PROCEEDINGS OF SPIE

SPIDigitalLibrary.org/conference-proceedings-of-spie

Front Matter: Volume 11304

, "Front Matter: Volume 11304," Proc. SPIE 11304, Advances in Display Technologies X, 1130401 (4 March 2020); doi: 10.1117/12.2570038

SPIE.

Event: SPIE OPTO, 2020, San Francisco, California, United States

PROCEEDINGS OF SPIE

Advances in Display Technologies X

Jiun-Haw Lee
Qiong-Hua Wang
Tae-Hoon Yoon
Editors

5–6 February 2020
San Francisco, California, United States

Sponsored and Published by
SPIE

Volume 11304

Proceedings of SPIE 0277-786X, V. 11304

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

Advances in Display Technologies X, edited by Jiun-Haw Lee, Qiong-Hua Wang,
Tae-Hoon Yoon, Proc. of SPIE Vol. 11304, 1130401 · © 2020 SPIE
CCC code: 0277-786X/20/\$21 · doi: 10.1117/12.2570038

Proc. of SPIE Vol. 11304 1130401-1

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 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 *Advances in Display Technologies X*, edited by Jiun-Haw Lee, Qiong-Hua Wang, Tae-Hoon Yoon, Proceedings of SPIE Vol. 11304 (SPIE, Bellingham, WA, 2020) Seven-digit Article CID Number.

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

ISBN: 9781510633711
ISBN: 9781510633728 (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 © 2020, 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 \$21.00 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/20/\$21.00.

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.

**SPIE. DIGITAL
LIBRARY**
SPIEDigitalLibrary.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*

AR AND VR DISPLAYS

- 11304 02 **Key issues and technologies for AR/VR head-mounted displays (Keynote Paper)** [11304-1]
- 11304 05 **Holographic waveguide-type three dimensional augmented reality display using the full-color holographic optical element mirror array** [11304-4]
- 11304 06 **Projection-type integral 3D display using mirrors facing each other for a wide viewing angle with a downsized system** [11304-5]

OPTICS FOR AR/VR DISPLAYS

- 11304 07 **Triple-coating surface waveguide for augmented reality to achieve large field of view (Invited Paper)** [11304-6]
- 11304 08 **Wavelength-multiplexed multifocal displays (Invited Paper)** [11304-7]
- 11304 09 **Super-resolution foveated imaging system for near-eye display (NED) using tilting concave mirror** [11304-8]
- 11304 0A **Depth enhancement of integral imaging AR display with an electrowetting microlens array** [11304-9]

AR/VR DISPLAYS USING DMDS OR OTHER SLM DEVICES: JOINT SESSION WITH 11294 AND 11304

- 11304 0C **Spatial light modulators with large phase-modulation: application to encode lenses with very short focal lengths** [11304-11]

3D AND PROJECTION DISPLAYS

- 11304 0E **Volumetric technology: enabling near-work compatible AR displays** [11304-13]

LED, TFT, AND LCD

- 11304 OH **MicroLED display: the next-generation display technology (Invited Paper)** [11304-17]
- 11304 OI **High-efficiency micro-LED displays with indistinguishable color shift (Invited Paper)** [11304-18]
- 11304 OK **Influence of mechanical bending strain on bias-stress stability of flexible top-gate p-type SnO TFTs (Invited Paper)** [11304-20]
- 11304 OL **Achieving 1 μ m pixel pitch display for electronic holography (Invited Paper)** [11304-21]

POSTER SESSION

- 11304 OT **An extended depth-of-field projection method using a high-speed projector with a synchronized oscillating variable focus lens** [11304-29]
- 11304 OU **LED-based automotive exterior displays and interior signage for autonomous cars** [11304-30]
- 11304 IO **Synthesis of computer-generated hologram using Fourier ptychographic approach with intermediate pupil function** [11304-37]
- 11304 I3 **Retinal image generation method for retinal projection type super multi-view 3D head-mounted display** [11304-40]
- 11304 I4 **Control method of active parallax barrier and binocular image for glasses-free stereoscopic display according to viewing position** [11304-41]
- 11304 I7 **Foveated high-resolution light-field system based on integral imaging for near-eye displays** [11304-44]
- 11304 IC **3D surface reconstruction using Talbot effect and Fourier transform of phase objects** [11304-49]
- 11304 IF **Assessment of spatial perception for a multi-layer volumetric display: the effect of exocentric and egocentric distance on relative depth judgements** [11304-52]

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.

Bang, Kiseung, 02	Lu, Matthew, 08
Blankenbach, Karlheinz, 0U	Moreno, Ignacio, 0C
Chen, Enguo, 08	Nakamura, Hiroy, 14
Chen, Jian-Zhang, 0K	Narels, M., 0E
Cheng, I-Chun, 0K	Ochs, Daniel, 0U
Cho, Jaebum, 10	Olivares-Pérez, Arturo, 1C
Choi, Ji Hun, 0L	Ortiz-Gutiérrez, Mauricio, 1C
Chou, Pei-Ting, 0I	Osmanis, I., 0E
Cottrell, Don M., 0C	Osmanis, K., 0E
Darkhanbaatar, Nyamsuren, 05	Ozols, A., 0E
Davis, Jeffrey A., 0C	Panke, Karola, 1F
Delesa-Velina, Mara, 1F	Park, Sang-Hee Ko, 0L
Erdenebat, Munkh-Uchral, 05	Pérez Cortés, Mario, 1C
Gertners, U., 0E	Pi, Jae-Eun, 0L
Gou, Fangwang, 0I	Pladere, Tatjana, 1F
Gutierrez, Benjamin K., 0C	Ponce de León Villanueva, Yenisey del Rocío, 1C
Hamagishi, Goro, 14	Reichel, Steffen, 0U
Hsiang, En-Lin, 0I	Shin, Chang-Won, 05
Hsu, Shu-Ming, 0K	Shin, Dooseub, 0A, 17
Hwang, Chi-Sun, 0L	Smukulis, R., 0E
Hwang, Chi-Young, 0L	Su, Guo-Dung J., 07
Ibarra Torres, Juan Carlos, 1C	Tabata, Satoshi, 0T
Isele, Robert, 0U	Takahashi, Hideya, 13, 14
Ishikawa, Masatoshi, 06, 0T	Tan, Guan-Jun, 0I
Jeong, Jinsoo, 02, 10	Wang, Lihui, 0T
Jeong, Jong-Rae, 05	Watanabe, Yoshihiro, 06, 0T
Kim, Cheoljoong, 0A	Won, Yong Hyub, 09, 0A, 17
Kim, Gi Heon, 0L	Wu, Jian-Lin, 07
Kim, Hee-Ok, 0L	Wu, Shin-Tson, 08, 0I
Kim, Jinwoong, 0L	Xu, Hongjin, 0T
Kim, Joo Yeon, 0L	Yang, Jong-Heon, 0L
Kim, Nam, 05	Yasui, Masahiko, 06
Kim, Yong-Hae, 0L	Yoo, Chanhung, 02
Kitada, Tomoya, 14	Yoo, Dongheon, 10
Kohno, Junya, 13	Yoshimoto, Kayo, 13, 14
Konosonoka, Vita, 1F	Zabels, R., 0E
Koo, Gyohyun, 09, 0A, 17	Zhan, Tao, 08
Krumina, Gunta, 1F	Zou, Junyu, 08
Kusafuka, Kaoru, 14	
Kwon, Ki-Chul, 05	
Lan, Yi-Fen, 0I	
Lee, Byoung-ho, 02, 10	
Lee, Byoung-hyo, 02	
Lee, Kwang-Heum, 0L	
Lee, Won-Jae, 0L	
Leong, Jia Chee, 09, 17	
Li, Yun-Li, 0H, 0I	
Lin, Wei-Chen, 0K	
Liu, Ying-Tsang, 0H	

Conference Committee

Symposium Chairs

Sailing He, KTH Royal Institute of Technology (Sweden) and Zhejiang University (China)
Yasuhiro Koike, Keio University (Japan)

Symposium Co-chairs

Connie J. Chang-Hasnaian, University of California, Berkeley (United States)
Graham T. Reed, Optoelectronics Research Centre, University of Southampton (United Kingdom)

Program Track Chair

Liang-Chy Chien, Kent State University (United States)

Conference Chairs

Jiun-Haw Lee, National Taiwan University (Taiwan)
Qiong-Hua Wang, Beihang University (China)
Tae-Hoon Yoon, Pusan National University (Korea, Republic of)

Conference Program Committee

Karlheinz Blankenbach, Hochschule Pforzheim (Germany)
Pierre M. Boher, ELDIM (France)
Liangcai Cao, Tsinghua University (China)
Liang-Chy Chien, Kent State University (United States)
Tien-Lung Chiu, Yuan Ze University (Taiwan)
Nobuyuki Hashimoto, Citizen Watch Company, Ltd. (Japan)
Yi-Pai Huang, Apple Inc. (United States)
Byoungcho Lee, Seoul National University (Korea, Republic of)
Sin-Doo Lee, Seoul National University (Korea, Republic of)
Akihiro Mochizuki, i-CORE Technology, LLC (United States)
Michael Witek, Merck KGaA (Germany)

Session Chairs

- 1 AR and VR Displays
Lo Chen, Kent State University (United States)

- 2 Optics for AR/VR Displays
Byoung-ho Lee, Seoul National University (Korea, Republic of)
- 3 AR/VR Displays using DMDs or other SLM Devices: Joint Session with 11294 and 11304
Alex Lyubarsky, Texas Instruments Inc. (United States)
Hong Hua, Wyant College of Optical Sciences (United States)
- 4 3D and Projection Displays
Tae-Hoon Yoon, Pusan National University (Korea, Republic of)
- 5 LED, TFT, and LCD
Tien-Lung Chiu, Yuan Ze University (Taiwan)
- 6 OLED Physics
Shun-Wei Liu, Ming Chi University of Technology (Taiwan)
- 7 OLED Applications
Yuh-Renn Wu, National Taiwan University (Taiwan)