PROCEEDINGS OF SPIE

SPIDigitalLibrary.org/conference-proceedings-of-spie

Front Matter: Volume 8606

, "Front Matter: Volume 8606," Proc. SPIE 8606, Vertical External Cavity Surface Emitting Lasers (VECSELs) III, 860601 (13 March 2013); doi: 10.1117/12.2025055

SPIE.

Event: SPIE LASE, 2013, San Francisco, California, United States

PROCEEDINGS OF SPIE

Vertical External Cavity Surface Emitting Lasers (VECSELs) III

Jennifer E. Hastie
Editor

3–5 February 2013
San Francisco, California, United States

Sponsored by
SPIE

Cosponsored by
Coherent, Inc. (United States)

Published by
SPIE

Volume 8606

Proceedings of SPIE 0277-786X, V.8606

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

Vertical External Cavity Surface Emitting Lasers (VECSELs) III, edited
by Jennifer E. Hastie, Proc. of SPIE Vol. 8606, 860601 · © 2013 SPIE
CCC code: 0277-786X/13/\$18 · doi: 10.1117/12.2025055

Proc. of SPIE Vol. 8606 860601-1

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 *Vertical External Cavity Surface Emitting Lasers (VECSELs) III*, edited by Jennifer E. Hastie, Proceedings of SPIE Vol. 8606 (SPIE, Bellingham, WA, 2013) Article CID Number.

ISSN: 0277-786X

ISBN: 9780819493750

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

SESSION 1 POWER SCALING I

- 8606 02 **Design of high-efficiency semiconductor disk lasers (Invited Paper)** [8606-1]
P. Unger, A. Hein, F. Demaria, S. Menzel, M. Rampp, A. Ziegler, Ulm Univ. (Germany)
- 8606 04 **High power (23W) vertical external cavity surface emitting laser emitting at 1180 nm (Invited Paper)** [8606-3]
T. Leinonen, S. Ranta, M. Tavast, Tampere Univ. of Technology (Finland); R. Epstein, G. Fetzer, Sandalphon, N. Van Lieu, Areté Associates (United States); M. Guina, Tampere Univ. of Technology (Finland)

SESSION 2 ULTRAFAST VECSELS I: HIGH AVERAGE POWER

- 8606 05 **Passively mode-locked femtosecond VECSELS with high average output power (Invited Paper)** [8606-4]
M. Scheller, A. Laurain, College of Optical Sciences, The Univ. of Arizona (United States); S. W. Koch, Philipps-Univ. Marburg (Germany); J. V. Moloney, College of Optical Sciences, The Univ. of Arizona (United States)
- 8606 06 **Characterization of nonlinear gain parameters in VECSELS to optimize femtosecond high average power operation (Invited Paper)** [8606-5]
M. Mangold, V. J. Wittwer, O. D. Sieber, M. Hoffmann, M. Golling, T. Südmeyer, U. Keller, ETH Zurich (Switzerland)
- 8606 07 **Towards VECSEL frequency combs (Invited Paper)** [8606-6]
K. G. Wilcox, Univ. of Southampton (United Kingdom)
- 8606 08 **Supercontinuum generation with femtosecond pulse fiber amplified VECSELS** [8606-7]
C. R. Head, H.-Y. Chan, J. S. Feehan, D. P. Shepherd, S. Alam, A. C. Tropper, J. H. V. Price, K. G. Wilcox, Univ. of Southampton (United Kingdom)

SESSION 3 INTRACAVITY TECHNIQUES

- 8606 0A **Intracavity-enhanced laser cooling of solids using high power VECSELS at 1020 nm (Invited Paper)** [8606-9]
M. Sheik-Bahae, M. Ghasemkhani, A. R. Albrecht, The Univ. of New Mexico (United States); D. V. Seletskiy, Univ. of Konstanz (Germany); J. G. Cederberg, Sandia National Lab. (United States); S. D. Melgaard, The Univ. of New Mexico (United States)

- 8606 0B **30W peak-power 3ns pulse-width operation of a 2 μ m electro-optically cavity-dumped VECSEL** [8606-10]
S. Kaspar, M. Rattunde, T. Töpper, S. Adler, U. T. Schwarz, C. Manz, K. Köhler, J. Wagner, Fraunhofer-Institut für Angewandte Festkörperphysik (Germany)

SESSION 4 SPECTRAL COVERAGE

- 8606 0D **Investigation of InAs quantum dashes for 1.45-2.1 μ m vertical external cavity surface emitting laser active regions** [8606-12]
T. J. Rotter, P. Ahirwar, D. M. Shima, S. J. Addamane, C. P. Hains, L. R. Dawson, G. Balakrishnan, The Univ. of New Mexico (United States)
- 8606 0E **TEM based analysis of III-Sb VECSELs on GaAs substrates for improved laser performance** [8606-13]
P. Ahirwar, D. Shima, T. J. Rotter, S. P. R. Clark, S. J. Addamane, C. P. Hains, L. R. Dawson, G. Balakrishnan, The Univ. of New Mexico (United States); R. Bedford, Air Force Research Lab. (United States); Y. Y. Lai, A. Laurain, J. Hader, J. V. Moloney, College of Optical Sciences, The Univ. of Arizona (United States)

SESSION 5 ELECTRICAL PUMPING AND DEVICE PACKAGING

- 8606 0F **Recent progress in wafer-fused VECSELs emitting in the 1310nm and 1550nm bands (Invited Paper)** [8606-14]
A. Sirbu, A. Caliman, A. Mereuta, K. Pierscinski, Ecole Polytechnique Fédérale de Lausanne (Switzerland); A. Rantamäki, J. Lyytikäinen, J. Rautiainen, Tampere Univ. of Technology (Finland); V. Iakovlev, N. Volet, Ecole Polytechnique Fédérale de Lausanne (Switzerland); O. Okhotnikov, Tampere Univ. of Technology (Finland); E. Kapon, Ecole Polytechnique Fédérale de Lausanne (Switzerland)
- 8606 0G **Passively modelocked electrically pumped VECSELs (Best Paper Award)** [8606-15]
C. A. Zaugg, W. P. Pallmann, M. Mangold, V. J. Wittwer, ETH Zurich (Switzerland); H. Moench, S. Gronenborn, Philips Technologie GmbH Photonics (Germany); M. Miller, Philips Technologie GmbH U-L-M Photonics (Germany); B. W. Tilma, T. Südmeyer, U. Keller, ETH Zurich (Switzerland)
- 8606 0H **Analysis of single-mode efficiency of electrically pumped VECSELs** [8606-16]
T. Schwarz, M. Berens, RWTH Aachen Univ. (Germany); S. Gronenborn, J. Kolb, Philips Technologie GmbH Photonics (Germany); P. Loosen, RWTH Aachen Univ. (Germany) and Fraunhofer-Institut für Lasertechnik (Germany); M. Miller, Philips Technologie GmbH U-L-M Photonics (Germany); H. Mönch, Philips Technologie GmbH Photonics (Germany); R. Wester, Fraunhofer-Institut für Lasertechnik (Germany)
- 8606 0I **Automated assembly of VECSEL components** [8606-17]
C. Brecher, N. Pyschny, S. Haag, T. Mueller, Fraunhofer-Institut für Produktionstechnologie (Germany)

SESSION 6 POWER SCALING II: THERMAL MANAGEMENT

- 8606 0L **Effects of cryogenic temperatures on the performance of CW VECSELs** [8606-20]
O. J. Morris, K. G. Wilcox, C. R. Head, A. P. Turnbull, Univ. of Southampton (United Kingdom);
I. Farrer, H. E. Beere, D. A. Ritchie, Univ. of Cambridge (United Kingdom); A. C. Tropper,
Univ. of Southampton (United Kingdom)

SESSION 7 ULTRAFast VECSELs II

- 8606 0M **Self mode locked OPSL: role of high-order modes in starting self-mode-locked operation (Invited Paper)** [8606-21]
H. C. Liang, Y. C. Lee, J. C. Tung, K. W. Su, Y. F. Chen, K. F. Huang, National Chiao Tung Univ. (Taiwan)
- 8606 0N **Advances in mode-locked semiconductor disk lasers (Invited Paper)** [8606-22]
L. Kornaszewski, N. Hempler, C. J. Hamilton, G. T. Maker, G. P. A. Malcolm, M Squared Lasers Ltd. (United Kingdom)
- 8606 0O **Generation of 200-fs pulses with a short microcavity VECSEL** [8606-23]
A. P. Turnbull, K. G. Wilcox, C. R. Head, O. J. Morris, Univ. of Southampton (United Kingdom);
I. Farrer, D. A. Ritchie, Univ. of Cambridge (United Kingdom); A. C. Tropper, Univ. of Southampton (United Kingdom)
- 8606 0P **Exploring spatio-temporal dynamics of an optically pumped semiconductor laser with intracavity second harmonic generation** [8606-24]
Y. C. Lee, H. C. Liang, J. C. Tung, K. W. Su, Y. F. Chen, K. F. Huang, National Chiao Tung Univ. (Taiwan)

SESSION 8 SINGLE FREQUENCY

- 8606 0Q **Noise properties of NIR and MIR VECSELs (Invited Paper)** [8606-25]
M. Myara, M. Sellahi, Institut d'Electronique du Sud, CNRS, Univ. Montpellier 2 (France);
A. Laurain, Institut d'Electronique du Sud, CNRS, Univ. Montpellier 2 (France) and College of Optical Sciences, The Univ. of Arizona (United States); A. Michon, Ctr. de Recherche sur l'Hétéro-Epitaxie et ses Applications, CNRS (France) and Lab. de Photonique et de Nanostructures, CNRS (France); I. Sagnes, Lab. de Photonique et de Nanostructures, CNRS (France); A. Garnache, Institut d'Electronique du Sud, CNRS, Univ. Montpellier 2 (France)
- 8606 0R **Optically pumped external-cavity semiconductor lasers for precision spectroscopy and laser cooling of atomic Hg (Invited Paper)** [8606-26]
J. R. Paul, C. R. Lytle, Y. Kaneda, J. Moloney, T.-L. Wang, R. J. Jones, College of Optical Sciences, The Univ. of Arizona (United States)

- 8606 OS **Tunable high-purity microwave signal generation from a dual-frequency VECSEL at 852 nm** [8606-28]
F. A. Camargo, Lab. Charles Fabry, CNRS, Univ. Paris-Sud XI (France); N. Girard, Thales Research and Technology (France); J. M. Danet, LNE-SYRTE, CNRS, Observatoire de Paris (France); G. Baili, L. Morvan, D. Dolfi, Thales Research and Technology (France); D. Holleville, S. Guérandel, LNE-SYRTE, CNRS, Observatoire de Paris (France); I. Sagnes, Lab. de Photonique et de Nanostructures, CNRS (France); P. Georges, G. Lucas-Leclin, Lab. Charles Fabry, CNRS, Univ. Paris-Sud XI (France)

POSTER SESSION

- 8606 OT **Efficient thermoelectric cooling of concentrated heat loads** [8606-27]
J. Hershberger, R. Smythe, Laird Technologies (United States); X. Gu, Laird Technologies (China); R. F. Hill, Laird Technologies (United States)

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)

Program Track Chair

Klaus P. Streubel, OSRAM GmbH (Germany)

Conference Chair

Jennifer E. Hastie, University of Strathclyde (United Kingdom)

Conference Program Committee

Sophie Bouchoule, CNRS Laboratoire de Photonique et de
Nanostructures (France)
Juan L. Chilla, Coherent, Inc. (United States)
Arnaud Garnache, University Montpellier 2 (France)
Mircea Guina, Tampere University of Technology (Finland)
Elyahou Kapon, Ecole Polytechnique Fédérale de Lausanne
(Switzerland)
Ursula Keller, ETH Zurich (Switzerland)
Jerome V. Moloney, The University of Arizona (United States)
Anne C. Tropper, University of Southampton (United Kingdom)

Session Chairs

- 1 Power Scaling I
Jerome V. Moloney, The University of Arizona (United States)
- 2 Ultrafast VECSELs I: High Average Power
Ursula Keller, ETH Zurich (Switzerland)

- 3 Intracavity Techniques
Jennifer E. Hastie, University of Strathclyde (United Kingdom)
- 4 Spectral Coverage
Mircea Guina, Tampere University of Technology (Finland)
- 5 Electrical Pumping and Device Packaging
John-Mark Hopkins, University of Strathclyde (United Kingdom)
- 6 Power Scaling II: Thermal Management
Juan L. Chilla, Coherent, Inc. (United States)
- 7 Ultrafast VECSELs II
Anne C. Tropper, University of Southampton (United Kingdom)
- 8 Single Frequency
Alexei Sirbu, Ecole Polytechnique Fédérale de Lausanne
(Switzerland)