

PROCEEDINGS OF SPIE

# ***Emerging Liquid Crystal Technologies XI***

**Liang-Chy Chien  
Dick J. Broer  
Hirotugu Kikuchi  
Nelson V. Tabiryan**  
*Editors*

**16–17 February 2016  
San Francisco, California, United States**

*Sponsored and Published by*  
SPIE

**Volume 9769**

Proceedings of SPIE 0277-786X, V. 9769

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

Emerging Liquid Crystal Technologies XI, edited by Liang-Chy Chien, Dick J. Broer,  
Hirotugu Kikuchi, Nelson V. Tabiryan, Proc. of SPIE Vol. 9769, 976901  
© 2016 SPIE · CCC code: 0277-786X/16/\$18 · doi: 10.1117/12.2239911

Proc. of SPIE Vol. 9769 976901-1

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](http://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 *Emerging Liquid Crystal Technologies XI*, edited by Liang-Chy Chien, Dick J. Broer, Hirotsugu Kikuchi, Nelson V. Tabiryan, Proceedings of SPIE Vol. 9769 (SPIE, Bellingham, WA, 2016) Six-digit Article CID Number.

ISSN: 0277-786X  
ISSN: 1996-756X (electronic)  
ISBN: 9781510600041

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](http://SPIE.org)

Copyright © 2016, 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](http://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/16/\$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](http://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 six-digit CID article numbering system structured as follows:

- 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.

# Contents

- v *Authors*
- vii *Conference Committee*
- ix *Introduction*

---

## **SESSION 1 OPTICAL CONTROL AND MODULATION**

---

- 9769 02 **Fast and ultrafast all-optical control of light in nematic and smectic-A liquid crystals (Keynote Paper)** [9769-1]
- 9769 04 **Plasmonic color tuning (Invited Paper)** [9769-3]

---

## **SESSION 2 BLUE PHASES AND APPLICATIONS**

---

- 9769 06 **Calculation of confocal microscope images of cholesteric blue phases (Invited Paper)** [9769-5]

---

## **SESSION 3 OPTICAL MANIPULATION AND IMAGING**

---

- 9769 0B **Photonic crystals, light manipulation, and imaging in complex nematic structures (Invited Paper)** [9769-10]
- 9769 0C **Nematic liquid crystals used to control photo-thermal effects in gold nanoparticles (Invited Paper)** [9769-11]
- 9769 0D **Nanoscale imaging of defects in layered liquid crystals (Invited Paper)** [9769-12]

---

## **SESSION 4 LENSES AND SPATIAL LIGHT MODULATORS**

---

- 9769 0F **LC-lens array with light field algorithm for 3D biomedical applications (Invited Paper)** [9769-14]

---

## **SESSION 5 PHOTO-ALIGNMENT AND PHOTO-ACTIVE MATERIALS**

---

- 9769 0J **Photoaligning and photopatterning technology: applications in displays and photonics (Keynote Paper)** [9769-18]
- 9769 0L **New architectures of liquid-crystal-based lenticular lenses in index matching approach for display applications (Invited Paper)** [9769-20]

---

**SESSION 6 ELECTRO-OPTICAL PROCESSES**

---

- 9769 0P **Liquid crystal devices with continuous phase variation based on high-permittivity thin films (Invited Paper)** [9769-24]
- 9769 0Q **Nanotube networks in liquid crystals** [9769-43]

---

**SESSION 7 NOVEL PHOTONIC MATERIALS I**

---

- 9769 0T **Solvent effect on columnar formation in solar-cell geometry (Invited Paper)** [9769-27]
- 9769 0U **Transmission polarized optical microscopy of short-pitch cholesteric liquid crystal shells** [9769-28]

---

**SESSION 8 NOVEL PHOTONIC MATERIALS II**

---

- 9769 0W **Liquid crystal light shutters for simultaneous control of haze and transmittance (Invited Paper)** [9769-30]
- 9769 0X **Liquid crystal alignment on ZnO nanostructure films (Invited Paper)** [9769-31]
- 9769 0Y **Hot pen and laser writable photonic polymer films (Invited Paper)** [9769-32]
- 9769 12 **Continuous phase modulation in polymer-stabilized liquid crystals (Invited Paper)** [9769-36]

---

**POSTER SESSION**

---

- 9769 14 **Bistable light shutter using dye-doped liquid crystals for a see-through display** [9769-39]
- 9769 15 **Observation of thermally induced movement of a beam deflected by a liquid crystal spatial light modulator** [9769-40]
- 9769 18 **Numerical modeling of polarization gratings by rigorous coupled wave analysis** [9769-44]
- 9769 19 **Dielectrophoretic manipulation of nematic and isotropic droplets** [9769-45]
- 9769 1A **Narrow band pass filter using birefringence film and quarter-wave film** [9769-46]

## Authors

Numbers in the index correspond to the last two digits of the six-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first four 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.

Alp, Baran, 0Y  
Bastiaansen, Cees W. M., 0Y  
Beeckman, Jeroen, 0P  
Boruah, Bosanta R., 15  
Braun, L., 12  
Čančula, Miha, 0B  
Cattaneo, Laura, 02  
Chen, Mu-Zhe, 0X  
Chigrinov, Vladimir, 0J  
Chu, Chao-Yu, 0F  
Chu, Wen-Chun, 0F  
Chung, Yueh-Feng, 0X  
Čopar, Simon, 0B  
Curri, Maria Lucia, 0C  
De Sio, Luciano, 0C  
Escuti, Michael J., 18  
Fukuda, Jun-ichi, 06  
Geng, Yong, 0U  
Hassanfiroozi, Amir, 0F  
Heo, Joon, 0W, 14  
Hsieh, Po-Yuan, 0F  
Hsuan, Yun, 0F  
Huang, Yi-Pai, 0F  
Huh, Jae-Won, 0W, 14  
Hyman, R., 12  
Jákli, A., 0D  
Javidi, Bahram, 0F  
Jeng, Shie-Chang, 0X  
Kikuchi, Hirotsugu, 06  
Kim, Chiwoo, 0L  
Kim, Hwi, 04  
Kim, Hyungjin, 0L  
Kim, Jiyeon, 0L  
Kim, K. H., 0T  
Kim, Se-Um, 0L  
Kim, Y. S., 0T  
Kimel, Alexey, 02  
Kolosova, V., 12  
Konwar, Santanu, 15  
Labardi, M., 0T  
Lagerwall, Jan Peter Felix, 0Q, 0T, 0U  
Lavrentovich, O. D., 0D  
Lee, Bomi, 19  
Lee, Byoung-ho, 04  
Lee, Dong-kun, 1A  
Lee, Seung-Yeol, 04  
Lee, Sin-Doo, 0L  
Lorenz, A., 12  
Martinez, Manuel, 0F  
Moirangthem, Monali, 0Y  
Mur, Urban, 0B  
Mušević, Igor, 02  
Neyts, Kristiaan, 0P  
Noh, JungHyun, 0U  
Okumura, Yasushi, 06  
Palermo, Giovanna, 0C  
Park, J. H., 0T  
Park, Y. W., 0T  
Pezzi, Luigia, 0C  
Placido, Tiziana, 0C  
Rasing, Theo, 02  
Ravnik, Miha, 0B  
Savoini, Matteo, 02  
Scalia, Giusy, 0Q, 0T  
Schenning, Albertus P. H. J., 0Y  
Shimizu, Y., 0T  
Song, Jang-Kun, 19, 1A  
Sosa-Vargas, L., 0T  
Štimulak, Mitja, 0B  
Stumpel, Jelle E., 0Y  
Tabiryan, Nelson, 0C  
Takanishi, Y., 0T  
Teunissen, Pit, 0Y  
Umeton, Cesare, 0C  
Urbanski, Martin, 0Q  
Veltri, Alessandro, 0C  
Vitek, Maruša, 02  
Wilkinson, T. D., 12  
Willekens, Oliver, 0P  
Xiang, Xiao, 18  
Yamamoto, J., 0T  
Yang, Sheng-Hsiung, 0X  
Yoon, Tae-Hoon, 0W, 14  
Yu, Byeong-Hun, 0W, 14  
Yun, Hansik, 04  
Zhang, C., 0D  
Žumer, Slobodan, 0B



# Conference Committee

## *Symposium Chairs*

**Jean-Emmanuel Broquin**, IMEP-LAHC (France)  
**Shibin Jiang**, AdValue Photonics, Inc. (United States)

## *Symposium Co-chairs*

**David L. Andrews**, University of East Anglia (United Kingdom)  
**Alexei L. Glebov**, OptiGrate Corporation (United States)

## *Program Track Chair and Conference Chair*

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

## *Conference Co-chairs*

**Dick J. Broer**, Technische Universiteit Eindhoven (Netherlands)  
**Hirotsugu Kikuchi**, Kyushu University (Japan)  
**Nelson V. Tabiryan**, BEAM Engineering for Advanced Measurements  
Company (United States)

## *Conference Program Committee*

**Vladimir G. Chigrinov**, Hong Kong University of Science and  
Technology (Hong Kong, China)  
**Harry J. Coles**, University of Cambridge (United Kingdom)  
**Antonio M. Figueiredo Neto**, Universidade de São Paulo (Brazil)  
**Andy Y. G. Fuh**, National Cheng Kung University (Taiwan)  
**Heinz S. Kitzrow**, Universität Paderborn (Germany)  
**Jan P. Lagerwall**, Université du Luxembourg (Luxembourg)  
**Yi-Hsin Lin**, National Chiao Tung University (Taiwan)  
**Kristiaan Neyts**, Universiteit Gent (Belgium)  
**Masanori Ozaki**, Osaka University (Japan)  
**Ci-Ling Pan**, National Tsing Hua University (Taiwan)  
**Miha Ravnik**, University of Ljubljana (Slovenia)  
**Ivan I. Smalyukh**, University of Colorado at Boulder (United States)  
**Timothy J. White**, Air Force Research Laboratory (United States)  
**Ming Hsien Wu**, Hamamatsu Corporation (United States)  
**Shin-Tson Wu**, CREOL, The College of Optics and Photonics, University  
of Central Florida (United States)  
**Huai Yang**, Peking University (China)  
**Tae-Hoon Yoon**, Pusan National University (Korea, Republic of)  
**Yanlei Yu**, Fudan University (China)

### Session Chairs

- 1 Optical Control and Modulation  
**Nelson V. Tabiryan**, BEAM Engineering For Advanced Measurements Company (United States)  
**Antonio M. Figueiredo Neto**, Universidade de São Paulo (Brazil)
- 2 Blue Phases and Applications  
**Dirk J. Broer**, Technische Universit t Eindhoven (Netherlands)  
**Jan P. F. Lagerwall**, Universit  du Luxembourg (Luxembourg)
- 3 Optical Manipulation and Imaging  
**Etienne Brasselet**, Universit  Bordeaux 1 (France)  
**Masanori Ozaki**, Osaka University (Japan)
- 4 Lenses and Spatial Light Modulators  
**Vladimir G. Chigrinov**, Hong Kong University of Science and Technology (Hong Kong, China)  
**Slobodan Žumer**, University of Ljubljana (Slovenia)
- 5 Photo-Alignment and Photo-active Materials  
**Igor Muševic**, Jožef Stefan Institute (Slovenia)  
**Ivan I. Smalyukh**, University of Colorado at Boulder (United States)
- 6 Electro-Optical Processes  
**Tae-Hoon Yoon**, Pusan National University (Korea, Republic of)  
**Yi-Hsin Lin**, National Chiao Tung University (Taiwan)
- 7 Novel Photonic Materials I  
**Yan-Qing Lu**, Nanjing University (China)  
**Jun-ichi Fukuda**, National Institute of Advanced Industrial Science and Technology (Japan)
- 8 Novel Photonic Materials II  
**Timothy J. White**, Air Force Research Laboratory (United States)  
**Giusy Scalia**, Universit  du Luxembourg (Luxembourg)

## Introduction

The Emerging Liquid Crystal Technologies (ELCT) conference at Photonics West was started in 2005. It evolved from the conference on Liquid Crystal Materials, Devices and Applications conference of SPIE. The ELCT conference is now firmly established as one of the key conference focusing on liquid crystal materials, devices, and applications.

The 2016 conference on Emerging Liquid Crystal Technologies XI (ELCT-XI) provided a forum for academic and industrial scientists and engineers to present high-impact scientific and technological research on recent advances in materials, devices, and applications. Numerous emerging topics on liquid crystal science and technology have taken advantage of unique anisotropic properties of liquid crystal materials to significantly improve the performance of existing devices or create new devices.

The topics of ELCT-XI included: Optical Control and Modulations, Blue Phase and Applications, Optical Manipulation and Imaging, Lenses and Spatial Light Modulators, Photo-Alignment and Photo-active Materials, Electro-Optical Processes, and Novel Photonic Materials. The conference featured keynote, invited, topical oral, and poster papers.

We hope you had stimulating and enjoyable experiences at Emerging Liquid Crystal Technologies XI at Photonics West 2016 in San Francisco, California!

**Liang-Chy Chien**  
**Dick J. Broer**  
**Hirotsugu Kikuchi**  
**Nelson V. Tabiryan**

