

PROCEEDINGS OF SPIE

Frontiers in Ultrafast Optics: Biomedical, Scientific, and Industrial Applications XIII

**Alexander Heisterkamp
Peter R. Herman
Michel Meunier
Stefan Nolte**
Editors

**3–5 February 2013
San Francisco, California, United States**

Sponsored by
SPIE

Cosponsored by
Amplitude Systèmes (France)
APE GmbH (Germany)

Published by
SPIE

Volume 8611

Proceedings of SPIE 0277-786X, V.8611

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

Frontiers in Ultrafast Optics: Biomedical, Scientific, and Industrial Applications XIII, Alexander Heisterkamp,
Peter R. Herman, Michel Meunier, Stefan Nolte, Eds., Proc. of SPIE Vol. 8611, 861101 · © 2013 SPIE
CCC code: 0277-786X/13/\$18 · doi: 10.1117/12.2022936

Proc. of SPIE Vol. 8611 861101-1

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 *Frontiers in Ultrafast Optics: Biomedical, Scientific, and Industrial Applications XIII*, edited by Alexander Heisterkamp, Peter R. Herman, Michel Meunier, Stefan Nolte, Proceedings of SPIE Vol. 8611 (SPIE, Bellingham, WA, 2013) Article CID Number.

ISSN: 0277-786X

ISBN: 9780819493804

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.



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

ix *Conference Committee*

SESSION 1 MICRO AND NANO MANIPULATION OF CELLS, OPTICAL TRANSFECTION

- 8611 03 **High-throughput optical injection of mammalian cells using a non-diffracting beam in a microfluidic platform** [8611-2]
H. A. Rendall, R. F. Marchington, B. B. Praveen, Univ. of St. Andrews (United Kingdom); G. Bergmann, Friedrich-Schiller-Univ. Jena (Germany); Y. Arita, Univ. of St. Andrews (United Kingdom); A. Heisterkamp, Friedrich-Schiller-Univ. Jena (Germany); F. J. Gunn-Moore, K. Dholakia, Univ. of St. Andrews (United Kingdom)
- 8611 04 **Femtosecond optical transfection as a tool for genetic manipulation of human embryonic stem cells** [8611-3]
M. L. Torres-Mapa, Univ. of St. Andrews (United Kingdom); J. Gardner, H. Bradburn, J. King, Roslin Cellab (United Kingdom); K. Dholakia, F. Gunn-Moore, Univ. of St. Andrews (United Kingdom)

SESSION 2 TISSUE AND SURGICAL APPLICATIONS OF ULTRASHORT PULSE LASERS

- 8611 0A **Pump-probe investigation of fs-LIOB in water by simultaneous spatial and temporal focusing** [8611-9]
R. Kammel, R. Ackermann, Friedrich-Schiller-Univ. Jena (Germany); A. Tünnermann, S. Nolte, Friedrich-Schiller-Univ. Jena (Germany) and Fraunhofer-Institut für Angewandte Optik und Feinmechanik (Germany)

SESSION 3 NOVEL MEDICAL APPLICATIONS OF ULTRAFAST LASERS

- 8611 0D **Harmonic nanoparticles for nonlinear bio-imaging and detection (Invited Paper)** [8611-12]
L. Bonacina, T. Magouroux, A. Rogov, Univ. of Geneva (Switzerland); D. Staedler, Ecole Polytechnique Fédérale de Lausanne (Switzerland); C. Joulaud, Univ. de Savoie (France); S. Schwung, FEE GmbH (Germany); S. Passemard, Ecole Polytechnique Fédérale de Lausanne (Switzerland); R. Le Dantec, Y. Mugnier, Univ. de Savoie (France); D. Rytz, FEE GmbH (Germany); S. Gerber-Lemaire, Ecole Polytechnique Fédérale de Lausanne (Switzerland); J.-P. Wolf, Univ. of Geneva (Switzerland)
- 8611 0F **Label free optimal dynamic discrimination of biological macromolecules** [8611-14]
S. Afonina, A. Rondi, D. Kiselev, L. Bonacina, J. P. Wolf, Univ. of Geneva (Switzerland)
- 8611 0G **Femtosecond pumped lasing from the fluorescent protein DsRed in a one dimensional random cavity** [8611-15]
T. M. Drane, H. Bach, M. Shapiro, V. Milner, The Univ. of British Columbia (Canada)

SESSION 4 ULTRAFAST LASER SOURCES FOR BIOMEDICAL USE

- 8611 OJ **100-fs-level diode-pumped Yb-doped laser amplifiers** [8611-18]
M. Delaigue, J. Pouysegur, S. Ricaud, C. Hönninger, E. Mottay, Amplitude Systèmes (France)
- 8611 OK **A new small-package super-continuum light source for optical coherence tomography** [8611-19]
S. Meissner, P. Cimalla, Technische Univ. Dresden (Germany); B. Fischer, Fraunhofer-Institut für Zerstörungsfreie Prüfverfahren (Germany); C. Taudt, T. Baselt, P. Hartmann, Westsächsische Hochschule Zwickau (Germany); E. Koch, Technische Univ. Dresden (Germany)
- 8611 OL **Defense of fake fingerprint attacks using a swept source laser optical coherence tomography setup** [8611-20]
S. Meissner, Technische Univ. Dresden (Germany); R. Breithaupt, Bundesamt für Sicherheit in der Informationstechnik (Germany); E. Koch, Technische Univ. Dresden (Germany)

SESSION 5 ULTRAFAST LASER SOURCES AND INSTRUMENTATION

- 8611 ON **3D ultrafast laser scanner** [8611-22]
A. Mahjoubfar, K. Goda, Univ. of California, Los Angeles (United States) and California NanoSystems Institute (United States); C. Wang, Univ. of California, Los Angeles (United States); A. Fard, Univ. of California, Los Angeles (United States) and California NanoSystems Institute (United States); J. Adam, Univ. of California, Los Angeles (United States); D. R. Gossett, California NanoSystems Institute (United States) and Univ. of California, Los Angeles (United States); A. Ayazi, E. Sollier, O. Malik, E. Chen, Y. Liu, R. Brown, N. Sarkhosh, Univ. of California, Los Angeles (United States); D. Di Carlo, California NanoSystems Institute (United States) and Univ. of California, Los Angeles (United States); B. Jalali, Univ. of California, Los Angeles (United States) and California NanoSystems Institute (United States)
- 8611 OP **Simultaneous measurement of two ultrashort pulses at different wavelengths using double blind polarization-gate frequency-resolved optical gating** [8611-24]
T. C. Wong, R. Trebino, Georgia Institute of Technology (United States)
- 8611 OQ **New, simplified algorithm for cross-correlation frequency resolved optical gating** [8611-25]
D. J. Kane, Mesa Photonics, LLC (United States)
- 8611 OR **The coherent artifact in modern pulse measurement** [8611-26]
M. Rhodes, Georgia Institute of Technology (United States); G. Steinmeyer, Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie (Germany); J. Ratner, R. Trebino, Georgia Institute of Technology (United States)
- 8611 OS **Temporal self-reconstruction of few-cycle nondiffracting wavepackets** [8611-27]
S. König, M. Bock, S. K. Das, A. Treffer, R. Grunwald, Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie (Germany)

SESSION 6 ULTRAFAST LASER VOLUME STRUCTURING I

- 8611 0W **The influence of distributed rare earth dopant on the performance of waveguide lasers fabricated by the femtosecond laser direct-write technique** [8611-31]
Y. Duan, A. McKay, P. Dekker, M. J. Steel, M. Withford, Macquarie Univ. (Australia)

SESSION 7 ULTRAFAST LASER VOLUME STRUCTURING II

- 8611 0Y **The underlying structure of ultrashort pulse laser-induced nanogratings** [8611-33]
F. Zimmermann, S. Richter, Friedrich-Schiller-Univ. Jena (Germany); A. Plech, Karlsruher Institut für Technologie (Germany); S. Döring, Friedrich-Schiller-Univ. Jena (Germany); M. Heinrich, Friedrich-Schiller-Univ. Jena (Germany) and CREOL, The College of Optics and Photonics, Univ. of Central Florida (United States); M. Steinert, Friedrich-Schiller-Univ. Jena (Germany); U. Peschel, Friedrich-Alexander-Univ. Erlangen-Nürnberg (Germany); E.-B. Kley, Friedrich-Schiller-Univ. Jena (Germany); A. Tünnermann, S. Nolte, Friedrich-Schiller-Univ. Jena (Germany) and Fraunhofer-Institut für Angewandte Optik und Feinmechanik (Germany)

SESSION 8 ULTRAFAST LASER VOLUME STRUCTURING III

- 8611 11 **Adaptive control of pulse front tilt, the quill effect and directional ultrafast laser writing** [8611-36]
P. S. Salter, R. D. Simmonds, M. J. Booth, Univ. of Oxford (United Kingdom)
- 8611 12 **Femtosecond laser ablation properties of transparent materials: impact of the laser process parameters on the machining throughput** [8611-37]
V. V. Matyitsky, F. Hendricks, J. Aus der Au, High Q Laser GmbH (Austria)
- 8611 13 **On the wavelength dependence of femtosecond laser interactions inside band gap solids** [8611-38]
S. Leyder, D. Grojo, Ph. Delaporte, M. Lebugle, Lab. Lasers, Plasmas et Procédés Photoniques, CNRS, Aix-Marseille Univ. (France); W. Marine, CINAM, CNRS, Aix-Marseille Univ. (France); N. Sanner, M. Sentis, O. Utéza, Lab. Lasers, Plasmas et Procédés Photoniques, CNRS, Aix-Marseille Univ. (France)

SESSION 9 ULTRAFAST LASER MICROMACHINING I: FUNDAMENTALS: JOINT SESSION WITH CONFERENCES 8607 AND 8611

- 8611 17 **Time-resolved spectroscopy characterization of femtosecond fiber laser induced plasma** [8611-42]
H. Huang, L.-M. Yang, J. Liu, PolarOnyx, Inc. (United States)
- 8611 18 **Study on the influence of repetition rate and pulse duration on ablation efficiency using a new generation of high power ytterbium doped fiber ultrafast laser** [8611-43]
J. Lopez, CELIA, CNRS/CEA, Univ. Bordeaux 1 (France); R. Torres, ALPhANOV (France); Y. Zaouter, Amplitude Systèmes (France); P. Georges, M. Hanna, Institut Optique Graduate School (France); E. Mottay, Amplitude Systèmes (France); R. Kling, ALPhANOV (France)

**SESSION 10 ULTRAFAST LASER MICROMACHINING II: FUNDAMENTALS: JOINT SESSION WITH
CONFERENCES 8607 AND 8611**

- 8611 1A **Micro-structuring of thin titanium films with ultrashort laser pulses** [8611-45]
R. Moser, T. Gschwilm, A. Zacherle, G. Heise, H. P. Huber, Munich Univ. of Applied Sciences
(Germany); G. Marowsky, Laser Lab. Göttingen (Germany)
- 8611 1B **Transient temperature modeling and shock wave observation in confined laser ablation of
thin molybdenum films** [8611-46]
M. Domke, J. Sotrop, S. Rapp, M. Börger, D. Felsl, H. P. Huber, Munich Univ. of Applied
Sciences (Germany)

SESSION 11 ULTRAFAST LASER MICROMACHINING III: JOINT SESSION WITH CONFERENCES 8607 AND 8611

- 8611 1C **Ultrastable bonding of glass with femtosecond laser bursts** [8611-47]
S. Richter, F. Zimmermann, S. Döring, Friedrich-Schiller-Univ. Jena (Germany);
A. Tünnermann, S. Nolte, Friedrich-Schiller-Univ. Jena (Germany) and Fraunhofer-Institut für
Angewandte Optik und Feinmechanik (Germany)

SESSION 12 ULTRAFAST LASER MICROMACHINING IV: JOINT SESSION WITH CONFERENCES 8607 AND 8611

- 8611 1D **Influence of ambient pressure on the hole formation process in ultrashort pulse laser deep
drilling** [8611-48]
S. Döring, S. Richter, T. Ullsperger, Friedrich-Schiller-Univ. Jena (Germany); A. Tünnermann,
S. Nolte, Friedrich-Schiller-Univ. Jena (Germany) and Fraunhofer-Institut für Angewandte
Optik und Feinmechanik (Germany)

POSTER SESSION

- 8611 1H **Laser time-of-flight measurement based on multi-channel time delay estimation** [8611-52]
C. Li, Q. Chen, G. Gu, T. Man, Nanjing Univ. of Science and Technology (China)
- 8611 1I **Characterization of femtosecond laser filament-fringes in titanium** [8611-54]
Md. S. Ahsan, KAIST (Korea, Republic of) and Khulna Univ. (Bangladesh); F. Dewanda, KAIST
(Korea, Republic of); F. Ahmed, M. B. G. Jun, Univ. of Victoria (Canada); M. S. Lee, KAIST
(Korea, Republic of)
- 8611 1J **Liquid jet generated by thermocavitation bubbles within a droplet** [8611-55]
J. P. Padilla-Martinez, Instituto Nacional de Astrofísica, Óptica y Electrónica (Mexico);
D. Banks, Univ. of California, Riverside (United States); J. C. Ramirez-San-Juan, Instituto
Nacional de Astrofísica, Óptica y Electrónica (Mexico); G. Aguilar, Univ. of California,
Riverside (United States); R. Ramos-García, Instituto Nacional de Astrofísica, Óptica y
Electrónica (Mexico)
- 8611 1M **Laser-induced structural modifications in glass using a femtosecond laser and a CO₂ laser**
[8611-58]
T. Tamaki, S. Nakazumi, K. Nakamura, S. Ono, Nara National College of Technology
(Japan)

- 8611 1N **Defect detection in laser powder deposition components by laser thermography and laser ultrasonic inspections** [8611-59]
S. P. Santospirito, Kingston Computer Consultancy Ltd. (United Kingdom); R. Łopatka, Polkom Badania (Poland) and Warsaw Univ. of Technology (Poland); D. Cerniglia, Univ. degli Studi di Palermo (Italy); K. Słyk, B. Luo, Kingston Computer Consultancy Ltd. (United Kingdom); D. Panggabean, J. Rudlin, TWI Ltd. (United Kingdom)

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)

Conference Chairs

Alexander Heisterkamp, Friedrich-Schiller-Universität Jena (Germany)
Peter R. Herman, University of Toronto (Canada)
Michel Meunier, Ecole Polytechnique de Montréal (Canada)
Stefan Nolte, Friedrich-Schiller-Universität Jena (Germany)

Conference Program Committee

Craig B. Arnold, Princeton University (United States)
James E. Carey III, SiOnyx Inc. (United States)
Xun Gu, Max-Planck-Institut für Quantenoptik (Germany)
Denise M. Krol, University of California, Davis (United States)
Eric Mazur, Harvard University (United States)
Michael M. Mielke, Raydiance, Inc. (United States)
Eric P. Mottay, Amplitude Systèmes (France)
Christopher B. Schaffer, Cornell University (United States)
Alexander Szameit, Friedrich-Schiller-Universität Jena (Germany)
Alfred Vogel, Universität zu Lübeck (Germany)
Wataru Watanabe, National Institute of Advanced Industrial Science
and Technology (Japan)

Session Chairs

- 1 Micro and Nano Manipulation of Cells, Optical Transfection
Alexander Heisterkamp, Friedrich-Schiller-Universität Jena (Germany)
- 2 Tissue and Surgical Applications of Ultrashort Pulse Lasers
Michel Meunier, Ecole Polytechnique de Montréal (Canada)

- 3 Novel Medical Applications of Ultrafast Lasers
Alexander Heisterkamp, Friedrich-Schiller-Universität Jena (Germany)
- 4 Ultrafast Laser Sources for Biomedical Use
Eric P. Mottay, Amplitude Systèmes (France)
- 5 Ultrafast Laser Sources and Instrumentation
Michael M. Mielke, Raydiance, Inc. (United States)
- 6 Ultrafast Laser Volume Structuring I
Peter R. Herman, University of Toronto (Canada)
- 7 Ultrafast Laser Volume Structuring II
Peter R. Herman, University of Toronto (Canada)
- 8 Ultrafast Laser Volume Structuring III
Rafael Piestun, University of Colorado at Boulder (United States)
- 9 Ultrafast Laser Micromachining I: Fundamentals: Joint Session with Conferences 8607 and 8611
Yong Feng Lu, University of Nebraska-Lincoln (United States)
- 10 Ultrafast Laser Micromachining II: Fundamentals: Joint Session with Conferences 8607 and 8611
Stefan Nolte, Friedrich-Schiller-Universität Jena (Germany)
- 11 Ultrafast Laser Micromachining III: Joint Session with Conferences 8607 and 8611
Haibin Zhang, Electro Scientific Industries, Inc. (United States)
- 12 Ultrafast Laser Micromachining IV: Joint Session with Conferences 8607 and 8611
Klaus Sokolowski-Tinten, Universität Duisburg-Essen (Germany)