The Physics Of Solar Cells Properties Of Semiconductor Materials

HATFIELD FRIDA

Handbook of Photovoltaic Science and Engineering World Scientific
Solar energy conversion plays a very important role in the rapid introduction of renewable energy, which is essential to meet future energy demands without further polluting the environment, but current solar panels based on silicon are expensive due to the cost of raw materials and high energy consumption during production. The way forward is to move towards thin-film solar cells using alternative materials and low-cost manufacturing methods. The photovoltaic community is actively researching thin-film solar cells based on amorphous silicon, cadmium telluride (CdTe), copper indium gallium diselenide (CIGS), and dye-sensitised and organic materials. However, progress has been slow due to a lack of proper understanding of the physics behind these devices. This book concentrates on the latest developments and attempts to improve our understanding of solid-state device physics. The material presented is mainly experimental and based on CdTe thin-film solar cells. The author extends these new findings to CIGS thin-film solar cells and presents a new device design based on graded bandgap multi-layer solar cells. This design has been experimentally tested using the well-researched GaAs/AlGaAs system, and initial devices have shown impressive device parameters. These devices are capable of absorbing all radiation (UV, visible and infra-red) within the solar spectrum and combine "impact ionisation" and "impurity photovoltaic" effects. The improved device understanding presented in this book should impact and guide future photovoltaic device development and low-cost thin-film solar panel manufacture. This new edition features an additional chapter besides exercises and their solutions, which will be useful for academics teaching in this field.
Principles of Solar Cells, LEDs and Diodes John Wiley & Sons
The new edition of this highly regarded textbook provides a detailed overview of the most important characterization techniques for solar cells and a discussion of their advantages and disadvantages. It describes in detail all aspects of solar cell function, the physics behind every single step, as well as all the issues to be considered when improving solar cells and their efficiency. The text is now complete with examples of how the appropriate characterization techniques enable the distinction between several potential limitation factors, describing how quantities that have been introduced theoretically in earlier chapters become experimentally accessible. With exercises after each chapter to reinforce the newly acquired knowledge and requiring no more than standard physics knowledge, this book enables students and professionals to understand the factors driving conversion efficiency and to apply this to their own solar cell development.
Springer Science & Business Media
The book provides an explanation of the operation of photovoltaic devices from a broad perspective that embraces a variety of materials concepts, from nanostructured and highly disordered organic materials, to highly efficient devices such as the lead halide perovskite solar cells. The book establishes from the beginning a simple but very rich model of a solar cell, in order to develop and understand step by step the photovoltaic operation according to fundamental physical properties and constraints. It emphasizes the aspects pertaining to the functioning of a solar cell and the determination of limiting efficiencies of energy conversion. The final chapters of the book establish a more refined and realistic treatment of the many factors that determine the actual performance of experimental devices: transport gradients, interfacial recombination, optical losses and so forth. The book finishes with a short review of additional important aspects of solar energy conversion, such as the photonic aspects of spectral modification, and the direct conversion of solar photons to chemical fuel via electrochemical reactions.
Thin Film Device Physics For Solar Cell Applications Springer Nature
This book provides a comprehensive introduction to the physics of the photovoltaic cell. It is suitable for undergraduates, graduate students, and researchers new to the field. It covers: basic physics of semiconductors in photovoltaic devices; physical models of solar cell operation; characteristics and design of common types of solar cell; and approaches to increasing solar cell efficiency. The text explains the terms and concepts of solar cell device physics and shows the reader how to formulate and solve relevant physical problems. Exercises and worked solutions are included.
Thin-Film Crystalline Silicon Solar Cells CRC Press
PHYSICS OF Solar Energy Science/Physics/Energy The definitive guide to the science of solar energy You hold in your hands the first, and only, truly comprehensive guide to the most abundant and most promising source of alternative energy—solar power. In recent years, all major countries in the world have been calling for an energy revolution. The renewable energy industry will drive a vigorous expansion of the global economy and create more “green” jobs. The use of fossil fuels to power our way of living is moving toward an inevitable end, with sources of coal, petroleum, and natural gas being fiercely depleted. Solar energy offers a ubiquitous, inexhaustible, clean, and highly efficient way of meeting the energy needs of the twenty-first century. This book is designed to give the reader a solid footing in the general and basic physics of solar energy, which will be the basis of research and development in new solar engineering technologies in the years to come. As solar technologies like solar cells, solar thermal power generators, solar water heaters, solar photochemistry applications, and solar space heating-cooling systems become more and more prominent, it has become essential that the next generation of energy experts—both in academia and industry—have a one-stop resource for learning the basics behind the science, applications, and technologies afforded by solar energy. This book fills that need by laying the groundwork for the projected rapid expansion of future solar projects.
Physics of Solar Cells World Scientific Publishing Company
Photovoltaic cells provide clean, reversible electrical power from the sun. Made from semiconductors, they are durable, silent in operation and free of polluting emissions. In this book, experts from all sectors of the PV community — materials scientists, physicists, production engineers, economists and environmentalists — give their critical appraisals of where the technology is now and what its prospects are. Contents:The Past and Present (M D Archer)Device Physics of Silicon Solar Cells (J O Schumacher & W Wettling)Principles of Cell Design (J Poortmans et al.)Crystalline Silicon Solar Cells (M A Green)Amorphous Silicon Solar Cells (C R Wronski & D E Carlson)Cadmium Telluride Solar Cells (D Bonnet)Cu(In,Ga)Se2 Solar Cells (U Rau & H W Schock)Super-High Efficiency III-V Tandem and Multijunction Cells (M Yamaguchi)Organic Photovoltaic Devices (J J M Halls & R H Friend)Quantum Well Solar Cells (J Nelson)Thermophotovoltaic Generation of Electricity (T J Coutts)Concentrator Cells and Systems (A Luque)Cells and Systems for Space Applications (C M Hardingham)Storage of Electrical Energy (R M Dell)Photovoltaic Modules, Systems and Applications (N M Pearsall & R Hill)The Photovoltaic Business: Manufacturers and Markets (B McNelis)The Economics of Photovoltaic Technologies (D Anderson)The Outlook for PV in the 21st Century (E H Lysen & B Yordi) Readership: Physicists, chemists and engineers. Keywords:Electricity;Photovoltaics;Cadmium;Solar CellsReviews:“... is an excellent resource for its intended readership of students, scientists and technologists working in the area ... it is well indexed, and includes a handy list of useful web and library references. At the very least, the book deserves a place in the library of every research institution and company working on renewable energy.”Nature “With a broad range of coverage, many references in each chapter, and an appendix listing useful quantities, factors and symbols, this book would be an excellent reference source for any one working in the field of photovoltaics.”IEEE Electrical Insulation Magazine “It is timely, up-to-date and a very comprehensive work. The chapters are written by leading experts in their field who are able to communicate the technology and their enthusiasm ... Photovoltaic R&D is a multi-disciplinary activity, and most chapters should be accessible to

advanced undergraduate students, postgraduates and researchers with a wide range of backgrounds. It can be recommended to those starting a PhD in the area and to existing researchers in other fields who wish to find out what all the excitement is about."Contemporary Physics
The Physics of Solar Cells John Wiley & Sons
This book contains chapters in which the problems of modern photovoltaics are considered. The majority of the chapters provide an overview of the results of research and development of different types of solar cells. Such chapters are completed by a justification for a new solar cell structure and technology. Of course, highly effective solar energy conversion is impossible without an in-depth examination of the solar cell components as physical materials. The relations between structural, thermodynamic, and optical properties of the physical material without addressing the band theory of solids are of both theoretical and practical interest. Requirements formulated for the material are also to be used for maximally efficient conversion of solar radiation into useful work.
Physics and Technology of Amorphous-Crystalline Heterostructure Silicon Solar Cells BoD – Books on Demand
Solar Cell Device Physics offers a balanced, in-depth qualitative and quantitative treatment of the physical principles and operating characteristics of solar cell devices. Topics covered include photovoltaic energy conversion and solar cell materials and structures, along with homojunction solar cells. Semiconductor-semiconductor heterojunction cells and surface-barrier solar cells are also discussed. This book consists of six chapters and begins by introducing the reader to the basic physical principles and materials properties that are the foundations of photovoltaic energy conversion, with emphasis on various photovoltaic devices capable of efficiently converting solar energy into usable electrical energy. The electronic and optical properties of crystalline, polycrystalline, and amorphous materials with both organic and inorganic materials are considered, together with the manner in which these properties change from one material class to another and the implications of such changes for photovoltaics. Generation, recombination, and bulk transport are also discussed. The two mechanisms of photocarrier collection in solar cells, drift and diffusion, are then compared. The remaining chapters focus on specific solar cell device classes defined in terms of the interface structure employed: homojunctions, semiconductor-semiconductor heterojunctions, and surface-barrier devices. This monograph is appropriate for use as a textbook for graduate students in engineering and the sciences and for seniors in electrical engineering and applied physics, as well as a reference book for those actively involved in solar cell research and development.
Physics of Solar Cells Wiley
This book provides a comprehensive introduction to the physics of the photovoltaic cell. It is suitable for undergraduates, graduate students, and researchers new to the field. It covers: basic physics of semiconductors in photovoltaic devices; physical models of solar cell operation; characteristics and design of common types of solar cell; and approaches to increasing solar cell efficiency. The text explains the terms and concepts of solar cell device physics and shows the reader how to formulate and solve relevant physical problems. Exercises and worked solutions are included.
Solar Cells John Wiley & Sons
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Peter Würfel describes in detail all aspects of solar cell function, the physics behind every single step, as well as all the issues to be considered when improving solar cells and their efficiency. Based on the highly successful German version, but thoroughly revised and updated, this edition contains the latest knowledge on the mechanisms of solar energy conversion. Requiring no more than standard physics knowledge, it enables readers to understand the factors driving conversion efficiency and to apply this knowledge to their own solar cell development.
Copper Zinc Tin Sulfide-Based Thin-Film Solar Cells John Wiley & Sons
The fundamental concept of the book is to explain how to make thin film solar cells from the abundant solar energy materials by low cost. The proper and optimized growth conditions are very essential while sandwiching thin films to make solar cell otherwise secondary phases play a role to undermine the working function of solar cells. The book illustrates growth and characterization of Cu2ZnSn(S1-xSex)4 thin film absorbers and their solar cells. The fabrication process of absorber layers by either vacuum or non-vacuum process is readily elaborated in the book, which helps for further development of cells. The characterization analyses such as XPS, XRD, SEM, AFM etc., lead to tailor the physical properties of the absorber layers to fit well for the solar cells. The role of secondary phases such as ZnS, Cu2-xS,SnS etc., which are determined by XPS, XRD or Raman, in the absorber layers is promptly discussed. The optical spectroscopy analysis, which finds band gap, optical constants of the films, is mentioned in the book. The electrical properties of the absorbers deal the influence of substrates, growth temperature, impurities, secondary phases etc. The low temperature I-V and C-V measurements of Cu2ZnSn(S1-xSex)4 thin film solar cells are clearly described. The solar cell parameters such as efficiency, fill factor, series resistance, parallel resistance provide handful information to understand the mechanism of physics of thin film solar cells in the book. The band structure, which supports to adjust interface states at the p-n junction of the solar cells is given. On the other hand the role of window layers with the solar cells is discussed. The simulation of theoretical efficiency of Cu2ZnSn(S1-xSex)4 thin film solar cells explains how much efficiency can be experimentally extracted from the cells. One of the first books exploring how to conduct research on thin film solar cells, including reducing costs Detailed instructions on conducting research
Thin-Film Solar Cells John Wiley & Sons
With the decline in the world's natural resources, the need for new and cheaper energy sources is evolving. One such source is the sun which generates heat and light which can be harnessed and used to our advantage. This reference book introduces the topic of photovoltaics in the form of flexible solar cells. There are explanations of the principles behind this technology, the engineering required to produce these products and the future possibilities offered by this technology. The chemistry and physics of the cells (both organic and inorganic) are clarified as well as production methods, with information how this can then be applied to the nanoscale as well. A complete guide to this new and exciting way of producing energy which will be invaluable to a variety of people from material scientists, chemists, electrical engineers, to management consultants and politicians.
Handbook of the Physics of Thin-Film Solar Cells Springer
This book contains detailed information on the types, structure, fabrication, and characterization of organic solar cells (OSCs). It discusses processes to improve efficiencies and the prevention of degradation in OSCs. It compares the cost-effectiveness of OSCs to those based on crystalline silicon and discusses ways to make OSCs more economical. This book provides a practical guide for the fabrication, processing, and characterization of OSCs and paves the way for further development in OSC technology.
Organic Solar Cells Elsevier
This first comprehensive description of the most important material properties and device aspects closes the gap between general books on solar cells and journal articles on chalcogenide-based photovoltaics. Written by two very renowned authors with years of practical experience in the field, the book covers II-VI and I-III-VI2 materials as well as energy conversion at heterojunctions. It also discusses the latest semiconductor heterojunction models and presents modern analysis concepts. Thin film technology is explained with an emphasis on current and future techniques for mass production, and the book closes with a compendium of failure analysis in photovoltaic thin film modules. With its overview of the semiconductor physics and technology needed, this practical book is ideal for students, researchers, and manufacturers, as well as for the growing number of engineers and researchers working in companies and institutes on chalcogenide photovoltaics.
Development of Solar Cells Springer Science & Business Media
This book covers in a textbook-like fashion the basics or organic solar cells, addressing the limits of photovoltaic energy conversion and giving a well-illustrated introduction to molecular electronics with focus on the working principle and characterization of organic solar cells. Further chapters based on the author's dissertation focus on the electrical processes in organic solar cells by presenting a detailed drift-diffusion approach to describe exciton separation and charge-carrier transport and extraction. The results, although elaborated on small-molecule solar cells and with focus on the zinc phthalocyanine: C60 material system, are of general nature. They propose and demonstrate experimental approaches for getting a deeper understanding of the dominating processes in amorphous thin-film based solar cells in general. The main focus is on the interpretation of the current-voltage characteristics (J-V curve). This very standard measurement technique for a solar cell reflects the electrical processes in the device. Comparing experimental to simulation data, the author discusses the reasons for S-Shaped J-V curves, the role of charge carrier mobilities and energy barriers at interfaces, the dominating recombination mechanisms, the charge carrier generation profile, and other efficiency-limiting processes in organic solar cells. The book concludes with an illustrative guideline on how to identify reasons for changes in the J-V curve. This book is a suitable introduction for students in engineering, physics, material science, and chemistry starting in the field of organic or hybrid thin-film photovoltaics. It is just as valuable for professionals and experimentalists who analyze solar cell devices.
Advances in Thin-Film Solar Cells John Wiley & Sons
This book presents a comprehensive overview of the fundamental concept, design, working protocols, and diverse photo-chemicals aspects of different solar cell systems with promising prospects, using computational and experimental techniques. It presents and demonstrates the art of designing and developing various solar cell systems through practical examples. Compared to most existing books in the market, which usually analyze existing solar cell approaches this volume provides a more comprehensive view on the field. Thus, it offers an in-depth discussion of the basic concepts of solar cell design and their development, leading to higher power conversion efficiencies. The book will appeal to readers who are interested in both fundamental and application-oriented research while it will also be an excellent tool for graduates, researchers, and professionals working in the field of photovoltaics and solar cell systems.
Solar Cell Device Physics John Wiley & Sons
This book provides a review of all types of silicon solar cells. The scope includes monocrocrystalline Si solar cells, polycrystalline and amorphous thin-film silicon solar cells, and tandem solar cells. Production, treatment and development of these devices are reviewed. Limitations of these devices, design optimization, testing and fabrication methods are covered. In addition, current status and future prospects for the further development of silicon solar cells are addressed. Special emphasis is given to methods of attaining high efficiency and thereby cost-effective solar power. The aim of the book is to provide the reader with a complete overview about the recent advances in the structure and technology of all generations of silicon solar cells.
Advanced Solar Cell Materials, Technology, Modeling, and Simulation World Scientific Publishing Company
With the increasing world-energy demand there is a growing necessity for clean and renewable energy. The sun being one of the most abundant potential sources accounts for less than 1% of the global energy supply. The market for solar cells is one of the most strongly increasing markets, even though the prize of conventional solar cells is still quite high. New emerging technologies, such as organic and hybrid solar cells have the potential to decrease the price of solar energy drastically. This book offers an introduction to these new types of solar cells and discusses fabrication, different architectures and their device physics on the bases of the author's teaching course on a master degree level. A comparison with conventional solar cells will be given and the specialties of organic solar cells emphasized.
Third Generation Photovoltaics Walter de Gruyter GmbH & Co KG
Solar Cells and Energy Materials takes an in-depth look at the basics behind energy, solar energy as well as future and alternative energy materials. The author presents insights into the current state-of-the-art of solar cells, including their basic science, inorganic, organic and Perovskite-type cells. The author also gives an outlook into next generation energy materials and sources. The focus of this book is not only the presentation of available and developing energy materials, but their thorough examination and characterization. In addition to solar cell technology and the promising application of nanostructures like quantum dots, the author discusses the science and potential of nuclear fusion materials and other energy materials like hydrogen storage materials, BN nanomaterials, alternative fuel cells and SIC FET.

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