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Advanced Characterization Techniques for Thin Film Solar Cells

Second, Extended Edition

Volume 1



Advanced Characterization Techniques For Thin Film Solar Cells

Mowafak Al-Jassim, Nancy Haegel



Advanced Characterization Techniques For Thin Film Solar Cells:

Advanced Characterization Techniques for Thin Film Solar Cells, 2016 *Advanced Characterization Techniques for Thin Film Solar Cells* Daniel Abou-Ras, Thomas Kirchartz, Uwe Rau, 2016-07-13 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

Advanced Characterization of Thin Film Solar Cells Mowafak Al-Jassim, Nancy Haegel, 2020-09-17 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 *Electronic Characterisation of Earth-Abundant Sulphides for Solar Photovoltaics* Thomas James Whittles, 2018-07-31 This book examines the electronic structure of earth abundant and environmentally friendly materials for use as absorber layers within photovoltaic cells The corroboration between high quality photoemission measurements and density of states calculations yields valuable insights into why these materials have demonstrated poor device efficiencies in the vast literature cited The book shows how the materials underlying electronic structures affect their properties and how the band positions make them unsuitable for use with established solar cell technologies After explaining these poor efficiencies the book offers alternative window layer materials to improve the use of these absorbers The power of photoemission and interpretation of the data in terms of factors generally overlooked in the literature such as the materials oxidation and phase impurity is demonstrated Representing a unique reference guide the book will be of considerable interest and value to members of the photoemission community engaged in solar cell research and to a wider materials science audience as well *Spatially Resolved Characterization in Thin-Film Photovoltaics* Matevž Bokalič, Marko Topič, 2015-01-22 The book is devoted to the spatial characterization of solar cells and PV modules It is written both as a monograph as well as a succinct guide for the state of the art spatial characterization techniques and approaches Amongst the approaches discussed are visual imaging electro and photo

luminescence imaging thermography and light beam induced mapping techniques Emphasis is given on the luminescence image acquisition and interpretation due to its great potential Characterization techniques are accompanied by simulation tools The contents are aimed at a readership of students and senior researchers in R D as well as engineers in industry who are newcomers to the spatial characterization of either solar cells or PV modules The concepts and approaches presented herein are based on but not limited to case studies of real thin film PV devices Key features Review of spatially resolved characterization techniques and accompanying SPICE simulations in photovoltaics Use of spatially resolved characterization techniques and their combinations for the identification of inhomogeneities in small area CdTe and dye sensitized solar cells Case studies of electroluminescence imaging of commercial PV modules c Si CIGS CdTe a Si tandem and triple junction thin film Si The contents are aimed at a readership of students and senior researchers in R D as well as engineers in industry who are newcomers to the spatial characterization of either solar cells or PV modules The concepts and approaches presented herein are based on but not limited to case studies of real thin film PV devices Key features Review of spatially resolved characterization techniques and accompanying SPICE simulations in photovoltaics Use of spatially resolved characterization techniques and their combinations for the identification of inhomogeneities in small area CdTe and dye sensitized solar cells Case studies of electroluminescence imaging of commercial PV modules c Si CIGS CdTe a Si tandem and triple junction thin film Si

Silicon Based Thin Film Solar Cells Roberto Murri, 2013-03-20 *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

Copper Zinc Tin Sulfide-Based Thin-Film Solar Cells Kentaro Ito, 2015-02-23 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

Solar Cell Materials Arthur Willoughby, 2014-01-13 This book presents a comparison of solar cell materials including both new materials based on organics nanostructures and novel inorganics and developments in more traditional photovoltaic materials It surveys the materials and materials trends in the field including third generation solar cells multiple energy level cells thermal approaches and the modification of the solar spectrum with an eye firmly on low costs energy efficiency and the use of abundant non toxic materials *Fundamentals of Solar Cell Design* Inamuddin, Mohd Imran Ahamed, Rajender Boddula, Mashallah Rezakazemi, 2021-07-30 Edited by one of the most well respected and prolific engineers in the world and his team this book provides a comprehensive overview of solar cells and explores the history of evolution and present scenarios of solar cell design classification properties various semiconductor materials thin films wafer scale transparent solar cells and other fundamentals of solar cell design Solar cells are semiconductor devices that convert light photons into electricity in photovoltaic energy conversion and can help to overcome the global energy crisis Solar cells have many applications including remote area power systems earth orbiting satellites wristwatches water pumping photodetectors and remote radiotelephones Solar cell technology is economically feasible for commercial scale power generation While commercial solar cells exhibit good performance and stability still researchers are looking at many ways to improve the performance and cost of solar cells via modulating the fundamental properties of semiconductors Solar cell technology is the key to a clean energy future Solar cells directly harvested energy from the sun's light radiation into electricity are in an ever growing demand for future global energy production Solar cell based energy harvesting has attracted worldwide attention for its notable features such as cheap renewable technology scalable lightweight flexibility versatility no greenhouse gas emission and economy friendly and operational costs Thus solar cell technology is at the forefront of renewable energy technologies which are used in telecommunications power plants small devices to satellites Large scale implementation can be manipulated by various types used in solar cell design and exploration of new materials towards improving performance and reducing cost Therefore in depth knowledge about solar cell design is fundamental for those who wish to apply this knowledge and understanding in industries and academics This book provides a comprehensive overview on solar cells and explores the history to evolution and present scenarios of solar cell design classification properties various semiconductor materials thin films wafer scale transparent solar cells and so on It also includes solar cells characterization analytical tools theoretical modeling practices to enhance conversion efficiencies applications and patents This outstanding new volume Provides state of the art information about solar cells Is a unique reference guide for researchers in solar energy Includes

novel innovations in the field of solar cell technology Audience This book is a unique reference guide that can be used by faculty students researchers engineers device designers and industrialists who are working and learning in the fields of semiconductors chemistry physics electronics light science material science flexible energy conversion industrial and renewable energy sectors

Physics of Thin-Film Photovoltaics Victor G. Karpov, Diana Shvydka, 2021-11-09 PHYSICS OF THIN FILM PHOTOVOLTAICS Tackling one of the hottest topics in renewables thin film photovoltaics the authors present the latest updates technologies and applications offering the most up to date and thorough coverage available to the engineer scientist or student It appears rather paradoxical that thin film photovoltaics PVs are made of materials that seem unacceptable from the classical PV perspective and yet they often outperform classical PV This exciting new volume solves that paradox by switching to a new physics paradigm Many concepts here fall beyond the classical PV scope The differences lie in device thinness microns instead of millimeters and morphology non crystalline instead of crystalline In such structures the charge carriers can reach electrodes without recombination On the other hand thin disordered structures render a possibility of detrimental lateral nonuniformities recombination highways and their energy spectra give rise to new recombination modes The mechanisms of thermal exchange and device degradation are correspondingly unique The overall objective of this book is to give a self contained in depth discussion of the physics of thin film systems in a manner accessible to both researchers and students It covers most aspects of the physics of thin film PV including device operations material structure and parameters thin film junction formation analytical and numerical modeling concepts of large area effects and lateral non uniformities physics of shunting both shunt growth and effects and device degradation Also it reviews a variety of physical diagnostic techniques proven with thin film PV Whether for the veteran engineer or the student this is a must have for any library This outstanding new volume Covers not only the state of the art of thin film photovoltaics but also the basics making this volume useful not just to the veteran engineer but the new hire or student as well Offers a comprehensive coverage of thin film photovoltaics including operations modeling non uniformities piezo effects and degradation Includes novel concepts and applications never presented in book format before Is an essential reference not just for the engineer scientist and student but the unassuming level of presentation also makes it accessible to readers with a limited physics background Is filled with workable examples and designs that are helpful for practical applications Is useful as a textbook for researchers students and faculty for understanding new ideas in this rapidly emerging field Audience Industrial professionals in photovoltaics such as engineers managers research and development staff technicians government and private research labs also academic and research universities such as physics chemistry and electrical engineering departments and graduate and undergraduate students studying electronic devices semiconductors and energy disciplines

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