PROCEEDINGS OF SPIE

[SPIDigitalLibrary.org/conference-proceedings-of-spie](https://spiedigitallibrary.org/conference-proceedings-of-spie)

Front Matter: Volume 10181

, "Front Matter: Volume 10181," Proc. SPIE 10181, Advanced Optics for Defense Applications: UV through LWIR II, 1018101 (21 June 2017); doi: 10.1117/12.2280583

Event: SPIE Defense + Security, 2017, Anaheim, CA, United States

PROCEEDINGS OF SPIE

Advanced Optics for Defense Applications: UV through LWIR II

Jay N. Vizgaitis
Bjørn F. Andresen
Peter L. Marasco
Jasbinder S. Sanghera
Miguel P. Snyder
Editors

9–10 April 2017
Anaheim, California, United States

Sponsored and Published by
SPIE

Volume 10181

Proceedings of SPIE 0277-786X, V. 10181

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

Advanced Optics for Defense Applications: UV through LWIR II, edited by Jay N. Vizgaitis, Bjørn F. Andresen, Peter L. Marasco, Jasbinder S. Sanghera, Miguel P. Snyder, Proc. of SPIE Vol. 10181, 1018101
© 2017 SPIE · CCC code: 0277-786X/17/\$18 · doi: 10.1117/12.2280583

Proc. of SPIE Vol. 10181 1018101-1

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 SPIEDigitalLibrary.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 *Advanced Optics for Defense Applications: UV through LWIR II*, edited by Jay N. Vizgaitis, Bjørn F. Andresen, Peter L. Marasco, Jasbinder S. Sanghera, Miguel P. Snyder, Proceedings of SPIE Vol. 10181 (SPIE, Bellingham, WA, 2017) Seven-digit Article CID Number.

ISSN: 0277-786X

ISSN: 1996-756X (electronic)

ISBN: 9781510608634

ISBN: 9781510608641 (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 © 2017, 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/17/\$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

v	<i>Authors</i>
vii	<i>Conference Committee</i>

OPTICAL DESIGN AND ANALYSIS I

10181 03	Design of multiband optics using updated athermal/achromatic glass map [10181-2]
10181 04	Comparison of gimbal approaches to decrease drag force and radar cross sectional area in missile application [10181-3]
10181 05	Optimization of electro-optic phase shifters for integrated optical phased arrays [10181-4]

GRIN

10181 08	Ternary versus binary material systems for gradient index optics (Invited Paper) [10181-8]
10181 09	Optical design of athermal, multispectral, radial GRIN lenses [10181-9]
10181 0A	Using GRIN to save 50% lens weight for an 8x rifle scope design [10181-10]
10181 0B	IR GRIN optics: design and fabrication [10181-11]
10181 0C	Athermal achromat theory for polymer gradient index optics [10181-12]

OPTICAL DESIGN AND ANALYSIS II

10181 0E	Using material advances in chalcogenide glasses to improve imaging lenses in the 8-14 μm waveband [10181-13]
10181 0F	Digital correction of aberrations introduced by tilted plane-parallel plates in convergent beams [10181-15]
10181 0G	A system perspective on designing for field-dependent SNR in wide-angle point-source detection lenses [10181-16]
10181 0H	Expanding the mission plan for large scale telescope systems via skew path optical conditioners [10181-17]

COATINGS AND FILTERS

- 10181 OJ **Design of broadband anti-reflective metasurfaces based on an effective medium approach** [10181-19]
- 10181 OK **Large area precision optical coatings by pulse magnetron sputtering** [10181-20]
- 10181 OM **The angular dependence of optical interference filters in the Near IR can be greatly reduced through the use of novel coating materials and design strategies** [10181-22]
- 10181 ON **Optimizing the effect of electric-field enhancement in nodular defects** [10181-23]
- 10181 OO **Optimizing ITO for incorporation into multilayer thin film stacks for visible and NIR applications** [10181-32]
- 10181 OP **Characterization of reactive plasma ion assisted HfO₂ films for low loss optical coatings in the DUV and MWIR** [10181-33]

MATERIALS AND MANUFACTURING I

- 10181 OR **Structural modification of Ga-La-S glass for a new family of chalcogenides** [10181-25]
- 10181 OS **Assessment of an approach to printed polymer lenses** [10181-35]

MATERIALS AND MANUFACTURING II

- 10181 OT **Progress on high-performance rapid prototype aluminum mirrors** [10181-26]
- 10181 OU **Chalcogenide molded freeform optics for mid-infrared lasers** [10181-27]

SELECT PAPERS IN OPTICS

- 10181 OV **Mid-infrared imaging fiber bundle** [10181-29]
- 10181 OW **UV scale calibration transfer from an improved pyroelectric detector standard to field UV-A meters and 365 nm excitation sources** [10181-30]
- 10181 OX **Non-mechanical beam steering in the mid-wave infrared** [10181-34]

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.

Aghajani, A., 0R	Leischnig, Steffen, 0K
Alexay, Christopher, 0H	Levita, Zachary, 0O
Alvarez, Oseas, 0U, 0V	Lindberg, George, 0B
Anderson, Mike, 0X	Ma, Bin, 0N
Atalick, S., 0F	Macik, Dwayne D., 05
Bartzsch, Hagen, 0K	Madsen, Christi K., 05
Bayya, Shyam, 0B	Mait, J., 08
Beadie, G., 08, 0A, 0C	Marasco, Peter L., 0S
Bekele, Robel Y., 0X	Marshall, G., 0F
Boyd, Andrew M., 09	Mayer, T., 0J
Bravo, Tyler E., 05	McClain, Collin, 0B
Brown, Douglas, 0O	Milojkovic, P., 08
Bundesmann, Carsten, 0K	Morgan, K. A., 0R
Bungay, C., 0J	Morrish, Alan, 0O
Cangemi, Michael J., 0P	Myers, Jason D., 0X
Chenard, Francois, 0U, 0V	Myrick, Bruce H., 0T
Cheng, Xinbin, 0N	Naciri, Jawad, 0X
Chinhong, Christopher J., 0P	Nguyen, Vinh, 0B
Christodoulides, D. N., 0J	Nye, N. S., 0J
Cline, Robert A., 0G	Olson, S. Craig, 0G
Cooksey, C. C., 0W	Oudard, Jean Francois, 0P
Craig, C., 0R	Palmer, Troy A., 0H
Davis, Scott R., 0X	Pentecost, Seeley M., 05
Deegan, John, 0B	Platten, Jim E., 0P
D'Iallo, Michael J., 0P	Podobedov, V. B., 0W
Drescher, Andy, 0K	Ramsey, J. L., 03
Eppeldauer, G. P., 0W	Ravagli, A., 0R
Espinal, Francisco A., 05	Rivero-Baleine, C., 0J
Flynn, R. A., 08, 0A, 0C	Rommel, Scott D., 0X
Foot, Bob, 0S	Roschuk, Tyler, 0O
Frach, Peter, 0K	Sakarya, Doğan Uğur, 04
Franks, J. W., 0E	Sanghera, Jasbinder S., 0B, 0V, 0X
Frantz, Jesse A., 0X	Savastinuk, John, 0H
Gibson, Daniel, 0B, 0V	Schuster, N., 0E
Gloess, Daniel, 0K	Shaw, Leslie B., 0V, 0X
Goodman, Timothy D., 0G	Sodergren, Bennett, 0X
Goschurny, Thomas, 0K	Sparks, Andrew W., 0G
Gotjen, Henry, 0X	Spillmann, Christopher M., 0X
Greenhalgh, C., 0F	Sprague, Robert W., 0M
Grune, Harald, 0K	Swisher, A., 0J
Hartung, Ullrich, 0K	Szapiel, S., 0F
He, Tao, 0N	Taddeo, David, 0O
Heisig, Andreas, 0K	Thorpe, M., 0F
Hewak, D. W., 0R	Tuenge, S., 0J
Jiao, Hongfei, 0N	Unger, Blair, 03, 0B
Kolacz, Jakub S., 0X	Verplancke, J., 0E
Kotov, Mikhail, 0B	Vizgaitis, Jay, 0B
Leischnig, Lothar, 0K	Wamboldt, Leonard, 0P
	Wang, Jue, 0P

Wang, Ying-Ju, 0X
Wang, Zhanshan, 0N
Weatherby, E. C., 0R
Woodard, Kenneth S., 0T
Yi, Allen, 0U
Zeimpekis, I., 0R
Zhang, Jinlong, 0N
Ziemkiewicz, Michael, 0X

Conference Committee

Symposium Chair

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

Symposium Co-chair

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

Conference Chairs

Jay N. Vizgaitis, optX imaging system (United States)
Bjørn F. Andresen, RICOR Cryogenic & Vacuum Systems (Israel)
Peter L. Marasco, Air Force Research Laboratory (United States)
Jasbinder S. Sanghera, U.S. Naval Research Laboratory
(United States)
Miguel P. Snyder, U.S. Army Night Vision & Electronic Sensors
Directorate (United States)

Conference Program Committee

Christopher C. Alexay, StingRay Optics, LLC (United States)
Guy Beadie, U.S. Naval Research Laboratory (United States)
Kyle R. Bryant, U.S. Army AMRDEC (United States)
Robert B. Chipper, Raytheon EO Innovations (United States)
John P. Deegan, Rochester Precision Optics, LLC (United States)
Mark Durham, DRS Technologies, Inc. (United States)
Anatoly M. Filachev, Orion Research-and-Production Association
(Russian Federation)
Stephen T. Lee, Thales Optronics Ltd. (United Kingdom)
Craig Olson, L-3 Communications (United States)
Harbinder Rana, Defence Science and Technology Laboratory
(United Kingdom)
Clara Rivero-Baleine, Lockheed Martin Missiles and Fire Control
(United States)
Joël Rollin, Thales Angénieux S.A. (France)
Harry H. Schlemmer, Airbus DS Optronics GmbH (Germany)
Doron Sturlesi, Rafael Advanced Defense Systems Ltd. (Israel)
Alan Symmons, LightPath Technologies, Inc. (United States)
Stan Szapiel, Raytheon ELCAN Optical Technologies (Canada)
Nicholas A. Thompson, Qioptiq Ltd. (United Kingdom)
Jue Wang, Corning Specialty Materials, Inc. (United States)

Session Chairs

- 1 Optical Design and Analysis I
 Kyle R. Bryant, U.S. Army AMRDEC (United States)
 Craig Olson, L-3 Sonoma EO (United States)
- 2 Opto-Mechanics
 Kyle R. Bryant, U.S. Army AMRDEC (United States)
 Craig Olson, L-3 Sonoma EO (United States)
- 3 GRIN
 Peter L. Marasco, Air Force Research Laboratory (United States)
 Jasbinder S. Sanghera, U.S. Naval Research Laboratory
 (United States)
- 4 Optical Design and Analysis II
 Christopher Alexay, StingRay Optics, LLC (United States)
 Peter L. Marasco, Air Force Research Laboratory (United States)
- 5 Coatings and Filters
 Jue Wang, Corning Specialty Materials, Inc. (United States)
 Jasbinder S. Sanghera, U.S. Naval Research Laboratory
 (United States)
- 6 Materials and Manufacturing I
 Alan Symmons, LightPath Technologies, Inc. (United States)
 John Deegan, Rochester Precision Optics, LLC (United States)
- 7 Materials and Manufacturing II
 Alan Symmons, LightPath Technologies, Inc. (United States)
 John Deegan, Rochester Precision Optics, LLC (United States)
- 8 Select Papers in Optics
 Guy Beadie, U.S. Naval Research Laboratory (United States)