

PROCEEDINGS OF SPIE

High Contrast Metastructures IV

Connie J. Chang-Hasnain
David Fattal
Fumio Koyama
Weimin Zhou
Editors

11–12 February 2015
San Francisco, California, United States

Sponsored and Published by
SPIE

Volume 9372

Proceedings of SPIE 0277-786X, V. 9372

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

High Contrast Metastructures IV, edited by Connie J. Chang-Hasnain, David Fattal,
Fumio Koyama, Weimin Zhou, Proc. of SPIE Vol. 9372, 937201 · © 2015 SPIE
CCC code: 0277-786X/15/\$18 · doi: 10.1117/12.2190557

Proc. of SPIE Vol. 9372 937201-1

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 *High Contrast Metastructures IV*, edited by Connie J. Chang-Hasnain, David Fattal, Fumio Koyama, Weimin Zhou, Proceedings of SPIE Vol. 9372 (SPIE, Bellingham, WA, 2015) Article CID Number.

ISSN: 0277-786X

ISBN: 9781628414622

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 © 2015, 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/15/\$18.00.

Printed in the United States of America.

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



SPIDigitalLibrary.org

Paper Numbering: Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print. Papers are published as they are submitted and meet publication criteria. A unique 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.

Contents

v *Authors*
vii *Conference Committee*

SESSION 1	HARNESSING LIGHT
9372 03	High index contrast integrated optics in the cylindrical coordinate (Invited Paper) [9372-2]
SESSION 2	VCSELS
9372 06	High-contrast grating reflectors for 980 nm vertical-cavity surface-emitting lasers (Invited Paper) [9372-5]
9372 07	Fabrication of SiC membrane HCG blue reflector using nanoimprint lithography [9372-6]
9372 08	Heterogeneously-integrated VCSEL using high-contrast grating on silicon [9372-7]
SESSION 3	RESONATORS
9372 09	Membrane-in-the-middle optomechanics with high-contrast gratings (Invited Paper) [9372-8]
9372 0C	Light emission characteristics of nonpolar a-plane GaN-based photonic crystal defect cavities (Invited Paper) [9372-11]
9372 0D	Air-suspended TiO₂-based HCG reflectors for visible spectral range [9372-12]
SESSION 4	NOVEL DEVICES
9372 0E	Virtually image phased array based on Bragg reflector waveguide for large-port optical switching (Invited Paper) [9372-13]
9372 0F	Bringing mirrors to rest: grating concepts for ultra-precise interferometry (Invited Paper) [9372-14]
9372 0G	Low-loss adiabatically-tapered high-contrast gratings for slow-wave modulators on SOI [9372-15]
9372 0H	Highly efficient polarization control using subwavelength high contrast transmitarrays [9372-16]

SESSION 5 METASTRUCTURES

- 9372 0J **Design and fabrication of 3D high-contrast metastructure THz cage waveguides** [9372-18]
- 9372 0K **Active coloration with flexible high contrast metastructures** [9372-19]

SESSION 6 ENGINEERING OF METASTRUCTURES

- 9372 0N **Parameter-tolerant design of high contrast gratings (Invited Paper)** [9372-22]
- 9372 0O **On-chip broadband spectral filtering using planar double high-contrast grating reflectors**
[9372-23]
- 9372 0P **Efficient high NA flat micro-lenses realized using high contrast transmitarrays** [9372-24]

SESSION 7 REFLECTORS AND RESONATORS

- 9372 0S **GaAs/AlOx high-contrast grating mirrors for mid-infrared VCSELs (Invited Paper)** [9372-27]
- 9372 0T **Antireflection subwavelength gratings on optical fiber tips fabricated by a dedicated UV nano imprint lithography system (Invited Paper)** [9372-28]
- 9372 0U **Integration of GaAs-based VCSEL array on SiN platform with HCG reflectors for WDM applications** [9372-29]
- 9372 0V **Perturbation model for the control of the spectral properties of high contrast gratings**
[9372-30]
- 9372 0W **Guided resonance reflective phase shifters** [9372-31]

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.

Almuneau, Guilhem, 0N, 0S
Arbabi, Amir, 0H, 0O, 0P, 0W
Baets, Roel, 0U
Bagheri, Mahmood, 0H, 0P
Ball, Alexander J., 0P
Ben Bakir, Badhise, 0G
Bengtsson, Jörgen, 0D, 0U
Benyattou, Taha, 0V
Blanchard, Cédric, 0V
Cai, Xinlun, 03
Carlsson, Stefan, 0D
Cerutti, Laurent, 0N, 0S
Chang-Hasnain, Connie J., 08, 0J, 0K
Chevallier, Christyves, 0N, 0S
Czyszanowski, T., 06
Dang, Gerard, 0J
Dems, M., 06
Duprez, Hélène, 0G
Faraon, Andrei, 0H, 0O, 0P, 0W
Ferrara, James, 08, 0K
Ferrotti, Thomas, 0G
Fressengeas, Nicolas, 0N, 0S
Gauthier-Lafaye, Olivier, 0N, 0S
Gebski, M., 06
Genty, Frédéric, 0N, 0S
Grillet, Christian, 0V
Gustavsson, Johan S., 0D, 0U
Haglund, Åsa, 0D, 0U
Haglund, Emanuel P., 0U
Haglund, Erik, 0U
Hane, Kazuhiro, 0T
Harduin, Julie, 0G
Hashemi, Ehsan, 0D
Hassan, Karim, 0G
Horie, Yu, 0H, 0O, 0P, 0W
Huang, Shyh-Jer, 0C
Jacquet, Joel, 0N
Jamois, Cécile, 0V
Kanamori, Yoshiaki, 0T
Kao, Tsung Sheng, 0C
Kapraun, Jonas, 0K
Kley, Ernst-Bernhard, 0F
Koyama, Fumio, 07, 0E
Kroker, Stefanie, 0F
Kumari, Sulakshna, 0U
Kuo, Hao-Chung, 0C
Kuzior, O., 06
Laaroussi, Youness, 0N, 0S
Lai, Ying-Yu, 07
Larsson, Anders, 0U
Lawall, John, 09
Le Thomas, Nicolas, 0U
Leclercq, Jean-Louis, 0V
Letartre, Xavier, 0V
Lin, Da-wei, 0C
Lin, Jyun-Hao, 0C
Lu, Tien-Chang, 07, 0C
Matsutani, Akihiro, 07
Menezo, Sylvie, 0G
Okochi, Masaaki, 0T
Pałka, N., 06
Qiao, Pengfei, 08
Roelkens, Gunther, 0U
Rossbach, Georg, 0D
Sanchez, Dorian, 0U
Sciancalepore, Corrado, 0G
Su, Yan-Kuin, 0C
Sun, Tianbo, 0J
Szerling, A., 06
Taysing-Lara, Monica, 0J
Tsao, Che-Wei, 0C
Tünnermann, Andreas, 0F
Viktorovitch, Pierre, 0V
Wang, Q. J., 06
Wang, Ruijun, 0U
Wang, Shing-Chung, 07, 0C
Wasiak, M., 06
Westbergh, Petter, 0U
Wójcik-Jedlińska, A., 06
Wu, Tzeng-Tsong, 0C
Xie, Y. Y., 06
Xu, Z. J., 06
Yang, Weijian, 08, 0J
Yu, Siyuan, 03
Zhang, D. H., 06
Zhang, Ning, 03
Zhou, Weimin, 0J
Zhu, Li, 08, 0K

Conference Committee

Symposium Chairs

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

Symposium Co-chairs

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

Program Track Chair

Ali Adibi, Georgia Institute of Technology (United States)

Conference Chairs

Connie J. Chang-Hasnain, University of California, Berkeley
(United States)
David Fattal, LEIA Inc. (United States)
Fumio Koyama, Tokyo Institute of Technology (Japan)
Weimin Zhou, U.S. Army Research Laboratory (United States)

Conference Program Committee

Markus-Christian Amann, Walter Schottky Institut (Germany)
Il-Sug Chung, Technical University of Denmark (Denmark)
Ernst-Bernhard Kley, Friedrich-Schiller-Universität Jena (Germany)
Philippe Lalanne, Institut d'Optique Graduate School (France)
John R. Lawall, National Institute of Standards and Technology
(United States)
Tien-Chang Lu, National Chiao Tung University (Taiwan)
Rainer F. Mahrt, IBM Research – Zürich (Switzerland)
Gunther Roelkens, Universiteit Gent (Belgium)
Pierre Viktorovitch, Ecole Centrale de Lyon (France)
Alan E. Willner, The University of Southern California (United States)
Ming C. Wu, University of California, Berkeley (United States)
Anshi Xu, Peking University (China)

Session Chairs

- 1 Harnessing Light
Fumio Koyama, Tokyo Institute of Technology (Japan)
- 2 VCSELS
Connie J. Chang-Hasnain, University of California, Berkeley
(United States)
- 3 Resonators
Siyuan Yu, University of Bristol (United Kingdom)
- 4 Novel Devices
Tien-Chang Lu, National Chiao Tung University (Taiwan)
- 5 Metastructures
John R. Lawall, National Institute of Standards and Technology
(United States)
- 6 Engineering of Metastructures
Andrea Fiore, Technische Universiteit Eindhoven (Netherlands)
- 7 Reflectors and Resonators
Werner H. Hofmann, Technische Universität Berlin (Germany)