Advances In Thin Film Solar Cells

Beginning with an overview and historical background of Copper Zinc Tin Sulphide (CZTS) technology, subsequent chapters cover properties of CZTS thin films, different preparation methods of CZTS thin films, a comparative study of CZTS and CIGS solar cell, computational approach, and future applications of CZTS thin film solar modules to both ground–mount and rooftop installation. The semiconducting compound (CZTS) is made up earth–abundant, low–cost and non–toxic elements, which make it an ideal candidate to replace Cu(In,Ga)Se2 (CIGS) and CdTe solar cells which face material scarcity and toxicity issues. The device performance of CZTS–based thin film solar cells has been steadily improving over the past 20 years, and they have now reached near commercial efficiency levels (10%). These achievements prove that CZTS–based solar cells have the potential to be used for large–scale deployment of photovoltaics. With contributions from leading researchers from academia and industry, many of these authors have contributed to the improvement of its efficiency, and have rich experience in preparing a variety of semiconducting thin films for solar cells.

Thin film photovoltaic-based solar modules produce power at a low cost per watt. They are ideal candidates for large-scale solar farms

as well as building-integrated photovoltaic applications. They can generate consistent power, not only at elevated temperatures but also on cloudy, overcast days and at low sun angles.Thin film photovoltaics are second-generation solar cells produced by depositing one or more thin layers, or thin films, of photosensitive material on a suitable substrate such as glass, polymer, or metal. Thin film solar cells are based on various materials such as cadmium telluride (CdTe), copper indium gallium diselenide (CIGS), and amorphous thin film silicon (a-Si, TF-Si) are commercially used in several conventional and advanced technologies.

Thin-film solar cells are either emerging or about to emerge from the research laboratory to become commercially available devices finding practical various applications. Currently no textbook outlining the basic theoretical background, methods of fabrication and applications currently exist. Thus, this book aims to present for the first time an in-depth overview of this topic covering a broad range of thin-film solar cell technologies including both organic and inorganic materials, presented in a systematic fashion, by the scientific leaders in the respective domains. It covers a broad range of related topics, from physical principles to design, fabrication, characterization, and applications of novel photovoltaic devices.

The Polycrystalline Thin Film Solar Cells Program, part of the United

States National Photovoltaic Program, performs R & D on copper indium diselenide and cadmium telluride thin films. The objective of the Program is to support research to develop cells and modules that meet the U.S. Department 2of Energy's long-term goals by achieving high efficiencies (15% - 20%), low-cost ($501m), and long-time reliability (30 years). The importance of work in this area is due to the fact that the polycrystalline thin-film CulnSe2 and CdTe solar cells and modules have made rapid advances. They have become the leading thin films for PV in terms of efficiency and stability. The U.S. Department of Energy has increased its funding through an initiative through the Solar Energy Research Institute in CulnSe2 and CdTe with subcontracts to start in Spring 1990.

Handbook of the Physics of Thin-Film Solar Cells

Advances in Photovoltaics: Part 3

Prepared for the Conference on Space Power Sponsored by the International Astronautical Federation, Cleveland, Ohio, June 5-7, 1989

Materials Challenges

Photoenergy and Thin Film Materials

This book provides recent development in thin-film solar cells (TFSC). TFSC have proven the promising approach for

terrestrial and space photovoltaics. TFSC have the potential to change the device design and produce high efficiency devices on rigid/flexible substrates with significantly low manufacturing cost. TFSC have several advantages in manufacturing compared to traditional crystalline Si-solar cells like less requirement of materials, can be prepared with earth's abundant materials, less processing steps, easy to dispose, etc. Several universities/research institutes/industry in India and abroad are involved in the research area of thin-film solar cells. The book helps the readers to find the details about different thin-film technologies and its advancement at one place. Each chapter covers properties of materials, its suitability for PV applications, simple manufacturing processes and recent and past literature survey. The issues related to the development of high efficiency TFSC devices over large area and its commercial and future prospects are discussed. Despite their wide availability and relatively low prices, the conventional energy sources have harmful consequences on

the environment and are exhaustible. In order to circumvent these negative effects, the renewable energies in general and the photovoltaic energy in particular are becoming more and more attractive. Solar cell is an electrical device that converts light into electricity at the atomic level. These devices use inorganic or organic semiconductor materials that absorb photons with energy greater than their bandgap to promote energy carriers into their conduction band. They do not pollute the atmosphere by releasing harmful gases, do not require any fuel to produce electricity, and do not move parts so they are rugged. Solar panels have a very long life and do not need much maintenance.

Photovoltaic technology has now developed to the extent that it is close to fulfilling the vision of a "solar-energy world," as devices based on this technology are becoming efficient, low-cost and durable. This book provides a comprehensive treatment of thin-film silicon, a prevalent PV material, in terms of its semiconductor nature, starting out with the physical properties, but concentrating on device

applications. A special emphasis is given to amorphous silicon and microcrystalline silicon as photovoltaic materials, along with a model that allows these systems to be physically described in the simplest manner possible, thus allowing the student or scientist/engineer entering the field of thin-film electronics to master a few basic concepts that are distinct from those in the field of conventional semiconductors. The main part of the book deals with solar cells and modules by illustrating the basic functioning of these devices, along with their limitations, design optimization, testing and fabrication methods. Among the manufacturing processes discussed are plasma-assisted and hot-wire deposition, sputtering, and structuring techniques.

This book provides a fundamental discussion, latest research & developments, and the future of thin films and photoenergy materials, two developing areas that have the potential to spearhead the future of industry. Photoenergy materials are expected to be a next generation key material to provide

secure, safe, sustainable and affordable energy. Photoenergy devices are known to convert the sunlight into electricity. This type of devices is very much simple in design with having a major advantage with their structure as stand-alone systems to provide outputs up to megawatts. They have been applied as a power source, solar home systems, remote buildings, water pumping, megawatt scale power plants, satellites, communications, and space vehicles. With such a list of enormous applications, the demand for photoenergy devices is growing every year. On the other hand, thin films coating, which can be defined as fusion of surface science, materials science, and applied physics, are progressing as a unified discipline of scientific industry. A thin film can be termed as a very fine or thin layer of material coated on a particular surface, that can be in the range of a nanometer in thickness to several micrometers in size. Thin films are being applied it a number of fields ranging from protection purposes to electronic semiconductor devices.

Silicon Thin-film Solar Cells

Solar Cells
Advanced Concepts in Photovoltaics

A Practical Guide

This book will provide an authoritative reference on the various aspects of materials science that will impact the next generation of photovoltaic (PV) module technology. The materials emphasis will bring a fresh perspective to the literature and will highlight the many issues that are often buried in other texts where the solution to materials challenges can be crucial in developing a new PV technology. The emphasis of the book will be on the range of thin film PV materials. Thin film PV is growing more rapidly that crystalline silicon and although only 10% of the current market could dominate in the longer term. This book will address the fundamental aspects of PV solar cell materials and give a comprehensive description of each of the major thin film materials either in research or in production. Particular attention will be given to the key materials drivers of solar conversion efficiency, long term stability, materials costs and materials sustainability. The book will be essential reading for materials scientists, energy technologists and all those involved in solid-state physics.

This paper focuses on the rapid recent advances made by thin film solar cell technologies, namely, amorphous silicon, copper indium diselenide, and cadmium telluride. It also indicates the several advantages of thin films. Various consumer

products and power applications using thin film solar cells are also discussed. The increasing interest among the utilities for PV system applications is also elucidated. Solar cell energy is the single most pressing issue facing humanity, with a more technologically advanced society requiring better energy resources. This book discusses technologies broadly, depending on how they capture and distribute solar energy or convert it into solar power. The major areas covered in this book are: • The theory of solar cells, which explains the conversion of light energy in photons into electric current. The theoretical studies are practical because they predict the fundamental limits of a solar cell. • The design and development of thin-film technology-based solar cells. • State of the art for bulk material applied for solar cells based on crystalline silicon (c-Si), also known as "solar grade silicon," and emerging photovoltaics.

This volume is the third of a set of seven on the topic of photovoltaics. Solar cell-related technologies covered here include: ribbon silicon; heterojunction crystalline silicon; wafer equivalent crystalline silicon; and other advanced silicon solar cell structures and processes. Semiconductors and Semimetals has distinguished itself through the careful selection of well-known authors, editors, and contributors. Originally widely known as the "Willardson and Beer" Series, it has succeeded in publishing numerous landmark volumes and chapters. The series publishes timely, highly relevant volumes intended for long-term impact and reflecting the truly interdisciplinary nature of the field. The volumes in Semiconductors and Semimetals have been and will continue to be of great interest to

physicists, chemists, materials scientists, and device engineers in academia, scientific laboratories and modern industry. Written and edited by internationally renowned experts Relevant to a wide readership: physicists, chemists, materials scientists, and device engineers in academia, scientific laboratories and modern industry

Thin-Film Solar Cells

Encyclopedia of Alternative and Renewable Energy

Crystal Growth of Silicon for Solar Cells

Implications of Advances in Thin Film Solar Cell Technology

Advances in Research and Development

Nanostructured solar cells are very important in renewable energy sector as well as in environmental aspects, because it is environment friendly. The nano-grating structures (such as triangular or conical shaped) have a gradual change in refractive index which acts as a multilayer antireflective coating that is leading to reduced light reflection losses over broadband ranges of wavelength and angle of incidence. There are different types of losses in solar cells that always reduce the conversion efficiency, but the light reflection loss is the most important factor that decreases the conversion efficiency of solar cells significantly. The antireflective coating is an optical coating which is applied to the surface of lenses or any optical devices to reduce the light reflection losses. This coating assists for the light trapping capturing capacity or improves the efficiency of optical devices, such as lenses or solar cells. Hence, the

multilayer antireflective coatings can reduce the light reflection losses and increases the conversion efficiency of nanostructured solar cells.

The field of coatings and thin-film technologies is rapidly advancing to keep up with new uses for semiconductor, optical, tribological, thermoelectric, solar, security, and smart sensing applications, among others. In this sense, thin-film coatings and structures are increasingly sophisticated with more specific properties, new geometries, large areas, the use of heterogeneous materials and flexible and rigid coating substrates to produce thin-film structures with improved performance and properties in response to new challenges that the industry presents. This book aims to provide the reader with a complete overview of the current state of applications and developments in thin-film technology, discussing applications, health and safety in thin films, and presenting reviews and experimental results of recognized experts in the area of coatings and thin-film technologies.

Silicon Based Thin Film Solar Cells explains concepts related to technologies for silicon (Si) based photovoltaic applications. Topics in this book focus on ‘new concept’ solar cells. These kinds of cells can make photovoltaic power production an economically viable option in comparison to the bulk crystalline semiconductor technology industry. A transition from bulk crystalline Si solar cells toward thin-film technologies reduces usage of active material and introduces new concepts based on nanotechnologies. Despite its importance, the scientific development and understanding of new solar cells

is not very advanced, and educational resources for specialized engineers and scientists are required. This textbook presents the fundamental scientific aspects of Si thin films growth technology, together with a clear understanding of the properties of the material and how this is employed in new generation photovoltaic solar cells. The textbook is a valuable resource for graduate students working on their theses, young researchers and all people approaching problems and fundamental aspects of advanced photovoltaic conversion.

Polycrystalline thin-film solar cells have reached a levelized cost of energy that is competitive with all other sources of electricity. The technology has significantly improved in recent years, with laboratory cell efficiencies for cadmium telluride (CdTe), perovskites, and copper indium gallium diselenide (CIGS) each exceeding 22 percent. Both CdTe and CIGS solar panels are now produced at the gigawatt scale. However, there are ongoing challenges, including the continued need to improve performance and stability while reducing cost. Advancing polycrystalline solar cell technology demands an in-depth understanding of efficiency, scaling, and degradation mechanisms, which requires sophisticated characterization methods. These methods will enable researchers and manufacturers to improve future solar modules and systems.

From Fundamentals to Applications

Physics and Technology

Recent Advances in Thin Film Photovoltaics
Fabrication, Characterization and Applications
Progress in Thin Film Solar Photovoltaic Technologies
Advances in Thin-Film Solar CellsCRC Press
What key business process output measure(s) does Silicon Thin-Film Solar Cells leverage and how? What are your current levels and trends in key Silicon Thin-Film Solar Cells measures or indicators of product and process performance that are important to and directly serve your customers? Does Silicon Thin-Film Solar Cells analysis show the relationships among important Silicon Thin-Film Solar Cells factors? Do we all define Silicon Thin-Film Solar Cells in the same way? Is Silicon Thin-Film Solar Cells currently on schedule according to the plan? Defining, designing, creating, and implementing a process to solve a business challenge or meet a business objective is the most valuable role... In EVERY company, organization and department. Unless you are talking a one-time, single-use project within a business, there should be a process. Whether that process is managed and implemented by humans, AI, or a combination of the two, it needs to be designed by someone with a complex enough perspective to ask the right questions. Someone capable of asking the right questions and step back and say, 'What are we really trying to accomplish here? And is there a different way to look at it?' For more than twenty years, The Art of Service's Self-Assessments empower people who can do just that - whether their title is marketer, entrepreneur, manager, salesperson, consultant, business process manager,

executive assistant, IT Manager, CxO etc... - they are the people who rule the future. They are people who watch the process as it happens, and ask the right questions to make the process work better. This book is for managers, advisors, consultants, specialists, professionals and anyone interested in Silicon Thin-Film Solar Cells assessment. All the tools you need to an in-depth Silicon Thin-Film Solar Cells Self-Assessment. Featuring 487 new and updated case-based questions, organized into seven core areas of process design, this Self-Assessment will help you identify areas in which Silicon Thin-Film Solar Cells improvements can be made. In using the questions you will be better able to: - diagnose Silicon Thin-Film Solar Cells projects, initiatives, organizations, businesses and processes using accepted diagnostic standards and practices - implement evidence-based best practice strategies aligned with overall goals - integrate recent advances in Silicon Thin-Film Solar Cells and process design strategies into practice according to best practice guidelines Using a Self-Assessment tool known as the Silicon Thin-Film Solar Cells Scorecard, you will develop a clear picture of which Silicon Thin-Film Solar Cells areas need attention. Included with your purchase of the book is the Silicon Thin-Film Solar Cells Self-Assessment downloadable resource, which contains all questions and Self-Assessment areas of this book in a ready to use Excel dashboard, including the self-assessment, graphic insights, and project planning automation - all with examples to get you started with the assessment right away. Access instructions can be found in the book. You are free to use the Self-Assessment contents in

your presentations and materials for customers without asking us - we are here to help.

This book presents recent advances in experimental and theoretical research on energy materials, focusing on materials that can potentially be used in the production of solar cells, hydrogen and energy storage devices. It discusses in detail the latest synthetic methods, processes, characterization methods and applications of materials like perovskite materials, metal sulfides, nanomaterials, and two-dimensional, transition metal dichalcogenides.

The most comprehensive, authoritative and widely cited reference on photovoltaic solar energy Fully revised and updated, the Handbook of Photovoltaic Science and Engineering, Second Edition incorporates the substantial technological advances and research developments in photovoltaics since its previous release. All topics relating to the photovoltaic (PV) industry are discussed with contributions by distinguished international experts in the field. Significant new coverage includes: three completely new chapters and six chapters with new authors device structures, processing, and manufacturing options for the three major thin film PV technologies high performance approaches for multijunction, concentrator, and space applications new types of organic polymer and dye-sensitized solar cells economic analysis of various policy options to stimulate PV growth including effect of public and private investment Detailed treatment covers: scientific basis of the photovoltaic effect and solar cell operation the production of solar silicon and of silicon-based solar cells and

modules how choice of semiconductor materials and their production influence costs and performance making measurements on solar cells and modules and how to relate results under standardised test conditions to real outdoor performance photovoltaic system installation and operation of components such as inverters and batteries. architectural applications of building-integrated PV Each chapter is structured to be partially accessible to beginners while providing detailed information of the physics and technology for experts. Encompassing a review of past work and the fundamentals in solar electric science, this is a leading reference and invaluable resource for all practitioners, consultants, researchers and students in the PV industry.

Volume 25 (Advanced Thin Film Solar Cell Techniques)

Advanced Characterization of Thin Film Solar Cells

Advances in Thin-Film Solar Cells

Thin-Film Silicon Solar Cells

Thin Film Solar Cells

This book, a continuation of the series "Advances in Materials Research," is intended to provide the general basis of the science and technology of crystal growth of silicon for solar cells. In the face of the destruction of the global environment,the degradationofworld-widenaturalresourcesandtheexha- tion of energy sources in the twenty-?rst century, we all have a sincere desire for a better/safer world in the future. In these days, we strongly believe that it is

important for us to rapidly developanewenvironment-friendlycleanenergyconversionsystemusingsolar energyastheultimatenaturalenergysource. Forinstance,mostofournatural resources and energy sources will be exhausted within the next 100 years. Speci?cally, the consumption of oil, natural gas, and uranium is a serious problem. Solar energy is the only ultimate natural energy source. Although 30% of total solar energy is re?ected at the earth ' s surface, 70% of total solar energy can be available for us to utilize. The available solar energy amounts to severalthousand times larger than the world ' s energy consumption in 2000 of about 9,000 Mtoe (M ton oil equivalent). To manage 10% of the world ' s energy consumption at 2050 by solar energy, we must manufacture 40 GW solar cells per year continuously for 40 years. The required silicon feedstock is about 400,000 ton per year. We believe that this is an attainable target, since it can be realized by increasing the world production of silicon feedstock by 12times asmuchasthe presentproductionat2005.

This introduction to the physics of silicon solar cells focuses on thin cells, while reviewing and discussing the current status of the important technology. An analysis of the spectral quantum efficiency of thin solar cells is given as well as a full set of analytical models. This is the first comprehensive treatment of light trapping techniques for the enhancement of the optical

absorption in thin silicon films.

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.

This handbook is a compendium giving a comprehensive description of the basics of semiconductor physics relevant to the design and analysis of thin film solar cell materials. It starts from the basics of material science, describing the material and its growth, defect and electrical properties, the basics of its interaction with photons and the involved statistics, proceeding to space

charge effects in semiconductors and pn-junctions. Most attention is given to analyze homo- and hetero-junction solar cells using various models and applying the field-of-direction analysis for discussing current voltage characteristics, and helping to discover the involvement of high-field effects in solar cells. The comprehensive coverage of the main topics of - and relating to - solar cells with extensive reference to literature helps scientists and engineers at all levels to reach a better understanding and improvement of solar cell properties and their production. The author is one of the founders of thin film solar cell research.

Copper Zinc Tin Sulfide-Based Thin Film Solar Cells

Next Generation Photovoltaics and Its Applications

Thin-Film Crystalline Silicon Solar Cells

Advanced Characterization Techniques for Thin Film Solar Cells

Coatings and Thin-Film Technologies

This is an advanced book on thin film solar cell techniques. This technique uses direct-gap semiconductors such as CIGS and CdTe pose minimum manufacturing costs and is now increasing in popularity amongst industries. The field of photovoltaics has seen a large-scale manufacturing of the second genesis of thin film solar modules and has succeeded in constructing powerful solar plants in many countries across the globe.

This has led to an increase in the manufacturability of thin film solar modules as compared to wafer or ribbon Si modules. Thin films like CIGS and CdTe will soon take over wafer-based silicon solar cells as the superior photovoltaic technology. This book elucidates the scientific and technological difficulties of increasing the photoelectric efficiency of thin film solar cells. It covers various aspects of thin film solar cells processing, modeling and sensitive issues, analysis of monograin layer solar cell etc. The book will be beneficial for readers interested in this subject.

Physics of Thin Films: Advances in Research and Development primarily deals with the influence of ions or optical energy on the deposition, properties, and etching on thin films. The book is a collection of five articles, with one article per chapter. Chapter 1 covers ionized cluster beam deposition; epitaxy; and film-formation mechanism. Chapter 2 discusses the activated reactive evaporation process; the deposition of refractory compounds; the role of plasma in the process; and its applications. Chapter 3 focuses on ion-beam processing of optical thin films; ion sources and ion-surface interactions; and the different kinds of bombardment involved. Chapter 4 deals with laser induced etching - its mechanisms, methods, and applications. Chapter 5 talks about contacts to

GaAs devices; Fermi-level pinning; and heterojunction contacts. The book is recommended for physicists and engineers in the field of electronics who would like to know more about thin films and the progresses in the field.

The first comprehensive book on thin-film solar cells, potentially a key technology for solving the energy production problem in the 21st century in an environmentally friendly way. It covers a wide range of scientific and technological aspects of thin film semiconductors - deposition technologies, growth mechanisms and the basic properties of amorphous and nano-crystalline silicon - as well as the optimum design theory and device physics of high-efficiency solar cells, especially of single-junction and multi-junction solar cells. The development of large-area solar cell modules using single and multi-junction solar cells is also considered. Examples of recent photovoltaic systems are presented and analysed.

The book focuses on advanced characterization methods for thin-film solar cells that have proven their relevance both for academic and corporate photovoltaic research and development. After an introduction to thin-film photovoltaics, highly experienced experts report on device and materials characterization methods such as electroluminescence analysis,

capacitance spectroscopy, and various microscopy methods. In the final part of the book simulation techniques are presented which are used for ab-initio calculations of relevant semiconductors and for device simulations in 1D, 2D and 3D. Building on a proven concept, this new edition also covers thermography, transient optoelectronic methods, and absorption and photocurrent spectroscopy.

Advances in Thin-film Solar Cells for Lightweight Space Photovoltaic Power

Chalcogenide Photovoltaics

Thin Films Photovoltaics

Recent Advances in Thin Films

Advances in the Development of Efficient Thin Film CdS/Cu2S Solar Cells

This volume comprises the expert contributions from the invited speakers at the 17th International Conference on Thin Films (ICTF 2017), held at CSIR-NPL, New Delhi, India. Thin film research has become increasingly important over the last few decades owing to the applications in latest technologies and devices. The book focuses on current advances in thin film deposition processes and characterization including thin film measurements. The chapters

cover different types of thin films like metal, dielectric, organic and inorganic, and their diverse applications across transistors, resistors, capacitors, memory elements for computers, optical filters and mirrors, sensors, solar cells, LED's, transparent conducting coatings for liquid crystal display, printed circuit board, and automobile headlamp covers. This book can be a useful reference for students, researchers as well as industry professionals by providing an up-to-date knowledge on thin films and coatings.

This book concentrates on the latest developments in our understanding of solid-state device physics. The material presented is mainly experimental and based on CdTe thin-film solar cells. It extends these new findings to CIGS thin-film solar cells and presents a new device design based on graded bandgap multilayer 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 combines "impact ionization" and "impurity photovoltaic" effects. The improved device understanding

presented in this book should impact and guide future device design and low-cost thin-film solar panel manufacture.

The amorphous materials and thin-film solar cells program was initiated by the US Department of Energy in 1978 and then transferred to the Solar Energy Research Institute. The aim of the present DOE/SERI program is to achieve 5-year DOE research goals by addressing photovoltaic research in single-junction amorphous thin films as well as the most promising option in high-efficiency, multijunction solar cells. Multiyear subcontract awards initiated in 1983 were designed to demonstrate a stable, small-area, p-i-n solar cell of at least 12% (AMI) efficiency, a stable submodule of at least 8% (AMI) efficiency, a stable submodule of at least 8% (AMI) efficiency (total area, 1000 cm/sup 2/), and a proof-of-concept multijunction amorphous silicon alloy thin-film solar cell that will lead to achieving an 18% efficiency goal in 1988.

Photovoltaic (PV) solar energy is expected to be the world's largest source of electricity in the future. To enhance the long-term reliability of PV modules, a thorough understanding of failure mechanisms is of vital importance. In addition, it is important to address the potential downsides to this technology. These include

the hazardous chemicals needed for manufacturing solar cells, especially for thin-film technologies, and the large number of PV modules disposed of at the end of their lifecycles. This book discusses the reliability and environmental aspects of PV modules.
Handbook of Photovoltaic Science and Engineering
Advances in Energy Materials
Reliability and Ecological Aspects of Photovoltaic Modules
U.S. Polycrystalline Thin Film Solar Cells Program
Recent Technological Advances in Thin Film Solar Cells

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. This book describes the diverse range of materials and fabrication methods now available to take photovoltaic systems into the third generation and exceed the Shockley-Quieisser limit. 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.
Solar Panels and Photovoltaic Materials
Nanostructured Solar Cells
An Assessment of Solar Hydrogen Energy Systems
Physics of Thin Films
Theory, Materials and Recent Advances