Preface

Nanostructured materials lie at the heart of fundamental advances in modern science and engineering, and hold the key to the next generation of energy conversion and storage devices. An enormous variety of nanostructures and the resulting materials have been successfully developed by a tremendous amount of techniques in the face of limited fossil fuels and ever-increasing energy requirements. The past decades have witnessed considerable progress in the field of nanostructured materials for advanced energy applications. Polymers, in particular, have the ability to produce nanostructures by self-assembly, assisted organization, templated growth, in-situ hybridization, and/or ex-situ recombination strategies which enable the rational design and optimal fabrication of nanostructured polymers, nanoarchitectured inorganics, and organic-inorganic nanocomposites.

With contributions from 50 internationally renowned experts with interdisciplinary and broad perspectives, this book is likely one of the most authoritative references ever published that focuses solely on the state-of-the-art knowledge of polymer-engineered nanostructures, their unique properties, and the new cutting edge, breakthroughs, future horizons, and insights into such functional materials for energy applications. With over 2500 references, 370 figures, and 14 tables included, this book attempts to offer a highly valuable source for scientists, students, and engineers working in the field of photovoltaics, fuel cells, thermoelectrics, piezoelectrics, ferroelectrics, batteries, supercapacitors, and photocatalysis. Based on the above topics, this book contains the following three parts and 18 chapters.

Part I includes six chapters, which outline the recent advancements of engineering nanostructures with polymers and polymer processing techniques.

Chapter 1 reports on the preparation of nanostructured ceramic fibers with tailored morphologies and hierarchical architectures through polymer-mediated electrospinning and the energy-related applications of the as-fabricated fibers.

Chapter 2 provides an overview on the design and fabrication of various metal, semiconductor, and polymer nanostructures using polymer microbeads and adjusting processing parameters.

Chapter 3 illustrates the top-down technique strategies for the fabrication of metal-containing polymers with well-defined nanostructures.

Chapter 4 summarizes the recent development of porous polymer materials, including covalent organic frameworks, hyper-crosslinked polymers, conjugated microporous polymers, macroporous polymers, and their synthetic methods as well as potential applications.

Chapter 5 discusses the fabrication strategies and formation mechanisms of structure-tailored polymer photonic crystals and their responsive characteristics under various external stimuli.

Chapter 6 describes the design and synthesis methods of nanostructured polymeric materials with diverse stimuli-responsive features and their multifunctional smart applications.

Part II includes six chapters which are focused on the energy storage applications of polymer-engineered nanostructures.

Chapter 7 introduces the fabrication of polymer nanofibers and their derived carbon-based nanofibers with a particular focus on their applications in rechargeable batteries and supercapacitors.

Chapter 8 reviews recent studies on the synthesis of graphene/conducting polymer composites and their supercapacitor applications.

Chapter 9 presents the recent development of conducting polymer/inorganic nanohybrids as electrodes for rechargeable batteries, fuel cells, and supercapacitors.

Chapter 10 introduces general strategies for constructing polymer-derived carbon/inorganic composites and the rational design of electrode materials for high-performance batteries and electrocatalytic hydrogen evolution.

Chapter 11 reports on the formulation, design, and performance tailoring of polymer-based electrolytes by incorporating nanoparticles and/or by adding organic solvents or ionic liquids for electrochemical energy applications.

Chapter 12 introduces theoretical considerations for concomitantly increasing the dielectric permittivity and breakdown strength of polymer nanocomposites. Recent studies on core-shell structured and dielectric anisotropy polymer nanocomposites for high energy density were further reviewed.

Part III includes six chapters which are focused on the energy conversion applications of polymer-engineered nanostructures.

Chapter 13 describes the latest developments of flexible piezoelectric and pyroelectric polymers and their nanocomposites for energy harvesting.

Chapter 14 focuses on the recent progress of nanostructured polymers and polymer/inorganic nanocomposites with multidimensional nanostructures for thermoelectric applications.

Chapter 15 deals with the use of polymer/inorganic nanocomposite materials in various categories of polymer electrolyte membrane fuel cells.

Chapter 16 summarizes the influence of chemical structures on the orientation of semiconducting polymer backbones and the device performances.

Chapter 17 focuses on the recent work in the design, fabrication, and surface modification of metal oxide semiconductors to improve the performance of excitonic solar cells.

Chapter 18 provides an overview on the development of nanostructured porous polymers for metal-free photocatalysis.

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