



OPEN Improved sustainability of solar panels by improving stability of amorphous silicon solar cells

Gautam Ganguly

As the world grapples with global warming, it becomes imperative to carefully examine the sustainable energy technology choices. Solar is the fastest growing clean energy source but today it contributes little to the electricity generated, so future installations will dwarf the existing installed base. There is a factor of 2–4 decrease in the energy payback time from the dominant crystalline silicon technology to thin film technologies. Essential criteria like use of abundant materials and simple but mature production technology point to amorphous silicon (a-Si) technology. Here we delve into the primary issue impeding adoption of a-Si technology—the Staebler Wronski Effect (SWE), that generates metastable, light induced defects which reduce the performance of a-Si based solar cells. We demonstrate that a simple change leads to a significant reduction in SWE power loss and define a clear path to elimination of SWE, allowing the technology to be widely adopted.

Solar cells are an important component of the sustainable energy mix required to contain global warming and the move to electricity based rather than a fossil fuel based economy. While cumulative solar installations aggregate 1.2 TW^{1,2} this contributes less than 5% of the electricity generated worldwide³. Clearly, the immensity of future installations will dwarf the current installed base. It therefore behooves us to take a careful look at our technology choices for the future. Since the current energy use is dominated by fossil fuels, the energy required to produce solar panels is very important in the contribution it makes to global warming. This energy requirement needs to be compared to the energy generated when the solar panel is deployed, and this is captured in the EPBT^{4,5}. EPBT is reduced by the specific yield (SY = energy generated in the field/ power output under standard condition/) of the solar panels which captures the standard power rating system used for solar panels that is measured at 25 °C and 1000 W/m² irradiance, and the energy generated by the solar panel in the field, which is impacted by the actual operating temperature that is typically much higher than 25 °C (about 40 °C on average) as well as the irradiance which is typically lower than 1000 W/m² (200–800 W/m²). Comparison of different commercially available technologies reveal that thin film technologies have lower EPBT^{4,5}. This accrues from the smaller temperature dependence of power⁶ and hence generate more energy at the higher than 25 °C operating temperatures and they also have a smaller irradiance dependence of power output⁷ resulting in more energy generation at the lower than 1000 W/m² irradiance in the field. While the industry has largely ignored these realities because the power output under standard (STC) conditions is easier to measure, technology based EPBT^{4,5} and SY⁸ can be determined and is significantly lower (2–4 times) for thin film technologies compared to the crystalline silicon technology that constitutes 95% of the industry currently.

Of the thin film technologies, a-Si has the advantage of the highest SY and uses abundant materials, requires the lowest manufacturing temperatures (about 200 °C) and the thinnest semiconductor layers (less than 5000 nm)^{9,10}. It suffers from one fatal issue—the so-called SWE¹¹ which limits its efficiency to 13% for three junction solar cells^{10,11}. However, 16% three junction solar cells have been demonstrated, before SWE^{10,11}, and over 20% four junction solar cells have been projected, in the absence of SWE¹². a-Si technology has already been proven in commercial volume production by numerous companies. The improvement of efficiency in the absence of SWE would put this technology in the very short EPBT range relative to other technologies⁷ and make it the first choice for sustainability.

Current best performance a-Si solar cells use a so-called hydrogen dilution method¹³ that reduces SWE, but single junction cells deposited at about 0.1 nm/s still exhibit about 20% SWE power losses while two and three junction cells have smaller losses¹⁴. It is well known that substrate temperature is a significant factor in the amount of SWE performance loss in a-Si based solar cells¹⁵. However, we have shown that it is not the substrate temperature but the chamber or gas temperature that determines the SWE performance loss¹⁶. This can be understood in terms of the polysilane based origins proposed for the SWE defects¹⁷ and suggests that reactions

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Stability Of Amorphous Silicon Materials And Solar Cells

Hong Meng, Wei Huang



Stability Of Amorphous Silicon Materials And Solar Cells:

Stability of Amorphous Silicon Materials and Solar Cells B. L. Stafford, 1991 A reference for scientists working on amorphous silicon photovoltaic research and manufacturing Researchers interested in solar energy should also find this volume of use **Solar Energy Update**, 1984 **Semiconductor Photovoltaic Cells** Chunfu Zhang, Jincheng Zhang, Xiaohua Ma, Qian Feng, 2021-02-25 This book explores the scientific basis of the photovoltaic effect solar cell operation various types of solar cells and the main process used in their manufacture It addresses a range of topics including the production of solar silicon based solar cells and modules the choice of semiconductor materials and their production relevant costs and performance device structures processing and manufacturing options for the three major thin film PV technologies high performance approaches for multi junction concentrator and space applications and new types of organic polymer and dye sensitized solar cells The book also presents a concept for overcoming the efficiency limit of today's solar cells Accessible for beginners while also providing detailed information on the physics and technology for experts the book is a valuable resource for researchers engineers and graduate students in fields such as physics materials energy electrical and electronic engineering and microelectronics **Energy: a Continuing Bibliography with Indexes**, 1981 **Disordered Materials** Stadford R. Ovshinsky, 2012-12-06 Landmark contributions to science and mechanisms for the origin of the phenomena and technology are rarely recognized at the time of reached important conclusions about the physical publication Few people even in technical areas nature of the materials at equilibrium and their recognized the importance of developments such as electronic nonequilibrium properties Many of these the transistor the laser or electrophotography ideas were condensed into a publication for Physical until well after their successful demonstration Review Letters paper 1 in this collection This So called experts in fact tend to resist new paper immediately attracted attention to the field inventions a natural instinct based on a combination and directly lead to the initiation of large research tion of fear of obsolescent expertise and jealousy efforts at both industrial laboratories and univer arising from lack of active participation in the ties throughout the world Inevitably there was discovery the usual amount of controversy with many experts Denigration of new ideas is a relatively simultaneously taking positions 2 and 3 above safe modus operandi since the vast majority It has now been well over 20 years since eventually are abandoned well short of commerciality the original publication date and an objective view However a successful device can be identified by can be taken in hindsight **Energy**, 1981 **Eco- and Renewable Energy Materials** Yong Zhou, 2015-08-15 Eco and Renewable Energy Materials provides a survey of the current topics and the major developmental trends in the rapidly growing research area of clean energy materials This book covers but is not limited to photochemical materials fuels from light fuel cells electricity from fuels batteries electricity storage and hydrogen production and storage This book is intended as a vehicle for the dissemination of research results on energy based material science in the form of commissioned reviews and commentaries This book is for scientists and engineers interested in energy

related materials compounds and electronic devices Prof Yong Zhou is currently serving as a full professor at the Eco Materials and Renewable Energy Research Center ERERC Nanjing University China Handbook of Surfaces and Interfaces of Materials, Five-Volume Set Hari Singh Nalwa, 2001-10-26 This handbook brings together under a single cover all aspects of the chemistry physics and engineering of surfaces and interfaces of materials currently studied in academic and industrial research It covers different experimental and theoretical aspects of surfaces and interfaces their physical properties and spectroscopic techniques that have been applied to a wide class of inorganic organic polymer and biological materials The diversified technological areas of surface science reflect the explosion of scientific information on surfaces and interfaces of materials and their spectroscopic characterization The large volume of experimental data on chemistry physics and engineering aspects of materials surfaces and interfaces remains scattered in so many different periodicals therefore this handbook compilation is needed The information presented in this multivolume reference draws on two decades of pioneering research on the surfaces and interfaces of materials to offer a complete perspective on the topic These five volumes Surface and Interface Phenomena Surface Characterization and Properties Nanostructures Micelles and Colloids Thin Films and Layers Biointerfaces and Applications provide multidisciplinary review chapters and summarize the current status of the field covering important scientific and technological developments made over past decades in surfaces and interfaces of materials and spectroscopic techniques with contributions from internationally recognized experts from all over the world Fully cross referenced this book has clear precise and wide appeal as an essential reference source long due for the scientific community The complete reference on the topic of surfaces and interfaces of materials The information presented in this multivolume reference draws on two decades of pioneering research Provides multidisciplinary review chapters and summarizes the current status of the field Covers important scientific and technological developments made over past decades in surfaces and interfaces of materials and spectroscopic techniques Contributions from internationally recognized experts from all over the world 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 **Energy Research Abstracts**, 1990 **Scientific and Technical Aerospace Reports**, 1992 **Solar Cells** Sandeep Arya, Prerna Mahajan, 2023-11-16 This book highlights developments in the field of solar cells The chapters in this book address a wide range of topics including the spectrum of light received by solar cell devices the basic functioning of a solar cell and the evolution of solar cell technology during the last 50 years It places particular emphasis on silicon solar cells CIGS based solar cells organic solar cells perovskite solar cells and hybrid solar cells The book describes in detail the fabrication processes employed for different

categories of solar cells It also provides the characterization techniques utilized in this sector to evaluate the performance of solar cells and the scope of this domain in the future Overall it presents the essential theoretical and practical concepts of solar cells in an easy to understand manner *Photovoltaic Energy Program Contract Summary*, 2001 Thin Film Solar Cells Jef Poortmans, Vladimir Arkhipov, 2006-10-16 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 **Tenth E.C. Photovoltaic Solar Energy Conference** A. Luque, G. Sala, Willeke Palz, G. dos Santos, P. Helm, 2012-12-06 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 Becquerelle lecture 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 *Flexible Electronic Packaging and Encapsulation Technology* Hong Meng, Wei Huang, 2024-03-25 Flexible Electronic Packaging and Encapsulation Technology A systematic introduction to the future of electronic packaging Electronic packaging materials are among the most important components of the broader electronics industry capable of facilitating heat dissipation redistributing stress on electronic components and providing environmental protections for electronic systems Recent advances in integrated circuits especially the development of flexible electronic technology have placed increasingly stringent demands on the capabilities of electronic packaging These technologies have the potential to reshape our world and they demand a generation of engineers capable of harnessing that potential Flexible Electronic Packaging and Encapsulation Technology meets this demand with an introduction to the cutting

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SERI Photovoltaic Advanced Research and Development Bibliography, 1982-1985 ,1986 **Clean Electricity From Photovoltaics** Mary D Archer,Robert Hill,Juergen O Schumacher,2001-06-04 Photovoltaic cells provide clean reversible electrical power from the sun Made from semiconductors they are durable silent in operation and free of polluting emissions In this book experts from all sectors of the PV community materials scientists physicists production engineers economists and environmentalists give their critical appraisals of where the technology is now and what its prospects are a

Sixteenth European Photovoltaic Solar Energy Conference H. Scheer,B. McNelis,W. Palz,H.A. Ossenbrink,P. Helm,2020-11-25 The European Photovoltaic Solar Energy Conferences are dedicated to accelerating the impetus towards sustainable development of global PV markets The 16th in the series held in Glasgow UK brought together more than 1500 delegates from 72 countries and provided an important and vital forum for information exchange in the field The Conference Proceedings place on record a new phase of market development and scientific endeavour in the PV industry representing current and innovative thinking in all aspects of the science technology markets and business of photovoltaics In three volumes the Proceedings present some 790 papers selected for presentation by the scientific review committee of the 16th European Photovoltaic Solar Energy Conference The comprehensive range of topics covered comprise Fundamentals Novel Devices and New Materials Thin Film Cells and Technologies Space Cells and Systems Crystalline Silicon Solar Cells and Technologies PV Integration in Buildings PV Modules and Components of PV Systems Implementation Strategies National Programs and Financing Schemes Market Deployment in Developing Countries These proceedings are an essential reference for all involved in the global PV industry scientists researchers technologists and those with an interest in global market trends The conference was organised by WIP Renewable Energies Munich Germany

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