

Preface

Nanoscience and nanotechnology involve studying and working with materials at the nanometer scale, and stretch across the whole spectrum of science and technology. Generally speaking, nanoscience concentrates on the fundamental relationships between the physical properties of materials and their nanoscale dimensions, and the underlying sciences for nanoscale synthesis, assembly and characterization. Nanotechnology mainly deals with the design, fabrication and application of nanomaterials. The research and development in nanoscience and nanotechnology require the collaborations between researchers from different disciplines, such as physics, chemistry, materials science, electrical engineering, mechanical engineering and biomedical engineering. The ultimate goal of nanoscience and nanotechnology is to develop materials, devices and systems that outperform the ones developed based on the conventional sciences and technologies, and to create completely novel functionalities.

The advances in nanoscience and nanotechnology exhibit great varieties, and the nanoscience and nanotechnology in engineering is one of the most active and the most important areas in the field of nanoscience and nanotechnology. It directly relates the research activities in nanoscience and nanotechnology to industries and daily life, and numerous nanomaterials, nanodevices and nanosystems for various engineering purposes have been developed and applied for human betterment. Many universities are developing and delivering courses on this area, and we therefore realize the urgent need for an appropriate textbook.

This is the first book that systematically discusses the engineering aspects of nanoscience and nanotechnology from the fundamental level, and includes the breakthrough milestones and the latest developments in this area. It is specially tailored to be a textbook for undergraduates, graduates and those seeking short-term professional trainings. It may also

serves as a reference desk resource for both academic and industrial researchers interested in this area.

This book consists of eight chapters. Each chapter provides an overview of a specific topic with examples chosen primarily for their educational purposes, and it is organized in a way that fits readers from different science and engineering disciplines. Students are encouraged to expand on the topics discussed in this book by reading the references provided at the end of each chapter.

The first chapter provides the fundamental knowledge of nanoscience and nanotechnology. It starts with introducing the origins of nanoscience and nanotechnology, followed by discussing the general schemes and classification of nanotechnology. The challenges in nanoscience and nanotechnology are analyzed subsequently. Chapter 2 discusses the physical and biological aspects of nanoscience and nanotechnology. After introducing the basics of quantum physics and the fundamentals of nanophysics, the crystal structures and physical properties of materials are discussed, followed by the physical aspects of nanochemistry. After that, the biological aspects of nanoscience and nanotechnology are discussed.

Chapter 3 outlines the technologies for nanoscale fabrication and characterization. These techniques provide the experimental bases for nanoscience and nanotechnology in engineering. This chapter starts with the approaches for nanoscale fabrications, including bottom-up approach and top-down approach. The techniques for characterizing the unique properties of nanomaterials are discussed subsequently, including atomic structure, chemical composition, size, shape and surface area, and the properties of nanoparticles in biological systems.

Based on the fundamental concepts, theoretical backgrounds and experimental techniques discussed in the first three chapters, the following five chapters discuss five important topics on nanoscience and nanotechnology in engineering, including carbon nanomaterials, nanostructured materials, polymer nanotechnology, nanocomposites and organic electronics.

Among different kinds of nanomaterials, carbon nanomaterials are the most popular. Chapter 4 presents a systematic discussion on various types of carbon nanomaterials, including fullerenes, carbon nanotubes

and carbon nanofoams. For each type of carbon nanostructures, their synthesizing methods, specific properties and typical applications are discussed.

The properties of nanomaterials are strongly dependent on their structures at the nanometer scale. Chapter 5 deals with the synthesis, properties and applications of typical nanostructured materials, including nanopowders, nanoporous materials, nanodusts, nanowires and nanotubes. Special attention is paid on three-dimensional zinc oxide nanostructures.

Chapter 6 concentrates on a special kind of soft nanotechnology, polymer nanotechnology. After introducing electroactive polymers, the fabrication of polymer nanowires, polymer nanotubes, and three-dimensional polymer nanostructures are discussed.

Due to their unprecedented combinations of properties, nanocomposites are widely used for engineering applications. Various types of nanocomposites are discussed in Chapter 7, mainly including ceramic matrix nanocomposites, metal matrix nanocomposites, magnetic nanocomposites, polymeric nanocomposites, and nano-bio-composites. At the end of this chapter, a brief discussion is made on smart and intelligent nanocomposites, which are regarded as the future of materials science and technology.

The use of individual molecules, such as carbon nanotubes or other organic compounds, as electronic components offers promising alternatives to current microelectronic devices. Chapter 8 deals with nanoscale electronics with a focus on organic electronics. After discussing the fabrication and properties of pentacene thin films, typical organic sensors and their applications are discussed, with emphasis laid on strain sensors and ion-sensitive field effect transistors.

In preparing this book, it is always kept in our mind to relate the speculative concepts in nanoscience and nanotechnology to practical research and development activities. This book contains our many years of experiences and achievements in this area, and a lot of technical details are released for the first time.

Some of the materials for this book are taken from many lectures and courses we presented around the world. The valuable comments from the participants of these lectures and courses greatly enriched the contents of

this book. Meanwhile, we would like to indicate that this book is a compilation of the work carried out by many researchers, and we greatly appreciate their valuable contributions in this area. We are also very grateful to the publisher and the staff for their constant encouragement, guidance and support during this project.

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