PROCEEDINGS OF SPIE

Eighth International Conference on Solid State Lighting

Ian T. Ferguson Tsunemasa Taguchi Ian E. Ashdown Seong-Ju Park Editors

11–13 August 2008 San Diego, California, USA

Sponsored and Published by SPIE

Volume 7058

Proceedings of SPIE, 0277-786X, v. 7058

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 Eighth International Conference on Solid State Lighting, edited by Ian T. Ferguson, Tsunemasa Taguchi, Ian E. Ashdown, Seong-Ju Park, Proceedings of SPIE Vol. 7058 (SPIE, Bellingham, WA, 2008) Article CID Number.

ISSN 0277-786X ISBN 9780819472786

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 © 2008, 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/08/\$18.00.

Printed in the United States of America.

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



SPIEDigitalLibrary.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
- ix Introduction

SOLID STATE LIGHTING AND OLEDS PLENARY SESSION

7058 02 Why the developing world is the perfect market place for solid state lighting [7058-101] C. Schultz, Light Up The World (Canada); I. Platonova, G. Doluweera, D. Irvine-Halliday, Light Up The World (Canada) and Univ. of Calgary (Canada)

SOURCE PERFORMANCE I

7058 05 On-chip very low junction temperature GaN-based light emitting diodes by selective ion implantation [7058-03]

Y.-W. Cheng, H.-H. Chen, M.-Y. Ke, C.-P. Chen, J. Huang, National Taiwan Univ. (Taiwan)

7058 07 Design and fabrication of optical homogenizer with micro structure by injection molding process [7058-46]
 C.-C. A. Chen, National Taiwan Univ. of Science and Technology (Taiwan); S.-W. Chang, C.-J. Weng, Instrument Technology Research Ctr. (Taiwan)

APPLICATION

7058 0A Rapid prototyping of an adaptive light source for mobile manipulators with EasyKit and EasyLab [7058-08]

M. Wojtczyk, S. Barner, M. Geisinger, A. Knoll, Technische Univ. München (Germany)

OLEDS AND SOLID STATE LIGHTING: JOINT SESSION WITH CONFERENCE 7051

7058 0D Improvement of efficiency droop in resonance tunneling LEDs (Invited Paper) [7058-12] C. Liu, W. N. Wang, P. A. Shields, S. Denchitcharoen, F. Causa, D. E. W. Allsopp, Univ. of Bath (United Kingdom)

SOURCE PERFORMANCE II

7058 OE Lumiramic: a new phosphor technology for high performance solid state light sources (Invited Paper) [7058-13] H. Bechtel, P. Schmidt, W. Busselt, B. S. Schreinemacher, Philips Research Europe Aachen (Germany) 7058 0G Analysis of strain relaxation and emission spectrum of a free-standing GaN-based nanopillar [7058-15] Y -R. Wu National Jaiwan Univ. (Jaiwan): P. Yu C. H. Chiu National Chiao-Tung Univ.

Y.-R. Wu, National Taiwan Univ. (Taiwan); P. Yu, C. H. Chiu, National Chiao-Tung Univ. (Taiwan); C.-Y. Chang, National Taiwan Univ. (Taiwan); H. C. Kuo, National Chiao-Tung Univ. (Taiwan)

- Thermal characterization of single-die and multi-die high power light-emitting diodes
 [7058-16]
 A. Keppens, Univ. College Kaho St.-Lieven (Belgium) and K. U. Leuven (Belgium);
 D. De Smeyter, Univ. College Kaho St.-Lieven (Belgium); W. R. Ryckaert, Univ. College Kaho St.-Lieven (Belgium); G. Deconinck, K. U. Leuven (Belgium);
 P. Hanselaer, Univ. College Kaho St.-Lieven (Belgium) and K. U. Leuven (Belgium);
- 7058 01 Effect of PdZn film on the performance of green light-emitting diodes [7058-43] J.-Y. Kim, M.-K. Kwon, C. Y. Cho, S.-J. Lee, S.-J. Park, Gwangju Institute of Science and Technology (Korea, Republic of); S. Kim, J. W. Kim, Y. C. Kim, Samsung Electro-Mechanics Co., Ltd. (Korea, Republic of)

LED I

7058 OK	Metalorganic chemical vapor deposition of GaN and InGaN on ZnO substrate using Al ₂ O ₃ as a transition layer [7058-18] N. Li, SJ. Wang, Georgia Institute of Technology (United States); CL. Huang, Z. C. Feng,
	National Taiwan Univ. (Taiwan); A. Valencia, J. Nause, Cermet, Inc. (United States); C. Summers, I. Ferguson, Georgia Institute of Technology (United States)
7058 OL	Layered oxonitrido silicate (SiON) phosphors for high power LEDs [7058-19] P. Schmidt, A. Tuecks, H. Bechtel, D. Wiechert, Philips Research Europe Aachen (Germany); R. Mueller-Mach, G. Mueller, Philips Lumileds Lighting Co. (United States); W. Schnick, Munich Univ. (Germany)
7058 OM	Remote phosphor LED modules for general illumination: toward 200 lm/W general lighting LED light sources [7058-20]
	C. Hoelen, H. Borel, J. de Graaf, M. Keuper, M. Lankhorst, C. Mutter, L. Waumans, R. Wegh, Philips Lighting (Netherlands)
7058 ON	Phosphor-free white light-emitting diode using InGaN/GaN multiple quantum wells grown on microfacets [7058-44]
	C. Cho, IK. Park, MK. Kwon, JY. Kim, SJ. Park, Gwangju Institute of Science and Technology (Korea, Republic of); D. R. Jung, K. W. Kwon, NINEX Co., Ltd. (Korea, Republic of)
	LED II
7058 0Q	External efficiency and thermal reliability enhanced multi-chip package design for light emitting diodes [7058-23]

M.-H. Tang, T.-H. Wu, G.-D. J. Su, National Taiwan Univ. (Taiwan)

7058 OR LED array: Where does far-field begin? [7058-25] I. Moreno, Univ. Autónoma de Zacatecas (Mexico); C.-C. Sun, National Central Univ. (Taiwan)

GROWTH

- 7058 0S Optical and structural properties of dual wavelength InGaN/GaN multiple quantum well light emitting diodes (Invited Paper) [7058-26]
 Z. C. Feng, T.-W. Kuo, National Taiwan Univ. (Taiwan); C. Y. Wu, Uni-Light Technology Corp. (Taiwan); H.-L. Tsai, J.-R. Yang, National Taiwan Univ. (Taiwan); Y. S. Huang, National Taiwan Univ. of Science & Technology (Taiwan); I. T. Ferguson, Georgia Institute of Technology (United States); W. Lu, Fisk Univ. (United States)
- Formation of visible single-mode light sources using quantum dots [7058-28]
 S. Baig, Univ. of Miami (United States); J. Xu, P. Wu, New Span Opto-Technology Inc. (United States); B. Chen, M. Wang, Univ. of Miami (United States)
- MOVPE growth of AlGaN/GaN superlattices on ZnO substrates for green emitter applications [7058-29]
 H. Yu, S. Wang, N. Li, W. Fenwick, A. Melton, Georgia Institute of Technology (United States);
 M. H. Kane, Univ. of Oklahoma (United States); B. Klein, I. Ferguson, Georgia Institute of Technology (United States)
- 7058 0W Improvement of leakage current and optical properties of GaN-based LEDs by chemical etching of p-GaN [7058-47]
 T.-Y. Park, C.-H. Cho, I.-K. Park, S.-J. Park, Gwangju Institute of Science and Technology (Korea, Republic of)

OPTICS

- Ffficient and cost-effective polarized-light backlights for LCDs (Invited Paper) [7058-31]
 H. J. Cornelissen, H. J. B. Jagt, Philips Research (Netherlands); D. J. Broer, Philips Research (Netherlands) and Univ. of Technology Eindhoven (Netherlands); C. W. M. Bastiaansen, Univ. of Technology Eindhoven (Netherlands)
- 7058 0Y Highly efficient (infra)-red-conversion of InGaN light emitting diodes by nanocrystals, enhanced by color selective mirrors [7058-32]
 J. Roither, M. V. Kovalenko, W. Heiss, Univ. of Linz (Austria)
- 7058 10 An integrated LED reflector for backlight system [7058-34] C.-H. Chien, Z.-P. Chen, Tatung Univ. (Taiwan)
- 7058 11 Creating a desired lighting pattern with an LED array [7058-35] I. Moreno, Univ. Autónoma de Zacatecas (Mexico)

SOURCE PERFORMANCE III

 Polarization engineering of III-nitride nanostructures for high-efficiency light emitting diodes (Invited Paper) [7058-45]
 N. Tansu, R. A. Arif, H. Zhao, G. S. Huang, Y.-K. Ee, Lehigh Univ. (United States)

POSTER SESSION

7058 16 Improved performance of hybrid polymer light-emitting device by using inorganic nanocomposite and polymer solutions [7058-30]
 A. M. Hussain, B. Neppolian, S. H. Kim, J. Y. Kim, H.-C. Choi, K. Lee, S.-J. Park, Gwangju Institute of Science and Technology (Korea, Republic of)

Author Index

Conference Committee

Conference Chairs

Ian T. Ferguson, Georgia Institute of Technology (United States)
 Tsunemasa Taguchi, Yamaguchi University (Japan)
 Ian E. Ashdown, Philips Lighting Company (Canada)
 Seong-Ju Park, Gwangju Institute of Science and Technology (South Korea)

Program Track Chair

Ian T. Ferguson, Georgia Institute of Technology (United States)

Program Committee

Srinath K. Aanegola, GE Lumination LLC (United States) Andrew A. Allerman, Sandia National Laboratories (United States) Lianghui Chen, Institute of Semiconductors (China) Steven P. DenBaars, University of California, Santa Barbara (United States) Kevin J. Dowling, Color Kinetics Inc. (United States) Volker K. Härle, OSRAM Opto Semiconductors GmbH (Germany) Christoph G. Hoelen, Philips Lighting B.V. (Netherlands) Jianzhong Jiao, OSRAM Opto Semiconductors Inc. (United States) Matthew H. Kane, University of Oklahoma (United States) Asif M. Khan, University of South Carolina (United States) Michael R. Krames, Philips Lumileds Lighting Company (United States) Yung-Sheng Liu, National Tsing Hua University (Taiwan) Shuji Nakamura, University of California, Santa Barbara (United States) Eun-Hyun Park, EpiValley Company, Ltd. (South Korea) Robert V. Steele, Strategies Unlimited (United States) Brent K. Wagner, Georgia Institute of Technology (United States) Chih-Chung Yang, National Taiwan University (Taiwan)

Session Chairs

Solid State Lighting and OLEDs Plenary Session Ian T. Ferguson, Georgia Institute of Technology (United States)

Source Performance I Tsunemasa Taguchi, Yamaguchi University (Japan) Application Tsunemasa Taguchi, Yamaguchi University (Japan)

OLEDs and Solid State Lighting: Joint Session with Conference 7051 Ian T. Ferguson, Georgia Institute of Technology (United States)

Source Performance II

Seong-Ju Park, Gwangju Institute of Science and Technology (South Korea)

LED I

Edward D. Petrow, Lincoln Technical Services, Inc. (United States)

LED II

Norbert Linder, OSRAM Opto Semiconductors GmbH (Germany)

Growth

Eric C. Bretschneider, Lighting Science Group Corporation (United States)

Optics

Jeff Nause, Cermet, Inc. (United States)

Source Performance III

Zhe-Chuan Feng, National Taiwan University (Taiwan)

Introduction

The Eighth International Conference on Solid State Lighting, part of the SPIE annual meeting, took place from 11–13 August 2008 in San Diego, California.

Contained in these proceedings are the 25 submitted papers of invited and contributing presenters in this conference. The topics covered by these papers range from semiconductor fabrication and characterization to solid state lighting systems development. They are representative of an unmistakable progression from academic research to industrial commercialization, fulfilling a promise that began with the first solid state lighting conference in 2001. At the same time, they also demonstrate that much exciting work remains to be done in the field.

The conference chairs would like to thank SPIE for hosting this meeting, as well as the program committee members, the authors, and the session chairs for making this meeting a technical success, and for providing valued and timely research on solid state lighting.

> lan T. Ferguson Tsunemasa Taguchi lan E. Ashdown Seong-Ju Park