

PROCEEDINGS OF SPIE

Metamaterials VIII

Vladimir Kuzmiak
Peter Markos
Tomasz Szoplik
Editors

17–18 April 2013
Prague, Czech Republic

Sponsored by
SPIE

Cooperating Organisations
HiPER Project (United Kingdom)
ELI Beamlines (Czech Republic)
International Commission For Optics

Published by
SPIE

Volume 8771

Proceedings of SPIE 0277-786X, V.8771

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

Metamaterials VIII, edited by Vladimir Kuzmiak, Peter Markos, Tomasz Szoplik, Proc. of SPIE
Vol. 8771, 877101 · © 2013 SPIE · CCC code: 0277-786X/13/\$18 · doi: 10.1117/12.2030984

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 *Metamaterials VIII*, edited by Vladimir Kuzmiak, Peter Markos, Tomasz Szoplik, Proceedings of SPIE Vol. 8771 (SPIE, Bellingham, WA, 2013) Article CID Number.

ISSN: 0277-786X

ISBN: 9780819495730

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. 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

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

| | |
|-----|----------------------|
| vii | Conference Committee |
| ix | Introduction |

PERIODIC NANOSTRUCTURES I

- 8771 07 **Preparation and characterization of silver nanowires films for infrared radiation shielding** [8771-7]
M. C. Larciprete, A. Belardini, G. Leahu, R. Li Voti, F. Mura, Univ. degli Studi di Roma La Sapienza (Italy); A. Albertoni, BFi OPTiLAS S.A. (Italy); C. Sibilica, Univ. degli Studi di Roma La Sapienza (Italy)
- 8771 09 **Funneling of light in combinations of metal-insulator-metal resonators** [8771-9]
P. Bouchon, ONERA (France); Q. Lévesque, ONERA (France), and Lab. de Photoniques et Nanostructures, CNRS (France); F. Pardo, Lab. de Photonique et de Nanostructures, CNRS (France); P. Chevalier, ONERA (France), and Lab. de Photoniques et Nanostructures, CNRS (France); C. Koechlin, ONERA (France); J.-L. Pelouard, Lab. de Photonique et de Nanostructures, CNRS (France); R. Haïdar, ONERA (France), and Lab. de Photonique et de Nanostructures, CNRS (France)

METAMATERIALS II

- 8771 0D **Transformation optics and metamaterials at infrared wavelength: engineering of permittivity and permeability** [8771-13]
R. Ghasemi, Institut d'Électronique Fondamentale, Univ. Paris Sud (France); A. Degiron, Institut d'Électronique Fondamentale, Univ. Paris Sud (France) and Ctr. National de la Recherche Scientifique (France); X. Leroux, Institut d'Électronique Fondamentale, Univ. Paris Sud (France); A. Lupu, Institut d'Électronique Fondamentale, Univ. Paris Sud (France) and Ctr. National de la Recherche Scientifique (France); A. de Lustrac, Institut d'Électronique Fondamentale, Univ. Paris Sud (France) and Univ. Paris Ouest (France)
- 8771 0E **Negative index resonant states: a route toward nonmetal plasmonics and metamaterials** [8771-14]
V. Mocella, P. Dardano, IMM, CNR, Unità di Napoli (Italy); A. C. De Luca, Istituto di Biochimica delle Proteine, CNR (Italy); E. De Tommasi, I. Rendina, S. Romano, IMM, CNR, Unità di Napoli (Italy)

PLASMONICS I

- 8771 0H **Enhancement of the dynamic Casimir effect within a metal photonic crystal** [8771-17]
T. Ueta, Jikei Medical Univ. (Japan)

8771 OI **Asymmetric transmission of surface plasmon polaritons** [8771-18]
V. Kuzmiak, Institute of Photonics and Electronics of the ASCR, v.v.i. (Czech Republic);
A. A. Maradudin, Univ. of California, Irvine (United States)

8771 OJ **Metal-dielectric photonic devices for spatial filtering and image contrast enhancement**
[8771-19]
A. Pastuszczak, P. Wróbel, T. Stefaniuk, M. Stolarek, M. Wlazło, R. Kotyński, Univ. of Warsaw
(Poland)

METAMATERIALS III

8771 OK **Asymmetrical hyperbolic media and their potential applications in photovoltaics and photonics (Invited Paper)** [8771-20]
I. S. Nefedov, Aalto Univ. School of Electrical Engineering (Finland); L. A. Melnikov, Saratov State Technical Univ. (Russian Federation); E. I. Nefedov, Aalto Univ. (Finland)

8771 OL **Resonant terahertz response of TiO₂ microspheres** [8771-21]
F. Dominec, C. Kadlec, H. Němec, F. Kadlec, Institute of Physics of the ASCR, v.v.i. (Czech Republic); R. Yahiaoui, LOMA, CNRS, Univ. Bordeaux 1 (France); U.-C. Chung, C. Elissalde, M. Magliione, ICMCB, CNRS, Univ. Bordeaux 1 (France); P. Mounaix, LOMA, CNRS, Univ. Bordeaux 1 (France); P. Kužel, Institute of Physics of the ASCR, v.v.i. (Czech Republic)

8771 ON **Coupling mechanisms of resonators in the THz regime** [8771-23]
N. Gneiding, O. Zhuromskyy, U. Peschel, Friedrich-Alexander-Univ. Erlangen-Nürnberg (Germany)

PLASMONICS II

8771 OO **Surface plasmon photodetectors (Invited Paper)** [8771-24]
P. Berini, Univ. of Ottawa (Canada)

PLASMONICS III: TECHNOLOGY

8771 OV **Block-copolymer-based plasmonic metamaterials** [8771-33]
A. Capretti, SPIN, CNR, Univ. degli Studi di Napoli Federico II (Italy); F. Auriemma, C. De Rosa, R. Di Girolamo, C. Forestiere, G. Miano, Univ. degli Studi di Napoli Federico II (Italy); G. P. Pepe, SPIN, CNR, Univ. degli Studi di Napoli Federico II (Italy)

PERIODIC NANOSTRUCTURES II

8771 OW **Diffraction control of reflected beam by chirped mirror (Invited Paper)** [8771-34]
Y.-C. Cheng, Univ. Politècnica de Catalunya (Spain); M. Peckus, S. Kicas, Vilnius Univ. (Lithuania); J. Trull, C. Cojocar, R. Vilaseca, Univ. Politècnica de Catalunya (Spain); R. Drazdys, Vilnius Univ. (Lithuania); K. Staliunas, Univ. Politècnica de Catalunya (Spain) and Institutió Catalana de Reserca i Estudis Avançats (Spain)

- 8771 0X **Study of the anomalous refraction produced by self-assembled gold nanowires** [8771-35]
A. Belardini, G. Leahu, M. C. Larciprete, M. Centini, C. Sibilia, Univ. degli Studi di Roma La Sapienza (Italy); C. Martella, M. Giordano, D. Chiappe, F. Buatier de Mongeot, Univ. degli Studi di Genova (Italy)
- 8771 0Y **Metamaterial fishnet structure formed from nanoimprint lithography** [8771-37]
G. J. Sharp, M. Yuce, Univ. of Glasgow (United Kingdom); X. Hu, and Univ. of Glasgow (United Kingdom), and City Univ. of Hong Kong (Hong Kong, China); M. Sinworapun, A. Z. Khokhar, N. P. Johnson, Univ. of Glasgow (United Kingdom)
- 8771 0Z **Transmission through a two dimensional quantum metamaterial** [8771-38]
R. D. Wilson, M. J. Everitt, J. H. Samson, S. E. Salelev, A. M. Zagoskin, Loughborough Univ. (United Kingdom); T. P. Spiller, Univ. of Leeds (United Kingdom)

POSTER SESSION

- 8771 10 **Cyclic MAM synthesis of SPION/BaMoO₄:Er³⁺,Yb³⁺ composite and its optical properties** [8771-39]
C. S. Lim, Hanseo Univ. (Korea, Republic of); V. V. Atuchin, A.V. Rzhhanov Institute of Semiconductor Physics (Russian Federation)
- 8771 12 **Preparation and characterization of Sr₃V₂O₈ nanoparticles performed via cyclic MAS route** [8771-41]
C. S. Lim, Hanseo Univ. (Korea, Republic of); V. V. Atuchin, A.V. Rzhhanov Institute of Semiconductor Physics (Russian Federation)
- 8771 15 **Simulations of some nanomaterials having magnetic properties in the paramagnetic region** [8771-44]
N. F. Mirela, Aurel Vlaicu Univ. of Arad (Romania)
- 8771 18 **Electromagnetic parameter retrieval at oblique incidence** [8771-47]
S. I. Khan, R. M. De La Rue, T. D. Drysdale, N. P. Johnson, Univ. of Glasgow (United Kingdom)
- 8771 1A **The formation and structural parameters of new double molybdates RbLn(MoO₄)₂ (Ln = Pr, Nd, Sm, Eu)** [8771-50]
O. D. Chimitova, Baikal Institute of Nature Management (Russian Federation); V. V. Atuchin, A.V. Rzhhanov Institute of Semiconductor Physics (Russian Federation); B. G. Bazarov, Baikal Institute of Nature Management (Russian Federation); M. S. Molokeev, Kirensky Institute of Physics (Russian Federation); Z. G. Bazarova, Baikal Institute of Nature Management (Russian Federation)
- 8771 1B **Superconductors in plasmonics and metamaterials: some experimental data** [8771-51]
M. Gombos, IMM, CNR, Univ. degli Studi di Salerno (Italy) and SPIN, CNR, Univ. degli Studi di Salerno (Italy); S. Romano, I. Rendina, IMM, CNR, Univ. degli Studi di Salerno (Italy); R. Ciancio, IOM, CNR, Lab. Nazionale TASC Trieste (Italy); G. Carapella, SPIN, CNR, Univ. degli Studi di Salerno (Italy); V. Mocella, IMM, CNR, Univ. degli Studi di Salerno (Italy)

8771 1C **High efficiency ultra-thin silicon photonic crystal based solar cells** [8771-52]
G. Di Martino, P. Dardano, V. Mocella, I. Rendina, IMM, CNR, Unità di Napoli (Italy)

Author Index

Conference Committee

Symposium Chairs

Jiri Homola, Institute of Photonics and Electronics of the ASCR, v.v.i.
(Czech Republic)
Chris Edwards, Central Laser Facility, Science and Technology
Facilities Council (United Kingdom)
Mike Dunne, Lawrence Livermore National Laboratory (United States)
Ivo Rendina, CNR, Istituto per la Microelettronica e Microsistemi
(Italy)

Honorary Symposium Chair

Miroslav Miller, Institute of Photonics and Electronics of the ASCR, v.v.i.
(Czech Republic)

Conference Chairs

Vladimir Kuzmiak, Institute of Photonics and Electronics of the ASCR,
v.v.i. (Czech Republic)
Peter Markos, Slovak University of Technology (Slovakia)
Tomasz Szoplik, University of Warsaw (Poland)

Conference Programme Committee

Jiri Ctyroký, Institute of Photonics and Electronics of the ASCR, v.v.i.
(Czech Republic)
Didier Felbacq, Université Montpellier 2 (France)
F. Javier García de Abajo, Consejo Superior de Investigaciones
Científicas (Spain)
Harald W. Giessen, Universität Stuttgart (Germany)
Nigel P. Johnson, University of Glasgow (United Kingdom)
Maria Kafesaki, Foundation for Research and Technology-Hellas
(Greece)
Yuri S. Kivshar, The Australian National University (Australia)
Rafal Kotynski, University of Warsaw (Poland)
Andrei Lavrinenko, Technical University of Denmark (Denmark)
Concita Sibilia, Università degli Studi di Roma La Sapienza (Italy)
Constantin Simovski, Aalto University School of Science and
Technology (Finland)
Costas M. Soukoulis, Iowa State University (United States)
Martin Wegener, Karlsruher Institut für Technologie (Germany)
Nikolay I. Zheludev, Optoelectronics Research Center (United
Kingdom)

Richard W. Ziolkowski, The University of Arizona (United States)

Session Chairs

- 1 Metamaterials I
Vladimir Kuzmiak, Institute of Photonics and Electronics of the ASCR,
v.v.i. (Czech Republic)
- 2 Periodic Nanostructures I
Pierre Berini, University of Ottawa (Canada)
- 3 Metamaterials II
Alessandro Belardini, Università degli Studi di Roma La Sapienza (Italy)
- 4 Plasmonics I
Constantin Simovski, Aalto University School of Electrical Engineering
(Finland)
- 5 Metamaterials III
Tomasz Szoplik, University of Warsaw (Poland)
- 6 Plasmonics II
Jean-Jacques Greffet, Laboratoire Charles Fabry (France)
- 7 Plasmonics III: Technology
Nigel P. Johnson, University of Glasgow (United Kingdom)
- 8 Periodic Nanostructures II
Peter Markos, Slovak University of Technology (Slovakia)

Introduction

The eighth SPIE conference (the fourth one held in Prague) in this series of conferences on metamaterials has brought together the scientific communities of metamaterials, plasmonics and nanophotonics. The conference provided a forum for both researchers and industry professionals and stimulated interaction between both communities and simultaneously took advantage of the synergy arising from conferences on nonlinear optics and its applications (8772), optical sensors (8774) and photonic crystal fibres (8775). Invited lectures shared recent achievements and novel concepts, namely complex viscoelastic properties of high contrast composites with complex viscoelastic properties, advances in radiative heat transfer at the nanoscale, active nanoplasmonic metamaterials, recent progress in material and computational methods, and theory and applications of hyperbolic metamaterials, and surface plasmon photodetectors have been presented by top experts in the field.

The speakers in contributed papers presented recent achievements in the investigation of new effects in metal-insulator-metal structures, novel techniques for engineering of permittivity and permeability used in transformation optics and metamaterials in infrared range. In the field of energy conversion the potential applications in photovoltaics arising from using spoof plasmons and non-symmetrical hyperbolic media have been discussed. Advances in plasmon spectroscopy and imaging of individual metal nanoparticles as well as new effects associated with nanoparticles e.g. probing optical properties of a quantum dot and their applications in sensors have been reported in several interesting presentations. An anomalous refraction produced by self-assembled nanowires and progress in preparation and characterization of silver nanowires for infrared radiation shielding have been reported. Nonlinear effects in plasma materials associated with Raman spectroscopy and properties of dissipative optical solitons in microcavities have been discussed. In the field of magneto-optical plasmonic structures MO activity from magnetic and electric dipolar modes in magnetoplasmonic nanodiscs and numerical simulations of one-way waveguides in THz range have been reported.

As chairs of this meeting we would like to express our thanks to all those participants who contributed through their presentations, to session chairs and to program committee members.

Vladimir Kuzmiak
Peter Markos
Tomasz Szoplik

