

PROCEEDINGS OF SPIE

Advanced Optics for Imaging Applications: UV through LWIR IV

Jay N. Vizgaitis
Peter L. Marasco
Jasbinder S. Sanghera
Editors

14–15 April 2019
Baltimore, Maryland, United States

Sponsored and Published by
SPIE

Volume 10998

Proceedings of SPIE 0277-786X, V. 10998

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

Advanced Optics for Imaging Applications: UV through LWIR IV, edited by Jay N. Vizgaitis
Peter L. Marasco, Jasbinder S. Sanghera, Proc. of SPIE Vol. 10998, 1099801
© 2019 SPIE · CCC code: 0277-786X/19/\$18 · doi: 10.1117/12.2538098

Proc. of SPIE Vol. 10998 1099801-1

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 *Advanced Optics for Imaging Applications: UV through LWIR IV*, edited by Jay N. Vizgaitis, Peter L. Marasco, Jasbinder S. Sanghera, Proceedings of SPIE Vol. 10998 (SPIE, Bellingham, WA, 2019) Seven-digit Article CID Number.

ISSN: 0277-786X
ISSN: 1996-756X (electronic)

ISBN: 9781510626614
ISBN: 9781510626621 (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

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

OPTICAL MATERIALS I

10998 02	Fabrication of high refractive index, infrared transmitting organically modified chalcogenide (ORMOCHALC) polymers (Rising Researcher Presentation) [10998-1]
10998 04	Temperature-dependent dispersion fitting for a recent infrared glass catalog [10998-3]
10998 05	Index of refraction change in common chalcogenide glasses due to precision glass molding [10998-4]

OPTICAL MATERIALS II

10998 09	Underlying causes of hygroscopic stability in high-quality replicated composite optics [10998-8]
----------	---

GRIN MATERIALS

10998 0B	High-performance surface-engineered gradient refractive index (GRIN) coatings [10998-10]
10998 0D	Multispectral IR optics and GRIN [10998-12]
10998 0E	Scalable laser-written Ge-As-Pb-Se chalcogenide glass-ceramic films and the realization of infrared gradient refractive index elements [10998-13]

OPTICAL SYSTEMS DESIGN I

10998 0J	Optical design of multi-material, general rotationally symmetric GRIN lenses [10998-19]
10998 0K	Big, bold, and bothersome: challenges of designing large format, infrared lens assemblies [10998-20]
10998 0L	Infrared optics innovation enabled by new material and designs [10998-23]

OPTICAL SYSTEMS DESIGN II

- 10998 0M **Experimental verification of a MWIR/LWIR 3x continuous zoom lens (Rising Researcher Paper)**
[10998-24]
- 10998 0N **Metric zoom and you: an accurate tomorrow, approximately today** [10998-25]
- 10998 0O **Air-LUSI: Autonomous telescope design for lunar spectral irradiance measurements** [10998-26]

MISCELLANEOUS PAPERS IN OPTICS

- 10998 0S **Enhance image resolution with nearest neighbor pixel deconvolution** [10998-30]
- 10998 0U **Infrared thermospectroscopic imaging and tomography of confined process** [10998-32]

FREEFORM OPTICS

- 10998 0W **Concurrent engineering of a next-generation freeform telescope: optical design** [10998-34]
- 10998 0X **Concurrent engineering of a next-generation freeform telescope: mechanical design and manufacture** [10998-35]
- 10998 0Y **Concurrent engineering of a next-generation freeform telescope: metrology and test**
[10998-36]

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.

Abiso, Yana, 0L	Savastinuk, John, 0K
Baker, Colin C., 02	Schiesser, Eric M., 0W
Bauer, Aaron, 0W	Stover, Eric, 04
Bayya, Shyam, 0D	Sunal, Paul, 0B
Beadie, Guy, 04, 0D	Turpie, Kevin, 0O
Bettinger, Joshua B., 0N	Vizgaitis, Jay, 0D
Boyd, Andrew M., 0J	Vogel, Steven H., 0N
Boyd, Darryl A., 02	Wachtel, P. F., 05, 0M
Bruce, Robert C., 0B	Wang, Yu, 0S
Campbell, R., 0M	Yin, Gufan, 0E
Cataford, Andrew, 0O	Yu, Xia, 0L
Chen, Neo, 0L	Zaldivar, Rafael, 09
Davies, Matthew A., 0X	Zhu, Jenny, 0L
Deegan, J. P., 05, 0M	
Dugrenier, Andrew E., 0K	
Evans, Chris J., 0Y	
Ferrelli, Geena, 09	
Gadsden, S. Andrew, 0O	
Gibson, Daniel, 04, 0D	
Hopper, Laura E., 0Y	
Horvath, Nicholas W., 0X	
Hu, Juejun, 0E	
Huang, Robert, 0L	
Kang, Myungkoo, 0E	
Kim, Hyun, 09	
Kim, Woohong, 02	
Kotov, Mikhail, 0D	
Lehtihet, Moncef, 0U	
Leng, Jacques, 0U	
Lindberg, G. P., 05, 0M	
Lu, Yujing, 0S	
Malendevych, Teodor, 0E	
Mayer, Theresa S., 0B	
McClain, Collin C., 02, 0D	
Miller, Jimmie A., 0Y	
Mingareev, Ilya, 0E	
Murray, Ian B., 0E	
Musgraves, J. D., 05, 0M	
Myers, Jason D., 02	
Nguyen, Vinh Q., 02, 0D	
Noste, Todd, 0Y	
Packard, Brian, 0N	
Pradere, Christophe, 0U	
Ramsey, J. L., 05, 0M	
Richardson, Kathleen A., 0E	
Richardson, Martin C., 0E	
Rivero-Baleine, Clara, 0B	
Rolland, Jannick P., 0W	
Sanghera, Jasbinder S., 02, 0D	

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, Georgia Institute of Technology (United States)

Conference Chairs

Jay N. Vizgaitis, optX imaging systems (United States)
Peter L. Marasco, Air Force Research Laboratory (United States)
Jasbinder S. Sanghera, U.S. Naval Research Laboratory
(United States)

Conference Program Committee

Christopher C. Alexay, StingRay Optics, LLC (United States)
Bjørn F. Andresen, Consultant, Infrared Technologies & Applications
(Israel)
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)
Stephen P. McGeoch, Thales Optronics Ltd. (United Kingdom)
Craig Olson, L-3 Communications (United States)
Clara Rivero-Baleine, Lockheed Martin Missiles and Fire Control
(United States)
Joël Rollin, Thales Angénieux S.A. (France)
Harry H. Schlemmer, HENSOLDT Optronics GmbH (Germany)
Miguel P. Snyder, U.S. Army RDECOM CERDEC NVESD (United States)
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 Materials I
 Jasbinder S. Sanghera, U.S. Naval Research Laboratory
 (United States)
 John P. Deegan, Rochester Precision Optics, LLC (United States)
- 2 Optical Materials II
 Jasbinder S. Sanghera, U.S. Naval Research Laboratory
 (United States)
 John P. Deegan, Rochester Precision Optics, LLC (United States)
- 3 GRIN Materials
 Guy Beadie, U.S. Naval Research Laboratory (United States)
 Clara Rivero-Baleine, Lockheed Martin Missiles and Fire Control
 (United States)
- 4 Metamaterials and Metasurfaces
 Clara Rivero-Baleine, Lockheed Martin Missiles and Fire Control
 (United States)
 Guy Beadie, U.S. Naval Research Laboratory (United States)
- 5 Optical Systems Design I
 Kyle R. Bryant, U.S. Army AMRDEC (United States)
- 6 Optical Systems Design II
 Kyle R. Bryant, U.S. Army AMRDEC (United States)
- 7 Miscellaneous Papers in Optics
 Peter L. Marasco, Air Force Research Laboratory (United States)
 Miguel P. Snyder, U.S. Army RDECOM CERDEC NVESD (United States)
- 8 Freeform Optics
 Peter L. Marasco, Air Force Research Laboratory (United States)
 Miguel P. Snyder, U.S. Army RDECOM CERDEC NVESD (United States)