PROCEEDINGS OF SPIE

SPIDigitalLibrary.org/conference-proceedings-of-spie

Front Matter: Volume 10629

, "Front Matter: Volume 10629," Proc. SPIE 10629, Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE) Sensing XIX, 1062901 (8 June 2018); doi: 10.1117/12.2322392

SPIE.

Event: SPIE Defense + Security, 2018, Orlando, FL, United States

PROCEEDINGS OF SPIE

Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE) Sensing XIX

Jason A. Guicheteau
Augustus Way Fountain III
Chris R. Howle
Editors

16–18 April 2018
Orlando, Florida, United States

Sponsored and Published by
SPIE

Volume 10629

Proceedings of SPIE 0277-786X, V. 10629

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

Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE) Sensing XIX, edited by
Jason A. Guicheteau, Augustus Way Fountain III, Chris R. Howle, Proc. of SPIE Vol. 10629,
1062901 · © 2018 SPIE · CCC code: 0277-786X/18/\$18 · doi: 10.1117/12.2322392

Proc. of SPIE Vol. 10629 1062901-1

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 these proceedings:

Author(s), "Title of Paper," in *Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE) Sensing XIX*, edited by Jason A. Guicheteau, Augustus Way Fountain III, Chris R. Howle, Proceedings of SPIE Vol. 10629 (SPIE, Bellingham, WA, 2018) Seven-digit Article CID Number.

ISSN: 0277-786X

ISSN: 1996-756X (electronic)

ISBN: 9781510617698

ISBN: 9781510617704 (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 © 2018, 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/18/\$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	<i>Authors</i>
ix	<i>Conference Committee</i>
xi	<i>Introduction</i>

SESSION 1 KEYNOTE SESSION

10629 02	First results of a QCL-OPA based standoff system, for detecting hazardous substances in the IR-fingerprint domain (Keynote Paper) [10629-1]

SESSION 2 ADVANCES IN CHEMICAL THREAT SENSING I

10629 04	Detection and identification of chemical warfare agents using mid wave infrared active hyperspectral imaging (Invited Paper) [10629-3]
10629 05	Threat detection using a standoff, wide-area hyperspectral Raman imaging sensor [10629-4]
10629 06	Photonic micro-gas-chromatography detection of chemical threat agents [10629-5]
10629 07	UV Raman imaging of surface contaminants using tunable laser and narrow bandpass filters [10629-6]

SESSION 3 ADVANCES IN CHEMICAL THREAT SENSING II

10629 09	High-speed and large-area scanning of surfaces for trace chemicals using wavelength-tunable quantum cascade lasers [10629-8]
10629 0A	Enabling standoff detection of hazardous materials using a fiber optic coupled quantum cascade infrared laser system [10629-9]

SESSION 4 RADIOLOGICAL, NUCLEAR SENSING

10629 0C	UAV-based LiDAR and gamma probe with real-time data processing and downlink for survey of nuclear disaster locations [10629-11]
10629 0D	Effect of additives: organic-metal oxide nanocomposites for γ-ray sensors [10629-12]

- 10629 OE   **Radiation induced defects in high-Z shielded Ytterbium doped fibers** [10629-13]
- 10629 OF   **Development of the Virtual Source Training Toolkit for physically accurate simulation of the response of handheld radiation detectors** [10629-14]
- 10629 OG   **Characterization of uranium ore concentrate chemical composition via Raman spectroscopy** [10629-15]

SESSION 5   BIOLOGICAL THREAT DETECTION

- 10629 OH   **Advancements in MOF characterization for enhanced MALDI sensing** [10629-16]
- 10629 OI   **Grating coupled-surface plasmon resonance and fluorescent plasmonics biosensor for diagnosis of Lyme disease** [10629-17]
- 10629 OJ   **Rapid optical detection and classification of microbes in suspicious powders** [10629-18]

SESSION 6   EXPLOSIVE DETECTION

- 10629 OK   **Recent development of UV Raman standoff explosive detection systems for near trace detection** [10629-19]
- 10629 OM   **Comparison of handheld Raman sensors through opaque containers** [10629-21]
- 10629 ON   **Using infrared backscatter imaging spectroscopy to detect trace explosives at standoff distances** [10629-22]
- 10629 OP   **High-confidence discrimination of explosive materials on surfaces using a non-spectroscopic optical biomimetic sensing method** [10629-24]

SESSION 7   PHOTONIC INTEGRATED CIRCUIT THREAT SENSING I

- 10629 OQ   **Enhanced whispering gallery mode sensors** [10629-25]
- 10629 OR   **Whispering-gallery microresonators for sensing technologies** [10629-26]

SESSION 8   VAPOR, AEROSOL DETECTION

- 10629 OS   **Remote sensing of chlorine using UV lidar at U.S. Army Dugway Proving Ground** [10629-27]
- 10629 OT   **Four-wavelength lidar for in-situ speciation of aerosols** [10629-28]

- 10629 OU   **Development and calibration of an eye-safe elastic backscatter lidar for chemical and biological aerosol tracking** [10629-29]
- 10629 OV   **Optical parametric oscillator-based trace detection of gases in the mid-infrared region using phase-fluctuation optical heterodyne spectroscopy** [10629-30]
- 10629 OX   **Detecting unknown chemical clouds at distance with multispectral imagery** [10629-32]

SESSION 9   PHOTONIC INTEGRATED CIRCUIT THREAT SENSING II

- 10629 OY   **Localization and quantification of trace-gas fugitive emissions using a portable optical spectrometer** [10629-33]
- 10629 OZ   **Design, manufacture, and testing of a silicon nitride ring resonator-based biosensing platform** [10629-34]
- 10629 10   **Fish-bone subwavelength grating waveguide photonic integrated circuit sensor array** [10629-35]
- 10629 11   **Real-time gas analysis using mid-infrared microcavities** [10629-36]

SESSION 10   CBE THREAT SIGNATURE MODELING AND ALGORITHM ADVANCEMENTS

- 10629 12   **Accurate measurement of the optical constants for modeling organic and organophosphorous liquid layers and drops** [10629-41]
- 10629 13   **Simulating ATR spectra for detecting nerve agent-sorbent binding** [10629-38]
- 10629 14   **On constructing surface-distributed-scatterer ensembles for analysis of deposited-explosive-particle diffuse-reflectance spectra** [10629-39]
- 10629 15   **Mid-infrared reflection signatures for trace chemicals on surfaces** [10629-40]
- 10629 16   **Modeling liquid organic thin films on substrates** [10629-37]
- 10629 17   **Infrasound threat classification: a statistical comparison of deep learning architectures** [10629-42]
- 10629 18   **Deep wavelet scattering features for infrasonic threat identification** [10629-43]
- 10629 19   **Active standoff chemical identification detector** [10629-44]

POSTER SESSION

- 10629 1D   **Enhanced photoacoustic spectroscopy sensitivity through intra-cavity OPO excitation**
[10629-49]
- 10629 1E   **Fiber-based chemical sensing and sensing platforms with colorimetric dyes** [10629-50]
- 10629 1F   **Near-field infrasound classification of rocket launch signatures** [10629-51]

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.

Aggarwal, Ishwar D., 0P	Enderle, Sandra, 0V
Alazarine, Aymeric, 0X	Engelmann, Sebastian, 0Y
Andrews, Benjamin, 06	Ewing, Kenneth J., 0A, 0P
Arnold, Bradley, 0D	Farrell, Mikella E., 0P, 10
Arnone, David, 0A	Favier, Sylvain, 0X
Awanzino, Cédric, 02	Frandsen, Monte, 0T
Babnick, Robert, 0K	Furstenberg, Robert, 06, 0N, 13, 14
Barwicz, Tymon, 0Y	Gattass, Rafael R., 0A
Bernacki, Bruce E., 12, 16	Gay, Le Brun, 0X
Berry, R. James, 0S	Giardini, Stephen, 1E
Bhartia, R., 0J	Giblin, Jay P., 19
Bickford, Justin R., 10	Gill, Puneet, 0D
Bird, Alan, 0T	Gomer, Nathaniel R., 05
Blake, Thomas A., 16	Goyal, Anish K., 09, 15
Blanchard, Sébastien, 0X	Green, William M. J., 0Y
Bonner, Gerald M., 0V	Grisard, A., 02
Breshike, Christopher J., 06, 0N	Guicheteau, Jason A., 0H, 0M
Brown, Daniel, 0F	Guignon, Ernest, 0I
Brown, William L., 0S, 0U	Gutty, F., 02
Bryan, Kaylen J., 17, 18, 1F	Hardy, Hunter, 0K
Bryan, Michael R., 0Z	Head, C. Robin, 04
Bryan, Samuel A., 0G	Hempler, Nils, 04
Brygo, François, 02	Hennessy, Conor, 1E
Busse, Lynda, 0A	Hensley, Joel M., 19
Butler, S. D., 0E	Herron, Joshua P., 0S, 0U
Cady, Nathaniel C., 0I	Hinterhofer, Thomas, 0C
Cantley, Lauren, 1E	Hofstätter, Michael, 0C
Cho, Pak, 10	Holthoff, Ellen L., 0P, 10
Choa, Fow-Sen, 0D	Howle, Chris R., 0A
Chou, Eunice, 0I	Hug, W. F., 0J
Clauter, Dean A., 17, 18	Hugger, Stefan, 02
Clewes, Rhea J., 04, 0A	Hutchens, Thomas C., 0P
Cognetti, John S., 0Z	Jabbour, Rabin E., 0H
Conghuyentonn, Thuyan, 0K	Jiang, Xuefeng, 0R
Cooper, Christopher, 0D	Jin, Tiening, 11
Corbey, Jordan F., 0G	Johnson, Timothy J., 0G, 12, 16
Cosofret, Bogdan R., 0F	Kamlapurkar, Swetha, 0Y
Cruz, D., 0E	Kane, Justin, 0A
Cullum, Brian, 0D	Kastek, Mariusz, 02
Danby, Tyler O., 12	Kelley, David B., 09, 15
Davidson, Morgan, 0T	Kelly, Lisa, 0D
Dayal, Vishall, 0D	Kendziora, Christopher A., 06, 0N, 13, 14
De Vetter, Brent M., 12	Khater, Marwan, 0Y
Decoste, Jared, 0H	Kim, Jin Ho, 1E
Dixon, John P., 19	Kim, Y., 13, 14
Dominguez, Dawn, 06	Kingsborough, Richard P., 1E
Dunn, Malcolm H., 0V	Klein, Levente, 0Y
Dupuis, Julia R., 19	Kotidis, Petros, 09, 15
Emmons, Erik D., 0H	Kozak, Dmitry, 06

Kullander, F., 07
 Kunz, Jürgen, 02
 Kusterbeck, Andrew, 06, 0N
 Lallier, E., 02
 Lambrakos, S. G., 13, 14
 Lamsal, Nirmal, 05
 Landström, L., 07
 Larat, C., 02
 Lee, Do-Joong, 1E
 Lee, Linda, 0A
 Lemire, George W., 0S, 0U
 Li, Cheng, 0Q
 Lin, Pao Tai, 11
 Lin, Yi-Pin, 0I
 Lopez, Enrique, 0A
 Lorenzen, Arne, 02
 Lundén, H., 07
 Major, Kevin J., 0A, 0P
 Maker, Gareth T., 04
 Malcolm, Graeme P. A., 04
 Mansur, David J., 19
 Marchack, Nathan, 0Y
 Marchant, Sarah, 04
 Marinelli, William J., 19
 Martin, Yves, 0Y
 McGill, R. Andrew, 06, 0N, 13, 14
 McLeod, Euan, 0Q
 Miller, Benjamin L., 0Z
 Molner, Tim, 0K
 Moore, Kori D., 0U
 Münzhuber, Franz, 02
 Muralidhar, Ramachandran, 0Y
 Myers, Tanya L., 12, 16
 Nelson, Matthew P., 05
 Nguyen, Q., 0J
 Nguyen, Viet, 0N
 Odessey, Rachel, 1E
 Orcutt, Jason S., 0Y
 Osgood, Richard M., 1E
 Oswal, P., 0J
 Page, William, 0I
 Papantonakis, M. R., 13
 Papiillon, D., 02
 Pearson, James T., 0S
 Pellegrino, Paul M., 0P
 Peter, Adrian M., 17, 18, 1F
 Peterson, Gregory, 0H
 Peterson, Jim, 0T
 Pfennigbauer, Martin, 0C
 Piatkowski, Tadeusz, 02
 Pilar, Arturo, 0I
 Polak, Adam, 0V, 1D
 Potter, Matthew G., 0P
 Poutous, Menelaos K., 0P
 Prasad, Narasimha, 0D
 Pushkarsky, Michael, 0A
 Qavi, Abraham J., 0R
 Quigley, Keegan, 1E
 Raab, Michael, 02
 Rappeport, Eric, 0F
 Rattunde, Marcel, 02
 Reid, R. D., 0J
 Roberts, C. A., 13
 Rothbacher, Dieter, 0C
 Rothschild, Mordechai, 1E
 Ruxton, Keith, 04
 Sanghera, Jasbinder S., 0A, 0P
 Schares, Laurent, 0Y
 Schraml, Stephan, 0C
 Schwarz, M., 02
 Shabaev, A., 13, 14
 Shaw, L. Brandon, 0A
 Shokhirev, Kirill, 0F
 Sijapati, K., 0J
 Singh, N. B., 0D
 Singleton, B. J., 0E
 Smith, Anthony O., 17, 18, 1F
 Smith, Kaleb E., 17, 18, 1F
 Smith, Paul, 0D
 Solomon, Mitchell L., 17, 18, 1F
 Sosa, Norma, 0Y
 Sova, Stacey, 0D
 Steiner, Daniel J., 0Z
 Stievater, Todd, 06
 Stolyarov, Alexander, 1E
 Stothard, David J. M., 0V, 1D
 Su, Ching Hua, 0D
 Su, Judith, 0Q
 Su, Yin-Fong, 0G
 Sun, Haiyin, 05
 Sweet, Lucas E., 0G
 Taubman, Matthew S., 12
 Taubner, Benjamin, 0I
 Teimourpour, M. H., 0Q
 Teng, Chu C., 0Y
 Tholl, Hans Dieter, 02
 Thomas, Jack W., 0V
 Tonkyn, Russell G., 0G, 12
 Tripathi, Ashish, 0H
 Tysk, Shane, 1E
 Ullrich, Andreas, 0C
 van Kessel, Theodore G., 0Y
 Vunck, Darius, 0K
 Wästerby, P., 07
 Waterbury, Rob, 0K
 Wilcox, Phillip G., 0H, 0M
 Wilsenack, Frank, 02
 Wilson, Christopher R., 0P
 Wojcik, Michael, 0T, 0U
 Wood, Derek, 09, 15
 Wooden, Jason, 0T
 Wright, John, 0F
 Wysocki, Gerard, 0Y
 Xiong, Chi, 0Y
 Xu, Jimmy, 1E
 Yang, Lan, 0R
 Zenteno, Gabriel, 0I
 Zhang, Eric J., 0Y
 Zhou, Junchao, 11

Conference Committee

Symposium Chair

Arthur A. Morrish, Raytheon Space and Airborne Systems
(United States)

Symposium Co-chair

Ruth Moser, Air Force Research Laboratory (United States)

Conference Chairs

Jason A. Guicheteau, U.S. Army Edgewood Chemical Biological
Center (United States)

Augustus Way Fountain III, U.S. Army Edgewood Chemical Biological
Center (United States)

Chris R. Howle, Defence Science and Technology Laboratory
(United Kingdom)

Conference Program Committee

Russell G. Bartholomew, U.S. Army Edgewood Chemical Biological
Center (United States)

Christopher C. Carter, Johns Hopkins University Applied Physics
Laboratory (United States)

Darren K. Emge, U.S. Army Edgewood Chemical Biological Center
(United States)

Anthony Esposito, Defense Threat Reduction Agency (United States)

Timothy J. Johnson, Pacific Northwest National Laboratory
(United States)

Aaron LaPointe, U.S. Army Night Vision & Electronic Sensors
Directorate (United States)

Paul M. Pellegrino, U.S. Army Research Laboratory (United States)

Session Chairs

- 1 Keynote Session
Jason A. Guicheteau, U.S. Army Edgewood Chemical Biological
Center (United States)
- 2 Advances in Chemical Threat Sensing I
Jason A. Guicheteau, U.S. Army Edgewood Chemical Biological
Center (United States)

- 3   Advanced in Chemical Threat Sensing II
    Christopher R. Howle, Defence Science and Technology Laboratory
    (United Kingdom)
- 4   Radiological, Nuclear Sensing
    Timothy J. Johnson, Pacific Northwest National Laboratory
    (United States)
- 5   Biological Threat Detection
    Jason A. Guicheteau, U.S. Army Edgewood Chemical Biological
    Center (United States)
- 6   Explosive Detection
    Aaron LaPointe, U.S. Army Night Vision & Electronic Sensors
    Directorate (United States)
- 7   Photonic Integrated Circuit Threat Sensing I
    Paul M. Pellegrino, U.S. Army Research Laboratory (United States)
- 8   Vapor, Aerosol Detection
    Christopher C. Carter, Johns Hopkins University Applied Physics
    Laboratory (United States)
- 9   Photonic Integrated Circuit Threat Sensing II
    Paul M. Pellegrino, U.S. Army Research Laboratory (United States)
- 10   CBE Threat Signature Modeling and Algorithm Advancements
    Darren K. Emge, U.S. Army Edgewood Chemical Biological Center
    (United States)

Introduction

The 19th meeting of the CBRNE Sensing Conference met as part of the 2018 SPIE Defense and Commercial Sensing (DCS) Symposium in Orlando, Florida. The Conference extended over the course of three days and 10 sessions. Session co-chair Dr. Jason Guicheteau of the U.S. Army Edgewood Chemical Biological Center (ECBC) opened this year's conference by noting the program has continued to grow over its 19 years, from just over a dozen papers discussing chemical and biological (CB) sensing only, to more than 50 presentations and posters in 2018 spanning each element of the CBRNE spectrum, and with representation from the United States, Canada, and Europe.

This year marked the introduction of a new, and we hope permanent, session on photonic integrated circuit (PIC) technologies specifically for CBRNE sensing. Six presentations across two sessions described recent advancements in gas, aerosol, and biological sensing applications of integrated photonics technology. This field is rapidly advancing, leveraging developments from the telecommunications industry for the unique challenges of CBRNE sensing with the aim of developing accurate, miniaturized single particle detectors in an affordable way.

This year we also had the reemergence of a session specifically on algorithms and modeling for CBRNE sensors after a hiatus for several years. The session on "Threat Signature Modeling and Algorithm Advancements" highlighted recent advances in CBRNE detection. Half of the presentations in this session presented work funded by the Intelligence Advanced Research Projects Activity (IARPA) through the Standoff Illuminator for Measuring Absorbance and Reflectance Infrared Light Signatures (SILMARILS) program. A major focus of these efforts is modeling the radiative transfer of contaminated rough surfaces towards improving the stand-off detection of threat materials.

Key papers you may want to take notice of:

Judith Su from the University of Arizona and **Lan Yang** from Washington University in St. Louis, MO each presented papers on their own recent developments to further enhance the sensitivity of whispering gallery mode (WGM) optical resonators.

Lars Landström of the Swedish Defence Research Agency presented a novel approach to ultraviolet (UV) Raman imaging of surface contaminants using tunable laser and narrow bandpass filters. In this method, UV Raman hyperspectral data cubes were acquired by filtered imaging of a tunable laser-illuminated field of view to obtain Raman spectra at each pixel.

Nathaniel Cady from the State University of New York Polytechnic Institute presented work to develop a grating-coupled surface plasmon resonance and grating-coupled fluorescent plasmonics (GC-SPR/GC-FP) biosensor for the rapid, multiplexed detection of *Borrelia burgdorferi* infection.

Diana Cruz from the Air Force Institute of Technology presented early work aimed at determining whether defects in ytterbium doped fibers (YDF) exposed to radiation was the result of neutron emissions or some other cause.

Michael R. Papantonakis from NRL discussed the persistence of explosive particles in various environmental conditions, particularly those left within a fingerprint.

Joshua P. Herron from Utah State University discussed the development of an eye-safe elastic backscatter LiDAR for CB aerosol tracking.

Tanya L. Myers of PNNL presented work on determining index of refraction (n) and extinction coefficient (k) optical constants for modeling optical phenomena in media and at interfaces.

Once again we want to thank the committee who really makes this conference happen. This year marks the last year for one of us (AWF) as a Conference Co-chair. Dr. Fountain has been part of the Conference for the past 17 years and Chair or Co-chair the past 14 years. He will remain active with the Conference, but will be turning over the Chairmanship to Drs. Guicheteau and Howle. Next year the 20th meeting of the CBRNE Sensing Conference will be held in Baltimore, Maryland. The conference plans to have several invited talks to review the advances over the past two decades in CBRNE sensing. Selected proceedings papers will be invited to submitted as peer reviewed articles in the SPIE Journal "Optical Engineering" after the Conference. Mark your calendars now and please plan on attending this historic event.

Jason A. Guicheteau
Augustus Way Fountain III
Chris R. Howle