Preface

As a renewable energy source, solar energy can be harvested and will be increasingly important in the inevitable transition from our current level of dependence on fossil fuels. One of the biggest challenges in photovoltaic technology is how to increase the photocurrent conversion efficiency. Since solar cells were developed several decades ago, consistent efforts have been made in exploring variables that influence optimal efficiency. In recent years, research into high-efficiency solar cells has accelerated with the rapid emergence of new materials and devices showing promising performance characteristics. To achieve further increases in the photocurrent conversion efficiency, it is necessary to choose a suitable material, fabricate a device with proper structure, and to understand the physics behind the materials and devices as a basis for developing new approaches to optimize the materials and device characteristics.

This book addresses these issues comprehensively. It covers the physics needed to understand the performance of a high-efficiency solar cell, presents a variety of novel materials that have emerged in recent years, and describes device optimization approaches such as light-trapping structures and surface plasmons. Chapter 1 is a general introduction to many aspects of high-efficiency Si solar cells developed over the last 20 years. Some representative examples of high-efficiency Si solar cells with excellent performance are presented. Chapter 2 describes the dominant mechanism of radiative recombination in c-Si and the dependence of the intensity of the edge luminescence on the intensity of its excitation. Chapter 3 analyzes the balance between generation, recombination, and transport, and its effect on the photocurrent and open circuit voltage of solar cells for overcoming the Shockley-Quiesser limit. Chapters 4 and 5 focus on nanostructures for use in solar cells, including nanowires and quantum wells and dots. High band gap silicon nanocrystal solar cells are discussed in Chap. 6.

In Chap. 7, thiophene-based copolymers synthesized by electropolymerization and used as a hole transport layer in organic photovoltaic cells are presented. Chapter 8 focuses on molecular engineering of efficient dyes for p-type semiconductor sensitization. Chapter 9 describes the production and characterization of Luminescent Solar Concentrator devices based on the dye Lumogen Red

305 dispersed in a matrix (polysiloxane). Chapter 10 introduces the manipulation of energy and electron transfer processes in a light-harvesting assembly in engineered FRET-based solar cells, and efficient near-infrared absorption donor materials for dye-sensitized and organic solar cells. Chlorophyll-derived- , cyclic-Tetrapyrrole-based Purpurins are described in Chap. 11. Chapter 12 highlights the materials, interfaces, and devices of hybrid solar cells. Chapter 13 studies porous TiO_2 nanoparticles applied in PEDOT: PSS photovoltaic devices.

Chapters 14–21 cover device issues of high-efficiency solar cells. Chapter 14 studies the textured microstructures and the photonic nanostructures for light-trapping structures, aiming to suppress the surface reflection. Anti-reflective silicon oxide p-layer for thin-film silicon solar cells is introduced in Chap. 15. Chapters 16 and 17 cover plasmonic silicon solar cells and plasmon-enhanced excitonic solar cells. Finally, Chaps. 18–21 discuss some key aspects of III–V solar cells, including the interfaces (Chap. 18), the anti-reflective coating (Chap. 19), radiation effects (Chap. 20), and the epitaxial lift-off technology used in III–V solar cells (Chap. 21).

The editors would like to express their great appreciation to all of the authors for their excellent chapters. Their enthusiasm and care as seen in every word makes us believe that this book will be an indispensable reference for students, scientists, and engineers in exploring high-efficiency solar cells. We hope it will be seen in retrospect as a milestone volume in this rapidly developing research area. We also thank Mr. Yanpeng Shi for helpful editorial assistance. All of the postgraduate students in our laboratory, especially those working on high-efficiency solar cells, provided much help and a stimulating environment for research. Our appreciation also goes to Springer staff for their support. Finally, the editors acknowledge the support of the National Natural Science Foundation of China under Grant No. 61274066.

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