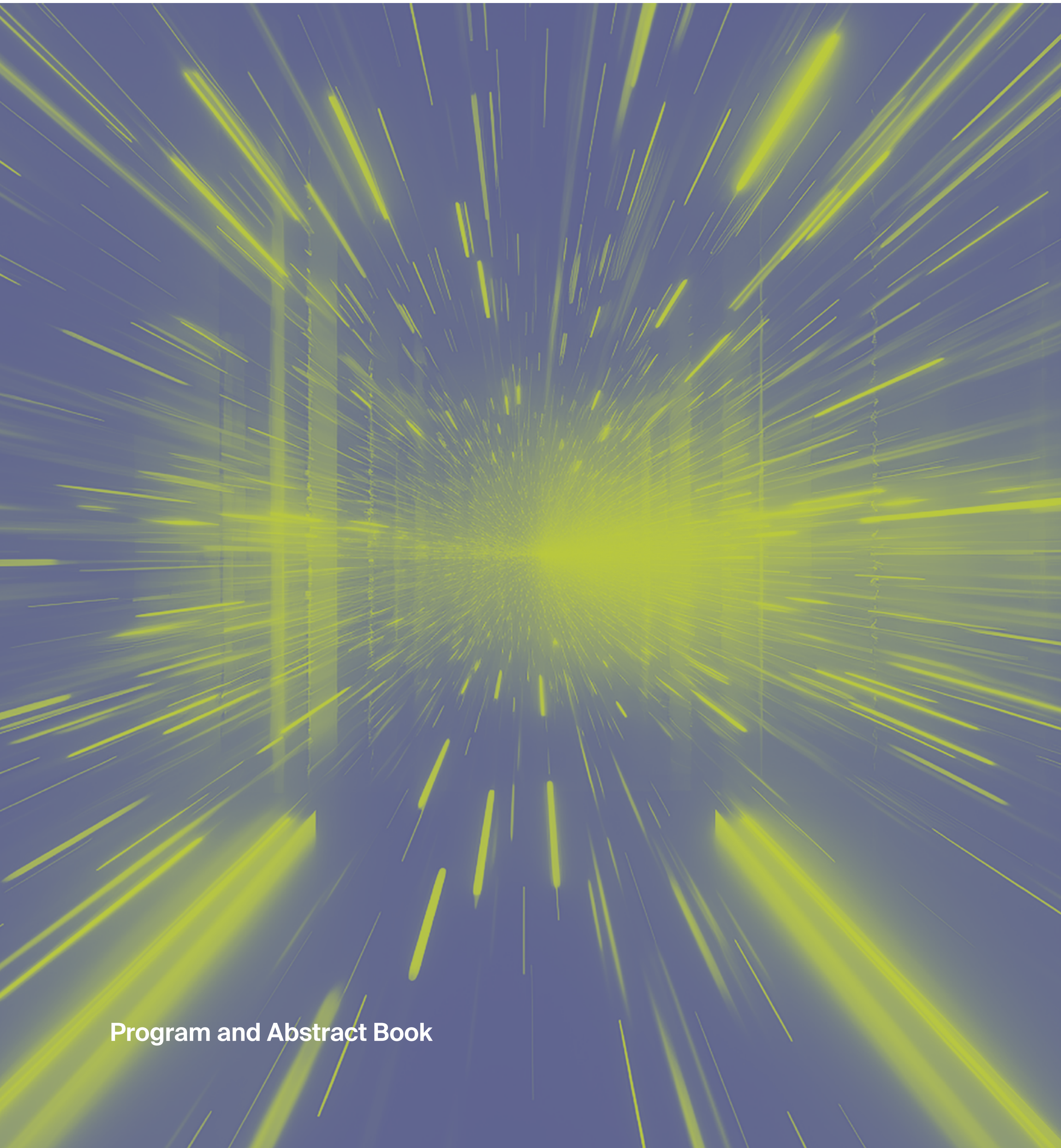
IOCP
2024
Conference

The 1st International Online Conference on Photonics

14–16 October 2024 | Online



Program and Abstract Book

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The 1st International Online Conference on Photonics

14–16 October 2024 | Online

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Welcome from the Chairs

Dear Colleagues,

The 1st International Online Conference on Photonics, centered around the theme of optics and photonics, is scheduled to take place from **October 14–16, 2024**. This conference aims to highlight and facilitate the utilization of recent advancements in all areas related to optics and photonics, as well as to address complex issues, exchange the latest scientific breakthroughs, and guide the development of future technologies and processes in these fields.

This conference is an excellent opportunity for Optics and Photonics researchers and scientists to interact with each other, communicate with colleagues, learn from each other, share ideas and experiences, jointly solve problems, and suggest alternative solutions for a better future in the Optics and Photonics industry. The main topics of this conference are as follows:

S1. Biophotonics and Biomedical Optics
S2. Optical Communication and Network
S3. Optoelectronics and Optical Materials
S4. Lasers, Light Sources and Sensors
S5. Optical Interaction Science
S6. Quantum Photonics and Technologies
S7. New Applications Enabled by Photonics Technologies and Systems

Submitted abstracts will be reviewed by the conference committee. All accepted abstracts will be available online in Open Access form on Sciforum.net during and after the conference. Participants have the chance to win four highly coveted Best Oral Presentation Awards and Best Poster Presentation Awards, with prize money.

On behalf of the Organizing Committee, I welcome your attendance at the 1st International Online Conference on Photonics.

Prof. Dr. Francesco Prudenzano
Conference Chair
Department of Electrical Engineering and Information, Polytechnic University of Bari, Bari, Italy

Prof. Dr. Huabei Jiang
Conference Co-Chair
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Dr. Maurizio Ferrari
Conference Co-Chair
Italian National Research Council | CNR, Rome, Italy

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Journal Webpage: https://www.mdpi.com/journal/photonics

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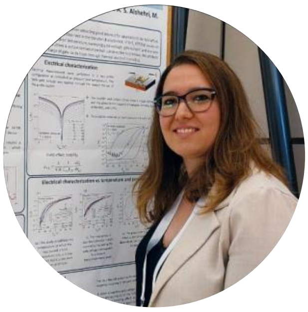

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Program Overview

The 1st International Online Conference on Photonics

14–16 October 2024, CEST, Online

	14th Oct	15th Oct	16th Oct
Morning	**Session 2.** Optical Communication and Network **Session 6.** Quantum Photonics and Technologies	**Session 1.** Biophotonics and Biomedical Optics	**Session 4.** Lasers, Light Sources and Sensors
	Break	Break	Break
Afternoon	**Session 3.** Optoelectronics and Optical Materials	**Session 5.** Optical Interaction Sciences **Session 8.** New Applications Enabled by Photonics Technologies and Systems	**Session 4.** Lasers, Light Sources and Sensors

IOCP 2024 Program

14th October 2024 (Monday

Session 2. Optical Communication and Network
Session 6. Quantum Photonics and Technologies

Time: 9:00 AM (CEST, Basel) | 03:00 AM (EDT, New York) | 3:00 PM (CST Asia, Beijing)

Time in CEST	Speaker	Title
09:00–09:10	*Welcome from the Event Chair* *Prof. Dr. Francesco Prudenzano*	
09:10–09:15	*Welcome from the Session Chairs* *Dr. Paolo Bardella & Dr. Satyendra Kumar Mishra*	
09:15–09:40	**Invited Speaker** Dr. Cuiwei He	Fluorescent Concentrators/Antennas in Optical Wireless Communication
09:40–10:05	**Invited Speaker** Dr. Ofelia Durante	Electrical and Optoelectronic Characterization of Van der Waals BP/MoS2 Heterostructures for innovative photodetectors and for quantum technologies
10:05–10:20	Selected Speaker Quandong Huang	Three-dimensional waveguide structure forming mode manipulating devices
10:20–10:35	Selected Speaker José Ángel Praena	Integrated Bragg Grating Spectra
10:35–10:50	Selected Speaker Wiesław Leoński	Legget–Garg inequality and its violation for a two-mode entangled bosonic system
10:50–11:05	Selected Speaker Spyridon Kosionis	Controlling four-wave mixing in a semiconductor quantum dot through coupling with a metal nanospheroid
11:05–11:20	Selected Speaker Rafael Ramos Uña	Moderate-refractive-index and high-refractive-index dielectric cylindric dimers for QD fluorescence enhancement

Session 3. Optoelectronics and Optical Materials

Time: 01:00 PM (CEST, Basel) | 07:00 AM (EDT, New York) | 07:00 PM (CST Asia, Beijing)

Time in CEST	Speaker	Title
01:00–01:10	*Welcome from the Session Chairs* *Dr. Anna Łukowiak & Dr. Maurizio Ferrari*	
01:10–01:35	**Invited Speaker** Dr. Wilfried Blanc	Nanoparticles in Optical Fibers, a Game-Changer
01:35–01:50	Selected Speaker Pawel Gluchowski	Exploring the Use of Luminescent Powder Additives in Coatings Produced via the Plasma Electrolytic Oxidation Technique for Various Applications
01:50–02:05	Selected Speaker Dominika Czekanowska	Photocatalytic properties of PEO coatings prepared using 2D materials
02:05–02:20	Selected Speaker Baidong Wu	Optimized Wide-Angle Metamaterial Bandpass Filters: Enhanced Performance with Multi-Layer Designs and 1D Ternary Photonic Crystals
02:20–02:35	Selected Speaker Grazia Giuseppina Politano	Optical properties of Graphene Nanoplatelets on amorphous Germanium substrates
02:35–02:50	Selected Speaker Wojciech Michał Piotrowski	Investigation of spectroscopic properties of LaAlO3:Ti3+ for lifetime-based thermometry
02:50–03:05	Selected Speaker Chandra Mani Adhikari	Thickness Dependency of Carbon Nanotube Thin Films' Opto-Plasmonic Properties

15th October 2024 (Tuesday)

Session 1. Biophotonics and Biomedical Optics

Time: 09:00 AM (CEST, Basel) | 03:00 AM (EDT, New York) | 03:00 PM (CST Asia, Beijing)

Time in CEST	Speaker	Title
09:00–09:10	*Welcome from the Session Chair Prof. Dr. Ambra Giannetti*	
09:10–09:30	**Invited Speaker** Dr. Ilaria Rea	Multifunctional hybrid nanoparticles for biomedical applications
09:30–09:50	**Invited Speaker** Dr. Pedro Jorge	Photonic Tools for Biochemical Sensing and Micromanipulation: From Optical Fiber Sensors and Microresonators to Optical Tweezers.
09:50–10:10	**Invited Speaker** Dr. Giuseppe Quero	SERS optrode optical fiber-based sensors for biosensing applications
10:10–10:25	**Selected Speaker** Juan H. Espinoza-Rodriguez	Thermographic analysis of a porcine gel doped with the photosensitizer PpIX: A dosimetric study for Photodynamic Therapy
10:25–10:40	**Selected Speaker** Adel Shaaban Awad Elsharkawi	Optical Fiber Dosimetry System for Gamma Radiation Facilities
10:40–10:55	**Selected Speaker** Xiu Wen	High-performance phase imaging based on scanning modulation
10:55–11:10	**Selected Speaker** Galyna Ivanivna Dovbeshko	How to recognize the formation of lipid rafts in membranes: FTIR spectroscopy data

Session 5. Optical Interaction Sceinces
Session 8. New Applications Enabled by Photonics Technologies and Systems

Time: 03:00 PM (CEST, Basel) | 09:00 AM (EDT, New York) | 09:00 PM (CST Asia, Beijing)

Time in CEST	Speaker	Title
03:00–03:10	*Welcome from the Session Chairs Dr. Arun Kumar & Dr. Pasquale Pagliusi*	
03:10–03:30	**Invited Speaker** Dr. Hiroyuki Fujii	Effects of sub-micro particle properties on light scattering in dense colloidal suspensions
03:30–03:50	**Invited Speaker** Prof. Dr. Boris Malomed	Multidimensional solitons in optics and related fields
03:50–04:10	**Invited Speaker** Dr. Walter Fuscaldo	Terahertz techniques, materials, meta surfaces, and their applications
04:10–04:25	**Selected Speaker** Masaaki Magari	Numerical investigation of optimal structure for dynamic plasmonic color generated via photothermal deformation of a metal semi-shell structure
04:25–04:40	**Selected Speaker** Daqing Piao	Explaining the decline in the yield of luminescence after surpassing a phase of saturation as the dose of stimulation continues to increase
04:40–04:55	**Selected Speaker** Yannis Paulus	Photoacoustic Microscopy, Optical Coherence Tomography, and Fluorescence Imaging-Guided Stem Cell Retinal Therapy
04:55–05:10	**Selected Speaker** Tahsin Akalin	Photonic devices and original probes for terahertz near field microscopy
05:10–05:25	**Selected Speaker** Tiziana Ritacco	Optical Modulation of Nematic and Cholesteric Reactive Mesogens by Two-Photon Lithography

16th October 2024 (Wednesday)

Session 4. Lasers, Light Sources and Sensors

Time: 9:00 AM (CEST, Basel) | 03:00 AM (EDT, New York) | 03:00 PM (CST Asia, Beijing)

Time in CEST	Speaker	Title
09:00–09:10	*Welcome from the Session Chair Dr. Flavio Esposito*	
09:10–09:35	**Invited Speaker** Dr. Valeria Demontis	Single-Crystal Hybrid Perovskites as Next-Generation Optoelectronic Materials for Photodetection
09:35–10:00	**Invited Speaker** Dr. Rossana Dell'Anna	Color center fabrication in diamond at FBK.
10:00–10:15	**Selected Speaker** Maja Szymczak	Luminescence Manometry Based on Ni2+ Ions Emission in Doped Spinel
10:15–10:30	**Selected Speaker** Bartosz Bondzior	White light generation from tin-doped condensed borates
10:30–10:45	**Selected Speaker** Sónia Fernandes	Carbons Dots based on sustainable carbon precursors and their potential for sensing applications
10:45–11:00	**Selected Speaker** Gabriela Croitoru	Y-branch splitters inscribed in Nd3+:YAG ceramics by picosecond-laser beam writing

Session 4. Lasers, Light Sources and Sensors (Extra session)

Time: 03:00 PM (CEST, Basel) | 09:00 AM (EDT, New York) | 09:00 PM (CST Asia, Beijing)

Time in CEST	Speaker	Title
03:00–03:10	*Welcome from the Session Chair Dr. Giuseppe Quero*	
03:10–03:25	**Selected Speaker** Lifu Jiang	Camera Calibration Algorithm Based on Brightness Non-uniformity Correction and Grating Phase-Shifting Method
03:25–03:40	**Selected Speaker** Ziyang Li	Universal Clarity Evaluation Function for Autofocus Based on Amplitude Differences of Fractional Fourier Transform
03:40–03:55	**Selected Speaker** Natalia Miniajluk-Gaweł	Application of aerodynamic levitation to the formation of glass ceramics
03:55–04:10	**Selected Speaker** Fu Longhu	Motion-blurred image reconstruction and velocity measurement
04:10–04:25	**Selected Speaker** Patrycja Zdeb	From Visible Light to UVC: Upconverting Phosphor Doped with Pr3+ Ions for Germicidal Applications
04:25–04:40	**Selected Speaker** Nadiia Rebrova	Luminescent properties of Pr3+ doped fluoroperovskite

Session 1. Biophotonics and Biomedical Optics

sciforum-095831: Comparison of different Far-UVC sources with regards to intensity stability, estimated antimicrobial efficiency and potential human hazard in comparison to a conventional UVC lamp

Ben Sicks [1], Florian Maiss [1], Christian Lingenfelder [2], Cornelia Wiegand [3] and Martin Hessling [1,*]

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[2] Zimmer MedizinSysteme GmbH, Junkersstraße 9, 89231 Neu-Ulm, Germany
[3] University Hospital Jena, Am Klinikum 1, 07747 Jena, Germany

The recently much-noticed Far-UVC spectral range offers the possibility of inactivating pathogens without necessarily posing a major danger to humans. Unfortunately, there are various Far-UVC sources that differ significantly in their longer wavelength UVC emission and, subsequently, in their risk potential. Therefore, a simple assessment method for Far-UVC sources is presented here. In addition, the temporal intensity stability of Far-UVC sources was examined in order to reduce possible errors in irradiation measurements. For this purpose, four far-UVC sources and a conventional Hg lamp were each spectrally measured over 60 h and mathematically evaluated for their antimicrobial effect and hazard potential using available standard data. Only two filtered KrCl lamps were found to emit at stable intensity after a warm-up time of 10 min. With regard to the antimicrobial effect, the radiation efficiencies of all examined (Far-) UVC sources were more or less similar. However, the calculated differences in the potential human hazard to eyes and skin were more than one order of magnitude. The two filtered KrCl lamps were the safest, followed by an unfiltered KrCl lamp, a Far-UVC LED and, finally, the Hg lamp. When experimenting with these Far-UVC radiation sources, the irradiance should be checked more than once. If UVC radiation is to be or could be applied in the presence of humans, filtered KrCl lamps are a much better choice than any other available Far-UVC sources.

sciforum-095712: Four-Frame Structured Illumination Microscopy Based on Checkerboard Pattern

Yiran Wang *, Ziyang Li, Gangshan Liu and Zhengjun Liu

School of Physics, Harbin Institute of Technology, Harbin 150001, China

Structured illumination microscopy (SIM) is a mainstream super-resolution imaging technique that is applied in fluorescence microscopy, effectively doubling the lateral resolution compared to conventional methods. Compared to other popular fluorescence super-resolution techniques such as STORM and STED, SIM offers advantages through its reduced light exposure, faster imaging speeds, and, consequently, lower phototoxicity and photobleaching, making it particularly suitable for live cell imaging. However, traditional 2D-SIM requires nine sequentially captured raw structured illumination images to reconstruct a single super-resolution image. This results in a ninefold increase in acquisition time compared to standard wide-field imaging. Reducing the exposure time can mitigate motion artifacts but at the cost of image quality; conversely, increasing the exposure time can heighten phototoxicity, impacting the overall observation time and imaging efficiency.

To address these challenges, we propose a novel method called 4CSIM, which replaces sinusoidal illumination with a checkerboard-patterned structure, requiring only four raw images to achieve super-resolution imaging. In 4CSIM, instead of treating the entire image as a whole, we establish a point-wise relationship between the pixels in the reconstructed super-resolution image and the corresponding pixels in the original SIM images, reconstructing the Fourier spectrum of the super-resolution image pixel by pixel. The checkerboard illumination pattern enables this "point-wise reconstruction" method, with the reconstruction process involving only three-dimensional matrix operations. Compared to the existing 4SIM method, 4CSIM significantly accelerates image reconstruction due to its non-iterative nature and low memory usage, avoiding the trade-off between a high frame rate acquisition and reconstruction speed observed in 4SIM methods.

In summary, 4CSIM enhances both the acquisition frame rate and reconstruction speed of SIM technology, making real-time video imaging feasible.

sciforum-095919: How to recognize the formation of lipid rafts in membranes: FTIR spectroscopy data

Galyna Ivanivna Dovbeshko [1,*], Olena Petrivna Gnatyuk [1], Uliana Kostiantynivna Afonina [1], Maryna Volodymyrivna Olenchuk [1], Grygorii Pavlovych Monastyrskyi [1] and Tetina Oleksandrivna Borysova [2]

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[2] Department of Neurochemistry of the Palladin Institute of Biochemistry, National Academy of Sciences of Ukraine, 9 Leontovicha Str., 01054 Kyiv, Ukraine

It is known that lipids of different compositions play a fundamental role in the organization of cell membranes. Membranes consists of highly mobile individual molecules (mainly lipids and proteins) in dynamic equilibrium undergoing transient interactions organized into a three-dimensional supramolecular structure. The lipid and protein components of the membrane are not held together by covalent interactions. Recent studies showed that a lipid membrane has specific domains containing sphingolipids (SM) and cholesterol (Ch) known as lipid rafts. The latter have a liquid ordering phase (dense phase) organized in the environment of liquid-crystalline or fluidic liquid disordering phase. Changes in lipid composition caused by the nonspecific influence of various amphiphilic and hydrophobic drugs, viruses, etc., are supposed to modify the plasma membrane, which in turn affects the membrane receptors.

Here, we investigated a model of lipid rafts formation and the influence on its lipid compositions of the antiviral drug remdesivir which is used for the treatment of severe cases of COVID-19 disease. FTIR molecular bands were chosen as spectral markers. With FTIR spectroscopy, the marker spectral regions for the lipid rafts were: 1) the region of C=O vibrations of 1670-1640 cm^{-1}, 2)1570-1520 cm^{-1} corresponding to C=C vibrations, and 3) the region of 1400-1364 cm^{-1} assigned to C -H bending vibrations. In the case of the liquid-ordered phase, the IR absorption bands centered at 1644 cm^{-1} and 1548 cm^{-1} shift towards high-frequency, and the band at 1400 cm^{-1} toward the low-frequency, which indicates a decrease in the raft domains integrity in the membrane.

In addition to DOPC, changes in the ratio of lipids (SM and Ch) and remdesivir are able to disrupt the structure of the lipid rafts. Following the changes in the structure of the lipid rafts, we could clear up the mechanism of the influence of environmental factors including drugs and propose an additional test.

sciforum-095838: Investigation of the optical contrast between nanofiber mats and mammalian cells dyed with fluorescent and other dyes

Nora Dassmann, Bennet Brockhagen and Andrea Ehrmann *

Faculty of Engineering and Mathematics, Bielefeld University of Applied Sciences and Arts, 33619 Bielefeld, Germany

Electrospinning can be used to prepare nanofiber mats from diverse polymers and polymer blends with embedded metallic, ceramic, or other types of nanoparticles. Such nanofiber mats have been investigated for diverse applications, such as filtration, batteries, and supercapacitors; food packaging; or biomedicine and biotechnology. A large area of research is the application of nanofibrous membranes in tissue engineering. Typically, the cell adhesion and proliferation as well as the viability of mammalian cells are tested by seeding the cells on the substrates under examination, cultivating them for a defined period of time, and finally dyeing them to enable differentiation between cells and substrates under a white light or fluorescence microscope. While this procedure works well for cells cultivated in well plates or petri dishes, other substrates may undesirably also be colored by the dye. Here, we show investigations of the optical contrast between dyed CHO DP-12 (Chinese hamster ovary) cells and different nanofiber mats electrospun from pure poly(acrylonitrile) (PAN) as well as PAN/gelatin, PAN/keratin, and PAN/TiO_2. After cultivation for 5 days, the cells were fixed with glyoxal and afterwards dyed with haematoxylin–eosin (H&E), PromoFluor 488 premium, 4,6-diamidino-2-phenylindole (DAPI), or Hoechst 33342. Examination by white light or fluorescence microscopy, respectively, revealed that, in particular, the PAN/gelatin nanofiber mats—which were the most advantageous regarding cell growth—were also colored by the dyes. This paper reports the optimized dyeing parameters to maximize the optical contrast between CHO cells and nanofiber mats.

sciforum-097969: LCSr-SeNet: A Super-resolution and segmentation network for lung cytopathological images

Gangshan Liu *, Yiran Wang and Zhengjun Liu

School of Physics, Harbin institute of Technology, Harbin 150001, China

Digital pathology images often suffer from a low resolution due to limitations in acquisition and storage, which severely affects diagnosis and machine analysis. To address the issue of low-resolution pulmonary H&E-stained sections, we propose a deep learning network model, the lung cytopathological images super-resolution and segmentation network (LCSr-SeNet), which aims to simultaneously enhance image resolution and achieve cell segmentation. LCSr-SeNet consists of two modules: a super-resolution module and a segmentation module. The super-resolution module, through progressive feature extraction and reconstruction, significantly enhances the details and clarity of pathology images. The segmentation module then precisely segments the enhanced high-resolution images, distinguishing cancer cells from normal cells. In quantitative evaluations, LCSr-SeNet demonstrates significant advantages in both image resolution enhancement and cell segmentation tasks. In terms of its peak signal-to-noise ratio (PSNR) and structural similarity index (SSIM), LCSr-SeNet significantly outperforms traditional methods. Additionally, in cell segmentation tasks, the model exhibits excellent performance in metrics such as the Dice coefficient and intersection over union (IoU), greatly improving the segmentation accuracy and robustness. LCSr-SeNet successfully overcomes the challenges posed by low-resolution sections, achieving precise segmentation and localization of cells in pulmonary tissues. This innovative method provides a new solution for pulmonary pathology image analysis and holds promise for significant contributions to the diagnosis and treatment of lung cancer.

sciforum-095930: Low-Power Optogenetic Excitation and Suppression of Human Ventricular Cardiomyocytes Expressed with ChRmine and *Hc*KCR1

Gur Pyari *, Himanshu Bansal and Sukhdev Roy

Department of Physics and Computer Science, Dayalbagh Educational Institute, Dayalbagh Agra, 282005, INDIA

Low-power, high-fidelity optical excitation and the effective suppression of uncoordinated heartbeats are major challenges in cardiac optogenetics. Recently, a red-shifted, cation-conducting channelrhodopsin known as ChRmine, derived from the *Rhodomonas lens* (also attributed to the marine ciliate *Tiarina fusus*), has been discovered. ChRmine exhibits high light sensitivity and generates a large photocurrent for optical excitation. In addition, a potassium (K^+)-conducting channelrhodopsin from *Hyphochytrium catenoids* (*Hc*KCR1) has also been discovered. *Hc*KCR1 exhibits a reversal potential close to the resting membrane potential of the targeted cardiac cells, making it suitable for optical suppression. In this paper, we present a theoretical model and a detailed analysis of optogenetic excitation and the suppression of cardiac activity using ChRmine and *Hc*KCR1 in human ventricular cardiomyocytes (HVCMs). The present study shows that in ChRmine-expressing HVCMs, action potential (AP) can be triggered at 6 $\mu W/mm^2$ on illuminatation with 10 ms light pulse, which enables deeper excitation up to ~ 8 mm from the pericardial surface at safe light irradiances. High-fidelity optical pacing with ChRmine-expressing HVCMs is achievable up to 2.5 Hz at 0.7 ms light pulse and 0.58 mW/mm^2, which is an order of magnitude lower than the previously used opsins. *Hc*KCR1 effectively suppresses action potentials by shunting the cell membrane potential to the resting state at a light irradiance of 1 mW/mm^2. Furthermore, *Hc*KCR1 enables precise shortening of the AP duration at a very low irradiance of 1 $\mu W/mm^2$ on illuminating the cell during the repolarization phase. The present study highlights the advantages of the newly discovered ChRmine and *Hc*KCR1 opsins for low-intensity optogenetic pacing and complete suppression of uncoordinated heartbeats. The results are useful for designing energy-efficient, light-induced cardiac pacemakers and for the effective treatment of cardioversion and tachycardia, as well as for extending the scale of cardiac optogenetics.

sciforum-105188: Multifunctional hybrid nanoparticles for biomedical applications

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Nanomedicine has proven to be a promising avenue for the diagnosis and treatment of various diseases, offering customised solutions that are more specific and effective compared to conventional methods. The main components of nanomedicine are engineered nanoparticles (NPs), which can be produced from a variety of materials. Organic, inorganic, metallic, and polymeric NPs, including dendrimers, micelles, and liposomes, are examples of NPs that are widely explored in nanomedicine. Among them, inorganic NPs offer several advantages, such as tunable size and surface chemistry, high surface-to-volume ratio, chemical stability, biocompatibility, and unique optical, magnetic and electrical properties.

In this work, the use of porous biosilica-based NPs is described for biomedical applications. The NPs are derived from diatomite, a material of sedimentary origin formed from the remains of diatom skeletons. Diatomite-based NPs (DNPs) can be produced in a size range between 100 and 400 nm by a mechanical process based on ultrasound application and filtering. DNPs are characterized by a porous morphology, which is useful for the efficient loading of drugs. Moreover, they can be made photoluminescent for imaging purposes. The biocompatibility and cellular uptake of DNPs are demonstrated using different cancer cell lines, including human epidermoid, breast, cervical, and colorectal cancer cells. The silica surface can be chemically modified by various functionalization strategies to increase the drug uptake capacity of DNPs and improve the pharmacokinetic and pharmacodynamic profiles of the delivered drugs.

A hybrid nanosystem constituted by DNPs covered by gold NPs acting as SERS substrates is proposed for simultaneous intracellular drug sensing and delivery. This nanosystem constitutes the first example of a multifunctional platform realized from diatomite. Active targeting strategies, performed by immobilizing ligands on NPs, are also explored to enhance drug delivery efficiency.

sciforum-095647: Optical Fiber Dosimetry System for Gamma Radiation Facilities

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This research presents an innovative fiber optic dosimetry sensor tailored for radiation measurement in biological environments. The aim is to achieve a two-dimensional (2D) spatial distribution of radiation by using an array of sensors that are arranged in a custom-designed holder. In this investigation, the FLIXCAT™ FlexHD1 Fiber-Optic Dosimeter (FOD) was irradiated using a ^{137}Cs γ-ray source, highlighting a discrepancy of up to 61% between the actual irradiated dose and the reconstructed dose inside animal subjects. Employing the FOD as a novel dosimeter, specifically in in vivo biological systems, necessitated biocompatibility studies to assess their interaction with real tissue and their influence on inflammatory markers in the blood.

This study initiated with the surgical implantation of three cylindrical FODs, along with three standard TLD_100 dosimeters at various in vivo points (behind the neck, right femur, and abdomen). Subsequent to implantation, both FOD and TLD_100 samples were subjected to gamma radiation and analyzed post-extraction. The observed discrepancy between the actual irradiation dose and the reconstructed dose within the animal is due to the dosimeter directly receiving the unimpeded true dose in open air, unlike within the animal's body, where various tissues attenuate radiation from its point of entry to the dosimeter's location. This attenuation is influenced by factors like tissue thickness and type and the depth of the dosimeter from the body surface.

For implant validation, Magnetic Resonance Imaging (MRI) was performed to detect the dosimeters at three different points in the animal's body. MRI confirmed that implants (dosimeters) were present at all three locations without signs of oedema or inflammation. Additionally, there was no cell infiltration, confirming the sterility and biocompatibility of the dosimeters. Our results underscore the potential of the novel FOD in accurately measuring effective radiation doses for various organs in vivo, without inducing adverse effects.

sciforum-095830: Prototype of a Public Computer System with Fast Automatic Touchscreen Disinfection by Integrated UVC LEDs and Total Reflection

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Public touchscreens, such as those used in ATMs or ticket payment systems, which are accessed by different people in a short period of time, could transmit pathogens and thus spread infections. Therefore, the aim of this study was to develop and test a prototype of a touchscreen system for the public sector that disinfects itself quickly and automatically between two users without harming any humans.

A quartz pane was installed in front of a commercial 19" monitor, into which 120 UVC LEDs emitted laterally. The quartz plate acted as a light guide and irradiated microorganisms on its surface, but—due to total reflection—not the user in front of the screen. A near-infrared touch frame was installed to recognize touch. The antibacterial effect was tested through intentional staphylococci contamination.

The prototype, composed of a Raspberry Pi microcomputer with a display, a touchscreen, and a touch frame was developed, as well as a simple game programmed that briefly switched on the UVC LEDs between two users. The antimicrobial effect was so strong that 1% of the maximum UVC LED current was sufficient for a 99.9% staphylococci reduction within 25 s. At 17.5% of the maximum current, no bacteria were observed after 5 s. The residual UVC irradiance at a distance of 100 mm in front of the screen was only 0.18 and 2.8 μW/cm^2 for both currents, respectively. This would allow users to stay in front of the system for 287 or 18 minutes, even if the LEDs would emit UVC continuously, and not be turned off after a few seconds as in the presented device.

Therefore, fast, automatic touchscreen disinfection with UVC LEDs is already possible today and with higher currents, disinfection durations below 1 s seems to be feasible, while the light guide approach virtually prevents the direct irradiation of the human user.

sciforum-095571: SERS optrode optical fiber-based sensors for biosensing applications

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Over the past two decades, optical fiber sensing technology has made considerable progress in sensor design, manufacturing process optimization, and system integration, and it has become an integral part of advanced sensing technologies. Various optical principles, such as interference, scattering, total internal reflection, and surface plasmon resonance, are applied in designing optical fiber (OF) sensors. As an emerging OF sensor device, nanostructured plasmonic OF sensors have attracted significant attention due to their superior performance and peculiar properties, realizing the Lab on fiber concept. As nanostructured plasmonic OF sensors feature the characteristics of both traditional OF sensors and plasmonic sensors, they exhibit unique advantages and can be used as powerful biochemical sensing tools or integrated photonic devices. A simple approach is also the use of metal nanoparticles in order to modify the side or end of the optical fiber to excite the surface plasmon resonance effect. One of the main branches in the "Lab on Fiber" field is optical-fiber based SERS, which seeks to combine the advantages of both SERS and optical fibers. This combination aims to create powerful, flexible, robust, and miniaturized spectroscopic tools for remote and highly sensitive detection of low-concentration molecular analytes in a variety of environments, including harsh conditions.

sciforum-100777: Thermographic analysis of a porcine gel doped with the photosensitizer PpIX: A dosimetric study for Photodynamic Therapy

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Photodynamic therapy (PDT) is an emerging cancer treatment in which a specific wavelength (laser) is used to activate a molecule that is sensitive to light (photosensitizer) and damages cancer cells. Prior to treating a patient with PDT, a reliable dosimetric verification method is required, since the success of the treatment depends on the accurate delivery of the photodynamic dose. The present study evaluates the response of a possible dosimeter based on porcine gel with dispersion properties (intralipid emulsion to mimic human skin) doped with the photosensitizer PpIX (absorbent property) under different radiation doses of a 635 nm laser (PpIX excitation). The porcine gel was synthesized both with and without PpIX. To determine the effect of the radiation dose on both porcine gels, the dose enhancement factor was quantified. For this, IR thermography measurements were taken on doped and non-doped gels. The radiation-induced temperature (ΔT) changes of the PpIX-loaded gel samples compared to the control samples (without PpIX) after red laser irradiation at different doses (15, 30, 45, 60, and 100 J/cm^2) showed a significant dose enhancement that was greater than unity, except for 45 J/cm^2. Our findings show that porcine gels respond to a range of radiation doses that include the standard dose (37 J/cm^2) used for skin treatments, making them attractive for use as dosimeters that are capable of being read by a thermal imaging camera.

sciforum-100760: Where Macro Physics meets Nano: Effect of Geometry on Thermodynamics and Optics

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In the physical world, patterns of different sizes and forms are ubiquitous, from the nanoworld to the macroworld and, ultimately, gigantic like galaxies and the universe itself. At the atomic level, various geometric forms, such as the angles between atomic bonds and the spatial distribution of electronic density, fix the system's configuration and, therefore, its reactivity. On a larger scale, the helical spirals of DNA, the lattice patterns of crystals and supramolecular assemblies, the shapes of cells, and various assemblies of cells within tissues are examples of the most common patterns exhibited by nature. Nanostructured materials possess properties that depend on size and shape, distinctly differing from their bulk counterparts. These nanopatterns and morphologies influence biological organisms' thermal and optical management, which is essential for life. This management is often interwoven with the size and geometry of patterns. Elucidating its properties and occurrence is of high importance for understanding our world. In this study, we reveal, on a phenomenological level, the effect of the nanoscale patterns on thermal management. Besides the fundamental importance of exposing the structural constraints that are responsible for unusual thermodynamic response, the presented study offers the concept of shaping heat capacity on command by controlling the geometry without changing the system's chemistry.

Session 2. Optical Communication and Network

sciforum-095900: Integrated Bragg Grating Spectra

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Introduction

A methodology suitable for analyzing strong IBG (Integrated Bragg Grating) is presented using the Transfer Matrix Method (TMM) based on the translation of any waveguide's physical structure into a matrix of effective refractive indexes, n_{eff}, which is wavelength-dependent and describes the behavior of light in the IBG while avoiding the use of approximations like in Coupled Mode Theory.

IBGs have special characteristics that require a methodology that considers any tiny variation in geometry. These have a notable impact on the value of n_{eff} because of the high refractive index contrast of SOI (Silicon on Insulator) and therefore on the spectrum of the transfer function.

Method

Starting with a given IBG geometry, we mapped the waveguide structure into a matrix, *N'*, of effective refractive indices, which are functions of the wavelength and position along the IBG, $n_{eff}(\lambda,z)$. Subsequently, the TMM was applied using *N'* to characterize each layer and interface of the IBG. Finally, the reflectivity and phase spectra were obtained, i.e., the transfer function.

Using this methodology, four apodization methods (corrugation width, lateral delay, duty cycle, and periodic phase modulations) and different chirp methods are presented and compared. Also, the presence of additional Bragg orders is demonstrated as a result of the Fourier transform equivalence between the IBG apodization and its transfer function in reflection. To demonstrate the generality of the methodology, two technological platforms, SOI and Al_2O_3, are analyzed.

Results

Simulations allow us to obtain the reflectivity and phase spectra, i.e., the IBG transfer function. The goodness of each method is observed, as well as the second and third Bragg order spectra. The Al_2O_3 platform shows more robustness against fabrication errors.

Conclusions

TMM is the most suitable methodology for analyzing an IBG. Apodization, chirp methods, and higher Bragg orders are demonstrated to improve transfer functions.

sciforum-096372: Three-dimensional waveguide structure forming mode manipulating devices

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Three-dimensional waveguide structure forming mode manipulating devices

Mode multiplexing technology is a promising technology to increase the optical communication capacity, where a 3D waveguide structure is a neat solution for manipulating the modes with their symmetry in horizontal and vertical direction or their combination. Three-dimensional photonic-integrated vertical directional couplers are applied to form the mode multiplexer, where the mode (de)multiplexer serves for spatial (de)multiplexing the spatial guide modes in a few-mode waveguide. These guide modes are the waveguide modes such as the E11, E21, and E12 modes. In addition, the directional couplers (either the horizontal directional couplers or the vertical directional couplers) can be formed by using adiabatic tapered waveguides. The usage of the tapered waveguide can be functioned as a wavelength expander. In addition, the fabrication of the 3D waveguide structure can be utilized by using the multi-step photolithography processing methodology. For example, we have demonstrated the fabrication of a hybrid-core planar waveguide forming mode multiplexer by using multi-step photolithography processing for the realization of a high-order-mode band-passed function. Also, the passive device can be further developed to be an active device for dynamically manipulating the guided modes. In conclusion, the 3D waveguide structure forming mode manipulating devices are powerful in a mode division multiplexing system for the optical communication.

sciforum-100574: Dual-Band Shared Aperture Multimode OAM Multiplexing Antenna Based on Reflective Metasurface

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Compared with conventional planar electromagnetic waves, vortex electromagnetic waves carrying orbital angular momentum (OAM) are unique beams with a helical phase structure and a toroidal amplitude field. Due to the infinity of OAM modes and orthogonality between different modes, a completely new degree of freedom independent of time, frequency, and polarization domains is provided. OAM waves have great potential in terms of channel expansion and improving spectral efficiency. And with the progress of research, how to transmit more information and have more channel capacity has been a hot issue. In this paper, a novel single-layer dual-band orbital angular momentum (OAM) multiplexed reflective metasurface array antenna is proposed. We firstly design a metasurface that can realize dual-band nearly 360° phase coverage at 7 and 12 GHz, and realize 2-bit coding metasurface cells by obtaining suitable geometrical parameters through simulation optimization, and then we obtain the position of each cell in the array away from the feed source by computing. Afterwards, the corresponding phase compensation and the phase gradient required for specific mode OAM beam generation are calculated from the position of each cell in the array, and a 30×30 reflective metasurface array is obtained, which can independently generate different modes of OAM beams in the C and Ku bands, and complete flexible beam control in each operating band, providing a new possibility for realizing more transmission frequency bands and larger channel capacity in communication applications.

sciforum-105539: Fluorescent Concentrators/Antennas in Optical Wireless Communication

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Optical wireless communication (OWC) is expected to play a crucial role in future wireless communication networks due to its several advantages, including a license-free spectrum, robustness to electromagnetic interference, and ultra-wide bandwidth that enables very high transmission data rates. In most OWC systems, the received light typically requires amplification in the optical domain using lenses or compound parabolic collectors (CPCs). However, these approaches are constrained by the conservation of étendue, which results in a limited field of view (FOV) of the optical receiver.

Recent studies have shown that fluorescent concentrators/antennas can effectively concentrate light without being limited by étendue. Since the concentration principle of these antennas is based on fluorescence, they can achieve both high concentration gain and a wide FOV. Nevertheless, the photoluminescence (PL) lifetime of these antennas introduces an additional bandwidth-limiting factor. Fortunately, advancements in materials science techniques have significantly reduced the PL lifetime to just a few nanoseconds or even lower, thereby supporting the transmission of data at a high rate . This talk reviews the recent trend of exploring new fluorescent concentrators in various OWC applications, including visible light communications (VLCs) and underwater OWCs. These concentrators include those made from commercially available fluorescent fibers, as well as organic and inorganic fluorescent materials.

sciforum-095335: High-Speed 10Gbps Optical Signal Transmission over a Hybrid Single-Mode Fiber (SMF) and Multi-Mode Fiber (MMF) System Using OptiSystem

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In this study, we explore the transmission of a high-speed 10Gbps optical signal over a hybrid Single-Mode Fiber (SMF) and Multi-Mode Fiber (MMF) system using Optisystem. The optical signal is initially transmitted over 5-20 kilometers of an SMF, ensuring minimal dispersion and loss while maintaining signal integrity. Following the SMF transmission, the signal is coupled into an MMF, which operates in the LP01 mode. The MMF generates 16 distinct modes, each carrying the optical field of the transmitted signal. The simulation outcomes demonstrate that the hybrid system can sustain high signal quality and low BER across different fiber spans, showing resilience against modal dispersion and attenuation. By optimizing parameters like laser wavelength, modulation format, and receiver sensitivity, we achieved efficient signal transmission suitable for high-speed applications. This research underscores the potential of hybrid SMF-MMF systems to meet the growing demand for high-bandwidth communication in contemporary optical networks, especially where integrating different fiber types can offer a more adaptable and scalable solution. In addition, this multimode transmission approach aims to leverage the capacity of MMFs to handle multiple modes. Future work will investigate advanced modulation techniques and the effects of environmental factors on system performance to further improve the reliability and efficiency of hybrid optical networks.

sciforum-095933: Ultrafast All-Optical Computing with CoTCPP Surface-supported Metal–Organic Framework Nanofilms

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Ultrafast all-optical computing is essential for overcoming the speed and efficiency limitations of electronic systems, enabling rapid data processing and transmission with minimal energy consumption. The main challenges in all-optical computing include developing materials with strong, fast, and reversible nonlinear optical properties, as currently used materials often require high power and lack durability. Managing optical losses and maintaining signal integrity over distances and components is crucial, necessitating low-loss waveguides and efficient light confinement. Integrating nanoscale optical components with high precision and miniaturization demands advanced fabrication techniques and innovative designs for scalable all-optical circuits. Developing novel materials with enhanced nonlinear optical properties, including organic materials, graphene, plasmonic nanostructures, transition metal dichalcogenides, MXenes, and advanced metal–organic frameworks, can significantly improve the performance of optical switches and logic gates.

In this paper, we present a theoretical model and comprehensive analysis of ultrafast transitions between reverse saturable absorption and saturable absorption in CoTCPP surface-supported metal–organic framework (SURMOF) nanofilms with femtosecond (fs) laser pulses at 400 nm.

The effects of laser input intensity, thickness, concentration, and nonlinear absorption coefficients on transmittance have been studied to optimize all-optical switching in recently reported CoTCPP SURMOF nanofilms. We demonstrate ultralow-power and ultrahigh-contrast all-optical switching in SURMOF nanofilms and use the results to design all-optical fs AND, OR, NOT, universal NOR, and NAND logic gates. The percentage modulation of the Boolean all-optical NAND logic gate with CoTCPP SURMOF nanofilms is greater compared to $MoTe_2$ nanofilms and BODIPY derivative compound ZL-61. A passive photonic diode with CoTCPP/ZL-61 has also been designed, which results in a nonreciprocity of 17 dB.

Based on CoTCPP SURMOF nanofilms, various combinational circuits that include an adder, subtractor, multiplexer, and encoder can be designed and explored using ultrafast all-optical logic gates. The remarkable nonlinear optical properties of CoTCPP SURMOFs open exciting prospects for ultrafast all-optical computing.

Session 3. Optoelectronics and Optical Materials

sciforum-096703: Photocatalytic properties of PEO coatings prepared using 2D materials

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Plasma electrolytic oxidation (PEO) is an electrochemical process recognized as one of the most effective techniques for functional coatings. In this process, a high voltage is applied to the electrolyte, resulting in a plasma discharge on the surface of a light metal alloy substrate, forming a hard and dense ceramic coating. We incorporated several powders of well-known semiconductor photocatalysts, including TiO_2-graphene, 2D-WO_3, 2D-MoO_3, and 2D-Bi_2WO_6, as additives to the electrolyte. Our objective was to produce plates with coatings of the aforementioned 2D photocatalysts, which show high potential for degrading various organic pollutants in water.

The photocatalysis process we utilized is based on reactions that occur on the coating surfaces in the presence of water and sunlight. Specifically, under UV-VIS light, electrons and holes are photogenerated in the semiconductor PEO-layer. These, in turn, react with dissolved oxygen, hydroxyl ions, and water to form reactive oxygen species, which effectively degrade pollutants into simpler molecules.

We tested coatings with homogeneous, single layers of photocatalysts as well as combinations forming multilayer structures. As a result, the obtained layers demonstrated high photocatalytic activity against organic compounds under UV-VIS irradiation. Our research focused on preparing highly porous coatings composed of 2D structures with enhanced photocatalytic properties, suitable for easy application in water remediation.

sciforum-091381: Analysis of opto-electronic characteristics of $Zr_?Hf_{1-?}O_2/Al/Zr_?Hf_{1-?}O_2$ thin-films deposited at different substrate temperature

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Introduction

The opto-electronic characteristics of Zr-doped HfO_2 have been thoroughly investigated by many researchers, yet further research is needed to fully understand these materials. To improve the electrical and optical characteristics of Zr-doped HfO_2 films, experiments involving novel structures are crucial. The analysis of various characteristics of $Zr_?Hf_{1-?}O_2$/Al/ $Zr_?Hf_{1-?}O_2$ trilayer thin-films is still under consideration.

Methods

In this study, $Zr_?Hf_{1-?}O_2$/Al/ $Zr_?Hf_{1-?}O_2$ trilayer thin-films was deposited with different substrate temperatures, varied from 25 to 300 ◦C, using magnetron sputtering. The trilayer film was deposited on *n* type silicon substrates to examine structural and electrical properties. The purpose of depositing the trilayer film on commercial glass substrates was to investigate its optical properties. Zr and HfO_2 targets were co-sputter deposited to form the top and bottom layers of $Zr_?Hf_{1-?}O_2$. Using a pure Al target, DC sputtering was used to deposit the intermediate metal layer. Various techniques such as grazing incidence x-ray diffraction, field emission scanning electron microscopy, atomic force microscopy, cross-sectional transmission electron microscopy, and energy-dispersive x-ray spectroscopy were employed for structural analysis. UV–VIS spectroscopy has been employed to investigate the optical characteristics of the films. The MOS structure with gate electrodes of 100 μm was fabricated using UV photolithography followed by electron beam evaporation technique. Capacitance–voltage and current–voltage measurements were conducted to evaluate the electrical characteristics of the trilayer thin-films.

Results

The physical characterization indicates that increasing the substrate temperature enhances the crystallinity, grain size, and surface roughness of the trilayer thin-films. The trilayer thin-film deposited at 300 ◦C exhibits enhanced optical transmittance across 400 to 1100 nm wavelengths. Furthermore, this film exhibits excellent performance in terms of figure of merit, leakage current, and breakdown performance.

Conclusions

These qualities suggest that the films deposited at 300°C hold potential for application in optoelectronic devices.

sciforum-098046: Anti-Stokes UVC emission silicate glasses with luminescence properties doped with Pr^{3+} ions in wide spectral regions

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The importance and relevance of creating materials with the ability to absorb photons from the environment or sunlight and subsequently convert them into photons of the bactericidal range of the spectrum (220-280 nm) are due to the need to create self-sterilizing surfaces without the use of ultraviolet lamps. The use of such surfaces can help to permanently reduce the content of adsorbed microbes. The intense luminescence of Pr^{3+} ions in a wide range of wavelengths, including in the UV-C range (200-280 nm), allows them to be used as activator ions in the creation of materials emitting in the ultraviolet region.

The SrO-CaO-MgO-SiO_2 glasses doped with Pr^{3+} ions were synthesized. We investigated the absorption and luminescence spectra of the glass samples in the wide spectral range, their luminescence lifetimes, the Up-converted UVC luminescence using a 444 nm diode laser, and the effect of temperature on the spectral properties of the glasses.

The up-convection luminescent radiation in the UV region nm with the maximum at 275 nm in the doped glasses upon excitation by lower-frequency radiation was obtained. The luminescence of Pr^{3+} ions in the glasses corresponded to the spectral maxima in blue, reddish-orange, and near-infrared spectral regions. The results of the investigation of Pr^{3+} ions' luminescence as a temperature function show that temperature elevation gives rise to a moderate lowering of Pr^{3+} ion luminescence in the visible region and emission band extension, especially at longer wavelengths. The effect of the increasing temperature on the $^3H_4 \rightarrow ^3P_2$ absorption band is insignificant. Thus, excitation of the up-converted emission of Pr^{3+} ions can be efficient even at a high laser diode power.

Synthesized glasses can be used as materials for photonic applications, including in the creation of light-emitting diodes and the development of UV self-sterilizing surfaces.

The study is described in more detail in [*Materials*,Vol.*17*(2024)1771].

sciforum-100761: Blue- and Green-Emitting Carbon Dots Embedded in SiO_2 and SiO_2–CaO Monolith Glass: Analysys of Optical Properties

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Carbon dots (CDs) have been widely studied as an alternative to quantum dots, semiconductors, and rare-earth-element-doped structures, as they are non-toxic and metal-free optical materials [1,2]. In medicine, they might be used, for example, in drug delivery, diagnostic, and sensing [3].

CDs were synthesized using low-temperature ammonium citrate pyrolysis, and their structure (XRD, TEM, FT-IR) and optical properties were analyzed. The TEM analysis showed that blue-emitting carbon dots (bCDs) have spherical shapes with a 4-7 nm diameter, and green-emitting CDs (gCDs) have the shape of rods with a length of 20-50 nm. The sol–gel method was used to synthesize silica and silica–calcia monoliths with embedded CDs. The aim of the experiment was to obtain composites in which the luminescence of the CDs could be observed and further used to monitor different biological processes. For that reason, glasses with different concentrations of CDs (0.03-0.2 wt.%) were prepared, and optical properties (absorption, excitation, and emission) were measured. It was found that the addition of urea during the synthesis of CDs led to a change in the emission color of the CDs from blue (λ_{em}: 450 nm) to green (λ_{em}: 540 nm). Comparing the emission spectra of the CDs, colloids, and composites, changes in the maximum emission and its intensity were observed. The emission intensity of CDs is lower in glass structures, and the maximum emission shows a red shift in glass composites. Spectroscopic measurements showed that the luminescence intensity and emission maximum depend on the excitation wavelength.

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sciforum-099873: Carbon Dots/TiO_2 hybrids for photocatalytic degradation of drugs in the water

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The presented results show the synergistic effects of combining two photocatalysts (titanium oxide (TiO_2) and carbon dots (CDs)) on the enhancement of water remediation. This research involves the synthesis of fluorescent and phosphorescent carbon dots (CDs and PhCDs, respectively) and preparation of the composites, whereby they are incorporated into TiO_2 pores. Structural analysis, using X-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM), and Brunauer--Emmett--Teller (BET) techniques, was conducted to assess the compositional and morphological changes resulting from CD incorporation into TiO_2.

Infrared (IR) and Raman spectroscopy allowed us to identify functional groups on the CD surface, enabling control of the optical properties of the composites. Spectroscopic studies revealed a shift in the absorption edge for the PhCDs/CDs@TiO_2 composites compared to pure TiO_2, which shows that it is possible to modulate the excitation range in the visible range. Photocatalytic activity measurements show that the PhCDs@TiO_2 composite exhibited higher activity compared to single catalysts. This enhancement is attributed to a slowdown in carrier recombination due to electron trapping in the energy band gap, leading to more efficient electron--hole separation and an increase in photocatalytic activity.

The study's results indicate that the PhCDs@TiO_2 composite has significant potential for the efficient decomposition of organic compounds in water, offering a promising solution for environmental clean-up. Additionally, the use of carbon dots opens new avenues for enhancing and modifying existing photocatalysts, paving the way for future advancements in photocatalytic applications.

sciforum-094965: Chromatic dispersion of chalcogenide-glass-based photonic crystal fibre with ultra-high numerical aperture

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Photonic Crystal fibres have been gaining attention since 1995, when the first PCF was introduced. The flexibility to alter various properties of a PCF just by varying its geometrical properties, like the hole size, pitch, or number of rings, makes it versatile and more convenient to use as compared to normal optical fibres. We report a chalcogenide glass (As2Se3)-based photonic crystal fibre with a solid core. The proposed PCF has an ultra-high numerical aperture value reaching up to 1.82 for the explored wavelength range of 1.8-10 μm in the mid-infrared region. With this, the PCF has a high light-gathering capacity. With negative dispersion reaching up to approx. -2000 ps/km-nm at 4.8 micrometres, the fibre acts as a dispersion compensating fibre, with confinement loss being close to zero for higher values of wavelength. The value of dispersion is significantly less due to the regular variation in the size of the holes in the transverse direction, as compared to the design when there is no gradation. The value of the numerical aperture increases as the pitch increases from 0.92 to 0.96 and then to 1 micrometre, at a particular wavelength value. The design has been optimized with the appropriate value of the perfectly matched layer to obtain the best results.

sciforum-100052: Down-Conversion Mechanisms in Tb^{3+}/Yb^{3+}-Activated Silica–Hafnia Glass-Ceramic Films: Temperature and Excitation Power Dependence

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Transparent glass ceramics activated with rare earth ions are valued for their excellent optical properties [1]. Silica–hafnia binary systems have emerged as an ideal matrix for integrating rare earth ions into hafnia nanocrystals, resulting in a considerable increase in luminescence and allowing for a wide variety of important applications. This work focuses on the Tb^{3+}/Yb^{3+}-driven down-conversion process, widely utilized in photovoltaic systems.

Following a well-consolidated protocol and an appropriate thermal treatment, the silica–hafnia glass-ceramic films were fabricated using the spin-coating technique via the sol–gel method. Interestingly, sol–gel technology offers the ability to create multicomponent materials with controlled composition, shape, morphology, and optical properties for the final product.

This investigation concentrates on silica–hafnia glass-ceramic films with a composition of $70SiO_2$-$30HfO_2$ that have been doped with 19% rare earth ions ([Tb + Yb] / [Si + Hf] = 19%). Two primary findings are examined: (a) the temperature dependence of the intensity and broadening of the Yb^{3+} emission band at 975 nm and (b) the $Tb^{3+} \rightarrow Yb^{3+}$ energy transfer mechanism, which is based on proposed mechanisms from the existing literature. Furthermore, the power dependence of Yb^{3+} luminescence ($^2F_{5/2} \rightarrow {}^2F_{7/2}$) is examined in relation to this subject [2].

In summary, these results underline the suitability of SiO_2-HfO_2 glass ceramics for photonic applications and enhance our understanding of the $Tb^{3+} \rightarrow Yb^{3+}$ down-conversion dynamics in this system.

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sciforum-099845: Exploring the Use of Luminescent Powder Additives in Coatings Produced via the Plasma Electrolytic Oxidation Technique for Various Applications

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Plasma Electrolytic Oxidation (PEO) is a surface treatment process that has been extensively studied in recent years for its ability to produce thick, dense metal oxide coatings. This process is especially effective on light metals, primarily enhancing their wear and corrosion resistance. Recently, the PEO process has also been used to produce composite coatings by adding luminescent nanoparticles to the electrolyte. This work presents the spectroscopic properties of PEO coatings on light metal alloys with luminescent particle additions. To increase the functionality of these coatings, various phosphors were incorporated, thereby enhancing their functional capabilities. The coatings' structure and morphology were characterized using X-ray Diffraction (XRD) and Scanning Electron Microscopy (SEM), both on the surface and in cross-section. Additionally, the chemical composition of the layers was analyzed using Glow Discharge Optical Emission Spectroscopy (GDOES) and Energy-Dispersive Spectroscopy (EDS) on both the surface and cross-sections. The photocatalytic properties of the coatings were evaluated on samples containing graphene@TiO_2 particles by monitoring the photodegradation of bisphenol A using UV-Vis absorption spectroscopy. For temperature-sensing properties, $Er_{0.02}Yb_{0.4}Y_{1.58}O_3$ additives were tested. Contactless temperature measurements were conducted across a broad temperature range to determine the most effective range for practical use. Furthermore, SiO-CaO glasses doped with Yb^{3+}/Er^{3+} ions were utilized to prepare coatings on alloys that were intended for implant applications. These coatings were assessed for their ability to monitor layer bioactivity and the growth of hydroxyapatite, which is crucial for implant integration and functionality.

It was shown that the incorporation of various luminescent additives into the PEO electrolyte for coating light metal alloys enhances a surface's mechanical properties and introduces new functionalities for a wide range of optical applications.

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sciforum-100672: Fast method for the measurement of dispersion of integrated waveguides utilizing Michelson interferometry effects

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Introduction

We demonstrate a method for measuring the dispersion of a device under test (DUT), which utilizes light reflections at the edge and within an integrated waveguide to create a Michelson interferometer. The interference fringes of the Michelson interferometer depend on the group delay experienced in it.

Methods

In the DUT, the reflected power is recorded during a single, fast laser sweep. For an optical cavity with a free spectral range of **Δf**, the group delay **(τ)** is inversely proportional to **Δf** [1]. By finding the local period in the reflected spectrum, τ can be found as a function of frequency, and from this, the dispersion as the slope of τ.

Results

The DUT is a linearly chirped Bragg grating designed to generate a dispersion of **-45.9 ps^2**. We took nine different measurements of the same device. From the experimental data, τ was found to be noisy at low frequencies and only the linear portion of τ was considered. We found the dispersion to be **(-45.5± 11.2) ps^2**.

Conclusions

Our step-by-step data analysis confirms that, analyzing interferometric fringes from DUT light reflections offers a fast method for measuring photonic iIntegrated circuit dispersion, which aligns well with design values. This approach could serve as an alternative to established methods [2], which we will further verify in the future.

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sciforum-095733: Investigation of spectroscopic properties of $LaAlO_3$:Ti^{3+} for lifetime-based thermometry

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Inorganic nanocrystals doped with transition metal ions combine several advantageous features: (1) high chemical and photochemical stability with (2) efficient luminescence resulting from the high absorption cross-section and (3) tunabile spectral positions of the absorption and emission bands depending on the chosen host material. The most extensively studied transition metal ions in optical spectroscopy are Cr^{3+} and Mn^{4+} ions, which seems promising for many applications related to their red or infrared emission [1,2]. However, their properties have already been determined in many host materials, making it possible to roughly predict their behavior in others and thus assume certain limitations. This issue does not apply to Ti^{3+} ions, the stabilization of which beyond the well-known sapphire has only been confirmed in a few host materials. Meanwhile, it has already been presented that the emission and excited state lifetimes of Ti^{3+} ions are characterized by a significant dependence on temperature changes, which may be beneficial for luminescent thermometry [3]. Moreover, Ti^{3+} ions can be characterized by relatively long excited state lifetimes of the order of several tens of milliseconds. Therefore, step-by-step optimization of the synthesis condition and dopant concentration of $LaAlO_3$ doped with Ti^{3+} ions will be presented in order to understand the influence of dopant concentration on spectroscopic properties and the thermal quenching process. Finally, the influence of non-stoichiometric ion distribution on the above properties will be analyzed.

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sciforum-105231: Nanoparticles in Optical Fibers, a Game-Changer.

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Since the 1970s, optical fibers have undergone considerable development and are now used in a very wide range of applications, covering telecommunications, the environment, medical applications, etc., thanks to the development of amplifiers, lasers, and sensors. Such progress has been made possible by the considerable work carried out to improve the transparency of optical fibers, i.e., by removing absorbing centers (such as iron ions) and structural and compositional heterogeneity. In contrast to this approach, a new family of optical fibers has been developed in recent years, incorporating heterogeneity, such as dielectric nanoparticles. Such fibers were first envisaged as a means of locally modifying the chemical and structural environment of luminescent ions (rare-earth and transition metal ions) in order to offer new fiber lasers and amplifiers. However, light scattering induced by the nanoparticles imposes severe drawbacks for those applications. Very recently, light scattering has been reported to be of great interest to developing sensors (temperature, stress, chemistry, biology, etc.). To exploit the light-scattering property, two main methods wereused to analyzed the sensors, based on optical backscatter reflectometry and transmission reflexion analysis. This presentation will review these fibers, presenting the fabrication processes, the fundamental issues involved in nanoparticle formation, and their different applications.

sciforum-095869: Optical properties of Graphene Nanoplatelets on amorphous Germanium substrates

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In this work, we investigate the integration of graphene nanoplatelets (GNPs) with amorphous germanium (Ge) substrates. The unique properties of amorphous Ge, such as its ability to introduce localized energy states and disorders, significantly influence the electronic interactions within the composite material. These peculiarities, including density variations and distinct optical properties, are crucial in determining the overall behavior of the GNPs–amorphous Ge composite.

Germanium films were deposited onto glass substrates using DC magnetron sputtering, followed by the deposition of GNPs through a dip-coating process. The optical properties of these composites were meticulously characterized using Variable Angle Spectroscopic Ellipsometry (VASE) across a wavelength range of 300–1000 nm and incident angles between 50° and 70°. A comprehensive spectral fit was achieved using a generalized oscillator model incorporating three Gaussian oscillators.

Our findings reveal a significant alteration in the optical properties resulting from the interaction between GNPs and the amorphous Ge substrate. This interaction likely involves the merging of electronic states from both materials, leading to an increased density of states at the Fermi level and enhanced optical absorption. The resulting composite exhibited an improved refractive index and extinction coefficient, suggesting a stronger light–matter interaction.

These enhanced optical properties underscore the potential of GNPs–amorphous Ge composites in various optoelectronic applications. This study provides a deeper understanding of the interaction mechanisms at play, paving the way for the development of advanced materials with tailored optical properties for specific technological applications.

sciforum-095931: Optical Resonance in a Low-Symmetry Photonic Crystal Cavity

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Photonic crystals are periodic dielectric structures that exhibit photonic band gaps that strongly depend on the geometry of the lattice elements and material properties [1,2]. Since the design parameters of the photonic crystal structure are amenable to modification and adjustments, light can be manipulated and easily controlled, guided, and trapped in these structures [3]. Conventional photonic crystals have high-symmetry unit cells. Low-rotational-symmetry structures are formed by breaking the high symmetry in the photonic crystal unit cell. Low-symmetry structures are more sensitive to light manipulation and provide more control and flexibility over light with geometric and structural diversity [4]. In this study, the resonance effect in the cavity structure of a square-lattice photonic crystal composed of C2-type low-symmetry dielectric rods is investigated. The band structure, equi-frequency contours, and transmission spectra of the low-rotational-symmetry photonic crystal are obtained with Lumerical and MEEP software to examine the resonance [5,6]. Analyzing optical properties through symmetry manipulation and resonance refraction will contribute to understanding light collimation and confinement.

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sciforum-095840: Optimized Wide-Angle Metamaterial Bandpass Filters: Enhanced Performance with Multi-Layer Designs and 1D Ternary Photonic Crystals

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Introduction

Metamaterial-based optical filters are commonly used to address the 'blue-shift' issue as they exploit the absorption of the material and interplays of photonic crystals. A shift-free bandpass filter based on a silicon nanosphere (SiNP) with gold as a core--shell array was developed. However, the single-layer design's blocking performance is relatively weak due to inadequate absorption and scattering. Moreover, it faces pronounced difficulties with transverse electric (TE) polarized light at a high angle of incidence (AOI); therefore, an extra AOI insensitive edge-filter design was employed. The optimized bandpass metamaterial filter demonstrates high insensitivity to AOI and stronger blocking performance, evidenced by its high optical density (OD = 2.35).

Method

A systematic design protocol that combined fullwave simulation software (CST) and transfer-matrix-based thin-film filter design software (Essential Macleod, ESM) was employed to optimize the design.

Results

The fundamental single layer is composed of infinite unit cells in a primitive cubic lattice configuration. Each unit cell comprises silicon nitride (SiN) as the host medium and a SiNP with a gold shell. To address the poor blocking performance problem, a second meta-layer was introduced. Furthermore, to remove the undesired peaks observed at high AOI, an AOI insensitive edge filter was introduced. It incorporates "H/2 L H/2" units, where H and L denote the high (Amorphous silicon) and low (SiN) refractive index materials, respectively, each with a quarter wavelength thickness. The final optimized design significantly enhances the OD up to 2.35 for TE polarization and 1.75 for transverse magnetic polarization.

Conclusions

In conclusion, a multi-layer, wide-angle, shift-free bandpass filter was successfully designed using the combined design protocol and further optimized by introducing an AOI insensitive edge filter. It demonstrates high OD in the stopband at all AOI due to the introduction of the second meta-layer and edge-filter design.

sciforum-095231: Thickness Dependency of Carbon Nanotube Thin Films' Opto-Plasmonic Properties

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Thin films with a thickness of a few nanometers to a few tens of nanometers, also called trans-dimensional (TD) materials, are an exceptional tool to tune various opto-plasmonic properties of a system that are unattainable when using both single-layered two-dimensional (2D) counterparts and/or three-dimensional (3D) bulk counterparts. Taking the planned periodic arrangement of single-walled carbon nanotube (SWCNT) films as an example, we semi-analytically calculate the dynamical conductivities and dielectric responses of a TD film as a function of the photon frequency and radius of the SWCNT. The periodic array of SWCNs has an anisotropic dielectric response, which is almost a constant and is the same as that of the host dielectric medium in the perpendicular direction of the alignment of the SWCNT array due to the depolarization effect that SWCNTs have. However, the dielectric response depends on the incident photon energy, in addition to the film's thickness, the SWCN's sparseness, inhomogeneity, and the SWCNT's diameter. The energy difference between the resonant absorption peak and the plasmonic peak varies with the thickness of the film. We reveal that thinner SWCNT TD films have a comparatively stronger exciton-plasmon coupling than thicker SWCNT TD films.

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Session 4. Lasers, Light Sources and Sensors

sciforum-091302: Advancing Sensing Capabilities: Hybrid Integration of Orthogonal Mode Couplers with Plasmonic Waveguides

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Plasmonic sensors offer ultra-sensitive detection capabilities at the nanoscale, enabling the detection of slight variations in refractive index, molecular binding events, and environmental conditions. Their compact size and compatibility with integrated circuits make them promising candidates for various applications, ranging from biomedical diagnostics to environmental monitoring and beyond. In this study, a comprehensive numerical investigation is conducted using the finite element method (FEM) to analyze a plasmonic sensor employing a metal–insulator–metal (MIM) waveguide for temperature sensing applications. The sensor configuration includes a resonant cavity that is coupled to the MIM bus waveguide and filled with a PDMS polymer. Initially, the device's sensitivity is approximately −0.44 nm/°C. While recognizing the existence of various sensitive plasmonic sensor designs, a gap in understanding the light coupling mechanisms to nanoscale waveguides is identified. To address this, a novel approach is employed: orthogonal mode couplers specifically tailored for plasmonic chips utilizing MIM waveguide-based sensors . Through optimization, the hybrid system, comprising silicon couplers and an MIM waveguide, exhibits optimized transmission ranging from −1.73 dB to −2.93 dB across a broad wavelength spectrum of 1450–1650 nm. The strategic integration of these couplers not only distinguishes the proposed plasmonic sensor but also positions it as a highly promising solution for an extensive range of sensing applications.

sciforum-095806: Universal Clarity Evaluation Function for Autofocus Based on Amplitude Differences of Fractional Fourier Transform

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In coherent diffraction imaging systems, autofocusing technology is used to precisely detect the distance from the detector plane to the sample plane, which is a critical factor affecting imaging resolution and quality. We propose a new clarity evaluation function (CEF) based on amplitude differences of fractional Fourier transform (ADFrFT), which focuses on issues of commonly used CEFs such as poor adaptability to the environment and samples, poor noise robustness, and significant oscillations. ADFrFT is based on the fractional-domain features of the sample as the autofocusing criterion and adds a new parameter for adjusting the ratio of fusion between the spatial and frequency domains. This parameter can take the sample type and detection scenario as prior knowledge and can be flexibly selected according to actual situations. Compared with various qualitative and quantitative CEFs, it relaxes the requirements of sample and scenario types, while guaranteeing accuracy, and the features of the autofocus curves can switch between spatial and frequency domain types. We also propose an autofocus strategy that first searches for the initial range of the focal length and then subdivides the search to optimize in the right direction, which can be achieved only using ADFrFT to obtain autofocus curves of two different characteristics. We demonstrate the effectiveness, flexibility, and versatility of ADFrFT through autofocus simulations and experiments. In the coaxial multi-distance coherent diffraction imaging experiment, we achieved a higher imaging quality compared to physical ranging by accurately correcting the diffraction distance through ADFrFT autofocus.

sciforum-095737: Application of aerodynamic levitation to the formation of glass ceramics

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The lighting industry is intensively looking for materials that can generate white light, similar to sunlight. WLED is a new type of semiconductor lighting device, widely used today due to its low cost, long service life, energy efficiency, excellent reliability and environmental friendliness. Commonly used WLED lighting generates light that contains too strong a blue component and no red one, which has a negative impact on health. Our solution is to use Ba_2MgMoO_6 (BMM) as a host for Sm^{3+}, as a potential red phosphor to improve the color characteristics of WLEDs.

In this study, the red phosphor of 1% Sm^{3+} ion doped BMM with a double perovskite structure was prepared using a co-precipitation method. Next we obtained amorphous structures in the form of balls with a diameter of 1.0 mm, using a unique aerodynamic levitation method. Then, an attempt was made to obtain glass ceramics by crystallising BMM crystallites surrounded by an amorphous structure by heating it at the designated crystallization temperature. The structural and spectroscopic properties of the obtained materials were analyzed.

We can successfully conclude that the obtained BMM:Sm^{3+} materials are good candidates as a red phosphor (CRI=91 and CCT=2943 K), giving a warm white emission. Temperature measurements brought us completely unexpected results. The relative sensitivity calculated from FIR has a maximum of 2.7% K^{-1} at -30 °C and another local maximum of 1.6% K^{-1} at 75 °C. This value is one of the highest achieved for luminescence thermometry performed only using Sm^{3+} ions. This is an extremely promising precedent for temperature sensing using perovskite materials with high symmetry. Transparent glass samples were obtained (Fig. 1). From the XRD patterns, only a broad diffuse peak is observed, which indicates that the samples are totally amorphous, without any traces of crystalline structure. The SEM images show the homogeneous topography of the sample.

sciforum-095841: Camera Calibration Algorithm Based on Brightness Non-uniformity Correction and Grating Phase-Shifting Method

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Machine vision is extensively utilized in diverse fields such as target detection and dimension measurement due to its inherent characteristics of high speed, precision, safety, and reliability, facilitating enhanced operational efficiency and quality assurance. However, influenced by factors such as processing technology and assembly techniques, non-uniform brightness and optical distortion significantly impact visual measurement results. To solve this issue, we propose a camera distortion correction method based on brightness non-uniformity compensation. This method preprocesses vignetted images using an improved simulated annealing algorithm with image entropy, processes the phase-shift and checkerboard patterns captured by the camera to obtain the intrinsic and extrinsic parameters of the camera, and corrects the distorted images. The proposed method significantly improves camera calibration accuracy and image rectification effectiveness compared to traditional camera calibration methods through advanced image preprocessing techniques. The experimental results demonstrate that after brightness non-uniformity correction, the error can be reduced by more than 80%. Using geometric distortion as an evaluation criterion, our method achieves an accuracy improvement of over 25% compared to Zhang's algorithm. It exhibits versatility across domains including camera calibration, target identification, and detection, thereby augmenting the precision and efficiency of visual assessments. By implementing our proposed approach, advancements can be made in the refinement of visual measurement techniques, bolstering the reliability and efficacy of data analysis in fields reliant on visual data processing.

sciforum-095881: Carbons Dots based on sustainable carbon precursors and their potential for sensing applications

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Carbon Dots (CDs), a fluorescent carbon-based nanomaterial, can be seen as more appealing than molecular fluorophores and metallic nanoparticles due to their properties. These include good water solubility, biocompatibility, high stability, low toxicity, adjustable fluorescence, and easy surface functionalization. These features have led to their increasing use in fields such as sensing, bioimaging, and photocatalysis, among others. In fact, CDs' unique photoluminescence properties show promising potential for sensing applications. CDs have been shown to serve as sensing receptors in nanoprobes, in which their features can be used as a sensing signal. Metal cations, non-metal ions, solvents, pesticides, and organic compounds are examples of analytes for which CDs can be used as sensors.

Relevantly, CDs can be produced from different carbon sources, including various types of organic waste. Thus, CDs could contribute toward a circular economy and upcycling waste. However, waste-based CDs usually have a low fluorescence quantum yield (QY_{FL}20%), which limits their practical applications (especially in sensing).

Herein, we developed a hydrothermal synthesis strategy for CDs that employs different organic wastes as carbon precursors and consistently generates CDs with appreciable fluorescence. This strategy was validated by testing different types of waste: corn stover—CD@CS; coffee—CD@C; sawdust—CD@S; and cork—CD@CK. These CDs present similar fluorescence profiles, with emission and excitation maximums at ~440 and ~350 nm, respectively. More importantly, the QY_{FL} of these CDs presents significant values (CD@CS: 39.3%; CD@C: 24.6%; CD@S: 35.9%; CD@CK: 21.8%). So, we obtained CDs from different waste materials without compromising their performance in terms of QY_{FL}, which is essential for their future use in sensing applications.

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sciforum-095804: From Visible Light to UVC: Upconverting Phosphor Doped with Pr^{3+} Ions for Germicidal Applications

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Antibiotic resistance is a global health crisis driven by the overuse and misuse of antibiotics. To combat this, effective disinfection of air, water, and surfaces is crucial. Ultraviolet C (UVC) lamps, emitting 220-280 nm radiation, have been used for this purpose since the 1930s. Since UVC radiation does not naturally reach the Earth's surface, microbes have not developed resistance to it.

In this work, we synthesized UVC-emitting phosphor doped with Pr^{3+} ions via a high-temperature solid-state reaction. Praseodymium ions are highly effective for UV luminescence due to their interconfigurational transitions between the 5d and 4f levels. Upon Stokes excitation, we observed broad-band emission in the 230–350 nm range, corresponding to the 4f5d → ^3H_j and ^3F_j transitions. Notably, the same results were obtained with visible (444 nm) excitation. This upconversion (UC) of visible light into UVC can occur through two mechanisms: energy transfer upconversion (ETU) and excited-state absorption (ESA). We analyzed UC luminescence's dependence on the pumping power and Pr^{3+} concentration, as well as the decay kinetics of upconverted light, and found that both mechanisms can occur with varying effectiveness.

The upconversion properties of the prepared materials make them attractive candidates for mercury-free UVC devices, where high-energy photons can be generated by excitation with low-energy radiation. Additionally, these materials have the potential for use in self-cleaning surfaces that emit UVC radiation when exposed to sunlight [2].

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sciforum-091934: Laser emissions from buried depressed-cladding waveguides inscribed in Nd^{3+}:CLNGG laser crystals by picosecond-laser beam writing

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Picosecond (ps-) laser systems can be successfully employed in ultrafast micromachining due to some specific characteristics such as extended system stability, reduced costs, increased laser pulse energies, and higher repetition rates. However, there are only a few reports in the literature regarding the fabrication of waveguides in glasses and crystalline materials with laser systems delivering pulses of few ps-pulse duration [1]. In general, such waveguides are realized with femtosecond (fs-) laser sources and by using a line-by-line translation inscription technique along a defined shape [2].

In this work, we are reporting on the fabrication of buried depressed-cladding waveguides in a 0.7-at.% Nd:CLNGG disordered crystal by ps-laser beam writing. The laser emission performances were characterized under the pump at 807 nm with a fiber-coupled diode laser. For a quasi-continuous-wave pumping regime, a waveguide with 100 mm diameter (circular cross-section) delivered laser pulses at 1.06 mm with energy E_p= 0.35 mJ for a pump pulse energy of E_{pump}= 13.3 mJ (corresponding to an overall optical-to-optical efficiency h_o= 0.03), with a slope efficiency of h_s = 0.04. Such waveguides are good candidates for the realization of integrated laser sources consisting of cladding waveguides pumped by diode lasers and for the generation of ultra-short laser pulses at 1 mm.

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sciforum-100758: Luminescence Manometry Based on Ni^{2+} Ions Emission in Doped Spinel

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The spectroscopic properties of Ni^{2+} ions are particularly intriguing due to their emission in the near-infrared (NIR) range, which enables various potential applications [1]. One notable potential application of the luminescence of Ni^{2+} ions is pressure sensing, due to the dependence of the energy of the $^3T_{2g}$ level on the strength of the crystal field, which is altered by pressure-induced changes in the metal--oxygen distances [2]. Consequently, applying pressure should affect the spectroscopic properties of Ni^{2+} ions. To explore the potential of Ni^{2+} ions as luminescent manometers, we investigated the luminescence of Ni^{2+} ions in doped spinel-type gallate under applied hydrostatic pressure. The change in energy of the $^3T_{2g}$ excited state of Ni^{2+} caused by the change in crystal field strength resulted in a significant spectral shift of the emission band associated with the $^3T_{2g}\rightarrow{}^3A_{2g}$ electronic transition of Ni^{2+} ions, exceeding 10 nm GPa^{-1}. Based on this substantial shift, we proposed a ratiometric readout mode using the luminescence intensity ratio (LIR), defined by integrated two spectral ranges of the broad emission band of Ni^{2+} ions. This approach, which is uncommon for luminescence manometry, offers exceptional high-pressure sensitivity of more than 50% GPa^{-1}, while also ensuring temperature-independent pressure readouts. Our results demonstrate the significant potential of both the ratiometric approach and the utilization of Ni^{2+} ions for optical pressure sensing applications.

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sciforum-095864: Luminescent properties of Pr^{3+} doped fluoroperovskite

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Metal halide perovskites have garnered significant attention over the years as they exhibit a diverse range of properties, making them key materials for numerous applications across various industrial fields, from catalysts and piezoelectrics to optics materials, scintillators and solar cells. Of particular interest is the use of halide perovskites as matrices for upconversion, which involves the interaction of low-energy light photons with matter, resulting in high-energy luminescent emission. One of the priority tasks is the search of new phosphors that efficiently convert visible light into ultraviolet (UV) radiation. Ultraviolet light initiates photochemical reactions that damage or destroy the DNA and RNA in cells and viruses, making it effective for surface disinfection, wastewater treatment and cancer phototherapy [1]. The most damaging type of UV radiation is UVC (100-280 nm).

This paper presents for the first time an investigation of visible-to-UVC upconversion luminescence in Pr^{3+}-doped fluoroperovskite crystallites. The upconversion properties of these crystallites are compared with those of $LiYF_4$:Pr^{3+} phosphor. In addition, luminescent properties in the visible range will be presented.

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sciforum-095294: Motion-blurred image reconstruction and velocity measurement

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The reconstruction of motion-blurred images and the acquisition of target velocity are widely used in image processing, computer vision and so on. Using traditional optical methods such as Hough transform or differential multiplier, it is difficult to obtain high-resolution and high-definition image quality reconstruction results. Although using deep learning methods for image reconstruction can obtain better results, it will also bring some problems, such as huge data volume, long training time and complex data set construction. In this study, we firstly propose a method based on optimized Radon transform and optical model, combined with adaptive erosion operation, which can process motion-blurred images of various styles and degrees by giving their blur information exactly. Secondly, we construct a sharpness evaluation function scoring algorithm to filter the reconstructed images, which can use blurred information to reconstruct high-fidelity images. Finally, we design a velocity measurement method based on an optical imaging camera system by using blurred prior information. The results show that the blurry image reconstruction and velocity measurement have high robustness and can deal with motion blur in simulations and experiments. The method proposed in this paper can reconstruct a variety of motion-blurred images with high fidelity, and can accurately calculate the motion velocity of the target, which has great application value in the field of image processing, computer vision, and so on.

sciforum-095876: Nanosecond UV Laser Direct Writing of Graphene on Polybenzimidazole Thin Film and Glass Substrates

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Laser direct writing offers precise material treatment with minimal thermal damage, crucial for controlled energy application, beam-material interaction, and heat penetration. Traditional methods for large-area graphene growth, such as chemical vapor deposition (CVD), typically require metallic precursors like Cu and Ni. However, recent advancements have demonstrated the potential for non-metallic precursors. Notably, Rice University showed that CO2 laser irradiation could convert polyimide (PI) and polyetherimide (PEI) into graphene. In this study, we present a laser direct writing technique for forming graphene patterns on polybenzimidazole (PBI) thin films and glass substrates using a low-cost nanosecond UV laser system. This method avoids thermal damage to substrates and eliminates the need for metallic precursors. The UV laser induces photochemical reactions, breaking molecular bonds to form graphene without harming the substrate.

The methodology involves dissolving PBI in dimethylacetamide (DMAC) to create a solution, which is then coated on glass sheets. After drying the coated glass, a nanosecond UV laser is used to treat the PBI-coated sheet, forming flaky silver-black graphene. Optimal laser conditions include a wavelength of 355 nm, a pulse duration of 100 ns, a frequency of 50 kHz, and a scanning speed of 20 mm/s. A Q factor of around 16.4 yields the best results, producing graphene with a resistance of approximately 50Ω over 2 mm.

Raman spectroscopy confirms the graphene formation, indicated by the characteristic 2D peak and the D/G peak ratio, which reflects the degree of carbon crystallization and defect ratio.

In conclusion, this cost-effective nanosecond UV laser technique offers a scalable approach to graphene production on PBI films and glass substrates, presenting a significant advancement in non-thermal, metal-free graphene fabrication.

sciforum-100561: Optical and upconversion properties of new phosphates activated by Pr^{3+}

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Currently, luminescent materials can be found in many important devices, including optical sources, displays, lasers, data storage, dosimeters, high-speed luggage scanners, and CT scanners. In most cases, these are semiconductor materials consisting of a host lattice doped with an activator (transition or rare earth ion). Host matrices doped with rare earth elements and exhibiting luminescence initially caught the attention of scientists in the 1930s. However, more in-depth research into these materials started in the 1960s. In subsequent years, the interest in them has steadily grown due to the development of new applications and the evolving industrial requirements for known materials. One of the extraordinary properties of rare-earth-doped materials that demonstrate luminescence is upconversion emission. There is a strong demand for generating artificial UV light for purposes such as surface decontamination, photopolymerization, solar hydrogen production, and the treatment of skin diseases, including cancer. The current methods of UV generation are costly, inefficient, and harmful to the environment. Therefore, one of the innovative approaches for UV generation is visible-to-ultraviolet upconversion. The Pr^{3+} ion, which predominantly emits in the UVC range (100-280 nm), is the most unique and least-studied activator in this context.

In this study, crystallites of new phosphates doped with varying concentrations of Pr^{3+} were synthesized using the solid-state method. The structure, optical, and upconversion properties in the UV-vis range were examined. Methods for improving the intensity of upconversion emission will be discussed.

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sciforum-106643: Single-Crystal Hybrid Perovskites as Next-Generation Optoelectronic Materials for Photodetection

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Single-crystal hybrid perovskites (SC-HP) stand out as prominent materials in the family of next-generation semiconductors, owing to their outstanding properties, including tunable bandgaps, high absorption coefficients, excellent photophysical properties, intense luminescence, and their low-cost solution-based processability [1, 2]. Compared to their polycrystalline counterparts, single-crystal perovskites exhibit longer carrier lifetimes and diffusion lengths, lower trap state density, and enhanced environmental stability [3,4]. Two-dimensional SC-HP are especially interesting as their long-range ordered multiple quantum well structure induces additional properties such as large excitonic effects.

In this work, we present the progress in the growth of single crystal hybrid perovskites using the space-confined approach. We then investigate the structural properties, morphology, and optoelectronic behavior of 2D thin film of PEA_2PbI_4 single-crystals grown with this technique. We fabricate a planar photodetector and study its spectral photoresponse as a function of temperature and wavelength and its stability under environmental conditions.

The results demonstrate the synthesis of high-quality single crystalline materials, displaying low defect density and suppressed bias induced ion migration, and provide advancement in the comprehension of photodetection mechanisms in this material.

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sciforum-095594: Study on Fast Autofocusing Method in Coherent Diffraction Imaging System

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Autofocusing technology is an essential automatic adjustment technology that relies on the clarity evaluation function to achieve clear and accurate imaging in imaging systems. This technology originated from traditional optical microscopes and has been widely promoted in the new generation of microscopic imaging systems, as well as in the more extensive application of computational microscopy imaging technology. Microscopic imaging is closely related to autofocusing technology, from the focusing process of the microscope stage to the calculation of distance parameters in computational imaging technology. Achieving fast and intelligent autofocusing performance in microscopic imaging systems is a pressing research task for the disciplines that apply computer vision automatic detection systems.

In this context, an autofocusing algorithm based on the Tanimoto coefficient was proposed to solve the problems of inaccuracy and low sensitivity of autofocusing results in colour microscopy due to complex colour changes. Background areas without useful information will result in a large amount of computation and affect the accuracy of autofocusing results. The Harris corner detection operator was used to extract the salient feature region as the definition evaluation object. In order to solve the contradiction between ergodic search and high-precision autofocusing in multi-range coherent diffraction imaging, a focusing algorithm based on subdivision search is proposed to accelerate the autofocusing process.

sciforum-093117: The effect of geometric anisotropy on the heating of gold nanoparticles under a femtosecond pulse

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Gold nanospheroids and cylinders exhibit two surface plasmon resonances, transverse (T mode) and longitudinal (L mode), in the infrared band. In accordance with the dipolar plasmonic response of spheroids, an increase in the aspect ratio (η) causes the two resonances to split further apart spectrally, with the T mode undergoing a blue shift while the L mode moves towards longer wavelengths.

We present in this work a numerical approach to studying the effect of anisotropy on the heating of prolate gold nanoparticles (GNs) interacting with a Ti–Sapphire laser oscillating at a wavelength of 800 nm. The GNs are cooled in water, and the heat transfer from the particles to the water is assumed to occur without mass transfer. The effect of η on the GN temperatures is investigated under 100-femtosecond laser pulse irradiation and 1 J/m2 fluence, and several values of η are considered: 2, 3, 4, and 5. First, the extinction cross-section of randomly oriented GNs was computed in the quasi-static limit using the Rayleigh–Gans formulae. Second, the ultrafast dynamics of the heat inside the GNs and at the GN/water interface were modeled through two temperature equations and Fourier's law, respectively. The numerical simulation was carried out by a code written in C++ language. It was found that the maximum temperature at the GN/water interface increases as a function of η but does not exceed a certain value corresponding to η= 4.5, and this is independent of the size of the GNs.

sciforum-102949: Ultra-Sensitive Photonic-Crystal-Fibre-Based Refractive Index Sensor for Efficient Alcohol Detection at Near-Infrared Region

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This paper describes the development and evaluation of an ultra-sensitive modified circular photonic crystal fibre (MC-PCF) sensor for efficient alcohol detection. Operating at 850 nm, the sensor has exceptional relative sensitivity and low confinement losses, making it suitable for a wide range of practical applications. The MC-PCF sensor was developed using Comsol Multiphysics and a finite element method to improve light--matter interaction by increasing sensitivity and precision. Performance metrics such as relative sensitivity, confinement loss, and nonlinear coefficients were assessed for various alcohols (methanol, ethanol, propanol, butanol, and pentanol). The sensor has impressive relative sensitivity values: 95.51% for methanol, 97.2% for ethanol, 97.85% for propanol, 98.69% for butanol, and 99.4% for pentanol. The confinement losses are 2.345×10^{-9}, 1.022×10^{-9}, 8.656×10^{-10}, 1.821×10^{-9}, and 3.097×10^{-9} dB/m, respectively. Methanol, ethanol, propanol, butanol, and pentanol have nonlinear coefficients of 78.95, 75, 73.69, 73.03, and 72.54 $W^{-1}km^{-1}$, respectively. The numerical apertures for the MC-PCF sensor at an 850 nm operating wavelength are 0.2599 for methanol, 0.2566 for ethanol, and 0.2567 for propanol, butanol, and pentanol. The optimized design of the MC-PCF sensor significantly improves light--matter interaction, resulting in high precision and rapid response when detecting changes in alcohol concentration. This makes the proposed sensor a strong and dependable solution for industrial quality control, medical diagnostics, and environmental monitoring. In summary, the MC-PCF sensor's outstanding sensitivity and low confinement loss at the near-infrared region demonstrate its potential for effective alcohol detection across various fields.

sciforum-096638: White light generation from tin-doped condensed borates

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Introduction

Condensed borates are compounds constructed of three-dimensional lattices of borate groups BO_3 and BO_4. They can form amorphous materials (glasses), ordered matrices (crystals), or a mixture of the two (glass–ceramics). They are characterized by high stiffness, which yields a high emission efficiency and stability of the luminescence against host modifications. Divalent tin (Sn^{2+}) is a ns^2-type luminescent center, which has found use in the fabrication of phosphors and scintillating materials. Sn^{2+} can be excited in UV and exhibits a very wide emission band, spanning the whole visible range. The position of the excitation and emission maxima depend on the host material to some degree.

Methods

This study comprises an extended investigation into the luminescence of the divalent tin (Sn^{2+}) in condensed borates. The studied condensed borate systems include 25 MgO–12.5 La_2O_3–62.5 B_2O_3 ($LaMgB_5O_{10}$), labeled as LaMBO, which can be obtained in both a crystalline and an amorphous form. It can also form a glass–ceramic through the process of isochemical crystallization. The amorphous and crystalline samples of condensed borates were investigated and their structure, optical properties and luminescence were evaluated. Emission and excitation spectra, as well as decay times and quantum yield, were recorded.

Results

The results indicate that Sn^{2+} can exhibit a range of luminescence in the studied hosts, ranging from a blueish, cool white emission to red-tinted, warm white emission. The correlated color temperature (CCT) of the emission can be tuned using an excitation light of different wavelengths in the UV spectral range or by using two-wavelength excitation. The samples exhibit a high color rendering index (CRI) of >95 in the relevant CCT range and a high quantum yield >80%.

Conclusions

The condensed borate materials, doped with divalent tin, are promising materials for novel, efficient, dual-excitation phosphors for high CRI wLED with tunable CCT. Further insight into the structure of condense borate glass–ceramics can provide interesting fields of applications.

sciforum-091930: Y-branch splitters inscribed in Nd^{3+}:YAG ceramics by picosecond-laser beam writing

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Direct writing with ultrashort laser pulses is considered to be a very efficient technique for fabricating 3D waveguide structures, such as s-curved waveguides, beam splitters or Y-type waveguides, because it allows for the fabrication of structures with arbitrary geometries in various transparent materials. Among them, Y-branch splitters represent basic elements for the development of integrated photonic devices of interest in various applications, including power dividers, interferometers, multiplexers or micro-fluidic devices.

In this work, we report on the realization of Y-branch beam splitters in 1.1-at.% Nd:YAG ceramics by picosecond-laser beam writing. Laser emission performances were investigated under the pump at 807 nm with fiber-coupled diode lasers. For quasi-continuous-wave pumping, laser emission at 1.06 mm was generated for all waveguides. The linear waveguide (NYAG-Y0; 150 mm width x 100 mm height) yielded laser pulses with an energy of E_p= 2.2 mJ for a pump energy of E_{pump}= 12.8 mJ at 807 nm (corresponding to an overall optical-to-optical efficiency, η_o, of 0.17); the slope efficiency was η_s= 0.21. The NYAG-Y1 waveguide (1° splitting angle; 75 mm width x 100 mm height) emitted laser pulses with a maximum energy of E_p= 1.32 mJ (η_o= 0.10 and η_s= 0.12). Furthermore, the NYAG-Y2 waveguide (2° splitting angle; 75 mm width x 100 mm height) yielded laser pulses with a lower energy of E_p= 1.20 mJ at an efficiency of η_o= 0.09 and with a slope of η_s= 0.11. The emission performances of these Y-branch waveguide beam splitters confirm that they are promising candidates for realizing the use of integrated devices of interest for various advanced photonics circuits.

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Session 5. Optical Interaction Science

sciforum-100022: Numerical investigation of optimal structure for dynamic plasmonic color generated via photothermal deformation of a metal semi-shell structure

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Introduction

The dyes and pigments widely used in coloring methods are often toxic, chemically unstable at high temperatures, prone to fading under ultraviolet rays, and cannot easily color objects of sub-micron size or smaller. Photonic crystals and dielectric multi-layers have limited spatial resolution, a low refractive index, and limited coloration. In order to solve these issues, we computationally demonstrate that dynamic wavelength tuning via the photothermal deformation of a metal semi-shell on a self-assembling nanoparticle can achieve a wide color gamut.

Methods

The calculation includes the shape of the structure, thickness of the metal of the semi-shell on a core, wavelength, angle of incidence, polarization, chromaticity coordinates, and evaluation index by area on the chromaticity diagram. From the reflectance spectra calculated using the discrete dipole approximation, the tristimulus values XYZ of the light are plotted in CIELuv space. The area enclosed by all coordinate points of all the tristimulus values is determined.

The core material is fused silicon oxide, the substrate material is aluminum, and the deposition material is silver, which is known as a thermally deformable plasmonic metal. The nanosphere diameter is 100 nm, the substrate thickness is 40 nm, and the deposition thicknesses are 15, 20, and 25 nm. The semi-shell capping angle varies from 30° to 90°.

Results

The color coordinates were calculated from the reflectance spectra of nanospheres with the silver semi-shells of 15, 20, and 25 nm in thickness, plotted in CIELuv space, and yielded the gamut area of 2.3×10^{-2}, 2.6×10^{-2}, and 2.2×10^{-2}, respectively, at the two-dimensional density of 19.8 μm^{-2}.

Conclusions

Silver semi-shells of 20 nm thickness showed the largest gamut area for nanospheres with 100 nm diameters at a density of 19.8 μm^{-2} on Al substrate. Further investigations at various densities will be conducted to determine the optimal structure.

sciforum-093263: A Quantitative Ultraviolet (UV) Spectrophotometric Analysis of ZOPICLONE as a Cyclopyrrolone Sedative Hypnotic Drug in Pharmaceutical Tablets

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Zopiclone is a Cyclopyrrolone sedative hypnotic drug, which considerably increases the normal transmission of gamma-aminobutyric acid (GABA) in the Central Nervous System, via modulating GABA-A-type receptors. The aim of this research was to exactly find and quantify the amount of pure Zopiclone, as an active substance in tablets. Zopiclone as a pure active substance was dissolved in Dioxane p.a. as a solvent to obtain a standard solution, 1.2 µg / mL, which showed an absorption maximum in the Ultraviolet (UV) range A = 0.231 that has corresponded to λ = 282 nm. Prepared pure standard solution absorbances for the studied concentration range between 0.60 µg/mL and 16.80 µg/mL were read out at the maximum absorption wavelength **λ. = 282 nm** of Zopiclone solutions in Dioxane p.a. as a solvent. The amount of pure Zopiclone calculated on a pharmaceutical tablet was found to be **7.214322 mg**, very close to the officially stated active substance content **(7.5 mg)**. The average allowed percentage deviation value found was (+) 3.80904 %, below the maximum official value of **± 10%** stated by the Romanian, European, and International Pharmacopoeias Rules. The spectrophotometric UV analysis method was subjected to the statistical validation procedure. Sandell Sensitivity, the interference test, stability of prepared standard solutions, system precision, method precision, and analysis accuracy were found within the normal range of values. The statistical analysis has revealed a very good linearity of the UV proposed method, in the standard concentration range from 0.60 µg / mL to 16.80 µg / mL. Linear regression coefficient R^2 = 0.9997386 and correlation coefficient R= 0.9998693; R^2 > 0.9990 and R > 0.9990 were located within the normal official range of values. Standard error of the linear regression was SE = 0.0027056, SE 1. Detection Limit LOD = 0.2848 µg / mL and Quantitation Limit LQ = 0.9493 µg / mL were found to be within the normal range of values.

sciforum-095814: Bessel beam array generation using an axicon lens and grating

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Arrays of non-diffractive beams, such as Bessel beams, are important for applications in emerging fields of microscopy, photonics, nonlinear optics, optical trapping, beam shaping, laser fabrication, etc. Our study focused on the generation of an array of zero-order Bessel beams, primarily using passive optical elements, i.e., an axicon lens, telescope, and a nanosecond laser-fabricated grating. At first, one-dimensional and two-dimensional gratings of periods in the range of 120 to 800 μm and a fill factor of 0.5 were fabricated using a diode-pumped solid-state nanosecond pulsed laser with a central wavelength of 1064 nm, a nominal pulse width of 2 ns, and a maximum pulse energy of 1 mJ. The efficacy of thus-fabricated gratings in generating a Bessel beam array was then evaluated using a beam imaging setup. To do so, a Gaussian laser beam with a central wavelength of 532 nm was incident on thegrating, followed by an axicon lens and a telescope, to generate an array of micro-Bessel beams. The generated Bessel beam array was then characterised by a 4f imaging system. The radial beam profiles of micro-Bessel beams were recorded all along the beam propagation direction and were subsequently processed using MATLAB software. The retrieved physical characteristics of Bessel beams generated with an axicon only (i.e., without grating) are as follows: Bessel central core FWHM of 0.9 μm, longitudinal FWHM of 220 μm. When gratings were employed, diverging Bessel beam arrays of dimensions up to [5 x 5] were obtained. After a certain propagation distance, depending on the period of grating, zero- and first-diffraction-order Bessel beams in the array emerged, with visible Bessel characteristics. It was also observed that the characteristics of Bessel beams in an array format remained invariant from isolated Bessel beams.

sciforum-102429: Effects of sub-micro particle properties on light scattering in dense colloidal suspensions

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Dense colloidal suspensions, whose volume fraction is larger than 5%, are encountered in various research fields, such as slurry in chemical engineering, soymilk in food science, and intravenous fat emulsion in medical pharmacy. It is significant to assess non-destructively the particle properties of the suspensions, such as particle size distribution in the sub-micrometer scale and dispersion degree. Near-infrared spectroscopy has the potential to enable the assessment based on a relation between light-scattering and particle properties. The suspensions strongly scatter light. However, the assessment is still under development because the relation has not been fully understood yet. In a dense suspension, the interference of the electric fields scattered by the particles strongly influences the light-scattering properties, the so-called interference effect. Since the 1980s, many researchers have studied the interference effect in suspensions at different volume fractions using the dependent scattering theory (DST), which is the electromagnetic theory. However, the mechanism of the effect needs to be clarified because of their complicated dependence on the particle size and its distribution, optical wavelengths, etc. We developed the DST in a polydisperse system to examine a relation between the particle size distribution and light scattering properties. Our numerical results showed the logarithmic distribution strongly influences the scattering properties. We also developed an analytic model equation for the volume-fraction dependence of the scattering properties. The equation allows us to evaluate the interference effects on the particle properties rapidly by a single parameter. Our results are indispensable for developing near-infrared spectroscopy using scattered light.

sciforum-095328: Explaining the decline in the yield of luminescence after surpassing a phase of saturation as the dose of stimulation continues to increase

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Introduction

The time-course of the luminescence of a material after stopping the stimulating radiation characterizes the life-time of the radiative transitions that are converted after stimulation. And the yield of luminescence increases as the dose of stimulation increases, until reaching a saturation phase. Several experiments since 1993, however, have revealed that as the stimulation dose exceeds a saturation level, the luminescence yield may decline. And there is a lack of modelling-based understanding of this phenomenon. This work aims to present a model that may help understand the post-saturation decline of the luminescence yield.

Methods

Spatially resolved delayed luminescence from yeast irradiated by ultraviolet-containing intense light was acquired by using a cooled CCD over a fixed duration (100 seconds) of exposure post photo-stimulation. The duration of the photo-stimulation varied over six orders of magnitude, from 1 millisecond to 1000 seconds. By using an irradiation–integration interleaved method [Piao, 2024], the yield of delayed luminescence of the yeast as a function of the irradiation dose was acquired in a total of five measurements. The dose–response of the yield of delayed luminescence consistently revealed a decline after saturation that is not explained by the common model of delayed luminescence. We propose a modification to the common three-level model of delayed luminescence to explain the post-saturation decline.

Results

The decline in the integrated delayed luminescence observed by our measurements is equivalent to the decline in the commonly measured starting amplitude of the delayed luminescence commonly measured. By setting a limit to the number of the material's atomic states that can be stimulated towards delayed luminescence, the common three-level model approach can lead to a reduction in the starting amplitude of the delayed luminescence after all pumpable states have been exhausted by the pumping dose.

Conclusions

A model is proposed for the post-saturation decline of the luminescence yield of yeast. The insights may be relevant to pump-probe applications.

sciforum-095334: Magnetization manipulation using ultra-short laser pulses in ferromagnetic cells for spintronics applications

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Magnetization reversal processes and magnetization dynamics in general are of utmost importance for many spintronics applications. Such ultrafast dynamics can be measured, e.g., using pump–probe experiments with pulsed lasers, in which a strong pump laser excites a sudden change in the magnetization vector, leading to a precession (measured by the weak probe laser) until the relaxed state is reached again. Such measurements, however, are challenging due to the necessary overlap of both laser beams on the sample. An easier approach would be modeling this process. Such a model has been developed based on the micromagnetic simulation MagPar. Using simulated ultra-short laser pulses, we investigated a matrix of separate ferromagnetic cylindrical cells to prototype possible memory applications. The cells made of FePt were immersed in an MgO layer to satisfy adequate thermal conditions. The heat-transport problem was solved using the two-temperature model. Simulations were performed using the micromagnetic Landau–Lifshitz–Bloch (LLB) equation and the finite element method (FEM) to mimic realistic shapes of material objects as well as to include magneto-optic and thermal fields. The calculations were carried out for different distances between cells and a variety of laser pulse durations and intensities. The obtained results provide information about stability conditions for magnetization states and the possible spatial density of such memory devices.

sciforum-095385: Magneto-optical investigation of surface magnetization in comparison with bulk magnetization

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The exchange bias (EB) is a unidirectional anisotropy in ferro-/antiferromagnetic (FM/AFM) systems which primarily leads to a horizontal shift of the magnetic hysteresis loop after field-cooling through the Néel temperature of the AFM. After being discovered in Co/CoO core-shell nanoparticles, it is nowadays investigated in diverse material systems. Co/CoO thin film systems are among those most widely studied. Here, we report measurements at different temperatures, below and above the Néel temperature of CoO, for different sample orientations with respect to the external magnetic field. The samples were produced by a molecular beam epitaxy growth of 8 nm Co on CoO(100) substrates after the substrates had been irradiated by heavy ions (xenon or uranium) to induce defects in the AFM. While the EB was relatively small, measurements of the bulk magnetization at low temperatures revealed unusually shaped hysteresis loops. Measurements of the magneto-optic Kerr effect, on the other hand, in which laser light interacts only with the surface magnetic layer, showed simple, nearly rectangular hysteresis loops. The transverse magnetization component was examined by changing the laser's linear polarization direction. In this way, differences between magnetization reversal processes in xenon and uranium-irradiated samples could be shown. This study underlines the possibility to optically detect the magnetization at a sample surface, as opposed to other techniques which measure the bulk magnetization, and thus the advantage of complementary information on surface and bulk magnetization from optical and non-optical measurement methods.

sciforum-095212: Multidimensional solitons in optics and related fields

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It is commonly known that the interplay of linear and nonlinear effects gives rise to solitons, i.e., self-trapped localized structures, in a wide range of physical settings, including optics, Bose-Einstein condensates (BECs), hydrodynamics, plasmas, condensed-matter physics, etc. Nowadays, solitons are considered as an interdisciplinary class of modes, which feature diverse internal structures. While most experimental realizations and theoretical models of solitons have been elaborated in one-dimensional (1D) settings, a challenging issue is the prediction of stable solitons in 2D and 3D media. In particular, multidimensional solitons may carry an intrinsic topological structure in the form of vorticity. In addition to the "simple" vortex solitons, fascinating objects featuring complex structures, such as hopfions, i.e., vortex rings with internal twist, have been predicted too. A fundamental problem is the propensity of multidimensional solitons to be unstable (naturally, solitons with a more sophisticated structure, such as vortex solitons, are more vulnerable to instabilities). Recently, novel perspectives for the creation of stable 2D and 3D solitons were brought to the attention of researchers in optics and BEC. The present talk aims to provide an overview of the main results and ongoing developments in this vast field. An essential conclusion is the benefit offered by the exchange of concepts between different areas, such as optics, BEC, and hydrodynamics. A thorough survey of the topic is provided in a new book: B. A. Malomed, "Multidimensional Solitons" (American Institute of Physics, Melville, NY, 2022).

Session 6. Quantum Photonics and Technologies

sciforum-095892: Moderate-refractive-index and high-refractive-index dielectric cylindric dimers for QD fluorescence enhancement

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The emission enhancement of quantum emitters is crucial for the development of quantum technologies based on single-photon sources. Metallic nanoparticles have been initially considered with this aim due to their ability to produce strong electromagnetic energy concentrations (hot spots) at the emitters' position. However, metallic nanostructures suffer from high non-radiative losses. To address this, high-refractive-index dielectric (HRID) nanoparticles, characterized by exhibiting Mie resonances with negligible absorption in specific spectral ranges, have emerged as an alternative. Additionally, dielectric nanoparticles can exhibit magnetic responses despite being non-magnetic materials. The interference between electric and magnetic resonances can result in directional properties, potentially increasing the collection efficiency of scattered radiation. Despite these advantages, HRID nanoparticles do not enhance light emission as much as metallic ones. In contrast, hybrid metal–dielectric nanostructures can offer greater functionality and efficiency compared to purely metallic or dielectric nanoparticles.

Recently, moderate-refractive-index (MRI) dielectric nanoparticles have been numerically and experimentally demonstrated to enhance the emission of excitons in 2D materials. These MRI materials ($n \approx 2.2$) exhibit broadband Mie resonances, enabling the simultaneous enhancement of multiple excitons.

In this work, different dimer configurations are analyzed with the objective of enhancing the photoluminescence signal of a quantum dot located in the dimer gap. Dimers of pure metallic, pure HRID, pure MRI dielectric, and hybrid combinations of metallic and dielectric nanoparticles, either HRID or MRI, are numerically explored. For each case, the excitation enhancement, Purcell factor at the emission wavelengths, and directionality are studied by means of the Finite Element Method in COMSOL Multiphysics. Through the results obtained, we can conclude that the combination of MRI and HRID nanoparticles can provide large values of the photoluminescence signal (4–4.8 for MRI combinations and 5.4-7 for HRID) with low losses (with the ratio of the radiative to non-radiative power being between 0.63 and 0.7).

sciforum-095939: Controlling four-wave mixing in a semiconductor quantum dot through coupling with a metal nanospheroid

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We study the coherent interaction between a hybrid nanostructure and a strong pump electromagnetic field as well as a weak electromagnetic probe field, focusing on how various parameters influence the line shape of the four-wave-mixing (FWM) spectrum. More specifically, we examine the dependence of the FWM spectrum exhibited by a semiconductor quantum dot that is coupled with an ellipsoidal metal nanospheroid (MNS) on the interparticle distance and the depolarization factor. First, we derive the differential equations that determine the evolution of the density matrix elements in the rotating wave and dipole approximations and expand the density matrix elements, to first order with respect to the weak probe field. We then solve the equations of the density matrix, in steady state, and calculate the FWM spectrum. The investigation of the impact of the interparticle distance and the depolarization factor on the position and the width of the resonance follows. The derivation of analytical solutions of specific density matrix elements enables us to calculate the effective Rabi frequency that is introduced in the dressed-state description to predict the position of the effective resonances appearing in light-matter interaction. We demonstrate that the spectral line shape shifts from triple-peaked to single-peaked, while its amplitude is significantly suppressed, when the interparticle distance drops below a critical value that depends on the depolarization factor of the MNS. The highest critical distance occurs for a prolate MNS with high eccentricity, provided that the incident field's polarization direction is parallel with the nanostructure's symmetry axis, and the pump field detuning is positive and has a high absolute value. The spectral profile shows negligible dependence on the interparticle distance for an exactly resonant pump field with a polarization vector perpendicular to the MNS's polar axis, especially if the MNS is an oblate spheroid with high eccentricity.

sciforum-106641: Electrical and Optoelectronic Characterization of Van der Waals BP/MoS_2 Heterostructures for innovative photodetectors and for quantum technologies

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In recent years, heterojunctions formed by stacking two-dimensional (2D) materials have attracted considerable interest because of their outstanding electronic and optoelectronic characteristics. These have paved the way for new device structures and uses. The combination of black phosphorus (BP) and molybdenum disulfide (MoS_2) is particularly noteworthy for its potential in creating state-of-the-art optoelectronic devices. This research explores the dynamics between BP, MoS_2, and chromium (Cr) contacts, shedding light on the electrical characteristics of a BP/MoS_2 heterojunction that exhibits rectifying behavior, mainly n-type conduction, and a significant ON/OFF current ratio. The higher unexpected current observed in the presence of a negative bias applied to both the MoS_2 and BP sides is clarified through an energy band model that includes a type II heterojunction at the BP/MoS_2 interface. In this case, Cr makes a Schottky contact with MoS_2 and an ohmic contact with BP. The BP/MoS_2 heterojunction also shows a remarkable photoresponse, which increases linearly with the incident light power, reaching a responsivity of 100 µA/W to white light with an incident power of 50 µW. Time-resolved photocurrent experiments show a fast response, with rise times of less than 200 milliseconds. Moreover, the rectifying characteristics at lower pressure present a kink in the forward region revealing different conduction mechanisms, namely drift-diffusion and band-to-band tunnelling. The results of this work highlight the potential of BP/MoS2 heterostructures for applications in low-power electronics, high-performance transistors, photodetector, and sensitive pressure sensors [1,2,3].

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sciforum-098792: Generation of Entangled Photon Pairs from high-Quality-Factor Silicon Micro-ring Resonator at near-zero anomalous dispersion

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The intrinsic non-linearity in silicon has led to this material being proven to be quite useful in the field of quantum optics. A quantum signal source in the form of single photons is an inherent requirement to the principle of quantum key distribution technology for secure communications, since a message that is encrypted via a quantum source cannot be branched or stolen. Here, we present the numerical simulations of a silicon ring with 6-micron radius side-coupled to the bus waveguide as a source for the generation of single photons by exploring the process of degenerate spontaneous four-wave mixing (SFWM). The free spectral range (FSR) is quite large, which simplifies the extraction of signal/idler pairs. The phase matching condition is considered by studying relevant parameters like dispersion and non-linearity. We optimize the ring to achieve a high quality factor by varying the gap between the bus and the ring waveguide. This is the smallest ring studied for photon pair generation, with a quality factor as high as 10^5. The width of the waveguides is chosen so that the phase matching condition is satisfied, allowing for the propagation of fundamental modes only. The bus waveguide should be pumped at one of the ring resonances with minimum dispersion (1543.5 nm in our case) so that the principle of energy conservation is satisfied. The photon pair generation rates achieved are already better in the low-pump-power regimes in comparison to those discussed in the literature. Such miniaturized structures will prove beneficial for future on-chip architectures where multiple single photon source devices are required on the same chip.

sciforum-095883: Integrated high-dimensional quantum gates using two-dimensional multimode interference waveguides

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The concept of high-dimensional multiphotonic gates has many potential applications. As an example, encoding qubit information in high-dimensional systems has significant advantages in terms of robustness against errors and can reduce quantum circuit complexities, and high-dimensional error-correction codes have shown advantages in terms of resources. Furthermore, high-dimensional multiphoton gates can be used for Bell-state or Greenberger–Horne–Zeilinger-state measurements, which are an essential requirement of quantum communication protocols. As a high-dimensional degree of freedom, the orbital angular momentum (OAM) of photons can be used for this purpose.

In this work, integrated high-dimensional quantum gates are proposed for the first time. The structure of the proposed integrated quantum gates includes properly designed multimode interference (MMI) waveguides. In MMI waveguides, an input field profile can be reproduced in single or multiple images at periodic intervals along the propagation direction of the waveguide. This property is called self-imaging. Using the beam propagation method (BPM) for simulating OAM modes in MMI waveguides, it has been shown that at the shortest length for self-imaging occurrence, the sign of the topological charge of the even OAM modes is reversed, while the odd OAM modes remain unchanged. The charge conversion property of the MMI waveguides for even higher-order OAM modes can be used to implement the integrated quantum gates in a simple way. For instance, for an input state of (-2, -1, 0, 1), the quantum logic gate of X can be implemented using the proposed MMI waveguide followed by a first-order spiral phase plate (SPP), in that the SPP adds +1 to the mode, leading to (-1,0,1,2). Afterwards, the MMI waveguide reverses the sign of the even modes without any change in the odd modes, which leads to the correct output modes: (-1,0,1, -2).

sciforum-100504: Legget–Garg inequality and its violation for a two-mode entangled bosonic system

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Quantum correlations are crucial in modern quantum photonics research. The first discussions concerning quantum correlations were presented in the first half of the 20th century [1]. Nevertheless, currently, one can find many papers dealing with those topics. It is worth noting that some of these are devoted to optical and photonic models, and some concern proposals of new photonic systems.

Many papers deal with quantum correlations, especially in the context of applications of the considered quantum models in quantum information theory systems. At this point, one can mention correlations such as quantum entanglement, quantum steering, and Bell-type nonlocalities. These correlations are mostly related to spatial nonlocalities. On the other hand, one can ask about the existence of the counterparts of such nonlocalities in the time domain. The topics related to them are devoted to violating Legget–Garg inequalities (LGI) [2,3], which we consider here.

In this communication, we consider a system of two mutually coupled quantum nonlinear oscillators that are continuously driven by an external coherent field. For such a model, we discuss temporal correlations, examining LGI's violation. We analyze various scenarios of measurements based on projection onto different Bell states, showing that the possibility of violating LGI inequalities is related to the choice of different projectors.

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sciforum-100569: The entanglement generation in a system of two nonlinear quantum oscillators

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The creation and manipulation of quantum states are essential in developing quantum information theory and its applications. Such states can be applied in quantum communication, cryptography, and quantum computing. The states, defined in a finite-dimensional Hilbert space (truncated states), are relevant in this context. The physical systems in which finite-dimensional states can be generated, and the system's evolution can, thus, be limited to a certain number of n-photon states, are called quantum scissors [1]. For the cases of linear and nonlinear systems, we refer to them as linear and nonlinear quantum scissors, respectively.

In this communication, we consider a system consisting of two identical nonlinear Kerr-type quantum oscillators excited by a series of ultra-short pulses. The oscillators are coupled to each other, and the interaction between them is of the linear type. We discuss how the excitation influences the system's generation of strongly entangled states. In addition, we demonstrate that the effectiveness of creating maximally or almost maximally entangled states depends strongly on the applied excitation scheme and on the time between two subsequent pulses. In particular, we investigate how entanglement production depends on the frequencies of the excitations and on the fact that both subsystems are excited simultaneously or not [2,3].

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Session 7. New Applications Enabled by Photonics Technologies and Systems

sciforum-095179: Adaptive iterative guided filtering for suppressing background noise in ptychographical imaging

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In many industrial applications, military technology, and biomedical fields, coherent diffraction imaging technology has gradually replaced classical camera imaging methods. Coherent diffraction imaging extends the Ptychographic Iterative Engine (PIE) technique, which provides a large field of view in addition to high-resolution imaging. However, in the actual imaging process, there are many kinds of noise with different intensities and distributions in the reconstructed image due to the mechanism of PIE and imaging equipment. These noises will not only slow down the imaging speed and reduce the imaging quality, but also lead to the failure of direct image reconstruction. In this paper, an adaptive iterative guided filtering algorithm is proposed based on PIE reconstruction characteristics. By introducing a filter control factor into the PIE reconstruction algorithm, the intensity of the filter will gradually increase with PIE iteration. The edge-preserving property of the guided filter can protect the details well. According to the TOG evaluation function, compared with unfiltered PIE reconstruction, the method increased by 0.625, and the image quality improved by 50%. Compared with other image filtering functions, the TOG of reconstructed images increased by 20%. In terms of operation efficiency, this method increases the operation time by less than 10%, and its efficiency is higher than other filtering algorithms under the same iteration times.

sciforum-095625: Prior-free Separation Strategy for Effective Speckle Information under Strong Ambient Light Illumination

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Imaging through scattering media is an important research topic in many fields, but it remains challenging. Imaging techniques based on optical memory effects have been extensively studied, but most methods require operations in dark environments. The extra interfering light submerges the speckle information in the spatial noise, resulting in a lower reconstruction quality of the image. In this paper, a principal component analysis method based on singular value decomposition is proposed for imaging under strong interference light. By selecting an appropriate singular value decomposition mode, the environment noise and effective speckle information are fitted to reconstruct the target object. The feasibility and reconstruction effect of this method are verified by experiments. The effective information extracted by the method proposed in this paper is very similar to that obtained under dark room conditions and strong interference light conditions. The selection of singular values is also discussed. This method can still extract speckle information about the unexposed part of the image even if some information is lost due to exposure. Our method can realize the separation of effective speckle information and ambient noise without prior knowledge, breaking through the limitation of the dark room environment of scattering imaging, and because our method can directly separate the target object information from the original speckle, it may be combined with other scattering imaging techniques.

sciforum-095584: Compressed Hermite–Gaussian differential single-pixel imaging

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In contrast to the array detector, the single-pixel detector (SD) has a range of advantages, including heightened quantum efficiency, attenuated dark noise, and expedited response time. These advantages engender the extensive utility of single-pixel imaging (SPI) within numerous imaging fields. Traditional single-pixel imaging (SPI) encounters challenges such as a high sampling redundancy and poor imaging quality, constraining its widespread application. Despite a range of orthogonal modulation modes having been employed in structured illumination to enhance imaging performance, some encoding issues still persist in information sampling, impeding the further progression of SPI. We propose an SPI method based on orthogonal Hermite–Gaussian (HG) moments, achieving improved imaging reconstruction through differential modulation of HG basis patterns and linear weighting of the acquired intensity. Moreover, we incorporate compressed sensing algorithms within the framework of HG-SI, integrating moment-based sampling strategies to optimize imaging capability under sparse measurements.

Both simulations and experiments confirm the superior imaging quality and computation efficiency of our proposed Hermite–Gaussian single-pixel imaging (HG-SI), especially at low measurement levels. Our research underscores the effectiveness of HG modulation in SPI reconstruction, enabling high-quality outcomes via compressed sampling. Our method entails no additional setups or constraints compared to other SPI modes, making it applicable to a wide range of SPI scenarios. This advancement propels the investigation of optical field modulation modes within SPI and holds promise in offering a universal solution for weak-intensity and non-visible light microscopy.

sciforum-100736: Eu_2O_3-PVA Saturable Absorber Thin-Film-Based All-Optical C-band Switch

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In this study, the all-optical C-band switching capability of the nonlinear characteristics of Europium Oxide-Polyvinyl Alcohol (Eu_2O_3-PVA)-based saturable absorber (SA) thin film is experimentally shown. Eu2O3-PVA-based thin film saturable absorber was fabricated using a simple method and its all-optical switching performance was obtained by installing an all-fibre-based experimental testbed. In the experiments, a continuous wave (CW) signal at 1555 nm with an optical power of 20.41 mW generated by a tuneable laser source was converted into a variable frequency square-wave-modulated switching signal using a mechanical shutter/modulator. This modulated switching signal was then applied to the Eu2O3-PVA-based SA thin film with a CW signal at 1545 nm with an optical power of 3.47 mW provided by another tuneable laser source to switch the absorption characteristics of the SA between high-loss and low-loss cases. It has been shown that the 1545 nm CW signal was optically ON--OFF switched due to nonlinear absorption loss variations in SA generated by the saturating switching light at 1555 nm. In the experiments, all-optical switching in Eu2O3-PVA-based saturable absorber thin film succeeded for switching frequencies up to 4 KHz. The rise and fall times of the modulated light measured at 302 Hz were 500 µs and 350 µs on average, respectively.

sciforum-095630: Infrared small target tracking based on tensor structure

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Infrared small target tracking on complex backgrounds is a challenging research hotspot, which plays an important role in target warning, ground monitoring and flight guidance. In an infrared background image, the target occupies few pixels and has low contrast and no specific shape; the target edge is not obvious, lacks texture and is point-like; and there are often difficulties in the tracking process such as target occlusion, background clutter and rapid movement, which increase the difficulty of tracking infrared weak and small targets. In order to improve the tracking performance of traditional correlation filters for small targets, we design a target-tracking algorithm based on the structure tensor, which is a symmetric, semi-positive definite matrix that can represent a certain regularity in the neighbourhood of a point in the space, and the structural tensor feature extraction method is used as an epistemic model of the tracking algorithm, which can adequately describe the characteristics of the small targets that exhibit sudden changes in grey scale and are not correlated with the neighbourhood. Compared with origional correlation filters, it has a great advantage in extracting the structural information of the small target. Experiments show that, compared with other tracking algorithms, our proposed tracking algorithm effectively avoids the influence of false alarms in infrared target tracking under complex environments and has a significant advantage in terms of its accuracy index and high computational efficiency.

sciforum-100666: Optical Modulation of Nematic and Cholesteric Reactive Mesogens via Two-Photon Lithography

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The modulation of the optical response of structures fabricated in reactive mesogens (RMs) has proven to be a versatile and innovative strategy in creating polymeric devices with the tailored optical properties typical of liquid crystals. [1-3]

Among the fabricating techniques, two-photon lithography (TPL) stands out as one of the most suitable technologies for producing complex 3D objects with high sub-wavelength resolution [4] and, at the same time, it allows us to modify the RMs' internal architecture.

Here, we show how the nematic phase is perturbed when TPL is performed along an angle that is not parallel or perpendicular to the director vector, resulting in the reordering of RMs. This leads to a reorientation of the optical axis and birefringence, which can be finely controlled in terms of the writing parameters (i.e., laser power, scan speed, periodicity).

Similar studies performed on cholesteric RMs aim to demonstrate the possibility of fabricating devices with customizable photonic band gaps across the entire visible spectrum, simply by tuning the energy dose delivered during manufacturing[5]. A further modulation of the optical device response can be achieved through temperature control. [6]

These studies are exploited to fabricate innovative security devices, that cannot be replaced with other technologies or materials.

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sciforum-095759: Photoacoustic Microscopy, Optical Coherence Tomography, and Fluorescence Imaging-Guided Stem Cell Retinal Therapy

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Purpose

Stem cell therapy has the potential to treat currently incurable diseases, such as geographic atrophy in macular degeneration. However, tracking stem cells after transplantation is a major challenge. This study demonstrates an advanced, non-invasive, high-resolution, multimodality platform technology for the longitudinal visualization of damaged retinal pigment epithelium (RPE) using photoacoustic microscopy (PAM), optical coherence tomography (OCT), and fluorescence microscopy (FM) in living rabbits.

Methods

Millisecond laser photocoagulation was applied to 12 New Zealand rabbits to create RPE damage. On day 4 post-laser treatment, each eye received a subretinal injection of 30 μL (3.3×10^6 cells/ μL) human-induced pluripotent stem cells differentiated to RPE (hiPSC-RPE) cells labeled with ultrapure chain-like gold nanoparticle (CGNP) clusters conjugated with indocyanine green. The CGNP clusters have a red-shifted optical absorption in the near-infrared window, and their diameter of 7-8 nm after disassembly enables renal excretion. hiPSC-RPE cells were followed up to 8 months after transplantation by color fundus photography, PAM, OCT, and FM.

Results

PAM images at 650 nm showed the distribution of the hiPSC-RPE cells, demonstrating that the cells rapidly localized to laser burns within 1 week and remained at the laser burn sites with signal for a duration of 8 months. PAM images at 578 nm visualized the microvasculature. Cells were observed using FM up to 28 days post-injection with a significant reduction in fluorescence signal by 1 month. The co-registration of PAM and OCT images validated the location of hiPSC-RPE cells to RPE injury sites. Histological and immunofluorescence images confirmed the imaging results. TEM and confocal images demonstrated CGNP clusters within hiPSC-RPE cells without affecting the cell's morphology, pigmentation, and RPE differentiation or function.

Conclusions

This research presents an innovative platform technology for the longitudinal imaging of cell-based therapies in living animals for a duration of 8 months using PAM, OCT, and FM imaging.

sciforum-094528: Photon Dispersion in Gradient Phase Fields Enables Rapid and High-Fidelity Scattering Imaging

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Photon scattering-induced wavefront aberrations impose significant limitations on optical imaging within scattering media, particularly in environments characterized by diffusion. Scattering imaging techniques leveraging memory effects offer a promising avenue for imaging under the regime of multiple scattering. Nonetheless, the presence of interference phase traps inherent to scattered light often results in failures and distortion. We propose an algorithm for computational imaging to address the challenges. By employing gradient-based calculations to delineate the phase distribution of photon ensembles amidst diffuse scattering, we preemptively assess the convergence or divergence of the state of the retrieval algorithm prior to recovery. This proactive strategy serves to circumvent disruptions caused by interference traps, expediting the identification of the accurate state from a myriad of stochastic photon projections, thereby facilitating rapid and high-fidelity scattering retrieval. Through rigorous experimentation involving dozen-group targets and each group with 100 repeated trials, we quantitatively evaluate the proposed method. Our research demonstrates a substantial enhancement in success rates, approximately 3 times higher than those without interference mitigation, while achieving a reduction in computational time, down to 0.2 of the original. This approach introduces a novel scattering imaging technique, 'achieving more with less,' offering technical support for dynamic video imaging in intricate scattering environments such as biological tissues and atmospheric conditions.

sciforum-100712: Photonic devices and original probes for terahertz near field microscopy

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In the field of photonics and biophotonics the need of higher resolution for **microscopy and nanoscopy** is of prime interest for many applications like **semiconductors industry** (carrier density) or biological studies and diagnostics. After a detailed description of the free space approach using tips just like those used for AFM or original ones that we have proposed few years ago, we will focus on the guided wave approach and particularly on a solution for microscopy-on-chip with an integrated photonic source that generate terahertz waves. Both approaches with **free space** or **guided waves** are presented with an original topology in each case. For free space infrared and terahertz waves, the shape of the tip plays a key role for an antenna-like coulpling with the sample. For the guided mode approach, the electromagnetic confinement around a single conductor which acts as a **plasmonic** circuit is exploited to bring efficiently the sensing wave to the sample. Concerning biological studies, we will also see how the proposed approaches are compatible with liquid media opening many areas of **biophotonics** applications. The key point is the **on-chip-integration** of the active photonic device which is the UTC-PD (Uni-traveling-carrier Photodiode) that can generate millimeter and terahertz waves with an ultrabroad behaviour that is useful for hyperspectral imaging.

sciforum-095817: Single-pixel imaging techniques

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In the Fourier Single-Pixel Imaging (F-SPI) framework, Fourier basis patterns serve as orthogonal bases. An LED light source is reflected onto a Digital Micromirror Device (DMD) to modulate the light field, which is subsequently focused onto the sample's focal plane using an optical setup. A single-pixel detector captures the light intensity, and the object image is reconstructed via the four-step phase shift algorithm. An L-norm-based compressed reconstruction algorithm is introduced to achieve high-quality F-SPI at reduced spectrum sampling rates. Both simulation and experimental results indicate that the NESTA algorithm outperforms the D-AMP algorithm in terms of imaging efficiency, while ensuring superior imaging quality. The NESTA algorithm is adopted as the compressed sensing framework (CSF). These findings suggest that the proposed method can significantly enhance the sparse sensing module of F-SPI, facilitating rapid and high-quality image reconstruction. The Fourier regularization reconstruction mode and sub-pixel shift artifact removal algorithm are introduced to further reduce the imaging time consumption and suppress the imaging noise artifacts to a certain extent. Building upon the experimental validation of imaging efficiency in the Fourier Single-Pixel Imaging Compressed Sensing System (SPI-CSS), we discuss the Pixel Single-Pixel Imaging (P-SPI) scheme, which utilizes Zernike polynomials as orthogonal bases. In this approach, the modulated light field conforms to the Zernike polynomial patterns. The imaging process involves repeating the steps of Fourier Single-Pixel Imaging to record light intensity, followed by iteratively summing the product of Zernike polynomials and Zernike moments to reconstruct the target image. Experimental results demonstrate that P-SPI can effectively reconstruct images even at low sampling rates. Furthermore, compared to F-SPI, P-SPI exhibits a superior robustness to background noise within the SPI-CSS framework. This advantage extends the applicability of P-SPI to more complex environments, highlighting its potential for broader use in challenging imaging scenarios.

sciforum-095731: Single-shot quantitative phase imaging using polarization-multiplexed LED illumination via space-domain Kramers–Kronig relations

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The quantitative phase imaging technique based on the Kramers-Kronig relation is an innovative computational imaging method that does not require iteration and only needs four low-resolution images to achieve a large spatial bandwidth-time product, optimizing imaging performance. Based on this, the method employs polarization-multiplexed LED illumination, with three LED components each covered by 0°/45°/135° polarization filters, providing numerically aperture-matched illumination for the sample. Using Malus's Law, the three polarized light fields recorded by the polarization camera are decoupled, allowing us to obtain intensity images of LED illumination from three different angles in a single measurement. The intensity images for each polarization channel are separated and processed, and the spectral subregions of different channels are rotated and shifted to reconstruct the spectrum. Compared to traditional Fourier ptychography and rapid quantitative phase imaging techniques based on the spatial-domain Kramers-Kronig relation, this technology uses single-frame capture to successfully deduce the quantitative phase distribution of samples from intensity information, significantly increasing the frame rate of acquisition and reducing the overall acquisition time. It is highly suitable for dynamic imaging, such as live cell observation, and minimizing the impact of motion artifacts. Because it can provide higher resolution and a broader range of applications, this technology is expected to become an important tool in the fields of biomedical and surface inspection.

sciforum-105638: Terahertz Techniques, Materials, Metasurfaces, and Their Applications

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The terahertz (THz) portion of the electromagnetic frequency spectrum—approximately from 0.3 THz to 3 THz—is recently gaining much attention. Numerous applications, such as security screening and high data-rate wireless links to name but two relevant examples can benefit of the non-ionizing character of THz radiation with respect to X-rays and the increased resolution and bandwidth with respect to microwave techniques. It is essential to accurately characterize the THz properties of materials with appropriate techniques capable of dealing with dielectric, metal-dielectric, and conductive samples and provide results over a relatively wide range of frequencies with sufficient frequency resolution. In this respect, THz time-domain spectroscopy (THz-TDS) is a valuable tool, although the commonly used transmission mode fails to be effective when used on highly reflective samples, such as thin conducting films, or metasurfaces; both components that are widely used in THz applications. On the other hand, the less explored THz-TDS in reflection mode has recently been proven to be a very effective technique for accurately characterizing such kinds of components, as well as most of the dielectric and conductive materials used in THz applications. For this purpose, in this abstract we will show the measurement protocols that we recently developed for obtaining an accurate electromagnetic characterization of materials and components at THz. Specific care will be taken to the dispersive models employed to simultaneously fit the THz-TDS measurements and comply with electromagnetic theory. We will show a variety of experimental validations over commercial dielectric materials (e.g., Rogers, ciclo-olephins, dry resists), novel 2-D materials (e.g., graphene, graphene oxide, transition metal dichalcogenides), thin conducting films (e.g., aluminum zinc oxide, indium tin oxide, and titanium), and metasurfaces (e.g., patch arrays, strip gratings, and fishnets). Finally, we will briefly comment on how the latter components can profitably be used to realize THz radiating devices.

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