PROCEEDINGS OF SPIE

Photonics for Energy III

Haizheng Zhong Rui Zhu Samuel D. Stranks Jianpu Wang Editors

15–16 October 2023 Beijing, China

Sponsored by SPIE COS—Chinese Optical Society

Cooperating Organizations

Tsinghua University (China) • Peking University (China) • University of Science and Technology of China (China) • Zhejiang University (China) • Tianjin University (China) • Beijing Institute of Technology (China) • Beijing University of Posts and Telecommunications (China) • Nankai University (China) • Changchun University of Science and Technology (China) • University of Shanghai for Science and Technology (China) • Capital Normal University (China) • Huazhong University of Science and Technology (China) • Beijing Jiaotong University (China) • China Jiliang University (China) • Shanghai Institute of Optics and Fine Mechanics, CAS (China) • Changchun Institute of Optics, Fine Mechanics and Physics, CAS (China) • Institute of Semiconductors, CAS (China) • Institute of Optics and Electronics, CAS (China) • Institute of Physics, CAS (China) • Shanghai Institute of Technical Physics, CAS (China) • China Instrument and Control Society (China) • Optical Society of Japan (Japan) • Optical Society of Korea (Republic of Korea) • Australian and New Zealand Optical Society • Optics and Photonics Society of Singapore (Singapore) • European Optical Society

Supporting Organizations
China Association for Science and Technology (CAST) (China)
Department of Information of National Nature Science Foundation, China (NSFC) (China)

Published by SPIE

Volume 12763

Proceedings of SPIE 0277-786X, V. 12763

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

Photonics for Energy III, edited by Haizheng Zhong, Rui Zhu, Samuel D. Stranks, Jianpu Wang, Proc. of SPIE Vol. 12763, 1276301 ⋅ © 2023 SPIE 0277-786X ⋅ doi: 10.1117/12.3021922

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 SPIEDigitalLibrary.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 *Photonics for Energy III*, edited by Haizheng Zhong, Rui Zhu, Samuel D. Stranks, Jianpu Wang, Proc. of SPIE 12763, Seven-digit Article CID Number (DD/MM/YYYY); (DOI URL).

ISSN: 0277-786X

ISSN: 1996-756X (electronic)

ISBN: 9781510667754

ISBN: 9781510667761 (electronic)

Published by

SPIE

P.O. Box 10, Bellingham, Washington 98227-0010 USA Telephone +1 360 676 3290 (Pacific Time) SPIE.ora

3FIE.OIG

Copyright © 2023 Society of Photo-Optical Instrumentation Engineers (SPIE).

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 fees. To obtain permission to use and share articles in this volume, visit Copyright Clearance Center 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.

Printed in the United States of America by Curran Associates, Inc., under license from SPIE.

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



Paper Numbering: A unique citation identifier (CID) number is assigned to each article in the Proceedings of SPIE 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 ix	Symposium Committees Conference Committee
	PHOTONICS FOR ENERGY I
12763 05	Perovskite as color conversion materials for micro-LED display (Invited Paper) [12763-4]
	PHOTONICS FOR ENERGY IV
12763 OI	Nanoscale light focusing of colloidal nanostructures for enhanced silicon solar cells [12763-20]
	PHOTONICS FOR ENERGY V
12763 ON	Interface treatment by oxygen plasma for PEDOT:PSS/silicon hybrid solar cell [12763-26]
	PHOTONICS FOR ENERGY VI
12763 OR	Perovskite-germanium heterostructure with periodical nanoparticles for broadband light harvesting [12763-31]
	DIGITAL POSTER SESSION
12763 OV	A wide field-of-view optical receiver based on a ball lens retroreflector for resonant beam charging applications [12763-16]
12763 OW	HTL doping density optimization for photovoltaic assessment of Pb-free Cs ₂ NaGaBr ₆ n-i-p solar cell [12763-21]
12763 OX	An investigation of inorganic ETL materials for carbon-based HTL-free perovskite solar cell [12763-30]
12763 OY	A design of thin metal-nitrides broadband meta-absorber for application of solar energy [12763-35]

Symposium Committees

Symposium Chairs

Bernard Kress, *President*, SPIE (United States) and Google (United States)

Qihuang Gong, Honorary President, Chinese Optical Society (China) and Peking University (China)

General Chairs

Ying Gu, President, Chinese Optical Society (China) and Chinese People's Liberation Army General Hospital (China) Wenqing Liu, Vice President, Chinese Optical Society (China) and Anhui Institute of Optics and Fine Mechanics (China)

Technical Program Chairs

Zejin Liu, Vice President, Chinese Optical Society (China) and National University of Defense Technology (China)
 Xiangang Luo, Institute of Optics and Electronics (China)
 Xingde Li, Johns Hopkins University (United States)

Technical Program Co-chairs

Wei Huang, Northwestern Polytechnical University (China) Guobin Fan, China Academy of Engineering Physics (China) Qingming Luo, Hainan University (China) Ninghua Zhu, Institute of Semiconductors (China) Fengyi Jiang, Nanjing University (China)

Organizing Committee

Suotang Jia, Vice President, Chinese Optical Society (China) and Shanxi University (China)

Xiaomin Ren, Vice President, Chinese Optical Society (China) and Beijing University of Posts and Telecommunications (China)

Wenjie Wang, Vice President, Chinese Optical Society (China) and Sunny Optical Technology (Group) Company, Ltd. (China)

Jianda Shao, Vice President, Chinese Optical Society (China) and Shanghai Institute of Optics and Fine Mechanics (China)

Hong Jin, Vice President, Chinese Optical Society (China) and Changchun Institute of Optics, Fine Mechanics and Physics (China)

Yunquan Liu, Vice President, Chinese Optical Society (China) and Peking University (China)

Xinliang Zhang, Xidian University (China)

Yanqing Lu, Nanjing University (China)

Chuanfeng Li, University of Science and Technology of China (China)

Wei Hao, Xi'an Institute of Optics and Precision Mechanics (China)

Qun Hao, Changchun University of Science and Technology (China)

Yidong Huang, Tsinghua University (China)

Yongtian Wang, Beijing Institute of Technology (China)

Xiaocong Yuan, Shenzhen University (China)

Limin Tong, Zhejiang University (China)

Xiaoying Li, Tianjin University (China)

Yan Li, Peking University (China)

Jianxin Chen, Fujian Normal University (China)

Weiwei Liu, Nankai University (China)

Jian Wang, Huazhong University of Science and Technology (China)

Secretaries-General

Xu Liu, Secretary General, Chinese Optical Society (China) and Zhejiang University (China)

Bo Gu, Deputy Secretary General, Chinese Optical Society (China)

Hong Yang, Deputy Secretary General, Chinese Optical Society (China) and Peking University (China)

Tianrui Zhai, Deputy Secretary General, Chinese Optical Society (China) and Beijing University of Technology (China)

Local Organizing Committee Chair

Xu Liu, Secretary General, Chinese Optical Society (China) and Zhejiang University (China)

Local Organizing Committee Co-chairs

Hong Yang, Deputy Secretary General, Chinese Optical Society (China) and Peking University (China)

Yuhong Wan, Beijing University of Technology (China)

Liquan Dong, Beijing Institute of Technology (China)

Local Organizing Committee

Wei Xiong, Chinese Optical Society (China)

Yu Xiang, Peking University (China)

Yong Zeng, Beijing University of Technology (China)

Nan Zhang, Beijing Institute of Technology (China) Ruiqing Jia, Chinese Optical Society (China) Xiao Li, Chinese Optical Society (China) Jianxin Sun, Chinese Optical Society (China)

Technical Organizing Committee

Hossein Asghari, Loyola Marymount University (United States)

Liangcai Cao, Tsinghua University (China)

P. Scott Carney, The Institute of Optics, University of Rochester (United States)

Benyong Chen, Zhejiang Sci-Tech University (China)

Qionghai Dai, Tsinghua University (China)

Gerd Ehret, Physikalisch-Technische Bundesanstalt (Germany)

Xinyu Fan, Shanghai Jiao Tong University (China)

Zheyu Fang, Peking University (China) and Rice University (United States)

Ying Gu, Chinese People's Liberation Army General Hospital (China)

Sen Han, University of Shanghai for Science and Technology (China) and Suzhou H&L Instruments LLC (China)

Inamar Hartl, Deutsches Elektronen-Synchrotron (Germany)

Qiongyi He, Peking University (China)

Werner Hofmann, Deutsches Patent- und Markenamt (Germany)

Minghui Hong, Xiamen University (China)

Shibin Jiang, AdValue Photonics, Inc. (United States)

Tina Kidger, Kidger Optics Associates (United Kingdom)

Chang-Seok Kim, Pusan National University (Korea, Republic of)

Dai-Sik Kim, Ulsan National Institute of Science and Technology (Korea, Republic of)

Chuan-Feng Li, University of Science and Technology of China (China)

Xingde Li, Johns Hopkins University (United States)

Ming Li, Institute of Semiconductors (China)

Baojun Li, Jinan University (China)

Wei Li, Institute of Semiconductors (China)

Jun Liu, Shanghai Institute of Optics and Fine Mechanics (China)

Qingming Luo, Hainan University (China)

Ting-Chung Poon, Virginia Polytechnic Institute and State University (United States)

Yuji Sano, Institute for Molecular Science (Japan) and Osaka University (Japan)

Kebin Shi, Peking University (China)

Nuannuan Shi, Institute of Semiconductors (China)

Tsutomu Shimura, The University of Tokyo (Japan)

Samuel Stranks, University of Cambridge (United Kingdom)

Takuo Tanaka, RIKEN (Japan)

Masahiko Tani, University of Fukui (Japan)

Limin Tong, Zhejiang University (China)

Kazumi Wada, Massachusetts Institute of Technology (United States)

Yongtian Wang, Beijing Institute of Technology (China)

Jianpu Wang, Nanjing University of Technology (China)

Ting Wang, Institute of Physics (China)

Rengmao Wu, Zhejiang University (China)

Rongshi Xiao, Beijing University of Technology (China)

Minghong Yang, Wuhan University of Technology (China)

Jianhua Yao, Zhejiang University of Technology (China)

Hiroshi Yoshikawa, Nihon University (Japan)

Changyuan Yu, The Hong Kong Polytechnic University

(Hong Kong, China)

Xiao-Cong Yuan, Shenzhen University (China)

Jianzhong Zhang, Harbin Engineering University (China)

Xuping Zhang, Nanjing University (China)

Xinliang Zhang, Wuhan National Research Centre for Optoelectronics (China)

Cunlin Zhang, Capital Normal University (China)

Xi-Cheng Zhang, The Institute of Optics, University of Rochester (United States)

Zhenrong Zheng, Zhejiang University (China)

Haizheng Zhong, Beijing Institute of Technology (China)

Changhe Zhou, Jinan University (China)

Zhiping Zhou, Peking University (China)

Rui Zhu, Peking University (China)

Dan Zhu, Huazhong University of Science and Technology (China)

Conference Committee

Conference Chairs

Haizheng Zhong, Beijing Institute of Technology (China)
Rui Zhu, Peking University (China)
Samuel D. Stranks, University of Cambridge (United Kingdom)
Jianpu Wang, Nanjing University of Technology (China)

Conference Program Committee

Tae-Woo Lee, Seoul National University (Korea, Republic of)

Qihua Xiong, Tsinghua University (China)

Yabing Qi, Okinawa Institute of Science and Technology Graduate University (Japan)

Anita Ho-Baillie, The University of Sydney (Australia)

Osman M. Bakr, King Abdullah University of Science and Technology (Saudi Arabia)

Sheng Xu, University of California, San Diego (United States)

Feng Gao, Linköping University (Sweden)

Jia Zhu, Nanjing University (China)

 $\textbf{Michael Saliba}, \ \textbf{Universit\"{a}t Stuttgart (Germany)} \ \ \textbf{and} \\$

Forschungszentrum Jülich (Germany)

Wolfgang R. Tress, Zurich University of Applied Sciences (Switzerland)

Yuan Yang, Columbia University (United States)

Haizheng Zhong, Beijing Institute of Technology (China)

Wei Zhang, University of Surrey (United Kingdom)

Feng Liu, Shanghai Jiao Tong University (China)

Hin-Lap Yip, City University of Hong Kong (Hong Kong, China)

Jingshan Luo, Nankai University (China)

Zhi-Kuang Tan, National University of Singapore (Singapore)

Guichuan Xing, University of Macau (Macao, China)