

# Preface

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 materials 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 mesomechanical 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 micromechanical 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. Different methods of damage evolution modelling, in particular in materials with ductile (aluminium, cobalt) and brittle matrices, are applied to investigate the interrelations between microstructures and strength of these materials. Chapter 4 provides an insight into several methods of micromechanical computational modelling of materials with interpenetrating phases using graded materials. It defines the matrixity model and demonstrates its application to the analysis of different materials. Multilayer models of graded materials, functionally graded finite elements, multiparticle unit cells with graded particle distribution and voxel based method of the 3D FE mesh generation are described in this chapter as well as models of graded materials used for milling applications.

Chapter 5 deals with methods of atomistics and dislocation modelling of the material behaviour and damage.

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