

# PROCEEDINGS OF SPIE

[SPIDigitalLibrary.org/conference-proceedings-of-spie](https://spiedigitallibrary.org/conference-proceedings-of-spie)

## Front Matter: Volume 8239

Proceedings of SPIE

Proceedings of SPIE, "Front Matter: Volume 8239," Proc. SPIE 8239, High Power Laser Materials Processing: Lasers, Beam Delivery, Diagnostics, and Applications, 823901 (15 February 2012); doi: 10.1117/12.923569

**SPIE.**

Event: SPIE LASE, 2012, San Francisco, California, United States

# PROCEEDINGS OF SPIE

## ***High Power Laser Materials Processing: Lasers, Beam Delivery, Diagnostics, and Applications***

**Eckhard Beyer  
Timothy Morris**  
*Editors*

**24–26 January 2012  
San Francisco, California, United States**

*Sponsored and Published by*  
SPIE

**Volume 8239**

Proceedings of SPIE, 0277-786X, v. 8239

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 Laser Materials Processing: Lasers, Beam Delivery, Diagnostics, and Applications*, edited by Eckhard Beyer, Timothy Morris, Proceedings of SPIE Vol. 8239 (SPIE, Bellingham, WA, 2012) Article CID Number.

ISSN 0277-786X

ISBN 9780819488824

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 © 2012, 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/12/\$18.00.

Printed in the United States of America.

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

The logo for SPIE Digital Library features the word "SPIE" in a bold, sans-serif font above the words "Digital Library" in a smaller, sans-serif font. To the right of the text is a stylized graphic consisting of three vertical bars of increasing height from left to right, with a curved line above them.

[SPIDigitalLibrary.org](http://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 INVITED SESSION

---

- 8239 03 **The story of laser brazing technology (Invited Paper)** [8239-02]  
P. Hoffmann, R. Dierken, ERLAS Erlanger Lasertechnik GmbH (Germany)
- 8239 04 **Innovations in laser cladding and direct metal deposition (Invited Paper)** [8239-03]  
F. Brückner, S. Nowotny, Fraunhofer IWS (Germany); C. Leyens, Fraunhofer IWS (Germany) and Technische Univ. Dresden (Germany)
- 8239 05 **Structural strengthening of rocket nozzle extension by means of laser metal deposition (Invited Paper)** [8239-04]  
M. Honoré, Force Institute (Denmark); L. Brox, M. Hallberg, Volvo Aero Corp. (Sweden)

---

## SESSION 2 LASERS AND LASER SYSTEMS IN MACRO PROCESSING

---

- 8239 07 **Frequency doubled high-power disk lasers in pulsed and continuous-wave operation** [8239-06]  
S. Weiler, TRUMPF Inc. (United States); A. Hangst, C. Stolzenburg, I. Zawischa, D. Sutter, A. Killi, S. Kalfhues, TRUMPF Laser GmbH & Co. KG (Germany); U. Kriegshaeuser, M. Holzer, TRUMPF Laser- und Systemtechnik GmbH (Germany); D. Havrilla, TRUMPF Inc. (United States)
- 8239 08 **Lasers for industrial production processing: tailored tools with increasing flexibility** [8239-07]  
W. Rath, ROFIN-SINAR Laser GmbH (Germany)
- 8239 0A **High-power transmission characterization of Chalcogenide glasses using a Tm: fiber laser system** [8239-09]  
P. Kadwani, J. Bradford, R. A. Sims, CREOL, The College of Optics and Photonics, Univ. of Central Florida (United States); D. Musgraves, K. Richardson, Clemson Univ. (United States); L. Shah, M. C. Richardson, CREOL, The College of Optics and Photonics, Univ. of Central Florida (United States)

---

## SESSION 3 APPLICATIONS: WELDING

---

- 8239 0B **Advantages of fibre lasers in 3D metal cutting and welding applications supported by a 'beam in motion (BIM)' beam delivery system** [8239-10]  
T. Scheller, A. Bastick, M. Griebel, JENOPTIK Automatisierungstechnik GmbH (Germany)
- 8239 0C **T-joints of Ti alloys with hybrid laser-MIG welding: macro-graphic and micro-hardness analyses** [8239-12]  
R. Spina, D. Sorgente, G. Palumbo, L. D. Scintilla, Politecnico di Bari (Italy); M. Brandizzi, A. A. Satriano, Consorzio CALEF (Italy); L. Tricarico, Politecnico di Bari (Italy)

- 8239 0D **Improvements of the welding performance of plasma arcs by a superimposed fibre laser beam** [8239-13]  
A. Mahrle, S. Rose, M. Schnick, T. Pinder, Technische Univ. Dresden (Germany); E. Beyer, Technische Univ. Dresden (Germany) and Fraunhofer IWS Dresden (Germany); U. Füssel, Technische Univ. Dresden (Germany)
- 8239 0E **Bead characterization of disk-laser butt welding of thin AA 2024 sheets** [8239-41]  
F. Caiazzo, V. Alfieri, F. Cardaropoli, V. Sergi, Univ. degli Studi di Salerno (Italy)
- 8239 0F **Through the optical combiner monitoring in remote fiber laser welding of zinc coated steels** [8239-38]  
D. Colombo, B. M. Colosimo, B. Previtali, Politecnico di Milano (Italy); D. Bassan, M. Lai, Ctr. Ricerche Fiat S.C.p.A. (Italy); G. Masotti, El.En. S.p.A. (Italy)

---

#### SESSION 4 APPLICATIONS: SURFACE TREATMENT AND CLADDING

- 8239 0G **Identification of phase transformation using optical emission spectroscopy for direct metal deposition process (Invited Paper)** [8239-15]  
L. Song, Univ. of Michigan (United States); C. Wang, Univ. of Michigan (United States) and Dalian Univ. of Technology (China); J. Mazumder, Univ. of Michigan (United States)
- 8239 0H **The use of novel, direct diode lasers for large area hard-facing and high deposition rate cladding to enhance surface wear and corrosion resistance** [8239-16]  
S. Brookshier, J. Washko, K. Parker, F. Gaebler, W. Juchmann, Coherent, Inc. (United States)
- 8239 0I **Laser heat treatment with latest system components** [8239-17]  
S. Bonss, J. Hannweber, U. Karsunke, S. Kuehn, M. Seifert, Fraunhofer IWS Dresden (Germany); E. Beyer, Fraunhofer IWS Dresden (Germany) and Technische Univ. Dresden (Germany)
- 8239 0J **Local heat treatment of high strength steels with zoom-optics and 10kW-diode laser** [8239-18]  
M. Baumann, V. Krause, Laserline GmbH (Germany); G. Bergweiler, Fraunhofer-Institut für Lasertechnik (Germany); M. Flaischerowitz, F+K Werkstoffprüfung und Labor GmbH (Germany); J. Banik, ThyssenKrupp Steel Europe AG (Germany)
- 8239 0L **Multi-kW laser cladding using cylindrical collimators and square-formed fibers** [8239-20]  
M. Blomqvist, S. Campbell, Optoskand AB (Sweden); J. Latokartano, J. Tuominen, Tampere Univ. of Technology (Finland)

---

#### SESSION 5 APPLICATIONS: CUTTING

- 8239 0M **Wavelength dependency in high power laser cutting and welding (Invited Paper)** [8239-21]  
D. Havrilla, S. Ziermann, TRUMPF Inc. (United States); M. Holzer, TRUMPF Laser- und Systemtechnik GmbH (Germany)
- 8239 0N **Energy balance in disk and CO<sub>2</sub> laser beam inert gas fusion cutting** [8239-22]  
L. D. Scintilla, L. Tricarico, Politecnico di Bari (Italy); A. Wetzig, Fraunhofer IWS Dresden (Germany); E. Beyer, Fraunhofer IWS Dresden (Germany) and Univ. of Technology Dresden (Germany)

- 8239 0O **Applicability of various beam sources for high power laser cutting of non-oriented electrical steel** [8239-23]  
R. Siebert, Fraunhofer IWS Dresden (Germany) and TRUMPF Sachsen GmbH (Germany) and Technische Univ. Dresden (Germany); H. Thonig, TRUMPF Sachsen GmbH (Germany); A. Wetzig, Fraunhofer IWS Dresden (Germany); E. Beyer, Fraunhofer IWS Dresden (Germany) and Technische Univ. Dresden (Germany)
- 8239 0P **Tailor cutting of crystalline solar cells by laser micro jet** [8239-24]  
F. Bruckert, Synova S.A. (Switzerland); E. Pilat, Institut National de l'Energie Solaire (France); P. Piron, P. Torres, B. Carron, B. Richerzhagen, Synova S.A. (Switzerland); M. Pirot, R. Monna, Institut National de l'Energie Solaire (France)
- 8239 0Q **Combining remote ablation cutting and remote welding: opportunities and application areas** [8239-25]  
J. Musiol, Institute for Machine Tools and Industrial Management (Germany); M. Luetke, Fraunhofer IWS Dresden (Germany); M. Schweier, J. Hatwig, Institute for Machine Tools and Industrial Management (Germany); A. Wetzig, E. Beyer, Fraunhofer IWS Dresden (Germany); M. F. Zaeh, Institute for Machine Tools and Industrial Management (Germany)

---

#### SESSION 6 BEAM DELIVERY AND DIAGNOSTICS I

---

- 8239 0R **Mid-infrared imaging Fourier transform spectrometry for high power fiber laser irradiated fiberglass composites (Invited Paper)** [8239-26]  
R. I. Acosta, K. C. Gross, G. P. Perram, Air Force Institute of Technology (United States)
- 8239 0S **Spectroscopic closed loop control of penetration depth in laser beam welding process** [8239-27]  
T. Sibillano, A. Ancona, CNR-IFN UOS Bari (Italy); D. Rizzi, F. Mezzapesa, Univ. degli Studi e Politecnico di Bari (Italy); A. R. Konuk, R. Aarts, B. Huis in 't Veld, Univ. Twente (Netherlands); P. M. Lugarà, CNR-IFN UOS Bari (Italy) and Univ. degli Studi e Politecnico di Bari (Italy)
- 8239 0T **NIR-camera-based online diagnostics of laser beam welding processes** [8239-28]  
F. Dorsch, H. Braun, S. Keßler, D. Pfitzner, TRUMPF Werkzeugmaschinen GmbH + Co. KG (Germany); V. Rominger, TRUMPF Laser- und Systemtechnik GmbH (Germany)
- 8239 0U **High-power fiber optic cable with integrated active sensors for live process monitoring** [8239-29]  
O. Blomster, M. Blomqvist, H. Bergstrand, M. Pålsson, Optoskand AB (Sweden)

---

#### SESSION 7 BEAM DELIVERY AND DIAGNOSTICS II

---

- 8239 0V **Beam delivery systems and processing heads for 1µm high brightness laser cutting systems** [8239-30]  
H. Zimer, R. Niedrig, B. Wedel, HIGHYAG Lasertechnologie GmbH (Germany)
- 8239 0W **Unique beam delivery and processing tools for high power solid state laser processing** [8239-31]  
T. Ryba, D. Havrilla, TRUMPF Inc. (United States); M. Holzer, M. Bea, TRUMPF Laser- und Systemtechnik GmbH (Germany)

- 8239 0X **Maximum uptime and minimum focus shift in high-power 1 $\mu$ m laser beam delivery** [8239-32]  
T. Kugler, Laser Mechanisms, Inc. (United States)
- 8239 0Y **Ultra-low absorption glasses and optical coatings for reduced thermal focus shift in high power optics** [8239-33]  
D. T. Carpenter, C. S. Wood, O. Lyngnes, N. G. Traggis, Precision Photonics Corp. (United States)
- 8239 0Z **Self-compensation of thermal lensing in optics for high-brightness solid-state lasers** [8239-34]  
S. Piehler, C. Thiel, A. Voss, M. Abdou Ahmed, T. Graf, Univ. Stuttgart (Germany)
- 8239 10 **Fabrication and characteristic of a multicore fiber for high power laser delivery** [8239-35]  
H. Wei, S. Chen, J. Li, C. Tang, Yangtze Optical Fibre and Cable Co., Ltd. (China); P. Yan, Shenzhen Univ. (China)

---

#### POSTER SESSION

---

- 8239 11 **Controlling the thermally induced focal shift in laser processing heads** [8239-36]  
J.-P. Negel, F. Abt, D. Blázquez-Sánchez, A. Austerschulte, M. Hafner, T. Liebig, P. von Strobl-Albeg, R. Weber, M. Abdou Ahmed, A. Voss, T. Graf, Univ. Stuttgart (Germany)
- 8239 13 **Study of a fiber laser assisted friction stir welding process** [8239-39]  
G. Casalino, S. Campanelli, A. D. Ludovico, N. Contuzzi, A. Angelastro, Politecnico di Bari (Italy)
- 8239 14 **Parameters in selective laser melting for processing metallic powders** [8239-40]  
T. Kurzynowski, E. Chlebus, B. Kuźnicka, J. Reiner, Wrocław Univ. of Technology (Poland)

*Author Index*

# Conference Committee

## *Symposium Chairs*

**Friedhelm Dorsch**, TRUMPF Werkzeugmaschinen GmbH + Co. KG  
(Germany)

**Alberto Piqué**, Naval Research Laboratory (United States)

## *Symposium Cochairs*

**Bo Gu**, IPG Photonics Corporation (China)

**Andreas Tünnermann**, Friedrich-Schiller-Universität Jena (Germany)

## *Program Track Chair*

**Gregory J. Quarles**, BE Meyers & Company Inc. (United States)

## *Conference Chairs*

**Eckhard Beyer**, Fraunhofer-Institut für Werkstoff- und Strahltechnik  
(Germany)

**Timothy Morris**, TRUMPF Inc. (United States)

## *Program Committee*

**Milan Brandt**, RMIT University (Australia)

**Craig Bratt**, Fraunhofer USA, Inc. (United States)

**Edward Chlebus**, Wroclaw University of Technology (Poland)

**Ingomar Kelbassa**, RWTH Aachen (Germany)

**Wolfgang Knapp**, Coopération Laser Franco-Allemande (France)

**Isamu Miyamoto**, Osaka University (Japan)

**Thomas P. Pearsall**, European Photonics Industry Consortium (France)

**Silke Pflueger**, Laserline Inc. (United States)

**Michael Schmidt**, Friedrich-Alexander-Universität Erlangen-Nürnberg  
(Germany)

**Jens Standfuss**, Fraunhofer-Institut für Werkstoff- und Strahltechnik  
(Germany)

**Anja Techel**, Fraunhofer-Institut für Werkstoff- und Strahltechnik  
(Germany)

**Luigi Tricarico**, Politecnico di Bari (Italy)

**Kunihiko Washio**, Paradigm Laser Research Ltd. (Japan)

**Andreas Wetzig**, Fraunhofer-Institut für Werkstoff- und Strahltechnik  
(Germany)

**Minlin Zhong**, Tsinghua University (China)



### *Session Chairs*

- 1 Invited Session  
**Eckhard Beyer**, Fraunhofer-Institut für Werkstoff- und Strahltechnik  
(Germany)
- 2 Lasers and Laser Systems in Macro Processing  
**Silke Pflueger**, Laserline Inc. (United States)
- 3 Applications: Welding  
**Timothy Morris**, TRUMPF Inc. (United States)
- 4 Applications: Surface Treatment and Cladding  
**Christoph Leyens**, Technische Universität Dresden (Germany)
- 5 Applications: Cutting  
**Andreas Wetzig**, Fraunhofer-Institut für Werkstoff- und Strahltechnik  
(Germany)
- 6 Beam Delivery and Diagnostics I  
**Kunihiko Washio**, Paradigm Laser Research Ltd. (Japan)
- 7 Beam Delivery and Diagnostics II  
**Wolfgang Knapp**, Coopération Laser Franco-Allemande (France)