

PROCEEDINGS OF SPIE

Laser Applications in Microelectronic and Optoelectronic Manufacturing (LAMOM) XVIII

Xianfan Xu
Guido Hennig
Yoshiki Nakata
Stephan W. Roth
Editors

4–7 February 2013
San Francisco, California, United States

Sponsored and Published by
SPIE

Volume 8607

Proceedings of SPIE 0277-786X, V.8607

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

Laser Applications in Microelectronic and Optoelectronic Manufacturing (LAMOM) XVIII, edited by
Xianfan Xu, Guido Hennig, Yoshiki Nakata, Stephan W. Roth, Proc. of SPIE Vol. 8607, 860701
© 2013 SPIE · CCC code: 0277-786X/13/\$18 · doi: 10.1117/12.2025057

Proc. of SPIE Vol. 8607 860701-1

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 *Laser Applications in Microelectronic and Optoelectronic Manufacturing (LAMOM) XVIII*, edited by Xianfan Xu, Guido Hennig, Yoshiaki Nakata, Stephan W. Roth, Proceedings of SPIE Vol. 8607 (SPIE, Bellingham, WA, 2013) Article CID Number.

ISSN: 0277-786X

ISBN: 9780819493767

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 © 2013, 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/13/\$18.00.

Printed in the United States of America.

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



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 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

ix Conference Committee

NANOSCALE MATERIALS SYNTHESIS AND PROCESSING: JOINT SESSION WITH CONFERENCES 8607 AND 8609

- 8607 02 **Formation of quantum dots from precursors in polymeric films by ps-laser** [8607-1]
G. Račiukaitis, EKSPLA (Lithuania) and Ctr. for Physical Sciences & Technology (Lithuania);
P. Gečys, Ctr. for Physical Sciences & Technology (Lithuania); F. Antolini, L. Stroea, ENEA UTTMATEF (Italy); A. K. Bansal, I. D. W. Samuel, The Univ. of St. Andrews (United Kingdom);
S. Allard, U. Scherf, Bergische Univ. Wuppertal (Germany); L. Ortolani, CNR, Istituto per la Microelettronica e Microsistemi (Italy)
- 8607 03 **Growth of periodic ZnO nano-crystals on buffer layer patterned by interference laser irradiation** [8607-2]
D. Nakamura, T. Shimogaki, K. Okazaki, M. Higashihata, Kyushu Univ. (Japan); Y. Nakata, Osaka Univ. (Japan); T. Okada, Kyushu Univ. (Japan)
- 8607 04 **Sintering of solution-based aluminum nano-particles by laser ignition** [8607-3]
J. Zhang, Panasonic Boston Lab. (United States)

ULTRAFAST LASER MICROMACHINING I: FUNDAMENTALS: JOINT SESSION WITH CONFERENCES 8607 AND 8611

- 8607 0C **Time and space resolved investigations of confined fs ablation of Ta₂O₅/Pt thin film systems** [8607-11]
S. Rapp, J. Rosenberger, M. Domke, G. Heise, Hochschule für Angewandte Wissenschaften München (Germany); M. Schmidt, Friedrich-Alexander Univ. Erlangen-Nürnberg (Germany); H. P. Huber, Hochschule für Angewandte Wissenschaften München (Germany)
- 8607 0D **Factors controlling the incubation in the application of ps laser pulses on copper and iron surfaces** [8607-12]
B. Neuenschwander, B. Jaeggi, M. Schmid, Berner Fachhochschule Technik und Informatik (Switzerland); A. Dommann, A. Neels, T. Bandi, Ctr. Suisse d'Electronique et de Microtechnique SA (Switzerland); G. Hennig, Daetwyler Graphics AG (Switzerland)

ULTRAFAST LASER MICROMACHINING II: FUNDAMENTALS: JOINT SESSION WITH CONFERENCES 8607 AND 8611

- 8607 0E **High throughput laser micro machining on a rotating cylinder with ultra short pulses at highest precision** [8607-13]
B. Jaeggi, B. Neuenschwander, T. Meier, M. Zimmermann, Berner Fachhochschule Technik und Informatik (Switzerland); G. Hennig, Daetwyler Graphics AG (Switzerland)

ULTRAFAST LASER MICROMACHINING III: JOINT SESSION WITH CONFERENCES 8607 AND 8611

- 8607 0G **Double-pulse irradiation of ultrafast laser for high-efficiency glass microwelding (Invited Paper) [8607-15]**
K. Sugioka, S. Wu, K. Midorikawa, RIKEN (Japan)
- 8607 0H **Selective localised modifications of silicon crystal by ultrafast laser induced micro-explosion [8607-16]**
L. Rapp, B. Haberl, J. E. Bradby, E. G. Gamaly, J. S. Williams, The Australian National Univ. (Australia); S. Juodkasis, Swinburne Univ. of Technology (Australia); A. V. Rode, The Australian National Univ. (Australia)

ULTRAFAST LASER MICROMACHINING IV: JOINT SESSION WITH CONFERENCES 8607 AND 8611

- 8607 0K **Micro-hole drilling with femtosecond fiber laser [8607-19]**
H. Huang, L.-M. Yang, J. Liu, PolarOnyx, Inc. (United States)

DIAGNOSTICS IN LASER PROCESSING

- 8607 0O **Quantum cascade laser-based sensing to investigate fast laser ablation process [8607-23]**
F. P. Mezzapesa, V. Spagnolo, CNR-IFN UOS Bari (Italy) and Univ. degli Studi e Politecnico di Bari (Italy); A. Ancona, CNR-IFN UOS Bari (Italy); G. Scamarcio, CNR-IFN UOS Bari (Italy) and Univ. degli Studi e Politecnico di Bari (Italy)
- 8607 0Q **Two-photon excited fluorescence in the LYB:Eu monoclinic crystal: new scheme for single-beam dual-voxel direct laser writing in crystals [8607-25]**
Y. Petit, LOMA, CNRS, Univ. Bordeaux (France) and ICMCB, CNRS, Univ. Bordeaux (France); A. Royon, N. Marquestaut, LOMA, CNRS, Univ. Bordeaux (France); M. Dussauze, ISM, CNRS, Univ. Bordeaux (France); A. Fargues, P. Veber, V. Jubera, T. Cardinal, ICMCB, CNRS, Univ. Bordeaux (France); L. Canioni, LOMA, CNRS, Univ. Bordeaux (France)

3D MANUFACTURING II

- 8607 0T **Laser processing of 2D and 3D metamaterial structures (Invited Paper) [8607-29]**
N. A. Charipar, K. M. Charipar, H. Kim, M. A. Kirleis, R. C. Y. Auyeung, U.S. Naval Research Lab. (United States); A. T. Smith, Nova Research, Inc. (United States); S. A. Mathews, A. Piqué, U.S. Naval Research Lab. (United States)
- 8607 0U **Optical tweezers in microassembly [8607-30]**
A. Ostendorf, R. Ghadiri, S. I. Ksouri, Ruhr-Univ. Bochum (Germany)
- 8607 0V **Hologram design for holographic laser machining inside transparent materials [8607-31]**
M. Sakakura, N. Fukua, Y. Shimotsuma, K. Hirao, K. Miura, Kyoto Univ. (Japan)
- 8607 0X **Investigation of cw and ultrashort pulse laser irradiation of powder surfaces: a comparative study [8607-61]**
R. Ebert, F. Ullmann, J. Schille, U. Loeschner, H. Exner, Hochschule Mittweida (Germany)

LASER DIRECT WRITE

- 8607 0Y **Film-free laser microprinting of transparent solutions (Invited Paper)** [8607-33]
P. Serra, A. Patrascioiu, J. M. Fernández-Pradas, J. L. Morenza, Univ. de Barcelona (Spain)
- 8607 0Z **Applications of laser printing for organic electronics (Invited Paper)** [8607-34]
P. Delaporte, LP3, CNRS, Aix-Marseille Univ. (France); A. Ainsebaa, Ctr. Microelect Provence, Ecole Nationale Supérieure des Mines (France); A.-P. Alloncle, LP3, CNRS, Aix-Marseille Univ. (France); M. Benetti, Istituto di Acustica "O.M. Corbino", CNR (Italy); C. Boutopoulos, National Technical Univ. of Athens (Greece); D. Cannata, F. Di Pietrantonio, Istituto di Acustica "O.M. Corbino", CNR (Italy); V. Dinca, National Institute for Lasers, Plasma and Radiation Physics (Romania), Univ. de Barcelona (Spain) and Paul Scherrer Institut (Switzerland); M. Dinescu, National Institute for Lasers, Plasma and Radiation Physics (Romania); J. Dutroncy, ACXYS Technology (France); R. Eason, M. Feinaugle, The Univ. of Southampton (United Kingdom); J.-M. Fernández-Pradas, Univ. de Barcelona (Spain); A. Grisel, MICROSENS (Switzerland); K. Kaur, LP3, CNRS, Aix-Marseille Univ. (France) and The Univ. of Southampton (United Kingdom); U. Lehmann, MICROSENS (Switzerland); T. Lippert, Paul Scherrer Institut (Switzerland); C. Loussert, TAGSYS RFID (France); M. Makrygianni, National Technical Univ. of Athens (Greece); I. Manfredonia, BIOSENSOR srl. (Italy); T. Mattie, Paul Scherrer Institut (Switzerland); J.-L. Morenza, Univ. de Barcelona (Spain); M. Nagel, F. Nüesch, EMPA (Switzerland); A. Palla-Papavlu, National Institute for Lasers, Plasma and Optics (Romania), Univ. de Barcelona (Spain) and Paul Scherrer Institut (Switzerland); L. Rapp, LP3, CNRS, Aix-Marseille Univ. (France); N. Rizvi, Laser Micromachining Ltd. (United Kingdom); G. Rodio, BIOSENSOR srl. (Italy); S. Sanaur, Ctr. Microelect Provence, Ecole Nationale Supérieure des Mines (France); P. Serra, Univ. de Barcelona (Spain); J. Shaw-Stewart, EMPA (Switzerland); C. L. Sones, The Univ. of Southampton (United Kingdom); E. Verona, Istituto di Acustica "O.M. Corbino", CNR (Italy); I. Zergioti, National Technical Univ. of Athens (Greece)
- 8607 11 **Maskless selective laser patterning of PEDOT:PSS on barrier/foil for organic electronics applications** [8607-36]
D. Karnakis, T. Stephens, Oxford Lasers Ltd. (United Kingdom); G. Chabrol, Institut d'Électronique du Solide et des Systèmes (France)

LASER PATTERNING AND DRILLING

- 8607 12 **High resolution laser patterning of ITO on PET substrate** [8607-37]
T. Zhang, D. Liu, Stony Brook Univ. (United States) and Advanced Energy Research and Technology Ctr. (United States); H. K. Park, D. X. Yu, Yuco Optics Corp. (United States) and Advanced Energy Research and Technology Ctr. (United States); D. J. Hwang, Stony Brook Univ. (United States) and Advanced Energy Research and Technology Ctr. (United States)

- 8607 14 **Laser cutting of carbon fiber reinforced plastics (CFRP) by 1kW cw fiber laser irradiation** [8607-39]
H. Niino, Y. Kawaguchi, T. Sato, A. Narazaki, Advanced Laser and Process Technology Research Association (Japan) and National Institute of Advanced Industrial Science and Technology (Japan); R. Kurosaki, Advanced Laser and Process Technology Research Association (Japan); M. Muramatsu, Y. Harada, Advanced Laser and Process Technology Research Association (Japan) and National Institute of Advanced Industrial Science and Technology (Japan); K. Wakabayashi, T. Nagashima, Z. Kase, Advanced Laser and Process Technology Research Association (Japan) and Miyachi Corp. (Japan); M. Matsushita, K. Furukawa, Advanced Laser and Process Technology Research Association (Japan) and Shin Nippon Koki Co., Ltd. (Japan); M. Nishino, Advanced Laser and Process Technology Research Association (Japan) and Mitsubishi Chemical Corp. (Japan)
- 8607 16 **Novel micro-dots design to resolve Hotspot appeared on ultra-slim LEDs backlight** [8607-41]
W.-P. Chan, M. Tsai, Y.-R. Chiou, Forhouse Corp. (Taiwan); C.-S. Jao, Forhouse Corp. (Taiwan) and Industrial Technology Research Institute (Taiwan)

PHOTOVOLTAICS

- 8607 17 **Rapid laser scanning based surface texturing for energy applications and laser-assisted doping** [8607-42]
M. Quigley, D. Liu, Stony Brook Univ. (United States) and Advanced Energy Research and Technology Ctr. (United States); H. K. Park, D. X. Yu, Yuco Optics Corp. (United States) and Advanced Energy Research and Technology Ctr. (United States); D. J. Hwang, Stony Brook Univ. (United States) and Advanced Energy Research and Technology Ctr. (United States)
- 8607 18 **Anti-reflective polymer-nanocomposite coatings fabricated by RIR-MAPLE** [8607-43]
S. Singaravelu, AppliFlex LLC. (United States); D. C. Mayo, Vanderbilt Univ. (United States); H. K. Park, K. E. Schriver, AppliFlex LLC. (United States); R. F. Haglund Jr., Vanderbilt Univ. (United States)
- 8607 19 **Scribing of thin film solar cells by picosecond and nanosecond pulsed lasers and performance improvement by gas injection** [8607-45]
D. J. Hwang, D. Liu, Stony Brook Univ. (United States) and Advanced Energy Research and Technology Ctr. (United States); H. K. Park, D. X. Yu, Yuco Optics Corp. (United States) and Advanced Energy Research and Technology Ctr. (United States)

PHOTOVOLTAICS, ALTERNATIVE ENERGY SOURCES AND ADVANCED ENERGY STORAGE SYSTEMS: JOINT SESSION WITH 8607 AND 8608

- 8607 1B **Investigation of a reliable all-laser scribing process in thin film Cu(In,Ga)(S,Se)₂ manufacturing** [8607-47]
R. Witte, B. Frei, S. Schneeberger, Solneva SA (Switzerland); S. Bücheler, S. Nishiwaki, EMPA (Switzerland); A. Burn, M. Muralt, V. Romano, Berner Fachhochschule Technik und Informatik (Switzerland); L. Krainer, Onefive GmbH (Switzerland)

POSTER SESSION

- 8607 1F **Fresnel attenuator of laser radiation power** [8607-50]
J. Owsiak, Military Univ. of Technology (Poland); Y. Avdeev, A.N. Severtsov Institute of Ecology and Evolution (Russian Federation); A. A. Liberman, All-Russia Research Institute of Optical and Physical Measurements (Russian Federation); A. A. Kovalev, A. S. Mikryukov, S. A. Moskalyuk, All-Russia Research Institute of Optical and Physical Measurements (Russian Federation); J. Noga, Military Univ. of Technology (Poland); A. Rembielińska, LOT Polish Airlines (Poland); J. Walczuk, Agency for Restructuring and Modernisation of Agriculture (Poland)
- 8607 1I **Measuring the complex refractive index of metals in the solid and liquid state and its influence on the laser machining** [8607-53]
M. Schmid, S. Zehnder, P. Schwaller, B. Neuenschwander, J. Zürcher, U. Hunziker, Berner Fachhochschule Technik und Informatik (Switzerland)
- 8607 1J **Laser processing system development of large area and high precision** [8607-54]
H. Park, K. Ryu, T. Hwang, ASTJETEC Co., Ltd. (Korea, Republic of)
- 8607 1K **Sub-ns and ps laser performance and results** [8607-55]
J. Kilmer, M. Terraciano, Y. Yin, Photonics Industries International, Inc. (United States)
- 8607 1L **Femtosecond laser based in-fiber long period grating fabrication for improved solution sensing** [8607-57]
F. Ahmed, Univ. of Victoria (Canada); M. S. Ahsan, M. S. Lee, KAIST (Korea, Republic of); M. B. G. Jun, Univ. of Victoria (Canada)
- 8607 1N **Micromachining of Ti-3Al-2.5V tubes by nanosecond Nd:YAG laser** [8607-59]
Y. Lin, Alfred E. Mann Foundation for Scientific Research (United States); M. C. Gupta, Univ. of Virginia (United States)

Author Index

Conference Committee

Symposium Chairs

Bo Gu, Bos Photonics (United States)
Andreas Tünnermann, Fraunhofer-Institut für Angewandte Optik und Feinmechanik (Germany) and Friedrich-Schiller-Universität Jena (Germany)

Symposium Cochairs

Friedhelm Dorsch, TRUMPF Werkzeugmaschinen GmbH + Co. KG (Germany)
Alberto Piqué, U.S. Naval Research Laboratory (United States)

Program Track Chairs

Henry Helvajian, The Aerospace Corporation (United States)
James S. Horwitz, U.S. Department of Energy (United States)

Conference Chairs

Xianfan Xu, Purdue University (United States)
Guido Hennig, Daetwyler Graphics AG (Switzerland)
Yoshiki Nakata, Osaka University (Japan)
Stephan W. Roth, BLZ Bayerisches Laserzentrum GmbH (Germany)

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)
Ralf Knappe, LUMERA LASER GmbH (Germany)
Yongfeng Lu, University of Nebraska-Lincoln (United States)
Michel Meunier, Ecole Polytechnique de Montréal (Canada)
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)
Gediminas Raciukaitis, Center for Physical Sciences and Technology (Lithuania)

Andrei V. Rode, The Australian National University (Australia)
Klaus Sokolowski-Tinten, Universität Duisburg-Essen (Germany)
Razvan Stoian, Laboratoire Hubert Curien (France)
Koji Sugioka, RIKEN (Japan)

Session Chairs

- 1 Nanoscale Materials Synthesis and Processing: Joint Session with Conferences 8607 and 8609
Guido Hennig, Daetwyler Graphics AG (Switzerland)
- 2 Nanoscale Patterning: Joint Session with Conferences 8607 and 8609
Xianfan Xu, Purdue University (United States)
- 3 Ultrafast Laser Micromachining I: Fundamentals: Joint Session with Conferences 8607 and 8611
Yong Feng Lu, University of Nebraska-Lincoln (United States)
- 4 Ultrafast Laser Micromachining II: Fundamentals: Joint Session with Conferences 8607 and 8611
Stefan Nolte, Friedrich-Schiller-Universität Jena (Germany)
- 5 Ultrafast Laser Micromachining III: Joint Session with Conferences 8607 and 8611
Haibin Zhang, Electro Scientific Industries, Inc. (United States)
- 6 Ultrafast Laser Micromachining IV: Joint Session with Conferences 8607 and 8611
Klaus Sokolowski-Tinten, Universität Duisburg-Essen (Germany)
- 7 Diagnostics in Laser Processing
Hee K. Park, State University of New York (United States) and Yuco Photonics Systems Corporation (United States)
- 8 3D Manufacturing I
Henry Helvajian, The Aerospace Corporation (United States)
- 9 3D Manufacturing II
Gediminas Raciukaitis, Institute of Physics (Lithuania)
- 10 Laser Direct Write
Hiroyuki Niino, National Institute of Advanced Industrial Science and Technology (Japan)
- 11 Laser Patterning and Drilling
Stephan W. Roth, BLZ Bayerisches Laserzentrum GmbH (Germany)

- 12 Photovoltaics
Yoshiki Nakata, Osaka University (Japan)
- 13 Photovoltaics, Alternative Energy Sources and Advanced Energy Storage Systems: Joint Session with 8607 and 8608
Hee K. Park, State University of New York (United States) and Yuco Photonics Systems Corporation (United States)
Udo Klotzbach, Fraunhofer IWS Dresden (Germany)