

PROCEEDINGS OF SPIE

Fourth Conference on Sensors, MEMS, and Electro-Optic Systems

Monuko du Plessis
Editor

18–20 September 2016
Skukuza, Kruger National Park, South Africa

Organized by
Denel Dynamics (South Africa)

Sponsored by
Denel Dynamics (South Africa) • Airbus Defence and Space (South Africa) • Enterprises
University of Pretoria (South Africa) • Azoteq (South Africa) • ECM Technologies (South Africa)
• Solid State Technology (South Africa) • Saetra (South Africa) • Eagle Technology
(South Africa)

Published by
SPIE

Volume 10036

Proceedings of SPIE 0277-786X, V. 10036

SPIE is an international society advancing an interdisciplinary approach to the science and application of light.

Fourth Conference on Sensors, MEMS, and Electro-Optic Systems, edited by Monuko du Plessis, Proc. of SPIE
Vol. 10036, 1003601 · © 2017 SPIE · CCC code: 0277-786X/17/\$18 · doi: 10.1117/12.2272843

The papers in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. Additional papers and presentation recordings may be available online in the SPIE Digital Library at SPIDigitalLibrary.org.

The papers reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from this book:

Author(s), "Title of Paper," in *Fourth Conference on Sensors, MEMS, and Electro-Optic Systems*, edited by Monuko du Plessis, Proceedings of SPIE Vol. 10036 (SPIE, Bellingham, WA, 2017) Article CID Number.

ISSN: 0277-786X
ISSN: 1996-756X (electronic)

ISBN: 9781510605138
ISBN: 9781510605145 (electronic)

Published by

SPIE

P.O. Box 10, Bellingham, Washington 98227-0010 USA
Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445
SPIE.org

Copyright © 2017, Society of Photo-Optical Instrumentation Engineers.

Copying of material in this book for internal or personal use, or for the internal or personal use of specific clients, beyond the fair use provisions granted by the U.S. Copyright Law is authorized by SPIE subject to payment of copying fees. The Transactional Reporting Service base fee for this volume is \$18.00 per article (or portion thereof), which should be paid directly to the Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923. Payment may also be made electronically through CCC Online at copyright.com. Other copying for republication, resale, advertising or promotion, or any form of systematic or multiple reproduction of any material in this book is prohibited except with permission in writing from the publisher. The CCC fee code is 0277-786X/17/\$18.00.

Printed in the United States of America.

Publication of record for individual papers is online in the SPIE Digital Library.

SPIE. DIGITAL LIBRARY
SPIDigitalLibrary.org

Paper Numbering: *Proceedings of SPIE* follow an e-First publication model. A unique citation identifier (CID) number is assigned to each article at the time of publication. Utilization of CIDs allows articles to be fully citable as soon as they are published online, and connects the same identifier to all online and print versions of the publication. SPIE uses a seven-digit CID article numbering system structured as follows:

- The first five digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B ... 0Z, followed by 10-1Z, 20-2Z, etc. The CID Number appears on each page of the manuscript.

Contents

- vii *Authors*
ix *Conference Committee*
xi *Introduction*

SILICON OPTOELECTRONICS

- 10036 02 **Prospects of efficient band-to-band emission in silicon LEDs (Invited Paper)** [10036-60]
10036 03 **Stimulation of 450, 650 and 850-nm optical emissions from custom designed silicon LED devices by utilizing carrier energy and carrier momentum engineering** [10036-79]
10036 04 **Wavelength dispersion characteristics of integrated silicon avalanche LEDs: potential applications in futuristic on-chip micro- and nano-biosensors** [10036-80]
10036 05 **Silicon nanowire hot electron electroluminescence** [10036-19]

CARBON BASED DEVICES

- 10036 06 **Quantum device prospects of superconducting nanodiamond films (Invited Paper)** [10036-61]
10036 07 **Low temperature magneto transport features of rare earth element functionalized carbon nanotube network devices for spintronic applications** [10036-44]
10036 08 **Nanomanipulation device fabrication: multilayerd graphene and OFET devices** [10036-50]

INTEGRATED SENSOR MICROSYSTEMS

- 10036 09 **Development of a multi-sensor CMOS ASIC** [10036-71]
10036 0A **Integration of ZnO nanoparticle transistors on freestanding flexible substrates** [10036-107]
10036 0B **Recent advances in the modelling of the thermal conductance of uncooled microbolometers** [10036-64]
10036 0C **Development of paper-based electrochemical sensors for water quality monitoring** [10036-106]

BIOSENSORS

- 10036 OD **Surface functionalization of glassy carbon electrodes via adsorption, electrografting and click chemistry using quantum dots and alkynyl substituted phthalocyanines: a brief review** [10036-62]
- 10036 OE **Optimization of fibre Bragg refractometer sensor parameters for bio-chemical applications** [10036-56]
- 10036 OF **High resolution CMOS capacitance-frequency converter for biosensor applications** [10036-13]
- 10036 OG **Micro-incubator for bacterial biosensing applications** [10036-49]
- 10036 OH **An air quality sensing system for cool air storage** [10036-53]
- 10036 OI **Colorimetric detection for paper-based biosensing applications** [10036-51]
- 10036 OJ **Development of paper-based wireless communication modules for point-of-care diagnostic applications** [10036-18]

SENSOR READ-OUT ELECTRONICS

- 10036 OK **Complementary field-effect transistors for flexible electronics** [10036-103]
- 10036 OL **The characterisation and design improvement of a paper-based E.coli impedimetric sensor** [10036-69]
- 10036 OM **Managing piezoelectric sensor jitter: kinematic position tracking applications** [10036-8]
- 10036 ON **Near infrared spectrometric technique for testing fruit quality: optimisation of regression models using genetic algorithms** [10036-26]
- 10036 OO **CMOS in-pixel optical pulse frequency modulator** [10036-52]
- 10036 OP **A low-power CMOS operational amplifier IC for a heterogeneous paper-based potentiostat** [10036-72]
- 10036 OQ **Comparison of inkjet-printed silver conductors on different microsystem substrates** [10036-57]
- 10036 OR **Handheld chemiresistive gas sensor readout system** [10036-75]

SENSOR TECHNOLOGY

- 10036 OS **Staring array sensor model for simulation implementation** [10036-30]
- 10036 OT **Numerical modeling and signal to noise ratio evaluation of correlation pulsing code techniques in a Raman-Rayleigh distributed temperature fiber sensor** [10036-42]

- 10036 0U **Photodarkening effect and optical properties of a nanocomposite material polymer/Fe₃O₄ magnetic nanoparticles** [10036-73]

LASER SOURCES AND DETECTOR TECHNOLOGY

- 10036 0V **Improving the laser brightness of a commercial laser system** [10036-17]
- 10036 0W **Characterising laser beams with liquid crystal displays** [10036-14]
- 10036 0X **A 1550-nm all-optical VCSEL-to-VCSEL wavelength conversion of a 8.5 Gb/s data signal and transmission over a 24.7- km fibre** [10036-25]
- 10036 0Y **Digital implementation of a laser frequency stabilisation technique in the telecommunications band** [10036-4]
- 10036 0Z **High-frequency pulsed laser response of a PIN InGaAs photodetector** [10036-46]

SENSORS FOR IOT, SPACE AND REMOTE SENSING APPLICATIONS

- 10036 10 **Verification measurements of the Karoo Array timing system: a laser radar based time transfer system** [10036-74]
- 10036 11 **Remote optical observations of actively burning biomass fires using potassium line spectral emission** [10036-105]
- 10036 12 **Effect of the atmosphere on the color coordinates of sunlit surfaces** [10036-29]
- 10036 13 **Characterisation of diode-connected SiGe BiCMOS HBTs for space applications** [10036-28]
- 10036 14 **Measuring sub-picosecond optical propagation delay changes on optical fibre using photonics and radio frequency components** [10036-66]

SEMICONDUCTOR SENSORS: MATERIALS AND STRUCTURES FOR IR DETECTION

- 10036 15 **Mid-infrared detection in p-GaAs/AlGaAs heterostructures with a current blocking barrier** [10036-10]
- 10036 16 **MWIR sensor well fill: sources, effects and mitigation** [10036-31]

SEMICONDUCTOR SENSORS: MATERIALS AND STRUCTURES FOR UV DETECTION

- 10036 17 **Devices based on InGaN/GaN multiple quantum well for scintillator and detector applications (Invited Paper)** [10036-34]
- 10036 18 **Hydrogen donors in ZnO and TiO₂ (Invited Paper)** [10036-48]

MEMS AND OPTO-MECHANICAL MODELLING

- 10036 19 **Structured detailed opto-mechanical tolerance modeling** [10036-33]
- 10036 1A **MEMS directional acoustic sensor for locating sound sources** [10036-21]
- 10036 1B **TEGs as self-sufficient power supply for sensors and microelectromechanical systems**
[10036-16]

Authors

Numbers in the index correspond to the last two digits of the seven-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first five digits reflect the volume number. Base 36 numbering is employed for the last two digits and indicates the order of articles within the volume. Numbers start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B...0Z, followed by 10-1Z, 20-2Z, etc.

Abbott, Thomas, 10, 14
Adams, G., 10
Alves, Fabio, 1A
Axelevitch, A., 0U
Bauermeister, E., 10
Bezuidenhout, Petroné H., 0C, 0J, 0L, 0P, 0Q
Bhattacharyya, Somnath, 06, 07, 08
Blažek, Karel, 17
Boiyo, D. Kiboi, 0X
Bosscha, Peter, 0R
Botha, C., 08
Brink, C., 0I
Brůža, Petr, 17
Burger, J. P., 10
Chauhan, Dilip, 15
Chen, Li, 15
Churochkin, D., 06
Clasen, Estine, 0G
Coleman, Christopher, 07, 08
Conning, Mariette, 0C
de Souza, Alvaro, 07
Dudley, Angela, 0W
Dujardin, Christophe, 17
du Plessis, Monuko, 05, 0B, 0O
du Toit, Jurie, 0R
Fernandes, M., 08
Flahaut, Emmanuel, 07
Forbes, Andrew, 0V, 0W
Gamatham, R. R. G., 0X, 10
Ghoor, I. S., 0F
Gibbon, T. B., 0X, 10
Goss, Tristan M., 16
Griffith, Derek J., 11
Grobler, Michael, 0E, 0T, 0Y
Harea, D., 0U
Heuken, Michael, 17
Hilleringmann, Ulrich, 0A, 0K, 1B
Hospodková, Alice, 17
Hubáček, Tomáš, 17
Hulcius, Eduard, 17
Isingizwe Nturambirwe, J. Frédéric, 0N
Isoe, G. M., 0X
Jivan, Pritesh, 0Y
Joubert, Trudi-Heleen, 05, 0F, 0G, 0H, 0I, 0L, 0O, 0P, 0Q, 0R
Julie, Roufurd P. M., 14
Kaboko, J. J. M., 0T
Kapp, F., 10
Karar, A., 0E
Karunasiri, Gamani, 1A
Khomu, Malome T., 0M
Khorasani, S., 08
Korvink, Jan G., 0J
Kriel, H., 10
Kuldová, Karla, 17
Kumar, S., 0L
Kruger, Jené, 0Q
Laikhtman, A., 0U
Lambrechts, J. Wynand, 0Z, 13
Land, Kevin, 0C, 0F, 0G, 0J, 0L, 0P
Lavrov, Eduard V., 18
Ledoux, Gilles, 17
Leitch, A. W. R., 0X
Levendis, D., 08
Li, Lianhe, 15
Linfield, Edmund H., 15
Litvin, Igor, 0V
Mager, Dario, 0J
Magidimisha, Edwin, 11
Malan, J. A., 10
Manuel, Rodolfo Martínez, 0Y
Martinez, R. M., 0T
Mashazi, Philani, 0D
Mbanjwa, Mesuli, 0C
Meshalkin, A., 0U
Meyer, Johan, 0E
Meyers, Thorsten, 0A, 0K
Mkwakikunga, Bonex, 0R
Mtsuko, D., 06, 08
Naicker, Amy, 07
Naidoo, Darryl, 0V, 0W
Ncube, Siphophile, 07, 08
Nel, Nicolaas E., 0O
Ngoy, T. J., 0H
Niki, Martin, 17
Nxele, Siphesihle Robin, 0D
Nyokong, Tebello, 0D
Okhai, Timothy A., 04
Opara, Umezuruike L., 0N
Oswald, Jiří, 17
Ozoemena, Kenneth, 0C
Pacherová, Oliva, 17
Palaniyandy, Nithyadharseni, 0C
Pánek, Dalibor, 17
Pangrác, Jiří, 17
Perera, A. G. Unil, 15
Perold, Willem J., 0N
Polleux, Jean-Luc, 03, 04

Sandrock, C., 08
Schmitz, Jurriaan, 02
Schoeman, Johan, 0B, 0L
Schönhoff, M., 1B
Shimaponda, M., 0T
Siebrits, R., 10
Sinha, Saurabh, 13
Smith, Suzanne, 0C, 0J
Snyman, Lukas W., 03, 04
Strydom, Andre, 07
Swan, William, 1A
Swart, P. C., 19
van Brakel, Adriaan, 0Y
van der Merwe, D. G., 09
Venter, Johan, 13
Vidor, Fábio F., 0A, 0K
Viljoen, Johan W., 12
Wiederoder, M., 0L
Willers, Cornelius J., 0S, 12, 16
Willers, Maria S., 0S
Xu, K., 03
Zheng, Haitao, 0C
Žíková, Markéta, 17

Conference Committee

Conference Chairs

Christo Schutte, Denel Dynamics (South Africa)

Conference Co-chairs

Monuko du Plessis, University of Pretoria (South Africa)

Trudi-Heleen Joubert, University of Pretoria (South Africa)

Philip Minnaar, Denel Dynamics (South Africa)

Program Committee

Monuko du Plessis, (Chair), University of Pretoria (South Africa)

Somnath Bhattacharyya, University of the Witwatersrand
(South Africa)

Reinhardt Botha, Nelson Mandela Metropolitan University
(South Africa)

Johan Burger, SKA Africa (South Africa)

Trudi-Heleen Joubert, University of Pretoria (South Africa)

Dieter Mellet, Azoteq (South Africa)

Willem Perold, Stellenbosch University (South Africa)

Pieter Rademeyer, INSiAVA (South Africa)

Christo Schutte, Denel Dynamics (South Africa)

Lukas Snyman, University of South Africa (South Africa)

Hendrik Swart, University of the Free State (South Africa)

Robert van Zyl, Cape Peninsula University of Technology (South Africa)

Nelis Willers, Airbus DS Optronics (Pty) Ltd., (South Africa)

Editorial Committee

Monuko du Plessis, (Editor), University of Pretoria (South Africa)

Somnath Bhattacharyya, University of the Witwatersrand
(South Africa)

Reinhardt Botha, Nelson Mandela Metropolitan University
(South Africa)

Trudi-Heleen Joubert, University of Pretoria (South Africa)

Dieter Mellet, Azoteq (South Africa)

Willem Perold, Stellenbosch University (South Africa)

Pieter Rademeyer, INSiAVA (South Africa)

Christo Schutte, Denel Dynamics (South Africa)

Lukas Snyman, University of South Africa (South Africa)

Hendrik Swart, University of the Free State (South Africa)

Robert van Zyl, Cape Peninsula University of Technology (South Africa)

Nelis Willers, Airbus DS Optronics (Pty) Ltd., (South Africa)

Session Chairs

- 1 Silicon Optoelectronics
Monuko du Plessis, University of Pretoria (South Africa)
- 2 Carbon Based Devices
Somnath Bhattacharyya, University of the Witwatersrand (South Africa)
- 3 Integrated Sensor Microsystems
Trudi-Heleen Joubert, University of Pretoria (South Africa)
- 4 Biosensors
Willem Perold, Stellenbosch University (South Africa)
- 5 Sensor Read-out Electronics
Philip Minnaar, Denel Dynamics (South Africa)
- 6 Sensor Technology
Dieter Mellet, Azoteq (South Africa)
- 7 Laser Sources and Detector Technology
Johan Burger, SKA Africa (South Africa)
- 8 Sensors for IoT, Space and Remote Sensing Applications
Robert van Zyl, Cape Peninsula University of Technology (South Africa)
- 9 Semiconductor Sensors: Materials and Structures for IR Detection
Reinhardt Botha, Nelson Mandela Metropolitan University (South Africa)
- 10 Semiconductor Sensors: Materials and Structures for UV Detection
Lukas Snyman, University of South Africa (South Africa)
- 11 MEMS and Opto-mechanical Systems
Nelis Willers, Airbus DS Optronics (Pty) Ltd. (South Africa)

Introduction

The Fourth South African Conference on Sensors, MEMS and Electro-Optical Systems (SMEOS 2016) was held 18–20 September 2016, in Skukuza, the main rest camp in the Kruger National Park, South Africa, after a very successful first SMEOS 2009, second SMEOS 2011 and third SMEOS 2014. Sensors and Electro-Optical Systems are technologies with many applications worldwide, and are also identified as such by the South African government through the Departments of Science and Technology.

The aim of SMEOS 2016 was to provide a common forum for international researchers and developers to exchange information about their latest research findings, ideas, developments and applications in all areas pertaining to design, fabrication and application in the fields of interest to SMEOS 2016. This is a relatively small field of expertise in South Africa and working together with international colleagues is of the utmost importance.

Monuko du Plessis

