PROCEEDINGS OF SPIE

High-Power Lasers and Technologies for Optical Countermeasures II

Willy L. Bohn Marc Eichhorn Gareth D. Lewis Editors

16–18 September 2024 Edinburgh, United Kingdom

Sponsored by SPIE

Event Sponsor Leonardo MW Ltd. (United Kingdom)

General Sponsors HGH Infrared Systems (France) • Photon Lines Ltd. (United Kingdom) • Pro-Lite Technology Ltd. (United Kingdom) • Thales (United Kingdom)

Cooperating Organisations Cranfield University (United Kingdom) • Quantum Security and Defense Working Group (United Kingdom) • CENSIS (United Kingdom) • Innovate UK (United Kingdom) • Optoelectronics Research Centre (United Kingdom) • Photonics21 (Germany) • Technology Scotland (United Kingdom) • Science and Technology Facilities Council (United Kingdom) • UKQuantum (United Kingdom) • Visit Britain (United Kingdom)

Published by SPIE

Volume 13201

Proceedings of SPIE 0277-786X, V. 13201

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

High-Power Lasers and Technologies for Optical Countermeasures II, edited by Willy L. Bohn, Marc Eichhorn, Gareth D. Lewis, Proc. of SPIE Vol. 13201, 1320101 · © 2024 SPIE · 0277-786X · doi: 10.1117/12.3054797

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: Author(s), "Title of Paper," in *High-Power Lasers and Technologies for Optical Countermeasures II*, edited by Willy L. Bohn, Marc Eichhorn, Gareth D. Lewis, Proc. of SPIE 13201, Seven-digit Article CID Number (DD/MM/YYYY); (DOI URL).

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

ISBN: 9781510681101 ISBN: 9781510681118 (electronic)

Published by **SPIE** P.O. Box 10, Bellingham, Washington 98227-0010 USA Telephone +1 360 676 3290 (Pacific Time) SPIE.org Copyright © 2024 Society of Photo-Optical Instrumentation Engineers (SPIE).

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 fees. To obtain permission to use and share articles in this volume, visit Copyright Clearance Center 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.

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.



Paper Numbering: A unique citation identifier (CID) number is assigned to each article in the Proceedings of SPIE 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 Conference Committee

LASER AND BEAM COMBINATION

- 13201 02 Advanced concepts of Ho³⁺:YAG and ZGP OPO sources (Invited Paper) [13201-1]
- 13201 03 Numerical modelling of far-field intensity patterns in coherent beam combining (Best Paper Award) [13201-6]
- 13201 04 Cavity free optical parametric oscillators [13201-7]

LASER EFFECTS AND SIMULATIONS I

- 13201 05 Space laser engagement to defeat satellites (Invited Paper) [13201-8]
- 13201 06 Decomposition and vulnerability of CFRP under laser impact with powers of up to 120 kW [13201-16]
- 13201 07 Measuring and modelling laser heating of metals, coatings, and other construction materials [13201-17]
- 13201 08 Modelling the complete DTIN killchain: a comparative study of laser and kinetic effectors with RADAR detection against small drones in counter-UAS scenarios [13201-19]
- 13201 09 Evaluation of directed energy laser weapon impacts on satellites through thermal simulation with MuSES [13201-20]

LASER EFFECTS AND SIMULATIONS II

- 13201 0A Assessing laser dazzling effects on UAV cameras and collision avoidance in laboratory and field settings [13201-21]
- 13201 OB Simulation of the reflection of a high energy laser beam at the sea surface for laser safety assessments [13201-22]
- 13201 OC Non-linear laser dazzling an off-band filtered mid-infrared imager [13201-25]

LASER APPLICATIONS

13201 OD	Considerations on thermal blooming in relation to modern HEL systems [13201-27]
13201 OE	High-energy lasers for C-UAS applications [13201-23]
13201 OF	The influence of optical turbulence on closed-loop DIRCM identification performance [13201-28]
13201 0G	High energy lasers as an anti-satellite capability (Invited Paper) [13201-29]

Conference Committee

Symposium Chair

Ric Schleijpen, TNO Defence, Security and Safety (Netherlands)

Symposium Co-chairs

Chantal Andraud, Ecole Normale Supérieure de Lyon (France) **Robert A. Lamb**, Leonardo MW Ltd. (United Kingdom)

Conference Chairs

 Willy L. Bohn, BohnLaser Consult (Germany)
 Marc Eichhorn, Fraunhofer-Institut f
ür Optronik, Systemtechnik und Bildauswertung IOSB (Germany)
 Gareth D. Lewis, Royal Military Academy (Belgium)

Conference Program Committee

Frances Bodrucki, The University of North Carolina at Charlotte (United States) Pierre Bourdon, ONERA (France) Christopher D. Burgess, Defence Science and Technology Laboratory (United Kingdom) **M. J. Daniel Esser**, Heriot-Watt University (United Kingdom) **Robert J. Grasso**, NASA Goddard Space Flight Center (United States) Markus Henriksson, FOI-Swedish Defence Research Agency (Sweden) James P. Hitscherich, U.S. Army Combat Capabilities Development Command (United States) Itor James, Defence Science and Technology Laboratory (United Kingdom) Arkadiy A. Lyakh, University of Central Florida (United States) William Ted Masselink, Humboldt-Univ. zu Berlin (Germany) Richard Maulini, Alpes Lasers SA (Switzerland) Curtis R. Menyuk, University of Maryland, Baltimore County (United States) **Eric D. Park**, Q-Peak, Inc. (United States) Jasbinder S. Sanghera, U.S. Naval Research Laboratory (United States) Ric H. M. A. Schleijpen, TNO Defence, Security and Safety (Netherlands) Bastian Schwarz, Fraunhofer-Institut für Optronik, Systemtechnik und Bildauswertung IOSB (Germany)

Ove Steinvall, Swedish Defence Research Agency (Sweden) Alexander M. J. van Eijk, TNO Defence, Security and Safety (Netherlands)

Hans-Dieter Tholl, Diehl BGT Defence GmbH & Company KG (Germany)

Marijke Vandewal, Royal Military Academy (Belgium)