

PROCEEDINGS OF SPIE

Laser Applications in Microelectronic and Optoelectronic Manufacturing (LAMOM) XXV

Gediminas Račiukaitis

Carlos Molpeceres

Jie Qiao

Aiko Narazaki

Editors

3–5 February 2020

San Francisco, California, United States

Sponsored by

SPIE

Cosponsored by

Okamoto Optics Works (Japan)

Plymouth Grating Laboratory (United States)

Published by

SPIE

Volume 11267

Proceedings of SPIE 0277-786X, V. 11267

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

Laser Applications in Microelectronic and Optoelectronic Manufacturing (LAMOM) XXV, edited by
Gediminas Račiukaitis, Carlos Molpeceres, Jie Qiao, Aiko Narazaki, Proc. of SPIE Vol. 11267
1126701 · © 2020 SPIE · CCC code: 0277-786X/20/\$21 · doi: 10.1117/12.2569916

Proc. of SPIE Vol. 11267 1126701-1

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 SPIDigitalLibrary.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) XXV*, edited by Gediminas Račiukaitis, Carlos Molpeceres, Jie Qiao, Aiko Narazaki, Proceedings of SPIE Vol. 11267 (SPIE, Bellingham, WA, 2020) Seven-digit Article CID Number.

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

ISBN: 9781510632974
ISBN: 9781510632981 (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 © 2020, 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 \$21.00 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/20/\$21.00.

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**

SPIDigitalLibrary.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	<i>Authors</i>
vii	<i>Conference Committee</i>

LASER PROCESSING OF POLYMERS

- 11267 06 **Optical waveguide on silicon made by zone melting method** [11267-42]
- 11267 09 **High speed laser printing and sintering of flexible RFID antennas and fingerprint sensors** [11267-47]

ULTRAFAST LASER-INDUCED MODIFICATIONS IN TRANSPARENT MATERIALS: JOINT SESSION WITH 11267 AND 11270

- 11267 0B **Laser induced modifications in transparent materials using azimuthally modulated axicon beams** [11267-9]

LASER-BASED PROCESSES FOR ELECTRONICS

- 11267 0F **Surface functionalization of flexographic printing forms using a femtosecond laser for adjustable material transfer in MID production processes** [11267-13]
- 11267 0H **Laser processing of titanium: oxide formation for electronic applications** [11267-15]

LASER NANOPROCESSING

- 11267 0I **Nanoparticle synthesis via femtosecond laser reduction in liquid (Invited Paper)** [11267-16]
- 11267 0J **Energy generation on an array of nanoparticles on a surface** [11267-17]
- 11267 0L **Effect of front-contact laser texturing in thin-film solar cells** [11267-19]

UPSCALING LASER PROCESSING UTILIZING ADVANCED BEAM SHAPING

- 11267 0P **High-precision ultrashort pulsed laser processing of metal foils using an advanced multibeam optic (Best Student Paper Award)** [11267-23]

11267 OR **Scaling percussion drilling processes by ultrashort laser pulses using advanced beam shaping**
[11267-25]

TOWARDS HIGH-EFFICIENT LASER ABLATION

11267 OT **Machining metals and silicon with GHz bursts: surprising tremendous reduction of the specific removal rate for surface texturing applications** [11267-27]

11267 OV **Micromachining flexibility by tunable ultrashort pulse duration, pulse-on-demand, and hybrid processing from single pulse to GHz burst with TruMicro Series 2000** [11267-29]

ULTRAFast LASER PROCESSING OF GLASS, CERAMICS AND SEMICONDUCTORS

11267 OW **Ultrafast and precision processing of glass by selective absorption of fiber-laser pulse into femtosecond-laser-induced filament (Invited Paper)** [11267-30]

11267 OZ **Micro laser assisted single point diamond turning of brittle and hard materials** [11267-33]

MODELLING AND PROCESS CONTROL

11267 10 **High-precision laser ablation using OCT closed-loop control (Invited Paper)** [11267-35]

11267 13 **Position observer based galvanometer scanner and XY stage synchronization for large area processing** [11267-38]

INTEGRATION OF DEVICES INSIDE BULK TRANSPARENT MATERIALS

11267 14 **3D glass nanofluidics fabricated by femtosecond laser processing for study of cancer cell metastasis and invasion (Invited Paper)** [11267-39]

11267 17 **From proof of principle to 98.5% yield of a high-speed laser processing tool (Invited Paper)**
[11267-44]

POSTER SESSION

11267 1B **Fabrication of sub-micrometer periodic nanostructures using pulsed laser interference for efficient light trapping in optoelectronic devices** [11267-46]

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.

Ankri, Jonathan, 09
Arnaldo, Daniel, 09
Arutinov, Gari, 09
Auyeung, Raymond C. Y., 0H
Baitrukonis, Justas, 0B
Barthels, T., 0P
Behera, S., 1B
Bhut, Bhavesh A., 13
Bodlapati, Charan, 0Z
Boley, Steffen, 10
Braz, Nuno, 09
Budnicki, Aleksander, 0V
Buser, Matthias, 10
Butkus, Simas, 0T
Canteli, David, 0L
Chaja, Michalina V., 0T
Charipar, Kristin M., 0H
Charipar, Nicholas A., 0H
Chou, M. F., 0J
Cobb, Brian, 09
De la Vega, Fernando, 09
Diekamp, Holger, 0V
Dowling, Keith J., 13
Eberhardt, Christian, 0V
Fehrenbacher, Axel, 0V
Fernández, Susana, 0L
Flamm, D., 0R
Fu, T. C., 0J
Fuehrra, Benjamin, 0V
Gafner, Markus, 0T
Geremia, Riccardo, 09
Giesbers, Merijn, 09
Ginter, Markus, 0V
Gotovski, Pavel, 0B
Graf, Thomas, 10
Grossmann, D., 0R
Han, I. S., 1B
Hanuka, Uriel, 06
Hellstern, J., 0R
Hirsiger, Thomas, 0T
Hoffmann, Gerd-Albert, 0F
Holder, Daniel, 10
Hong, J. Y., 0J
Hopkinson, M., 1B
Hsu, Yu John, 13
Ito, Yusuke, 0W
Jansen, Florian, 0V
Jäschke, Peter, 0F
Jin, C., 1B
Jukna, Vytautas, 0B
Kabla, Ayala, 09
Kaierle, Stefan, 0F
Kalaitzis, Agamemnon, 09
Kanal, Florian, 0V
Kang, Di, 0Z
Kariyapperuma, Darshana, 09
Karnakis, Dimitris, 09
Kawano, H., 14
Kim, Heungsoo, 0H
Koch, Jürgen, 0F
Koritsoglou, Olga, 09
Kumkar, M., 0R
Leis, Artur, 10
Li, Jin, 13
Lucas, Mark S., 13
Makrygianni, Marina, 09
Melamed, Alon, 09
Melamed, Semyon, 09
Miyawaki, A., 14
Molpeceres, Carlos, 0L
Morales, Miguel, 0L
Musi, Christopher, 0H
Nacius, Ernestas, 0B
Nagasawa, Ikuo, 0W
Nagato, Keisuke, 0W
Navare, Jayesh, 0Z
Neuenschwander, Beat, 0T
Nießen, M., 0P
Norval, Shane, 09
Obata, K., 14
Orlov, Sergej, 0B
Overmeyer, Ludger, 0F
Piqué, Alberto, 0H
Price, Richard, 09
Quentin, Ulf, 0V
Ravindra, Deepak, 0Z
Reininghaus, M., 0P
Remund, Stefan, 0T
Sailer, Marc, 0R, 0V
Santos, José D., 0L
Scelle, Raphael, 0V
Schwarzbaum, Arye, 09
Serien, D., 14
Shahar, Amit, 13
Shahinian, Hossein, 0Z
Shibata, Akihiro, 0W
Sima, F., 14
Sinvani, Moshe, 06

Sivam, Seethram, 13
Slevas, Paulius, 0B
Sperling, Patrick, 0V
Sugioka, K., 14
Sugita, Naohiko, 0W
Sutter, Dirk H., 0V
Tan, Chuong, 0V
Terbrueggen, Ralf, 17
Theodorakos, Ioannis, 09
Tibbetts, Katharine Moore, 0I
Tiferet, Maor, 06
Too, Patrick, 09
Torres, Ignacio, 0L
Tuohi, Simon, 09
Ulcinas, Orestas, 0B
Urniezius, Aivaras, 0T
Wang, Y., 0P
Wang, Y., 1B
Weber, Rudolf, 10
Wei, P. S., 0J
Wienke, Alexander, 0F
Yoshizaki, Reina, 0W
Zacharatos, Filimon, 09
Zalevsky, Zeev, 06
Zaytsev, Dmytro, 0Z
Zergioti, Ioanna, 09
Zigman, Yair, 06

Conference Committee

Symposium Chairs

Beat Neuenschwander, Berner Fachhochschule Technik und Informatik (Switzerland)

Xianfan Xu, Purdue University (United States)

Symposium Co-chairs

Craig B. Arnold, Princeton University (United States)

Takunori Taira, Institute for Molecular Science (Japan)

Program Track Chairs

Henry Helvajian, The Aerospace Corporation (United States)

Guido Hennig, Daetwyler Graphics AG (Switzerland)

Conference Chairs

Gediminas Račiukaitis, Center for Physical Sciences and Technology (Lithuania)

Carlos Molpeceres, Universidad Politécnica de Madrid (Spain)

Conference Co-chairs

Jie Qiao, Rochester Institute of Technology (United States)

Aiko Narazaki, National Institute of Advanced Industrial Science and Technology (Japan)

Conference Program Committee

Craig B. Arnold, Princeton University (United States)

Jan J. Dubowski, Université de Sherbrooke (Canada)

Costas P. Grigoropoulos, University of California, Berkeley (United States)

Bo Gu, Bos Photonics (United States)

Henry Helvajian, The Aerospace Corporation (United States)

Guido Hennig, Daetwyler Graphics AG (Switzerland)

Heinz P. Huber, Hochschule für Angewandte Wissenschaften München (Germany)

Tetsuya Makimura, University of Tsukuba (Japan)

Michel Meunier, Ecole Polytechnique de Montréal (Canada)

Yoshiki Nakata, Osaka University (Japan)

Beat Neuenschwander, Berner Fachhochschule Technik und Informatik (Switzerland)
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 LAMOM XXV Anniversary
Gediminas Račiukaitis, Center for Physical Sciences and Technology (Lithuania)
- 2 Laser Processing of Polymers
Jie Qiao, Rochester Institute of Technology (United States)
- 3 Ultrafast Laser-induced Modifications in Transparent Materials: Joint Session with 11267 and 11270
Roberto Osellame, CNR-Istituto di Fotonica e Nanotecnologie (Italy)
- 4 Laser-based Processes for Electronics
Carlos Molpeceres, Universidad Politécnica de Madrid (Spain)
Jie Qiao, Rochester Institute of Technology (United States)
- 5 Laser Nanoprocessing
Tadatake Sato, National Institute of Advanced Industrial Science and Technology (Japan)
- 6 Upscaling Laser Processing Utilizing Advanced Beam Shaping
Guido Hennig, Daetwyler Graphics AG (Switzerland)
- 7 Towards High-efficient Laser Ablation
Carlos Molpeceres, Universidad Politécnica de Madrid (Spain)
- 8 Ultrafast Laser Processing of Glass, Ceramics and Semiconductors
Aiko Narazaki, National Institute of Advanced Industrial Science and Technology (Japan)
- 9 Modelling and Process Control
Gediminas Račiukaitis, Center for Physical Sciences and Technology (Lithuania)

- 10 Integration OD Devices Inside Bulk Transparent Materials
Carlos Molpeceres, Universidad Politécnica de Madrid (Spain)

