SFM'18

6th International Symposium "Optics and Biophotonics"
22nd International School for Junior Scientists and Students on Optics, Laser Physics & Biophotonics

Organized by

Saratov State University (SSU)

Research-Educational Institute of Optics and Biophotonics of SSU

International Research-Educational Center of Optical Technologies for Industry and Medicine "Photonics" ofSSU

Institute of Biochemistry & Physiology of Plants & Microorganisms of the RAS

Institute of Precision Mechanics and Control of theRAS (IPMC RAS)

Saratov State Medical University n.a. V.I. Razumovsky

Volga Region Center of New Information Technologies ofSSU

Tomsk State University

ITMO University

Bauman Moscow State Technical University (BMSTU)

Institute of Solid State Physics of theRAS

Prokhorov Institute of General Physics of the RAS

Research Center of Biotechnology of the RAS

Biomedical Photonics Committee of Chinese Optical Society, China

SPIE Student Chapter of SSU

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SPIE Student Chapter of Institute of Solid State Physics of the RAS

SPIE Student Chapter of Samara University

OSA Student Chapter of SSU

OSA Student Chapter of (BMSTU)

6th International Symposium Optics and Biophotonics

Conference on Optical Technologies in Biophysics & Medicine XX

Co-chairs: **Elina A. Genina,** Saratov State University; Tomsk State University**, Valery V. Tuchin,** Saratov State University, Institute of Precision Mechanics and Control RAS, Tomsk State University

Secretary: **Polina A. Timoshina,** Saratov State University, Tomsk State University

International Program Committee: Alexey N. Bashkatov, Saratov State Univ., **Walter Blondel**, Univ. of Lorraine (France), **Wei Chen**, Univ. of Central Oklahoma (USA); **Kishan Dholakia**, Univ. of St. Andrews (UK); **Maria Farsari**, FORTH-IESL (Greece), **Paul M.W. French**, Imperial College of Sci., Technol. & Med. (UK); **James G. Fujimoto**, MIT (USA); **Steven L. Jacques**, Tufts School of Engineering(USA); **Vyacheslav Kalchenko,** Weizmann Institute of Science (Israel)**, Sean J. Kirkpatrick**, Michigan Technological Univ. (USA); **Kirill V. Larin**, Univ. of Houston (USA), Saratov State Univ.; **Jürgen M. Lademann**, Charité Universitätsmedizin Berlin (Germany); **Martin Leahy**, National Univ. of Ireland, Galway and RCSI (Ireland); **Qingming Luo**, Huazhong Univ.of Sci. & Technol.(China); **Francesco S. Pavone**, University of Florence (Italy); **Juergen Popp**, LeibnizInst. of Photonic Technol., Jena (Germany); **Alexey P. Popov**, Univ. of Oulu (Finland), **Alexander V. Priezzhev**, M.V. Lomonosov Moscow State Univ. (Russia); **Lihong Wang**, Caltech(USA); **Ruikang K. Wang**, Univ. of Washington (USA); **Dan Zhu**, Huazhong Univ. of Sci. and Technol. (China)

September 26, Wednesday

INVITED LECTURE/ORAL SESSION BIOPHYSICS I

(Building 10, Main Conference Hall)

Chair: **Metin Akay**, University of Houston, USA

14.20-14.40
Invited
Laser speckle dynamics in flow imaging - beyond the contrast,
<u>Dmitry Postnov</u>[1,2], Evren Erdener[1], Jianbo Tang[1], David Boas[1], [1]Neurophotonics Center, Boston University, Boston, USA; [2]Faculty of Health and Medical Sciences, Copenhagen University, Copenhagen, Denmark

14.40-15.00
Invited
Optical properties of skin as predictors of chronic diseases
<u>Ivan Bratchenko</u>[1], Lyudmila Shamina[1], Dmitry Artemyev[1], Oleg Myakinin[1], Yulia Khristoforova[1], Dmitriy Kornilin[1], Vladimir Grishanov[1], Valery Zakharov[1], Peter Lebedev[1], Larisa Rogozina[2], Daria Pimenova[2], Alexander Moryatov[2], Sergey Kozlov, [1]Samara University; [2]Samara State Medical University, Russia

15.00-15.20
Invited
OCT in ENT: Otitis media with effusion diagnosing
<u>Pavel Shilyagin</u>, Dmitry Terpelov, Valery Gelikonova, Alexey Novozhilov, Timur Abubakirov, Grigory Gelikonov, Andrey Shakhov, Valentin Gelikonov, Institute of Applied Physics RAS, N.-Novgorod, Russia

15.20-15.35
Erbium laser perforation and active delivery of photodynamic agent in PDT therapy of onychomycosis
<u>Anastasia Tavalinskaya</u>, A.V. Belikov, S.N. Smirnov, ITMO University, Saint Petersburg, Russia

15.35-15.50
Conventional Raman and SERS of body fluids for cancer detection
<u>Lyudmila Shamina</u>[1], Ivan Bratchenko[1], Dmitry Artemyev[1], Oleg Myakinin[1], Julia Starikova[1], Elena Tupicova[1], Igor Platonov[1], Alexander Moryatov[2], Sergey Kozlov[2], Valery Zakharov[1], [1]Samara University; [2]Samara State Medical University, Russia

15.50-16.05
Spatial speckle-correlometry and polarimetry technique for nondestructive investigation of biological objects
<u>Ekaterina Korneeva</u>, Maria Putintseva, Peter the Great St.Petersburg Polytechnic University, Russia

16.05-16.20
Study of microvascular reaction on the application of capsicum plaster by imaging photoplethysmography
<u>Maxim Volynsky</u>[1], Oleg Mamontov[1,2,3], Rashid Giniatullin[1,4,5], and Alexei Kamshilin[1], [1]ITMO University; [2]Pavlov First Saint Petersburg State Medical University; [3]Almazov National Medical Research Centre, Saint Petersburg; [4]Kazan Federal

September 27, Thursday

INVITED LECTURE/ORAL SESSION BIOPHYSICS II

(Building 10, Main Conference Hall)

Chair: **Walter Blondel**, University of Lorraine, CNRS, CRAN, France

11.30-11.50

Invited

Optical coherence tomography of malignant brain tumors ex vivo

Irina Dolganova[1,2,3], P. Aleksandrova[3], K. Zaytsev[2,3,4], A. Kosyrkova[5], S.-I. Beshplav[5], I. Reshetov[2], A. Potapov[5], V. Tuchin[6], [1]Institute of Solid State Physics of RAS, Chernogolovka; [2]Sechenov First Moscow State Medical University, Moscow; [3]Bauman Moscow State Technical University; [4]Prokhorov General Physics Institute of RAS, [5]Burdenko Neurosurgery Institute, Moscow; [6]Saratov State University, Saratov, Russia

11.50-12.10

Invited

Fiber optics probes as optical bridges between spectroscopy and medicine

Olga Bibikova[1,2], Urszula Zabarylo[3], Anastasya Melenteva[4], Valeria Belikova[4], Iskander Usenov[1], Tatiana Sakharova[1], Olaf Minet[3], Viacheslav Artyushenko[1], [1]art photonics GmbH, Germany,[2]Research-Educational Institute of Optics and Biophotonics, Saratov State University, Russia, [3]Center for Radiology C6, Medical Physics and Optical Diagnostics, CBF, Charité-Universitätsmedizin, Germany, [4]Samara University, Russia

12.10-12.30

Invited

Towards the monitoring of cardiovascular and neurohydrodynamics to assess glymphatic function,

Teemu Myllylä, University of Oulu, Finland

12.30-12.45

Low–coherence optical fiber sensors using diamond structures

Daria Majchrowicz, M. Jędrzejewska-Szczerska, Gdańsk University of Technology, Gdańsk, 11/12 Gabriela Narutowicza Street, Poland

12.45-13.00

Fluorescent indices of Tradescantia leaves under various lighting conditions, Olesya Kalmatskaya,V.A. Karavaev, A.N. Tikhonov, Lomonosov Moscow State University, Faculty of Physics, Russia

13.00-13.15

Reaction of the cardiovascular system on the cold-stress test assessed by camera-based photoplethysmography

Valery Zaytsev[1], Oleg Mamontov[2], Alexei Kamshilin[1],[1] ITMO University, Saint Petersburg, Russia,[2] Almazov National Medical Research Centre, Saint Petersburg, Russia

POSTERSESSION BIOPHYSICS

(Building 3, 3rd floor Hall)

Chair (B): **Anton Dyachenko**, Saratov State University (Russia)

18.30-19.30

1B. **Investigation of blood microcirculation parameters in patients with rheumatic diseases by videocapillaroscopy and laser Doppler flowmetry during cold pressor test** Dmitry Stavtsev[1], Mikhail Volkov[2], Nikita Margaryants[2], Andrey Potemkin[2], Viktor Dremin[1], Igor Kozlov[1], Irina Makovik[1], Evgeny Zherebtsov[3], Andrey Dunaev[1], [1]Research and Development Center of Biomedical Photonics, Orel State University named after I.S. Turgenev, Orel, Russia, [2]Computer Photonics and Videomatics Department, Saint Petersburg National Research University of Information Technologies, Mechanics and Optics, Saint Petersburg, Russia, [3]Aston Institute of Photonic Technologies, Aston University, Birmingham, UK

2B. **Influence of local pressure on the oscillations of cutaneous blood flow** Mikhail Mezentcev[1], Elena Potapova[1], Valerii Shupletsov[1], Irina Mizeva[2] ,[1]Orel State University named after I.S. Turgenev, Orel, Russia, [2]Institute of continuous media mechanics, Ural Branch of RAS, Perm

3B. **Refractive index sensor based on double hybrid plasmonic waveguide** Muhammad Ali Butt, Samara National Research University, Russia

4B. **Vasodilatation rate under local heating test in controls and patients with diabetes mellitus** Elena Zharkikh, Orel State University, Russia

5B. **Optical needle system for blood vessels detection during stereotactic biopsy of brain tumors,** Elena Kiseleva, Privolzhskiy Research Medical University, Research Institute of Biomedical Technologies, Russia

6B. **New technique for determination of electrophoretic mobility of colloidal system** Ekaterina Savchenko, Peter the Great Saint-Petersburg Polytechnic University, Russia

7B. **Pilot studies of the synchronization in skin blood flow oscillations in contralateral limbs** Yulia I. Loktionova[1], S.A. Bryanskaya[1], I.O. Kozlov[1], E.V. Zharkikh[1], E.A. Zherebtsov[2], A.I. Zherebtsova[1], V.V.Sidorov[3], S.S. Sokolovski[2], A.V. Dunaev[1], E.U. Rafailov[2], [2]Aston Institute of Photonic Technologies, Aston University, Aston Triangle, Birmingham, UK, [3]SPE "LAZMA" Ltd, Moscow, Russia

8B. **Laser speckle contrast imaging of abdominal organs in rat model** Evgenia Seryogina[1], Viktor Dremin[1], Anton Sdobnov[2], Igor Kozlov[1], Mikhail Mezentsev[1], Andrian Mamoshin[1], Alexander Alyanov[1], Andrey Dunaev[1], [1]Orel State University named after I.S. Turgenev, Russia, [2]Faculty of Information Technology and Electrical Engineering, University of Oulu, Oulu, Finland

9B. **Influence of local pressure on the oscillations of cutaneous blood flow** Mikhail Mezentseva[1], Elena Potapova[1], Valerii Shupletsov[1], Irina Mizeva[2],[1]Orel State University named after I.S. Turgenev, Orel, Russia, [2]Institute of continuous media mechanics, Ural Branch of RAS, Perm, Russia

10B. **Spectral analysis of dural implants using chemometric analysis** Timchenko P.E.[1], Timchenko E.V.[1], Volova L.V.[2], Kiyko Nikita[1], [1]Samara University,[2] Samara State Medical University, Russia

11B. **Chemometric analysis of raman spectra to assess the suitability of bone tissue in the production of bioimplants** Timchenko P.E.[1], Timchenko E.V.[1], Oleg Frolov[1], M.D. Markova[1], [1]Samara University, Russia

12B. **OCT based three-dimensional strain mapping for elastography and relaxography** Alexander Sovetsky[1], Alexander Matveyev[1], Ekaterina Gubarkova[2], Lev Matveev[1], Anton Plekhanov[2], Grigory Gelikonov[1], Dmitry Shabanov[1], Elena Zagaynova[2], Natalia Gladkova[2], Vladimir Zaitsev[1], [1]Institute of Applied Physics RAS, Russia, [2]Privolzhsky Research Medical University, Russia

13B. **Seminal works on mitogenetic radiation from experiments with onion to "cancer quencher"** I.V. Volodyaev[1], E.V. Naumova[2], D.A. Isaev[3], A.E. Naumova[4], [1]Biological faculty of M.V. Lomonosov Moscow State University, Moscow, Russia, [2]Rzhanov Institute of Semiconductor Physics, Novosibirsk, Russia, [3]All-Russia Research and Development Institute of Irrigation Fishery, Moscow, Russia, [4]Saratov State University, Saratov, Russia

14B. **The mirror artifact elemination in SD-OCT** Pavel Shilyagin, Dmitry Terpelov, Valentin Gelikonov, Grigory Gelikonov, Institute of Applied Physics RAS, Russia

15B. **Improvement of photodiagnosis using 5-ALA/PpIX, ZnPc and GaIZnPc photosensitizers in combination with vaso-dilatation drugs** Alexandr Khorovodov[1], Ekaterina Borisova[2], Ilana Agranovich[1], Anastasia Shintenkova[1], Veronika Shimanova[1], Matvey Kanevsky[1], Nikita Navolokin[3], Tsanislava Genova – Hristova[2], Ivan Angelov[4] , Vanya Mantareva[4], Oxana Semyachkina-Glushkovskaya[1], [1]Saratov State University, Russia, [2]Institute of Electronics-Bulgarian Academy of Sciences,Sofia, Bulgaria, [3]Saratov State Medical University, Russia, [4]Institute of Organic Chemistry with Centre of Phytochemistry - Bulgarian Academy of Sciences,Sofia, Bulgaria

16B. **Estimation of color characteristics by spectral data under photobleaching of glycated dentine** Natalia Kazadaeva, Tatiana Kashina, Alexandr Pravdin, Leonid E. Dolotov, Saratov State University, Russia

17B. **Myocardium laser welding with infrared radiation** L. Frolov[1], A.E. Moskalensky[1], S.G. Sokolovski[2], [1]Laboratory of Optics and Dynamics of Biological Systems Department of Physics NSU, Russia, [2]AIPT, School of Engineering and Applied Sciences, Aston University, Birmingham, UK

18B. **Automatic malignant melanoma recognition using a dermatoscopy imaging tool** Semyon Konovalov[1], Oleg A. Melsitov[1], Oleg O. Myakinin[1], Ivan A. Bratchenko[1], Alexander Moryatov[2], Sergey Kozlov[2], Valery Zakharov[1], [1]Samara University, Russia, [2]Samara State Medical University, Russia

19B. **Modeling of a local temperature field photoinduced in a medium with plasmon nanoparticles** Sergey Zarkov[1], Avetisyan Yuriy[1], Yakunin Alexander[1], Akchurin Georgy[1,2], Akchurin Garif[1,2], Tuchin Valery[1,2,3], [1]Institute of Precision Mechanics and Control, Russian Academy of Sciences, Russia; [2]Saratov State University, Russia; [3]Tomsk State University, Russia

20B. **Thermooptics of structures based on ordered arrays of plasmon nanoparticles and their applications** Yakunin Alexander[1], Avetisyan Yuriy[1], Sergey Zarkov[1], Akchurin Georgy[1,2], Akchurin Garif[1,2], Tuchin Valery[1,2,3], [1]Institute of Precision Mechanics and Control, Russian Academy of Sciences, Russia; [2]Saratov State University, Russia; [3]Tomsk State University, Russia

21B. **Regularities of local heating in laser irradiation of biotissues doped by gold nanostars** Akchurin Garif[1,2], Avetisyan Yuriy[1], Sergey Zarkov[1], Akchurin Georgy[1,2], Yakunin Alexander[1], Tuchin Valery[1,2,3], [1]Institute of Precision Mechanics and Control, Russian Academy of Sciences, Russia; [2]Saratov State University, Russia; [3]Tomsk State University, Russia

22B. **Orientational invariance of the integral absorption of laser radiation by plasmon-**

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конеференция оптические технологии в биофизике и медицине

Conference on Optical Technologies in Biophysics & Medicine XX

Co-chairs: **Elina A. Genina,** Saratov State University; Tomsk State University**, Valery V. Tuchin,** Saratov State University, Institute of Precision Mechanics and Control RAS, Tomsk State University

Secretary: **Polina A. Timoshina,** Saratov State University, Tomsk State University

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September 26, Wednesday

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14.20-14.40

Invited

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Dmitry Postnov[1,2], Evren Erdener[1], Jianbo Tang[1], David Boas[1], [1]Neurophotonics Center, Boston University, Boston, USA; [2]Faculty of Health and Medical Sciences, Copenhagen University, Copenhagen, Denmark

14.40-15.00

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Optical properties of skin as predictors of chronic diseases

Ivan Bratchenko[1], Lyudmila Shamina[1], Dmitry Artemyev[1], Oleg Myakinin[1], Yulia Khristoforova[1], Dmitriy Kornilin[1], Vladimir Grishanov[1], Valery Zakharov[1], Peter Lebedev[1], Larisa Rogozina[2], Daria Pimenova[2], Alexander Moryatov[2], Sergey Kozlov, [1]Samara University; [2]Samara State Medical University, Russia

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OCT in ENT: Otitis media with effusion diagnosing

Pavel Shilyagin, Dmitry Terpelov, Valery Gelikonova, Alexey Novozhilov, Timur Abubakirov, Grigory Gelikonov, Andrey Shakhov, Valentin Gelikonov, Institute of Applied Physics RAS, N.-Novgorod, Russia

15.20-15.35

Erbium laser perforation and active delivery of photodynamic agent in PDT therapy of onychomycosis

Anastasia Tavalinskaya, A.V. Belikov, S.N. Smirnov, ITMO University, Saint Petersburg, Russia

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Conventional Raman and SERS of body fluids for cancer detection

Lyudmila Shamina[1], Ivan Bratchenko[1], Dmitry Artemyev[1], Oleg Myakinin[1], Julia Starikova[1], Elena Tupicova[1], Igor Platonov[1], Alexander Moryatov[2], Sergey Kozlov[2], Valery Zakharov[1], [1]Samara University; [2]Samara State Medical University, Russia

15.50-16.05

Spatial speckle-correlometry and polarimetry technique for nondestructive investigation of biological objects

Ekaterina Korneeva, Maria Putintseva, Peter the Great St.Petersburg Polytechnic University, Russia

16.05-16.20

Study of microvascular reaction on the application of capsicum plaster by imaging photoplethysmography

Maxim Volynsky[1], Oleg Mamontov[1,2,3], Rashid Giniatullin[1,4,5], and Alexei Kamshilin[1], [1]ITMO University; [2]Pavlov First Saint Petersburg State Medical University; [3]Almazov National Medical Research Centre, Saint Petersburg; [4]Kazan Federal

27 сентября, четверг

September 27, Thursday

INVITED LECTURE/ORAL SESSION BIOPHYSICS II

(Building 10, Main Conference Hall)

Chair: **Walter Blondel**, University of Lorraine, CNRS, CRAN, France

11.30-11.50

Invited

Optical coherence tomography of malignant brain tumors ex vivo

Irina Dolganova[1,2,3], P. Aleksandrova[3], K. Zaytsev[2,3,4], A. Kosyrkova[5], S.-I. Beshplav[5], I. Reshetov[2], A. Potapov[5], V. Tuchin[6], [1]Institute of Solid State Physics of RAS, Chernogolovka; [2]Sechenov First Moscow State Medical University, Moscow; [3]Bauman Moscow State Technical University; [4]Prokhorov General Physics Institute of RAS, [5]Burdenko Neurosurgery Institute, Moscow; [6]Saratov State University, Saratov, Russia

11.50-12.10

Invited

Fiber optics probes as optical bridges between spectroscopy and medicine

Olga Bibikova[1,2], Urszula Zabarylo[3], Anastasya Melenteva[4], Valeria Belikova[4], Iskander Usenov[1], Tatiana Sakharova[1], Olaf Minet[3], Viacheslav Artyushenko[1], [1]art photonics GmbH, Germany,[2]Research-Educational Institute of Optics and Biophotonics, Saratov State University, Russia, [3]Center for Radiology C6, Medical Physics and Optical Diagnostics, CBF, Charité-Universitätsmedizin, Germany, [4]Samara University, Russia

12.10-12.30

Invited

Towards the monitoring of cardiovascular and neurohydrodynamics to assess glymphatic function,

Teemu Myllylä, University of Oulu, Finland

12.30-12.45

Low–coherence optical fiber sensors using diamond structures

Daria Majchrowicz, M. Jędrzejewska-Szczerska, Gdańsk University of Technology, Gdańsk, 11/12 Gabriela Narutowicza Street, Poland

12.45-13.00

Fluorescent indices of Tradescantia leaves under various lighting conditions, Olesya Kalmatskaya,V.A. Karavaev, A.N. Tikhonov, Lomonosov Moscow State University, Faculty of Physics, Russia

13.00-13.15

Reaction of the cardiovascular system on the cold-stress test assessed by camera-based photoplethysmography

Valery Zaytsev[1], Oleg Mamontov[2], Alexei Kamshilin[1],[1] ITMO University, Saint Petersburg, Russia,[2] Almazov National Medical Research Centre, Saint Petersburg, Russia

постерная сессия биофизика

POSTERSESSION BIOPHYSICS

(Building 3, 3rd floor Hall)

Chair (B): **Anton Dyachenko**, Saratov State University (Russia)

18.30-19.30

1B. **Investigation of blood microcirculation parameters in patients with rheumatic diseases by videocapillaroscopy and laser Doppler flowmetry during cold pressor test** Dmitry Stavtsev[1], Mikhail Volkov[2], Nikita Margaryants[2], Andrey Potemkin[2], Viktor Dremin[1], Igor Kozlov[1], Irina Makovik[1], Evgeny Zherebtsov[3], Andrey Dunaev[1], [1]Research and Development Center of Biomedical Photonics, Orel State University named after I.S. Turgenev, Orel, Russia, [2]Computer Photonics and Videomatics Department, Saint Petersburg National Research University of Information Technologies, Mechanics and Optics, Saint Petersburg, Russia, [3]Aston Institute of Photonic Technologies, Aston University, Birmingham, UK

2B. **Influence of local pressure on the oscillations of cutaneous blood flow** Mikhail Mezentcev[1], Elena Potapova[1], Valerii Shupletsov[1], Irina Mizeva[2] ,[1]Orel State University named after I.S. Turgenev, Orel, Russia, [2]Institute of continuous media mechanics, Ural Branch of RAS, Perm

3B. **Refractive index sensor based on double hybrid plasmonic waveguide** Muhammad Ali Butt, Samara National Research University, Russia

4B. **Vasodilatation rate under local heating test in controls and patients with diabetes mellitus** Elena Zharkikh, Orel State University, Russia

5B. **Optical needle system for blood vessels detection during stereotactic biopsy of brain tumors,** Elena Kiseleva, Privolzhskiy Research Medical University, Research Institute of Biomedical Technologies, Russia

6B. **New technique for determination of electrophoretic mobility of colloidal system** Ekaterina Savchenko, Peter the Great Saint-Petersburg Polytechnic University, Russia

7B. **Pilot studies of the synchronization in skin blood flow oscillations in contralateral limbs** Yulia I. Loktionova[1], S.A. Bryanskaya[1], I.O. Kozlov[1], E.V. Zharkikh[1], E.A. Zherebtsov[2], A.I. Zherebtsova[1], V.V.Sidorov[3], S.S. Sokolovski[2], A.V. Dunaev[1], E.U. Rafailov[2], [2]Aston Institute of Photonic Technologies, Aston University, Aston Triangle, Birmingham, UK, [3]SPE "LAZMA" Ltd, Moscow, Russia

8B. **Laser speckle contrast imaging of abdominal organs in rat model** Evgenia Seryogina[1], Viktor Dremin[1], Anton Sdobnov[2], Igor Kozlov[1], Mikhail Mezentsev[1], Andrian Mamoshin[1], Alexander Alyanov[1], Andrey Dunaev[1], [1]Orel State University named after I.S. Turgenev, Russia, [2]Faculty of Information Technology and Electrical Engineering, University of Oulu, Oulu, Finland

9B. **Influence of local pressure on the oscillations of cutaneous blood flow** Mikhail Mezentseva[1], Elena Potapova[1], Valerii Shupletsov[1], Irina Mizeva[2],[1]Orel State University named after I.S. Turgenev, Orel, Russia, [2]Institute of continuous media mechanics, Ural Branch of RAS, Perm, Russia

10B. **Spectral analysis of dural implants using chemometric analysis** Timchenko P.E.[1], Timchenko E.V.[1], Volova L.V.[2], Kiyko Nikita[1], [1]Samara University,[2] Samara State Medical University, Russia

11B. **Chemometric analysis of raman spectra to assess the suitability of bone tissue in the production of bioimplants** Timchenko P.E.[1], Timchenko E.V.[1], Oleg Frolov[1], M.D. Markova[1], [1]Samara University, Russia

12B. **OCT based three-dimensional strain mapping for elastography and relaxography** Alexander Sovetsky[1], Alexander Matveyev[1], Ekaterina Gubarkova[2], Lev Matveev[1], Anton Plekhanov[2], Grigory Gelikonov[1], Dmitry Shabanov[1], Elena Zagaynova[2], Natalia Gladkova[2], Vladimir Zaitsev[1], [1]Institute of Applied Physics RAS, Russia, [2]Privolzhsky Research Medical University, Russia

13B. **Seminal works on mitogenetic radiation from experiments with onion to "cancer quencher"** I.V. Volodyaev[1], E.V. Naumova[2], D.A. Isaev[3], A.E. Naumova[4], [1]Biological faculty of M.V. Lomonosov Moscow State University, Moscow, Russia, [2]Rzhanov Institute of Semiconductor Physics, Novosibirsk, Russia, [3]All-Russia Research and Development Institute of Irrigation Fishery, Moscow, Russia, [4]Saratov State University, Saratov, Russia

14B. **Подавление зеркальных артефактов в спектральной ОКТ.** П.А. Шилягин, Д.А. Терпелов, В.М. Геликонов, Г.В. Геликонов ИПФ РАН, Россия

15B. **Improvement of photodiagnosis using 5-ALA/PpIX, ZnPc and GaIZnPc photosensitizers in combination with vaso-dilatation drugs** Alexandr Khorovodov[1], Ekaterina Borisova[2], Ilana Agranovich[1], Anastasia Shintenkova[1], Veronika Shimanova[1], Matvey Kanevsky[1], Nikita Navolokin[3], Tsanislava Genova – Hristova[2], Ivan Angelov[4] , Vanya Mantareva[4], Oxana Semyachkina-Glushkovskaya[1], [1]Saratov State University, Russia, [2]Institute of Electronics-Bulgarian Academy of Sciences,Sofia, Bulgaria, [3]Saratov State Medical University, Russia, [4]Institute of Organic Chemistry with Centre of Phytochemistry - Bulgarian Academy of Sciences,Sofia, Bulgaria

16B. **Estimation of color characteristics by spectral data under photobleaching of glycated dentine** Natalia Kazadaeva, Tatiana Kashina, Alexandr Pravdin, Leonid E. Dolotov, Saratov State University, Russia

17B. **Myocardium laser welding with infrared radiation** L. Frolov[1], A.E. Moskalensky[1], S.G. Sokolovski[2], [1]Laboratory of Optics and Dynamics of Biological Systems Department of Physics NSU, Russia, [2]AIPT, School of Engineering and Applied Sciences, Aston University, Birmingham, UK

18B. **Automatic malignant melanoma recognition using a dermatoscopy imaging tool** Semyon Konovalov[1], Oleg A. Melsitov[1], Oleg O. Myakinin[1], Ivan A. Bratchenko[1], Alexander Moryatov[2], Sergey Kozlov[2], Valery Zakharov[1], [1]Samara University, Russia, [2]Samara State Medical University, Russia

19B. **Modeling of a local temperature field photoinduced in a medium with plasmon nanoparticles** Sergey Zarkov[1], Avetisyan Yuriy[1], Yakunin Alexander[1], Akchurin Georgy[1,2], Akchurin Garif[1,2], Tuchin Valery[1,2,3], [1]Institute of Precision Mechanics and Control, Russian Academy of Sciences, Russia; [2]Saratov State University, Russia; [3]Tomsk State University, Russia

20B. **Thermooptics of structures based on ordered arrays of plasmon nanoparticles and their applications** Yakunin Alexander[1], Avetisyan Yuriy[1], Sergey Zarkov[1], Akchurin Georgy[1,2], Akchurin Garif[1,2], Tuchin Valery[1,2,3], [1]Institute of Precision Mechanics and Control, Russian Academy of Sciences, Russia; [2]Saratov State University, Russia; [3]Tomsk State University, Russia

21B. **Regularities of local heating in laser irradiation of biotissues doped by gold nanostars** Akchurin Garif[1,2], Avetisyan Yuriy[1], Sergey Zarkov[1], Akchurin Georgy[1,2], Yakunin Alexander[1], Tuchin Valery[1,2,3], [1]Institute of Precision Mechanics and Control, Russian Academy of Sciences, Russia; [2]Saratov State University, Russia; [3]Tomsk State University, Russia

22B. **Orientational invariance of the integral absorption of laser radiation by plasmon-**

THE MIRROR ARTIFACT ELEMINATION IN SD-OCT

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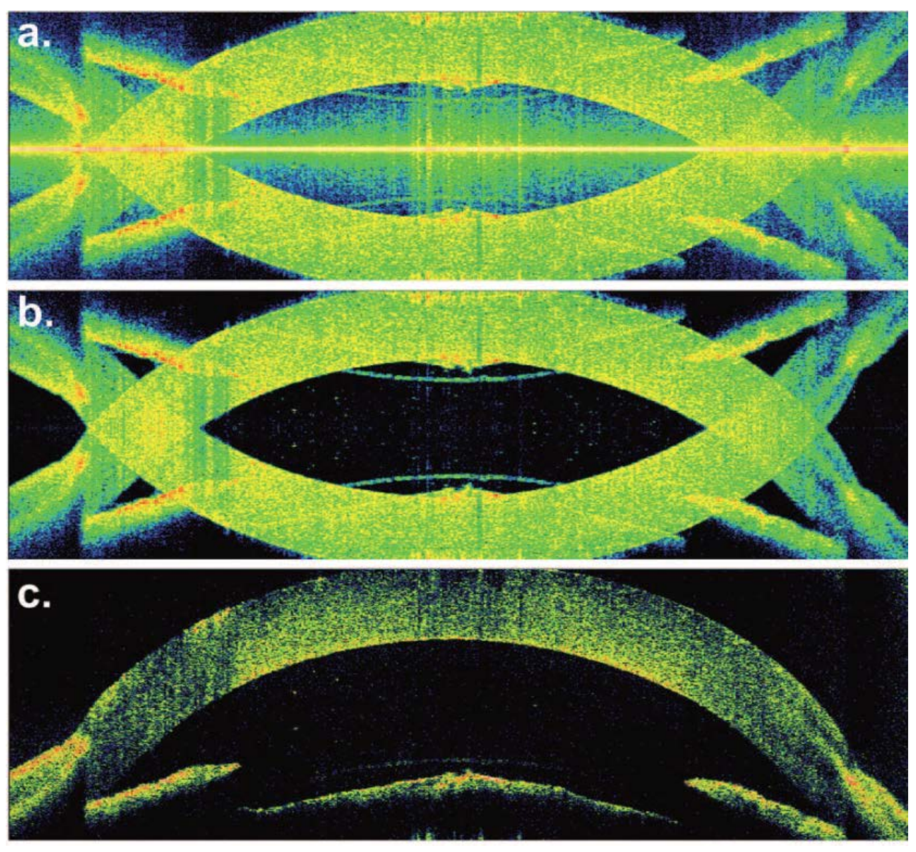
Abstract. *An efficient technique for constructing the achromatic phase shift in the reference arm of spectral-domain OCT is presented. The technique is based on a wavelength-dependent optical delay line using a diffractive grating as a dispersive element. Several setups are described and compared.*

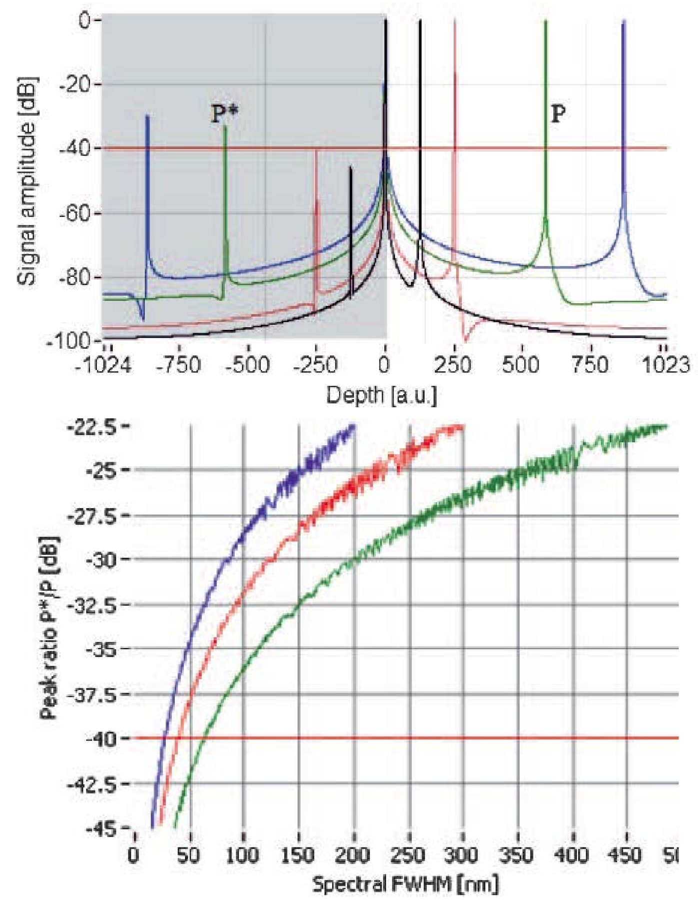
Motivation



Leitgeb R.A., Wojtkowski M. Complex and Coherence Noise Free Fourier Domain OCT // In: *Optical Coherence Tomography: Techology and Applications*, Fujimoto J.G., Drexler W., Editors. Berlin: Springer. 2008. p. 177-207.

In 2017 IAP RAS in collaboration with Krasnogorsky optical-mechanical plant started the project devoted to development of optical coherence tomography apparatus for ophthalmic use. While the evaluating the modern OCT devices commercially available for the clinical use, we found that the mirror artifact problem is not been solved for these devices. At the same time, this solution is required to simplify the anterior segment investigations due to large value of the depth between cornea and crystalline surfaces.

Spectral domain optical coherence tomography (SD-OCT) is based on measuring of optical spectrum of sum of two interfering waves: the reference one and the backscattered from the object one [1, 2]. Because of the obtained spectrum is the real function of optical frequency, the reconstructed by Fourier transformation image has mirror-symmetrical structure relative to zero of path-difference shown at the left image [1]. Some methods of eliminating of the mirror artifacts, obtained for SD-OCT [3-6], are based on consecutive obtaining of spectral components with different phase shift between reference and object waves. The simultaneous obtaining of full complex spectrum makes possible eliminating the influence of Doppler phase shifts of moving scatterers in the object [7, 8]. The simultaneous obtaining of quadrature interference components in spectrometer-based OCT by using polarization optics was proposed in [9]. The most disadvantage of methods based on the use of fixed-length shift in interferometer is the dependence of the obtained phase shift and common optical frequency of separately registered spectral component. It causes strong limitations in source bandwidth to finely elininate the mirror artifacts (the right image).



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SYSTEM EVALUATION

The limitation of the possibility to eliminate the mirror artifact in SD OCT by the use of the optical delay was estimated in [13]. The simplest way to construct the complex-valued spectrum in SD OCT is to use a pair of consequently registered real spectra with π/4 relative phase shift to combine them into a sum like

$$S(w)=S_{Re}(w)+i\,S_{Im}(w) \quad (1)$$

The Fourier image of eq.(1) contains no mirror component, but currently, in most cases, the delay between the reference and object waves is varied by changing the optical path length of the reference arm. This causes the appearance of an additional phase delay for the spectral components w different from the central one w_0, for which a required delay is set:

$$\varphi(w)=\pi(w-w_0)/4w_0 \quad (2)$$

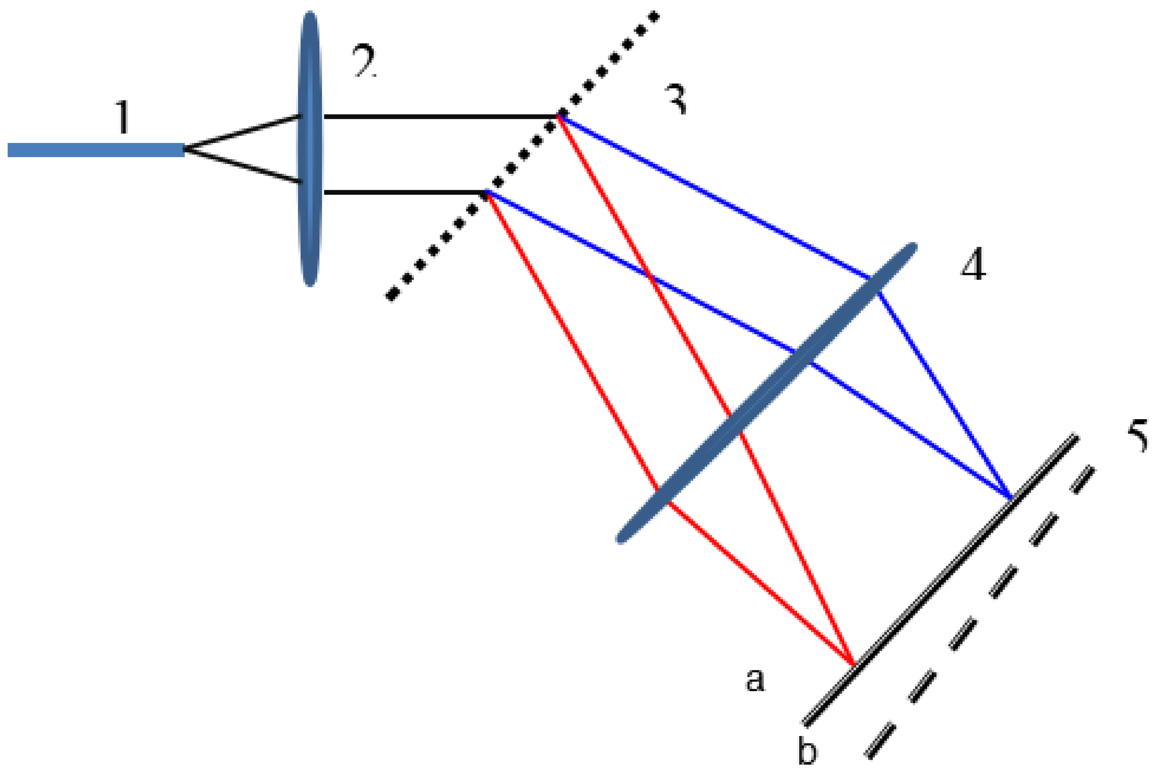
The result is a disturbance of the phase relationships between the individual components, which in turn substantially restricts the applicability of the method when using the broadband sources [13, 14]. In modern SD OCT sources with spectral band width up to 20% are used. In this case the calculated spectrum $S^*(w)$ contains a true term $S(w)$ and a symmetric to zero component multiplied by φ (w):

$$S^*(w)=S(w) + \varphi(w)\, S_{Re}(w) \quad (3)$$

It is easy to show that the mirror artifact value is determined by the Fourier image of φ (w), so the ratio between true image and mirror artifact may be found in dB as

$$D_i/D_m=-20 \log [\max(FT(\varphi(w)))] \quad (4)$$

So the key to decrease the mirror artifact influence to the OCT image is to minimize the φ (w) power by creating the own delay for each spectral component.



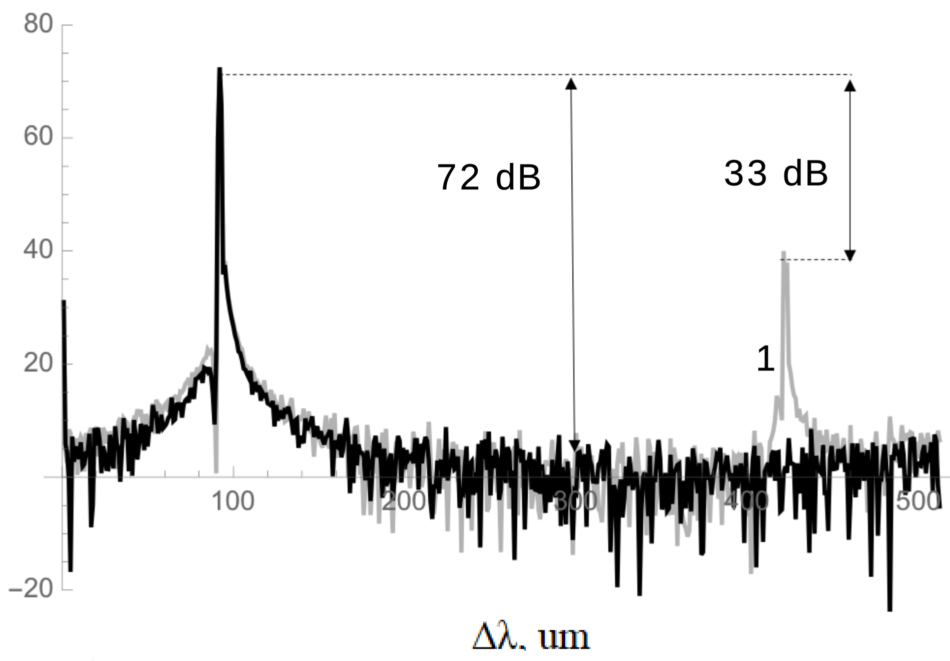
The phase shifter setup: (1) fiber tip, (2) collimating lens, (3) diffractive grating, (4) cat-eye lens, (5) reference mirror

The figure on left shows the general optical setup of the proposed phase shifter. The diffractive grating 3 is placed in the space between collimating lens 2 and the cat-eye 4 in the reference arm of the interferometer. For the initial state *a* the optical delays are equal for each spectral component. The state *b* is obtained by simultaneous shifting the mirror along the main ray and tilting it for a little angle to obtain equal phase shift for different spectral components.

If the cat-eye lens has a few mm focal length, the tilting angle is less than 10^{-2} radians. It results in absence of any intensity losses caused by reference mirror tilting, so the setup seems to be realizable.

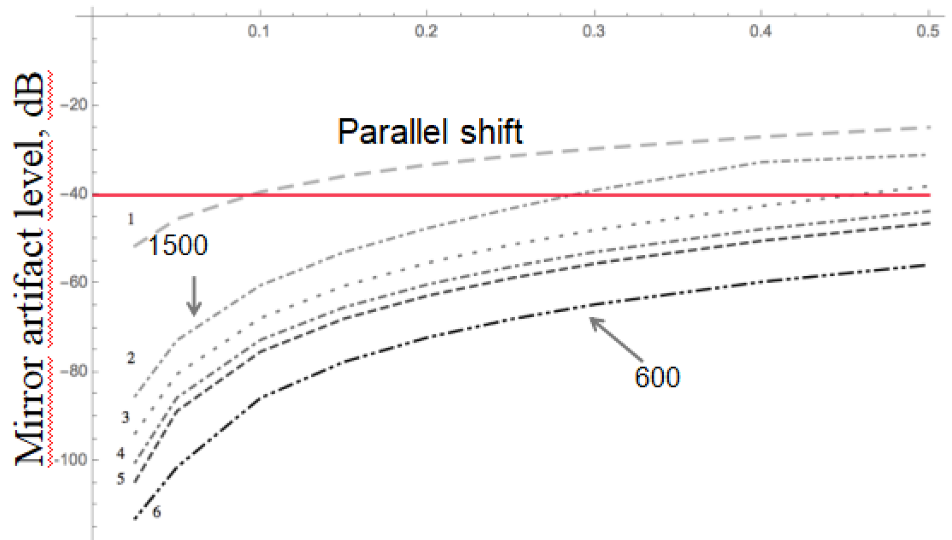
We provided numerical estimations of the possibility of mirror artifact elimination using the proposed setup. The figures on the right are calculated for the conventional reference arm shift setup (curve 1) and grating-based setup (other curves) for the probing source with 1060 nm central wavelength.

The upper image represents the A-scan of a single surface providing SNR of 72dB. The curve 1 (gray) was simulated for 100 nm source bandwidth. It contains a 33 dB lower mirror peak in accordance to [3]. The black curve is simulated for the use of 600 lpmm diffractive grating placed in a Bragg configuration. The image contains no visible mirror peak.



In order to estimate the effectiveness of the use of diffractive grating as a dispersive element in a phase modulating process in OCT a series of different frequency gratings were simulated.

The lower to the right figure represents the estimated dependence of the level of mirror artifact from the used source bandwidth. The line 1 was calculated for common phase shifter used no dispersive elements according to [13]. Other curves are calculated for different density gratings positioned by Bragg angle to the collimated beam. The figure clearly shows that the use of any grating provides the elimination of the mirror artifact for the 40 dB level for the most of sources used in OCT. The higher efficacy of the lower frequency gratings seems to be caused by the higher linearity of the dependence between diffraction angle and wavelength in Bragg configuration.



The mirror artifact level as a function of source bandwidth for different gratings used (central wavelength 1.06 um)

Conclusion

We have proposed the technique for obtaining an achromatized phase shift for spectral-domain OCT using wide-band source. The use of proposed phase shifter will allow reconstructing OCT images free from mirror artifacts in wide range of broad band sources of probing light.

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Acknowledgments

The research was supported by Contract of the Russian Federation no. 14.610.21.0014 (unique no. 0000000007417P2X0002) dated to October 3 of 2017.

Подавление зеркальных артефактов в спектральной ОКТ

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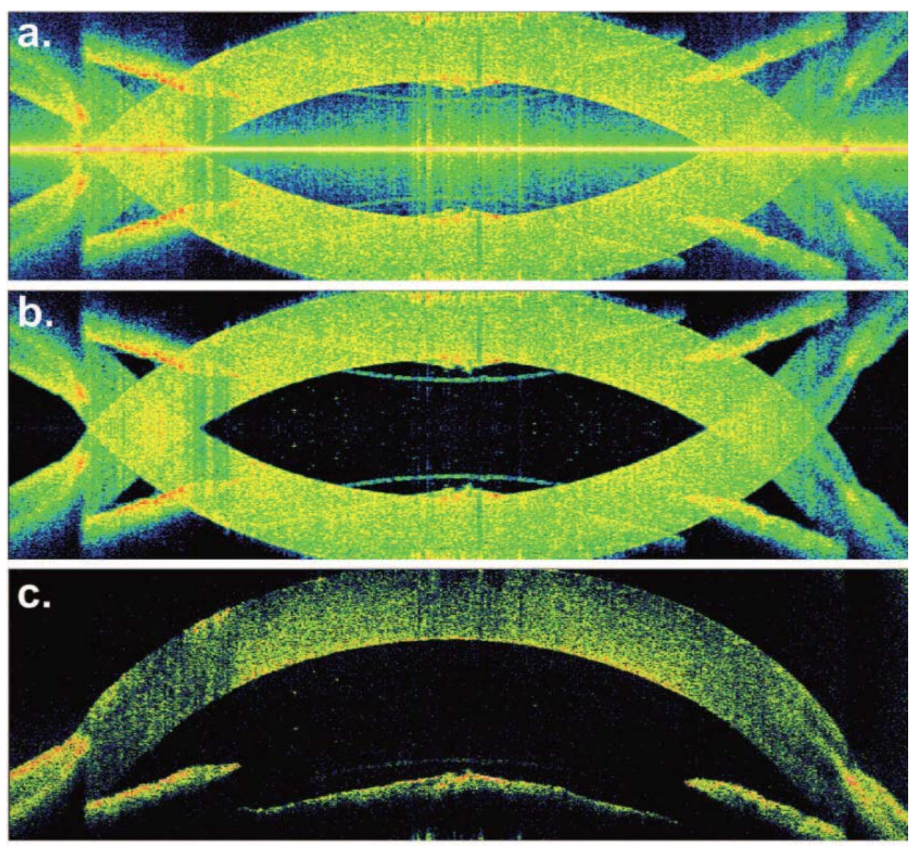
Аннотация. *Представлен эффективный метод построения ахроматического фазового сдвига в эталонном плече ОКТ спектральной области. Методика основана на использовании оптической линии задержки, длина которой зависит от длины волны, с использованием дифракционной решетки в качестве дисперсионного элемента.*

Мотивация



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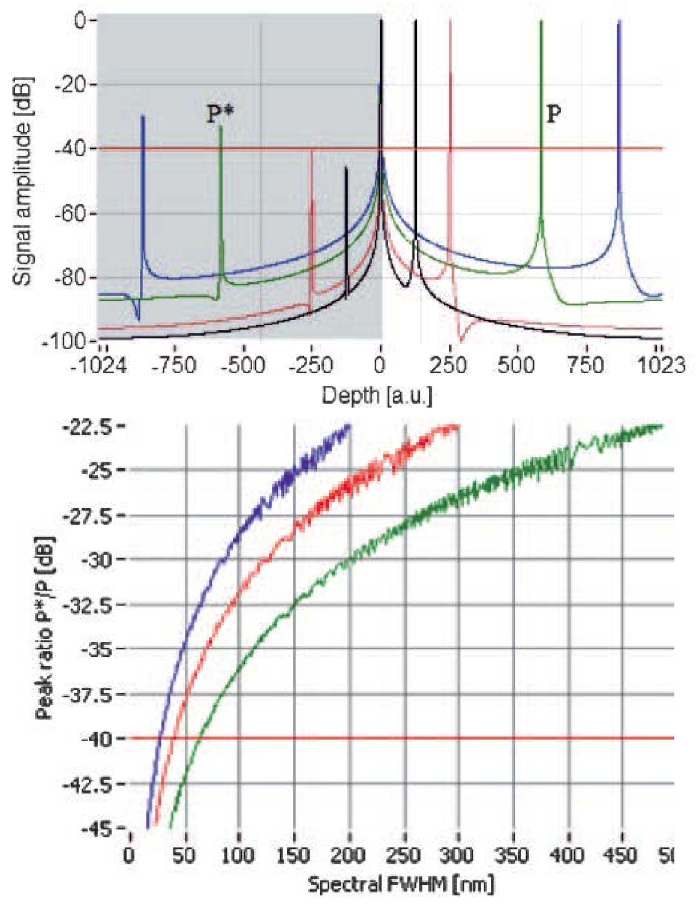
В 2017 году в ИПФ РАН совместно с Красногорским оптико-механическим заводом стартовал проект, посвященный разработке аппарата оптической когерентной томографии для офтальмологического применения. В то время как оценка современных устройств ОСТ, коммерчески доступных для клинического использования, мы обнаружили, что проблема зеркального артефакта не была решена для этих устройств. В то же время это решение необходимо для упрощения исследований переднего сегмента из-за большого значения глубины между роговицей и кристаллическими поверхностями.

Оптическая когерентная томография в спектральной области (SD-OCT) основана на измерении оптического спектра суммы двух мешающих волн: эталонной и обратной рассеяния от объекта один 1, 2. Из-за полученного спектра реальная функция оптической частоты реконструированное с помощью преобразования Фурье изображение имеет зеркально-симметричную структуру относительно нуля разности путей, показанного на левом изображении 1. Некоторые способы устранения зеркальных артефактов, полученных для SD-OCT 3-6, основаны на последовательном получении спектральные компоненты с различным сдвигом фаз между опорной и объектными волнами. Одновременное получение полного комплексного спектра позволяет исключить влияние доплеровских фазовых сдвигов движущихся рассеивателей в объекте 7, 8. Одновременное получение квадратурных интерференционных составляющих в ОКТ на основе спектрометра с использованием поляризационной оптики было предложено в 9. Наибольший недостаток Из методов, основанных на использовании сдвига фиксированной длины в интерферометре, лежит зависимость полученного фазового сдвига и общей оптической частоты отдельно регистрируемой спектральной составляющей. Это вызывает сильные ограничения в полосе пропускания источника для точного устранения зеркальных артефактов (правильное изображение).



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Описание подхода

Ограничение возможности устранения зеркального артефакта в SD OCT с помощью оптической задержки было оценено в 13. Самый простой способ построения комплексного спектра в SD OCT - это использование пары последовательно зарегистрированных реальных спектров с π / 4 относительный сдвиг фазы, чтобы объединить их в сумму, как

$$S(w)=S_{Re}(w)+i\,S_{Im}(w) \quad (1)$$

Фурье образ эк. (1) не содержит зеркальный компонента, но в настоящее время, в большинстве случаев, задержка между эталонной и объектными волнами изменяется путем изменения оптической длиной пути опорного плеча. Это вызывает появление дополнительной фазовой задержки для спектральных составляющих w, отличных от центральной w0, для которой установлена необходимая задержка :

$$\varphi(w)=\pi(w-w_0)/4w_0 \quad (2)$$

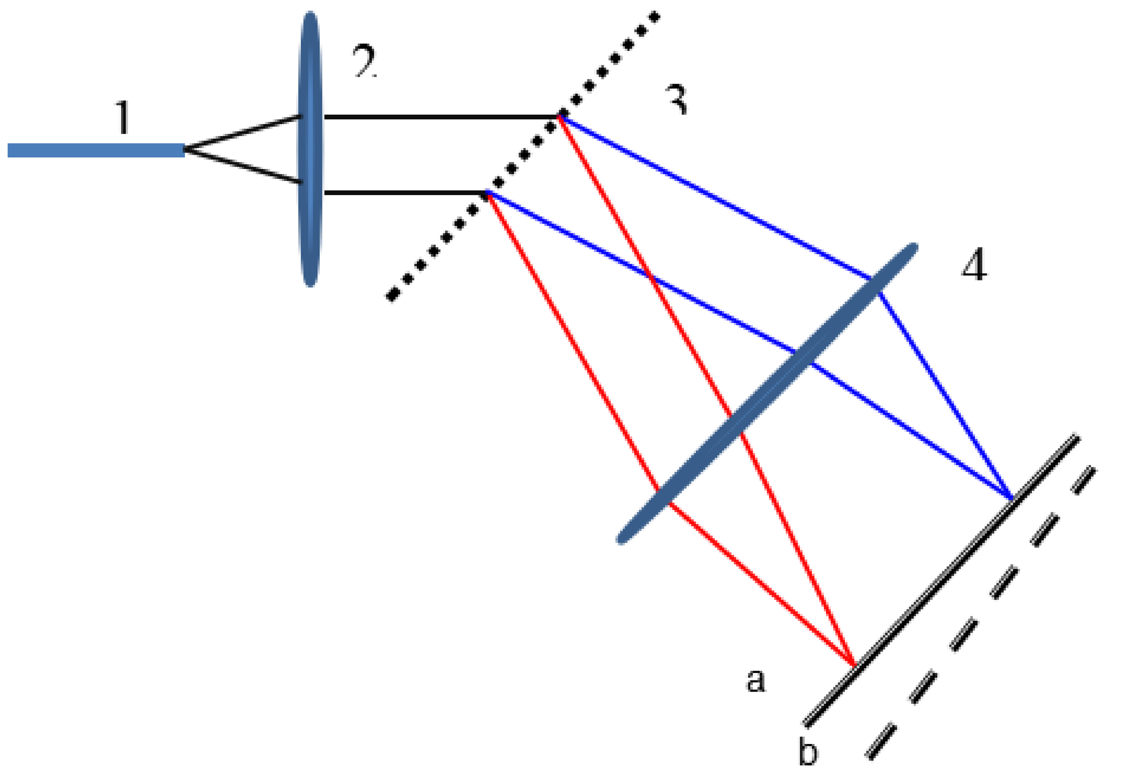
Результатом является нарушение фазовых отношений между отдельными компонентами, что, в свою очередь, существенно ограничивает применимость метода при использовании широкополосных источников 13, 14. В современных SD OCT источники с шириной спектральной полосы до 20% используются. В этом случае вычисленный спектр S * (w) содержит истинное слагаемое S (w) и компоненту, симметричную нулю, умноженную на φ (w):

$$S^*(w)=S(w) + \varphi(w)\, S_{Re}(w) \quad (3)$$

Легко показать, что значение зеркального артефакта определяется по фурье-изображению φ (w), поэтому соотношение между истинным изображением и зеркальным артефактом может быть найдено в дБ как

$$D_i/D_m=-20\log[\max(FT(\varphi(w)))] \quad (4)$$

Таким образом, ключом к уменьшению влияния зеркального артефакта на ОКТ-изображение является минимизация мощности φ (w) путем создания собственной задержки для каждого спектрального компонента.



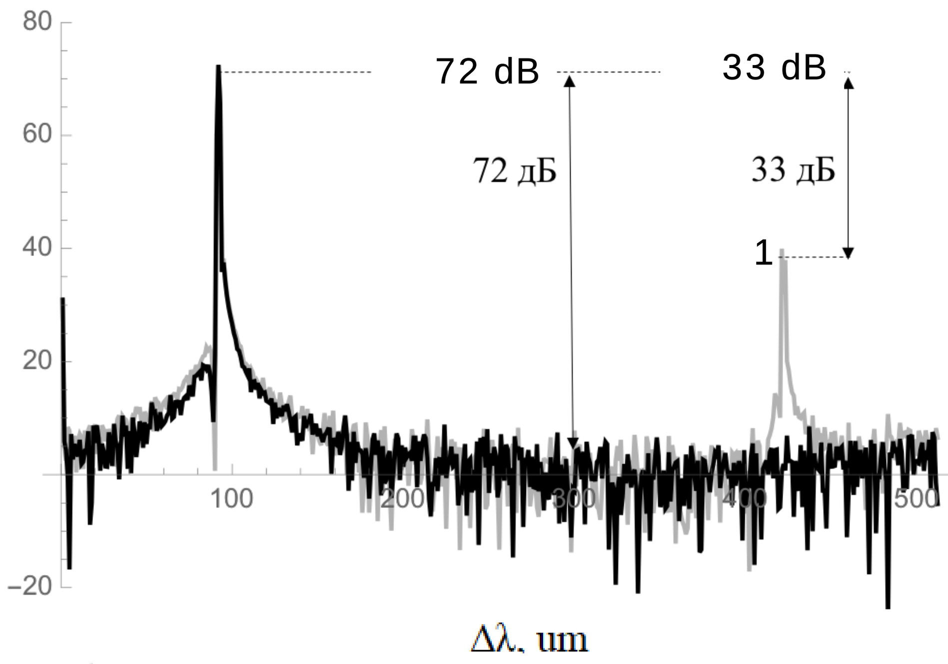
The phase shifter setup: (1) fiber tip, (2) collimating lens, (3) diffractive grating, (4) cat-eye lens, (5) reference mirror

На рисунке слева показана общая оптическая схема предлагаемого фазовращателя. Дифракционная решетка 3 расположена в пространстве между коллимирующей линзой 2 и кошачьим глазом 4 в контрольном плече интерферометра. Для начального состояния а оптические задержки равны для каждого спектрального компонента. Состояние b получается путем одновременного смещения зеркала вдоль основного луча и наклона его на небольшой угол, чтобы получить одинаковый фазовый сдвиг для разных спектральных составляющих.

Если фокусное расстояние объектива «кошачий глаз» составляет несколько мм, угол наклона составляет менее 0,01 радиан. Это приводит к отсутствию каких-либо потерь интенсивности, вызванных наклоном опорного зеркала, так что установка, как представляется, реализуема.

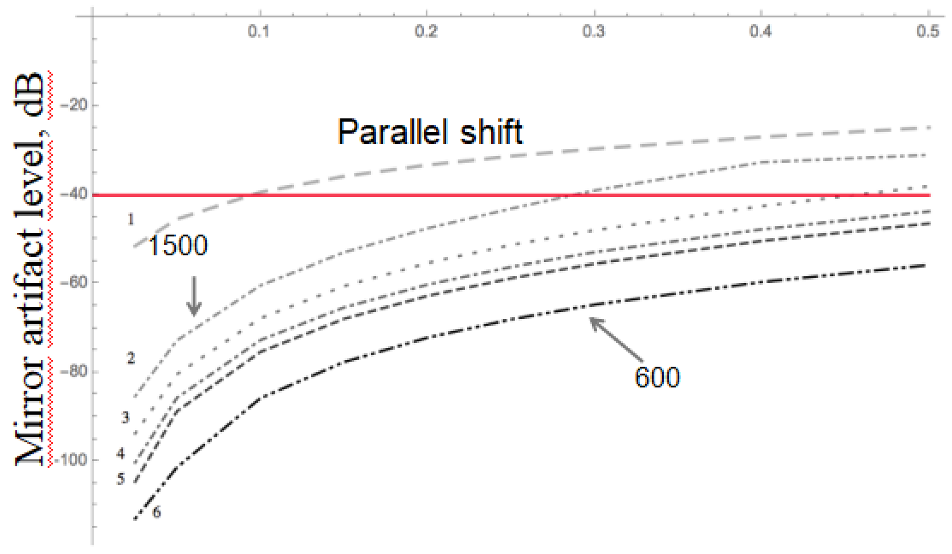
Приведены численные оценки возможности устранения зеркальных артефактов с использованием предложенной установки. Цифры на правом рассчитываются для обычного опорного рычага настройки сдвига (кривая 1) и дифракционной решетки на основе установки (другие кривые) для зондирующего источника с 1060 нм центральной длины волны.

Верхнее изображение представляет собой А-сканирование одной поверхности, обеспечивающее ОСШ 72 дБ. Кривая 1 (серая) была смоделирована для ширины полосы источника 100 нм. Он содержит 33 дБ нижнего зеркального пика в соответствии с 3. Черная кривая моделируется для использования дифракционной решетки 600 л / мм, размещенной в конфигурации Брэгга. Изображение не содержит видимого зеркального пика.



Для оценки эффективности использования дифракционной решетки в качестве дисперсионного элемента в процессе фазовой модуляции в ОКТ была смоделирована серия различных частотных решеток.

Нижний правый показатель представляет предполагаемую зависимость уровня зеркального артефакта от используемой полосы пропускания источника. Линия 1 была рассчитана для общего фазовращателя, в котором не использовались дисперсионные элементы в соответствии с 13. Другие кривые рассчитаны для решеток различной плотности, расположенных под углом Брэгга к коллимированному пучку. На рисунке ясно видно, что использование любой решетки обеспечивает устранение зеркального артефакта для уровня 40 дБ для большинства источников, используемых в ОСТ. По-видимому, более высокая эффективность решеток с более низкой частотой обусловлена более высокой линейностью зависимости между углом дифракции и длиной волны в брэгговской конфигурации.



The mirror artifact level as a function of source bandwidth for different gratings used (central wavelength 1.06 um)

Заключение

Мы предложили методику получения ахроматизированного фазового сдвига для ОКТ спектральной области с использованием широкополосного источника. Использование предложенного фазовращателя позволит реконструировать ОКТ-изображения без зеркальных артефактов в широком диапазоне широкополосных источников зондирующего света.

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Acknowledgments

Работа поддержана Соглашением с Минобрнауки России №14.610.21.0014 (ИГК 0000000007417P2X0002) от 03 октября 2017.