PROCEEDINGS OF SPIE

Fundamentals of Laser-Assisted Micro- and Nanotechnologies 2013

Vadim P. Veiko
Tigran A. Vartanyan
Editors

24–28 June 2013
St. Petersburg-Pushkin, Russian Federation

Organized by
National Research University of Information Technologies, Mechanics and Optics (Russian Federation)
General Physics Institute of Russian Academy of Sciences (Russian Federation)

Sponsored by
Russian Federation Ministry of Education and Science (Russian Federation) • National Research University of Information Technologies, Mechanics and Optics (Russian Federation) • Russian Foundation for Basic Research • General Physics Institute of Russian Academy of Sciences • Dynasty Foundation • Leading Scientific School of Russian Federation "Fundamentals of Laser-Assisted Micro- and Nano Technologies" • Tzarskoje Selo State Museum (Russian Federation) • Laser Track Ltd. (Russian Federation) Lasers & Apparatus TM Ltd. (Russian Federation) • Lasertech Ltd., Lasers Center ICo • Laser Center ITMO TRIZ Centre "Tvortchestvo" Ltd. (Russian Federation) • "LaserVarioRakurs" • East-West-Science Center (OWWZ), Kassel University (Germany) • Russian Portal of IT, Optics & Photonics (ITOP)

Cooperating Organization
Laser Association, D.S. Rozhdestvensky Russian Optical Society

Published by
SPIE

Volume 9065

Proceedings of SPIE 0277-786X, V. 9065

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

Fundamentals of Laser-Assisted Micro- and Nanotechnologies 2013, edited by Vadim P. Veiko, Tigran A. Vartanyan,
Proc. of SPIE Vol. 9065, 906501 · © 2013 SPIE · CCC code: 0277-786X/13/$18 · doi: 10.1117/12.2053832

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 *Fundamentals of Laser-Assisted Micro- and Nanotechnologies 2013*, edited by Vadim P. Veiko, Tigran A. Vartanyan, Proceedings of SPIE Vol. 9065 (SPIE, Bellingham, WA, 2013) Article CID Number.

ISSN: 0277-786X
ISBN: 9780819499929

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

Printed in the United States of America.

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

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

LASER CLEANING AND ARTWORKS CONSERVATION

BIOMEDICAL LASER APPLICATIONS

LASERS AND OPTICS RELATED RESEARCH

Symposium Committees

Honorary Chairs

Vladimir N. Vasiliev, NRU ITMO (Russian Federation)
Ivan A. Shcherbakov, GPI RAS (Russian Federation)

Symposium Chairs

Vadim P. Veiko, NRU ITMO (Russian Federation)
Vitaly I. Konov, GPI RAS (Russian Federation)

Program Committee Cochairs

B. Chichkov, Laser Zentrum (Germany)
S. Garnov, GPI RAS (Russian Federation)
A. Piqué, NRL (United States)
M. J. Soileau, CREOL, The College of Optics and Photonics, University of Central Florida (United States)
K. Sugioka, RIKEN (Japan)
V. Veiko, NRU ITMO (Russian Federation)

Scientific Secretary

T. Vartanyan, NRU ITMO (Russian Federation)

Conference for Young Scientists, Engineers, and Students on Intensive Laser Actions and Applications

A. Fedorov, NRU ITMO (Russian Federation)
V. Gordienko, Moscow State University (Russian Federation)
G. Račiukaitis, Center for Physical Sciences and Technology (Lithuania)
S. Stafeev, NRU ITMO (Russian Federation)

Conference on Photophysics of Nano-scale Systems

F. Hubenthal, Universität Kassel (Germany)
T. Vartanyan, NRU ITMO (Russian Federation)

Conference on Intensive Laser Action in Biology and Medicine

G. Altshuler, Palomar Medical Technology Inc. (United States)
V. Bagratashvili, ILIT RAS (Russian Federation)
V. Khramov, NRU ITMO (Russian Federation)

Conference on Femtosecond Laser-Matter Interaction and Technologies

V. Gordienko, Moscow State University (Russian Federation)
T. Szörenyi, József Attila University (Hungary)
E. Yakovlev, NRU ITMO (Russian Federation)

Young Scientists Workshop on Terahertz Radiation Interaction with Matter

S. Garnov, GPI RAS (Russian Federation)
S. Kozlov, NRU ITMO (Russian Federation)
A. Shkurinov, Moscow State University (Russian Federation)

Workshop on Laser Cleaning and Artworks Conservation

V. Parfenov, St. Petersburg State Electrotechnical University (Russian Federation)
A. Semerok, CEA, DEN, SEARS/LISL (France)
E. Shakhno, NRU ITMO (Russian Federation)

Workshop on Phase-Change Processes in Optical Materials and Memory Alloys

A. Kolobov, Nanoelectronics Research Institute, AIST (Japan)
N. Nikonorov, NRU ITMO (Russian Federation)

Workshop on High–Power Fiber Lasers Applications

A. Kourkov, GPI RAS (Russian Federation)
V. Serebryakov, NRU ITMO (Russian Federation)
S. Smirnov, Lasertech (Russian Federation)

Organizing Committee Cochairs

A. Allas, NRU ITMO (Russian Federation)
E. Brui, NRU ITMO (Russian Federation)
V. Komolov, NRU ITMO (Russian Federation)
E. Yakovlev, NRU ITMO (Russian Federation)

International Advisory Committee

S. Anisimov (Russian Federation)
S. Ashmontas (Lithuania)
K. Fotakis (Greece)
S. Gaponov (Russian Federation)
V. Gapontsev (Russian Federation)
S. Garanin (Russian Federation)
A. Grigoryants (Russian Federation)
P. Kashkarov (Russian Federation)
W. Kautek (Austria)
I. Kazuyoshi (Japan)
Yu. Kivshar (Australia)
V. Klimov (Russian Federation)
O. Krokhin (Russian Federation)
A. Luches (Italy)

I. Mijamoto (Japan)
V. Ochkin (Russian Federation)
V. Orlovich (Belarus)
V. Panchenko (Russian Federation)
R. Poprawe (Germany)
A. Sergeev (Russian Federation)
V. Soifer (Russian Federation)
M. Soskin (Ukraine)
F. Träger (Germany)
A. Zheltikov (Russian Federation)
L. Zhigiley (United States)
A. Ionin (Russian Federation)

International Program Committee

C. Arnold (United States)
F. Bachmann (Germany)
A. Caricato (Italy)
Y. Cheng (China)
O. Efimov United States)
V. Detalle (France)
V. Gordienko (Russian Federation)
V.Gruzdev (United States)
H. Helvajian (United States)
P. Hermann (Canada)
F. Hubenthal (Germany)
N. Inogamov (Russian Federation)
Y. Jiang (China)
A. Kolobov (Japan)
V. Komolov (Russian Federation)
S. Kozlov (Russian Federation)
Y. Lu (United States)
B. Luk'yanchuk (Singapore)
M. Meunier (Canada)
I. Mihailescu (Romania)
A. Ostendorf (Germany)
V. Parfenov (Russian Federation)
G. Račiukaitis (Lithuania)
B. Rethfeld (Germany)
A. Semerok (France
P. Serra (Spain)
I. Shiganov (Russian Federation)
A. Shkurinov (Russian Federation)
I. Smurov (France)
A. Sukhorukov (Russian Federation)
T. Szörenyi (Hungary)
M. Tribelsky (Russian Federation)
Y. Tsuboi (Japan)
G. Turichin (Russian Federation)
T. Vartanyan (Russian Federation)
E. Wintner (Austria)
E. Yakovlev (Russian Federation)

Organizing Committee

A. Fedorov
V. Khramov
V. Parfenov
A. Petrov
S. Sarnakov
V. Serebryakov
S. Stafeev
S. Smirnov
T. Vartanyan

Introduction

This volume presents selected papers of the International Symposium on Fundamentals of Laser-Assisted Micro- and Nanotechnologies (FLAMN-13).

This symposium continues in a new format from well-known traditional symposia, ILATA (Intensive Laser Actions and Technological Applications), consisting of LAMN (Laser-Assisted Microtechnologies) and LMI (Laser-Matter Interaction) conferences, originally organized in former Leningrad, USSR since the mid-1960s. Laser-assisted micro- and nanotechnology is one of the first and rapidly growing areas of research, development, and production.

The symposium was devoted to the wide spectrum of laser micro– and nanoprocessing, from physical fundamentals of different processes and their experimental demonstration, to the industrial set-ups and their realization. Topics covered by FLAMN–13 included theoretical and experimental aspects of laser-matter interaction applied to laser micro- and nanotechnology.

The sessions of FLAMN-13 were visited by over 350 participants including 200 speakers, approximately 80 of them from abroad (Australia, Austria, Belarus, China, France, Germany, Mexico, Hungary, Italy, Japan, Korea, Lithuania, Romania, Spain, Switzerland, United Kingdom, United States). About 225 papers were presented (110 orals, 115 posters); this volume contains 44 selected papers.

For convenience of readers, the papers in these proceedings are arranged into six topical sections:

Section 1: Laser-matter interaction
Section 2: Laser-assisted micro- and nanotechnologies
Section 3: Laser-induced phase – structure modification
Section 4: Laser cleaning and artworks conservation
Section 5: Biomedical laser applications
Section 6: Lasers and optics related research.

The program committee expresses its gratitude to all the institutions and persons who contributed to organizing, supporting, and holding the conference.

Personal thanks to the FLAMN-13 Cooperating and Sponsoring organization

ITMO	RFBR		GPI RAS
SPIE (publisher)	Dynasty Foundation	LSS of RF “Fundamentals of LAMN”	IT, optics & photonics
East-West-Science Center (OWWZ)		State Museum "Tzarskoje Selo"	

Vadim P. Veiko
Tigran A. Vartanyan