Engineering Materials

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Valery P. Matveenko *Editors*

Mechanics of Advanced Materials

Analysis of Properties and Performance

Springer

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Preface

In the last two decades, Mechanics of Materials as a discipline has experienced a type of revival. The main reason for this has been a continuing introduction of new materials (or even their classes) with extraordinary microstructures, properties and performance. Carbon nanotubes, quantum dots, bulk metallic glasses and graphene are some of the examples. This revival process was additionally enhanced by an application-related drive to expose these—as well as previously known and used—materials to harsher conditions: high strains, strain rates, loads and temperatures as well as combinations of various loading and environmental factors. Recent developments in aerospace, energy, automotive and defence industries as well as in microelectronics were possible thanks to extended usability envelopes for various components and structures.

Another important factor was the introduction of technologies allowing the production of materials and even final parts with precise control of their microstructural features, and, hence, properties and performances. A typical example is additive manufacturing—more known as *3d printing*—that can reproduce detailed microstructural patterns, developed by researchers in *silico*; it currently also has a capability to use multiple materials, gradual changes in properties—and with continuously improving spatial resolution.

This progress affected significantly Mechanics of Materials that its broadly used classical formulations does not fully meet the new challenges. This volume presents some of the current developments and trends in this field covering experimental, theoretical and numerical approaches and results. The examined materials include established ones such as metals and alloys (including, *i. a.*, pure indium), or polymeric fibrous networks as well as new types of materials: bulk metallic glasses, smart materials and metamaterials with a negative Poisson's ratio. Properties and deformation behaviours of composites with various types of constituents are also discussed.

Among the theoretical matters presented are the use of a phase-field formalism and its finite-element realisation for analysis of crack initiation and propagation in brittle materials; a statistical scheme for mechanics of composites with random reinforcement employing correlation functions of the second and higher orders and

a variational formulation for quasi-harmonic vibrations of an electro-viscoelastic smart material consisting of elastic, viscoelastic and piezoelectric elements. All these theoretical schemes are also accompanied by examples of their numerical implementations for various case studies. Some dedicated numerical approaches and algorithms are also offered in other parts of the volume.

A wide range of experimental methods are discussed: tests at small scale (nanoindentation and micropillar compression); creep at various temperatures; wedge indentation etc. These tests were performed on specimens of various shapes and dimensions, for different stress/strain states and microstructures.

Thus, this volume would be of interest to researchers and engineers working on links between microstructures of advanced materials and their mechanical properties and performance.

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The last decades have seen a large extension of types of materials employed in various applications. In many cases these materials demonstrate mechanical properties and performance that vary significantly from those of their traditional counterparts. Such uniqueness is sought – or even specially manufactured – to meet increased requirements on modern components and structures related to their specific use. As a result, mechanical behaviors of these materials under different loading and environmental conditions are outside the boundaries of traditional mechanics of materials, presupposing development of new characterization techniques, theoretical descriptions and numerical tools. The book presents interesting examples of recent developments in this area. Among the studied materials are bulk metallic glasses, metamaterials, special composites, piezoelectric smart structures, nonwovens, etc.

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