PREFACE

The majority of materials, especially metals, are used in the form of polycrystals. It is well recognized that many properties of polycrystalline materials are determined by grain boundaries (GBs). Grain boundaries appreciably affect many practically important mechanical and physical properties of construction materials. Grain-boundary diffusion plays a key role in such practically important processes as Coble creep, sintering, diffusion induced grain boundary migration (DIGM), various discontinuous reactions, recrystallization and grain growth.

The purpose of this Volume is to provide a collection of recent contributions in the field of structure, thermodynamics and diffusion properties of grain boundaries and interfaces. The Volume includes reviews of both experimental and theoretical studies carried out by well-recognized scientists whose publications are well-known and widely cited.

In Chapter 1 Professors Belova and Murch review and analyse transient solute GB diffusion by means of their developed computer simulation technique of Lattice Monte Carlo (LMC). In their review they analyse two cases of solute segregation in GB diffusion, (i) solute atoms are homogeneously distributed along the tracer source plane but their mobility is not high at this plane; and (ii) the mobility of the solute atoms along the tracer source plane is comparable with their mobility along the grain boundary.

In Chapter 2 Professor Popov (and Sergeev) consider a specification of the classical Fisher model of GB diffusion based on the data of emission Mossbauer spectroscopy and analyze the additional data which can be extracted from the data of Mossbauer studies. The possibility of determination of GB diffusion parameters is based on the combined treatment of radiotracer analysis and Mossbauer spectroscopy data using the specified model of GB diffusion. This approach is demonstrated by an example of GB diffusion of Co in W and Mo.

During the last two decades, severe plastic deformation (SPD) processing has attracted significant research interest because it is an effective way to produce ultrafine-grained (UFG) metals and alloys, which results in the enhancement of various mechanical and functional properties. The properties of UFG materials depend considerably on the structure and behavior of their internal interfaces – grain boundaries. Therefore, UFG materials are commonly defined as interface-controlled materials. Specific features of GBs in such materials are considered in Chapters III and IV.

In Chapter III Professor Valiev presents experimental data demonstrating the super-strength and "positive" slope of the Hall-Petch relation when passing from the micro- to the nanostructured state in a number of metallic materials subjected to SPD. The nature of the superior strength is associated with new strengthening mechanisms and the difficulty of generating dislocations from grain boundaries with segregations. This new approach is used for achieving the enhanced strength in several commercial Al and Ti alloys as well as steels subjected to SPD processing.

In Chapter IV Professor Divinski presents an overview of the current understanding of diffusion properties of grain boundaries in SPD-processed materials. The results are evaluated with respect to the types of SPD, defects introduced and processing parameters. The properties of deformation-modified grain boundaries, such as width, diffusivity, diffusion mechanism and excess free volume are examined.

Chapter V by Professor Sauvage (and Nasedkina) is a brief review on the role of grain boundaries and other crystalline defects (especially dislocations and SPD-induced vacancies) in the SPD-induced phase transformations, namely, dynamic precipitation or particles dissolution.

In Chapter VI Professor Straumal and colleagues demonstrate that severe plastic deformation by high-pressure torsion (HPT) leads to phase transitions and strong grain refinement in several metallic alloys. It is shown that the SPD-treatment at ambient temperature T_{SPD} is frequently equivalent to the heat treatment at a certain elevated (effective) temperature T_{eff}. In this review, the methods of determination of the effective temperature after the HPT of metallic alloys are discussed as well as the SPD-driven acceleration of diffusion.

In Chapter VII by Professors Naidenkin and Grabovetskaya (and Mishin), experimental studies on grain boundary diffusion and various processes controlled by it in UFG materials produced by different techniques of SPD are reviewed.

In Chapter VIII Professor Kondratiev and co-workers briefly review approaches to the description of grain-boundary diffusion in nanostructured and sub-microcrystalline materials produced by SPD. The model of diffusional mass transfer in the medium with a strong spatial dependence of diffusivity and its application to the GB diffusion problem is presented.

In Chapter IX Professor Andrievsky considers the role of interfaces in the behavior of nanomaterials at extremes. The main statements of the nanomaterials concept are shortly considered. Current developments in the metallic nanomaterials stability under thermal, irradiation, deformation and corrosion actions are generalized and discussed in detail.

In Chapter X by Professors Gottstein and Shvindlerman the thermodynamics and kinetics of one-dimensional structural elements and the stability of nanocrystalline materials are considered.

In Chapter XI Professor Popova (and Deryagina) present a review of their studies and available publications on the formation of superconducting Nb_3Sn layers under various regimes of diffusion annealing in multifilamentary Nb/Cu–Sn superconductors of different design. The role of grain boundaries in the achievement of high performance of these materials is discussed.

In Chapter XII by Professors Gusak and Kozubski (and Tyshchenko) grain growth in open systems is analyzed for the cases of flux-driven ripening during soldering, flux-driven lateral growth during deposition of thin films, flux-driven lateral growth during reactive growth of intermediate phase, and flux-driven lateral growth of antiphase domains in FCC-phase A_3B and BCC-phase AB during the diffusion growth of an ordered phase layer.

In Chapter XIII by Professor Molodov recent research on grain boundary migration is reviewed and the results of experimental efforts over recent years to study the motion of grain boundaries under various driving forces are analyzed.

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