IOCO
2026
Conference

The 1st International Online Conference on Optics

25–27 March 2026 | Online

Program and Abstract Book

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The 1st International Online Conference on Optics

25–27 March 2026 | Online

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Welcome from the Chairs

Dear Colleagues,

It is our great pleasure to invite you to join the **1st International Online Conference on Optics (IOCO 2026)**, which will be hosted online from 25 to 27 March 2026.

The conference serves as a premier platform for optics researchers and enthusiasts to share their latest findings, innovative ideas, and practical experiences in the fields of optics and photonics. **IOCO 2026** will present the state of the art and exciting new developments in optics relating to the following topics:

S1. Biomedical Optics;
S2. Optoelectronics and Optical Engineering;
S3. Geometrical Optics;
S4. Photonics and Optical Communications;
S5. Laser Sciences and Technology;
S6. Quantum Optics;

IOCO 2026 will enable you to share and discuss your most recent research findings with the vibrant global community of scientists and engineers in the field.

IOCO 2026 will make your presentation accessible to hundreds of researchers worldwide, with the active engagement of the audience in question-and-answer sessions and discussion groups, which will take place online.

The conference committee will review the submitted abstracts. The authors of accepted contributions will have their work displayed in an abstract collection. Following the conference, outstanding contributions will be invited to be submitted as full-length papers for publication in *Optics*.

We hope you will join us, present your work at **IOCO 2026**, and be part of this exciting online event.

Best regards,

Prof. Dr. Costantino De Angelis
Conference Chair
Department of Information Engineering, University of Brescia, Brescia, Italy

Prof. Dr. Thomas Seeger,
Conference Chair
Institut Fluid- und Thermodynamik, Lehrstuhl für Technische Thermodynamik, Universität Siegen, Paul-Bonatz-Straße 9-11, Germany

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- **Rapid Publication**: manuscripts are peer-reviewed and a first decision is provided to authors approximately 22.1 days after submission; acceptance to publication is undertaken in 6.6 days (median values for papers published in this journal in the second half of 2025).
- **Recognition of Reviewers**: APC discount vouchers, optional signed peer review, and reviewer names published annually in the journal.

Impact Factor: 1.6 (2024); 5-Year Impact Factor: 1.5 (2024)

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Prof. Dr. Yuriy Garbovskiy

Department of Physics and Engineering Physics, Central Connecticut State University, New Britain, USA

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Institute of Applied Physics "N. Carrara" (IFAC), National Research Council (CNR), Florence, Italy

Dr. Marco Gandolfi

Department of Information Engineering, University of Brescia, Brescia, Italy

Professor Rick Trebino

School of Physics, Georgia Institute of Technology, Atlanta, GA, USA

Prof. Dr. Luca Poletto

National Research Council, Institute for Photonics and Nanotechnologies, Padova, Italy

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Canada Research Chair in Liquid Crystals and Behavioral Biophotonics, Laval University, Quebec, Canada

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Invited Speakers

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Dr. Luigi Santamaria Amato

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Professor Subhash Hanamant Risbud

Distinguished Professor Emeritus of Materials Science and Engineering at the University of California in Davis and Graduate Group Membership in Chemical Engineering and Mechanical Engineering, Davis, California, USA

Program Overview

	25 March 2026	26 March 2026	27 March 2026
Morning	S6. Quantum Optics	S1. Biomedical Optics	S4. Photonics and Optical Communications
Afternoon	S5. Laser Sciences and Technology	S3. Geometrical Optics	S2. Optoelectronics & Optical Engineering

IOCO 2026 Program

25 March 2026

S6. Quantum Optics

Time: 9:00 (CET (Basel) | 04:00 EDT (New York) | 16:00 CST (Asia, Beijing)

Time (CET)	Speaker	Title
09:00-09:10	**Prof. Dr. Costantino De Angelis** **Prof. Dr. Thomas Seeger** Event Chairs	Welcome & Opening Remarks
09:10-09:20	**Dr. Andrea Salamon** Session Chair	Welcome from the Session Chair
09:20-09:40	**Dr. Paolo Piergentili** Invited Speaker	Quantum Noise Limited Transducers for Quantum Networks
	Oral Presentations	S6. Quantum Optics
09:40-09:55	**Fabrizio Barbato** Selected Speaker	Rapid Prototyping on SOI 220 nm of Integrated Optical Structures with Polymer Vladding within the QUANTEP Collaboration
09:55-10:10	**Riccardo Ciciotti** Selected Speaker	Development of Te/Bi2Se3 Heterostructures for Photodetectors Sensitive to VIS and NIR Wavelengths
10:10-10:25	**Federico Rapuzzi** Selected Speaker	Advanced Nanomanipulation and Nanofabrication for Silicon Photonic Waveguide-Based Polarization Modulators Enabled by Semiconductor Nanomaterials
10:25-10:40	**Ajeethkumar Rengarajan** Selected Speaker	Developing Superconducting Nanowire Single Photon Detectors with Photon Number Resolving Capability
10:40-10:55	**Ilya Galaktionov** Selected Speaker	Efficiency Comparison of Stochastic and Gradient Descent Algorithms for Laser Beam Focusing into a Single-Mode Fiber
10:55-11:10	**Greta Andrini** Selected Speaker	Engineering Silicon Color Centers for Scalable Quantum Photonic Technologies
11:10-14:00		Break

S5. Laser Sciences and Technology

Time: 14:00 (CET, Basel) | 09:00 (EDT, New York) | 21:00 (CST Asia, Beijing)

Time (CET)	Speaker	Title
14:00-14:10	**Dr. Guido Toci** Session Chair	Welcome from the Session Chair
14:10-14:40	**Professor Rick Trebino** Keynote Speaker	Measuring Everything You've Always Wanted to Know About a Light Pulse
14:40-15:10	**Prof. Dr. Luca Poletto** Keynote Speaker	Raman Spectroscopy for Gas Detection: Applications to Energy and Agrifood
15:10-15:40	**Dr. Angela Pirri** Keynote Speaker	A Systematic Investigation of the Energy-Transfer Mechanisms in Dy:Lu3Al5O12 Ceramics Co-doped with Tb3+ for Developing Yellow Lasers
15:40-16:00	**Dr. Luigi Santamaria Amato** Invited Speaker	Quantum Inspired Imaging and Spectroscopy
	Oral Presentations	S5. Laser Sciences and Technology
16:00-16:15	**António J.O. Ferreira** Selected Speaker	Controlling Laser Energy Deposition at Polymer Interfaces via Optical Absorbance Engineering
16:15-16:30	**Svetlana Boshnakova** Selected Speaker	Method for Additive Manufacturing in the Automotive Sector for Surfaces Enhanced with Properties of Steel Components

26 March 2026

S1. Biomedical Optics

Time: 9:00 (CET (Basel) | 04:00 EDT (New York) | 16:00 CST (Asia, Beijing)

Time (CET)	Speaker	Title
09:00-09:10	**Dr. Giuseppe Trusso Sfrazzetto** **Dr. Francesco Chiavaioli** Session Chairs	Welcome from the Session Chairs
09:10-09:30	**Dr. Rosalba Pitruzzella** Invited Speaker	Optics and Chemistry in Sensing: Polymer Imprinting as an Innovative Strategy for Sensitive Optical Waveguides
09:30-09:50	**Dr. Rosella Santonocito** Invited Speaker	A Single-Device Approach to Multiplexed Health Monitoring Using Fluorescent Array Sensors
	Oral Presentations	S1. Biomedical Optics
09:50-10:05	**Rukmani Singh** Selected Speaker	Lossy Mode Resonance-Based Optical Fiber Sensors for the Label-Free Detection of Osteosarcoma-Related Biomarkers
10:05-10:20	**Claudia Borri** Selected Speaker	A Preliminary Cytocompatibility Study of Electrospun Nanofibrous Matrices for their Integration into a Fiber-Based Biophotonic Sensing Platform
10:20-10:35	**Oleh Demianyk** Selected Speaker	Chiral Sensing Enhancement via Subwavelength Plasmonic Gratings
10:35-10:50	**Laura Marcela Valencia-Granada** Selected Speaker	Multispectral Image Analysis for the Characterization of an Experimental Artificial System Integrating Breast Tissue and Blood Vascularization
10:50-14:00		Break

S3. Geometrical Optics

Time: 14:00 (CET, Basel) | 09:00 (EDT, New York) | 21:00 (CST Asia, Beijing)

Time (CET)	Speaker	Title
14:00-14:10	**Dr. Davide Rocco** Session Chair	Welcome from the Session Chair
14:10-14:40	**Dr. Marco Gandolfi** Keynote Speaker	Opto-thermal tunability in phase-change metasurfaces
14:40-15:00	**Dr. Pablo De Gracia** Invited Speaker	Optical Quality Through Focus of Multifocal Contact Lenses used for Myopia Control
15:00-15:20	**Dr. Grazia Giuseppina Politano** Invited Speaker	Variable-Angle Spectroscopic Ellipsometry for Optical Characterization of Advanced Materials
15:20-15:40	**Dr. Giuseppe Brunetti** Invited Speaker	Phase-Change Materials for Reconfigurable and Non-Volatile Microwave Photonics
15:40-16:00	**Professor Subhash Hanamant Risbud** Invited Speaker	Fused Silica Optical Glass Processed Rapidly Using Quartz Sand From Homerun Resources Company (HMRFF)
	Oral Presentations	S3. Geometrical Optics
16:00-16:20	**Marco Gandolfi** Selected Speaker	Metalens Optimization: the Look-Up Table Approach and Beyond

27 March 2026

S4. Photonics and Optical Communications

Time: 9:00 (CET (Basel) | 04:00 EDT (New York) | 16:00 CST (Asia, Beijing)

Time	Speaker	Title

(CET)		
09:00-09:10	**Dr. Jiahao Huo** Session chair	Welcome from the Session Chair
09:10-09:40	**Professor Paulo Monteiro** Keynote Speaker	Optical Wireless Communications: Powering Ultra-High-Capacity Connectivity
09:40-10:00	**Dr. Meisam Abdollahi** Invited Speaker	Intelligent Computing and Silicon Photonics
10:00-10:20	**Dr. Giovanna Calo** Invited Speaker	Mode asymmetry in magneto-plasmonic waveguides for integrated non-reciprocal devices
	Oral Presentations	S4. Photonics and Optical Communications
10:20-10:35	**Vladimir Toporovsky** Selected Speaker	Dual-Wavelength Adaptive Optical System for Free-Space Communications Performance Improvement
10:35-10:50	**Oleh Yermakov** Selected Speaker	Metasurface-Based Near-Field Polarization Transformer for Localized Light
10:50-11:05	**Jaime Cariñe** Selected Speaker	Adaptive Phase Stabilization in Fiber-Optic Systems for Quantum Information
11:05-11:20	**Gustavo Machi Matsumine** Selected Speaker	Photonic Band Gap Optimization in SiC-air crystals via Grey Wolf Optimizer
11:20-14:00		Break

S2. Optoelectronics & Optical Engineering

Time: 14:00 (CET, Basel) | 09:00 (EDT, New York) | 21:00 (CST Asia, Beijing)

Time (CET)	Speaker	Title
14:00-14:10	**Prof. Dr. Yuriy Garbovskiy** Session Chair	Welcome from the Session Chair
14:10-14:40	**Prof. Dr. Tigran Galstian** Keynote Speaker	Liquid Crystal Adaptive Biomedical Optics
14:40-15:00	**Dr. Manuel Jesús Hermoso-Orzáez** Invited Speaker	Angle-Dependent Glare Behavior in LED Luminaires: A Unified cosm Model for Urban Observers
	Oral Presentations	S2. Optoelectronics & Optical Engineering
15:00-15:15	**Hiroyuki Fujii** Selected Speaker	Modeling Light Scattering and Agglomeration of Colloidal Suspensions: Fast Calculations of Polydisperse Dense Systems
15:15-15:30	**Pengfei Yang** Selected Speaker	Influence of Nose Curvature on Depolarization of Blunt Cones Based on the Integral Equation Method
15:30-15:45	**Haitian Liu** Selected Speaker	Validation of a Near-infrared Laser Beam Profiler at 2 μm Using a Rotating Detector
15:45-16:00	**Salima El Amrani** Selected Speaker	Optical Spectroscopy of Tb^{3+}/Yb^{3+} Rare Earth Ions in Silica-Hafnia Sol–Gel for Photovoltaic Applications
16:00-16:15	**Christian Hernández Álvarez** Selected Speaker	From Luminescent Thermometry to Optical Current Sensing
16:15-16:30	**Yeraldin Alejandra Velez Galvis** Selected Speaker	Optimization of Perovskite Solar Cell Performance Through Machine Learning
16:30-16:40	**Prof. Dr. Costantino De Angelis** **Prof. Dr. Thomas Seeger** Event Chairs	Closing Remarks

S1. Biomedical Optics

sciforum-160134: Multispectral Image Analysis for the Characterization of an Experimental Artificial System Integrating Breast Tissue and Blood Vascularization

Laura Marcela Valencia-Granada [1,*], Milton Humberto Medina-Barreto [2], Luis Felipe Toro-Orozco [1], Catarina Martin-Castano [1], Yenberson Guarumo-Jimenez [3], Juan Camilo Moreno-García [1] and Jenniffer Bustamante-Mejía [1]

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[2] Department of Physics, Universidad Tecnológica de Pereira, Pereira, 660004, Colombia
[3] Faculty of Mechanics, Universidad Tecnológica de Pereira, Pereira, 660004, Colombia

This work focuses on the acquisition and analysis of the multispectral behavior of mammary tissue representing glandular tissue, adipose tissue, and/or a tumor, incorporating a perfusion system, in order to characterize the constructed structure using image-processing algorithms applied to the acquired data. A synthetic model was fabricated from organic materials in relative proportions that simulate the two typical breast tissues—glandular and adipose—together with a material that presumably represents the tumor. The specimens consist of an outer ring (glandular or adipose tissue) containing the tumor at its center, and the entire system is traversed by two tubes carrying a fluid that mimics blood circulation. Two lamps irradiate the structure to thermally stimulate the surface, thereby enabling the simultaneous acquisition of thermographic images and spectral images in the visible region, which were subsequently processed using Python. An experimental and computational procedure was developed to acquire and process multispectral images of the simulated tissues. The algorithm implemented for thermographic acquisition enabled the identification of two differentiated regions during thermal wave propagation by employing the K-means algorithm. In addition, the temporal evolution during the cooling process allowed the cooling constant to be identified as a characteristic parameter of the process. Regarding the acquisition of multispectral images in the visible range (MSI), it was possible to differentiate diffuse reflectance among the different simulated tissues and the vascularization system. The applied methodology enabled a comprehensive analysis that facilitated the understanding of thermal responses as a function of time in the implemented experimental model. The algorithm allowed the segmentation of regions of interest, delineating regions associated with distinctive spectral contrasts. The results are consistent with the mathematical models studied, enabling an adequate differentiation among the tissues.

sciforum-158571: A preliminary cytocompatibility study of electrospun nanofibrous matrices for their integration into a fiber-based biophotonic sensing platform

Claudia Borri [1,*], Giorgia Montalbano [2], Ilaria Corvaglia [2], Barbara Adinolfi [1], Alberto Rovera [2], Rukmani Singh [1], Ambra Giannetti [1], Maria Giorgia Spasari [2], Davide Luca Janner [2], Shadab Dabagh [1], Francesco Baldini [1], Chiara Vitale Brovarone [2], Sonia Lucia Fiorilli [2] and Francesco Chiavaioli [1]

[1] National Research Council of Italy (CNR), Institute of Applied Physics "Nello Carrara" (IFAC), 50019 Sesto Fiorentino, Italy
[2] Department of Applied Science and Technology, Politecnico di Torino, 10129 Turin, Italy

Introduction

The use of diagnostic methods or devices that are increasingly efficient, accurate, and able to ensure prompt intervention to prevent the progression of aggressive pathologies, such as cancer, is now more fundamental than ever. In this context, to assess the sensing capacity in the presence of tumor cells with a biophotonic platform, based on lossy mode resonance fiber sensors coated with scaffolded nanomaterials and integrated with microfluidic chips, we have preliminarily electrospun three different nanofibrous substrates onto glass planar supports and evaluated their cytocompatibility with a cellular model of human osteosarcoma.

Methods

About 18.000 cells were seeded in complete growth medium onto uncoated or treated glass coverslips in 12-well plates. Cell adhesion, morphology and proliferation were observed after 24 and 48 hours by optical microscopy and several images were captured by using a 10× objective lens magnification after cell washing and medium renewal. A colorimetric cell viability assay was then performed at 48 hours by transferring each coverslip into new multi-well plates and by adding 5% Water-Soluble Tetrazolium 8 (WST-8) in complete medium for 2 hours at 37°C. Cell supernatants were transferred into 96-well plates to quantify the absorbance of formazan at 450 nm using a microplate reader. Formazan is produced via WST-8 reduction by mitochondrial dehydrogenases of viable cells and results in a yield directly proportional to the number of living cells.

Results

Except for a single polymer, all matrices remained unchanged after the incubation with cell culture medium for up to 48 hours. In all electrospun coverslips, cells had properly adhered to the substrates, and their morphology was comparable to the control cells seeded onto uncoated supports. The cells were metabolically active and the viable amount in all treated samples was comparable to relative controls.

Conclusions

These promising results lay the groundwork for the next phase of optimization of the final biophotonic sensing device integrated with microfluidics.

sciforum-163383: Biofilm prevention through irradiation with visible light?

Martin Hessling [1,*], Ben Sicks [1], Klea Lila [1], Felix Capanni [1] and Vinzent Forstmeier [2]

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Introduction

Biofilms are communities of microorganisms on moist surfaces that are difficult to remove and can repeatedly release microorganisms. This causes significant problems in many areas, such as food technology and medicine as biofilms can cause infections in patients that can be potentially fatal. One approach to preventing biofilm formation on surfaces that has not yet been extensively researched is to irradiate them with visible blue or violet light, both of which are known for their antimicrobial effect on planktonic bacteria.

Methods

Various bacterial suspensions (*Bacillus subtilis*, Pseudomonas stutzeri, Streptococcus cristatus and Pseudomonas syringae) were placed in 24-well MTPs (microtiter plates) and irradiated with violet or blue light for up to 6 days. During this time, they were shaken at room temperature at a frequency of 100 rpm. The irradiation intensities were 0 mW/cm^2, 10 mW/cm^2, or 20 mW/cm^2. After each day, the bacterial suspension was aspirated and the biofilm at the bottom of the well was assessed by absorption measurement and microscopy imaging.

Results

In almost all experiments, thin biofilms were found on the well bottoms after 24 hours, even on the irradiated microtiter plates. In general, however, the level of absorption or biofilm formation was lower on the irradiated MTPs than on the non-irradiated ones. For *Bacillus subtilis*, irradiation prevented biofilm formation during the observation period. Surprisingly, in most experiments, blue light had a stronger effect than violet light, which does not correspond to previous reports regarding their effect on planktonic bacteria.

Conclusion

Violet and blue light have a positive effect on suppressing the formation of new biofilm, but the applied maximum irradiance of 20 mW/cm^2 was not able to prevent the formation of new biofilms. Further investigations with higher irradiance levels are necessary to determine whether it is possible to inhibit the formation of new biofilms altogether.

sciforum-163448: Chiral sensing enhancement via subwavelength plasmonic gratings

Oleh Demianyk [1,*], Sergey Polevoy [2], Vladimir Tuz [1] and Oleh Yermakov [3]

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Chirality is used to describe the asymmetry of a physical system that cannot be superimposed on its mirror images. Despite being chemically identical, chiral molecules can differ drastically in their biological activity, exhibiting therapeutic or toxic effects depending on their handedness. The primary challenge during the measurement of chiral substances is that most conventional methods are often limited by weak chiroptical signals at low concentrations of molecules.

To address this gap, we investigated a system consisting of a 50 nm gold film coated with a chiral analyte on a quartz substrate. By employing the Kretschmann prism-coupling configuration, we excited surface plasmon polaritons with a TM-polarized plane wave to analyze the resulting reflection spectra. It is observed that the presence of a chiral medium leads to a small non-zero response in orthogonal (transverse electric) polarization due to magneto-electric coupling. As a result, an angular difference emerges between the spectral resonances in terms of right- and left-handed circularly polarized waves. The magnitude of this angular shift determines the sensitivity of the sensor—a larger shift corresponds to higher sensitivity.

To overcome the film's limitations, we replaced it with a gold subwavelength grating. This approach amplified the chiral sensitivity by nearly two orders of magnitude. The reason for this enhancement is explained by the Rayleigh anomaly, which occurs when a diffracted wave propagates tangentially to the grating surface, transitioning into an evanescent mode. Consequently, the coupling between the evanescent wave strongly localized at the edges of the grating and the chiral substance leads to the significant amplification of the chiroptical response.

We demonstrated that the structural transition from thin films to subwavelength gratings significantly improves the limits of chiral detection. These findings offers a promising platform for detecting small concentrations of chiral biomolecules in real time for pharmaceutical and biomedical applications.

sciforum-163651: Fluorescence and Raman Spectroscopy for Morphological and Biochemical Analysis of Eukaryotic Cells

Maria Crina Isac

Department of Biology, Faculty of Biology, Alexandru Ioan Cuza University of Iași, Iași, 700506, Romania

Fluorescence and Raman spectroscopy provide complementary optical approaches for detailed analysis of eukaryotic cells, enabling simultaneous investigation of structural and biochemical properties. Fluorescence-based imaging techniques, including wide-field and confocal microscopy, allow high-resolution visualization of cellular morphology, subcellular organelles, and dynamic processes. Specific fluorescent probes and dyes facilitate selective labeling of biomolecules, enhancing the detection of proteins, nucleic acids, and lipids within live or fixed cells. Raman spectroscopy, in contrast, offers label-free chemical characterization by detecting vibrational signatures of molecular bonds, providing insights into cellular composition, metabolic states, and biomolecular interactions. The integration of fluorescence imaging and Raman spectroscopy enables multidimensional analysis, combining spatial, morphological, and molecular information. These optical methods have been applied in studies of cell differentiation, apoptosis, disease-related alterations, and drug response, highlighting their versatility in both basic and applied biological research. Key technical considerations, including signal-to-noise optimization, spectral resolution, and photobleaching effects, are critical for accurate data acquisition and interpretation. Advances in instrumentation, such as confocal Raman microscopy and multimodal platforms, are expanding the capabilities of optical cell analysis, allowing real-time monitoring and high-throughput assessment. Emerging trends include the development of novel fluorescent probes, enhancement of Raman sensitivity, and integration with machine learning for automated cellular characterization. Collectively, fluorescence and Raman spectroscopy represent powerful and complementary tools for quantitative, high-resolution investigation of eukaryotic cells, supporting ongoing research in cellular biology and biomedical applications.

sciforum-163214: Lossy mode resonance-based optical fiber sensors for the label-free detection of osteosarcoma-related biomarkers

Rukmani Singh [1,*], Claudia Borri [1], Ambra Giannetti [1], Girogia Montalbano [2], Pablo Zubiate [3], Ignacio Del Villar [4], Davide Janner [2] and Francesco Chiavaioli [1]

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[4] Department of Electrical, Electronic and Communication Engineering, Institute of Smart Cities (ISC), Public University of Navarre, Pamplona 31006, Spain

Introduction

The effect of cancer on health, society, and global economy makes early identification and treatment of the disease by biomarker detection in body fluids one of the biggest challenges in the modern world. Current gold-standards (PCR, flow cytometry, immunofluorescence, western blotting, ELISA, etc.) remain laborious, operator-dependent, time-consuming, and require large sample volumes. Therefore, an effective and real-time monitoring platform with clinically relevant limits of detection (LODs) for cancer diagnosis using biofluids remains urgent. To fulfil this demand, we introduce a compact biophotonic platform that integrates lossy mode resonance-based optical fiber sensors with embedded microfluidics.

Methods

The device employs a D-shaped single-mode optical fiber coated with a thin film of SnO_2 that supports the generation of lossy mode resonance (LMR), a physical phenomenon enabling high sensitivity and resolution in the detection of biomolecules, while retaining key advantages of optical fibers, such as unique light control, flexibility, electromagnetic immunity, robustness in harsh environments, and compatibility with optoelectronics. Firstly, the sensing surface is functionalized with a commercial polymer (Eudragit L100) to provide COOH groups. Afterwards, the sensor is integrated into a specially engineered microfluidic system and then the sensing surface is passivated with bovine serum albumin (BSA) to suppress nonspecific adsorption and improve assay specificity. Finally, the platform is evaluated across clinically relevant concentration ranges of transforming growth factor beta 1 (TGF-β_1) as an osteosarcoma-related biomarker.

Results

The device showcases excellent analytical performance in a standard running buffer (PBS), with a clinically relevant LOD of 5 pg/mL for TGF-β_1, demonstrating strong potential for early cancer biomarker detection.

Conclusions

These promising results lay the groundwork for the next experimental tests using clinically mimicking biofluids to assess the real performance of the biophotonic sensing device integrated with microfluidics.

sciforum-163196: Multifunctional dendrimer-based magnetite nanocarrier for pH-responsive drug delivery and MRI hyperthermia in breast cancer theranostics

Shadab Dabagh [1,*], Hamed Ghorbanpoor [2], Merve Nur Soykan [2], Ayla Eker Sarıboyacı [2], Barbara Adinolfi [1], Ambra Giannetti [1], Zesen Li [3], Ni Lan [3], Bai-Ou Guan [3], Hüseyin Avci [2], Yang Ran [3] and Francesco Chiavaioli [1]

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Introduction

Breast cancer remains a major global health challenge, motivating the development of multifunctional nanoplatforms that unify diagnosis and therapy. This study presents a novel dendrimer-functionalized magnetite nanocarrier ($MAGSiAG_1$) and its ibuprofen-loaded derivative ($IBU@MAGSiAG_1$) designed for synergistic chemotherapy, magnetic hyperthermia, and MRI-guided theranostics.

Methods

Magnetite nanoparticles are synthesized and sequentially coated with SiO_2, APTES, cyanuric chloride, and poly(amidoamine) (PAMAM) G_1 dendrimer. Ibuprofen was loaded through sonication-assisted adsorption. Structural and physicochemical characterization was performed using different spectroscopic and imaging- and potential-based techniques, like FTIR, XRD, TGA, DLS, zeta potential, VSM, and SEM/TEM. pH-responsive drug release was evaluated across physiological and tumor-mimicking conditions. T2 relaxation and hence r2 relaxivity were quantified in MRI phantoms, and hyperthermia treatment was assessed under alternating magnetic field conditions (200 kHz, 100–150 Oe). *In vitro* cytotoxicity and live/dead imaging were conducted on MCF-7 breast cancer and EA. hy926 endothelial cells.

Results

$IBU@MAGSiAG_1$ featured stable spherical nanocarriers (~70 nm, −39 mV) with high ibuprofen loading (>90%). Drug release was accelerated at acidic pH (5.0–6.5) mimicking a cancer microenvironment, while it was suppressed at physiological pH 7.4. The nanocarriers retained superparamagnetic (35–40 emu/g) features and achieved therapeutic hyperthermia temperatures (~45 °C) at 150 Oe. High relaxivity (358.9 ± 5 $mM^{-1}\,s^{-1}$ for $MAGSiAG_1$; 335.0 ± 49.8 $mM^{-1}\,s^{-1}$ for $IBU@MAGSiAG_1$) confirmed strong MRI contrast enhancement. MCF-7 viability decreased to ~60% at 400 µg/mL, while EA.hy926 cells remained highly viable at ≤300 µg/mL, indicating selective therapeutic action.

Conclusions

This multifunctional dendrimer nanocarrier integrated MRI contrast enhancement, magnetic hyperthermia, and pH-triggered ibuprofen release into a single platform, enabling targeted ablation of breast cancer cells with acceptable biocompatibility. These results highlight its strong potential for personalized and image-guided cancer theranostics.

S2. Optoelectronics & Optical Engineering

sciforum-163262: Power-Overlap Modal Decomposition for Predictive SMS Fiber Interference Modeling

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Single-mode–multimode–single-mode (SMS) fiber structures are widely used in optical engineering as compact and low-complexity platforms for refractive-index (RI), temperature, and strain sensing, where spectral features arise from multimode interference (MMI) within the multimode fiber (MMF) section. Despite their practical relevance, predictive modeling remains challenging for large-diameter MMF segments because the number of guided modes can be very large, making the choice of a sufficient modal basis unclear and often computationally prohibitive.

This work presents a numerical framework to quantify how MMF diameter and length govern modal excitation and the resulting transmission spectrum, while enabling a justified reduction in the modal space. For each geometric configuration, MMF eigenmodes and propagation constants are computed, and the propagated field is sampled on transverse planes along the device length. A power-normalized modal decomposition is then performed using overlap integrals between the propagated transverse fields (Ep, Hp) and the MMF eigenmode fields (Em, Hm). This yields complex modal coefficients am(z) and the modal power distribution Pm(z), which are used to rank modes by contribution and to determine a minimal subset that ensures spectral convergence.

The approach provides a physically grounded criterion to select the required number of modes and to assess the impact of higher-order modes on dominant spectral features. The transmission spectrum is interpreted as the accumulated differential phase among the excited modes and their recapture at the output single-mode fiber, offering a practical route toward accurate and computationally efficient simulation of SMS devices for optical sensing and related photonic engineering applications.

sciforum-163413: Optical ultrasonic imaging of geological structure models

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Geological structure models are seismic physical models constructed based on geological structures and formations according to specific similarity ratios. In laboratory settings, ultrasonic or laser-ultrasonic techniques are utilized to perform model imaging for field exploration activities. Experiments with seismic physical models have found extensive applications in petroleum and gas exploration. These applications include studying the fundamental laws of wave propagation and seismic response of typical geological structures. The ultrasonic signals transmitted within these complex physical models generally display weak intensities. Therefore, it is necessary to excite high-intensity broadband ultrasonic waves as sources and, at the same time, use high-performance ultrasonic sensors to collect the model echoes.

Traditional piezoelectric transducers have been extensively utilized in the ultrasonic detection and imaging of seismic physical models. In contrast, laser ultrasonic technology possesses the ability to excite ultrasonic fields on the surfaces of objects with various scales and morphologies. These ultrasonic fields possess remarkable characteristics, including a wide bandwidth, multiple modes, and high intensity. In addition, optical fiber ultrasonic sensors are micro-acoustic sensors that employ optical fibers as the sensitive detection elements. Relative to electromagnetic transducers, these sensors demonstrate a superior sensitivity, a broadband frequency response, a compact size, and resistance to electromagnetic interference.

This work mainly presents the sensing mechanism and research status of laser ultrasound transducers and optical fiber ultrasonic sensors developed by our group. In the context of ultrasonic imaging technology for geological structural models, comparative analyses have been carried out on the research progress of conventional electroacoustic transducers, novel fiber-optic ultrasonic sensors, and emerging laser ultrasonic technology, as well as the technological issues and challenges involved.

sciforum-163283: Optimization of perovskite solar cell performance through machine learning

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This work presents a machine-learning-based methodology for optimizing perovskite solar cells performance using a freely accessible synthetic dataset generated from numerical simulations of devices in SCAPS-1D. The dataset includes systematic variations of the device's geometric, optical, and defect-related parameters, enabling an extensive exploration of the design space without the need for additional simulations. A Support Vector Regression (SVR) model with a radial basis function (RBF) kernel was trained as a surrogate model to predict power conversion efficiency (PCE) from the geometrical and optical variables of the device. For the optimization stage, a multi-objective framework based on Pareto-front analysis was implemented to balance the trade-off between maximizing PCE and minimizing prediction errors. As result, a cell architecture with a maximum PCE of 29.82% was identified, with predictive performance characterized by R^2 = 0.9124, MAE = 1.8470, and RMSE = 2.8773, supporting the use of SVR-RBF as a surrogate model on open synthetic data. To enhance physical interpretability, the SHAP framework was applied to quantify the influence of each optical parameter to the PCE, revealing the dominant factors associated with layer thicknesses, optical properties, and defect densities. The proposed approach demonstrates the potential of interpretable machine learning as a physics-informed design tool for high-performance perovskite solar cells, providing clear guidelines for device optimization in optoelectronic and photonic applications.

sciforum-163671: Validation of a Near-infrared Laser Beam Profiler at 2 μm Using a Rotating Detector

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Optical beam profiling is essential for characterizing beam quality and diffraction for the optimization of laser-based systems. However, in wavelength ranges such as near-infrared, commercially available beam profilers are often costly, limiting their accessibility. There is therefore a clear need for low-cost and flexible beam profiling approaches that can operate across a broad wavelength range while maintaining acceptable accuracy and robustness. We present a beam-profiling system based on a rotating photodiode that reconstructs the 1D beam intensity profile via angular scanning. A single photodiode on a motorized stage rotates around the beam's axis with an angular resolution less than 0.1 degrees, corresponding to a spatial resolution of 0.1mm, while a microcontroller with a fast-sampling analog-to-digital converter (ADC) performs real-time data acquisition of the detected signal. We validated the system using a 2 μm laser source. At a propagation distance of 140 mm, the rotating diode profiler measured a beam width of 7.3 mm, compared to 6.5 mm from a commercial Thorlabs profiler. Given the photodiode width of 0.3mm, the step resolution, variations in the fit results from beam asymmetries, and variations in the beam itself, the difference is within the expected tolerances. Reconstructed profiles showed good agreement with a Gaussian distribution, and the measured beam diameters were highly repeatable. Our rotating diode profiler is a cost-effective and scalable alternative to scanning slit and camera-based systems, especially for near-infrared wavelength regimes, making it suitable for research, development and instructional applications. Commercial infrared beam profilers cost 6,000 USD and up, while our rotating photodiode system can be implemented for under 400 USD—representing a greater than 10-fold cost reduction.

sciforum-163042: 3-Ethylcarbazole as a building block for new OLED host materials achieving EQEs over 20%

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Organic light-emitting diodes (OLEDs) have garnered significant attention due to advantages ranging from innovative product design possibilities to highly efficient and sustainable light sources, creating a demand for new high-performance materials. Addressing this need, new ethylcarbazole-based D-A-D host materials were synthesized using one- or two-step nucleophilic aromatic substitution routes and evaluated for their suitability in OLEDs. Materials had one (**CzeCzS**, **CzeCzM**) or two (**eCz2S**, **eCz2M**) ethylcarbazole units paired with either sulfonyl (**CzeCzS**, **eCz2S**) or methanone (**CzeCzM**, **eCz2M**) electron acceptors. Thermal and morphological analyses showed that all materials are highly resistant to degradation, with decomposition temperatures ranging from 393 to 436 °C, and they form stable amorphous films with high T_g values (89–112 °C). Photophysical measurements revealed high triplet state energies (2.71 – 2.90 eV), indicating that these compounds can serve as hosts for both green phosphorescent and yellow TADF emitters. Device studies highlighted that methanone-bridged hosts outperformed phenylsulfonyl analogues due to more balanced charge transport and improved exciton confinement. When applied as host materials to a green phosphorescent emitter, a maximum EQE of 16.5% was achieved. Incorporating these hosts into blended co-host architectures led to notable efficiency enhancements, with external quantum efficiency values surpassing 20%. The best-performing device, based on the **eCz2M/**B3PyMPM co-host system, achieved an EQE of 20.3%, a luminance efficiency of 72.7 cd/A, and a power efficiency of 95.1 lm/W. Also, for a yellow-emitting TADF OLED prototype, our co-host systems enabled the achievement of an EQE of 10.3%. This work demonstrates that methanone–ethylcarbazole D-A-D structures are strong candidates for next-generation efficient OLED host materials. This work provides fundamental knowledge for developing advanced host materials for both TADF and phosphorescent OLED technologies.

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sciforum-160967: A long wave cutoff perfect absorber with a nanocone array structure

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We report a long wave cutoff perfect absorber (LWCPA) with a nanocone array structure. Each nanocone unit comprises an InP cone grown on a SiO_2 substrate, with three layers of stacked structures nested inside: from bottom to top, these are Si_3N_4 blocks, Cr blocks, and Au cones. The structure exhibits outstanding absorption performance from ultraviolet to near-infrared wavelengths, achieving an average absorption of 97.9% in the 200–820 nm band. A sharp transition occurs as absorption drops dramatically from 95% at 820 nm to 10% at 1880 nm, with an average absorption of only 3.5% in the non-absorption band of 1880–4000 nm. Key performance metrics include an extinction ratio of 9.78 dB, an extinction difference of 85%, and a cutoff slope of 0.234 nm^{-1}. Considering that this structure may be applied to photoelectric conversion systems in the future, the present invention incorporates Si_3N_4 in advance and verifies that the absorption rate remains at a high level under its influence, thereby laying the groundwork for subsequent application of this structure in photoelectric conversion systems. The design was optimized via finite-difference time-domain (FDTD) simulations, with structural parameters such as nanocone height and base dimensions fine-tuned to enhance absorption and cutoff characteristics. This LWCPA offers an efficient strategy for ideal solar heat absorber design, with significant potential for applications in renewable energy technologies, including solar thermal photoelectric and solar thermal energy systems.

sciforum-162098: Accurate Determination of Thin Pet Film Structural Disorder and Bandgap Energy by Absorption Optical Spectroscopy

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Absorption optical spectroscopy allows measuring structural disorder and fundamental electronic properties (e.g., bandgap energy, E_g) of solid polymers by combining the interferometric and extinction information contained in UV-Vis-NIR spectra. Here, as an example, a thin polyethylene terephthalate (PET) film has been optically investigated before and after mild uniaxial/biaxial hand stretching, in order to establish the effect of such mechanical deformation on thickness, structural disorder, and bandgap energy. Thin PET films are frequently used in electronic packaging, magnetic tapes, and adhesive tape for various electronic purposes, like thermal insulators for battery, LCD and electromagnetic absorption board fixings, etc. These polymeric films typically undergo hand stretching during their use/application. The PET film thickness has been accurately calculated on the basis of the interference fringe spacing in the optical spectrum, and these values have been used for calculating the absorption coefficient and building Urbach and Tauc plots. The optical spectrum of thin PET film shows a cutoff threshold (transparent-opaque transition) at 300nm, corresponding to an E_g value of 3.96 eV. Such a transparent-opaque transition is characterized by sharp behavior (Urbach energy of 45.0 eV), which is indicative of a low structural disorder of the unstretched polymer. It has been verified that disorder and electronic structure remain practically unmodified by the slight stretching deformation (i.e., Urbach and bandgap energies do not change). Since the PET film E_g value does not depend on the deformation degree, this physical parameter can be considered as a 'fingerprint' of the solid polymer, thus allowing its distinction from other types of polymeric solids. Accurate E_g determination for solid polymer identification is a pivotal issue in the area of microplastics, where the required remediation/recycling approach strictly depends on plastic nature.

sciforum-162082: Adaptive Dimming Strategies for Urban LED Lighting: A MATLAB-Based simulation framework

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LED lighting in urban areas has expanded exponentially over the years, mainly due to its energy and cost savings. Currently, most LED street lights operate at a constant power output, regardless of traffic and pedestrian activity. In this research, a simulation is developed using MATLAB software to design different adaptive regulation strategies with the aim of further improving the energy efficiency of these lights, while maintaining acceptable visibility conditions.

This work integrates LED photometric data, the behaviour of electronic PWM regulators and the calculation of illuminance on the road surface. Two main control strategies are considered: attenuation profiles according to the time of day and traffic-sensitive attenuation according to car detection events. This approach will allow a comparison to be made in terms of energy consumption, illuminance distribution and essential lighting requirements.

This study will enable both municipalities and designers to evaluate the main characteristics of adaptive lighting using a modelling approach together with test scenarios before its implementation on the streets and on any urban road. A flexible methodology is proposed to enable future research to include real sensor data, environmental factors, and additional attenuation algorithms. This will allow for more accurate assessments in decision-making in smart city applications.

sciforum-163585: Copolymers with pendent phenoxazine/arylbenzimidazole moieties as bipolar polymeric host materials for green PhOLEDs

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A group of vinyl copolymers containing electronically isolated phenoxazine as an electron-donating unit and either 2-phenylbenzimidazole or 2-(2-pyridyl)benzimidazole as electron-accepting units was synthesized via a multistep synthetic route. The corresponding vinyl monomers were polymerized by cationic polymerization in solution to obtain amorphous bipolar polymeric materials. The chemical structures and molecular characteristics of the synthesized copolymers were fully characterized by NMR spectroscopy, elemental analysis, and gel permeation chromatography. Thermal and morphological properties were investigated using thermogravimetric analysis and differential scanning calorimetry. All materials exhibited high thermal stability, with initial thermal degradation temperatures in the range of 300–320 °C. Furthermore, the polymers demonstrated very high glass transition temperatures between 151 and 160 °C, indicating the excellent morphological stability of amorphous films, with only a minor dependence on the nature of the aromatic acceptor chromophore. The synthesized copolymers were evaluated as host materials in phosphorescent organic light-emitting diodes (PhOLEDs), using bis(2-phenylpyridine)(acetylacetonato)iridium(III), [$Ir(ppy)_2(acac)$] as the emissive dopant. Devices based on the copolymer PPxPy1, incorporating phenoxazine and 2-(2-pyridyl)benzimidazole units, exhibited promising electroluminescent performance, characterized by a low turn-on voltage of 3.0 V, a maximum luminance exceeding 2000 cd/m^2, and a maximum current efficiency of approximately 13.4 cd/A. A similar device employing the copolymer PPxP3, containing phenoxazine and 2-phenylbenzimidazole chromophores, showed the best overall performance, achieving a low turn-on voltage of 3.0 V, a maximum brightness above 2800 cd/m^2, and a maximum current efficiency of about 13.0 cd/A. These results demonstrate the potential of phenoxazine–benzimidazole-based vinyl copolymers as thermally robust and efficient host materials for phosphorescent OLED applications.

sciforum-163126: Correlating Structural Disorder and Refractive Index Sensitivity in Pmma Fibers

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While Polymer Optical Fibers (POFs) are favored for their mechanical resilience, increasing their sensitivity typically requires hazardous chemical etching that damages the fiber surface. To avoid these chemical defects, we propose a physical alternative: a "thermal bandgap modulation" protocol. The core idea was to determine if heat treatment alone could tune the fiber's surface for better sensitivity, while avoiding the structural damage often caused by chemical methods. We tested Polymethyl Methacrylate (PMMA) fibers across three distinct thermal stages: stress relaxation (100°C), viscoelastic transition (150°C), and the onset of oxidative degradation (200°C). Rather than relying on standard transmission methods, we analyzed the fibers using reflection spectroscopy in the 300–700 nm range. By applying the Kubelka–Munk transformation to this reflection data, we were able to calculate the optical band gap (E_g) and Urbach energy (E_u)—metrics that are rarely used in macroscopic sensor fabrication.

Our results show a clear difference in how the material behaves based on its thermal history. At 100°C, the fiber simply relaxes, keeping its transparency and a stable UV-limit band gap. However, at 200°C, we observed a distinct narrowing of the optical band gap as the absorption edge moved toward the visible spectrum. This shift matched a widening of the Urbach tail, which indicates the formation of carbon-rich clusters and increased structural disorder. We found that this induced disorder is not just damage; it acts as a tunable parameter that is directly linked to a significant rise in sensitivity. By carefully managing the thermodynamic state of the polymer, we present a sustainable, high-precision way to build intrinsic fiber optic sensors.

sciforum-163459: Design and Analysis of Achromatic Metalenses in the Visible Regime

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Metalenses based on optical metasurfaces enable wavefront manipulation using subwavelength nanostructures and provide a promising route toward compact and integrated optical systems. However, strong chromatic aberration caused by wavelength-dependent phase responses remains a major obstacle for practical metalens applications in the visible regime.

In this work, we present the design and analysis of an achromatic metalens operating in the visible spectrum using silicon nitride (Si_3N_4) dielectric metasurfaces. The metalens employs a phase-engineering strategy based on propagation-phase modulation of polarization-independent nanostructures. By constructing a unit-cell phase library through systematic parameter scanning, the phase responses at different wavelengths are accurately mapped. An interleaved arrangement strategy is introduced, where meta-atoms designed for different target wavelengths are alternately distributed within a single metalens aperture, enabling multi-wavelength phase compensation without increasing structural complexity.

Numerical simulations demonstrate that the proposed metalens achieves near-coincident focal positions across a broad visible wavelength range. The focal length variation is significantly suppressed compared with conventional single-wavelength metalenses. The metalens exhibits stable focusing behavior with symmetric focal spots, consistent focal sizes, and improved chromatic tolerance. The results confirm that the interleaved design effectively mitigates chromatic focal shift while maintaining high transmission efficiency.

This study provides a practical and scalable approach to achieving achromatic focusing in visible-wavelength metalenses. The proposed Si_3N_4-based interleaved design offers strong potential for compact imaging systems, integrated photonics, and visible-light optical devices.

sciforum-167695: From Luminescent Thermometry to Optical Current Sensing

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Reliable measurement of electric current is essential in many technological and industrial contexts, particularly in environments where conventional electrical sensors are limited by electromagnetic interference, electrical contact requirements, or accessibility constraints. Optical sensing strategies based on luminescent materials offer an attractive alternative due to their noninvasive nature, immunity to magnetic fields, and potential for remote operation. In this work, an optical approach for current monitoring is presented using thermally sensitive upconversion luminescence. The sensing system is based on $NaYF_4$:Yb^{3+},Er^{3+} particles dispersed in a photocurable resin and deposited as a coating on a resistive element. Under near-infrared excitation, the material exhibits temperature-dependent upconversion emissions arising from thermally coupled energy levels of Er^{3+}. A calibration procedure was first carried out by correlating the luminescence intensity ratio with temperature over the range 298–328 K. Subsequently, electrical current was applied to a ceramic resistor, and the resulting self-heating was monitored optically through changes in the luminescent response. A clear relationship between the applied current and the luminescence intensity ratio was observed, reflecting the temperature increase induced by Joule heating. The sensor was evaluated for direct currents between 0 and 2.2 A, a range defined by the electrical and thermal characteristics of the resistor. The measurements demonstrated good repeatability and an estimated current resolution of approximately 0.01 A. The calibration was shown to remain stable across different ambient temperatures within the studied range. The proposed luminescence-based strategy enables accurate, remote measurement of electric current without direct electrical contact. Its flexibility, precision, and adaptability to different resistive components make it a promising tool for current sensing in environments where traditional techniques are impractical or invasive.

sciforum-163358: Influence of Nose Curvature on Depolarization of Blunt Cones Based on the Integral Equation Method

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Based on the Integral Equation Method (IEM), the influence of target curvature on electromagnetic scattering depolarization characteristics is investigated. The studied target is a blunt-nosed cone, whose nose geometry is modeled using three typical surfaces—spherical, ellipsoidal, and parabolic caps—in order to analyze the effect of different curvature distributions on polarization scattering mechanisms. Surface roughness parameters are incorporated into the model, and the depolarization characteristics of various nose geometries are systematically examined under different roughness conditions and incidence angles. Within the IEM framework, both single-scattering and multiple-scattering contributions are taken into account to compute the co-polarized and cross-polarized scattering components, from which the depolarization ratio is obtained.

Numerical simulation results indicate that nose curvature has a significant impact on depolarization characteristics, and this influence exhibits distinct dependence on the incidence angle. Compared with the spherical nose, the ellipsoidal and parabolic noses, due to their continuously varying local curvature, show stronger polarization coupling effects at moderate and large incidence angles. As surface roughness increases, multiple scattering becomes more pronounced, leading to enhanced polarization mixing and a noticeable increase in the depolarization level. These results provide theoretical insight into polarization scattering modeling and depolarization mechanism analysis for complex curved targets.

sciforum-163620: Laboratory Tests of a Low-Cost Multispectral Camera for Environmental Monitoring

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Widespread distribution of inexpensive CMOS image sensors has enabled researchers, including enthusiasts and educators, to create low-cost multispectral imagers for environmental studies. In this paper, we present the methods and results of some laboratory tests of a low-cost portable multispectral camera, previously designed for the monitoring of vegetation. The study was aimed at evaluating the parameters that affect the performance of the multispectral camera. The angular size of the field of view and the resulting focal length was calculated from an image of an object with known dimensions set at a predefined distance, using trigonometric relations. Depth of field and hyperfocal distance distributions were calculated from the aperture diameter and distance to the object. To test the spectral homogeneity of the field of view, parallel and uniform light from the overcast sky was directed at the sensor, and then the ratio between red and green values in the resulting image was considered. The study proposes some methods to resolve the tasks of performance assessment for a low-cost multispectral camera. The calculated total focal distance of the camera was 58 mm, and the angular size of its field of view was 3.6 degrees. The calculated depth of field ranged from 2 mm to infinity (following the definition of hyperfocal distance). Hyperfocal distance values ranged from 52.5 to 885.6 m for the smallest and the greatest aperture correspondingly. Adjustments of the optical system using the parallel daylight beam allowed us to reduce the standard deviation of the red-to-green ratio over the image down to 0.025, showing an acceptably small spectral inhomogeneity.

sciforum-163480: Modeling light scattering and agglomeration of colloidal suspensions: fast calculations of polydisperse dense systems

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Colloidal suspensions are essential and found in various nano- and micro-scale engineering and scientific fields, such as slurries in chemical engineering, colloidal photocatalysts in environmental remediation, and milk in food science. High concentrations are in high demand across various industries, such as for improving product quality and reducing transport costs by reducing the weight of suspensions. The development of a method to non-destructively evaluate particle properties (such as particle size distribution and aggregation degree) of high-concentration colloidal solutions is urgently needed. Light-scattering techniques have been extensively developed as promising tools for evaluating particle properties. Meanwhile, most developed techniques require sample dilution, with the volume fraction typically less than 5%. Thus, the method is still under development. For this development, simultaneous and appropriate modeling of the particle properties and light scattering, along with a fast solution method, is essential. In this study, a fast calculation method was developed based on the local monodisperse approximation to the dependent scattering theory (DST). Previously, we proposed a rapid method for polydisperse systems without particle agglomeration; here, we extended it to agglomerated systems. The DST describes the far-field interference between the scattered electric fields in dense colloidal systems. We successfully achieved a speedup of over 800 times in computation, while maintaining the same accuracy in describing the DST results. Our findings provide forward modeling for developing nanotechnology to evaluate the particle properties non-destructively using scattered light.

sciforum-167674: Optical spectroscopy of Tb^{3+}/Yb^{3+} rare earth ions in silica-hafnia sol–gel for photovoltaic applications

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Frequency conversion plays a key role in controlling relaxation dynamics in rare-earth-doped materials and underlies numerous photonic applications, particularly in photovoltaics. In this context, spectral conversion aims to optimize solar radiation absorption by shifting poorly absorbed wavelengths toward ~980 nm, corresponding to the bandgap region of crystalline silicon. Glass–ceramic systems have been shown to be especially effective for tailoring energy transfer mechanisms between rare earth ions [1]. Among them, silica–hafnia binary matrices have emerged as promising hosts for incorporating rare earth ions into hafnia nanocrystals, resulting in enhanced luminescence efficiency and expanded application potential.

In this work, we investigate the Tb^{3+}/Yb^{3+}-mediated down-conversion process in silica–hafnia glass–ceramic thin films as a strategy to improve the spectral response of silicon-based solar cells. The films were prepared via a sol–gel spin-coating method followed by an appropriate thermal treatment, enabling precise control over composition, morphology, and optical properties [2].

Photoluminescence measurements performed under 476 nm excitation reveal a strong emission from Yb^{3+} ions associated with the 2F5/2→2F7/2 transition after Tb^{3+} excitation, demonstrating an efficient energy transfer from Tb^{3+} to Yb^{3+}. These results confirm the efficiency of the down-conversion mechanism in the silica–hafnia glass–ceramic system and highlight its relevance for photovoltaic spectral conversion applications.

In summary, this study demonstrates that Tb^{3+}/Yb^{3+}-codoped silica–hafnia glass–ceramic thin films constitute a promising and tunable system for efficient spectral down-conversion in silicon-based photovoltaic technologies.

[1] Salima El Amrani , Lamyae Oulmaati , Giancarlo C. Righini , Maurizio Ferrari, Mohammed Reda Britel, Adel Bouajaj. Ceramics International (2025) 51(12) 16645-16649. https://doi.org/10.1016/j.ceramint.2024.10.448.

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sciforum-163653: Phase encoding with random binary phase plates for photon-limited imaging

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Photon-limited imaging of weak scattering objects is strongly affected by shot noise, leading to reduced contrast and variable phase retrieval. Introduction of phase-encoding elements can improve image formation by converting phase variations into measurable intensity modulations; however, conventional phase plates such as Zernike or vortex designs impose fixed symmetries and often lack robustness when photon budgets are low. This work dives into a simulation-based investigation of random binary phase plates as an alternative encoding approach for photon-limited computational imaging.

Image formation is modelled using scalar diffraction theory and angular-spectrum propagation through transmission phase plates composed of randomly distributed binary phase regions. Low dose detection is explicitly incorporated using Poisson noise statistics. Image recovery is performed using regularized inverse filtering, followed through systematic comparison of different phase-encoding methods devoid of complex reconstruction algorithms.

The results indicate that random binary phase encoding introduces wavefront diversity that possibly improves spatial–frequency mixing and stabilizes image reconstruction under strong shot noise. Relative to conventional symmetric phase plates, the random designs exhibit better CNR [Contrast to noise ratio] and reduced sensitivity to photon loss at detected photon levels below 10^3. The dependence of imaging performance on phase-plate feature size is also examined, identifying parameter combinations that enhance noise robustness while maintaining reconstruction fidelity.

S3. Geometrical Optics

sciforum-167732: Metalens Optimization: the Look-Up Table Approach and Beyond

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A metalens is an advanced optical element that uses a metasurface—an array of nanoscale resonators (NRs)—to manipulate light at the subwavelength scale. In contrast to conventional lenses, which focus light through curved glass or plastic surfaces, metalenses control optical wavefronts by precisely engineering the geometry, dimensions, and spatial arrangement of NRs. This approach enables effective aberration correction and high focusing efficiency and resolution, while offering a significantly thinner and lighter form factor compared to traditional lenses.

The widely used approach to design a metalens starts from the generation of a *Look-Up Table* (LUT), i.e., a pre-calculated library containing dissimilar NRs that can impart a phase in the 0-2π range by simply tuning a few geometrical parameters. Once the LUT is generated, the NRs are carefully placed in the metalens to assign, at every spatial point, the required phase to achieve the desired performance. However, to compute the LUT, the NRs are usually placed in a perfectly periodic array, an assumption that fails when the NRs are then displaced into the real metalens. Thus, the LUT method implies an intrinsic error limiting its performance. Some recent studies have raised concerns regarding the reported performance of metalenses in the existing literature. For this reason, the modelling of a full metalens to evaluate its actual focusing efficiency, and methods beyond the standard LUT approach for the metalens design, are necessary.

In this work, we consider a 2D cylindrical metalens focusing light in the NIR range. After calculating the LUT and engineering the metalens, we first evaluate its actual performance and then we envision how to improve them.

sciforum-167842: Modeling of a High-Frequency SAW Resonator on $Si/AlN/SiO_2/LiNbO_3$ Multilayer Substrate

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This paper presents the modeling and simulation of a multilayer surface acoustic wave (SAW) resonator designed to operate at a center frequency of 30 GHz. The proposed structure consists of a layered stack of silicon (Si), aluminum nitride (AlN), silicon dioxide (SiO_2), and lithium niobate ($LiNbO_3$), with gold (Au) interdigitated transducer (IDT) electrodes placed on the top surface. This multilayer configuration enhances surface wave confinement and piezoelectric efficiency while maintaining compatibility with silicon-based integration platforms. A two-dimensional finite element model is developed in COMSOL Multiphysics, incorporating the elastic and dielectric properties of each material. The IDT electrodes are modeled as terminals, with a 1 V excitation applied to one electrode and the other grounded. A frequency-domain sweep is performed over the range of 28 GHz to 32 GHz to extract key performance indicators such as the input impedance (Zin) and the S11 reflection coefficient. Simulation results confirm the presence of a Rayleigh-type SAW, tightly confined near the surface of the $LiNbO_3$ layer. The primary resonance is observed at 29.57 GHz, which aligns well with the designed acoustic wavelength. This work demonstrates the effectiveness of multilayer SAW resonators for future MEMS, RF filtering, and acoustic sensing applications at the nanoscale, with high frequency selectivity and integration potential.

S4. Photonics and Optical Communications

sciforum-171161: Dual-wavelength adaptive optical system for free-space communications performance improvement

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The analysis of the efficiency of laser radiation transmission through the atmosphere from the point of view of an alternative to existing radio communication methods of information transfer is based on determining the influence of negative effects such as scattering, the absorption of radiation, and the turbulence of air flows on the optical beam. The influence of scattering and absorption in the atmosphere is usually minimized by choosing an appropriate radiation wavelength, primarily the in near-IR spectrum. Atmospheric turbulence occurs due to uneven heating of the underlying earth's surface. Such heating causes local fluctuations in the refractive index of air, which leads to the appearance of an optical path difference of propagating optical rays. As the radiation propagates along the transmission path, the number of fluctuations increases; consequently, the wavefront of the beam arriving at the receiving focusing system has a shape that is far from flat, which manifests itself as a focal spot with a shape different from the diffraction-limited one. Various modifications of adaptive optics systems are typically used to reduce turbulence effects. As a result, an optical circuit was created that simulates a wireless communication channel, with two laser beams simultaneously directed along the atmospheric path, with wavelengths of 1550 nm and 830 nm. The first beam transmits the primary radiation, while the second beam analyzes the characteristics of the introduced turbulence onto a Shack–Hartmann wavefront sensor, as the sensor's sensitivity lies in the frequency range of 400–1100 nm. Artificial turbulence was generated using a fan heater, and the resulting phase fluctuations were corrected using the bimorph wavefront corrector.

sciforum-168335: Fano-Resonant Coupled Sagnac Loop Resonator for Enhanced Integrated Refractive Index Sensing

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Introduction

Integrated photonic refractive index sensors are increasingly important for chemical and biological sensing due to their high sensitivity, compact footprint, and compatibility with silicon-based fabrication technologies. Resonant photonic structures that support sharp spectral features are particularly attractive, as they enable enhanced detection of small refractive-index variations through precise wavelength tracking.

Methods

In this work, a silicon-on-insulator (SOI) refractive index sensor based on a coupled-resonator optical waveguide (CROW) architecture is presented. The design employs two inversely coupled Sagnac loop reflectors connected by a self-coupled feedback waveguide, generating Fano-type asymmetric resonances through discrete–continuum interference. Numerical simulations based on the finite-element method were used to analyze the influence of structural parameters, including loop radius, coupling gap, and feedback length. Refractive index sensing was evaluated over the range of 1.33–1.36 by monitoring resonance wavelength shifts.

Results

The ridge waveguide configuration exhibited stable asymmetric resonances with sensitivities between 106 and 120 nm/RIU. By incorporating a subwavelength-grating segment into the feedback waveguide to enhance evanescent field interaction, the sensor sensitivity was increased to 185.8–212.2 nm/RIU while preserving resonance asymmetry and spectral stability.

Conclusion

The proposed coupled Sagnac loop CROW sensor demonstrates high sensitivity, tunability, and fabrication tolerance in a compact footprint. These characteristics highlight its strong potential for integrated biochemical and environmental sensing applications.

sciforum-163998: Adaptive Phase Stabilization in Fiber-Optic Systems for Quantum Information

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Fiber-optic Mach–Zehnder interferometers are fundamental building blocks in modern photonic and quantum information systems, enabling precise phase manipulation for applications ranging from coherent communications to quantum state preparation and measurement. Nevertheless, their performance is inherently limited by phase noise induced by environmental perturbations, such as temperature fluctuations and mechanical vibrations. This challenge becomes increasingly severe as the dimensionality and complexity of the interferometric architecture grow, particularly in multi-path and high-dimensional fiber-optic networks. In this talk, we present an adaptive control approach for the stabilization of phase fluctuations in complex fiber-optic interferometers. The proposed method dynamically adjusts the control action based on the system response, allowing it to operate effectively in nonlinear regimes without requiring an explicit system model. Numerical studies performed on high-dimensional N×NN \times NN×N interferometric architectures illustrate the scalability and robustness of the approach under realistic noise conditions. Experimental validation is carried out using correlated photon pairs, demonstrating stable and sustained phase locking in fiber-based interferometers relevant to quantum information applications. The results show that the adaptive strategy provides strong resilience to phase noise while maintaining long-term stability. Furthermore, the control scheme is well suited for real-time implementation on FPGA platforms, supporting low-latency operation and practical deployment. These features make the proposed approach attractive for both classical photonic systems and emerging quantum technologies based on fiber-optic interferometry.

sciforum-163665: Blind Point Spread Function Estimation for Enhanced Spatial Loss Analysis in Optical Time-Domain Reflectometry

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Optical time-domain reflectometry (OTDR) is widely used for fault detection and optical path loss characterization in optical fiber systems and networks. While long pulses are necessary for adequate signal-to-noise ratio and measurement range, they blur localized fault events, degrading both spatial resolution and the ability to detect non-reflective or weakly reflective localized losses. For short-distance optical systems that cascade multiple optical components where spatial resolution in the 10 cm to 1 m range is desired, this limitation is particularly significant. This work addresses these constraints through developing blind pulse spread function (PSF) estimation and post-processing of OTDR traces. Our method exploits localized reflection events (such as induced reference reflections at known locations) to estimate the system's impulse response without requiring hardware modifications or independent pulse characterization. The estimated PSF is then used to perform deconvolution, along with noise reduction processing, on OTDR traces acquired from commercial instruments on laboratory systems. By iteratively refining PSF estimates and applying advanced signal processing techniques adapted from image deconvolution literature, we aim to enhance spatial resolution and improve detection fidelity for discrete loss events. We will present preliminary results from OTDR trace simulations demonstrating the feasibility of blind PSF estimation using iterative optimization methods. Ongoing measurements using commercial OTDR instruments on laboratory systems will be conducted to validate the approach on real-world data.

sciforum-163184: Metasurface-based near-field polarization transformer for localized light

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Polarization is a basic electromagnetic unit of information. It can easily be controlled and adjusted for plane waves propagating in the bulk media. However, it is still a challenge to manipulate the polarization of the localized light, i.e. in the near-field region.

In this work, we discover the near-field polarization degree of freedom offering two configurations for the practical implementation based on (i) all-dielectric metasurfaces in visible and near-infrared ranges, and (ii) self-complementary metasurfaces in microwaves. The first approach assumes a general design strategy for all-dielectric nanostructures that supports TE-TM degenerate guided modes. It is broadly applicable across a wide spectral range, including the visible, infrared, terahertz, and microwave regimes. In what follows, we consider a metasurface consisting of identical disk-shaped high-index dielectric resonators. Each disk exhibits the Mie resonances, and we adjust the collective Mie-like response. The second approach is based on the Babinet's duality principle implemented in a self-complementary metasurface. It has been recently investigated that surface waves supported by the self-complementary metasurface exhibit degenerate TE-TM dispersion in certain directions, leading to a near-field polarization degree of freedom.

Finally, we demonstrate the excitation of surface waves with on-demand polarization and a planar compact near-field waveguide polarizer. Both devices are subwavelength and have been verified experimentally for microwaves. The results obtained form a new direction for near-field polarization photonics, leading to a plethora of compact planar polarization devices for manipulating localized light.

sciforum-163424: Photonic Band Gap Optimization in SiC-air crystals via Grey Wolf Optimizer

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We developed an efficient inverse-design approach using the Grey Wolf Optimizer (GWO) to synthesize two-dimensional photonic crystal (PC) structures with large photonic band-gap (PBG). Using this method, we identified a new optimal SiC–air PC configuration for transverse magnetic (TM) polarization, achieving a PBG with a Gap-to-Midgap Ratio (GMR) of 34.55%.

Photonic crystals are periodic dielectric structures composed of materials with contrasting refractive indices, enabling the formation of PBGs that prevent electromagnetic wave propagation. The inverse design of PCs is challenging due to the high number of degrees of freedom and the intrinsic complexity of Maxwell's equations. The GWO is a metaheuristic based on grey wolves' hunting behavior: pursuit, encirclement, and attack. It offers strong global search capabilities, robustness against local minima, and simpler operators compared to other swarm-based optimizers; therefore, we investigate its suitability for this task.

The python-GWO was first validated with standard benchmark functions and then coupled to a Matlab–FORTRAN Finite Element Method (FEM) solver. The PC unit cell, arranged in a triangular lattice, was discretized into a 10×10 grid (100 bits), each assigned either SiC (n = 2.6) or air. The FEM solver computed dispersion diagrams, and the GMR served as the optimization objective. The optimized TM structure achieved a GMR of 34.55%, and GWO convergence curves helped verify solution saturation by hyperparameter.

In conclusion, the GWO proved effective for fast inverse design of SiC–air PCs, yielding a crystal configuration with significantly improved PBG for the TM polarization.

sciforum-167205: Photophysical Characterization of Nanocomposites Formed by Silver Nanoparticles and Methylene Blue

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Introduction

Silver nanoparticles (AgNPs) are capable of producing a plasmonic effect, which can amplify the local electric field of certain materials, such as methylene blue (MB), resulting in fluorescence spectra with increased intensity. However, for this effect to occur, two conditions must be met: (i) spectral overlap between the extinction spectrum of the AgNPs and the absorption spectrum of MB, and (ii) an intermediate distance (10–20 nm) between the AgNPs and the material whose electromagnetic signal is to be amplified.

Methodology

Initially, AgNPs were synthesized using a bottom-up approach by reducing an Ag^+ solution with $NaBH_4$, yielding nanoparticles with an extinction band overlapping the absorption band of MB. Subsequently, different volumes of AgNPs (10, 20, and 40 μL) were mixed with MB to obtain a final MB concentration of 10 μmol L^{-1}. A 10 μmol L-1 MB solution without AgNPs was used as a control. Spectrofluorimetric measurements were performed to evaluate the effects on the MB + AgNP systems and on MB alone.

Results

Fluorescence measurements were carried out for each sample, revealing variations in fluorescence intensity relative to isolated MB. Upon the addition of 10, 20, and 40 μL of AgNPs, the fluorescence intensity increased by 5.7%, 2.5%, and 1.7%, respectively. These results indicate that higher volumes of AgNPs did not lead to the further enhancement of MB fluorescence intensity.

Conclusion

In conclusion, at the studied concentration, it is possible to achieve an amplification of the fluorescence signal of MB using the synthesized AgNPs; however, the optimal added volume was approximately 10 μL. These findings may contribute to the development of improved outcomes in treatments that employ phototherapy.

sciforum-167805: Plasmon-Induced Fluorescence Enhancement of Methylene Blue by Silver Nanoparticles

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Introduction

Silver nanoparticles (AgNPs) exhibit optical properties associated with surface plasmon resonance, which can enhance the local electric field in the vicinity of molecules such as methylene blue (MB), leading to increased fluorescence intensity. For this amplification to be effective, two criteria must be fulfilled: (i) spectral overlap between the extinction spectrum of the AgNPs and the absorption spectrum of MB; and (ii) an appropriate distance, estimated to be between 10 and 20 nm, between the nanoparticles and the emitting molecule, enabling electromagnetic coupling without fluorescence quenching.

Methodology

AgNPs were synthesized using a bottom-up approach through the chemical reduction of Ag^+ ions with sodium borohydride ($NaBH_4$), yielding nanoparticles with an extinction band compatible with the absorption region of MB. Subsequently, different volumes of the AgNP suspension (10, 20, and 40 µL) were added to MB solutions, adjusting the final dye concentration to 15 µmol L^{-1}. An MB solution at the same concentration, without AgNPs, was used as a control. The samples were analyzed by spectrofluorimetry to evaluate the fluorescence behavior of MB in the absence and presence of the nanoparticles.

Results and Discussion

The association of MB with AgNPs resulted in changes in fluorescence intensity. An increase of 9.0% was observed with the addition of 10 µL of AgNPs, whereas volumes of 20 and 40 µL led to smaller enhancements of 6.1% and 5.4%, respectively. These findings indicate that increasing the amount of nanoparticles does not necessarily result in greater fluorescence signal amplification.

Conclusion

It is concluded that fluorescence enhancement of MB is feasible under the studied conditions, with the addition of 10 µL of AgNPs being the most effective. These results highlight the potential of this system for applications in phototherapy and other photoinduced processes.

sciforum-161910: Super-resolution imaging enabled by nonlinear optical response of upconversion nanoparticles

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Exploration of the optical nonliniear response in different lanthanide emitters, including photon avalance (PA) luminescence and the emission saturation phenomenon has profound implications in plentiful frontier applications. In the past few years, our studies have reported several universal mechanisms to exhibit giant nonlinear responses in various avalanching emitters and generated record-breaking nonlinear responses up to the 60th order in high-lying emitting levels for various emitters. By enabling full-spectrum PA luminescence ranging from the visible to near-infrared regions in various emitters, such as Tb^{3+}, Eu^{3+}, Dy^{3+}, Nd^{3+},Tm^{3+}, Er^{3+}, Ho^{3+} and Yb^{3+}, multi-color super-resolution imaging can be realized with a resolution of about 100 nm. Moreover, by further increasing the excitation intensity, the emissions become saturated. By replacing the excitation beam with a doughnut-shaped one, the emission saturation efffect tunes the inner dip of the detected PSF, enabled sub-40 nm super-resolution imaging in 200μm pig kidney slices. Studying these mechanisms opens up exciting avenues for new flexible and high-efficiency PA modulation in multilayer nanostructures, enabling the application of PA in more technologies, such as super-resolution imaging, lithography, and optical detection. In this report, we briefly introduced the mechanism and principles of nonlinear responses in upconversion nanoparticles and highlighted their novel applications in the field of super-resolution imaging.

S5. Laser Sciences and Technology

sciforum-169727: Controlling Laser Energy Deposition at Polymer Interfaces via Optical Absorbance Engineering

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Laser transmission welding relies on controlled laser–matter interaction at polymer interfaces, where the optical absorbance and transmission between parts to be welded governs the local energy deposition and the subsequent melting of both materials. This work explores an absorptance-based strategy to enhance laser–matter interaction independently of the intrinsic optical properties of the material that plays the role of absorbent component. A dark masking agent was introduced at the interface of a typical overlap joint to locally increase absorbance for a wavelength of 1070 nm (a continuous-wave ytterbium fiber laser). The influence of laser power on the fusion zone morphology was evaluated. Optical microscopy and mechanical testing were employed to assess the impact of the masking agent. Overall, it significantly altered the laser–matter interaction, leading to enhanced energy absorption and clearly promoting greater material melting. Microscopic observations revealed improved interfacial continuity and polymer cell bridging, indicating more efficient conversion of optical energy into effective load-bearing material. These results demonstrate that interfacial absorbance control is a powerful optical strategy for tailoring laser energy deposition in laser transmission welding. The proposed approach broadens the applicability of laser-based polymer joining and highlights the central role of optical absorbance in governing process efficiency and joint performance.

sciforum-163423: Erbium-doped fluoride microstructured fibers for 2.8 μm lasing

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Erbium (Er^{3+})-doped fluoride microstructured fibers based on ZBLYAN glasses, which are recognized for low intrinsic loss in the mid-infrared (MIR) region and strong compatibility with rare-earth ion doping, are fabricated via the stack-and-draw method. This technique enables precise replication of preset air-hole configurations, effectively suppressing parasitic losses in the MIR band and creating a stable gain environment for 2.8 μm lasing, which originates from the $^4I_{11/2} \rightarrow {}^4I_{13/2}$ energy level transition of Er^{3+} ions. Using a 976 nm laser diode in an end-pumping configuration, stable 2.8 μm lasing is achieved from an 86 cm-long Er^{3+}-doped fluoride microstructured fibers. The system delivers a maximum unsaturated output power of ~34 mW and a slope efficiency of only up to 4.2%-low performance mainly caused by ~4% Fresnel reflection at one fiber end, which provides insufficient photon feedback and induces significant cavity loss. Systematic studies explore the effects of key parameters. Overly short fibers lack sufficient gain accumulation, while overly long ones amplify scattering loss. An increased Er^{3+} concentration enhances gain generation and improves laser efficiency. By contrast, insufficient Er^{3+} concentration fails to provide adequate gain, restricting laser output performance. Resonator reflectivity with an appropriate value facilitates the efficient generation of 2.8 μm lasing. These results confirm Er^{3+}-doped fluoride microstructured fibers as promising gain media for 2.8 μm lasers, supporting potential applications in biomedical spectroscopy and environmental gas sensing.

sciforum-167704: Method for Additive Manufacturing in the Automotive Sector for Surfaces Enhanced with Properties of Steel Components

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Introduction

In modern vehicles, new enhancements are being sought for engine components, break discs, and valves, using light-weight materials which are applicable not only in conventional cars but also in electric vehicles. The utilization of novel additive manufacturing aims to reduce energy loss and mechanical stress, improving component longevity at a lower cost.

Method

Theeffective hardfacing of silicon carbide (SiC) over stainless steel was achieved using a Rofin Sinar Nd:YAG 2 kW robotized laser system with powder feedstock. Different Metal Matrix Composites (MMCs) were manufactured using Laser Directed Energy Deposition (DED-LB), making it possible to additively manufacture near-net-shaped parts while having the freedom to obtain variable geometries for the surface layout. Samples were prepared from teh following flat products of EN 10088: X2CrTi12(1.4512, AISI 409), X15CrNi25-20 (1.4840, AISI 310), X5CrNi18-10 (1.4301, AISI 304), and X1CrNiMoCuN20-18-7 (1.4547, UNS: S31254). The reinforcement comprised a fine carbide powder of SiC, and the MMCs were produced after the solidification of the molten mixture. The study included an assessment of the interface zones and measurement of their microhardness, as well as microstructural analysis with visual defect evaluation focused on porosity and microcracking detection.

Results

In order to increase durability and heat and wear resistance, advanced MMC sample components for various vehicles applications were explored. In one layer with a thickness of 1.5 mm, composed of X1NiCrMoCuN20-18-7 and SiC, the hardness characteristic was observed to be about 25 MPA higher than that experimentally obtained for the base material. For the same MMC, the carbide–metal interface zoneswere investigated.No cracks were observed, and it displayed a porosity of ≈ 1.57 %. DED-LB MMC possess excellent thermal stability and resistance to abrasion.

Conclusion

Laser application allows various geometric applications on the surfaces of car parts. The appropriate selection of component phases can enable thedesign of parts with specific functionality, where the interaction between the microstructure and properties is complex.

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S6. Quantum Optics

sciforum-167571: Rapid prototyping on SOI 220 nm of integrated optical structures with polymer cladding within the QUANTEP collaboration

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Introduction

QUANTEP develops quantum-optics devices using silicon photonics. Foundry runs highlighted the need for in-house prototyping for fast iterations, often before final oxide encapsulation and before full optical testing is available. We present a SOI 220 nm workflow where a reversible polymer overcladding acts as a non-permanent photonic environment to accelerate early fabrication of nanowaveguides and grating couplers, compatible with post-processing such as metallization and local rework.

Methods

Patterns were defined by electron-beam lithography (EBL) on SOI 220 nm and transferred by reactive ion etching (RIE). In this first iteration, an Al hard mask improved pattern transfer; in parallel, the flow migrated toward high-etch-resistance resists (e.g., CSAR-class) to reduce complexity in subsequent runs. The design set included full-etch and partial-etch grating coupler (GC) variants: full-etch structures were obtained by RIE, while partial-etch regions were implemented locally by ion beam (FIB) milling and quantified by atomic force microscopy (AFM). Selected chips were coated with approximately 2 um polymethyl methacrylate (PMMA) to enable waveguide confinement; EBL-defined windows preserved access for alignment, metallization, and local rework while keeping polymer coverage on photonic areas. Etch depths and film thicknesses were obtained from AFM and tilted-stage SEM.

Results and Conclusions

SEM confirms fabrication of nanowaveguides and GC structures. AFM validates a partial-etch depth of 65 +/- 6 nm versus a 70 nm target and verifies PMMA thickness. The workflow provides a SOI 220 nm prototyping route combining RIE transfer, FIB partial-etch, and reversible polymer overcladding. While not replacing final SiO2 encapsulation, PMMA increases processing flexibility and enables access windows, metallization, and local rework that would be more complex with oxide cladding.

sciforum-166763: Development of Te/Bi_2Se_3 heterostructures for photodetectors sensitive to VIS and NIR wavelengths

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In recent years, two-dimensional materials (2DMs) have attracted considerable interest for their remarkable properties, which allow for them to be employed in many fields. In particular, 2DMs are increasingly finding application in the field of optoelectronics, with the aim of reducing manufacturing costs and device dimensions to enhance their efficiency. Furthermore, the van der Waals lattice structure of 2DMs enables them to be easily integrated with silicon technology. Unfortunately, the thin nature of these materials might result in weak light absorption. To address this issue, heterostructures of 2DMs are fabricated: combining them allows the tuning of electronic bandgaps, obtaining low-cost devices in a given range of wavelengths. Topological insulators (TIs) are 2DMs characterized by an insulating bulk gap and Dirac helical electronic surface states. Among these, Bi_2Se_3 demonstrates considerable potential in high-speed detection, due to the high mobility of surface electronic states and its 0.3 eV bandgap, which enable it to operate at telecommunications wavelengths (λ=1550 nm). On the other hand, Te is a material with a thickness-dependent bandgap which extends from 0.3 eV (bulk) to 1.2 eV (monolayer). The absorbance of Te films in the infrared range is higher than Bi_2Se_3 of the same thickness. Considering these properties, we fabricated, through a low-cost vapor–solid deposition technique, a photodetector based on a Te/Bi_2Se_3 heterostructure, deposited onto a prepatterned n-Si substrate, in order to increase performance in both the VIS and IR spectral range. Single layers of Te and Bi_2Se_3 and Te/Bi_2Se_3 heterostructures were separately characterized by XRD and SEM to investigate their structural and morphological properties. The obtained Te/Bi_2Se_3 photodetectors are sensitive to both VIS (λ=633 nm) and IR (λ=1550 nm) light, exhibiting a responsivity of 2.6 A/W and a detectivity of 2.6 x 10^{11} Jones at λ=633 nm, and showing a linear and ultrafast response (108 ns).

sciforum-167558: Advanced nanomanipulation and nanofabrication for silicon photonic waveguide-based polarization modulators enabled by semiconductor nanomaterials

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This work is conducted within the framework of the INFN QUANTEP (QUAntum Technologies Experimental Platform) experiment, an initiative aimed at developing a shared experimental platform for the advanced study of optical quantum technologies based on silicon photonics. The project pursues four primary strategic objectives: the design of silicon photonic circuits for quantum computing, the engineering of integrated single-photon sources, the development of integrated single-photon detectors operating at room temperature, and the application of quantum nanomaterials for the realization of integrated devices for polarization control. Specifically, the research presented herein focuses on two crucial aspects for the success of the experiment, adopting a dual-methodological approach. First, specific chip fabrication processes were optimized and completed using dual-beam instrumentation. Leveraging the expertise acquired in Focused Ion Beam (FIB) technology, platinum-assisted deposition was performed to create intra-chip electrical contacts. This technique proved instrumental in effectively operating on complex topologies, such as etched or non-planar areas, which are challenging to process using conventional fabrication techniques. Simultaneously, extensive use was made of FIB technology for the deposition and deterministic positioning of nanostructures on the chip, a key procedure to ensure experimental functionality and enable the modulation of the input optical signal polarization. To achieve this goal, an ad hoc experimental protocol was developed to synergistically integrate different techniques: Electron Beam Lithography (EBL) and subsequent drop-casting, combined with the use of nano-manipulators integrated within the FIB system. The employment of these tools enabled not only the cleaning of the substrate from unwanted residues resulting from the drop-casting process but also the controlled deposition of various nanowires in the vicinity of the waveguide with high spatial precision. This paper details the complete sequence of fabrication steps and the operational strategies implemented to achieve the deterministic positioning of the nanostructures.

sciforum-166521: Developing Superconducting Nanowire Single Photon Detectors with Photon Number Resolving Capability

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Introduction

Superconducting nanowire single-photon detectors (SNSPDs) are pivotal to quantum information science due to their high detection efficiency and low timing jitter. However, traditional SNSPDs are limited by a binary response, necessitating the development of photon number resolving (PNR) capabilities for advanced quantum communication and sensing. While spatial multiplexing has enabled PNR resolution up to 24 photons, scaling these architectures to 32 pixels while maintaining detection uniformity and minimizing crosstalk remains a significant technical challenge.

Methods

We report the complete development cycle of a PNR-SNSPD, from design optimization to nanofabrication. The fabrication process depositing a 6 nm superconducting thin film via DC magnetron sputtering at room temperature. A three-step electron beam lithography (EBL) process was employed: PMMA for contact pads (10 nm Ti/60 nm Au), HSQ (hydrogen silsesquioxane) for the nanowire geometry, and a final PMMA layer as a resist for AuPd resistors (5 nm Ti/85 nm Au). The nanowire pattern was transferred using hybrid reactive ion etching (RIE), whereas the contact pad and resistor patterns were defined by electron beam evaporation followed by a lift-off procedure.

Results

SEM characterization successfully verified the morphological integrity of the 32-pixel PNR-SNSPD arrays. Material optimization of NbTiN films demonstrated that the superconducting transition temperature (Tc) is highly sensitive to the nitrogen concentration ratio. We achieved a peak Tc of approximately 11.4 K for thicker films and around 9 K for thinner films at 5% nitrogen concentration, followed by a monotonic decrease in Tc as the nitrogen concentration increased toward 25%.

Conclusions

Our results demonstrate a robust fabrication pathway for high-density 32-pixel SNSPD arrays. The optimization of NbTiN deposition parameters provides a viable route to improving device performance and operational stability. These advancements contribute to the scalable production of PNR-capable detectors essential for high-fidelity quantum state characterization.

sciforum-163049: Efficiency comparison of stochastic and gradient descent algorithms for laser beam focusing into a single-mode fiber

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This study investigates the performance of stochastic and gradient descent algorithms within an active optical system for free-space optical communication applications. The primary function of the adaptive optical system in this context is to dynamically focus a laser beam through a diaphragm emulating a single-mode optical fiber input, utilizing the specified control algorithms. The efficiency of the focusing process is quantified by the proportion of total laser energy transmitted through the diaphragm. The selected algorithms offer a comparative advantage in implementation simplicity over more common alternatives such as stochastic parallel gradient descent (SPGD) or genetic algorithms.

The core objective of the study is to increase the integrated photodiode signal, which serves as the system's merit function, and to iteratively enhance this signal by applying wavefront correction. This correction aims to reshape the laser beam's wavefront to minimize transmission losses through the target aperture. A feedback control loop was established between a piezoelectric deformable mirror and the photodiode, using stochastic and gradient descent algorithms to optimize the aperture's phase profile. The fundamental goal of these optimization routines is to maximize the energy density in the far-field focal spot. This is achieved by minimizing the spot diameter toward the diffraction limit while concurrently increasing its peak intensity.

Empirical findings indicate that the stochastic algorithm, by its nature, progresses rapidly and converges in fewer iterations, albeit with lower final precision. In contrast, the gradient descent algorithm converges more slowly but yields a superior final value for the merit function. Experimental results demonstrated that a 45 mm piezoelectric mirror with 32 control channels was capable of focusing approximately 90% of the initial beam energy through diaphragms of 19 μm and 9 μm diameter, using either optimization strategy.

sciforum-167773: Engineering silicon color centers for scalable quantum photonic technologies

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The demonstration of single-photon emission in the near-infrared range in silicon offers an enticing perspective for developing industrial-scale silicon-based single-photon sources that emit at telecom wavelengths. Among the recently identified Si-based quantum emitters, the G center is a carbon-related point defect in silicon with an emission spectrum characterized by a zero-phonon line (ZPL) emission at 1279 nm, and with appealing features for the implementation of quantum technologies, including defect coupling with nuclear and electron spin degrees of freedom.

Theoretical studies have shown that the configuration of this complex represents a structurally metastable state [1], thereby raising the need to optimize the post-implantation thermal treatment, which is currently one of the main factors limiting the scalable manufacturing of color centers in silicon.

In this contribution, we report the activities based on two primary directives. The first one aims to understand the role of radiation damage during the ion implantation process, which is used to introduce extrinsic impurities into the silicon lattice. The emission properties of intrinsic self-interstitial W centers in high-purity and C-rich silicon substrates, following keV implantation, are investigated using single-photon-sensitive cryogenic confocal microscopy. This technique enables the identification of the effects of post-implantation thermal treatment on the formation of telecom quantum emitters.

The second experimental approach aims to explore more responsive thermal processing and implantation protocols to achieve higher creation yields. Here, we present the direct and non-destructive localized activation of G centers upon spatially resolved ns-pulsed laser annealing in keV carbon-implanted high-purity silicon substrates. Specifically, this approach involves ns heat transients during the annealing step, offering a practical off-equilibrium pathway for competitive processes in forming defective complexes and radically different possibilities for defect engineering [2].

[1] Deák, P., et al., Nat. Commun. 14, 1–6 (2023)
[2] Andrini, G. et al., Commun. Mater., 5, 47, (2024)

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