Advanced Silicon Materials For Photovoltaic Applications

The world of today must face up to two contradictory energy problems: on the one hand, there is the sharply growing consumer demand in countries such as China and India. On the other hand, natural resources are dwindling. Moreover, many of those countries which still possess substantial gas and oil supplies are politically unstable. As a result, renewable natural energy sources have received great attention. Among these, solar-cell technology is one of the most promising candidates. However, there still remains the problem of the manufacturing costs of such cells. Many attempts have been made to reduce the production costs of "conventional" solar cells (manufactured from monocrystalline silicon using diffusion methods) by instead using cheaper grades of silicon, and simpler pn-junction fabrication. That is the "hero" of this book; the heterojunction solar cell.

Advanced Silicon Materials for Photovoltaic ApplicationsJohn Wiley & Sons

Vol 2A: Basic Technologies Handbook of Crystal Growth, 2nd Edition Volume IIA (Basic Technologies) presents basic growth technologies and modern crystal cutting methods. Particularly, the methodical fundamentals and development of technology in the field of bulk crystallization on both industrial and research scales are explored. After an introductory chapter on the formation of minerals, ruling historically the basic crystal formation parameters, advanced basic technologies from melt, solution, and vapour being applied for research and production of the today most important materials, like silicon, semiconductor compounds and oxides are presented in detail. The interdisciplinary and general importance of crystal growth for human live are illustrated. Vol 2B: Growth Mechanisms and Dynamics Handbook of Crystal Growth, 2nd Edition Volume IIB (Growth Mechanisms and Dynamics) deals with characteristic mechanisms and dynamics accompanying each bulk crystal growth method discussed in Volume IIA. Before the atoms or molecules pass over from a position in the fluid medium (gas, melt or solution) to their place in the crystalline face they must be transported in the fluid over macroscopic distances by diffusion, buoyancy-driven convection, surface-tension-driven convection, and forced convection (rotation, acceleration, vibration, magnetic mixing). Further, the heat of fusion and the part carried by the species on their way to the crystal by conductive and convective transport must be dissipated in the solid phase by well-organized thermal conduction and radiation to maintain a stable propagating interface. Additionally, segregation and capillary phenomena play a decisional role for chemical composition and crystal shaping, respectively. Today, the increase of high-quality crystal yield, its size enlargement and reproducibility are imperative conditions to match the strong economy. Volume 2A Presents the status and future of Czochralski and float zone growth of dislocation-free silicon Examines directional solidification of silicon ingots for photovoltaics, vertical gradient freeze of GaAs, CdTe for HF electronics and IR imaging as well as antiferromagnetic compounds and super alloys for turbine blades Focuses on growth of dielectric and conducting oxide crystals for lasers and non-linear optics Topics on hydrothermal, flux and vapour phase growth of III-nitrides, silicon carbide and diamond are explored Volume 2B Explores capillarity control of the crystal shape at the growth from the melt Highlights modeling of heat and mass transport dynamics Discusses control of

convective melt processes by magnetic fields and vibration measures Includes imperative information on the segregation phenomenon and validation of compositional homogeneity Examines crystal defect generation mechanisms and their controllability Illustrates proper automation modes for ensuring constant crystal growth process Exhibits fundamentals of solution growth, gel growth of protein crystals, growth of superconductor materials and mass crystallization for food and pharmaceutical industries

Inorganic Photovoltaic Solar Energy

Electricity from Photovoltaic Solar Cells

E-MRS 2008 Spring Conference Symposium K

Scientific and Technical Aerospace Reports

Energy Technology 2020: Recycling, Carbon Dioxide Management, and Other Technologies

Handbook of Photovoltaic Silicon

Perovskite Photovoltaics: Basic to Advanced Concepts and Implementation examines the emergence of perovskite photovoltaics, associated challenges and opportunities, and how to achieve broader development. Consolidating developments in perovskite photovoltaics, including recent progress solar cells, this text also highlights advances and the research necessary for sustaining energy. Addressing different photovoltaics fields with tailored content for what makes perovskite solar cells suitable, and including commercialization examples of large-scale perovskite solar technology. The book also contains a detailed analysis of the implementation and economic viability of perovskite solar cells, highlighting what photovoltaic devices need to be generated by low cost, non-toxic, earth abundant materials using environmentally scalable processes. This book is a valuable resource engineers, scientists and researchers, and all those who wish to broaden their knowledge on flexible perovskite solar cells. Includes contributions by leading solar cell academics, industrialists, researchers and institutions across the globe Addresses different photovoltaics fields with tailored content for what makes perovskite solar cells different Provides commercialization examples of large-scale perovskite solar technology, giving users detailed analysis on the implementation, technical challenges and economic viability of perovskite solar cells

Apart from oxygen, silicon is the most commonly occurring element on Earth. Silicon materials have many applications in the manufacturing technology of microelectronic components, integrated circuits, and photovoltaic generators. Circuit complexity and higher degrees of integration of components require constant improvement and control of silicon's properties. This book provides information on silicon materials, their use, and their impact on the modern

world economy.

I have great pleasure in presenting the Proceedings of the 10th European Photovoltaic Solar Energy Conference held in Lisbon from 8 to 12 April 1991. These Proceedings contain all the scientific papers delivered at the Conference. The following is a short summary of the Conference activities. The Conference was opened by the Minister of Industry and Energy of Portugal, Eng. Luis Mira do Amaral. At the opening ceremony the Becquerel Prize, created by the Commission of the European Communities, was awarded to Professor Werner Bloss of the University of Stuttgart, and presented by Professor Philippe Bourdeau, Director at the Directorate-General for Science, Research and Development. The Becquerellecture delivered by Professor Bloss constituted the scientific opening to the conference. About 760 delegates from 53 countries presented around 350 contributions, 50 of them as plenary lectures; the contributions were selected among the many papers submitted, this time more strictly than ever before. Also a selected group of scientists were invited to deliver 15 review lectures, to provide an adequate context to the contributions to the Conference. A Symposium on Photovoltaics in Developing Countries, which was very well attended, took place as a parallel event. The Symposium provided an opportunity to hear not only experts of the industrialized countries, but also speakers from the countries where photovoltaics provides services of paramount value.

Program Summary

MIS and PN Junction Solar Cells on Thin-film Polycrystalline Silicon

Third Generation Photovoltaics

SERI Photovoltaic Advanced Research and Development Bibliography, 1982-1985

Basic Research on Advanced Silicon Materials for High-performance Photovoltaic Devices

Single-crystal Silicon

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.

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 collection addresses the pressing needs for sustainable technologies with reduced energy consumption and environmental pollutions and the development and application of alternative sustainable energy to maintain a green environment and efficient and long-lasting energy supply. Contributors represent both industry and academia and focus on new and efficient energy technologies including innovative ore beneficiation, smelting technologies, and recycling and waste heat recovery, as well as emerging novel energy solutions. The volume also covers a broad range of mature and new technological aspects of sustainable energy ecosystems, processes that improve energy efficiency, reduce thermal emissions, and reduce carbon dioxide and other greenhouse emissions. Authors also explore the valorization of materials and their embodied energy including byproducts or coproducts from ferrous and nonferrous industries, batteries, electronics, and other complex secondary materials.

Energy Research Abstracts

Handbook of Crystal Growth

Solar Silicon Processes

Emerging Photovoltaic Materials
Basic Research on Advanced Silicon Materials for High Performance Photovoltaic Devices
Papers Presented at the E-MRS 2010 Spring Meeting - Symposium J, Silicon-based Nanophotonics, Strasbourg, France, 7-11 June 2010

The Photovoltaic Advanced Silicon (PVAS) Branch at the Solar Energy Research Institute (SERI) has initiated a comparative study to assess the potential of MIS-type solar cells for low-cost terrestrial photovoltaic systems in terms of performance, stability, and cost-effectiveness. Several types of MIS and SIS solar cells are included in the matrix study currently underway. This approach compares the results of MIS and p/n junction solar cells on essentially identical thin-film polycrystalline silicon materials. All cell measurements and characterizations are performed using uniform testing procedures developed in the Photovoltaic Measurements and Evaluation (PV M and E) Laboratory at SERI. Some preliminary data on the different cell structures on thin-film epitaxial silicon on metallurgical-grade substrates are presented here.

The utilization of sun light is one of the hottest topics in sustainable energy research. To efficiently convert sun power into a reliable energy - electricity - for consumption and storage, silicon and its derivatives have been widely studied and applied in solar cell systems. This handbook covers the photovoltaics of silicon materials and devices, providing a comprehensive summary of the state of the art of photovoltaic silicon sciences and technologies. This work is divided into various areas including but not limited to fundamental principles, design methodologies, wafering techniques/fabrications, characterizations, applications, current research trends and challenges. It offers the most updated and self-explanatory reference to all levels of students and acts as a quick reference to the experts from the fields of chemistry, material science, physics, chemical engineering, electrical engineering, solar energy, etc..

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.

The Power of Renewables

Silicon Materials

Silicon & Beyond

Advanced Silicon Materials Research for Electronic and Photovoltaic Applications ; [... Held from May 26 to 30 in Strasbourg (France)]

Solar Research Publications Catalog

Technologies, Challenges, and Opportunities

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.

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 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.

Thin-Film Silicon Solar Cells
Basic Research on Advanced Silicon Materials for High-performance Photovoltaic Devices Volume 2
Silicon Heterojunction Solar Cells
Fabrication, Characterization and Applications
From Fundamentals to Applications
Basic Research on Advanced Silicon Materials for High-performance Photovoltaic Devices Volume 1

A fundamental challenge in the development and deployment of solar photovoltaic technology is a reduction in cost enabling direct competition with fossil-fuel-based energy sources. A key driver in this cost reduction is optimized device efficiency, because increased energy output leverages all photovoltaic system costs, from raw materials and module manufacturing to installation and maintenance. To continue progress toward higher conversion efficiencies, solar cells are being fabricated with increasingly complex designs, including engineered nanostructures, heterojunctions, and novel contacting and passivation schemes. Such advanced designs require a comprehensive and unified understanding of the optical and electrical device physics at the microscopic scale. This thesis focuses on a microscopic understanding of solar cell optoelectronic performance and its impact on cell optimization. We consider this in three solar cell platforms: thin-film crystalline silicon, amorphous/crystalline silicon heterojunctions, and thin-film cells with nanophotonic light trapping. The work described in this thesis represents a powerful design paradigm, based on a detailed physical understanding of the mechanisms governing solar cell performance. Furthermore, we demonstrate the importance of understanding not just the individual mechanisms, but also their interactions. Such an approach to device optimization is critical for the efficiency and competitiveness of future generations of solar cells.

Polycrystalline silicon (commonly called "polysilicon") is the material of choice for photovoltaic (PV) applications. Polysilicon is the purest synthetic material on the market, though its processing through gas purification and decomposition (commonly called "Siemens" process) carries high environmental risk. While many current optoelectronic applications require high purity, PV applications do not and therefore alternate processes and materials are being explored for PV grade silicon. Solar Silicon Processes: Technologies, Challenges, and Opportunities reviews current and potential future processing technologies for PV applications of solar silicon. It describes alternative processes and issues of material purity, cost, and environmental impact. It covers limits of silicon use with respect to high-efficiency solar cells and challenges arising from R&D activities. The book also defines purity requirements and purification

processes of metallurgical grade silicon (MG-Si) and examines production of solar grade silicon by novel processes directly from MG-Si and/or by decomposition of silane gas in a fluidized bed reactor (FBR). Furthermore, the book: Analyzes past research and industrial development of low-cost silicon processes in view of understanding future trends in this field. Discusses challenges and probability of success of various solar silicon processes. Covers processes that are more environmentally sensitive. Describes limits of silicon use with respect to high-efficiency solar cells and challenges arising from R&D activities. Defines purity requirements and purification processes of MG-Si. Examines production of solar grade silicon directly from MG-Si.

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.

Flat-Plate Solar Array Project of the U.S. Department of Energy's National Photovoltaics Program : 10 Years of Progress, October 1985

Physical Chemistry of Semiconductor Materials and Processes

Advanced Solar Energy Conversion

EMRS 2008 Spring Conference Symposium K: Advanced Silicon Materials Research for Electronic and Photovoltaic Applications

Solar Energy Update

Bulk Crystal Growth

The 2013 Materials Science eBook Sampler includes select material from seven Materials Science titles. Titles are from a number of Wiley imprints including Wiley, Wiley-VCH, Wiley-American Ceramic Society, Wiley-Scrivener and Wiley-The Minerals, Metals and Materials Society. The material that is included for each selection is the book’s full Table of Contents as well as a sample chapter. If you would like to read more from these books, you can purchase the full book or e-book at your favorite online retailer.

The United States and China are the world's top two energy consumers and, as of 2010, the two largest economies. Consequently, they

have a decisive role to play in the world's clean energy future. Both countries are also motivated by related goals, namely diversified energy portfolios, job creation, energy security, and pollution reduction, making renewable energy development an important strategy with wide-ranging implications. Given the size of their energy markets, any substantial progress the two countries make in advancing use of renewable energy will provide global benefits, in terms of enhanced technological understanding, reduced costs through expanded deployment, and reduced greenhouse gas (GHG) emissions relative to conventional generation from fossil fuels. Within this context, the U.S. National Academies, in collaboration with the Chinese Academy of Sciences (CAS) and Chinese Academy of Engineering (CAE), reviewed renewable energy development and deployment in the two countries, to highlight prospects for collaboration across the research to deployment chain and to suggest strategies which would promote more rapid and economical attainment of renewable energy goals. Main findings and concerning renewable resource assessments, technology development, environmental impacts, market infrastructure, among others, are presented. Specific recommendations have been limited to those judged to be most likely to accelerate the pace of deployment, increase cost-competitiveness, or shape the future market for renewable energy. The recommendations presented here are also pragmatic and achievable.

Photovoltaics, the direct conversion of sunlight to electricity, is now the fastest growing technology for electricity generation. Present "first generation" products use the same silicon wafers as in microelectronics. "Second generation" thin-films, now entering the market, have the potential to greatly improve the economics by eliminating material costs. Martin Green, one of the world’s foremost photovoltaic researchers, argues in this book that "second generation" photovoltaics will eventually reach its own material cost constraints, engendering a "third generation" of high performance thin-films. The book explores, self-consistently, the energy conversion potential of advanced approaches for improving photovoltaic performance and outlines possible implementation paths.

Opportunities and Challenges for China and the United States

Book Excerpts by J. Genzer, D. Richerson, A. Tiwari, M. Horstemeyer, K. Kolasinski, M. Köhl, R. Tilley

Thin Film Solar Cells

Perovskite Photovoltaics

Advances in Photovoltaics: Part 3

Advanced Silicon Materials for Photovoltaic Applications

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. Th series publishes timely, highly relevant volumes intended for long-term impact and reflecting the truly interdisciplinary nature of the field. Th volumes in Semiconductors and Semimetals have been and will continue to be of great interest to physicists, chemists, materials scientists device engineers in academia, scientific laboratories and modern industry. Written and edited by internationally renowned experts Relevant

a wide readership: physicists, chemists, materials scientists, and device engineers in academia, scientific laboratories and modern industry
Today, the silicon feedstock for photovoltaic cells comes from processes which were originally developed for the microelectronic industry. It
covers almost 90% of the photovoltaic market, with mass production volume at least one order of magnitude larger than those devoted to
microelectronics. However, it is hard to imagine that this kind of feedstock (extremely pure but heavily penalized by its high energy cost) co
remain the only source of silicon for a photovoltaic market which is in continuous expansion, and which has a cumulative growth rate in exc
of 30% in the last few years. Even though reports suggest that the silicon share will slowly decrease in the next twenty years, finding a way
manufacture a specific solar grade feedstock in large quantities, at a low cost while maintaining the quality needed, still remains a crucial
issue. Thin film and quantum confinement-based silicon cells might be a complementary solution. Advanced Silicon Materials for Photovolta
Applications has been designed to describe the full potentialities of silicon as a multipurpose material and covers: Physical, chemical and
structural properties of silicon Production routes including the promise of low cost feedstock for PV applications Defect engineering and the
role of impurities and defects Characterization techniques, and advanced analytical techniques for metallic and non-metallic impurities Thin
film silicon and thin film solar cells Innovative quantum effects, and 3rd generation solar cells With contributions from internationally
recognized authorities, this book gives a comprehensive analysis of the state-of-the-art of process technologies and material properties,
essential for anyone interested in the application and development of photovoltaics.

The development of semiconductor devices began a little more than a century ago, with the discovery of the electrical conductivity of ionic
solids. Today, solid state technologies form the background of the society in which we live. The aim of this book is threefold: to present the
background physical chemistry on which the technology of solid state devices is based; secondly, to describe specific issues such as the ro
defects on the properties of solids, and the crucial influence of surface properties; and ultimately, to look at the physics and chemistry of
growth processes, both at the bulk and thin–film level, together with some issues relating to the properties of nano–devices. Divided into fiv
chapters, it covers: Thermodynamics of solids, including phases and their properties and structural order Point defects in semiconductors
Extended defects in semiconductors and their interactions with point defects and impurities Growth of semiconductor materials Physical
chemistry of semiconductor materials processing With applications across all solid state technologies,the book is useful for advanced stude
and researchers in materials science, physics, chemistry, electrical and electronic engineering. It is also useful for those in the semiconduct
industry.

Polycrystalline Silicon

Proceedings of the International Conference, held at Lisbon, Portugal, 8–12 April 1991

Advanced Concepts in Photovoltaics

Materials Challenges

Solar Panels and Photovoltaic Materials

Photovoltaic Program