

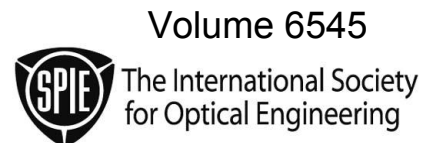
PROCEEDINGS OF SPIE

Window and Dome Technologies and Materials X

Randal W. Tustison
Editor

11–12 April 2007
Orlando, Florida, USA

Sponsored and Published by
SPIE—The International Society for Optical Engineering



Proceedings of SPIE—The International Society for Optical Engineering, 9780819466679, v. 6545

SPIE is an international technical society dedicated to advancing engineering and scientific applications of optical, photonic, imaging, electronic, and optoelectronic technologies.

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 X*, edited by Randal W. Tustison, Proceedings of SPIE Vol. 6545 (SPIE, Bellingham, WA, 2007) Article CID Number.

ISSN 0277-786X

ISBN 9780819466679

Published by

SPIE—The International Society for Optical Engineering

P.O. Box 10, Bellingham, Washington 98227-0010 USA

Telephone 1 360/676-3290 (Pacific Time) · Fax 1 360/647-1445

<http://www.spie.org>

Copyright © 2007, The 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 <http://www.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/07/\$18.00.

Printed in the United States of America.

Contents

vii *Conference Committee*

SESSION 1 LONG-WAVELENGTH INFRARED TRANSPARENT MATERIALS

- 654502 **Development of hot-pressed and chemical-vapor-deposited zinc sulfide and zinc selenide in the United States for optical windows (Invited Paper)** [6545-01]
D. C. Harris, Naval Air Systems Command (USA)
- 654503 **International development of chemical vapor deposited zinc sulfide** [6545-02]
J. McCloy, Raytheon Missile Systems (USA)
- 654504 **Optical properties of epitaxial single-crystal chemical-vapor-deposited diamond** [6545-03]
G. Turri, Y. Chen, M. Bass, CREOL/College of Optics and Photonics/Univ. of Central Florida (USA); D. Orchard, QinetiQ Ltd. (United Kingdom); J. E. Butler, S. Magana, T. Feygelson, D. Thiel, K. Fourspring, Naval Research Lab. (USA); J. Pentony, S. Hawkins, M. Baronowski, R. V. Dewees, M. D. Seltzer, A. Guenther, D. C. Harris, Naval Air Systems Command (USA); C. M. Stickley, DARPA (USA)
- 654505 **Spectral characterization of diffractively structured GaAs using the ARISTMS** [6545-04]
P. Coulter, M. Wilson, MilSys Technologies, LLC (USA)

SESSION 2 GLASSES

- 654507 **Fluorinated silicate glass for conventional and holographic optical elements** [6545-06]
L. Glebov, CREOL/College of Optics and Photonics/Univ. of Central Florida (USA)
- 654508 **Development of a laser glass for the National Ignition Facility** [6545-07]
J. S. Hayden, SCHOTT North America, Inc. (USA); J. H. Campbell, S. A. Payne, Lawrence Livermore National Lab. (USA)

Pagination: 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 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.

SESSION 3 MICRO- AND NANO-CRYSTALLINE OPTICAL MATERIALS AND STRUCTURES

- 654509 **Spark plasma sintering and forming of transparent polycrystalline Al₂O₃ windows and domes** [6545-49]
D. Jiang, D. M. Hulbert, U. Anselmi-Tamburini, T. Ng, D. Land, A. K. Mukherjee, Univ. of California, Davis (USA)
- 65450A **Nanocomposite optical ceramics for infrared windows and domes** [6545-09]
T. Stefanik, R. Gentilman, P. Hogan, Raytheon Integrated Defense Systems (USA)
- 65450E **Polycrystalline yttrium aluminum garnet (YAG) for IR transparent missile domes and windows** [6545-13]
J. C. Huie, Raytheon Integrated Defense Systems (USA); C. B. Dudding, J. McCloy, Raytheon Missile Systems (USA)

SESSION 4 MODELING, CHARACTERIZATION, AND FABRICATION I

- 65450F **Optical properties of Nd doped and undoped polycrystalline YAG** [6545-15]
M. E. Thomas, A. K. Carr, D. Limsui, Johns Hopkins Univ. Applied Physics Lab. (USA); J. C. Huie, Raytheon Integrated Defense Systems (USA)
- 65450G **Erosion studies of infrared dome materials** [6545-16]
R. M. Sullivan, Naval Air Warfare Ctr. (USA); A. Phelps, Univ. of Dayton Research Institute (USA); J. C. Kirsch, U.S. Army Aviation and Missile RDEC (USA); E. A. Welsh, Lockheed Martin Missiles and Fire Control (USA); D. C. Harris, Naval Air Systems Command (USA)
- 65450I **BRDF and BSDF models for diffuse surface and bulk scatter from transparent windows** [6545-18]
M. E. Thomas, Johns Hopkins Univ. Applied Physics Lab. (USA); D. D. Duncan, Oregon Health and Science Univ. (USA)
- 65450J **Application of nondestructive optical techniques in the detection of surface and subsurface defects in sapphire** [6545-19]
I. A. Akwani, D. L. Hibbard, K. T. Jacoby, Exotic Electro-Optics (USA)
- 65450K **Characterization of AFB sapphire single crystal composites for infrared window application** [6545-20]
H.-C. Lee, H. E. Meissner, Onyx Optics, Inc. (USA)
- 65450L **Simulation and experimental results of sub-aperture transmitted wavefront measurements of a window using a time-delayed source** [6545-21]
M. B. Dubin, Breault Research Organization (USA); W. P. Kuhn, Opt-E (USA)

SESSION 5 MODELING, CHARACTERIZATION, AND FABRICATION II

- 65450N **Transmitted wavefront metrology of hemispheric domes using scanning low-coherence dual-interferometry (SLCDI)** [6545-23]
D. W. Diehl, C. Cotton, C. J. Ditchman, B. Statt, ASE Optics, Inc. (USA)
- 65450O **Time-delayed source and interferometric measurement of domes and windows** [6545-24]
W. P. Kuhn, Opt-E (USA); M. Dubin, Breault Research Organization (USA)

- 65450P **Laser-assisted pre-finishing of optical ceramic materials** [6545-25]
J. C. Rozzi, O. H. Clavier, M. D. Barton, Create Inc. (USA)
- 65450Q **Developments in the finishing of domes and conformal optics** [6545-26]
A. B. Shorey, W. Kordonski, J. Tracy, M. Tricard, QED Technologies (USA)
- 65450R **Contact mechanics models and algorithms for dome polishing with UltraForm Finishing (UFF)** [6545-27]
C. Bouvier, S. M. Gracewski, S. J. Burns, Univ. of Rochester (USA)
- 65450S **Improving surface figure and microroughness of IR materials and diamond turned surfaces with magnetorheological finishing (MRF)** [6545-28]
C. Supranowitz, C. Hall, P. Dumas, B. Hallock, QED Technologies (USA)

SESSION 6 OPTICAL COATINGS AND SURFACE STRUCTURES

- 65450T **High durability antireflection coatings for silicon and multispectral ZnS** [6545-29]
S. Joseph, O. Marcovitch, Y. Yadin, D. Klaiman, N. Koren, H. Zipin, Rafael-Optical Components Ctr. (Israel)
- 65450V **iDLC: hardcoat for chalcogenide glass and other IR materials** [6545-31]
K. Rogers, J. Ward, Umicore Coating Services (United Kingdom); Y. Guimond, Umicore IR Glass (France)
- 65450X **Effects of mesh voids on insertion loss of metallic mesh coatings** [6545-33]
J. Halman, K. Ramsey, V. Sawtelle, Battelle Memorial Institute (USA)
- 65450Y **Update on the development of high performance anti-reflecting surface relief micro-structures** [6545-34]
D. S. Hobbs, B. D. MacLeod, J. R. Riccobono, TelAztec LLC (USA)

SESSION 7 VISIBLE TO MID-WAVELENGTH INFRARED TRANSPARENT MATERIALS AND APPLICATIONS

- 654512 **An improved soft-chemistry approach to the preparation of spinel powders** [6545-38]
R. Cook, TDA Research, Inc. (USA)
- 654514 **Polycrystalline transparent spinel domes for multimode seeker applications** [6545-40]
A. A. DiGiovanni, A. LaRoche, L. Schubel, L. Fehrenbacher, Technology Assessment and Transfer (USA); D. W. Roy, Consultant (USA)
- 654517 **Critical parameters for grinding large sapphire window panels** [6545-43]
J. R. Bashe, G. Dempsey, I. A. Akwani, K. T. Jacoby, D. L. Hibbard, Exotic Electro-Optics (USA)
- 654519 **Improvements in large window and optics production** [6545-45]
B. Hallock, B. Messner, C. Hall, C. Supranowitz, QED Technologies (USA)

POSTER SESSION

- 65451C **Reduced angle-shift infrared bandpass filter coatings** [6545-48]
B. M. Lairson, J. Mosier, K. Gibbons, J. H. Sternbergh, M. A. George, Deposition Sciences, Inc. (USA)

Author Index

Conference Committee

Symposium Chair

John C. Carrano, Luminex Corporation (USA)

Symposium Cochair

Larry B. Stotts, Defense Advanced Research Projects Agency (USA)

Program Track Chair

Gabor F. Fulop, Maxtech International, Inc. (USA)

Conference Chair

Randal W. Tustison, Raytheon Company (USA)

Program Committee

Joel Askinazi, Goodrich Corporation (USA)
Richard L. Gentilman, Raytheon Integrated Defense Systems (USA)
Daniel C. Harris, Naval Air Systems Command (USA)
James C. Kirsch, U.S. Army Research, Development and Engineering Command (USA) and U.S. Army Aviation and Missile Command (USA)
John McCloy, Raytheon Missile Systems (USA)
Robert J. Ondercin, Air Force Research Laboratory (USA)
Roger M. Sullivan, Naval Air Warfare Center (USA)
Michael E. Thomas, Johns Hopkins University Applied Physics Laboratory (USA)

Session Chairs

- 1 Long-wavelength Infrared Transparent Materials
Michael E. Thomas, Johns Hopkins University Applied Physics Laboratory (USA)
- 2 Glasses
Richard L. Gentilman, Raytheon Integrated Defense Systems (USA)
- 3 Micro- and Nano-crystalline Optical Materials and Structures
Daniel C. Harris, Naval Air Systems Command (USA)
- 4 Modeling, Characterization, and Fabrication I
John McCloy, Raytheon Missile Systems (USA)

- 5 Modeling, Characterization, and Fabrication II
James C. Kirsch, U.S. Army Research, Development and Engineering
Command (USA) and U.S. Army Aviation and Missile Command (USA)
- 6 Optical Coatings and Surface Structures
Robert J. Ondercin, Air Force Research Laboratory (USA)
- 7 Visible to Mid-wavelength Infrared Transparent Materials and Applications
Joel Askinazi, Goodrich Corporation (USA)