Meccanica (2014) 49:2549–2550
DOI 10.1007/s11012-014-0040-9

Multi-scale and multi-physics modelling for complex materials

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Published online: 20 August 2014

1 Foreword

Complex materials, used in many engineering and technology fields or present in nature, are characterized by an internal structure, made of very different constituents arranged according to various geometries, and by generally non-linear and non-elastic constitutive behaviour. It is widely recognized that important macroscopic properties, such as the macroscopic stiffness and strength, are governed by processes that occur at one to several scales below the level of observation. A thorough understanding of how these processes influence the gross behaviour is key to the analysis of existing and the design of performance improved composite materials.

The present volume is a special issue of invited papers focused on multiscale and multiphysics methodologies for the simulation the of complex materials behaviour. A primary aim of this collection is to give an overview of the interdisciplinary research oriented to the modelling of materials with complex microstructures and complex behaviour, thus providing a theoretical, computational and experimental framework for bridging the gap between mechanical engineering and material science.

The papers represent a survey of several approaches proposed for studying materials with internal structure (at the nano, micro, meso-scale), ranging from fibre or particle composites up to porous, cementitious and masonry-like materials. Laminated, functionally graded materials and materials with random microstructure are covered. The basic multiscale modelling strategies, towards modern complex multiphase materials subjected to various types of mechanical, thermal loadings as well as environmental effects are included.

While highlighting the underlying conceptual, theoretical and experimental bases concerning a wide range of complex constitutive models (plasticity, damage, fracture, etc.), attention is focused on the computational issues. In all the contributions mechanics is coupled with other concurrent physical

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phenomena. Attention is also given to the description of material complex behaviours dominated by the microstructure through enhanced constitutive models with internal lengths scales and advanced computational strategies developed for the solution of the related boundary problems. These models account for any kind of non-locality via the introduction of integral or higher order descriptions or continua with additional degrees of freedom.

We hope these research issues will provide opportunities to identify and discuss future developments in the field of multiscale modelling and design of advanced materials. Special thanks are directed to the editor Alberto Carpinteri for giving us the opportunity of selecting and collecting papers on this topic in a special issue of this journal and to the editorial manager Giuseppe Lacidogna for assisting us in the editorial work.