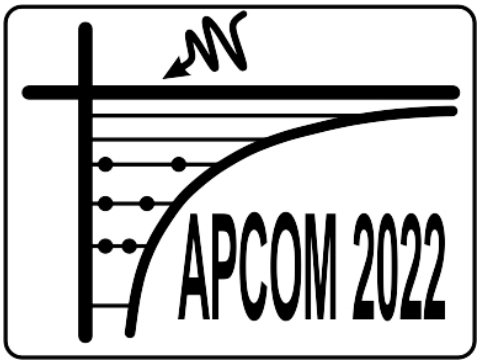

20th Asia-Pacific Conference on Fundamental Problems of Opto- and Microelectronics

APCOM-2022

dedicated to
100th anniversary of Nobel Prize Laureate in Physics
Academician Nikolay Basov

Vladivostok 2022

Partners and Sponsors

We wish to thank the following organizations for their contribution to the success of this conference:

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- Quantum Electronics

- Laser Physics

- Optoelectronics, Instrumentation and Data Processing

- Optical Memory and Neural Networks

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General information

The 20th Asia-Pacific Conference on Fundamental Problems of Opto- and Microelectronics
02 – 06 October 2022, Vladivostok, Russia

APCOM 2022 aims to bring together the Photonics, Optoelectronics and Microelectronics research communities in the heart of Vladivostok, a capital city of Russian Far East. This year the anniversary 20th APCOM is dedicated to 100th anniversary of Nobel Prize Laureate in Physics Academician Nikolay Basov.
The technical programme includes plenary talks, featured invited and oral talks and carefully selected flash talks following poster section in the areas of

- Advanced laser technologies, nanofabrication, laser material processing (Section 1)
- Advanced optoelectronic and photonic sensing techniques and measurement systems (Section 2)
- Light-emitting and other novel materials & structures for photonics, opto- and microelectronics (Section 3)
- Optoelectronics and photonics for medicine and life sciences (Section 4)
- Optical information and optical data processing. Holography. Optical Crystals. Photorefractive effect and its applications (Section 5).

The APCOM conference will be organized in one session. The programme will feature 90 **presentations** over 4 days including 4 plenary, 16 invited, 30 oral presentations, around 15 flash talks and 40 posters from 7 different countries.

Poster Session

APCOM 2022 will present a total of 40 posters during a poster session to take place on Wednesday, 05 October 2022 from 17:00 to 18:30. The poster session will start from the 5-min flash talks related to the poster presentations carefully chosen by APCOM advisory board. Light snacks and soft drinks will be provided during the session.

Young presenter competition

Oral, flash-talk and poster competition sponsored by APCOM Organizing Committee and General Sponsor will be arranged to award the several young scientists. The prizes will be awarded on the Closing Ceremony, which will take place on 05 October 2022 from 19:00.

Instructions for Poster Presenters

Each author is provided with one bulletin board measuring 125 cm high and 120 cm wide on which to display a summary of the paper. We recommend to follow A1 format for poster preparation. Fixing material (tape) will be provided. The boards will be marked with the presenter's name. Authors are requested to display their poster on their allocated board in the morning of 05 October. In order to present their work and answer questions, authors are requested to appear in the vicinity of their poster during the session.

Speakers' Information

Speakers are asked to check-in with the session chair in the conference room ten minutes before the session begins. The conference rooms are equipped with microphone, beamer, and computer. Presenters are asked to transfer their presentation files by USB memory stick. Usage of own laptops is not recommended as it can cause delays upon connection. Presentation times for oral presentations are as follows:
Plenary talks: 40 minutes
Invited talks: 25 minutes
Oral talks: 15 minutes including time for question, answers and discussion.
Flash talks: 5 minutes + Poster Session

Online participants

Online presentations will be arranged with Zoom platform (www.zoom.us). Connection links will be shared with online participants few days before the beginning of the conference. For **online poster session participants** the reduced fee allows to post the poster on the conference website. Additionally, upon request participant can ask organizers to print and hang the printed poster. Participants that want to use this option are asked to contact organizers at apcom@dvo.ru.

Welcome Reception

A **reception** will be organized on Monday 03 October 2022, 18:30 - 20:00.

Closing dinner

A dinner will be organized on 05 October 2022 from 18:45 just after the Closing ceremony.

Conference Language

The official language of the conference is English.

Conference Digest

The registration fee includes one printed programme.

Registration Information

The registration fees for the meeting include admission to all sessions of the conference. It also includes participant bag, admission to coffee breaks according to the conference schedule as well as to the Welcome reception and Closing dinner. Lunches are not included.

Conference Location

APCOM 2022 will take place at the building of Presidium of FEB RAS situated at the center of Vladivostok:
50 Svetlanskaya Street, Vladivostok, 690091
Fax: +7 423 222 8750
E-mail: dvo@hq.febras.ru
Phone: +7 423 222 8750
http://www.febras.ru/
(see also http://apcom.dvo.ru/2022/gorod.html)

Weather in Vladivostok

The average minimum night temperature in Vladivostok in October is +1.0°C. The average daytime temperature lies around +15°C. The Vladivostok weather forecast can be viewed at https://primpogoda.ru/weather/vladivostok

Programme at a Glance

Monday, 3rd October 2022

09:00 - 09:30	Conference Registration
09:30 - 10:00	APCOM-2022 Opening Ceremony
10:00 - 10:40	Plenary Section I
10:40 - 11:30	Section 1-I: Advanced laser technologies, nanofabrication, laser material processing
11:30 - 11:50	Coffee Break
11:50 - 13:05	Section 1-II: Advanced laser technologies, nanofabrication, laser material processing
13:05 - 14:30	Lunch Time
14:30 - 16:10	Section 1-III: Advanced laser technologies, nanofabrication, laser material processing
16:10 - 16:30	Coffee break
16:30 - 17:35	Section 1-IV: Advanced laser technologies, nanofabrication, laser material processing
17:35 - 18:15	Plenary Section II
18:30	APCOM-2022 Welcome Reception

Tuesday, 4th October 2022

10:00 - 10:40	Plenary Section III
10:40 - 11:20	Section 2-I: Advanced optoelectronic and photonic sensing techniques and measurement systems
11:20 - 11:40	Coffee Break
11:40 - 13:20	Section 2-II: Advanced optoelectronic and photonic sensing techniques and measurement systems
13:20 - 14:30	Lunch Time
14:30 - 16:05	Section 3-I: Light-emitting and other novel materials & structures for photonics, opto- and microelectronics
16:05 - 16:25	Coffee Break
16:25 - 17:40	Section 3-II: Light-emitting and other novel materials & structures for photonics, opto- and microelectronics
18:00	City Tour / Excursion

Wednesday, 5th October 2022

10:00 - 10:40	Plenary Section IV
10:40 - 11:25	Section 4-I: Optoelectronics and photonics for medicine and life sciences
11:25 - 11:45	Coffee break
11:45 - 12:45	Section 3-III: Light-emitting and other novel materials & structures for photonics, opto- and microelectronics
12:45 - 14:15	Lunch Time
14:15 - 16:05	Section 5-I: Optical information and optical data processing. Holography. Optical Crystals. Photorefractive effect and its applications.
16:05 - 16:20	Coffee Break
16:20 - 18:30	5-min flash talks and poster session with snacks and drinks
18:45 - 22:00	APCOM 2022 Closing Ceremony and Dinner

Thursday, 6th October 2022

10:00 - 12:00	Round table dedicated to 100th anniversary of Nobel Prize Laureate Nikolay Basov
12:00 - 13:00	Lunch Time
13:00 - 22:00	Lab Tours and Social Program

Friday, 7th October 2022

10:00 - 19:00	Departure of Participants

Plenary Speakers

Prof. Dmitry Gorin

Skolkovo Institute of Science and Technology, Moscow, Russia

Title: Combination of Photonic Tools and Nanostructured Materials for Imaging, Sensing and Theranostics

Plenary section I, Monday 3rd October, 10:00 - 10:40

Abstract

This talk will review the combination of nanostructured materials and photonic tools that can be used for their visualization, navigation and remote-controlled release of bioactive substances, and last but not least, the application of optical sensors for early diagnosis and evaluation treatment efficiancy. There are many biological objects that can be used as markers of various pathological states including cancer. These comprise, but are not limited to, proteins, exosomes, and circulation tumor cells. Exosomes are a very promising marker for early cancer diagnosis and even for evaluating treatment efficiency. An exosome is a small vesical at 100 nm size produced by a cell. Exosomes contain specific proteins and are distributed on the surface of cell membrane. The exosomes can be sent by both normal and pathological cells. It can be used for early diagnosis of neuro, cardio, and onco-diseases [1]. We have already elaborated a different types of photonic based sensors including SERS [2], nanozyme based optical sensor [3,4], hollow-core microstructured fibres [5], and photonic integrated circuits [6]. The combination of a photonic integrated circuits (PIC), a microfluidic devices (MF) and a surface modification can improve not only the sensitivity but also the specificity of exosomes' detection.

Additionaly, the application of photonic and acoustic tools can be used for visualization, navigation of multimodal and multifunctional carriers and remote-controlled release of bioactive substances. These particles will combine the ability to deploy drugs in a controllable manner with physical triggering, multimodal detection, and visualization as well as sensing of important biological markers. It was required to apply a new bottom-up method as layer-by-layer assembly [7] and freezing induced loading [8] and their combination [9,10]. It can be allowed us to vary the volume fraction of components and their chemical composition led to the control of the optical and thermal properties of multifunctional carriers [11]. Raman spectroscopy is perspective method for *in situ* monitoing of freezing induced loading method [12]. Physical targeting of carriers was realized by the gradient of the magnetic field [13], optical tweezers approach [14]. Acoustics has a good perspective for the same purpose. The carrier sensitivity to external influences such as laser irradiation, ultrasound treatment can be changed by variation of volume fraction and chemical composition of inorganic nanoparticles and/or organic dyes in the carrier shells, as well as chemical composition and a phase state of core [15]. The same approach is applied for drug delivery carriers imaging by MRI, FT, US and optoacoustics using inorganic nanoparticles and/or organic dyes, and gas/liquid cores as contrast or functional agents [4,9,10]. The combination of photonic tools with microstructured materials has a good perspective for application in biology and medicine.

This work was partly supported by RFBR Project 19-53-80047 BRICS_t.

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Prof. Sergey Makarov
ITMO University, Saint-Petersburg, Russia

Title: Halide perovskite microcrystals for optical applications

Plenary section II, Monday 3rd October, 17:35 - 18:15

Abstract

Recently, the study of halide perovskites has attracted enormous attention due to their exceptional optical and electrical properties. As a result, this family of materials can provide a prospective platform for modern nanophotonics [1] and metaphotonics [2,3], allowing us to overcome many obstacles associated with the use of conventional semiconductor materials. Resonant halide perovskite micro- and nanocrystals is a rapidly developing research area driven by its potential applications for lasers, nanophotonics, and optoelectronic devices. Here, we overview the recent progress in the field of halide perovskite nanophotonics starting from single-particle light-emitting microcrystals supporting lasing generation [4] to the larger designs where the perovskite microlasers are coupled with waveguiding systems [5,6] or represent individual functional optical elements [7,8].

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Prof. Alexander Shkurinov
Lomonosov Moscow State University, Moscow, Russia

Title: New trends in conversion of femtosecond laser radiation into the terahertz frequency range

Plenary section III, Tuesday 4th October, 10:00 - 10:40

Abstract

Terahertz photonics has received intensive development with the advent of laser radiation sources, creating the prerequisites for the development of terahertz optoelectronics. In my message I will tell the history of this direction, the results of its latest achievements and say a few words about the upcoming achievements.

I will talk about the foundations of modern terahertz photonics and optoelectronics with the ultimate goal of developing methods for diagnosing matter using electromagnetic radiation in the terahertz frequency range of high intensity. The lecture begins with an introductory part, which tells the story of the emergence of a new branch of photonics and optoelectronics, which uses electromagnetic radiation in the terahertz frequency range. I will analyze the main properties of this radiation, its specificity for application in various fields of knowledge, including in the optics of superstrong electromagnetic fields. Next, I will discuss the fundamentals of the interaction of electromagnetic radiation with matter, with a general focus on the specificity of the frequency range.

The final part of the lecture is devoted to the presentation of the physical foundations of the key applications of radiation in the terahertz frequency range associated with the use of superstrong terahertz fields.

Prof. Alexei Kamshilin
Almazov National Medical Research Centre, Saint-Petersburg, Russia

Title: Imaging photoplethysmography as a reliable tool for monitoring tissue perfusion during open brain and abdominal surgeries

Plenary section IV, Wednesday 5th October, 10:00 - 10:40

Abstract

Assessment of microcirculation and tissue perfusion parameters is extremely important during surgical interventions, especially during operations on the brain and abdominal organs. Such a system must be handy, non-invasive, and directly integrated into the surgical workflow. To date, there is no standard procedure for assessing blood circulation in routine clinical practice. All the technical proposals are in the stage of research and development. This report is discussing features of imaging photoplethysmography (IPPG) application to intraoperative visualization and quantitative assessment of tissue perfusion. Measurement of perfusion using photoplethysmography has been known since the 30s of the last century. Nevertheless, discussions of the physiological model underlying this method are still ongoing. In 2015, an alternative model of light modulation in interaction with blood vessels *in vivo* was proposed in our group [1]. Based on this model, a system of intraoperative visualization of blood flow in organs was developed.

From an instrumental point of view, this system is very simple, since it uses only video recording of an area under study with a digital camera followed by appropriate data processing. The video is recorded under incoherent green light. The most important distinguishing feature is synchronous recording of video frames and electrocardiogram. When processing video data, we use correlation methods to assess how much changes in the optical signal follow heartbeats. Despite the very shallow penetration of green light into the tissues, the system allows us to assess the functioning of deeper blood vessels, in particular, to assess arterial tone against the background of significant displacements and changes in the geometry of organs during surgery. In this report, I present an overview of recent pilot studies on monitoring blood flow parameters during open brain [2] and abdominal surgeries [3,4] using the IPPG system. The developed system allows for contactless monitoring of blood flow in cortex and abdominal organs in real time with high spatial resolution. It was demonstrated that the quantitative assessment of blood perfusion by IPPG is in good agreement with that obtained by ICG-fluorescence angiography. IPPG can become an objective quantitative monitoring system for tissue perfusion in the operating room due to its simplicity, low cost and no need for any agent injections.
This research was financially supported by the Russian Science Foundation (Grant No. 21-15-00265).

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Monday (October, 3rd)

09:00 - 09:20
Conference Registration

09:20 - 09:35
APCOM-2022 Opening Ceremony

09:35 - 09:50
Yuri Kulchin
Institute of Automation and Control Processes FEB RAS, Vladivostok, Russia
Nobel Prize Laureate in Physics Academician Nikolay Basov and his role in establisment of scientific school in laser Physics at the Russian Far East

09:50 - 10:00
Andrei Naumov
P.N. Lebedev Physical Institute of RAS, Troitsk Branch, Moscow, Russia
Troitsk Branch of Lebedev Physical Institute RAS - Scientific Heritage of Academician N.G.Basov

Plenary Section I
Chairman: Prof. Roman Romashko

10:00 - 10:40 Plenary
Dmitry Gorin
Skolkovo Institute of Science and Technology, Moscow, Russia
Combination of photonics tools and nanostructured materials for imagining, sensing and theranostics

Section 1-I: Advanced laser technologies, nanofabrication, laser material processing
Chairman: Dr. Gleb Tselikov

10:40 - 11:05 Invited
Mikhail Lapine
University of Technology Sydney, Sydney, Australia
Optical and acoustic sorting of nanoparticles

11:05 - 11:30 Invited
Vadim Veiko
ITMO University, Saint-Petersburg, Russia
Laser local oxidation of thin metal films: physics and applications for photonics, optoelectronics and microelectronics components fabrication

11:30 - 11:50
Coffee Break

Section 1-II: Advanced laser technologies, nanofabrication, laser material processing
Chairman: Prof. Mikhail Lapine

11:50 - 12:15 Invited
Gleb Tselikov
Center for Photonics and 2D Materials, Moscow Institute of Physics and Technology, Dolgoprudny, Russia
Tunable optical properties of transition metal dichalcogenide nanoparticles

12:15 - 12:40 Invited Online
Sergei Kulinich
Tokai University, Tokyo, Japan
Decorated TiO_2 nanoparticles prepared by means of laser processing in liquid phase and their use as photocatalysts

12:40 – 13:05 Invited
Aleksandr Kuchmizhak
Institute of Automation and Control Processes FEB RAS, Vladivostok, Russia
Structural coloring and anti-counterfeiting enabled by direct femtosecond laser printing

13:05 - 14:30
Lunch Time

Section 1-III: Advanced laser technologies, nanofabrication, laser material processing
Chairman: Dr. Aleksandr Kuchmizhak

14:30 – 14:55 Invited Online
Alexey Porfirev
Image Processing Systems Institute of RAS, Samara, Russia
Laser Processing of Polarization-Sensitive Media with Structured Light

14:55 – 15:10 Oral
Dmitry Shuleyko
Moscow State Universtity, Moscow, Russia
Femtosecond laser-induced surface periodic structures formation on phosphorous- and boron-doped amorphous silicon films

15:10 – 15:25 Oral
Evgeniia Khairullina
Institute of Chemistry, Saint Petersburg University, Saint-Petersburg, Russia
Laser-assisted fabrication of electrode materials on the surface of flexible polymers

15:25 – 15:40 Oral
Alexandr Marunchenko
ITMO University, Saint-Petersburg, Russia
Laser ablation of carbon nanotube thin film for fabrication of halide-perovskite flexible photodetector

15:40 – 15:55 Oral
Aleksandra Levshakova
Institute of Chemistry, Saint Petersburg University, Saint-Petersburg, Russia
Deep eutectic solvents for laser induced synthesis of functional materials

15:55 – 16:10 **Oral**

Aleksandr Shevlyagin

Institute of Automation and Control Processes FEB RAS, Vladivostok, Russia

Laser-perforated transparent electrodes made of Ca disilicide and digermanide thin films for UV-MIR applications

16:10 - 16:30

Coffee Break

Section 1-IV: Advanced laser technologies, nanofabrication, laser material processing
Chairman: Dr. Aleksandr Kuchmizhak

16:30 – 16:45 **Oral**

Svetlana Saparina

Kazan Federal University, Kazan, Russia

Amorphous carbon thin films for optical sensing of humidity

16:45 – 17:10 **Invited**

Eugeniya Sheremet

Tomsk Polytechnic University, Tomsk, Russia

Graphene-based wearables to address the challenges of bioelectronics

17:10 – 17:35 **Invited**

Raul D. Rodriguez

Tomsk Polytechnic University, Tomsk, Russia

Photothermal heating in plasmonic nanoreactors

Plenary Section II
Chairman: Prof. Roman Romashko

17:35 – 18:15 **Plenary Online**

Sergey Makarov

ITMO University, Saint-Petersburg, Russia

Halide perovskite microcrystals for optical applications

18:15 - 18:30

Kirill Zhilin

SC "LLS", Saint-Petersburg, Russia

Nordlase: Russian production of laser and laser systems

18:30

APCOM-2022 Welcome Reception

Tuesday (October, 4th)

Plenary Section III
Chairman: Prof. Roman Romashko

10:00 - 10:40 **Plenary**

Alexander Shkurinov

Lomonosov Moscow State University, Moscow, Russia

New trends in conversion of femtosecond laser radiation into the terahertz frequency range

Section 2-I: Advanced optoelectronic and photonic sensing techniques and measurement systems
Chairman: Prof. Jianzhong Zhang

10:40 – 11:05 **Invited**

Anatoly Pushkarev

ITMO University, Saint-Petersburg, Russia

Hydrogen halide gas detection with a single perovskite nanowire laser

11:05 – 11:20 **Oral**

Konstantin Ovchinnikov

Perm State University, Perm, Russia

Application of optical frequency domain reflectometry for the study of polarization maintaining fibers

11:20 - 11:40

Coffee Break

Section 2-II: Advanced optoelectronic and photonic sensing techniques and measurement systems
Chairman: Prof. Oleg Vitrik

11:40 - 12:05 **Invited Online**

Jianzhong Zhang

Harbin Engineering University, Harbin, China

Research and Development of Bismuth and Erbium co-Doped Optical Fibers with O-L Emission

12:05 – 12:20 **Invited Online**

Zhi Zhou

Hainan University, Haikou, China

Novel Smart Sensors for Structural Health Monitoring on infrastructures

12:20 – 12:35 **Oral**

Cai Shuhao

ITMO University, Saint-Petersburg, Russia

A miniaturized fiber sensing system based on precise length adjustment in tens of nanometer

12:35 – 12:50 **Oral Online**

Guohui Lv

College of Electronic Engineering, Heilongjiang University, China

Realization of an Ultra-High-Pressure Dynamic Calibrate System by Drop Hammer Based on Fiber Bragg Grating Strain Sensor

12:50 – 13:05 **Oral Online**

Junqing Li

School of Physics, Harbin Institute of Technology, China

Single-mode Single-circular-polarization Maintaining Chiral Anti-resonat Fibers

13:05 - 14:30

Lunch Time

Section 3–I: Light-emitting and other novel materials & structures for photonics, opto- and microelectronics

Chairman: Dr. Aleksandr Kuchmizhak

14:30 – 14:55 **Invited**

Anton Kharitonov

Kazan Federal University, Kazan, Russia

Broadband plasmonics with titanium oxynitride

14:55 – 15:20 **Invited**

Aleksandr Mironenko

Institute of Chemistry FEB RAS, Vladivostok, Russia

Surface enhanced fluorescence on nanostructured dielectric surfaces

15:20 – 15:35 **Oral**

Dmitry Yakubovsky

Moscow Institute of Physics and Technology, Dolgoprudny, Russia

Scanning near-field optical microscopy study of ultra-thin metal films on MoS_2 crystals

15:35 – 15:50 **Oral**

Elena Chernykh

Kazan Federal University, Kazan, Russia

Sensing phase transitions in solids using thermoplasmonics

15:50 – 16:05 **Oral**

Dmitriy Grudinin

Center for Photonics and 2D Materials, Moscow Institute of Physics and Technology, Dolgoprudny, Russia

Broadband anisotropic optical properties of hBN

16:05 - 16:25

Coffee Break

Section 3-II: Light-emitting and other novel materials & structures for photonics, opto- and microelectronics

Chairman: Dr. Aleksandr Mironenko

16:25 – 16:50 **Invited**

Alexei V. Emeline

Saint Petersburg University, Saint-Petersburg, Russia

Halide perovskite structure manipulation altering their electronic and optical properties

16:50 – 17:15 **Invited**

Andrei Naumov

P.N. Lebedev Physical Institute of RAS Troitsk Branch, Moscow, Russia

Fluorescence nanoscopy of single molecules and quantum dots

17:15 – 17:30 **Oral**

Artem Cherepakhin

Institute of Automation and Control Processes FEB RAS, Vladivostok, Russia

Microlasers and Micro-optics enabled by direct laser patterning of halide perovskites

17:30 – 17:45 **Oral**

Ruslan Azizov

ITMO University, Saint-Petersburg, Russia

Resonant periodic Light-Emitting structures based on thin films of CdSe/CdZnS core/shell nanoplatelets

17:45 – 18:00 **Oral**

Almaz Gazizov

Kazan Federal University, Kazan, Russia

Plasmon-enhanced anti-Stokes Raman scattering based on local density of states engineering

18:00 – 18:15 **Oral Online**

Georgy Ermolaev

Moscow Institute of Physics and Technology, Dolgoprudny, Russia

Optical Phase Engineering with Atomically Thin Transition Metal Dichalcogenides

18:15 – 18:30 **Oral Online**

Marwa Ali El-Sayed

Moscow Institute of Physics and Technology, Dolgoprudny, Russia

Ellipsometric analysis of low-dimensional materials over broad spectral ranges for optoelectronic and photonic applications

18:40

City Tour / Excursion

Wednesday (October, 5th)

Plenary Section IV
Chairman: Prof. Dmitry Gorin

10:00 – 10:40 **Plenary**
Alexei Kamshilin
Almazov National Medical Research Centre, Saint-Petersburg, Russia
Imaging photoplethysmography as a reliable tool for monitoring tissue perfusion during open brain and abdominal surgeries

Section 4-I. Optoelectronics and photonics for medicine and life sciences.
Chairman: Prof. Alexei Kamshilin

10:40 – 10:55 **Oral**
Ervin Nippolainen
University of Eastern Finland, Kuopio, Finland
Spectroscopic techniques for joint tissue evaluation

10:55 – 11:10 **Oral**
Dmitry Stavtsev
I.M. Sechenov First Moscow State Medical University, Moscow, Russia
Laser Speckle Contrast Imaging System for Monitoring Cerebral Blood Flow in Neurosurgery

11:10 – 11:25 **Oral**
Gennadii Piavchenko
I.M. Sechenov First Moscow State Medical University, Moscow, Russia
Approaches to the diagnosis of disorders of cerebral blood flow and tissue structure of the cerebral cortex in acute life-threatening conditions

11:25 - 11:45
Coffee Break

Section 3-III: Light-emitting and other novel materials & structures for photonics, opto- and microelectronics.
Chairman: Dr. Anton Kharitonov

11:45 – 12:00 **Oral**
Dmitry Shtarev
Far Eastern Federal University, Vladivostok, Russia
Structural properties of hexamethylenediamine-based hybrid perovskites

12:00 – 12:15 **Oral**
Alexander Syuy
Moscow Institute of Physics and Technology, Dolgoprudny, Russia
New Solid Solution MAX Phases: $(Ti_{0.5},Nb_{0.5})_3AlC_2$, $(Ti_{0.5},Ta_{0.5})_3AlC_2$ and MXenes based on them

12:15 – 12:30 **Oral**
Andrey Amosov
Institute of Automation and Control Processes FEB RAS, Vladivostok, Russia
Influence of Surface Carbon Impurities on the Nonlinear Properties of Silica Nanoparticles

12:30 – 12:45 **Oral**
Nikolay Vanyushkin
Far Eastern Federal University, Vladivostok, Russia
Lasing threshold of conical modes in 1D photonic crystals

12:45 - 14:15
Lunch Time

Section 5-I: Optical information and optical data processing. Holography. Optical Crystals. Photorefractive effect and its applications.
Chairman: Prof. Alexei Kamshilin

14:15 – 14:40 **Invited**
Stanislav Shandarov
Tomsk State University of Control Systems and Radioelectronics, Tomsk, Russia
Interaction of circularly polarized light beams in the cubic gyrotropic photorefractive crystals

14:40 – 14:55 **Oral Online**
Valery Naunyka
Mozyr State Pedagogical University named after I.P. Shamyakin, Belarus
Effect of optical activity on degenerated four-wave mixing in cubic photorefractive crystal

14:55 – 15:10 **Oral**
Alexander Konoshonkin
V.E. Zuev Institute of Atmospheric Optics SB RAS, Tomsk, Russia
Umov Effect for Large Nonspherical Particles

15:10 – 15:25 **Oral**
Alexey Bulanov
Il'ichev Pacific Oceanological Institute of FEB RAS, Vladivostok, Russia
Using of ultrasound in an automated laser induced breakdown spectroscopy complex for the study of spectral characteristics of seawater in the tasks of operational study of carbon polygons

15:25 – 15:40

Oral Online

Maral Amanova

Institute of Telecommunications and informatics of Turkmenistan, Ashgabat, Turkmenistan

Determination of non-zero components of the flexoelectric tensor of physical values in crystals using covariant methods

15:40 – 16:05

Invited Online

Nikolay Petrov

ITMO University, Saint-Petersburg, Russia

Phase retrieval imaging with terahertz monochromatic radiation and multiplane data acquisition

16:05 - 16:20

Kirill Zhilin

SC "LLS", Saint-Petersburg, Russia

Unique laser technologies in the current realities

16:20 - 16:35

Coffee Break

16:35 - 18:45

5-min flash talks and poster session with snacks and drinks

18:45 - 22:00

APCOM 2022 closing ceremony and Dinner

Thursday (October, 6th)

10:00 – 12:00

Round table dedicated to 100th anniversary of Nobel Prize Laureate Nikolay Basov

12:00 - 13:00

Lunch Time

13:00 - 22:00

Lab Tours and Social Program

Friday (October, 7th)

10:00 – 19:00

Departure of Participants

List of flash talks and poster session participants on 5th October

P1. **Aleksey Ankushev** Time resolved LIBS spectroscopy of human hair (Far Eastern Federal University, Vladivostok, Russia)
P2. **Artem Basakin** Melt-pool Temperature Control in Laser Additive Process (IACP FEB RAS, Vladivostok, Russia)
P3. **Oleg Bashkov** Wavefront Laser Beam Model Formation Analysis (Komsomolsk-on-Amur State Technical University, Komsomolsk-on-Amur, Russia)
P4. **Oleg Bashkov** Registration of acoustic emission by fiber-optic sensors of acoustic emission during the destruction of fiberglass
P5. **Anzhelika Belaventseva** The study of thermoregulatory vasodilation of blood vessels by imaging photoplethysmography (IACP FEB RAS, Vladivostok, Russia)
P6. **Alexander Bezpaly** Optical waveguide structures induced in a surface-doped lithium niobate crystal for optoelectronic devices (Tomsk State University of Control Systems and Radioelectronics, Tomsk, Russia)
P7. **Yulia Borodaenko** Fabrication of anti-reflection coatings on GaSe crystal surfaces by laser-induced periodic surface structuring (IACP FEB RAS, Vladivostok, Russia)
P8. **Anton Bryansky** Effect of the stressed state of a polymer composite material on acoustic emission signals recorded by fiber-optic sensors (Komsomolsk-on-Amur State Technical University, Komsomolsk-on-Amur, Russia)
P9. **Anton Bryansky** Sensitivity of fiber-optic sensors when registering acoustic emission in an aluminum alloy plate
P10. **Viktor Dolgirev** Research of light diffraction on electrically controlled multilayer inhomogeneous PPM-LC structures with smooth optical inhomogeneity (Tomsk State University of Control Systems and Radioelectronics, Tomsk, Russia)
P11. **Viktor Dolgirev** Holographic formation of chirped multilayer inhomogeneous PPM-LC diffraction structures
P12. **Ilya Efimov** Determination of SARS-CoV-2 concentration using an optical biosensor based on a photonic crystal with a defective layer (Far Eastern Federal University, Vladivostok, Russia)
P13. **Timofey Efimov** Laser micromechanical biosensor for biofilm detection (IACP FEB RAS, Vladivostok, Russia)
P14. **Ivan Egorshin** Section of electrons bremsstrahlung scattered by an ion in a homogeneous electric field (Pacific State University, Khabarovsk, Russia)
P15. **Sergey Fomchenkov** Refractive Bi-Conic Axicon for Generation of Azimuthally Polarized Radiation (Samara National Research University, Samara, Russia)
P16. **Adel Garifullin** Acceleration of chemical reactions in hybrid one-dimensional photonic crystals based on high-index metamaterials (Kazan Federal University, Kazan, Russia)
P17. **Stanislav Gurbatov** Hybrid metal-semiconductor nanoparticles produced by laser ablation in liquid for optical nanosensing, anti-counterfeiting and photothermal conversion (IACP FEB RAS, Vladivostok, Russia)
P18. **Ahmed Kamal Ibrahim Abu-Nab** Towards a Microbubble Dynamics of Laser Lithotripsy Processes in Soft Tissue (Moscow Institute of Physics and Technology, Dolgoprudny, Russia)
P19. **Alexander Kholin** Monochromatic LEDs effect on rocket (Eruca sativa. Mill.) morphogenesis and productivity (IACP FEB RAS, Vladivostok, Russia)
P20. **Yuri Konin** Wide temperature range fiber optic sensor (ITMO University, Saint Petersburg, Russia)
P21. **Daniil Gilev** Fiber Optic Resonators for Angular Rate Sensors (Perm State University, Perm, Russia)
P22. **Igor Kuznetsov** Increasing measuring range of an MZI electro optic electric field sensor by using a MZI modulators array (Tomsk State University of Control Systems and Radioelectronics, Tomsk, Russia)
P23. **Vladimir Lisitsa** Comparison of the sensitivity of spectral methods for multi-element analysis of atmospheric aerosol using short and ultrashort laser pulses (IACP FEB RAS, Vladivostok, Russia)
P24. **Pavel Ovchinnikov** On the Possibilities of Using the Evolutionary Algorithm «USPEX» to Search for New Hybrid Perovskites (Far Eastern Federal University, Vladivostok, Russia)
P25. **Andrey Panov** Possibility of anapole state in dielectric nanohole array metasurfaces with different hole shapes (IACP FEB RAS, Vladivostok, Russia)
P26. **Georgii Pavliuk** The Manipulation of Liquid Microdroplets by Non-Uniform Electrostatic Fields (IACP FEB RAS, Vladivostok, Russia)
P27. **Olga Pikoul** Laser Conoscopy of Two-component Optical Systems from Gyrotropic Crystals (Far Eastern State Transport University, Khabarovsk, Russia)
P28. **Olga Pikoul** Laser Conoscopy and Photoinduced Light Scattering in a Lithium Niobate Crystal Doped with Y(0.24 wt.%): Mg(0.63 wt.%)
P29. **Alexandr Podlesnykh** 3X3 coupler Mach-Zender interferometric strainmeter (IACP FEB RAS, Vladivostok, Russia)
P30. **Evgeny Rassolov** Fiber-Optic Sensors for Acoustic Emission Monitoring (IACP FEB RAS, Vladivostok, Russia)
P31. **Pia Sarkar** Review on the Evolution of 6G and Terahertz Communication for Highspeed information processing (Dept of Electronics & Comm. Engineering, B.P. Poddar Institute of Management and Technology, Kolkata, India)
P32. **Nikita Selivanov** Growth of hybrid halide perovskite single crystals of high structural and optical qualities (Saint Petersburg State University, Saint-Petersburg, Russia)
P33. **Aleksandr Sergeev** Enhancement of infrared-emitting quantum dots photoluminescence via plasmonic nanoarrays (IACP FEB RAS, Vladivostok, Russia)
P34. **Victor Shishko** Calculation of the signal of a scanning lidar for remote sensing of cirrus clouds containing predominantly horizontally oriented crystals (V.E. Zuev Institute of Atmospheric Optics RAS, Tomsk, Russia)
P35. **Dmitry Storozenko** Numerical simulation of optical-fiber sensor of acoustic emission originated in composite material (IACP FEB RAS, Vladivostok, Russia)
P36. **Sergey Syubaev** Anti-Counterfeit Labeling Enabled by Laser-Printed Silicon Mie Resonators (IACP FEB RAS, Vladivostok, Russia)
P37. **Alexander Syuy** Laser etching of quasi-1D TiS3 nanoribbons by Raman spectrophotometer (Moscow Institute of Physics and Technology, Dolgoprudny, Russia)
P38. **Aigul Valitova** Dispersion relations as a method for studying the optical properties of metasurfaces (Kazan Federal University, Kazan, Russia)
P39. **Dmitry Yan** Enhancement of Photoluminescence in Mesoporous Silicon and Nickel-Mesoporous Silicon Nanocomposites after Thermal Annealing in Argon (Far Eastern State Transport University, Khabarovsk, Russia)
P40. **Huanyu Yang** Optical-electrical Co-sensing System and Reciprocal Temperature Compensation (Dalian University of Technology, Dalian, China)

Invited Speakers

3rd Oct ***10:40 - 11:05***

Optical and acoustic sorting of nanoparticles

M. Lapine[a,b,*], D.A. Shilkin[c], I.A. Toftul[b,d], E.V. Lyubin[c], M.R. Shcherbakov[c], A.A. Fedyanin[c], and Yu. S. Kivshar[d]

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Abstract — We report on the use of optical or acoustic forces for selective sorting of nanoparticles. The forces employed for nanoparticle manipulation arise from the excitation of Mie resonances at frequencies which are determined by the size of nanoparticles. Therefore, for a given wavelength of the incident beam, magnitude of the resulting force depends on the size of a nanoparticle. Thus, by using several beams simultaneously, and pointing them at appropriate angles, we are able to push nanoparticles of different sizes in specific directions. In this way, drift direction is uniquely defined by particle size, for a certain range of sizes. With an example of silicon nanoparticles in water, and laser beams of 532 and 638 nm, we demonstrate reliable angular separation continuously in a range from 125 to 165 nm in diameter. Further on, we show that a similar separation mechanism can be achieved with the help of acoustic forces, with this method offering greater flexibility owing to tunability of acoustic source frequencies. Finally, we discuss general advantages and limitations of this sorting method.

3rd Oct ***11:05 - 11:30***

Laser local oxidation of thin metal films: physics and applications for photonics, optoelectronics and microelectronics components fabrication

V.P. Veiko[a,*], V.P. Korol'kov[b], G.V. Odintsova[a], D.A. Sinev[a]

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Abstract — Local laser oxidation (in a normal atmosphere) is an effective means of laser thermochemical recording of complex patterns on metal films with opaque and transparent oxides. The physics of the process depends on the duration of the laser exposure and the characteristics of metal films and their oxides. Spatial resolution is an important issue in laser treatment of thin films in micro- and nanoelectronics and photonics. The report discusses the possibility of realizing a resolution less than the size of the laser spot and the wavelength of light - above the diffraction limit. It is based on the strong nonlinear dependence of the growth rate of metal oxides on the temperature in the laser impact zone, as well as on other nonlinear effects. It has been theoretically shown and experimentally confirmed that the sharper the intensity distribution inside the laser spot, the higher the thermochemical resolution of the laser image. Thin films of transition metals (chromium, titanium and zirconium) are very promising for high-resolution laser recording. Dots and lines are implemented for diffractive optical elements up to 100 nm in size and less with a laser spot diameter of about 500 nm. The local formation of laser-induced periodic surface structures and competing interference lithography can also become the basis for the fabrication of new optical elements. The areas of application for the manufacture of various components and the implementation of processes in photonics, optoelectronics and microelectronics are discussed - from diffractive optical elements and shaft-code converters to color laser marking and laser artistic miniatures.

3rd Oct ***11:50 - 12:15***

Tunable optical properties of transition metal dichalcogenide nanoparticles

G. Tselikov[a,*], G. Ermolaev[a], Anton Popov[a], A. Syuy[a], D. Panova[a], A. Arsenin[a], and V. Volkov[a]

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Abstract — Two-dimensional (2D) layered transition metal dichalcogenides (TMDCs) have attracted tremendous research interests due to their unique properties for developing new-generation electronic and optoelectronic devices [1]. TMDCs exhibit a strong excitonic response, ensuring non-trivial optical phenomena enabled by strong light-matter interactions: exciton-polariton transport, enhanced second and third harmonic generation, high refractive index and giant optical anisotropy [2]. Thus, nanostructures made from TMDCs represent unique platform for realization of light-matter interaction at the nanoscale. This work is dedicated to laser engineering of spherical resonant Mie-excitonic nanoparticles from layered materials, particularly TMDCs. It was found that for all the NPs its structure is formed by polycrystalline inner part covered by fullerene-like outer shell. Such a complex structure can be explained by a two-step growth of nanoparticles during the relaxation of plasma during the ablation step. First, the polycrystalline core is formed during the initial growth stage at high temperatures, then the outer shell is forming during the thermodynamically stable growth. As a result, the preserved layered crystalline structure of laser ablated NPs ensures the Mie-excitonic behavior of its optical response. We demonstrate the laser-based approach for synthesis of water-dispersed ultra-stable spherical TMDC nanoparticles (NPs) of variable size 10-150 nm. Such nanoparticles demonstrate exciting optical and electronic properties inherited from the TMDC crystals, due to preserved crystalline structure, which offers a unique combination of pronounced excitonic response and high refractive index value, making possible a strong concentration of electromagnetic field in nanoparticles. The work was supported the Russian Science Foundation (grant № 21-79-00206).

[1] Q. Wang et. al, Nat. Nanotechnol. 7, 699 (2013)
[2] G. Ermolaev et. al, Nat. Commun. 12, 854 (2021)

3rd Oct ***12:15 - 12:40***

Decorated TiO2 Nanoparticles Prepared by Means of Laser Processing in Liquid Phase and Their Use as Photocatalysts

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Abstract — Laser ablation in liquid (LAL) is a simple, convenient, and "green" laboratory method to prepare various nanomaterials. In this approach, laser beam is typically focused on a solid target immersed in liquid medium, thus generating nanostructures with various morphologies, sizes, and chemistry (depending on laser parameters and the nature of both the target and liquid used). Its modification, laser irradiation in liquid (LIL), is a sister technique in which laser beam typically irradiates solid particles suspended in liquid, which permits to modify or tune various micro- or nanoparticles. Using these two approaches, diverse semiconducting nanomaterials (mainly metal oxides, sulfides and carbides) with potential use in optoelectronics, catalysis, and gas-sensing were reported. The present talk will deal with TiO2 nanomaterials produced by means of LAL/LIL and their application as photocatalysts. The nanomaterials were prepared either from metallic Ti or by irradiating commercially available titania powders followed by their decoration with noble-metal nanoparticles.

When tested as photocatalysts, such materials demonstrated efficiency, decaying organic molecules both in liquid and gas phase.

3rd Oct ***12:40 - 13:05***

Structural Coloring and Anti-Counterfeiting Enabled by Direct Femtosecond Laser Printing

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Abstract - Laser-matter interaction provides facile and high-performing way for surface nano-structuring. Tightly focused femtosecond laser pulse interacting with thin noble-metal films are of special practical interest owing to ability to produce unique 2D and 3D surface nanostructures in a well-controlled and reproducible manner. Fabricated laser-printed nanostructures can resonantly interact with incident optical radiation allowing to locally tune optical properties of the surface opening pathways for various applications as structural coloring, marking, sensing, etc. Here, we justify direct femtosecond-laser printing, a simple and scalable technology, for fabrication of high-resolution (25,000 dots per inch) and durable physically unclonable one-way function labels with a substantially large encoding capacity of 10^{895} and a simple spectroscopy-free optical signal readout. The proposed tags are comprised of laser-printed plasmonic nanostructures exhibiting unique light scattering behavior and unclonable 3D geometry. Uncontrollable stochastic variation of the nanostructure geometry in the process of their spot-by-spot printing results in random and broadband variation of the scattering color of each laser printed "pixel", making laser-printed patterns unique and suitable for PUF labeling. Moreover, direct femtosecond laser nanopatterning of metal-insulator-metal (MIM) sandwich designed to support Fabry-Perot mode in the visible spectral range was carried out to demonstrate high-resolution multi-color printing of structural colors in reflection. By varying the applied pulse energy, the type of the surface modification (evolving form hollow nanobumps and nanojets to through holes and spallative craters) can be controlled to tune the local surface reflectivity resulting in variation of the surface color observed in reflection with ordinary optical microscope. Moreover, we demonstrated facile single step printing of multi-color images at resolution up to 25,000 dots per inch justifying the applicability of the developed approach for structural color marking and optical information encryption.

3rd Oct ***14:30 - 14:55***

Laser Processing of Polarization-Sensitive Media with Structured Light

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Abstract — The sensitivity of some materials such as azopolymers and chalcogenide glasses to the polarization of illuminating laser radiation and the use of this effect for their laser processing has long been known [Z Sekkat, M Dumont, Appl. Phys. B 53(2), 121 (1991)]. However, active development continues in the field of application of light structured in amplitude/phase and polarization for processing such materials, since these beams provide more opportunities for the formation of unusual two-dimensional and three-dimensional reliefs that, in principle, cannot be produced using Gaussian laser beams. Structured laser beams make it possible to control the morphology of structures formed on the surface and in the volume of materials both at the nano- and micro-levels. Here, we present some examples of the use of structured laser beams for precision laser processing of thin films of carbazole-based polymer 9-(2,3-epoxypropyl) carbazole (EPC) and azo dye Disperse Orange 3 (DO3) as well as nanomultilayer structures based on the chalcogenide glasses As_2S_3 and a-Se. This work was financially supported by Russian Science Foundation (grant No. 22-79-10007).

3rd Oct ***16:45 - 17:10***

Graphene-based wearables to address the challenges of bioelectronics

E. Sheremet[a,*], G. Murastov[a], E. Abyzova[a], L. Dogadina[a], V. Menselintsev[a], M. Fatkullin[a], K. Brazovskiy[a], R.D. Rodriguez[a]

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Abstract - Wearable electronics is a new generation of devices that allows one to monitor or stimulate the human body. Medical or performance purposes can require monitoring heart health, muscle activity, perspiration rate, etc. Many currently available devices have very limited use due to skin irritation, lack of convenience for the user, and low signal quality. In this talk, we will discuss the requirements these devices have to meet and the challenges material science is facing. Further, we present our group's progress in developing laser-based approaches to fabricate materials for wearable applications. In particular, we tackle some of the key issues of creating a bioelectrode for long-term monitoring of electrical potentials. The electrode is based on laser-reduced graphene oxide and shows crucial benefits: does not require an electrolytic gel that tends to cause adverse skin reactions and dry out, leading to signal loss; is suitable for long-term monitoring without signs of inflammation, clearly outperforming the commercial counterparts; signal quality is on par with the medical grade Ag/AgCl electrodes. Moreover, the latest results show how to apply this method for "smart clothes" applications opening new prospects in terms of convenience for the user. The reported study was funded by project Priority 2030-NIP/IZ-007-0000-2022.

3rd Oct ***17:10 - 17:35***

Photothermal heating in plasmonic nanoreactors

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Abstract - Understanding the precise mechanism of plasmonic photocatalysis is essential for translating ideas about solar fuels into reality. However, there are two different views on how this process works: one involving electronic excitations and another suggesting acoustic phonon mediation in the form of heat. In this talk we will discuss how self-assembled monolayers are used to determine which way leads to a complete view of plasmon photocatalysis. Plasmon spectroscopy in a multiparametric investigation as a function of time, temperature, wavelength, power, at spatial dimensions from the micro- to the nano-scale proved key to solving this problem. We show that the photothermal contribution is critical, particularly in gold nanoparticles, providing this material with an excellent activity rivaling that of Ag. Finally, we will discuss the actual quantification of photothermal heating using Si nanowires as localized temperature probes and charge transfer evidenced by Raman enhancement driven by temperature. This presentation clears up our view on this evolving field of research, helping us understand photothermal heating's contribution to plasmonic and light-induced reactions. The reported study was funded by projects Priority 2030-NIP/IZ-007-0000-2022 and RFBR and DFG, project number 21-53-12045.

4th Oct ***10:40 - 11:05***

Hydrogen halide gas detection with a single perovskite nanowire laser

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Abstract — Halide perovskite nanowires (NWs) have emerged as multifunctional materials for the modern optoelectronic devices and optically pumped laser structures. The latter exhibit low-threshold high-quality Fabry-Pérot lasing in the whole visible range. Superior characteristics of NW lasers make them decent candidates for optical sensing. So far, strain and vapor (organic analytes) sensors have been demonstrated. In the meanwhile, volatile analytes such as hydrogen halides (HX, X = Cl, Br, I) readily react with halide perovskites and result in anion exchange between the analyte molecule and crystal lattice. Instead of organic molecules that change the refractive index of NW laser surrounding medium, direct chemical modification of perovskite crystal lattice via anion exchange reaction (AER) is supposed to induce a remarkable optical response in NW laser exposed to HX gas even at its low concentration. This promising feature complimented by the hazard of HX gases for human health and addressing a relevant task of human safety in the chemical industry promotes the development of a cost-effective highly-sensitive detector selective to any HX analyte. In this work, optical detection of HCl gas with solution-processed perovskite $CsPbBr_3$ NW lasers synthesized on nanostructured Al_2O_3 substrate is presented. It is established, that AER between NWs and analyte molecules results in the formation of a core-shell $CsPbBr_3$-$CsPb(Cl,Br)_3$ structure. The shell has lower refractive index as compared to that of the core. Therefore, the formation of the shell reduces the field confinement for experimentally observed laser modes and provokes an increase in their frequency. This phenomenon is confirmed by the coherency of the data derived from XPS spectroscopy, powder X-ray diffraction, spatially resolved EDX analysis, micro-photoluminescence data, as well as numerical modeling for Cl− ion diffusion and the shell-thickness-dependent spectral position of eigenmodes in a core-shell perovskite cavity. The revealed optical response allows detection of HCl gas in the 5−500 ppm range.

4th Oct ***11:40 - 12:05***

Research and Development of Bismuth and Erbium co-Doped Optical Fibers with O-L Emission

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Abstract — With the continuous development of 5G, Internet of things, cloud computing, the bandwidth requirements of optical fiber communication are increasing sharply. All-wave fibers could achieve low loss transmission in the O-L band, however, there were no suitable lasers and amplifiers in this band, which became a bottleneck for further capacity expansion, the key challenge was active fibers. Bismuth and erbium co-doped optical fiber (BEDF) with O-L ultrabroadband emission could solve this problem. The development of BEDF would be reviewed firstly. Then the fabrication processes were focused, including MCVD, stack and draw, additive manufacturing. Finally, the applications and existing challenges were presented.

4th Oct ***14:30 - 14:55***

Broadband plasmonics with titanium oxynitride

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Abstract — Electromagnetic phenomena accompanying plasmon resonances underpin a rich diversity of photonic devices. Noble metals have long constituted a material platform for plasmonics. Recent years have witnessed a realization of photonic devices based on alternative plasmonic media. This enabled to implement novel functionalities previously unattainable with the conventional materials. Recently, tunable optical materials, such as transition metal nitrides (TiN, ZrN, HfN) and conducting metal oxides (ITO, AZO, GZO), have attracted a broad interest. The spectral position of plasmon resonance in these media can be tuned within visible and near-infrared ranges at the synthesis stage. Nevertheless, plasmon resonance can still be excited at only one frequency. This work highlights a new class of plasmonic materials – transition metal oxynitrides – that demonstrate a broadband plasmonic response. We show that titanium oxynitride can exhibit peculiar properties, such as double-epsilon-near-zero behavior and flat dispersion of real permittivity. This allows for excitation of plasmon resonance within a continuous frequency range. The applications of broadband plasmonic materials in thermophotonics, superlensing and sensing are discussed. This paper has been supported by the Kazan Federal University Strategic Academic Leadership Program (PRIORITY-2030).

4th Oct ***14:55 - 15:20***

Surface enhanced fluorescence on nanostructured dielectric surfaces

A.Yu. Mironenko[a,*], M.V. Tutov[a], A.K. Chepak[a], E.V. Mitsai[b], and A.A. Kuchmizhak[b]

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Abstract — Here, we applied direct laser-induced surface structuring to drive phase transition of amorphous silicon (a-Si) into nanocrystalline (nc) Si imprinted as regular arrangement of Si nanopillars passivated with SiO2 layer. Along with surface morphology, nc-Si/SiO2 volume ratio can be also controlled via laser processing parameters allowing to tailor optical properties of the produced textured surfaces to achieve anti-reflection performance or partial transmission in the visible spectral range. By taking advantage of good wettability, enlarged surface area and remarkable light-trapping characteristics of the produced hierarchical morphologies, we demonstrated surface enhanced fluorescent sensor that allowed to identify metal cations providing sub-nM detection limit unachievable by conventional fluorescent measurements in solutions.

4th Oct ***16:25 - 16:50***

Halide perovskite structure manipulation altering their electronic and optical properties

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Abstract — Halide perovskites explosively attracted attention since the very first report of the possibility to use them as an absorber layer in solar cells in 2009. In addition to the record achievements in the efficiency of perovskite solar cells, they found a wide application in various fields of optoelectronics and photonics. A distinguished feature of halide perovskites is a great flexibility of their chemical composition, which in turn, leads to the possibility of desired tuning of their electronic and optical properties in a wide range. Particularly, a manipulation with the types of different cations results in the drastic alteration of the lattice structure transforming halide perovskites from the “classical” 3D bulk crystals to quasi low dimensional (0D, 1D, 2D) derivatives, which structure and therefore, optical and electronic properties, are dictated by the size and type of the large organic cations. At the same time, manipulation by the chemical composition

of the "classical" 3D halide perovskites with respect to both cation and anion sublattices allows to control defect distribution, exciton behavior and corresponding luminescence properties, that opens a wide prospective for their applications in various areas of photonics and optoelectronics. During the presentation the different pathways for the chemical and structural manipulations with halide perovskites will be discussed and their optical and electronic consequences will be demonstrated. The studies are supported by the Government of Russian Federation within the project № 075-15-2022-1112.

4th Oct ***16:50 - 17:15***

Fluorescence nanoscopy of single molecules and quantum dots

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Abstract - The lecture discusses the recent results of our group (www.single-molecule.ru) in the field of spectromicroscopy of single molecules and semiconductor colloidal quantum dots (QD). We overview experimental techniques and advantages of fluorescence spectroscopy/nanoscopy of single molecules, and quantum emitters in general, incl. at cryogenic temperatures. The microscopic nature of the blinking photoluminescence effect of single QDs, the results of studies of local field effects, as well as the processes of spectral diffusion and electron-phonon coupling in impurity polymer media with quantum dots and organic molecules are considered. The results of a comparative analysis with data obtained by other methods (photon echo, Raman scattering, electron microscopy) are presented. The capabilities of the three-dimensional (3D-) fluorescence nanoscopy technique implemented according to the scheme of the double-helix point spread function (DHPSF) with the use of adaptive optics tools are demonstrated. The lecture presents the results obtained by the team of authors of the Leading Scientific School of Russia headed by RAS Corr. Memb. A.V. Naumov (NSh-776.2022.1.2, www.single-molecule.ru). Researches were supported by State Contract of MPGU (AAAA-20-120061890084-9).

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5th Oct ***14:15 - 14:40***

Interaction of circularly polarized light beams in the cubic gyrotropic photorefractive crystals

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Abstract — We report on the theoretical and experimental investigations of two-beam interaction for circularly polarized a steady pump wave and a phase-modulated signal wave in the cubic photorefractive crystals of sillenite family, such as $Bi_{12}SiO_{20}$ and $Bi_{12}TiO_{20}$. In these gyrotropic crystals the interacting beams retain of their own circular polarizations, which have the same signs at transmission geometry of interaction and characterized by the opposite signs (left- and right-hand polarizations) at reflection one. It is shown that the phase-demodulation signal at the interaction of this kind is determined additionally by electrogyration and flexogyration effects.

5th Oct ***15:40 - 16:05***

Phase retrieval imaging with terahertz monochromatic radiation and multiplane data acquisition

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Abstract — The talk presents an overview of our works on phase imaging with monochromatic terahertz sources. We are developing an approach for iterative phase retrieval from intensity distributions acquired in different diffraction planes, transverse to the optical axis. We validated our approach on several THz sources (a Gunn diode with a frequency multiplication chain and a quantum cascade laser), receivers and data acquisition modes. The latter include sequential raster scanning using a single Schottky diode with two complementary lock-in amplifiers ensuring hight dynamic range detection (a); recording of several images in each plane by matrix photodetectors of two manufacturers (INO and I2S) with sequential averaging (b); and on-the-go measurement while the motorized translation stage is moving (c). In addition, we analyzed the performance of several phase retrieval algorithms at various experimental conditions. Thus, a comprehensive evaluation of the possibilities of the developed approach is given.

Oral Speakers

3rd Oct ***14:55 - 15:10***

Femtosecond laser-induced surface periodic structures formation on phosphorous- and boron-doped amorphous silicon films

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Abstract — Ultrafast laser irradiation is a powerful tool for modification of thin amorphous silicon (a-Si) films' properties to improve their performance in thin-film photovoltaics and optics [1]. Application of femtosecond laser pulses allows achieving simultaneous crystallization in the bulk and laser-induced periodic surface structures (LIPSS) formation on the surface of the a-Si film. The LIPSS formed due to the excitation of surface plasmon-polaritons (SPP), induce electrical anisotropy of a-Si film [2], as well as birefringence and dichroism, which is perspective for polarization-sensitive devices [3]. In this work we irradiated phosphorous-doped n-a-Si and boron-doped p-a-Si films with thickness 400–1200 nm by

femtosecond laser pulses (λ = 1250 nm, τ = 150 fs, ν = 10 Hz) in scanning mode at various moving speeds. The laser fluence was 0.15 – 0.3 J/cm^2. We demonstrated LIPSS formation in all cases on the irradiated surfaces. The LIPSS were orthogonal to the laser polarization. Their period was close to λ (from 1100±100 to 840±70 nm) and the relief height varied from 150±50 to 300±100 nm. Observed LIPSS period decrease with increasing the total irradiation dose of the film can be explained by a shift in the value of the SPP resonant period, caused by growth of the relief height [4]. The Raman spectra demonstrated formation of nonuniformly distributed crystalline silicon (c-Si) phase within irradiated films with the volume fraction maximum at the surface up to 82±13% for p-a-Si, and up to 19±3% for n-a-Si. Dark conductivity of irradiated a-Si films increased by up to 7 orders (up to $1.2 \cdot 10^{-2}$ S/cm) compared to initial films, due to the crystalline Si phase formation. We also observed nonlinearity of the conductivity dependence for the irradiated a-Si films, which was caused by nonuniform c-Si phase distribution within film depth. LIPSS formation induced electrophysical anisotropy in all samples: the dark conductivity was up to 10 times higher along the LIPSS ridges. Observed anisotropy may be explained by LIPSS depolarizing influence, ablated surface relief and uneven crystalline phase distribution within a-Si films. The investigation was funded by the Russian Science Foundation (grant 22-19-00035).

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3rd Oct ***15:10 - 15:25***

Laser-assisted fabrication of electrode materials on the surface of flexible polymers

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Abstract - Laser-assisted technique for the fabrication of sensor-active materials based on transitions metals on the surface of flexible polymers (PI, PEN, and etc.) has been developed. Non-enzymatic electrochemical sensors are characterized by structural simplicity with comparison to enzymatic ones, which provides higher reproducibility and quality control for mass production. In addition, they have a higher sensitivity due to the direct electron transfer from the analyte molecule to the electrocatalytically active center of an electrode without using a mediator or an enzyme. The optimal conditions for polymer surface activation using laser sources for subsequent selective metallization within the activated region were determined. The fabricated copper layers were modified with different nanostructures to enhance their electrocatalytical activity towards selected analytes. Using the procedures of formation of gold and Cu_xO_y-$Cu(OH)_2$ nanoparticles, it was shown that localization of the chemical transformations with metallic copper as a reagent ensures high spatial selectivity and adhesion of the forming nanostructures. In comparison with pure copper electrodes, these composite materials exhibit much better electrocatalytic performance concerning the non-enzymatic identification of biologically important disease markers such as glucose, hydrogen peroxide, and dopamine. The proposed method does not require the use of a template allowing to create patterns of any desired shape, for example, for rapid prototyping, moreover this technique exhibit great processing speed and scalability. Authors would like to acknowledge Russian Science Foundation (grant 20-79-10075) for financial support of this study.

3rd Oct ***15:25 – 15:40***

Laser ablation of carbon nanotube thin film for fabrication of halide-perovskite flexible photodetector

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Abstract — Metal-halide perovskites have developed significantly in the optoelectronics applications like solar cells, photodetectors and light-emitting diodes. In addition to required set of optoelectronic parameters such as long carrier diffusion length, high carrier absorption and charge carrier mobilities, the family of halide-perovskites can be cheaply fabricated and is compatible with flexible substrates. However, the currently employed complex structures for flexible optoelectronics require very accurate choice of materials. In this work we pattern carbon nanotube thin films directly on a flexible substrate with laser ablation method. Afterwards, we synthesize cesium lead tribromide microcrystals with a low-cost synthesis and obtain flexible highly responsive photodetector in a lateral structure design. The proposed fabrication approach will be useful for scaling halide-perovskite flexible optoelectronics devices.

3rd Oct ***15:40 – 15:55***

Deep eutectic solvents for laser induced synthesis of functional materials

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Abstract — Development of new technologies for fabrication of metallic electrically conductive structures on various dielectric substrates is necessary not only for standard electrical circuits, but also for flexible electronics, sensors and other modern devices [1]. In this work, the possibility of laser-induced deposition of transition metals onto dielectric substrates under laser irradiation using deep eutectic solvents (DES) has been demonstrated. DES is a mixture of proton donor and proton acceptor, which has a melting point much lower than that of individual compounds. The use of DES instead of aqueous solutions helped to significantly increase the laser deposition rate. The proposed approach can successfully compete with existing laser microprinting techniques. Appropriate stable DES compositions containing different metal salts and/or target dopants were selected for all systems, and laser synthesis conditions in DES were optimized. Both physical and chemical parameters affecting the processes were studied. Scanning speed of laser beam, radiation power and type (pulsed/continuous) were studied as physical parameters; different compositions of solutions were considered as chemical parameters. It was shown that these parameters have a significant influence on the physico-chemical and morphological characteristics of the resulting structures. We expect that the use of this method will allow fast and easy creation of sensor platforms for electrochemical analysis. This work was supported by RFBR (20-33-70277) and Grants Council of the President of the Russian Federation (project МК-1521.2020.3). The authors also express their gratitude to the SPbU Nano-technology Centre, the Centre for Optical and Laser Materials Research and the Centre for X-ray Diffraction Studies.

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3rd Oct ***15:55 – 16:10***

Laser-perforated transparent electrodes made of Ca disilicide and digermanide thin films for UV-MIR applications

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Abstract — We report a highly transparent in the wide band optical range of (0.4-5) μm mesh electrodes fabricated on thin (50-150 nm) films of calcium disilicide ($CaSi_2$) and digermanide ($CaGe_2$) by flat top beam shaped laser ablation. Compared with continuous films, mesh electrodes demonstrate two- and six-fold increases in the figure of merit (FOM=-1/[R_s×ln(T)], where T is optical transmittance and R_s is sheet resistance) up to 0.86 and 0.75 Ω^{-1}, respectively. Despite the very low area density of 0.22 (defined as the ratio of the film coverage area after ablation to the total area), both materials retain low R_s values not exceeding 20 Ω/sq. (+27% compared to initial films), while there is a marked increase in the average transmittance above 90% from the visible to middle infrared spectral ranges. The most pronounced changes are observed in the (500-1500) nm range, which are characterized by 3 times higher transparency in comparison with untreated films, while that of in the (1500-5000) nm range are intrinsically as high as 85% for $CaSi_2$ and $CaGe_2$ films owing to their semimetal nature. Raman measurements showed that even at the lowest area density of 0.08, laser ablation does not strongly affect the crystallinity of the rest of $CaSi_2$ and $CaGe_2$ films, which explains high residual electrical conductivity. Thus, obtained results suggest that laser-perforated $CaSi_2$ and $CaGe_2$ thin films have a great potential as transparent conducting materials for Si and Ge optoelectronic devices and applications.

3rd Oct ***16:30 – 16:45***

Amorphous carbon thin films for optical sensing of humidity

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Abstract — Amorphous carbon (a-C) thin films consist from a large number of disordered graphite-like nanosized clusters. Edge and point-type defects of the carbon clusters are chemically active and easily interact with water molecules and products of its dissociation from the environment. Chemical functionalization of a-C films with oxygen- and hydrogen-containing groups affects their optical and electrical properties. In this work, we study the chemical functionalization of a-C films (10-100 nm thick) by examining their temperature-dependent behavior of electrical resistance and Raman scattering. A change in the electrical resistance of the samples is observed during their cyclic heating and cooling in air. The water-enriched a-C film shows a 20% increase in magnitude of electrical resistivity after a heating and cooling cycle. These results are confirmed by measurements of Raman scattering of the a-C films. Raman spectra of the a-C films are decomposed into elementary components associated with COH, COOH, C-O-C, C=O groups. In this work we introduce a spectroscopic indicator "porosity" which can play the role of a quantitative indicator of the water content in the a-C films. In the future, the a-C films can be used as the main functional elements of flexible humidity sensors.

4th Oct ***11:05 – 11:20***

Fiber Optic Resonators for Angular Rate Sensors

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Abstract - Fiber-optic ring resonators can be used in various fields of science and technology as miniature detectors and sensors of physical quantities. To determine the operating parameters of a measuring sensor, it is necessary to define the free spectral range, width at half maximum, finesse and Q-factor with an acceptable accuracy. To measure the resonant characteristics, the method of tuning the center frequency of the laser with a fixed rate can be used, but it has large error due to the nonlinearity of the tuning. The authors managed to reduce the error caused by the nonlinearity by using a reference asymmetric Mach-Zehnder interferometer and applying the Hilbert transforms. In this scheme, the interferometer generates an optical beat signal on the photodetector, which is a harmonic signal, the frequency of which is related to the delay time in the interferometer arm. The use of the Hilbert transform helps to extract information about the phase noise of the beat signal from a periodic signal, which makes it possible to take into account the nonlinearity of the tuning of the laser center frequency in further analysis. This method possible to reduce the relative measurement error of the resonator performance characteristics from 15% to 0.5%. This technique makes it possible to measure not only operating characteristics with good accuracy, but also to record the change in these characteristics, which improves the accuracy of detectors and sensors based on optical resonators.

4th Oct ***12:05 – 12:20***

Narrowband Fano Resonances and Electromagnetically Induced Transparency-Like Effects in a Bent Waveguide Fabry-Perot Resonator with Variable Reflectivity Mirrors

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Abstract — Narrowband Fano resonances and effects similar to electromagnetically induced transparency have been demonstrated in the bent waveguide-based Faby-Perot resonator with mirrors of nonuniform reflectivity. The phenomena are shown to arise from the coupling between the fundamental mode of the core and a whispering gallery mode of the bent waveguide's cladding. The influence of all major geometric parameters of the resonator on the resonant features in its transmission and reflection spectra is investigated. The results obtained in the paper open up new possibilities in the design of novel functional elements of photonics, for example, portable high-resolution refractometers for bio- and chemosensing systems and optical sensors of mechanical effects such as strain, stress, deformation or displacement.

4th Oct ***12:20 – 12:35***

A miniaturized fiber sensing system based on precise length adjustment in tens of nanometer

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Abstract — Fiber Mach-Zehnder interferometer (FMZI) micro-cavity length adjustment in tens of nanometers by chemical etching for refractive index sensing system miniaturization was firstly reported. This etching process is capable of adjusting the length of micro-structure at the order of tens of nanometers, and achieving such high precision without involving complicated and expensive nano-fabrication facilities. The chemical etching opens up the fiber micro-cavity and redshifts its resonant wavelength at the rate of 3.6 nm/min, upon an estimated etching speed of 41.5 nm/min. The shift of the micro-cavity's resonant wavelength close to the LD's emitting wavelength is achieved by such precise length adjustment for sensing system miniaturization. The miniaturized FMZI is experimentally applied to the refractive index sensing for ethanol solutions. The measured transmission is in good linearity with regards to the solution index and the sensitivity is -12.8 dB for 0.0043 RIU (refractive index unit) difference in this study. The miniaturized FMZI index-sensing system can be portable and operating at a fast speed, which is well suited for practical field applications.

4th Oct ***12:35 – 12:50***

Realization of an Ultra-High-Pressure Dynamic Calibrate System by Drop Hammer Based on Fiber Bragg Grating Strain Sensor

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Abstract - In this letter, we propose a novel technique for dynamic ultra-high-pressure calibration that measured pressure by FBG based strain sensor. Generally, the traditional method of dynamic ultra-high-pressure calibration by standard sensor is costly and it is difficult to improve the accuracy. Therefore, we prefer FBG strain sensor to replace the standard sensor to calibrate the ultra-high pressure. In this proposal, the calibration process is that the central wavelength of the FBG attached to the elastic element changes rapidly with the strain of the elastic element during the drop hammer impact, synchronously. This allows the calibration accuracy to be easily increased to 0.02% and the cost to be reduced by 1/100 compared to traditional calibration techniques. The experiment results show that coefficient of linear correlation between the strain waveform and the pressure signal reaches 0.999. The strain calibration based on FBG is of great significance to the measurement and calibration of dynamic ultra-high-pressure sensors.

4th Oct ***12:50 – 13:05***

Single-mode Single-circular-polarization Maintaining Chiral Anti-resonat Fibers

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Abstract — Different from the optical fibers based on the total internal reflection, anti-resonant fibers (ARFs) can confine light in the region with a low refractive index by the reflection from the layer of high refractive index. ARFs do not need to rely on a strictly periodic structure to guide light unlike the photonic bandgap-photonic crystal fibers. In ARFs there exist the coupling between the modes of core and cladding. ARFs with asymmetrically distributed cladding tubes are frequently used in the maintaining linear polarization, which can solve the issue that it is difficult to integrate traditional bulk polarizers into modern fiber systems. Actually, there are still no reports about the circular polarization-maintaining ARFs. Here, we propose a novel circular polarization-maintaining anti-resonant fiber, which is achieved by introducing dielectrically chiral materials into the cladding tubes of ARFs. The proposed fiber can realize the operation of single-mode single-circular polarization (SMSCP) with low loss in a certain band. The handedness of circular polarization can be controlled by the sign of chiral parameters. In addition, the proposed fiber performs a good bending resistance, that is, the fiber can keep the operation of SMSCP even if the bending radius approaches a few centimeters. We believe that the proposed fiber can find some applications in optical communication, polarization imagining and chiral biosensing.

4th Oct ***15:20 – 15:35***

Scanning near-field optical microscopy study of ultra-thin metal films on MoS_2 crystals

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Abstract — Ultra-thin metal films are an essential platform of two-dimensional (2D) materials compatible and flexible optoelectronics. Interfaces based on two-dimensional MoS_2 can significantly improve the growth of ultra-thin metal films. Characterization of thin and ultra-thin film-based devices requires consideration of nanocrystalline structure, local optical and electrical properties of metal-2D interface, since they could be dramatically different from the bulk material. Recently it was demonstrated that the growth of gold on CVD monolayer and exfoliated MoS_2 crystals is specific and leads to continuous metal film, which demonstrate high optical response and conductivity at thicknesses below 10 nm. In contrast with CVD monolayers, mechanically exfoliated flakes of MoS_2 are atomically smooth and defect-free surfaces what can be effectively used in studying the growth and properties of metal films. In this work, we studied optical response and morphology of ultra-thin gold films deposited on MoS_2 crystal flakes transferred onto SiO_2/Si substrate by scattering-type scanning near-field optical microscopy (s-SNOM). Being a highly sensitive method s-SNOM can be used to characterize morphological homogeneity and local optical response of ultra-thin films at the nanoscale. It was shown, that optical properties and structural morphology of the ultra-thin gold films on MoS_2 crystals provide high plasmonic response and their potential use in optoelectronics and photonics applications.

4th Oct ***15:35 – 15:50***

Sensing phase transitions in solids using thermoplasmonics

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Abstract — When developing micro- and nanodevices of photonics and optoelectronics, the key task is to determine the temperature stability of nanosized solids included being part of their architecture. The thermal stability of such materials is characterized by the temperature of phase transitions such as glass transition and melting. Plasmonic nanostructures that generate heat on the nanoscale under

the action of light in conditions of plasmon resonance provide a unique opportunity to sensing these parameters in nanoconfined solids. However, despite the obvious simplicity of this approach, enhanced absorption of light by resonant nanostructures does not guarantee the desired optical heating in those cases where the thermal conductivity of the thermostat significantly exceeds the thermal conductivity of the plasmonic nanostructure. In this regard, we propose an approach to controlling the heating of plasmonic nanostructures by nanostructuring the thermostat surface. We demonstrate this using a two-dimensional array of TiN:Si voxels, which are a system of stacked titanium nitride and silicon nanocylinders. The optical heating of plasmon nanostructures can be directly controlled by the height of silicon columns at a fixed value of the pump intensity. The height of silicon nanopillar sets the operating temperature range, while the pumping intensity allows one to control the temperature in this range. We register this effect using Raman thermometry. Using plasmonic metasurface with array of TiN:Si voxels, we demonstrate the detection of the such phase transitions in nanoconfined polymers as the glass transition temperature and melting temperature at the nanoscale using Raman spectroscopy.

4th Oct ***15:50 – 16:05***

Broadband anisotropic optical properties of hBN

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Abstract — High refractive index, giant anisotropy and negligible optical loss are important properties of the material to be used to create nanophotonic structures such as metasurfaces, waveguides and Mie resonators. However, widely used materials (Si, TiO2, GaP) do not exhibit anisotropic properties and have a limited suitable spectral range. In this work, it is shown that hexagonal boron nitride (hBN) exhibits all the necessary properties for nanophotonics applications in the broadband wavelength range. In particular, we used a combination of near-field optical microscopy and ellipsometry to obtain accurate values of the dielectric constant tensor hBN. The results show negligible optical loss, a refractive index of 2.75 and a birefringence of 0.7 in the measured range from deep UV (250 nm) to near infrared (1700 nm) wavelengths. We have also demonstrated the possibility of using hBN for subwavelength waveguides (40 nm wide) and handedness-preserving mirrors.

4th Oct ***17:15 – 17:30***

Microlasers and Micro-optics enabled by direct laser patterning of halide perovskites

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Abstract - Halide perovskites have recently appeared as a novel class of materials possessing intriguing combination of optical andoptoelectronic properties revolutionizing such areas as solar cell technologies and light-emitting devices. Inexpensive chemical synthesis was recently adopted to fabricate humidity-robust monocrystalline 2D microstructures (as microplates and nanowhiskers) promising for various applications ranging from nanoscale coherent light sources for next-generation optical communications to actively tunable micro-optic devices. In particular, realization of various micro-optics based on 2D perovskites hold promise considering ultra-smooth surface of chemically synthesized microcrystals as well as potential ability for in-situ variation of the material optical properties via simple vapor-phase anion exchange reaction. Common lithography-based fabrication methods such as ion- and electron-beam milling are not only money- and time-consuming for mass production but also cause strong degradation of the perovskite photoluminescence properties if complex modifications in fabrication methods are not being used. Recently, gentle femtosecond (fs)-laser processing appeared as a promising non-destructive approach for perovskite micro- and nanopatterning. However, the quality of resulted optical elements was not perfect, because typically multi-pulse scanning exposure of the perovskite surface leaving rough deteriorated ablation layer which prevents fabrication of high quality state-of-the-art micro-optical devices. In this work, we discussing our resent progress in fabrication of advanced 2D diffraction-optical elements and microlasers in chemically synthesized CsPbBr3 perovskite microcrystals and nanowires via direct imprinting with single-pulse fs-laser projection lithography. In particular, fabrication of micro-scale Fresnel zone plates (FZP) for generation of tightly focused laser beam, as well as binary spiral micro-axicons and binary fork-shaped gratings (FSGs) allowing generation of vortex beams in reflection mode and nanograting on surface of nanowire that allowing directional lasing was demonstrated. Ultrafast laser-induced thermalization rate and extremely low conductivity of the CsPbBr3 material resulted in ultra-smooth ablation of perovskite microcrystals. The achieved results highlight the CsPbBr3 microcrystals as a promising material for realization of various complicated designs that can be directly imprinted using non-destructive and practically relevant laser technologies.

4th Oct ***17:30 – 17:45***

Resonant periodic Light-Emitting structures based on thin films of CdSe/CdZnS core/shell nanoplatelets

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Abstract - Compared to traditional semiconductor quantum dots, amplified spontaneous emission threshold for films based on CdSe/CdZnS nanoplatelets (NPLs) is observed at lower threshold values. Symmetry breaking in two-dimensional NPLs leads to conservation of angular momentum and softens the effect of Auger recombination. The use of this material in the creation of light-emitting devices will make it possible to overcome the characteristics of existing analogues. In this work, two approaches to the formation of a light-emitting layer were applied: spin-coating and oriented self-assembly. The decrease in the spatial inhomogeneity of the surface from ±5 nm with spin-coating to ±1 nm with oriented self-assembly is confirmed by studies carried out on an atomic force microscope (AFM). The creation of resonant structures was carried out directly from the light-emitting layer. The absence of additional layers and structures make it possible to get rid of the energy losses caused by them. Numerical modeling was carried out by the modal Fourier method to assess the effect of the thickness of the light-emitting layer, as well as the period of the structures on the final optical properties of the device being created. Surface modification was carried out using direct laser writing (DLW) and AFM-lithography methods. The DLW method turned out to be the most optimal for structuring thick

films from CdSe/CdZnS NPLs. Back focal plane (BFP) angle-resolved measurements of structured films were carried out, fabricated according to the design. The numerical simulation results were confirmed by the observation of photoluminescence enhancement and directional outcoupling effects. The results presented in this work are valuable in the development of LEDs with improved outcoupling. At the same time, directly-written optical cavities can become the basis for creating distributed feedback lasers or lasers based on bound states in the continuum.

4th Oct ***17:45 – 18:00***

Plasmon-enhanced anti-Stokes Raman scattering based on local density of states engineering

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Abstract - One of the challenges of nanophotonics is the optical cooling of solids. It's desirable for quantum technologies as well as for the optical control of local temperature at the nanoscale. The optical Raman cooling implies enhanced anti-Stokes scattering (ARS) compared to Stokes scattering. Recent works have proposed ways based on either enhanced ARS in a semiconductor or suppressing Stokes scattering. We consider plasmon-enhanced Raman scattering in a layered insulator-metal-insulator (IMI) system. In this work, we make the mode analysis and the numerical simulations of local density of electromagnetic states (LDOS) for IMI structures with varied thickness of the metallic layer. The simulations have shown that there is dramatic enhancement of LDOS in the frequencies of both the surface and the volume plasmon resonances. When emitter is inside the medium, then additional peak of LDOS appears exactly at the plasma frequency. This makes it possible to use IMI structures to enhance Raman scattering. On the other hand, the anti-Stokes radiation of the emitter is coupled to the surface less efficiently than the Stokes radiation. Due to the fact that both low-frequency eigenmodes are surface modes and the high-frequency mode is delocalized, energy is capable of dissipating into free space through ARS. Our work is a step towards the development of structured photonic materials for optical cooling of solids. The work was financially supported by Russian Science Foundation (grant no. 21-72-00052). The work of S.S.K. (eigenmode analysis) has been supported by the Kazan Federal University Strategic Academic Leadership Program.

4th Oct ***18:00 – 18:15***

Optical Phase Engineering with Atomically Thin Transition Metal Dichalcogenides

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Abstract — Layered materials present a promising platform for immobilization of biological molecules and their enhanced sensing in biosensors. However, mainly they serve as a functional layer and only increase sensor performance. In contrast, our biosensor design relies solely on atomically thin transition metal dichalcogenides, which strong dielectric response results in topological phase singularities. Around these singularities, an optical phase has a rapid variation, which we leveraged for label-free sensing. It allows us to achieve a very stable biosensor with an enormous sensitivity of 7.5·104 degrees per refractive index unit. Additionally, singular points can be used for any atomically thin layers of high refractive index materials and provide enhanced absorption in these layers. Therefore, proposed topological phase singularities represent a universal platform for next-generation biosensors and nanophotonics.

4th Oct ***18:15 – 18:30***

Ellipsometric analysis of low-dimensional materials over broad spectral ranges for optoelectronic and photonic applications

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Abstract - Two-dimensional (2D) materials-based photonics has recently attracted rapidly growing interest. Because of this, the investigation of the optical properties of 2D materials presents a very active area of research. It has an important presence in the development of new photonic components, optical devices, and the enhancement of existing functionalities. In this research work, we present an experimental study of the optical properties of a variety of layered van der Waals materials with different thicknesses by means of spectroscopic ellipsometry (SE) conducted in a broad spectral range from infrared to ultraviolet. Spectroscopic ellipsometry allowed us to determine optical bandgaps, the refractive index, and the extinction coefficient through the proper design of SE models and the proper selection of the dispersion oscillator models for each sample. The obtained results are of great importance for the development of photo-responsive devices in the UV spectrum bands, as well as for potential applications in the area of optoelectronics and nanotechnology.

5th Oct ***10:40 – 10:55***

Spectroscopic techniques for joint tissue evaluation

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Abstract — Osteoarthritis (OA) often initiate from articular cartilage injuries. OA is preceded by molecular changes in the precellular matrix before changes in extracellular matrix structure and composition become visually apparent or clinically detectable. Limited knowledge on the molecular mechanisms and pathophysiology of cartilage degeneration requires the prevailing understanding of specific changes at the tissue level during initiation of cartilage degeneration. Therefore, there is a critical unmet need for approaches that would enable probing of biological tissues at different scales, from molecular through cellular to tissue-levels. This could provide knowledge enabling development of novel biomarkers and deeper understanding of the mechanisms of cartilage degeneration. The near-infrared (NIR), mid-infrared (MIR), and Raman spectroscopy have shown potential in clinical orthopaedic applications. MIR and Raman spectroscopy provide high molecular sensitivity to degenerative changes in superficial articular cartilage; this information is very important for detecting pathological changes related to early OA. On the other hand, NIR spectroscopy allows monitoring of osteoarthritis-related changes in deep cartilage tissue and subchondral bone. The strengths of these modalities can be amalgamated in a multimodal approach to improve the sensitivity, reproducibility, and reliability to diagnose cartilage injuries and evaluate their surrounding tissue to prevent the initiation and progression of OA. This study aims to investigate, via modelling and experimental validation, the interaction between light and connective tissues, in order to understand component-specific and

depth-dependent contributions to the spectral response of joint connective tissues. This understanding will then be applied for characterizing different levels of connective tissue degeneration.

5th Oct ***10:55 – 11:10***

Laser Speckle Contrast Imaging System for Monitoring Cerebral Blood Flow in Neurosurgery

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Abstract - During neurosurgical operations, blood flow monitoring is of great importance for the surgeon to make informed decisions. This is particularly important for neurovascular interventions such as clipping cerebral vessel aneurysms. Fluorescence angiography and Doppler sonography are standard in such surgeries, which has a number of limitations. Laser speckle contrast imaging (LSCI) is widely used, which can provide non-invasive blood flow control throughout the operation without the introduction of special contrast agents. This method is based on the irradiation of living tissues with coherent laser radiation, which is backscattered and forms a random interference speckle pattern. This speckle pattern is recorded by a digital camera and statistically processed to determine to obtain blood flow images in vessels and the microcirculatory bed. A number of studies have demonstrated the use of LSCI for monitoring of cerebral blood flow during neurosurgical interventions. The LSCI system was tested by us on a rat model with simulated blood flow disorders. In this work, a prototype LSCI system was developed for use in the behavior of neurosurgical operations on patients. A standard Carl Zeiss operating microscope was supplemented with an 802 nm laser light source and a monochrome camera, which was connected to the side port of the microscope. This system does not interfere with the standard operation of the microscope, which allows continuous monitoring of the cerebral blood flow during the entire operation. The study was supported by the Russian Science Foundation (Project No.22-65-00096).

5th Oct ***11:10 – 11:25***

Approaches to the diagnosis of disorders of cerebral blood flow and tissue structure of the cerebral cortex in acute life-threatening conditions

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Abstract - Cerebral blood flow in heart failure and stroke is one of the serious life-threatening statements that require an immediate help to the patient. In our research we assessed it with multi-modal diagnostic facilities, such as laser speckle contrast imaging. The results of laser speckle contrast imaging show a notable reduction of cerebral blood flow in small and medium size vessels during a few minutes of heart failure, meanwhile in stroke it was found local signs of hemodynamical changes. The results of diffuse reflectance spectra measurements display a more rapid grow of the perfusion of deoxygenated blood in case of circulatory disorder. Structural analysis of cerebral cortex under the microscope showed notably higher reduction of size of the neurons due to their wrinkling within brain tissues influenced by stroke. The brain tissues altered with the heart arrest present mild hypoxic changes of neuronal morphology. Thus, the study suggests that heart failure is more life-threatening acute pathology that causes serious brain injury while in stroke it was found that the hemodynamic and structural changes are local and less expressed. The study was supported by the Russian Science Foundation (Project No.22-65-00096).

5th Oct ***11:45 – 12:00***

Structural properties of hexamethylenediamine-based hybrid perovskites

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Abstract — The work is devoted to the study of the structural properties of a number of hybrid halogen-lead perovskites, in which the organic cation is represented by hexamethylenediamine. Technologies have been developed for obtaining both polycrystalline and single-crystal samples of hybrid perovskites with various anions - chlorine, bromine, and iodine. The structural properties of the synthesized hybrid perovskites were studied in a wide temperature range - from 100 to 295 K. Changes in the main parameters of crystal lattices with temperature were revealed and analyzed. It has been suggested that the observed changes may be associated with conformational changes in the organic cation.

5th Oct ***12:00 – 12:15***

New Solid Solution MAX Phases: $(Ti_{0.5},Nb_{0.5})_3AlC_2$, $(Ti_{0.5},Ta_{0.5})_3AlC_2$ and MXenes based on them

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Abstract - We used the common pressureless sintering approach and successfully synthesized the following previously unreported aluminum-containing solid solution 312 $M_{n+1}AX_n$ phases: $(Ti_{0.5},Nb_{0.5})_3AlC_2$, $(Ti_{0.5},Ta_{0.5})_3AlC_2$. The MAX phase composition was proved by the complementary techniques of XRD, SEM and EDS. Rietveld analysis of powder X-ray diffraction patterns was used to calculate the lattice parameters and phase fractions. Heating Ti, Al, C with the addition of Nb and Ta elemental powders in the molar ratio of 1.5 : 1.5 : 1.1 : 2 up to 1450 °C for 8 h in the dynamic vacuum resulted in samples with dominant volume fraction of the MAX phase. Afterwards, all the novel MAX phases were successfully transformed to MXenes using the standard MILD protocol – chemical etching of aluminum layers in the mixture of HCl acid with LiF. MXenes were characterized by the number of methodic, including: XRD, SEM, TEM, EDS, AFM, Raman and XPS. The study was supported by the Russian Science Foundation grant No. 22-19-00094.

5th Oct ***12:15 – 12:30***

Influence of Surface Carbon Impurities on the Nonlinear Properties of Silica Nanoparticles

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Abstract - Studies of nonlinear properties of nanosystems consisting of dielectric nanoparticles in a dielectric matrix demonstrate the presence of not typical optical nonlinearity in the fields of low-intensity laser radiation. This nonlinearity has an unusual behavior: radiation with photon energies from 1.1 to 3 eV is absorbed in the medium, despite the wide bandgap of nanoparticles and matrix (Egap > 3 eV), the refractive index of the nanosystem depends nonmonotonically on the intensity of laser radiation, increases at low intensities to a maximum and decreases with further power growth, nonlinearity is observed in nanosystems with permittivity of the matrix is less than of the material of nanoparticles. In present work we study the nonlinear properties of nanosystems containing two types of silica nanoparticles in polydimethylsiloxane (PDMS). The experimental results reveal the nonlinear response of nanoparticles with high carbon impurities on its surface is insignificant in contrast to the response of nanoparticles with low carbon impurities surface. Although, luminescence study demonstrates the carbon origin electronic transitions are out of nonlinear response range, but the influence of carbon surface states on nanoparticles nonlinearity is confirmed by the fact that nanoparticles annealed at 250 C begin to exhibit not typical nonlinear properties and the carbon assigned luminescence band significantly decrease. Based on the obtained data, we conclude that carbon impurities on the nanoparticles surface changes the permittivity of the nanoparticle surrounding matrix leads to the absence of an anomalous low-threshold nonlinear response.

5th Oct ***12:30 – 12:45***

Lasing threshold of conical modes in 1D photonic crystals

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Abstract - In this work, we investigated numerically the relationship between the lasing threshold, the density of states (DOS), and field localization in binary 1D photonic crystals (PC) for several conical (non-axis) modes. The angular dependence of the corresponding quantities for the two polarizations was obtained, and it was shown that the relationship between the threshold and DOS is complex, especially near the Brewster angle in the case of p-polarization. The parameters for binary PC with equal lasing thresholds for edge modes of the same order were found. A strong correlation between the ratio of thresholds and field localizations of the two edge modes was found for s-polarization. The results of this work can be used for optimizing lasers based on 1D PCs, both for normal and off-axis lasing.

5th Oct ***14:40 – 14:55***

Effect of optical activity on degenerated four-wave mixing in cubic photorefractive crystal

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Abstract — A system of coupled waves equations for calculating the vector amplitudes of linearly polarized light waves during their degenerate contra-directional four-wave mixing in a cubic photorefractive crystals of 23 and $\bar{4}3m$ space group in general spatial orientation is obtained. Linear electrooptic, photoelastic, and inverse piezoelectric effects, as well as natural optical activity, crystal absorption, and circular dichroism are taken into consideration. The crystal orientation dependencies for different values of azimuth of the linear polarization of the signal wave at the entrance face and the crystal thickness are analyzed for cubic photorefractive materials such as GaAs and $Bi_{12}SiO_{20}$ of (110)-cut. It is shown that the crystal orientation dependencies of the reflectivity for $Bi_{12}SiO_{20}$ exhibiting strong optical activity are much different from the ones derived from non-optically active GaAs crystal. It takes place due to the fact that under the combined action of the induced anisotropy and optical activity, the conditions of diffraction of the light waves during their four-wave mixing by holographic gratings formed in the $Bi_{12}SiO_{20}$ crystal change with respect to ones in GaAs. It is established that the effect of optical activity on reflectivity significantly depends on the values of the crystal orientation angle and the input polarization azimuth of the signal wave. Optical activity can lead to both decreasing and increasing of energy transfer between the mixing waves in dependence on the conditions of holographic experiment.

5th Oct ***14:55 – 15:10***

Umov Effect for Large Nonspherical Particles

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Abstract — The report presents a solution to the problem of light scattering on randomly oriented particles of irregular shape for particles with sizes of 100, 140, 170 and 200 microns for a wavelength of 0.532 microns for various refractive indices. The solution was obtained within both the framework of the physical optics method (for the exact backscattering direction) and within the geometric optics approximation (for the scattering angles within the range from 1 to 179 degrees). The obtained solutions made it possible to build a diagram of the dependence of the geometrical albedo of a particle on the maximum degree of polarization to test the Umov effect. It has been shown that if the imaginary part of the refractive index less than 0.001, the Umov effect is performed with good accuracy. However, for the case when the imaginary part of the refractive index is greater than 0.001 and the specular component of the scattered radiation begins to dominate in the solution, the Umov effect is violated. The obtained results are interesting for optical data processing.

5th Oct ***15:10 – 15:25***

Using of ultrasound in an automated laser induced breakdown spectroscopy complex for the study of spectral characteristics of seawater in the tasks of operational study of carbon polygons

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Abstract - Due to the increase in anthropogenic pressure on ecosystems and the introduction of international taxes on carbon emissions, it is relevant to study the quality of wastewater, emissions and "burial" of carbon dioxide in various environments, which are called carbon dumps. Optical and acoustic spectroscopy methods allow for real-time continuous measurements, both in-situ and remotely. Regular measurements made in the water column are not enough to solve many fundamental and applied problems. The use of breakdown and laser induced breakdown spectroscopy for elemental analysis of liquids is well known. Unfortunately, the sensitivity of the method is not so high compared to modern chemical methods. It is relevant to increase the sensitivity of the laser induced breakdown

spectroscopy method, since in other respects, especially in terms of efficiency and cheapness, the laser induced breakdown spectroscopy method is potentially more promising compared to traditional chemical methods. The paper demonstrates some of the capabilities of an automated complex that allows it to be used quickly in full-scale and laboratory conditions with high sensitivity of analysis. The operation of the complex is based on the use of ultrasound, which makes it possible to create an aerosol from the liquid under study, and simultaneously generate an optical breakdown with the registration of atomic lines of carbon, sodium, calcium and magnesium.

5th Oct ***15:25 – 15:40***

Determination of non-zero components of the flexoelectric tensor of physical values in crystals using covariant methods

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Abstract — The calculation of non-zero components of the flexoelectric tensor of the fourth rank f_{ijmr} for a cubic crystal of symmetry class 23 is performed. The number of non-zero components of tensors for a crystal of symmetry class 23 is determined for two variants of internal symmetry: $[V^2]V^2$ and $[[V^2]^2]$. It is shown that the type of crystal internal symmetry affects the form of the flexoelectric tensor. Examples of calculation of non-zero components of the flexoelectric tensor of the fourth rank f_{ijmr} using the Python programming language are given. As far as we know, the calculation using the covariant methods of Academician F.I. Fedorov for the determination of non-zero components of tensors of higher ranks of physical quantities in crystals was carried out for the first time.

Poster Session

5th Oct ***P1***

Spectral and temporal characteristics of laser plasma generated on the surface of human hair by femtosecond pulses

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Abstract — Experimental studies of the spectral-temporal characteristics of plasma generated on the surface of human hair by femtosecond laser pulses (40 and 650 fs) with a value of 1.1 mJ have been carried out. The time dependence of the intensity of Ca I (422.67 nm), Ca II (393.37 нм), Na I (588.98 нм), Mg I (285.21 нм), Mg II (280.27 нм) , Zn I (213.86 нм) , Zn II (202.54 нм), C I (247.86 нм) and the decay of the continuous spectrum in the interval from 0 to 1 μs has been studied.

5th Oct ***P2***

Melt pool Temperature Control in Laser Additive Process

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Abstract - Additive manufacturing of metal parts is characterized by the rapid development and the wide application. It is hard to imagine modern engineering without using additive technologies. To provide the required quality of the product, careful control should be applied at each step of the process: by process engineers at the design stage, and then by the laser additive system operators, when the design is being implemented. A decision support system for the calculation/ selection of process parameters of the technological process of additive manufacturing and additional operating parameters of the equipment is being developed in IACP FEB RAS. It will facilitate choosing correct settings for a technological equipment, allowing the product to meet the existing industry-specific regulatory requirements. At the stage of metal parts production, the control and evaluation processes for the computed laser additive manufacturing parameters play a substantial role. The equipment is controlled by LaserNet, KUKA.CNC, KUKA.LaserTech, SprutCAM and other software. It is in some way able to maintain the required pre-computed parameters for the technological process. But currently there is no suitable metrological equipment for live-time control of the temperature changes, when laser fusion of metallic material takes place above 1000 K. The lack of temperature monitoring systems for the moving melt pool leads to imperfections inside the synthesized material. And that in turn leads to limitations on using laser technologies for industries producing parts with strict quality requirements. Unlike the existing thermodynamic processes optical diagnostic methods for the melt pool, created by focused laser beam, IACP FEB RAS conducts researches of the intensity melted metal radiation in the UV spectrum, excluding the range of the laser radiation being used. The obtained results demonstrate a linear correlation between the UV spectrum intensity, current melt temperature value and laser radiation power density. Further development of the obtained technological solution of temperature registration above 1000 K will improve the means of metrological assurance of additive manufacturing for systems of operational control of laser melting of metals. The presented study is performed within the state task of IACP FEB RAS (0202-2021-0001) and by grant 20-01-00449 from the Russian Foundation for Basic Research.

5th Oct ***P3***

Wavefront Laser Beam Model Formation Analysis

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Abstract — Estimate the nature of changing in the curvature of the wavefront surface in the initial position, which is formed at the exit pupil aperture of the optical system located directly behind the last refractive surface. To solve the problem, an experimental setup has been developed, consisting of a semiconductor laser and an aberration optical system with a mechanism for moving screens. The arrangement of the optical system with a radiation source at a given limiting parameter causes an increase in the action of wave aberration, which ensures the redistribution of the intensity in the transverse section of the converted laser beam. The center of the diaphragm and the mark on the screen are located on the same axis, which coincides with the axis of the converted laser beam. A functional dependence was obtained between the value of the inclination angle of the normal to the axis of the converted laser beam of the interference structure on the value of the radial location of the point of intersection of the normal with the surface of the wavefront relative to the axis of the laser beam. Based on the application of modern optical system technologies, this article analyzes the

problems of laser beam changing in spatial-geometric parameters, amplitude-phase and to obtain a measuring system by using proposed parameter of interference structure in the cross section of the laser beam. This work was supported by a grant from the President of the Russian Federation for state support of leading scientific schools of the Russian Federation (project NSh-452.2022.4).

5th Oct ***P4***

Registration of acoustic emission by fiber-optic sensors of acoustic emission during the destruction of fiberglas

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Abstract — Fiber-optic sensors have a number of features that determine the effectiveness of their use for diagnostics of PCM structures. These features include the tolerance of the fiber sensors to electromagnetic radiation, which allows to diagnosis in fields of aircraft and shipbuilding. It is also an important fact that the optical fibers can be integrated into the object structure to protect them and minimize the used space. The small cross section of the fibers does not introduce significant changes into the architecture of the reinforcing element when they are integrated into the interlayer space of the layered composite material. In case of a surface arrangement of optical fibers, binders of a similar nature as a matrix material of a polymer composite are used, providing one material. However, the specificity of this type of sensors is the distribution of sensitive elements that are located in the structure of the material, in contrast to the widely used local piezoelectric transducers. Experimental acoustic emission data obtained using a piezoelectric transducer and a multimode optical fiber glued to a specimen surface. Static tensile test of a FGRP specimen was done on a SHIMADZU universal testing machine. FGRP specimens were made by vacuum infusion method using Derakane 411-350 binder and 10 layers of 62004 fiberglass. A comparative analysis of the destruction process was performed using parameters of acoustic emission signals, such as peak frequencies in the case of registration by a piezoelectric transducer, and level energy changes of wavelet decomposition in the case of a fiber-optic sensor. Acoustic emission signals recorded by fiber-optic sensors at the level of interference are identified, and the application boundaries of the sensors are determined. This work was supported by Russian Science Foundation (project No. 21-19-00896).

5th Oct ***P5***

The study of thermoregulatory vasodilation of blood vessels by imaging photoplethysmography

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Abstract — The endothelium of the vascular bed is the largest and most active endocrine organ, which plays a huge role both in the regulation of the microvasculature tone and in maintaining of vascular homeostasis [1]. Endothelial dysfunction provokes by arterial hypertension, diabetes and impaired glucose tolerance, increased body mass index and obesity, lipid disorders. In this paper, the possibility of assessing the functional state of endotheliocytes using the method of imaging photoplethysmography [2] is presented. The study assesses the perfusion response to local controlled heating (up to 40–42 °C) on a large area of the outer surface of the middle third of the volunteer's forearm. It has been established that rapid heating (about 3.5-5°C in 1 min) causes to variations in the amplitude of perfusion modulation in the endothelial frequency range. The variation is biphasic and is due to the appearance of an axon reflex in the first phase of heating and vasodilation, which develops due to the production of nitric oxide by the endothelium in the second phase of heating [3]. Spectral analysis in the basis of wavelets made it possible to reveal the difference in the amplitude of endothelial oscillations for the selected groups of volunteers. It is assumed that this distinction can be used as a diagnostic indicator of disturbances in certain regulatory mechanisms of the microcirculatory system in a number of diseases. This research was financially supported by the Russian Science Foundation (Grant No. 21-15-00265).

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5th Oct ***P6***

Optical waveguide structures induced in a surface-doped lithium niobate crystal for optoelectronic devices

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Abstract — The results of characteristics of optically induced waveguide structures are investigated. Waveguide structures were formed by point-by-point inducing the refractive index changes of the experimental sample via various exposure conditions of the surface layer by laser radiation with a wavelength of λ = 532 nm. The formed waveguide structures were studied by using the experimental setups according to the Jamin and Mach-Zehnder interferometer schemes.

5th Oct ***P7***

Fabrication of anti-reflection coatings on GaSe crystal surfaces by laser-induced periodic surface structuring

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Abstract — GaSe monocrystals hold promise for various applications including nonlinear optics, metrology, spectroscopy and quantum electrodynamics. However, performance of this material is limited by high Fresnel reflection, while common multi-layer antireflection coating technologies are hardly applicable owing to adhesion problems. Antireflection microstructures (ARMs) represent an alternative way for tuning surface reflectivity. Direct laser processing technologies utilizing femtosecond (fs) pulses allow to create diverse surface morphologies including so-called laser-induced periodic surface structures (LIPSS) promising for ARM application. In this work, ARMs representing LIPSS with different orientation, period and roughness were fabricated on the surface of a GaSe crystal for the first time by direct fs laser patterning. The fabricated structures were characterized by scanning electron microscopy, Raman spectroscopy,

Fourier-transform infrared spectroscopy, while their optical properties were accessed using Finite-Difference Time-Domain simulations. The LIPSS ARMs formed on both sides of the GaSe monocrystals were shown to provide 20% increase in total transmittance within 5 - 14 μm spectral range compared to untreated GaSe surface, highlighting applicability of the laser processing methods for improvement of the optical characteristics of the nonlinear crystals.

5th Oct ***P8***

Effect of the stressed state of a polymer composite material on acoustic emission signals recorded by fiber-optic sensors

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Abstract — Fiber optic acoustic emission sensors are characterized by the fact that the entire fiber acts as a sensitive element of the measuring system. In conditions where the sensitive element is integrated into the structure of the studied product, it is important to take into account the effect of static impacts on the characteristics of integrated sensors. In this work a series of acoustic emission signals generated by a Hsu-Nielsen source under conditions of various loads specified by static tension was studied. Acoustic signals were recorded by a single-mode optical fiber integrated into the structure between the layers of the FGRP specimen. The FGRP specimen was produced by a vacuum infusion technique using Derakane 411-350 binder and 10 layers of 62004 fiberglass. The optical fiber was implemented in the central part of the specimen when laying out the composite package. The specimen was loaded with a universal testing machine with stops at various stress levels until the destruction of the specimen. Acoustic waves were recorded by a measuring system based on an adaptive interferometer. Peculiarities of changes in the frequency spectra of acoustic emission signals recorded by fiber-optic and piezoelectric transducers were noticed. This work was supported by a grant from the President of the Russian Federation for state support of leading scientific schools of the Russian Federation (project NSh-452.2022.4).

5th Oct ***P9***

Sensitivity of fiber-optic sensors when registering acoustic emission in an aluminum alloy plate

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Abstract — The main problems of fiber-optic sensors based on an adaptive interferometer are their low sensitivity compared to piezoelectric transducers and the registration of acoustic waves by the entire surface of the fiber. The combination of these features introduces significant differences in the shape and spectra of acoustic emission signals in comparison with the signals recorded by local piezoelectric transducers which are used traditionally. The paper presents the results of a comparative analysis of the waveforms, spectra and calculated parameters of acoustic emission signals generated by a Hsu-Nielsen source when acoustic waves are excited in an aluminum alloy plate. An aluminum alloy plate 600 x 600 mm in size and 2 mm thick was used as an object for the generation, propagation and registration of acoustic waves. The analysis results of the sensitivity of the single- and multimode fibers used in an adaptive interferometer of the photorefractive crystal type, the effect of the technical design of fiber stacking on the sensors sensitivity and the spectra of recorded acoustic emission signals are presented. It was established that the multi-pass stacking of the optical fibers allows to effectively increase the signal-to-noise ratio. The highest sensitivity of the measuring system was found on the adaptive interferometer based on a photorefractive CdTe crystal. This work was supported by Russian Science Foundation (project No. 21-19-00896) and by a grant from the President of the Russian Federation for state support of leading scientific schools of the Russian Federation (project NSh-452.2022.4).

5th Oct ***P10***

Research of light diffraction on electrically controlled multilayer inhomogeneous PPM-LC structures with smooth optical inhomogeneity

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Abstract — Multilayer inhomogeneous holographic diffraction structures are attracting increasing attention of many researchers. These structures can potentially be used as elements of spectral filters, as well as for forming sequences of ultrashort laser pulses. Their peculiarity lies in their angular selectivity, which is a set of local maxima, where their number and width depend on the ratio of the buffer layer thickness to the diffraction layer thickness. In this paper a theoretical model of light diffraction on electrically controlled multilayer inhomogeneous holographic diffraction structures formed in a photopolymer material with a high proportion of nematic liquid crystals is presented and numerical simulations of diffraction characteristics for such structures are performed. Control of the diffraction characteristics of such structures using an external electrical action becomes possible due to the anisotropic properties of PPM-LC. At the same time the high LC content in the material results in optical inhomogeneity in the depth of each diffraction layer. When such layer is exposed to an electric field, the LC director rotates to varying degrees, which may lead to an increase in phase mismatch when such structures are read. However, when certain diffraction layers are exposed to an electric field not only the angle selectivity can be transformed but also the angle selectivity can be significantly shifted. The presented theoretical model of light diffraction on electrically controlled multi-layer heterogeneous holographic PPM-LC diffraction structures and the numerical simulation results can serve as a basis for further development of electrically controlled spectral filters.

5th Oct ***P11***

Holographic formation of chirped multilayer inhomogeneous PPM-LC diffraction structures

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Abstract - The diffraction characteristics of multilayer inhomogeneous PPM-LC holographic diffraction structures have several distinctive features. They possess not only high diffraction efficiency but also unique angular selectivity, which is a set of local maxima. The selective response of such structures can be transformed by manipulating both the thickness ratio of the diffraction layer and the buffer layer and the effect of an external electric field on certain layers. They can find wide application as electrically controlled tunable spectral filters due to these features. However, the level of local maximums of angular

selectivity of such structures is not uniform, which affects their possible applicability as optical spectral filters, where it is necessary to maintain the equality of the channel pass. To solve this problem, the use of chirped multilayer inhomogeneous holographic PPM-LC diffraction structures is proposed. These structures are formed by means of light beams, which have amplitude-phase inhomogeneity. As a consequence of this the period of the formed structure and the amplitude of the refractive index harmonic at each point of the diffraction layer could be different, which causes changes in the level of angular selectivity in the lateral zones for the diffracted radiation. This paper presents theoretical research of the holographic formation process of chirped multilayer inhomogeneous PPM-LC diffraction structures. It was found that the lattice profiles can have two-dimensional inhomogeneity and also differ from layer to layer, which is due to both changes in the period of the structure and the influence of material absorption.

5th Oct ***P12***

Determination of SARS-CoV-2 concentration using an optical biosensor based on a photonic crystal with a defective layer

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Abstract — We propose a new optical biosensor based on a silicon dioxide and titanium dioxide photonic crystal with a defect layer, which can determine the concentration of SARS-CoV-2 in water by the defect mode shift. Two mathematical models for calculating the refractive index of a homogeneous mixture at different concentrations of pathogens are considered in this work. Four types of defective photonic crystal with different arrangement of layers inside an ideal photonic crystal and their influence on the performance of the sensor have been studied, in particular, structures with and without mirror symmetry have been considered. The sensitivity and amplitude of defect mode were examined as a function of the thickness of the defect layers. Also, the peculiarities of edge modes in the presence of defect layers were also investigated. The peculiarities of field localization in a defective photonic crystal were considered. Finally, the wavelength dependence of the defect mode on the SARS-CoV-2 concentration was obtained and the sensitivity of the sensor at different wavelengths was determined.

5th Oct ***P13***

Laser micromechanical biosensor for biofilm detection

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Abstract — The aim of this work is to create a laser biosensor based on microresonant probes using adaptive interferometry to detect the resonant frequency of the sensing element. AFM cantilevers with a rectangular shape are used as sensing elements. The biological films to be measured were attached to the catilever by multistage activation of the surface. Cantilvers have natural frequencies in the range of 100-350 kHz. Natural oscillations of cantilevers are excited by short laser pulses. The out-of-plane cantilever vibrations measured by interferometer which using of photorefractive crystal CdTe of cubic symmetry for converting of phase changes of object wave into intensity changes. Adaptive properties of a dynamic hologram stabilize the working point of the interferometer in the maximum sensitivity range. Biological films of PMMA, chitazan, BSA, and bacterial films were studied in the work. The experimentally obtained dispersion of the eigenoscillation frequencies provides error of mass measurement no worse $\Delta m = 9\times10^{-12}$ g in the air. Preliminary results obtained allow one to conclude that system based on adaptive interferometer can be a promising tool for detection ultra-small objects and measurement their masses. The reported study was funded by Russian science foundation, project number 21-19-00896.

5th Oct ***P14***

Section of electrons bremsstrahlung scattered by an ion in a homogeneous electric field

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Abstract - The bremsstrahlung cross section for electrons scattered by an ion in a uniform electric field is obtained. Transitions of emitting electrons to states in which it is reflected from the potential barrier of the external field are considered, and the contribution to the emission of photons by electrons when they move in a uniform electric field is taken into account, while in [1, 2] the effect of the external field on bremsstrahlung was taken into account only due to the redistribution of the average charge density of radiating electrons during their reflection (interference) from the potential barrier of the external field. This effect was also not taken into account in works that took into account the contribution to the emission of photons by electrons when they move in an external field, but without interference [3 – 5]. It is shown that the cross sections found can differ markedly from the corresponding cross sections for electrons scattered by an isolated Coulomb center, if we assume that the ion is in a quasi-homogeneous and quasi-stationary electric field with a strength of V/cm and a frequency of Hz, which is currently achievable under laboratory conditions.

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5th Oct ***P15***

Refractive Bi-Conic Axicon for Generation of Azimuthally Polarized Radiation

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Abstract — Now, considerable attention of researchers is being attracted by the possibility of forming cylindrical vector beams such as azimuthally and radially polarized beams. Such structured laser beams find applications in many areas – laser manipulation, laser material processing, optical microscopy, optical communications etc. There are various approaches to the formation of such inhomogeneously polarized laser beams. All methods have their advantages and disadvantages. Here, we propose a refractive bi-conic axicon for the transformation of a circular-polarized beams into an azimuthally polarized ring form vortex beam. The principle of operation is to use two conic surfaces: polarization conversion occurs on the inner surface due to the refraction of beams at the Brewster angle and the outer surface is used to collimate the converted beam. This is the essential difference between the proposed element and the previously proposed approaches. Bi-conic axicon is much simpler and cheaper to produce and does not need etching of diffractive relief at

nanoscale in comparison with other elements. This work was financially supported by Russian Science Foundation (grant No. 22-12-00041).

5th Oct ***P16***

Acceleration of chemical reactions in hybrid one-dimensional photonic crystals based on high-index metamaterials

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Abstract — Metamaterials with highly tunable refractive indices greatly enhance light-matter interaction in one-dimensional photonic crystals. As has been recently shown, the ionization energies of atoms placed in air voids of photonic crystals can be dramatically changed. The origin of the effect is the modification of the interaction of an electron with its own radiation field that gives rise to the change of the electron electromagnetic mass. For the first time the electromagnetic mass comes to play in describing physical processes. The mass correction is anisotropic and depends on the electron states. The photonic crystal mass correction is an observable and is described by an operator. The effect is strongly enhanced when the photonic crystal is made from highly tunable refractive index metamaterials, and the controllability of these materials gives rise to the controllability of the ionization energies over a wide range. In this work, the method of experimental verification of the quantum electrodynamic effect based on the observation of shifts in the spectral lines of helium atoms injected in the gas phase in air voids of hybrid one-dimensional PC by optical spectroscopy techniques is suggested. The current investigation can be used in controlling the physicochemical properties of atoms, acceleration of chemical reactions, in the development of new tunable lasers, new sources of linear spectrum, *etc*.

5th Oct ***P17***

Hybrid metal-semiconductor nanoparticles produced by laser ablation in liquid for optical nanosensing, anti-counterfeiting and photothermal conversion

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Abstract — Recent progress in hybrid nanomaterials composed of dissimilar constituents permitted to improve performance and functionality of novel devices developed for optoelectronics, catalysis, medical diagnostic and sensing. However, the rational combination of such contrasting materials as noble metals and semiconductors within individual hybrid nanostructures by a ready-to-use and lithography-free fabrication approach is still a standing challenge. In our recent works, we used nanosecond-laser ablation of the semiconductor nanoparticle suspensions and bulk targets in functionalizing solutions containing precursor noble metal salts for generation of novel metal-semiconductor (Au@Si, Ag@Si, Au@TiO_2) nanoparticles exhibiting unique morphology and optical properties. Generated nanomaterials were proved their usefulness for realization of SERS-based optical nanosensors for identification of molecular species at trace concentrations, anti-counterfeit labels based on physically unclonable function approach as well as solar steam generator that permits to increase the water evaporation rate by 2.5 times compared with that of pure water under identical 1 sun irradiation conditions [1-3].

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5th Oct ***P18***

Towards a Microbubble Dynamics of Laser Lithotripsy Processes in Soft Tissue

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Abstract — In many technical and biomedical applications, the interaction of cavitation microbubbles in a fluid medium or close to a boundary commonly takes place. Bubble-bubble interaction with the ensuing violent collapse of the bubble, followed by shock wave emission with the formation of a high-speed liquid jet has been linked to erosion damage on solid surfaces in hydraulic machinery as well as some adverse effects on cells and tissue, which exposed to diagnostic and therapeutic ultrasound. In the current model, the formation of microbubble dynamics using the modified Rayleigh-Plesset equations with the measured laser pulse experimentally. In addition, the strength of cavitation has also been exploited in biomedical applications to facilitate targeted drug and gene delivery, improve kidney stone breakup in shock wave lithotripsy, and increase the effectiveness of high-intensity focused ultrasound in cancer therapy.

5th Oct ***P19***

Monochromatic LEDs effect on rocket (Eruca sativa. Mill.) morphogenesis and productivity

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Abstract — In this study the effect of different monochromatic light modes on rocket (Eruca sativa. Mill.) plant development was evaluated. LED light sources significance increases rapidly at the wide application range and have acquired an important role in plant development. Some morphological parameters of the plants were analyzed. Plants grew in a closed growth chambers where three light intensities (100, 1000, and 1400 µmol m^{-2} s^{-1}) provided by three types of LEDs developed at IACP FEB RAS: red (R), green (G), blue (B), and photoperiod (light/dark – 16/8 h) were used and compared with warm white light (WW) (control) with an energy ratio (%) in the red-green-blue range of R38:G52:B10. The performed analyzes showed that the highest values of the shoot fresh weight occurred under R2, G2, and WW3 treatments, respectively. The greatest total leaf area values occurred under WW1, B1, and G2, respectively. The highest dry weight content occurred under WW2, WW3, and R2, respectively. The data showed that the application of B2, G2, R2, and WW3 light modes resulted in an increase in growth and productivity as compared with the other treatments and the control. Thus, the monochromatic blue (B2), green (G2), and red (R2) light modes with 1000 µmol m^{-2} s^{-1} intensities were the most favorable for plants development among others and could be used for optimization of plant cultivation. The effectiveness of LEDs developed at IACP FEB RAS is acknowledged. The study showed the importance of plant growth under monochromatic RGB spectra.

5th Oct *P20*

Wide temperature range fiber optic sensor

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Abstract — Currently, fiber Bragg gratings are the main type of sensor structure in fiber optic sensors. However, during their creation the protective-strength coating is removed, which reduces the strength and flexibility of the fiber and limits the field of application of such sensors. A solution to this problem could be the creation of a fiber-optic sensor using a new technology in which the protective-strength coating is not damaged, and the sensor structure is created using a fusion effect. When recording the sensor structure in a given area of the fiber, the conditions for generating a plasma focus are created, after the passage of which a structure of microneedles of various shapes is formed. Sensors created using such technology can operate in a wide temperature range. The aim of the present study is to determine the dependence of changes in the spectral characteristics of the sensor in the temperature range from 4K to 700 K.

5th Oct *P21*

Application of optical frequency domain reflectometry for the study of polarization maintaining fibers

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Abstract — Polarization maintaining fibers (PMF) are used in various fields of photonics and telecommunications, so the study of the propagation of optical radiation in such fibers and the determination of the parameters of these fibers is an important task. So, for example, to work with a Mach-Zehnder interferometer, it is important to know the time delay or the difference in arm lengths. One of the methods that solve this problem is optical frequency domain reflectometry, which has a high spatial resolution, sensitivity, and measurement speed. A new method for determining the difference in the lengths of PMF during measurements by the method of optical reflectometry in the frequency domain is presented. If the fibers under study are adjusted at an angle of 45° to the optical axes of the output fibers of the reflectometer, then the detected signal exhibits beat frequencies caused by intermode interference of light fields with orthogonal polarizations. The beat frequencies obtained by analyzing the detected signal contain information about the delay time and the total length of the studied optical fibers. A model is proposed that explains the physical nature of the occurrence of beat frequencies, demonstrates the high accuracy of agreement between numerical calculations and experimental results, and shows the influence of certain parameters on the position and magnitude of these frequencies on the reflectogram. To improve the accuracy of determining the parameters of the studied optical fibers, various methods were used to compensate for the nonlinearity of the laser tuning using an asymmetric interferometer.

5th Oct *P22*

Increasing measuring range of an MZI electro optic electric field sensor by using a MZI modulators array

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Abstract - Thanks to lithium niobate optical properties and high electro optic coefficients electro optic electric field sensors based on lithium niobate are widely used. Since electro optic sensors does not conduct electricity in the sensitive element electro optic sensors are noise-resistant and wide banded. Due to development of radio communication systems carrier frequencies are become higher. Controlling of higher carrier frequencies require a higher frequency electric field sensor. Because switching voltage of bulk lithium niobate sensors are high their frequency bands are limited. To obtain a sensor with a necessary frequency band it should be based on a thin film of lithium niobate. Using of thin films allows miniaturizing waveguide structures, reducing switching voltage and increasing frequency band by shortening electrodes. The most common sensitive element of the modern electro optic electric field sensor is an electro optic modulator in the configuration of Mach-Zehnder interferometer (MZI). The measuring range of an MZI electro optic sensor is limited by value of modulator's switching voltage. As mentioned above modern thin-film based sensor has reduced switching voltages in range 1-5 V, so their possibilities of measuring high strength electric fields are limited. However, small geometric sizes of thin film waveguides allow to place dozens of integrated MZI modulators with different switching voltages on a single chip. The purpose of this work is to investigate possibility of increasing measuring range of an electro optic field sensor by using a few MZI modulators with different characteristics.

5th Oct *P23*

Comparison of the Sensitivity of Spectral Methods for Multi-element Analysis of Atmospheric Aerosol Using Short and Ultrashort Laser Pulses

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Abstract - We have obtained limits of detection (LoD) of Al (396.15nm), Ba (553.35nm), Ca (422.67nm), Mg (285.21nm), Na (588.99nm) and Mn (403.08nm) in liquid-droplet aerosol by filament-induced spectroscopy (R-FIBS) using ultrashort laser pulses (60 fs, 800 nm, 4.4 mJ). The limit of detection of the Na by emission line (588.99 nm) in a liquid-droplet aerosol was obtained by laser induced breakdown spectroscopy (LIBS) using short laser pulses (7 ns, 1064 nm, 550 mJ). The obtained results were compared within the framework of the methods used.

5th Oct *P24*

On the Possibilities of Using the Evolutionary Algorithm «USPEX» to Search for New Hybrid Perovskites

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Abstract - The paper analyzes various approaches to creating neural networks for searching and predicting the properties of new hybrid perovskites. Based on the analysis of the case, a conclusion was made

about the limitations of existing approaches. It is shown that the evolutionary algorithm "USPEX" can be used to model new hybrid perovskites. The first data on the modeling of hybrid perovskites with various organic cations, performed using the evolutionary algorithm " USPEX ", are presented.

5th Oct ***P25***

Possibility of anapole state in dielectric nanohole array metasurfaces with different hole shapes

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Abstract — The optical anapole resonances in nanostructures display strong field confinement and substantially suppressed scattering. In this study using three-dimensional finite-difference time-domain simulations, it is shown that high refractive index dielectric nanohole array metasurfaces having different profiles of the holes can possess the anapole state. The multipole decomposition including the dipole electric toroidal moment for the lattice elements of the arrays is provided. The anapole state in the lattice elements is illustrated by time-averaged distributions of the energy. As a result, high-index freestanding metasurfaces with anapole state can be designed.

5th Oct ***P26***

The Manipulation of Liquid Microdroplets by Non-Uniform Electrostatic Fields

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Abstract — The manipulation of liquid microdroplets is essential in certain areas of research such as microengineering, microfluidics, sensors and lab-on-a-chip. At the same time, it is important to ensure the possibility of microdroplets moving along predetermined trajectories with high-speed movement (100 mm/s), coalescence and droplet separation, and ease of implementation of the technique. As a rule, microdroplets are controlled by thermal, magnetic, electrical, techniques. However, the currently demonstrated approaches cannot provide all the necessary requirements for the manipulation of microdroplets. We report here a method based on the use of non-uniform electrostatic fields that enables manipulation of a water droplet on a superhydrophobic surface fabricated on polytetrafluoroethylene (PTFE). In particular, we demonstrate that the electrodes embedded in the superhydrophobic substrate, when voltage is applied, create a non-uniform electrostatic field, once in which the droplet begins to move towards the position of the electrode. This approach allows fast and non-contact control one or a group of microdroplets, coalescence, is easy to implement and, in our opinion, has a huge technological potential.

5th Oct ***P27***

Laser Conoscopy of Two-component Optical Systems from Gyrotropic Crystals

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Abstract — The interference features in divergent radiation beams for two-component optical systems of gyrotropic crystals were considered in this work. The optical system allows to change the angle between crystal plates optical axes and the system axis, which leads to changes in the conoscopic (interference) patterns of the crystal-optical system, by which the rotation sign and the optical sign of the system components can be determine. The experiment showed that an optical system consisting of two gyrotropic plates exhibits the properties of both a gyrotropic and a non-gyrotropic crystal. When observing the conoscopic pattern of two gyrotropic crystalline plates having the same optical sign, a third additional ring structure appears on the screen. The dependence of the type of this structure on the angle between the optical axes of the plates is considered on the example of $LiIO_3$ crystalline plates of considerable thickness. The paper presents the dependences of the phase difference between ordinary and extraordinary beams on the angle of incidence for a system of two plates cut perpendicular to the optical axis, with different angles between the optical axes of the plates. When two gyrotropic crystalline plates with different optical signs, set at a small angle, are observed in divergent beams, only two conoscopic patterns of crystals appear on the screen. The calculation of the phase difference between the ordinary and extraordinary rays, introduced in this case by a two-component system, shows the possibility of creating a tunable composite phase plate. Such a plate is convenient in that the phase difference can be controlled both by changing the angle between the optical axis of the plate and the axis of the system, and by changing the angle of incidence of the beam on the system as a whole.

5th Oct ***P28***

Laser Conoscopy and Photoinduced Light Scattering in a Lithium Niobate Crystal Doped with Y(0.24 wt.%): Mg(0.63 wt.%)

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Abstract — The method of laser conoscopy and photoinduced light scattering was used to study the optical homogeneity and features of structural distortions when using laser radiation of low power P ~ 1 mW to minimize the possible influence of the photorefractive effect, as well as a power of 90 mW, the use of which made it possible to detect and study distortions arising from the action of light in a double-doped $LiNbO_3$:Y(0.24wt.%):Mg(0.63%) crystal. The experiment showed that, at a laser radiation power of P ~ 1 mW, the conoscopic patterns of the samples under study correspond to the conoscopic patterns of uniaxial optically homogeneous crystals. Anomalous optical biaxiality manifests itself in conoscopic patterns with an increase in the laser radiation power up to ~90 mW. In this case, the black "Maltese cross" loses its correct shape, a significant gap appears in the center of the pattern, and the sharpness and contrast of the image are generally reduced in the conoscopic pattern. The distortions that appear in the conoscopic pattern correspond to the rapid opening of the photoinduced light scattering indicatrix with increasing laser radiation power. For the $LiNbO_3$:Y(0.24 wt.%):Mg(0.63%) crystal, a complex dynamics of the development of the PILS pattern over time is observed. In the first seconds of irradiation, a strongly elongated central layer appears, which does not divide into two halves with time, but remains intact. On the periphery, a smaller spot appears at the beginning, which gradually resolves. These changes are due to a complex redistribution of energy between ordinary and extraordinary rays.

5th Oct *P29*

3X3 coupler Mach-Zender interferometric strainmeter

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Abstract — The fiber-optic Mach-Zender interferometric strainmeter based on 3x3 coupler is developed. The possibility of effective strain transmittion from kevlar wire to sensing arm optical coil is shown and the successful operation of the algorithm for phase demodulation from the 3x3 coupler is demonstrated. The recorded oscillations frequency range values, threshold sensitivity, and the maximum amplitude of the recorded signals is determined. It is shown that the device can be used for a seismic deformation monitoring system to prevent man-made disasters at the underground mines.

5th Oct *P30*

Fiber-Optic Sensors for Acoustic Emission Monitoring processing

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Abstract — In this work, the efficiency of fiber-optic coil-type sensors for monitoring acoustic emission (AE) signals is investigated. The possibility of increasing the sensitivity of fiber-optic sensors by changing of geometric parameters and material for sensors manufacture is considered. Experimental studies of the operation of AE sensors were performed. For each sensor, the mean square amplitude of the signals (RMS) was obtained, as well as the amplitude-frequency response in the frequency range from 100 Hz to 600 kHz.On the basis of the results obtained, the optimal material and geometric shape of the sensor base were determined, which together make it possible to optimally increase the sensitivity of the acoustic fiber-optic AE sensor. The study was financially supported by the Russian Science Foundation (grant no. 21-19-00896).

5th Oct *P31*

Review on the Evolution of 6G and Terahertz Communication for Highspeed information processing

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Abstract — The imminent development and deployment of 6G technology demands high-speed data transfer with least latency. Terahertz (THz) spectrum is anticipated to provide the essential higher bandwidth with potential to increase network capacity greatly and further realization of 6G communication. But there are several challenges in terahertz technology like efficient sources, detectors, communication systems and reliable infrastructure for network implementation that are yet to be addressed and may need several years in development. Currently a similar communication design would face path loss, fading, poor signal quality due to inevitable molecular absorption, attenuations due to rain, cloud, gaseous molecules. While enhanced signal transmission power may offset some effect at a higher energy consumption and cost of system design. Power optimization and management would be another challenge in THz frequencies. Spectral efficiency and capacity may be improved due by Non-Orthogonal Multiple Access (NOMA) technique combined with Mutiple Input Multiple Output (MIMO) antenna system. However, stable successive interference cancellation technique used in NOMA is still another challenge. Further to our development of chip-integrable uncooled terahertz microbolometer arrays as chip-integrable sensing device, and reconfigurable graphene nanopatch antenna compatible with the same, this article explores the opportunity in communication and network application for high-speed information processing. In this work reviews the opportunities and challenges in the development of sources, detectors, communication systems prospective for 6G Communication in general and specific to that with THz spectrum. This paper was partially supported by the Device Development Programme (DST/TDT/DDP-38/2021), by the Department of Science Technology, Ministry of Science and Technology, Government of India.

5th Oct *P32*

New method to grow single crystals of hybrid halide perovskites of high structural and optical quality as promising materials for laser-active media

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Abstract — For more than ten years, a great attention of researchers around the world has been attracted to organo-inorganic lead halide perovskites – a new class of semiconductor materials. From both a fundamental and applied point of view a particular interest are directed toward single crystals of halide perovskites. By now, a large number of studies indicates a prospect of their application as active media in laser systems. The most promising and most frequently used synthesis methods of halide perovskite single crystals are their growth from solutions using suitable solvents. However, these methods demonstrate some significant disadvantages, since they typically require the elevated temperatures, which negatively affects the quality of the grown crystals, preliminary synthesis of hydrogen halide salts of amines, special equipment for slow heating/cooling of solutions, the use of organic solvents that can be embedded in the crystal lattice of synthesized perovskites and thereby form solvates, etc. The method developed in our laboratory for the synthesis of single crystals of perovskites in a silicate gel is devoid of the disadvantages mentioned above. This method is based on the well-known approach to form single crystals of compounds, which are not dissolvable in water, (such as PbI_2) in silica gel. The method is based on the effect of lower solubility of halide perovskite in hydrochloric acid (HX) compared to the corresponding lead halide (PbX_2). Crystal growth occurs at room temperature only due to the counter diffusion of components in silica gel. Thanks to this, it is possible to form single crystals of compounds of high structural and optical quality, suitable as materials for laser generation. The studies are supported by the Government of Russian Federation within the project № 075-15-2022-1112.

5th Oct *P33*

Enhancement of infrared-emitting quantum dots photoluminescence via plasmonic nanoarrays

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Abstract — Control over the radiative and non-radiative channels of the IR-emitting quantum dots (QDs) is crucially important to improve performance of related devices. Here, we study spontaneous photoluminescence (PL) enhancement of mercury telluride QDs coupled to plasmonic nanoantenna arrays supporting collective plasmon mode spectrally matching QD's PL spectrum. Our systematic studies revealed how PL enhancement varies with QDs layer thicknesses as well as laser excitation and emission collection conditions, providing deeper insight into the QD/plasmonic arrays interaction. We demonstrated that careful adjustment of excitation and emission collection parameters leads to more than an order of magnitude enhancement of spontaneous emission of HgTe QDs coupled with periodical plasmonic arrays with resonances spectrally matched to QDs absorption and emission bands. The region of QDs layer thickness, wherein plasmon-related quenching and dot-to-dot resonance energy transfer have the minimal impact and, hence the PL enhancement has the maximal factor, had been determined.

5th Oct *P34*

Calculation of the signal of a scanning lidar for remote sensing of cirrus clouds containing predominantly horizontally oriented crystals

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Abstract — The results of numerical simulation of the signal of a scanning lidar for the case of sounding a cloud containing quasi-horizontally oriented plate crystals are presented. It is shown that in this case, the vertically oriented lidar is "blinded" by the specular component of the scattered radiation, while the signal of a scanning lidar is sensitive to the shape of the crystal. The results of the numerical calculation confirm the presence of a sharp increase in the depolarization ratio in the vicinity of scanning angles of 30 degrees, which was observed earlier in the experiment. It has been established that the presence of this enhancement in the depolarization ratio is a sign of the ideal shape of the lamellar crystal and can be used to interpret the data of experimental observations.

5th Oct *P35*

Numerical simulation of optical-fiber sensor of acoustic emission originated in composite material

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Abstract — Numerical modeling of a fiber-optic acoustic emission sensor is performed in this work. The finite element method is used to calculate the deformation field of the core and cladding of a quartz fiber under the influence of an acoustic field created by an acoustic emission source in a multilayer composite material. The influence of the parameters of the cladding of an optical fiber on the value of the deformation response of its core has been studied. The optimal values of the parameters (thickness, Young's modulus, Poisson's ratio) of the shell were found to increase the specific sensitivity of the sensor by more than two times. The sensitivity comparison of various geometric configurations of the introduction of an optical fiber into a composite material has been performed.

5th Oct *P36*

Anti-Counterfeit Labeling Enabled by Laser-Printed Silicon Mie Resonators

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Abstract — Fighting against falsification of valuable items remains crucial social-threatening challenge stimulating never-ending search for novel anti-counterfeiting strategies. Here, direct femtosecond-laser patterning of thin glass-supported amorphous Si films is proposed for scalable and highly reproducible fabrication of anti-counterfeit labels composed of Raman-active hemispherical Si nanoparticles. Laser printing conditions allow to precisely control the diameter of the formed NPs ensuring translation of their dipolar Mie resonance position within the entire visible spectral range. Two-temperature molecular dynamic simulations clarifies the origin of the α-Si NP formation by rupture of the molten Si layer driven by a negative GPa-range pressure near the liquid-solid interface. Arrangement of the laser-printed Mie-resonant NP allows to create hidden anti-counterfeit labels offering several easy-to-realize information encryption strategies, additional protection modalities, facile Raman mapping readout as well as dense information recording.

5th Oct *P37*

Laser etching of quasi-1D TiS3 nanoribbons by Raman spectrophotometer

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Abstract - In this work, we study the laser etching capabilities of TiS_3 nanoribbons by Raman spectrophotometer laser. The experiments were carried out with different nanoribbons with a thickness varying from 100 to 150 nm, prepared on a silicon substrate via mechanical exfoliation technique. The resulting etching depth was in the range of 20–25 nm with no oxidation. The etching depth was independent of the initial thickness of the nanoribbons, which suggests that if samples had a smaller initial thickness, a monolayer can be obtained. We also observed significant, up to 3–4 nm improvement of the surface roughness of etched samples, which makes the laser etching promising for the development of flexible, efficient, and reliable optoelectronic devices. Fabrication method of TiS_3 nanoribbons, laser settings, and thinning characteristics will be described.

5th Oct *P38*

Dispersion relations as a method for studying the optical properties of metasurfaces

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Abstract — In this paper, we study the possibility of effective control of the optical properties of plasmons by varying the position and width of the band gap in the intrinsic energy spectrum of the structure under consideration. New possibilities for controlling the optical properties of plasmons can form the basis for the creation of optical cooling, optical switches. In this case, it becomes possible to optimize the parameters of the structure before its experimental implementation. We have established that additional extraordinary optical modes arise in the metasurface, the dispersion of which can be correctly designed. The presence of periodicity leads to the appearance of additional modes in the high-frequency region, similar to the existing low-frequency modes. As the thickness of the Au metasurface increases, the low-frequency even modes disappear. An analysis of the behavioral features of the dispersion curves obtained in the simulation shows that in the model under consideration, unusual effects can be obtained in the low-frequency and high-frequency regions. Near the high-frequency band gap of the photonic crystal, a transmission band arises corresponding to the Tamm plasmon polariton localized at the boundary between the photonic crystal and the metal layer. It is shown that the position and size of the photonic band gaps strictly depend on the relative refractive index, and as its value increases, they narrow and tend to zero. The interaction of Tamm plasmon polaritons localized at the boundaries leads to mode splitting. As a result, symmetric and antisymmetric modes arise.

5th Oct ***P39***

Enhancement of Photoluminescence in Mesoporous Silicon and Nickel-Mesoporous Silicon Nanocomposites after Thermal Annealing in Argon

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Abstract - The results of comprehensive studies of meso-porous silicon-nickel (meso-PS-Ni) nanocomposites formed by anodic etching followed by Ni electrodeposition (ED) from the 0.1M NiCl2 aqueous solution are presented. Morphology, transverse sample cleavage and Ni distribution in them, Raman and PL spectra were studied before and after annealing at T=450°C for 20 minutes in argon atmosphere (P=0.2Torr). Raman data analysis (□=473 nm) for all ED times before and after annealing showed the presence of 630-690 cm-1 peak associated with nickel suboxides (NiOx), which was confirmed by SEM and EDX data. Before annealing, the PL peaks at □=□□□□nm and 473 nm strongly increased compared to those for meso-PS for 7 and 8 minutes of ED with a small “red” shift of 0.03 – 0.15 eV and decreased in amplitude with a large “blue” shift by 0.2 – 0.9 eV for 5 and 6 minutes of ED. A comprehensive data analysis showed that the “red” shift is due to formation of radiative recombination centers in the form of Ni ions in the meso-PS matrix, and the “blue” shift is associated with the formation of NiOx nanocrystals, which are direct-gap semiconductors with strong PL. After annealing the samples for all ED durations, a multiple increase in the PL peak amplitudes at □=□□□□nm and 473 nm for 6 and 7 minutes of ED with small changes in their positions, as well as a strong “blue” shift (0.38 eV) of meso-PS PL (405 nm) peak, which is associated with average size decrease of silicon nanocrystals upon annealing with argon.

5th Oct ***P40***

Optical-electrical Co-sensing System and Reciprocal Temperature Compensation

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Abstract - An optical-electrical co-sensing (OESC) system which can simultaneously provide the accurate strain measurement in a limited range and the rough strain measurement throughout the entire range has been proposed in this paper. The conceptual design, sensing mechanism and reciprocal temperature compensation method have been discussed. Firstly, the sensing principle of the OESC system is introduced. Then a translation table tensile test has been conducted to validate that the OECS system can provide reliable strain measurement. Subsequently, an algorithm of reciprocal temperature compensation has been proposed for temperature compensation without additional temperature sensors. Finally, a laboratory test was conducted to verify the reciprocal temperature compensation of DOFS and CC-FPI in OESC system. The findings from the study have demonstrated that the proposed OECS system can be used to measure the structural strain throughout the entire damage range with a satisfactory accuracy without extra temperature compensation.