures within the microstructural and component scales. Encompassing both computational mechanics and computational materials science disciplines, this volume offers an analysis of the current techniques and selected topics important to industry researchers, such as deformation, creep and fatigue of primarily metallic materials. Researchers, engineers and professionals involved with predicting performance and failure of materials will find Computational Methods for Microstructure-Property Relationships a valuable reference.

Micromechanics of Composites: Multipole Expansion Approach, Second Edition outlines substantial recent progress in the development of the multipole expansion method and focuses on its application to actual micromechanical problems. The book covers micromechanics topics such as conductivity and elasticity of particulate and fibrous composites, including those with imperfect and partially debonded interfaces, nanocomposites, cracked solids, and more. Complete analytical solutions and accurate numerical data are presented in a unified manner for the multiple inhomogeneity models of finite, semi-, and infinite heterogeneous solids. This new edition has been updated to include the theories and techniques of the multipole expansion method. Two entirely new chapters covering the conductivity and elasticity of composites with ellipsoidal inhomogeneities and anisotropic constituents have been added. A special emphasis is made on the heterogeneous solids with imperfect interfaces, including the nanoporous and nanocomposite materials. Gives a systematic account on the multipole expansion method, including its theoretical foundations, analytical and numerical techniques, and a new, dipole moment-based approach to the homogenization problem Contains detailed analytical and numerical analyses of a variety of micromechanical multiple inhomogeneity models, providing clear insight into the physical nature of the problems under study Provides a reliable theoretical framework for developing the full-field based micromechanical theories of a composite's strength, brittle/fatigue damage development, and other properties

The 22nd International Congress of Theoretical and Applied Mechanics (ICTAM) of the International Union of Theoretical and Applied Mechanics was hosted by the Australasian mechanics community in the city of Adelaide during the last week of August 2008. Over 1200 delegates met to discuss the latest development in the fields of theoretical and applied mechanics. This volume records the events of the congress and contains selected papers from the sectional lectures and invited lectures presented at the congresses six mini-symposia.

Atomistic and Continuum Modeling of Nanocrystalline Materials develops a complete and rigorous state-of-the-art analysis of the modeling of the mechanical behavior of nanocrystalline (NC) materials. Among other key topics, the material focuses on the novel techniques used to predict the behavior of nanocrystalline materials. Particular attention is given to recent theoretical and computational frameworks combining atomistic and continuum approaches. Also, the most relevant deformation mechanisms governing the response of nanocrystalline materials are addressed and discussed in correlation with available experimental data.

Advanced Methods and Theoretical Concepts

Wave Propagation, Diagnostics and Control in Anisotropic and Inhomogeneous Structures

Design and Analysis of Materials and Engineering Structures

Deformation Mechanisms and Scale Transition

Handbook of Micromechanics and Nanomechanics

Micromechanics of Composites

This book brings together some 20 chapters on state-of-the-art research in the broad field of computational plasticity with applications in civil and mechanical engineering, metal forming processes, geomechanics, nonlinear structural analysis, composites, biomechanics and multi-scale analysis of materials, among others. The chapters are written by world leaders in the different fields of computational plasticity.

Structural Interfaces and Attachments in Biology

Proceedings of the 22nd International Congress of Theoretical and Applied Mechanics, held in Adelaide, Australia, 24 - 29 August, 2008.

IUTAM Symposium on Mechanical Behavior and Micro-Mechanics of Nanostructured Materials

Heterogeneous Media

MSMF-4 : Proceedings of the Fourth International Conference on Materials Structure & Micromechanics of Fracture, Brno, Czech Republic, June 23-25, 2004

Materials Structure & Micromechanics of Fracture IV