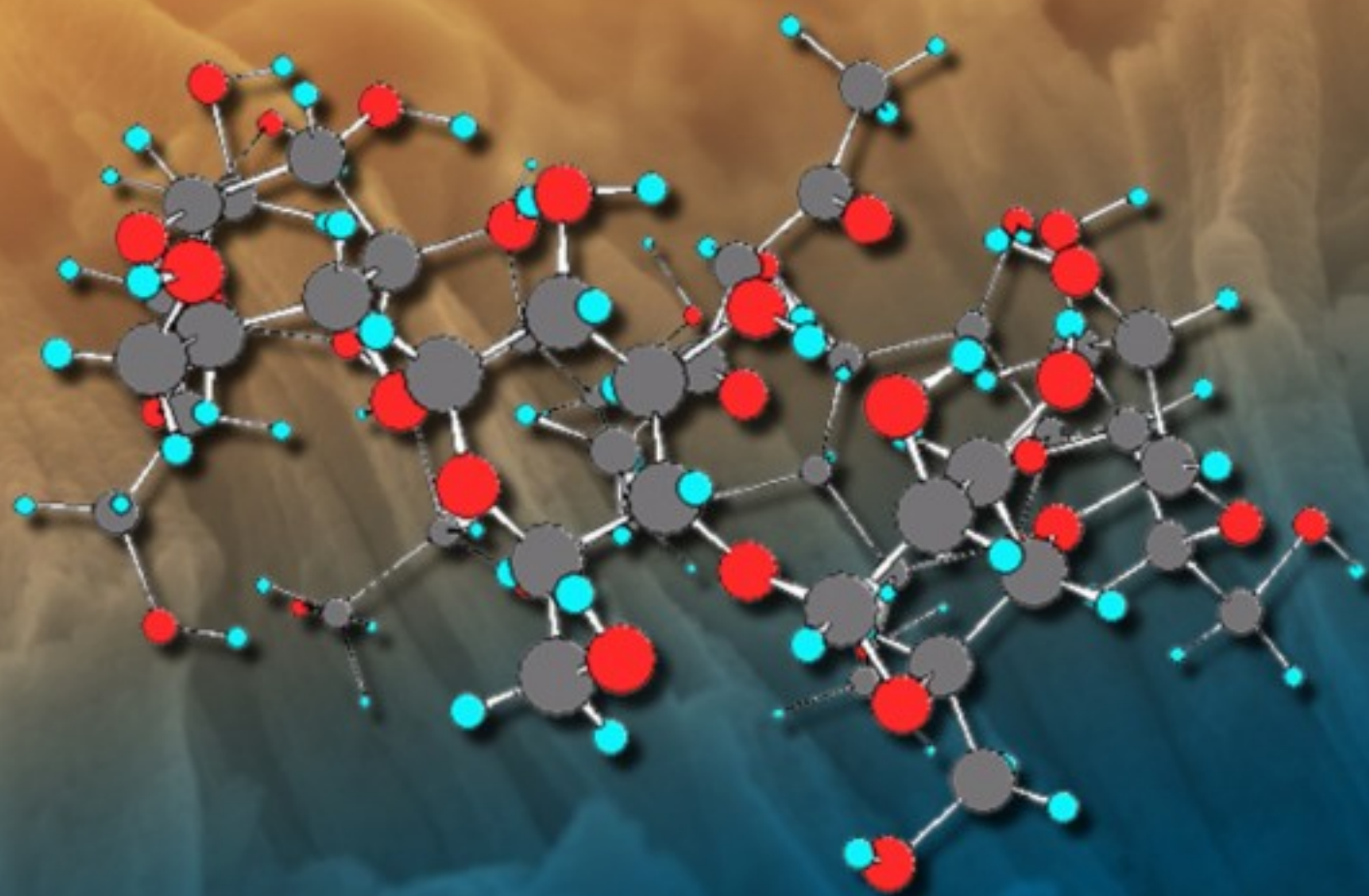


ISSN 1726-5479

# SENSORS **11** vol. 146 & TRANSDUCERS **/12**



## Nanosensors and Nanodevices

International Frequency Sensor Association Publishing





**Editors-in-Chief:** professor Sergey Y. Yurish, tel.: +34 696067716, e-mail: editor@sensorsportal.com

### Editors for Western Europe

Meijer, Gerard C.M., Delft University of Technology, The Netherlands  
Ferrari, Vittorio, Università di Brescia, Italy

### Editors for North America

Datskos, Panos G., Oak Ridge National Laboratory, USA  
Fabien, J. Josse, Marquette University, USA  
Katz, Evgeny, Clarkson University, USA

### Editor South America

Costa-Felix, Rodrigo, Inmetro, Brazil

### Editor for Eastern Europe

Sachenko, Anatoly, Ternopil State Economic University, Ukraine

### Editor for Asia

Ohyama, Shinji, Tokyo Institute of Technology, Japan

### Editor for Africa

Maki K.Habib, American University in Cairo, Egypt

### Editor for Asia-Pacific

Mukhopadhyay, Subhas, Massey University, New Zealand

## Editorial Advisory Board

- Abdul Rahim, Ruzairi**, Universiti Teknologi, Malaysia  
**Ahmad, Mohd Noor**, Northern University of Engineering, Malaysia  
**Annamalai, Karthigeyan**, National Institute of Advanced Industrial Science and Technology, Japan  
**Arcega, Francisco**, University of Zaragoza, Spain  
**Arguel, Philippe**, CNRS, France  
**Ahn, Jae-Pyoung**, Korea Institute of Science and Technology, Korea  
**Arndt, Michael**, Robert Bosch GmbH, Germany  
**Ascoli, Giorgio**, George Mason University, USA  
**Atalay, Selcuk**, Inonu University, Turkey  
**Atghiaee, Ahmad**, University of Tehran, Iran  
**Augutis, Vygtantas**, Kaunas University of Technology, Lithuania  
**Avachit, Patil Lalchand**, North Maharashtra University, India  
**Ayesh, Aladdin**, De Montfort University, UK  
**Azamimi, Azian binti Abdullah**, Universiti Malaysia Perlis, Malaysia  
**Bahreyni, Behraad**, University of Manitoba, Canada  
**Baliga, Shankar, B.**, General Motors Transnational, USA  
**Baoxian, Ye**, Zhengzhou University, China  
**Barford, Lee**, Agilent Laboratories, USA  
**Barlingay, Ravindra**, RF Arrays Systems, India  
**Basu, Sukumar**, Jadavpur University, India  
**Beck, Stephen**, University of Sheffield, UK  
**Ben Bouzid, Sihem**, Institut National de Recherche Scientifique, Tunisia  
**Benachaiba, Chellali**, Universitè de Bechar, Algeria  
**Binnie, T. David**, Napier University, UK  
**Bischoff, Gerlinde**, Inst. Analytical Chemistry, Germany  
**Bodas, Dhananjay**, IMTEK, Germany  
**Borges Carval, Nuno**, Universidade de Aveiro, Portugal  
**Bouchikhi, Benachir**, University Moulay Ismail, Morocco  
**Bousbia-Salah, Mounir**, University of Annaba, Algeria  
**Bouvet, Marcel**, CNRS – UPMC, France  
**Brudzewski, Kazimierz**, Warsaw University of Technology, Poland  
**Cai, Chenxin**, Nanjing Normal University, China  
**Cai, Qingyun**, Hunan University, China  
**Calvo-Gallego, Jaime**, Universidad de Salamanca, Spain  
**Campanella, Luigi**, University La Sapienza, Italy  
**Carvalho, Vitor**, Minho University, Portugal  
**Cecelja, Franjo**, Brunel University, London, UK  
**Cerda Belmonte, Judith**, Imperial College London, UK  
**Chakrabarty, Chandan Kumar**, Universiti Tenaga Nasional, Malaysia  
**Chakravorty, Dipankar**, Association for the Cultivation of Science, India  
**Changhai, Ru**, Harbin Engineering University, China  
**Chaudhari, Gajanan**, Shri Shivaji Science College, India  
**Chavali, Murthy**, N.I. Center for Higher Education, (N.I. University), India  
**Chen, Jiming**, Zhejiang University, China  
**Chen, Rongshun**, National Tsing Hua University, Taiwan  
**Cheng, Kuo-Sheng**, National Cheng Kung University, Taiwan  
**Chiang, Jeffrey (Cheng-Ta)**, Industrial Technol. Research Institute, Taiwan  
**Chiriac, Horia**, National Institute of Research and Development, Romania  
**Chowdhuri, Arijit**, University of Delhi, India  
**Chung, Wen-Yaw**, Chung Yuan Christian University, Taiwan  
**Corres, Jesus**, Universidad Publica de Navarra, Spain  
**Cortes, Camilo A.**, Universidad Nacional de Colombia, Colombia  
**Courtois, Christian**, Universite de Valenciennes, France  
**Cusano, Andrea**, University of Sannio, Italy  
**D'Amico, Arnaldo**, Università di Tor Vergata, Italy  
**De Stefano, Luca**, Institute for Microelectronics and Microsystem, Italy  
**Deshmukh, Kiran**, Shri Shivaji Mahavidyalaya, Barshi, India  
**Dickert, Franz L.**, Vienna University, Austria  
**Dieguez, Angel**, University of Barcelona, Spain  
**Dighavkar, C. G.**, M.G. Vidyamandir's L. V.H. College, India  
**Dimitropoulos, Panos**, University of Thessaly, Greece  
**Ding, Jianning**, Jiangsu Polytechnic University, China  
**Djordjevic, Alexander**, City University of Hong Kong, Hong Kong  
**Donato, Nicola**, University of Messina, Italy  
**Donato, Patricio**, Universidad de Mar del Plata, Argentina  
**Dong, Feng**, Tianjin University, China  
**Drljaca, Predrag**, Instersema Sensoric SA, Switzerland  
**Dubey, Venketesh**, Bournemouth University, UK  
**Enderle, Stefan**, Univ. of Ulm and KTB Mechatronics GmbH, Germany  
**Erdem, Gursan K. Arzum**, Ege University, Turkey  
**Erkmen, Aydan M.**, Middle East Technical University, Turkey  
**Estelle, Patrice**, Insa Rennes, France  
**Estrada, Horacio**, University of North Carolina, USA  
**Faiz, Adil**, INSA Lyon, France  
**Fericean, Sorin**, Balluff GmbH, Germany  
**Fernandes, Joana M.**, University of Porto, Portugal  
**Francioso, Luca**, CNR-IMM Institute for Microelectronics and Microsystems, Italy  
**Francis, Laurent**, University Catholique de Louvain, Belgium  
**Fu, Weiling**, South-Western Hospital, Chongqing, China  
**Gaura, Elena**, Coventry University, UK  
**Geng, Yanfeng**, China University of Petroleum, China  
**Gole, James**, Georgia Institute of Technology, USA  
**Gong, Hao**, National University of Singapore, Singapore  
**Gonzalez de la Rosa, Juan Jose**, University of Cadiz, Spain  
**Granell, Annette**, Goteborg University, Sweden  
**Graff, Mason**, The University of Texas at Arlington, USA  
**Guan, Shan**, Eastman Kodak, USA  
**Guillet, Bruno**, University of Caen, France  
**Guo, Zhen**, New Jersey Institute of Technology, USA  
**Gupta, Narendra Kumar**, Napier University, UK  
**Hadjiloucas, Sillas**, The University of Reading, UK  
**Haider, Mohammad R.**, Sonoma State University, USA  
**Hashsham, Syed**, Michigan State University, USA  
**Hasni, Abdelhafid**, Bechar University, Algeria  
**Hernandez, Alvaro**, University of Alcalá, Spain  
**Hernandez, Wilmar**, Universidad Politecnica de Madrid, Spain  
**Homentcovschi, Dorel**, SUNY Binghamton, USA  
**Horstman, Tom**, U.S. Automation Group, LLC, USA  
**Hsiai, Tzung (John)**, University of Southern California, USA  
**Huang, Jeng-Sheng**, Chung Yuan Christian University, Taiwan  
**Huang, Star**, National Tsing Hua University, Taiwan  
**Huang, Wei**, PSG Design Center, USA  
**Hui, David**, University of New Orleans, USA  
**Jaffrezic-Renault, Nicole**, Ecole Centrale de Lyon, France  
**James, Daniel**, Griffith University, Australia  
**Janting, Jakob**, DELTA Danish Electronics, Denmark  
**Jiang, Liudi**, University of Southampton, UK  
**Jiang, Wei**, University of Virginia, USA  
**Jiao, Zheng**, Shanghai University, China  
**John, Joachim**, IMEC, Belgium  
**Kalach, Andrew**, Voronezh Institute of Ministry of Interior, Russia  
**Kang, Moonho**, Sunmoon University, Korea South  
**Kaniasas, Eugenijus**, Vienna University of Technology, Austria  
**Katake, Anup**, Texas A&M University, USA  
**Kausel, Wilfried**, University of Music, Vienna, Austria  
**Kavasoglu, Nese**, Mugla University, Turkey  
**Ke, Cathy**, Tyndall National Institute, Ireland  
**Khelfaoui, Rachid**, Université de Bechar, Algeria  
**Khan, Asif**, Aligarh Muslim University, Aligarh, India  
**Kim, Min Young**, Kyungpook National University, Korea South  
**Ko, Sang Choon**, Electronics. and Telecom. Research Inst., Korea South  
**Kotulska, Malgorzata**, Wroclaw University of Technology, Poland  
**Kockar, Hakan**, Balikesir University, Turkey  
**Kong, Ing**, RMIT University, Australia  
**Kratz, Henrik**, Uppsala University, Sweden

**Krishnamoorthy, Ganesh**, University of Texas at Austin, USA  
**Kumar, Arun**, University of Delaware, Newark, USA  
**Kumar, Subodh**, National Physical Laboratory, India  
**Kung, Chih-Hsien**, Chang-Jung Christian University, Taiwan  
**Lacnjevac, Caslav**, University of Belgrade, Serbia  
**Lay-Ekuakille, Aime**, University of Lecce, Italy  
**Lee, Jang Myung**, Pusan National University, Korea South  
**Lee, Jun Su**, Amkor Technology, Inc. South Korea  
**Lei, Hua**, National Starch and Chemical Company, USA  
**Li, Fengyuan (Thomas)**, Purdue University, USA  
**Li, Genxi**, Nanjing University, China  
**Li, Hui**, Shanghai Jiaotong University, China  
**Li, Sihua**, Agiltron, Inc., USA  
**Li, Xian-Fang**, Central South University, China  
**Li, Yuefa**, Wayne State University, USA  
**Liang, Yuanchang**, University of Washington, USA  
**Liawruangrath, Saisunee**, Chiang Mai University, Thailand  
**Liew, Kim Meow**, City University of Hong Kong, Hong Kong  
**Lin, Hermann**, National Kaohsiung University, Taiwan  
**Lin, Paul**, Cleveland State University, USA  
**Linderholm, Pontus**, EPFL - Microsystems Laboratory, Switzerland  
**Liu, Aihua**, University of Oklahoma, USA  
**Liu Changgeng**, Louisiana State University, USA  
**Liu, Cheng-Hsien**, National Tsing Hua University, Taiwan  
**Liu, Songqin**, Southeast University, China  
**Lodeiro, Carlos**, University of Vigo, Spain  
**Lorenzo, Maria Encarnacio**, Universidad Autonoma de Madrid, Spain  
**Lukaszewicz, Jerzy Pawel**, Nicholas Copernicus University, Poland  
**Ma, Zhanfang**, Northeast Normal University, China  
**Majstorovic, Vidosav**, University of Belgrade, Serbia  
**Malyshev, V.V.**, National Research Centre 'Kurchatov Institute', Russia  
**Marquez, Alfredo**, Centro de Investigacion en Materiales Avanzados, Mexico  
**Matay, Ladislav**, Slovak Academy of Sciences, Slovakia  
**Mathur, Prafull**, National Physical Laboratory, India  
**Maurya, D.K.**, Institute of Materials Research and Engineering, Singapore  
**Mekid, Samir**, University of Manchester, UK  
**Melnyk, Ivan**, Photon Control Inc., Canada  
**Mendes, Paulo**, University of Minho, Portugal  
**Mennell, Julie**, Northumbria University, UK  
**Mi, Bin**, Boston Scientific Corporation, USA  
**Minas, Graca**, University of Minho, Portugal  
**Mishra, Vivekanand**, National Institute of Technology, India  
**Moghavvemi, Mahmoud**, University of Malaya, Malaysia  
**Mohammadi, Mohammad-Reza**, University of Cambridge, UK  
**Molina Flores, Esteban**, Benemérita Universidad Autónoma de Puebla, Mexico  
**Moradi, Majid**, University of Kerman, Iran  
**Morello, Rosario**, University "Mediterranea" of Reggio Calabria, Italy  
**Mounir, Ben Ali**, University of Sousse, Tunisia  
**Mrad, Nezh**, Defence R&D, Canada  
**Mulla, Imtiaz Sirajuddin**, National Chemical Laboratory, Pune, India  
**Nabok, Aleksey**, Sheffield Hallam University, UK  
**Neelamegam, Periasamy**, Sastra Deemed University, India  
**Neshkova, Milka**, Bulgarian Academy of Sciences, Bulgaria  
**Oberhammer, Joachim**, Royal Institute of Technology, Sweden  
**Ould Lahoucine, Cherif**, University of Guelma, Algeria  
**Pamidighanta, Sayanu**, Bharat Electronics Limited (BEL), India  
**Pan, Jisheng**, Institute of Materials Research & Engineering, Singapore  
**Park, Joon-Shik**, Korea Electronics Technology Institute, Korea South  
**Passaro, Vittorio M. N.**, Politecnico di Bari, Italy  
**Penza, Michele**, ENEA C.R., Italy  
**Pereira, Jose Miguel**, Instituto Politecnico de Setebal, Portugal  
**Petsev, Dimiter**, University of New Mexico, USA  
**Pogacnik, Lea**, University of Ljubljana, Slovenia  
**Post, Michael**, National Research Council, Canada  
**Prance, Robert**, University of Sussex, UK  
**Prasad, Ambika**, Gulbarga University, India  
**Prateepasen, Asa**, Kingmoungut's University of Technology, Thailand  
**Pugno, Nicola M.**, Politecnico di Torino, Italy  
**Pullini, Daniele**, Centro Ricerche FIAT, Italy  
**Pumera, Martin**, National Institute for Materials Science, Japan  
**Radhakrishnan, S.**, National Chemical Laboratory, Pune, India  
**Rajanna, K.**, Indian Institute of Science, India  
**Ramadan, Qasem**, Institute of Microelectronics, Singapore  
**Rao, Basuthkar**, Tata Inst. of Fundamental Research, India  
**Raouf, Kosai**, Joseph Fourier University of Grenoble, France  
**Rastogi Shiva, K.**, University of Idaho, USA  
**Reig, Candid**, University of Valencia, Spain  
**Restivo, Maria Teresa**, University of Porto, Portugal  
**Robert, Michel**, University Henri Poincare, France  
**Rezazadeh, Ghader**, Urmia University, Iran  
**Royo, Santiago**, Universitat Politècnica de Catalunya, Spain  
**Rodriguez, Angel**, Universitat Politècnica de Catalunya, Spain  
**Rothberg, Steve**, Loughborough University, UK  
**Sadana, Ajit**, University of Mississippi, USA  
**Sadeghian Marnani, Hamed**, TU Delft, The Netherlands  
**Sapozhnikova, Ksenia**, D.I.Mendeleyev Institute for Metrology, Russia  
**Sandacci, Serghei**, Sensor Technology Ltd., UK  
**Saxena, Vibha**, Bbhba Atomic Research Centre, Mumbai, India  
**Schneider, John K.**, Ultra-Scan Corporation, USA  
**Sengupta, Deepak**, Advance Bio-Photonics, India  
**Seif, Selemani**, Alabama A & M University, USA  
**Seifter, Achim**, Los Alamos National Laboratory, USA  
**Shah, Kriyang**, La Trobe University, Australia  
**Sankarraaj, Anand**, Detector Electronics Corp., USA  
**Silva Giraó, Pedro**, Technical University of Lisbon, Portugal  
**Singh, V. R.**, National Physical Laboratory, India  
**Slomovitz, Daniel**, UTE, Uruguay  
**Smith, Martin**, Open University, UK  
**Soleimanpour, Amir Masoud**, University of Toledo, USA  
**Soleymanpour, Ahmad**, University of Toledo, USA  
**Somani, Prakash R.**, Centre for Materials for Electronics Technol., India  
**Sridharan, M.**, Sastra University, India  
**Srinivas, Talabattula**, Indian Institute of Science, Bangalore, India  
**Srivastava, Arvind K.**, NanoSonix Inc., USA  
**Stefan-van Staden, Raluca-Ioana**, University of Pretoria, South Africa  
**Stefanescu, Dan Mihai**, Romanian Measurement Society, Romania  
**Sumriddetchka, Sarun**, National Electronics and Comp. Technol. Center, Thailand  
**Sun, Chengliang**, Polytechnic University, Hong-Kong  
**Sun, Dongming**, Jilin University, China  
**Sun, Junhua**, Beijing University of Aeronautics and Astronautics, China  
**Sun, Zhiqiang**, Central South University, China  
**Suri, C. Raman**, Institute of Microbial Technology, India  
**Sysoev, Victor**, Saratov State Technical University, Russia  
**Szewczyk, Roman**, Industr. Research Inst. for Automation and Measurement, Poland  
**Tan, Ooi Kiang**, Nanyang Technological University, Singapore  
**Tang, Dianping**, Southwest University, China  
**Tang, Jaw-Luen**, National Chung Cheng University, Taiwan  
**Teker, Kasif**, Frostburg State University, USA  
**Thirunavukkarasu, I.**, Manipal University Karnataka, India  
**Thumbavanam Pad, Kartik**, Carnegie Mellon University, USA  
**Tian, Gui Yun**, University of Newcastle, UK  
**Tsiantos, Vassilios**, Technological Educational Institute of Kaval, Greece  
**Tsigara, Anna**, National Hellenic Research Foundation, Greece  
**Twomey, Karen**, University College Cork, Ireland  
**Valente, Antonio**, University, Vila Real, - U.T.A.D., Portugal  
**Vanga, Raghav Rao**, Summit Technology Services, Inc., USA  
**Vaseashta, Ashok**, Marshall University, USA  
**Vazquez, Carmen**, Carlos III University in Madrid, Spain  
**Vieira, Manuela**, Instituto Superior de Engenharia de Lisboa, Portugal  
**Vigna, Benedetto**, STMicroelectronics, Italy  
**Vrba, Radimir**, Brno University of Technology, Czech Republic  
**Wandelt, Barbara**, Technical University of Lodz, Poland  
**Wang, Jiangping**, Xi'an Shiyou University, China  
**Wang, Kedong**, Beihang University, China  
**Wang, Liang**, Pacific Northwest National Laboratory, USA  
**Wang, Mi**, University of Leeds, UK  
**Wang, Shinn-Fwu**, Ching Yun University, Taiwan  
**Wang, Wei-Chih**, University of Washington, USA  
**Wang, Wensheng**, University of Pennsylvania, USA  
**Watson, Steven**, Center for NanoSpace Technologies Inc., USA  
**Weiping, Yan**, Dalian University of Technology, China  
**Wells, Stephen**, Southern Company Services, USA  
**Wolkenberg, Andrzej**, Institute of Electron Technology, Poland  
**Woods, R. Clive**, Louisiana State University, USA  
**Wu, DerHo**, National Pingtung Univ. of Science and Technology, Taiwan  
**Wu, Zhaoyang**, Hunan University, China  
**Xiu Tao, Ge**, Chuzhou University, China  
**Xu, Lisheng**, The Chinese University of Hong Kong, Hong Kong  
**Xu, Sen**, Drexel University, USA  
**Xu, Tao**, University of California, Irvine, USA  
**Yang, Dongfang**, National Research Council, Canada  
**Yang, Shuang-Hua**, Loughborough University, UK  
**Yang, Wuqiang**, The University of Manchester, UK  
**Yang, Xiaoling**, University of Georgia, Athens, GA, USA  
**Yaping Dan**, Harvard University, USA  
**Ymeti, Aurel**, University of Twente, Netherland  
**Yong Zhao**, Northeastern University, China  
**Yu, Haihu**, Wuhan University of Technology, China  
**Yuan, Yong**, Massey University, New Zealand  
**Yufera Garcia, Alberto**, Seville University, Spain  
**Zakaria, Zulkarnay**, University Malaysia Perlis, Malaysia  
**Zagnoni, Michele**, University of Southampton, UK  
**Zamani, Cyrus**, Universitat de Barcelona, Spain  
**Zeni, Luigi**, Second University of Naples, Italy  
**Zhang, Minglong**, Shanghai University, China  
**Zhang, Quintao**, University of California at Berkeley, USA  
**Zhang, Weiping**, Shanghai Jiao Tong University, China  
**Zhang, Wenming**, Shanghai Jiao Tong University, China  
**Zhang, Xueji**, World Precision Instruments, Inc., USA  
**Zhong, Haoxiang**, Henan Normal University, China  
**Zhu, Qing**, Fujifilm Dimatix, Inc., USA  
**Zorzano, Luis**, Universidad de La Rioja, Spain  
**Zourob, Mohammed**, University of Cambridge, UK

# Contents

Volume 146  
Issue 11  
November 2012

www.sensorsportal.com

ISSN 1726-5479

## Research Articles

- Diffusion in Carbon Nanotubes: Details, Characteristics, Comparisons at Nanolevel**  
*Paolo Di Sia* ..... 1
- Synthesis Characterization and Humidity Sensing Properties of Sol-gel Derived Novel Nanomaterials of  $\text{LaSr}_x\text{Fe}_{1-x}\text{O}_{3-\delta}$**   
*Mary Teresita V., Jeseentharani V., Avila Josephine B., Jeyaraj B., Arul Antony S.* ..... 8
- Gas Sensing Characteristics of ZnO Nanowires Fabricated by Carbothermal Evaporation Method**  
*Roghayeh Imani and Mohammad Orvatinia* ..... 17
- In-Situ Decoration of Electrostatically Functionalized Multiwalled Carbon Nanotubes with  $\beta\text{-Ni(OH)}_2$  Nanoparticles for Low Temperature  $\text{NO}_2$  Detection**  
*Richa Saggar, Vasuda Bhatia, Prashant Shukla, Nitin Bhardwaj, Vinod K Jain* ..... 28
- Synthesis and Characterization of ZnO Nanoparticles as Prepared by Gel-combustion and ZnO Nanomorphologies by Sol-gel**  
*Mario F. Bianchetti, Marjeta Maček-Krzmanc, Ines Bracko, Sreco D. Skapin and Noemi E. Walsøe de Reca* ..... 36
- Multiwalled Carbon Nanotubes Reinforced Cement Composite Based Room Temperature Sensor for Smoke Detection**  
*Prashant Shukla, Vasuda Bhatia, Vikesh Gaur, Nitin Bhardwaj, Vinod Kumar Jain* ..... 48
- A Facile and Green Synthesis of Small Silver Nanoparticles in  $\beta$ -cyclodextrins Performing as Chemical Microreactors and Capping Agents**  
*Giorgio Ventimiglia and Alessandro Motta* ..... 59
- Electrostatically Functionalized Multi-Walled Carbon Nanotubes Based Flexible and Non-Enzymatic Biosensor for Glucose Detection**  
*Bhawana Singh, Vasuda Bhatia, V. K. Jain.* ..... 69
- Amperometric Acetylcholinesterase Biosensor Based on Poly (Diallyldimethylammonium Chloride)/Gold Nanoparticles/Multi-walled Carbon Nanotubes-chitosans Composite Film-modified Electrode**  
*Xia Sun, Zhili Gong, Yaoyao Cao, Xiangyou Wang* ..... 78
- Structural, Morphological and Optical Properties of Spray Deposited Nano-crystalline CdO Thin Films**  
*Maqbul A. Barote, Elahipasha U. Masumdar.* ..... 90
- A Novel Amperometric Immunosensor Based on  $\{\text{MWCNTs-COOH-CHIT}\}_2/\text{GNPs}$  for Detection of Chlorpyrifos**  
*Xia Sun, Lu Qiao, Xiangyou Wang* ..... 96

<b>Y<sup>3+</sup> Added Nanocrystallite Mg-Cd Ferrite LPG, Cl<sub>2</sub> and C<sub>2</sub>H<sub>5</sub>OH Sensors</b> <i>Ashok B. Gadkari, Tukaram J. Shinde, Pramod N. Vasambekar.....</i>	110
<b>Immunosensor Based on Gold Nanoparticles-multi-walled Carbon Nanotubes-chitosans Composite and Prussian Blue for Detection of Chlorpyrifos</b> <i>Xia Sun, Falan Li, Xiangyou Wang.....</i>	121
<b>Nanostructured CdFe<sub>2</sub>O<sub>4</sub> Thick Film Resistors as Ethonal Gas Sensors</b> <i>S. V. Bangale, R. D. Prakshale, S. R. Bamane.....</i>	133
<b>A Novel Combustion Route for the Preparation of Nanocrystalline LaAlO<sub>3</sub> Oxide Based Electronic Nose Sensitive to NH<sub>3</sub> at Room Temperature</b> <i>K. A. Khamkar, S. V. Bangale, V. V. Dhapte, D. R. Patil, S. R. Bamane.....</i>	145
<b>Gold Nanoparticle Amplification Combined with Quartz Crystal Microbalance DNA Based Biosensor for Detection of <i>Mycobacterium Tuberculosis</i></b> <i>Thongchai Kaewphinit, Somchai Santiwatanakul and Kosum Chansiri.....</i>	156
<b>Structural, Morphological and Optical Properties of Spray Deposited Nanocrystalline ZnO Thin Films: Effect of Nozzle to Substrate Distance</b> <i>Elahipasha U. Masumdar, Maqbul A. Barote.....</i>	164
<b>Zinc and Pyrrole-added Akaganeite (<math>\beta</math>-FeOOH) Films by Ultrasonic Spray Pyrolysis Assessed as Propane Sensors</b> <i>Carlos Torres Frausto, Alejandro Avila-Garcia.....</i>	170
<b>Potentiometric Determination of Low Content of Water in Different Organic Solvents Using NASICON Based Probe</b> <i>Parul Yadav and M. C. Bhatnagar.....</i>	182
<b>Development of Electrochemical Sensors for the Detection of Mercury by CNT/Li<sup>+</sup>, C<sub>60</sub>/Li<sup>+</sup> and Activated Carbon Modified Glassy Carbon Electrode in Blood Medium</b> <i>Muhammed M. Radhi, Dawood S. Dawood, Nawfal K. Al-Damlooji and Tan W. Tee.....</i>	191

Authors are encouraged to submit article in MS Word (doc) and Acrobat (pdf) formats by e-mail: [editor@sensorsportal.com](mailto:editor@sensorsportal.com)  
Please visit journal's webpage with preparation instructions: <http://www.sensorsportal.com/HTML/DIGEST/Submission.htm>

International Frequency Sensor Association (IFSA).

**Promoted by IFSA**

## Gyroscopes and IMUs for Defense, Aerospace & Industrial Report up to 2017

This report highlights market share analysis by application field and technology,  
as well as global company shipments and technology breakdown

**Order online:**  
[http://www.sensorsportal.com/HTML/Gyroscopes\\_and\\_IMUs\\_markets.htm](http://www.sensorsportal.com/HTML/Gyroscopes_and_IMUs_markets.htm)



The Fourth International Conference on Sensor Device Technologies and Applications

## SENSORDEVICES 2013

25 - 31 August 2013 - Barcelona, Spain

**Tracks:** Sensor devices - Ultrasonic and Piezosensors - Photonics - Infrared - Gas Sensors - Geosensors - Sensor device technologies - Sensors signal conditioning and interfacing circuits - Medical devices and sensors applications - Sensors domain-oriented devices, technologies, and applications - Sensor-based localization and tracking technologies - Sensors and Transducers for Non-Destructive Testing

**Deadline for papers: 30 March 2013**

<http://www.iaria.org/conferences2013/SENSORDEVICES13.html>



The Seventh International Conference on Sensor Technologies and Applications

**Deadline for papers:  
30 March 2013**

## SENSORCOMM 2013

25 - 31 August 2013 - Barcelona, Spain

**Tracks:** Architectures, protocols and algorithms of sensor networks - Energy, management and control of sensor networks - Resource allocation, services, QoS and fault tolerance in sensor networks - Performance, simulation and modelling of sensor networks - Security and monitoring of sensor networks - Sensor circuits and sensor devices - Radio issues in wireless sensor networks - Software, applications and programming of sensor networks - Data allocation and information in sensor networks - Deployments and implementations of sensor networks - Under water sensors and systems - Energy optimization in wireless sensor networks

<http://www.iaria.org/conferences2013/SENSORCOMM13.html>



The Sixth International Conference on Advances in Circuits, Electronics and Micro-electronics

## CENICS 2013

25 - 31 August 2013 - Barcelona, Spain

**Deadline for papers: 30 March 2013**

**Tracks:** Semiconductors and applications - Design, models and languages - Signal processing circuits - Arithmetic computational circuits - Microelectronics - Electronics technologies - Special circuits - Consumer electronics - Application-oriented electronics

<http://www.iaria.org/conferences2013/CENICS13.html>

## Nanostructured CdFe<sub>2</sub>O<sub>4</sub> Thick Film Resistors as Ethanol Gas Sensors

\* S. V. BANGALE, R. D. PRAKSHALE, S. R. BAMANE

Metal Oxide Research, Laboratory, Department of Chemistry,  
Dr. Patangrao Kadam Mahavidyalaya, Sangli, 416416 (M.S.) India

Tel.: 0233-2535993, fax: 0233-2535993

\* E-Mail: [bangale\\_sv@rediffmail.com](mailto:bangale_sv@rediffmail.com)

*Received: 6 April 2012 /Accepted: 23 November 2012 /Published: 30 November 2012*

---

**Abstract:** Semiconductive nanoparticles of CdFe<sub>2</sub>O<sub>4</sub> were synthesized by a solution combustion technique. This process is a convenient, environment friendly, inexpensive and efficient for the preparation of CdFe<sub>2</sub>O<sub>4</sub> nanomaterial. The synthesized material is characterized by Thermo gravimetric Differential analysis (TG/DTA), X-ray Diffraction studied (XRD), Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM) techniques. Conductance response of the nanocrystalline CdFe<sub>2</sub>O<sub>4</sub> thick film is measured by exposing the film to reducing gases like ethanol, acetone, ammonia, H<sub>2</sub>S and hydrogen. The sensor exhibited a fast response and a good recovery. The results demonstrated that CdFe<sub>2</sub>O<sub>4</sub> can be used as a gas-sensing material which has a high sensitivity and good selectivity to ethanol gas at 200 ppm. *Copyright © 2012 IFSA.*

**Keywords:** CdFe<sub>2</sub>O<sub>4</sub>, TEM, Ethanol gas sensor, Thick film, Gas response.

---

### 1. Introduction

Semiconductor metal oxides as gas sensing materials have been extensively studied for a long time due to their advantageous features, such as good sensitivity to the ambient conditions and simplicity in fabrication [1-10]. Nevertheless, there are still some critical limitations to be overcome for the commercial sensors based on particulate or thin-film semiconductor metal oxides, such as limited maximum sensitivity, high working temperatures and lack of long-term stability. Recently, several groups reported the sensors based on semiconductor nanowires and nanoribbons. Ethanol-sensing material has been widely and deeply studied. Conventional ethanol sensors, mostly based on SnO<sub>2</sub>

[11], ZnO [12], TiO<sub>2</sub> [13], and Fe<sub>2</sub>O<sub>3</sub> [14], and usually suffering from cross-response to other gases, need a high working temperature, or have low long-term stability, although they have rather high response to ethanol. So the research for new ethanol-sensing materials and developing the properties of conventional ethanol sensing materials has become an active research field. New ethanol sensors are based on In<sub>2</sub>O<sub>3</sub> [15], V<sub>2</sub>O<sub>5</sub> [16], and complex oxide [17-21]. Their properties still need further investigation. Ethanol is explosively utilized for beverages, industrial and scientific sectors. Ethanol is a hypnotic [22] gas having toxic nature. Heavy exposure and/or consumption of alcoholic beverages, particularly by smokers, increase the risk of cancer [23-24] of the upper respiratory and digestive tracks. Alcoholic cirrhosis leads to liver cancer. Amongst the women, the chance of breast cancer increase with alcoholic consumption or exposure. Those working on ethanol synthesis have great chances of being victims of respiratory and digestive track cancer. So there is a great demand and emerging challenges for monitoring ethanol gas at trace level.

In this paper, we have synthesized CdFe<sub>2</sub>O<sub>4</sub> nanoparticles by novel combustion reaction. One of our aims is to develop a general synthesis method and explore the gas sensing properties of the CdFe<sub>2</sub>O<sub>4</sub> nanopowder. We found that the process is a convenient, environment friendly, inexpensive and efficient. Furthermore, the CdFe<sub>2</sub>O<sub>4</sub> obtained possesses excellent gas-sensing responses to reducing gas and grain size is about 50-100 nm. This discovery could aid in the synthesis of low cost and CdFe<sub>2</sub>O<sub>4</sub> is outstanding in promoting the sensing properties of C<sub>2</sub>H<sub>5</sub>OH in air.

## **2. Materials and Methods**

### **2.1. Materials**

All the reagents are of analytical grade and are used as received without further purification. Cadmium nitrate [Cd(NO<sub>3</sub>)<sub>2</sub>·6H<sub>2</sub>O], iron nitrate [Fe(NO<sub>3</sub>)<sub>2</sub>·6H<sub>2</sub>O], citric acid are purchased from Sigma-Aldrich chemical reagents Co. (USA).

### **2.2. Methods**

For the present study, polycrystalline CdFe<sub>2</sub>O<sub>4</sub> powder was prepared by combustion route using Citric acid as fuel. The materials used as precursors were Cadmium nitrate hexahydrate Cd (NO<sub>3</sub>)<sub>2</sub> · 6H<sub>2</sub>O, Fe (NO<sub>3</sub>)<sub>2</sub>·6H<sub>2</sub>O Iron nitrate hexahydrate (all these were procured from A.R. Grade of Qualligen) and Citric acid (Nuclear band). Citric acid possesses a high heat of combustion. It is an organic fuel and provides a platform for redox reactions during the course of combustion. Initially the Cadmium nitrates, Iron nitrates and Citric acid are taken in the 1:1:4 stoichiometric amount and dissolved in a 250 ml beaker then slowly string by using glass rod then clear solution was obtained. Solution formed was evaporated on hot plate in temperature range 70 °C to 80 °C gives thick gel. The gel was kept on a hot plate for auto combustion and heated in the temperature range 170 °C to 180 °C. The nanocrystalline CdFe<sub>2</sub>O<sub>4</sub> powder was formed within 40-50 minutes. And then sintered at about 800 °C for about 4 hours then we got brown colour shining powder of nanocrystalline CdFe<sub>2</sub>O<sub>4</sub>.

### **2.3. Thick Film Formation**

Cadmium ferrites powder was ground in an agate pastel-moter to ensure sufficiently fine particle size. The fine powder was calcined at 800 °C for 24 h in air and re-ground. The thixotropic paste was formulated by mixing the resulting CdFe<sub>2</sub>O<sub>4</sub> fine powder with a solution of ethyl cellulose (a temporary binder) in a mixture of organic solvents such as butyl carbitol acetate, and turpineol. The ratio of inorganic and organic path was kept as 75:25 in formulating the paste. The paste was then used

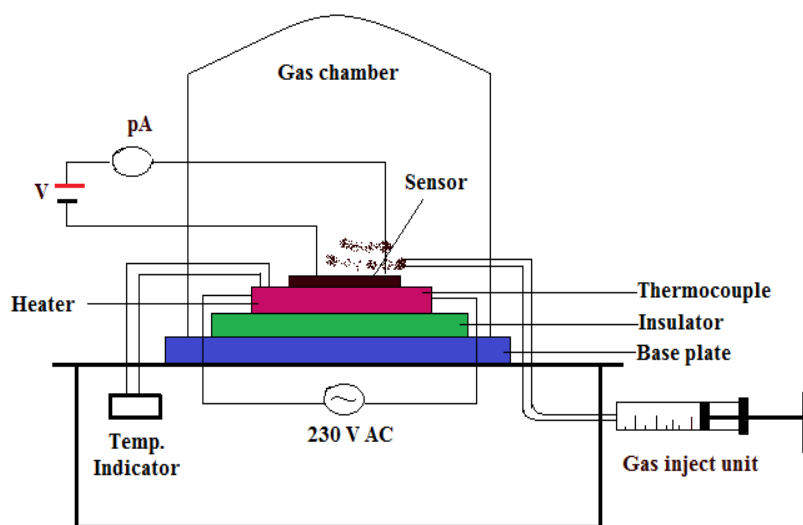
to prepare thick films. The thixotropic paste was screen printed on a glass substrate in desired patterns. The films prepared were fired at 500 °C for 24 h.

## 2.4. Characterization Techniques

The as –prepared samples were characterized by TG/DTA thermal analyzer (SDT Q600 V 20.9 Build 20), XRD Philips Analytic X-ray B.V. (PW-3710 Based Model diffraction analysis using Cu-K $\alpha$  radiation), scanning electron microscope (SEM, JEOL JED 2300) A JEOL JEM–200 CX transmission electron microscope operating at 200 kV analysis.

## 2.5. Fabrication and Analysis of Gas Sensors

The sensing performance of the sensors was examined using a “static gas-sensing system. There were electrical feeds through the base plate. The heating was constant on the base plate to heat the sample under test up to required operating temperatures. The current passing through the heating element was monitored using a relay with adjustable ON/OFF time intervals. A Cr-Al thermocouple was used to sense the operating temperature of the sensors. The output of the thermocouple was connected to digital temperature indicators. A gas inlet valve was fitted at one port of the base plate. The required gas concentration inside the static system was achieved by injecting a known volume of test gas using a gas-injecting syringe. A constant voltage was applied to the sensors, and current was measured by a digital Pico-ammeter. Air was allowed to pass into the glass dome after every Gases exposure cycle as shown in Fig. 1.



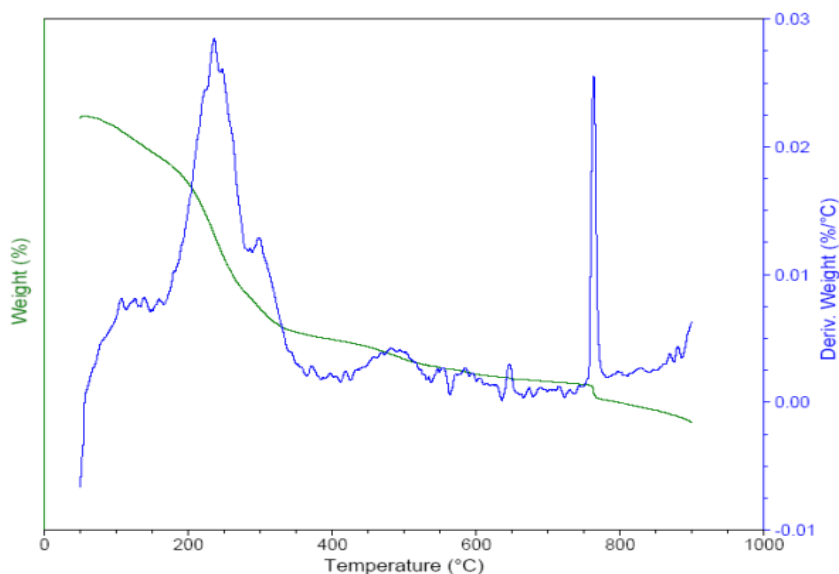
**Fig. 1.** Block diagram of static gas sensing setup.

## 3. Result and Discussion

### 3.1. TG-DTA Analysis

The TG curve recorded for thermal decomposition of CdFe<sub>2</sub>O<sub>4</sub> is shown in Fig. 2. The curve indicates that the slight weight loss in CdFe<sub>2</sub>O<sub>4</sub> powder due to little loss of moisture, carbon dioxide and nitrogen gas. The DTA curve of CdFe<sub>2</sub>O<sub>4</sub> recorded in static air, curve shows that CdFe<sub>2</sub>O<sub>4</sub> did not decompose, but weight loss was due to dehydrogenation decarboxylation and denitration and yield

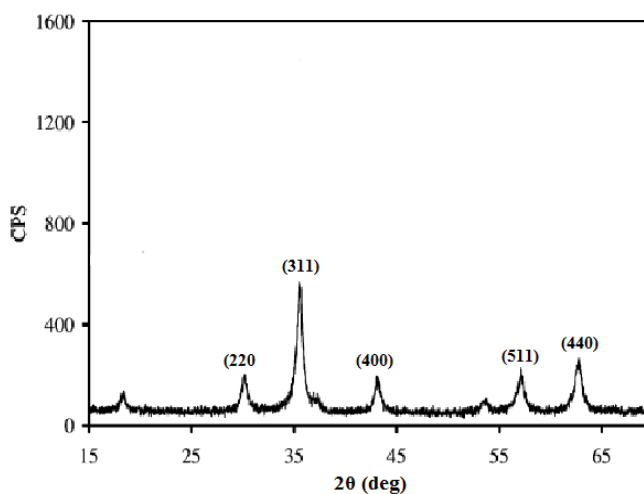
final product at 775 °C. This weight loss and weight gained was very negligible. This weight change was in the range of 0.02 % only. These indicate that the synthesized powder was almost stable from the beginning.



**Fig. 2.** TG - TDA curve of CdFe<sub>2</sub>O<sub>4</sub> as synthesized powder.

### 3.2. X-Ray Diffraction Studies

The XRD pattern shown in the Fig. 3. The XRD pattern shows that the product is pure spinel oxide CdFe<sub>2</sub>O<sub>4</sub> with a cubic structure. The diffraction data are good agreement with JCPD card of CdFe<sub>2</sub>O<sub>4</sub> (JCPDS No.24-1016) The average crystalline size of CdFe<sub>2</sub>O<sub>4</sub> spinel powder was estimated with the help of Scherrer's equation  $t = 0.9\lambda / \beta \cos\theta$  [25-28] where  $t$  is the thickness of the crystals (in angstroms),  $\lambda$  is the X-ray wavelength and  $\theta$  is the Bragg angle  $\beta$  is the integral breath that depends on the width of the most predominant peak at 100% intensity = 1.54056 Å. The average particle size of nanocrystalline CdFe<sub>2</sub>O<sub>4</sub> was ~ 48 nm. CdFe<sub>2</sub>O<sub>4</sub> nanocrystals are more attractive in the field of gas sensing application.



**Fig. 3.** X-ray diffraction patterns of CdFe<sub>2</sub>O<sub>4</sub> as synthesized powder.

### 3.3. Particle Size Analysis

Particle size distribution studies have been carried out by using dynamic light scattering techniques (DLS) Via Laser input energy of 632 nm). It was observed that cadmium iron oxide nanoparticles have narrow size distribution within the range of about 30-50 nm (Fig. 4), which are similar to the values calculated from Scherrer equation.

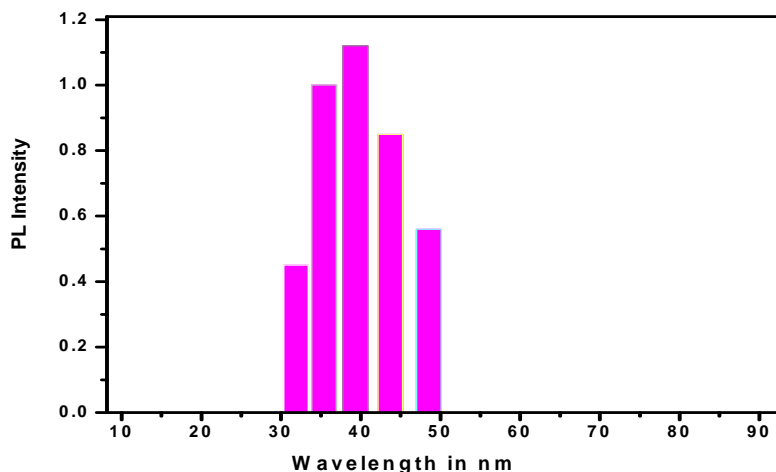


Fig. 4. Particle size Distribution of mixed precursor  $\text{CdFe}_2\text{O}_4$  at  $800^\circ\text{C}$  in air for 4 h.

### 3.4. SEM Analysis

The microstructure of the  $800^\circ\text{C}$  sintered samples can be visualized from scanning electron microscope (SEM) tool. Fig. 5 depicts SEM images of  $\text{CdFe}_2\text{O}_4$  powder it shown the particle morphology of high resolution the particle are most irregular in shape with a nanosized range of 80-150 nm some particles are found as agglomerations containing very fine particles. It can be observed that  $\text{CdFe}_2\text{O}_4$  have uniformed size. It seems that surfaces are smooth, spongy and pores are seen in the micrograph.

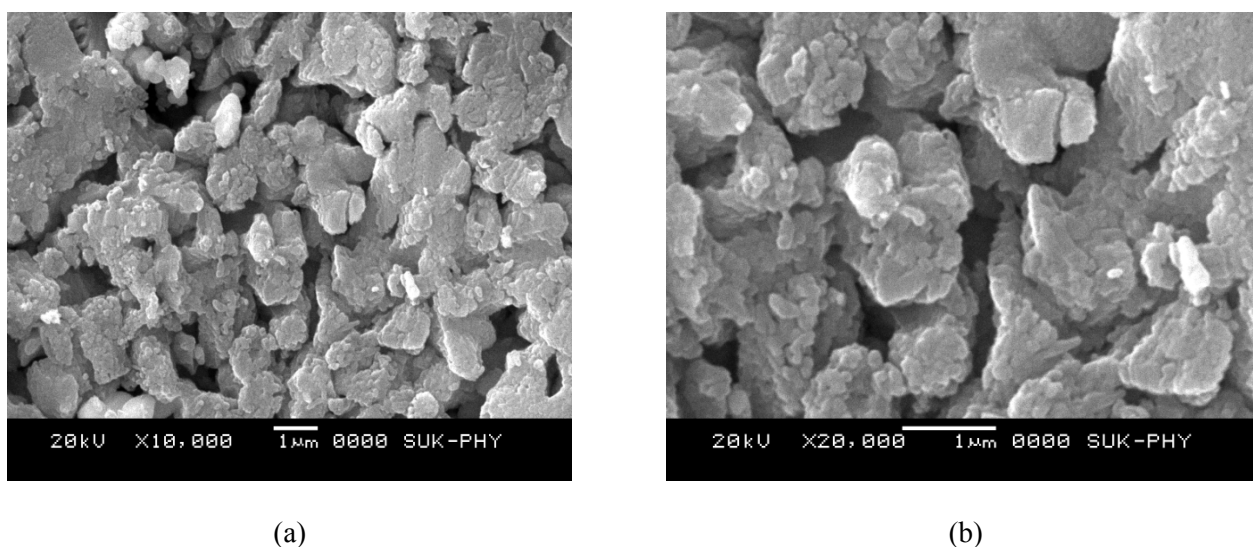
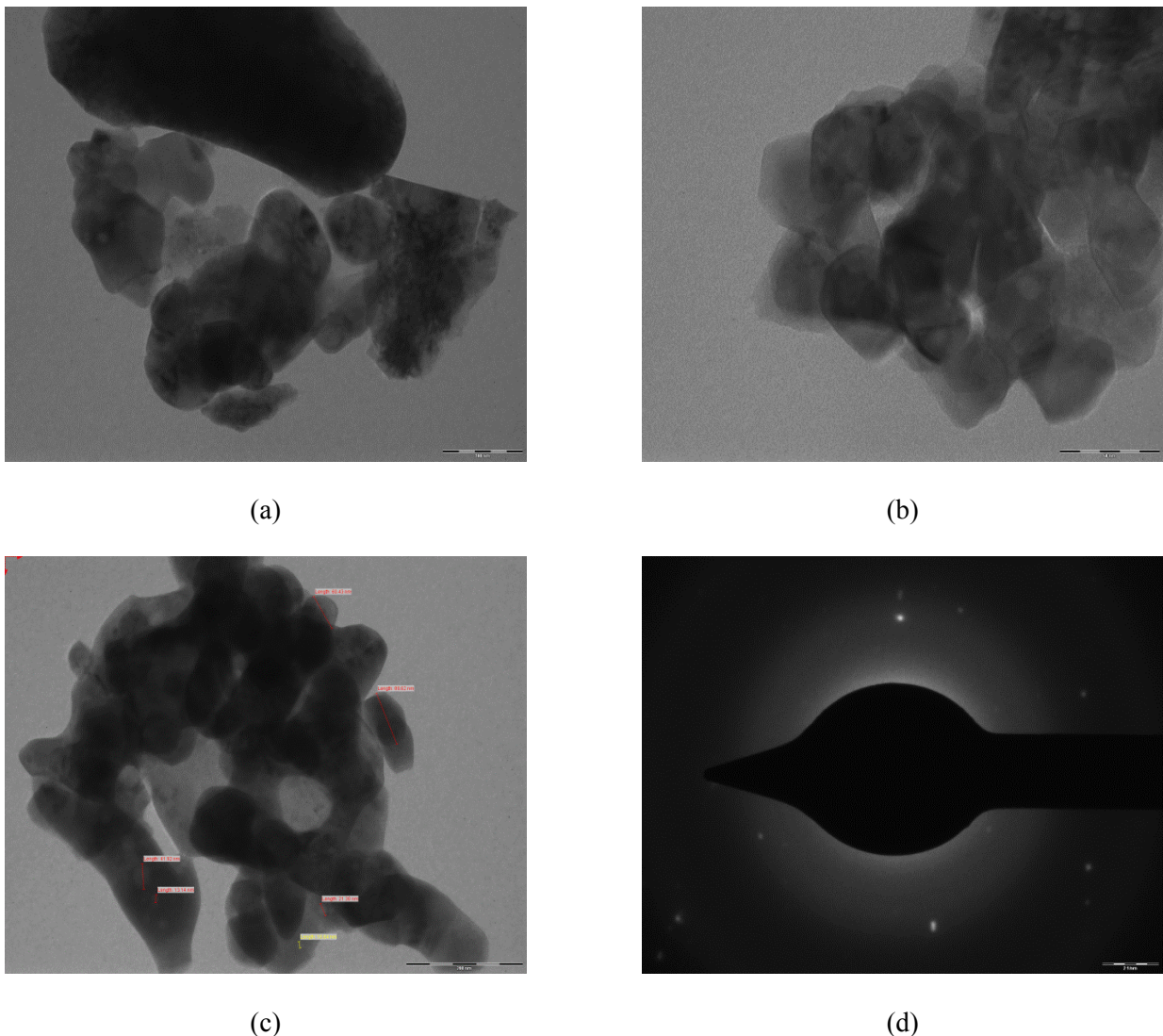


Fig. 5. SEM images of mixed precursor  $\text{CdFe}_2\text{O}_4$  at  $800^\circ\text{C}$  in air for 4 h (a) low resolution, and (b) high resolution.

### 3.5. TEM Analysis

Fig. 6 (a, b) show TEM micrographs of the specimens calcined at 800 °C, respectively. It can be seen that calcining temperature has an obvious influence on morphology for samples. The 800 °C sample consists of spheroidic grains with narrow size distribution ( $60 \pm 100$  nm), whereas 800 °C sample is composed of small grains with various shapes due to the coexistence of multi-phases. According to the result from XRD, however, we consider that the spheroidic particles ( $\sim 50$  nm in size) mainly distributed in the left and right sides of Fig. 6(c) belong to the phase of CdO; whereas the aggregates with smaller grain size located in the centre of Fig. 3 (a) is a mixture of CdFe<sub>2</sub>O<sub>4</sub>. The selected area electron diffraction (SAED) pattern Fig. 6 (d) shows the spot type pattern which is indicative of the presence of single crystallite particles. No evidence was found for more than one pattern, suggesting the single phase native of the material.



**Fig. 6.** TEM (a, b, c) images of mixed precursor CdFe<sub>2</sub>O<sub>4</sub> (b) SAED pattern.

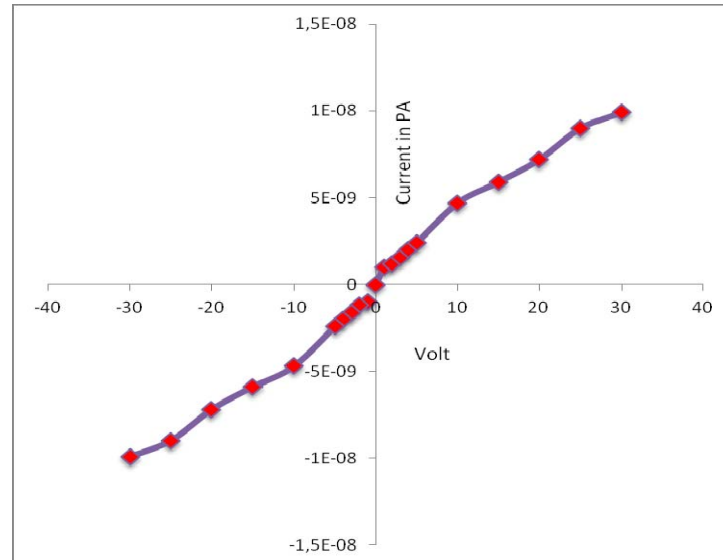
### 3.6. Thickness Measurement

The thicknesses of the films were observed to be in the range from 25-35 $\mu$ m. The reproducibility of the film thickness was achieved by maintaining the proper rheology and thixotropy of the paste.

## 4. Electrical Properties of Sensor

### 4.1. I-V Characteristics

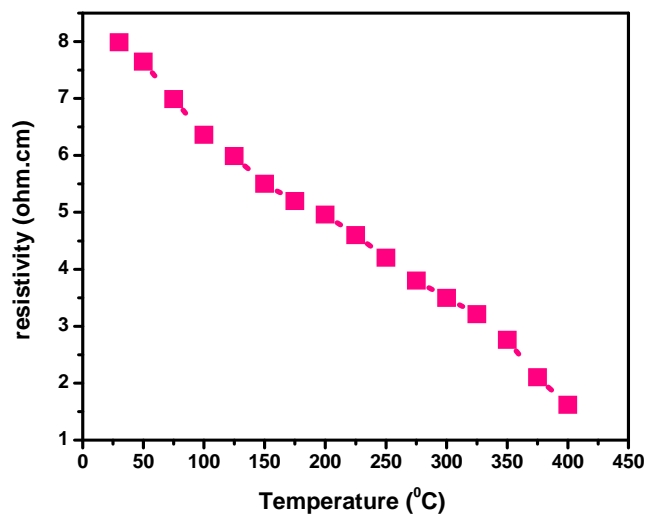
Fig. 7 depicts I-V characteristics of CdFe<sub>2</sub>O<sub>4</sub> films. It is clear from the symmetrical I-V characteristics that the silver contacts on the films were ohmic in nature. The voltage applied was in the range 1-30 V.



**Fig. 7.** I-V characteristics of the sensor.

### 4.2. Electrical Conductivity

The variation of resistivity CdFe<sub>2</sub>O<sub>4</sub> with temperature is shown in Fig. 8 and it was found that the resistivity of CdFe<sub>2</sub>O<sub>4</sub> sample decreases with operating temperature. The decreases in resistivity with increasing temperature could be attributed to negative temperature coefficient of resistance and semiconducting nature of CdFe<sub>2</sub>O<sub>4</sub>. It is observed from Fig. 8 that the electrical resistivity of the CdFe<sub>2</sub>O<sub>4</sub> films is nearly linear in the temperature range from 50-400 °C in ambient air.



**Fig. 8.** Resistivity-temperature profiles of CdFe<sub>2</sub>O<sub>4</sub>.

## 5. Sensing Performance of Sensor

### 5.1. Gas Response, Selectivity, Response and Recovery Time

The relative response (S) to a target gas is defined as the ratio of the change in conductance of a sample upon exposure of the gas to the original conductance in air, which can be calculated by following equation.

$$S = \frac{G_g - G_a}{G_a},$$

where  $G_a$  is the conductance in air, and  $G_g$  is the conductance in a sample gas. Specificity or selectivity is defined as the ability of a sensor to respond to a certain gas in the presence of different gases. Response time (RST) is defined as the time requires for a sensor to attain 90 % of the maximum increases in conductance on exposure to the target gas. Recovery time (RCT) is the time taken to get back 90 % of the original conductance in air.

### 5.2. Sensing Performance of CdFe<sub>2</sub>O<sub>4</sub> Thick Films

#### 5.2.1. Response of Sensors to Various Gases

The response of CdFe<sub>2</sub>O<sub>4</sub> sample variation for different gases with operating temperature is represented in Fig. 9. It is clear from the figure that the gas responses goes on increasing and attain to their respective maxima and decreased further with increase in operating temperatures. It is clear from the figure that the CdFe<sub>2</sub>O<sub>4</sub> shows the largest response to ethanol vapours at 350 °C.

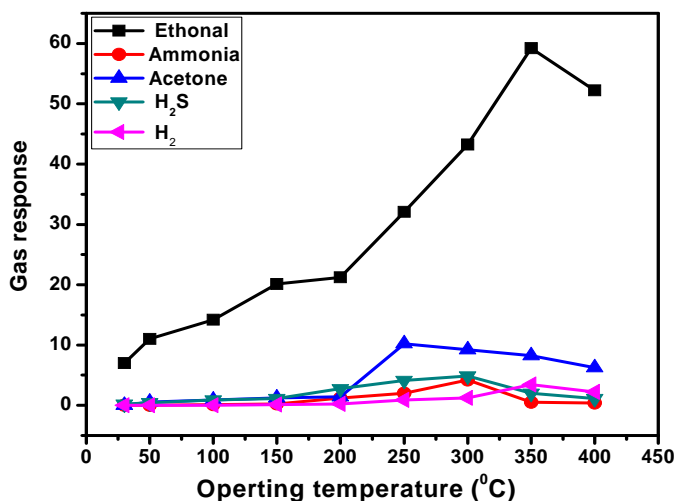
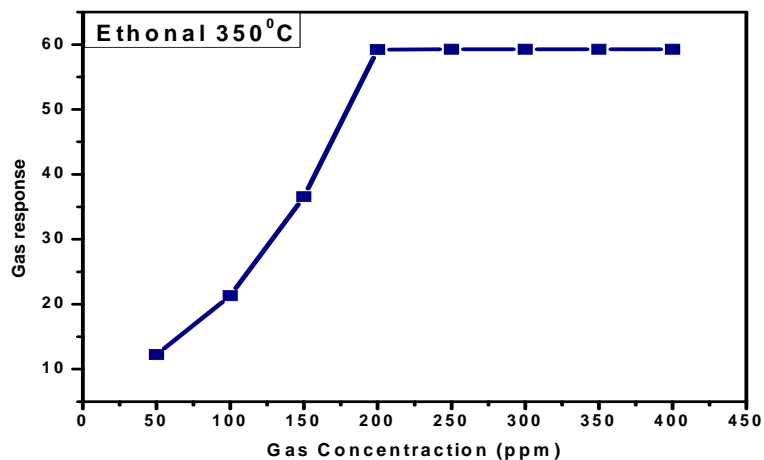


Fig. 9. Variation for different gas responses with operating temperatures.

#### 5.2.2. Active Region of Sensor

Fig. 10. depicts the variation of gas response of CdFe<sub>2</sub>O<sub>4</sub> sample with ethanol vapour concentrations. It is clear from the figure that the gas response goes on increasing linearly with gas concentration up to 200 ppm and saturated beyond it. The rate of increase in gas response was relatively larger up to 200 ppm. The monolayer of the gas molecules formed on the surface could cover the whole surface of

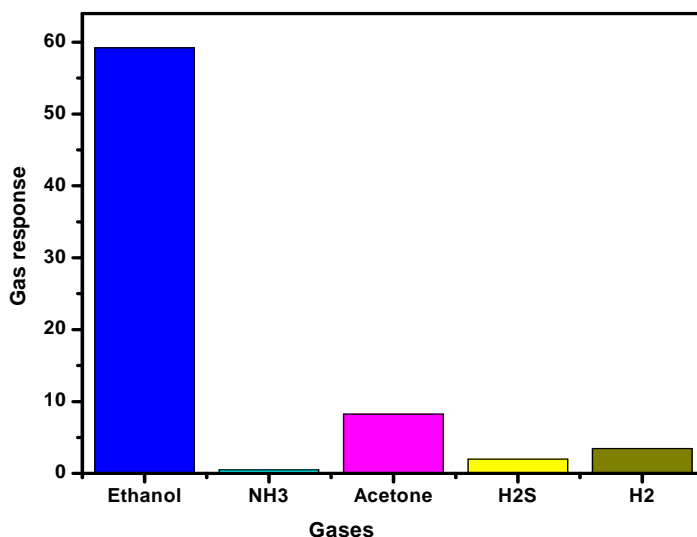
the film. The gas molecules from that layer would reach the surface active sites of the film. The excess gas molecules would remain idle and would not reach surface active site of the sensor. So, the gas response at higher concentrations of the gas is not expected to increase further in large extent. Thus, the active region of the sensor would be up to 200 ppm.



**Fig. 10.** Variation of gas response with gas concentration.

### 5.2.3. Selectivity Factors of CdFe<sub>2</sub>O<sub>4</sub> for Various Gases

It is observed from Fig. 11. That the CdFe<sub>2</sub>O<sub>4</sub> sensors give maximum response to ethanol vapours (200 ppm) at 350 °C. The sensors showed highest selectivity for ethanol against all other tested gases Acetone, H<sub>2</sub>S, H<sub>2</sub> and NH<sub>3</sub>.



**Fig. 11.** Selectivity factor of sensor for various gases.

### 5.2.4. Response and Recovery Time

Fig. 12 depicts the response and recovery of CdFe<sub>2</sub>O<sub>4</sub> sensor are the response was quick (~ 40 s) to 200 ppm of ethanol, while the recovery was fast (~ 50 s). The quick response may be due to faster

oxidation of gas. The negligible quantity of the surface reaction product and its high volatility explains its quick response and fast recovery to its initial chemical status.

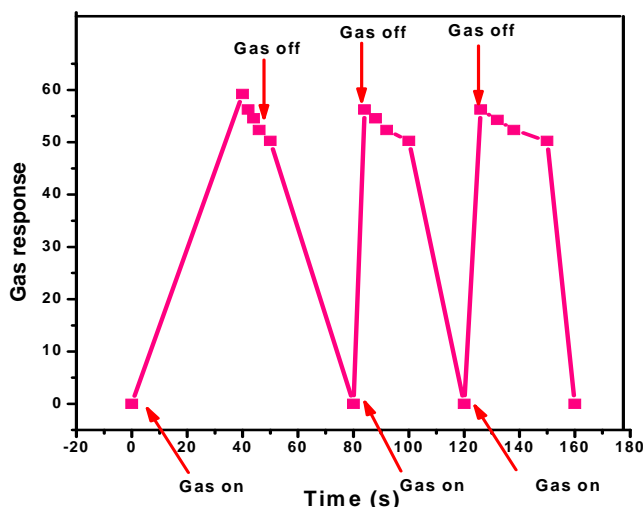
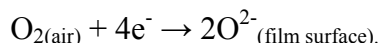


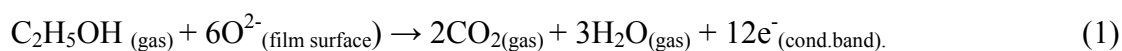
Fig. 12. Response and recovery of the sensors.

## 6. Discussion

The working principle of the thick film semiconducting gas sensors is based on the change of the electronic conductivity of the semiconducting material upon exposure to ethanol vapours. The interaction of ethanol gas molecules with surface of thick film causes the transfer of electrons between semiconducting surface and adsorbents. The atmospheric oxygen molecule  $O_2$  is adsorbed on the surface of the thick film. They capture the electrons from conduction band of the thick film material as



It results in decreasing electronic conductivity of the film. The  $CdFe_2O_4$  sample was not as per the stoichiometric proportion and all samples were observed to be oxygen-deficient. This deficiency gets reduced due to adsorption of atmospheric molecular oxygen. This helps to decrease electronic conductivity of the film. Upon exposure, ethanol molecules get oxidized with the adsorbed oxygen ions, by following a series of intermediate stages, producing  $CO_2$  and  $H_2O$ . This results in evolving oxygen as electrically neutral atoms trapping behind the negative charges on the film surface. Upon exposure of ethanol gas, the energy released in decomposition of ethanol molecule would be sufficient for trapped electron to jump increase in the conductivity of the thick film of  $CdFe_2O_4$ . These generated electrons and donor level in the energy band gap of  $CdFe_2O_4$  will contribute to increase in conductivity. When ethanol reacts with oxygen a complex series of reactions take place, ultimately converting the ethanol to carbon dioxide and water as follows



This shows n-type conduction mechanism. Thus on oxidation, single molecule of ethanol liberates twelve electrons (1) in conduction band and results in increase in conductivity of the sensors. Increase in operating temperature causes oxidation of large number of ethanol molecules, thus producing very large number of electron resulting conductivity increases to a large extent. This may be the reason why the gas response increases with operating temperature. The thermal energy (temperature) at which the gas response is maximum, is the actual thermal energy needed to activate the material for progress in

reaction. However, the response decreases at higher operating temperature, as the oxygen adsorbates are desorbed from the surface of the sensor. Also, at higher temperature, the carrier concentration increases due to intrinsic thermal excitation and the Debye length decreases. This may be one of the reasons for decreased gas response at higher temperature.

## 7. Conclusions

From the study, following conclusions can be made for the sensing performance of the sensors.

- (I) Nanocrystalline  $\text{CdFe}_2\text{O}_4$  has synthesized by self combustion route. This synthesis route may be used for the synthesis of other metal oxide.
- (II) The phase formation of the  $\text{CdFe}_2\text{O}_4$  is investigated by TG-DTA, XRD, TEM techniques. The synthesized product shows single phase of inverse spinel structure with an average diameter 50-100 nm.
- (IV) Among all other additives tested,  $\text{CdFe}_2\text{O}_4$  is outstanding in promoting the ethanol gas sensing mechanism.
- (V)  $\text{CdFe}_2\text{O}_4$  to be optimum and showed highest response to ethanol vapours at 350 °C.
- (VI) The sensor showed very rapid response (~ 40s) and gives recovery (~ 50s) to ethanol vapours.
- (VII) Sensing mechanism of  $\text{CdFe}_2\text{O}_4$  was the substitution of lattice oxygen by ethanol gas. Material gains electrons in this substitution.
- (VIII) The sensor has good selectivity to ethanol against, Acetone,  $\text{H}_2\text{S}$ ,  $\text{NH}_3$  and  $\text{H}_2$ ,

## Acknowledgement

The author S. V. Bangale is thankful to director IIT Bombay for providing the TEM facility.

## References

- [1]. K. Byrappa, M. Yoshimura, Handbook of Hydrothermal Technology, *Noyes Publications*, New Jersey, USA, 2001.
- [2]. Z. V. Marinkovic, L. Mancic, P. Vulic, O. Milosevic, The influence of mechanical activation on the stoichiometry and defect structure of a sintered  $\text{ZnO-Cr}_2\text{O}_3$  system, *Mater. Sci.*, 453, 2004, pp. 456-461.
- [3]. S. Levy, D. Diella, V. Pavese, A. Dapiaggi, M. Sani, A P-V equation of state, thermal expansion, and P-T stability of synthetic ( $\text{ZnCr}_2\text{O}_4$  spinel), *Am. Mineral.* 90, 2005, pp. 1157-1167.
- [4]. X. Niu, W. Du, W. Du, Preparation and gas sensing properties of  $\text{ZnM}_2\text{O}_4$  (M = Fe, Co, Cr) *Sens. Actuators B*, 99, 2004, pp. 405-415.
- [5]. R. G. Chandran, K. C. Patil, A rapid method to prepare crystalline fine particle chromite powder, *Mater. Lett.*, 12, 1992, pp. 437-450.
- [6]. Z. V. Marinkovic, L. Mancic, R. Maric, O. Milosevic, Preparation of nanostructure Zn-Cr-O spinel powder by Ultrasonic spray pyrolysis, *J. Eur. Ceram. Soc.*, 21, 2001, pp. 2051-2067.
- [7]. S. V. Bangale, D. R. Patil and S. R. Bamane, Nanostructured Spinel  $\text{ZnFe}_2\text{O}_4$  for the Detection of Chlorine Gas, *Sensors & Transducers*, Vol. 134, Issue 11, November 2011, pp. 107-119.
- [8]. S. V. Bangale, S. M. Khetre, D. R. Patil and S. R. Bamane, Simple Synthesis of  $\text{ZnCo}_2\text{O}_4$  Nanoparticles as Gas-sensing Materials, *Sensors & Transducers*, Vol. 134, Issue 11, November 2011, pp. 95-106.
- [9]. S. V. Bangale, S. R. Bamane, Nanostructured  $\text{MgFe}_2\text{O}_4$  Thick Film Resistors as Ethanol Gas Sensors Operable at Room Temperature, *Sensors & Transducers*, Vol. 137, Issue 2, February 2012, pp. 176-188.
- [10]. D. R. Patil, L. A. Patil, Ammonia Sensing Resistors Based on  $\text{Fe}_2\text{O}_3$ -Modified ZnO of ZnO Based Thick Film Sensor to  $\text{NH}_3$  at Room Temperature, *Sens. Actuators B*, 120, 2006, pp. 316.
- [11]. T. Siyama, A. Kato, A new detector for gaseous components using semiconductor thin film, *Anal. Chem.*, 34, 1962, pp. 1502-1503.
- [12]. T. Jinkawa, G. Sakai, J. Tamaki, N. Miura, N. Yamazoe, *J. Mol. Catal. A: Chem.*, 155, 2000, pp. 193.

- [13].F. Paraguay, J. Morales, W. Estrada, E. Andrade, M. Miki-Yoshida, *Thin Solid films*, 373, 2000, pp. 137.
- [14].C. Garzella, E. Bontempi, L. E. Depero, A. Vomiero, G. Della Mea, G. Sberveglieri, *Sens. Actuators B*, 93, 2003, pp. 495.
- [15].C. V. G. Reddy, W. Cao, O. K. Tan, W. Zhu, *Sens. Actuators B*, 81, 2002, p. 170.
- [16].V. S. Vaishnav, P. D. Patel, N. G. Patel, Measurement of the dc resistance of semiconductor thin film–gas systems: Comparison to several transport models, *Thin Solid Films*, 490, 2005, p. 94.
- [17].J. F. Liu, X. Wang, Q. Peng, Y. D. Li, Vanadium Pentoxide Nanobelts: Highly Selective and Stable Ethanol Sensor Materials, *Adv. Mater.*, 17, 2005, pp. 764.
- [18].J. Liu, X. Wang, Q. Peng, Y. Li, Vanadium Pentoxide Nanobelts: Highly Selective and Stable Ethanol Sensor Materials, *Advanced Materials*, 17, 2005, pp. 764-767.
- [19].Zhang Tianshu, P. Hing, Zhang Jiancheng, Kong Lingbing, Ethanol-sensing characteristics of cadmium ferrite prepared by chemical coprecipitation, *Materials Chemistry and Physics*, 61, 1999, pp. 192-198.
- [20].Xiangdong Lou, Shuping Liu , Dongyang Shi , Wenfei Chu, Ethanol-sensing characteristics of CdFe<sub>2</sub>O<sub>4</sub> sensor prepared by sol–gel method, *Materials Chemistry and Physics*, 105, 2007, pp. 67–70.
- [21].Fengxiu Miao, Zanhong Deng, Xianshun L, Guixin Gu, Songming Wan, Xiaodong Fang, Qingli Zhang, Shaotang Yin, Fundamental properties of CdFe<sub>2</sub>O<sub>4</sub> semiconductor thin film, *Solid State Communications*, 150, 2010, pp. 2036–2039.
- [22].Y. L. Liu, Z. M. Liu, Y. Yang, H. F. Yang, G. L. Shen, R. Q. Yu, *Sens. Actuators B*, 107, 2005, pp. 600.
- [23].G. H. Sodhi, Fundamental Concepts of environmental Chemistry, *Narosa Publishing House*, New Delhi, 2002, p. 135.
- [24].C. Xiangfeng, L. Xinggin and M. Guangyao, *Sens. Actuators B*, Vol. 65, 2000, pp. 64
- [25].S. V. Bangale, S. R. Bamane, Preparation and Study of H<sub>2</sub>S Gas Sensing Behavior of ZnFe<sub>2</sub>O<sub>4</sub> Thick Film Resistors, *Sensors & Transducers*, Vol. 137, Issue 2, February 2012, pp. 123-136.
- [26].S. V. Bangale, S. M. Khetre and S. R. Bamane, Synthesis, characterization and hydrophilic properties of nanocrystalline ZnFe<sub>2</sub>O<sub>4</sub> oxide, *Archives of Applied Science Research*, 3, 2011, pp. 471-479.
- [27].Sachin V. Bangale and S. R. Bamane, Synthesis characterization and electrical properties of nanocrystalline ZnMgO by combustion route, *Der Chemica Sinica*, 2, 2011, pp. 22-29.
- [28].Sachin V. Bangale, D. R. Patil and S. R. Bamane, Preparation and electrical properties of nanocrystalline MgFe<sub>2</sub>O<sub>4</sub> oxide by combustion route, *Archives of Applied Science Research*, 3, 2011, pp. 506-513.

---

2012 Copyright ©, International Frequency Sensor Association (IFSA). All rights reserved.  
(<http://www.sensorsportal.com>)



**Promoted by IFSA**

**MEMS : Uncooled Infrared Imaging:  
Commercial & Military Applications  
Report up to 2017**

Market forecasts till 2017 with in-depth analysis of commercial and military markets is provided, along with a description of the main active players and the latest technological evolutions and future trends.

**Order online:**  
[http://www.sensorsportal.com/HTML/Detectors\\_for\\_Thermography.htm](http://www.sensorsportal.com/HTML/Detectors_for_Thermography.htm)

## Guide for Contributors

---

### Aims and Scope

*Sensors & Transducers Journal* (ISSN 1726-5479) provides an advanced forum for the science and technology of physical, chemical sensors and biosensors. It publishes state-of-the-art reviews, regular research and application specific papers, short notes, letters to Editor and sensors related books reviews as well as academic, practical and commercial information of interest to its readership. Because of it is a peer reviewed international journal, papers rapidly published in *Sensors & Transducers Journal* will receive a very high publicity. The journal is published monthly as twelve issues per year by International Frequency Sensor Association (IFSA). In addition, some special sponsored and conference issues published annually. *Sensors & Transducers Journal* is indexed and abstracted very quickly by Chemical Abstracts, IndexCopernicus Journals Master List, Open J-Gate, Google Scholar, etc. Since 2011 the journal is covered and indexed (including a Scopus, Embase, Engineering Village and Reaxys) in Elsevier products.

### Topics Covered

Contributions are invited on all aspects of research, development and application of the science and technology of sensors, transducers and sensor instrumentations. Topics include, but are not restricted to:

- Physical, chemical and biosensors;
- Digital, frequency, period, duty-cycle, time interval, PWM, pulse number output sensors and transducers;
- Theory, principles, effects, design, standardization and modeling;
- Smart sensors and systems;
- Sensor instrumentation;
- Virtual instruments;
- Sensors interfaces, buses and networks;
- Signal processing;
- Frequency (period, duty-cycle)-to-digital converters, ADC;
- Technologies and materials;
- Nanosensors;
- Microsystems;
- Applications.

### Submission of papers

Articles should be written in English. Authors are invited to submit by e-mail [editor@sensorsportal.com](mailto:editor@sensorsportal.com) 8-14 pages article (including abstract, illustrations (color or grayscale), photos and references) in both: MS Word (doc) and Acrobat (pdf) formats. Detailed preparation instructions, paper example and template of manuscript are available from the journal's webpage: <http://www.sensorsportal.com/HTML/DIGEST/Submission.htm> Authors must follow the instructions strictly when submitting their manuscripts.

### Advertising Information

Advertising orders and enquires may be sent to [sales@sensorsportal.com](mailto:sales@sensorsportal.com) Please download also our media kit: [http://www.sensorsportal.com/DOWNLOADS/Media\\_Kit\\_2012.pdf](http://www.sensorsportal.com/DOWNLOADS/Media_Kit_2012.pdf)



# International Frequency Sensor Association Publishing Call for Books Proposals

Sensors, MEMS, Measuring instrumentation, etc.



## Benefits and rewards of being an IFSA author:

1

### Royalties

Today IFSA offers most high royalty in the world: you will receive 50 % of each book sold in comparison with 8-11 % from other publishers, and get payment on monthly basis compared with other publishers' yearly basis.

2

### Quick Publication

IFSA recognizes the value to our customers of timely information, so we produce your book quickly: 2 months publishing schedule compared with other publishers' 5-18-month schedule.

3

### The Best Targeted Marketing and Promotion

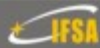
As a leading online publisher in sensors related fields, IFSA and its Sensors Web Portal has a great expertise and experience to market and promote your book worldwide. An extensive marketing plan will be developed for each new book, including intensive promotions in IFSA's media: journal, magazine, newsletter and online bookstore at Sensors Web Portal.

4

### Published Format: printable pdf (Acrobat).

When you publish with IFSA your book will never go out of print and can be delivered to customers in a few minutes.

You are invited kindly to share in the benefits of being an IFSA author and to submit your book proposal or/and a sample chapter for review by e-mail to [editor@sensorsportal.com](mailto:editor@sensorsportal.com). These proposals may include technical references, application engineering handbooks, monographs, guides and textbooks. Also edited survey books, state-of-the-art or state-of-the-technology, are of interest to us. For more detail please visit: [http://www.sensorsportal.com/HTML/IFSA\\_Publishing.htm](http://www.sensorsportal.com/HTML/IFSA_Publishing.htm)



International Frequency Sensor Association (IFSA) Publishing

## Digital Sensors and Sensor Systems: Practical Design

Sergey Y. Yurish



Formats: printable pdf (Acrobat) and print (hardcover), 419 pages

ISBN: 978-84-616-0652-8,  
e-ISBN: 978-84-615-6957-1

The goal of this book is to help the practitioners achieve the best metrological and technical performances of digital sensors and sensor systems at low cost, and significantly to reduce time-to-market. It should be also useful for students, lectures and professors to provide a solid background of the novel concepts and design approach.

### Book features include:

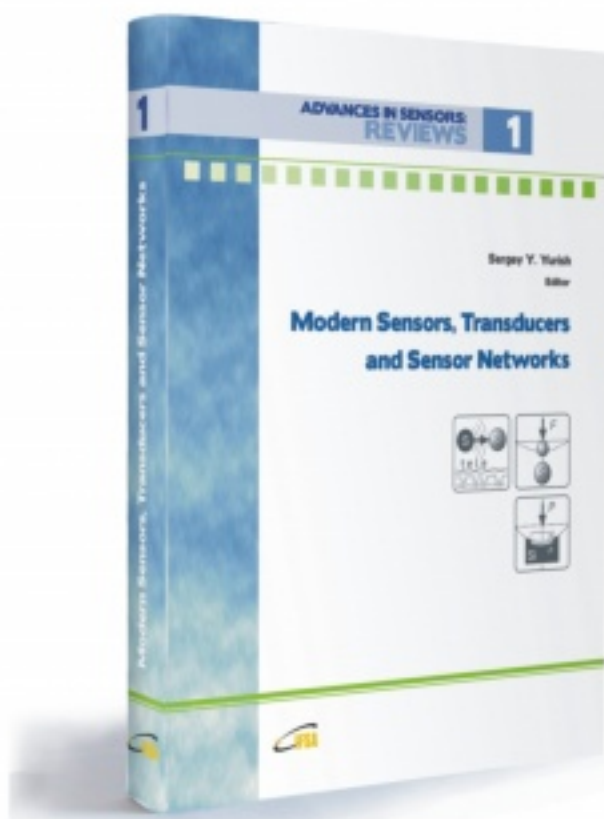
- Each of chapter can be used independently and contains its own detailed list of references
- Easy-to-repeat experiments
- Practical orientation
- Dozens examples of various complete sensors and sensor systems for physical and chemical, electrical and non-electrical values
- Detailed description of technology driven and coming alternative to the ADC a frequency (time)-to-digital conversion

*Digital Sensors and Sensor Systems: Practical Design* will greatly benefit undergraduate and at PhD students, engineers, scientists and researchers in both industry and academia. It is especially suited as a reference guide for practitioners, working for Original Equipment Manufacturers (OEM) electronics market (electronics/hardware), sensor industry, and using commercial-off-the-shelf components

[http://sensorsportal.com/HTML/BOOKSTORE/Digital\\_Sensors.htm](http://sensorsportal.com/HTML/BOOKSTORE/Digital_Sensors.htm)

**Sergey Y. Yurish**  
Editor

## Modern Sensors, Transducers and Sensor Networks



*Modern Sensors, Transducers and Sensor Networks* is the first book from the Advances in Sensors: Reviews book Series contains dozen collected sensor related state-of-the-art reviews written by 31 internationally recognized experts from academia and industry.

Built upon the series Advances in Sensors: Reviews - a premier sensor review source, the *Modern Sensors, Transducers and Sensor Networks* presents an overview of highlights in the field. Coverage includes current developments in sensing nanomaterials, technologies, MEMS sensor design, synthesis, modeling and applications of sensors, transducers and wireless sensor networks, signal detection and advanced signal processing, as well as new sensing principles and methods of measurements.

*Modern Sensors, Transducers and Sensor Networks* is intended for anyone who wants to cover a comprehensive range of topics in the field of sensors paradigms and developments. It provides guidance for technology solution developers from academia, research institutions, and industry, providing them with a broader perspective of sensor science and industry.

Order online:

[http://sensorsportal.com/HTML/BOOKSTORE/Advance\\_in\\_Sensors.htm](http://sensorsportal.com/HTML/BOOKSTORE/Advance_in_Sensors.htm)



[www.sensorsportal.com](http://www.sensorsportal.com)