

PROCEEDINGS OF SPIE

# ***Practical Holography XXVII: Materials and Applications***

**Hans I. Bjelkhagen  
V. Michael Bove, Jr.**  
*Editors*

**3–4 February 2013  
San Francisco, California, United States**

*Sponsored and Published by*  
SPIE

**Volume 8644**

Proceedings of SPIE 0277-786X, V.8644

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

Practical Holography XXVII: Materials and Applications, edited by Hans I. Bjelkhagen, V. Michael Bove, Jr.,  
Proc. of SPIE Vol. 8644, 864401 · © 2013 SPIE · CCC code: 0277-786X/13/\$18 · doi: 10.1117/12.2022361

Proc. of SPIE Vol. 8644 864401-1

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 *Practical Holography XXVII: Materials and Applications*, edited by Hans I. Bjelkhagen, V. Michael Bove Jr., Proceedings of SPIE Vol. 8644 (SPIE, Bellingham, WA, 2013) Article CID Number.

ISSN: 0277-786X

ISBN: 9780819494139

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 © 2013, 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/13/\$18.00.

Printed in the United States of America.

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



[SPIDigitalLibrary.org](http://SPIDigitalLibrary.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 as 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

- ix *Conference Committee*
- xi *Introduction*
- xiii *Group IV photonics for the mid infrared (Plenary Paper) [8629-1]*  
*R. Soref, The Univ. of Massachusetts at Boston (United States)*
- xxix *Light in a twist: optical angular momentum (Plenary Paper) [8637-2]*  
*M. J. Padgett, Univ. of Glasgow (United Kingdom)*

---

## SESSION 1 MATERIALS AND PROCESSES I

---

- 8644 02 **Non-Bragg diffraction orders in holographic recording and its application to one-shot phase-shifting holographic interferometry [8644-1]**  
P. P. Banerjee, G. Nehmetallah, U. Abeywickrema, Univ. of Dayton (United States);  
S. F. Lyuksyutov, Univ. of Akron (United States); N. Kukhtarev, Alabama A&M Univ. (United States)
- 8644 04 **Three dimensional (3D) parallel processing holographic lithography using femtosecond laser pulse [8644-3]**  
A. Fauzi, S.-J. Kim, Chungbuk National Univ. (Korea, Republic of); J.-R. Jung, Suwon Science College (Korea, Republic of); S.-H. Jeon, Univ. of Incheon (Korea, Republic of);  
N. Kim, Chungbuk National Univ. (Korea, Republic of)
- 8644 05 **Versatile phase stabilization technique for holographic recording of large aperture volume Bragg gratings [8644-4]**  
D. B. Ott, I. B. Divliansky, M. A. SeGall, L. B. Glebov, CREOL, The College of Optical Sciences, Univ. of Central Florida (United States)

---

## SESSION 2 MATERIALS AND PROCESSES II

---

- 8644 06 **Collimating beam shaper for holography and interferometry [8644-5]**  
A. Laskin, V. Laskin, AdlOptica Optical Systems GmbH (Germany)
- 8644 07 **One-step 3D full-colour and achromatic transmission holograms digitally printed using a 440nm pulsed laser for embossed applications [8644-7]**  
S. Zacharovas, A. Nikolskij, Geola Digital uab (Lithuania); R. Bakanas, Geola Digital uab (Lithuania) and Kaunas Univ. of Technology (Lithuania); D. Brotherton-Ratcliffe, Geola Technologies Ltd. (United Kingdom)
- 8644 08 **The effect of aberrated recording beams on reflecting Bragg gratings [8644-8]**  
M. SeGall, D. Ott, I. Divliansky, L. B. Glebov, CREOL, The College of Optical Sciences, Univ. of Central Florida (United States)

---

**SESSION 3 DIGITAL HOLOGRAPHY I**

---

- 8644 09 **Development of full-color full-parallax digital 3D holographic display system and its prospects (Invited Paper)** [8644-9]  
X. Xu, X. Liang, Y. Pan, R. Zheng, Z. A. Lum, P. P. Mar Yi Lwin, S. Solanki, A\*STAR-Data Storage Institute (Singapore)
- 8644 0A **Study of a holographic TV system based on multi-view images and depth maps** [8644-10]  
T. Senoh, Y. Ichihashi, R. Oi, H. Sasaki, K. Yamamoto, National Institute of Information and Communications Technology (Japan)
- 8644 0B **Real-time reconstruction of digital holograms with GPU** [8644-11]  
M. Dođar, H. A. İlhan, M. Özcan, Sabanci Univ. (Turkey)
- 8644 0C **Autofocusing in digital holography** [8644-12]  
H. A. İlhan, M. Dođar, M. Özcan, Sabanci Univ. (Turkey)

---

**SESSION 4 DIGITAL HOLOGRAPHY II**

---

- 8644 0D **Realistic 3D image reconstruction in CGH with Fourier transform optical system** [8644-13]  
T. Ichikawa, Hokkaido Univ. (Japan); K. Yamaguchi, Tokyo Univ. of Science (Japan); Y. Sakamoto, Hokkaido Univ. (Japan)
- 8644 0E **Using electronic holography to generate speckle-free and shaded reconstructed images** [8644-14]  
T. Kurihara, Y. Takaki, Tokyo Univ. of Agriculture and Technology (Japan)
- 8644 0F **Large-pixel-count hologram data processing for holographic 3D display** [8644-15]  
Y. Pan, X. Xu, X. Liang, Z. A. Lum, R. Zheng, P. P. Mar Yi Lwin, A\*STAR-Data Storage Institute (Singapore)
- 8644 0G **Calculation technique for a holographic stereogram generation from multi-view images** [8644-16]  
K. Ikeda, Y. Takaki, Tokyo Univ. of Agriculture and Technology (Japan)
- 8644 0H **Progress in updatable photorefractive polymer-based holographic displays via direct optical writing of computer-generated fringe patterns** [8644-17]  
S. Jolly, J. Barabas, D. Smalley, V. M. Bove Jr., MIT Media Lab. (United States)

---

**SESSION 5 APPLICATIONS I**

---

- 8644 0I **Holofos: an optimized LED illumination system for color reflection holograms display** [8644-19]  
A. Sarakinos, N. Zervos, A. Lembessis, Hellenic Institute of Holography (Greece)

- 8644 OJ **Quantitative phase noise in a two-color low coherence digital holographic microscope** [8644-20]  
Z. Monemhaghdoost, Ecole Polytechnique Fédérale de Lausanne (Switzerland);  
F. Montfort, Ecole Polytechnique Fédérale de Lausanne (Switzerland) and Lyncée Tec SA  
(Switzerland); Y. Emery, Lyncée Tec SA (Switzerland); C. Depeursinge, Lyncée Tec SA  
(Switzerland) and Ecole Polytechnique Fédérale de Lausanne (Switzerland); C. Moser,  
Ecole Polytechnique Fédérale de Lausanne (Switzerland)
- 8644 OK **Holographic elements and holographic techniques used in photonics** [8644-21]  
G. L. Heidt, D. Speer, Wasatch Photonics, Inc. (United States)

---

**SESSION 6 APPLICATIONS II**

---

- 8644 OL **Color holography: recent improvements and applications (Invited Paper)** [8644-18]  
H. I. Bjelkhagen, Hansholo Consulting Ltd. (United Kingdom)
- 8644 OM **A real-space interactive holographic display based on a large-aperture HOE** [8644-46]  
J. Khan, Holoxica Ltd. (United Kingdom) and Heriot-Watt Univ. (United Kingdom);  
C. Can, Holoxica Ltd. (United Kingdom); A. Greenaway, Heriot-Watt Univ. (United  
Kingdom); I. Underwood, The Univ. of Edinburgh (United Kingdom)

---

**SESSION 7 HOLOGRAPHY, PERCEPTION AND ART**

---

- 8644 OQ **Assembling a holographic scene** [8644-45]  
M. Mrongovius, Ctr. for the Holographic Arts (United States) and Academy of Media Arts  
(Germany)
- 8644 OR **The hologram as a space of illusion** [8644-27]  
R. M. Oliveira, Univ. of Aveiro (Portugal)
- 8644 OS **Time cognition: inside and outside the holographic space** [8644-28]  
I. Azevedo, Univ. School of Arts of Coimbra (Portugal), Univ. of Porto (Portugal), and  
De Montfort Univ. (United Kingdom); M. Richardson, De Montfort Univ. (United Kingdom);  
L. M. Bernardo, Univ. of Porto (Portugal)

---

**POSTER SESSION**

---

- 8644 OW **Short-wave boundary of applicability of relief-phase reflecting holograms on a thin film of a chalcogenide glassy semiconductor** [8644-31]  
S. N. Koreshev, National Research Univ. of Information Technologies, Mechanics and  
Optics (Russian Federation); V. P. Ratushnyi, HoloGrate, JSC (Russian Federation)
- 8644 OX **Direct fringe printer for computer-generated holograms: improvement of printing speed**  
[8644-32]  
H. Yoshikawa, T. Yamaguchi, S. Kajiro, Nihon Univ. (Japan)

- 8644 0Y **Hologram recording method for 1 Tbit/in<sup>2</sup>** [8644-33]  
S. Ozawa, K. Okubo, H. Kurata, T. Yamada, S. Yoshida, M. Yamamoto, Tokyo Univ. of Science (Japan)
- 8644 0Z **The design of ROM-type holographic memory with iterative Fourier transform algorithm** [8644-34]  
H. Akamatsu, K. Yamada, N. Unno, S. Yoshida, J. Taniguchi, M. Yamamoto, Tokyo Univ. of Science (Japan)
- 8644 10 **Spatial frequency study of holograms with albumins material** [8644-35]  
M. J. Ordóñez-Padilla, A. Olivares-Pérez, L. R. Berriel-Valdos, Instituto Nacional de Astrofísica, Óptica y Electrónica (Mexico)
- 8644 11 **Spatial frequency behavior of holograms made with pectin and oxidizing agents** [8644-36]  
M. J. Ordóñez-Padilla, A. Olivares-Pérez, Instituto Nacional de Astrofísica, Óptica y Electrónica (Mexico); N. Grijalva-Ortiz, Benemérita Univ. Autónoma de Puebla (Mexico); I. Fuentes-Tapia, Instituto Nacional de Astrofísica, Óptica y Electrónica (Mexico)
- 8644 12 **Measurement method for objective evaluation of reconstructed image quality in CGH** [8644-37]  
K. Suzuki, Y. Sakamoto, Hokkaido Univ. (Japan)
- 8644 13 **Eyepiece-type full-color electro-holographic display for binocular vision** [8644-38]  
T. Yoneyama, C. Yang, Y. Sakamoto, Hokkaido Univ. (Japan); F. Okuyama, Suzuka Univ. of Medical Science (Japan)
- 8644 14 **Compound common-path digital holographic microscope** [8644-39]  
W. Qu, Z. Wang, C. Y. Cheng, Ngee Ann Polytechnic (Singapore); A. Asundi, Nanyang Technological Univ. (Singapore)
- 8644 15 **Holographic diffraction gratings to measure micromovements** [8644-40]  
A. Olivares-Pérez, Instituto Nacional de Astrofísica, Óptica y Electrónica (Mexico); M. A. Lara-Peña, J. A. García-Monge, P. A. Valencia-Acuña, J. M. Villa-Hernández, Univ. de Sonora (Mexico); I. Fuentes-Tapia, Instituto Nacional de Astrofísica, Óptica y Electrónica (Mexico)
- 8644 16 **Acrylamide-adhesive as holographic recording medium** [8644-41]  
S. Toxqui-López, Benemérita Univ. Autónoma de Puebla (Mexico); A. Olivares-Pérez, I. Fuentes-Tapia, Instituto Nacional de Astrofísica, Óptica y Electrónica (Mexico)
- 8644 17 **An optical symmetric cryptographic system with simultaneous encryption and transmission of binary data and secret key by using dual phase-shifting digital holography** [8644-42]  
S. K. Gil, Univ. of Suwon (Korea, Republic of); S. H. Jeon, Univ. of Incheon (Korea, Republic of); J. R. Jung, Suwon Science College (Korea, Republic of)
- 8644 18 **Fast generation of video hologram patterns by use of motion vectors of three-dimensional objects** [8644-43]  
X. -B. Dong, H.-M. Choi, M.-W. Kwon, S.-C. Kim, E.-S. Kim, Kwangwoon Univ. (Korea, Republic of)

- 8644 19 **Holographic optical element for head-mounted display application using photopolymer**  
[8644-44]  
J. A. Piao, M.-L. Piao, Chungbuk National Univ. (Korea, Republic of); E.-S. Kim, EunSung  
Display Co., Ltd (Korea, Republic of); N. Kim, Chungbuk National Univ. (Korea, Republic of)

*Author Index*



# Conference Committee

## *Symposium Chair*

**David L. Andrews**, University of East Anglia Norwich (United Kingdom)

## *Symposium Cochairs*

**Alexei L. Glebov**, OptiGrate Corporation (United States)  
**Klaus P. Streubel**, OSRAM GmbH (Germany)

## *Program Track Chair*

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

## *Conference Chairs*

**Hans I. Bjelkhagen**, Glyndŵr University (United Kingdom) and  
Hansholo Consulting Ltd. (United Kingdom)  
**V. Michael Bove, Jr.**, MIT Media Laboratory (United States)

## *Conference Program Committee*

**Frank C. Fan**, Shenzhen AFC Technology Company, Ltd. (China)  
**Gerald L. Heidt**, Wasatch Photonics, Inc. (United States)  
**Toshio Honda**, Toppan Printing Company, Ltd. (Japan)  
**Fujio Iwata**, Toppan Printing Company, Ltd. (Japan)  
**Tung H. Jeong**, Lake Forest College (United States)  
**Michael A. Klug**, Zebra Imaging, Inc. (United States)  
**Martina L. Mrongovius**, RMIT University (Australia), Center for the  
Holographic Arts (United States), and Academy of Media Arts,  
Cologne KHM (Germany)  
**Martin J. Richardson**, De Montfort University (United Kingdom)  
**Hiroshi Yoshikawa**, Nihon University (Japan)

## *Session Chairs*

- 1 Materials and Processes I  
**Hans I. Bjelkhagen**, Glyndŵr University (United Kingdom) and  
Hansholo Consulting Ltd. (United Kingdom)
- 2 Materials and Processes II  
**Hans I. Bjelkhagen**, Glyndŵr University (United Kingdom) and  
Hansholo Consulting Ltd. (United Kingdom)

- 3 Digital Holography I  
**V. Michael Bove, Jr.**, MIT Media Laboratory (United States)
- 4 Digital Holography II  
**V. Michael Bove, Jr.**, MIT Media Laboratory (United States)
- 5 Applications I  
**Hiroshi Yoshikawa**, Nihon University (Japan)
- 6 Applications II  
**Gerald L. Heidt**, Wasatch Photonics, Inc. (United States)
- 7 Holography, Perception and Art  
**Martina L. Mrongovius**, RMIT University (Australia), Center for the Holographic Arts (United States), and Academy of Media Arts, Cologne KHM (Germany)

## Introduction

The SPIE Practical Holography Conference, which takes place every year in late January or early February, is an important international event in the field of holographic applications and recording materials. This year marks the twenty-seventh meeting of the Practical Holography conference which is part of the Photonics West event. The conference provides a venue for all aspects of holography: art, display, metrology, scientific, security, storage, materials and processes, CGHs and HOEs. The conference also brings together participants from all over the world. In addition, an evening Holography Technical Meeting focuses on new developments, applications, holography events, and demonstrations.

This year's conference (as always) featured long-time participants and new members of the Practical Holography community sharing many novel and interesting contributions in various holographic fields during two days of oral presentations and a poster session. The oral presentations divided into seven sessions on four main topics: materials and processes, digital holography, applications, and perception and art. The materials and processes papers show the continued innovations in ways of capturing and reproducing holograms, while digital holography presentations show the increasing maturity of methods for real-time acquisition and display of dynamic holographic imagery. Artistic and communicative uses of holography have always been an important part of this event and the chairs are pleased to see the continuation of this tradition. As always, holography is finding its place in yet more applications, and new methods are being developed in support of the needs of the expanded application domains.

The conference chairs would like to thank the authors (both those new to this conference and returning authors) as well as the session chairs and the program committee members for their contributions to this conference. We look forward to seeing you again in San Francisco, in February 2014. And we invite those readers of this volume who have not previously taken part to consider joining us.

**Hans I. Bjelkhagen**  
**V. Michael Bove, Jr.**