DEVELOPMENTS in Optics and Communications 2017

Book of Abstracts

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13th International Young Scientist conference

Developments in Optics and Communications 2017

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1 Welcome

The Organizing Committee kindly welcomes you to the 13th International Young Scientist conference “Developments in Optics and Communications 2017”. This conference is organized jointly by University of Latvia SPIE student chapter and OSA Latvian student chapter. The purpose of this conference is to bring together students and young scientists working experimentally and theoretically in the fields of optics and photonics to share and exchange new ideas and to establish contacts for future collaboration. The conference traditionally covers the following topics:

- Laser Physics and Spectroscopy;
- Biophotonics;
- Optical Materials and Phenomena;
- Optics in Communications;
- Vision Science.

The organizers wish you a fruitful conference and a pleasant and memorable stay in the capital of Latvia!

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2 Program

Thursday, 6th of April		
8:50 – 9:20	Registration	
9:20 – 9:30	Opening session	
9:30 – 9:40	OPTEK	
9:40 – 10:20	IN01	Invited: Harilaos Ginis
10:20 – 10:32	A01	Vision Science contributed talks
10:32 – 10:44	A02	
10:44 – 10:56	A03	
10:56 – 11:24	IN02	Invited: Maris Ozolins
11:24 – 11:44	Coffee break	
11:44 – 12:24	B01	Optics in Communications contributed talks
12:24 – 12:36	B02	
12:36 – 12:48	B03	
12:48 – 13:00	B04	
13:00 – 14:00	Lunch	
14:00 – 14:40	IN03	Invited: Anatolijs Šarakovskis
14:40 – 14:52	C01	Optical Materials and Phenomena contributed talks
14:52 – 15:04	C02	
15:04 – 15:16	C03	
15:16 – 15:28	C04	
15:28 – 15:40	C05	
15:40 – 15:50	Short break	
15:50 – 17:30	P…	Poster session (Vis + OptCom + OptMat)
17:30 – 19:00	Tour to Old Riga	

Friday, 7th of April		
9:00 – 9:10	Morning session	
9:10 – 9:20	Introduction and achievements of UL SPIE	
9:20 – 10:00	IN04	Invited: Johannes de Boer
10:00 – 10:12	D01	Biophotonics contributed talks
10:12 – 10:24	D02	
10:24 – 10:36	D03	
10:36 – 10:48	D04	
10:48 – 11:00	D05	
11:00 – 11:20	Coffee break	
11:20 – 12:00	IN05	Invited: Marcis Auziņš
12:00 – 12:12	E01	Laser Physics and Spectroscopy contributed talks
12:12 – 12:24	E02	
12:24 – 12:36	E03	
12:36 – 12:48	E04	
12:48 – 13:00	E05	
13:00 – 14:00	Lunch	
14:00 – 14:30	IN06	Invited: Tatjana Pladere
14:30 – 15:30	Workshop	
15:30 – 15:40	Short Break	
15:40 – 17:20	P…	Poster session (Bio + LasPhys)
17:20 – 17:30	Closing Session	
17:30 – 20:00	Dinner	

Detailed Program & Schedule

Straylight in the human eye

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The human eye has optical imperfections that deteriorate retinal image quality. Monochromatic and chromatic aberrations are studied deterministically based on geometrical and refractive index considerations. Straylight, in other words light that is propagated stochastically after scattering at the ocular media or diffused through the ocular wall is studied statistically.

The physical mechanisms of straylight in the human eye are diverse, however a remarkably simple approximation can describe their light distribution in the eye and its impact on vision. The impact of straylight in visual performance is analysed in psychophysical terms. Recently, high dynamic range optical methods for the measurement of straylight on the human eye have been developed.

The impact of keratoconus apex position on visual acuity and contrast sensitivity

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Introduction: Change of corneal shape for keratoconus patients can change the optical quality of the eye and retinal image quality and that reduce contrast sensitivity by light scattering *(Jinabhai, O'Donnell, 2011)*. Studies have shown that the measurement of high-contrast visual acuity isn't the best characteristic of visual function *(de Freitas Santos Paranhos et al. 2010)*.

Method: In our study were included 14 keratoconus patients (24 eyes) from 1 to 3 grades. We had 9 patients with keratoconus apex at the center and 15 with keratoconus apex on the periphery. Visual acuity and contrast sensitivity were measured at 3 m with the best spectacle correction and without correction using FrACT program 3.9.3. In the study contrast sensitivity was measured in following frequencies – 1, 3, 5, 7, 9, 11, 13 and 15 cpd.

Results: Acquired data in our study shows that patients with keratoconus have lower contrast sensitivity at medium and higher frequencies (starting from 5 cpd). A statistically significant difference is for patients with the apex at the center compared with apex on the periphery both with ($p = 0.008$) and without ($p = 0.008$) spectacle correction. A statistically significant difference is for patients with the apex at the center with and without spectacle correction (0.02) but it doesn't appears for patients with apex on the periphery with and without correction ($p = 0.06$).

Conclution: Acquired data in our study doesn't show that contrast sensitivity decrease starts to different special frequencies. If the keratoconus apex is at the center, then the results show that the spectacle correction improves the contrast sensitivity at lower spatial frequencies (1, 3 and 5 cpd), while medium and high spatial frequencies remain unchanged. If the keratoconus apex is on the periphery, then contrast sensitivity becomes worse at frequencies 1, 5, 7, 9 and 11 cpd with spectacle correction then without.

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Fixational eye movements in biological motion detection

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Studies analyzing the perception of biological motion in peripheral visual field (Laicane et al., 2016; Gurnsey et al., 2008) explore whether stimulus magnification can compensate for the reduced performance of biological motion detection in the periphery. And although these studies demonstrate that the perception of biological motion in the peripheral visual field (up to 15 degrees) can be equally good as in central visual field, none of them uses any control for fixation stability.

When fixating eyes are not completely stable. Small eye movements can still be observed even if the patient reports steady fixation. These eye movements (tremor, drift and microsaccades) are called the fixational eye movements (Conde et al., 2004). Since it has been demonstrated that the orientation of covert attention causes reduced rate of microsaccades, as well as alters the direction preference of the microsaccades towards the stimulus (Engbert and Kliegl, 2003; Pastukhov and Braun, 2010), we wanted to explore if the covert attentional processes in biological motion detection tasks alter the characteristics of microsaccades as well as if the task performance is related to the microsaccades.

In our pilot study we used biological motion and the scrambled version of biological motion. The stimuli weredemonstrated in 15 degrees periphery (stimulus used by Laicane et al., 2016) and the task given to the participants was to discriminate whether the demonstrated stimulus was a point-light walker or its scrambled version. By using microsaccade detection algorithm developed by Engbert and Kliegl (2003) we analyzed (1) the rate and (2) the direction of microsaccades in biological motion detection task, as well as (3) if microsaccade parameters were connected to task performance.

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Direct write lithography for practical implementation of the method of coded diffraction patterns

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In various fields of optics a very actual problem is the so called phase problem, i.e., the information about phase is lost when the image is formed. Various techniques exist to retrieval the information about phase. Very popular numerical method used to retrieve the missing information about the phase is the method of coded diffraction patterns [1]. Its effectiveness has been shown in simulations. However, this method has not been demonstrated experimentally. The purpose of this study is to implement this method in a real optical setup. The study involves designing 3D structures in a photoresistive layer, binary masks and recovering the information about the phase. First, grayscale masks will be designed by varying transmittance of a Sn/In bilayer [2] (see Fig. 1 left). Usually, gradual masks are formed in the Sn/In bilayer using an Ar laser (λ = 488/514 nm) that is focused on the Sn/In bilayer. The sample is scanned in X-Y plane and intensity of the laser beam is modulated simultaneously. In this study, applicability of the direct write

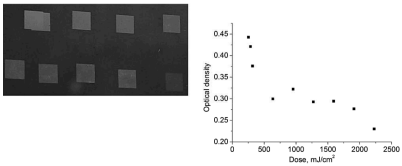

Figure 1: Grayscale masks to be used for creating 3D structures in a photoresistive layer (left) and changes of the optical density with laser power (right)

photolithography system μPG 101 (Heidelberg Instruments) for design of the grayscale masks in a Sn/In bilayer is analysed. The device emits laser radiation at wavelength 375 nm. The Sn/In (2 nm Sn and 40 nm In) bilayer was sputtered on a glass surface in a vacuum coating device. For every dose level the optical density was calculated. The optical density of fully exposed area was 0.22 while unexposed area had optical density 0.45 (see Fig. 1 right). Next, the masks will be placed over a layer of a grayscale photoresist. The binary masks was designed in a chrome layer that was randomly modulated. Generally, the optical density varied linearly with the laser power. The method will also be used to design a new type of wavefront sensors and to compensate the effects of the vitreous floaters.

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Illusory perception using color mobile displays

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Virtual reality adapters hand in hand with mobile phones gain popularity due to drastically increasing of speed of processors and pixel density. Many of researchers use these options to create illusory visual scenes, where color is one of constitutive factor. That can base on the eye specifics to refract differently diverse wavelength beams and also on the diversity of density of color light perception fields in eye at different sight eccentricities. Present report analyses a number of previously published visual illusions [1,2] such as Chromostereopsis, Break of the curveball, Rotating Reversals and new data obtained in studies of these illusions using stimuli with variable color content.

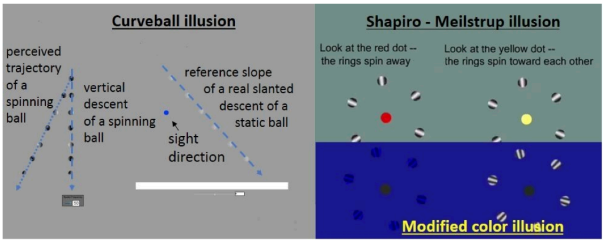

Figure 2: Break of curveball illusion.

Figure 1: Break of curveball illusion. Observer perceives a vertically falling ball in eye periphery as an oblique motion if the ball is spinning. Observers task is to decide: is the slope of the illusory motion in the left periphery steeper as a real slope at the right periphery (no spinning here). Rotating reversal illusion. Observers decision on the rotating direction of spot depends how far in periphery he observes the motion. Here a decisive role plays the colors of scene. Spots real motion is counterclockwise, modulated grating rotates clockwise.

However displays nowadays use more wide active matrix control of pixels that allows to develop thin bendable AMOLED color light emitters. Chromophores of this solution have short emission bands, that can lead to adverse impact on eye macula pigments and initiate melatonin regeneration cycle disorders. Present report touches the most popular display type emission and eye retina absorption spectra to evaluate the Blue Hazard risk factor of prolongated and direct viewing of emitted screens especially in midnight hours.
Author M.O. was supported by IMIS2.

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Towards the Scalable Cloud Platform for Non-Invasive Skin Cancer Diagnostics

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The significance of early stage disease diagnostics is keystone in modern medicine. Especially in cancer diagnostics, where chance of curing is high if it is detected at the early stage. As per EU statistics skin cancer has the highest mortality rate (86% at the late stage) along with $>$95% chance of curing if detected early. Since diagnostics of the skin can be relatively easily diagnosed without visiting specialized clinics, it is very good candidate for creating automated diagnostics device. That is the focusing point of the research project in cooperation with Biophotonics laboratory of the University of Latvia.

Skin cancer diagnostic devices (eg. MoleMax, DermDOC) are already known among professional dermatologists. With a development of smartphones, several skin diagnostic projects have been implemented (eg. DermLite X, SkinVision). They provide low cost and easily accessible diagnostic to everyone. Nevertheless, there are significant limitations of camera and processing power of smartphones. Some took one step further and combined smartphone with additional optics and illumination module (eg. HandyScope, DermLite).

Our research team is going to design the portable device that will allow untrained personal performing skin cancer diagnostics. The specifics of the device include: modular and interchangeable structure, cloud based algorithm processing. All of the above will bridge the gap between ready to use public device and laboratory prototype. Such architecture allows making quick changes and implementing latest achievements of the scientific group. The illumination module includes multispectral LEDs, polarizing and dichroic filters. That allows performing diffuse reflectance, photobleaching and other methods. The cloud based image processing allows using complex algorithms, that would be limited by portable device computational power. As well as making quick changes without the need of the access to device itself.

Study of thermo-optical processes by Mach-Zehnder interferometric method

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One of the main focuses for scientists that work with nonlinear optical (NLO) materials is creating all-optical devices for optical data processing, storage and transmission. To implement these devices in practice, it is important to have materials with pronounced NLO properties. In case of opto-optical transistors, it is essential to have materials that possess Kerr effect - change of refractive index due to optical irradiance. At the same time refractive index changes can be created by accumulated heat or other thermo-optical processes. Due to these effects, magnitude of Kerr effect can be overestimated because of various experimental parameters. Also it is important to understand how to evade thermal effects in materials to create properly working opto-optical devices. Due to this it is essential to understand different mechanisms that can lead to refractive index changes. One of the ways to analyse previously mentioned changes is by using Mach-Zehnder interferometric (MZI) method.

Compared with other experimental methods, MZI combines simple data processing, high sensitivity as well as simple experimental setup. One of draw backs of this method is difficulties to implement it for very short laser pulses (shorter than 1 ps).

In this work we implemented an MZI experimental setup and studied thermo-optical properties of chloroform. Experimental measurements were carried out using lasers with various pulse repetition rates and pulse duration times. This allowed us to separate and study different thermo-optical processes.

The financial support provided by Scientific Research Project for Students and Young Researchers Nr. SJZ/2016/10 realized at the Institute of Solid State Physics, University of Latvia is greatly acknowledged.

Comparison of Nonlinear Fourier Transform methods performance and accuracy

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In an attempt to expand the remits and adherent throughputs of nonlinear fibre-optic systems, off late, there has been a huge surge in interest in the so-called nonlinear Fourier Transform (NFT) as an alternative nonlinearity mitigation method [1]. This method relies intrinsically on the dynamical transmission modes of the nonlinear Schrödinger equation for estimating the spectrum of a potentially nonlinear signal. [1-3]. The efficient computation of NFT is therefore of paramount importance for the development of effective digital signal processing methods, the key requirements being the development of fast enough numerical algorithms capable of reducing propagation delays in the optical line that are simultaneously accurate enough to provide good quality transmission. The forward NFT operation itself is modelled using the Zakharov-Shabat scattering formalism [2,3]. In contrast to the *conventional* Fourier transform, NFT spectrum includes continuous and discrete complex parts (the latter defining the solitonic components). The present work is aimed at comparing and calibrating the relative merits and demerits of the available computational algorithms studying methods of continuous and discrete NFT spectra computation. Continuous spectra can be obtained from specifically optimised ODE methods while to analyse discrete spectra we will need to develop accurate and fast numerical architectures to evaluate complex zeros of nonlinear kernel functions [4]. To-

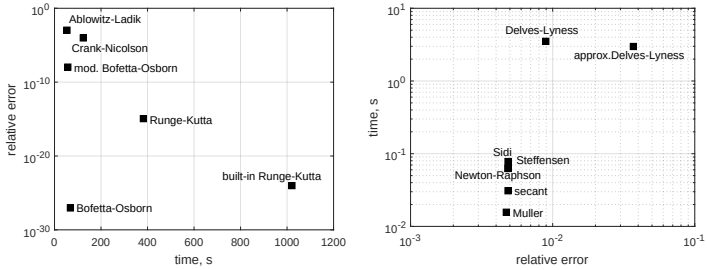

Figure 3: Computational time versus error for continuous and discrete spectrum methods.

wards this end, we found that the Bofetta-Osborn method shows better performance and accuracy for continuous spectrum computation. For analysing discrete spectra, iterative recursion is more accurate and faster than countour integration approaches, whereas countour integration approaches seem to be promising for multi-solitonic systems.

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System Design and Analysis of a Novel Wavelength Reused High Speed Bidirectional ROF-WDM-PON Architecture using a M-QAM OFDM SSB Modulation Technique to Mitigate Chromatic Dispersion, Reflection and Rayleigh Backscattering over a Single Mode Fiber

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The research mainly focuses on designing a bidirectional access network comprising of Wavelength Division Multiplexing - Orthogonal Frequency Division Multiplexing - Passive Optical Networks (WDM-OFDM-PON) with Radio over Fiber (RoF). Bidirectional transmission over a network reduces the required number of fibers and uses one optical source, lowering the cost compared to unidirectional transmission. However, in bidirectional optical access networks signal passing through single mode fiber experiences non linear losses such as Chromatic dispersion and Rayleigh Backscattering (RB), thus limiting the transmission distance and spectral efficiency of the system. If these two drawbacks are mitigated then the data rate can be increased by utilizing the same existing fiber architecture for bidirectional transmission. Hence, a system needs to be designed to meet the above requirements.

A novel m-QAM OFDM Single Sideband (SSB) architecture is proposed for centralized light source (CLS) bidirectional RoF. A mathematical model is developed for the proposed architecture to accurately measure the performance of the transmission system and also to analyze the effect of interferometric noise caused by the RB and Reflections (RE). The model takes into the account the different modulation schemes employed at the OLT and the ONU using a MZM, the optical launch power and the bit-rates of the downstream and upstream signals, the gain of the amplifiers at the OLT and the ONU, the RB-RE noise, chromatic dispersion of the SMF and optical filter responses. In addition, the model analyzes all the components of the RB-RE noise such as carrier RB, signal RB, carrier RE and signal RE, thus providing the complete representation of all the physical phenomena involved. An optical m-QAM OFDM SSB signal acts as a test signal to validate the model which provides excellent agreement with simulation results.

The transmission technique consists of transmitting the downstream signal data on the higher 1st order SB of the SSB signal and reusing the same optical carrier to transmit the upstream signal data on the lower -1st order sideband of the SSB signal such that the spectral overlap between the optical data spectrum and the RB and RE noise is minimum. The optical signal to Rayleigh noise ratio (OSRNR) and OLT, ONU gain are calculated such that the effect of the RB-RE interferences of the 2nd order harmonics is minimum. The other advantage of the proposed architecture is that the reflections of RB-RE of carrier and data signals are eliminated.

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Upconversion luminescence in rare-earth doped oxyfluoride materials

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For some decades much attention has been paid for studies of upconversion processes in rare-earth doped materials, which involve the absorption of multiple photons (usually infrared) and subsequent emission of one single photon (visible or ultraviolet). Upconversion effect could be used in different applications such as lasers, infrared quantum counters, next-generation lighting or displays, biological nanolabels and others [1].

Complex fluorides, especially rare-earth doped NaREF4 (RE = Y3 +, La3 + or Gd3 +), are promising materials for the upconversion luminescence mostly due to low phonon energy of their matrices and multisite nature of the crystalline lattice allowing for efficient energy transfer between the sites [2].

In this presentation, an introduction of upconversion luminescence, its mechanisms and properties will be given followed by a review of some recent results obtained in our group related to site-selective spectroscopy of Er3 + in NaLaF4 and erbium doped □-NaYF4 for the first time obtained in transparent oxyfluoride glass ceramics by melt-quenching and subsequent heat treatment of the precursor glass.

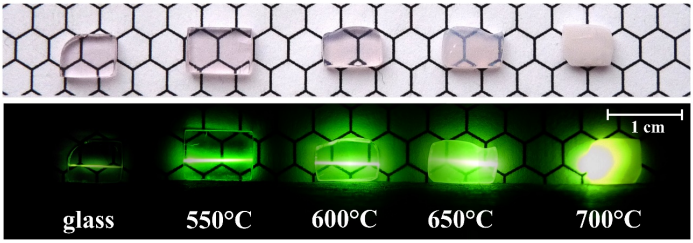

Figure 4: Upconversion luminescence in oxyfluoride glass and glass ceramics samples under excitation at 980 nm.

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Deconvolution and analysis of UV-Vis absorption spectra of sterically challenged push-pull chromophores by comparison with DFT calculations

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There has always been interest in sterically hindered chromophores among the spectroscopist community,[1,2] and this study considers such interesting examples as derivatives of 2-(4-aminobenzylidene)-1,3-bis(dicyanomethylene)indane. Their UV-Vis absorption spectra comprises broad band in the red region, corresponding to two intramolecular CT transitions. Inequivalence of these is the direct consequence of steric hindrance between one of the dicyanomethylene groups and the aniline moiety. Interplay between tendency to form a planar, delocalized π-electron system and the other one, to reduce sterical hindrance, determines ground-state geometry with positive bond-length alternation (BLA) even in most polar solvents. The actual amount, as well as atomic charge sum on either the donor or the acceptor fragment, is considerably dependent on the density functional in use. Interestingly, when methyl subsituents on the aniline N atom are replaced with tritylacetoxyethyl ones, amount of charge transfer in the ground state mitigates significantly. In calculation of absorbance spectra, effects of different type of molecular cavity, iterative computation of the solvent reaction field and non-electrostatic interaction were also considered.

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Photoluminescence properties of dysprosium and europium co-doped oxyfluoride glasses and glass ceramics

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RE ions doped oxyfloride glasses and glass ceramics have been extensively investigated in the last decades for prospective applications in scintillators, infrared detectors, phosphors for white light emitting diodes (WLEDs) and others thanks to their favourable properties- stable oxide matrix and the low phonon energy of fluoride crystals. [1, 2] Much effort is aimed to develop highly efficient WLEDs using RE ions co-doped glass ceramic materials as phosphors, white light emission from Dy−Eu co-doped samples has been reported.[3]

In the present research, series of SiO_2-Al_2O_3-CaO-CaF_2 glasses have been prepared, doped with Dy_2O_3 (0-1mol%) un Eu_2O_3 (0-1mol%) using the melt quenching method. Glass ceramics were obtained by heating the as-made glasses at temperature of 680^0C and 750^0C. Photoluminescence emission and excitation, as well as luminescence decay measurements of the samples were performed. DTA and XRD measurements were performed as well.

Single doped samples, activated with 0.5 mol% Dy^{3+} show the highest luminescence intensity with respect to co-doped samples and samples with Dy^{3+} in higher concentrations. Luminescence excitation measurements and luminescence decay kinetics approve the energy transfer (ET) process from Dy^{3+} to Eu^{3+} ions in all samples, ET efficiency in the glasses and glass ceramics is similar. In the glass ceramics, a partial reduction from Eu^{3+} to Eu^{2+} ions is observed. The luminescence of Eu^{2+} ions in the blue spectral range allows to obtain white light emission of the glass ceramics under UV excitation.

This work was carried out thanks to SIA “MikroTik” donation. Donations are administered by the University of Latvia Foundation

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Relationship between local structure and optical properties of copper molybdate

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Copper molybdate ($CuMoO_4$) is expected to have six phases [1] and is interesting due to piezochromic and thermocrohic properties. At room temperature and atmospheric pressure $CuMoO_4$ crystal is in α phase with triclinic structure (space group P-1) and a bright green colour [2,3]. By decreasing temperature below -73°C [4] or by applying pressure [2], the colour changes into brown due to the first order phase transition between α and γ phases. Similar colour change of different origin occurs in α phase upon heating up to about 400°C [3].

In this study we investigate the relationship between structural effects and optical properties of α-$CuMoO_4$ in the temperature range from room temperature up to 700°C using X-ray absorption spectroscopy (XAS) at the Cu and Mo K-edges and reverse Monte-Carlo (RMC) simulations with evolutionary algorithm (EA) approach [5].

Extended X-ray absorption fine structure (EXAFS) contains information about local environment around absorbing atoms. RMC/EA-EXAFS approach allowed us to create 3D structural model consistent with the experimental data and to follow a change of the local structure of α-$CuMoO_4$ upon temperature variation. As a result, the relationship between structural and optical properties of α-$CuMoO_4$ can be obtained.

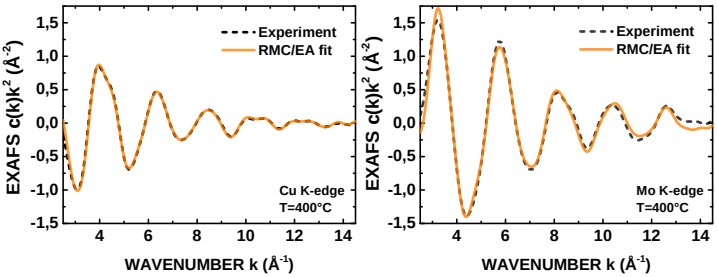

Figure 5: Example of RMC/EA calculations for the Cu and Mo K-edges EXAFS spectra of α-$CuMoO_4$ at 400°C. Dashed lines - experiment, solid lines - fit.

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Combined white light emission of europium ions in glass ceramics

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Rare earth ions in various hosts are promising materials for optical applications. In this work oxyfluoride glass ceramics containing europium ions are studied as potential candidates for white light-emitting-diodes (w-LEDs).

Conventional melt quenching technique synthesized glasses have been heated at different temperatures to create nano-crystalline glass ceramics. The obtained samples have been characterized by differential thermal analysis (DTA), X-ray diffraction (XRD), electron paramagnetic resonance (EPR) and optical spectroscopy methods.

The red photoluminescence of Eu^{3+} ions in the parent glass changes to white after the formation of SrF_2, $NaAlSiO_4$ and $SrNa_2Al_4Si_4O_{16}$ crystallites in glass ceramics. Change in $^5D_0$–$^7F_1$ and $^5D_0$–$^7F_2$ transition intensity ratio is observed suggesting Eu^{3+} ions in the glass ceramics enter a high symmetry site. The EPR spectra also indicate the presence of Eu^{2+} ions in the crystalline phase, which are responsible for wide emission bands in the blue and green regions of the photoluminescence spectrum.

Financial support provided by Scientific Research Project for Students and Young Researchers Nr. SJZ/2016/3 realized at the Institute of Solid State Physics, University of Latvia is greatly acknowledged.

PHOTOLUMINISCENCE AND AMPLIFIED SPONTANEOUSE EMISSION OF NEAT bis-DCM DERIVATIVE CONTAINING THIN FILMS

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Active medium of organic solid-state laser consists of organic molecules. 4-(dicyanomethylene)-2-methyl-6-(p-dimethylaminostyryl)-4H-pyran (DCM) is in nowadays well-known red light emitting compound, which are widely used as laser dye. Less investigated and not so widely used laser dyes are bis-DCM and its derivatives which could be used in deep red – infrared lasers. Due to several important requirements, only part of at the present time known organic compounds are suitable to be used as laser active medium. One of the most important and decisive parameters in accordance with which organic compounds are allowed to be used in preparation of laser active medium are requirement of existence of photoluminescence and amplified spontaneous emission (ASE) in those compounds.

Previously made experiments with glass forming pyranylidene (bis-DCM) derivates has shown good luminescence and amplified spontaneous emission properties [1], which makes bis-DCM perspective for use in organic solid state lasers.

In this work were investigated photoluminescence and amplified spontaneous emission of several new original bis-DCM derivatives that forms amorphous thin films from solution. Neat films were made by dissolving organic compounds in chloroform, thus obtaining necessary ratio solutions, which then were spin-coated on the glass substrate. Photoluminescence in bis-DCM derivates containing thin films were excited by continuous wave laser at 410 nm. Photoluminescence quantum yield was measured by the calibrated system Fluorescence spectrometer Pico Master 1 (Photo Med GmbH). Amplified spontaneous emission was excited by Ekspla 310 series pulse laser at 532 nm due to strong absorption of bis-DCM at this wavelength. The irradiation area on surface of the sample was stripe form with dimension 3x0.4 mm^2. Light emission was measured at the edge of the sample.

Approximated experimental points with a straight line through the relevant calculations were derived amplified spontaneous emission threshold value, absorption and gain coefficient values, which are the important characterizing parameters of studied compounds.

This work was supported by A.Riekstina SIA “Mikrotīkls” donation, administered by University of Latvia Foundation.

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Binocular summation of uneven images on screen and in visual perception

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The main purpose of this research is to determine the mechanism in which human visual systems creates united visual representation if images of both eyes differ in contrast and colour. Such conditions in human's body are equivalent with eye diseases such as cataract or cornea degeneration.

Specific array of stimuli was created and mathematical stimuli summation model was created on computer by the means of image calculation.

For the perceptive part of the research the stimuli is presented on mobile phone screen, whilst the separation of visual pathways is achieved via VirtualReality device. The subjective visual response was measured by psychophysical methods. Previous adaptation period was added to enhance psychophysical response

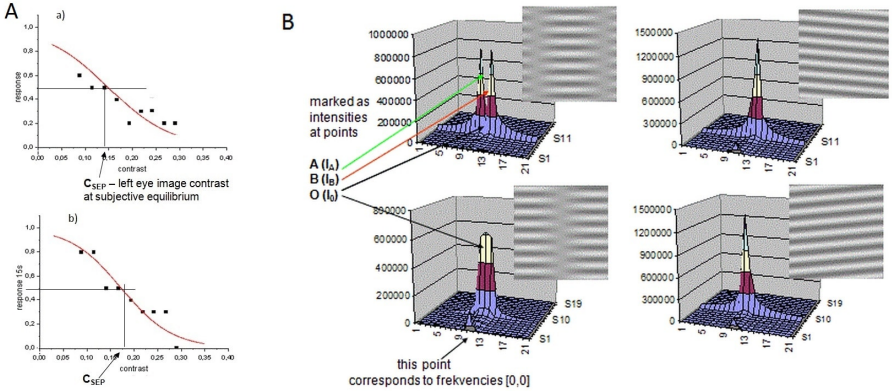

Figure 6: Fig.1.A – psychophysical curve showing subjective response after: a - 5s long adaptation period, b - 15s long adaptation period; B – Fourier spectra of stimuli and their subsctractions and additions.

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Blur adaptation with Snellen E and Landolt C optotypes

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Visual system continuously adapts to recent visual experience [1], and in case of the blur adaptation there is a compensation process that leads to improvement in defocused visual acuity [2]. The aim of our study is to evaluate effect of blur adaptation on visual acuity using two types of stimuli: Landolt C and Snellen E optotypes. 8 subjects are participating in this study (4 emmetropes and 4 myopes). Best corrected visual acuity, visual acuity immediately after introduction of fogging ophthalmic lens for simulation of 2.0 D myopia and adapted visual acuity after 30 minutes is measured using both Snellen E and Landolt C optotypes. Results at the moment show that there is not significant connection between best corrected visual acuity and deterioration in visual acuity as effect of 2.0 D myopia simulation. All participants show increased visual acuity after blur adaptation period (see Fig. 18). Although best visual acuity with both optotypes is similar, visual acuity immediately after introduction of blur was better using Snellen E optotypes than Landolt C optotypes. Similar connection was observed also in case of adapted visual acuity.

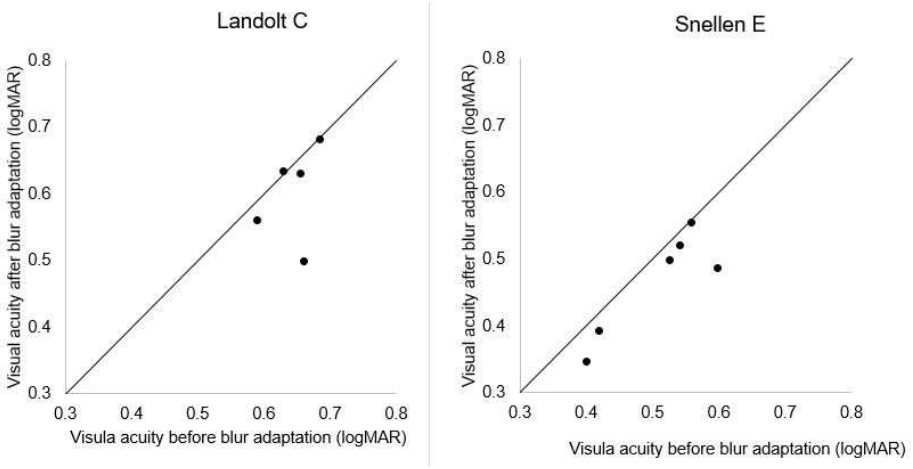

Figure 7: Defocused (2.0 D) visual acuity before and after blur adaptation measured with Landolt C optotypes (on the left) and Snellen E optotypes (on the right).

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Estimation of optical fiber melting temperature from the Planck's law using a grating spectrometer

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While melting of a tip of a fused-silica optical-fiber with an oxygen-propane torch a small ball is formed due to the surface tension effect. We intend to use such balls as whysperinggallery-mode (WGM) microresonators for optical biosensor applications 18. They guide light by the total internal reflection, and increase the effective interaction length of the evanescent wave with the adsorbed biomolecules on the surface from a liquid sample. The temperature at the melting zone can be estimated from the color of the glow. The same fiber that is being melted is used to guide the light to a miniature USB grating spectrometer (Ocean Optics JAZ). Temperature can be estimated by fitting according to the Planck's law [2]. Method has a potential industrial application to monitor the temperature during the fiber bundle production [3]. This research was supported

Figure 8: a) Microresonator formed by melting of a fiber tip. b) Recorded emmision spectra at different temperatures. Higher temperature shifts the emmision spectrum to blue wavelengths. Corrections need to be made for spectrometer sensitivity and emmissivity.

by ERAF Nr. 1.1.1.1/16/A/259 and LU partnership with Z-Light.

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Optical studies of electrically patterned groups of silver nanoparticles

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Presently, silver and gold nanostructures are widely applicable in optics and plasmonic. The reason is the possibility of surface plasmon resonance excitation in visible spectral range, which is accompanied by local electric field enhancement. This is relevant, for example, to surface-enhanced Raman scattering (SERS). While nanostructured metal films provide Raman signal enhancement factor up to 10^8, isolated nanostructures composed of one or several nanoparticles (NPs) are prospective for individual molecules and cells detection and analysis. Thus, an important issue is revealing the correlation between optical resonant properties of the metal NPs and their morphology and arrangement in groups.

These correlations were studied for colloidal and lithographically made NPs, and we present an optical investigation of silver NPs formed on a glass surface using recently developed electric-field induced patterning technique. The morphology and the arrangement of the grown NPs were characterized using scanning electron and atomic force microscopy. The optical properties of the individual and coupled NPs varying in their height, lateral size and interparticle gap were studied using results of dark-field spectroscopy and numerical modeling. Near-field microscopy was applied to visualize hotspots nearby the groups of three and four NPs. Finally, we performed SERS measurements of the Rhodamine 6G dye to verify the capability of the fabricated nanostructures to enhance Raman signal.

Optical studies of grown structures allowed us to deduce the influence of NP parameters on spectral position of surface plasmon resonance and Raman signal enhancement by the NP. The enhancement factors of different nanostructures are compared with standard silver nanostructured film.

Engineering of metal sulfide nanowire photoresistors

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Potential applications of nanomaterials in electronics and optoelectronics is a topical research subject due to possible miniaturization of currently used devices and due to interesting properties that materials exhibit in nanoscale. There is an ongoing research on fabrication methodologies of nanowire based prototype devices and their characteristics. One of the perspective research topics is focused on utilizing semiconducting nanowires as photodetectors.

PbS, In_2S_3 and CdS nanowires were grown on a silica wafer by atmospheric pressure chemical vapour deposition, and were characterized using scanning and transmission electron microscopy. Using nanomanipulator, as grown nanowires were placed on gold microelectrodes produced by direct write laser lithography and welded using focused ion beam assisted platinum deposition. Current-voltage (I-V) characteristics and photocurrent were measured for such nanowires by illuminating with a light of different wavelengths and illumination intensity.

The effect of the utilized preparation method on the photoresistor properties is discussed, as well as the photocurrent dependence on illumination wavelength for studied materials.

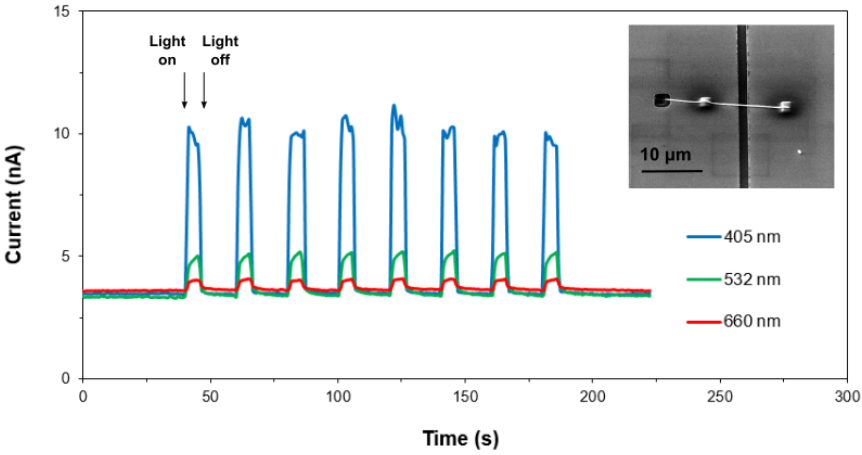

Figure 9: Measured photoresponse of CdS nanowire photodetector for different wavelengths (I = 3 W/cm^2). Inset: Scanning electron microscope image of the photoresistor.

Financial support provided by Scientific Research Project for Students and Young Researchers Nr. SJZ/2016/6 realized at the Institute of Solid State Physics, University of Latvia and by National research program IMIS2 is is greatly acknowledged.

Preparation and optical properties of polarizing films based on Poly(vinyl alcohol) – Heteropolyacid nanocomposites

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We report on a new type of dichroic polarizing films based on the acid-catalyzed thermal dehydration of poly(vinyl alcohol) [1]. These polarizing films are superior in moist heat resistance to conventional poly(vinyl alcohol)-based films [2], have good optical properties, such as a high degree of polarization and transmittance, and can be readily obtained with thickness of the order of micrometers. We present an approach to overcome deficiencies of traditional PVA-polyene polarizing films by avoiding the use of mineral liquid acids in the catalysis of PVA dehydration.

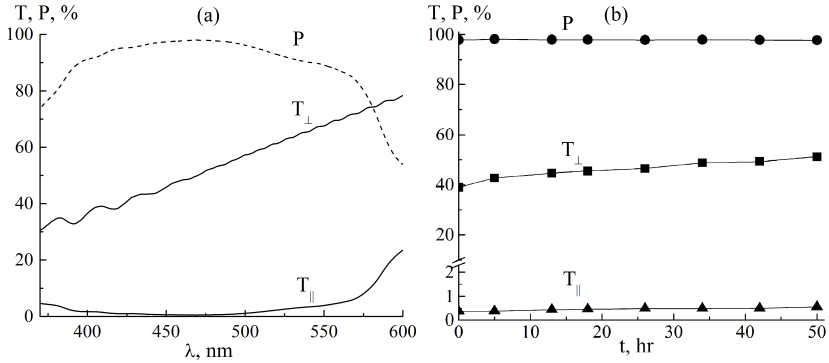

Figure 10: (a) Polarized transmittance ($T_\perp$, $T_\parallel$) spectra and the degree of polarization (P) of 8.8-μm-thick polarizing film obtained by stretching and subsequent annealing of PVA–TPA nanocomposite film, (b) the optical properties of this film at λ = 466 nm as a function of its residence time in hot humid air (60°C, 90% RH).

Figure 1(a) shows polarized transmittance ($T_\perp$, $T_\parallel$) spectra of PVA-polyene-TPA polarizing film with the thickness of 8.8 μm. Also shown in Figure 1 is the degree of polarization of the film, $P(\%) = 100x(T_\perp - T_\parallel)/(T_\perp + T_\parallel)$. In the wavelength range of 380–570 nm the film is not transparent to the light polarized parallel to the stretching direction of the film while it transmits 40 to 70% of light with the orthogonal polarization. The polarizing properties of the film do not deteriorate even upon 50 hr exposure to harsh environmental conditions (60°C, 90% RH), as is seen in Figure 1(b).

Polarizing films with even better optical properties could be obtained by increasing the degree of film stretching and optimizing the stretching conditions.

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Guidelines for design of e-study materials

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E-study use is increasing, its main content is information for self-education and it is delivered to the user through the modern technologies that provide more great opportunities. To successfully reach the user, information must be presented in a comprehensible and easy to remember way.
The article devoted to the recommended presentation of information in e-study in order the text can be easier to read by the human and it can be better to perceive and memorize.[1] It is dedicated to technologies that could help to build and analyse types of presentation. There are presenting various of examples.
The authors offer recommendation Guidelines for e-study materials development and presentation, assessment and presenting, considering user needs and requirements of research as well as literature study research, and based on the visual science foundations and previous research [2]. The focus for the development of Guidelines was particularly on the visual function importance in reading and learning process as clear and stable text perception primarily provides by near visual functions. There are in a structured manner presented the recommendations for a user-friendly e-study material design - style, size, spacing, position, colour - which should be applied for easy perception with visual processes, thus helping the learning process and to facilitate memorization.
As it is more need in teaching methods and learning environment that is user-oriented, then guidance specifics may be different for each of the e-study targeting groups that are divided primarily into three groups: children, adults, and seniors, because each group has a different way of the needs, requirements, and visual perception, as well as it is be need to consider other existing features of user, which may differ from the standard and affect efficiency of recommendations. In this work deals with a part of the targeting group - adults.

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Smart Meters Electrical Energy Hourly Data Availability Impact on Users Electrical Energy Usage Behaviour

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Smart meters help monitoring the hourly power consumption and reduce it.

Smart meters provide users with electricity consumption data for each hour of the day. The consumers note the hours during which they consume more power and what is the price of electricity at these hours. If the price is not satisfactory, the users can reduce the consumption where possible. Consumers may choose to use fewer electrical devices at the same time, enabling the producer to reduce the power generation volume and preserve the environment, as well as avoiding overload of power transmission systems.

The aim of the work is to achieve an optimal power consumption. This aim has been put forward because new smart meters are being installed, which enable the monitoring of hourly power consumption as well as the electricity market price, thus reducing the cost of the electricity consumed.

Data of more than 80 users obtained from smart meters during 2014-2016 was processed as part of the study. The data was differentiated in groups and processed, load curve were prepared to analyse whether consumers power consumption has decreased in long term.

Analysis of the processed data shows that, in long term, users have not decreased their consumption despite having access to power consumption data.

Based on these findings, proposals have been developed about how to encourage customers to better monitor their power consumption and decrease it. Recommendations on how to better inform the customers have been prepared for JSC ”Sadales tīkls”.

Optical Coherence Tomography, and polarization sensitive OCT and Self Interference Fluorescence Microscopy

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Structural imaging of the retina by OCT has become an indispensable part of clinical practice. However, the potential of OCT signals has not yet fully been exploited. In this presentation the next step in analysis of OCT signals is presented.

Currently OCT images show the strength of the backscattered signals from the retina, but the signal strength is not related to actual tissue properties. Signals can be processed to show the attenuation coefficient, a tissue property that describes the scattering strength of the tissue. Polarization sensitive OCT shows the birefringence of the nerve fiber layer, which might be related to the axon density, and could be an important parameter in the progression of glaucoma. Doppler OCT can image the blood vessel structure in the human retina, and quantitative flow analysis in the human retina seems within reach.

Acetone and benzene detection using CRDS

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Acetone is an organic molecule produced and disposed of in the human body, however, people with diabetes produce it in larger amounts. Also after strenuous exercise or while dieting the amount of acetone produced is larger. In normal concentrations benzene in air isn't harmful to animals or plants. Nevertheless, it has been proven to be carcinogen. For places people work for hours with fuel, glue, paint, detergents etc. the monitoring of benzene levels in the air and the breath of employees after work might be crucial. Cavity Ring-Down Spectroscopy (CRDS) is a method that avoids typical sensitivity limitations to detect gas phase molecules in air. Using CRDS real-time speed, high precision and sensitivity measurements of environmental and emission monitoring are possible.

We have constructed a CRDS set-up to measure the concentration of acetone/benzene in the air and human breath using a 266 nm pulse laser. Also we tried to determine the degree of sensitivity for the set-up. To measure the sensitivity both pre-made bags with known concentration from 1 ppm of to 950 ppm benzene were used (see Fig. 1) as well as breath samples from volunteers after doing different activities were collected and examined.

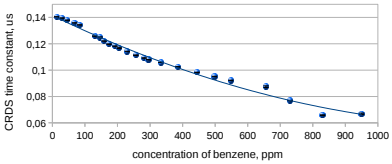

Figure 11: The dependency of the ring-down time constant from the concentration of benzene.

The results show that it is possible to detect the concentration of benzene using the CRDS set-up, however, it was noted that for larger concentrations the measurements have to be longer to achieve stability of time constant. At the same time it was noted that the set-up has some long term stability issues with both the laser and the vacuum pump. The results of breath samples show that slight differences of CRDS time constant can be seen in before and after activity measurements of the samples. This indicates that the sensitivity level of the set-up is high enough to detect the change of acetone exhaled.

In conclusion, the CRDS set-up is sensitive to both acetone and benzene of different concentrations, although some problems with long term stabilities are observed.

Acknowledgements
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Ptychographic microscopy via wavelength scanning

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A wavelength scanning Ptychographic Iterative Engine (ws-PIE) is proposed to reconstruct high quality amplitude and phase images of the specimen. While common ptychography takes a longer time to transversely scan the sample during the data acquisition, the proposed ws-PIE fundamentally reduces the data acquisition time significantly and avoids its heavy dependence on the accuracy of the scanning mechanism. The experimental arrangement is shown in Fig.18. This method can be easily implemented for imaging in the field of material and biological sciences with the aid of wavelength-swept laser sources that are now commercially available. The feasibility of ws-PIE is demonstrated numerically and experimentally. Fig.13 shows the experimental results.

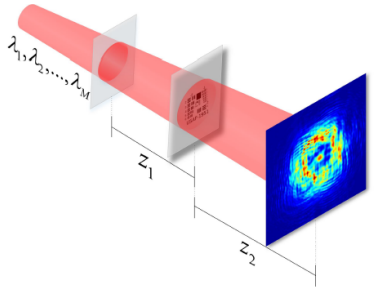

Figure 12: Schematic of the setup for ws-PIE. Diffraction patterns were recorded by repeating the exposure with different wavelengths. The distance between the pinhole and sample is z1. The diffraction patterns are collected by a two-dimensional detector placed at z2 away from the sample.

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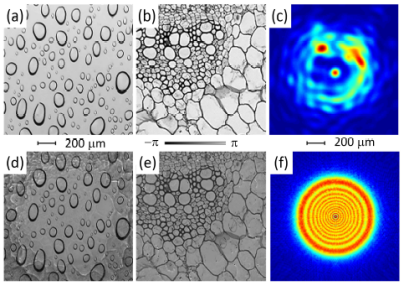

Figure 13: Simulation results of ws-PIE(a) Original modulus and (b) phase transmission image of the object. (c) Simulated diffraction pattern with 700 nm illumination. (d) and (e) are modulus and phase images reconstructed using ws-PIE obtained from 10 diffraction patterns at 10 nm scanning step beginning at 700 nm. (f) Represents the recovered illumination amplitude in the object plane for 750 nm.

Double-snapshot mapping of four skin chromophores

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Skin chromophore distribution maps can be used to determine skin health status and follow up skin recovery process after bruises and other interactions. Here we use four chromatic illumination and a double-snapshot technique [1] to map four-chromophores: oxy-hemoglobin, deoxy-hemoglobin, melanin and bilirubin or beta-carotene.

We use specially created device - switchable four laser illuminator - and a smartphone located on the device. Imaging technique is based on double-snapshot – firstly, we take an image using three lasers emitting at 405 nm, 532 nm and 659 nm wavelength and, secondly, we take another image using three lasers emitting at 448 nm, 532 nm and 659 nm wavelength. We use moving reflective element to provide uniform illumination and laser speckle reduction.

Photos are taken by CMOS smartphone camera with AZ Camera application. Images are processed using MATLAB software. Four monochromatic images are extracted from two trichromatic images [2].

Chromophore distribution maps are obtained by using 4 equations based on the Beer-Lambert law [3]:

$$\begin{cases} lnk_1 = -l_1(c_a \cdot \varepsilon_a(\lambda_1) + c_b \cdot \varepsilon_b(\lambda_1) + c_c \cdot \varepsilon_c(\lambda_1) + c_d \cdot \varepsilon_d(\lambda_1)) \\ lnk_2 = -l_2(c_a \cdot \varepsilon_a(\lambda_2) + c_b \cdot \varepsilon_b(\lambda_2) + c_c \cdot \varepsilon_c(\lambda_2) + c_d \cdot \varepsilon_d(\lambda_2)) \\ lnk_3 = -l_3(c_a \cdot \varepsilon_a(\lambda_3) + c_b \cdot \varepsilon_b(\lambda_3) + c_c \cdot \varepsilon_c(\lambda_3) + c_d \cdot \varepsilon_d(\lambda_3)) \\ lnk_4 = -l_4(c_a \cdot \varepsilon_a(\lambda_4) + c_b \cdot \varepsilon_b(\lambda_4) + c_c \cdot \varepsilon_c(\lambda_4) + c_d \cdot \varepsilon_d(\lambda_4)) \end{cases} \quad (1)$$

k_j - spectral reflectance at j-wavelength (1 = 405 nm, 2 = 448 nm, 3 = 532 nm, 4 = 659 nm), l_j - wavelength-dependent mean optical path length (j= 1, 2, 3, 4), c_i - relative concentration of the chromophore (a - oxy-hemoglobin, b - deoxy-hemoglobin, c - melanin, d - bilirubin or beta-carotene) and $\varepsilon_i(\lambda_j)$ - extinction coefficient of the specified chromophore (i = a, b, c, d) at fixed wavelength (j= 1, 2, 3, 4).

Device is planned to be tested on different skin malformations like bruises, vascular and pigmented skin lesions.

This work was supported by the Latvian national research program SOPHIS under the grant agreement #10-4/VPP-4/11.

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CONTROL OF OCHRATOXIN-ABY IMMUNE BIOSENSOR BASED ON THE SURFACE PLASMON RESONANCE

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Ochratoxin-A (OTA) is one of the most dangerous mycotoxins. It is a natural contaminant of grains and legumes, produced by *Aspergillus* and *Penicillium* fungi. Therefore, it is important to control the quality parametersor even the presence ofmycotoxins in products in real time at all stages of cultivation, processing and transportation of products.Ochratoxin-A were chosen as model objects.

Nanometer-thick-gold-film was prepared by vapour deposition of metal on the glass surface of the prism.To achieve high density of the immune components immobilization on the transducer surfaces we preliminary treated them by polyelectrolytes (polyalylamine hydrochloride (PPA)). After that the transducer surface was treated by protein A from *Staphylococcus aureus* to achieve oriented immobilization of specific antibodies in advance, and, to prevent nonspecific adsorption, additionally samples were incubated with bovine albumin serum (BSA).

It can seen that with the proposed approach it is possible to reveal Ochratoxin-A at the concentration as low as from 5 ng/ml.

SPR based immune biosensor may be recommended for both screening observation of environmental objects and for verification of preliminary obtained results by any other approaches.

The use of remote photoplethysmography system for regional anesthesia monitoring in operating room

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In orthopedic surgeries when delivering the anesthetic it is often not so easy to actually recognize the moment when the regional anesthesia (RA) has become effective and the surgeon can begin to cut. So far there are a few subjective methods widely used, like the temperature or touch test. We propose a method that is non-invasive and can give measurable evaluation in the moment when the anesthetic has become effective.

A simple and inexpensive remote photoplethysmography (rPPG) system for monitoring the effectiveness of regional anesthesia was developed and tested. The system involves surgical lamp as light source, compact video camera and computer with custom developed software. Data from eight patients were processed and the effectiveness of regional anesthesia was calculated.

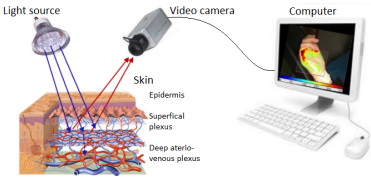

Figure 14: The principle of rPPG technique.

Local anesthetic affects the sympathetic vascular tone by resulting in vasodilation and subsequent rising of microcirculation intensity in the palm skin. This leads to the increase of amplitude of fast-varying rPPG signal detected by our system. The effectiveness of RA was evaluated in 8 clinical cases in Hospital of Traumatology and Orthopedics, Riga, Latvia. The perfusion response slightly differs across the patients, depending on the heterogeneity of the group of patients and the variance of anesthetic procedure. The PPGA maximum value (100%) was found empirically: from the subject having best RA effect, and 50% of PPGA maximum value was suggested as the threshold of a successful anesthesia. The effectiveness of RA was expressed by PPGA signal maxima/minima ratio, which is different from subject to subject.

The results showed that the standard surgical lamp can be used as a light source together with the high dynamic range camera for remote monitoring of skin microcirculation.

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Level anti-crossing studies in color centers in diamond

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Over the recent years, negatively charged nitrogen-vacancy centers (NV) in diamond have emerged as a promising future technology for sensing applications. That is due to their high sensitivity and inherent scalability, which ranges from single NV centres, offering a few nanometre spatial resolution, to bulk sensors, providing enhanced field sensitivity. Despite these advantages, however, several important fundamental and technological challenges of NV-based sensing remain open.

Recent developments in magnetic field sensing with negatively charged nitrogen-vacancy centers in diamond employ magnetic-field dependent features in the photoluminescence. These features can be studied in presence of the microwave radiation or this radiation can be eliminated.

Here, we study three approaches towards improving the magnetometric sensitivity using the ground-state level anti-crossing (GSLAC) feature of the NV center at a background magnetic field of 102.4 mT. Following the first approach, we investigate the feature parameters for precise alignment in a dilute diamond sample; the second approach extends the sensing protocol into absorption via detection of the GSLAC in the diamond transmission of a 1042nm laser beam [1].

The third approach in addition of the laser radiation, employs microwave field in different frequency ranges. When the microwave field frequency is in the range of 5,9 GHz we are studying microwave radiation caused resonant depolarisation of the NV centres in the ground state due to traditions between mixed levels in the vicinity of anti-crossing point and distant spin state magnetic sub-level.

If the microwave field frequency is much lower, below 100 MHz, we are studying NV centre angular momentum resonant depolarisation by the microwave radiation causing transitions between magnetic sub-levels in the vicinity of the anti-crossing point.

All the studies are supported by the model of NV centre interaction with light in the presence of magnetic field and microwave radiation, based on our previous experience of similar studies in atomic systems [2].

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Optical vortex microscopy - object reconstruction

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Optical Vortex Scanning Microscope (OVSM) uses focused laser beam with an optical vortex to scan the sample. The current setup of the OVSM was presented in [1]. The setup is based on the carrier frequency interferometry. Optical vortex is generated by spiral phase plate (vortex lens). The optical vortex can be moved inside the focused light spot by shifting the vortex lens [2, 3]. The range of this movement in the observation plane is reduced comparing to the range of the vortex lens shift. Thus, we have a precise way for sample scanning. This new scanning method was tested experimentally with simple phase micro-objects. It was shown that our system is sensitive to small phase disturbances which have an impact on both optical vortex position and phase profile [4,5].

One of the challenges for the OVSM is finding the effective procedures for surface topography reconstruction. We proposed a new experimental setup shown to support the works focused on this problem. The Spatial Light Modulator (SLM) is used as an object generator. SLM allows to introduce any phase disturbance with specified value and size into the beam. SLM is illuminated by the vortex beam (beam carrying optical vortex). Our system gives an opportunity to measure optical vortex response due to phase modifications introduced by the SLM.

Experimental setup of OVSM, new setup to measure optical vortex reaction to simple phase object, object reconstruction algorithm and experimental results will be presented. This results show the way in which OVSM should be developed.

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Numerical simulation of circular dichroism enhancement in gold nanorods array

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Since the discovery of negative refraction in artificial, great attention has been paid to the development of novel effects, such as: super resolution, predefined spatial distribution and values of constitutive parameters, etc [1]. While this field of research is very promising, metamaterials are strictly limited by high losses and the resonant nature of composite structures. Focusing on these facts, we have considered the effect of enhancement of circular dichroism (CD) for chiral medium in a periodic array of gold nanorods. Using conventional definition of bi-isotropic constitution equation in formulation of Lindell-Sihvola the bi-isotropic optical coefficient was extracted from the experimental CD spectra of HgS nanocrystals [2].

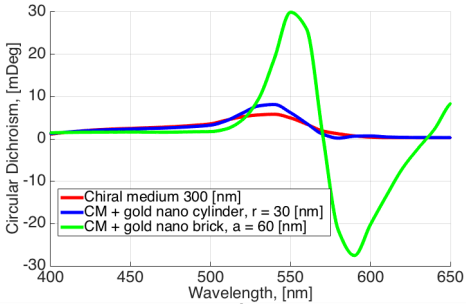

Figure 15: Circular dichroism spectra for chiral layer of HgS nanocrystals (h = 300nm and period = 110nm) and enhancement of circular dichroism of HgS nanocrystals inside the periodic array of golden nanocylinders (r = 30nm) and nanobricks (a = 60nm).

Using COMSOL Multiphysics, we obtained the CD spectra from the transmission of left and right circularly polarized light through a chiral medium both with and without a rectangular grid of gold nanocylinders/nanobricks see in Fig.1. This work demonstrated that the effect of CD enhancement grows from the resonant amplification of chiral medium absorbance via golden nanorods array and also CD enhanced by the near field scattering from periodic structure which supports longitudinal component of electromagnetic field that switches metamaterial in hyperbolic regime.

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Probing meat freshness by visible and near-infrared spectroscopy

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Among meat processing techniques, optical methods, especially the spectral techniques in visual and near-infrared wavelengths are among recent advances promising for non-destructive, fast, real-time, online monitoring of meat [1]. The color of meat is largely determined at the meat surface by the relative amounts of three forms of myoglobin, i.e. deoxymyoglobin, metmyoglobin, and oxymyoglobin. The subsequent changes can be detected non-destructively and sensitively by visible absorption characteristics [2]. In this study, changes in reflectance spectra of meat have been detected at room temperature by means of visible and near-infrared spectroscopy. We have used two different setups including a portable hand-held spectrophotometer coupled with a linear array of optical fibers for spectral measurements within 400-1000 nm wavelength range and a spectrophotometer with an integrating sphere with two detectors to measure a larger range (400-1700 nm). From the pictures below (Fig. 18), it can be seen that the absorbance spectra measured at different times are easily distinguishable. Moreover, the wavelengths around 760 nm (Fig.18.a), 970 nm (Fig.18.b), 1200 nm (Fig.18.c) responsible for fat content and near 1600 nm (Fig.18.d) for protein content, change. In addition, the reflectance intensity for specific wavelengths during time has a decreasing trend indicating degradation of the components.

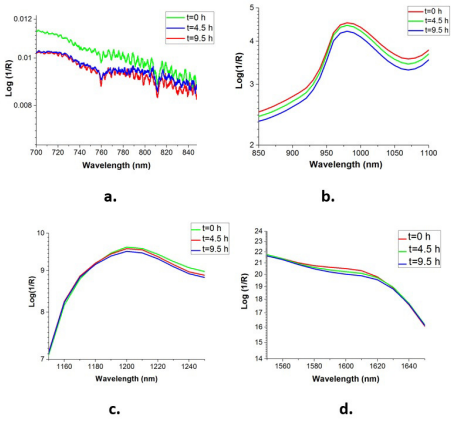

Figure 16: Significant changes in reflectance spectra for three different times for second setup.

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Estimation of Mn and Co valence states of $Sr_{1-x}Ce_xMn_{1-y}CoO_{3-\delta}$

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We present results of measurement of temperature dependence of valence state and soft X-ray absorption spectra of double-substitution $Sr_{1-x}Ce_xMn_{1-y}CoO_{3-\delta}$ solid solutions. It was found that in the solid solution $Sr_{0.8}Ce_{0.2}Mn_{0.8}CoO_{2.96}$, cobalt and cerium ions are in the Co^{2+} and Ce^{4+} valence states, respectively. About 90% of manganese ions in $Sr_{0.8}Ce_{0.}2Mn_{0.8}CoO_{2.96}$ are in the $4+$ state, and the rest of them are in the $3+$ state. About 75% of cobalt ions are in the higt-spin Co^{3+} state and 25% of cobalt ions are in the $2+$ state. X-ray spectroscopy results coincide well with the results of magnetic measurements of the same samples.

Acknowledgement

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Tunneling luminescence studies in SrAl2O4:Eu, Dy

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A long afterglow luminescent material SrAl2O4:Eu,Dy was prepared by high temperature solid-state reaction method. This material is widely applicable due to its high luminescent efficiency and remarkably long afterglow. The processes responsible for long lasting luminescence were studied by means of luminescence spectra, thermally stimulated luminescence and afterglow kinetics. Two processes are found to contribute in excited Eu2+ creation – the thermally released electrons direct recombination with Eu3+ and electron tunneling from a trap to Eu3+. The mechanism for long afterglow is proposed including both processes and the possible contribution of these processes at different temperatures is discussed. Previously only thermally stimulated processes were considered to be responsible for the long lasting afterglow of the material. Proof for tunneling luminescence processes in this material is presented.

Studying nanoparticles effect on RBCs aggregation with optical tweezers

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Nowadays nanoparticles (NPs) are widely used for different needs, from industry to biomedicine. Despite benefits bringing by NPs, basic principles of NPs interactions with living cells is not understood yet [1].

Our double-channel optical tweezers setup allows trapping red blood cells (RBCs) by two focused laser beams. To evaluate aggregation of RBCs, the aggregating force Fa were measured (see Fig. 18) - the minimum force required to stop RBCs from overlapping [2] when cells being in contact with each other. RBCs were incubated with different NPs at the 0.01 wt% concentration. The aggregation force for untreated RBCs in platelet-free donor plasma was Fa $= 7.9 \pm 3.5$ pN and served as a control.

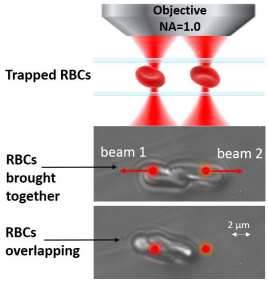

Figure 17: Aggregation force measurement between two trapped RBCs.

After 1h incubation with nanodiamonds (Kay diamond, USA) with the average diameter of 100 nm, the aggregation force increased to Fa $= 14.3 \pm 5.2$ pN; the similar effect, Fa $= 14.0 \pm 4.6$ pN, was observed for RBCs treated with RODI TiO_2 NPs 240 nm in size (Kemira, Finland). In contrast, no changes were observed, comparing to the control when RBCs were treated with Hombitan TiO_2 NPs 180 nm in size (Kemira, Finland) and ZnO NPs (Sigma-Aldrich, Germany) with the average diameter of 300 nm, where aggregation forces were Fa $= 8.4 \pm 3.6$ and Fa $= 7.3 \pm 3.7$, respectively.

The study reveals that NPs of certain size and material affect RBCs aggregation. We suggest these NPs can cause the thromboembolic effect if intravenously introduced.

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Biocompatible polyelectrolyte submicron capsules as delivery platforms for GFP gene expression

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Porous vaterite containers are studied with respect to intracellular drug delivery applications. This will permit control of the pharmacokinetics allowing for applications like preventive drug administration or scheduled application of pharmaceuticals during long term therapy. Experiments with various types of payloads, providing different molecular weights and zetapotentials, demonstrate a flexible way of tailoring the payload delivery time via the molecular properties of the cargo. A cellular uptake experiment shows no cytotoxicity, no influence on cell viability, and fast penetration of substance-loaded containers into cells. Release from polyelectrolyte multilayer microcapsules represents one of the most important steps enabling practical use of the microcapsules [1-3]. In this paper we aim to assess the in vivo cellular uptake and delivery siRNA by polyelectrolyte microcapsules for green fluorescence protein (GFP) gene expression. This mechanism aims at drug delivery applications involving scheduled administration or time-controlled delivery before reaching the release site, where it has clear advantages over common carrier systems exhibiting release directly after release [4-5]. A number of biological and non-biological applications are envisaged by proper encapsulation of molecules of interest and their release performance. In photodynamic therapy (PDT), photosensitizers are required to arrive in high concentrations at selective targets like cancer cells avoiding toxicity in healthy tissue. In this work, we propose the application of delivery system in the form of polyelectrolyte submicron capsules for this task

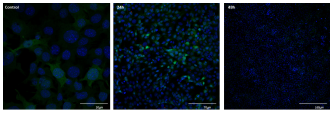

Figure 18: Confocal images of the Mk4 GFP cells after siRNA knock down GFP transfection

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The Impact Of Microorganisms To Modify The Induction Of Chlorophyll Fluorescence In Vetch Plants Planting On Soils Contaminated With ^{137}cs

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In the presented research,we present the results of the the photosynthetic apparatus of *Vicia sativa* L., grown on soils contaminated with ^{137}Cs assessment using "Floratest" fluorometer.Induction of chlorophyll fluorescence (IChF) method was used to estimate the state of plants photosynthetic complex by examining the curve, generated as a result of measurements.

Presented research aimed to determine the parameters of IChF curve for vetch plants. Plantswere inoculated with 5 species of bacteriathat might potentially block radionuclide uptake (*Agrobacterium radiobacter* IMBB-7246, *Azotobacter chroococcum* UKMB-6082, *A. chroococcum* UKMB-6003, *Bacillus megaterium* UKMB-5724, *Rhizobium leguminosarumbv. viceae*) and grown in sod-podzolic,chernozem andpeat-bog soils, contaminated with ^{137}Cs (4000 Bq/kg).

In accordance with our results, combination of soil radionuclide contamination and presence of *B.megaterium* UKM B-5724 is the most stressful for photosynthetic complex of plants, as the number of inactive chlorophyll increased. Other bacteria have not shown inhibiting effect in almost all types of soil.

Non-invasive evaluation of skin pathologies by RGB autofluorescence imaging

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The goal of the study was to develop a method for the evaluation of skin diseases by analyzing planar distribution of intensity and photobleaching parameters in RGB images. Autofluorescence images of healthy and diseased human skin excited in vivo using 405 nm LEDs were periodically captured by a smartphone RGB camera. Overall images from 43 subjects with benign and malignant lesions were investigated using MATLAB and Python software. Photobleaching analysis was conducted using a modification of an algorithm described previously [1]. The autofluorescence intensity at green channel of each image was extracted for further image processing. Background intensity of each pixel in the new images was first found and then subtracted to isolate autofluorescence intensity values. Ranges of photobleaching parameter values and pixel intensity values will be compared for different skin diseases to find the best evaluation method when analyzing new images.

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Modelling light propagation in healthy and pathological human skin

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As increasingly more people expose their skin to the sun while traveling or ultraviolet radiation sunbaths for cosmetic purposes, various types of skin cancers, including melanoma, become more widespread due to the excess ultraviolet radiation absorbed by the skin which can cause damage to skin cell DNA, creating uncontrollable cell growth [1]. Early diagnosis of skin cancer leads to far better survival rates and lower treatment costs, as the cancerous growth can be simply removed from the surface of the skin before it has spread to deeper layers.

A method of diagnosis is proposed in this study, which involves the analysis of skin chromophore maps attained with multispectral imaging for the purpose of differentiating benign and malignant cases of skin pathologies. The validation of this technique is performed by the inverse Monte Carlo method, which involves modelling light interaction with human tissue [2]. Monte Carlo modelling has been tested and proven to be an accurate representation of this light-tissue interaction by multiple studies [3].

The results of this research show that this inverse Monte Carlo approach combined with the chromophore mapping technique lets us determine the concentrations of different chromophores within the affected tissue. This information then in turn allows to determine whether or not this pathology is malignant.

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Intralipid thawing observation by Laser Speckle Contrast Imaging

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Laser Speckle Contrast Imaging (LSCI) is a powerful low cost method allowing non-contact, full-field and real-time flow systems mapping. It is widely known that laser speckle is a random phenomenon which has been statistically described by Goodman [1]. If any parts of illuminated object are moving it is introduces blurring of the speckle pattern during observation with fixed camera exposure duration. The blurring leads to a reduction in speckle contrast and can be used to obtain information about movement in object by statistical analyzing of blurring degree.

In current study, with the ultimate aim to understand the speckle patterns formation in the non-ergodic to ergodic phase transition LSCI approach has been applied for monitoring of dynamics of thawing of the Intralipid samples. Thawing is a complex process during which the dynamic properties of the scattering medium are changed dramatically. In the experiments, "frozen" speckle patterns for solid sample of frozen Intralipid without any motions, a Brownian motion after the total thawing of the sample, and convectional centrifugal micro-flows in the intermediate thawing stage have been observed.

The obtained results demonstrate the essential potential of LSCI as a powerful tool for widely available application not only in the perfusion mapping, but also for monitoring and characterization of complex processes in liquids, including e.g. observation of convectional centrifugal micro-flows in the intermediate thawing stage. Current study has a strong potential to be used in future studies of speckle patterns formation in the non-ergodic to ergodic phase transition and development of phenomenological model.

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The triplet and singlet ”twins” low-lying electronic states of UO_3 molecule

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Practical significance of uranium trioxide is, first of all, connected with nuclear energy requirements. But there is a great interest from a fundamental point of view. Considerable attention is directed for the determination of the electronic structure and geometry of this molecule. Experimental studies of the molecular uranium trioxide carried out at low temperatures in argon matrix and *ab initio* calculations indicated not typical for most trioxides C_{2v} point group for the molecule. But all the computation studies for the UO_3 molecule were performed in single configuration approximation. Thus, a research of the electronic structure using quantum chemical methods of high-level theory is worthwhile.

We carry out calculations of potential energy surfaces (PESs) of the ground and first exited states as functions of internal coordinates at the multi-configuration CASSCF(6,8) level of theory with the SA-procedure for 2 states (triplet and singlet). We used Stuttgart ECP80MWB for U atom and corresponding TZ basis set, cc-pVTZ basis set for O atom. We firstly determined triplet to be a ground state near the PES minimum of the UO_3 molecule. The energy difference between the ground triplet and first exited singlet electronic states along the diagonal intersection of the the PESs is presented in Fig. 19. The PESs are situated very close, the difference between states at the minimum of the ground state (for example, at (118.14°, 118.14°)) is about 15 cm^{-1}. Up to (109.20°, 109.20°) singlet state is the lowest one, but then singlet and triplet states are swapped and the triplet occurs to be a ground state. The triplet state indicates transient character of chemical bonds and possible paramagnetic properties of the UO_3 molecule, that offer possibilities for studying such molecules in magnetic traps, instead of matrices, which can interact with single molecules.

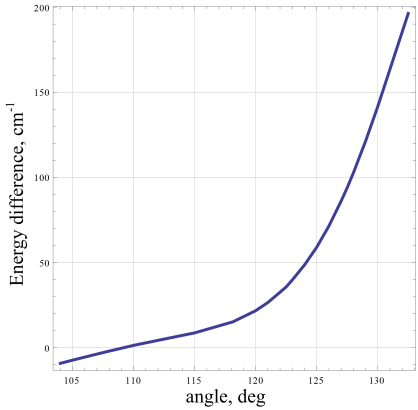

Figure 19: Energy difference between the ground and first exited states of UO_3 molecule.

Spectral properties of adamantane-containing compounds, promising for the development of antibacterial drugs: experimental and theoretical insights

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The adamantane derivatives represent a class of organic compounds finding extensive medical applications owing to their ability to therapeutic activity. It is found that the presence in the structure of compound adamantyl group almost always increases the degree of its biological activity. In this work the structural and spectral characteristics of adamantane derivatives (3-(adamantan-1-yl)-1-[(4-benzylpiperazin-1-yl)methyl]-4-phenyl-1H-1,2,4 triazole-5(4H)-thione, $C_{30}H_{37}N_5S$, or compound I, and 3-(adamantan-1-yl)-4-ethyl-1-[(4-phenylpiperazin-1-yl)methyl]-1H-1,2,4-triazole-5(4H)-thione, $C_{25}H_{35}N_5$, or compound II) were studied.

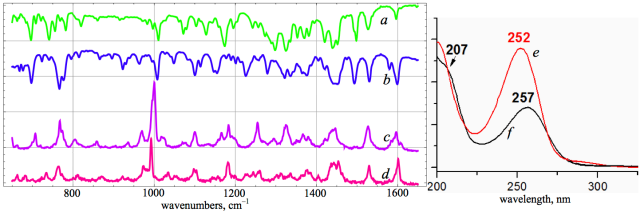

Figure 20: The FTIR (a, b), Raman (c, d) and UV/Vis (e, f) spectra of the compound I (a, c, e) and II (b, d, f).

The FTIR spectra (Fig. 20, a, b) have been measured in reflection mode in the range of 3200–650 cm^{-1}. Raman scattering spectra in the range of 3200–150 cm^{-1} (Fig. 20, c, d) have been measured using a second harmonic (532 nm) of the Nd:YAG laser. The electronic absorption (UV/Vis) spectra of the solutions of the compounds in ethanol (Fig. 20, e, f) have been measured in the range of 450–200 nm. Calculations of the structural and spectral vibrational characteristics of the molecules were performed using the standard cc-pVDZ basis by DFT methods with the help of the hybrid B3LYP functional. Calculations of the UV/Vis spectra were performed in the TDDFT and MRPT (Multi Reference Perturbation Theory) approximations. On the basis of the calculations the complete interpretation of the spectra was obtained. The biological activity indices Pa (probability to be active) have been predicted. The predicted Pa indices have high values. For example, the Pa value for analgesic activity for the compound I is 0.816. The comprehensive experimental and theoretical studies of the optical properties of some adamantane-containing compounds carried out, and it may be useful in medicinal chemistry and for the drugs design.

Spectroscopic studies of bismuth containing high frequency electrodeless light sources

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In this work we compare emission spectra of bismuth containing high frequency electrodeless lamps (HFEDLs) made at Institute of Atomic Physics and Spectroscopy, and commercially available lamps.

HFEDLs usually are made of SiO_2 glass filled with buffer gas and working element, in this case buffer gas is argon and working element is bismuth. Lamp consists of spherical bulb with diameter of 1 cm and small side arm.

Plasma under study are HFEDLs with different fillings: (1)$BiI_3 + Ar$ (buffer gas pressure 3.1 Torr), (2) $Bi + SbI_3 + Ar$ (buffer gas pressure 2.8 Torr), and commercially available HFEDL containing bismuth. To excite plasma the lamp is placed in electromagnetic field with frequency of 250 MHz. Lamps are operated at different excitation generator voltage values (21 - 29 V).

The emission spectra of the light sources are registered by means of Ocean Optics spectrometer HR4000 (with diffraction grating 300 lines/mm and CCD array with 3648 pixels, covered wavelength range 200-1100 nm).

The preliminary measurement results indicate the occurrence of self modulation regime at voltage values above 23 V for HFEDLs made at Institute of Atomic Physics and Spectroscopy, as well as emission of different molecules, for instance BiI (at 428 nm) and OH (at 310 nm).

The work was partially supported by program “Multifunctional materials and composites, photonics and nanotechnology” (IMIS 2, Project No 1, Photonics and materials for photonics).

High Resolution Spectroscopic Study and Deperturbation Analysis of the $A^1\Sigma^+$ and $b^3\Pi$ states of Cesium Dimer by Laser Induced Fluorescence.

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In homonuclear as well as heteronuclear diatomic alkali molecules that contain heavy atoms, e. g. Rb or Cs, the lowest excited $A^1\Sigma^+$ and $b^3\Pi$ states are strongly coupled due to the strong spin-orbit interaction. Because of this, these entangled states may be considered as a single A-b complex with intricate energy level structure. The A-b complex is highly relevant because of the opportunity of its usage as intermediate states for relocating the vibrationally excited cooled molecules into their absolute rovibronic ground state $X^1\Sigma^+$ ($v_x = 0$,$J_x = 0$). In order to provide an accurate description of such a system thorough experimental study and elaboration of the deperturbation method is needed. In the present work we continue the study of the $A^1\Sigma^+$ and $b^3\Pi$ states of Cs_2 molecule performed in [1]. We aim to obtain more systematic data, which cover larger energy range, and to apply coupled – channel deperturbation method in order to describe the complex with an experimental accuracy c.a. 0.01 cm^{-1}, similarly as in KCs [2]. Laser induced fluorescence spectra A-b $--> X^1\Sigma^+$ were recorded by Fourier transform spectrometer (Bruker IFS125 HR) with a resolution 0.03 cm^{-1}. Cesium molecules were produced in the stainless heat - pipe. The laser beam was sent into the heat - pipe passing through a pierced mirror and the backwards fluorescence was collected by the same mirror and focused on the input aperture of the spectrometer. The titan-sapphire laser (MBR 110, Coherent) was used for excitation. Currently, applying direct excitation of the A-b complex we have obtained more than 1500 term values which are involved in the fit. The refined deperturbation model can reproduce the term values (more than 95 percent) of the A- b complex with a very small standard deviation of 0.005cm^{-1}. This study is performed in collaboration with A.V. Stolyarov and E.A. Pazyuk (Moscow State University, Department of Chemistry). The support from State Research Program IMIS[2] and State support within program A5-AZ27 is gratefully acknowledged.

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Modulation polarimetry of plasmonic nanostructure

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Researches of surface plasmons resonances phenomenon provide fundamental knowledge in solid-state physics of nanomaterials. The modulation polarimetry technique allows to detect any types of resonant interaction: resonant excitations of surface plasmons po- laritons (on infinite flat metal-dielectric surface) or localized surface plasmons (on sepa- rated metal nanoparticles and between metal nanoparticles due to electrodynamic/dipole-dipole interactions).

Systematic investigations of informativeness of polarization difference parameter were performed. The registered signal is the polarization difference (,) = Rs - Rp, which is a magnitude of difference between the intensities of the reflection coefficients of s- and p-polarized light (Rs and Rp, respectively). The parameter is a Q-component of the Stokes vector. Recently, the diagnostic method of modulation polarimetry proved to be effective for the study of porous film and composite structures [1, 2, 3, 4]. In the work [4], the morphology properties of surface zeolite layers with the different thickness on silicon wafers have been studied by using MPS technique.

This parameter characterizes the amplitude anisotropy of metal r composite nanofilms. This modulation technique involves various experimental configurations: external, internal reflection and spectroscopy of angle of isotropic reflection.

Modulation polarimetry is a highly informative instrument for characterization of optical and morphological features of metal, metal-dielectric and semiconductor nanostructures.

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