

# Preface

The purpose of this text is to provide a foundation for understanding the theory and mechanisms behind the effects of irradiation on metals and alloys. The subject is divided into three parts, each of which is subdivided into individual chapters that together provide a unified picture of how radiation interacts with and alters the structure and properties of metallic materials. Part I consists of five chapters that together, focus on the *radiation damage process* and provide the formalism for the prediction of the amount and spatial configuration of the damage produced by bombarding particles. Chapter 1 treats the interactions between particles that result in the transfer of energy from the incident particle to the target atoms. Chapter 2 focuses on determination of the number of displacements produced by the bombarding particles, and Chap. 3 describes the spatial configurations of the resulting defects. Chapter 4 provides background on the equilibrium concentration of point defects and their diffusion. Chapter 5 treats diffusion and reactions between point defects under irradiation that are fundamental to all of the observable effects.

While radiation damage describes the state of the irradiated material, radiation effects are concerned with defect behaviour in the solid after formation. Part II (Chaps. 6–11) covers the *physical effects* of irradiation on metals. Chapter 6 describes radiation-induced segregation, which is a direct consequence of radiation-enhanced diffusion. Chapters 7 and 8 address the nucleation and growth of dislocation loops and voids, the defect aggregates that determine much of the behavior of irradiated alloys. Chapter 9 covers the stability of phases under irradiation and irradiation-induced precipitation and precipitate dissolution. Chapter 10 extends the effects of irradiation to the unique processes resulting from ion irradiation such as composition changes, sputtering, and exfoliation. Finally, Chap. 11 describes the use of ion irradiation to emulate the effects of neutron irradiation in reactor components.

*Mechanical and environmental effects* of radiation damage (Part III) are distinguished from physical effects by the application of stress and a corrosive environment. Hardening and deformation of alloys under irradiation are discussed in

Chap. 12. Creep deformation and growth are treated in Chap. 13, and the effect of irradiation on crack nucleation and propagation resulting either from static or fatigue loading is discussed in Chap. 14. Irradiation also has a profound effect on corrosion and stress corrosion cracking as these degradation modes often constitute the limiting processes for many reactor designs. Chapter 15 includes the basics of corrosion and stress corrosion cracking that are required for understanding the combined effects of irradiation, corrosion, and stress discussed in Chap. 16.

The chapters contain examples and illustrations of radiation effects and sample calculations to quantify and describe the observations. Problems at the end of each chapter are designed to reinforce the main concepts of each chapter and to challenge the reader on his or her comprehension of the topics covered within. Taken together, the chapter text, examples, illustrations, and end-of-chapter problems provide a comprehensive treatment of the effects of irradiation on metals and alloys.

The subject matter in this text will likely require two academic terms to complete. Many of the topics rely on a basic knowledge of disciplines that constitute the underlying basis for irradiation effects: thermodynamics and kinetics of solids, crystal structure, defects and dislocations, physical metallurgy, elasticity and plasticity, deformation and fracture and corrosion and stress corrosion cracking. The text either presents the requisite background for each of these topics, or provides references of other sources where good treatments can be found.

This book should also be useful to researchers who would like to learn more about the subject, or who would like a more complete and integrated treatment of the topics than can be found in individual papers on the subject. While the chapters are integrated with one another and each chapter builds upon the sum of the previous chapters, it is possible to read selected chapters for just that topic.

As a final comment, the author would like to note that this book was written by sorting, organizing, and condensing information from several texts and numerous journal and conference papers to arrive at a comprehensive description of the processes constituting radiation materials science. A conscientious effort was made to acknowledge and give credit to the original sources of the ideas, theories, mathematical developments, and drawings contained herein. For occasional oversights that may have occurred during the condensation process, the author offers his apologies. He is indebted to the many authors and publishers who provided material and illustrations for this text.

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