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Yoshihiro Hamakawa (Ed.)

Thin-Film Solar Cells

Next Generation Photovoltaics and Its Applications

With 210 Figures

Springer

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Preface

The development of clean energy resources as alternatives to oil has become one of the most important challenges for modern science and technology. The obvious motivation for these efforts is to reduce the air pollution resulting from the mass consumption of fossil fuels and to protect the ecological cycles of the biosystems on Earth. Analyses of future energy usage envision that the energy structure in the 21st century will be characterized as a "Best Mix Age" involving different renewable energy forms.

Among the wide variety of renewable energy projects in progress, photovoltaics is the most promising as a future energy technology. It is pollution-free and abundantly available everywhere in the world, even in space, and can also operate with diffuse light. However, a major barrier impeding the development of large-scale bulk power applications of photovoltaic systems is the high price of solar cell modules. Therefore, reduction of the costs of solar cells is of prime importance. To achieve this objective, tremendous R&D efforts have been made over the past two decades in a wide variety of technical fields ranging from solar-cell materials, cell structure, and mass production processes to the photovoltaic systems themselves. As the result, about an order of magnitude cost reduction has been achieved in the past 10 years. According to a recent survey, however, a further cost reduction, to one fifth of the present level, is necessary if photovoltaic energy is to match the present conventional electricity price. Looking back at the past cost reduction measures, one can identify two remaining technologies for further efficiency improvement and cost reduction. The most promising of these is the thin-film solar-cell technology, which has both material saving and efficiency increase whilst at the same time allowing mass-production. The other approach is to exploit the merits of mass production for all photovoltaic system components such as solar cells and modules, inverters etc., also enhancing the market penetration of concepts such as the photovoltaic roof integrated solar house project, building solar tiles, photovoltaic electricity purchasing system, and others that have been initiated in the last few years.

In the past two decades, remarkable advances have been seen in both the physics and the technology of the tetrahedrally bonded amorphous semiconductors. In particular, much attention has been addressed to exploiting vital properties of these materials such as the controllability of their valence electrons, their excellent photoconductivity and significantly higher optical absorption coefficient as compared with crystalline semiconductors. They thus possess enormous potential as opto-electronic materials. In addition to these essential physical properties, they also possess some unique advantages from the technological viewpoint such as the possibility of mass-production through large-area non-epitaxial growth on any substrate material. This corresponds in a very timely fashion to the requirements for developing a low-cost solar cell as a new energy resource. With the aid of the national and/or semi-national projects for renewable energy development, an accelerating expansion of this field has been witnessed in recent years in both basic physics and technology. This new knowledge also opens up some other new application fields such as TFT LCD, laser printers, electro-photoreceptors, three-dimensional integrated devices, and quantum well devices, etc. The remarkable progress in amorphous silicon alloy systems has induced further interest in understanding the basic physics of thin films of other semiconductors such as CIS (copper indium selenide) and its alloys, and has triggered the birth of new kinds of high efficiency solar cell with multi-band-gap stacked (or tandem) type solar cells for the next generation solar photovoltaics.

Recently, there have been a number of books published on the subject of amorphous semiconductors. The principal concern of all these books has been the physics of amorphous semiconductors with emphasis on the random structure solids, and their electronic and optical properties. Although tremendous R&D efforts have been made in the practical application of amorphous semiconductors recently, there have been neither journals nor books published on the subject of material preparation technologies and device applications in relation to thin film solar cells. The purpose of this volume is to summarize the present status of the device physics of thin film solar cells, to describe application systems and to stimulate scientists and engineers working to advance this young, but very promising, clean energy technology.

It is the editor's earnest hope that this book will be helpful not only to all interested researchers and engineers but also to the directors and project supervisors in this new area. Moreover, the contents of the book will lead to further acceleration of advances in this rapidly expanding technological field. In the selection and preparation of the contents for this volume, many people have assisted with support and expert advice. First the authors would like to express their sincere appreciation to the ministry of Education, Special Research Project Office on "Science and Technology of Amorphous and Nanocrystalline Semiconductors", and also the New Sunshine Project Headquarters Office for releasing their supported research aids to the authors. We would like to acknowledge Dr. Claus E. Ascheron, Physics Editor, Springer-Verlag, for his kind help and advice during the editorial stages.

Kusatsu, Shiga, Japan
In a gentle breeze through green leaves,
Early summer 2003 *Yoshihiro Hamakawa*

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