## PROCEEDINGS OF SPIE

# **Optical Technologies for Telecommunications 2019**

Vladimir A. Andreev Anton V. Bourdine Vladimir A. Burdin Oleg G. Morozov Albert H. Sultanov Editors

19-21 November 2019 Kazan, Russian Federation

Organized by Kazan National Research Technical University (Russian Federation) Povolzhskiy State University of Telecommunications and Informatics (Russian Federation) Ufa State Aviation Technical University (Russian Federation)

Published by SPIE

Volume 11516

Proceedings of SPIE 0277-786X, V. 11516

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

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 *Optical Technologies for Telecommunications 2019*, edited by Vladimir A. Andreev, Anton V. Bourdine, Vladimir A. Burdin, Oleg G. Morozov, Albert H. Sultanov, Proceedings of SPIE Vol. 11516 (SPIE, Bellingham, WA, 2020) Seven-digit Article CID Number.

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

ISBN: 9781510638396 ISBN: 9781510638402 (electronic)

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 © 2020, 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 \$21.00 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/20/\$21.00.

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:** Proceedings of SPIE follow an e-First publication model. A unique citation identifier (CID) number is assigned to each article 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

#### OPTICAL TELECOMMUNICATION TECHNOLOGIES AND SYSTEMS

| 11516 02   | Optical transport network management via machine learning and ontology-based technique [11516-2]   |
|--|--|
| 11516 03   | Forming vortex Bessel beam for optical communication at the wavelength of 1530 nm [11516-7]  |
| 11516 04   | Holographic method for storage of digital information [11516-31]   |
| 11516 05   | The problem of provisioning optical VPN [11516-37]   |
| 11516 06   | Method of increasing the secrecy of radio signal transmission of RoF segment based on the use of chirped optical signals [11516-41]  |
| 11516 07   | Simulation of data transmission on simple fiber acousto-optic channel [11516-42]   |
| 11516 08   | Leveling the risks of timing attacks based on permutation decoding [11516-66]  |
| 11516 09   | The experimental impulse-radio transmission based on spectral modulation technique for high-<br>speed communication system under the SCRF mask regulations [11516-67]  |
|  |  |
|  | PASSIVE AND ACTIVE COMPONENTS OF OPTICAL TELECOMMUNICATION   |
| 11516 0A   | PASSIVE AND ACTIVE COMPONENTS OF OPTICAL TELECOMMUNICATION Nonlinear spiral phase plates for generation of light fields with orbital angular momentum [11516-1]  |
| 11516 OA<br>11516 OB   | PASSIVE AND ACTIVE COMPONENTS OF OPTICAL TELECOMMUNICATION         Nonlinear spiral phase plates for generation of light fields with orbital angular momentum [11516-1]         Evaluating the influence of the refractive index dispersion of a harmonic lens on focusing properties [11516-9]  |
| 11516 0A<br>11516 0B<br>11516 0C                                     | PASSIVE AND ACTIVE COMPONENTS OF OPTICAL TELECOMMUNICATION         Nonlinear spiral phase plates for generation of light fields with orbital angular momentum [11516-1]         Evaluating the influence of the refractive index dispersion of a harmonic lens on focusing properties [11516-9]         Analysis of the rays path in the axicon taking into account their refraction and reflection [11516-10]   |
| 11516 OA<br>11516 OB<br>11516 OC<br>11516 OD                         | PASSIVE AND ACTIVE COMPONENTS OF OPTICAL TELECOMMUNICATION         Nonlinear spiral phase plates for generation of light fields with orbital angular momentum [11516-1]         Evaluating the influence of the refractive index dispersion of a harmonic lens on focusing properties [11516-9]         Analysis of the rays path in the axicon taking into account their refraction and reflection [11516-10]         Modeling the generation of a light spiral by the helical diffractive microaxicon in a three-dimensional model [11516-11]  |
| 11516 OA<br>11516 OB<br>11516 OC<br>11516 OD<br>11516 OE             | PASSIVE AND ACTIVE COMPONENTS OF OPTICAL TELECOMMUNICATION         Nonlinear spiral phase plates for generation of light fields with orbital angular momentum [11516-1]         Evaluating the influence of the refractive index dispersion of a harmonic lens on focusing properties [11516-9]         Analysis of the rays path in the axicon taking into account their refraction and reflection [11516-10]         Modeling the generation of a light spiral by the helical diffractive microaxicon in a three-dimensional model [11516-11]         The calculation of subwavelength diffraction optical elements based on gratings with a variable period using high-performance computer systems [11516-13]  |
| 11516 OA<br>11516 OB<br>11516 OC<br>11516 OD<br>11516 OE<br>11516 OF | PASSIVE AND ACTIVE COMPONENTS OF OPTICAL TELECOMMUNICATION         Nonlinear spiral phase plates for generation of light fields with orbital angular momentum [11516-1]         Evaluating the influence of the refractive index dispersion of a harmonic lens on focusing properties [11516-9]         Analysis of the rays path in the axicon taking into account their refraction and reflection [11516-10]         Modeling the generation of a light spiral by the helical diffractive microaxicon in a three-dimensional model [11516-11]         The calculation of subwavelength diffraction optical elements based on gratings with a variable period using high-performance computer systems [11516-13]         Efficient generation of arrays of closed-packed light rings [11516-14] |

| 11516 OH | Use of diffractive optical elements for beam intensity redistribution [11516-18]  |
|----------|---|
| 11516 0  | Polarization state analyzer/generator based on the three-stage polarization controller [11516-19]                           |
| 11516 OJ | Forming of periodic three-dimensional intensity distributions based on superposition of spherical harmonics [11516-21]      |
| 11516 OK | Formation of microstructures in an azopolymer using paraxial vortex Gaussian beams [11516-25]                               |
| 11516 OL | Design features of microwave photonic radars [11516-30]   |
| 11516 OM | Limit values of reflectivity of the periodic structure created by ultrasound in a crystal [11516-32]                        |
| 11516 ON | Polarization correction for propagation constant of a mode in a curved optical fiber [11516-38]                             |
| 11516 00 | Femtosecond optical pulse propagation in an optical fiber with high birefringence [11516-40]                                |
| 11516 OP | Gauss-Laguerre modes parameters of curved optical fiber with coating [11516-44]   |
| 11516 OQ | Model for calculating the mode coupling coefficients of a curved optical fiber [11516-45]                                   |
| 11516 OR | "Chirp To Amplitude" converter on the base of erbium fiber optic amplifier for photon radio emitters controlling [11516-57] |
| 11516 OS | A concept of microwave photonic sensor systems based on three component addressed fiber<br>Bragg gratings [11516-58]        |
| 11516 OT | DAS quazi-distributed system combined with temperature measuring on addressed fiber Bragg gratings [11516-59]               |
| 11516 OU | Reflection and transmission of focused light beam at a dielectric interface [11516-60]                                      |
| 11516 0V | Polarization effects of light in an optical fiber [11516-61]  |
| 11516 OW | Rotation of polarization vector in graded index waveguide [11516-62]  |
| 11516 OX | Devices for backscattered and reflected signals processing based on integrated photonics [11516-69]                         |
| 11516 OY | Study of the vibration detection using few-mode optical fiber [11516-70]  |
| 11516 OZ | OAM signal emitter based on a ring resonator [11516-71]   |
| 11516 10 | Mode converter based on ring resonator for integrated photonics [11516-72]  |

| 11516 11 | Resonance metal-dielectric structures based on CdTe for finding the concentration of solvents |
|----------|---|
|          | in the IR region [11516-74]   |

- 11516 12 Address fiber optical sensor for relative humidity measuring in a switchgear [11516-75]
- 11516 13 Polarisation multiplexed addressed fiber Bragg grating sensors [11516-79]

#### ONE-DIMENSION AND MULTI-DIMENSION OPTICAL SIGNALS DATA PROCESSING

- 11516 14 Mathematical modeling of the optical response from addressed fiber Bragg structure based on Lorentz function [11516-3]
- 11516 15 Mathematical modeling of optical response of address fiber Bragg structure using Gauss function [11516-4]
- 11516 16 Edge detection in images using energy characteristics [11516-5]
- 11516 17 Numerical approaches to solving the Schrödinger non-linear equations system for wave propagation in an optical fiber (Invited Paper) [11516-6]
- 11516 18 Spatial analogue of the Huygens-Kirchhoff principle and its application for simulation of random radiating systems [11516-12]
- 11516 19 Calculation of Karhunen-Loeve functions of given correlation function [11516-16]
- 11516 1A Application of a neural network for calculating the surface relief of a different level two-zone lens with an increased depth of field [11516-17]
- 11516 1B Highly sensitive method for remote analysis of diagnostic images [11516-20]
- 11516 1C Reconstruction of images in video analytics systems with ultra-wide angle optics [11516-23]
- 11516 1D Multidimensional signals superposition of triangulation optical sensors for measurement solid deforming [11516-26]
- 11516 1E **Processing multidimensional signals of triangulation optical sensors for recognition railway objects** [11516-27]
- 11516 1F Multidimensional optical video signals superposition for measurement offset and rotation angle with additive and multiplicative noise [11516-28]
- 11516 1G **Processing multidimensional signals of video surveillance for recognition railway objects** [11516-29]
- 11516 1H **3D image file creation methods for autostereoscopic displays** [11516-33]

## 11516 11 The study of elastic streaming processing of multidimensional optical signals in a distributed computing environment [11516-36]

11516 1J Radar image modeling and recognition [11516-55]

#### OPTICAL NETWORKS MAINTENANCE, CONTROL AND RESTORATION

- 11516 1K Generation of scalable wavefront for testing optical systems [11516-24]
- 11516 1L Lifetime prediction algorithm for an optical cable of cable link under exploitation [11516-35]
- 11516 1M Prony decomposition algorithm for processing polarization reflectometry data to determine the distributions of excess optical fiber length in a cable [11516-39]
- 11516 1N Simple method for localization of events on traces of group of fibers from the same fiber optic link segment [11516-43]
- 11516 10 Fast and simple method for estimation of the insertion loss at the connection of singlemode optical fibers with contaminated ferrule end faces [11516-48]
- 11516 1P Method for estimation of Brillouin scattering signal parameters [11516-78]

#### ADVANCED TECHNOLOGIES FOR OPTICAL TELECOMMUNICATIONS

- 11516 10 Intelligent video systems for unmanned aerial vehicles based on diffractive optics and deep learning (Invited Paper) [11516-56]
- 11516 1R Development of an experimental stand for the prototype of the radio-over-fiber telecommunication system with generation OAM signals generation in the W-band [11516-68]
- 11516 1S **Design of vortex optical fibers for RoF systems: Part I: overview and alternative solutions** [11516-65]
- 11516 1T Design of vortex optical fibers for RoF systems: Part II: pilot samples of chiral microstructured optical fibers [11516-52]
- 11516 1U Recognition of vortex beams with a wavelength of 1530 nm in aerosol and turbulent media [11516-73]
- 11516 1V Total adaptation is an important trend of imaging systems development [11516-80]
- 11516 1W Multi-channel system of quantum key distribution with frequency coding based on the AMPM-PMAM electro-optical scheme [11516-81]

- 11516 1X Result-oriented project management as a soft skills development methodology for students studying optical communication systems [11516-22]
- 11516 1Y **Project-based education as a cross-functional competences development approach** [11516-34]