One-Dimensional Nanostructures

One-dimensional (1D) nanostructures such as nanowires, nanorods, nanotubes, and nanobelts typically have lengths between 1 and 100 nanometers and length/width aspect ratios ranging from 100 to more than 100000. They can serve as excellent model systems to study electronic transport and optical phenomena, mechanical properties, and many other characteristics, with the simplifying advantages of small size and reduced dimensionality. 1D nanostructures have attracted much attention by researchers, as they are not only at the forefront of fundamental materials research but also have a wide range of potential applications in nanoelectronics, optoelectronics, sensors, catalysis, plasmonics, etc. As with other nanomaterials, the preparation, characterization, and application of 1D nanostructures is a strongly interdisciplinary field, attracting worldwide efforts by researchers from chemistry, physics, materials science, and biology.

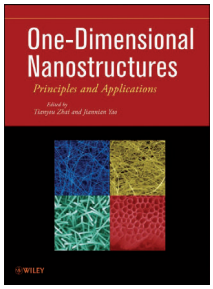
The book *One-Dimensional Nanostructures—Principles and Applications*, edited by Tianyou Zhai and Jiannian Yao, consolidates a wealth of information regarding 1D nanostructures into one volume. With contributions from 68 experts worldwide, the book contains 25 chapters that review the underlying principles and the latest breakthroughs, covering synthesis, properties, and device applications.

Although every chapter of the book is concerned to some extent with the preparation of 1D nanostructures, Chapters 1–5 focus especially on synthesizing various 1D materials by different approaches. Chapter 1 describes the technique of growing 1D inorganic/metallic nanomaterials using multifunctional porous templates made of anodic aluminum oxide (AAO). Chapter 2 gives an overview of the bottom-up construction of 1D coordination polymers (CPs) based on metal–ligand systems using the concepts of supramolecular chemistry. Chapter 3 describes the supercritical-fluid–liquid–solid (SFLS) process, which has potential for commercial-scale production by growing semiconductor nanowires (SNWs). Chapter 4 gives a comprehensive overview of the progress on different types of colloidal SNWs based on wet-chemistry approaches, from both theoretical and experimental aspects. Chapter 5 focuses on the core–shell effect on nucleation and growth of nanoscale silicides, which is essential for a fundamental understanding of the kinetics of nanoscale materials.

The main focus of Chapters 6–10 is on the properties of 1D structures, particularly their electronic and optical properties. Chapter 6 describes some salient features of electronic structures and properties of carbon nanotubes and graphene, and discusses charge transfer interactions. Chapter 7 focuses on the phonon properties of various 1D SNWs and heterostructures as investigated by Raman scattering spectroscopy, together with synthesis of the materials. Chapter 8 concentrates on the optical properties, charge carrier dynamics, and applications of nanostructured hematite (α-Fe_2O_3), which is the most common form of the most abundant metal oxide on earth. Chapter 9 reports on advanced doping techniques for developing 1D semiconductor materials, which show novel optical phenomena involving the interaction of light with matter, the slowing of light, and waveguide and nonlinear photonics. Chapter 10 deals with biological and bio-inspired nanofibrillar structures based on the self-organization of peptides and proteins, which show pronounced quantum confinement effects that are reflected in electronic, optical, piezoelectric, and other properties.

Chapters 11–25 review 1D nanostructures in a wide range of applications. Energy-related applications are the main content of Chapters 11–13. While Chapter 12 focuses on the fabrication, characterization, and photovoltaic applications of p–n junction silicon nanowire arrays, Chapter 11 reviews state-of-the-art research on the use of 1D nanomaterials, mainly SNWs and nanopillars, for energy harvesting technologies such as photovoltaics, piezoelectrics, and thermoelectrics. Chapter 13 reviews the most recent developments in nanomaterials with respect to their use in both cathodes and anodes for lithium batteries, with the focus on 1D nanostructured metal oxides. Chapters 14–18 address the applications of 1D nanostructures in photonics and optoelectronics with the focus on different materials, including carbon nanotubes (Chapter 14), metal oxide nanostructures (Chapter 16), and organic 1D nanostructures (Chapters 17 and 18). In contrast to the investigation of arrays of 1D nanostructures, Chapter 15 reviews the use of scanning probe microscopy (SPM) to study local electrical and optoelectronic properties of single 1D nanostructures.

Applications in other areas and research topics are summarized in Chapters 19–25: fundamental 1D physics, and progress in the construction of an infrared photon detector based on Type II superlattices (Chapter 19); the development of gas sensors by using quasi-1D metal oxides based on electrical and optical transduction principles (Chapter 20); progress in plasmonics using 1D nanostructures, including a plasmonic waveguide, surface-enhanced Raman scattering/fluorescence, solar cells, and photovoltaics (Chapter 21); spin transport in 1D systems and the construction of



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spintronics devices using spin effects on a mesotropic length scale (Chapter 22); high-performance field emitters (FEs) based on 1D inorganic nanostructures (Chapter 23); field-effect transistors (FETs) based on 1D systems that reach the quantum capacitance limit, which is beneficial for the intrinsic performance of a device (Chapter 24); developments in forming bioelectrical interfaces between cells and tissues to measure extracellular signals using nanowire FETs (Chapter 25).

To summarize, in this book the editors and the authors have succeeded in bringing a large amount of information together in one place. It covers all the major classes of 1D nanostructures, the underlying principles in synthesis and physical properties, and the construction and demonstration of devices. This book is ideally suitable for students (especially PhD students) and researchers in both academia and industry to gain a grasp of current knowledge in this rapidly advancing research area. It not only provides comprehensive overviews and is a valuable source of references that serve as a starting point, it will also help readers with experience in the field to advance their research by introducing interdisciplinary elements.

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