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 6 册

固态器件 I

CHEMICAL SENSORS: COMPREHENSIVE SENSOR TECHNOLOGIES

Solid State Devices I

Ghenadii Korotcenkov 主编

影印版

哈爾濱工業大學出版社
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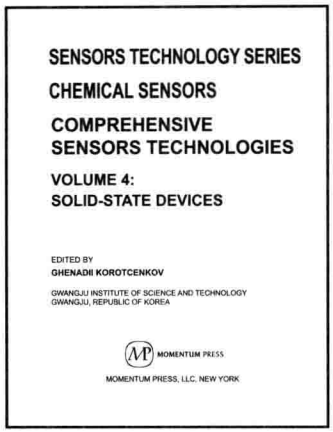
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PREFACE TO CHEMICAL SENSORS: COMPREHENSIVE SENSORS TECHNOLOGIES

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 theses 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 4: SOLID-STATE DEVICES

The field of solid-state chemical sensor design is a research field of increasing interest as a result of the demands for reliable, inexpensive, and portable systems for environmental monitoring, assessing indoor air quality, food quality control, military, and many other applications. Solid-state chemical sensors, because they can be microfabricated using modern technologies of mass production, may be able to realize those requirements in practice. Solid-state sensor technology has advanced remarkably during the past few decades and is rapidly becoming an essential technology. As a result, many solid-state chemical sensors are now commercially available, and researchers are working to develop next-generation solid-state sensors that have all the necessary requirements, including small size, low production costs, and low power consumption.

The goal of this volume is to provide a critical assessment of the new trends in the field of solid-state chemical sensors, by describing the working principle and the applications related to the different types of solid-state sensors. In this volume the reader will find detailed descriptions of solid-state chemical sensors such as conductometric gas sensors, Schottky, FET, and work-function chemical sensors. Capacitance, pyroelectric, calorimetric, mass-sensitive, and acoustic wave chemical sensors are also analyzed in detail. Reduction in size from bulk to polycrystalline and nanostructured sensing materials, from micro- to nano-sized transducers, while promising high sensitivity, small size, high speed, low cost, and increased selectivity, requires new design considerations that should consider factors such as integration with other devices and device lifetime. At present, microfabrication has reached a stage of serious application and is accepted as a good alternative to classical "macroscopic" technologies. Therefore, approaches to microfabrication of chemical sensors and to integration are discussed in this volume as well. Future trends in solid-state sensors design are also described. So, the volume gives a survey of the latest state of technology and contributes to preparing the ground for future achievements in both solid-state sensor research and development of solid-state sensor technologies.

We believe that this book covers all topics of solid-state chemical sensors from fundamentals of operation and construction of devices to optimal materials for those sensors and approaches to achieving better operating characteristics. The reader will find a strong emphasis not only on "what" and "how," but also on "why." Specialists and newcomers to the field will find this book easy to use. Each chapter has its own introduction and list of references, in order to make it accessible to any reader notwithstanding his or her background in related subjects. Since the last decade has seen an enormous amount of activity

in the field of solid-state sensor systems, this book represents a valuable and accessible guide and reference for researchers with up-to-date examples and state-of-the-art results.

We need to admit that a number of edited surveys and monographs related to solid-state chemical sensors have been published during recent decades. However, the present volume analyzes this field of science and technology both fully and in detail. In addition, the majority of published books were written more than 10 years ago, which is a long period of time for such a rapidly developing field as chemical sensors. Since then many new technologies and new ideas have appeared and been realized.

This book is intended for scientists, engineers, and manufacturers involved in the development, design, and application of solid-state chemical sensors. Undergraduate and graduate students can use this book to extend their knowledge in the field of chemical sensors.

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.

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