PROCEEDINGS OF SPIE

SPIDigitalLibrary.org/conference-proceedings-of-spie

Front Matter: Volume 7594

, "Front Matter: Volume 7594," Proc. SPIE 7594, MOEMS and Miniaturized Systems IX, 759401 (24 March 2010); doi: 10.1117/12.859648

SPIE.

Event: SPIE MOEMS-MEMS, 2010, San Francisco, California, United States

PROCEEDINGS OF SPIE

MOEMS and Miniaturized Systems IX

Harald Schenk
Wibool Piyawattanametha
Editors

25–27 January 2010
San Francisco, California, United States

Sponsored and Published by
SPIE

Volume 7594

Proceedings of SPIE, 0277-786X, v. 7594

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

The papers included 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. The papers published in these proceedings 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 *MOEMS and Miniaturized Systems IX*, edited by Harald Schenk, Wibool Piyawattanametha, Proceedings of SPIE Vol. 7594 (SPIE, Bellingham, WA, 2010) Article CID Number.

ISSN 0277-786X

ISBN 9780819479907

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 © 2010, 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/10/\$18.00.

Printed in the United States of America.

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

SPIDigitalLibrary.org

Paper Numbering: Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print and on CD-ROM. Papers are published as they are submitted and meet publication criteria. A unique, consistent, permanent citation identifier (CID) number is assigned to each article at the time of the first publication. Utilization of CIDs allows articles to be fully citable as soon they are published online, and connects the same identifier to all online, print, and electronic versions of the publication. SPIE uses a six-digit CID article numbering system in which:

- The first four 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. The complete citation is used on the first page, and an abbreviated version on subsequent pages. Numbers in the index correspond to the last two digits of the six-digit CID number.

Contents

- ix Conference Committee
- xi *Emerging research in micro and nano systems: opportunities and challenges for societal impact (Plenary Paper) [7593-201]*
Y. B. Gianchandani, Univ. of Michigan (United States)
- xix *Shaping light: MOEMS deformable mirrors for microscopes and telescopes (Plenary Paper) [7595-203]*
T. Bifano, Boston Univ. Photonics Ctr. (United States)

MOEMS-MEMS PLENARY SESSION

- 7594 02 **MEMS technologies for artificial retinas** (Plenary Paper) [7594-202]
W. Mokwa, RWTH Aachen Univ. (Germany)

SESSION 1 MEMS AND MINIATURIZED SCANNERS FOR ENDOMICROSCOPY: JOINT SESSION WITH CONFERENCE 7558

- 7594 04 **MEMS devices for laser camera systems for endoscopic applications (Invited Paper)** [7594-02]
C. Drabe, Fraunhofer-Institut für Photonische Mikrosysteme (Germany); R. James, Microvision, Inc. (United States); H. Schenk, T. Sandner, Fraunhofer-Institut für Photonische Mikrosysteme (Germany)
- 7594 05 **In vivo 3D and Doppler OCT imaging using electrothermal MEMS scanning mirrors (Invited Paper)** [7594-03]
J. Sun, S. Guo, Univ. of Florida (United States); L. Wu, WiOptix, Inc. (United States); S.-W. Choe, B. Sorg, H. Xie, Univ. of Florida (United States)

SESSION 2 MICRO-OPTICS FOR ENDOMICROSCOPY: JOINT SESSION WITH CONFERENCE 7558

- 7594 06 **MEMS deformable mirrors for focus control in vital microscopy** [7594-04]
B. J. Lutzenburger, M. J. Moghimi, S. J. Lukes, Montana State Univ. (United States); B. Kaylor, Bridger Photonics, Inc. (United States); D. L. Dickensheets, Montana State Univ. (United States)
- 7594 07 **High-speed liquid lens with 2-ms response and 80.3-nm root-mean-square wavefront error** [7594-05]
H. Oku, M. Ishikawa, The Univ. of Tokyo (Japan)

SESSION 3 DISPLAY AND IMAGING I

- 7594 08 **Pixtronix digital micro-shutter display technology: a MEMS display for low power mobile multimedia displays (Invited Paper)** [7594-06]
T. Brosnihan, R. Payne, J. Gandhi, S. Lewis, L. Steyn, M. Halfman, N. Hagood, Pixtronix, Inc. (United States)
- 7594 09 **Resonance MEMS mirrors design considerations (Invited Paper)** [7594-07]
S. Sourani, bTendo Ltd. (Israel)
- 7594 0A **Evolution of MEMS scanning mirrors for laser projection in compact consumer electronics** [7594-08]
J. Tauscher, W. O. Davis, D. Brown, M. Ellis, Y. Ma, M. E. Sherwood, D. Bowman, M. P. Helsel, S. Lee, J. W. Coy, Microvision, Inc. (United States)
- 7594 0B **Nonlinear mathematical model for a biaxial MOEMS scanning mirror** [7594-09]
Y. Ma, W. O. Davis, M. Ellis, D. Brown, Microvision, Inc. (United States)

SESSION 4 DISPLAY AND IMAGING II

- 7594 0C **Synchronized microscanner array for large aperture receiver optics of LIDAR systems** [7594-10]
T. Sandner, T. Grasshoff, M. Wildenhain, H. Schenk, Fraunhofer Institute for Photonic Microsystems (Germany)
- 7594 0D **Large aperture MEMS scanner module for 3D distance measurement** [7594-11]
T. Sandner, M. Wildenhain, C. Gerwig, H. Schenk, Fraunhofer Institute for Photonic Microsystems (Germany); S. Schwarzer, H. Wölfelschneider, Fraunhofer Institute for Physical Measurement Techniques (Germany)
- 7594 0E **Surface micro-machined SU-8 2002 membrane mirrors for focus control** [7594-12]
S. J. Lukes, Montana State Univ. (United States); D. Lämmle, Albert-Ludwigs-Univ. Freiburg (Germany); D. L. Dickensheets, Montana State Univ. (United States)
- 7594 0F **Deformable silicon membrane for dynamic linear laser beam diffuser** [7594-13]
J. Masson, Ecole Polytechnique Fédérale de Lausanne (Switzerland); A. Bich, SUSS MicroOptics SA (Switzerland); H. P. Herzig, R. Bitterli, W. Noell, T. Scharf, Ecole Polytechnique Fédérale de Lausanne (Switzerland); R. Voelkel, K. J. Weible, SUSS MicroOptics SA (Switzerland); N. F. de Rooij, Ecole Polytechnique Fédérale de Lausanne (Switzerland)

SESSION 5 MOEM COMPONENTS AND SYSTEMS I

- 7594 0H **Rotating out-of-plane micromirror** [7594-17]
S. Oak, G. Edmiston, G. Sivakumar, G. Ramirez, T. Dallas, Texas Tech Univ. (United States)
- 7594 0I **CMOS Geiger-mode avalanche photodiode detectors for time and intensity resolved measurements** [7594-18]
W. G. Lawrence, T. Tozian, C. Stapels, J. F. Christian, Radiation Monitoring Devices Inc. (United States); G. D. Derderian, J. P. Derderian, Dipole Engineering (United States); G. Varadi, Radiation Monitoring Devices Inc. (United States)

SESSION 6 MOEM COMPONENTS AND SYSTEMS II

- 7594 0J **High aspect ratio micromirror array with two degrees of freedom for femtosecond pulse shaping (Invited Paper)** [7594-19]
S. M. Weber, Ecole Polytechnique Fédérale de Lausanne (Switzerland) and Univ. de Genève (Switzerland); W. Noell, S. Lani, F. Jutzi, P. Brühlmeier, Ecole Polytechnique Fédérale de Lausanne (Switzerland); D. Kiselev, J. Extermann, L. Bonacina, J.-P. Wolf, Univ. de Genève (Switzerland); N. F. de Rooij, Ecole Polytechnique Fédérale de Lausanne (Switzerland)
- 7594 0K **Optical position feedback and phase control of MOEMS scanner mirrors** [7594-20]
A. Tortschanoff, M. Lenzhofer, A. Frank, Carinthian Tech Research AG (Austria); M. Wildenhain, T. Sandner, H. Schenk, Fraunhofer Institute for Photonic Microsystems (Germany); A. Kenda, Carinthian Tech Research AG (Austria)
- 7594 0L **Development of a miniaturized optical viscosity sensor with an optical surface tracking system** [7594-21]
H. Abe, R. Nagamachi, Y. Taguchi, Y. Nagasaka, Keio Univ. (Japan)
- 7594 0M **Tunable optofluidic dye laser with novel cavity** [7594-22]
W. Song, A. E. Vasdekis, D. Psaltis, Ecole Polytechnique Fédérale de Lausanne (Switzerland)

SESSION 7 SPACE APPLICATIONS I

- 7594 0N **JWST microshutter array system and beyond (Invited Paper)** [7594-24]
M. J. Li, NASA Goddard Space Flight Ctr. (United States); A. D. Brown, MEI Technologies (United States); A. S. Kutyrev, Univ. of Maryland, College Park (United States); H. S. Moseley, NASA Goddard Space Flight Ctr. (United States); V. Mikula, The Catholic Univ. of America (United States)
- 7594 0O **Development of a tilt actuated micromirror for applications in laser interferometry** [7594-25]
W. Kronast, U. Mescheder, B. Müller, A. Nimo, Hochschule Furtwangen Univ. (Germany); C. Braxmaier, T. Schuldt, Univ. of Applied Sciences Konstanz (Germany)
- 7594 0P **Realization and characterization of a MEMS-based programmable slit mask for multi-object spectroscopy** [7594-26]
M. Canonica, Ecole Polytechnique Fédérale de Lausanne (Switzerland); S. Waldis, Univ. of Neuchâtel (Switzerland); F. Zamkotsian, P. Lanzoni, Lab. d'Astrophysique de Marseille (France); W. Noell, N. de Rooij, Ecole Polytechnique Fédérale de Lausanne (Switzerland)

SESSION 8 SPACE APPLICATIONS II

- 7594 0Q **Carbon nanotube-based digital vacuum electronics and miniature instrumentation for space exploration (Invited Paper)** [7594-27]
H. Manohara, R. Toda, R. H. Lin, A. Liao, M. Mojarradi, Jet Propulsion Lab. (United States)

- 7594 OR **Development of a slab waveguide spatial heterodyne spectrometer for remote sensing** [7594-28]
M. Florjańczyk, York Univ. (Canada) and National Research Council Canada (Canada); P. Cheben, S. Janz, B. Lamontagne, J. Lapointe, National Research Council Canada (Canada); A. Scott, York Univ. (Canada) and COM DEV Ltd. (Canada); B. Solheim, York Univ. (Canada); D.-X. Xu, National Research Council Canada (Canada)
- 7594 OS **MOEMS for space application: the European Space Agency strategy for photonics components (Invited Paper)** [7594-39]
S. Hernandez, M. Zahir, F. Filhol, L. Marchand, European Space Agency (Netherlands)

SESSION 9 MICRO SPECTROMETERS AND OPTICAL FILTER

- 7594 OT **Miniaturized tunable integrated Mach-Zehnder MEMS interferometer for spectrometer applications (Invited Paper)** [7594-30]
D. Khalil, Ain Shams Univ. (Egypt) and Si-Ware Systems (Egypt); H. Omran, Ain Shams Univ. (Egypt); M. Medhat, B. Saadany, Si-Ware Systems (Egypt)
- 7594 OU **Miniaturized MEMS-based spectrometric sensor for process control and analysis of carbonated beverages** [7594-31]
A. Kenda, M. Kraft, A. Tortschanoff, Carinthian Tech Research AG (Austria); C. Wagner, B. Lendl, Technische Univ. Wien (Austria); T. Sandner, H. Schenk, Fraunhofer Institute for Photonic Microsystems (Germany)
- 7594 OV **Recent advances in expanding the spectral range of MEMS Fabry-Perot filters** [7594-32]
M. Ebermann, N. Neumann, Infratec GmbH (Germany); K. Hiller, Chemnitz Univ. of Technology (Germany); E. Gittler, JENOPTIK Laser, Optik, Systeme GmbH (Germany); M. Meinig, S. Kurth, Fraunhofer ENAS (Germany)
- 7594 OW **Prototyping of MWIR MEMS-based optical filter combined with HgCdTe detector** [7594-33]
D. A. Kozak, B. Fernandez, Univ. of California, Santa Cruz (United States); S. Velicu, EPIR Technologies (United States); J. Kubby, Univ. of California, Santa Cruz (United States)
- 7594 OX **Design and fabrication of a micro-mirror for spectroscopy** [7594-34]
K. A. G. Prakash, S. Dhabai, E. Bhattacharya, S. Bhattacharya, Indian Institute of Technology Madras (India)

POSTER SESSION

- 7594 OY **Design and experimental results for a compact laser printer optical system with MEMS scanning mirror (Invited Paper)** [7594-14]
T. Suzuki, D. Seki, S. Fujii, Y. Mukai, Nalux Co., Ltd. (Japan)
- 7594 OZ **Design and characterization of MEMS interferometric sensing** [7594-35]
R. Snyder, A. Siahmakoun, Rose-Hulman Institute of Technology (United States)
- 7594 10 **A novel free-space MEMS-based variable optical delay line** [7594-36]
M. A. Basha, Univ. of Waterloo (Canada); N. Dechev, Univ. of Victoria (Canada); S. Safavi-Naeini, S. Chaudhuri, Univ. of Waterloo (Canada)

- 7594 11 **Design of spectrometers and ended-ended systems** [7594-37]
A. G. Rojas-Hernandez, A. Vera-Marquina, D. Berman-Mendoza, A. Garcia-Juarez, Univ. de Sonora (Mexico)
- 7594 12 **MEMS temperature scanner: principles, advances, and applications** [7594-38]
T. Otto, R. Saupe, Fraunhofer Research Institution for Electronic Nano Systems (Germany); V. Stock, TQ Systems Chemnitz GmbH (Germany); T. Gessner, Fraunhofer Research Institution for Electronic Nano Systems (Germany) and Chemnitz Univ. of Technology (Germany)

Author Index

Conference Committee

Symposium Chair

Thomas J. Suleski, The University of North Carolina at Charlotte
(United States)

Symposium Cochair

Harald Schenk, Fraunhofer Institute for Photonic Microsystems
(Germany)

Conference Chairs

Harald Schenk, Fraunhofer Institute for Photonic Microsystems
(Germany)
Wibool Piyawattanametha, NECTEC (Thailand) and Stanford University
(United States)

Program Committee

Susanne Arney, Alcatel-Lucent Bell Laboratories (United States)
Wyatt O. Davis, Microvision, Inc. (United States)
David L. Dickensheets, Montana State University (United States)
Jean-Christophe Eloy, Yole Développement (France)
Sonia García-Blanco, Institut National d'Optique (Canada)
Jason C. Heikenfeld, University of Cincinnati (United States)
Wilfried Noell, University of Neuchâtel (Switzerland)
Yong-Hwa Park, Samsung Advanced Institute of Technology (Korea,
Republic of)

Session Chairs

- 1 MEMS and Miniaturized Scanners for Endomicroscopy: Joint Session
with Conference 7558
David L. Dickensheets, Montana State University (United States)
- 2 Micro-optics for Endomicroscopy: Joint Session with Conference 7558
David L. Dickensheets, Montana State University (United States)
- 3 Display and Imaging I
Yong-Hwa Park, Samsung Advanced Institute of Technology (Korea,
Republic of)

- 4 Display and Imaging II
Jason Tauscher, Microvision, Inc. (United States)
- 5 MOEM Components and Systems I
Harald Schenk, Fraunhofer Institute for Photonic Microsystems
(Germany)
- 6 MOEM Components and Systems II
Hyejun Ra, Stanford University (United States)
- 7 Space Applications I
Sonia García-Blanco, Institut National d'Optique (Canada)
- 8 Space Applications II
Sonia García-Blanco, Institut National d'Optique (Canada)
- 9 Micro Spectrometers and Optical Filter
Wilfried Noell, University of Neuchâtel (Switzerland)