PROCEEDINGS OF SPIE

Photonic Materials, Devices, and Applications III

Ali Serpengüzel
Gonçal Badenes
Giancarlo C. Righini
Editors

4–6 May 2009
Dresden, Germany

Sponsored by
SPIE *Europe*
GMM VDE/VDI Gesellschaft Mikroelektronik, Mikro- und Feinmechanik

Cooperating Organizations
SPIE
Nanotechnology CC "Ultrathin functional films"
mst | news
Silicon Saxony

Published by
SPIE

Volume 7366

Proceedings of SPIE, 0277-786X, v. 7366

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 *Photonic Materials, Devices, and Applications III*, edited by Ali Serpengüzel, Gonçal Badenes, Giancarlo C. Righini, Proceedings of SPIE Vol. 7366 (SPIE, Bellingham, WA, 2009) Article CID Number.

ISSN 0277-786X
ISBN 9780819476401

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

Printed in the United States of America.

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

SPIEDigitalLibrary.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 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

Conference Committee

Symposium Chair

Thomas Becker, EADS Deutschland GmbH (Germany)

Symposium Cohairs

José Feliciano López, Universidad de Las Palmas de Gran Canaria (Spain)
Gerhard Krötz, University of Applied Sciences in Kempten (Germany)

Conference Chair

Ali Serpengüzel, Koç University (Turkey)

Conference Cochairs

Gonçal Badenes, Institut de Ciències Fotòniques (Spain)
Giancarlo C. Righini, Istituto di Fisica Applicata Nello Carrara, CNR (Italy)

Program Committee

Michael J. Adams, University of Essex (United Kingdom)
Mario N. Armenise, Politecnico di Bari (Italy)
Richard M. De La Rue, University of Glasgow (United Kingdom)
Patrice Féron, Ecole Nationale Supérieure des Sciences Appliquées et de Technologie (France)
Maurizio Ferrari, Istituto di Fotonica e Nanotecnologie, CNR (Italy)
Gershon Kurizki, Weizmann Institute of Science (Israel)
El-Hang Lee, Inha University (Korea, Republic of)
Alfred Leipertz, Friedrich-Alexander-Universität Erlangen (Germany)
Eric D. Mazur, Harvard University (United States)
Manuel Nieto-Vesperinas, Consejo Superior de Investigaciones Científicas (Spain)
Alim Örmeci, Max-Planck-Institut für Physik Komplexer Systeme (Germany)
Ekmel Özbay, Bilkent University (Turkey)
Yong-Le Pan, Yale University (United States)
Roberto R. Panepucci, Florida International University (United States)
Lorenzo Pavesi, Università degli Studi di Trento (Italy)
Valerio Pruneri, Institut de Ciències Fotòniques (Spain)
Manijeh Razeghi, Northwestern University (United States)
Ivo Rendina, Istituto per la Microelettronica e Microsistemi, CNR (Italy)
José R. Salcedo, Multiwave Photonics, S.A. (Portugal)

Vahid H. Sandoghdar, Eidgenössische Technische Hochschule (Switzerland)
Niyazi S. Sariciftci, Johannes Kepler Universität Linz (Austria)
Gustav Schweiger, Ruhr-Universität Bochum (Germany)

Session Chairs

1A Silicon Photonics I
Ali Serpengüzel, Koç University (Turkey)

1B Quantum Structures
Giancarlo C. Righini, Istituto di Fisica Applicata Nello Carrara, CNR (Italy)

2A Silicon Photonics II
Graham T. Reed, University of Surrey (United Kingdom)

2B Nanophotonics I
Maurizio Ferrari, Istituto di Fotonica e Nanotecnologie, CNR (Italy)

3A Silicon Photonics III
Ivo Rendina, Istituto per la Microelettronica e Microsistemi, CNR (Italy)

3B Nanophotonics II
Nikolai Gaponik, Technische Universität Dresden (Germany)

4A Photonic Atoms I
Ali Serpengüzel, Koç University (Turkey)

4B Quantum Communication
Paolo Tombesi, Università degli Studi di Camerino (Italy)

5A Photonic Atoms II
Gustav Schweiger, Ruhr-Universität Bochum (Germany)

5B Quantum Communication II
Gershon Kurizki, Weizmann Institute of Science (Israel)

6A Photonic Applications
Valerio Pruneri, ICFO - Instituto de Ciencias Fotónicas (Spain)

6B Quantum Communication III
Marek Zukowski, Univwersytet Gdański (Poland)

7A Photonic Crystals, Glasses, Metamaterials I
Rainer F. Mahrt, IBM Zürich Research Laboratory (Switzerland)

7B Terahertz Photonics
El-Hang Lee, Inha University (Korea, Republic of)

8A Photonic Crystals, Glasses, Metamaterials II
Richard M. De La Rue, University of Glasgow (United Kingdom)

8B Photonic Devices
Giancarlo C. Righini, Istituto di Fisica Applicata Nello Carrara, CNR (Italy)

9A Photonic Crystals, Glasses, Metamaterials III
Ekmel Ozbay, Bilkent University (Turkey)

9B Integrated Photonics
Manijeh Razeghi, Northwestern University (United States)

10A Photonic Crystals, Glasses, Metamaterials IV
Ceferino López, Consejo Superior de Investigaciones Científicas (Spain)

10B Novel Photonic Materials
Tolga Tekin, Fraunhofer-Institut für Zuverlässigkeit und Mikrointegration (Germany)

Introduction

Photons from a wide spectral range are continuing to influence our daily life. Today optical science and photonics engineering are developing at a faster pace than before. Beginning with the new millennium, countries are officially including optics and photonics in their research programs to cover application fields from automotive and home lighting to information and communications, from life sciences and health to displays, from remote sensing to nondestructive diagnostics, and from material processing to photovoltaics. More and more academic degree programs are being offered in optical sciences and photonics engineering, and soon there will be a new batch of optical scientists and photonics engineers roaming the planet. These are indeed very exciting times for all of us.

The scope of this conference on photonics materials, devices, and applications has been to bring together optical scientists and photonics engineers, who work on the different aspects of this fascinating science and technology in academia, industry, and government laboratories and research centers throughout the world. The aim has been to provide an interdisciplinary update and review of innovations in photonic materials, devices and applications, as well as theoretical, experimental, and numerical tools that support these innovations. This year's conference included topics such as photonic atoms, photonic crystals and glasses, metamaterials, nanophotonics, terahertz photonics, novel photonic materials, photonic devices, photonic applications, integrated photonics, silicon photonics, quantum structures, and quantum communication.

Ordered photonic atoms leading to photonic crystals, and disordered ones leading to photonic glasses, are in a class of their own. Metamaterials continue to fascinate us with their counterintuitive behavior. Silicon microphotonics is developing at a fast pace to integrate itself with silicon microelectronics. Integrated photonics is reaching down to the nanometer scale from the micrometer scale. Quantum communication is discussed in depth by focusing on noise, entanglement, and decoherence. Terahertz photonics imaging and communication open up a whole new spectral band. Quantum and nanophotonic structures are investigated for future application areas as well as for contribution to the fundamental science.

Although this volume includes only a fraction of the world's research and development efforts in the vast field of optical science and photonics engineering, we hope that these papers by world renowned experts pave the path for all of us towards future optical discoveries and photonics inventions. We would like to especially thank our conference sponsors, European Office of Aerospace R&D and Deutsche Forschungsgemeinschaft.

Ali Serpengüzel
Gonçal Badenes
Giancarlo C. Righini