

PROCEEDINGS OF SPIE

***High-Power Diode Laser  
Technology and Applications VI***

**Mark S. Zediker**

*Editor*

**21–23 January 2008  
San Jose, California, USA**

*Sponsored and Published by*  
**SPIE**

**Volume 6876**

Proceedings of SPIE, 0277-786X, v. 6876

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

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 *High-Power Diode Laser Technology and Applications VI*, edited by Mark S. Zediker, Proceedings of SPIE Vol. 6876 (SPIE, Bellingham, WA, 2008) Article CID Number.

ISSN 0277-786X  
ISBN 9780819470515

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](http://SPIE.org)

Copyright © 2008, 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/08/\$18.00.

Printed in the United States of America.

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



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

- ix Conference Committee  
xi *The long journey from idea to industrial science (Plenary Paper) [6874-26]*  
Holger Schlüter, TRUMPF Inc. (USA)

---

## SESSION 1 ADVANCED MOUNTING, COOLING, AND BEAM FORMATION

---

- 6876 02 **A high-brightness QCW pump source using a pre-aligned GRIN lens array with refractive beam correction [6876-01]**  
R. McBride, H. Baker, PowerPhotonic, Ltd. (United Kingdom); J.-L. Neron, S. Doric, Doric Lenses Inc. (Canada); C. Mariottini, E. Nava, E. Stucchi, P. Milanesi, CESI (Italy)
- 6876 03 **Improved cooling for high-power laser diodes [6876-04]**  
J. Vetrovec, Aqwest, LLC (USA)
- 6876 04 **Active cooling solutions for high power laser diodes stacks [6876-02]**  
Y. Karni, G. Klumel, M. Levy, Y. Berk, Y. Openhaim, Y. Gridish, A. Elgali, M. Avisar, M. Blonder, H. Sagy, A. Gertsenshtein, Semiconductor Devices (Israel)
- 6876 05 **8xxnm kW conduction cooled QCW diode arrays with both electrically conductive and insulation submounts [6876-03]**  
J. Du, H. Zhou, D. Schleuning, V. Agrawal, J. Morales, T. Hasenberg, M. Reed, Coherent, Inc. (USA)
- 6876 06 **Enhanced microchannel cooling for high-power semiconductor diode lasers [6876-05]**  
J. Dix, A. Jokar, Washington State Univ., Vancouver (USA); R. Martinsen, nLight Photonics (USA)
- 6876 07 **Composite-copper, low-thermal-resistance heat sinks for laser-diode bars, mini-bars and single-emitter devices [6876-06]**  
R. Miller, D. Liu, M. Horsinka, T. Nguyen, K. Kuppuswamy, T. Towe, H. Li, M. Berube, J. Harrison, E. Wolak, Spectra-Physics Lasers (USA)
- 6876 08 **Next-generation microchannel coolers [6876-07]**  
R. Feeler, J. Junghans, G. Kemner, E. Stephens, Northrop Grumman Cutting Edge Optronics (USA)
- 6876 09 **Thermal resistance in dependence of diode laser packages [6876-08]**  
M. Leers, K. Boucke, Fraunhofer Institute for Laser Technology (Germany); M. Götz, A. Meyer, Electrovac curamik GmbH (Germany); M. Kelemen, N. Lehmann, m2k-laser GmbH (Germany); F. Monti di Sopra, Lasag AG (Switzerland)

- 6876 0A **Passive cooling effects of low and high fill-factor 937nm 1 cm arrays** [6876-09]  
J. Hostetler, C.-L. Jiang, R. Roff, V. Negoita, TRUMPF Photonics Inc. (USA); S. Strohmaier, C. Tillkorn, TRUMPF Laser GmbH and Co. KG (Germany); R. Radionova, C. Miester, T. Vethake, U. Bonna, TRUMPF Photonics Inc. (USA); M. Huonker, C. Schmitz, TRUMPF Laser GmbH and Co. KG (Germany); F. Dorsch, TRUMPF Photonics Inc. (USA)
- 6876 0B **Beam shaping of high power diode lasers benefits from asymmetrical refractive micro-lens arrays** [6876-10]  
O. Homburg, A. Bayer, T. Mitra, J. Meinschien, L. Aschke, LIMO Lissotschenko Mikrooptik GmbH (Germany)

---

## **SESSION 2 HIGH-POWER LASER DIODE BARS AND ARRAYS**

---

- 6876 0C **Recent developments for BAR and BASE: setting the trends** [6876-11]  
N. Lichtenstein, M. Krejci, Y. Manz, J. Boucart, B. Valk, J. Müller, C. Button, S. Weiß, S. Pawlik, B. Sverdlov, Bookham AG (Switzerland)
- 6876 0D **High-power vertical-cavity surface-emitting arrays** [6876-12]  
J.-F. Seurin, C. L. Ghosh, V. Khalpin, A. Miglo, G. Xu, J. D. Wynn, P. Pradhan, L. A. D'Asaro, Princeton Optronics (USA)
- 6876 0E **High-power diode lasers for the 1.9 to 2.2 um wavelength range** [6876-13]  
M. T. Kelemen, J. Gilly, R. Moritz, m2k-laser GmbH (Germany); M. Rattunde, J. Schmitz, J. Wagner, Fraunhofer Institut für Angewandte Festkörperphysik (Germany)
- 6876 0F **High brilliance and high efficiency: optimized high power diode laser bars** [6876-14]  
R. Hülsewede, H. Schulze, J. Sebastian, JENOPTIK Diode Lab. GmbH (Germany); D. Schröder, J. Meusel, P. Hennig, JENOPTIK Laserdiode GmbH (Germany)
- 6876 0G **High-efficiency, high-power diode laser chips, bars, and stacks** [6876-15]  
H. Li, F. Reinhardt, I. Chyr, X. Jin, K. Kuppuswamy, T. Towe, D. Brown, O. Romero, D. Liu, R. Miller, T. Nguyen, T. Crum, T. Truchan, E. Wolak, J. Mott, J. Harrison, Spectra-Physics Lasers (USA)
- 6876 0H **10 W high-efficiency high-brightness tapered diode lasers at 976 nm** [6876-16]  
R. Ostendorf, G. Kaufel, R. Moritz, M. Mikulla, O. Ambacher, Fraunhofer Institute for Applied Solid State Physics (Germany); M. T. Kelemen, J. Gilly, m2k-laser GmbH (Germany)
- 6876 0I **8xx-10xx nm highly efficient single emitter pumps** [6876-17]  
V. Gapontsev, I. Berishev, V. Chuyanov, G. Ellis, I. Hernandez, A. Komissarov, N. Moshegov, O. Raisky, V. Rastokine, N. Strougov, P. Trubenko, L. Wright, A. Ovtchinnikov, IPG Photonics Corp. (USA)
- 6876 0J **Stable and compact mounting scheme for > 1kW QCW diode laser stacks at 940nm** [6876-18]  
C. Fiebig, B. Eppich, W. Pittroff, G. Erbert, Ferdinand-Braun-Institut für Höchstfrequenztechnik (Germany)

- 6876 0K **Highly reliable qcw laser bars and stacks** [6876-19]  
E. Deichsel, D. Schröder, J. Meusel, JENOPTIK Laserdiode GmbH (Germany); R. Hülsewede, J. Sebastian, JENOPTIK Diode Lab. GmbH (Germany); S. Ludwig, Jena-Optronik GmbH (Germany); P. Hennig, JENOPTIK Laserdiode GmbH (Germany)
- 6876 0L **12W CW operation of 640nm-band laser diode array** [6876-20]  
N. Shimada, K. Shibata, Y. Hanamaki, T. Hamaguchi, T. Yagi, Mitsubishi Electric Corporation (Japan)
- 6876 0M **650 nm tapered lasers with 1 W maximum output power and nearly diffraction limited beam quality at 500 mW** [6876-21]  
B. Sumpf, P. Adamiec, M. Zorn, P. Froese, J. Fricke, P. Ressel, H. Wenzel, M. Weyers, G. Erbert, G. Tränkle, Ferdinand-Braun-Institut für Höchstfrequenztechnik (Germany)

---

#### **SESSION 3 LASER DIODE BAR RELIABILITY I**

---

- 6876 0N **Reliability of ensembles multi-stripe laser diodes** [6876-22]  
E. Wolak, K. Kuppuswamy, B. Fidric, S.-K. Park, D. Liu, S. Cutillas, K. Johnson, H. Li, I. Chyr, F. Reinhardt, R. Miller, X. Jin, T. Nguyen, T. Towe, P. Cross, T. Truchan, R. Bullock, J. Mott, J. Harrison, Spectra-Physics Lasers (USA)
- 6876 0O **Emitter resolved analysis of packaged laser bars** [6876-23]  
T. Westphalen, M. Leers, C. Scholz, K. Boucke, Fraunhofer Institute for Laser Technology (Germany)

---

#### **SESSION 4 LASER DIODE BAR RELIABILITY II**

---

- 6876 0P **High reliability level on single-mode 980nm-1060 nm diode lasers for telecommunication and industrial applications** [6876-24]  
J. Van de Castele, M. Bettati, F. Laruelle, V. Cargemel, P. Pagnod-Rossiaux, P. Garabedian, L. Raymond, D. Laffitte, S. Fromy, D. Chambonnet, J. P. Hirtz, 3S Photonics (France)
- 6876 0Q **Passively cooled diode lasers in the cw power range of 120 to 200W** [6876-25]  
D. Lorenzen, J. Meusel, D. Schröder, P. Hennig, JENOPTIK Laserdiode GmbH (Germany)
- 6876 0R **Investigation of catastrophic degradation in high power multimode InGaAs strained quantum well single emitters** [6876-26]  
Y. Sin, N. Presser, B. Foran, S. C. Moss, The Aerospace Corp. (USA)
- 6876 0T **1 W reliable operation of broad area lasers and 8 W reliable operation of 5 mm wide laser bars at 650 nm** [6876-28]  
B. Sumpf, M. Zorn, J. Fricke, P. Ressel, H. Wenzel, G. Erbert, M. Weyers, G. Tränkle, Ferdinand-Braun-Institut für Höchstfrequenztechnik (Germany)

---

**SESSION 5 DIODE LASER SYSTEMS AND PUMP MODULES I**

---

- 6876 0U **Next generation high-brightness diode lasers offer new industrial applications (Invited Paper) [6876-29]**  
A. Timmermann, J. Meinschien, P. Bruns, C. Burke, D. Bartoschewski, LIMO Lissotschenko Mikrooptik GmbH (Germany)
- 6876 0V **High-brightness line generators and fiber-coupled sources based on low-smile laser diode arrays [6876-30]**  
J. Watson, D. Schleuning, P. Lavikko, T. Alander, D. Lee, P. Lovato, H. Winhold, M. Griffin, S. Tolman, P. Liang, T. Hasenberg, M. Reed, Coherent, Inc. (USA)
- 6876 0W **1.8kW diode laser system for fibre-delivery using brightness-enhanced diode stacks and a novel final beam-shaper [6876-31]**  
H. J. Baker, J. F. Monjardin, P. Kneip, D. R. Hall, Heriot-Watt Univ. (United Kingdom); R. McBride, PowerPhotonic, Ltd. (United Kingdom)
- 6876 0X **Highly efficient fiber coupling of laser diode bars with > 50% electro-optical efficiency out of the fiber core [6876-32]**  
U. Fornahl, M. Revermann, J. Meinschien, LIMO Lissotschenko Mikrooptik GmbH (Germany)
- 6876 0Y **High-brightness fiber-coupled diode laser development at Coherent [6876-33]**  
S. D. Roh, D. M. Grasso, Coherent, Inc. Direct Diode Systems (USA)

---

**SESSION 6 DIODE LASER SYSTEMS AND PUMP MODULES II**

---

- 6876 0Z **High brightness fiber laser pump sources based on single emitters and multiple single emitters [6876-34]**  
T. Scheller, L. Wagner, J. Wolf, G. Bonati, JENOPTIK Laserdiode GmbH (Germany); F. Dörfel, T. Gabler, JT optical engine GmbH (Germany)
- 6876 10 **cw, 325nm, 100mW semiconductor laser system as potential substitute for HeCd gas lasers [6876-35]**  
T. Schmitt, A. Able, R. Häring, TOPTICA Photonics AG (Germany); B. Sumpf, G. Erbert, G. Tränkle, Ferdinand-Braun-Institut für Höchstfrequenztechnik (Germany); F. Lison, W. G. Kaenders, TOPTICA Photonics AG (Germany)
- 6876 11 **High-power fiber-coupled stack arrays for pump applications [6876-36]**  
O. Romero, C.-H. Chen, J. Harrison, T. Towe, S. Ginter, H. Li, I. Chyr, J. Johnson, J. Egan, K. Dinh, Spectra-Physics Lasers (USA)
- 6876 12 **High-power high-efficiency fiber-coupled multimode laser-diode pump module (9XX nm) with high reliability [6876-37]**  
P. Yalamanchili, V. Rossin, J. Skidmore, K. Tai, X. Qiu, R. Duesterberg, V. Wong, S. Bajwa, K. Duncan, D. Venables, R. Verbera, Y. Dai, J.-P. Feve, E. Zucker, JDSU Corp. (USA)

---

**SESSION 7    RESULTS OF THE GERMAN NATIONAL FUNDING INITIATIVE BRIOLAS (BRILLIANT DIODE LASERS)**

---

- 6876 13 **Design and assembly of a miniaturized high-power laser bar to 50 µm fiber coupling module (Invited Paper) [6876-38]**  
E. Beckert, P. Schreiber, T. Burkhardt, Fraunhofer Institute for Applied Optics and Precision Engineering (Germany); E. Werner, JENOPTIK Laserdiode GmbH (Germany); R. Hülsewede, JENOPTIK Diode Lab. GmbH (Germany)
- 6876 14 **50 W passively cooled fiber-coupled diode laser at 976 nm for pumping fiber lasers using 100 µm fiber bundles [6876-39]**  
C. Wessling, St. Hengesbach, J. Geiger, J. Dolkemeyer, M. Traub, D. Hoffmann, Fraunhofer Institute for Laser Technology (Germany)
- 6876 15 **Brilliant high-power diode lasers based on broad area lasers (Invited Paper) [6876-40]**  
V. Krause, A. Koesters, Laserline GmbH (Germany); H. Koenig, U. Strauß, OSRAM Opto Semiconductors GmbH (Germany)
- 6876 16 **Brilliant high power laser bars for industrial applications [6876-41]**  
H. König, G. Grönninger, P. Brick, M. Reufer, OSRAM Opto Semiconductors GmbH (Germany); F. Bugge, G. Erbert, Ferdinand-Braun-Institut für Höchstfrequenztechnik (Germany); M. Stoiber, J. Biesenbach, DILAS Diolenlaser GmbH (Germany); D. Lorenzen, P. Hennig, JENOPTIK Laserdiode GmbH (Germany); U. Strauß, OSRAM Opto Semiconductors GmbH (Germany)
- 6876 17 **Diffractive optical elements fabricated for beam shaping of high-power diode lasers [6876-42]**  
H. Vogt, R. Biertümpfel, E. Pawlowski, SCHOTT AG (Germany)
- 6876 18 **A comprehensive reliability study of high-power 808 nm laser diodes mounted with AuSn and indium [6876-43]**  
H. Kissel, G. Seibold, J. Biesenbach, DILAS Diolenlaser GmbH (Germany); G. Groenninger, G. Herrmann, U. Strauß, OSRAM Opto Semiconductors GmbH (Germany)
- 6876 19 **Screening of high power laser diode bars in terms of stresses and thermal profiles [6876-44]**  
J. W. Tomm, M. Ziegler, T. Q. Tien, F. Weik, Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie (Germany); P. Hennig, J. Meusel, JENOPTIK Laserdiode GmbH (Germany); H. Kissel, G. Seibold, J. Biesenbach, DILAS Diolenlaser GmbH (Germany); G. Groenninger, G. Herrmann, U. Strauß, OSRAM Opto Semiconductors GmbH (Germany)
- 6876 1A **Accurate determination of absolute temperatures of GaAs based high-power diode lasers [6876-45]**  
M. Ziegler, J. W. Tomm, F. Weik, T. Elsaesser, Max-Born-Institut (Germany); C. Monte, J. Hollandt, Physikalisch-Technische Bundesanstalt (Germany); H. Kissel, G. Seibold, J. Biesenbach, DILAS Diolenlaser GmbH (Germany)
- 6876 1B **Diode laser modules based on new developments in tapered and broad area diode laser bars [6876-46]**  
B. Köhler, S. Ahlert, T. Brand, M. Haag, H. Kissel, G. Seibold, M. Stoiber, J. Biesenbach, DILAS Diolenlaser GmbH (Germany); W. Reill, G. Grönninger, M. Reufer, H. König, U. Strauß, OSRAM Opto Semiconductors GmbH (Germany)

- 6876 1C **High-power laser bars with emission in the red spectral range for medical applications** [6876-47]  
K. Boucke, Fraunhofer Institute for Laser Technology (Germany); W. Schmid, OSRAM Opto Semiconductors GmbH (Germany); W. Brandenburg, Fraunhofer Institute for Laser Technology (Germany); M. Mueller, U. Strauß, OSRAM Opto Semiconductors GmbH (Germany)

---

## SESSION 8 HIGH BRIGHTNESS AND NARROW LINENWIDTH LASER DIODES

---

- 6876 1D **Single mode fiber coupled tapered laser module with frequency stabilized spectrum** [6876-48]  
M. Haverkamp, G. Kochem, K. Boucke, Fraunhofer Institute for Laser Technology (Germany)
- 6876 1E **Advances in high-brightness semiconductor lasers** [6876-49]  
M. L. Osowski, W. Hu, R. M. Lammert, S. W. Oh, P. T. Rudy, T. Stakelon, J. E. Ungar, QPC Lasers, Inc. (USA)
- 6876 1F **High-power high-brightness single-emitter laser diodes at Axcel Photonics** [6876-50]  
W. Gao, Z. Xu, L. Cheng, K. Luo, K. Shen, A. Mastrovito, Axcel Photonics, Inc. (USA)
- 6876 1H **Emission wavelength stabilization in broad area lasers coupled to fiber Bragg gratings** [6876-52]  
B. Sverdlov, S. Mohrdiek, S. Pawlik, N. Matuschek, N. Lichtenstein, Bookham AG (Switzerland)
- 6876 1J **5 W frequency stabilized 976 nm tapered diode lasers** [6876-54]  
P. Friedmann, J. Gilly, S. Moritz, m2k-laser GmbH (Germany); R. Ostendorf, Fraunhofer Institute for Applied Solid State Physics (Germany); M. T. Kelemen, m2k-laser GmbH (Germany)

---

## POSTER SESSION

---

- 6876 1K **Tunable DFB semiconductor lasers with active feedback for frequency stability** [6876-55]  
B. Bobbs, A. Montalvo, Sabeus, Inc. (USA)
- 6876 1M **Fibre-coupled air-cooled high-power diode laser systems** [6876-57]  
D. Bartoszewski, J. Meinschien, U. Fornahl, LIMO Lissotschenko Mikrooptik GmbH (Germany)

Author Index

# Conference Committee

## Symposium Chairs

**Henry Helvajian**, The Aerospace Corporation (USA)  
**Friedrich G. Bachmann**, Rofin-Sinar Laser GmbH (Germany)

## Symposium Cochairs

**Peter R. Herman**, University of Toronto (Canada)  
**Donald J. Harter**, IMRA America, Inc. (USA)

## Program Track Chair

**E. Fred Schubert**, Rensselaer Polytechnic Institute (USA)

## Conference Chair

**Mark S. Zediker**, Coherent Direct Diode Systems (USA)

## Program Committee

**Friedrich G. Bachmann**, Rofin-Sinar Laser GmbH (Germany)  
**Jason Farmer**, nLight Corporation (USA)  
**Stefan W. Heinemann**, Fraunhofer USA Inc. (USA)  
**Volker K. Krause**, Laserline GmbH (Germany)  
**Erik P. Zucker**, JDSU Corporation (USA)

## Session Chairs

- 1 Advanced Mounting, Cooling, and Beam Formation  
**Mark S. Zediker**, Coherent Direct Diode Systems (USA)
- 2 High-Power Laser Diode Bars and Arrays  
**Erik P. Zucker**, JDSU Corporation (USA)
- 3 Laser Diode Bar Reliability I  
**Robert J. Martinsen**, nLight Corporation (USA)
- 4 Laser Diode Bar Reliability II  
**Robert J. Martinsen**, nLight Corporation (USA)
- 5 Diode Laser Systems and Pump Modules I  
**Volker K. Krause**, Laserline GmbH (Germany)
- 6 Diode Laser Systems and Pump Modules II  
**Volker K. Krause**, Laserline GmbH (Germany)

- 7    Results of the German National Funding Initiative BRIOLAS  
     (BRilliant dIOde LASers)  
**Friedrich G. Bachmann**, Rofin-Sinar Laser GmbH (Germany)
- 8    High Brightness and Narrow Linewidth Laser Diodes  
**Robert J. Martinsen**, nLight Corporation (USA)