# Organic Solar Cells Fundamentals Devices And

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## JIMMY EWING

**Fundamentals of Solar Cell Design** Academic Press
Solar PV is now the third most important renewable energy source, after hydro and wind power, in terms of global installed capacity. Bringing together the expertise of international PV specialists Photovoltaic Solar Energy: From Fundamentals to Applications provides a comprehensive and up-to-date account of existing PV technologies in conjunction with an assessment of technological developments. Key features: Written by leading specialists active in concurrent developments in material sciences, solar cell research and application-driven R&D. Provides a basic knowledge base in light, photons and solar irradiance and basic functional principles of PV. Covers characterization techniques, economics and applications of PV such as silicon, thin-film and hybrid solar cells. Presents a compendium of PV technologies including: crystalline silicon technologies; chalcogenide thin film solar cells; thin-film silicon based PV technologies; organic PV and III-Vs; PV concentrator technologies; space technologies and economics, life-cycle and user aspects of PV technologies. Each chapter presents basic principles and formulas as well as major technological developments in a contemporary context with a look at future developments in this rapidly changing field of science and engineering. Ideal for industrial engineers and scientists beginning careers in PV as well as graduate students undertaking PV research and high-level undergraduate students.
*Large-scale full-solution, vacuum-free gravure printed ITO-free flexible organic solar cells* Royal Society of Chemistry
Organic Electronics is a novel field of electronics that has gained an incredible attention over the past few decades. New materials, device architectures and applications have been continuously introduced by the academic and also industrial communities, and novel topics have raised strong interest in such communities, as molecular doping, thermoelectrics, bioelectronics and many others. Organic Flexible Electronics is mainly divided into three sections. The first part is focused on the fundamentals of organic electronics, such as charge transport models in these systems and new approaches for the design and synthesis of novel molecules. The first section addresses the main challenges that are still open in this field, including the important role of interfaces for achieving high-performing devices or the novel approaches employed for improving reliability issues. The second part discusses the most innovative devices which have been developed in recent years, such as devices for energy harvesting, flexible batteries, high frequency circuits, and flexible devices for tattoo electronics and bioelectronics. Finally the book reviews the most important applications moving from more standard flexible back panels to wearable and textile electronics and more futuristic applications like ingestible systems. Reviews the fundamental properties and methods for optimizing organic electronic materials including chemical doping and techniques to address stability issues; Discusses the most promising organic electronic devices for energy, electronics, and biomedical applications; Addresses key applications of organic electronic devices in imagers, wearable electronics, bioelectronics.
Organic Photovoltaics Elsevier
This book addresses the rapidly developing class of solar cell materials and designed to provide much needed information on the fundamental principles of these materials, together with how these are employed in photovoltaic applications. A special emphasize have been given for the space applications through study of radiation tolerant solar cells. This book present a comprehensive research outlining progress on the synthesis, fabrication and application of solar cells from fundamental to device technology and is helpful for graduate students, researchers, and technologists engaged in research and development of materials.
**Perovskite Photovoltaics and Optoelectronics** CRC Press
Written for use as a text and reference for those interested in how new materials may be used to capture, store, and use solar energy for alternative energy resources in everyday life, Solar Fuels: Materials, Physics, and Applications discusses the fundamentals of new materials and the physical processes involved in their mechanisms and design. This book offers clear examples of current state-of-the-art organic and inorganic solar cell materials and devices used in the field, and includes experiments testing solar capability along with standardized examples. Last, but not least, it also gives a clear outline of the challenges that need to be addressed moving forward.
*Practical Handbook of Photovoltaics* Oxford University Press, USA
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.
**Characterization Techniques for Perovskite Solar Cell Materials** John Wiley & Sons
As part of the growing sustainable and renewable energy movement, the design, manufacture and use of photovoltaic devices is increasing in pace and frequency. The Handbook of Photovoltaics will be a 'benchmark' publication for those involved in the design, manufacture and use of these devices. The Handbook covers the principles of solar cell function, the raw materials, photovoltaic systems, standards, calibration, testing, economics and case studies. The editors have assembled a cast of internationally-respected contributors from industry and academia. The report is essential reading for: Physicists, electronic engineers, designers of systems, installers, architects, policy-makers relating to photovoltaics. A thorough update to the 'benchmark' publication from a cast of industrial and academic international experts ensures top quality information from multiple stakeholder perspectives Covers all things PV- from principles of solar cells and their raw materials, to the installation and design of full PV systems, including standards, testing, economics and environmental impacts Case studies, practical examples and reports on the latest advances take the new edition of this amazing resource beyond a vast collection of knowledge, into the realm of real world applications
*Organic and Hybrid Solar Cells* World Scientific
Bachelor Thesis from the year 2014 in the subject Technology, grade: 1,0, Friedrich-Alexander University Erlangen-Nuremberg, course: Nanotechnologie, language: English, abstract: This bachelor thesis presents the fabrication and evaluation of large-scale full-solution roll-to-roll processed, ITO-free flexible organic solar cells in a modified inverted device geometry by gravure printing on a discrete laboratory-scale printing system. The layer stack is based on flexible PET substrate whereupon the back silver cathode was printed on top. The electron transport layer of ZnO and a double light absorbing photoactive layer of P3HT:PCBM, the hole transport layer of PEDOT:PSS and front silver anode were printed consecutively. All layers were roll-to-roll gravure printed from solution under full ambient vacuum-free conditions at a web speed of 2 m min−1. The completed solar cells were characterized by J-V and comprising layers by light beam induced current measurements. For fast testing and reproducibility experiments the remaining layers of the stack after each gravure printed film were deposited by slot-die coating and flexographic printing on a single roll coating system. Unfortunately functional organic solar cells of a fully gravure printed layer stack could not be found. A power conversion efficiency of 0.15 % of partly roll-to-roll gravure printed and residuary roll-based slot-die coated and flexographic printed organic solar cells under AM1.5G illumination was obtained. The thesis contains a brief introduction in the topic of renewable energies and organic photovoltaic followed by the state of art in two-dimensional gravure printing organic solar cells and the motivation to particularly foreground this fabrication method. In the fundamentals part the working principle, device geometries, affiliated by the concept of ITO-free organic solar cells and materials in an organic photovoltaic device including characterization methods are presented. Afterwards large-scale manufacturing techniques of organic photovoltaic comprising coating and printing technologies are reviewed and the roll-to-roll manufacturing strategies are introduced. In the experimental part the design, machinery and equipment used and fabrication of gravure printed flexible organic solar cell are chronologically described in detail in connection with presenting and discussing the results after characterizing the completed solar cells. Challenges that were faced during the studies are described subsequently and solutions of appeared problems are presented. A conclusion and outlook finalizes the thesis.
**Electronic Processes in Organic Semiconductors** Springer Nature
Photovoltaics technology, or solar cell, has been developed for more than a half century. This idea that utilizes energy from an infinite resource is indeed fascinating and drives scientists and engineers to devote themselves to this field. It is one of the major renewable energy types which accounts for 2% of the global total electricity consumption in 2018 and this percentage is still growing in a steady trend. According to a publicized prediction, the solar power could supply 20% of the total electricity demand in 2030 because of drastically dropping price per watt. Although a brilliant future of solar cell is projected, there are still many unknown physical phenomena and engineering difficulties nonetheless. These challenges in photovoltaics are thus of our interest to work on. The state of art highest efficiency photovoltaics is multi-junction inorganic solar cell, which is used in astronautic application. Yet the complicated fabrication processes and high cost limit its usage. It is the reason that silicon solar cell with moderate efficiency and process rules the whole solar cell market. However, the world still needs a different type of solar cell to fulfill the requirements of low weight, flexible, transparent, non-toxic and solution process compatibility to accustom to the other environment conditions. Organic solar cell is one of the strong candidates for reaching this target. In this dissertation, I aim to achieve high efficiency organic solar cells in single-junction and multi-junction structure with different strategies. There are the modification of charge transport layer and interconnecting layer for a better Ohmic contact and fermi level pining as well as the sub-cell current matching by third photo-active component. In Chap. 3, the project for improving the transport properties of single junction devices has been explored. A high mobility Indium Oxide In2O3 as an universal electron transport layer was chosen and improved the original device efficiencies for 10%. The physical fundamentals for efficiency improvement have been found that the crystalline In2O3 with highly aligned nanocrystallites can induce the crystallization of polymer into a preferential molecular packing for the charge transport and the charge extraction in the crystalline In2O3 devices is significantly faster than its counterpart devices. Based on the work principle of Fermi level pinning, organic tandem solar cells with a tunnel junction consisted of zirconium (IV) acetylacetonate (Zr-Acac) has been developed and discussed in Chap. 4. The Zr-Acac has a suitable low work function to pin the Fermi level of the interconnecting layer and hence, can effectively behave as the charge recombination function for the tandem device. Furthermore, Zr-Acac requires a least harmful preparation process method in the tandem devices. Comparing to the reference device, the Zr-Acac interconnecting layer can effectively enhance the efficiency by 20%. The other strategies to

improve the tandem organic solar cells with the ternary structure have been discussed in Chap. 5 and Chap. 6. Broadening the light absorption spectrum needs the optimization of current matching among different sub-cells with good interconnecting layer. Herein, it is firstly discovered that using ternary blend sub-cell in tandem device can finely optimize the current matching via tuning the materials composition in the ternary blend. The voltage-current trade-off in the tandem devices can be achieved. Due to the amorphous nature of the used small molecular, the phase separation in this ternary blend upon heating is sufficiently suppressed, resulting in a good thermal stability and viable for a better environment of interconnecting layer preparation. The device efficiency measured in the lab has reached 13% and the certified device efficiency is 11.5% by NREL, which achieves the world record as of October 2018. My conclusion and future perspective of these works on organic solar cells are summarized in Chap. 7.

Halide Perovskites John Wiley & Sons

Perovskite Photovoltaics and Optoelectronics Discover a one-of-a-kind treatment of perovskite photovoltaics In less than a decade, the photovoltaics of organic-inorganic halide perovskite materials has surpassed the efficiency of semiconductor compounds like CdTe and CIGS in solar cells. In Perovskite Photovoltaics and Optoelectronics: From Fundamentals to Advanced Applications, distinguished engineer Dr. Tsutomu Miyasaka delivers a comprehensive exploration of foundational and advanced topics regarding halide perovskites. It summarizes the latest information and discussion in the field, from fundamental theory and materials to critical device applications. With contributions by top scientists working in the perovskite community, the accomplished editor has compiled a resource of central importance for researchers working on perovskite related materials and devices. This edited volume includes coverage of new materials and their commercial and market potential in areas like perovskite solar cells, perovskite light-emitting diodes (LEDs), and perovskite-based photodetectors. It also includes: A thorough introduction to halide perovskite materials, their synthesis, and dimension control Comprehensive explorations of the photovoltaics of halide perovskites and their historical background Practical discussions of solid-state photophysics and carrier transfer mechanisms in halide perovskite semiconductors In-depth examinations of multi-cation anion-based high efficiency perovskite solar cells Perfect for materials scientists, crystallization physicists, surface chemists, and solid-state physicists, Perovskite Photovoltaics and Optoelectronics: From Fundamentals to Advanced Applications is also an indispensable resource for solid state chemists and device/electronics engineers.

Elsevier

This book covers the recent advances in photovoltaics materials and their innovative applications. Many materials science problems are encountered in understanding existing solar cells and the development of more efficient, less costly, and more stable cells. This important and timely book provides a historical overview, but concentrates primarily on the exciting developments in the last decade. It includes organic and perovskite solar cells, photovoltaics in ferroelectric materials, organic-inorganic hybrid perovskite, materials with improved photovoltaic efficiencies as well as the full range of semiconductor materials for solar-to-electricity conversion, from crystalline silicon and amorphous silicon to cadmium telluride, copper indium gallium sulfide selenides, dye sensitized solar cells, organic solar cells, and environmentally-friendly copper zinc tin sulfide selenides.

Emerging Solar Energy Materials Academic Press

This book covers fundamentals of organometal perovskite materials and their photovoltaics, including materials preparation and device fabrications. Special emphasis is given to halide perovskites. The opto-electronic properties of perovskite materials and recent progress in perovskite solar cells are described. In addition, comments on the issues to current and future challenges are mentioned.

Organic-Inorganic Halide Perovskite Photovoltaics Springer Science & Business Media

Organic Solar Cells A timely and singular resource on the latest advances in organic photovoltaics Organic photovoltaics are gaining widespread attention due to their solution processability, tunable electronic properties, low temperature manufacture, and cheap and light materials. Their wide range of potential applications may result in significant near-term commercialization of the technology. In Organic Solar Cells: Materials Design, Technology and Commercialization, renowned scientist Dr. Liming Ding delivers a comprehensive exploration of organic solar cells, including discussions of their key materials, mechanisms, molecular designs, stability features, and applications. The book presents the most state-of-the-art developments in the field alongside fulsome treatments of the commercialization potential of various organic solar cell technologies. The author also provides: Thorough introductions to fullerene acceptors, polymer donors, and non-fullerene small molecule acceptors Comprehensive explorations of p-type molecular photovoltaic materials and polymer-polymer solar cell materials, devices, and stability Practical discussions of electron donating ladder-type heteroacenes for photovoltaic applications In-depth examinations of chlorinated organic and single-component organic solar cells, as well as the morphological characterization and manipulation of organic solar cells Perfect for materials scientists, organic and solid-state chemists, and solid-state physicists, Organic Solar Cells: Materials Design, Technology and Commercialization will also earn a place in the libraries of surface chemists and physicists and electrical engineers.

*The Physics of Solar Cells* CRC Press

Organic photovoltaic (OPV) cells have the potential to make a significant contribution to the increasing energy needs of the future. In this book, 15 chapters written by selected experts explore the required characteristics of components present in an OPV device, such as transparent electrodes, electron- and hole-conducting layers, as well as electron donor and acceptor materials. Design, preparation, and evaluation of these materials targeting highest performance are discussed. This includes contributions on modeling down to the molecular level to device-level electrical and optical testing and modeling, as well as layer morphology control and characterization. The integration of the different components in device architectures suitable for mass production is described. Finally, the technical feasibility and economic viability of large-scale manufacturing using fast inexpensive roll-to-roll deposition technologies is assessed.

Principles of Solar Cells, LEDs and Related Devices John Wiley & Sons

Organic Solar CellsCRC Press

**Design and Synthesis of New Organic Semiconductors for Organic Solar Cells** Elsevier

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.

**Solar Cells** Springer

The second edition of the text that offers an introduction to the principles of solar cells and LEDs, revised and updated The revised and updated second edition of Principles of Solar Cells, LEDs and Related Devices offers an introduction to the physical concepts required for a comprehensive understanding of p-n junction devices, light emitting diodes and solar cells. The author – a noted expert in the field – presents information on the semiconductor and junction device fundamentals and extends it to the practical implementation of semiconductors in both photovoltaic and LED devices. In addition, the text offers information on the treatment of a range of important semiconductor materials and device structures including OLED devices and organic solar cells. This second edition contains a new chapter on the quantum mechanical description of the electron that will make the book accessible to students in any engineering discipline. The text also includes a new chapter on bipolar junction and junction field effect transistors as well as expanded chapters on solar cells and LEDs that include more detailed information on high efficiency devices. This important text: Offers an introduction to solar cells and LEDs, the two most important applications of semiconductor diodes Provides a solid theoretical basis for p-n junction devices Contains updated information and new chapters including better coverage of LED out-coupling design and performance and improvements in OLED efficiency Presents student problems at the end of each chapter and worked example problems throughout the text Written for students in electrical engineering, physics and materials science and researchers in the electronics industry, Principles of Solar Cells, LEDs and Related Devices is the updated second edition that offers a guide to the physical concepts of p-n junction devices, light emitting diodes and solar cells.

*Organic Photovoltaics* Academic Press

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

*Clean Electricity from Photovoltaics* CRC Press

Solar cells are semiconductor devices that convert light photons into electricity in photovoltaic energy conversion and can help to overcome the global energy crisis. Solar cells have many applications including remote area power systems, earth-orbiting satellites, wristwatches, water pumping, photodetectors and remote radiotelephones. Solar cell technology is economically feasible for commercial-scale power generation. While commercial solar cells exhibit good performance and stability, still researchers are looking at many ways to improve the performance and cost of solar cells via modulating the fundamental properties of semiconductors. Solar cell technology is the key to a clean energy future. Solar cells directly harvest energy from the sun's light radiation into electricity are in an ever-growing demand for future global energy production. Solar cell-based energy harvesting has attracted worldwide attention for their notable features, such as cheap renewable technology, scalable, lightweight, flexibility, versatility, no greenhouse gas emission, environment, and economy friendly and operational costs are quite low compared to other forms of power generation. Thus, solar cell technology is at the forefront of renewable energy technologies which are used in telecommunications, power plants, small devices to satellites. Aiming at large-scale implementation can be manipulated by various types used in solar cell design and exploration of new materials towards improving performance and reducing cost. Therefore, in-depth knowledge about solar cell design is fundamental for those who wish to apply this knowledge and understanding in industries and academics. This book provides a comprehensive overview on solar cells and explores the history to evolution and present scenarios of solar cell design, classification, properties, various semiconductor materials, thin films, wafer-scale, transparent solar cells, and so on. It also includes solar cells' characterization analytical tools, theoretical modeling, practices to enhance conversion efficiencies, applications and patents.

Emerging Photovoltaic Materials CRC Press

The present volume describes and explains the fundamentals of organic/plastic solar cells in a manner accessible to both researchers and students. It provides an up-to-date and comprehensive account of these materials and corresponding devices, which will play a key role in future solar energy systems.

*Smart Multifunctional Nano-inks* John Wiley & Sons
Nanostructured Materials for Solar Energy Conversion covers a wide variety of materials and device types from inorganic materials to organic materials. This book deals with basic semiconductor physics, modelling of nanostructured solar cell, nanostructure of conventional solar cells such as silicon, CIS and CdTe, dye-sensitized solar cell, organic solar cell, photosynthetic materials, fullerene, extremely thin absorber (ETA) solar cell, quantum structured solar cell, intermediate band solar cell, carbon nanotube, etc. including basic principle and the latest results. There are many books written on conventional p-n junction solar cells, but few books focus on new concepts in this area. * Focuses on the use of nanostructured materials for solar energy * Looks at a wide variety of materials and device types * Covers both organic and inorganic materials