

PROCEEDINGS OF SPIE

Laser Applications in Microelectronic and Optoelectronic Manufacturing (LAMOM) XXII

**Beat Neuenschwander
Costas P. Grigoropoulos
Tetsuya Makimura
Gediminas Račiukaitis**
Editors

**30 January–2 February 2017
San Francisco, California, United States**

Sponsored by
SPIE

Cosponsored by
Okamoto Optics (Japan)
Plymouth Grating Laboratory (United States)

Published by
SPIE

Volume 10091

Proceedings of SPIE 0277-786X, V. 10091

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

Laser Applications in Microelectronic and Optoelectronic Manufacturing (LAMOM) XXII, edited by
Beat Neuenschwander, Costas P. Grigoropoulos, Tetsuya Makimura, Gediminas Račiukaitis, Proc. of SPIE
Vol. 10091, 1009101 · © 2017 SPIE · CCC code: 0277-786X/17/\$18 · doi: 10.1117/12.2276097

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 *Laser Applications in Microelectronic and Optoelectronic Manufacturing (LAMOM) XXII*, edited by Beat Neuenschwander, Costas P. Grigoropoulos, Tetsuya Makimura, Gediminas Račiukaitis, Proceedings of SPIE Vol. 10091 (SPIE, Bellingham, WA, 2017) Seven-digit Article CID Number.

ISSN: 0277-786X

ISSN: 1996-756X (electronic)

ISBN: 9781510606234

ISBN: 9781510606241 (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 © 2017, 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/17/\$18.00.

Printed in the United States of America.

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



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

-
- vii Authors
 - ix Conference Committee

LASER PROCESSES I: THIN FILMS

- 10091 02 **Laser processing of VO₂ thin films for THz devices and metamaterials (Invited Paper)** [10091-1]
- 10091 04 **Tailoring of graphite oxide electrical properties using laser irradiation** [10091-3]
- 10091 05 **Low temperature deposition of inorganic films by excimer laser assisted chemical vapor deposition** [10091-4]
- 10091 06 **Damage free Al doping on 4H-SiC with passivation films using XeF excimer laser irradiation in AlCl₃ acid solution** [10091-5]

LASER PROCESSES II: PRODUCTION TECHNOLOGIES

- 10091 08 **Co-propagating FWM of axial symmetric laser pulse with femtosecond duration** [10091-14]

LASER PROCESSES III: APPLICATIONS

- 10091 0B **Laser-assisted manufacturing of super-insulation materials** [10091-10]
- 10091 0C **High speed, mask-less, laser controlled deposition of microscale tungsten tracks using 405 nm wavelength diode laser** [10091-11]
- 10091 0D **Laser assisted hybrid additive manufacturing of thermoelectric modules** [10091-12]
- 10091 0F **Laser processing for precise fabrication of the THz optics** [10091-7]

ENABLING THROUGHPUT AND QUALITY SCALING

- 10091 0G **Throughput scaling by spatial beam shaping and dynamic focusing (Invited Paper)** [10091-15]
- 10091 0H **Inline measurement for quality control from macro to micro laser applications (Invited Paper)** [10091-16]
- 10091 0I **New random trigger-feature for ultrashort-pulsed laser increases throughput, accuracy and quality in micromachining applications** [10091-17]

- 10091 OJ **Influence of the pulse duration and the experimental approach onto the specific removal rate for ultra-short pulses** [10091-18]

NANOSTRUCTURED OPTICAL FIBERS: JOINT SESSION WITH CONFERENCES 10091 AND 10094

- 10091 OK **FBG inscription in multimode microfiber via point-by-point radiation with femtosecond laser (Best Student Paper Award)** [10091-19]
- 10091 OL **Femtosecond-pulse inscription of fiber Bragg gratings in multimode graded index fiber** [10091-20]

SCRIBING TRANSPARENT MATERIALS: JOINT SESSION WITH CONFERENCES 10091 AND 10094

- 10091 ON **Modification of glass using an axicon-generated non-symmetrical Bessel-Gaussian beam** [10091-22]

ULTRAFAST LASERS FOR CHARACTERIZATION: JOINT SESSION WITH CONFERENCES 10091 AND 10094

- 10091 OR **Ultrafast laser energy deposition in copper revealed by simulation and experimental determination of optical properties with pump-probe ellipsometry** [10091-26]
- 10091 OS **Numerical study of the influence of picosecond laser spot size on laser ablation of metal for high laser fluence cases** [10091-27]

LASER PROCESSING WITH PLASMONICS: JOINT SESSION WITH CONFERENCES 10091 AND 10093

- 10091 OT **Nanograting formation in air through plasmonic near-field ablation induced by femtosecond laser pulses (Invited Paper)** [10091-28]

LASER GENERATED NANOSTRUCTURES: JOINT SESSION WITH CONFERENCES 10091 AND 10093

- 10091 OW **Direct printing of micro/nanostructures by femtosecond laser excitation of nanocrystals** [10091-31]

INDUSTRIAL APPLICATIONS: PROCESSES: JOINT SESSION WITH CONFERENCES 10091 AND 10094

- 10091 OZ **Ultrashort-pulsed laser material processing with high repetition rate burst pulses** [10091-34]
- 10091 10 **Studies on nanosecond 532nm and 355nm and ultrafast 515nm and 532nm laser cutting super-hard materials** [10091-35]

POSTER SESSION

- 10091 15 **Polycarbonate resin drilling by longitudinally excited CO₂ laser** [10091-40]
- 10091 19 **Temperature control of CO₂ laser glass melting for fiber processing technology** [10091-44]
- 10091 1B **Laser surface modification of ZnO for solar converters** [10091-46]
- 10091 1C **Beam shaping by spatial light modulator and 4f system to square and top-flat for interference laser processing (Best Student Poster Award)** [10091-47]
- 10091 1E **Ultrafast laser scribing of transparent conductive oxides in Cu(In,Ga)Se₂ solar cells via laser lift-off process: the control of laser-induced damage** [10091-49]

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.

Afanasjev, Valentin, 1B	Minkevičius, Linas, 0F
Akitsu, Tetsuya, 15	Miyaji, Godai, 0T
Ammann, Hubert, 0I	Miyanaga, Noriaki, 1C
Asano, T., 06	Miyazaki, Kenzo, 0T
Auyeung, Raymond C. Y., 02	Mukhin, Nikolay, 1B
Babin, Sergey A., 0L	Nakamura, D., 06
Barkauskas, Jurgis, 04	Nakata, Yoshiki, 1C
Benetti, Marco, 0I	Narazaki, Aiko, 1C, 1E
Bergner, K., 0G	Nargelienė, Viktorija, 04
Breckenfeld, Eric, 02	Neuenschwander, Beat, 0I, 0J, 0S
Charipar, Kristin M., 02	Niaura, Gediminas, 04
Charipar, Nicholas A., 02	Niino, Hiroyuki, 1E
Dostovalov, Alexandr V., 0L	Niki, Shigeru, 1E
Dudutis, Juozas, 0N	Nishinaga, Jiro, 1E
Eyama, Takashi, 0O	Nolte, S., 0G
Flamm, D., 0G	Oehler, Andreas, 0I
Gečys, Paulius, 0N	O'Neill, William, 0C
Grishkanich, Aleksandr, 1B	Osawa, Kazuhito, 1C
Grossmann, D., 0G	Pan, Heng, 0W
He, Jiaji, 0K	Park, Byung Kyu, 0B
Hirsch, Sören, 1B	Park, Jongmin, 05
Hu, Di, 0K	Patel, Rajesh, 0X
Huber, Heinz P., 0R	Pichot, Jean Francois, 0H
Hwang, David J., 05, 0B, 0D	Piqué, Alberto, 02
Iakovlev, Alexey, 1B	Račiukaitis, Gediminas, 0F, 0N
Ikeda, A., 06	Rapp, Stephan, 0R
Ikenoue, H., 06	Redka, Dmitriy, 1B
Indrišiūnas, Simonas, 0F	Remund, Stefan, 0I, 0J
Ishizuka, Shogo, 1E	Romano, Valerio, 0S
Jaeggi, Beat, 0I, 0J	Sato, Tadatake, 1E
Jebali, M. A., 19	Schmidt, Michael, 0R
Jitsuno, Takahisa, 15	Schoenleber, Martin, 0H
Kablukov, Sergey I., 0L	Schulze, Jochen, 0H
Kaiser, M., 0G	Shibata, Hajime, 1E
Kamikawa-Shimizu, Yukiko, 1E	Shoji, Tatsuya, 1C
Kašalynas, Irmantas, 0F	Shou, Wan, 0W
Kato, Masaya, 15	Šnaiukas, Ramūnas, 0F
Kim, Heungssoo, 02	Sparkes, Martin, 0C
Kleiner, J., 0G	Suwa, A., 06
Kogel-Hollacher, Markus, 0H	Takada, Hideyuki, 1E
Kramer, T., 0J	Tao, Sha, 10
Kuchik, Igor E., 08	Ten, Jyi Sheuan, 0C
Kuk, Seungkuk, 05	Terukov, Evgeniy, 1B
Kumkar, M., 0G	Tewolde, Mahder, 0D
Lee, Woo Il, 0B	Torizuka, Kenji, 1E
Longtin, Jon P., 0D	Trofimov, Vyacheslav A., 08
Lukša, Algimantas, 04	Trusovas, Romualdas, 04
Mathews, Scott A., 02	Tsuboi, Yasuyuki, 1C
Mayerhofer, Roland, 0Z	Tsuchiya, T., 06

Uno, Kazuyuki, 15
Voisiat, Bogdan, 0F
Wang, Anbo, 0K
Wang, Brian, 10
Wang, Zhen, 0B
Wassermann, Dominique, 0I
Winter, Jan, 0R
Wolf, Alexey A., 0L
Xuan, Haifeng, 0K
Yang, Shuo, 0K
Yoshida, Masataka, 1C
Zhang, Jie, 10
Zhang, Tao, 05, 0B, 0D
Zhang, Yiming, 0S
Zhao, Jay, 10
Zimmermann, F., 0G
Zlobina, Ekaterina A., 0L

Conference Committee

Symposium Chairs

Reinhart Poprawe, Fraunhofer-Institut für Lasertechnik (Germany)
Koji Sugioka, RIKEN (Japan)

Symposium Co-chairs

Guido Hennig, Daetwyler Graphics AG (Switzerland)
Yongfeng Lu, University of Nebraska-Lincoln (United States)

Program Track Chairs

Beat Neuenschwander, Berner Fachhochschule Technik und Informatik (Switzerland)
Henry Helvajian, The Aerospace Corporation (United States)

Conference Chairs

Beat Neuenschwander, Berner Fachhochschule Technik und Informatik (Switzerland)
Costas P. Grigoropoulos, University of California, Berkeley (United States)
Tetsuya Makimura, University of Tsukuba (Japan)
Gediminas Račiukaitis, Center for Physical Sciences and Technology (Lithuania)

Conference Program Committee

Craig B. Arnold, Princeton University (United States)
J. Thomas Dickinson, Washington State University (United States)
Jan J. Dubowski, Université de Sherbrooke (Canada)
Bo Gu, Bos Photonics (United States)
Henry Helvajian, The Aerospace Corporation (United States)
Sami T. Hendow, Adaptive Laser Processing (United States)
Guido Hennig, Daetwyler Graphics AG (Switzerland)
Heinz P. Huber, Hochschule für Angewandte Wissenschaften München (Germany)
Michel Meunier, Ecole Polytechnique de Montréal (Canada)
Yoshiki Nakata, Osaka University (Japan)
Hiroyuki Niino, National Institute of Advanced Industrial Science and Technology (Japan)
Alberto Piqué, U.S. Naval Research Laboratory (United States)
Andrei V. Rode, The Australian National University (Australia)

Stephan Roth, BLZ Bayerisches Laserzentrum GmbH (Germany)
Klaus Sokolowski-Tinten, Universität Duisburg-Essen (Germany)
Razvan Stoian, Laboratoire Hubert Curien (France)
Koji Sugioka, RIKEN (Japan)
Xianfan Xu, Purdue University (United States)
Steven M. Yalisove, University of Michigan (United States)

Session Chairs

- 1 Laser Processes I: Thin Films
Beat Neuenschwander, Berner Fachhochschule Technik und Informatik (Switzerland)
- 2 Laser Processes II: Production Technologies
Costas P. Grigoropoulos, University of California, Berkeley (United States)
- 3 Laser Processes III: Applications
Tetsuya Makimura, University of Tsukuba (Japan)
- 4 Enabling Throughput and Quality Scaling
Gediminas Račiukaitis, Center for Physical Sciences and Technology (Lithuania)
- 5 Nanostructured Optical Fibers: Joint Session with Conferences 10091 and 10094
Roberto Osellame, CNR-Istituto di Fotonica e Nanotecnologie (Italy)
- 6 Scribing Transparent Materials: Joint Session with Conferences 10091 and 10094
Peter R. Herman, University of Toronto (Canada)
- 7 Laser Interaction Dynamics: Joint Session with Conferences 10091 and 10094
Guido Hennig, Daetwyler Graphics AG (Switzerland)
- 8 Ultrafast Lasers for Characterization: Joint Session with Conferences 10091 and 10094
Jean-Philippe Colombier, Université Jean Monnet Saint-Etienne (France)
- 9 Laser Processing with Plasmonics: Joint Session with Conferences 10091 and 10093
David B. Geohegan, Oak Ridge National Laboratory (United States)

- 10 Laser Generated Nanostructures: Joint Session with Conferences 10091 and 10093
Theobald Lohmueller, Ludwig-Maximilians-Universität München (Germany)
- 11 Industrial Applications: Systems: Joint Session with Conferences 10091 and 10094
Eric P. Mottay, Amplitude Systèmes (France)
- 12 Industrial Applications: Processes: Joint Session with Conferences 10091 and 10094
Malte Kumkar, TRUMPF Laser- und Systemtechnik GmbH (Germany)

