Preface

Nanotechnology offers the promise of providing sensors capable of achieving many ideal characteristics, particularly those associated with speed, selectivity, sensitivity, and size reduction. Therefore, the development of nanoscale sensors is one of the most active areas in all of nanotechnology. Although the obvious advantages of miniaturization have driven a pronounced trend in sensor development for the past 50 years, new properties are realized at the nanoscale due to the inherent benefits of working directly at the molecular level where the sensing phenomena take place.

With immobilized bioreceptor probes selective for target analyte molecules, nanoscale biosensors have been extensively studied and used in different fields. As a result, the first group of the chapter contributions (r 1–4) describes general concepts of nanoscale biosensor design and application. Chapter 1 reviews the contribution of the evolving science of nanobiotechnology to precise sensing and quantification of water-borne contaminants. The use of portable nanobiosensors capable of instant field tests would help in screening sources of drinking water without the need for expensive and bulky analytical instruments. Future research directions for the fabrication of improved, fast-acting sensitive nanobiosensors are provided in this chapter as well. Chapter 2 discusses the general concept of surface-enhanced Raman spectroscopy (SERS), which is an increasingly exploited tool for the study of cell biology. Using SERS, noble-metal nanoparticles can be interrogated with wavelengths of light to which cells exhibit minimal autofluorescence, and return useful information about their immediate chemical environment. At the beginning of Chap. 3, nanowire-based field effect transistor biosensors are introduced. Afterwards, this chapter reviews the theoretical basis of BioFET-SIM models describing both single and multiple charges on the analyte. The use of the interface and its relative command line version are briefly shown. Finally, possible applications of the BioFET-SIM model are presented. In Chap. 4, the focus is on the basic photoelectrochemical sensor or biosensor, including basic principles and new progress using different semiconductor materials. A variety of detection mechanisms and the characteristics of photoelectrochemical sensors and biosensors are also introduced and their future developments are prospected and discussed.

The second part of this book (Chaps. 5 and 6) reviews the progress of hydrogen gas sensors and photodetectors based on ZnO nanostructures. Chapter 5 reviews the synthesis and fabrication of pure and doped ZnO nanoscaled materials for hydrogen sensing applications. Both gas-phase growth and solution growth methods are described. Afterwards, the fabrication of nanoscaled sensors based on ZnO nanostructures and their characteristics are discussed. The results include several methods that were employed to enhance nanosensor performance, such as increasing the surface/volume ratio, impurity doping, and surface functionalization. In Chap. 6, different types of photodetector device structures and architectures are presented. With a brief review of the growth/synthesis processes, this chapter also provides a synopsis of the most recent developments in the field of research and design of optoelectronic sensors and related devices based on nano- and microscale ZnO.

Another important part of this book (Chaps. 7 and 8) offers details of nanoscale sensors based on nanocarbon materials. Nanocarbons, such as carbon nanotubes (CNTs) and nanosheets of graphene or graphene oxide, as well as their hybrids with nanosized noble metals and semiconducting oxides, have emerged as new types of thin film gas sensors with advanced sensing performance. Chapter 7 aims to summarize progress in processing and characterization of nanosized hybrids based on nanocarbons and various nanoparticles for thin film gas sensors. The primary purpose of Chap. 8 is to assist and encourage researchers who are new to the field of carbon nanotubes and stretchable sensors in starting to explore and prototype nanotube-enabled devices and materials. While the primary focus is on how to use "off-the-shelf" components to prepare carbon nanotubes for use in a wide variety of applications, specific emphasis is placed on 2D patterning of nanotubes and stretchable electronics.

The last chapter (Chap. 9) presents the design, modeling, fabrication, and characterization of in-plane resonant nano-electro-mechanical (NEM) sensors based on the mass detection principle. In this chapter, the numerical modeling of IP-RSGFET sensors is also presented using a three-dimensional finite-element-method electro-mechanical simulation of IP-RNEM sensors combined with a NEM/MOS hybrid circuit simulation. The results of the modeling and experimental analysis provide a realistic guideline for further improvement and characterization of these ultrasensitive sensors.

We appreciate the creative work and contributions from all of the authors in this book. The book should be very useful to scientists and engineers who are already exploring the nanoscale sensors field, as well as to graduate and postgraduate students specializing in physics, chemistry, bioengineering, electronics, and materials science who are considering future projects and research opportunities. The editors also gratefully acknowledge the financial support of the National Natural Science Foundation of China through Grant NSFC- 61204098 and 61371046.

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