

PROCEEDINGS OF SPIE

Solid State Lasers XXIX: Technology and Devices

W. Andrew Clarkson
Ramesh K. Shori
Editors

4–6 February 2020
San Francisco, California, United States

Sponsored and Published by
SPIE

Volume 11259

Proceedings of SPIE 0277-786X, V. 11259

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

Solid State Lasers XXIX: Technology and Devices, edited by W. Andrew Clarkson,
Ramesh K. Shori, Proc. of SPIE Vol. 11259, 1125901 · © 2020 SPIE
CCC code: 0277-786X/20/\$21 · doi: 10.1117/12.2569742

Proc. of SPIE Vol. 11259 1125901-1

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 SPIDigitalLibrary.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 *Solid State Lasers XXIX: Technology and Devices*, edited by W. Andrew Clarkson, Ramesh K. Shori, Proceedings of SPIE Vol. 11259 (SPIE, Bellingham, WA, 2020) Seven-digit Article CID Number.

ISSN: 0277-786X
ISSN: 1996-756X (electronic)

ISBN: 9781510632813
ISBN: 9781510632820 (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.

**SPIE. DIGITAL
LIBRARY**

SPIDigitalLibrary.org

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*

EYE SAFE AND MID-IR LASERS I

- 11259 02 **1.34 μm Nd:YVO₄ laser passively Q-switched by V:YAG and optimized for lidar** [11259-1]
11259 05 **1.7 μm diode-pumped Tm:GGAG and Tm, Ho:GGAG 2-2.1 μm laser** [11259-4]
11259 06 **Passively Q-switched 10 mJ Tm:YLF laser with efficient OPO conversion to mid-IR** [11259-5]
11259 07 **Compact 12mJ mid-IR pulsed source using an intracavity KTA OPO followed by a CSP OPA**
[11259-6]

EYE SAFE AND MID-IR LASERS II

- 11259 0C **Crystal host engineering for transition metal lasers** [11259-11]

STRUCTURED BEAMS

- 11259 0E **Q-switched vortex laser using a Sagnac interferometer as an output coupler** [11259-13]
11259 0G **Diode-pumped Yb:CALGO laser with conical refraction output** [11259-15]
11259 0H **High purity twisted light from a metasurface solid state resonator** [11259-16]

NOVEL LASER CONCEPTS

- 11259 0J **Narrow linewidth tunable and dual wavelength compact Alexandrite laser** [11259-18]
11259 0K **Nd:YLF/KGW intracavity Raman laser in DBMC configuration emitting at 1147 and 1163 nm in TEM₀₀** [11259-19]

PULSED LASERS I

- 11259 0N **Scalable amplification with a high gain x energy product at room temperature using a thick slab of Yb³⁺:YAG** [11259-22]
- 11259 0P **Passively Q-switched Nd:YVO₄ laser operating at 914 nm** [11259-24]
- 11259 0Q **Ultra-compact >100kHz Q-switched Alexandrite lasers** [11259-25]

PULSED LASERS II

- 11259 0T **Fiber-coupled high-power diode-pumped solid-state lasers for laser cleaning** [11259-28]
- 11259 0U **A fiber/solid-state hybrid laser system for ion beam control in a particle accelerator** [11259-29]
- 11259 0W **High average power passively Q-switched Yb:YAG micro-laser** [11259-31]
- 11259 0Y **Active pulse underwater vision system** [11259-33]

LASER MATERIAL CHARACTERIZATION I

- 11259 0Z **Yb concentration influence of on thermal lensing in Yb:LuAG and Yb:YAG lasers at cryogenic temperatures: modeling and experimental study** [11259-34]
- 11259 10 **Efficient laser operation of Yb:Lu₃Al₅O₁₂ transparent ceramics fabricated from laser ablated nanopowders** [11259-35]
- 11259 11 **Growth, spectroscopy and laser operation of Yb³⁺, Na⁺/Li⁺-codoped CNGG-type garnets promising for ultrafast lasers** [11259-36]

LASER MATERIAL CHARACTERIZATION II

- 11259 13 **Recent progress in mechanically Q-switched 2.94 μm Er:YAG – promising pump source for 4-μm room temperature Fe:ZnSe lasers** [11259-78]
- 11259 15 **Time-gated measurements of fusion-class laser beam profiles** [11259-39]
- 11259 17 **Spatially resolved B-integral measurements on the NIF laser** [11259-41]
- 11259 18 **Precision diagnostic system enhancements and recommissioning for advanced laser beam characterization at the National Ignition Facility** [11259-42]

- 11259 19 **Tunable Cr²⁺,Fe²⁺:Zn_{1-x}Mn_xSe (x = 0.05) and (x = 0.3) lasers around 4.4 μm at 78 K pumped by a 1.94 μm Tm: fiber laser via Cr²⁺ → Fe²⁺ energy transfer [11259-43]**
- 11259 1A **Spectroscopic characterization of Fe:ZnAl₂O₄, Fe:MgAl₂O₄ and Fe:InP crystals for mid-IR laser applications [11259-44]**

ULTRAFAST LASERS I

- 11259 1F **Femtosecond 100 W-level OPCPAs from near-IR to short-wave-IR wavelengths [11259-49]**

ULTRAFAST LASERS II

- 11259 1H **Operation of a novel, dual function thin slab ultrafast amplifier at 1030nm, 515nm and 343nm [11259-51]**
- 11259 1I **0.5 terawatt laser based on a hybrid architecture for high energy diode-pumped lasers delivering sub-500 fs pulses [11259-52]**
- 11259 1J **10 petawatt lasers for extreme light applications [11259-53]**
- 11259 1K **High temporal contrast, diode pumped, femtosecond laser providing 200fs, 1053nm pulses for seeding large scale Nd:glass laser systems [11259-54]**
- 11259 1L **High power CEP-stable OPCPA at 800nm [11259-55]**

UV-VIS LASERS

- 11259 1M **2 kW cw laser in the green wavelength regime for copper welding (Invited Paper) [11259-56]**
- 11259 1O **Multiple and selectable wavelength green laser generation based on coaxial diode-end-pumping [11259-58]**
- 11259 1P **High efficiency gallium nitride laser diode pumped CW ruby laser [11259-59]**

POSTER SESSION

- 11259 1Q **Temperature influence on Er:GGAG crystal spectroscopic properties and its lasing at 3 μm [11259-60]**
- 11259 1R **Efficient composite Nd:YVO/Nd:GVO laser with in-band pumping [11259-61]**
- 11259 1S **Dual-wavelength Yb:CALGO laser with wavelength spacing tunability [11259-62]**

- 11259 1T **Performance of diode-pumped Yb:YAP lasers with different crystal orientations** [11259-63]
- 11259 1U **Generation of THz frequency offset with dual-wavelength Yb:KGW laser** [11259-64]
- 11259 1V **Simplified cavity design for KLM Ti:sapphire oscillators** [11259-65]
- 11259 1W **Thermal lensing in diode-pumped Yb:CALGO and Yb:KGW lasers** [11259-66]
- 11259 1X **Programmable, pulse shaped diode laser** [11259-67]
- 11259 21 **Samarium-doping concentration influence on spectroscopic parameters of Sm:YAG crystal** [11259-71]
- 11259 23 **Fe:ZnMnTe laser generating around 5 μm at 78 K** [11259-73]
- 11259 25 **Generation of 40 W, 400 fs pulses at 1 MHz repetition rate from efficient, room temperature Yb:YAG double-pass amplifier seeded by fiber CPA system** [11259-75]
- 11259 27 **Multi-watt continuous-wave and passively Q-switched Tm:CaYAlO₄ micro-lasers** [11259-77]
- 11259 28 **Laser spectroscopic and saturation properties of GR1 centers in synthetic diamond** [11259-79]
- 11259 29 **73-fs SESAM mode-locked Tm,Ho:CNGG laser at 2061 nm** [11259-80]
- 11259 2D **Spectral density contrast in DPSS and ECD lasers for quantum and other narrow-linewidth applications** [11259-84]

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.

Aguiló, Magdalena, 10, 11, 27
Akbari, R., 0G, 1S, 1T, 1U, 1V, 1W
Ambrosio, Antonio, 0H
Bae, Ji Eun, 27
Balabanov, Stanislav, 1A
Baleanu, A., 1J
Banici, R., 1J
Bartulevicius, T., 25
Basyrova, Liza, 10
Baumann, Frank, 1M
Belyaev, Alexander, 1A
Berry, Patrick A., 0C
Birch, Rolf B., 1H
Birkin, David, 1H
BisCh, Stefanie, 1M
Boháček, Pavel, 05, 1Q
Boudjemaa, L., 1J
Boulet, Johan, 0N
Brisset, Jean-Gabriel, 11
Brockmann, Rüdiger, 1M
Buß, J. H., 1F, 1L
Cai, Huaqiang, 11
Caldararu, C., 1J
Camy, Patrice, 11
Capasso, Federico, 0H
Casagrande, O., 1J
Čech, Miroslav, 19
Chalus, O., 1J
Chen, Mengting, 27
Chen, Weidong, 29
Chen, Zhenqiang, 27
Chinn, Stephen R., 0W
Cohen, S. J., 15, 17, 18
Cole, Brian, 06, 07
Cook, Gary, 0C
Courjaud, Antoine, 11
Coyne, Bryce K., 1A
Dai, Shibo, 27
Dai, Xiaojun, 11
Damzen, Michael J., 0E, 0J, 0Q
Dancus, I., 1J
De Boisdeffre, B., 1J
Dekorsy, Thomas, 0P
Derycke, C., 1J
Di Nicola, J. M., 15, 17, 18
Díaz, Francesc, 10, 11, 27
Dold, Eva-Maria, 1M
Doroshenko, Maxim E., 19, 23
Durand, Magali, 11
Erdmann, Rainer, 1X
Erickson, M. A., 15, 17, 18
Evans, Jonathan W., 0C
Fedorov, Vladimir, 13, 1A, 28
Fedorova, K. A., 0G
Ferreira, Marilyn S., 0K
Fey, Paul, 1X
Fibrich, Martin, 05
Folta, J. A., 15, 17, 18
Forbes, Andrew, 0H
Fulford, Benjamin, 1H
Gavory, Bastien, 11
Geberbauer, Jan Willem T., 0E
Ghenuche, P., 1J
Ginis, Vincent, 0H
Goldberg, Lew, 06, 07, 0W
Golz, T., 1F, 1L
Gontier, Emilien, 11
Gottesman, N. S., 18
Gradinariu, A., 1J
Grguraš, I., 1F, 1L
Griebner, Uwe, 10, 11, 27, 29
Gruzevich, Y. K., 0Y
Guina, Mircea, 29
Handler, A. D., 15, 17, 18
Härkönen, Antti, 29
Harris, Thomas R., 0C
Havlák, Lubomír, 05, 1Q
Hays, Alan, 06, 0W
Huang, Yao-Wei, 0H
Hurd, E. R., 15
Jambunathan, Venkatesan, 27
Jelínek, Michal, 19, 23
Jelínková, Helena, 05, 0Z, 19, 1Q, 21, 23
Jolly, Alain, 0N
Jurek, Karel, 05, 1Q
Kaiser, Elke, 1M
Kane, Thomas J., 02
Kapitch, Nick, 21
Karki, Krishna, 13, 1A
Karpushko, F., 2D
Kerridge-Johns, William R., 0E
Khodakovskaia, M. S., 0Y
Khodakovskii, V. N., 0Y
Killi, Alexander, 1M
King, Vernon, 06
Kolliopoulos, G., 1J
Kopf, Daniel, 1K
Kovalenko, Nazar O., 19, 23

Kratochvíl, Jan, 05, 1Q
 Krupke, William F., 1P
 Kubeček, Václav, 19
 Kulcsar, Gabor, 1K
 Lanier, T. E., 15, 17, 18
 Lauritsen, Kristian, 1X
 Laux, S., 1J
 Leach, Jeffrey, 0W
 Lee, Jason R., 1H
 Liu, Kefei, 1O
 Liu, Yang, 1O
 Liu, Yun, 0U
 Loiko, Pavel, 10, 11, 1T, 1W, 27, 29
 Lucianetti, Antonio, 27
 Lureau, F., 1J
 Machinet, Guillaume, 0N
 Madeikis, K., 25
 Major, A., 0G, 1R, 1S, 1T, 1U, 1V, 1W, 27
 Maksimov, Roman, 10
 Markham, Matthew, 28
 Martyshkin, Dmitry, 13
 Mateos, Xavier, 10, 11, 27, 29
 Matras, G., 1J
 McCarthy, John C., 07
 McDaniel, Sean A., 0C
 McIntosh, Chris, 0W
 Michailovas, A., 25
 Mirov, Sergey, 13, 1A, 28
 Mocek, Tomas, 27
 Morbieu, T., 1J
 Nadimi, M., 1R
 Naegele, Marco, 0P
 Naidoo, Darryl, 0H
 Naziru, A., 1J
 Neagu, L., 1J
 Nejezchleb, Karel, 0Z, 21
 Němec, Michal, 05, 19, 1Q, 21
 Nettleton, John, 07
 Nikl, Martin, 05, 1Q
 Olejniczak, B. L., 15, 17
 Onyenekwu, C., 1R
 Ordoñez, M. E., 18
 Pan, Zhongben, 11, 29
 Park, Tae Gwan, 27
 Pask, Helen M., 0K
 Pellegrina, A., 1J
 Petrov, Valentin, 10, 11, 27, 29
 Pomeranz, Leonard A., 07
 Prandolini, M. J., 1F, 1L
 Pricking, Sebastian, 1M
 Qiao, Hongzhan, 1O
 Qiu, Cheng-Wei, 0H
 Radier, C., 1J
 Rafailov, E. U., 0G
 Rakhman, Abdurahim, 0U
 Ren, Yuan, 0T
 Rey, G., 1J
 Reza, Md. A. R., 0G, 1S
 Ricaud, S., 1J
 Ridderbusch, Heiko, 0P
 Riedel, Robert, 1F, 1L
 Říha, Adam, 19, 23
 Rotermund, Fabian, 27
 Saci, Abdelhak, 1I
 Schepler, Kenneth L., 0C
 Schönau, Thomas, 1X
 Schranz, Erdal, 1K
 Schulz, M., 1F, 1L
 Schunemann, Peter G., 07
 Sephton, Bereneice, 0H
 Serres, Josep Maria, 10, 11, 27
 Sevillano, Pierre, 1I
 Sheng, Quan, 1O
 Shitov, Vladislav, 1O
 Simon-Boisson, C., 1J
 Smolski, Viktor, 1A
 Sokolovskii, G. S., 0G
 Sroor, Hend, 0H
 Stites, Ronald W., 0C
 Stoppel, Klaus, 0P
 Subedi, Shova, 13, 1A, 28
 Šulc, Jan, 05, 0Z, 1Q, 21, 23
 Suomalainen, Soile, 29
 Švejkar, Richard, 1Q
 Szutor, B., 2D
 Tate, T. H., 15
 Tawy, Goronwy, 0J, 0Q
 Terzin, Igor S., 19, 23
 Trunda, Bohumil, 05, 1Q
 Ursescu, D., 1J
 Vallés, Adam, 0H
 Veselis, L., 25
 Veselský, Karel, 0Z
 Vyhídal, David, 23
 Wang, Li, 29
 Wang, Yicheng, 11, 29
 Wang, Yong, 0T
 Wegner, P. J., 15, 17, 18
 Wetter, Niklaus U., 0K
 Widmayer, C., 15, 17
 Williams, W., 17
 Xu, Degang, 1O
 Xu, J., 1T
 Xu, Jun, 27
 Xu, Xiaodong, 1T, 27
 Yang, Dewang, 0T
 Yang, S. T., 15, 17, 18
 Yao, Jianquan, 1O
 Yuan, Hualei, 1I
 Yue, Fangxin, 27
 Zaske, Sebastian, 1M
 Zavadilová, Alena, 21
 Zawilski, Kevin T., 07
 Zhan, Qiwen, 0H
 Zhao, Yongguang, 29
 Zhong, Kai, 1O
 Zweiback, Jason, 1P

Conference Committee

Symposium Chairs

Beat Neuenschwander, Berner Fachhochschule Technik und Informatik (Switzerland)
Xianfan Xu, Purdue University (United States)
Craig B. Arnold, Princeton University (United States)
Takunori Taira, Institute for Molecular Science (Japan)

Symposium Co-chairs

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

Program Track Chairs

Kunihiko Washio, Paradigm Laser Research Ltd. (Japan)
John Ballato, Clemson University (United States)

Conference Chairs

W. Andrew Clarkson, University of Southampton (United Kingdom)
Ramesh K. Shori, SPAWAR Systems Center (United States)

Conference Program Committee

Gary Cook, Air Force Research Laboratory (United States)
Dennis G. Harris, Dennis Harris Associates (United States)
Helena Jelínková, Czech Technical University in Prague (Czech Republic)
Christian Kränkel, Leibniz-Institut für Kristallzüchtung (Germany)
Jacob I. Mackenzie, University of Southampton (United Kingdom)
Markus Pollnau, University of Surrey (United Kingdom)
Narasimha S. Prasad, NASA Langley Research Center (United States)
Bojan Resan, Fachhochschule NordWestschweiz (Switzerland)
Nikolay E. Ter-Gabrielyan, U.S. Army Research Laboratory (United States)

Session Chairs

- 1 Eye Safe and Mid-IR Lasers I
Ramesh K. Shori, Naval Information Warfare Center Pacific (United States)

- 2 Eye Safe and Mid-IR Lasers II
Ramesh K. Shori, Naval Information Warfare Center Pacific
(United States)
- 3 Structured Beams
Dennis G. Harris, Dennis Harris Associates (United States)
- 4 Novel Laser Concepts
Narasimha S. Prasad, NASA Langley Research Center (United States)
- 5 Pulsed Lasers I
W. Andrew Clarkson, Optoelectronics Research Center
(United Kingdom)
- 6 Pulsed Lasers II
W. Andrew Clarkson, Optoelectronics Research Center
(United Kingdom)
- 7 Laser Material Characterization I
Nikolay E. Ter-Gabrielyan, U.S. Army Combat Capabilities
Development Command (United States)
- 8 Laser Material Characterization II
Nikolay E. Ter-Gabrielyan, U.S. Army Combat Capabilities
Development Command (United States)
- 9 Ultrafast Lasers I
W. Andrew Clarkson, Optoelectronics Research Center
(United Kingdom)
- 10 Ultrafast Lasers II
Helena Jelínková, Czech Technical University in Prague
(Czech Republic)
- 11 UV-VIS Lasers
Helena Jelínková, Czech Technical University in Prague
(Czech Republic)