

PROCEEDINGS OF SPIE

Window and Dome Technologies and Materials XIII

**Randal W. Tustison
Brian J. Zelinski**
Editors

**1–2 May 2013
Baltimore, Maryland, United States**

Sponsored and Published by
SPIE

Volume 8708

Proceedings of SPIE 0277-786X, V. 8708

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

Window and Dome Technologies and Materials XIII, edited by Randal W. Tustison, Brian J. Zelinski,
Proc. of SPIE Vol. 8708, 870801 · © 2013 SPIE · CCC code: 0277-786X/13/\$18 · doi: 10.1117/12.2031924

Proc. of SPIE Vol. 8708 870801-1

The papers included 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. The papers published in these proceedings 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 this book:

Author(s), "Title of Paper," in *Window and Dome Technologies and Materials XIII*, edited by Randal W. Tustison, Brian J. Zelinski, Proceedings of SPIE Vol. 8708 (SPIE, Bellingham, WA, 2013) Article CID Number.

ISSN: 0277-786X

ISBN: 9780819494993

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 © 2013, 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/13/\$18.00.

Printed in the United States of America.

Publication of record for individual papers is online in the SPIE Digital Library.



SPIDigitalLibrary.org

Paper Numbering: Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print and on CD-ROM. Papers are published as they are submitted and meet publication criteria. A unique, consistent, permanent citation identifier (CID) number is assigned to each article at the time of the first 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, print, and electronic versions of the publication. SPIE uses a six-digit CID article numbering system in which:

- The first four 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. The complete citation is used on the first page, and an abbreviated version on subsequent pages. Numbers in the index correspond to the last two digits of the six-digit CID Number.

Contents

vii *Conference Committee*

ADVANCE IN THE MID-WAVELENGTH INFRARED WINDOW TECHNOLOGY I

- 8708 04 **Scale up of large ALON windows** [8708-3]
L. M. Goldman, S. Balasubramanian, U. Kashalikar, R. Foti, S. Sastri, Surmet Corp. (United States)
- 8708 05 **Transparent ceramics for sensor applications** [8708-4]
M. V. Parish, M. R. Pascucci, N. Corbin, B. Puputti, CeraNova Corp. (United States)
- 8708 06 **Large-size spinel windows and domes** [8708-5]
J. L. Sepulveda, R. O. Louffy, S. Ibrahim, S. Bilodeau, Materials and Electrochemical Research Corp. (United States)
- 8708 07 **Manufacturing process scale-up of optical grade transparent spinel ceramic at ArmorLine Corporation** [8708-6]
J. Spilman, J. Voyles, J. Nick, L. Shaffer, ArmorLine Corp. (United States)

ADVANCE IN THE MID-WAVELENGTH INFRARED WINDOW TECHNOLOGY II

- 8708 09 **Assessment of low-expansion tungstates for thermal-shock-resistant infrared windows** [8708-8]
D. C. Harris, L. Cambrea, Naval Air Systems Command (United States)
- 8708 0A **Transparent ceramics for spacecraft windows** [8708-9]
J. A. Salem, NASA Glenn Research Ctr. (United States)
- 8708 0B **Multi-functional windows** [8708-10]
N. Nag, L. M. Goldman, S. Balasubramanian, S. Sastri, Surmet Corp. (United States)
- 8708 0C **Synthesis and characterization of large optical grade sapphire windows produced from a horizontal growth process** [8708-42]
J. B. Levine, T. Burks, J. Ciraldo, M. Montgomery, A. Novoselov, S. Podlozhenov, Rubicon Technology Inc. (United States)
- 8708 0D **New gelling systems to fabricate complex-shaped transparent ceramics** [8708-44]
Y. Yang, Y. Wu, New York State College of Ceramics at Alfred Univ. (United States)

ADVANCE IN THE MID-WAVELENGTH INFRARED WINDOW TECHNOLOGY III

- 8708 0F **Advancements in MWIR window materials and structures** [8708-12]
M. E. Thomas, W. J. Tropf, Johns Hopkins Univ. Applied Physics Lab. (United States)

ADVANCES IN LONG-WAVELENGTH INFRARED WINDOW AND DOME PROCESSING TECHNOLOGY

- 8708 OL **Transparent zinc sulfide processed from nanocrystalline powders** [8708-19]
D. Gao, T. S. Stefanik, Nanocerox, Inc. (United States)
- 8708 ON **Infrared-transmitting glass-ceramics: a review** [8708-20]
J. S. McCloy, B. J. Riley, D. A. Pierce, B. R. Johnson, A. Qiao, Pacific Northwest National Lab. (United States)

OPTICAL SURFACE TREATMENTS, COATINGS, AND MICROSTRUCTURES

- 8708 OO **Challenges of developing hemispherical ZnS domes coated with a durable antireflection coating** [8708-22]
S. Joseph, E. Kassous, D. Yadlovker, A. Levi, O. Marcovich, A. Shinman, H. Zipin, Rafael Advanced Defense Systems Ltd. (Israel)
- 8708 OP **Recent advancements in anti-reflective surface structures (ARSS) for near- to mid-infrared optics** [8708-23]
C. M. Florea, Sotera Defense Solutions, Inc. (United States); L. E. Busse, S. S. Bayya, B. Shaw, U.S. Naval Research Lab. (United States); I. D. Aggarwal, The Univ. of North Carolina at Charlotte (United States); J. S. Sanghera, U.S. Naval Research Lab. (United States)
- 8708 OQ **Performance measurements of infrared windows with surface structures providing broadband wide-angle antireflective properties** [8708-24]
B. Zollars, S. Savoy, Q. Xue, J. John, K. Hoover, G. Elpers, R. Wood, Nanohmics, Inc. (United States)
- 8708 OT **ZnS/diamond composite coatings for infrared transmission applications formed by the aerosol deposition method** [8708-45]
S. D. Johnson, F. J. Kub, C. R. Eddy Jr., U.S. Naval Research Lab. (United States)

NOVEL APPLICATIONS AND CHARACTERIZATION TOOLS FOR OPTICAL WINDOWS AND DOMES

- 8708 OX **Design of uniform window heating structures for electro-optical systems** [8708-30]
M. W. Pieratt, S. Carney, M. Stout, D. L. Hibbard, G. Miller, LightWorks Optical Systems (United States)
- 8708 OY **Spinel domes with integrated electromagnetic interference protection** [8708-31]
T. Heil, G. Slavik, A. Smith, J. Kutsch, L. Renomeron, I. Vesnovsky, A. LaRoche, L. Fehrenbacher, Technology Assessment & Transfer, Inc. (United States); M. Somers, J. McLellan, B. Mayers, Nano Terra, Inc. (United States)
- 8708 OZ **Electromagnetic sensing for deterministic finishing gridded domes** [8708-32]
S. L. Galbraith, Resodyn Corp. (United States)

- 8708 10 **Multimodal characterization of transparent dome blanks** [8708-33]
J. S. Steckenrider, J. Torcedo, J. Kutsch, Technology Assessment & Transfer, Inc.
(United States)

METROLOGY AND FINISHING OF FLAT, FREE-FORM, AND CONFORMAL OPTICS

- 8708 11 **Ultrasonic processing of hard materials for conformal optics** [8708-35]
E. Fess, R. Bechtold, M. Bechtold, F. Wolfs, OptiPro Systems (United States)
- 8708 12 **Deterministic manufacturing of large sapphire windows** [8708-36]
T. Lambropoulos, E. Fess, S. DeFisher, OptiPro Systems (United States)
- 8708 13 **Freeform and conformal optical manufacturing** [8708-37]
S. DeFisher, E. Fess, F. Wolfs, OptiPro Systems (United States)
- 8708 14 **Interferometric tomography metrology of conformal optics** [8708-38]
M. Gutin, O. Gutin, X.-M. Wang, D. Ehlinger, Applied Science Innovations, Inc. (United States)
- 8708 15 **Advances in freeform optics fabrication for conformal window and dome applications** [8708-39]
J. DeGroote Nelson, A. Gould, N. Smith, K. Medicus, M. Mandina, Optimax Systems, Inc. (United States)
- 8708 16 **Recent advances in high-performance window fabrication** [8708-40]
J. B. Taylor, R. Boland, E. Gowac, P. Stupik, M. Tricard, Zygo Corp. (United States)
- 8708 17 **Patterning and hardening of gold black infrared absorber by shadow mask deposition with ethyl cyanoacrylate** [8708-41]
D. Panjwani, N. Nader-Esfahani, D. Maukonen, I. Rezadad, J. Boroumand, E. Smith, J. Nath, R. E. Peale, Univ. of Central Florida (United States)

Author Index

Conference Committee

Symposium Chair

Kenneth R. Israel, Major General (USAF Retired)(United States)

Symposium Cochair

David A. Whelan, Boeing Defense, Space, and Security (United States)

Conference Chairs

Randal W. Tustison, Raytheon Integrated Defense Systems
(United States)

Brian J. Zelinski, Raytheon Missile Systems (United States)

Conference Program Committee

Joel Askinazi, Goodrich Corporation (United States)

Rick Gentilman, Raytheon Integrated Defense Systems
(United States)

Daniel C. Harris, Naval Air Warfare Center Weapons Division
(United States)

Brian K. Jones, U.S. Army Research, Development and Engineering
Command (United States)

John S. McCloy, Pacific Northwest National Laboratory
(United States)

Richard Porter, Air Force Research Laboratory (United States)

Michael E. Thomas, Johns Hopkins University Applied Physics
Laboratory (United States)

Session Chairs

- 1 Advance in the Mid-Wavelength Infrared Window Technology I
Daniel C. Harris, Naval Air Warfare Center Weapons Division
(United States)
- 2 Advance in the Mid-Wavelength Infrared Window Technology II
Brian J. Zelinski, Raytheon Missile Systems (United States)
- 3 Advance in the Mid-Wavelength Infrared Window Technology III
Richard Gentilman, Raytheon Integrated Defense Systems
(United States)

- 4 Advances in Long-Wavelength Infrared Window and Dome Processing Technology
Randal W. Tustison, Raytheon Integrated Defense Systems
(United States)
- 5 Optical Surface Treatments, Coatings, and Microstructures
John S. McCloy, Pacific Northwest National Laboratory (United States)
- 6 Optical and Mechanical Properties: Measurement and Prediction
Michael E. Thomas, Johns Hopkins University Applied Physics Laboratory (United States)
- 7 Novel Applications and Characterization Tools for Optical Windows and Domes
Joel Askinazi, UTAS (United States)
- 8 Metrology and Finishing of Flat, Free-Form, and Conformal Optics
Daniel C. Harris, Naval Air Warfare Center Weapons Division
(United States)