

PROCEEDINGS OF SPIE

# ***Photonics Applications in Astronomy, Communications, Industry, and High Energy Physics Experiments 2024***

**Ryszard S. Romaniuk  
Andrzej Smolarz  
Waldemar Wójcik**  
*Editors*

**27–30 June 2024  
Lublin, Poland**

*Organized by*  
Lublin University of Technology (Poland)  
Warsaw University of Technology (Poland)  
Photonics Society of Poland (Poland)  
Polish Optoelectronics Committee of the Association of Polish Electrical Engineers (Poland)  
Committee of Electronics and Telecommunications, Polish Academy of Sciences (Poland)

*Published by*  
SPIE

**Volume 13400**

Proceedings of SPIE 0277-786X, V. 13400

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

Photonics Applications in Astronomy, Communications, Industry, and High Energy Physics Experiments 2024,  
edited by Ryszard S. Romaniuk, Andrzej Smolarz, Waldemar Wójcik, Proc. of SPIE  
Vol. 13400, 1340001 · © 2024 SPIE · 0277-786X · doi: 10.1117/12.3058889

Proc. of SPIE Vol. 13400 1340001-1

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 [SPIDigitalLibrary.org](http://SPIDigitalLibrary.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 *Photonics Applications in Astronomy, Communications, Industry, and High Energy Physics Experiments 2024*, edited by Ryszard S. Romaniuk, Andrzej Smolarz, Waldemar Wójcik, Proc. of SPIE 13400, Seven-digit Article CID Number (DD/MM/YYYY); (DOI URL).

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

ISBN: 9781510685789  
ISBN: 9781510685796 (electronic)

Published by  
**SPIE**  
P.O. Box 10, Bellingham, Washington 98227-0010 USA  
Telephone +1 360 676 3290 (Pacific Time)  
[SPIE.org](http://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](http://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.

**SPIE. DIGITAL LIBRARY**  
[SPIDigitalLibrary.org](http://SPIDigitalLibrary.org)

---

**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

- vii Conference Committee
- ix Introduction

---

## CONFERENCE OVERVIEW

---

- 13400 02 **Photonics applications and web engineering: WILGA 2024 (Invited Paper)** [13400-36]

---

## BIOMEDICAL APPLICATIONS

---

- 13400 03 **Thin-layer chromatography image segmentation for toxicological studies (Invited Paper)** [13400-1]
- 13400 04 **Mueller matrix and laser induced imaging of the myocardium histological sections in the diagnosis of long-term consequences of COVID19** [13400-3]
- 13400 05 **Polarization mapping of optical anisotropy architectonics laser induced images in monitoring biological tissue necrosis** [13400-6]
- 13400 06 **3D polarimetry of laser induced speckle fields for phase detection thyroid gland polycrystalline structure and traumatic necrosis of human internal organs** [13400-7]
- 13400 07 **Automated optical system of integrated photostimulation of the human nervous system** [13400-8]
- 13400 08 **Layer-by-layer phase scanning of polycrystalline blood facies laser induced images for determination thyroid gland cancer and tissues injury necrosis** [13400-9]
- 13400 09 **Polarization-phase laser induced and holographic reconstruction of blood facies polycrystalline architectonics in the diagnosis of long-term consequences of COVID-19** [13400-11]
- 13400 0A **Neural network method for assessing the effectiveness of the formation of pathological and keloid scars** [13400-12]
- 13400 0B **The method of pyramid contour Q-transformation of biomedical images** [13400-17]
- 13400 0C **Simulation modeling of conversion processes of polarized optical radiation in biological tissue** [13400-19]
- 13400 0D **Physical modeling of output cascades and terminal devices of laser medical equipment with a rectangular cross-section of the output optical beam (Invited Paper)** [13400-22]

- 13400 OE **High-performance information technology for processing large datasets and biomedical images to improve the accuracy of computer-aided decision support systems (Invited Paper)** [13400-25]
- 13400 OF **Digital ultrasound image processing method with an example of a hip joint condition study (Invited Paper)** [13400-26]
- 13400 OG **Human-beta-defensin-1, ferritin, and interleukin-6 in a mathematical model for predicting the effectiveness of anti-tuberculosis treatment** [13400-29]
- 13400 OH **Automated splint design system for nasal surgery** [13400-33]
- 13400 OI **Application of optical methods for measuring physiological parameters in the construction of telemedicine systems for the diagnosis of infants and children** [13400-34]

---

#### **MATERIALS, METROLOGY, AND IMAGE PROCESSING**

---

- 13400 OJ **Transformers in image super-resolution: a brief review** [13400-4]
- 13400 OK **Modern programming technologies in the tasks of identification and classification of military aircraft using machine learning algorithms** [13400-13]
- 13400 OL **Vacuum nanoscale carbon coatings** [13400-15]
- 13400 OM **Regression method for inverse correlation filters design for objects recognition** [13400-16]
- 13400 ON **Modified parallel-hierarchical transformation algorithm for processing of optical imaging** [13400-18]
- 13400 OO **Method of combined vector normalization of 3-D objects** [13400-20]
- 13400 OP **Image processing based on hybrid semi-supervised learning** [13400-28]
- 13400 OQ **Results of studies on the emissivity of metal powder for implementing an intelligent control approach in additive manufacturing** [13400-30]
- 13400 OR **Re-identification of people in a video stream based on a Kalman filter** [13400-31]

---

#### **COMPONENTS, COMMUNICATIONS, AND ICT FOR PHOTONICS**

---

- 13400 OS **FPGA matrix multiplication with resource optimization and constraints (Invited Paper)** [13400-2]
- 13400 OT **Method to improve information security in fiberoptic systems and networks** [13400-5]

- 13400 0U **Precision control model for chaotic laser generation in optical communication and laser measurement systems** [13400-10]
- 13400 0V **Monitoring of the road surface using a fiber sensor based on a fiber Bragg grid (Invited Paper)** [13400-14]
- 13400 0W **Application of optoelectronic components in intelligent systems** [13400-21]
- 13400 0X **Innovative approaches to creating digital content for programs in photonics and optoelectronics** [13400-23]
- 13400 0Y **Modelling a modified parallel-hierarchical transformation algorithm for laser beam image processing** [13400-32]
- 13400 0Z **Evaluating machine learning-based routing algorithms on various wireless network topologies** [13400-35]



# Conference Committee

## *Conference Chairs*

**Ryszard S. Romaniuk**, Warsaw University of Technology (Poland)  
**Andrzej Smolarz**, Lublin University of Technology (Poland)  
**Waldemar Wójcik**, Lublin University of Technology (Poland)

## *Program Committee*

**Waldemar Wójcik**, Lublin University of Technology (Poland)  
**Ryszard S. Romaniuk**, Warsaw University of Technology (Poland)  
**Andrzej Smolarz**, Lublin University of Technology (Poland)  
**Piotr Kisała**, Lublin University of Technology (Poland)  
**Andrzej Kotyra**, Lublin University of Technology (Poland)  
**Paweł Komada**, Lublin University of Technology (Poland)  
**Zbigniew Omiotek**, Lublin University of Technology (Poland)  
**Sławomir Ciężczyk**, Lublin University of Technology (Poland)  
**Jacek Kuszniér**, Białystok University of Technology (Poland)  
**Krzysztof Pozniak**, Warsaw University of Technology and CERN (Poland)  
**Sergii Pavlov**, Vinnitsya National Technical University (Ukraine)  
**Volodymyr Lytvynenko**, Kherson National Technical University (Ukraine)  
**Oleh Avrunin**, Kharkov National Technical University (Ukraine)  
**Nataliia Savina**, National University of Water and Environmental Engineering (Ukraine)  
**Nataliia Zabolotna**, Vinnitsya National Technical University (Ukraine)  
**Saule Rakhmetulina**, D. Serikbayev East Kazakhstan Technical University (Kazakhstan)  
**Saule Smailova**, D. Serikbayev East Kazakhstan Technical University (Kazakhstan)  
**Aliya Kalizhanova**, Institute of Information and Computational Technologies (Kazakhstan)  
**Orken Mamyrbayev**, Institute of Information and Computational Technologies (Kazakhstan)  
**Krzysztof Skorupski**, Lublin University of Technology (Poland)

## *Program Committee*

**Andrzej Smolarz**, Lublin University of Technology (Poland)  
**Damian Harasim**, Warsaw University of Technology (Poland)  
**Róża Dzierżak**, Lublin University of Technology (Poland)  
**Żaklin Grądz**, Lublin University of Technology (Poland)  
**Jacek Majcher**, Lublin University of Technology (Poland)





## Introduction

Wilga Symposium used to be a multidisciplinary and multi-conference meeting of young scientists and engineers. Wilga meetings and workshops aimed primarily at Ph.D. students and freshly graduated researchers. It was organized since 1995 two times a year, featuring winter and spring/summer editions. Since 2002 Wilga papers are published in the Proceedings of SPIE. The major topical track of Wilga used to be Photonics Applications. This track was extended to related fields and embraced coupling of photonics to other subjects like mechatronics, optoelectronics, laser technologies, electronics, communications, image processing, and information technologies.

Due to this coupling more complex and bigger systems were considered with core solutions containing photonics. Wilga meetings were also related with other optical, optoelectronic, and photonic conferences organized locally but of international extent. These conferences were Optical Fibers and Their Applications, with papers published in Proceedings of SPIE since 1986, and Laser Technology with papers published in Proceedings of SPIE since 1987.

The WILGA winter and summer meetings on Photonics Applications were initiated by the PERG-ELHEP Research Laboratory at the Institute of Electronic Systems of Warsaw University of Technology, Poland in 1995. The meetings started to be numbered with the winter edition of 1998, thus this year the summer edition 2024 was the 52nd jubilee. The Photonics Engineering Research Group joined forces with the Electronics Laboratory for High Energy Physics Experiments Laboratory at IES WUT to start organizing international research meetings on the integration of photonics, electronics, and mechatronics in demanding advanced applications. To start a new series of conferences is not always easy. In this particular case, the factors that strongly supported the beginning process for these meetings had domestic and international cooperation with young research teams, friendly cooperation with key research organizations, international support from SPIE and IEEE, and domestic support from the Association of Polish Electrical Engineers.

The essential factor was involvement of the initiating laboratory as well as international cooperation from laboratories like Deutsches Elektronen Synchrotron DESY in Hamburg, Germany; CERN in Geneva, Switzerland; Fermilab near Chicago, USA; and later with TJNAF in Newport News, USA; ITER in Cadarache, France; FAIR/GSI in Darmstadt, Germany; etc. Since 2002 SPIE – The International Society for Optics and Photonics generously agreed to support the WILGA Symposium and publish the proceedings of these young researchers' meetings in the Proceedings of SPIE. The volumes were published annually from joint winter and summer editions of WILGA Symposium under the common title Photonics Applications in Astronomy, Communications, Industry, and High Energy Physics Experiments.

For a number of years, SPIE has generously funded awards for the best student presentation in WILGA. WILGA, the Photonics Applications Symposium, was held at a small village resort owned by Warsaw University of Technology, Poland and is located 50 kilometres up the Vistula River from Warsaw. During the 25 years of numbered editions of the WILGA Symposium on Photonics Application, the meetings gathered more than 6000 young researchers, among them the majority of Ph.D. students active in Photonics, who published more than 2000 papers in Proceedings of SPIE, and 1000 papers elsewhere.

Since 2022 Wilga Symposium was intentionally moved to Lublin, with the major organizers residing in the Lublin University of Technology. The WILGA 2021, 2022, and 2024 Symposia on Photonic Applications gathered, partly via virtual links, a significant number of scholars from Ukraine who submitted content for publication which is also reflected in this volume of Proceedings. Some of Ukrainian scholars were able to come personally to Lublin which is a beautiful academic city located in eastern part of Poland not far away from the Ukrainian border.

The topical areas of these recent Wilga meeting were divided to three main sections: biomedical applications; materials, metrology, and image processing; components, communications, and ICT for photonics. These areas were discussed with participants to promote cooperation with Ukrainian research institutions and individual researchers. The editors would like to thank all Wilga Symposium participants, who made also this SPIE volume of proceedings possible.

**Andrzej Smolarz**  
**Ryszard S. Romaniuk**  
**Waldemar Wójcik**