

PROCEEDINGS OF SPIE

Fiber Lasers XX: Technology and Systems

V. R. Supradeepa
Editor

30 January – 2 February 2023
San Francisco, California, United States

Sponsored by
SPIE

Cosponsored by
NKT Photonics A/S (Denmark)
Active Fiber Systems GmbH (Germany)

Published by
SPIE

Volume 12400

Proceedings of SPIE 0277-786X, V. 12400

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

Fiber Lasers XX: Technology and Systems, edited by V. R. Supradeepa, Proc. of SPIE
Vol. 12400, 1240001 · © 2023 SPIE · 0277-786X · doi: 10.1117/12.2676986

Proc. of SPIE Vol. 12400 1240001-1

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 *Fiber Lasers XX: Technology and Systems*, edited by V. R. Supradeepa, Clémence Jollivet, Proc. of SPIE 12400, Seven-digit Article CID Number (DD/MM/YYYY); (DOI URL).

ISSN: 0277-786X

ISSN: 1996-756X (electronic)

ISBN: 9781510659056

ISBN: 9781510659063 (electronic)

Published by

SPIE

P.O. Box 10, Bellingham, Washington 98227-0010 USA

Telephone +1 360 676 3290 (Pacific Time)

SPIE.org

Copyright © 2023 Society of Photo-Optical Instrumentation Engineers (SPIE).

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 fees. To obtain permission to use and share articles in this volume, visit Copyright Clearance Center 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.

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: A unique citation identifier (CID) number is assigned to each article in the Proceedings of SPIE 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 *Conference Committee*

POWER SCALING OF FIBER LASERS AND AMPLIFIERS

- 12400 02 **5 kW single-mode output power from Yb-doped fibers with increased higher-order mode loss (Invited Paper)** [12400-1]
- 12400 03 **Performance of 915 nm pumped LMA Yb fiber designs for long-term reliable multi-kilowatt operation** [12400-2]
- 12400 05 **Recent progress of high-power single-frequency all-fiber oscillators and amplifiers (Invited Paper)** [12400-6]
- 12400 06 **700W single-frequency all-fiber amplifier** [12400-5]

THULIUM AND HOLMIUM DOPED FIBER LASERS AND AMPLIFIERS I

- 12400 08 **High efficiency of a holmium doped fiber laser in clad-pump configuration** [12400-7]
- 12400 09 **Short-wavelength-band tunable high-power Tm-doped fiber laser** [12400-8]
- 12400 0A **The effect of temperature dependence of thulium cross sections on thulium-doped fiber laser operation** [12400-9]

POWER COMBINING OF FIBER LASERS I

- 12400 0C **Deep-learning applied to coherent combining of fiber lasers: from numerical modelling to experimental demonstration** [12400-11]
- 12400 0E **188 W average power coherently combined Tm-doped fiber laser system delivering ultrashort pulses with 1.86 mJ energy** [12400-13]

POWER COMBINING OF FIBER LASERS II

- 12400 0G **Optimisation of coherent beam combination using deep learning (Invited Paper)** [12400-15]
- 12400 0H **4kW single-mode narrow-linewidth ytterbium fiber amplifier in all-fiber format and modular package** [12400-16]

THULIUM AND HOLMIUM DOPED FIBER LASERS AND AMPLIFIERS II

- 12400 OJ **Thulium- and holmium-doped high stability fiber amplifiers at 2 μm for next generation gravitational wave detectors** [12400-18]
- 12400 ON **Highly efficient, in-band pumped thulium-doped fibers for high-power ultrafast 2 μm wavelength laser systems** [12400-22]

MODAL INSTABILITY I

- 12400 OO **Fitting of a transverse mode instability model to experimental data** [12400-23]
- 12400 OQ **STRS and TMI effects in high power fiber amplifiers** [12400-25]
- 12400 OR **Transverse modal instability in two-mode fiber amplifiers: effect of input mode** [12400-26]

MODAL INSTABILITY II

- 12400 OS **Characterizing the transverse modes of optical fibers by singular value decomposition** [12400-27]
- 12400 OU **Mitigation of transverse mode instability in large mode area polarization maintaining fibers** [12400-29]
- 12400 OV **Photonic lantern based real-time modal instability diagnostic tool for high power fiber lasers** [12400-30]
- 12400 OW **The impact of core size scaling on the transverse mode instability threshold in fiber laser amplifiers** [12400-31]

NOVEL FIBER DESIGN AND MATERIALS I

- 12400 OX **All-solid antiresonant fiber design with hybrid light guidance mechanism** [12400-32]
- 12400 OY **49-core rod-type ytterbium-doped multicore fiber for high power operation (Invited Paper)** [12400-33]
- 12400 OZ **Optical core-to-core crosstalk in rod-type multicore fibers** [12400-34]

NOVEL FIBER DESIGN AND MATERIALS II

- 12400 10 **Gas-filled hollow-core fiber lasers for gas spectroscopy and imaging (Invited Paper)** [12400-48]
- 12400 11 **The impact of structural birefringence in multicore fibers** [12400-35]
- 12400 12 **Crystal-derived double-clad fibers for high gain and high efficiency Tm fiber lasers** [12400-36]
- 12400 13 **Analysis and fabrication of tapered multicore gain fibers for high power lasers** [12400-37]
- 12400 14 **Novel 30/400 ytterbium-doped LMA polarization-maintaining fiber with very efficient higher-order modes filtering capabilities** [12400-38]

HIGH PEAK POWER AND ULTRAFAST FIBER LASERS I

- 12400 16 **132 W, 1.3 mJ, sub-two-cycle pulses at 1.8 μm wavelength (Invited Paper)** [12400-40]
- 12400 18 **35/250 ytterbium-doped LMA polarization-maintaining fiber for high average and high peak power amplifiers** [12400-42]

HIGH PEAK POWER AND ULTRAFAST FIBER LASERS II

- 12400 19 **Spectral peak generation using ultrashort pulse fiber lasers (Invited Paper)** [12400-43]
- 12400 1A **0.6 mJ single-frequency pulsed fiber amplifier based on hybrid active fiber** [12400-44]
- 12400 1C **Radially polarized picosecond MOPA system based on double-clad ytterbium-doped spun tapered fiber with ring-shaped active core** [12400-46]
- 12400 1D **Polarization-multiplexed thulium-doped fiber laser for free-running dual-comb generation** [12400-47]

NOVEL FIBER LASERS AND AMPLIFIERS I

- 12400 1E **Long term, stable, 115W output from an erbium fiber amplifier pumped by a Raman fiber laser** [12400-49]

NOVEL FIBER LASERS AND AMPLIFIERS II

- 12400 1G **Spectral mitosis of the Stokes tone generated by two-tone pumped stimulated Brillouin scattering using a completely spectrally resolved model** [12400-51]
- 12400 1H **Highly stable fiber amplifier development and environmental component-testing for the space-based gravitational wave detector LISA** [12400-52]
- 12400 1I **900 nm swept source FDML laser with kW peak power** [12400-53]

POSTER SESSION

- 12400 1J **6.5 nJ, 20 MHz compact SESAM-free all-PM ultra-short pulse fiber seed laser pumped by a single butterfly laser-diode** [12400-54]
- 12400 1K **Experimental study of a F8L using an automated adjustment system based in polarization control plates** [12400-55]
- 12400 1L **1.5-kW narrow-linewidth FBG-based MOPA configuration fiber laser emitting at 1105 nm** [12400-56]
- 12400 1N **All-polarization-maintaining Yb-doped fiber oscillator with a hybrid ring-linear cavity of net anomalous dispersion** [12400-58]
- 12400 1O **Low ASE Er-Yb laser with single amplification stage** [12400-59]
- 12400 1Q **Multi-pass cell contrast improvement with enhanced frequency chirping** [12400-61]
- 12400 1R **Polarization-maintaining large-mode-area solid-core anti-resonant fiber at 1064 nm** [12400-62]
- 12400 1S **Reliable high-power erbium ytterbium codoped fiber amplifier for earth-satellite communications** [12400-63]
- 12400 1U **Modeling and simulation of crystalline fiber amplifiers** [12400-65]

Conference Committee

Symposium Chairs

Stefan Kaierle, Laser Zentrum Hannover e.V. (Germany)
John M. Ballato, Clemson University (United States)

Symposium Co-chairs

Craig B. Arnold, Princeton University (United States)
Takunori Taira, RIKEN/IMS (Japan)

Program Track Chairs

Akihiko Kasukawa, Furukawa Electric Co. (Japan)
Stuart D. Jackson, Macquarie University (Australia)

Conference Chair

V. R. Supradeepa, Center for Nano Science and Engineering (CeNSE)
(India)

Conference Co-chair

Clémence Jollivet, Coherent | Nufern (United States)

Conference Program Committee

Adrian L. Carter, Coherent | Nufern (Australia)
Fabio Di Teodoro, Raytheon Company (United States)
Mark Dubinskii, DEVCOM Army Research Laboratory (United States)
Heike Ebendorff-Heidepriem, The University of Adelaide (Australia)
Angel Flores, Air Force Research Laboratory (United States)
Gregory D. Goodno, Northrop Grumman Corporation (United States)
Ingmar Hartl, Deutsches Elektronen-Synchrotron (Germany)
Thomas W. Hawkins, Clemson University (United States)
Clifford Headley III, Leonardo Electronics US Inc. (United States)
Stuart D. Jackson, Macquarie University (Australia)
César Jáuregui-Misas, Friedrich-Schiller-Univ. Jena (Germany)
Manoj Kanskar, nLIGHT, Inc. (United States)
Martin Dybendal Maack, NKT Photonics A/S (Denmark)
Peter F. Moulton, MIT Lincoln Laboratory (United States)
Martin H. Muendel, Lumentum (United States)
Jeffrey W. Nicholson, OFS Fitel, LLC (United States)
Philippe Roy, XLIM (France)

Bryce N. Samson, IPG Photonics Corporation (United States)
Matthias Savage-Leuchs, Lockheed Martin Aculight Corporation
(United States)
Thomas Schreiber, Fraunhofer-Institut für Angewandte Optik und
Feinmechanik IOF (Germany)
Benedikt Schuhbauer, Laser Zentrum Hannover e.V. (Germany)
Lawrence Shah, Luminar Technologies, Inc. (United States)
L. Brandon Shaw, U.S. Naval Research Laboratory (United States)
Wei Shi, Tianjin University (China)
Paul Steinvurzel, The Aerospace Corporation (United States)
Pu Wang, Beijing University of Technology (China)
Michalis N. Zervas, Optoelectronics Research Center
(United Kingdom)
Pu Zhou, National University of Defense Technology (China)