Preface

This textbook is unique at present, since no other book on this subject currently exists. It is composed of two parts: Part I on the *Fundamentals of Diffusion* and Part II on *Diffusion in Ceramics (Experimental).*

Part I is quite general, explaining the basics of diffusion as first presented in a scholarly manner by Adolf Fick, in whose steps diffusion researchers the world over have been walking for decades. Following his fundamental laws of diffusion, progress has been made in the field by internationally distinguished theoreticians and experimentalists. Undoubtedly, the current stage in understanding of diffusion was reached as the result of precise measurements of diffusion coefficients in corroboration of basic theories. Although most of the experiments were initially performed on 'well-behaved' metals, such as the noble metals, later diffusion coefficient measurements extended to other metals and alloys and then to all solids, including ceramics. In order to understand lattice diffusion and to avoid the contribution of short-circuit diffusion (mainly in grain boundaries), single crystals were used alongside polycrystalline solids.

Part I contains 10 chapters. Chapter 1 considers macroscopic diffusion, the backbone of Fick's laws and solutions to various cases encountered in experimental diffusion. Microscopic (or atomic) diffusion is dealt with in Chap. 2. The basis of atomic transport is the random walk, which is believed to be the cornerstone of atomic diffusion. Often, the walk of a 'drunken sailor' exemplifies the randomness of diffusion. Diffusion is mainly the exchange of an atom with some defect arriving at its vicinity. Vacancy-dominated diffusion is the basic entity exchanging places with an atom, unless an interstitial mechanism of small atoms regulates the diffusion process. In Chap. 3, the Schottky and Frenkel defects involved in diffusion in ceramics are discussed. Interstitial diffusion is also included in this chapter, since it may be an important method of transport in ceramics. The thermodynamics of defect formation is illustrated for vacancies. Chapter 4 focuses on a discussion of diffusion mainly by vacancy and interstitial mechanisms. Self-diffusion, solute diffusion, and correlation effects in ionic crystals (some ceramics are ionic in nature) are the subject of Chap. 5. The relation between diffusion and conductivity is discussed. Integral parts of this chapter are binding, enhanced diffusion, and the isotope effect. Interdiffusion and Darken's equation are the main topics in Chap. 6. Grain-boundary diffusion is considered in Chap. 7, which also discusses self- and solute diffusion in grain boundaries, as well as diffusion in nano-materials. Self-diffusion and solute diffusion in dislocations are presented in Chap. 8, while Chap. 9 considers some important and commonly used experimental techniques, such as tracer technique, SIMS, and conductivity methods. Part 1 closes with some empirical rules for evaluating diffusion coefficients and activation energies in Chap. 10.

Part II is focused on the experimental observation of diffusion in ceramics, and selectively discusses five of the most technically important ceramics, examples of monolithic and single-phased ceramics: alumina (Al_2O_3), silicon carbide (SiC), magnesia (MgO), zirconia (ZrO_2), or yttria-stabilized zirconia (YSZ), and silicon nitride (Si_3N_4), representing the nitride ceramics. As far as possible, the discussion on diffusion for each of these ceramics follows the same pattern; thus, each discussion starts with self-diffusion of a certain ceramic component and then presents its solute (impurity) diffusion in single crystals, followed by its self- and solute diffusion in polycrystalline ceramics. Separate sections deal with the self-diffusion of each component and its solutes in grain boundaries, and then its self- and impurity (solute) diffusion in dislocations. Finally, each chapter summarizes the diffusion equations according to the outlined pattern, so that one can quickly find a diffusion equation relating the diffusion coefficient to the inverse temperature in an Arrhenius-type relation.

Actual problems are not presented for solution; lecturers may devise their own problems to challenge their students. Other books on diffusion may include such exercises, but this author encourages the readers to seek practical problems and their probable solutions in the field.

I would like to express my gratitude to all the publishers and authors for their permission to use and reproduce some of their illustrations and microstructures.

Last but not least, without the tireless devotion, help, understanding, and unlimited patience of my wife Ada, I could never have completed this book; despite my decades of teaching in this field, her encouragement was essential and her helpful attitude instrumental in inspiring me to write this book. Freeing me from all domestic chores enabled me to devote my time to writing and to concentrate my energy on accomplishing my goal. Also, my heartfelt thanks to Ethelea Katzenell, at the Ben-Gurion University of the Negev, for improving the English.

http://www.springer.com/978-3-319-18436-4

Diffusion in Ceramics
Pelleg, J.
2016, XXII, 448 p., Hardcover
ISBN: 978-3-319-18436-4