Preface

With the world population growth and the pursuit of improvement in human life standards, energy has become one of the greatest global challenges for man. The currently dominant dependence on fossil fuels not only accelerates diminishing of the natural resource, but also leads to severe environmental and climate impact. Among all the renewable energy sources, the sun is the ultimate clean energy source for humans—an hour of solar energy from sunlight is almost the same as the world energy consumption in one year ($\sim$16 TW). The pursuit of low cost solar cell technology has always been an important scientific and industrial field. The solution process of solar cell technologies such as organic solar cells (OPV) technology has attracted growing interest due to attractive features such as synthetic variability, low-temperature processing, and the possibility of producing light-weight, flexible, roll-to-roll compatible manufacturing. Particularly in the past decade, society has achieved significant progress in this field.

This book consists of 13 chapters written by leading experts in organic solar cell field, each covering a specific area of OPV technology categorized by the following four aspects of the book—Fundamentals, Materials, Devices, Fabrication technology/Applications.

Part I—*Fundamentals* is made of four chapters. In Chap. 1, Vardeny and Sheng used optical probe techniques including broadband femtosecond transient and continuous wave (cw) photomodulation spectroscopies and electroabsorption for studying the photoexcitation dynamics in classical polymer fullerene blends, and their results show that charge transfer complex (CTC) and film morphology play a crucial role in carrier photogeneration in these systems. So and co-workers addressed charge transport aspect of OPV polymers and blends in Chap. 2, where they introduce a new transport characterization tool—admittance spectroscopy (AS), to extract charge carrier mobility. In Chap. 3, using Photoemission Spectroscopy techniques, Gao et al. provided scientific insight into the improved charge transfer at the organic semiconductors and electrode interface by insertion of metal oxide buffer layers. It is followed by Shuai and co-workers' quantitative theoretical understanding of the optical and electronic processes in organic photovoltaic materials, including optical absorption and emission spectra for conjugated

oligomers, energy transfer in polymers, charge transport in organic semiconductors, and device modeling of heterojunction solar cells based on dynamic Monte Carlo simulation and the continuum model.

In Part II—*Materials*, three chapters covered three key material types in OPV. Hsu and co-workers reviewed recent advances in p-type conjugated polymers in Chap. 5, which also presented the principle of molecular design with structure-properties relationship. Cao, Huang and co-workers' review covers progress on linear Donor-Acceptor type conjugated polymers and acceptor pended conjugated polymers as p-type photoactive material, as well as the development of water/alcohol soluble conjugated polymer interfacial materials. In Chap. 7, Brunetti reviewed in detail the features and characteristics of fullerene and its derivatives as acceptors in bulk heterojunction solar cells.

In the third part—*Devices*, we have four chapters covering morphology, interface, plasmonics, and tandem OPV devices. Wei and co-workers reviewed reciprocal-space and real-space techniques to investigate the photoactive layer morphology in Chap. 8. The effects of the relative length scales of PCBM clusters and polymer (P3HT as example) crystallites on device performance were presented. Jen's team presented an overview of the recent development of effective interfacial materials (including organic, inorganic, and hybrid materials) used for both organic/metal and organic donor/acceptor interface engineering, and the integration of these materials in different device architectures to enhance efficiency and stability are also discussed. In Chap. 10, Chen et al. reviewed recent progress related to the incorporation of plasmonic nanostructures in OPVs as a means of enhancing power conversion efficiencies. Tandem solar cell concept and the recent progress in solution process tandem OPV devices were reviewed by Yang and Li et al. in Chap. 11, which has led to close to 12 % solar cell.

In the last part—*Fabrication and Application*, Guo presented a novel processing technology—ESSENCIAL—to achieve high performance, which was followed by report on high efficiency thick OPV devices, both are roll-to-roll fabrication friendly. The Chap. 13—was contributed by Zhu, who provided a review on the progress of (semi)transparent solar cell—a very unique feature of OPV with great potential in building integrated PV and portable electronics market.

This book is organized with the intention to provide a big picture of the latest progress in the OPV field for the general audience, and at the same time give in-depth discussion on fundamentals for interested audiences. We hope the book can serve its function to draw your attention to this emerging organic solar cell field with great potential.

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