Advanced Silicon Materials For Photovoltaic Applications

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.

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.

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

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.

Defects in Nanocrystals: Structural and Physico-

Chemical Aspects discusses the nature of semiconductor systems and the effect of the size and shape on their thermodynamic and optoelectronic properties at the mesoscopic and nanoscopic levels. The nanostructures considered in this book are individual nanometric crystallites, nanocrystalline films, and nanowires of which the thermodynamic, structural, and optical properties are discussed in detail. The work: Outlines the influence of growth processes on their morphology and structure Describes the benefits of optical spectroscopies in the understanding of the role and nature of defects in nanostructured semiconductors Considers the limits of nanothermodynamics Details the critical role of interfaces in nanostructural behavior Covers the importance of embedding media in the physico-chemical properties of nanostructured semiconductors Explains the negligible role of core point defects vs. surface and interface defects Written for researchers, engineers, and those working in the physical and physicochemical sciences, this work comprehensively details the chemical, structural, and optical properties of semiconductor nanostructures for the development of more powerful and efficient devices.

Lists citations with abstracts for aerospace related reports obtained from world wide sources and announces documents that have recently been

entered into the NASA Scientific and Technical Information Database.

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.

Photovoltaic systems enable the sun’s energy to be converted directly into electricity using semiconductor solar cells. The ultimate goal of photovoltaic research and development is to reduce the cost of solar power to reach or even become lower than the cost of electricity generated from fossil and nuclear fuels. The power conversion efficiency and the cost per unit area of the phototvoltaic system are critical factors that determine the cost of photovoltaic electricity. Until recently, the power conversion efficiency of single-junction

photovoltaic cells has been limited to approximately 33% - the so-called Shockley-Queisser limit. This book presents the latest developments in photovoltaics which seek to either reach or surpass the Shockley-Queisser limit, and to lower the cell cost per unit area. Progress toward this ultimate goal is presented for the three generations of photovoltaic cells: the 1st generation based on crystalline silicon semiconductors; the 2nd generation based on thin film silicon, compound semiconductors, amorphous silicon, and various mesoscopic structures; and the 3rd generation based on the unique properties of nanoscale materials, new inorganic and organic photoconversion materials, highly efficient multi-junction cells with low cost solar concentration, and novel photovoltaic processes. The extent to which photovoltaic materials and processes can meet the expectations of efficient and cost effective solar energy conversion to electricity is discussed. Written by an international team of expert contributors, and with researchers in academia, national research laboratories, and industry in mind, this book is a comprehensive guide to recent progress in photovoltaics and essential for any library or laboratory in the field.

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 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.

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.

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

Solar PV Power: Design, Manufacturing and Applications from Sand to Systems details developments in the solar cell manufacturing process, including information from system design straight through to the entire value chain of Solar PV Manufacturing. In addition, the book includes aspects of ground mounted grid connected solar PV systems and optimization for solar PV plants, economic analyses, and reliability and performance. The advances and processes of solar product technology and reliability, along with the performance of solar PV plants and operational and maintenance aspects with advance diagnostic techniques are also presented, making this an ideal resource. With rapid change in the manufacturing process, it is crucial for solar cells and solar PV modules to adapt to new developments in

solar products, especially with regard to reliability, financial aspects and performance. Includes detailed solar panel module assembly and analysis Offers new concepts for solar PV system design that are presented alongside field related issues and examples Saves time and resources by collecting all pieces of information needed by engineers in the same text

The knowledge of fundamental silicon questions and all aspects of silicon technology gives the possibility of improvement to both initial silicon material and devices on silicon basis. The articles for this book have been contributed by the much respected researchers in this area and cover the most recent developments and applications of silicon technology and some fundamental questions. This book provides the latest research developments in important aspects of silicon including nanoclusters, solar silicon, porous silicon, some technological processes, and silicon devices and also fundamental question about silicon structural perfection. This book is of interest both to fundamental research and to practicing scientists and also will be useful to all engineers and students in industry and academia.

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 provides a unique review of various aspects of metallic contamination in Si and Ge-based semiconductors. It discusses all of the important metals including their origin during crystal and/or device manufacturing, their fundamental properties, their characterization techniques and their impact on electrical devices' performance. Several control and possible gettering approaches are addressed. The book offers a valuable reference guide for all researchers and engineers studying advanced and state-of-the-art micro- and nano-electronic semiconductor devices and circuits. Adopting an interdisciplinary approach, it combines perspectives from e.g. material science, defect engineering, device processing, defect and device characterization, and device physics and engineering.

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

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.

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. 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 role of 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 five 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 students and researchers in materials science, physics, chemistry, electrical and electronic engineering. It is also useful for those in the semiconductor industry.

One of the first books to cover advanced silicon-based technologies, Advanced Silicon and Semiconducting Silicon Alloy-Based Materials and Devices presents important directions for research into silicon, its alloy-based semiconducting devices, and its development in commercial applications. The first section deals with single/mono crystalline silicon, focusing on the effects of heavy doping; the structure and electronic properties of defects and their impact on devices; the MBE of silicon, silicon alloys, and metals; CVD techniques for silicon and silicon germanium; the material properties of silicon germanium strained layers; silicon germanium heterojunction bipolar applications; FETs, IR detectors, and resonant tunneling devices in silicon, silicon germanium, and d-doped silicon; and the fascinating properties of crystalline silicon carbide and its applications. The second section explores polycrystalline silicon. It examines large grain polysilicon substrates for solar cells; the properties, analysis, and modeling of polysilicon TFTs; the technology of polysilicon TFTs in LCD displays; and the use of polycrystalline silicon and its alloys in VLSI applications. With contributors from leading academic and industrial research centers, this book provides wide coverage of fabrication techniques, material properties, and device applications.

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) could remain the only source of silicon for a photovoltaic market which is in continuous expansion, and which has a cumulative growth rate in excess 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 to 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 Photovoltaic 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.

Advanced Silicon Materials for Photovoltaic ApplicationsJohn Wiley & Sons

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..

Principles of Metal Refining and Recycling provides a self-contained introduction to the field of purification and recycling of metals. The scientific principles in the treatment of the various metals are the same. The importance of using a clean and properly alloyed metal is described in detail. The text covers thermodynamics, physical and transport properties, mixing, mass transfer and numerical models. It describes methods for removal of dissolved impurity elements, particles, and inclusions. It considers important aspects of the solidification process, remelting and adding of alloys. Recycling, future challenges and specific processes for each metal are discussed in detail. The book is a greatly extended update of the 1992 book Principles of Metal Refining by T. Abel Engh. It includes in particular the subjects of metal recycling, ferrous and non-ferrous metal refining, and metalloids like 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.