Front Matter: Volume 11042
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:


ISSN: 0277-786X
ISSN: 1996-756X (electronic)
ISBN: 9781510627505

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 © 2018, 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/18/$18.00.

Printed in the United States of America.

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

<table>
<thead>
<tr>
<th>Page</th>
<th>Title</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>vii</td>
<td>Authors</td>
<td></td>
</tr>
<tr>
<td>ix</td>
<td>Conference Committee</td>
<td></td>
</tr>
<tr>
<td>xi</td>
<td>Introduction</td>
<td></td>
</tr>
</tbody>
</table>

### GAS AND CHEMICAL LASERS

| 11042 02 | Optically pumped rare gas lasers (Invited Paper) [11042-30]                                                                        |                  |
| 11042 03 | High power laser activities at Kawasaki Heavy Industries, Ltd. (Invited Paper) [11042-38]                                          |                  |
| 11042 04 | Super-broadband hybrid mid-infrared laser systems [11042-14]                                                                     |                  |
| 11042 05 | Transverse optical pumping of e-beam excited high-pressure He/Ar mixture with a laser diode array [11042-16]                          |                  |
| 11042 06 | Lasing in optically pumped Ar:He mixture excited in a dielectric barrier discharge [11042-6]                                      |                  |
| 11042 07 | Improvement of line selected hydrogen fluoride laser output efficiency by cascade effect [11042-34]                                 |                  |
| 11042 08 | Energy-pooling processes of high-lying Xe atoms under the condition of ultrahigh pumped power [11042-27]                            |                  |
| 11042 09 | High power laser from OH + D₂ → HOD((v\text{HO}',v\text{HOD}',v\text{OD'}), J') + D reaction [11042-4]                                |                  |
| 11042 0A | Output characteristics comparison for cw OIL with different pumping types [11042-1]                                               |                  |
| 11042 0B | Computer simulation of electric energy distribution of CO gas mixture [11042-5]                                                      |                  |

### ALKALI LASERS

<p>| 11042 0C | Effects of rare gas collision partner and pump energy on the four-level Cs exciplex pumped alkali laser [11042-12]                   |                  |
| 11042 0D | Continuous wave diode pumped flowing-gas Cesium laser [11042-3]                                                                   |                  |</p>
<table>
<thead>
<tr>
<th>Session</th>
<th>Title</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>11042 0E</td>
<td>Theoretical study of unstable resonators for diode-pumped alkali laser using wave optics simulation</td>
<td>11042-25</td>
</tr>
<tr>
<td>11042 0F</td>
<td>Parametric study of the performance and beam quality of cesium DPAL: experiment and modelling</td>
<td>11042-11</td>
</tr>
<tr>
<td>11042 0G</td>
<td>Study on broadening of Na D&lt;sub&gt;1&lt;/sub&gt; and D&lt;sub&gt;2&lt;/sub&gt; lines spectra in sodium-argon mixture</td>
<td>11042-21</td>
</tr>
</tbody>
</table>

**SOLID STATE LASERS**

<table>
<thead>
<tr>
<th>Session</th>
<th>Title</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>11042 0H</td>
<td>Picosecond deep ultraviolet pulses generated by a 100 kHz thin-disk laser system</td>
<td>11042-13</td>
</tr>
<tr>
<td>11042 0I</td>
<td>High energy 1342 nm electro-optically cavity-dumped laser and picosecond regenerative amplifier</td>
<td>11042-15</td>
</tr>
<tr>
<td>11042 0J</td>
<td>A blue random laser based on solid waveguide gain films with plasmonics and scatters</td>
<td>11042-26</td>
</tr>
<tr>
<td>11042 0K</td>
<td>Principle of influence of static and dynamic intracavity gratings on spectral properties of high-power all-solid-state laser's radiation</td>
<td>11042-45</td>
</tr>
</tbody>
</table>

**RAMAN LASERS**

<table>
<thead>
<tr>
<th>Session</th>
<th>Title</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>11042 0L</td>
<td>The study of optical frequency-comb laser generated by stimulated Raman scattering</td>
<td>11042-40</td>
</tr>
<tr>
<td>11042 0M</td>
<td>Raman lasers for trace gas detection</td>
<td>11042-41</td>
</tr>
</tbody>
</table>

**MODULATING LASER PULSES**

<table>
<thead>
<tr>
<th>Session</th>
<th>Title</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>11042 0N</td>
<td>High pressure CO&lt;sub&gt;2&lt;/sub&gt; amplifiers for picosecond pulse amplification (Invited Paper)</td>
<td>11042-28</td>
</tr>
<tr>
<td>11042 0O</td>
<td>Alignment tolerances of self-imaging configurations for passive coherent beam combining</td>
<td>11042-22</td>
</tr>
<tr>
<td>11042 0P</td>
<td>Hybrid THL-100 laser system: results and prospect</td>
<td>11042-8</td>
</tr>
<tr>
<td>11042 0Q</td>
<td>Slippage effects on FEL saturated power in short pulse SASE devices</td>
<td>11042-31</td>
</tr>
</tbody>
</table>
LASER-MATTER INTERACTION

11042 OR Laser induced breakdown spectroscopy for in situ multielemental analysis during additive manufacturing process [11042-20]

11042 OS High energy excimer laser system for nanosecond annealing of semiconductor devices [11042-36]

11042 OT A single-shot near edge x-ray absorption fine structure spectroscopy using double stream gas puff target source [11042-33]

11042 OU Interaction of high power laser pulses with ensemble of solid particles [11042-47]

11042 OV Observation of inner surface laser-induced periodic surface structures in a microhole produced in a glass optical fiber by varying femtosecond laser pulse number and energy [11042-37]

LASER PLASMAS

11042 OW Optical pumped ultra-short pulse CO2 lasers as drivers of laser-plasma accelerators and other applications (Invited Paper) [11042-46]

11042 OX Target current: an appropriate parameter for characterizing the dynamics of laser-matter interaction [11042-7]

11042 OY Compact radiation sources based on laser-driven plasma waves [11042-48]

11042 OZ The ENEA discharge produced plasma extreme ultraviolet source and its patterning applications [11042-42]

SPACE APPLICATIONS AND REMOTE SENSING

11042 10 Radiation hardness assurance: innovative aspects and challenges [11042-32]

11042 11 Nuclear powered spaceborne laser for orbital debris removal [11042-39]

11042 12 Laser radars for marine monitoring [11042-29]

LIGHTING AND CULTURAL HERITAGE

11042 13 Lighting a smart society (Invited Paper) [11042-23]

11042 14 Influence of ultraviolet radiation on the color of blood stains embedded in the archaeological textile known as the Shroud of Turin [11042-24]
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.

Adnet, Audrey, 0S
Alekseev, S. V., 0P
Alpat, Behcet, 10
Anania, M. P., 0Y
Angelini, Federico, 12
Aniculaesei, C., 0Y
Asyutin, R. D., 0R
Austender, Ilya, 0D, 0F
Avdeev, Alexey, 11
Ballmann, C. W., 02
Barmashenko, Boris D., 0D, 0F
Battaglia, G., 0Y
Beau, François, 0S
Bellier, Cédric, 0S
Besaucèle, Hervé, 0S
Bian, Jintian, 0L
Bollanti, S., 0Z
Boreysho, Anatoly, 0K, 0U, 11
Botti, S., 0Z
Bouksou, Yacine, 0S
Brunner, E., 0W, 0Y
Brusatin, G., 0Z
Buryšková, Simona, 0X
Businaro, L., 0Z
Cai, Xianglong, 0G, 0J, 0L
Campbell, R. N., 0W
Carroll, D. L., 0C
Ceccato, Paul, 0S
Chatelain, Maxime, 0S
Chen, S., 0Y
Chen, Ying, 08, 0G, 0I, 0L
Chu, Junzhi, 08
Cikhardt, Jakub, 0X
Ciofini, Marco, 0O
Cipiccia, S., 0Y
Clark, A. B., 02
Colao, Francesco, 12
Dattoli, Giuseppe, 0Q
Delta Giustina, G., 0Z
Delle Site, Domenico, 0X
Di Lascio, Antonio, 14
Di Lazzaro, Paolo, 02, 14
Dostáli, Jan, 0X
Douris, Nabil, 0S
Drakin, Alexandr, 0S
Duda, Martin, 0T
Dudíčák, Roman, 0X
Duo, Lijing, 07
Dusserre, Hervé, 0S
Dutems, Cyril, 0S
Eichler, Hans J., 0M
Endo, Akira, 0H
Endo, Masamori, 0E
Ersfeld, B., 0Y
Fagroni, M., 0Z
Fedorov, A. N., 0R
Fedorowicz, Henryk, 0T
Fiorani, Luca, 12
Flora, F., 0Z
Fok, Tomasz, 0T
Gai, Boaoding, 0G, 0L
Gerardino, A., 0Z
Gil Reboredo, D., 0Y
Grant, D. W., 0Y
Grant, P., 0Y
Grishin, M. Ya., 0R
Guo, Jingwei, 08, 0G, 0I, 0J, 0L
Han, Jiande, 02, 06
He, Shan, 08, 0G, 0J
Heaven, Michael C., 02, 06
Heintzmann, Martin, 0S
Hokr, B., 0Z
Hong, Feng, 0J
Hu, Shu, 08, 0G, 0J, 0L
Huet, Karim, 0S
Hur, M. S., 0Y
Iacomussi, Paola, 13, 14
Inigo Garniz, L., 0Y
Ionin, Andrey, 04, 0S
Ivakin, Stanislav, 0L
Ivanov, M. V., 0P
Ivanov, N. G., 0P
Iyoda, Mitsuhiro, 0B
Jančárek, Alexandr, 0T
Jaroszynski, D. A., 0W, 0Y
Jin, Yuqi, 07, 08, 0J
Kang, T., 0Y
Katargin, Boris, 11
Kharirossova, Evelina I., 0A
Kholtin, Igor, 0S
Kinyaevskiy, I. O., 04
Klimachev, Yu. M., 04
Klír, Daniel, 0X
Kolarevich, K., 0Y
Kolchev, Alexey, 0U
Komszewski, A., 0Y
Kottov, A. A., 04
Kozlov, A. A., 04
Krása, Josef, 0X
Křús, Miroslav, 0X
Conference Committee

Symposium Chair

Paolo Di Lazzaro, ENEA (Italy)

Local Organizing Committee

Giulia Bartolomei, ENEA (Italy)
Sarah Bollanti, ENEA (Italy)
Monica Cimino, ENEA (Italy)
Gian Piero Gallerano, ENEA (Italy)
Flavio Miglietta, ENEA (Italy)
Daniele Murra, ENEA (Italy)

Program Committee

Michel L. Autric, Protisvalor Méditerranée SAS (France)
Boris D. Barmashenko, Ben-Gurion University of the Negev (Israel)
Willy L. Bohn, BohnLaser Consult (Germany)
Sarah Bollanti, ENEA (Italy)
Anatoly Sergey Boreysho, Laser Systems Ltd. (Russian Federation)
Pierre Bourdon, ONERA (France)
Paolo Di Lazzaro, ENEA (Italy)
Gian Piero Gallerano, ENEA (Italy)
Jarmila Kodymová, Institute of Physics of the ASCR, v.v.i. (Czech Republic)
Antonio Lapucci, Istituto Nazionale di Ottica (Italy)
Daniele Murra, ENEA (Italy)
Robert Walter, Consultant (United States)

International Advisory Committee

Kerim Allahverdiyev, TUBITAK Research Centre (Russian Federation)
Victor Apollonov, Prokhorov General Physics Institute (Russian Federation)
Petar Atanasov, Institute of Electronics (Bulgaria)
Michel L. Autric, Protisvalor Méditerranée SAS (France)
Boris D. Barmashenko, Ben-Gurion University of the Negev (Israel)
Willy Bohn, BohnLaser Consulting (Germany)
Anatoly Sergey Boreysho, Laser Systems Ltd. (Russian Federation)
Pierre Bourdon, ONERA (France)
David Carroll, CU Aerospace LLC (United States)
Paolo Di Lazzaro, ENEA (Italy)
Hans Eichler, Technische Universität Berlin (Germany)
Masamori Endo, Tokai University (Japan)
Andrey Ionin, Lebedev Physical Institute Moscow (Russian Federation)
Koichi Kasuya, Institute of Laser Technology (Japan)
Jarmila Kodymová, Institute of Physics of the ASCR, v.v.i. (Czech Republic)
Antonio Lapucci, Istituto Nazionale di Ottica (Italy)
Valery Losev, Institute of High Current Electronics (Russian Federation)
Timothy Madden, Air Force Research Laboratory (United States)
Kazuo Maeno, Katayanagi Institute (Japan)
Mohammad Mahdieh, University of Science and Technology (Iran)
Richard Mildren, Macquaire University (Australia)
Vladislav Panchenko, Kurchatov Institute (Russian Federation)
Bo Qi, Chengdu Institute of Optics and Electronics (China)
Salman Rosenwaks, Ben Gurion University (Israel)
Nikola Sabotinov, Institute of Solid State Physics (Bulgaria)
Feng-Ting Sang, Dalian Institute of Chemical Physics (China)
Dieter Schuöcker, Oberösterreichisches Laserzentrum (Austria)
Greg Tallents, University of York (United Kingdom)
Chun Tang, Institute of Applied Electronics (China)
Keith Truesdell, Air Force Research Laboratory (United States)
Robert Walter, Consultant (United States)
Kazuhiro Watanabe, Soka University (Japan)

Proceedings Review Committee

Boris D. Barmashenko, Ben-Gurion University of the Negev (Israel)
Willy Bohn, BohnLaser Consulting (Germany)
Sarah Bollant, ENEA (Italy)
Anatoly Sergey Boreysho, Laser Systems Ltd. (Russian Federation)
David Carroll, CU Aerospace LLC (United States)
Paolo Di Lazzaro, ENEA (Italy)
Masamori Endo, Tokai University (Japan)
Gian Piero Gallerano, ENEA (Italy)
Andrey Ionin, Lebedev Physical Institute Moscow (Russian Federation)
Jarmila Kodymová, Institute of Physics of the ASCR, v.v.i. (Czech Republic)
Antonio Lapucci, Istituto Nazionale di Ottica (Italy)
Valery Losev, Institute of High Current Electronics (Russian Federation)
Richard Mildren, Macquaire University (Australia)
Daniele Murra, ENEA (Italy)
Salman Rosenwaks, Ben Gurion University (Israel)

Session Chairs

1  Alkali Lasers
Zamik Rosenwaks, Ben Gurion University (Israel)
David Carroll, CU Aerospace LLC United States)
2 Gas and Chemical Lasers
Jarmila Kodymova, Institute of Physics of the ASCR, v.v.i.
(Czech Republic)

3 Solid State and Fiber Lasers
Willy Bohn, BohnLaser Consulting (Germany)

4 Raman Lasers
Robert Walter, Consultant (United States)

5 Laser-Matter Interaction and Microprocessing
Gian Piero Gallerano, ENEA (Italy)

6 Laser Plasmas
Sarah Bollanti, ENEA (Italy)
Daniele Murra, ENEA (Italy)

7 Modulating Laser Pulses
Pierre Bourdon, ONERA (France)

8 Poster Session
Sarah Bollanti, ENEA (Italy)
Daniele Murra, ENEA (Italy)
Introduction

The XXII International Symposium on High Power Laser Systems and Applications, (HPLS&A 2018), was held in Villa Mondragone, Frascati, Italy, 9-12, October 2018 and was organized by ENEA. The conference convened a few days after the announcement of the Nobel Prize in Physics, which was awarded to Arthur Ashkin, for his work on optical tweezers able to trap and manipulate living cells by their laser beam fingers and to Gérard Mourou and Donna Strickland, for their work on the generation of high-intensity, ultrashort laser pulses. This event has reignited the attention of the media on lasers and their applications. Let us hope this opportunity will attract young talent to work in this field.

Since 1976, the symposium has provided an international biennial forum to report and review innovative ideas and up-to-date progress and developments in the broad fields of laser systems and their applications. Topics include advances in high-power laser sources, resonators and laser beam control, applications, and novel approaches. Traditionally, the symposium is organized into a single session, thus allowing delegates to attend all oral and poster presentations and encouraging cross-fertilization between laser developers and users.

The above topics were addressed by 51 oral and 27 poster presentations, in a friendly and collaborative atmosphere, facilitated by the splendid scenery of Villa Mondragone. Creative discussions during coffee breaks and lunches allowed attendees to share common interests and begin new collaborations.

While the XXII International Symposium on High Power Laser Systems and Applications is now in the past, the ideas and connections delegates shared will live on, not only through our memories, but via this proceedings volume. Here you will find most of the excellent results presented during the sessions. I am confident they will provide a source of ideas and references to assist in your research efforts.

I would like to thank the delegates for attending the symposium and submitting the papers included in these proceedings. In particular, I heartily thank the ENEA colleagues who formed the local organizing committee for ensuring the symposium ran smoothly. My thanks also to the friends of the international advisory committee for their trust and their help to make the symposiums possible, to the members of the program committee for their valuable advice, to the session chairs for their effective work, and to the colleagues of the review committee who gave of their time to review the submitted manuscripts while maintaining high scientific standards. Finally, I would like to thank my wife Laura and my family, who made it all worthwhile.

Paolo Di Lazzaro