

PROCEEDINGS OF SPIE

Nonlinear Frequency Generation and Conversion: Materials and Devices XIX

Peter G. Schunemann
Kenneth L. Schepler
Editors

3–5 February 2020
San Francisco, California, United States

Sponsored and Published by
SPIE

Volume 11264

Proceedings of SPIE 0277-786X, V. 11264

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

Nonlinear Frequency Generation and Conversion: Materials and Devices XIX, edited by
Peter G. Schunemann, Kenneth L. Schepler, Proc. of SPIE Vol. 11264, 1126401
© 2020 SPIE · CCC code: 0277-786X/20/\$21 · doi: 10.1117/12.2569910

Proc. of SPIE Vol. 11264 1126401-1

The papers 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. Additional papers and presentation recordings may be available online in the SPIE Digital Library at SPIEDigitalLibrary.org.

The papers 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 these proceedings:

Author(s), "Title of Paper," in *Nonlinear Frequency Generation and Conversion: Materials and Devices XIX*, edited by Peter G. Schunemann, Kenneth L. Schepler, Proceedings of SPIE Vol. 11264 (SPIE, Bellingham, WA, 2020) Seven-digit Article CID Number.

ISSN: 0277-786X

ISSN: 1996-756X (electronic)

ISBN: 9781510632912

ISBN: 9781510632929 (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 © 2020, 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 \$21.00 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/20/\$21.00.

Printed in the United States of America by Curran Associates, Inc., under license from SPIE.

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



Paper Numbering: Proceedings of SPIE follow an e-First publication model. A unique citation identifier (CID) number is assigned to each article at the time of 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 and print versions of the publication. SPIE uses a seven-digit CID article numbering system structured as follows:

- 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.

Contents

vii	Authors
ix	Conference Committee

FREQUENCY COMBS

- 11264 04 **Milliwatt midinfrared from intrapulse difference frequency with a single erbium fiber laser** [11264-3]
- 11264 06 **High repetition rate sub-picosecond pulse generation through compression of adaptively optimised frequency combs based on phase-modulated continuous wave lasers** [11264-5]

SUPERCONTINUUM GENERATION

- 11264 07 **Multi-octave infrared femtosecond continuum generation in Cr:ZnS-GaSe and Cr:ZnS-ZGP tandems (Invited Paper)** [11264-6]
- 11264 09 **2-10 μm mid-infrared supercontinuum generation in cascaded optical fibers: experiment and modelling** [11264-8]
- 11264 0A **Demonstration of mid-IR supercontinuum generation using all-normal dispersion engineered tapered chalcogenide fiber** [11264-9]

OPTICAL PARAMETRIC DEVICES AND APPLICATIONS I

- 11264 0B **Back-conversion suppressed parametric frequency conversion for ultrawide bandwidth and ultrahigh efficiency devices (Invited Paper)** [11264-10]
- 11264 0C **Widely-tunable single fiber laser OPO for multimodal microscopy** [11264-11]
- 11264 0E **Ultra-broadband spontaneous parametric downconversion in periodically poled lithium niobate and electro-optic tuning of the optical parametric oscillation** [11264-13]

INFRARED GENERATION

- 11264 0F **Progress in ultrafast, mid-infrared optical parametric chirped pulse amplifiers pumped at 1 μm (Invited Paper)** [11264-14]
- 11264 0G **Electronically tunable, broadband middle infrared picosecond pulse generation via $\chi^{(3)}$ interaction** [11264-15]

- 11264 0H **Recent advances in high-power 2 μm fiber lasers for frequency conversion into the mid-IR**
[11264-16]

NEW NONLINEAR MATERIALS

- 11264 0X **Measurement of laser damage threshold of CdSiP₂ at 1064 nm and 1550 nm** [11264-32]
- 11264 0Y **Midwave infrared ultrashort pulse laser frequency conversion in single crystal, polycrystalline, and amorphous optical materials** [11264-33]

VISIBLE-UV GENERATION

- 11264 12 **High-efficiency single-pass >100mW continuous-wave UV-355nm generation by focusing optimization of 1064nm cascaded third harmonic generation in periodically poled lithium niobate crystals** [11264-38]
- 11264 13 **Shaping of picosecond laser pulses by second harmonic generation with time predelay**
[11264-39]
- 11264 14 **Generating kW laser light at 532 nm via second harmonic generation of a high power Yb-doped fiber amplifier** [11264-40]
- 11264 15 **Dual-channel laser system with gap-less tuning from 250-1300 nm at megahertz repetition rates for time-resolved photoelectron-emission microscopy and spectroscopy** [11264-41]

THZ GENERATION AND DETECTION

- 11264 16 **Robust optimization of single-cycle THz setups based on phase-matching via tilted pulse fronts using an incident-fluence metric** [11264-42]

OPTICAL PARAMETRIC DEVICES AND APPLICATIONS II

- 11264 19 **Continuous-wave optical parametric oscillators for mid-infrared spectroscopy (Invited Paper)**
[11264-45]
- 11264 1A **Mid-IR upconversion imaging: theory and applications** [11264-46]
- 11264 1B **An experimental demonstration of coherent combining applied to optical parametric oscillators** [11264-47]
- 11264 1D **Nonlinear interferometers for broadband mid-infrared spectroscopy** [11264-49]

STIMULATED RAMAN AND BRILLOUIN PROCESSES

- 11264 1F **Polarization of Brillouin scattered light in silica nanofibers** [11264-51]
- 11264 1I **Watt level pulsed Tm:YLF / KGW Raman laser operating at near-IR wavelengths** [11264-54]
- 11264 1J **Frequency doubling of graded-index fiber Raman lasers with multimode diode pumping** [11264-55]
- 11264 1K **Hollow-core fiber enhanced CW CARS of gases** [11264-56]
- 11264 1L **Conception and reproducibility study of efficient evanescent Raman converters based a nanofiber immersed in a liquid** [11264-57]
- 11264 1M **Enhancement of stimulated Brillouin scattering thresholds of high power narrow-linewidth fiber lasers through a simple line-broadening scheme using a combination of sinusoidal and white noise phase modulation** [11264-66]

POSTER SESSION

- 11264 1N **New thermo-optic dispersion formula for AgGaSe₂** [11264-58]
- 11264 1Q **Compact broadband femtosecond MIR source for hybrid sum frequency generation spectroscopy systems** [11264-61]
- 11264 1R **Periodically poled LiNbO₃ wavelength converter with buried waveguide in telecommunication wavelength** [11264-62]
- 11264 1T **Mid-infrared supercontinuum generation in an all-solid hybrid microstructured optical fiber** [11264-64]
- 11264 1U **Gain equalizable optical parametric amplifiers using few-mode fiber** [11264-65]
- 11264 1W **Phase-matching properties of LiIn(S_xSe_{1-x})₂** [11264-69]
- 11264 1Y **Suspended-core fluoride fiber for broadband supercontinuum generation** [11264-71]
- 11264 1Z **Supermode supercontinuum generation in the cladding of a photonic crystal fiber** [11264-72]
- 11264 20 **Modeling of intermodal couplings in large-mode area Yb-doped double-cladding fibers applied in continuous-wave high power fiber lasers** [11264-73]
- 11264 22 **LBO grown crystals habitus modification by the heat field configuration** [11264-76]

- 11264 23 **Nonlinear cross-polarization generation of optical wave propagating through a nanorods-based hyperbolic metamaterial** [11264-77]
- 11264 25 **Tunable, CW visible laser sources by frequency doubling of broadly tunable Raman fiber lasers** [11264-79]
- 11264 26 **Cascaded nonlinearity influence to high power femtosecond optical parametric oscillator** [11264-81]

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.

- | | |
|-------------------------------|----------------------------|
| A.S., Ashik, 1A | Fedorov, Vladimir, 07 |
| Ahmadi, Peyman, 14 | Fermann, Martin E., 04 |
| Aparanji, Santosh, 1M, 25 | Flemens, Noah, 0B |
| Arun, S., 25 | Forster, Patrick, 0H |
| Aschaffenburg, Daniel, 14 | Gapontsev, Valentin, 07 |
| Babin, Sergey A., 1J | Gehlot, Vatsal, 25 |
| Bae, In Ho, 0E | Ghosh, Amar N., 09 |
| Bai, Yusi, 1K | Godard, A., 1B |
| Barnakov, Yury, 07 | Godet, Adrien, 1F |
| Bartulevicius, Tadas, 1Q | Golz, T., 15 |
| Baselt, Tobias, 1Z | Grguraš, I., 15 |
| Batjargal, Orkhongua, 0C | Guha, Shekhar, 0X |
| Beugnot, Jean-Charles, 1F, 1L | Guo, Cheng, 1U |
| Bi, Wanjun, 1Y | Hartmann, Peter, 1Z |
| Bouhadida, Maha, 1L | Hastings, Michael, 0Y |
| Bourdon, P., 1B | Hauden, Martin, 1F |
| Brilland, Laurent, 09 | Heiner, Zsuzsanna, 0F |
| Buranasiri, Prathan, 23 | Hong, Kee Suk, 0E |
| Buret, Camille, 1F | Hsu, Chen-Shao, 12 |
| Buß, J. H., 15 | Huo, Nan, 1U |
| Caillaud, Céline, 09 | Huss, Guillaume, 09 |
| Cankaya, Huseyin, 16 | Inafune, K., 1R |
| Caprara, Andrea, 14 | Jacob, Jim, 1N |
| Carpenter, Amelia, 0X | Joulain, Franck, 09 |
| Cha, Myoungsik, 0E | Kablukov, Sergey I., 1J |
| Chahal, Radwan, 09 | Kärtner, Franz X., 16 |
| Chen, Chih-Rong, 12 | Kato, Kiyoshi, 1N, 1W |
| Chi, San-Hui, 0X | Kieleck, Christelle, 0H |
| Chou, Ming-Hsien, 12 | Kießling, Jens, 1D |
| Chowdhury, Enam, 0Y | Kieu, Khanh, 0C |
| Chrétien, Jacques, 1F | Kim, Byoung Joo, 0E |
| Chtouki, R., 1B | Kim, Deok Woo, 0E |
| Chyka, Michał, 13 | Kishimoto, T., 1R |
| Cozic, Solenn, 09 | Kokh, Alexander, 22 |
| Creeden, Daniel, 14 | Kokh, Dmitry, 22 |
| Cromey, Benjamin, 0C | Kolesík, Miroslav, 0Y |
| Crystal, Sean, 0C | Kononova, Nadegda, 22 |
| Cui, Liang, 1U | Kroh, Tobias, 16 |
| Danilevicius, Rokas, 1Q | Kubeček, Václav, 13 |
| Delaye, Philippe, 1L | Kühnemann, Frank, 1D |
| Demirbas, Umit, 16 | Kuznetsov, Aleksey G., 1J |
| Ding, Xiaoyue, 0B | Lai, Jui-Yu, 12 |
| Dontsova, Ekaterina I., 1J | Lasagni, Andrés Fabián, 1Z |
| Duda, Martin, 13 | Lebrun, Sylvie, 1L |
| Dudley, John, 09 | Lee, Dong Hoon, 0E |
| Durécu, A., 1B | Lee, Kevin F., 04 |
| Eichhorn, Marc, 0H | Li, Xiaoying, 1U |
| Ensley, Trenton, 0Y | Li, Yu, 1Y |
| Evmenova, Ekaterina A., 1J | Liao, Meisong, 1Y |

- Lin, Weixuan, 20
 Lindner, Chiara, 1D
 Liu, Yinyao, 1Y
 Lombard, L., 1B
 Madeikis, Karolis, 1Q
 Marcus, Gilad, 1I
 Martynaitis, G., 26
 Martyshkin, Dmitry, 07
 Matlis, Nicholas H., 16
 Matsumoto, Morio, 1T
 Meneghetti, Marcello, 09
 Mero, Mark, 0F
 Michailovas, Andrejus, 1Q
 Minelly, John, 14
 Mirov, Mike, 07
 Mirov, Sergey, 07
 Miyata, Kentaro, 1W
 Mocek, Tomáš, 13
 Mokan, Vadim, 14
 Moloney, Jerome, 0Y
 Moses, Jeffrey, 0B
 Moskalev, Igor, 07
 Murai, H., 1R
 Muraviev, Andrey, 07
 Naheur, Rotem, 1I
 Nair, Divya, 06
 Nelsen, Bryan, 1Z
 Nguyen, Hoa Phuoc Trung, 0A, 1T
 Nikolov, Ivaylo, 14
 Noach, Salman, 1I
 Novák, Ondřej, 13
 Ogawa, Y., 1R
 Ohishi, Yasutake, 0A, 1T, 1Y
 Okamoto, Takayuki, 1N
 Pavan Kumar, CH. S. S., 0E
 Pedersen, C., 1A
 Peppers, Jeremy, 07
 Perez, Eytan, 1I
 Pergament, Mikhail, 16
 Petrov, Georgi I., 0G
 Petrov, Valentin, 0F, 1W
 Phan Huy, Kien, 1F, 1L
 Planchat, C., 1B
 Poulain, Samuel, 09
 Prakash, Roopa, 06, 1M
 Prandolini, M. J., 15
 Qin, Yukun, 0C
 Raybaut, M., 1B
 Riedel, R., 15
 Rochette, Martin, 09, 20
 Rohwer, Timm, 16
 Romano, Clément, 0H
 Saini, Than Singh, 0A, 1T
 Sakai, Goichi, 1T
 Sasaki, H., 1R
 Schulz, M., 15
 Schunemann, Peter G., 04, 07, 0X
 Schweinsberg, Aaron, 0Y
 Sekine, N., 1R
 Selvaraja, Shankar Kumar, 06
 Shu, Qi-Ze, 14
 Smolski, Viktor, 07
 Smrž, Martin, 13
 Spinelli, Luis, 14
 Stasevičius, Ignas, 26
 St-Hilaire, François, 09
 Suliman, Neria, 1I
 Supradeepa, V. R., 06, 1M, 25
 Suzuki, Takenobu, 0A, 1T
 Sylvestre, Thibaut, 09, 1F
 Taudt, Christopher, 1Z
 Tidemand-Lichtenberg, P., 1A
 Tripepi, Michael, 0Y
 Troles, Johann, 09
 Tuan, Tong Hoang, 0A, 1T
 Umemura, Nobuhiro, 1N
 Underwood, Mitchell, 14
 Vainio, Markku, 19
 Valenzuela, Anthony, 0Y
 Vanderhoef, Laura, 0Y
 Vasilyev, Michael, 1U
 Vasilyev, Sergey, 07
 Venck, Sébastien, 09
 Vengris, Mikas, 26
 Veselis, Laurynas, 1Q
 Vikram, B. S., 06, 1M
 Vlezko, Vasily, 22
 Vodopyanov, Konstantin, 07
 Wang, Lu, 16
 Wang, Xinbing, 1K
 Wicharn, Surawut, 23
 Wolf, Sebastian, 1D
 Wolfe, Christopher, 0Y
 Wu, Dong-Yi, 12
 Wu, Karin, 12
 Xing, Luo, 0A, 1T
 Xiong, Dongsheng, 1K
 Xue, Tianfeng, 1Y
 Yakovlev, Vladislav V., 0G
 Zaukevicius, Audrius, 1Q
 Zawilski, Kevin T., 07, 0X
 Zhang, Long, 1Y
 Zhang, Renli, 1Y
 Zhang, Zhenzhen, 1U
 Zuo, Duluo, 1K

Conference Committee

Symposium Chairs

Beat Neuenschwander, Berner Fachhochschule Technik und Informatik (Switzerland)
Xianfan Xu, Purdue University (United States)

Symposium Co-chairs

Craig B. Arnold, Princeton University (United States)
Takunori Taira, Institute for Molecular Science (Japan)

Program Track Chairs

Vladimir Ilchenko, GM Cruise LLC (United States)
Paul O. Leisher, Lawrence Livermore National Laboratory (United States)

Conference Chairs

Peter G. Schunemann, BAE Systems (United States)
Kenneth L. Schepler, CREOL, The College of Optics and Photonics, University of Central Florida (United States)

Conference Program Committee

Darrell J. Armstrong, Sandia National Laboratories (United States)
Carlota Canalias, KTH Royal Institute of Technology (Sweden)
Shekhar Guha, Air Force Research Laboratory (United States)
Rita D. Peterson, Air Force Research Laboratory (United States)
Valentin Petrov, Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie (Germany)
Christopher R. Phillips, ETH Zurich (Switzerland)
Chaitanya Kumar Suddapalli, ICFO - Institut de Ciències Fotòniques (Spain)
Konstantin L. Vodopyanov, CREOL, The College of Optics and Photonics, University of Central Florida (United States)
Vladislav V. Yakovlev, Texas A&M University (United States)

Session Chairs

- 1 Frequency Combs
Peter G. Schunemann, BAE Systems (United States)

- 2 Supercontinuum Generation
Valentin Petrov, Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie (Germany)
- 3 Optical Parametric Devices and Applications I
Darrell J. Armstrong, Sandia National Laboratories (United States)
- 4 Infrared Generation
Shekhar Guha, Air Force Research Laboratory (United States)
- 5 Nonlinear Waveguide Devices
Shekhar Guha, Air Force Research Laboratory (United States)
- 6 New Concepts of Nonlinear Optics
Valentin Petrov, Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie (Germany)
- 7 New Nonlinear Materials
Rita D. Peterson, Air Force Research Laboratory (United States)
- 8 Visible-UV Generation
Darrell J. Armstrong, Sandia National Laboratories (United States)
- 9 THz Generation and Detection
Peter G. Schunemann, BAE Systems (United States)
- 10 Optical Parametric Devices and Applications II
Rita D. Peterson, Air Force Research Laboratory (United States)
- 11 Stimulated Raman and Brillouin Processes
Vladislav V. Yakovlev, Texas A&M University (United States)