

PROCEEDINGS OF SPIE

***Optical Materials and Structures
Technologies III***

**William A. Goodman
Joseph L. Robichaud**
Editors

**26–27 August 2007
San Diego, California, USA**

*Sponsored and Published by
SPIE*

Volume 6666

Proceedings of SPIE, 0277-786X, v. 6666

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

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 *Optical Materials and Structures Technologies III*, edited by William A. Goodman, Joseph L. Robichaud, Proceedings of SPIE Vol. 6666 (SPIE, Bellingham, WA, 2007) Article CID Number.

ISSN 0277-786X
ISBN 9780819468147

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 © 2007, 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/07/\$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, 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. Numbers in the index correspond to the last two digits of the six-digit CID number.

Contents

vii *Conference Committee*

SESSION 1 GLASS AND GLASS-CERAMICS

- 6666 02 **Manufacturing of lightweighted ZERODUR components at SCHOTT** [6666-01]
T. Döhring, A. Thomas, R. Jedamzik, H. Kohlmann, P. Hartmann, SCHOTT AG (Germany)
- 6666 03 **Strength aspects for the design of ZERODUR glass ceramics structures** [6666-02]
P. Hartmann, K. Nattermann, T. Döhring, M. Kuhr, P. Thomas, SCHOTT AG (Germany);
G. Kling, P. Gath, S. Lucarelli, EADS Astrium Satellites (Germany)
- 6666 04 **Athermal glass by design** [6666-03]
W. A. Goodman, Schafer Corp. (USA)
- 6666 05 **Optimization of Spectralon through numerical modeling and improved processes and designs** [6666-04]
B. Y. Chang, R. M. Huppe, C. Chase, D. P. D'Amato, Labsphere, Inc. (USA)

SESSION 2 SIC PROCESSING AND CHARACTERIZATION I

- 6666 06 **Advances in fabrication technologies for light weight CVC SiC mirrors** [6666-05]
K. Webb, Trex Enterprises Corp. (USA)
- 6666 07 **Development of lightweight SiC mirrors for the space infrared telescope for cosmology and astrophysics (SPICA) mission** [6666-06]
H. Kaneda, T. Nakagawa, Japan Aerospace Exploration Agency (Japan); T. Onaka, Univ. of Tokyo (Japan); K. Enya, H. Kataza, S. Makiuti, H. Matsuhara, M. Miyamoto, H. Murakami, H. Saruwatari, H. Watarai, Y. Y. Yui, Japan Aerospace Exploration Agency (Japan)
- 6666 08 **Development of a systematic approach to space qualification of silicon carbide for mirror applications** [6666-07]
I. A. Palusinski, I. Ghozeil, M. J. O'Brien, J. M. Geis, D. B. Witkin, The Aerospace Corp. (USA)
- 6666 09 **Metrology guided laser micromachining of SiC for mirrors** [6666-08]
R. L. Jacobsen, M. B. Scott, J. Pitz, Mound Laser and Photonics Ctr., Inc. (USA);
A. A. Goshtasby, J. Britton, D. Smith, Wright State Univ. (USA)
- 6666 0A **Rapid fabrication of lightweight SiC aspheres using reactive atom plasma (RAP) processing** [6666-09]
P. Subrahmanyam, G. Gardopee, Y. Verma, N. Li, T. Yu, T. Kyler, P. Fiske, P. Sommer, RAPT Industries, Inc. (USA)

SESSION 3 SIC PROCESSING AND CHARACTERIZATION II

- 6666 0B **Characterization of hydrogenated silicon carbide produced by plasma enhanced chemical vapor deposition at low temperature** [6666-10]
G. Pareschi, INAF, Osservatorio Astronomico di Brera (Italy); G. Taglioni, Galileo Avionica S.p.A. (Italy); S. Basso, O. Citterio, V. De Caprio, M. Ghigo, INAF, Osservatorio Astronomico di Brera (Italy); L. Novella, Galileo Avionica S.p.A. (Italy); A. Novi, D. Spiga, INAF, Osservatorio Astronomico di Brera (Italy); L. Stringhetti, INAF, IASF, Bo (Italy)
- 6666 0C **Ultrasonic NDE of silicon carbide lightweight systems** [6666-11]
A. R. Portune, R. A. Haber, R. E. Brennan, Rutgers Univ. (USA)

SESSION 4 SILICON + CARBON = SILICON CARBIDE I

- 6666 0D **SiC-SiC composites optics for UV applications** [6666-12]
W. Kowbel, J. C. Withers, MER Corp. (USA)
- 6666 0E **HB-Cesic composite for space optics and structures** [6666-13]
M. R. Krödel, ECM Ingenieur-Unternehmen für Energie- und Umwelttechnik GmbH (Germany); T. Ozaki, Mitsubishi Electric Corp. (Japan)
- 6666 0F **Design and fabrication of a single crystal silicon (SCSi) telescope: a success story** [6666-14]
D. R. McCarter, R. A. Paquin, E. McCarter, McCarter Machine, Inc. (USA)

SESSION 5 SILICON + CARBON = SILICON CARBIDE II

- 6666 0H **Carbon-carbon mirrors for exoatmospheric and space applications** [6666-16]
D. E. Krumweide, G. D. Wonacott, San Diego Composites (USA); P. M. Woida, R. Q. Woida, The Univ. of Arizona (USA); W. Shih, Allcomp, Inc. (USA)
- 6666 0I **Converted silicon carbide technology developments for optics** [6666-17]
C. Duston, K. Woestman, H. Vargas, Poco Graphite, Inc. (USA); B. deBlonk, Air Force Research Lab. (USA)
- 6666 0J **NTSIC: progress in recent two years** [6666-18]
K. Tsuno, K. Oono, H. Irikado, NEC TOSHIBA Space Systems, Ltd. (Japan); S. Suyama, Y. Itoh, Toshiba Corp. (Japan)
- 6666 0K **NTSIC (new technology silicon carbide): evaluation of microstructure of high-strength reaction-sintered silicon carbide for optical mirror** [6666-19]
S. Suyama, Y. Itoh, Toshiba Corp. (Japan)

SESSION 6 SILICON + CARBON = SILICON CARBIDE III

- 6666 0L **Fabrication and optical characterization of a segmented and brazed mirror assembly** [6666-20]
D. A. Bath, CoorsTek, Inc. (USA); S. C. Williams, QED Technologies (USA); M. Bougoin, Boostec, Inc. (France); G. J. Gardopée, Rapt Industries (USA)

- 6666 OM **Cesic and silicon: a perfect combination for high performance applications** [6666-21]
M. Krödel, ECM (Germany); M. J. Collon, cosine Research B.V. (Netherlands); R. Graue, D. Kampf, Kayser-Threde GmbH (Germany)
- 6666 ON **Manufacturing of a 3D complex hyperstable Cesic structure** [6666-22]
M. Kroedel, ECM (Germany); P. Courteau, Thales Alenia Space (France); A. Poupinet, SAGEIS CSO (France); G. Sarri, ESA (Netherlands)
- 6666 OO **Reaction bonded silicon carbide gimbaled pointing mirror** [6666-23]
J. Robichaud, A. Akerstrom, S. Frey, D. Crompton, P. Cucchiaro, G. Deveau, M. Peters, S. Mason, C. Ullathorne, L-3 Communications SSG-Tinsley, Inc. (USA)
- 6666 OQ **SLMS athermal technology for high-quality wavefront control** [6666-25]
W. A. Goodman, M. T. Jacoby, Schafer Corp. (USA)

SESSION 7 BERYLLIUM AND METALS I

- 6666 OR **Laser generated TiC reinforced with Fe-Al matrix composite layer on Al-Si alloy** [6666-26]
A. Viswanathan, D. Sastikumar, National Institute of Technology (India); H. Kumar, Raja Ramanna Ctr. for Advanced Technology (India); A. K. Nath, Indian Institute of Technology, Kharagpur (India)
- 6666 OS **Cryogenic design and predicted performance of the James Webb space telescope beryllium aft optics subsystem optical bench** [6666-27]
K. Martinez, J. Sullivan, A. Barto, J. Lewis, R. Franck, T. Dreher, B. Shogrin, J. Sokol, W. Tandy, Ball Aerospace and Technologies Corp. (USA)
- 6666 OT **Beryllium optics and beryllium-aluminum structures for reconnaissance applications** [6666-28]
M. J. Russo, S. LoBiondo, B. Coon, M. Engelhardt, W. Pinzon, BAE Systems (USA)

SESSION 8 BERYLLIUM AND METALS II

- 6666 OU **Mirrors from light-weight sintered microspheres combined with replication techniques** [6666-29]
M. P. Ulmer, S. Vaynman, M. E. Graham, A. Davis, S. Ehelert, Northwestern Univ. (USA); D. Baker, Advanced Powder Solutions Inc. (USA); T. G. Kaye, Spectrashift (USA)
- 6666 OV **The limits of classical beam theory for bent strip residual stress measurements in plated metals** [6666-30]
T. Sanderson, Raytheon Missile Systems (USA) and The Univ. of Arizona (USA)
- 6666 OW **38% Aluminum - 62% Beryllium shaped blank technology** [6666-31]
J. T. Knapp, Brush Wellman, Inc. (USA)

SESSION 9 MASTER'S SESSION

- 6666 0Z **Materials for high-energy laser windows: how thermal lensing and thermal stresses control the performance (Invited Paper)** [6666-34]
C. A. Klein, c.a.k. analytics, int'l (USA)
- 6666 10 **Optomechanical design, engineering, and assembly: 60 years of evolution (Invited Paper)**
[6666-35]
P. R. Yoder, Jr., Optical Engineering Consultant (USA)

POSTER SESSION

- 6666 12 **Theoretical analysis for double-liquid variable focus lens** [6666-38]
R. Peng, J. Chen, S. Zhuang, Univ. of Shanghai for Science and Technology (China)
- 6666 13 **Cryogenic performance of piezo-electric actuators for opto-mechanical applications**
[6666-42]
P. G. Halverson, T. J. Parker, M. Levine, Jet Propulsion Lab. (USA)

Author Index

Conference Committee

Conference Chairs

William A. Goodman, Schafer Corporation (USA)
Joseph L. Robichaud, L-3 Communications SSG-Tinsley, Inc. (USA)

Program Committee

Ray Boucarut, NASA Goddard Space Flight Center (USA)
Carol A. Click, SCHOTT North America, Inc. (USA)
David A. Content, NASA Goddard Space Flight Center (USA)
Brett J. de Blonk, Air Force Research Laboratory (USA)
Douglas Deason, U.S. Army Space and Missile Defense Command (USA)
Marc T. Jacoby, Schafer Corporation (USA)
Matthias R. Krödel, ECM GmbH (Germany)
Thomas B. Parsonage, Brush Wellman Inc. (USA)
John W. Pepi, L-3 Communications SSG-Tinsley, Inc. (USA)
David N. Strafford, ITT Industries, Inc. (USA)
Marc Tricard, QED Technologies Inc. (USA)
David V. Wick, Sandia National Laboratories (USA)

Session Chairs

- 1 Glass and Glass-Ceramics
Carol A. Click, SCHOTT North America, Inc. (USA)
- 2 SiC Processing and Characterization I
Brett J. de Blonk, Air Force Research Laboratory (USA)
- 3 SiC Processing and Characterization II
Brett J. de Blonk, Air Force Research Laboratory (USA)
- 4 Silicon + Carbon = Silicon Carbide I
John W. Pepi, L-3 Communications SSG-Tinsley, Inc. (USA)
- 5 Silicon + Carbon = Silicon Carbide II
Matthias R. Krödel, ECM GmbH (Germany)
- 6 Silicon + Carbon = Silicon Carbide III
Joseph L. Robichaud, L-3 Communications SSG-Tinsley, Inc. (USA)

- 7 Beryllium and Metals I
Thomas B. Parsonage, Brush Wellman Inc. (USA)
- 8 Beryllium and Metals II
Thomas B. Parsonage, Brush Wellman Inc. (USA)
- 9 MASTER's Session
William A. Goodman, Schafer Corporation (USA)