

PROCEEDINGS OF SPIE

Nonlinear Frequency Generation and Conversion: Materials, Devices, and Applications XII

Konstantin L. Vodopyanov
Editor

5–7 February 2013
San Francisco, California, United States

Sponsored and Published by
SPIE

Volume 8604

Proceedings of SPIE 0277-786X, V.8604

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

Nonlinear Frequency Generation and Conversion: Materials, Devices, and Applications XII
edited by Konstantin L. Vodopyanov, Proc. of SPIE Vol. 8604, 860401
© 2013 SPIE · CCC code: 0277-786X/13/\$18 · doi: 10.1117/12.2025040

Proc. of SPIE Vol. 8604 860401-1

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 *Nonlinear Frequency Generation and Conversion: Materials, Devices, and Applications XII*, edited by Konstantin L. Vodopyanov, Proceedings of SPIE Vol. 8604 (SPIE, Bellingham, WA, 2013) Article CID Number.

ISSN: 0277-786X

ISBN: 9780819493736

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

ix *Conference Committee*

SESSION 1 VISIBLE AND UV LASERS I

- 8604 02 **A narrow-band continuous-wave laser source at 191 nm (Invited Paper)** [8604-1]
M. Scholz, D. Opalevs, J. Stuhler, P. Leisching, W. Kaenders, TOPTICA Photonics AG (Germany);
G. Wang, X. Wang, R. Li, C. Chen, Technical Institute of Physics and Chemistry (China)
- 8604 03 **Two photon absorption and stimulated Raman scattering in alkali vapor lasers** [8604-2]
J. E. Gallagher, E. J. Hurd, K. C. Brown, G. P. Perram, Air Force Institute of Technology (United States)
- 8604 04 **Efficient concept generating 3.9 W of diffraction-limited green light with spectrally combined tapered diode lasers** [8604-3]
A. Müller, O. B. Jensen, Technical Univ. of Denmark (Denmark); K.-H. Hasler, B. Sumpf, G. Erbert, Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik (Germany); P. E. Andersen, P. M. Petersen, Technical Univ. of Denmark (Denmark)
- 8604 05 **Megawatt peak power UV microlaser** [8604-4]
R. Bhandari, T. Taira, The Institute for Molecular Science (Japan)

SESSION 2 VISIBLE AND UV LASERS II

- 8604 06 **Generation of tunable visible picosecond pulses by frequency-doubling of a quantum-dot laser in a PPKTP waveguide** [8604-5]
K. A. Fedorova, The Univ. of Dundee (United Kingdom); G. S. Sokolovskii, The Univ. of Dundee (United Kingdom) and Ioffe Physico-Technical Institute (Russian Federation); D. I. Nikitichev, The Univ. of Dundee (United Kingdom); P. R. Battle, AdvR, Inc. (United States); D. A. Livshits, Innolume GmbH (Germany); E. U. Rafailov, The Univ. of Dundee (United Kingdom)
- 8604 08 **Several watts compact CW green laser head without cooling by using PPMgSLT** [8604-7]
Y. Tomihari, S. Makio, M. Hoshi, M. Hatori, J. Hirohashi, K. Imai, H. Motegi, Y. Furukawa, Oxide Corp. (Japan)
- 8604 09 **Pulsed picosecond 766 nm laser source operating between 1-80 MHz with automatic pump power management** [8604-8]
T. Schönau, T. Siebert, R. Härtel, T. Eckhardt, D. Klemme, K. Lauritsen, R. Erdmann, PicoQuant GmbH (Germany)
- 8604 0A **Ultra-violet generation by third-harmonic conversion in conventional solid-core fibers** [8604-9]
Y. Takushima, Y. Orii, A. Higashitani, T. Manabe, Spectronix Corp. (Japan)

SESSION 3 TERAHERTZ GENERATION

- 8604 0B **High-power THz pulse generation and nonlinear THz spectroscopy (Invited Paper)** [8604-10]
K. Shinokita, H. Hirori, K. Tanaka, Kyoto Univ. (Japan); T. Mochizuki, C. Kim, H. Akiyama, The Univ. of Tokyo (Japan); L. N. Pfeiffer, K. W. West, Princeton Univ. (United States)
- 8604 0C **Intense THz radiation produced in organic salt crystals for high-field applications (Invited Paper)** [8604-11]
C. Vicario, C. Ruchert, Paul Scherrer Institut (Switzerland); C. P. Hauri, Paul Scherrer Institut (Switzerland) and Ecole Polytechnique Federale de Lausanne (Switzerland)
- 8604 0D **Comparative study on THz time-domain spectroscopy using 780-nm 1.3-ps laser pulses with different detections of LT-GaAs photoconductive antenna and ZnTe electro-optic sampling** [8604-12]
Y. Tadokoro, Y. Takida, Osaka City Univ. (Japan); H. Kumagai, Kitasato Univ. (Japan); S. Nashima, A. Kobayashi, Osaka City Univ. (Japan)
- 8604 0E **The widely tunable THz generation in QPM-GaAs crystal pumped by a near-degenerate dual-wavelength KTP OPO at around 2.127 μm** [8604-13]
D. Xu, W. Shi, K. Zhong, Y. Y. Wang, P. Liu, J. Yao, Tianjin Univ. (China)

SESSION 4 OPTICAL PARAMETRIC AND ULTRAFAST NONLINEAR DEVICES

- 8604 0H **Narrow bandwidth tunable optical parametric generator** [8604-17]
B. Dolasinski, P. Powers, Univ. of Dayton (United States)
- 8604 0I **Ho³⁺:LLF MOPA pumped RISTRA ZGP OPO at 3-5 μm** [8604-18]
G. Stoeppler, M. Schellhorn, M. Eichhorn, Institut Franco-Allemand de Recherches de Saint-Louis (France)

SESSION 5 NONLINEAR FIBER DEVICES AND APPLICATIONS

- 8604 0K **Widely tunable parametric generation of picosecond visible and mid-infrared radiation in optical fibers** [8604-20]
A. Giree, C. Jauregui, Friedrich-Schiller-Univ. Jena (Germany); J. Limpert, Friedrich-Schiller-Univ. Jena (Germany) and Helmholtz-Institute Jena (Germany); A. Tünnermann, Friedrich-Schiller-Univ. Jena (Germany), Helmholtz-Institute Jena (Germany) and Fraunhofer Institute for Applied Optics and Precision Engineering (Germany)
- 8604 0L **Polarization stabilization of vector solitons in circularly birefringent fibers induced by Raman effect** [8604-21]
E. A. Kuzin, B. A. Villagomez-Bernabe, N. Korneev, B. Ibarra-Escamilla, A. Gonzalez-García, Instituto Nacional de Astrofísica, Óptica y Electrónica (Mexico); O. Pottiez, Ctr. de Investigaciones en Óptica, A.C. (Mexico); M. Duran-Sanchez, Univ. Tecnológica de Puebla (Mexico)

- 8604 ON **Experimental and theoretical investigations of single-frequency Raman fiber amplifiers operating at 1178 nm** [8604-23]
I. Dajani, C. Vergien, Air Force Research Lab. (United States); B. Ward, U.S. Air Force Academy (United States); C. Robin, S. Naderi, A. Flores, Air Force Research Lab. (United States); J.-C. Diels, The Univ. of New Mexico (United States)

SESSION 6 MID-IR FREQUENCY COMB AND SUPERCONTINUUM GENERATION

- 8604 OO **Precision mid-infrared frequency combs and spectroscopic applications (Invited Paper)** [8604-24]
D. Gatti, Politecnico di Milano (Italy); A. Castrillo, Seconda Univ. degli Studi di Napoli (Italy); A. Gambetta, T. Sala, G. Galzerano, P. Laporta, Politecnico di Milano (Italy); L. Gianfrani, Seconda Univ. degli Studi di Napoli (Italy); M. Marangoni, Politecnico di Milano (Italy)
- 8604 OR **Multispectral mid-infrared imaging using frequency upconversion** [8604-27]
N. Sanders, J. S. Dam, O. B. Jensen, P. Tidemand-Lichtenberg, C. Pedersen, Technical Univ. of Denmark (Denmark)
- 8604 OS **High resolution mid-infrared spectroscopy based on frequency upconversion** [8604-28]
J. S. Dam, Q. Hu, P. Tidemand-Lichtenberg, C. Pedersen, Technical Univ. of Denmark (Denmark)
- 8604 OT **Intracavity molecular spectroscopy in the mid-IR using ultra-broadband optical parametric oscillator** [8604-29]
M. W. Haakestad, Stanford Univ. (United States) and Norwegian Defence Research Establishment (Norway); T. P. Lamour, Stanford Univ. (United States) and Heriot-Watt Univ. (United Kingdom); N. Leindecker, A. Marandi, K. L. Vodopyanov, Stanford Univ. (United States)

SESSION 7 NONLINEAR MATERIALS AND CHARACTERIZATION I

- 8604 OV **Progress in orientation-patterned GaP for next-generation nonlinear optical devices (Invited Paper)** [8604-31]
V. Tassev, M. Snure, R. Peterson, K. L. Schepler, R. Bedford, M. Mann, Air Force Research Lab. (United States); S. Vangala, Solid State Scientific Corp. (United States); W. Goodhue, Univ. of Massachusetts Lowell (United States); A. Lin, J. Harris, M. Fejer, Stanford Univ. (United States); P. Schunemann, BAE Systems, Inc. (United States)
- 8604 OW **Surface plasmon enhanced reflected second harmonic generation in periodically poled whispering gallery resonator** [8604-32]
A. Saha, N. Goswami, P. Dey, National Institute of Technology Agartala (India)
- 8604 OZ **Tapered nanowire waveguide layout for rapid optical loss measurement by 'cut-back' technique** [8604-35]
M. F. A. Muttalib, R. Y. Chen, S. J. Pearce, M. D. B. Charlton, Univ. of Southampton (United Kingdom)

SESSION 8 NONLINEAR MATERIALS AND CHARACTERIZATION II

- 8604 10 **Tailorable stimulated Brillouin scattering in silicon nanophotonics (Invited Paper)** [8604-36]
P. T. Rakich, H. Shin, Yale Univ. (United States); W. Qiu, Massachusetts Institute of Technology (United States); R. Jarecki, J. A. Cox, R. H. Olsson III, A. Starbuck, Sandia National Labs. (United States); Z. Wang, Univ. of Texas at Austin (United States)
- 8604 12 **Giant optical nonlinearity of graphene in a magnetic field** [8604-38]
X. Yao, A. Belyanin, Texas A&M Univ. (United States)

POSTER SESSION

- 8604 14 **An efficient WDM-OTDM converter for spectrum interrogation based on nonlinear effects in electro-absorption modulator** [8604-41]
C. Gao, Z. Wang, X. Qin, T. Wang, C. Ge, T. Yang, Tianjin Univ. (China)
- 8604 15 **Terahertz generation in quasi-phase-matched GaAs wafers by pulse CO₂ laser** [8604-42]
Z. Rao, Huazhong Univ. of Science and Technology (China) and Jiangxi Univ. of Traditional Chinese Medicine (China); X. Wang, D. Zuo, Huazhong Univ. of Science and Technology (China)
- 8604 16 **Fourth-harmonic generation of the CO₂ laser wavelength at 10.5910 μm in BaGa₄S₇** [8604-43]
K. Kato, Chitose Institute of Science and Technology (Japan) and Okamoto Optics Works, Inc. (Japan); T. Okamoto, T. Mikami, Okamoto Optics Works, Inc. (Japan); V. Petrov, Max-Born-Institute for Nonlinear Optics and Ultrafast Spectroscopy (Germany); V. Badikov, D. Badikov, Kuban State Technological Univ. (Russian Federation); V. Panyutin, Max-Born-Institute for Nonlinear Optics and Ultrafast Spectroscopy (Germany)
- 8604 18 **Parametric gain analysis in tellurite/phospho-tellurite hybrid microstructured optical fibers with an engineered chromatic dispersion** [8604-45]
E. P. Samuel, H. T. Tong, Z. Duan, M. Liao, K. Asano, T. Suzuki, Y. Ohishi, Toyota Technological Institute (Japan)
- 8604 1F **Tunable picosecond THz-wave generation based on trapezoidal MgO:LiNbO₃ crystal in novel pentagram-shaped pump-enhancement cavity** [8604-53]
Y. Takida, Osaka City Univ. (Japan) and The Japan Society for the Promotion of Science (Japan); Y. Tadokoro, Osaka City Univ. (Japan); H. Kumagai, Osaka City Univ. (Japan) and Kitasato Univ. (Japan); S. Nashima, A. Kobayashi, Osaka City Univ. (Japan)
- 8604 1I **Second-harmonic generation in Hg_{0.35}Cd_{0.65}Ga₂S₄ and Hg_{0.52}Cd_{0.48}Ga₂S₄** [8604-56]
K. Kato, Chitose Institute of Science and Technology (Japan) and Okamoto Optics Works, Inc. (Japan); T. Mikami, Okamoto Optics Works, Inc. (Japan); V. Petrov, Max-Born-Institute for Nonlinear Optics and Ultrafast Spectroscopy (Germany)
- 8604 1J **Effects of nonlinear phase modulation on quantum frequency conversion using four-wave mixing Bragg scattering** [8604-57]
L. Mejling, Technical Univ. of Denmark (Denmark); C. J. McKinstrie, Alcatel-Lucent Bell Labs. (United States); K. Rottwitt, Technical Univ. of Denmark (Denmark)

8604 1K **Nd:YAG laser pumped HgGa₂S₄ parametric oscillator** [8604-58]
K. Kato, Chitose Institute of Science and Technology (Japan); K. Miyata, MegaOpto, Co.
Ltd. (Japan)

Author Index

Conference Committee

Symposium Chairs

Bo Gu, Bos Photonics (United States)
Andreas Tünnermann, Fraunhofer-Institut für Angewandte Optik und
Feinmechanik (Germany) and Friedrich-Schiller-Universität Jena
(Germany)

Symposium Cochairs

Friedhelm Dorsch, TRUMPF Werkzeugmaschinen GmbH + Co. KG
(Germany)
Alberto Piqué, U.S. Naval Research Laboratory (United States)

Conference Chair

Konstantin L. Vodopyanov, Stanford University (United States)

Conference Cochair

Yehoshua Y. Kalisky, Nuclear Research Center Negev (Israel)

Conference Program Committee

Darrell J. Armstrong, Sandia National Laboratories (United States)
Pinhas Blau, Soreq Nuclear Research Center (Israel)
Majid Ebrahim-Zadeh, ICFO - Institut de Ciències Fotòniques (Spain)
Peter Günter, ETH Zurich (Switzerland)
Baldemar Ibarra-Escamilla, Instituto Nacional de Astrofísica, Óptica y
Electrónica (Mexico)
Yun-Shik Lee, Oregon State University (United States)
Rita D. Peterson, Air Force Research Laboratory (United States)
Peter Powers, University of Dayton (United States)
Peter G. Schunemann, BAE Systems (United States)
Kenneth L. Schepler, Air Force Research Laboratory (United States)
Andrei V. Shchegrov, KLA-Tencor Corporation (United States)
Wei Shi, Tianjin University (China)

Session Chairs

- 1 Visible and UV Lasers I
Andrei V. Shchegrov, KLA-Tencor Corporation (United States)
Yehoshua Y. Kalisky, Nuclear Research Center Negev (Israel)

- 2 Visible and UV Lasers II
Andrei V. Shchegrov, KLA-Tencor Corporation (United States)
Yehoshua Y. Kalisky, Nuclear Research Center Negev (Israel)
- 3 Terahertz Generation
Peter Günter, ETH Zurich (Switzerland)
Wei Shi, Tianjin University (China)
- 4 Optical Parametric and Ultrafast Nonlinear Devices
Darrell J. Armstrong, Sandia National Laboratories (United States)
Peter E. Powers, University of Dayton (United States)
- 5 Nonlinear Fiber Devices and Applications
Wei Shi, Tianjin University (China)
Darrell J. Armstrong, Sandia National Laboratories (United States)
- 6 Mid-IR Frequency Comb and Supercontinuum Generation
Konstantin L. Vodopyanov, Stanford University (United States)
Kenneth L. Schepler, Air Force Research Laboratory (United States)
- 7 Nonlinear Materials and Characterization I
Peter G. Schunemann, BAE Systems (United States)
Baldemar Ibarra-Escamilla, Instituto Nacional de Astrofísica, Óptica y Electrónica (Mexico)
- 8 Nonlinear Materials and Characterization II
Peter G. Schunemann, BAE Systems (United States)
Baldemar Ibarra-Escamilla, Instituto Nacional de Astrofísica, Óptica y Electrónica (Mexico)