21ST INTERNATIONAL YOUNG SCIENTIST CONFERENCE

"DEVELOPMENTS IN OPTICS AND COMMUNICATIONS"

DOC 2025

MAY 8TH - 10TH, 2025

- Optical Materials and Phenomena
- Laser Physics and Spectroscopy
- Communications
- Biophotonics
- Vision Science

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ABSTRACT BOOK

SWEB
Smart Windows for Zero Energy Buildings

UNIVERSITY OF LATVIA
FACULTY OF SCIENCE AND TECHNOLOGY

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LATVIJAS UNIVERSITĀTES
CIETVIELU FIZIKAS INSTITŪTS
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DOC 2025 Abstract Book

21st International Young Scientist Conference

Developments in Optics and Communications 2025

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Welcome

Dear participants of **DOC 2025,**

The Organizing Committee kindly welcomes you to the 20th International Young Scientist conference “Developments in Optics and Communications 2024”. The purpose of this conference is to bring together students and young scientists to discuss latest scientific results and upcoming trends in the fields of optics and photonics.

“Nothing in life is to be feared, it is only to be understood. Now is the time to understand more, so that we may fear less." – Marie Curie

Imagination is not confined to the realm of the artist or the dreamer—it is the spark that ignites every scientific breakthrough. While art gives us new ways to see the world, science, too, demands vision: a bold, creative leap into the unknown. In physics, imagination allows us to peer beyond what is visible, to propose unseen forces, hidden particles, and unfamiliar dimensions. It is the act of envisioning the invisible that leads to discovery. Just as Marie Curie imagined what lay hidden within the atom, modern physicists and vision scientists continue to rely on the courage to wonder—pushing boundaries, questioning the known, and daring to ask, what if? The path to understanding begins not with data, but with vision.

The Organizing Committee sincerely hopes that you will enjoy this conference and get new ideas and collaborations for your future in research

Best regards,
DOC 2025 Organizers

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Daniela Jermacane

Invited Speakers

Towards ‘EMERGE’ing sustainable printed electronics

Mohammad Yusuf Mulla
Research institutes of Sweden (RISE), Printed-Bio & organic electronics, Smart Hardware department, Digital systems division. Norrköping (Sweden)
E-Mail: yusuf.mulla@ri.se

Rapid digitalization of society has strained the natural resources aggravating the environmental challenges. Displays, sensors and electronic devices have become ubiquitous aspect of our day to day lives. Moreover, with the advent of low power and fast communication modes, Internet of Things/sensors (IoT/S) are now inherent part of our society. Increasing demand of such electronic devices traditionally based on non-sustainable materials & processes is adding into electronic-waste or e-waste in millions of tons. This raises need for future electronics to be based on sustainable alternative process and materials.

This talk will provide overview of developments towards ‘Green electronics’, addressing the pressing questions around sustainability, recyclability and biodegradability of electronic displays, sensors and circuitry. Sustainable processes such as photonic sintering, laser induced graphitization of sustainable materials will be discussed. Printed displays, energy storage, energy harvesters to sensors and circuits manufactured using sustainable additive manufacturing will be addressed. Electronics ‘Using’& ‘On’ sustainable materials such as cellulose, wood will be presented.

In addition, free offerings of state-of-the-art research infrastructure and expertise related to photonic and printed electronics by an EU project EMERGE will be discussed. Success stories from past EMERGE projects involving printing of sensors to antennas will be presented, highlighting the essence of collaborative sharing of research infrastructure with global community to help build green and sustainable society for future generations.

Acknowledgment: Thanks to the EMERGE project funded by European Commission’s Horizon 2020 research and innovation program under grant agreement number 101008701.

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Positronium laser cooling

Valts Krūmiņš
University of Latvia, Faculty of Science and Technology, Laser centre
AEgIS collaboration, CERN
E-Mail: valts.krumins@lu.lv

Positronium is the short-lived bound state between a positron and an electron. As a purely leptonic system, it is useful for bound-state QED tests and constraining violations to the Weak Equivalence Principle in the lepton sector. So far the precision of positronium measurements has been limited by the large velocity distribution of positronium sources.

The first Doppler laser cooling of positronium was performed at AEgIS (Antimatter Experiment, Gravity, Interferometry, and Spectroscopy) experiment based at CERN's Antimatter Factory [1]. It was achieved using 13S-23P transition in the 142 ns lifetime of the ortho-positronium. An alexandrite laser was custom-designed and built for the requirements of this experiments - pulse energies of several mJ in the deep UV (243 nm), bandwidth of about 100 GHz, pulse duration above 100 ns with a fast falling edge. Positronium cooling was observed by measuring the Doppler broadening of its 13S-33P line with a second laser, right after cooling was completed. The equivalent temperature of the positronium atoms exiting from a porous target (at room temperature) hit by a positron beam decreased from 380 K to 170 K.

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Statistical signal and image processing for eye research

D. Robert Iskander
Department of Biomedical Engineering,
Wroclaw University of Science and Technologies, Poland
E-Mail: robert.iskander@pwr.edu.pl

The lecture will cover three selected topics of undergoing research studies, in which statistical signal and image processing found to be applicable.

The lecture includes: (1) parsimonious modelling of cornea surface, (2) spectral characteristics of longitudinal eye movements and the discovery of ocular dicrotism, and (3) advances utilization of Optical Coherence Tomography speckle as a source of information.

Optical components under radiation: the case of densified silica

Nadège Ollier
Laboratoire des solides irradiés– IRAMIS CEA, Institut Polytechnique Palaiseau
E-Mail: nadege.ollier@polytechnique.edu

Silica glass is appreciated for its wide range of applications in optics, electronics, and materials science. Besides anomalous properties such exhibiting negative thermal expansion within specific temperature ranges, silica shows an ability to undergo irreversible densification under pressure. It can reach 20% of densification under 25 GPa at room temperature. One additional interesting property of silica glass is polyamorphism [1], which refers to the ability of a material to exist in multiple amorphous states with high-density amorphous (HDA) and low-density amorphous (LDA) phases [2]. Under radiation, at high doses, silica glass transitions into a “steady” state referred to as the "metamict-like" phase, associated with a density of 2.26 [3-4]. In this talk we will review quickly as an introduction the behavior of silica based optical component such as optical fibers in radiative environment. Then we will expose recent results on the behavior of densified silica under high energy electron irradiation [4-5]. In particular, we will discuss about the effect of high temperature (up to 1000 K) during irradiation. Those results are particularly important to better understand or predict the behavior of sensors such as Fiber Bragg Grating optical fibers used for nuclear applications.

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Bridging the Gap: Overcoming Manufacturing Challenges Through Scientific Innovation in Photonic Technologies

Aleksejs Bendins
Institute of Solid State Physics, University of Latvia
*E-Mail:*aleksejs.bendins@cfi.lu.lv

In the dynamic field of photonic technology, the journey from scientific discovery to industrial application is often hindered by technical challenges, limited resources, and workforce shortages. This presentation explores how scientific research can actively resolve practical manufacturing bottlenecks, using real-world examples from the speaker's dual role in academia and industry. The presentation highlights the importance of fostering strong industry-academia collaboration, showcasing how this synergy accelerates innovation, optimizes production workflows, and addresses the persistent gaps in equipment and personnel capacity.

SWEB – Smart Windows for Zero Energy Buildings

Adaptive Chromogenic Material for Smart Windows

Juris Purans
Institute of Solid State Physics, University of Latvia
E-mail: purans@cfi.lu.lv

The number of buildings featuring glass facades or large windows is steadily increasing, driven by rising living standards and evolving architectural trends. This shift highlights the growing need for energy-efficient building solutions. One promising approach involves the development of advanced glass coatings with tailored optical properties to [1] reduce heat transfer through windows and [2] block irritating visible (VIS) and ultraviolet (UV) light. Chromogenic thin films—such as electrochromic, thermochromic, and photochromic materials—are at the forefront of smart window (SW) technology and are expected to play a crucial role in the future of sustainable building design.

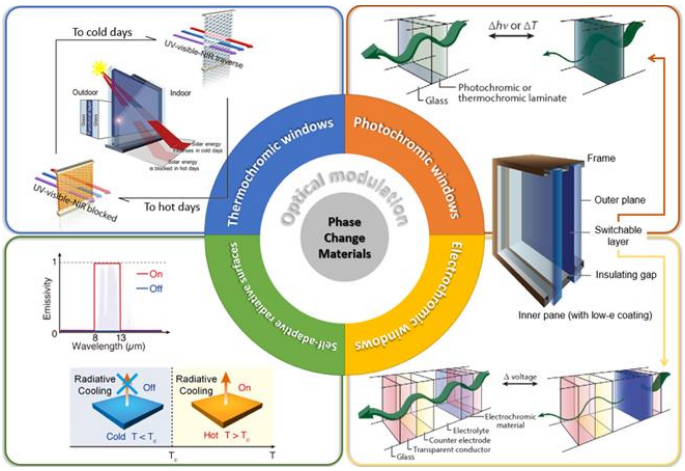

Figure 1. Schematics of adaptive for optical modulations, their mechanisms, and applications in energy-efficient windows: thermochromic windows, photochromic, electrochromic and self-adaptive radiative surfaces. Electrochromic and photochromic SW colour in response to the applied voltage and light, respectively. Thermochromic SW responses to the temperature.

Within the EU HORIZON project Smart Windows for Zero Energy Buildings, innovative single and multi-layered transition metal oxide (TMO) thin films have been designed and fabricated. These include electrochromic (WO_3 and NiO) and photochromic rare-earth metal oxy-hydrides Y-H-O, utilizing advanced reactive magnetron sputtering and industrially scalable roll-to-roll (R2R) deposition techniques.

Acknowledgment: Financial support was provided by the Project "Smart Windows for Zero Energy Buildings" (SWEB) GA nr. 101087367.

Functional Nanomaterials for Additive Manufacturing and Smart Windows

Boris Polyakov, Tamara Tsebriienko, Annamarija Trausa, Aleksandrs Novikovs.
Institute of Solid State Physics, University of Latvia
E-mail: boris.polyakov@cfi.lu.lv

Spray deposition and inkjet printing of various nanostructures are emerging complementary fabrication methods of additive manufacturing for creating functional coatings. Digital inkjet printing allows precise jetting of uniform droplets onto different substrates such as flexible plastic sheets, glass, silicon, etc. Small droplets (down to 1 picoliter) are produced by small diameter nozzles, which place strong requirements on both nanostructure size and physical properties of inks (viscosity, surface tension, boiling temperature). Spray deposition of functional inks has compromised resolution compared to inkjet printing, but can be used for covering of large area substrates, and benefits from less strict requirements for nanomaterials size. In particular, it allows to use nanowires (NWs) up to few tens of μm long, which is impossible for inkjet printing. Both techniques can be used for creating electrically conductive coatings by using metal nanostructures for deposition. Compared to well-established vacuum metal coating and lithography-based metallization processes, where metals are deposited from bulk metal targets using complicated manufacturing equipment (magnetrons, e-beam and thermal evaporators), spray deposition and printing benefit from significantly simpler equipment but are more demanding in choosing the materials and often involve post processing like sintering or annealing to improve electrical conductivity and performance of the coating.

In the present lecture will be given a brief overview 0D and 1D nanomaterials and their synthesis methods, and applicability of these nanomaterials for additive manufacturing (with focus on inkjet printing).

Acknowledgment: This research was supported by the Horizon Europe project SWEB No. 101087367.

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Adaptive Photochromic Thin Filma for Smart Windows

Smagul Karazhanov
Institute of Solid State Physics, University of Latvia
E-mail: smagul.karazhanov@cfi.lu.lv

Within the EU HORIZON project Smart Windows for Zero Energy Buildings, photochromic rare-earth metal oxy-hydrides Y-H-O, utilizing advanced reactive magnetron sputtering and industrially scalable roll-to-roll (R2R) deposition techniques.

We investigate the effective oxidation state and local environment of yttrium in photochromic YHO thin film structures produced by e-beam evaporation, along with their chemical structure and optical properties. Transmission electron microscopy images reveal the oxidized yttrium hydride thin film sample exhibiting a three-layered structure. X-ray photoelectron spectroscopy (XPS) measurements manifest that the oxidation state of yttrium is modified, dependent on the film's composition/depth. Furthermore, Ion beam analysis confirms that this variability is associated with a composition gradient within the film. X-ray absorption spectroscopy at the Y K-edge reveals that the effective oxidation state of yttrium is approximately +2.5 in the transparent/bleached state of YHO. Spectroscopic ellipsometry investigations showed a complex non-linear optical depth profile of the related sample confirming the dominant phase of YHO and the presence of $Y(_2)O(_3)$and Y towards the middle of the film. The first evidence of (n; k) dispersion curves for e-beam sputtered photochromic YHO thin films are reported for transparent and dark states.

Acknowledgment: Financial support was provided by the Project “Smart Windows for Zero Energy Buildings” (SWEB) GA nr. 101087367.

Spectroscopic Ellipsometry for In-depth Optical and Structural Profiling of Photochromic Yttrium Oxyhydride Thin Films

Ilze Aulika[1], Halil Arslan[1], Martins Zubkins[1], Alexey Kuzmin[1,] Smagul Karazhanov[1,2], Juris Purans[1]

[1] *Institute of Solid State Physics, University of Latvia, Riga, Latvia*

[2] *Institute for Energy Technology, Kjeller, Norway*

E-mail: ilze.aulika@cfi.lu.lv

Spectroscopic ellipsometry (SE) serves as a powerful, non-destructive technique to investigate the spatial-depth-resolved optical behaviour and structural evolution in photochromic yttrium oxyhydride (YHO) thin films. This study consolidates several SE-based investigations to demonstrate its critical role in unveiling the complex internal architecture and optical transitions associated with photoactivation in YHO systems.

We present SE-derived optical constant profiles (n, k) for stoichiovariant photochromic YHO films produced by e-beam evaporation, highlighting the presence of YHO, Y_2O_3, and pseudo-metallic Y within layered substructures. These findings were corroborated by TEM, XPS, and ion beam analysis, which revealed a graded chemical composition influencing SE dispersion curves across transparent and dark states [1].

Further, reactive pulsed-DC magnetron sputtered YH_xO_y films were studied using SE to profile the variation in refractive index through the depth of the film. This revealed a strong correlation with porosity and oxygen incorporation, which increased under higher deposition pressures [2].

SE also enabled time-resolved tracking of absorption coefficients during UV exposure, helping to distinguish between vacancy-induced changes in the optical absorption spectra. These changes, linked to hydride and oxide anion vacancies, matched closely with first-principles calculations and EXAFS measurements, revealing light-induced lattice relaxation mechanisms that directly influence the film's refractive behaviour [3].

Additionally, new in-situ SE mapping of the (n, k) during continuous UV irradiation will be presented, offering real-time insights into the dynamic photochromic switching of YHO films. Collectively, these studies underscore the indispensable role of SE in understanding and optimizing the functionality of phototropic thin films for smart window applications.

Acknowledgment: This research is supported by Horizon Europe project GA 101087367 "Smart Windows for Zero Energy Buildings (SWEB)".

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Optical and photochromic properties of YHO/MoO3 thin films

Edvards Strods[1], Martins Zubkins[1], Viktors Vibornijs[1], Edvins Letko[1], Karlis Kundzins[1], Dmitrii Moldarev[2], Anatolijs Sarakovskis[1], Daniel Primetzhofer[2], Juris Purans[1]

[1] *Institute of Solid State Physics, University of Latvia*

[2] *Department of Physics and Astronomy, Ångström Laboratory, Uppsala University*

E-mail: edvards.strods@cfi.lu.lv

Yttrium oxyhydride (YHO) thin films have shown potential as smart materials due to their reversible photochromic effect, achieving a photochromic contrast (ΔT_{vis}) of up to ~50% under UV-blue light exposure. However, the precise structure of YHO and the underlying mechanism of photochromism are not yet fully understood. YHO thin films are synthesized through the oxidation of yttrium hydride (YH_2) [1]. Parameters such as sputtering pressure and film thickness critically affect thin film optical and photochromic properties [2].

In this study, to further investigate and enhance YHO photochromic performance, double-layer YHO/MoO_3 coatings were deposited. Given the mobility of hydrogen in YHO, it was hypothesized that combining YHO with MoO_3 could create a synergistic effect, as hydrogen from YHO might intercalate into the MoO_3 layer, partly reducing Mo cations and forming molybdenum bronze. Results show a photochromic contrast improvement from 25-30% with YHO alone to 60% for the YHO/MoO_3 thin films, along with an increased coloration rate. The photochromic response of the double-layer coatings can be fine-tuned by adjusting the thickness and density of MoO_3. Both XPS and NRA indicate the formation of molybdenum bronze through Mo reduction and an increased hydrogen content in the upper MoO_3 film, respectively.

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Preparation of MoSe2 and WSe2 shells around ZnSe nanowires via magnetron sputtering and selenization

Luize Dipane, Liora Kotlara, Viktors Vibornijs, Katrina Laganovska, Aleksejs Zolotarjovs, Eriks Dipans, Jevgenijs Gabrusenoks, Boris Polyakov, Edgars Butanovs
Institute of Solid State Physics, University of Latvia
E-mail: luize.dipane@cfi.lu.lv

In this work, the growth of ZnSe-$MoSe_2$ and ZnSe-WSe_2 core-shell nanowires (NWs) was successfully demonstrated, offering promising avenues for advanced nanoscale optoelectronic applications.

The ZnSe NW were fabricated via the vapor-liquid-solid (VLS) growth mechanism, while transition metal dichalcogenide ($MoSe_2$ or WSe_2) shells were formed through a combination of oxide layer deposition via magnetron sputtering and selenization process via chemical vapor deposition (CVD). The process temperature was optimized to ensure uniform morphology shell growth and high-crystalline-quality heterostructures.

Nanostructures were characterized using X-ray diffraction, transmission electron microscopy, X-ray photoelectron spectroscopy and Raman spectroscopy and photoluminescence spectroscopy.

Acknowledgment: This research was supported by Latvian Council of Science project no. lzp-2022/1-0311.

Biophotonics

Phase retrieval approach for transmission matrix identification in polytetrafluoroethylene

Anna Santosa, Sergejs Fomins, Varis Karitāns
Institute of Solid-State Physics, University of Latvia
E-Mail: anna.santosa@cfi.lu.lv

Transmission matrix identification is a vital process in characterizing complex optical systems and analyzing light propagation through scattering media. Phase retrieval techniques provide a robust solution to this challenge by eliminating the need for direct phase measurements. Utilizing iterative algorithms and intensity-only measurements, these methods enable the reconstruction of the transmission matrix, offering valuable insights into the interactions between incident and transmitted light.

In our setup, the spatial light modulator is implemented using a BMC 140 segmented deformable mirror, while the sensor is an astronomy-grade ZWO ASI PRO5200 Peltier-cooled camera. The optical system incorporates two microscope objectives with a numerical aperture (NA) of 0.4, and the design wavelength is set at 632 nm. For experimental validation, 32 randomized pattern registrations were conducted as control measurements, and the same protocol was applied to a 20-micron-thick polytetrafluoroethylene (PTFE) film, which holds as a tissue phantom. PTFE is widely used as a diffuse reflector due to its ability to scatter light uniformly and it is often employed as a standard for reflectance calibration. Subsequently, seven widely-used phase retrieval algorithms [1] were employed to reconstruct the phase information.

Our analysis highlights that the Fienup [2] and Twisted Wirtinger Flow [3] methods exhibit the highest stability against noise, whereas other algorithms demonstrated reduced reconstruction reliability. This methodology has broad applications across imaging, optical communication, and wavefront engineering, paving the way for enhanced control and precise manipulation of light in complex environments.

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The Dependence of Photoplethysmography Signal on the Placement of Optical Fibers and Photodiode on the Palm

Tomass Ozoliņš, Ilze Irbe, Edgars Kviesis-Kipge, Vanesa Lukinsone
Institute of Atomic Physics and Spectroscopy, Faculty of Science and Technology, University of Latvia
E-mail: tomass.ozolins@edu.rtu.lv

Photoplethysmography (PPG) is used in pulse oximetry to measure oxygen saturation (SpO_2) by analyzing the reflected or transmitted light through biological tissues [1][2]. The PPG signal consists of a constant (DC) and varying (AC) component, with latter fluctuating due to blood pulsations [1]. Differences in the absorption properties of oxyhemoglobin and deoxyhemoglobin at various wavelengths enable the use of both AC and DC components from different wavelengths for SpO_2 determination [3].

This study investigates the use of light from two infrared lasers (808 nm and 1064 nm) delivered to the palm via optical fibers, to assess the effect of source-detector distance (the distance from the tip of fiber to the photodiode) and the angular placement of fiber on the PPG signal's AC amplitude, DC value, and AC/DC ratio. Diffusely reflected light was measured on the thenar eminence of five subjects at source-detector distances of 4, 8, 12, 16, and 20 mm, with multiple fiber angular positions at each distance.

The findings confirm previous studies indicating that the AC/DC ratio increases with greater source-detector distances [2][4][5]. Additionally, the study addresses the previously underexplored effect of the fiber's angle on the PPG signal. At shorter distances (4 mm and 8 mm), AC amplitude increases with larger angle, whereas at longer distances (12 mm to 20 mm), AC amplitude decreases as angle increases.

This study fills a research gap by investigating the impact of optical fiber and photodiode placement on the palm for PPG measurements.

Acknowledgment: The study was supported by the Taiwan–Latvia–Lithuania Cooperation Program, project No. LV-LT-TW/2023/3.

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Laser physics and spectroscopy

Determination of electron temperature in As-Ar inductively coupled plasma

Markuss Lācis[1], Anda Ābola[1], Gita Rēvalde[1,2]
[1]Institute of Atomic Physics and Spectroscopy, Faculty of Science and Technology, University of Latvia
[2]Institute of Physics and Materials Science, Faculty of Natural Sciences and Technology, Riga Technical University, Riga, Latvia
E-mail: lacism129@gmail.com

Electron temperature is a critical parameter in plasma diagnostics, influencing both the efficiency and stability of high-frequency electrodeless lamps (HFEDLs). HFEDLs use quartz bulbs with a small extension ("tail") containing the target element and a noble gas buffer to aid excitation and minimize wall interactions. In our As-Ar lamps, mounting the bulb in a ceramic holder within an excitation coil and applying 11–29 V ignites a stable plasma, with the cooler "tail" sequestering excess metal for consistent emission.

In this study, we investigate the electron temperature in an As-Ar inductively coupled plasma generated within HFEDLs, employing a non-invasive optical emission spectroscopy method. Electron-impact excitation rate coefficients were determined using a modified Arrhenius formulation analogous to that applied in previous studies on bismuth-containing lamp plasmas [1]. A semilogarithmic Boltzmann plot was constructed from the intensity distribution of selected argon spectral lines to deduce the electron temperature with high accuracy. Furthermore, the relationship between electron temperature and the generator voltage was systematically examined, revealing how higher applied voltages correlate with electron temperatures. These findings offer valuable insights into the plasma dynamics in HFEDLs and provide a robust diagnostic tool for optimizing lamp performance and plasma-based processes.

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Theoretical modelling of fountain fringe field fast switching LCD cells

Ciro Tipaldi, Ainars Ozols[1]
Institute of Solid-State Physics, University of Latvia
E-mail: c.f.tipaldi@gmail.com

Liquid crystal displays (LCD) are an established technology in our modern world, being used in a multitude of appliances. Despite this, there are still a number of ways in which improvements are necessary. One such application in need of improvement is in virtual/augmented reality (VR/AR) devices.

LCDs suffer from a limitation regarding their switching speed which directly affects the frame rate of AR devices. While the switch from the diffuse state to the transparent state can be quickened by simply increasing the electric field intensity between the top and bottom electrodes, the reverse process is limited by the relaxation speed of the LC. By using fountain fringe field (FFF) technology together with fast switching cholesteric LC devices [1], an increase in switching speed of up to 20% is expected for the transition between the transparent and diffuse state. In this regard, however, there are multiple aspects which need to be researched and improved, one of those being optical transmittance which is known to suffer due to the additional ITO electrodes.

Finite element modelling in COMSOL Multiphysics has been employed in order to optimize the FFF cell that would be used in the prototype. The spacings and sizes of the electrodes and dielectric coatings have been varied and the respective optical transmittances across the cell obtained, noting the emerging relationships. The results of modelling have allowed to find the optimal electrode spacings and sizes and thicknesses of dielectric layers in the cell which yield the most optical transmittance in the FFF state.

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Development of SERS Substrates by Silver Deposition on Copper

Kokis Tots, Vitols Kaspars, Tipaldi Ciro Federiko, Sarakovskis Anatolijs
Institute of Solid State Physics, University of Latvia
E-mail: tots.kokis@cfi.lu.lv

In recent decades, Raman spectroscopy has gained increasing attention as an analytical tool for studying crystalline and molecular vibration modes, as well as identifying chemical bonds and substances. However, non-amplified Raman signals are often weak, particularly when measuring substances at low concentrations, due to background interference, including luminescence. Therefore, the development of surface-enhanced Raman spectroscopy substrates is necessary. [1]

This study explores the fabrication of Ag-Cu SERS substrates via galvanic displacement, a fast and efficient method for achieving uniform enhancement. [2] The study investigates how different parameters such as the concentration of silver nitrate ($AgNO_3$), choice of solvent (deionized water, acetone/DI water, and ethanol/DI water), and reaction time affect the structure and SERS performance of the substrates. SERS measurements were performed using different concentrations of Rhodamine B, and the limit of detection was evaluated. The morphology and arrangement of silver particles were characterized using scanning electron microscopy (SEM).

SEM images reveal different silver morphologies, including faceted polygonal particles and leaf-like dendritic structures, depending on the experimental conditions. SERS measurements demonstrate an enhancement for Rhodamine B concentrations as low as 10^{-9} M, with uniformity observed at higher concentrations.

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Vision science

Perception of coherent motion in school-age children with and without reading difficulties

Monta Gerina, Evita Kassaliete, Evita Serpa, Sanija Zepa un Alise Ramane
Department of Optometry and Vision Science, Faculty of Science and Technology, University of Latvia, LV-1586 Riga, Latvia;
E-mail: mgerina751@gmail.com

Abstract. Reading is a complex cognitive process and an important tool for language acquisition, communication, and the exchange of information and ideas. Difficulties in reading fluently and understanding what is read affect school learning [1, 2]. Reading difficulties may be associated with impaired motion perception, which is an important component of visual perception. Motion perception matures earlier and independently of the native language [3]. The coherent motion detection threshold may help distinguish reading problems in school-age children [4].

Methods. 99 children from two Latvian schools of basic education voluntarily participated in the study. The results were compared between good and poor or average readers among 53 students from 2nd and 3rd grade (9.8 ± 1.6 years) and 46 students from 5th and 6th grade (10.1 ± 1.7 years). The coherent motion threshold was assessed using two types of random dot kinematogram tests at approximately 50 cm. The participant's task was to indicate in which of the four directions the signal dots were moving at 2 °/s, 5 °/s, and 2 °/s under both positive and negative screen contrast conditions. The execution time was not limited, but the task had to be performed until the computer program automatically displayed the threshold value of coherent motion perception.

Results. The results did not show a statistically significant difference in the magnitude of coherent motion threshold values between the two age groups and between poor or average readers and good readers.

Conclusions. The obtained results demonstrate that there are no age-related effects and any impact of reading ability on the coherent motion threshold results.

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Image brightness matters: Visual perception and comfort in augmented reality

Edvards Apsitis, Polina Survilo, Elizabete Griva, Jelizaveta Botina, Gunta Krumina, Tatjana Pladere
Department of Optometry and Vision Science, Faculty of Science and Technology, University of Latvia
E-mail: edvards.apsitis@lu.lv

Introduction. As augmented reality (AR) technology is increasingly adopted in professional fields such as healthcare and defense, visual discomfort and perceptual inaccuracies can hinder its practical use [1]. While previous studies have examined vergence-accommodation conflicts [2] and inter-individual differences in visual adaptation [3,4], the impact of brightness on user experience remains underexplored. Since brightness affects contrast perception and eye strain, understanding its influence on user performance and experience is essential for optimizing AR displays. This study investigates these effects to enhance AR system usability in the future.

Method. Individuals with normal binocular vision participated in the study. A multifocal AR headset (Lightspace Technologies) displayed images at three brightness levels (200, 300, and 400 cd/m^2). Participants completed psychophysical tests assessing their ability to discern image details. Before each task, they adjusted an arrow to indicate perceived image depth. All images were projected at a 50 cm distance. A symptom questionnaire was administered before and after each set of six trials per brightness level.

Results. Image detail perception was comparable at 200 and 300 cd/m^2 but declined slightly at 400 cd/m^2. Depth judgments remained consistent across all three brightness levels. However, higher brightness levels increased eye discomfort, particularly fatigue and dryness. Inter-individual variations were observed, with some participants experiencing double vision and significantly overestimating distances.

Conclusion. Increasing brightness to 400 cd/m^2 reduced user performance and comfort in indoor settings. These findings emphasize the need to optimize brightness levels to enhance AR user experience and usability.

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The Relationship Between Eye Astigmatism and Accommodation Disorders in School-Age Children

Ieva Ance Buksa [1], Evita Kassaliete [1], Angelina Ganebnaya [1], Evita Serpa [1], Aiga Svede [1], Ilze Ceple [1], Karola Panke [1], Gunta Krumina [1], Peter Georgiev Ivanov [2]

[1] *University of Latvia, Faculty of Exact Sciences and Technologies, Department of Optometry and Vision Science*

2 External consultants (info@Peter-ivanov.com)

E-mail: ievaancebuksa@inbox.lv

This study investigated the potential link between eye accommodation disorders and astigmatism by comparing the differences in astigmatism type: with-the-rule (WTR), against-the-rule (ATR) or oblique and its origins (total, corneal, or lens astigmatism) in 82 school-age children aged 6 to 12 years (mean age 9 ± 2 years) with diagnosed accommodation disorders (hypofunction and hyper-function) and a control group. Objective astigmatism was measured using the Huvitz Auto Ref/Keratometer HRK-1, and data from sphero-cylindrical notation were converted into the form of Jackson crossed cylinder vectors (JCC) for further analysis. Keratometry data from clinically analyses groups showed that corneal astigmatism in school-aged children was predominantly WTR. In contrast, refraction data, representing total astigmatism, showed controversies as ATR astigmatism is dominant in participants with diagnosed accommodation hypofunction and in the control group, though WTR astigmatism is dominant in participants with diagnosed accommodation hyperfunction. We found statistically significant differences in astigmatism axis when com-paring objective refractometry and calculated lens astigmatism axis between the group with diagnosed accommodation hyperfunction and the control group. The accommodation hyperfunction group showed that refractive axis tends to oblique astigmatisms direction. Our results suggest that astigmatism axis may serve as an additional indicator when identifying possible accommodation disorders, especially accommodation hyperfunction.

Computerized Game-Based Vision Training

Anastasija Jakoviča, Gunta Krūmiņa, Jeļena Slabcova
Department of Optometry and Vision Science, Faculty of Science and Technology, University of Latvia
E-Mail: ap18271@edu.lu.lv

In the modern world, visual therapy is gaining importance due to the increasing prevalence of vision disorders, many of which are associated with prolonged digital device use and reduced physical activity. Symptoms such as dry eye syndrome, visual discomfort, myopia, and binocular dysfunction have become widespread [1], [2], [3]. Vision therapy aims to develop and strengthen neural connections between the eyes and the brain through structured visual training, enhancing key visual functions. With advancements in technology, computerized vision therapy has emerged as a popular approach, offering automated solutions with reduced subjectivity and improved patient engagement [4].

In the previous phase of the study, a computer-based training system was developed which included three interactive tasks aimed at training vergence, accommodation, and fusion reserves. The setup included interchangeable lenses of -2.00 D and +2.00 D for accommodation training, and red-green filters for dissociation in vergence and fusion trainings. So far, 31 participants have been involved in the study, 11 of whom have completed the full training course.

Post-training analysis of these 11 participants showed improvements in visual functions. Accommodative facility increased by an average of 8.6 c/min (OD), 9.5 c/min (OS), and 8.5 c/min (OU), indicating a significant improvement in the ability to rapidly shift focus. Vergence facility remained stable or showed moderate improvement, with the highest individual gain reaching +17 c/min. Positive fusional reserves (BO) also increased: average distance break improved from 19.18 to 31.62 prism diopters, and recovery from 15.18 to 23.62, indicating enhanced binocular stability under divergence stress. These findings demonstrate that regular computerized training can effectively strengthen visual system functions, improving both endurance and adaptability.

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Assessment of subjective vision correction using the SiView AI-based equipment in patients with myopia

Marija Koleda[1], Aiga Švede[1], Jānis Dzenis[1], Tatjana Pladere[1], Laure Pichereau[2], Jerome Perderiset[2]

[1]*University of Latvia, Faculty of Exact Sciences and Technologies, Department of Optometry and Vision Science*

[2] *University of Orsay, Faculty of Sciences of Orsay*

E-Mail: marija.koleda23@gmail.com

Subjective refraction is the gold standard for determining optical correction, as it considers both optical and neurological factors [1]. Consequently, solutions for a faster and more accurate method of assessing subjective refraction are increasingly being explored. At the beginning of the 21st century, digital phoropters were introduced to streamline and improve the process of determining subjective refraction [2]. In recent years, machine learning algorithms have been used in optometry to predict subjective refraction [3].

The aim of our study is to analyze the possibilities of using artificial intelligence and the accuracy of measurements in assessing subjective vision correction in cases of myopia. In addition, the research tasks include evaluating the impact of several factors on the assessment of subjective refraction: the short-term use of smart devices before subjective refraction is adjusted, given the increasing amount of time spent using smart devices in daily life [4].

The study included 71 participants aged 18–40 years (mean age 23 ± 4 years). The inclusion criteria for participants were meeting the specified age range and having myopia (grades I, II, and III). Subjective refraction was assessed using a digital phoropter (Huvitz HDR-9000) and an optotype projector (Huvitz HCP-7000), both using the classical method and the artificial intelligence device SiviewExam®.

First-degree myopia was the most prevalent, affecting 66.2% to 68.5% of participants. Post-hoc testing revealed a statistically significant difference between the SiViewExam® measurements and the students' manually determined mean values for the spherical component ($p < 0.001$). The only statistically significant difference between the data before and after short-term smartphone use was found for the J0 parameter, measured using the autorefractometer method (0.09 ± 0.06 D). This finding was confirmed by both the parametric t-test ($p=0.002$) and the non-parametric Wilcoxon test ($p = 0.001$).Patients may experience asthenopic complaints even with a deviation of 0.50 D, particularly if there is an astigmatic component to the refraction [5].

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The impact of work-related fatigue on cognitive performance and eye movements in highly digitalized work environments

Linda Krauze[1], Tatjana Pladere[1], Aiga Švede[1], Henrijs Kalkis [2,3,] Zenija Roja[3], Jevgenijs Viznuks[2]

1 Department of Optometry and Vision Science, Faculty of Science and Technology, University of Latvia

[2]Faculty of Economics and Social Sciences, University of Latvia

[3]Department of Human Factors and Work Environment, Faculty of Medical and Life Sciences, University of Latvia

E-Mail: linda.krauze@lu.lv

Introduction. Increasing screen use in modern workplaces raises concerns about ergonomic and psychosocial overload. Work-related fatigue may affect cognitive performance and eye movements, influencing executive functions such as decision-making and attention [1,2]. Eye movement patterns, especially blink rate and pupil size, change with prolonged cognitive effort [2,3], while saccade and fixation changes are less consistent [4,5]. Individual differences make it difficult to identify universal fatigue biomarkers. This study aimed to examine the impact of work-related fatigue on cognitive performance and eye movements in digitalized work environments.

Method. 31 office workers from an IT company (14 men, 17 women; mean age 32±6 years) participated. Cognitive performance was assessed using the Wisconsin Card Sorting Test (WCST), where participants sorted cards by color, number of shapes, or form. The test included 60 trials, with sorting rules changing every 10 trials. Eye movement data—blink rate and fixation patterns—were recorded with Neon eye-tracking glasses (Pupil Labs, Germany). Measurements were conducted over three consecutive days, before and after work, to assess fatigue-related changes.

Results. WCST results showed gradual improvement over three days, with more correct answers and faster responses due to learning effects. No significant differences were found between morning and evening performance. However, blink rate increased in some participants in the evening, suggesting fatigue, while others showed no notable change. Fixation and saccade patterns showed no consistent differences.

Conclusions. Work-related fatigue does not impair cognitive flexibility over three days but may have cumulative effects over time. Individual variability in eye movements suggests that fatigue assessment should be personalized. Further research is needed to explore long-term fatigue effects and potential eye-tracking biomarkers, considering visual functions and other factors.

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Optical materials and phenomena

Planar n-Ga_2O_3/p-GaN ultraviolet light detector

Ashutosh Kumar[1], Sergiy Khartsev[2] , Edgars Butanov[3], Martin Berg[1], Ēriks Dipāns[3], Martins Zubkins[3], Edvards Strods[3], Qin Wang[1], Anders Hallén[2], Anatolijs Sarakovskis[3], Juris Purans[3], Peter Ramvall[1]

[1] RISE Research Institutes of Sweden, Ole Römers Väg 1, SE-223 63 Lund, Sweden

[2] KTH Royal Institute of Technology, Electrum 229, SE-164 40 Kista, Sweden

[3] Institute of Solid State Physics, University of Latvia, 8 Kengaraga Str., LV-1063 Riga, Latvia

E-mail: eriks.dipans@cfi.lu.lv

Gallium oxide (Ga_2O3) is a perspective emerging material for applications in far-UV photodetectors and power electronics due to its ultra-wide bandgap (~4.8 eV) [1]. Since p-type doping of Ga_2O_3 has proven to be difficult [2], fabrication of p-n heterojunctions using other p-type materials is a promising alternative. In this work, p-n heterojunction diode was created by depositing p-GaN using MOCVD on sapphire (Al_2O_3) substrate, followed by deposition of n-Ga_2O_3 using PLD. Ohmic contacts to n-Ga_2O_3 were achieved by deposition of Ti/Au and annealing at 470 °C in N_2 for 1 min, while Ni/Au was deposited for contacts with p-GaN. The fabricated device showed photoresponse to 275 nm light and exhibited electrical behavior typical for photodiodes. Results indicate a clear UV light response characteristics which point towards many potential uses of such a device, for example, in space applications, environment monitoring, early wildfire detection [3].

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Pyrophosphates as a potential matrix for ultraviolet emitting persistent luminescence phosphors

Didzis Salnajs[1], Dace Nilova[1], Jonas Stadulis[2], Aleksej Zarkov[2], Andris Antuzevics[1]

[1] *Institute of Solid State Physics, University of Latvia, Latvia*

2 Institute of Chemistry, Vilnius University, Lithuania

E-mail: didzis.salnajs@cfi.lu.lv

Materials with persistent luminescence in the ultraviolet (UV) region have attracted significant interest because of their potential applications in photocatalysis and photodynamic therapy [1-2]. For UV emission phosphors, a host material with an appropriate energy band structure and an activator with suitable electronic levels are required. UV radiation emission is often achieved with wide band-gap materials doped with rare-earth elements, such as Pr^{3+} and Gd^{3+} ions. Although pyrophosphate host family materials can be produced inexpensively and exhibit the necessary properties, they have only recently attracted attention for persistent luminescence research.

Pyrophosphates were synthesized using the wet co-precipitation synthesis method. The material composition was characterized by X-ray diffraction and Rietveld analysis. Electron paramagnetic resonance (EPR) measurements revealed charge transfer processes potentially involved in persistent luminescence mechanisms. Furthermore, luminescence and thermostimulated luminescence measurements revealed persistent emission in the UV-C to UV-B range (e.g. Fig 1. a).

Here we present the possibility of using pyrophosphate host matrices doped with Pr^{3+} and Gd^{3+} to achieve persistent luminescence in the UV emission range.

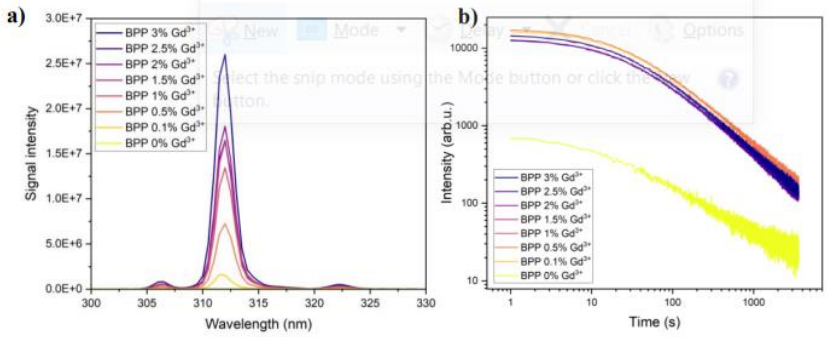

Fig 1. a) Photoluminiscence spectra of α-$Ba_2P_2O_7$; b) persistent luminescence decay kinetics of α-$Ba_2P_2O_7$

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Optical properties of novel DCM derivatives in the red-infrared spectrum

Marta Liedskalnina[1], Patricija Paulsone[1], Aivars Vembris[1], Elmars Zarins[2]
[1]*Institute of Solid-State Physics, University of Latvia*
[2]*Institute of Applied Chemistry, Riga Technical University*
E-Mail: marta.liedskalnina@cfi.lu.lv

A popular organic dye used for red lasers is 4-Dicyanomethylene-2-methyl-6-p-dimethylaminostyryl-4H-pyran (DCM). By modifying the DCM molecule, it is possible to alter its emission wavelengths to the infrared region. Molecules with effective amplified spontaneous emission (ASE) in the red and infrared region are difficult to synthesize. It is important to study these materials for laser development in fields such as biomedicine and telecommunications. [1]

In this work 10 DCM derivatives with emission in the red-infrared light region were studied to observe their optical properties. The dyes were prepared into thin films with the spin coating method. Additionally, the derivatives were made in a polyvinyl carbazole (PVK) matrix to prevent film crystallization. The samples were then used for thickness, absorption and emission spectra, photoluminescence quantum yield and ASE measurements. A nanosecond pulse laser was employed for ASE measurements. The excitation wavelength corresponded with the absorption maxima for each of the samples.

Altogether 13 samples were prepared and studied from 10 different DCM derivatives. Amplified spontaneous emission was obtained for most of the samples. The results show photoluminescence quantum yields ranging from 0.9% to 7.4% and ASE excitation energy thresholds from 41 to 460 μJ/cm^2. Photoluminescence of all the samples is in the red-infrared light region from 664 nm to 774 nm. The acquired data allows us to compare the optical properties of DCM derivatives with and without PVK matrix.

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Light-Triggered Shape Recovery in AgNP-Embedded Shape Memory Polymers for Remote Actuation Applications

Virginija Vitola, Milena Dile, Katrina Krizmane
Institute of Solid State Physics, University of Latvia
E-mail: virginija.vitola@cfi.lu.lv

Silver nanoparticles (AgNPs) are increasingly explored as efficient photothermal agents for remote-triggered actuation in smart material systems. In this study, AgNPs stabilized with polyvinylpyrrolidone (PVP) were synthesized via a microwave-assisted solvothermal method and embedded into a 3D-printable shape memory polymer matrix. Nanocomposites were printed with varying AgNP concentrations to investigate their light-responsive shape recovery behavior. Comprehensive characterization was performed using scanning electron microscopy (SEM), dynamic light scattering (DLS), UV-Vis absorption spectroscopy, and temperature measurements to evaluate nanoparticle morphology, size distribution, and optical properties. Shape recovery performance was quantified through bending angle measurements under light exposure, with tests revealing that nanocomposites containing optimally dispersed AgNPs exhibited efficient recovery when irradiated with a specific UV-blue diode. In contrast, control samples without nanoparticles showed no shape transformation under the same conditions. These results demonstrate the potential of AgNP-enhanced SMPs for precise, light-triggered actuation in applications such as soft robotics, biomedical devices, and responsive materials.

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Posters

Oculomotor Training for Bilateral Amblyopia with Eccentric Fixation: A Case Study

Kristine Kalnica-Dorosenko[1, 2]
1 Eye Diseases Clinic, Children's Clinical University Hospital, Riga
2 Department of Optometry and Vision Science, University of Latvia
E-Mail: kristinekalnica@gmail.com

Background: Bilateral amblyopia with eccentric fixation presents a significant challenge in visual rehabilitation. The magnitude and persistence of eccentric fixation (EF) are key in selecting amblyopia treatments to restore foveal fixation and optimal visual acuity (VA), as peripheral vision cannot achieve maximum acuity [1]. This case study evaluates the impact of saccadic and oculomotor training on visual function in/of a patient with bilateral amblyopia and EF.

Case: A 6-year-old female was referred for assessment of intermittent exotropia and potential future therapies. Despite standard refractive error, her VA was significantly below expectations. Binocular vision testing revealed intermittent exotropia and convergence insufficiency, indicating alignment and motor control issues. Examination of the ocular structures indicated normal findings, but optical coherence tomography revealed abnormal macular thickness and unstable EF. Visuoscopy confirmed EF, contributing to her reduced VA and slow motor responses.

Methods: An oculomotor training program was designed to improve saccadic accuracy, fixation stability, and vergence control. Over 3 months, the patient underwent intensive training to improve her visual system and stabilize fixation.

Results: After completing the training, the patient showed significant improvements in visual function. Fixation stability improved, and EF was reduced during visuoscopy. The patient's parents noted improved coordination, reduced clumsiness, and better visual attention during daily activities.

Conclusion: This case study demonstrates the potential of oculomotor training as an effective treatment for bilateral amblyopia with EF. While further research is required to standardize oculomotor training protocols and assess long-term outcomes, the findings suggest that oculomotor training could serve as a valuable adjunct or alternative to traditional therapies for amblyopia with EF.

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Objective colour vision assessment based on eye tracking data analysis

Anastasija Katanska[1], Ērika Krasta[1], Anete Kļavinska[1], Sergejs Fomins[2], Ilze Ceple[1], Renārs Trukša[1]

[1]*Department of optometry and vision science, Faculty of Science and Technology, University of Latvia*

[2]*Institute of Solid-State Physics, University of Latvia*

E-Mail: renars.truksa88@gmail.com

Red-green colour vision deficiencies affect approximately 0.5% of women and up to 8% of men [1]. The ability to accurately differentiate between coloured stimuli with varying spectral properties is particularly important for professionals in the transport sector, medical practitioners, graphic designers, and children, as colour codes play a significant role in educational processes. Traditionally, red-green colour deficiencies have been diagnosed using psychophysical methods that rely on subjective responses of individual's. However, recent technological advancements now allow objective identification of red-green deficiencies through DNA analysis [2]. DNA analysis method assesses whether an individual's genetic code contains the necessary information for normal L and M cone photopigments, which are essential for perceiving colours within the medium and long wavelength ranges of visible light. True, due to complexity the method is not universally available.

The current study introduces a novel, objective approach to colour vision assessment through eye movement analysis. The authors have designed a computerized colour vision test that incorporates dynamic luminance noise to obscure a moving chromatic stimuli [3]. During experimental sessions, participants were instructed to identify the direction of chromatic moving stimulus. Unlike traditional colour vision assessments, which require individuals to respond by pressing a keyboard button after stimulus presentation, this study recorded eye gaze coordinates alongside subjective responses during the stimulus demonstrations. Smooth pursuit eye movements were observed when participants successfully detected the moving stimulus, therefore providing an objective confirmation of their positive response.

Utilizing algorithms developed by the authors [4-6], a function was created to automatically analyse eye movement data, identifying gaze positions associated with smooth pursuit eye movements. This advancement facilitates the objective determination of responses to chromatic stimuli, enhancing the accuracy of colour vision assessments.

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Saccadic eye movements in school-aged children

Viktorija Golishkina, Ilze Ceple, Renars Truksa, Evita Kassaliete, Evita Serpa, Aiga Svede, Angelina Ganebnaya, Liva Volberga un Gunta Krumina
Department of Optometry and Vision Science, Faculty of Science and Technology, University of Latvia, LV-1586 Riga, Latvia
E-Mail: ilze.ceple@lu.lv

Abstract. Previous studies have demonstrated that saccadic eye movements in infants are slow and imprecise, however by the age of 7 saccadic eye movement dynamics tend to reach the adult levels. Saccadic eye movement accuracy peaks in adolescence, and after the age of 50, the peak velocity and accuracy begin to decline due to age-related changes in the brain [1, 2]. The current study comprehensively examines age-related changes in saccadic eye movement latency, peak velocity, and accuracy measurements of reflexive and antisaccade tasks in school-age children.

Methods. 295 children aged 7 to 12 years (9.3 ± 1.7 years; 140 boys and 155 girls) from four Latvian schools of basic education voluntarily participated in the study. Saccadic eye movement targets for anti-saccade and reflexive saccade tasks were presented at one spatial position. Eye movements were recorded with a Tobii Pro Fusion (Tobii, Sweden) video-oculograph, analyzing peak velocity, latency and accuracy of saccadic eye movements (120 Hz).

Results. The results demonstrate no significant age effect on the latency and accuracy measurements in both antisaccade and reflexive saccade tasks, however, a significant age effect on the peak velocity measurements was demonstrated only in the antisaccade task. The results of antisaccades directed to the right demonstrated that peak velocity decreased with age.

Conclusions. The obtained results demonstrate that there are no age-related effects on the parameters of rightward directed reflexive saccades (latency, peak velocity and accuracy) and antisaccades (latency and accuracy) and confirm the previous studies demonstrating that by the age of 7 years, the saccadic eye movement system performance has reached the adult level.

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Hard mask formation for dry silicon etching by imposing laser-induced periodic surface structures (LIPSS) via femtosecond laser-processing

Mantas Mikalkevičius[1], Mindaugas Juodėnas[1], Andrius Vasiliauskas[1], Sigitas Tamulevičius[1,2], Tomas Tamulevičius[1,2], Asta Tamulevičienė[1,2]

[1] *Institute of Materials Science of Kaunas University of Technology, K. Baršausko St. 59, LT-51423, Kaunas, Lithuania*

[2] *Department of Physics, Kaunas University of Technology, Studentų St. 50, LT-51368, Kaunas, Lithuania*

E-mail: mantas.mikalkevicius@ktu.lt

Laser-induced periodic surface structures (LIPSS) are a fascinating phenomenon arising from the interaction of intense laser radiation with a material [1]. It is a self-organized quasi-periodic structures with a sub-wavelength pitch. LIPSS in thin metal film-coated substrates offers a cheap and fast alternative for a hard mask fabrication. The laser-imposed periodic structures overcome the diffraction limit with typical periods of $0.83 \cdot \lambda$. The laser spot size is in a range of micrometers, and with the advent of fast laser beam scanners, it can be confidently scanned up to meters per second, meaning that the process is scalable.

In this work, Yb:KGW 1030 nm wavelength femtosecond laser Pharos (Light Conversion) was used to impose LIPSS in the 200 nm chrome thin film layer. The laser beam was scanned in straight lines using a galvanometric scanner SCANcube III 14 (Scanlab). To find the optimum fabrication conditions, the linear pulse overlap and adjacent line overlap were varied in the range of 75 – 95 % and of 0 – 58 %, respectively. Formed structures were analysed under a scanning electron microscope (SEM). The results with different pulse overlaps are depicted in Figure 1. It was observed that high-quality ripples can be obtained with 95 % pulse overlap, whereas 75% pulse overlap only increased the roughness of the surface. 58 % line overlap resulted in long, highly ordered periodic structure formation. LIPSS produced in chrome film was successfully used as a hard mask for deep reactive ion etching as it can withstand higher ion energies and longer etching durations. Since the period of the structures is close to the wavelength of visible light, it has potential application as a diffraction grating.

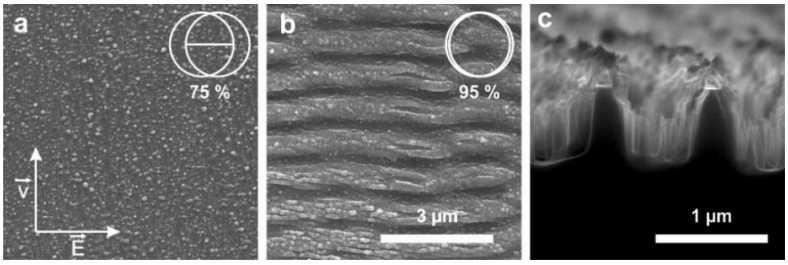

Fig. 1. SEM images of a laser-structured surface: a) 75 % pulse overlap, b) 95 % pulse overlap, c) cross-section image of etched structures in silicon. v and E vectors show scanning direction and electric field polarisation respectively.

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Ultrafast Second Harmonic Generation in N-Polar GaN/Al_2O_3/Ga-Polar GaN/AlGaN Waveguide Structure

Ignas Dailidėnas
Institute of Photonics and Nanotechnology, Vilnius University
E-Mail: ignas.dailidenas@ff.vu.lt

Quasi-phase matching is most commonly achieved using periodic poling structures, which are often complex to manufacture. Alternatively, modal phase matching (MPM) has been developed as a method for harmonic generation in waveguides. We present an innovative GaN waveguide structure for MPM green light second harmonic generation (SHG). Our waveguide structure is designed to increase optical mode overlap by utilizing polarity inversion of GaN layers and consists of a multilayered design of N-polar GaN/Al_2O_3/Ga-polar GaN/AlGaN/AlN/Sapphire, grown using metal-organic chemical vapor deposition (MOCVD) technology. The waveguide structure consists of a 507 nm Ga-polar and 91 nm N-polar GaN sandwich, separated by a 20 nm Al_2O_3 layer grown on a 420 nm AlGaN epilayer and sapphire. The 20 nm Al_2O_3 layer, dedicated for polarity inversion, was grown using atomic layer deposition. For better mode confinement in the waveguide core, a chemical vapor deposition TiO_2 layer was also deposited on top of the structure.

During experimentation, SHG measurements utilizing picosecond (ps) and femtosecond (fs) lasers were performed with the end-fire coupling method. Both fs and ps SHG presented a signal with peak conversion at around 1100 nm. Due to the wide fs pulse spectral width, the SHG signal exhibited a uniform spectral shape, while for the ps pulse, the SHG showed periodic peaks, each separated by 20 nm. The theoretical explanation for these periodic peaks involves modal interference between transverse magnetic (TM) and transverse electric (TE) modes. We are currently researching the detection of theoretically predicted SHG directed perpendicular to the waveguide surface.

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Impact of film thickness and AC parameters on ZnS:Mn based electroluminescent panels.

Madara Klave, Milena Dile, Marija Dunce, Ernests Einbergs, Aleksejs Zolotarjovs
[1]*Institute of Solid State Physics, University of Latvia*
E-mail: madara.klave@cfi.lu.lv

In modern display and lighting technologies, achieving reliable and efficient electroluminescence is critical. In this study, ZnS:Mn powders were synthesized using a microwave-assisted solvothermal method and then incorporated into thick film alternating-current powder electroluminescent (ACPEL) panels. The primary objective was to investigate how variations in film thickness and AC excitation parameters (voltage and frequency) affect electroluminescent performance. Panels were fabricated by depositing a ZnS:Mn/polyurethane composite thick films onto fluorine-doped tin oxide (FTO) substrates, with systematic testing performed under different AC conditions. Our measurements indicate that the characteristic Mn^{2+} emission at 585 nm remains stable across a range of excitation settings, while panels with thinner electroluminescent films exhibit higher brightness. These findings enhance our understanding of how film architecture influences device performance, potentially guiding further improvements in ACPEL panel design.

Relative transition probabilities of atomic niobium derived from intensity measurements in high-resolution spectra

Karina Korenika[1], Maris Tamanis[1], Ilze Klincare[1], Ruvin Ferber[1], Gönül Başar[2], Sophie Kröger[3]

[1]*Laser Centre, Faculty of Science and Technology, University of Latvia, 19 Rainis Blvd, LV-1586, Riga, Latvia*

[2]*Istanbul University, Faculty of Science, Physics Department, TR-34134 Vezneciler, Istanbul, Türkiye*

[3]*Hochschule für Technik und Wirtschaft Berlin, Wilhelminenhofstr. 75A, Berlin D-12459, Germany*

E-mail: karina.korenika.cl@gmail.com

Niobium (Nb), with atomic number 41, is the third member of the 4d-transition group elements and plays an important role in the investigation of the nucleosynthesis of heavy elements in the stars. It has only one stable isotope ^{93}Nb with nuclear spin I = 9/2 and its atomic spectrum is characterized by a broad hyperfine structure, see Fig. 1, caused by the large nuclear magnetic dipole moment. In present work we report on experimental studies of relative transition probabilities of atomic Nb; such information is necessary to evaluate the element abundance in the stellar atmosphere. The line intensity distributions for a number of line series originating from a common upper level, or branches, were obtained from Nb emission spectra produced in a hollow cathode discharge lamp in an argon atmosphere at a pressure of about 1.7 mbar in visible and near-IR spectral region, recorded by high-resolution Bruker IFS 125 HR Fourier transform spectrometer in the Laser Centre of the University of Latvia, see [1]. Experimental relative intensity distributions have been obtained from measurements of the areas below the line profiles. The respective relative transition probabilities for the branch from the odd parity upper level 24015.11 cm^{-1} are shown in Fig. 2. The spectral sensitivity of overall detection system was calibrated based on K_2 intensity distributions within the spectral region 13 500 – 16 500 cm^{-1} [2] and on Ar branching ratios within 16 000 – 24 000 cm^{-1}.

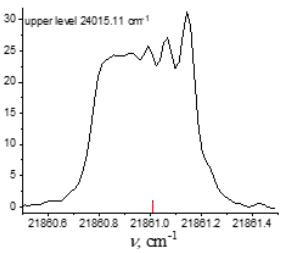

Fig. 1. Example of Nb spectral line from the upper level with energy 24015.11 cm^{-1} (J = 7/2) to the lower level with energy 2154.11 cm^{-1} (J = 7/2).

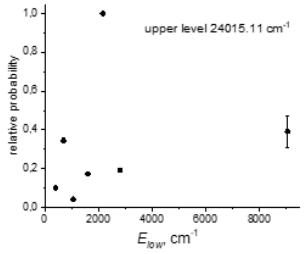

Fig.2. Normalized relative transition probabilities for the branch starting from the common upper level in Fig. 1 as dependent on energies of the lower levels.

Acknowledgment: Support by the Faculty of Science and Technology project "High-resolution spectroscopy studies of atoms and ions of rare earth elements important for astrophysics" is gratefully acknowledged.

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Hexadecapole moment creation in ^{87}Rb for obtaining magneto-optical signals without nonlinear-Zeeman-effect error: theoretical calculations

Arturs Mozers, Daniela Jermacane, Florian Gahbauer, and Marcis Auzinsh
Laser Centre, University of Latvia, Raina Boulevard 19, LV-1586 Riga, Latvia
E-mail: daniela.jermacane@lu.lv

Magneto-optical signals based on the Zeeman effect in atomic magnetometers can achieve some of the highest sensitivities and accuracy near zero magnetic field, where the Zeeman effect is very linear. However, even at 0.5 G, which corresponds to the earth's magnetic field, the nonlinear Zeeman effect (NLZ) introduces errors.

The Zeeman effect in the ^{87}Rb ground-state sublevels with total angular momentum $F_g = 2$ and magnetic quantum number $m_{Fg} = \pm 2$ is linear to high magnetic field values. It has been shown that coherences between these two sublevels can be excited by modulating the frequency of an exciting laser at twice the Larmor frequency [1], creating a hexadecapole ($\Delta m_F = 4$) and quadrupole ($\Delta m_F = 2$) moment in the angular momentum distribution of the atoms. The quadrupole moment, which exhibits NLZ, could be eliminated by a phase shift in the modulation frequency, retaining only the hexadecapole moment, which is completely linear. This specially prepared state creates a magnetic-field dependent rotation of a linearly polarized laser beam that passes through the rubidium vapor.

We plan to adapt this technique to fluorescence measurements and study the effect of relaxation on the signal amplitudes. It is important to understand the effect of relaxation, because the results in [1] were obtained in specially prepared cells whose walls were coated with paraffin. We are using a theoretical model to study the effects of various parameters on the signal from the hexadecapole moment. Thus far, we have obtained theoretical signals of ^{87}Rb hexadecapole moment excitation that can be used to create experimental system and increase accuracy of ^{87}Rb atomic magnetometers by using fluorescence signals.

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SWEB
Smart Windows for Zero Energy Buildings
UNIVERSITY OF LATVIA
FACULTY OF SCIENCE
AND TECHNOLOGY
magebit
LATVIJAS UNIVERSITĀTES
CIETVIELU FIZIKAS INSTITŪTS
INSTITUTE OF SOLID STATE PHYSICS
UNIVERSITY OF LATVIA
SPIE. STUDENT CHAPTER
UNIVERSITY
OF LATVIA
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