ISSN 1726-5479

# SENSORS & TRANSDUCERS

vol. 147
12/12


## Sensor Market Trends

International Frequency Sensor Association Publishing

IFSA

# Sensors & Transducers

**Volume 147, Issue 12**
**December 2012**

**www.sensorsportal.com**

**ISSN 1726-5479**



**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, Universitá 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,** Nothern 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, Vygantas**, 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 Monitors 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,** Universitaire 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
**Djordjevich, Alexandar,** 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
**Granel, 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 Alcala, 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
**Kaniusas, 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, Nezih,** 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
**Raoof, 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 Politecnica de Catalunya, Spain
**Rodriguez, Angel**, Universidad Politecnica de Cataluna, 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**, Bhbha 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
**Sankarraj, Anand**, Detector Electronics Corp., USA
**Silva Girao, 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, Qintao,** 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

Sensors & Transducers Journal (ISSN 1726-5479) is a peer review international journal published monthly online by International Frequency Sensor Association (IFSA).
Available in electronic and on CD. Copyright © 2012 by International Frequency Sensor Association. All rights reserved.

Sensors & Transducers Journal

# Contents

Volume 147
Issue 12
December 2012

www.sensorsportal.com

ISSN 1726-5479

## Research Articles

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

International Frequency Sensor Association (IFSA).

IFSA International Frequency Sensor Association (IFSA) Publishing

**Digital Sensors and Sensor Systems: Practical Design**

**Sergey Y. Yurish**


The goal of this book is to help the practicians 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

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

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

*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 practicians, 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

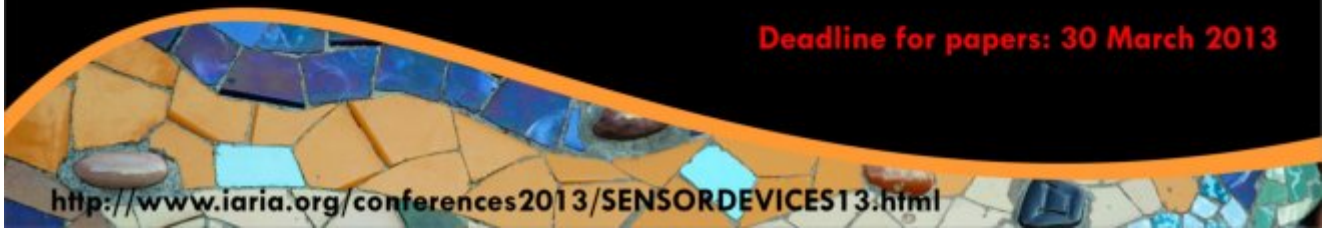
The Fourth International Conference on Sensor Device Technologies and Applications

# 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

*Sensors & Transducers Journal, Vol. 147, Issue 12, December 2012, pp. 95-107*

www.sensorsportal.com

**Sensors & Transducers**

**ISSN 1726-5479**
© 2012 by IFSA
*http://www.sensorsportal.com*

# Design and Development of an Instrument to Determine the Fluoride Ion Concentration in Certain Tooth Pastes

**Saraswathi PARIGI, * Sreelekha KANDE, * Nagaraju BOYA, * Raghavendra Rao KANCHI**

Department of Physics, S.D.G.S. College, Hindupur-515 202, Andhra Pradesh, India

* Electronics Laboratory, Department of Physics, Sri Krishnadevaraya University, Anantapur-515 055, Andhra Pradesh, India

E-mail: sreelekha2009@gmail.com, rajnaren5@gmail.com

*Received: 13 September 2012 /Accepted: 18 December 2012 /Published: 31 December 2012*

**Abstract:** The decline of dental caries in the industrialized countries can be attributed to wide spread use of fluorides. The Indian market share of dentifrices containing fluorides has increased day to day. For a fluoride dentifrice to the effective in the control of dental caries, and adequate concentration of the fluoride must be soluble. Several Indian fluoride dentifrices have in their packages as non – fluoridated tooth pastes and also in their formulations calcium phosphate as abrasive, which may react with fluoride. This study was designed to evaluate the determination of fluoride ion concentration in certain tooth pastes using the PC in the most consumed dentifrices in India. The fluoride ion concentration in certain tooth pastes was determined using the spectroscopic method and by using the PC. All dentifrices showed similar concentrations of total fluoride in all samples in accordance with the Indian legislation (Fluoride content of 1000 ppm). Some dentifrices showed in their packages as non- fluoridated tooth pastes. Although most of the Indian fluoridated dentifrices evaluated in this study contain fluoride they were found to have sufficient concentrations of fluoride ion to be effective in preventing dental caries. *Copyright © 2012 IFSA.*

**Keywords:** Tooth pastes, Optical fibre, Cuvette, Optical sensor, PC, DIOT Card.

## 1. Introduction

The prevalence of dental caries in developed countries has declined over the past several decades [1]. Several studies are in agreement that the main reason for the reduction of carries is the greater

availability of fluoride in the oral environment, particularly the increasing use of fluoridated dentifrice over the last 25 years [2].

In most western industrialized countries, the percentage of fluoridated dentifrices of all dentifrice sales is above 90 % with an upward trend. However, in order for the dentifrice to be efficient, it is important the fluoride is soluble in the formulation and it is regularly present in the oral cavity, so it can interfere with the phenomena of enamel – dentine demineralization and demineralization.

The Indian market share of dentifrices containing fluorides, such as sodium Mono Fluoro Phosphate (MFP) or Sodium Fluoride, has increased from 12 % in 1985 to 77 % in 2006. Until 1994, the market share of fluoridated tooth pastes were only 46 % but after the addition of fluoride into the most Popular Indian Tooth Pastes have in their formulations Declaim Phosphate as an abrasive, which may react with fluoride ions released from MFP.

The Indian legislation establishes the maximum fluoride content to be 1000 ppm which is permitted in a dentifrice. However the concentration of fluoride contained in the dentifrice is not indicated on the package.

Flora fluoridated dentifrice to be effective in controlling dental caries, and adequate concentration of fluoride must be soluble. The soluble forms of fluoride are able to interfere with the dynamics of the caries process, reducing the demineralization and activating the demineralization of dentine and enamel. Some forms of fluoride may link to the abrasive contained in the dentifrice formulation. Thus the total concentration of fluoride is not the concentration of the soluble and active fluoride contained in the Toothpaste.

The US Food and Drug Administration required that the soluble fluoride ion for NaF tooth pastes and soluble $F^-$ ions for MEP tooth pastes shall not be less than 60 % of the total fluoride content. The Standards Association of Australia and the European Community have laid down rules for the minimum amount of soluble fluoride that must be present in fluoride Tooth paste, throughout its shelf life. These rules require that at least 60 % of the total fluoride content be present as a soluble ion either as $F^-$ or $Po_3^{-4}$, $F_2^-$. The later ion is rapidly hydrolyzed in the mouth to provide F-. However some hydrolysis occurs slowly from the time of manufacture and combines with abrasive or other tooth paste constituents to form insoluble compounds so that the total soluble fluoride concentration falls with time. The minimum requirement for the anti-caries effect of a dentifrice is based on the available and stable fluoride in the formulation. However only the Indian legislation establishes the maximum fluoride to be 0.10 % to 0.15 % without specifying quality.

The measurement of fluoride ion is necessary in different fields of work. The fluoride ion is necessary to know the concentration levels in natural water since low fluorine i.e. < 1 ppm plays an important role in humans in the development of healthy bones and teeth. The estimation of fluoride ion gives valuable information. Therefore it is necessary to analyze the fluoride ion and to take proper and optimum precautions.

No doubt, several investigators developed techniques for the measurements for different ion concentrations in different samples and several manufacturers are producing a variety of instruments for estimation of ions [4]. But the attempts to design and develop the computer based integrated system for determination of fluoride ion in tooth paste is rather scarce particularly in India though they offer many advantages. Hence in the present study an attempt is made to design a computer based instrument for determination of fluoride ion concentration in tooth pastes. No studies about the percentage of fluoride ion concentration in Indian dentifrices were found in the literature survey, for justifying this study.

## 2. Experimental Setup

The block diagram of a PC based fluoride ion concentration measurement system used in the present work is shown in Fig. 1. It consists of the following:

1. Regulated power supply;
2. LED;
3. Sample holder;
4. Optical sensor (photo diode);
5. Feedback PD amplifier;
6. Data acquisition card;
7. PC.

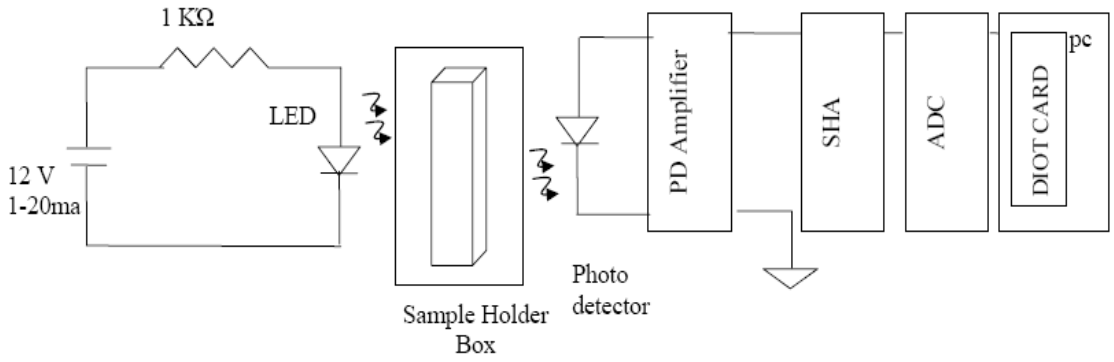



**Fig. 1.** Block diagram of PC based fluoride ion concentration measurement system.

### 2.1. Regulated Power Supply

A d.c power supply which maintains output voltage constant irrespective of a.c. mains fluctuations or load variations is known as regulated d.c. power supply. The regulated power supply is constructed in the laboratory using the standard components.

### 2.2. LED

In the present study LED [3] is used to emit the light and then incident on the solution through optical fibre. Light emitting diode (LED) is a semiconductor diode that emits incoherent narrow- spectrum light when electrically biased in the forward direction of the P-N Junction. This effect is a form of electro luminescence. An LED is usually a small area source often with extra optics added to the chip that shapes its radiation pattern.

The color of the emitted light depends on the composition and condition of the semi conducting material used, and can be infrared, visible or near – ultraviolet. An LED can be used as a regular house hold light source.

### 2.3. Sample Holder

In the present study cuvettes [4] are used for the purpose of filling the sample and blanks solutions. A cuvette is a kind of laboratory glass ware, usually a small tube of circular or square cross section,

scaled at one end, made of plastic glass or optical grade quartz and designed to hold samples for spectroscopic experiments. The set up was mounted on box and cuvette is inserted from the top face, sides opposite faces are connected with LED and photo detector and remaining face is closed. Total set up covered with a black photographic film.

## 2.4. Optical Sensor (Photo Diode)

Devices that convert the signal into electric form e.g. vacuum photo detectors, thermal detectors PIN junction photo detectors, photo transistors, photo resistors. In the present study, pin photo diode is used, as a detector.

## 2.5. Feedback PD Amplifier

Trans impedance Feedback Photo detector amplifier [5] is used for converting an input current signal which has AC and DC component from a photo diode into an output voltage. The input current signal varies, by producing a constant current source for supplementing the DC feedback current. Fig. 2 shows the feedback PD amplifier used in the present study. This comprises a photodiode, an operational amplifier and feedback network. At the input photodiode receives the current $I_{pd}$, the amplifier converts the input current $I_{pd}$ producing a differential output voltage $V_{out}$. The linearization is accomplished by the feedback network including feedback amplifier, low pass filter combination and a bypass circuit.

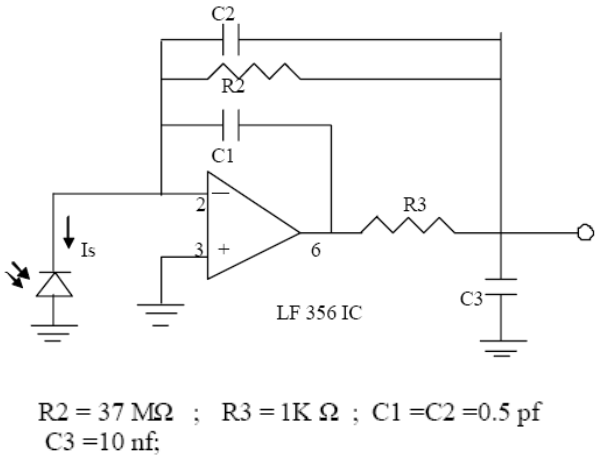



**Fig. 2.** Feedback PD amplifier.

## 2.6. Data Acquisition Card

In the present study, Data acquisition card (ALS – PL -02) is used [6]. It has ADC/DAC digital input /out puts compatible to XT/AT PC. This card provides 12 bit A/D conversion facility, jumper selectable 8 differential / 16 single ended channel, 12 bit D/A conversion facility (2 channels) and 48 programmable parallel input lines. All these features are required for designing a PC based fluoride ion concentration measurement system. In this scenario DIOT card is used in the present work. Fig. 3 shows the photograph of the DIOT card used in the present work.


**Fig. 3.** Photograph of the DIOT card.

### 2.7. Personal Computer

The output voltage coming from the feedback PD amplifier was measured by using PC through the Data acquisition card. The technique developed in the present study need extra plug in cards such as DIOT card [7]. Interfacing of the external hardware with PC was accomplished by DIOT card.

## 3. Method

The instrument requires a high brightness LED, regulated 12V power supply together with a series combination of a 510 Ω resistor and a 10 kΩ potentiometer was used as current source for the LED [8]. The current can be adjusted in the 1-20 mA range, assuming a $V_f$=1.8 V. A digital multimeter was included to adjust the current accurately. The 510Ω resistor sets the maximum current available and must always be included to avoid permanent damage to the LED due to an excessive current passing through it.

For a flexible operation, the emitted light was conducted through a fibre optic. A Polymeric type fibre with a 1 mm diameter was selected because of its low cost and low loss at the working wavelengths. The fibre is covered with a black polyethylene cladding. A homemade plastic coupling was use to join the fibre to the LED. The detector used was a light to voltage optical sensor this is a very small combining a photodiode and a transimpedence amplifier with a 16 MΩ integrated feedback resistor on a single IC. In appearance it is similar to a conventional low power transistor also having three leads used as ground, power supply and output.

The voltage signal produced by the incident light on the photo diode was read by the computer through the interfacing network. Soft ware is run to get the results. Thus intensity data are the primary data obtained. To transform these data into absorbance, a logarithmic transformation is needed, taking into account the well known relation of the primary data to the final absorbance values are obtained from the equation (1).

$$A = \log \{(E_0 - E_\infty) \div (E - E_\infty)\}, \quad (1)$$

where
E= is the potential measured with the sample placed into cell holder;
$E_0$= is the potential measured with the reference solution;
$E_\infty$ = is the potential in the absence of light.

## 4. Preparation of Tooth Pastes Solution and Determination of Fluoride Ion Concentration

0.5690 gm of tooth paste sample was weighed and dissolved in few CC'S of water in a beaker 5 to 6 drops of con $HN0_3$ or sulphuric acid is added to the solution. The mixture is boiled thoroughly for few minutes and cooled. The solution is carefully transferred into 250 ml standard flask. The contents in the breaker are washed and once again transferred & removed. The solution in the 250 ml standard flask is made up to the mark with double distilled water. Stopper is placed and the solution is shaken thoroughly to get a solution of uniform concentration. This solution is taken as reference standard solution of 0.1 M concentration [9]. Solutions of various concentrations are prepared by applying the principle of dilution. These solutions are taken in cuvettes. The voltage signal produced by the incident light on the photodiode was read by the computer, Thus intensity data are the primary data obtained. To transfer these data into absorbance a logarithmic transformation is needed.

The experimental results are plotted as absorbance versus volume. Absorbance data were calculated from the voltage measurements, and according to equation (1). A Good straight line is obtained in the tested interval indicating the method can be successfully follows the Beer's law, in spite of the fact that the deviation are expected when the radiation used is not monochromatic. The percentage of the fluoride is evaluated according to the graph. The same procedure is applied for all tooth pastes.

### 4.1. Preparation of Sodium Fluoride

A stock solution of sodium fluoride is prepared by dissolving 4.199 gm of sodium of fluoride in one litre distilled water to get a solution of 0.1 molar concentrations. The molecular weight of sodium fluoride is 41.99 gm. 41. 99 gm of sodium fluoride in 1000 ml is equal to 1 molar. 1000 ml of 1 molar contains 19 gm of fluoride in 1 liter. 0.1 molar contains 1.9 gm of fluoride in 1 liter. A stock solution 0.1 molar concentration is prepared by dissolving 1.05 gm of sodium fluoride in 250 ml standard flask by double distilled water. The solutions of various concentrations are prepared by applying the principle of dilution ($m_1v_1 = m_2 v_2$).

### 4.2. Statistical Analysis

The software is developed in "C" language in getting the voltage values for different concentrations of different tooth pastes. The absorbance values are observed in PC. The flow chart of 'C'program developed in the present work is given in Fig. 4.

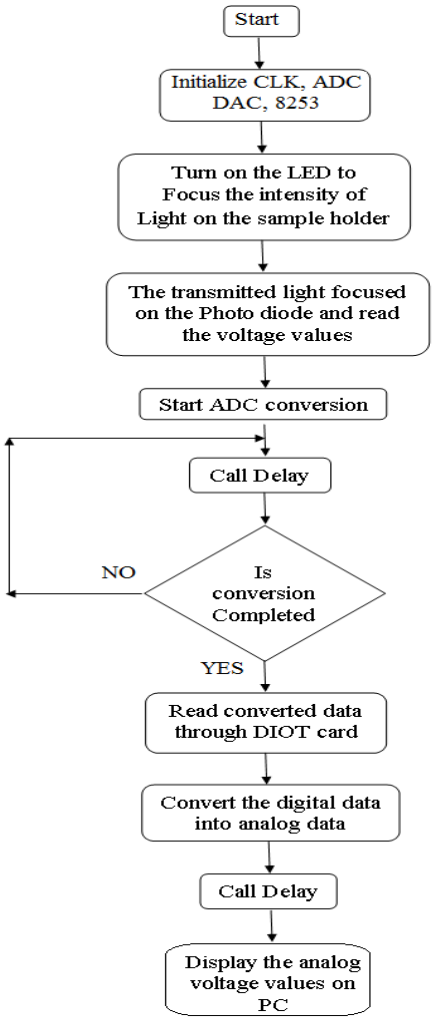



**Fig. 4.** Flow Chart.

## 5. Results

Experimental results are shown in tables 1-7 and figures 5-10.

**Table 1.** Pepsodent.

Estimation:
0.5690 -100 ml - 0.1 M
1.4225 -250 ml - 0.1 M
$E_0$ = -104.1 mV

| S.no | Volume | Voltage (e) | Voltage ($e_\infty$) | Absorbence |
|---|---|---|---|---|
| 1. | 10 | -99.9 | 1.5 | 0.0176 |
| 2. | 20 | -95.8 | 1.5 | 0.0352 |
| 3. | 30 | -91.5 | 1.5 | 0.0528 |
| 4. | 40 | -87.7 | 1.5 | 0.0704 |
| 5. | 50 | -83.6 | 1.5 | 0.088 |
| 6. | 60 | -79.9 | 1.5 | 0.1056 |

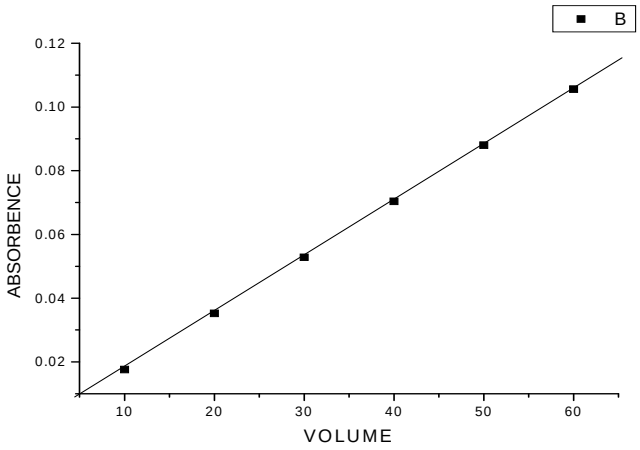



**Fig. 5.** Graph of Pepsodent tooth paste.

**Table 2.** Dabur Red.

Estimation:
0.5690 gm - 100 ml -0.1 M
1.4225 gm – 100 ml - 0.1 M
$E_0$ = -76.4 mV

| S.no | Volume | Voltage (e) | Voltage ($e_\infty$) | Absorbence |
|---|---|---|---|---|
| 1. | 10 | -72.3 | 1.5 | 0.02348 |
| 2. | 20 | -68.0 | 1.5 | 0.04696 |
| 3. | 30 | -64.4 | 1.5 | 0.07044 |
| 4. | 40 | -61.0 | 1.5 | 0.09392 |
| 5. | 50 | -57.9 | 1.5 | 0.1174 |
| 6. | 60 | -54.9 | 1.5 | 0.14088 |

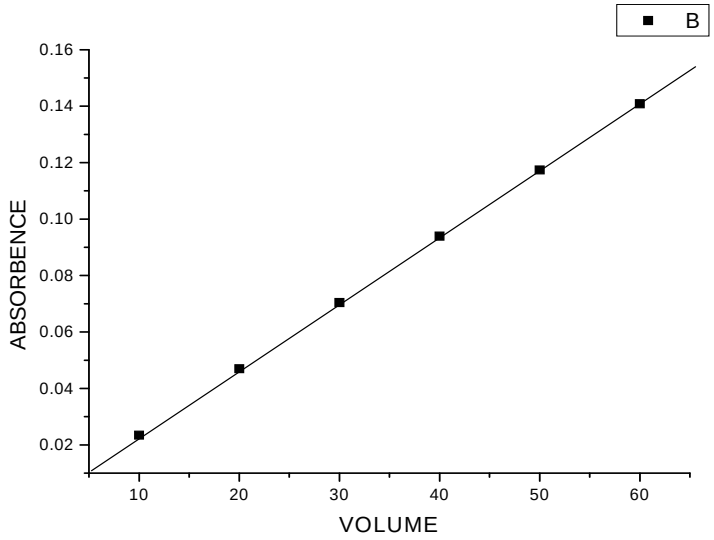



**Fig. 6.** Graph of Dabur Red tooth paste.

**Table 3.** Colgate.

Estimation:
0.5690 gm - 100 ml - 0.1M
1.4225 gm - 100 ml - 0.1 M
$E_0$ = -104.1 mV

| S.no | Volume | Voltage (e) | Voltage ($e_\infty$) | Absorbence |
|---|---|---|---|---|
| 1. | 10 | -97.9 | 1.5 | 0.02627 |
| 2. | 20 | -92 | 1.5 | 0.05285 |
| 3. | 30 | -86.6 | 1.5 | 0.0786 |
| 4. | 40 | -81.3 | 1.5 | 0.1056 |
| 5. | 50 | -76.5 | 1.5 | 0.1315 |
| 6. | 60 | -72 | 1.5 | 0.1573 |

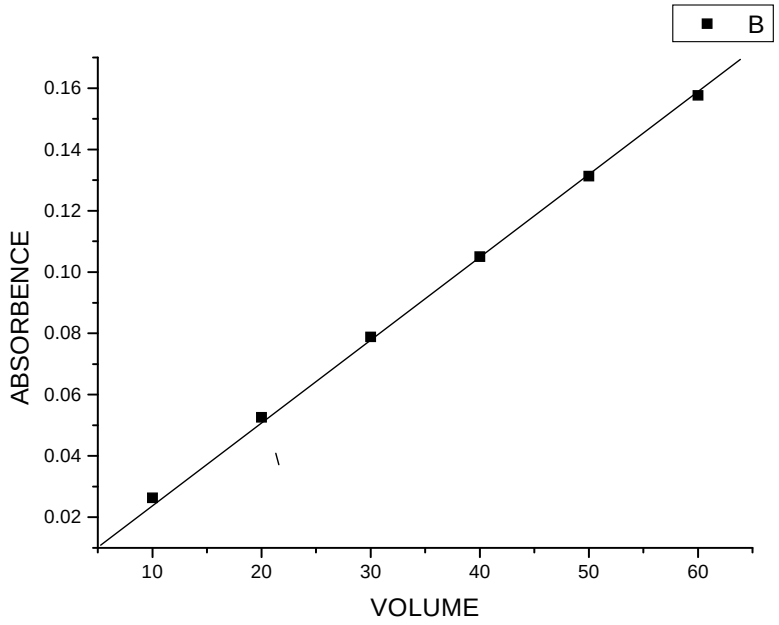



**Fig. 7.** Graph of Colgate tooth paste.

**Table 4.** Close Up.

Estimation:
0.5690 gm -100 ml -0.1M
1.4225 gm -100 ml -0.1M
$E_0$ = -76.4 mV

| S.no | Volume | Voltage (e) | Voltage ($e_\infty$) | Absorbence |
|---|---|---|---|---|
| 1. | 10 | -71.6 | 1.5 | 0.0276 |
| 2. | 20 | -67.1 | 1.5 | 0.0552 |
| 3. | 30 | -62.9 | 1.5 | 0.08265 |
| 4. | 40 | -58.9 | 1.5 | 0.1105 |
| 5. | 50 | -55.2 | 1.5 | 0.1379 |
| 6. | 60 | -51.7 | 1.5 | 0.1656 |

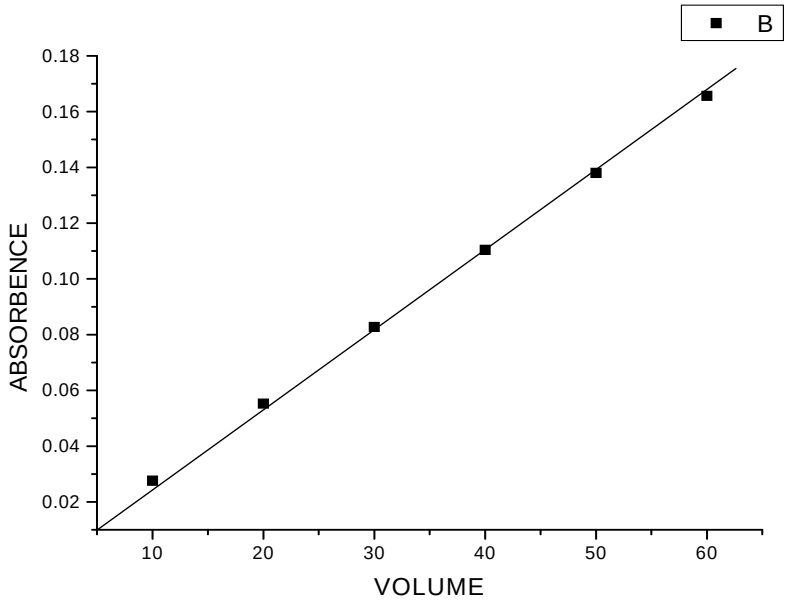



**Fig. 8.** Graph of Close Up Tooth paste.

**Table 5.** Anchor Gel.

Estimation:
0.5690 gm - 100 ml - 0.1M
1.4225 gm - 100 ml - 0.1 M
$E_0$ = -104.1 mV

| S.no | Volume | Voltage (e) | Voltage ($e_\infty$) | Absorbence |
|---|---|---|---|---|
| 1. | 10 | -94.1 | 1.5 | 0.0432 |
| 2. | 20 | -85.1 | 1.5 | 0.08614 |
| 3. | 30 | -76.8 | 1.5 | 0.1299 |
| 4. | 40 | -69.4 | 1.5 | 0.1730 |
| 5. | 50 | -62.7 | 1.5 | 0.2160 |
| 6. | 60 | -56.6 | 1.5 | 0.2594 |

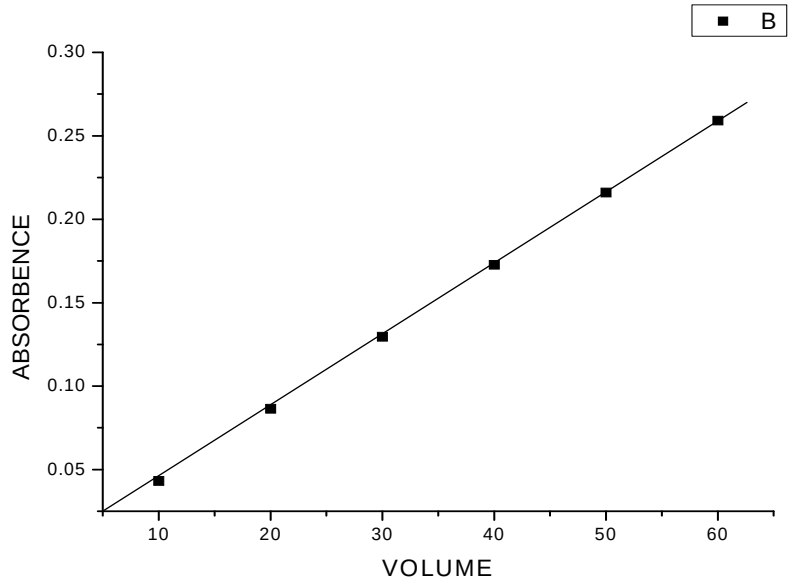



**Fig. 9.** Graph of the Anchor Gel tooth paste.

**Table 6.** Sodium Fluoride (NaF).

Estimation:
41.99 gm - 1000 ml - 1M
4.199 gm - 1000 ml - 0.1M
0.4199 gm - 100 ml - 0.1 M
$E_0$ = -209.6 mV

| S.no | Molarity | Voltage (e) | Voltage ($e_\infty$) | Absorbence |
|---|---|---|---|---|
| 1. | 0.005 | -200.1 | 1.5 | 0.0199 |
| 2. | 0.01 | -191.2 | 1.5 | 0.0396 |
| 3. | 0.015 | -182.6 | 1.5 | 0.05943 |
| 4. | 0.020 | -174.3 | 1.5 | 0.0794 |
| 5. | 0.025 | -166.5 | 1.5 | 0.09917 |
| 6. | 0.03 | -158.9 | 1.5 | 0.1192 |
| 7. | 0.035 | -151.7 | 1.5 | 0.1392 |
| 8. | 0.04 | -144.9 | 1.5 | 0.1589 |
| 9. | 0.045 | -138.1 | 1.5 | 0.1796 |

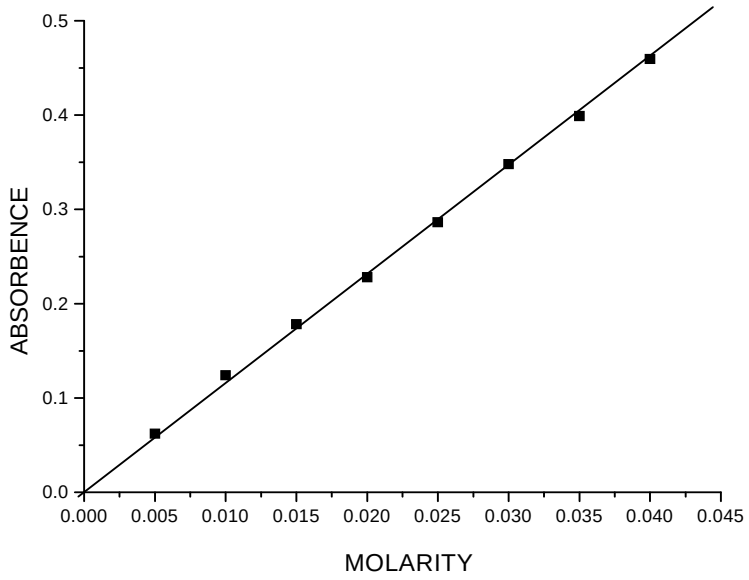



**Fig. 10.** Graph of Sodium Fluoride.

**Table 7.** Comparison Table.

| S.No | Tooth paste | Fluoride Ion Concentration | |
|---|---|---|---|
| | | Present study value (gm/L) | Indian standards (gm/L) |
| 1 | Pepsodent | 0.01 | 0.01 |
| 2. | Dabur red | 0.024 | NF |
| 3. | Colgate | 0.027 | 0.01 |
| 4. | Close up | 0.028 | 0.01 |
| 5. | Anchor gel | 0.045 | NF |

NF: Non Fluoridated

## 6. Discussion

The decline of dental caries in industrialized countries can be attributed to the wide spread use of fluorides, mainly in the form of fluoride dentifrices. Approximately 500 million people of the world's population now use fluoride dentifrice making it by far the most important fluoride delivery system. Tooth brushing with fluoride dentifrice has become an important public health measure in preventing caries.

The regular application of fluoride from Toothpaste confers protection primarily by exerting a topical effect on the erupted teeth. Fluoride interacts with the plaque /tooth system in four ways: (a) reduction of mineral solubility (b) inhibition of mineral dissolution (c) inhibition of acid production by Plaque bacteria and (d) the promotion of demineralization. However, the total fluoride contained in the dentifrice is not completely available. For the dentifrice to be effective in the prevention of caries, quantity as well as quality of fluoride is important.

The majority of dentifrices contain either fluoride in their composition as the fluoride ion (NaF) or as monoflurophosphate (MFP), which are considered active forms for controlling caries. Fluoride in dentifrice must be in the dentifrice in a soluble form to guarantee activity against caries. Depending on the formulation part of the fluoride may be inactive and this occurs mainly in the presence of calcium (Ca++) and fluoride ions ($F^-$). Although MFP is more stable in the presence of Ca++, because fluoride is linked covalently to phosphate it undergoes hydrolysis over time and release F-. This reacts with Ca++ to form insoluble fluoride that is inactive against caries.

Analyzing the five most Indian fluoridated dentifrices, I verified that the total fluoride concentrations in the samples on the individual dentifrices were reasonably close to the values provided by the manufactured companies. Amount of fluoride present in the different tooth pastes are tabulated in the tabular column. Over previous decades, the Government and dental professionals did not encourage the population to use fluoride products and their usages were strictly limited.

The acceptance of fluoridated dentifrices is changing in India and the effect of these changes can be observed in the increase of fluoridated dentifrices in the market share and the sudden increase in people consuming these products. However some (two) consumed dentifrices evaluated in this study did not specify the fluoride content on their packages. For the Indian consumers to make informed choices before purchase of a fluoride dentifrice, the packages should be clear in showing the fluoride concentration contained in the product.

The results of this study suggest that the dentifrice most consumed fluoridated dentifrices contain a sufficient concentration of soluble fluoride and may be used to prevent and control dental caries.

## References

[1]. Lina Naomi Hashizume, Ynara Bosco de Oliveira Lima, Yoko Kawaguchi and Jaime Aparecido Cury, Fluoride availability and stability of Japanese dentifrices, *Journal of Oral Sciences,* Vol. 45, No. 4, 2003, pp. 193-199.

[2]. Norio Teshima, Tadao Sakai, Keiro Higuchi, Motoyuki Takahashi, Tetsuo Komoda, Ken-ichi Kurahashi, Kate Grudpan, Flow Injection Simultaneous Determination of Copper and Iron inLubricating Oil Using a New Spectrophotometer with Dual Light-Emitting Diode, *J. Flow Injection Anal.*, Vol. 26, No. 2, 2009, pp. 139–142.

[3]. E. P. Serjeant, Potentiometry and Potentionmetric Titrations, *Wiley Publishing*, New York, 1984.

[4]. LED's – Wikipedia the free encyclopedia.

[5]. Seidl C., Knorr J., Zimmermannh H., Simple feed back network for Band width enhancement, *Electronics Letters,* Vol. 39, Issue 25, 11 Dec 2003, pp. 1849-1851.

[6]. ALS-PL- 02 ADC/DAC Card Manual.
[7]. Reference manual of AD/DA Card, *Electro Systems Associates*, Bangalore, India.
[8]. Juan D. Mozo, Manuel Galan and Emilio Roldán, Application of Light Emitting Diodes to Chemical Analysis: Determination of Copper in Water, *Journal of Chemical Education*, Vol. 78, Nr. 3, March 2001, p. 355.
[9]. Serife Tokalioglu, Senol Kartal, Ugur Sahin, Determination of fluoride in various samples and some infusions using a fluoride selective electrode, *Turk J. Chem.*, 28, 2004, pp: 203 – 211.

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


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.

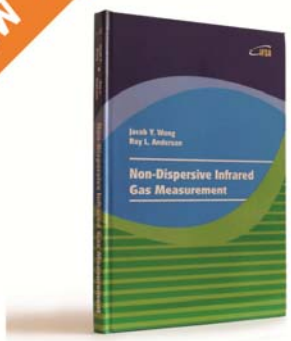
You are invited kindly to share in the benefits of being an IFSA author and to submit your book proposal or/and a sample chapter for review by e-mail to **editor@sensorsportal.com** These proposals may include technical references, application engineering handbooks, monographs, guides and textbooks. 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**

International Frequency Sensor Association (IFSA) Publishing

NEW BOOK

**Jacob Y. Wong, Roy L. Anderson**

## Non-Dispersive Infrared Gas Measurement




Written by experts in the field, the *Non-Dispersive Infrared Gas Measurement* begins with a brief survey of various gas measurement techniques and continues with fundamental aspects and cutting-edge progress in NDIR gas sensors in their historical development.

- It addresses various fields, including:
- Interactive and non-interactive gas sensors
- Non-dispersive infrared gas sensors' components
- Single- and Double beam designs
- Historical background and today's of NDIR gas measurements

Providing sufficient background information and details, the book Non-Dispersive Infrared Gas Measurement is an excellent resource for advanced level undergraduate and graduate students as well as researchers, instrumentation engineers, applied physicists, chemists, material scientists in gas, chemical, biological, and medical sensors to have a comprehensive understanding of the development of non-dispersive infrared gas sensors and the trends for the future investigation.

Formats: printable pdf (Acrobat) and print (hardcover),120 pages

ISBN: 978-84-615-9732-1,
e-ISBN: 978-84-615-9512-9

**http://sensorsportal.com/HTML/BOOKSTORE/NDIR_Gas_Measurement.htm**

**Sensors & Transducers Journal**

# 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 additional, 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 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/Submition.htm Authors must follow the instructions strictly when submitting their manuscripts.

## Advertising Information

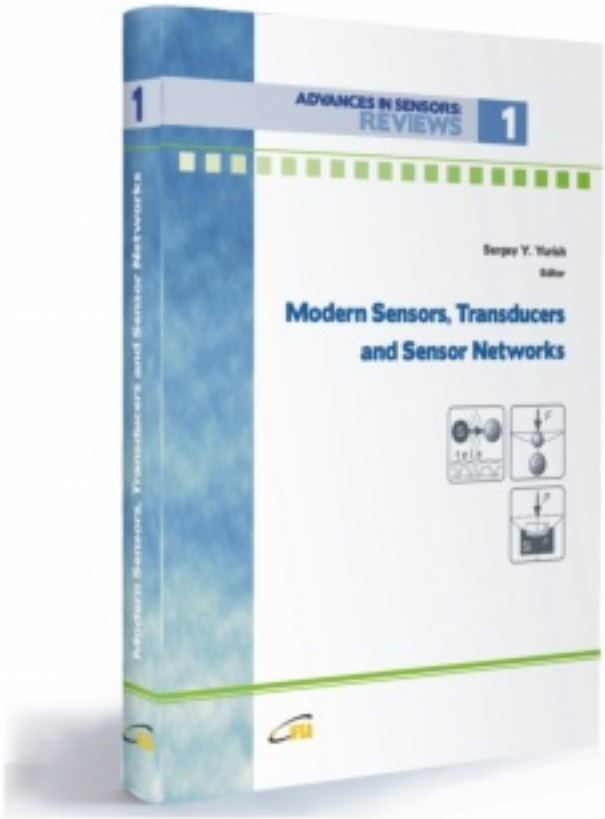
Advertising orders and enquires may be sent to sales@sensorsportal.com Please download also our media kit: http://www.sensorsportal.com/DOWNLOADS/Media_Kit_2012.pdf

International Frequency Sensor Association Publishing

ADVANCES IN SENSORS: REVIEWS 1

**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**

**www.sensorsportal.com**