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Sensing Material and Sensing Technology Series

化学传感器：传感材料基础

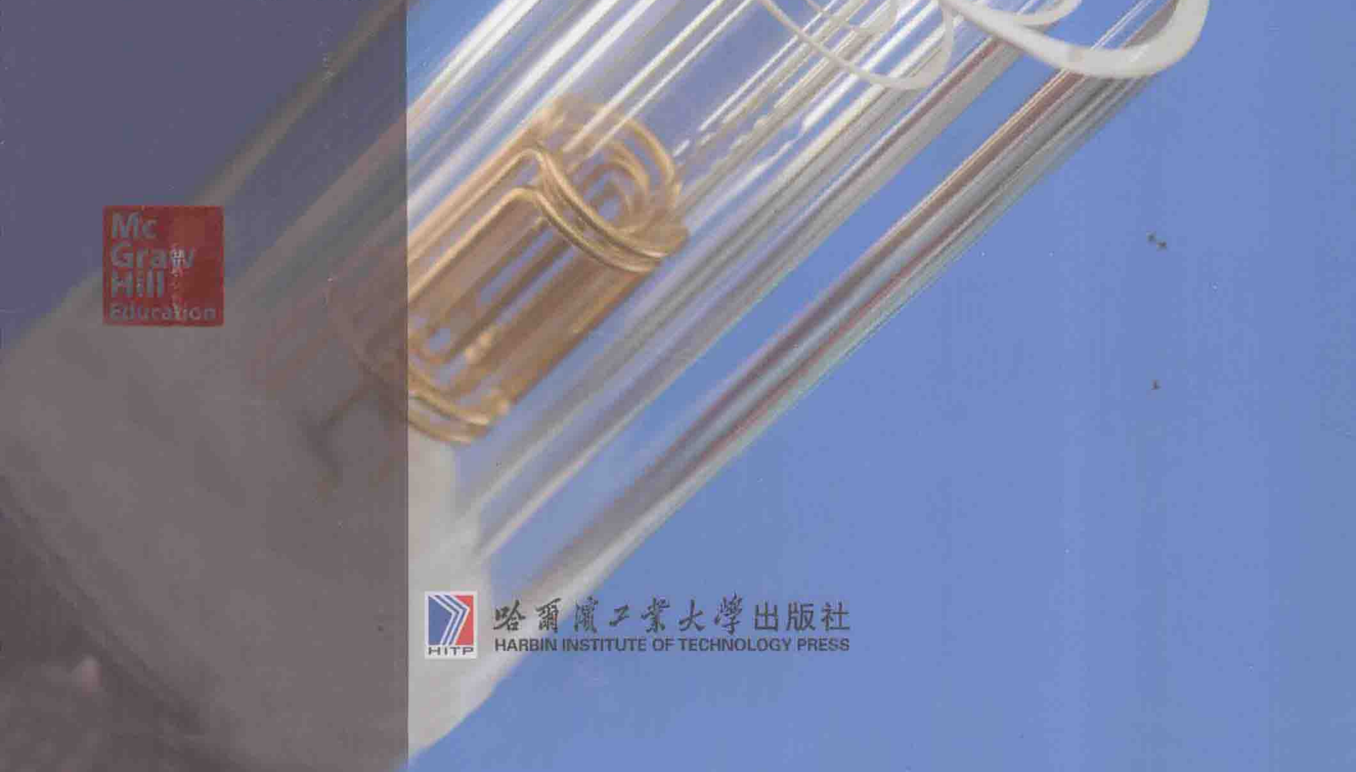
第4册
多孔纳米材料的特性及应用

CHEMICAL SENSORS: FUNDAMENTALS OF SENSING MATERIALS

The Characteristics and Applications of Porous Nanomaterials

Ghenadii Korotcenkov 主编

影印版



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Ghenadii Korotcenkov

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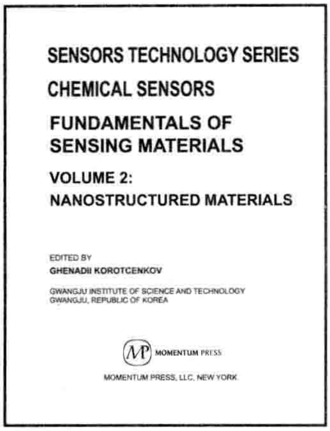
SENSORS TECHNOLOGY SERIES

CHEMICAL SENSORS

FUNDAMENTALS OF SENSING MATERIALS

VOLUME 2: NANOSTRUCTURED MATERIALS

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Preface to *Chemical Sensors: Fundamentals of Sensing Materials*

Sensing materials play a key role in the successful implementation of chemical and biological sensors. The multidimensional nature of the interactions between function and composition, preparation method, and end-use conditions of sensing materials often makes their rational design for real-world applications very challenging.

The world of sensing materials is very broad. Practically all well-known materials could be used for the elaboration of chemical sensors. Therefore, in this series we have tried to include the widest possible number of materials for these purposes and to evaluate their real advantages and shortcomings. Our main idea was to create a really useful "encyclopedia" or handbook of chemical sensing materials, which could combine in compact editions the basic principles of chemical sensing, the main properties of sensing materials, the particulars of their synthesis and deposition, and their present or potential applications in chemical sensors. Thus, most of the materials used in chemical sensors are considered in the various chapters of these volumes.

It is necessary to note that, notwithstanding the wide interest and use of chemical sensors, at the time the idea to develop these volumes was conceived, there was no recent comprehensive review or any general summing up of the fundamentals of sensing materials The majority of books published in the field of chemical sensors were dedicated mainly to analysis of particular types of devices. This three-volume review series is therefore timely.

This series, *Chemical Sensors: Fundamentals of Sensing Materials,* offers the most recent advances in all key aspects of development and applications of various materials for design of chemical sensors. Regarding the division of this series into three parts, our choice was to devote the first volume to the fundamentals of chemical sensing materials and processes and to devote the second and third volumes to properties and applications of individual types of sensing materials. This explains why, in *Volume 1: General Approaches,* we provide a brief description of chemical sensors, and then detailed discussion of desired properties for sensing materials, followed by chapters devoted to methods of synthesis, deposition, and modification of sensing materials. The first volume also provides general background information about processes that participate in chemical sensing. Thus the aim of this volume, although not exhaustive, is to provide basic knowledge about sensing materials, technologies used for their preparation, and then a general overview of their application in the development of chemical sensors.

Considering the importance of nanostructured materials for further development of chemical sensors, we have selected and collected information about those materials in *Volume 2: Nanostructured Materials*. In this volume, materials such as one-dimension metal oxide nanostructures, carbon nanotubes, fullerenes, metal nanoparticles, and nanoclusters are considered. Nanocomposites, porous semiconductors, ordered mesoporous materials, and zeolites also are among materials of this type.

Volume 3: Polymers and Other Materials, is a compilation of review chapters detailing applications of chemical sensor materials such as polymers, calixarenes, biological and biomimetric systems, novel semiconductor materials, and ionic conductors. Chemical sensors based on these materials comprise a large part of the chemical sensors market.

Of course, not all materials are covered equally. In many cases, the level of detailed elaboration was determined by their significance and interest shown in that class of materials for chemical sensor design.

While the title of this series suggests that the work is aimed mainly at materials scientists, this is not so. Many of those who should find this book useful will be "chemists," "physicists," or "engineers" who are dealing with chemical sensors, analytical chemistry, metal oxides, polymers, and other materials and devices. In fact, some readers may have only a superficial background in chemistry and physics. These volumes are addressed to the rapidly growing number of active practitioners and those who are interested in starting research in the field of materials for chemical sensors and biosensors, directors of industrial and government research centers, laboratory supervisors and managers, students and lecturers.

We believe that this series will be of interest to readers because of its several innovative aspects. First, it provides a detailed description and analysis of strategies for setting up successful processes for screening sensing materials for chemical sensors. Second, it summarizes the advances and the remaining challenges, and then goes on to suggest opportunities for research on chemical sensors based on polymeric, inorganic, and biological sensing materials. Third, it provides insight into how to improve the efficiency of chemical sensing through optimization of sensing material parameters, including composition, structure, electrophysical, chemical, electronic, and catalytic properties.

We express our gratitude to the contributing authors for their efforts in preparing their chapters. We also express our gratitude to Momentum Press for giving us the opportunity to publish this series. We especially thank Joel Stein at Momentum Press for his patience during the development of this project and for encouraging us during the various stages of preparation.

Ghenadii Korotcenkov

Preface to Volume 2: Nanostructured Materials

Nanomaterials and nanotechnology are new fields of science and technology. Fundamentally, nanotechnology is about manipulating and making materials at the atomic and molecular levels. It is expected that nanotechnology will change solid-state gas sensing dramatically and will probably gain importance in all fields of sensor application over the next 10 to 20 years. Nanotechnology is still in its infancy, but the field has been a hot area of research globally since a few years ago. It has been found that with reduction in size, novel electrical, mechanical, chemical, catalytic, and optical properties can be introduced. As a result, it has been concluded that one-dimensional structures will be of benefit for developing new-generation chemical sensors that can achieve high performance. Therefore, in the last decade, the study of 1-D materials has become a primary focus in the field of chemical sensor design. Synthesis of new nano objects and exploitation of their extraordinary properties is the goal and dream of many researchers engaged in the field of sensor design. In addition, it has also been established that 1-D structures may be ideal systems in which to study the nature of chemical sensing effects.

Although many people consider this a brand-new technology yielding cutting-edge applications for consumer products, researchers have in fact been working in the field of catalysis and gas-sensing effects for decades. What we call nanoparticle technology today actually began in the era of the 1950s–1980s, and chemical catalysis and gas sensor research and development have been conducted at the nanoscale ever since. Initially, research labs used the technology to increase the efficiency of heterogeneous catalysis and to improve the sensitivity of solid-state gas sensors. Nanoclusters of metal catalysts and nanograins of metal oxides with dimensions less than 10 nm were the main objects of research.

The recent development of advanced tools for characterizing materials at the nano- or subnanoscale has provided scientists with new insights for understanding and improving existing devices and clues for ways to design new nanostructured materials to make better catalysts and sensors. Recent research has thus led to new types of prospective nanostructured materials.

It is obviously difficult to cover all aspects of a dynamic research area such as nanotechnology. Of course, it is not possible to analyze in one volume every nanoparticulate matter and its role in the revolution of materials for chemical sensor applications. However, we have tried to cover this field more or less completely. This book, together with Volume 1, includes as much as possible the recent advances and breakthroughs in the area of nanomaterials for chemical sensors as achieved by research groups all over the world. These contributions have led to the emergence of some general guidelines.

This book includes eight chapters written by researchers who are at the forefront of their field, which address the role of nanomaterials in chemical sensors. One-dimensional metal oxide structures, carbon nanotubes, fullerenes, and metal nanoparticles are the objects of detailed analysis in the present volume. Processing, properties, and applications of porous semiconductors, zeolites, nanocomposites and ordered mesoporous materials are also discussed in this volume. A brief history of nanotechnology, particulars of nanomaterial properties, specificity, and future trends in nanotechnology can be found in this volume as well.

Ghenadii Korotcenkov

About the Editor

Ghenadii Korotcenkov received his Ph.D. in Physics and Technology of Semiconductor Materials and Devices in 1976, and his Habilitate Degree (Dr.Sci.) in Physics and Mathematics of Semiconductors and Dielectrics in 1990. For a long time he was a leader of the scientific Gas Sensor Group and manager of various national and international scientific and engineering projects carried out in the Laboratory of Micro- and Optoelectronics, Technical University of Moldova. Currently, he is a research professor at Gwangju Institute of Science and Technology, Gwangju, Republic of Korea.

Specialists from the former Soviet Union know G. Korotcenkov's research results in the study of Schottky barriers, MOS structures, native oxides, and photoreceivers based on Group III–V compounds very well. His current research interests include materials science and surface science, focused on metal oxides and solid-state gas sensor design. He is the author of five books and special publications, nine invited review papers, several book chapters, and more than 180 peer-reviewed articles. He holds 16 patents. He has presented more than 200 reports at national and international conferences. His articles are cited more than 150 times per year. His research activities have been honored by the Award of the Supreme Council of Science and Advanced Technology of the Republic of Moldova (2004), The Prize of the Presidents of Academies of Sciences of Ukraine, Belarus and Moldova (2003), the Senior Research Excellence Award of Technical University of Moldova (2001, 2003, 2005), a Fellowship from the International Research Exchange Board (1998), and the National Youth Prize of the Republic of Moldova (1980), among others.

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