

PROCEEDINGS OF SPIE

# ***Next-Generation Spectroscopic Technologies III***

**Mark A. Druy  
Christopher D. Brown  
Richard A. Crocombe**  
*Editors*

**5–6 April 2010  
Orlando, Florida, United States**

*Sponsored and Published by*  
SPIE

**Volume 7680**

Proceedings of SPIE, 0277-786X, v. 7680

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 *Next-Generation Spectroscopic Technologies III*, edited by Mark A. Druy, Christopher D. Brown, Richard A. Crocombe, Proceedings of SPIE Vol. 7680 (SPIE, Bellingham, WA, 2010) Article CID Number.

ISSN 0277-786X

ISBN 9780819481443

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](http://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](http://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

vii	Conference Committee
ix	Introduction

---

## APPLICATIONS OF NOVEL SPECTROMETERS

---

7680 04	<b>Universal explosive detection system for homeland security applications</b> [7680-03] V. Y. Lee, E. E. A. Bromberg, L-3 Communications CyTerra Corp. (United States)
7680 05	<b>A spoof detection method for contactless fingerprint collection utilizing spectrum and polarization diversity</b> [7680-04] G. Abramovich, M. Ganesh, K. Harding, S. Manickam, J. Czechowski, X. Wang, GE Global Research (United States); A. Vemury, U.S. Dept. of Homeland Security (United States)
7680 06	<b>Field-rugged sensitive hydrogen peroxide sensor based on tunable diode laser absorption spectroscopy (TDLAS)</b> [7680-05] M. B. Frish, J. R. Morency, M. C. Laderer, R. T. Wainner, K. R. Parameswaran, W. J. Kessler, M. A. Druy, Physical Sciences Inc. (United States)
7680 08	<b>Low-noise moisture meter with high-speed LED techniques</b> [7680-07] R. Aikio, H. Lindström, P. Suopajärvi, J. Malinen, VTT Technical Research Ctr. of Finland (Finland); M. Mäntylä, Metso Automation Oy (Finland)

---

## IMAGING

---

7680 0D	<b>Handheld hyperspectral imager</b> [7680-12] H. Saari, V.-V. Aallos, C. Holmlund, J. Malinen, J. Mäkyne, VTT Technical Research Ctr. of Finland (Finland)
7680 0E	<b>Comparative performance studies between tunable filter and push-broom chemical imaging systems</b> [7680-13] J. Malinen, H. Saari, VTT Technical Research Ctr. of Finland (Finland); G. Kemeny, Middleton Research (United States); Z. Shi, C. Anderson, Duquesne Univ. (United States)
7680 0F	<b>Detection of flexographic inks using NIR LCTF-based hyperspectral imaging</b> [7680-15] R. Leitner, A. Fritz, T. Arnold, M. De Biasio, Carinthian Tech Research AG (Austria)
7680 0H	<b>Near infrared spectral imaging of explosives using a tunable laser source</b> [7680-17] E. Margalith, L. K. Nguyen, OPOTEK, Inc. (United States); G. Klunder, Lawrence Livermore National Lab. (United States)

---

## ENABLING TECHNOLOGIES

---

- 7680 OJ **Thermopile linear array for spectroscopy applications** [7680-20]  
A. Levin, W. Baer, S. Harrigan, J. Zewicke, R. S. Toth, Dexter Research Ctr., Inc. (United States)
- 7680 OK **Capacitive sensing circuit for closed-loop control of wide tuning range microspectrometers** [7680-21]  
M. Susli, K. K. M. B. D. Silva, F. Boussaid, L. Faraone, J. M. Dell, The Univ. of Western Australia (Australia)
- 7680 OL **A novel high-brightness broadband light-source technology from the VUV to the IR** [7680-22]  
S. Horne, D. Smith, M. Besen, M. Partlow, D. Stolyarov, H. Zhu, W. Holber, Energetiq Technology, Inc. (United States)
- 7680 OM **Mid-IR sensing using external cavity quantum cascade lasers** [7680-23]  
T. Day, M. J. Weida, D. Arnone, M. Pushkarsky, P. Buerki, D. Caffey, V. Cook, E. B. Takeuchi, Daylight Solutions, Inc. (United States)
- 7680 ON **Infrared intracavity laser absorption spectrometer** [7680-24]  
G. Medhi, Univ. of Central Florida (United States); A. V. Muravjov, Zyberwear, Inc. (United States); H. Saxena, J. W. Cleary, C. J. Fredricksen, R. E. Peale, Univ. of Central Florida (United States); O. Edwards, Zyberwear, Inc. (United States)
- 7680 OO **Micro-electron spin resonance (ESR/EPR) spectroscopy** [7680-25]  
C. J. White, C. T. Elliott, J. R. White, Active Spectrum, Inc. (United States)

---

## NOVEL SPECTROMETERS

---

- 7680 OP **Ultra-sensitive NIR-spectrometer based on frequency up-conversion detector** [7680-26]  
L. Ma, O. Slattery, X. Tang, National Institute of Standards and Technology (United States)
- 7680 OQ **Portable open-path optical remote sensing (ORS) Fourier transform infrared (FTIR) instrumentation miniaturization and software for point and click real-time analysis** [7680-27]  
P. G. Zemek, S. V. Plowman, MIDAC Corp. (United States)
- 7680 OR **Performance trade-off modeling for a handheld FTIR spectrometric vapor identifier** [7680-28]  
D. W. Schiering, J. Arnó, Smiths Detection, Inc. (United States); R. G. Messerschmidt, Reflective Sciences, Inc. (United States); P. Zou, Smiths Detection, Inc. (United States)
- 7680 OS **High-speed resonant FTIR spectrometer** [7680-29]  
J. Rentz Dupuis, D. Carlson, J. Engel, OPTRA, Inc. (United States); B. Engel, Nelson Air Corp. (United States)
- 7680 OT **Sensitivity analysis of an assembled Fourier transform microspectrometer** [7680-30]  
J. Sin, W. H. Lee, H. E. Stephanou, The Univ. of Texas at Arlington (United States)
- 7680 OU **MEMS and piezo actuator-based Fabry-Perot interferometer technologies and applications at VTT** [7680-31]  
J. Antila, A. Miranto, J. Mäkynen, M. Laamanen, A. Rissanen, M. Blomberg, H. Saari, J. Malinen, VTT Technical Research Ctr. of Finland (Finland)

- 7680 OV **Portable NIR/MIR Fourier-transform spectrometer based on a common path lamellar grating interferometer** [7680-32]  
F. Merenda, S. Bühler, H. Farah, G. Boer, ARCOptix S.A. (Switzerland); T. Scharf, Ecole Polytechnique Fédérale de Lausanne (Switzerland)
- 7680 OW **CMOS-compatible LVOF-based visible microspectrometer** [7680-33]  
A. Emadi, H. Wu, G. de Graaf, R. F. Wolffenbuttel, Delft Univ. of Technology (Netherlands)
- 7680 OX **Point-and-stare operation and high-speed image acquisition in real-time hyperspectral imaging** [7680-34]  
R. D. Driver, D. P. Bannon, D. Ciccone, S. L. Hill, Headwall Photonics (United States)

---

#### POSTER SESSION

- 7680 OZ **Encapsulated thermopile detector array for IR microspectrometer** [7680-36]  
H. Wu, A. Emadi, G. de Graaf, R. F. Wolffenbuttel, Delft Univ. of Technology (Netherlands)

*Author Index*



# Conference Committee

## *Symposium Chair*

**Michael T. Eismann**, Air Force Research Laboratory (United States)

## *Symposium Cochair*

**William Jeffrey**, HRL Laboratories, LLC (United States)

## *Conference Chairs*

**Mark A. Druy**, Physical Sciences Inc. (United States)

**Christopher D. Brown**, Ahura Scientific, Inc. (United States)

**Richard A. Crocombe**, Thermo Fisher Scientific Inc. (United States)

## *Program Committee*

**John M. Dell**, The University of Western Australia (Australia)

**Erik Deutsch**, Block Engineering, LLC (United States)

**Richard D. Driver**, Headwall Photonics Inc. (United States)

**Jason M. Eichenholz**, Ocean Optics, Inc. (United States)

**Michael B. Frish**, Physical Sciences Inc. (United States)

**David M. Haaland**, Spectral Resolutions (United States)

**Fred Haibach**, Polychromix, Inc. (United States)

**Martin Kraft**, Carinthian Tech Research AG (Austria)

**Jouko O. Malinen**, VTT Optical Instruments (Finland)

**Christopher J. Manning**, Manning Applied Technologies, Inc. (United States)

**Curtis A. Marcott**, Light Light Solutions, LLC (United States)

**Robert G. Messerschmidt**, Rarelight (United States)

**Ellen V. Miseo**, Varian, Inc. (United States)

**David W. Schiering**, Smiths Detection (United States)

**Eric B. Takeuchi**, Daylight Solutions, Inc. (United States)

## *Session Chairs*

- 1 Applications of Novel Spectrometers  
**Richard A. Crocombe**, Thermo Fisher Scientific Inc. (United States)
- 2 Chemometrics  
**Christopher D. Brown**, Ahura Scientific, Inc. (United States)
- 3 Imaging  
**Mark A. Druy**, Physical Sciences Inc. (United States)

- 4    Enabling Technologies  
     **Christopher D. Brown**, Ahura Scientific, Inc. (United States)
- 5    Novel Spectrometers  
     **Richard A. Crocombe**, Thermo Fisher Scientific Inc. (United States)

## Introduction

The past twenty years have seen a massive investment in photonics, electronics and MEMS, aimed at developing new telecommunications capabilities and innovative consumer products. These investments have led to advances in miniature optics, light sources, tunable filters, array detectors, fiber optic sensors, and a range of other photonic devices, across the whole electromagnetic spectrum, along with technologies for their mass production. These and related advances are increasingly being exploited in new spectroscopic instruments.

Portable and handheld instruments are being developed that are often more sensitive and selective, smaller, cheaper, and more robust than their laboratory predecessors. Concurrent improvements in analytical theory, data analysis methods, and portable processors enable these spectroscopic devices to give specific answers to their non-specialist operators. Spectroscopy-based systems are now making critical judgments in environments and applications that were unreachable twenty years ago, from hazardous materials to the operating theater, and from field geologists to customs and border personnel.

Advances in array detectors (CCD, CID, InGaAs, InSb, MCT, etc.) are enabling a new generation of faster imaging spectrometers, with both laboratory and field applications. Again, advances in spectroscopic data processing are providing the ability to generate chemical-based images answers from the mass of data produced. Finally, spectrometers are being coupled to functionalized sensors to detect specific species.

This conference premiered at Optics East 2007 in Boston, MA and is now part of the SPIE Defense, Security, and Sensing Symposium. The emphasis of these Proceedings is on advanced technologies for spectroscopic instrumentation, particularly the IR, near-IR, and Raman molecular techniques. This two-day conference was divided into sessions focusing on applications of novel spectrometers, chemometrics, imaging, enabling technologies, and novel spectrometers. In all, over thirty papers were presented and we are pleased to be able to bring you twenty-four of them in these Proceedings.

On behalf of our program committee members, we hope that we can count on your participation in a future Next-Generation Spectroscopic Technologies conference.

**Mark A. Druy**  
**Christopher D. Brown**  
**Richard A. Crocombe**

