Book of Abstracts

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PLENARY PRESENTATION

Id-729

Challenges in Achieving Nuclear Fusion for Future Energy Production

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Abstract. Nuclear fusion is a very promising concept for unlimited safe energy supply for future generations. There are currently two main concepts to achieve nuclear fusion, i.e., magnetic confinement and inertial confinement. The magnetic fusion energy concept (MFE) is based on using strong magnetic fields to confine the hot plasma away from the reactor components to avoid any damage and to sustain the nuclear reaction. Several countries are currently participating together in building the world first International Thermonuclear Experimental Reactor (ITER) in France using the magnetic confinement concept (i.e., Tokamak design). The inertial fusion energy (IFE) concept is based on using strong laser beams to compress and implode tiny pellets in the center of a large chamber in a very short time and achieve ignition inertially before pellet debris expansion.

A key obstacle to a successful magnetic fusion energy production in Tokamaks is the performance of plasma-facing materials (PFMs) during normal and abnormal events. Normal operation includes the interactions of the escaping plasma particles and products with PFMs. Abnormal operations include short transient events resulting from loss of plasma confinement. These plasma instability events include disruptions, edge-localized modes, vertical displacement events, and runaway electrons. While tremendous efforts are being pursued to find ways to mitigate such events, a credible reactor design must be able to tolerate a few of these transient events. Energy production from the IFE concept also faces significant challenges despite the recent development achieving ignition at Lawrence Livermore National Laboratory.

The chamber walls in IFE reactors will also be exposed to harsh conditions following each target implosion. Key issues of the cyclic IFE reactor operation include intense photon and ion deposition, reflected laser beams deposition, wall thermal and hydrodynamic evolution, wall erosion and fatigue lifetime, and chamber clearing and evacuation to ensure desirable conditions prior to the next target implosion and ensure the desirable 10Hz operation for economically competitive energy production. In the case of a dry-wall vacuum chamber concept, the resulting target debris can interact and affect the surface wall materials in different ways. This can result in the emission of atomic (vaporization) and macroscopic particles (i.e., metal droplets, solid carbon flakes, or liquid splashing from coating materials, etc.), thereby limiting the lifetime of the wall.

We have designed and developed comprehensive computer packages (HEIGHTS) and lab experiments to enable simulation and conditions in real reactor geometry for both MFE and IFE concepts. HEIGHTS-MFE simulated the overall effects of plasma-material interaction processes during normal operation and transient events in MFE devices. These include all physical interaction processes of plasma and radiation with facing materials. Such details are critical in finding the best materials and in assessing the damage to all interior Tokamak rector components including hidden structure that were not directly exposed to these plasma transient events and never expected to be damaged. Our results show that unmitigated transient events in MFE rectors could cause significant damage to most interior and hidden components. Current ITER-like reactor designs may need to be modified to prevent or mitigate such damage. HEIGHTS-IFE simulated the interaction of various pellet debris, transmission through the chamber to the first wall, response of wall materials on reactor lifetime, and effectiveness of all proposed IFE chamber protection methods. Significant challenges exist in IFE reactor designs with no easy solutions to overcome. This work was partially supported by the US Department of Energy, Office of Fusion Energy Science (OFES)

Keywords: Magnetic and Inertial Fusion; Plasma and Photon Interactions; Transient Events; Pellet Debris; Heights.

INVITED PRESENTATION

Id-730

Visible Light as a Weapon Against Antibiotic Resistant Pathogens

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Abstract. Extensive use and misuse of antibiotics for treatment of humans and animals, and contamination of the environment, has resulted in an increasing number of resistant microbial strains. The spread of drug-resistant pathogens hampers our ability to treat common infections and to perform life-saving procedures. Antibiotic-resistance is the main cause for hospital infections with high morbidity and mortality and for the rise of medical care cost. Since pharmaceutical companies are reluctant to invest in the development of new classes of antibiotics, a solution is sought in finding alternative ways of antimicrobial treatment. A promising approach for eradication of antibiotic-resistant pathogens is photodynamic inactivation (PDI). It is based on the use of visible light and a photosensitizer (PS), a photosensitive compound which upon illumination generates reactive species capable of killing bacteria and fungi. Since such reactive species are short-lived in biological environment, only targets in close proximity to the PS are damaged. This makes the uptake and localization of the PS key variables which determine PDI efficacy and selectivity. In turn, both uptake and localization depend on interactions between the PS and the complex biomolecules and structures of which the cells are composed. Therefore, PS molecular features are essential for achieving maximal PDI efficiency and selectivity. On the other hand, PDI selectivity is based on differences between the host and invading microbes in cell architecture and content, plasma membrane composition, volume to surface ratio, and metabolic characteristics. This presentation discusses the influence of structural factors on cellular uptake, subcellular distribution, and photodynamic antimicrobial activity. It summarizes our experience in photoinactivation of antibiotic-resistant strains, potential microbial photodynamic targets, the possibility for development of resistance against PDI, and shares our current knowledge about the influence of PS's lipophilicity, charges, and three-dimensional shape on PDI efficiency.
Financial support was received from Kuwait University, grants MB01/18, YM08/20, YM05/22 and OMICSRU/RCF, projects SRUL02/13 & GM01/15

Keywords: Antimicrobial Photodynamic Therapy; Photosensitizer; Antibiotic Resistance; Antifungal; Photodynamic Inactivation.

INVITED PRESENTATION

Id-737

Recent Progress of Specialty Fiber Glass Processing and Applications in Fiber Lasers and Micro Photonics

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Abstract. Fiber lasers and fiber-based micro photonics devices have been increasingly used for material processing and micro-electronic applications in semiconductor, quantum computing, and sensing. These applications provide new opportunities and challenges for processing mm level large specialty fibers for high power handling and fiber nonlinearity mitigation down to micro or sub-micro scale for fiber-based micro-optical coupling in photonic integrated circuit (PIC) and micro resonators and additionally for non-silica soft glass fibers like ZBALN and chalcogenide fibers for lasers with wavelength beyond 2 μm. In this talk, we will present latest progress of fiber glass processing technologies utilizing CO2 laser and filament fusion methods for producing fiber-based micro coupling devices and microfiber tapers, for processing soft glass fibers, and for fabricating fiber combiners and end-cap devices. We will discuss the fiber processing principles and techniques, and further provide some practical application examples for fiber lasers and micro photonics.

Keywords: Fiber Glass; Photonics; Laser.

INVITED PRESENTATION

Id-739

Experimental Study on High Quality Micro-Holes with Large Aspect Ratio in Thick Metal Based on Femtosecond Laser Focus Shaping and Plasma Processing

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Abstract. Aiming at the problems of insufficient aspect ratio and poor hole wall quality in femtosecond laser drilling of thick metal, this paper introduced a processing strategy involving femtosecond laser focus shaping and plasma micromachining. On one hand, through the multifocal diffractive optical element, the single-focus femtosecond laser was shaped into a dual-focus laser along the beam propagation direction, thus prolonging the length of the spatial filament and making it more conducive for deep hole drilling. On the other hand, by inducing plasma through femtosecond laser in a water environment, the wall of micro-hole drilled in air could be machined to improve its quality. And then the influence of dual-focus laser drilling parameters on micro-hole morphology and aspect ratio was studied and compared with the results of single-focus processing. At the same time, the effect of laser-induced plasma machining on hole wall morphology and quality was studied. After the experiments, the processed micro-holes were analyzed by scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDS), laser confocal microscopy, and other methods. The experimental results have shown that the maximum aspect ratio of micro-holes obtained by dual-focus laser was 22.8, which was 11.8% higher than that of traditional single-focus laser drilling. In addition, the maximum processing capacity increased by 5.76%. In terms of processing quality, the roughness of the hole wall after plasma modification reduced by 67.3% compared with the unmodified hole wall. And the EDS analysis results have shown that the oxygen content on the hole wall was greatly reduced after plasma machining, and the oxide particles deposited on the hole wall were basically eliminated.

Keywords: Femtosecond Laser; Focus Shaping; Plasma Processing; Large Aspect Ratio Hole.

INVITED PRESENTATION

Id-740

Laser Applications for Space Instrumentation

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Abstract. A laser rangefinder provides a potent sensor for surface investigations of planetary objects. The instrument delivers accurate height profiles along-track for geo-morphological interpretation of surface features. Laser spot ground tracks allow exploration of impact basins, tectonic structures as well as potential cryo-volcanic features. ContData collection and analysis grants construction of digital terrain models (DTMs).Repeatedly gathered elevation data enables the study of time varying phenomena like tidal deformation, which in turn facilitates the investigation of dynamical processes in the planetary interior. A classical laser altimeter measures the time of flight between the outgoing laser pulse Tx and the backscattering return pulse Tx. The performance and signal to noise ratio is defined by the laser link budget equation. The talk reports about design, development, functional and performance tests of a laser altimeter instrument on-board the European Space Agency (ESA) mission JUICE. A diode-laser pumped Nd:YAG laser emits pulses at 1064 nm wavelength with nominally 17 mJ energy (9×10^{16} photons) and 5 ns duration at a repetition rate of 10 to 30 Hz. Q-switch pulse with repetition rate of up to 30 Hz within the analogue APD signal. The figure shows the transceiver unit of the laser instrument. The high integrated staggered laser and receiver electronics is mounted behind the M1 mirror (blue). APD is located in focus of the M2 mirror (green) and diode laser compartment is mounted on the bottom side of the unit. Spectral noise investigations and analysis provide operation on the theoretical limits. We point out the technical challenges of a laser application under space environmental condition and limited resources. The talk describes the functional subunits of the instrument split into Tx and Rx opto- electronics. The laser application completes a receiver channel using a single Si avalanche photodiode (APD) operating at a noise floor of about 300fA/√ in a 3dB bandwidth of 100MHz. During laser operation tests show that the instrument detects no crosstalk of any 200 A pumping pulse, duration 50 µs neither the 3 kV 10 ns active.

Keywords: Laser Altimeter; Planetary Surface Investigation; Digital Terrain Models (DTM); Avalanche Photodiode (APD); ESA JUICE Mission.

INVITED PRESENTATION

Id-741

Low-Capacitance, Large Active Area Dot-Avalanche Photodiodes in Silicon CMOS Technologies

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Abstract: Detecting low-power optical signals is a critical challenge in the field of optical sensing. Linear-mode avalanche photodiodes (APDs) are highly effective optical detectors for applications that require sensitive low-light detection, such as optical wireless communication (OWC), light detection and ranging (LiDAR), and imaging sensors. However, many optical sensor applications demand a larger light-sensitive area to efficiently couple incoming light, which presents a significant trade-off between active area and capacitance in conventional planar APD structures. In traditional designs, the photosensitive area is directly proportional to the size of the p/n junction, which increases capacitance and limits bandwidth as the active area expands. This is due to the electric field being confined below the p/n junction, allowing only carriers generated in this region to contribute to impact ionization. In this talk, I present a novel dot-avalanche photodiode (dot-APD) design that employs lateral depletion techniques

Keywords: CMOS; LiDAR; OWC.

INVITED PRESENTATION

Id-742

Optimizing QKD Efficiency in Fiber-Based Networks

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Abstract. Quantum Key Distribution (QKD) holds great promise for secure communication; however, like other optical technologies, its practical implementation faces challenges such as chromatic dispersion, timing uncertainty, and dark counts [1]. In this presentation, we introduce a novel approach to optimizing QKD efficiency by manipulating the chirp parameter of single-photon wave packets [2,3]. Our results demonstrate that fine-tuning this parameter significantly enhances key generation rates and extends the maximum secure communication range, even under substantial channel impairments. In addition to addressing chromatic dispersion and timing uncertainty, this talk will explore the coexistence of classical and quantum signals within a single optical fiber, a critical scenario for practical applications. Particular emphasis will be placed on the impact of Raman scattering, induced by classical signals, on QKD performance. By analyzing its influence on key generation rates, we provide insights into mitigating these effects for robust quantum communication. These findings offer a comprehensive framework for improving QKD protocols, enabling more efficient and secure implementations in fiber-based communication systems. This work paves the way for integrating quantum cryptographic technologies into existing optical networks, advancing their transition from theoretical concepts to real-world applications.

Keywords: Quantum Key Distribution; Key Generation Rate; Quantum Communication; Quantum Cryptography; Raman Scattering.

INVITED PRESENTATION

Id-749

Unusual Wave-mixing Processes in the Context of Modulation Instability

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Abstract. A pump carrier wave in a nonlinear dispersive system may decay by giving birth to blue- and redshifted satellite waves due to modulation or four-wave mixing instability. We analyze unusual situations where the satellites can be very different from the carrier wave. By example of the Generalized Nonlinear Schrödinger Equation (GNLSE), we show on one hand, that this can originate from numeric. However, the satellite can be so much redshifted that the wave either changes its propagation direction or even gets a negative frequency. The latter situations are beyond the GNLSE envelope approach and are addressed using the Maxwell equations.

Keywords: Nonlinear Optics; Modulation Instability; Wave Mixing; Generalized Nonlinear Schrödinger Equation.

INVITED PRESENTATION

Id-752

Weed Control with a Fiber Laser: Opportunities and Challenges

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Abstract. Increasing problems with herbicide resistance and the adverse environmental side effects of herbicide use have increased the demand for developing alternative methods to control weeds. Site-specific weed management can reduce the negative impact of weed control. Recently, there has been an increasing focus on using laser beams to control weeds by directing the laser beam toward the weed plant and killing or damaging it with heat. Lasers are energy demanding. Therefore, the laser beam should only be directed towards the meristem of the weed plant and not the whole infested area. Artificial intelligence can be used to locate and identify the meristem of weed plants, and mirrors can direct the laser toward the target point of the plant (Andreasen et al., 2022). Using a fiber laser beam with a diameter of 2 mm to control fifteen weeds per m^2 will only expose less than 0.02% of the area to the treatment. In contrast to herbicides, which stay in the environment longer with the risk of polluting the environment and harming living organisms immediately or over time, the laser beam only leaves behind the ashes from the hit plants. Therefore, laser weeding is much more eco-friendly than herbicide application and the most site-specific weed management method achievable. However, some weeds may regrow after laser treatment (Andreasen et al., 2024), and exposure to laser beams can also be dangerous for humans and other living organisms (Andreasen et al., 2023). We discuss the opportunities and challenges of laser weeding. This work was funded by the University of Copenhagen and the EU–project WeLASER “Sustainable Weed Management in Agriculture 297 with Laser-Based Autonomous Tools,” Grant agreement ID: 101000256, funded under H2020- 298 EU.3.2.1.

Keywords: Alternative Weed Control; Heating of Weeds; Irradiation of Weeds; Laser Weeding; Lasers in Agriculture.

INVITED PRESENTATION

Id-758

NMR and DFT Studies of the Photochemically Induced Processes of Quinazolinone-Based Glycoconjugate.

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Abstract. The process of isomerisation, associated with structural changes induced by UV or visible light, plays a key role in numerous biological processes [1]. These structural changes are frequently related to the bond rotation or intramolecular rearrangement from an energetically less stable conformation (*syn*-form) to a more energetically stable conformation (*anti*-form). This process is known as photoisomerisation and is frequently associated with conjugated multiple-bonds systems possessing heteroatoms. Recently, particular attention has been paid to compounds possessing highly conjugated systems, including quinazolinones, with aromatic substituents attached to the aliphatic chain, where the photoisomerisation process is associated with bond rotation at the multiple bond sites, namely the C=C, N=C and N=N linkages [2]. In this contribution we present NMR and DFT studies of a novel glycoconjugate with two *β*-glucopyranose units attached to a quinazolinone-like structure. This analysis is a continuation of our previous work on the photoisomerization of new derivatives with different types of substituents attached to the aromatic rings [3]. In contrast to the previous case, the new derivative exhibits a "crankshaft rotation", i.e. a simultaneous photoisomerisation process around the −N−N= and =CH−C− bonds of the −N−N=CH−C− linkage [4]. This process was confirmed by NMR spectroscopy, which demonstrated the presence of the newly formed corresponding *syn*-forms while the rest of the molecular structure remained virtually unchanged. The photochemically induced structural changes were investigated by NMR and DFT in three different solvents – water, methanol and DMSO. This work was financially supported by Slovak grant agencies VEGA 2/0071/22 and 2/0125/23.

Keywords: Photoisomerisation; Glycoconjugate; Crankshaft rotation; NMR; DFT.

INVITED PRESENTATION

Id-760

Long-Term Experience Photodynamic Therapy in HPV-Related Cervical Lesions

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Abstract. Photodynamic therapy (PDT) generates not only direct cytotoxic and vascular effects but also induces the production of cytokines such as IL-1b, IL-4, INF-a, INF-y, sIgA, and TNF-a. Additionally, PDT-treated tumor cells can stimulate macrophages to intensify the production of complement proteins C3, C5, and C9, pentraxin , sphingolipids, ceramide, and sphingosine-1-phosphate, as well as the expression of TLR 2, TLR 4, and C3aR. This induced local inflammatory response can initiate the formation of effective immunity, including antiviral immunity. Therefore, it is crucial to investigate the indicators of cervical mucosal immunity in HPV-associated diseases such as cervical precancer and cancer and to correlate them with virological, morphological, and digital markers of different clinical forms. The current research aim to analyze 5-year relapse-free period after photodynamic therapy of HPV-associated cervical lesions and cancer. A total of 1187 women were treated with photodynamic therapy (PDT) following the protocol described in. The antiviral and antitumor effectiveness was evaluated in 700 women who had more than one-year follow-up by cytology and Digene-test or PCR HPV-21 investigation after PDT. The effectiveness was estimated using the Kaplan-Meier relapse-free period. The photosensitizer based on Chlorin E6 (PHOTORAN E6, LLC "RANPHARMA", Russia) and laser apparatus "Lahta-Milon" (LLC "MILON GROUP", Russia) with a 662 nm wavelength were used for photodynamic therapy. The statistical analysis used the one-vs-all method. The Wilcoxon test ($p < 0.05$) was used to compare the quantitative variable between two matched samples that followed a non-normal distribution. A retrospective study confirmed the effectiveness of photodynamic therapy (PDT) in eliminating HPV and malignant transformation of cervical epithelial cells. PDT activated early markers of the antiviral innate immune response after 2 hours, such as TLRs 2, 3, 4, and 8, inducing an antiviral and antitumor immune response. The treatment showed challenging results for the LSIL group, with over 45% recurrence rate after 32 months, while over 80% of cervical intraepithelial neoplasia patients remained recurrence-free for more than 50 months. The HSIL group had a recurrence-free survival rate of 60% at 60 months. The recurrence-free survival rates for groups without SIL, with HSIL, and with Cancer were 68%, 63%, and 70%, respectively. PDT showed an anti-tumor effect for the LSIL, HSIL, and Cancer groups with 60-month recurrence-free survival rates of 73%, 77%, and 70%, respectively. Research had no sponsorship. Authors had no conflicts of interest.

Keywords: Photodynamic Therapy; Human Papillomavirus; Cervical Intraepithelial Lesions; Cervical Cancer; Relapse-Free Period.

INVITED PRESENTATION

Id-762

Beyond the Energy-Level Description of Electromagnetic (EM) Wave – Wave-Matter Interactions

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Abstract. To describe topological effects in EM wave–matter dynamics it is desirable to look for phenomena that are tangential at the atom's surface and perpendicular to the energy levels. In the present approach, emphasizing visible and longer wavelengths, the orbiting electron is followed graphically as a wave packet at its group velocity, and the absorption is modeled as a phase-coincidental Lorentz transformation of the signal's electric field from a non-local to a local frame of observation. The electron's aberration angle of its orbit is solved assuming it sees a linear world. This yields circular flux cells which can be related in frequency and size to the electron's de Broglie self-oscillation and the emerging Dirac monopole. The flux cells are interpreted as Stokes curl cells with counter-current self-canceling fluxes which makes the electron non-local, hence forming a basis from where it can emerge in its various forms; particle, wave, probability cloud, magnetic moment, excitons, etc. depending on how it is evoked. Its group velocity is related to these curl cells using a factorized Planck length (J. Phys. https://iopscience.iop.org/article/10.1088/1742-6596/1275/1/01205), which makes the fine structure constant describe circular currents and their associated magnetic dipoles. The theory offers a testable framework for predicting and describing EM wave–matter dynamics since it brings forward spatiotemporal details such as orbit position, phase, currents, and magnetic dipoles while also describing non-local phenomena in matter and the EM wave.

Keywords: Electromagnetic Radiation; Lorentz Transformation; Multi-Photon Absorption.

INVITED PRESENTATION

Id-763

Enhanced Sensitivity and Speed in Surface-Normal InGaAs Photodetectors through Waveguide-Plasmon Coupling with Au Gratings

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Abstract. We present an innovative approach to enhance the sensitivity and response speed of surface-normal InGaAs photodetectors by leveraging waveguide-plasmon coupling facilitated through an integrated Au grating. In the proposed configuration, surface plasmon (SP) modes excited at the Au/InP interface are coupled to waveguide (WG) modes within a thin InGaAs absorption layer, providing superior photon confinement and efficient light harvesting. This architecture addresses the longstanding trade-off between sensitivity and speed in surface-normal photodetectors by significantly enhancing the absorption efficiency in a reduced absorption layer thickness of 300 nm, achieving an efficiency of 51.4% at a wavelength of 1550 nm. In addition to sensitivity improvements, the proposed photodetector exhibits a 3-dB bandwidth of ~100 GHz, enabling ultrafast response. This performance is achieved by reducing the carrier transit time in the thin absorption layer and minimizing the RC time delay. A compact detection area of 3 × 3 μm^2, corresponding to six grating periods, ensures efficient SP mode excitation and further supports high-speed operation. Moreover, the photodetector demonstrates high polarization selectivity, with a polarization extinction ratio (PER) of 66.6 dB at 1550 nm, allowing selective detection of TM-polarized light. This feature is particularly advantageous for multi-valued modulation schemes used in space-division multiplexing systems.

Keywords: InGaAs Photodetectors; Waveguide-Plasmon Coupling; Au Gratings.

INVITED PRESENTATION

Id-765

In-Situ Measurement of Hole Depth in Ultrafast Laser Drilling Using Optical Coherence Tomography

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Abstract. Ultrafast laser drilling has found widespread applications in fields such as aerospace and semiconductors [1]. However, fluctuations during the drilling process remain a major challenge in advancing this technology toward high-end precision applications [2]. In-situ monitoring technologies have shown significant promise in addressing these issues [3]. Among current methods, spectral-domain optical coherence tomography (SD-OCT) has garnered attention for in-situ monitoring due to its unique characteristics, such as high resolution, direct depth measurement [4]. For instance, Webster et al. successfully applied SD-OCT to achieve the in-situ monitoring of keyhole depth during laser welding and laser ablation [5]. However, in the context of ultrafast laser trepanning drilling of metals, in-situ measurement of hole depth has not yet been realized due to the complex nature of the drilling trajectories and the evolving dynamics during the process. To address this, we propose a novel SD-OCT-based in-situ measurement of hole depth in ultrafast laser drilling. By systematically analyzing the multiple reflections of the detection beam at various positions during the trepanning drilling process, we demonstrate a position-synchronized scanning method that enables precise in-situ hole depth measurement, even under complex drilling trajectories. Experimental results show that the measurement accuracy can reach the micron scale. This study comprehensively demonstrates the feasibility of using SD-OCT for both in-situ hole depth measurement and real-time monitoring of hole evolution during ultrafast laser drilling. It underscores the potential of this approach for revealing complex machining phenomena, optimizing laser processing parameters, and achieving precise control in high-precision manufacturing applications. This work is supported by the National Natural Science Foundation of China [524B2065] and the National Key Research and Development Program of China [2023YFB4605900].

Keywords: Ultrafast Laser; Laser Drilling; In-Situ Monitoring; Optical Coherence Tomography; Hole Depth Measurement.

INVITED PRESENTATION

Id-766

Parametric Study and Optimization of CdS/CdTe Heterojunction Solar Cell

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Abstract. The major research challenges in photovoltaic systems are to increase the conversion efficiency and make the devices more cost effective. On this point, second generation solar cell materials still remain a potential field of research. Cadmium sulfide (CdS) and cadmium telluride (CdTe) compounds remain leading materials for the development of reliable and efficient photovoltaic cells. Two key properties of these materials are their band gaps (2.42 eV and 1.5 eV, respectively) close to the ideal for photovoltaic conversion efficiency (1.45 eV), and their high optical absorption coefficients. In this work, we performed a parametric optimization study of a heterojunction solar cell consisting of a cadmium sulfide buffer layer and a cadmium telluride layer that acts as an absorber. In order to obtain the best performance of such a structure, an analytical model is used to describe the electrical characteristics represented by the current-voltage density and the power-voltage density, using an equivalent circuit that takes into account the ohmic losses and leakage current. We then analyzed the photovoltaic output parameters by investigating the role of various physical parameters, such as junction depth, charge carrier lifetime, reflection of incident radiation, temperature, and surface recombination rates of minority carriers. Our calculations predict that the conversion efficiency of the optimized heterojunction can reach 26% under 1 solar air mass 1.5 global spectrum (AM1.5G). The present study could be very useful for simplifying the design of high-efficiency CdS/CdTe heterojunction solar cells.

Keywords: Analytical model; CdS/CdTe; Heterojunction; Solar Cell; Conversion Efficiency.

INVITED PRESENTATION

Id-774

Photobiomodulation During Deep Sleep

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Abstract. We present the technology for photobiomodulation (PBM) under electroencephalographic (EEG) control that incorporates modern state of the art facilities of optoelectronics and biopotential detection and that can be built of relatively cheap and commercially available components. These findings open a new niche in the development of smart technologies for phototherapy of brain diseases during sleep. In this study on mice, we demonstrate that photodynamic effects of 5-aminolevulenic acid and laser 635 nm cause reduction of network of the meningeal lymphatic vessels (MLVs) leading to suppression of lymphatic removal of beta-amyloid (Aβ) from the right lateral ventricle and the hippocampus. Using the original protocol of PBM under electroencephalographic monitoring of wakefulness and sleep stages in non-anesthetized mice, we discover that the 7-day course of PBM during deep sleep vs. wakefulness provides better restoration of clearance of Aβ from the ventricular system of the brain and the hippocampus. Our results shed light on the mechanism of PBM and show the stimulating effects of PBM on the brain lymphatic drainage that promotes transport of Aβ via the lymphatic pathway. The effects of PBM on the brain lymphatics in sleeping brain open a new niche in the study of restorative functions of sleep as well as it is an important informative platform for the development of innovative smart sleep technologies for the therapy of AD.

We also demonstrated stronger effects of photobiomodulation (PBM) on the brain's drainage system in sleeping vs. awake animals using confocal imaging of dye spreading in the brain and its further accumulation in the peripheral lymphatics on healthy male mice. Using the Pavlovian instrumental transfer probe and the 2-objects-location test, we found that the 10-day course of PBM during sleep vs. wakefulness promotes improved learning and spatial memory in mice. This research was supported by a grant from the Russian Science Foundation 23-75-30001

Keywords: Photobiomodulation; Sleep; Meningeal Lymphatic Vessels; Beta-Amyloid.

INVITED PRESENTATION

Id-775

Desing and Optimization of SiON Waveguide Structure for Athermal AWG

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Abstract. The swift progress in optical communication technologies has driven the need for highly efficient and stable photonic integrated circuits for coherent signal processing in the optical domain. Among these, Arrayed Waveguide Gratings (AWGs) have become essential components in Dense Wavelength Division Multiplexing (DWDM) systems. However, conventional AWGs are significantly impacted by temperature variations, leading to central wavelength shifts and higher insertion losses. This study aims to mitigate this issue by employing silicon oxynitride (SiON) and polymethyl methacrylate (PMMA) on a silicon substrate with a thermal silicon dioxide buffer layer, thereby enhancing the performance and reliability of AWG-based DWDM systems. We have developed an athermal waveguide structure that operates effectively across a wide temperature range of -40°C to 80°C without requiring active temperature control mechanisms. This waveguide forms the foundation for AWGs in photonic integrated circuits.

In this work, we have successfully demonstrated the design of an athermal waveguide structure using SiON and PMMA materials on a silicon substrate with a thermal silicon dioxide buffer layer. The temperature- dependent central wavelength shift (TD-CWS) of AWG was calculated by expression form reference [1]. The coefficients of thermal expansion, thermal optical coefficients and refractive index properties of SiON layer were used from [2-4]. The effective refractive index of the waveguide structure was calculated by Finite Element Method including thermo-optical effect in the temperature range from –40°C to 80°C at 1550 nm. The proposed structure effectively reduces AWG temperature-induced central wavelength shifts, achieving a temperature-dependent central wavelength shift of 0.866 pm/°C, which is smaller than previously reported values and in a larger temperature range [1]. This significant reduction enhances the reliability and efficiency of DWDM systems based on AWGs, making them suitable for deployment in environments with outside fluctuating temperatures. The integration of SiON and PMMA materials leverages the mature silicon photonics platform, ensuring compatibility with existing fabrication processes and facilitating the production of compact, cost-effective, and high-performance photonic devices for large-scale deployment. This work was funded by the EU NextGenerationEU through the Recovery and Resilience Plan for Slovakia under the project No. 09I03-03-V04-00684

Keywords: Athermal; Optical Waveguide; Sion; PMMA; Photonics Integrated Circuit.

INVITED PRESENTATION

Id-776

Optical Polymeric Sensors

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Abstract. Optical polymer sensors are an exciting area of research and technology that combines the unique properties of smart polymers with sensing applications. These sensors can detect and respond to various stimuli, making them highly versatile and useful in many fields. Optical polymer sensors can change their optical properties – such as reflectance, chromism, or luminescence – in response to environmental changes such as temperature, pressure, humidity, pH level or the presence of specific chemicals. These sensors work based on principles such as fluorescence, refractive index changes, or light scattering. They're valued for their flexibility, lightweight nature, and the ability to be integrated into various devices. This responsiveness allows them to act as effective sensors. These sensors can detect changes in body temperature or glucose levels, providing valuable data for health monitoring and management of chronic diseases such as diabetes. These sensors have attracted much attention due to the ability of polymers to respond to various conditions. These optical polymer sensors can also be used in self-indicating, self-sensing, or self-reporting materials where they indicate the conditions of a material or body by changing color or emitting a wavelength of light. Environmental monitoring by detection of pollutants in air and water, medical diagnostics in biosensors to detect biomarkers for diseases, food safety in monitoring freshness by detecting spoilage indicators in food products, structural health monitoring in civil engineering to assess the integrity of structures by detecting strain or stress, and wearable technology integrated into smart textiles to monitor physiological parameters like heart rate or hydration are the other applications of these versatile sensor materials.

Keywords: Smart Polymers; Optical Polymers; Polymer Sensors; Chromism; Luminescence; Reflectance.

INVITED PRESENTATION

Id-777

Analyzing Polarization-Induced Signatures Due to Mechanical Vibrations on an Optical Fiber

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Abstract: Mechanical movements or disturbances acting on an optical fiber will change the optical power level, phase and/or state of polarization. The magnitude of disturbances will have different impact on those physical quantities. The presentation will show that an eavesdropper of information from an optical fiber only causes an approximate 0.3 dB reduction of optical power, concerning a commercial transmission link of 40 km. Those levels of optical decrease in power level are difficult to detect without generating false alarms, due to natural variations in received optical power. This presentation will discuss the usage of polarization-induced signatures to detect the attempt to eavesdrop on an optical fiber. Any other types of mechanical vibrations cause different polarization signatures. Those signatures can be classified with machine learning technology to decide on suitable actions depending on whether the source of the vibrations is malicious to the fiber optical installation or not.

Keywords: Optical Fibers; Mechanical Vibration; Polarization.

INVITED PRESENTATION

Id-788

Perspectives PDT In Synergy Methods of Cancer Treatment

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Abstract. Introduction.Number of cancer cases with non-typical behavior are growing. Popular surgical, chemo- and radio therapy of cancer are limited by individual biology of tumors. Because to investigate in new approach in anti-cancer treatment actually. Our team performed research in modification PDT by synchronic chemotherapy. Theory is in synergy destroying tumor's cells from other sides. Material and methods. Clinical protocol included 2 groups pts. oral cancer. They are divided by p16+ and p16- types. Last cohort input in perioperative treatment chemotherapy DPF scheme and PDT chlorin-e6 in 640 nm wave. PDT addressed in primary tumor site in oral cavity in 200 Dg energy. Time of procedure performed till online-control utilization of medication in the tumor. Results. In both groups, to meet objective answer tumors. in scale of pathomorphology high level destroy of tumor's cells were in 1 and 2 group the same. Conversation. p16+ oral cancer have more best prognosis then p16-. It's directly connected with the answer of the tumor on to treatment. p16- oral cancer traditionally shows low level of the answer. Because to input in scheme of treatment new factors to make better results. Summary. Combining synchronic treatment of oral cancer by chemo- and PDT showed more effectiveness then separately.

Keywords: Photodynamic Therapy; Synergy Method; Cancer.

ORAL PRESENTATION

Id-744

Synthesis of Polymer Colloidal Nanoparticles with Optical and Electromagnetic Shielding Properties

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Abstract. The cement industry has for some time sought to find procedures that would effectively reduce the high energy consumption of producing cement. Timahdit oil shale can be potentially used as alternative prime materials in clinker manufacturing. The chemical and mineralogical composition of these materials and their thermal behavior indicate that they are energetically advantageous in the production of clinker; they can reduce the temperature required for clinkerisation. This study was focused into evaluating this possibility, to valorize these materials. Also, we explore the reactivity and burnability of clinker raw mixes containing Timahdit oil shale as alternative raw materials. The clinkers obtained at 1400°C were characterized as XRF, XRD, FTIR, OM and SEM/EDX.

The results show that raw mixes containing oil shale, with a particle size smaller than 45 µm, exhibited better reactivity and higher burnability, showing a law content of free lime in their clinkers. The microstructure of the clinkers showed the presence of the main clinker phases.

Keywords: Polymer Photonic Crystals; Colloidal Particles; Liquid Crystals; Mxenes; Electromagnetic Shielding Applications.

ORAL PRESENTATION

Id-770

Impact of Mandrel Diameter and Fiber Winding Layers on the Sensitivity of Fiber Optic Hydrophones

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Abstract. Fiber-based underwater acoustic sensors (hydrophones) are rapidly replacing traditional piezoelectric-based sensors due to their superior immunity to electromagnetic interference, compact design, and high sensitivity. These hydrophones are constructed by winding optical fibers around a cylindrical structure known as a mandrel.

This study investigates the impact of mandrel diameter and the number of fiber winding layers on the fiber-optic hydrophone sensitivity. Standard single-mode (SM) fibers with a 250 µm diameter were wound in single and double layers on mandrels with a 31 mm diameter, while a 26 mm mandrel was wound with a single layer. Sensitivity variations due to mandrel diameter were examined by comparing the 26 mm and 31 mm single-layer mandrels, while the effect of fiber layer count was assessed using the 31 mm mandrels with single and double layers. An optical setup employing a frequency diversity dual-pulse interrogation scheme was established to measure hydrophone sensitivities. Controlled water tank experiments were conducted to evaluate their underwater sensing performance.

The results showed that the 31 mm single-layer mandrel exhibited a sensitivity of -139.72 dB re rad/µPa, while the double-layer counterpart achieved -137.80 dB re rad/µPa, representing a 2 dB improvement. The 26 mm single-layer mandrel demonstrated a lower sensitivity of -142.53 dB re rad/µPa, approximately 3 dB lower than the 31 mm single-layer mandrel. In conclusion, increasing the mandrel diameter and fiber winding layers significantly enhances the fiber-optic hydrophone sensitivity, enabling more accurate acoustic sensing and supporting applications in deeper ocean environments.

Keywords: Fiber-optic Hydrophone; Underwater Acoustic Sensing; Mandrel; Sensitivity; Fiber Winding Layer.

ORAL PRESENTATION

Id-779

Online Measurement Method for Aircraft Engine Turbine Blades Based on Stereoscopic Vision

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Abstract. The vision-guided advanced manufacturing technology requires online measurement of the workpiece topography, followed by precise positioning for processing. Therefore, in response to the technical requirements for quickly and accurately obtaining the 3D surface of the clamped turbine blade, this paper proposes a stereo vision-based online measurement method for turbine blades of aircraft engines. The high-precision calibration of the visual system was achieved based on photogrammetry technology. The precise matching of stereo views was realized through epipolar constraint. The accurate multi-point cloud rotation stitching was achieved based on a marker-weighted method. The acceleration of FPP reconstruction computation was implemented through CUDA parallel programming. The method in this paper used only one set of vertical fringe images with three-frequency four-step phase shifting, achieving an average measurement error of less than 0.01mm within a 200mm field of view. The 500W-pixel stereo vision system employs GPU parallel reconstruction, with a computation time of less than 1 second for a single frame of 2.1-million-point clouds. Through several comparative experiments, the effectiveness of this method and the accuracy of the three-dimensional measurement results were demonstrated. This study is supported by the National Key Research and Development Program of China (grant no. 2023YFB4605900) and other projects

Keywords: Turbine Blade; Structured Light; Epipolar Constraint; Point Cloud Registration; CUDA Parallel Programming.

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ORAL PRESENTATION

Id-780

Stereo Vision-Based Precise Positioning and Adaptive Laser Processing Path Generation for Aircraft Components

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Abstract. Aircraft components, characterized by high precision, superior strength, and high-temperature resistance, pose significant challenges to conventional machining techniques. Ultrafast laser processing, as a non-contact technology, stands out due to its exceptional cutting quality and minimal heat-affected zone. This study introduces a stereo vision-based approach for online high-precision measurement and adaptive laser machining path generation. High-accuracy 3D point cloud data of target components are acquired through multi-view stereo vision. By integrating rigid initial registration and non-rigid local registration algorithms, precise mapping between theoretical and actual machining positions is achieved, particularly for components with deformation. A modified Trimmed Iterative Closest Point (TrICP) algorithm is employed to enhance local alignment accuracy, while 3D point cloud and 2D image processing synergistically enable feature extraction and path planning in complex regions. Experimental validation on ceramic core adaptive shaping demonstrates the method's efficacy, yielding residual burr widths below 70μm and per-piece processing time of 200 seconds. This approach significantly improves machining efficiency and adaptability, advancing automation in aerospace component manufacturing. This study is supported by the National Key Research and Development Program of China(grant no.2023YFB4605900)and other projects.

Keywords: Stereo Vision; Adaptive Laser Machining; 3D Point Cloud Registration; Aerospace Component Manufacturing; Laser Processing.

POSTER PRESENTATION

Id-723

Improved Autonomous Vehicle Sensors, Control and Development for Applications in Commercial and Industrial Vehicles

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Abstract. This paper presents the research study of designing an improved autonomous vehicle system to navigate the environment, utilizing the latest light sensors, communication technologies and control architectures. Autonomous vehicles are becoming increasingly popular in the modern world, to lessen the burden of physical driving. However, safety is an ever-prevalent issue, as well as the cost of technology and implementation which promotes the need for innovation in efficient lane detection and control strategies. The proposed design focuses on improved light sensors and the related control field, by exploring the feasibility of utilizing a deep machine-learning model of UNET architecture, with a Residual Network (ResNet) encoder, to enhance vision capability of lane detection. The design applied computer vision techniques to acquire lane imagery from camera light sensors and trained a deep learning model to perform semantic segmentation, which detected and distinguished between left and right boundaries. The lane detection pipeline provided the platform for the lateral and longitudinal control methods to facilitate the movement of the vehicle under limited restrictions, with pre-installed actuation and motor devices to control the acceleration pedal and steering wheel angle. A thorough investigation was conducted using an original formula of the Pure Pursuit controller and Stanley controller to extend the capabilities of specifically reducing the cross-track error. Improved and more detailed simulations were performed using the CARLA simulator, an open-source software used to test the design standard and performance of autonomous vehicles. The intention of the CARLA simulation was to showcase the performance of semantic segmentation model for lane detection and examine the lateral and longitudinal control methods such as the cross-track error of the vehicle, under several environmental conditions and system restrictions. A practical simulation was then set up by capturing and labelling real-world lane imagery to re-train the model and compare the dice loss and predictions of the lane boundaries, with the model used for the CARLA simulator, to warrant validation of the design. A comprehensive discussion is given to compare the improvements of the variation of the lateral control method compared to the current navigation approaches, as well as the influence of deploying UNET architecture with a ResNet encoder compared to other methods which can assist with future applications.

Keywords: Optical Sensing; Imaging Technologies.

POSTER PRESENTATION

Id-772

The Effectiveness of Photostimulation of Aging Brain

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Abstract. The increase in cognitive impairment among the elderly worldwide, and the lack of effective pharmacological treatments, require the development of alternative therapies. Photobiomodulation (PBM) is a promising approach for preventing early or mild age-related cognitive decline. However, its efficacy in elderly patients with significant cognitive dysfunction has not been fully established. Our study aimed to investigate the effects of PBM on cognitive function in male mice with age-related changes in brain function. Our results revealed an increase in brain beta-amyloid (Aß) levels and a decrease in brain drainage with age associated with cognitive decline. We found that cognitive decline was only observed in older (24-month-old) mice but not in younger (3- and 12-month-old) groups. Furthermore, old but not younger mice demonstrated significant changes in the network of the meningeal lymphatics manifested in the enlarged branches of basal meningeal lymphatic vessels that may contribute to the decline in brain drainage and cognitive function. PBM improved cognitive functions and Aß excretion in young and middle-aged mice, but not in older animals. These results suggest that PBM can be the effective method for stimulation of lymphatic removal of toxins from the brain and improvement of cognitive functions in young and middle age of mice, while old animals are not sensitive to PBM probably due to a decline in the function of the meningeal lymphatics that is an important target for PBM [1]. The development of approaches to improve the drainage function of meningeal lymphatic vessels in the late stages of ontogenesis (for example, PBM during sleep [2, 3]) will contribute to increasing the effectiveness of PBM in the elderly.
Research was supported by grant (No. 24-75-10047) from the Russian Science Foundation.

Keywords: Photobiomodulation; Aging Brain; Meningeal Lymphatic Vessels; Brain Drainage; Cognitive Functions.

POSTER PRESENTATION

Id-787

Q-Switched and Gain-Switched Fiber Lasers Operating in Pulsed and Continious Modes

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Abstract. This paper proposes the implementation of an all-fiber passively Q-switch and gain-switched laser, capable of operating in both pulsed and continuous laser generation modes, with switching between modes achieved by changing the pump power. The components of the laser source, such as the lengths of active and passive fibers, the concentration of active ions, and the reflection coefficients of the FBGs, are optimized such that increasing the pump power switches the operation from pulsed to continuous mode. Laser operating in the pulsed mode has an average power of 500 W and a pulse energy of 3 mJ at wavelengths of 1040 nm and 1070 nm, with an output beam quality of M^2= 2 and laser operating in continuous mode has an average power of 600 W at wavelengths of 1040 nm and 1070 nm.

Keywords: Fiber Laser; Q-Switch; Gain-Switch; Pulsed to Continuous Mode.

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	788 - Perspectives PDT in synergy methods of cancer treatment.