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

Augustus W. Fountain III
Editor

18–20 April 2016
Baltimore, Maryland, United States

Sponsored and Published by
SPIE

Volume 9824
# Contents

vii  **Authors**

ix  **Conference Committee**

xi  **Introduction**

## INTEGRATED PHOTONICS SENSING OF CBRNE THREATS

9824 02  Chemical and biological sensing applications of integrated photonics with an introduction to the American Institute for Manufacturing Integrated Photonics (AIM Photonics) [9824-1]

9824 03  Integrated mid-infrared photonic circuits for label-free biochemical sensing [9824-2]

9824 04  Nanophotonic waveguides for chip-scale Raman spectroscopy: theoretical considerations [9824-3]

9824 05  A label-free optical biosensor for serotyping "unknown" influenza viruses [9824-4]

## THE FUTURE OF CBRNE SENSING: APPLICATIONS OF QUANTUM SENSING

9824 07  Photon-sparse microscopy: trans-wavelength ghost imaging (Invited Paper) [9824-6]

## CURRENT PROGRESS IN CBRNE SENSING I

9824 0B  High sensitivity stand-off detection and quantification of chemical mixtures using an active coherent laser spectrometer (ACLaS) (Invited Paper) [9824-11]

9824 0C  Stand-off detection of explosives and precursors using compressive sensing Raman spectroscopy [9824-12]

9824 0D  Ultraviolet Raman scattering from persistent chemical warfare agents [9824-13]

9824 0E  Recent development of two new UV Raman standoff explosive detection systems [9824-14]

9824 0F  Trace material detection of surfaces via single-beam femtosecond MCARS (Best Paper Award) [9824-15]
**OPTICAL METHODS FOR SECURITY APPLICATIONS**

9824 0G  Applications of spatially offset Raman spectroscopy to defense and security (Invited Paper) [9824-16]

9824 0H  New designs for portable Raman instrumentation in defense applications (Invited Paper) [9824-17]

9824 0I  Bottled liquid explosive scanner by near infrared [9824-18]

9824 0J  Application of the modified transient plane source technique for early detection of liquid explosives [9824-19]

9824 0L  Characterization and control of tunable quantum cascade laser beam parameters for stand-off spectroscopy (Best Paper Award) [9824-21]

**CURRENT PROGRESS IN CBRNE SENSING II**

9824 0M  Standoff photoacoustic detections with high-sensitivity microphones and acoustic arrays (Invited Paper) [9824-22]

9824 0N  Progress towards a LaB₃-based associated particle imaging test bed for contraband detection and bulk materials analysis [9824-23]

9824 0O  Standoff photoacoustic sensing of trace chemicals by laser Doppler vibrometer [9824-24]

9824 0P  Spectral imaging of chemical compounds using multivariate optically enhanced filters integrated with InGaAs VGA cameras [9824-25]

**CURRENT PROGRESS IN CBRNE SENSING III**

9824 0Q  Chemical and explosive detection with long-wave infrared laser induced breakdown spectroscopy [9824-26]

9824 0R  Photoacoustic spectroscopy for trace vapor detection and standoff detection of explosives [9824-27]

9824 0S  Bioaerosol detection using single particle triggered LIBS [9824-28]

**ADVANCES IN ALGORITHMS FOR CBRNE SENSING**

9824 0U  Detection of gaseous plumes in airborne hyperspectral imagery [9824-30]

9824 0V  Hyperspectral image analysis for standoff trace detection using IR laser spectroscopy [9824-31]
<table>
<thead>
<tr>
<th>ID</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>9824 0W</td>
<td>Analysis of analytic nonresonant background removal algorithm for MCARS spectra [9824-32]</td>
</tr>
<tr>
<td>9824 0Y</td>
<td>Standoff detection: distinction of bacteria by hyperspectral laser induced fluorescence [9824-34]</td>
</tr>
<tr>
<td>9824 0Z</td>
<td>Analysis of continuum generation in bulk materials with a femtosecond Ti:Sapph laser [9824-35]</td>
</tr>
</tbody>
</table>

**RADIOLOGICAL AND NUCLEAR SENSING**

<table>
<thead>
<tr>
<th>ID</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>9824 11</td>
<td>Design and growth of novel compounds for radiation sensors: multinary chalcogenides [9824-37]</td>
</tr>
<tr>
<td>9824 12</td>
<td>Tritium-powered radiation sensor network [9824-38]</td>
</tr>
<tr>
<td>9824 14</td>
<td>Low-cost fabrication of high efficiency solid-state neutron detectors [9824-40]</td>
</tr>
<tr>
<td>9824 15</td>
<td>Raman spectroscopy for analysis of thorium compounds [9824-41]</td>
</tr>
</tbody>
</table>

**CURRENT PROGRESS IN CBRNE SENSING IV**

<table>
<thead>
<tr>
<th>ID</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>9824 16</td>
<td>Real-time short-wave infrared hyperspectral conformal imaging sensor for the detection of threat materials [9824-42]</td>
</tr>
<tr>
<td>9824 17</td>
<td>Airborne pipeline leak detection: UV or IR? [9824-43]</td>
</tr>
<tr>
<td>9824 18</td>
<td>A method to control the polymorphic phase for RDX-based trace standards [9824-44]</td>
</tr>
<tr>
<td>9824 19</td>
<td>Persistence of explosives under real world conditions [9824-45]</td>
</tr>
<tr>
<td>9824 1A</td>
<td>A new approach for detection of explosives based on ion mobility spectrometry and laser desorption/ionization on porous silicon [9824-46]</td>
</tr>
</tbody>
</table>

**POSTER SESSION**

<table>
<thead>
<tr>
<th>ID</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>9824 1B</td>
<td>Eye-safe infrared laser-induced breakdown spectroscopy (LIBS) emissions from energetic materials [9824-47]</td>
</tr>
</tbody>
</table>
Authors

Numbers in the index correspond to the last two digits of the six-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first four 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.

Ackermann, Sarah L. G., 0J
Adams, Katy, 19
Agassi, Eyal, 0U
Ågren, Matilda, 0C
Allard, Martin, 17
Argirakis, Brittney L., 18
Arnold, Brad, 11
Aspden, Reuben S., 07
Babin, François, 17
Babnick, Robert, 0E
Bateman, Robert, 0J
Bhat, Ishwara B., 14
Bickford, Justin, 02
Bowman Pilkington, Sherrie, 0F, 0W, 0Z
Boyd, Robert W., 07
Brady, John J., 18
Brown, El E., 0G, 1B
Buller, Gerald S., 07
Bufo, Shane, 0H
Butschek, L., 0V
Carroll, J. J., 0N
Carron, Keith, 0H
Chamberland, Martin, 0U
Chiara, C. J., 0N
Chistyakov, Alexander, 1A
Choa, Fow-Sen, 0M, 11
Cooper, Justin L., 0E
Dahal, Rajendra, 14
Danon, Yaron, 14
Demaree, J. D., 0N
Dovzhenko, Dmitriy, 1A
Dreyfous, A., 0V
Duschek, Frank, 0Y
Eichstaedt, Holger, 0U
English, Erik, 14
Felliner, Lea, 0Y
Fischer, Thomas, 19
Ford, Alan R., 0E
Fu, Y., 0O
Fuchs, F., 0V
Furstenberg, Robert, 0L, 19
Gagnon, Marc-André, 0U
Gemmeil, Nathan R., 07
Glimtoft, Martin, 0C
Gordon, Alexander D., 18
Gradmark, Per-Åke, 0S
Grahmann, J., 0V
Gravel, Jean-François, 17
Grünewald, Karin M., 0Y
Guardala, N. A., 0N
Guicheteau, Jason, 02, 0G
Gupta, Deepa, 0M
Hadfield, Robert H., 07
Handke, Jürgen, 0Y
Harris, Adam, 0J
Hausmann, Anita, 0Y
Hella, Mona M., 14
Henry Dunand, Carole, 05
Herrera, Francisco, 0E
Hirsch, Eltan, 0U
Holmström, Scott A., 04
Holthoff, Ellen L., 0R
Homerich, Uwe H., 0Q, 1B
Hopkins, Adam J., 0E
Hopkins, Rebecca, 0G
Howard, Andrew, 19
Howle, Christopher R., 0J
Hu, Q., 0O
Huang, Kuan-Chih, 14
Hugger, S., 0V
Itozaki, Hideo, 0I
Jacksen, Niels, 0P
Jarvis, J., 0V
Jin, Feng, 0Q, 1B
Johnson, Timothy J., 15
Julich, Sandra, 0Y
Karlsso, Annelle, 0S
Katis, Dinos, 12
Kendziora, Christopher A., 0L, 19
Khurkin, Jacob B., 04, 0M
Kirkwood, Robert A., 07
Kotkovskii, Gennadii, 1A
Kozak, Dmytry, 04
Kullander, Fredrik, 0D
Kumi-Barimah, Eric, 0Q
Kuzishchin, Yury, 1A
Landström, Lars, 0D, 0S
Lareau, Richard T., 18
Larsson, Anders, 0S
Lee, Linda, 0J
Lin, Pao Tai, 03
Lutz, Marc S., 0R
Liu, H., 0O
Lu, James J.-Q., 14
MacLeod, Neil A., 0B
Marcus, Logan S., 0R
Marsh, J. C., 0N
Martynov, Igor, 1A
McGill, R. Andrew, 04, 0L, 19
Mertens, Lena, 07
Miller, Benjamin L., 05
Morris, Peter A., 07
Nagaradona, Teja, 11
Nelson, Matthew P., 16
Nguyen, Viet, 0L, 19
Nordberg, Markus, 0C
Olsen, Khris B., 15
Ostendorf, R., 0V
Östmark, Henric, 0C
Padgett, Miles J., 07
Papantonakis, Michael R., 0L, 19
Pargmann, Carsten, 0Y
Pellegrino, Paul M., 0F, 0R, 0W, 0Z
Pohl, Ken, 0E
Priore, Ryan J., 0P, 16
Profeta, Luisa T. M., 0E
Pruessner, Marcel W., 04
Rabinovich, William S., 04
Ray, Bryan, 0H
Roberson, Stephen D., 0F, 0W, 0Z
Ruggeri, Alessandro, 07
Russo, Johnny A., 12
Samuels, Alan C., 0M, 0Q, 1B
Sandoval, Juan, 0E
Shi, Lei, 16
Singh, N. B., 11
Smith, Barry T., 18
Stievater, Todd H., 04
Strickland, Aaron, 0H
Su, Ching-Hua, 11
Su, Yin-Fong, 15
Svanavist, Mattias, 0C
Tanner, Michael G., 07
Tasca, Daniel S., 07
Tomasso, Herbert, 0Y
Tosi, Alberto, 07
Treado, Patrick J., 16
Trivedi, Sudhir B., 0M, 0Q, 1B
Vunck, Darius, 0E
Wagner, J., 0V
Walter, Arne, 0Y
Wang, Chen-Chia, 0M
Wösterby, Pär, 0D
Waterbury, Rob, 0E
Weidmann, Damien, 0B
Welz, Adam, 14
Wilson, Patrick, 05
Wu, Jia-Woei, 14
Yang, Clayton S.-C., 0Q, 1B
Yang, Q., 0V
Zbur, Lucas, 16
Zhang, Hanyuan, 05
Conference Committee

Symposium Chair

David A. Logan, BAE Systems (United States)

Symposium Co-chair

Donald A. Reago Jr., U.S. Army Night Vision & Electronic Sensors Directorate (United States)

Conference Chair

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

Conference Program Committee

Sylvie Buteau, Defence Research and Development Canada, Valcartier (Canada)
James P. Carney, Sandia National Laboratories (United States)
Christopher C. Carter, Johns Hopkins University Applied Physics Laboratory, LLC (United States)
Henry Chen, Brimrose Corporation of America (United States)
Darren K. Emge, U.S. Army Edgewood Chemical Biological Center (United States)
Jason A. Guicheteau, U.S. Army Edgewood Chemical Biological Center (United States)
Chris R. Howle, Defense Science and Technology Laboratory (United Kingdom)
Harry Ing, Bubble Technology Industries, Inc. (Canada)
Timothy J. Johnson, Pacific Northwest National Laboratory (United States)
Aaron LaPointe, U.S. Army RDECOM CERDEC NVESD (United States)
Paul M. Pellegrino, U.S. Army Research Laboratory (United States)
Cynthia R. Swim, U.S. Army Edgewood Chemical Biological Center (United States)
Christian Whitchurch, Defense Threat Reduction Agency (United States)
Session Chairs

1 Integrated Photonics Sensing of CBRNE Threats
   Jason A. Guicheteau, U.S. Army Edgewood Chemical Biological Center (United States)

2 The Future of CBRNE Sensing: Applications of Quantum Sensing
   Christopher R. Howle, Defence Science and Technology Laboratory (United Kingdom)

3 Current Progress in CBRNE Sensing I
   Jason A. Guicheteau, U.S. Army Edgewood Chemical Biological Center (United States)

4 Optical Methods for Security Applications
   Jason A. Guicheteau, U.S. Army Edgewood Chemical Biological Center (United States)

5 Current Progress in CBRNE Sensing II
   Aaron LaPointe, U.S. Army RDECOM CERDEC NVESD (United States)

6 Current Progress in CBRNE Sensing III
   Christopher C. Carter, Johns Hopkins University Applied Physics Laboratory, LLC (United States)

7 Chemical Detection: Joint Session with Conferences 9823 and 9824
   Vincent P. Schnee, U.S. Army RDECOM CERDEC NVESD (United States)
   Anthony A. Faust, Defence Research and Development Canada, Suffield (Canada)

8 Advances in Algorithms for CBRNE Sensing
   Darren K. Emge, U.S. Army Edgewood Chemical Biological Center (United States)

9 Radiological and Nuclear Sensing
   Henry Chen, Brimrose Corporation of America (United States)

10 Current Progress in CBRNE Sensing IV
    Paul M. Pellegrino, U.S. Army Research Laboratory (United States)
Introduction

The 17th meeting of the CBRNE Sensing Conference met as part of the 2016 SPIE Defense + Commercial Sensing (DCS) Symposium in Baltimore, MD. The Conference extended over the course of three days and 10 sessions, one of which for the first time was held jointly with the “Detection and Sensing of Mines, Explosive Objects, and Obscured Targets XXI” Conference. This year we initiated two new sessions. The first was “Integrated Photonics Sensing of CBRNE Threats”. This session highlighted recent advances in chemical and biological sensing applications of integrated photonics coming out of the American Institute for Manufacturing Integrated Photonics (AIM Photonics). The second new session “Applications of Quantum Sensing” looks to explore how advances in Quantum Optics can help solve key detection challenges for the CBRNE community. We plan to continue these sessions and open up new ones as the Conference travels with the 2017 SPIE DCS Symposium to Anaheim, California.

Key Papers and Highlights:

Pao Tai Lin of Texas A&M University presented interesting work on decreasing the size of detectors on a chip. The work increased the sensitivity for chemical detection by over 50 times. The device was able to differentiate multiple liquids (n-bromohexane, toluene, isopropanol, etc.) as well as the individual concentrations of multiple liquids (acetonitrile and ethanol) in a solution. A clear summary from the basic science and technology to the nanoengineering of the device was presented, and this research could be transitioned into smaller platforms for chemical and explosive weapon material detection.

Rebecca J. Hopkins of the Defence Science and Technology Laboratory presented a talk on the non-destructive detection and identification of samples spatially offset Raman spectroscopy (SORS). These samples can originate from security and defense applications as well as forensic science applications. Their current SORS methodology can reach up through 3 mm of polyvinyl chloride (PVC) pipe.

Matthew P. Nelson of ChemImage Corporation presented on their work of a real-time, adaptable, compressive sensing short-wave infrared hyperspectral imaging technology. This technology, dubbed Reconfigurable Conformal Imaging Sensor, could be used as a stand-off detector for trace detection of narcotics, explosives, chemical warfare agents, and other contraband on the surfaces of vehicles and walls.

Once again I want to thank my committee who really makes this conference happen. There is no way I could review all the abstracts and proceedings papers or host all the sessions without them. I am confident that this conference remains
the most important means of bringing together the leaders in the field of CBRNE sensing from every sector; government, academia and industry. I am already excited about next year’s conference and the new developments it will report on.

Augustus W. Fountain III