PROCEEDINGS OF SPIE

SPIDigitalLibrary.org/conference-proceedings-of-spie

Front Matter: Volume 10113

, "Front Matter: Volume 10113," Proc. SPIE 10113, High Contrast
Metastructures VI, 1011301 (4 April 2017); doi: 10.1117/12.2276124

SPIE.

Event: SPIE OPTO, 2017, San Francisco, California, United States

PROCEEDINGS OF SPIE

High Contrast Metastructures VI

Connie J. Chang-Hasnain

Andrei Faraon

Fumio Koyama

Weimin Zhou

Editors

31 January–2 February 2017

San Francisco, California, United States

Sponsored and Published by
SPIE

Volume 10113

Proceedings of SPIE 0277-786X, V. 10113

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

High Contrast Metastructures VI, edited by Connie J. Chang-Hasnain, Andrei Faraon,
Fumio Koyama, Weimin Zhou, Proc. of SPIE Vol. 10113, 1011301 · © 2017 SPIE
CCC code: 0277-786X/17/\$18 · doi: 10.1117/12.2276124

Proc. of SPIE Vol. 10113 1011301-1

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 VI*, edited by Connie J. Chang-Hasnain, Andrei Faraon, Fumio Koyama, Weimin Zhou, Proceedings of SPIE Vol. 10113 (SPIE, Bellingham, WA, 2017) Seven-digit Article CID Number.

ISSN: 0277-786X

ISSN: 1996-756X (electronic)

ISBN: 9781510606678

ISBN: 9781510606685 (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 © 2017, 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/17/\$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

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 seven-digit CID article numbering system in which:

- 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. 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

Contents

v	<i>Authors</i>
vii	<i>Conference Committee</i>

HIGH CONTRAST METASTRUCTURE DEVICES

10113 06	Dielectric metasurface-based freeform optics (Invited Paper) [10113-5]
----------	---

HIGH CONTRAST GRATING MIRRORS AND VCSELS

10113 0B	Multi-wavelength VCSEL arrays using high-contrast gratings (Invited Paper) [10113-10]
10113 0C	Physical principles of monolithic high-contrast gratings [10113-11]
10113 0D	Sub-wavelength gratings for mid-infrared wavelength range around 10 microns [10113-12]
10113 0E	Optimization of VCSELS incorporating monolithic subwavelength high-refractive-index contrast surface grating mirrors [10113-13]

DIFFRACTIVE OPTICS BASED ON DIELECTRIC METASURFACES I

10113 0F	Metalenses at visible wavelengths: an historical fresco (Invited Paper) [10113-14]
----------	---

DIFFRACTIVE OPTICS BASED ON DIELECTRIC METASURFACES II

10113 0M	Robust design of microlenses arrays employing dielectric resonators metasurfaces [10113-21]
----------	--

DISPERSION AND NONLINEAR EFFECTS

10113 0O	Flat nonlinear optics: metasurfaces for efficient frequency mixing (Invited Paper) [10113-23]
----------	--

NEW METASTRUCTURE PHENOMENA

10113 0U	Scattering and skin depth at the meso- and nanoscale [10113-29]
----------	--

NEW APPLICATIONS FOR METASTRUCTURES

- 10113 0X **Controlling nanoscale optical transmission with dielectric metasurfaces at visible wavelengths (Invited Paper) [10113-33]**

TUNABLE METASTRUCTURE DEVICES

- 10113 15 **Optimization of high-contrast metastructure silicon waveguides for wavelength-tunable delay (Invited Paper) [10113-41]**

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.

Alu, Andrea, 0O	Zhou, Weimin, 15
Amann, Markus-Christian, 0O	
Anderson, Stephen, 15	
Bäumer, Stefan M. B., 0M	
Belkin, Mikhail A., 0O	
Bengtsson, Jörgen, 0B	
Bishop, Wells, 0O	
Boehm, Gerhard, 0O	
Brener, Igal, 0O	
Cai, Haogang, 0X	
Chandra, Nitish, 0U	
Chavel, P., 0F	
Colburn, Shane C., 06	
Czaplewski, David, 0X	
Czyszanowski, Tomasz, 0E	
Demmerle, Frederic, 0O	
Dems, Maciej, 0C, 0E	
Fattal, David, 0B	
Gębski, Marcin, 0E	
Gerini, Giampiero, 0M	
Gomez-Diaz, J. Sebastian, 0O	
Gutter, Karen E., 15	
Gustavsson, Johan S., 0B	
Haglund, Åsa, 0B	
Haglund, Erik, 0B	
Hegarty, Stephen P., 0D	
Hogan, Brian, 0D	
Huyet, Guillaume, 0D	
Lalanne, P., 0F	
Larsson, Anders, 0B	
Lee, Jongwon, 0O	
Lewis, Liam, 0D	
Liu, Yingnan, 0O	
Lopez, Daniel, 0X	
Lott, James A., 0E	
Majumdar, Arka, 06	
Marciniak, Magdalena, 0E	
Mitra, Subrata, 0X	
Nookala, Nishant, 0O	
Ochalski, Tomasz, 0D	
Roy, Tapashree, 0X	
Silvestri, Fabrizio, 0M	
Sorin, Wayne V., 0B	
Tan, Michael, 0B	
Tymchenko, Mykhailo, 0O	
Vivas, Javier Romero, 0D	
Wolf, Omri, 0O	
Zhan, Alan, 06	

Conference Committee

Symposium Chairs

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

Symposium Co-chairs

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

Program Track Chair

Ali Adibi, Georgia Institute of Technology (United States)

Conference Chairs

Connie J. Chang-Hasnain, University of California, Berkeley
(United States)
Andrei Faraon, California Institute of Technology (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)
Mikhail A. Kats, University of Wisconsin-Madison (United States)
Arseniy I. Kuznetsov, A*STAR - Data Storage Institute (Singapore)
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)
Arka Majumdar, University of Washington (United States)
Bala Pesala, CSIR Madras Complex (India)
Jon A. Schuller, University of California, Santa Barbara (United States)
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)

Session Chairs

- 1 Harnessing Light
Weimin Zhou, U.S. Army Research Laboratory (United States)
- 2 High Contrast Metastructure Devices
Weimin Zhou, U.S. Army Research Laboratory (United States)
- 3 High Contrast Grating Mirrors and VCSELs
Pierre H. Chavel, Laboratoire Charles Fabry (France)
- 4 Diffractive Optics Based on Dielectric Metasurfaces I
Andrei Faraon, California Institute of Technology (United States)
- 5 Diffractive Optics Based on Dielectric Metasurfaces II
Mohammadreza Khorasaninejad, Harvard School of Engineering and Applied Sciences (United States)
- 6 Dispersion and Nonlinear Effects
Amir Arbabi, California Institute of Technology (United States)
- 7 New Metastructure Phenomena
Hamidreza Chalabi, The University of Texas at Austin (United States)
- 8 New Applications for Metastructures
Andrey A. Fedyanin, Lomonosov Moscow State University (Russian Federation)
- 9 Design and Fabrication Techniques
Karen Grutter, U.S. Army Research Laboratory (United States)
- 10 Tunable Metastructure Devices
Zubin Jacob, Purdue University (United States)