PROCEEDINGS OF SPIE

Emerging Liquid Crystal Technologies V

Liang-Chy Chien *Editor*

25–27 January 2010 San Francisco, California, United States

Sponsored and Published by SPIE

Volume 7618

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 *Emerging Liquid Crystal Technologies V*, edited by Liang-Chy Chien, Proceedings of SPIE Vol. 7618 (SPIE, Bellingham, WA, 2010) Article CID Number.

ISSN 0277-786X ISBN 9780819480149

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 © 2010, 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/10/\$18.00.

Printed in the United States of America.

 $\hbox{Publication of record for individual papers is online in the SPIE Digital Library.}$



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 ix	Conference Committee Introduction				
SESSION 1	EMISSIVE, HEADMOUNT AND PROJECTION DISPLAYS				
7618 03	Design of a free-form single-element head-worn display [7618-02] O. Cakmakci, K. Thompson, Optical Research Associates (United States); P. Vallee, J. Cote, Hedzopt Inc. (Canada); J. P. Rolland, Univ. of Rochester (United States)				
7618 04	Next-generation head-mounted display [7618-03] J. P. McGuire, Jr., Optical Research Associates (United States)				
7618 05	High power high bandwidth laser diode driver for next generation laser projectors [7618-04] A. Streck, W. Stork, Karlsruhe Institute of Technology (Germany); A. Wagner, Elovis GmbH (Germany)				
SESSION 2	3D DISPLAYS				
7618 06	Overview of 3D/2D switchable liquid crystal display technologies (Invited Paper) [7618-05] B. Lee, Seoul National Univ. (Korea, Republic of); JH. Park, Chungbuk National Univ. (Korea, Republic of)				
7618 07	Static 3D image space [7618-06] B. Koudsi, J. J. Sluss, Jr., The Univ. of Oklahoma (United States)				
7618 09	Resolution analysis of Fourier hologram using integral imaging and its enhancement [7618-09] N. Chen, JH. Park, N. Kim, Chungbuk National Univ. (Korea, Republic of)				
7618 0A	A new method for laser speckle suppression [7618-10] M. Tilleman, Elbit Systems of America LLC (United States)				
7618 OB	An artifact-metrics which utilizes laser speckle patterns for plastic ID card surface [7618-11] M. Yamakoshi, National Printing Bureau (Japan) and California Polytechnic State Univ. (United States); X. Rong, California Polytechnic State Univ. (United States); T. Matsumoto, Yokohama National Univ. (Japan)				
SESSION 3	NONLINEAR OPTICS AND LASING				
7618 OE	Liquid crystal waveguides: new devices enabled by >1000 waves of optical phase control (Invited Paper) [7618-47] S. R. Davis, G. Farca, S. D. Rommel, S. Johnson, M. H. Anderson, Vescent Photonics Inc. (United States)				

SESSION 4	NANOPARTICLES SELF-ASSEMBLY, DISPERSION AND MANIPULATION					
7618 OF	Quantum dot self-assembly in liquid crystal media (Invited Paper) [7618-15] L. S. Hirst, Univ. of California, Merced (United States); J. Kirchhoff, Univ. of California, Merced (United States) and Florida State Univ. (United States); R. Inman, S. Ghosh, Univ. of California, Merced (United States)					
SESSION 5	SPATIAL LIGHT MODULATORS					
7618 OJ	30 to 50 ns liquid-crystal optical switches (Invited Paper) [7618-19] M. W. Geis, R. J. Molnar, G. W. Turner, T. M. Lyszczarz, MIT Lincoln Lab. (United States); R. M. Osgood, B. R. Kimball, Natick Lab. Army Research, Development, and Engineering Ctr. (United States)					
7618 OK	Electroactive super elongation of carbon nanotube clusters in liquid crystal medium and its display application (Invited Paper) [7618-23] S. H. Lee, B. G. Kang, D. W. Kwon, Y. J. Lim, Chonbuk National Univ. (Korea, Republic of); K. Lee, Y. H. Lee, Sungkyunkwan Univ. (Korea, Republic of); M. Yun, Univ. of Pittsburgh (United States)					
SESSION 6	BIO-ACTIVE, BIO-INSPIRED MATERIALS AND APPLICATIONS					
7618 OL	Nonequilibrium fluctuations in metaphase spindles: polarized light microscopy, image registration, and correlation functions (Invited Paper) [7618-20] J. Brugués, D. J. Needleman, Harvard Univ. (United States)					
SESSION 7	NEW MATERIALS AND SUBSTRATES					
7618 0Q	Plastic substrate technologies for flexible displays (Invited Paper) [7618-26] T. Hanada, Teijin Ltd. (Japan); I. Shiroishi, Teijin Chemical Ltd. (Japan); T. Negishi, T. Shiro, Teijin Ltd. (Japan)					
7618 OS	Micro-actuators prepared from liquid crystalline elastomers in a microfluidic setup (Invited Paper) [7618-28] C. Ohm, Univ. Mainz (Germany); C. Serra, Lab. d'Ingénierie des Polymères pour les Hautes Technologies, CNRS, Univ. de Strasbourg (France); R. Zentel, Univ. Mainz (Germany)					
SESSION 8	POLYMER-STABILIZED LCDs					
7618 OU	Polymer-networked liquid crystal cell for omni-directional viewing-angle switching (Invited Paper) [7618-30] TH. Yoon, JI. Baek, KH. Kim, J. C. Kim, Pusan National Univ. (Korea, Republic of)					
7618 OV	Liquid crystal-directed polymer nanostructure for vertically aligned nematic cells [7618-31] V. Borshch, JY. Hwang, LC. Chien, Kent State Univ. (United States)					

SESSION 9	DYE-DOPED DEVICES				
7618 OW	Guest-host liquid crystal devices for adaptive window application (Invited Paper) [7618-8. Taheri, T. Kosa, V. Bodnar, L. Sukhomlinova, L. Su, C. Martincic, J. Chonko, EY. Park, AlphaMicron, Inc. (United States)				
7618 OY	Band-tunable color cone lasing emission based on a dye-doped cholesteric liquid crystofilm (Invited Paper) [7618-14] CR. Lee, SH. Lin, National Cheng Kung Univ. (Taiwan); HC. Yeh, National Kaohsiung Fir Univ. of Science and Technology (Taiwan); TD. Ji, JH. Liu, National Cheng Kung Univ. (Taiwan); PC. Yang, Chaoyang Univ. of Technology (Taiwan); TS. Mo, Kun Shan Univ. of Technology (Taiwan); SY. Huang, Chung Shan Medical Univ. (Taiwan); CT. Kuo, National Sun Yat-Sen Univ. (Taiwan); KY. Lo, National Chia Yi Univ. (Taiwan); A. YG. Fuh, National Cheng Kung Univ. (Taiwan)				
7618 OZ	Reflective display based on biphotonic effect-induced phase transition in dye-doped cholesteric liquid crystals [7618-34] A. YG. Fuh, SY. Huang, YS. Chen, HC. Jau, MS. Li, JH. Liu, National Cheng Kung Univ. (Taiwan); PC. Yang, Chaoyang Univ. of Technology (Taiwan)				
SESSION 10	HOLOGRAPHY AND HOLOGRAPHICALLY FORMED PDLCs				
7618 11	The dynamics of human sperm droplets on a liquid crystal and polymer composite film [7618-36] F. Lu, Ton Yen General Hospital (Taiwan); YH. Lin, National Chiao Tung Univ. (Taiwan); WC. Tsai, Ton Yen General Hospital (Taiwan); JJ. Li, TY. Chu, National Chiao Tung Univ. (Taiwan); HK. Hsu, WY. Li, Chi-Mei Optoelectronics Corp. (Taiwan)				
7618 12	Evaluations of liquid crystal panel as a random phase modulator for optical encryption systems based on the double random phase encoding [7618-37] Y. Harada, S. Fukuyama, Kitami Institute of Technology (Japan)				
7618 13	Electrical tuning of two-dimensional honeycomb photonic lattices using holographic polymer dispersed liquid crystals [7618-38] R. Ohira, M. Miki, Y. Tomita, Univ. of Electro-Communications (Japan)				
7618 14	Ultrafast switching liquid crystals for next-generation transmissive and reflective displays (Invited Paper) [7618-39] H. J. Coles, S. M. Morris, S. S. Choi, F. Castles, Univ. of Cambridge (United Kingdom)				
7618 15	High quality assembly of liquid crystal on silicon (LCOS) devices for phase-only holography [7618-46] Z. Zhang, A. M. Jeziorska-Chapman, N. Collings, M. Pivnenko, J. Moore, W. I. Milne, W. A. Crossland, D. P. Chu, Univ. of Cambridge (United Kingdom)				

POSTER SESSION

- 7618 16 Smart windows with functions of reflective display and indoor temperature-control [7618-40] I.-H. Lee, Y.-C. Chao, C.-C. Hsu, L.-C. Chang, Taipei Municipal Lishan High School (Taiwan); T.-L. Chiu, Yuan Ze Univ. (Taiwan); J.-Y. Lee, National Taiwan Univ. of Science and Technology (Taiwan); F.-J. Kao, National Yang-Ming Univ. (Taiwan); C.-K. Lee, J.-H. Lee, National Taiwan Univ. (Taiwan)
- 7618 18 Super-bright and short-lived photoluminescence of textured Zn₂SiO₄:Mn²⁺ phosphor film on **quartz glass** [7618-43] J. Park, K. Park, J. Lee, Pukyong National Univ. (Korea, Republic of); J. Kim, Pukyong National Univ. (Korea, Republic of) and The Univ. of Alabama (United States); K. Seo, K. Kwon, MUJIN Co. (Korea, Republic of); P. Kung, S. M. Kim, The Univ. of Alabama (United States)
- 7618 19 A metal-dielectric thin film with broadband absorption [7618-44] S.-H. Cho, J.-H. Kang, M.-K. Seo, J.-K. Yang, S.-Y. Kang, Y.-H. Lee, Korea Advanced Institute of Science and Technology (Korea, Republic of)
- 7618 1A Multi-domain liquid crystal alignment based on periodical polyimide micro-bars fabricated by inkjet printing [7618-45]

J.-Y. Hwang, L.-C. Chien, Kent State Univ. (United States)

Author Index

Conference Committee

Symposium Chair

E. Fred Schubert, Rensselaer Polytechnic Institute (United States)

Symposium Cochairs

Liang-Chy Chien, Kent State University (United States) **James G. Grote**, Air Force Research Laboratory (United States)

Program Track Chair

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

Conference Chair

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

Program Committee

Dirk J. Broer, Philips Research Nederland B.V. (Netherlands) Vladimir G. Chigrinov, Hong Kong University of Science and Technology (Hong Kong, China) Harry J. Coles, University of Cambridge (United Kingdom) **Gregory P. Crawford**, University of Notre Dame (United States) Andy Y. Fuh, National Cheng Kung University (Taiwan) Otto W. Haase, Technische Universität Darmstadt (Germany) Jun-ichi Hanna, Tokyo Institute of Technology (Japan) **Heinz-Siegfried Kitzerow**, Universität Paderborn (Germany) **Shunsuke Kobayashi**, Tokyo University of Science (Japan) Seung Hee Lee, Chonbuk National University (Korea, Republic of) Akihiro Mochizuki, Nano Loa, Inc. (United States) Ci-Ling Pan, National Chiao Tung University (Taiwan) Ryo Sakurai, Bridgestone Corporation (Japan) **Richard Sutherland**, SAIC (United States) Shin-Tson Wu, The College of Optics and Photonics, University of Central Florida (United States) Hiroshi Yokoyama, Kent State University (United States)

Session Chairs

Emissive, Headmount and Projection Displays
 Byoungho Lee, Seoul National University (Korea, Republic of)

- 2 3D Displays Tae-Hoon Yoon, Pusan National University (Korea, Republic of)
- Nonlinear Optics and LasingMasanori Ozaki, Osaka University (Japan)
- 4 Nanoparticles Self-Assembly, Dispersion and Manipulation **Yuen-Ron Shen**, University of California, Berkeley (United States)
- 5 Spatial Light Modulators
 Sin-Doo Lee, Seoul National University (Korea, Republic of)
- Bio-Active, Bio-Inspired Materials and Applications
 Linda S. Hirst, University of California, Merced (United States)
- 7 New Materials and Substrates Junji Watanabe, Tokyo Institute of Technology (Japan) Liang-Chy Chien, Kent State University (United States)
- 8 Polymer-Stabilized LCDsHiroshi Yokoyama, Kent State University (United States)
- 9 Dye-Doped Devices Ivan I. Smalyukh, University of Colorado at Boulder (United States)
- Holography and Holographically-Formed PDLCsAndy Y. Fuh, National Cheng Kung University (Taiwan)

Introduction

The 2010 SPIE Photonics West conference on Emerging Liquid Crystal Technologies V addresses current issues in liquid crystal materials, displays, devices and applications. The scope of the conference is extremely broad, especially with a featured plenary presentation on resonantly pumped optical Kerr nonlinearity and many frontier topics including the nanoparticles self-assembly, dispersion and manipulation, spatial light modulators, bio-active, bio-inspired materials and applications, new materials and substrates, polymer-stabilized liquid crystal displays, dye-doped devices, and holography and holographically formed polymer-dispersed liquid crystals. Furthermore, the cutting-edge works of liquid crystal in photonic systems such as emissive, headmount and projection displays, 3D displays, nonlinear optics and lasing represent the unique feature of the conference.

This conference provides a platform for leading principle investigators to present unpublished or the latest important results in a broad spectrum and enlightening discussion and idea exchange on the issues still in debate. The conference is particularly programmed and scheduled with ample time for presentation and discussion as well as poster presentations. Invited speakers representing both academia and industry come from a wide range of disciplines including, materials science, chemistry, physics and engineering. In addition, the group of participants also includes a good number of contributed oral presentations and poster papers which fosters the excitement of brain storming.

Liang-Chy Chien