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Michael J. Zehetbauer, Yuntian T. Zhu

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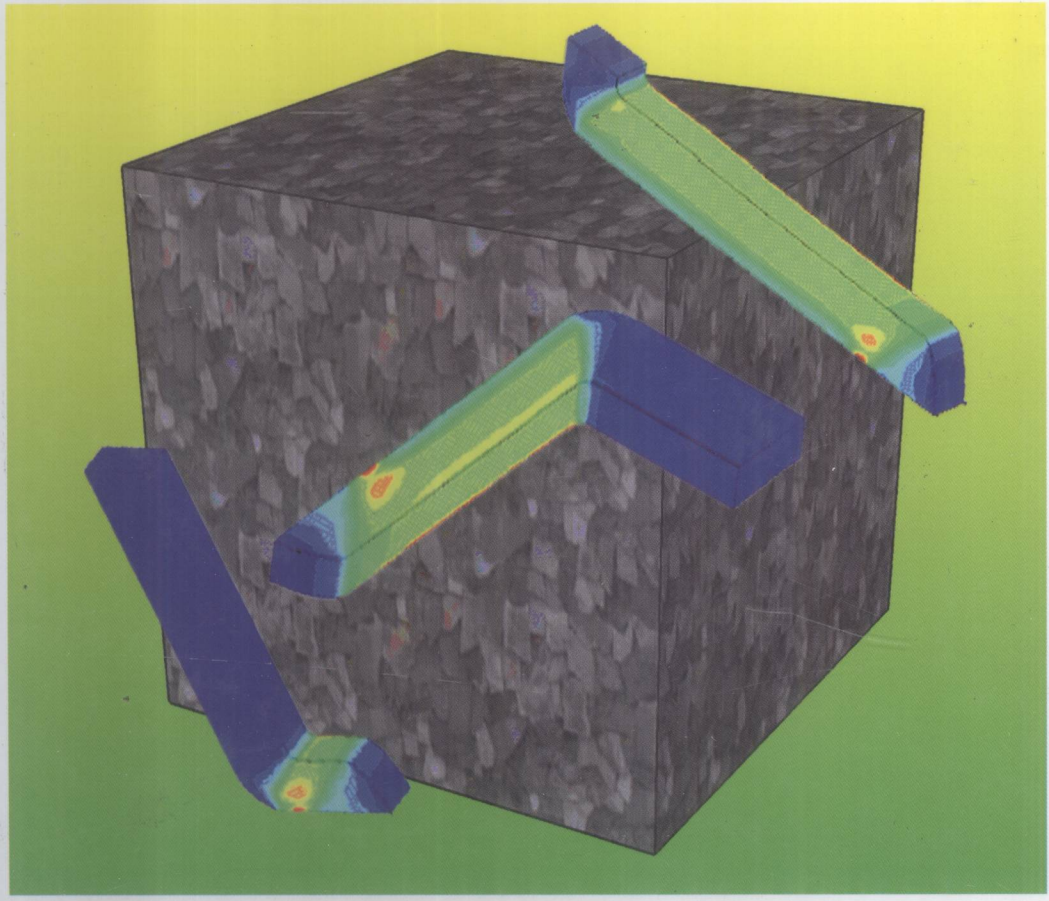

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and Yuntian Theodore Zhu

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Preface

Nanostructured materials have been at the cutting edge of modern materials science. This exciting field started in 1981 when Herbert Gleiter published his first papers on the unique and outstanding properties of nanostructured materials. The second surge in the field occurred in 1993 when Ruslan Valiev attempted to process nanostructured materials by the top-down approach of severe plastic deformation (SPD). The advantage of SPD is that it can process nanomaterials with large dimensions and no porosity, which paves the way to nanomaterials in bulk shape or, as we call them here, 'bulk nanostructured materials – BNMs'. Since 1993, SPD techniques have experienced exponential development, which is why the majority of the chapters in this book are concerned with them. At the same time, bottom-up techniques such as ball milling and consolidation, and crystallization from the amorphous state are also significantly represented in this book as these methods are promising techniques and have their own advantages. Moreover, the processing techniques largely determine the properties and dimensional limits of BNMs. For this reason we have devoted several chapters of the book to various processing methods for producing BNMs.

This book aims to collect the whole spectrum of current knowledge on BNMs. In addition to metals and alloys, it also includes nonmetallic nanomaterials such as semiconductors and ceramics. Several large chapters are devoted to the mechanical properties because they have been well investigated and understood, probably due to their close relevance to commercial applications. Certainly, another reason for their thorough understanding is due to the progress made by molecular dynamics (MD) simulations, which have become increasingly important to the field of nanomaterials. Therefore, one chapter of this book has been devoted to MD simulations.

BNMs also exhibit unique and interesting magnetic properties. Two chapters of this book present the magnetic properties of BNMs, which focus on hard and soft magnetism, magnetostriction and magnetoelectric properties.

A good understanding of properties demands reliable acquisition of microstructural data. This book comprises several chapters that describe characterization methods being used to study nanostructural features of BNMs. Naturally,

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HRTEM is the first choice for characterizing the nanostructures down to atomic resolution. Recently, advanced diffraction techniques, especially in combination with high-intensity synchrotron and neutron diffraction for *in-situ* investigations, have also proven to be very powerful in global structural information such as texture, internal strains, dislocation density and type, twin density, etc., which means that HRTEM and diffraction techniques yield complementary information on the nanostructures of BNMs.

The two final sections of the book discuss unique applications of BNMs, which not only benefit from the refined grain structure but also – as in case of SPD-processed BNM – from the high densities of SPD-induced lattice defects. On the one hand, these nanostructures allow for significant enhancement of diffusion processes, e.g., in applications like hydrogen storage and nitriding of steels. On the other hand, high defect densities promote the occurrence of phases that usually do not form under normal temperature, pressure and alloy content. Nanostructurization also promises attractive potentials in improving the mechanical properties of micro-electronic-mechanical systems (MEMS) and of material surfaces, as well as in increasing the properties of materials for medical applications, including biocorrosion resistance. The last chapter of the book discusses the advantages and viability of BNMs in commercial applications, in terms of technological innovation, industrial areas and possible turnovers.

In our opinion, the research and development of BNMs will make significant progress in the next few years to make them ready for several commercial applications. This will be achieved by further improving several material properties including ductility and fatigue strength. Different processing methods that are described in this book might be combined to produce BNMs with the desired material properties.

Our thanks go to the colleagues who contributed to this book, and to the Wiley-VCH publishing team, who kindly advised and helped us in editing this book. We are also grateful to our families, who showed much understanding and patience during the work. We hope that the readers of this book will find it informative and useful in their research and development of BNMs.

October 2008

Michael J. Zehetbauer & Yuntian T. Zhu
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