

PROCEEDINGS OF SPIE

***Sixteenth International
Conference on Solid State
Lighting and LED-based
Illumination Systems***

**Nikolaus Dietz
Ian T. Ferguson**
Editors

**8–9 August 2017
San Diego, California, United States**

Sponsored and Published by
SPIE

Volume 10378

Proceedings of SPIE 0277-786X, V. 10378

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

Sixteenth International Conference on Solid State Lighting and LED-based Illumination Systems,
edited by Nikolaus Dietz, Ian T. Ferguson, Proc. of SPIE Vol. 10378, 1037801
© 2017 SPIE · CCC code: 0277-786X/17/\$18 · doi: 10.1117/12.2296909

Proc. of SPIE Vol. 10378 1037801-1

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 *Sixteenth International Conference on Solid State Lighting and LED-based Illumination Systems*, edited by Nikolaus Dietz, Ian T. Ferguson, Proceedings of SPIE Vol. 10378 (SPIE, Bellingham, WA, 2017) Seven-digit Article CID Number.

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

ISBN: 9781510612136
ISBN: 9781510612143 (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 © 2017, 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/17/\$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. 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 *Authors*
vii *Conference Committee*

SESSION 1 APPLICATIONS FOR SOLID STATE LIGHTING USING LEDs AND OLEDS

- 10378 02 **Opportunities and challenges for 3D printing of solid-state lighting systems (Invited Paper)** [10378-35]
- 10378 05 **Cryogenic characterization of LEDs for space application** [10378-4]
- 10378 06 **Analysis of spectral power distributions for multichannel platforms in a patient room application** [10378-5]

SESSION 2 TESTING, RELIABILITY, AND STANDARDS FOR LED AND SOLID STATE LIGHTING

- 10378 08 **A comparison of color fidelity metrics for light sources using simulation of color samples under lighting conditions (Invited Paper)** [10378-6]
- 10378 09 **Low-NEP pyroelectric detectors for calibration of UV and IR sources and detectors** [10378-9]

SESSION 3 DEVICE LEVEL PACKAGING FOR SOLID STATE LIGHTING I

- 10378 0A **Ultra-high power semiconductor devices: heat-sinking using GaN-on-diamond (Invited Paper)** [10378-10]
- 10378 0D **Growth and characterization of GaN/AlGaN heterostructures on GaN substrate templates (Invited Paper)** [10378-13]

SESSION 4 DEVICE LEVEL PACKAGING FOR SOLID STATE LIGHTING II

- 10378 0K **Searching for the optimal synthesis parameters of InP/Cd_xZn_{1-x}Se quantum dots when combined with a broad band phosphor to optimize color rendering and efficacy of a hybrid remote phosphor white LED** [10378-20]
- 10378 0L **Fabrication of CuInS₂/ZnS quantum dots-based white light-emitting diodes with high color rendering index** [10378-21]

SESSION 5 SYSTEM LEVEL DESIGN AND OPTIMIZATION

- 10378 0M **High lumen density sources based on LED-pumped phosphor rods: opportunities for performance improvement (Invited Paper)** [10378-22]
- 10378 0N **Progress in extremely high brightness LED-based light sources (Invited Paper)** [10378-23]
- 10378 0O **The impact of the driving frequency on the output flux of high-power InGaAlP-LEDs during high-current pulsed operation** [10378-24]

POSTER SESSION

- 10378 0Q **Dome diagnostics system of optical parameters and characteristics of LEDs** [10378-8]
- 10378 0R **Universal fixture design for body mounted LED lights** [10378-26]
- 10378 0T **Modeling and simulation of a solar simulator with multi-wavelength high-power LEDs** [10378-28]
- 10378 0U **The color enhancement and collimation features of the multi-colored LEDs with different periodic microstructure on the top surface of TIR lens** [10378-29]
- 10378 0V **Analysis of stereo depth for 3D LED autostereoscopic displays based on the physical limitation** [10378-30]
- 10378 0X **Light box for investigation of characteristics of optoelectronics detectors** [10378-32]
- 10378 0Y **Smart street lighting solution for remote rural areas of India** [10378-33]
- 10378 0Z **High-speed modulation of GaN-based light emitting diode with embedded photonic crystals** [10378-34]

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.

An, Shu, 0V
Antonis, Piet, 0N
Boutillier, Mathieu, 05
Bruls, Dominique, 0M
Carron, Jérôme, 05
Chung, Shu-Ru, 0L
Cillierre, David, 05
Collazo, Ramon, 0D
Cooksey, C. C., 09
Correia, António, 0K
Danto, Pascale, 05
de Boer, Dick K. G., 0M, 0N
Delbergue, Audrey, 05
Dietz, Nikolaus, 0D
Dupont, Dorian, 0K
Eppeldauer, G. P., 09
Esposito, Tony, 06
Fu, Han-Kuei, 0U
Hajra, Debdyut, 0R, 0Y
Hanselaer, Peter, 0K
Hanssen, L. M., 09
Hassanzadeh, Sahar, 05
He, Zehao, 0V
Hens, Zeger, 0K
Hoelen, Christoph, 0M, 0N
How, Lip Sun, 05
Hsiao, Chih-Chun, 0L
Huang, JianJang, 0Z
Hubbard, Lance, 0D
Jagt, Henri, 0M
Jang, Junwoo, 08
Kadijk, Simon, 0N
Kang, Yoojin, 08
Kim, James J., 06
Kim, Yoon G., 0T
Kirste, Ronny, 0D
Koole, Rolf, 0N
Kuball, Martin, 0A
Kwon, Hyeokjun, 08
Lewis, Reuben T., 0T
Li, Yun, 0N
Lin, Tung-Ching, 0Z
Ma, Jianshe, 0V
Maniccia, Dorene, 06
Mazikowski, Adam, 0X
Meuret, Youri, 0K
Mita, Seiji, 0D
Morgott, Stefan, 0O
Mou, Xi, 02
Narendran, Nadarajah, 02
Pavlenko, Nikita A., 0Q
Perera, Indika U., 02
Peretyagin, Vladimir S., 0Q
Philippon, Anne, 05
Podobedov, V. B., 09
Rizzo, Patricia, 06
Ryckaert, Jana, 0K
Schulz, Benjamin, 0O
Sitar, Zlatko, 0D
Smet, Kevin, 0K
Su, Ping, 0V
Su, Yu-Sheng, 0L
Szreder, Agnieszka, 0X
Tessier, Mickael D., 0K
Thotagamuwa, Dinusha R., 02
Van De Voorde, Patrick, 0N
Vanbroekhoven, Vincent, 0N
Vernon, Mark, 0D
Woods, Vincent T., 0D
Ying, Shang-Ping, 0U
You, Zi-Xuan, 0Z

Conference Committee

Program Track Chair

José Sasián, College of Optical Sciences, The Univ. of Arizona
(United States)

Conference Chairs

Nikolaus Dietz, Georgia State University (United States)
Ian T. Ferguson, Missouri University of Science and Technology
(United States)

Conference Program Committee

Lianghui Chen, Institute of Semiconductors (China)
Wood-Hi Cheng, National Sun Yat-Sen University (Taiwan)
Hugo J. Cornelissen, Philips Research (Netherlands)
John W. Curran, LED Transformations, LLC (United States)
Zhe Chuan Feng, Guangxi University (China)
Christoph Hoelen, Philips Lighting B.V. (Netherlands)
Jian-Jang Huang, National Taiwan University (Taiwan)
Jianzhong Jiao, Consultant (United States)
Matthew H. Kane, Texas A&M University at Galveston (United States)
Asif M. Khan, University of South Carolina (United States)
Mike R. Krames, Arkesso (United States)
Martin Kuball, University of Bristol (United Kingdom)
Yung Sheng Liu, National Tsing Hua University (Taiwan)
Na Lu, Purdue University (United States)
Eun-Hyun Park, Semicon Light Co., Ltd. (Korea, Republic of)
Seong-Ju Park, Gwangju Institute of Science and Technology
(Korea, Republic of)
Jeff Quinlan, Acuity Brands Lighting, Inc. (United States)
Tae-Yeon Seong, Korea University (Korea, Republic of)
Nelson Tansu, Lehigh University (United States)
Chih-Chung Yang, National Taiwan University (Taiwan)
Yiting Zhu, Rensselaer Polytechnic Institute (United States)

Session Chairs

- 1 Applications for Solid State Lighting using LEDs and OLEDs
Ian T. Ferguson, Missouri University of Science and Technology
(United States)
- 2 Testing, Reliability, and Standards for LED and Solid State Lighting
Ian T. Ferguson, Missouri University of Science and Technology
(United States)
- 3 Device Level Packaging for Solid State Lighting I
Nikolaus Dietz, Georgia State University (United States)
- 4 Device Level Packaging for Solid State Lighting II
Nikolaus Dietz, Georgia State University (United States)
- 5 System Level Design and Optimization
Ian T. Ferguson, Missouri University of Science and Technology
(United States)