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Real-Time Environmental Monitoring UAV Sensors for Environmental Monitoring Environmental Monitoring with Arduino Sensor Systems for Environmental Monitoring Sensor Systems for Environmental Monitoring Integrated, Intelligent Sensor Fabrication Strategies for Environmental Monitoring Smart Sensors for Health and Environment Monitoring Application and State of Development for Remote Chemical Sensors in Environmental Monitoring Biosensors in Environmental Monitoring Optical Sensors for Biomedical Diagnostics and Environmental Monitoring Sensor Systems for Environmental Monitoring Smart Sensing Technology for Agriculture and Environmental Monitoring Semiconductor Gas Sensors Sensor Systems for Environmental Monitoring Environmental Analysis by Electrochemical Sensors and Biosensors Microelectronic Sensors for Environmental Monitoring Three Neural Network Based Sensor Systems for Environmental Monitoring Nanosensor Technologies for Environmental Monitoring Sensor Systems for Environmental Monitoring TORUS 3 - Toward an Open Resource Using Services A Sensor Data Fusion Procedure for Environmental Monitoring Applications by a Configurable Network of Smart Web-Sensors Sensors for Environmental Monitoring Based on Localized Surface Plasmons Sensors for Environmental Monitoring Nano-Micro Sensors and Systems in Healthcare and Environmental Monitoring Sensor Development for Physiological and Environmental Monitoring Smart Sensors for Real-Time Water Quality Monitoring Paper Based Sensors Environmental Sensing Calibration and Applications of Satellite Sensors for Environmental Monitoring Environmental Monitoring Using Microcantilever Sensors Seminar on Sensors for Environmental Monitoring The Role of Advanced Sensors in Environmental Monitoring and Pollution Control Practices Paper Microfluidics Mobile Sensor

Networks for Environmental Monitoring Disposable Electrochemical Sensors for Healthcare Monitoring Underground Sensing Mid-infrared Sensors for Environmental Monitoring Advances in Nanosensors for Biological and Environmental Analysis Novel Electrochemical Sensors for Environmental Monitoring and National Security Humidity Sensors

Stringent legislation is forcing manufacturing industry to be aware of the impact its operations have on the environment, in order to control and reduce the affect of those operations. Increasingly sophisticated equipment is required for this monitoring, and development of that equipment and strategies for its use is a multi-disciplinary field involving chemists, analytical scientists and engineers. This volume is divided into two parts, the first introducing the reader to the various sensor systems and illustrating the advantages and disadvantages those systems have for monitoring programmes, and the second introducing the problems associated with environmental monitoring, and showing how the sensors discussed in the first section can be applied to produce a thorough monitoring programme. There is presently an urgent need for rugged, low cost sensing systems for real-time, in situ chemical sensors for characterization and monitoring of ground water, contaminated soil and process streams. Recent advances in designing and fabricating microcantilever beams capable of detecting extremely small forces, mechanical stress and mass additions offer the promising prospect of environmental sensing with unprecedented sensitivity and dynamic range. The resonance frequency of a cantilever beam varies sensitively as a function of molecular adsorption. In addition, when the adsorption is confined to one side of the cantilever, the cantilever undergoes deflection due to adsorption-induced variation in surface free energy. Chemical selectivity can be achieved by coating the cantilevers with selective molecules. We have detected a number of ions such as Cs, Cr, Cu, Hg and methyl Hg in ground water with very high sensitivity. Recent results from nanocantilever sensor arrays will be presented. The field of plasmonics has shown extraordinary capabilities in realizing highly

sensitive and accurate sensors for environmental monitoring and measurement of biological analytes. The inherent potential of such devices has led to growing interest worldwide in commercial fiber optic chemical and biosensors. Optical Sensors for Biomedical Diagnostics and Environmental Monitoring is an essential resource for students, established researchers, and industry developers in need of a reference work on both the fundamentals and latest advances in optical fiber sensor technology in biomedical diagnostics and environmental monitoring. The book includes rigorous theory and experimental techniques of surface plasmon and lossy mode resonances, as well as real-time sensing applications of resonance techniques implemented over optical fiber substrate using bulk layer and/or nanostructures as transducer and sensing layers. In addition, discussion of various design options for real-time sensors in environmental monitoring and biomedical diagnostics make the book approachable to readers from multidisciplinary fields. During recent years both research activity and the number of reports on biosensor systems applied to environmental analysis have increased significantly. Compounds present in the environment have increasingly been shown to have effects on biological systems such as cells, enzymes, binding proteins, and DNA. In order to deal with the increasing demand for information about possible pollution of the environment there is need for improvements to analytical methods. Thus, biochemistry-based analytical methods should offer the possibility of monitoring these effects. This text provides an overview of existing biosensor principles, commercially available instruments, and related biochemical assays which have been developed and applied to environmental monitoring. Providing the reader with detailed information on methodology and a description of the practical application of selected sensors, this text also includes reports on established chemical methods for comparison. This volume presents fundamental principles together with examples of applications and discussion of drawbacks, and future developments. Of interest to all in the field of environmental analysis and biosensor technology, this text provides a comprehensive treatise on the latest

research and developments in the field. Remote sensing has witnessed a renaissance as new sensor systems, data collection capabilities and image processing methodologies have expanded the technological capabilities of this science into new and important applications areas. Perhaps nowhere has this trend been more evident than in the study of earth environments. Within this broad application area remote sensing has proven to be an invaluable asset supporting timely data gathering at a range of synoptic scales, facilitating the mapping of complex landscapes and promoting the analysis of environmental process. Yet remote sensing□s contribution to the study of human/environmental interaction is scattered throughout a rich and diverse literature spanning the social and physical sciences, which frustrates access to, and the sharing of the knowledge gained through, these recent advances, and inhibits the operational use of these methods and techniques in day to day environmental practice, a recognized gap that reduces the effectiveness of environmental management programs. The objective of this book is to address this gap and provide the synthesis of method and application that is currently missing in the environmental science, re-introducing remote sensing as an important decision-support technology. The book focuses on the different aspects of sensing technology, i.e. high reliability, adaptability, recalibration, information processing, data fusion, validation and integration of novel and high performance sensors specifically aims to monitor agricultural and environmental parameters. This book is dedicated to Sensing systems for Agricultural and Environmental Monitoring offers to variety of users, namely, Master and PhD degree students, researchers, practitioners, especially Agriculture and Environmental engineers. The book will provide an opportunity of a dedicated and a deep approach in order to improve their knowledge in this specific field. This book is a printed edition of the Special Issue "UAV Sensors for Environmental Monitoring" that was published in Sensors Stringent legislation is forcing manufacturing industry to be aware of the impact its operations have on the environment, in order to control and reduce the affect of those

operations. Increasingly sophisticated equipment is required for this monitoring, and development of that equipment and strategies for its use is a multi-disciplinary field involving chemists, analytical scientists and engineers. This volume is divided into two parts, the first introducing the reader to the various sensor systems and illustrating the advantages and disadvantages those systems have for monitoring programmes, and the second introducing the problems associated with environmental monitoring, and showing how the sensors discussed in the first section can be applied to produce a thorough monitoring programme. Disposable electrodes have been widely used as a sensing platform in electrical and electrochemical sensors owing to the possibility of quantitative detection using clinical biomarkers with high precision, sensitivity and reproducibility, which are necessary for accurate diagnosis of the health condition of an individual. This book focusses on the emerging disposable electrochemical sensors in the health sector and the advancement of analytical devices to monitor diabetic, cancer and cardiovascular patients using different nanomaterials. It discusses the upcoming strategies, advantages and the limitations of the existing devices using disposable electrodes. Uniquely, it covers in-depth knowledge of mechanistic features of various designs of screen-printing electrodes and the material aspects required of sensors developed for the healthcare field. It also looks at the portable devices using a variety of materials and the future directions for research in this area. Appealing to the health care industry, this book is aimed at academic and research institutes at both the graduate and postgraduate level. The contributors are leading experts in the field and they are providing guidance for the next decade of research in the field of disposable electrochemical biosensors. The sensor industry is a growing industry that has been predicted by Allied Market Research to be a multi-billion industry by 2022. One of the many key drives behind this rapid growth in the sensor industry is the increase incorporation of sensors into portable electrical devices. The value for sensor technologies are increased when the sensors are developed into innovative measuring system for application uses in the

Aerospace, Defense, and Healthcare industries. While sensors are not new, their increased performance, size reduction, and decrease in cost has opened the door for innovative sensor combination for portable devices that could be worn or easily moved around. With this opportunity for further development of sensor use through concept engineering development, three concept projects for possible innovative portable devices was undertaken in this research. One project was the development of a pulse oximeter devise with fingerprint recognition. The second project was prototyping a portable Bluetooth strain gage monitoring system. The third project involved sensors being incorporated onto flexible printed circuit board (PCB) for improved comfort of wearable devices. All these systems were successfully tested in lab. This book involves inter-disciplinary research in electrical, environmental, and chemical engineering. It describes methodologies and techniques of environmental monitoring for the detection of hazardous materials by using microelectronic sensors. Design considerations focus on improving key areas such as: (1) sampling methodology; (2) context awareness; and (3) sensor placement. Moreover, design techniques using wireless sensor networks (WSN) are applied to the detection of methylmercury (MeHg) and environmental parameters affecting its formation (methylation) and deformation (demethylation). This volume provides an overview of the recent advances in the field of paper microfluidics, whose innumerable research domains have stimulated considerable efforts to the development of rapid, cost-effective and simplified point-of-care diagnostic systems. The book is divided into three parts viz. theoretical background of paper microfluidics, fabrication techniques for paper-based devices, and broad applications. Each chapter of the book is self-explanatory and focuses on a specific topic and its relation to paper microfluidics and starts with a brief description of the topic□s physical background, essential definitions, and a short story of the recent progress in the relevant field. The book also covers the future outlook, remaining challenges, and emerging opportunities. This book shall be a tremendous up-to-date resource for researchers working in the area

globally. A study was performed on chemical sensor technology currently available and under development. The information was compiled into a format wherein information on the sensors is listed in a comparable manner. As introductory section is provided to illustrate the regulatory environment in which such sensor technology will be used. This information should allow corporations or federal agencies ready access to useful information for the potential licensing of sensor technology for commercial development or specific environmental monitoring operations. Although every attempt was made to identify as many chemical sensors as possible, we recognize that some may be missed inadvertently. The accuracy of the information provided by the various sources regarding the state of development for the various sensors was not verified. Judgments or opinions regarding the actual state of development or utility of these devices are not included in this report. However, we feel that this report accurately reflects the state of the art at the present time. This book discusses in detail the analysis and monitoring of the most important analytes in the environmental field. It also reviews the implementation, realization and application of sensor designs mentioned in the first volume of this set, dividing the coverage into global parameters, sensors of organics and sensors of inorganics. Abstract: The humidity, temperature, wind speed/direction micro sensors can be manufactured individually, resulting in three individual substrates. The integration of the three sensors into a single substrate is a vital challenge to achieve an integrated intelligent sensor so called a multiple sensor. This requires the integration of process flows and is a major challenge because adequate sensor performance must be maintained. Polyimide was selected as a humidity sensing material for its compatibility with conventional integrated circuit fabrication technology, negligible temperature dependence and good resistance against contamination. Nickel was selected for the temperature and wind speed/direction sensor because of its useful temperature coefficient and the advantage of its cost. Since the known wet etchant for nickel requires hard-baked photoresist, a method which does not attack the polyimide while removing the photoresist must be

developed. The method developed for etching nickel employs hard-bake-free photoresist. Other challenge was ensuring good thermal isolation for the wind speed/direction sensor fabricated on a silicon nitride layer preformed on top of a silicon wafer. Since silicon acts as a good heat sink, the silicon under the sensor was etched entirely away until the silicon nitride layer was reached. This structure achieved good thermal isolation resulting in small power consumption. This low power feature is essential for sensors deployed in fields where power access or replacement of power sources is restricted. This structure was compared with the structure created by polyimide plateau on a silicon nitride layer coated on a silicon substrate as a function of power consumption. Based on the examination of thermal isolation, the multiple sensor utilizing a MEMS technique was fabricated with a single-sided mask aligner. -- The characteristics of humidity sensors fabricated with polyimide were examined in detail with respect to variations of electrode structures, improvement of sensitivity, effect of process temperature, temperature and frequency dependence, and stability. The humidity sensor constructed with O2 plasma treated polyimide resulted an improvement in sensitivity and hysteresis. The investigation using XPS, FTIR and AFM concluded the chemical modification of polyimide played an important role in this improvement. The design, fabrication and results of a series of humidity sensors are quantified. -- There is always no unique packaging solution for sensors because of the application-specific nature of the sensors. This intelligent environmental monitoring system was designed to accommodate both an environmental sensor and its signal conditioning electronics circuitry (SICONEC) into a single package. The environmental sensors need direct exposure to the environment while SICONEC needs a sealed encapsulation to avoid environmental damage. A new style of packaging addressing these requirements was demonstrated using a hot embossing machine. The hot embossing machine was used to embed an integrated circuit (IC) in a bare die condition into a polycarbonate (PC) sheet. In this case, the IC was flipped down against the PC, which protects the front side of the IC

from the environmental damages. In a test phase, a die containing operational amplifiers was embossed into the PC. A humidity sensor and surface mount resisters were placed on the same surface of the PC to test the validity of this new technique. Interconnection between the embossed die and the humidity sensor was established using bonding wires. Copper tracks were also used to ensure all electrical connections for the die, the humidity sensor and the resistors. The results clarified the method developed. Details of process methods, issues and further potential improvement are reported. This book covers two most important applications of smart sensors, namely bio-health sensing and environmental monitoring. The approach taken is holistic and covers the complete scope of the subject matter from the principles of the sensing mechanism, through device physics, circuit and system implementation techniques, and energy issues to wireless connectivity solutions. It is written at a level suitable mainly for post-graduate level researchers interested in practical applications. The chapters are independent but complementary to each other, and the book works within the wider perspective of essential smart sensors for the Internet of Things (IoT). This is the second of three books based on the Integrated Smart Sensors research project, which describe the development of innovative devices, circuits, and system-level enabling technologies. The aim of the project was to develop common platforms on which various devices and sensors can be loaded, and to create systems offering significant improvements in information processing speed, energy usage, and size. This book contains substantial reference lists and over 150 figures, introducing the reader to the subject in a tutorial style whilst also addressing state-of-the-art research results, allowing it to be used as a guide for starting researchers. In this Chapter an original approach to sensor data fusion for environmental monitoring applications has been proposed. Care has been paid for an innovative design of the distributed network of wireless and smart web-sensors with remote data processing. The architecture of the network is dynamically configurable by an algorithm according to the requirements and the accuracy desired for the

monitoring. The sensors are able to measure the environmental electromagnetic field. A GPRS modem and a GPS module allow the single measuring unit to communicate remotely and to acquire information about its geographic location. In order to distribute the burden of measurement among several sensors, the monitored area (an urban centre) is divided in several local zones, where a set of sensors acquire a fixed number of data according to designed monitoring maps. Sampling time and location of the measurement points depend on topographical and environmental knowledge. The collected data are sent to ASP Web Pages accessible in reading only from identified users. The alone administrator has authorization to manage the whole network and to exchange information and commands with the sensors. Data and correlated information are remotely processed by an innovative data fusion procedure. The data fusion approach represents a suitable solution in order to manage a wide network and to process data from different sources. The developed procedure allows to minimize errors and faulty computing, by using information about the measurement uncertainty and the performances of the sensors. The data amount is processed and the same redundancy is used in order to increase the reliability and the accuracy of the results. A first level of data fusion provides information on alarm occurrences. So measured values are put in comparison with the exposure limit. The fuzzy decision making algorithm permits to qualify the comparison process minimizing possible occurrences of wrong decisions. A quality index values the consistency of the final decision alternative chosen. The estimation of the erroneous decision probabilities and the measurement uncertainty improve the computing results. A warning report shows the pollution status of the zones. Successively the results of the decisional process, information on sensor reliability and population density distribution are fused so to obtain a global view on the risk state in the whole area. The procedure is fault tolerant and permits the maximization of the useful information. In this way a more reliable result is got than that obtained from the single sensor, so greater efficacy and efficiency are achieved. The

projected measurement process is a complete solution in support of monitoring, controlling and alarm reporting applications for environmental purposes. Advanced materials and nanotechnology is a promising, emerging field involving the use of nanoparticles to facilitate the detection of various physical and chemical parameters, including temperature, humidity, pH, metal ion, anion, small organic or inorganic molecules, gases, and biomolecules responsible for environmental issues that can lead to diseases like cancer, diabetes, osteoarthritis, bacterial infections, and brain, retinal, and cardiovascular diseases. By monitoring environmental samples and detecting these environmental issues, advanced nanotechnology in this type of sensory technology is able to improve daily quality of life. Although these sensors are commercially available for the detection of monovalent cations, anions, gases, volatile organic molecules, heavy metal ions, and toxic metal ions, many existing models require significant power and lack advanced technology for more quality selectivity and sensitivity. There is room in these sensors to optimize their selectivity, reversibility, on/off ratio, response time, and their environmental stability in real-world operating conditions. This book explores the methods for the development and design of environmentally-friendly, simple, reliable, and cost effective electrochemical nanosensors using powerful nanostructured materials. More specifically, it highlights the use of various electrochemical-based biosensor sensors involved in the detection of monovalent cations, anions, gases, volatile organic molecules, heavy metal ions, and toxic metal ions, with the ultimate goal of seeing these technologies reach market. Underground Sensing: Monitoring and Hazard Detection for Environment and Infrastructure brings the target audience the technical and practical knowledge of existing technologies of subsurface sensing and monitoring based on a classification of their functionality. In addition, the book introduces emerging technologies and applications of sensing for environmental and geo-hazards in subsurface focusing on sensing platforms that can enable fully distributed global measurements. Finally, users will find a comprehensive exploration of the future of underground sensing

that can meet demands for preemptive and sustainable response to underground hazards. New concepts and paradigms based on passively powered and/or on-demand activated, embeddable sensor platforms are presented to bridge the gap between real-time monitoring and global measurements. Presents a one-stop-shop reference for underground sensing and monitoring needs that saves valuable research time Provides application cases for all technologies that are covered and described in detail Includes full, four color images of equipment and applications Designed to cover a wide variety of underground sensors, from agriculture to geohazards Compact, portable systems capable of quickly identifying contaminants in the field are of great importance when monitoring the environment. One of the missions of the Pacific Northwest Laboratory is to examine and develop new technologies for environmental restoration and waste management at the Hanford Site. In this paper, three prototype sensing systems are discussed. These prototypes are composed of sensing elements, data acquisition system, computer, and neural network implemented in software, and are capable of automatically identifying contaminants. The first system employs an array of tin-oxide gas sensors and is used to identify chemical vapors. The second system employs an array of optical sensors and is used to identify the composition of chemical dyes in liquids. The third system contains a portable gamma-ray spectrometer and is used to identify radioactive isotopes. In these systems, the neural network is used to identify the composition of the sensed contaminant. With a neural network, the intense computation takes place during the training process. Once the network is trained, operation consists of propagating the data through the network. Since the computation involved during operation consists of vector-matrix multiplication and application of look-up tables unknown samples can be rapidly identified in the field. The natural environment is complex and changes continuously at varying paces. Many, like the weather, we notice from day to day. However, patterns and rhythms examined over time give us the bigger picture. These weather statistics become climate and help us build an understanding

of the patterns of change over the long term. Real-Time Environmental Monitoring: Sensors and Systems introduces the fundamentals of environmental monitoring, based on electronic sensors, instruments, and systems that allow real-time and long-term data acquisition, data-logging, and telemetry. The book details state-of-the-art technology, using a practical approach, and includes applications to many environmental and ecological systems. In the first part of the book, the author develops a story of how starting with sensors, you can progressively build more complex instruments, leading to entire systems that end with databases and web servers. In the second part, he covers a variety of sensors and systems employed to measure environmental variables in air, water, soils, vegetation canopies, and wildlife observation and tracking. This is an emerging area that is very important to some aspects of environmental assessment and compliance monitoring. Real-time monitoring approaches can facilitate the cost effective collection of data over time and, to some extent, negate the need for sample, collection, handling, and transport to a laboratory, either on-site or off-site. It provides the tools you need to develop, employ, and maintain environmental monitors. This book, presented in three volumes, examines environmental disciplines in relation to major players in contemporary science: Big Data, artificial intelligence and cloud computing. Today, there is a real sense of urgency regarding the evolution of computer technology, the ever-increasing volume of data, threats to our climate and the sustainable development of our planet. As such, we need to reduce technology just as much as we need to bridge the global socio-economic gap between the North and South; between universal free access to data (open data) and free software (open source). In this book, we pay particular attention to certain environmental subjects, in order to enrich our understanding of cloud computing. These subjects are: erosion; urban air pollution and atmospheric pollution in Southeast Asia; melting permafrost (causing the accelerated release of soil organic carbon in the atmosphere); alert systems of environmental hazards (such as forest fires, prospective modeling of socio-spatial practices and land

use); and web fountains of geographical data. Finally, this book asks the question: in order to find a pattern in the data, how do we move from a traditional computing model-based world to pure mathematical research? After thorough examination of this topic, we conclude that this goal is both transdisciplinary and achievable. Sensors are being utilized to increasing degrees in all forms of industry. Researchers and industrial practitioners in all fields seek to obtain a better understanding of appropriate processes so as to improve quality of service and efficiency. The quality of water is no exception, and the water industry is faced with a wide array of water quality issues being present world-wide. Thus, the need for sensors to tackle this diverse subject is paramount. The aim of this book is to combine, for the first time, international expertise in the area of water quality monitoring using smart sensors and systems in order that a better understanding of the challenges faced and solutions posed may be available to all in a single text. Paper Based Sensors, Volume 89, the latest release in this comprehensive series that gathers the most important issues relating to the design and application of these cost-effective devices used in many industries, including health and environment diagnostics, safety and security, chemistry, optics, electrochemistry, nanoscience and nanotechnologies, presents the latest updates in the field. Chapters in this new release include Exploring paper as a substrate for electrochemical micro-devices, Paper-based sensors for application in biological compound detection, Printed paper-based (bio)sensors: design, fabrication and applications, Paper-based electrochemical sensing devices, Multifarious aspects of electrochemical paper-based (bio)sensors, Paper Based Biosensors for Clinical and Biomedical Applications, and more. Provides updates on the latest design in paper-based sensors using various nano and micromaterials Includes optical/electrical-based detection modes integrated within paper-based platforms Covers applications of paper-based platforms in diagnostics and other industries Advances in Nanosensors for Biological and Environmental Analysis presents the current state-of-art in nanosensors for biological and environmental analysis, also covering

commercial aspects. Broadly, the book provides detailed information on the emergence of different types of nanomaterials as transduction platforms used in the development of nanosensors. These include carbon nanotubes, graphene, 2-D transition metal dichalcogenides, conducting polymers and metal organic frameworks. Additional topics include sections on the way nanosensors have inspired new product development in various types of biological and environmental applications that are currently available and on the horizon. Features detailed information on various types of biological and environmental nanosensors Gives particular attention to the different categories of advanced functional interfaces, processes for their development, and application areas Includes the current state-of-the-art in terms of commercial aspects After the devastating tsunami in 2011, DYIers in Japan built their own devices to detect radiation levels, then posted their finding on the Internet. Right now, thousands of people worldwide are tracking environmental conditions with monitoring devices they□ve built themselves. You can do it too! This inspiring guide shows you how to use Arduino to create gadgets for measuring noise, weather, electromagnetic interference (EMI), water purity, and more. You□ll also learn how to collect and share your own data, and you can experiment by creating your own variations of the gadgets covered in the book. If you□re new to DIY electronics, the first chapter offers a primer on electronic circuits and Arduino programming. Use a special microphone and amplifier to build a reliable noise monitor Create a gadget to detect energy vampires: devices that use electricity when they□re □off□ Examine water purity with a water conductivity device Measure weather basics such as temperature, humidity, and dew point Build your own Geiger counter to gauge background radiation Extend Arduino with an Ethernet shield□and put your data on the Internet Share your weather and radiation data online through Pachube Semiconductor Gas Sensors, Second Edition, summarizes recent research on basic principles, new materials and emerging technologies in this essential field. Chapters cover the foundation of the underlying principles and sensing mechanisms of gas sensors, include expanded

content on gas sensing characteristics, such as response, sensitivity and cross-sensitivity, present an overview of the nanomaterials utilized for gas sensing, and review the latest applications for semiconductor gas sensors, including environmental monitoring, indoor monitoring, medical applications, CMOS integration and chemical warfare agents. This second edition has been completely updated, thus ensuring it reflects current literature and the latest materials systems and applications. Includes an overview of key applications, with new chapters on indoor monitoring and medical applications Reviews developments in gas sensors and sensing methods, including an expanded section on gas sensor theory Discusses the use of nanomaterials in gas sensing, with new chapters on single-layer graphene sensors, graphene oxide sensors, printed sensors, and much more

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