Preface

Semiconductor electronics is commonplace in every household. Semiconductor devices have enabled economically reasonable fiber-based optical communication, optical storage, and high-frequency amplification and have recently revolutionized photography, display technology, and lighting. By now solar energy harvesting with photovoltaics contributes a significant portion to the energy mix. Along with these tremendous technological developments, semiconductors have changed the way we work, communicate, entertain, and think. The technological progress of semiconductor materials and devices is evolving continuously with a large worldwide effort in human and monetary capital. For students, semiconductors offer a rich and exciting field with a great tradition, offering diverse fundamental and applied topics [1] and a bright future.

This book introduces students to semiconductor physics and semiconductor devices. It brings them to the point where they can specialize and enter supervised laboratory research. It is based on the two-semester semiconductor physics course taught at Universität Leipzig in its Master of Science physics curriculum. Since the book can be followed with little or no pre-existing knowledge in solid-state physics and quantum mechanics, it is also suitable for undergraduate students. For the interested reader several additional topics are included in the book that can be covered in subsequent, more specialized courses. The material is selected to provide a balance between aspects of solid-state and semiconductor physics, the concepts of various semiconductor devices and modern applications in electronics and photonics.

The first semester contains the fundamentals of semiconductor physics (Part I, Chaps. 1–10) and selected topics from Part II (Chaps. 11–20). Besides important aspects of solid-state physics such as crystal structure, lattice vibrations, and band structure, semiconductor specifics such as technologically relevant materials and their properties, doping and electronic defects, recombination, surfaces, and hetero- and nanostructures are discussed. Semiconductors with electric polarization and magnetization are introduced. The emphasis is put on inorganic semiconductors, but a brief introduction to organic semiconductors is given in Chap. 17. Dielectric structures (Chap. 19) serve as mirrors, cavities, and microcavities and are a vital part of many semiconductor devices. Other chapters give introduction to carbon-based nanostructures and transparent conductive oxides (TCOs). The third part (Part III, Chaps. 21–24) is dedicated to semiconductor applications and devices that are taught in the second semester of the course. After a general and detailed discussion of various diode types, their applications in electrical circuits, photodetectors, solar cells, light-emitting diodes, and lasers are treated. Finally, bipolar and field-effect transistors including thin-film transistors are discussed.

In the present text of the third edition, a few errors and misprints of the second edition have been corrected. Several topics have been extended and are treated in more depth, e.g., double donors and double acceptors, negative-U centers, Boltzmann transport equation, ionic conductivity, hopping conductivity, impact ionization, thermopower, polarons, intra-band transitions, amorphous semiconductors, disorder effects, heteroepitaxy on mismatched, curved and patterned substrates, and noise. A chapter on semiconductor surfaces has been added.

The list of references has been augmented by almost 400 quotations with respect to the list in the second edition. All references now include title and complete page numbers. The references have been selected to (i) cover important historical and milestone papers, (ii) direct to reviews and topical books for further reading and (iii) give access to current literature and up-to-date research. In Fig. 1, the original papers within the more than 1800 references in this book are shown by year. Roughly three phases of semiconductor physics and technology can be seen. Before the realization of the first transistor in 1947, only a few publications are noteworthy. Then an intense phase of understanding the physics of semiconductors and developing semiconductor technology and devices based on bulk semiconductors (mostly Ge, Si, GaAs) followed. At the end of the 1970s, a new era began with the advent of quantum wells and heterostructures, and later nanostructures (nanotubes, nanowires, and quantum dots) and new materials (e.g., organic semiconductors, nitrides or graphene). Also several very recent references to emerging topics such as 2D materials, topological insulators or novel amorphous semiconductors are given.

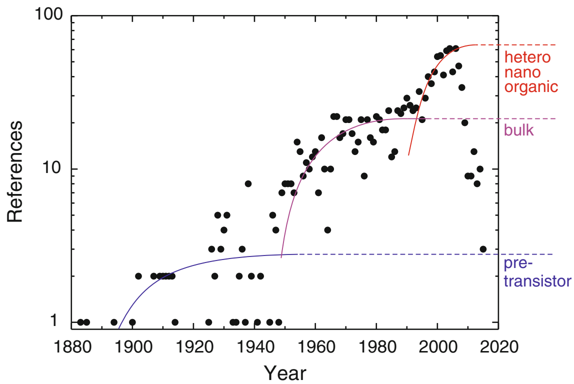

Fig. 1 Histogram of references in this book

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