# Preface

This book highlights the significant role played by the grain boundaries in the plastic behavior of crystalline materials. The need to understand this role increases with the development and the use of materials (metals, ceramics, etc.) with submicron sized grains. From well-established models to new experimental and simulation approaches, this book gives the state of the art on the relationship between the "grain boundary" object and its contribution to the mechanical properties of a material. The authors, amongst the best experts in the various fields addressed, give readers a comprehensive overview of their specialties, from the theoretical basics to the recent developments due to the appearance of new techniques.

Starting from the behavior of a grain boundary then going back to the contribution of a grain boundary network to the plasticity of a polycrystalline set, requires a multi-scale approach. This approach begins with the description of the grain boundary on an atomic scale and then details the elementary reactions – on a nano- and microscopic scale – between point defects, dislocations and grain boundaries, and finally takes an interest in the material behaviors – on mesoscopic and macroscopic scales – and in the laws ruling these behaviors. The project also requires coupling of physical, chemical and mechanical approaches.

These various approaches are discussed without excessive mathematical formality and are supported by many references. The presentation of the definitions, mechanisms and theoretical models is followed by the description of experiments and numerical simulations, which support the models. The examples cover various types of crystalline materials: metals

and metal alloys, ceramics, semiconductors, etc. The properties involved are: hot and cold deformation, creep, fatigue and fracture.

Each chapter holds stand-alone interest and is a good reference to acquire basic knowledge in a specific field, at the discretion of the reader. However, only reading the book as a whole provides the reader with an understanding of the role of the grain boundary in crystalline plasticity. The book is divided into six chapters:

– Chapter 1 discusses the basic notions of grain boundaries: their geometry, their structures and their defects. This chapter focuses on intergranular dislocations, which are deformation vectors;

– Chapter 2 details the elementary processes involved between dislocations and grain boundaries during deformation and the relaxation of the resulting stresses;

– Chapter 3 describes deformation and the stress states in the boundaries and in their vicinity during deformation; it discusses the material behavior as a function of the grain size and it quickly tackles recrystallization phenomena;

– Chapters 4 to 6 successively discuss:

1) the role of the grain boundaries in creep and in high temperature plasticity with an extension to the superplasticity phenomenon,

2) the behavior of the boundaries subjected to high and low temperature fatigue efforts on bi- and polycrystals, with a few key-elements: iron, stainless steel, copper, superalloys, etc.,

3) the response of grain boundaries to the fracture with particular focus on the effect of segregation on intergranular brittleness, but also focusing on embrittlement caused by liquid metals.

Providing an understanding of the influence of grain boundaries on crystalline plasticity has not yet been the subject of a dedicated book, although the subject constitutes a challenge for controlling material performances.

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