EXTENDED DEFECTS IN SEMICONDUCTORS

This book surveys the properties, effects, roles and characterization of structurally extended defects in semiconductors. The basic properties of extended defects (dislocations, stacking faults, grain boundaries and precipitates) are outlined, and their effect on the electronic properties of semiconductors, their role in semiconductor devices and techniques for their characterization are discussed. These topics are among the central issues in the investigation and applications of semiconductors and in the operation of semiconductor devices. Elucidation of the effects of extended defects on electronic properties of materials is especially important in view of the current advances in electronic device development that involve defect control and engineering at the nanometre level. The authors preface their treatment with an introduction to semiconductor materials and the book concludes with a chapter on point defect maldistributions.

This text is suitable for advanced undergraduate and graduate students in materials science and engineering, and for those studying semiconductor physics. The book may also serve as a reference for researchers in a wide variety of fields in the physical and engineering sciences.

D. B. Holt is an emeritus professor in the Department of Materials at Imperial College, London. His research has focused on the science and technology of semiconducting materials and devices, and developing and applying techniques for their chracterization in the scanning electron microscope.

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Electronic Properties, Device Effects and Structures

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Dedication and History

The idea for this book first arose during the (Northern-Hemisphere) Academic year (1969–70), which one of the authors, DBH, spent in the Department of Applied Physics of the University of New South Wales, in Sydney, Australia, working with Professor Dan Haneman (DH). DBH was then concerned with the use of the concept of dangling bonds in relation to defects while DH used the concept in relation to the then-new and unexpected ordered structures on atomically clean semiconductor free surfaces recently discovered by the then-new technique of LEED (low-energy electron diffraction) of which he had been one of the earliest users. It occurred to us (DH and DBH) that it would be useful to produce a critical overview of the whole field of the defects and surfaces of semiconductors from a common point of view. Work was begun on the writing of such a book; however, the field expanded explosively, changing and advancing so rapidly and giving rise to so large a literature on the topics concerned at such a rate that new information kept appearing more rapidly than it could be read, understood and reviewed. Consequently, after 10 or 15 years, the attempt had to be reluctantly abandoned as a failure. Much later, when the field had matured considerably and progress and change slowed somewhat, the present authors (DBH and BGY) took up the challenge again and when successful completion began to appear possible DBH tried via the Internet to obtain information to enable him to contact DH to inform him that the book was likely to appear at long last and to hopefully obtain his agreement and approval. Unfortunately, what was first obtained from the Internet was the obituary of DH. So Dan: Here is our book, at last, DBH. I am very sorry that it only appeared posthumously, in your case. However, if as we hope, it proves useful to folks in the field and students trying to enter it, this will be, in considerable part, to your credit.

Contents

Preface

One of the central issues in the investigation of semiconductors (and solid-state materials in general) is related to the study of various defects and their effects on materials' properties and the operation of electronic devices.

The topics of electronic properties of extended defects (i.e., dislocations, stacking faults, grain boundaries, and precipitates) in semiconductors and the influence of these defects on various electronic devices have been of great importance and interest for several decades. During this period of intensive research and development of semiconductor materials and devices, the majority of the defects and the mechanisms of their formation were elucidated. This was accompanied with concurrent efforts in eliminating the unwanted defects. For controlling properties of semiconductors through defect engineering, it is essential to understand the interactions between various defects and their effect on semiconductor and device characteristics.

With the development of various microscopy techniques, including scanning probe techniques, the fundamental properties of various defects have been better understood and many details have been further clarified.

The main objective of this book is to outline the basic properties of extended defects, their effect on electronic properties of semiconductors, their role in devices, and the characterization techniques for such defects. We hope that this book will be useful to both undergraduate and graduate students and researchers in a wide variety of fields in physical and engineering sciences.

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