Material Technologies and Applications to Optics, Structures, Components, and Sub-Systems

Joseph L. Robichaud
Matthias Krödel
William A. Goodman
Editors

26–28 August 2013
San Diego, California, United States

Sponsored and Published by SPIE
Contents

MATERIALS FOR SPACE TELESCOPE: JOINT SESSION WITH CONFERENCES 8837 AND 8860

8837 02 The market of huge monolithic mirror substrates for optical astronomy [8837-1]
T. Döhring, Univ. of Applied Sciences Aschaffenburg (Germany)

8837 03 Large silicon carbide optics for manufacturability [8837-2]
J. W. Pepi, J. Robichaud, G. Milsap, L-3 Communications IOS-SSG (United States)

METAL MATERIALS

8837 04 Aluminum alloy AA-6061 and RSA-6061 heat treatment for large mirror applications
[8837-3]
T. Newswander, B. Crowther, Space Dynamics Lab. (United States); G. Gubbels, R. Senden, RSP Technology (Netherlands)

8837 06 Cost effective aluminum beryllium mirrors for critical optics applications [8837-5]
C. Say, J. Duich, Inrad Optics (United States); C. Huskamp, R. White, IBC Advanced Alloys (United States)

8837 07 Isotropic behavior of an anisotropic material: single crystal silicon [8837-6]
D. R. McCarter, R. A. Paquin, McCarter Machine, Inc. (United States)

TEST AND ANALYSIS OF MATERIALS

8837 09 Optical test results of carbon composite mirrors from MISSE 7A [8837-8]
R. C. Romeo, R. N. Martin, Composite Mirror Applications, Inc. (United States)

8837 0A Processing of a stacked core mirror for UV applications [8837-10]
Cryogenic optical performance of a lightweighted mirror assembly for future space astronomical telescopes: correlating optical test results and thermal optical model (Invited Paper) [8837-11]

PANEL DISCUSSION: SPACE QUALIFICATION OF MATERIALS

ESA initiatives to improve mechanical design and verification methods for ceramic structures (Invited Paper) [8837-12]
G. Coe, European Space Research and Technology Ctr. (Netherlands); S. Behar-Lafenetre, L. Cornillon, M. Rancurel, Thales Alenia Space SAS (France); D. Denaux, EADS Astrium SAS (France); D. Ballhause, S. Lucarelli, EADS Astrium GmbH (Germany)

Influence of low-earth orbit exposure on the mechanical properties of silicon carbide [8837-13]
D. B. Wilkin, I. A. Palusinski, The Aerospace Corp. (United States)

CERAMIC MATERIALS I

Comparison of SiC mirror approaches [8837-14]
K. Carrigan, M. Riso, S. Khatri, C. Douglas, L-3 Communications IOS-SSG (United States)

HoneySiC: a new optomechanical material for low-areal cost and density [8837-15]
W. A. Goodman, Trex Enterprises Corp. (United States)

State-of-the-art silicon carbide optical telescope assembly for the JMAPS mission [8837-16]
D. Catropa, F. Azad, L-3 Communications IOS-SSG (United States)

Novel reactive chemical mechanical polishing technology for fabrication of SiC mirrors [8837-17]

Manufacturing and optical testing of 800 mm lightweight all C/SiC optics [8837-18]
H. Kaneda, Nagoya Univ. (Japan); M. Naitoh, T. Nakagawa, T. Imai, H. Katayama, M. Suganuma, Y. Tange, R. Sato, K. Enya, M. Kotani, K. Maruyama, Japan Aerospace Exploration Agency (Japan); T. Onaka, The Univ. of Tokyo (Japan); T. Kokusho, Nagoya Univ. (Japan)
<table>
<thead>
<tr>
<th>Page</th>
<th>Title</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>8837 0J</td>
<td>Effect of grain size on microstructure, properties, and surface roughness of reaction bonded SiC ceramics</td>
<td>M. Aghajanian, C. Emmons, M Cubed Technologies, Inc. (United States); S. Rummel, P. Barber, II-VI Inc. (United States); C. Robb, D. Hibbard, LightWorks Optical Systems (United States)</td>
</tr>
<tr>
<td>8837 0K</td>
<td>Cryogenic silicon carbide mirrors for infrared astronomical telescopes: lessons learnt from AKARI for SPICA (Invited Paper)</td>
<td>T. Onaka, The Univ. of Tokyo (Japan); H. Kaneda, Nagoya Univ. (Japan); M. Kawada, K. Enya, T. Nakagawa, Japan Aerospace Exploration Agency (Japan)</td>
</tr>
<tr>
<td>8837 0M</td>
<td>Fabrication of SiC aspheric mirrors with low mid-spatial error</td>
<td>F. Tinker, K. Xin, Aperture Optical Sciences Inc. (United States)</td>
</tr>
<tr>
<td>8837 0N</td>
<td>Correlation of mid-spatial features to image performance in aspheric mirrors</td>
<td>F. Tinker, K. Xin, Aperture Optical Sciences Inc. (United States)</td>
</tr>
<tr>
<td>8837 0P</td>
<td>Development of CFRP mirrors for space telescopes</td>
<td>S. Utsunomiya, T. Kamiya, R. Shimizu, Japan Aerospace Exploration Agency (Japan)</td>
</tr>
<tr>
<td>8837 0Q</td>
<td>Composite tube and plate manufacturing repeatability as determined by precision measurements of thermal strain</td>
<td>L. A. Riddle, J. R. Tucker, A. M. Bluth, ATK Space Structures (United States)</td>
</tr>
<tr>
<td>8837 0R</td>
<td>Prediction and measurement of composite tube twist and bending due to thermal loading</td>
<td>A. M. Bluth, J. R. Tucker, T. Thompson, ATK Space Structures (United States)</td>
</tr>
<tr>
<td>8837 0S</td>
<td>Development of transparent polycrystalline beta-silicon carbide</td>
<td>S. S. Bayya, G. R. Villalobos, U.S. Naval Research Lab. (United States); M. P. Hunt, University Research Foundation (United States); J. S. Sanghera, U.S. Naval Research Lab. (United States); B. M. Sadowski, I. D. Aggarwal, Sotera Defense Solutions, Inc. (United States); M. Cinibulk, Air Force Research Lab. (United States); C. Carney, K. Keller, UES, Inc. (United States)</td>
</tr>
<tr>
<td>8837 0T</td>
<td>Novel rapid polishing process for fabrication of sapphire windows</td>
<td>R. K. Singh, A. C. Arjunan, K. Balasundaram, Sinmat, Inc. (United States); J. Lee, Univ. of Florida (United States); G. Ling, D. Singh, Sinmat, Inc. (United States)</td>
</tr>
</tbody>
</table>
Silicate and direct bonding of low thermal expansion materials [8837-30]
G. Kalkowski, S. Fabian, Fraunhofer-Institut für Angewandte Optik und Feinmechanik (Germany); C. Rothhardt, Friedrich-Schiller-Univ. Jena (Germany); P. Zeller, Astrium GmbH (Germany); S. Risse, Fraunhofer-Institut für Angewandte Optik und Feinmechanik (Germany)

Recent developments in transparent spinel ceramic and composite windows [8837-31]
S. Bayya, G. Villalobos, W. Kim, J. Sanghera, U.S. Naval Research Lab. (United States); G. Chin, M. Hunt, University Research Foundation (United States); B. Sadowski, F. Miklos, I. Aggarwal, Sotera Defense Solutions, Inc. (United States)

Investigation of negative index in dispersive, chiral materials via contra-propagating velocities under second-order dispersion (GVD) [8837-32]
M. R. Chatterjee, T. Algadey, Univ. of Dayton (United States)

Author Index
Conference Committee

Program Track Chair

H. Philip Stahl, NASA Marshall Space Flight Center (United States)

Conference Chairs

Joseph L. Robichaud, L-3 Communications IOS-SSG (United States)
Matthias Krödel, ECM GmbH (Germany)
William A. Goodman, Trex Enterprises Corporation (United States) and Optical Materials Solutions LLC (United States)

Conference Program Committee

Shyam S. Bayya, U.S. Naval Research Laboratory (United States)
A. Marcel Bluth, ATK Aerospace Structures (United States)
Nathan Carlie, SCHOTT North America, Inc. (United States)
Vince M. Cowan, Air Force Research Laboratory (United States)
Hans-Peter Dumm, Air Force Research Laboratory (United States)
Richard A. Haber, Rutgers, The State University of New Jersey (United States)
Hidehiro Kaneda, Nagoya University (Japan)
Robert Michel, Materion Brush Beryllium & Composites (United States)
Ted Mooney, ITT Exelis (United States)
Takao Nakagawa, Japan Aerospace Exploration Agency (Japan)
Tsuyoshi Ozaki, Composites Research and Development Company, Ltd. (Japan)
John W. Pepi, L-3 Communications SSG-Tinsley (United States)
Margie F. Pinnell, University of Dayton (United States)
Michael N. Sweeney, General Dynamics-Global Imaging Technologies (United States)
David B. Wilkin, The Aerospace Corporation (United States)

Session Chairs

Materials for Space Telescopes: Joint Session with Conferences 8837 and 8860
Joseph L. Robichaud, L-3 Communications IOS-SSG (United States)

Metal Materials
Robert Michel, Materion Brush Beryllium & Composites (United States)

Test and Analysis of Materials
Joseph L. Robichaud, L-3 Communications IOS-SSG (United States)
Panel Discussion: Space Qualification of Materials
Joseph L. Robichaud, L-3 Communications IOS-SSG (United States)
Matthias Krödel, ECM GmbH (Germany)

Ceramic Materials I
William A. Goodman, Trex Enterprises Corporation (United States) and Optical Materials Solutions LLC (United States)

Ceramic Materials II
Chris Wainer, L-3 Communications IOS-SSG (United States)

Composite Materials
Lynn N. Allen, ITT Exelis (United States)

Glasses and Windows
John Pepi, L-3 Communications IOS-SSG (United States)
Introduction

These proceedings document the 2013 conference on Material Technologies and Applications to Optics, Structures, Components, and Sub-Systems. The conference took place from 26 August to 28 August 2013, as part of the broader Optics + Photonics Meeting in San Diego, California, USA. This was the inaugural conference in this area, expanding upon the scope of the previous conference on Optical Materials and Structures Technologies. The conference began with a Joint Session with the UV/Optical/IR Space Telescopes and Instruments: Innovative Technologies and Concepts conference, we thank those Conference Chairs, Dr. Howard A. MacEwen (Reviresco LLC) and Dr. James B. Breckinridge (Univ. of Arizona and Cal Tech), for collaborating with us and coordinating a well-attended and interesting opening session which covered a wide range of topics including low expansion glasses, SiC, and refractive materials, with an excellent capstone presentation from Dr. H. Philip Stahl, describing mirror technology development activities being led by the NASA Marshall Space Flight Center.

The next two days covered seven additional Sessions. The Metal Materials Session was chaired by Mr. Robert Michel (Materion) and provided updates on aluminum, beryllium-aluminum composites, and single crystal silicon material technologies. A Test and Analysis Session focused on a novel ULE mirror technology from ITT Exelis, and included results from radiation testing of Carbon fiber mirrors which were exposed to low earth orbit radiation on the International Space Station. Mr. Chris Wainer (L-3 Communications) worked as Session Chair for one of two Sessions on Ceramic Materials. These two Sessions covered a broad range of topics including a novel HoneySiC opto-mechanical material, mature reaction bonded SiC and Cesic® materials, applications of ceramics to high profile space programs (AKARI and JMAPS), and polishing and assembly of SiC systems. Mr. Lynn Allen (ITT) chaired a session on Composite Materials which described mature composite structures from ATK and maturing composite mirror technologies being explored by JAXA. The final session was on Glasses and Windows, Mr. John Pepi (L-3 Communications) chaired this session providing updates on novel window materials being developed at NRL, a newly developed bonding approach for low-expansion glasses, and the emerging area of negative index of dispersion materials.

One of the highlights of the conference was a panel discussion on the topic of “Space Qualification of Materials”. We were extremely pleased to have experts from around the world provide their different insights during this panel discussion, and the talks which preceded the panel discussion. Mr. Graham Coe (European Space Agency - Research and Technology Center), Dr. Vince M. Cowan (Air Force Research Laboratory), Prof. Takao Nakagawa (Japan Aerospace Exploration Agency), Mr. John W. Pepi (L-3 Communications IOS-Wilmington), and Dr. David B. Witkin (The Aerospace Corporation) engaged the attendees with an
active discussion on this controversial topic. We want to thank the panel participants for allowing us to create this unique opportunity for the community. At its core, this is what the entire Optics + Photonics Meeting is looking to do, create opportunities for an open dialogue on topical subjects, and create a venue where the world’s leading subject matter experts can be available for both formal presentations and informal hallway discussions. Thank you to all of the SPIE staff, our Program Committee, contributing authors, and conference attendees. We hope all participants came away from the meeting feeling re-energized about their areas of research and development and re-engaged with their broad community of collaborators, competitors, and customers.

Joseph L. Robichaud
Matthias Krödel
William A. Goodman