PROCEEDINGS OF SPIE

SPIDigitalLibrary.org/conference-proceedings-of-spie

Front Matter: Volume 10980

, "Front Matter: Volume 10980," Proc. SPIE 10980, Image Sensing Technologies: Materials, Devices, Systems, and Applications VI, 1098001 (10 July 2019); doi: 10.1117/12.2536842

SPIE.

Event: SPIE Defense + Commercial Sensing, 2019, Baltimore, MD, United States

PROCEEDINGS OF SPIE

Image Sensing Technologies: Materials, Devices, Systems, and Applications VI

**Nibir K. Dhar
Achyut K. Dutta
Sachidananda R. Babu**
Editors

**15–16 April 2019
Baltimore, Maryland, United States**

Sponsored and Published by
SPIE

Volume 10980

Proceedings of SPIE 0277-786X, V. 10980

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

Image Sensing Technologies: Materials, Devices, Systems, and Applications VI, edited by Nibir K. Dhar,
Achyut K. Dutta, Sachidananda R. Babu, Proc. of SPIE Vol. 10980, 1098001 · © 2019 SPIE
CCC code: 0277-786X/19/\$18 · doi: 10.1117/12.2536842

Proc. of SPIE Vol. 10980 1098001-1

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 *Image Sensing Technologies: Materials, Devices, Systems, and Applications VI*, edited by Nibir K. Dhar, Achyut K. Dutta, Sachidananda R. Babu, Proceedings of SPIE Vol. 10980 (SPIE, Bellingham, WA, 2019) Seven-digit Article CID Number.

ISSN: 0277-786X

ISSN: 1996-756X (electronic)

ISBN: 9781510626256

ISBN: 9781510626263 (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 © 2019, 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/19/\$18.00.

Printed in the United States of America by Curran Associates, Inc., under license from SPIE.

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>

ADVANCED HYPERSPECTRAL IMAGING I

10980 04	Panchromatic sharpening enabling low-intensity imaging of cultural heritage documents (Invited Paper) [10980-3]
10980 05	Anamorphic imaging spectrometers (Invited Paper) [10980-4]

ADVANCED HYPERSPECTRAL IMAGING III

10980 0A	Metamaterials based hyperspectral and multi-wavelength filters for imaging applications [10980-9]
----------	--

ADVANCED PHOTODETECTION AND EMITTER TECHNOLOGIES

10980 0E	Uncooled doped-Si thermopiles for thermal land imaging applications (Invited Paper) [10980-13]
10980 0F	BABAR: black array of broadband absolute radiometers for far infrared sensing [10980-14]
10980 0H	Recent progress on GaSb-based electrically-pumped VCSELs for wavelengths above 4 μm (Invited Paper) [10980-16]
10980 0I	Perfectly understood non-uniformity: methods of measurement and uncertainty of uniform sources [10980-42]

ADVANCED PHOTODETECTORS AND FOCAL PLANE ARRAY I

10980 0J	T2SL digital focal plane arrays for earth remote sensing applications (Invited Paper) [10980-17]
10980 0K	Linear-mode avalanche photodiode arrays in HgCdTe at Leonardo, UK: the current status (Invited Paper) [10980-20]

ADVANCED PHOTODETECTORS AND FOCAL PLANE ARRAY II

- 10980 OL **Rapid prototyping of single-photon-sensitive backside-illuminated silicon avalanche photodiode arrays** [10980-21]
- 10980 OM **High performance GaN/AlGaN ultraviolet avalanche photodiode detector technologies** [10980-22]

ADVANCED TECHNOLOGY I

- 10980 OP **Localized surface plasmon enhanced infrared photodetectors for uncooled imaging systems** [10980-25]
- 10980 OQ **Smart filters for image sensor enhancement** [10980-26]
- 10980 OR **Development of tunable longwave infrared metamaterial notch filters** [10980-27]

ADVANCED TECHNOLOGY II

- 10980 OT **Machine learning for avoiding stagnation in image-based wavefront sensing (Invited Paper)** [10980-29]
- 10980 OU **Broadband antireflection coatings for advanced sensing and imaging applications** [10980-30]
- 10980 OV **High energy neutron irradiation effects on molecular beam epitaxy HgCdTe-based focal plane arrays and cameras** [10980-31]

POSTER SESSION

- 10980 OY **Additive manufacturing for microwave and millimeter-wave antennas: a summary of current technology and experimentation** [10980-35]
- 10980 OZ **Enabling curved hemispherical arrays with Quilt Packaging interconnect technology** [10980-38]
- 10980 10 **Evaluation of tunable pixel-scale Fabry-Perot etalons for optical imaging** [10980-39]
- 10980 11 **CMOS image sensor with off-center circular apertures for depth extraction** [10980-40]
- 10980 12 **Accurate simulation of on-sensor compressed sensing using ISET** [10980-41]
- 10980 13 **Surface methodology for 3D printed multispectral systems** [10980-36]

- 10980 14 **IR absorption spectra for PCE, TCE, DCE, and VC molecules using density functional theory** [10980-43]
- 10980 15 **Electron transport response de-embedding for high-speed image sensors** [10980-45]
- 10980 16 **Sparse-sampling methods for hyperspectral infrared microscopy** [10980-46]
- 10980 18 **Industrial monocular multispectral 3D-imager** [10980-48]
- 10980 19 **Photocurrent enhancement of CVD MoS₂ photodetector via nanoplasmonics** [10980-49]
- 10980 1A **Design of materials for IR detectors using high Z elements for high energy radiation environment** [10980-50]
- 10980 1C **Simultaneous multi-wavelength laser spot detection and beam wander measurement using novel polymer imaging system** [10980-52]
- 10980 1D **3-D SAR imaging for multistatic GPR** [10980-53]
- 10980 1E **A novel near-infrared metalens using type I hyperbolic metamaterial** [10980-54]

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.

Arafin, S., 0H	Gupta, Pravir Singh, 12
Arnold, Bradley, 1A	Harber, David M., 0F
Aull, Brian F., 0L	Herrington, Mark, 0K
Babu, Sachidananda, 0J, 0M	Hill, Cory, 0J
Baker, Ian, 0K	Hipwood, Les, 0K
Bandyopadhyay, Avra S., 19	Holt, Jeff, 0I
Barnes, Keith, 0K	Huang, L., 14
Barrentine, Emily M., 0E	Huston, Dryver, 1D
Bendoym, Igor, 0A	Isgar, Vincent, 0K
Bernstein, Gary H., 0Z	Jablonski, Joe, 0I
Blanchard, Romain, 16	Joseph, Alicia T., 0E
Brown, Ari D., 0E	Jung, H., 0H
Bu, Ting, 1C	Kane, Timothy J., 0Y, 13
Celestre, R., 18	Kaul, Anupama B., 19
Chang, Seunghyuk, 11	Kehoe, Michael, 05
Chang, Y., 0V	Keo, Sam, 0J
Chang, Yun-Tzu, 15	Khoshakhlagh, Arezou, 0J
Choa, Fow-Sen, 1A	Kim, Sang-Hwan, 11
Choi, Byoung-Soo, 11	Kirk, William S., 05
Choi, Gwan Seong, 12	Knight, Thomas, 0Z
Choi, Kwong-Kit, 0J	Kokot, Alex M., 0Z
Ciampi, Joseph, 0L	Kotecki, Carl, 0E
Cooper, Christopher, 1A	Kulick, Jason M., 0Z
Crouse, David, 0A	Kumar, Prajnesh, 1C
Cullum, Brian, 1A	Kyamo, Mohamed J., 1E
Das, Rabindra, 0L	Lail, Brian A., 1E
Davidson, Joshua C., 0Y, 13	Lambert, Renee D., 0L
de Anda Orea, Carlos F., 19	Lambrakos, S. G., 14
DiPaula, Philip, 1A	Lee, Jewon, 11
Dobrowski, Luke, 0I	Lee, Jimin, 11
Dodge, Guy C., 05	Lee, Junwoo, 11
Donval, Ariela, 0Q	Lee, Sang-Jin, 11
D'Souza, Arvind, 0J	Lehman, John H., 0F
Dunn, Kaitlin, 0A	Leitz, Christopher W., 0L
Dupuis, Russell D., 0M	Liu, Youlin, 16
Durell, Chris, 0I	Lu, Tian, 0Z
Edwards, Daniel L., 10	Luong, Edward, 0J
Efstathiadis, Harry, 0U	Martini, Rainer, 1C
Felton, Bradley, 0L	Massa, L., 14
Fienup, James R., 0T	Masterjohn, Christopher, 0J
Fisher Masliah, Tali, 0Q	Maxey, Chris, 0K
Fisher, Anita, 0J	McIntosh, K. Alexander, 0L
Fütterer, R., 18	Messinger, David W., 04
Geiger, Andreas C., 16	Mikula, Vilem, 0E
Ghuman, Parminder, 0J, 0M	Mirbagheri, Golsa, 0A
Golomo, A., 18	Mirotnik, Mark S., 0R
Gross, Noam, 0Q	Narayanan, Ram M., 0Y, 13
Gunapala, Sarath, 0J	Nichols, Bruce, 0Z
Gupta, Neelam, 0R	Ninkov, Zoran, 10

Notni, G., 18
 O'Neill, Andrew D., 0Y, 13
 Ortega, Carlos, 0Z
 Paine, Scott W., 0T
 Park, JongHo, 11
 Partouche, Eran, 0Q
 Peery, Tyler R., 04
 Pepper, Brian, 0J
 Pereira, Mauricio, 1D
 Pethuraja, Gopal G., 0U
 Rabade, Saurabh, 0I
 Rabe, Steven, 0L
 Rafol, Sir, 0J
 Raisanen, Alan D., 10
 Reid, Riley A., 0E
 Richard, Erik C., 0F
 Rosenberger, M., 18
 Rutkowski, Joel, 0F
 Ryu, Kevin K., 0L
 Sachs, David, 1A
 Saenz, Gustavo A., 19
 Saraf, Sonali, 1A
 Scharpf, Dan, 0I
 Schuette, Daniel R., 0L
 Shin, Jang-Kyoo, 11
 Siders, Seth, 0Z
 Simpson, Garth J., 16
 Singh, N. B., 1A
 Smith, Casey, 05
 Soibel, Alexander, 0J
 Sood, Adam W., 0U
 Sood, Ashok K., 0M, 0U
 Stephens, Michelle S., 0F
 Straatsma, Cameron, 0F
 Su, Ching Hua, 1A
 Suo, Fei, 0P
 Süß, Andreas, 15
 Swanson, Rand, 05
 Ting, David, 0J
 Tomlin, Nathan A., 0F
 Tong, Jinchao, 0P
 Ulcickas, James R. W., 16
 Van Dorpe, Pol, 15
 Van Hoof, Chris, 15
 Velicu, S., 0V
 Volfson, David, 0L
 Weller, Harald, 0K
 Welser, Roger E., 0U
 Wijewarnasuriya, Priyalal S., 0U
 Witinski, Mark F., 16
 Xia, Tian, 1D
 Yoon, Sang, 0E
 Yung, Christopher S., 0F
 Zeller, John W., 0M, 0U
 Zhang, C., 18
 Zhang, Dao-Hua, 0P
 Zhang, Dayu, 1C
 Zhang, Yu, 1D

Conference Committee

Symposium Chairs

Jay Kumler, JENOPTIK Optical Systems, LLC (United States)
Ruth L. Moser, Air Force Research Laboratory (United States)

Symposium Co-chair

John M. Pellegrino, Electro-Optical Systems Laboratory, Georgia
Institute of Technology (United States)

Conference Chairs

Nibir K. Dhar, U.S. Army Night Vision & Electronic Sensors Directorate
(United States)
Achyut K. Dutta, Banpil Photonics, Inc. (United States)
Sachidananda R. Babu, NASA Earth Science Technology Office
(United States)

Conference Program Committee

Homayoon Ansari, Jet Propulsion Laboratory (United States)
Houtong Chen, Los Alamos National Laboratory (United States)
Arvind I. D'Souza, DRS Sensors & Targeting Systems, Inc.
(United States)
Michael D. Gerhold, U.S. Army Research Office (United States)
Parminder Ghuman, NASA Goddard Space Flight Center
(United States)
Randy Jacobs, U.S. Army RDECOM CERDEC NVESD (United States)
Marvin Jaime-Vasquez, U.S. Army Night Vision & Electronic Sensors
Directorate (United States)
Margaret Kim, The University of Alabama (United States)
Nobuhiko P. Kobayashi, University of California, Santa Cruz
(United States)
Sanjay Krishna, The Ohio State University (United States)
Rihito Kuroda, Tohoku University (Japan)
Hidenori Mimura, Shizuoka University (Japan)
Willie Padilla, Duke University (United States)
Vijay Parameshwaran, U.S. Army Research Laboratory (United States)
Mukti M. Rana, Delaware State University (United States)
Amrita Sahu, Altria Group, Inc. (United States)
Siva Sivananthan, Sivananthan Labs. (United States)
Ashok K. Sood, Magnolia Optical Technologies, Inc. (United States)

Priyalal S. Wijewarnasuriya, U.S. Army Research Laboratory
(United States)
Antoine Wojdyla, Lawrence Berkeley National Laboratory
(United States)

Session Chairs

- 1 Advanced Hyperspectral Imaging I
 Nibir K. Dhar, U.S. Army Night Vision & Electronic Sensors Directorate
 (United States)
 Amrita Sahu, Altria Group, Inc. (United States)
- 2 Advanced Hyperspectral Imaging II
 Amrita Sahu, Altria Group, Inc. (United States)
- 3 Advanced Hyperspectral Imaging III
 Amrita Sahu, Altria Group, Inc. (United States)
 Sachidananda R. Babu, NASA Earth Science Technology Office
 (United States)
- 4 Advanced Photodetection and Emitter Technologies
 Emily M. Barrentine, NASA Goddard Space Flight Center
 (United States)
 Achyut K. Dutta, Banpil Photonics, Inc. (United States)
- 5 Advanced Photodetectors and Focal Plane Array I
 Arvind I. D'Souza, Leonardo DRS (United States)
 Sarath D. Gunapala, Jet Propulsion Laboratory (United States)
- 6 Advanced Photodetectors and Focal Plane Array II
 Sanjay Krishna, The Ohio State University (United States)
- 7 Advanced Technology I
 Parminder Ghuman, NASA Goddard Space Flight Center
 (United States)
- 8 Advanced Technology II
 Emily M. Barrentine, NASA Goddard Space Flight Center
 (United States)
 Achyut K. Dutta, Banpil Photonics, Inc. (United States)