

PROCEEDINGS OF SPIE

# ***Vertical External Cavity Surface Emitting Lasers (VECSELs) IX***

**Ursula Keller**  
*Editor*

**5–6 February 2019**  
**San Francisco, California, United States**

*Sponsored by*  
SPIE

*Cosponsored by*  
Coherent, Inc. (United States)

*Published by*  
SPIE

**Volume 10901**

Proceedings of SPIE 0277-786X, V. 10901

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

Vertical External Cavity Surface Emitting Lasers (VECSELs) IX, edited by  
Ursula Keller, Proc. of SPIE Vol. 10901, 1090101 · © 2019 SPIE  
CCC code: 0277-786X/19/\$18 · doi: 10.1117/12.2531335

Proc. of SPIE Vol. 10901 1090101-1

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 *Vertical External Cavity Surface Emitting Lasers (VECSELs) IX*, edited by Ursula Keller, Proceedings of SPIE Vol. 10901 (SPIE, Bellingham, WA, 2019) Seven-digit Article CID Number.

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

ISBN: 9781510624443  
ISBN: 9781510624450 (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 © 2019, 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](http://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/19/\$18.00.

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**

[SPIEDigitalLibrary.org](http://SPIEDigitalLibrary.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

v *Authors*  
vii *Conference Committee*

---

## VECSEL OPTIMIZATION I

- 10901 03 **1.55- $\mu$ m wavelength wafer-fused OP-VECSELs in flip-chip configuration** [10901-3]  
10901 04 **High power widely tunable optically pumped semiconductor lasers** [10901-4]

---

## MID-IR AND THz VECSELs

- 10901 08 **VECSEL-based frequency comb in the MIR** [10901-8]

---

## VECSEL OPTIMIZATION II

- 10901 0A **Industrial low noise tunable integrated semiconductor laser: dynamic instability and route to single frequency operation (Invited Paper)** [10901-10]  
10901 0C **Modeling and experimental investigation of transverse mode dynamics in VECSEL** [10901-12]  
10901 0D **MECSELs with direct emission in the 760 nm to 810 nm spectral range: a single- and double-side pumping comparison and high-power continuous-wave operation** [10901-13]  
10901 0E **Influence of microscopic many-body scattering on multi-wavelength VECSEL lasing (Invited Paper)** [10901-14]

---

## MODELOCKING

- 10901 0F **Bifurcation scenario leading to multiple pulse emission in VECSELs (Invited Paper)** [10901-15]  
10901 0H **Investigations on the origins of self-mode-locking in vertical-external-cavity surface-emitting-lasers: nonlinear lensing and the role of the microcavity** [10901-17]  
10901 0I **Towards dual frequency comb VECSELs with DMD laser-ablated spatial mode masks** [10901-18]  
10901 0J **Femtosecond dual-comb MIXSEL (Invited Paper)** [10901-19]

---

**APPLICATIONS I**

---

10901 ON     **VECSEL for 3D LiDAR applications (Invited Paper)** [10901-23]

---

**POSTER SESSION**

---

10901 OU     **Development of electrically pumped VECSEL in the visible spectrum** [10901-30]

# 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.

Alfieri, C. G. E., 0J  
Apostolopoulos, Vasilis, 0I  
Bai, Yanbo, 04  
Beaudoin, Grégoire, 0A  
Bek, Roman, 0H  
Caliman, Andrei, 03  
Cerutti, Laurent, 0A  
Chen Sverre, Theo, 0I  
Chilla, Juan, 04  
Chomet, Baptiste, 0A  
Daykin, Jake, 0I  
Denet, Stéphane, 0A  
Diening, Andreas, 04  
Ferrières, Laurence, 0A  
Gallo, Pascal, 03  
Garnache, Arnaud, 0A, 0I  
Golling, M., 0J  
Gronenborn, Stephan, 0N  
Großmann, Marius, 0H  
Gu, Xi, 0N  
Guina, Mircea, 03, 0D  
Hader, Jorg, 0C, 0E  
Hausen, Jan P., 0F  
Heath, Daniel, 0I  
Herper, Markus, 0N  
Huang, Zhihua, 0U  
Jetter, Michael, 0H, 0U  
Jones, R. Jason, 08  
Kahle, Hermann, 0D  
Kapon, Eli, 03  
Keller, U., 0J  
Kilen, I., 0E  
Koch, Martin, 0H  
Koch, S. W., 0E  
Kolb, Johanna, 0N  
Kress, Sascha, 0H  
Kriso, Christian, 0H  
Laurain, Alexandre, 08, 0C  
Lecocq, Vincent, 0A  
Lüdge, Kathy, 0F  
Meinecke, Stefan, 0F  
Mereuta, Alexandru, 03  
Michler, Peter, 0H, 0U  
Miller, Michael, 0N  
Mills, Ben, 0I  
Moench, Holger, 0N  
Moloney, Jerome V., 08, 0C, 0E  
Munshi, Tasnim, 0H  
Myara, Mikhaël, 0A

Nechay, Kostiantyn, 03  
Nürnberg, J., 0J  
Penttinen, Jussi-Pekka, 0D  
Phung, Hoy-My, 0D  
Rahimi-Iman, Arash, 0H  
Rajala, Patrik, 0D  
Ranta, Sanna, 0D  
Rockmore, Robert, 08  
Sagnes, Isabelle, 0A  
Scholz, Christian, 04  
Stolz, Wolfgang, 0H  
Suruceanu, Grigore, 03  
Troppe, Anne, 0I  
Tukiainen, Antti, 0D  
Waldburger, D., 0J  
Weiss, Eli, 04  
Woods, Jonathan, 0I  
Xu, Zuntu, 04  
Zimmer, Michael, 0U



# Conference Committee

## *Symposium Chairs*

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

## *Symposium Co-chairs*

**Koji Sugioka**, RIKEN Center for Advanced Photonics (Japan)  
**Reinhart Poprawe**, Fraunhofer-Institut für Lasertechnik (Germany)

## *Program Track Chairs*

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

## *Conference Chair*

**Ursula Keller**, ETH Zurich (Switzerland)

## *Conference Program Committee*

**Juan L. Chilla**, Coherent, Inc. (United States)  
**Arnaud Garnache**, Université Montpellier (France)  
**Mircea Guina**, Tampere University of Technology (Finland)  
**Jennifer E. Hastie**, University of Strathclyde (United Kingdom)  
**Michael Jetter**, Universität Stuttgart (Germany)  
**Elyahou Kapon**, Ecole Polytechnique Fédérale de Lausanne (Switzerland)  
**Walter Lubeigt**, M Squared Lasers Ltd. (United Kingdom)  
**Jerome V. Moloney**, College of Optical Sciences, The University of  
Arizona (United States)  
**Wolfgang Stolz**, NAsP III/V GmbH (Germany)  
**Anne C. Tropper**, University of Southampton (United Kingdom)  
**Keith G. Wilcox**, University of Dundee (United Kingdom)

## *Session Chairs*

- 1 VECSEL Optimization I  
**Ursula Keller**, ETH Zurich (Switzerland)
- 2 Mid-IR and THz VECSELs  
**Mircea Guina**, Tampere University of Technology (Finland)

- 3 VECSEL Optimization II  
**Mark Kuznetsov**, Axsun Technologies (United States)
- 4 Modelocking  
**Jerome V. Moloney**, College of Optical Sciences, The University of Arizona (United States)
- 5 Applications I  
**Jennifer E. Hastie**, University of Strathclyde (United Kingdom)
- 6 Applications II  
**Thomas Südmeyer**, Université de Neuchâtel (Switzerland)