

# Preface

There exists considerable work involving isotropic and homogeneous solids. Most metallic and polymeric composite materials are heterogeneous in nature. The heterogeneity is the result of the presence of multiphases and interfaces both adhesively and cohesively in these composites. Their effective elastic properties are governed by the joint properties of the different phases, where volume fractions, directionality, inhomogeneity and anisotropy, and varied length and time scales govern these properties. Two major categories exist: composites with microscopic functional reinforcements/alloying elements and composites with nanoscopic reinforcements. The treatments of those two categories of composites are the focus of this work.

This edited book covers micromechanics and nanomechanics as applied to composite solids. Micromechanics employs traditional continuum mechanics techniques to describe the behavior of features in the order of microns. Nanomechanics, on the other hand, considers the atomic/molecular structures by employing molecular mechanics, molecular dynamics, sequential and concurrent coupling of length scales, and atomistic-based continuum techniques, among others. Whether micromechanics or nanomechanics are used in the treatment of composites, a representative unit cell or a representative volume element is typically developed and used to obtain a homogenized determination of the effective macroscopic properties of the composite. Many micromechanics, nanomechanics, and homogenization techniques exist, and it is the intention of this effort to provide the reader with recent advances in these fields. The unique property combinations that result from the introduction of fiber and alloying elements and additives, the interface, and the matrix provide greater opportunities for the development of advanced material technologies to meet the challenges of the next century.

There are three reasons for the surge and interest in micro- and nanomechanics research as applied to composite, functional materials, and granular structures. The first stems from the desire to tailor the properties of engineered materials to suit a specific application(s). The second, from the desire to reduce our carbon print and ensure effective use of resources. And the third, from the current advances in computational micromechanics, nanomechanics, and multiscale modeling techniques.

This book is not an attempt to exhaustively cover all the relevant topics on micromechanics, nanomechanics, and homogenization of heterogeneous solids. Instead, it is dedicated to recent developments in the field and its most exciting aspects. It covers a range of topics that clearly demonstrate the depth, the diversity, and the breadth of this fertile area of research which is governed by size/scale, anisotropy, and morphology dependence of interacting phases that define the bulk properties of the resulting materials. It contains 17 chapters authored/coauthored by some of the most talented and respected researchers in the community. Specifically, it covers the following important topics:

Sequential and concurrent atomistic multiscale modeling of multiphysics problems (Chapter 1), MD modeling of nanoindentation of multilayered graphene-reinforced nanocomposites (Chapter 2), MD studies of nanocomposites reinforced by defective CNTs (Chapter 3), Electrical conductivity of CNT- and Graphene-Based Nanocomposites (Chapter 4), Mechanical behavior of nanowires with high-order surface stress effects (Chapter 5), Design of nano-inhomogeneities with internal strain in antiplane deformations of Composites (Chapter 6), Ballistic performance of bimodal nanostructured and nanotwin-strengthened metals (Chapter 7), Full-field micromechanics of Precipitated SMAs (Chapter 8), Micromechanics of ferroic functional materials (Chapter 9), Micromechanics of bone modeled as a composite material (Chapter 10), Linear elastic composites containing spheroidal inclusions (Chapter 11), Time-incremental Eshelby-based homogenization scheme for viscoelastic heterogeneous materials (Chapter 12), Local spin effects on bulk properties of granule materials (Chapter 13), Parametric HFGMC micromechanics (Chapter 14), Parameterization of reinforcement phase distribution in continuous FRCs (Chapter 15), Micromechanical modeling of polymeric composites with moisture absorption (Chapter 16), General interface integral equations in elasticity of random structure composites (Chapter 17).

In each chapter, the state of the art in the respective field and the future trends are covered and discussed.

This effort offers an up-to-date coverage of diverse but highly related topics on modeling, characterization, and applications of micromechanics and nanomechanics in advanced and functional materials in a single volume. We believe that it is an excellent resource and it should be of interest to undergraduate and graduate physics and engineering students as well as researchers in academic institutions, government agencies and industries specializing in aerospace, mechanical, electrical, material science, mining, biomedical, and civil engineering. We are confident that the readers will find the information covered in this book current, useful, and informative. We are confident that the readers will find the information covered in this book current, useful, and informative.

Finally, we wish to take this opportunity to sincerely express our gratitude to the authors for their outstanding contributions in addressing many of the exciting new concepts and developments in micromechanics and nanomechanics of composites. Their informative efforts should guide both the experienced and the new-comers

to these fascinating areas of research. We are also indebted to our wives Valerie Meguid and Jackie Li for their affectionate encouragement and support throughout the different stages of this effort.

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