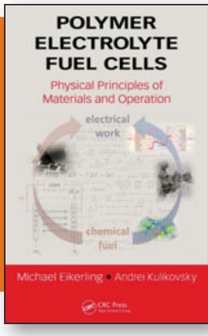


Polymer Electrolyte Fuel Cells: Physical Principles of Materials and Operation

Michael Eikerling and Andrei Kulikovsky

CRC Press, 2014
582 pages, $152.96
ISBN 9781439854051

This is a great book for people who are interested in learning how fuel cells work from electrochemical, polymer physics, and transport perspectives. The authors have organized these areas in an integrated way and with a balance between science and design.

The first chapter presents a general introduction to fuel cells, including design and structures, working principles, and current research focus. This is an excellent chapter for those who do not have a sufficient background in these subjects, or those who are interested in learning some basics.

The second chapter presents a deep discussion of polymer electrolyte membranes, a central part of fuel cells. The functions of the membrane are to separate the reactive gases and keep them in their own compartments, and to allow only hydrogen ions to migrate through the membrane and form an internal electric current. Proton transport is discussed in terms of water—proton interactions, hydrogel physics, and ionic fibrillary structures. A soliton theoretical model, water swelling of hydrogel, and modeling studies are introduced at proper levels.

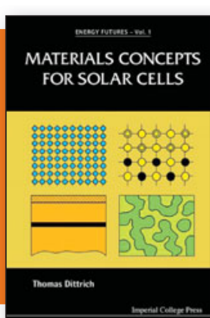
The third chapter describes catalyst layers. It provides a nice treatment of the relationships among microporous structures of the catalyst layers, electrochemical kinetics, and transport processes. This part explains the link between electrochemical reactions and polarization behavior that is key to understanding how chemical energy is converted into electrical energy. The reaction kinetics is related to the voltage of the battery. Discussions are included for a few subjects such as oxygen reduction reactions.

The fourth chapter discusses modeling studies of catalyst layer performance, many of which were performed by the authors and their colleagues. The modeling covers multiple processes, including cathode and anode polarization and various limiting cases imposed by the transport of reactants and hydrogen ions. Theoretical analysis is given for most of the subjects, which provides a comprehensive interpretation of the materials presented in prior chapters.

In the fifth chapter, modeling studies are expanded to cover a few practical aspects of batteries that limit their performance or cause problems. This bridges the theoretical studies with the performance of products.

The references are extensive and up to date. I would have liked to see more real pictures, although the illustrations are good. Overall, this is a nice reference book that I would recommend for students, engineers, and researchers in the field.

Reviewer: SuPing Lyu *is a principal researcher at Medtronic Inc., Mounds View, Minn., USA.*



Materials Concepts for Solar Cells

Thomas Dittrich

Imperial College Press, 2014
552 pages, $118.00 (hardcover)
ISBN 978-1-78326-444-5

Learning about renewable sources of energy is very pertinent in today's context. This textbook is targeted to students interested in the principles and applications of solar cells. It is divided into two parts, with the first part providing the basic principles of solar cells. This section is complemented by a second section where a more practical approach for materials used in the design and architecture of solar cells is presented. The index is comprehensive, and symbols, abbreviations, and acronyms are clearly provided at the beginning of the book. Each chapter contains a summary where the author recapitulates important points. Furthermore, the tasks or problems at the end of each chapter assist in assimilating concepts. The solutions to the tasks are also provided and serve as an auto-evaluation tool. Morever, equations and diagrams are abundant and useful. The bibliography is ample for further reading, and an index with keywords is also provided at the end of the book.

The first of 10 chapters provides an introduction to solar cells by explaining concepts such as I–V characteristics and quantum efficiency. The principles of photogeneration are presented in the second chapter along with practical issues of photon absorption and electron–hole generation. The different types of processes affecting the carrier lifetime, including recombination mechanisms, are discussed in the third chapter. The fourth chapter deals with charge separation of photogenerated carriers created in a *p–n* junction by its built-in potential. Connecting the *p–n* junction via an ohmic contact to an external load is well explained in the fifth chapter, which deals mainly with the physics of semiconductor-metal contacts. The sixth chapter concludes the first part of the book by discussing the maximum efficiency of a solar cell and its limitations.

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The materials-related concepts in the second part start from the seventh chapter where the most used solar-cell material—silicon—is discussed. In the eighth chapter, III–V semiconductor solar-cell materials are investigated. Their epitaxial growth and tandem solar cells are outlined, followed by the ninth chapter, which exclusively discusses thin-film solar cells. This includes transparent conducting oxides, amorphous and microcrystalline silicon, chalcopyrites (e.g., CIGS) and kesterites (e.g., CZTS), and the widely exploited CdTe solar cells. The final chapter introduces solar cells from a nanotechnology point of view. Here, quantum dots, organic and dye-sensitized solar cells, perovskite-sensitized solid-state solar cells, charge transport, and nanowire arrangements of solar cells are briefly surveyed.

The book is of good pedagogical value. Students as well as teachers can make use of this either as a main textbook or as a support for their lessons. However, this book deals with charge transport and band structures as well as other concepts in physics, and therefore targets mainly readers with a physics background. In general, the book is well written and provides a solid basis for studying solar cells.

Reviewer: Protima Rauwel*, the Institute of Physics, University of Tartu, Estonia.*

Nanomaterials and Devices

Donglu Shi, Zizheng Guo, and Nick Bedford

Elsevier, 2014
372 pages, $110.49
ISBN 978-1-4557-7754-9

The primary aim of this book is to provide introductory material on nanomaterials and nanotechnology for students at the college level. A secondary goal is to explore concepts of nanotechnology in teaching and research. The major focus is on nanodevices, which is meant to instill in researchers a motivation for developing practical applications. In addition to the text in the book, the authors provide online resources for probing further into the topics.

The book is divided into 12 chapters. Chapter 1 focuses on basic properties of nanomaterials. It contains three sections: a brief history of nanoscience and nanotechnology, characteristics of nanomaterials, and physical principles of nanoscale effects. Chapter 2 is aimed at characterization and analysis of nanomaterials, detailing scanning probe microscopy and atomic force microscopy. Other methods of characterization such as particle size and various properties are also briefly introduced. Chapter 3 covers carbon nanotubes, starting with allotropes of carbon and other structures (including graphene), followed by the types and nature, preparation, and applications of carbon nanotubes. Chapter 4 focuses on semiconductor quantum dots. In the four sections here, the authors describe the physical basis of the semiconductors, preparation of semiconductor quantum dots, laser devices based on quantum dots, and single photon sources.

The next chapter's focus is on nanomagnetic materials and is exhaustive in discussing the types, characteristics, examples, and preparation. The chapter concludes with giant magnetoresistance materials with applications in sensing devices. Chapter 6 covers nanoscale titanium oxide as a photocatalytic material and its applications. Chapter 7 discusses the electro-optical, optoelectronic, and piezoelectric applications of zinc oxide. Superconducting nanomaterials are discussed in chapter 8. After a brief introduction to superconductivity, there is discussion on physical principles, classification of superconductors, nano-superconductors, and their applications. Chapter 9 discusses nanobiological materials with detailed coverage of nanobiological, nanomedical, and magnetic particles in medicine, bioanalysis, and quantum dots in biological and medical applications. It concludes with a discussion of research progress in hypothermia. Chapter 10 covers nanoenergy materials, limiting coverage to nanostorage materials related to fuel cells and dye-sensitized solar cells. Chapter 11 focuses on nanocomposites. It starts with concepts, including surface modification, and concludes with core–shell structures of composites. The last chapter covers the basics of DNA and its nanotechnology with molecular motors.

However, the book contains pictures that are poor in quality (all black and white with no clarity). Also, there are a number of errors that can be corrected: some quantities are not presented with the correct units, data in some tables are not cited adequately, and it would be useful to explain the relationships between entities in some equations. Some of these problems can be attributed to typographical errors, but some of them will cause confusion for beginners, to whom the book is directed. The order of the chapters is somewhat disorganized. Chapter 12 would fit better after chapter 9; chapter 6 could follow chapter 10. The book is adequate reading material as a supplementary book for inspiring beginners in the field, rather than as a text for beginners. Readers should be cautioned regarding the errors and thus the book should not stand alone as one's go-to reference.

Reviewer: K.S.V. Santhanam *is a professor in the School of Chemistry and Materials Science at Rochester Institute of Technology, USA.*

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