

传感材料与传感技术丛书

Sensing Material and Sensing Technology Series

化学传感器：传感器技术

第10册

化学传感器的应用

CHEMICAL SENSORS:
COMPREHENSIVE SENSOR TECHNOLOGIES
The Application of Chemical Sensors

Ghenadii Korotcenkov 主编

影印版



哈尔滨工业大学出版社
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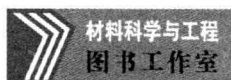
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材料科学与工程图书工作室

联系电话 0451-86412421

0451-86414559

邮箱 yh_bj@aliyun.com

xuyaying81823@gmail.com

zhxh6414559@aliyun.com

PREFACE TO **CHEMICAL SENSORS:** **COMPREHENSIVE SENSOR TECHNOLOGIES**

In spite of their century-long history, chemical sensors appeared on the commercial market only 50 years ago. In recent years, however, the field of chemical sensors has broadened and expanded greatly. At present, chemical sensors are being used in medicine, agriculture, industry, transport, environmental control, and other fields. However, the process of developing new sensors as well as improving older types of chemical sensors is still ongoing. New technologies and the toughening of ecological standards require more sensitive instruments with faster response times, better selectivity, and improved stability. The second half of this six-volume series on chemical sensors, devoted to *comprehensive sensor technologies*, describes these developments and the new processes and applications. These volumes are intended to be a primary source for both fundamental and practical information about where sensor technologies are now and where they are headed for the future. We are sure that Volumes 4–6 in this series will be a useful addition to the first three volumes, on *fundamentals of sensing materials*, in which various sensing materials that can be used in chemical sensors are discussed in detail. Analysis of chemical sensor design, fabrication, and functioning requires other approaches to description in comparison with materials science problems, and therefore we decided that consideration of materials and devices should be carried out separately. From our point of view, dividing the series into two parts as we have done results in more logical narration and more utility for readers who are interested in different aspects of chemical sensor design.

In this series we provide readers with a thorough understanding of the concepts behind chemical sensors, presenting the information necessary to develop such sensors, covering all aspects including fundamental theories, fabrication, functionalization, characterization, and real-world applications, so as to enable them to pursue their research and development requirements. Therefore, we hope that this series will help readers understand the present status of chemical sensors and will also act as an introduction, which may encourage further study, as well as an estimate of the roles that chemical sensors may play in the future.

Chemical Sensors: Comprehensive Sensor Technologies is a three-volume series, comprising Volumes 4, 5, and 6 in our series, *Chemical Sensors*. Volume 4 deals with solid-state devices, Volume 5 with electrochemical and optical sensors, and Volume 6 with applications of chemical sensors. The chapters included in the volumes consist of review and overview papers written by experts in the field. The authors

of each of the chapters were chosen very carefully and are all well known throughout the world in their fields of study. Therefore, these books provide an up-to-date account of the present status of chemical sensors, from fundamental science and processing to applications.

Specifically, Volume 4 includes descriptions of solid-state sensors such as conductometric or resistive gas sensors, Schottky-, FET-, capacitance-, and pyroelectric-type chemical sensors. Pellistors, mass-sensitive, and acoustic wave sensors are described as well. Integrated chemical sensors are also discussed in Volume 4. Volume 5 provides information related to electrochemical and optical sensors. Fundamentals of operation, methods of fabrication, and operating characteristics of electrochemical gas sensors, solid electrolyte-based gas sensors, ion-selective electrodes, CHEMFETs, and different types of optical, fiber optical, and chemoluminescence chemical sensors are discussed. Volume 6 is dedicated to detailed examination of opportunities for applications of chemical sensors in various areas of our lives, including medicine, industry, environmental control, agriculture, and transportation. It is the editor's wish that this volume will provide the reader with a detailed understanding of the many applications of chemical sensors in both today's world and that of the future. In these chapters one can also find descriptions of architecture and fundamentals of "electronic noses" and "electronic tongues," principles of wireless chemical sensor design, and possibilities for remote chemical sensing for atmospheric monitoring.

In this three-volume series, the authors present sensors that utilize various sensing materials and phenomena. The terminology and concepts associated with sensors are presented, including some of the relevant physical and chemical phenomena applied in the sensor signal transduction system. As is well known, chemical sensing is multidisciplinary by nature. The role of sensing materials in such phenomena is also detailed.

We need to note that the number of disciplines involved in the research and design of chemical sensors has increased dramatically. New knowledge and approaches are needed to achieve miniaturization, lower power consumption, and the ability to operate in complex environments for more selective, sensitive, and rapid determination of chemical and biological species. Compact analytical systems that have a sensor as one of the system components are becoming more important than individual sensors. Thus, in addition to traditional sensor approaches, a variety of new themes have been introduced to achieve the attractive goal of analyzing chemical species on the micro and nano scales. Therefore, throughout these books, numerous strategies for the fabrication and characterization of sensing materials and sensing structures which are employed in sensing applications are provided, and current approaches for chemical sensing are described.

This series can be utilized as a text for researchers and engineers as well as graduate students who are either entering the field for the first time, or who are already conducting research in these areas but are willing to extend their knowledge of the field of chemical sensors. We hope that these volumes will also be of interest to undergraduate students in chemical engineering, electronics, environmental control, and medicine. These books have been written in a way that final-year and graduate university students in the fields of chemistry, physics, electronics, biology, biotechnology, mechanics, and bioengineering can easily comprehend. We believe that practicing engineers or project managers which would like to use chemical sensors but don't know how to do so, and how to select optimal chemical sensors for specific applications, also will find useful information.

It is necessary here to comment briefly on the coverage of the literature. During our work on this series we tried to cover the field more or less completely. However, we need to acknowledge that an

appreciable number of relevant papers may remain unknown to the authors. Regarding these, the editors and contributing authors express regret, not only to the authors of such works, but also to the readers of our books.

Finally, we wish to thank all those who participated in the preparation of this series, including the contributing authors and copyright owners in Europe, the United States, Asia, and the rest of the world. We also wish to express our gratitude to the staff of Momentum Press, and in particular Joel Stein, for his kind assistance in bringing these volumes to fruition.

Ghenadii Korotcenkov

PREFACE TO VOLUME 6: CHEMICAL SENSORS APPLICATIONS

The market for chemical sensors continues to grow at a rapid rate, reflecting the wide range of possibilities for improving technological processes in industry and agriculture as well as living conditions that can be enhanced by the use of chemical sensors. The military, medicine, air/space, and security markets also continue to drive research and development in this area. At present it is hard to imagine an area where chemical sensors would be useless. On the contrary, we note that every day new areas arise in which new analytical instrumentation with modern functional opportunities is urgently needed.

It is necessary to admit, however, that the development of commercially successful chemical sensors is expensive and technically difficult, and also requires sophisticated market knowledge. This volume provides that knowledge. Just a list of some of the topics discussed—such as biomedical applications, water quality monitoring, food quality monitoring, environmental control, household applications, automotive applications, industrial processes, fire alarm systems, agricultural applications, law enforcement applications, air/space applications, military applications, etc.—provides a clear idea of the extensive analysis presented here, and how broad a perspective of the emerging sensor industry may be acquired.

Proper attention in this book is given to consideration of the principles and construction of “electronic noses” and “electronic tongues.” As is becoming widely recognized, the ability to design such devices represents a huge achievement by designers of chemical sensors.

Wireless sensors and remote chemical sensing, which are also discussed in this volume, constitute another trend in chemical sensors design, focused on building systems for global and local environmental monitoring. Nowadays, as our ecosystem is changing so rapidly and human-caused disasters occur more often, establishing such monitoring has become a priority.

Researchers, development engineers, and students can use this volume as a reference source during their work and study according to their interests. We hope that this book and the series as a whole will help all those concerned with sensor research, development, and application to succeed in this promising field. The volume contains comparisons and assessments of the various types of sensors with respect to their practical applications. Therefore, the users of chemical sensors will also benefit.

We believe that readers of this book will be able to do the following:

- Estimate the area of possible applications of chemical sensors.
- Know the advantages and disadvantages of various different types of chemical sensors.

- Understand the special requirements for sensors used in specific applications.
- Estimate the reliability of chemical sensors.
- Determine which sensor types are most appropriate for a given application.

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 eight books and special publications, 11 review papers, 10 book chapters, and more than 180 peer-reviewed articles. He holds 18 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.

CONTRIBUTORS

Beongki Cho (Chapter 7)

Department of Material Science and Engineering
and

Department of Nanobio Materials and Electronics
Gwangju Institute of Science and Technology
Gwangju 500-712, Republic of Korea

Zhuang Dafang (Chapter 4)

Data Center for Resources and Environmental Sciences
State Key Lab for Resources and Environmental Information Systems
Institute of Geographical Sciences and Natural Resources Research
Chinese Academy of Sciences
Beijing 100101, China

Saverio De Vito (Chapter 3)

Renewable Energy and Environment Advanced Physical Technologies Department
ENEA—Italian Institute for New Technologies
1-80055 Portici (NA), Italy

Jiang Dong (Chapter 4)

Data Center for Resources and Environmental Sciences
State Key Lab for Resources and Environmental Information Systems
Institute of Geographical Sciences and Natural Resources Research
Chinese Academy of Sciences
Beijing 100101, China

Alessandra Flammini (Chapter 3)

Department of Electronics for Automation
University of Brescia
38-25123 Brescia, Italy

Gábor Harsányi (Chapters 5 and 6)
Department of Electronics Technology
Budapest University of Technology and Economics
1521 Budapest, Hungary

Ghenadii Korotcenkov (Chapters 1 and 7)
Department of Material Science and Engineering
Gwangju Institute of Science and Technology
Gwangju 500-712, Republic of Korea
and
Technical University of Moldova
Chisinau 2001, Republic of Moldova

Joseph R. Stetter (Chapter 1)
KWJ Engineering, Inc.
Newark, California 94560, USA

Fredrik Winqvist (Chapter 2)
The Swedish Sensor Centre and the Division of Applied Physics
Department of Physics and Measurement Technology
Linköping University
SE-581 83 Linköping, Sweden

Huang Yaohuan (Chapter 4)
Data Center for Resources and Environmental Sciences
State Key Lab for Resources and Environmental Information Systems
Institute of Geographical Sciences and Natural Resources Research
Chinese Academy of Sciences
Beijing 100101, China

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