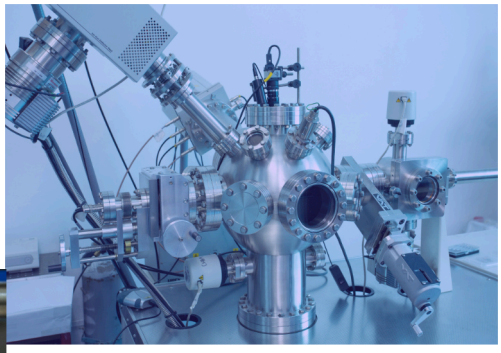

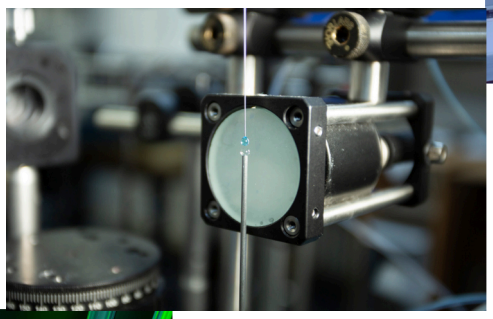

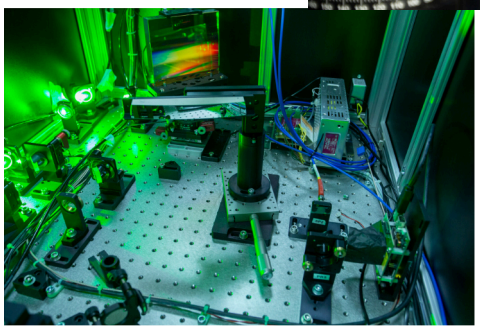

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2nd International Conference on Laser, Plasma, and Radiation – Science and Technology 2024

BOOK OF ABSTRACTS

ICLPR-ST 2024

Danube Delta, Romania
June 16-21, 2024

Organized by:

National Institute for Laser, Plasma and Radiation Physics
in partnership with Laser, Plasma and Radiation – Science and Technology Association

Editors:
Valentin CRACIUN, Maria DINESCU,
Ion N. MIHAILESCU, Bogdana MITU

Assistant editors:
Cristina POPA, Mioara BERCU, Ana-Maria BRATU

Following the successful **1st edition in 2022**, we are pleased to announce the second edition of **The International Conference on Laser, Plasma and Radiation – Science and Technology (ICLPR-ST),** which is organized by **INFLPR** in partnership with **Laser Plasma and Radiation – Science and Technology Association**, between June 16-21, 2024, in the magnificent scenery of the Danube Delta, Romania.

The ICLPR-ST conference brings together scientists and industry leaders to discuss advancements in laser, plasma, and radiation technology, as well as to explore future applications. Through a combination of plenary and invited lectures, as well as oral and poster contributions, the conference comprehensively addresses the fundamental principles, diagnostic methodologies, and advanced modeling techniques in laser, plasma, and radiation physics. It showcases the latest breakthroughs in optics, lasers, and photonics, as well as emerging approaches in thin films and nanomaterial synthesis and processing. Attendees are getting acquainted to the applications of these technologies in environmental science, life sciences, and energy sectors, while also exploring visionary technologies geared towards ensuring a sustainable future.

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We look forward to welcome you at ICLPR-ST in a dynamic and still relaxed atmosphere given by the rich programme combining the scientific presentations with social activities.

Valentin CRACIUN, Maria DINESCU, Ion N. MIHAILESCU, Bogdana MITU

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SUMMER SCHOOL

Introduction to low-temperature plasmas

Peter BRUGGEMAN[1]

[1]University of Minnesota, Department of Mechanical Engineering, Minneapolis, MN 55455, U.S.A.

Corresponding author: pbruggem@umn.edu

Low-temperature plasmas are a unique state of matter composed of neutral atoms and molecules, radicals, excited states, ions and electrons and have characteristic electron energies of a few eV to 10 eV with ionization degrees that are typically small. These energetic electrons can efficiently generate radicals, charged species, excited states and photons while maintaining low gas temperatures, enabling an exceptionally large variety of applications. Low-temperature plasmas have made a tremendous impact on our society and are extensively used in the microelectronics industry, electric propulsion systems enabling motion control of satellites orbiting Earth, industrial welding and material processing, and ozone generation in water treatment plants.

In this lecture, we will review the fundamentals of low-temperature plasma, their key properties and provide an overview of the different plasma excitation approaches. We will highlight their exceedingly large parameter space, including more than 10 orders of magnitude in power density and pressure leading to a broad range of properties and resulting applications.

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Ultrafast lasers basics

Razvan DABU

INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA
Corresponding author: razvan.dabu@inflpr.ro

Development of high power "table-top" ultra-short pulsed lasers is related to two breakthroughs in the laser science: femtosecond oscillators and chirped pulse amplification (CPA) technique [1]. Optical parametric CPA (OPCPA) was considered as an alternative technique [2].

Femtosecond pulses can be generated in optical resonators by Kerr-lens mode-locking of longitudinal oscillation modes included in the broad emission bandwidth of a laser medium, such as the Ti:sapphire crystal. Pulse duration is inversely proportional to the spectral bandwidth. Laser pulses of few nano-Joules energy and sub-10 fs pulse-width can be generated by using dielectric chirped mirrors with engineered negative phase dispersion to compensate for positive phase dispersion in the oscillator resonator. By direct amplification of femtosecond pulses, very high laser field intensity would be reached and harmful nonlinear optical effects would be produced. As a result, damages of optical components and severe distortions of the laser pulse temporal profile can be produced. The key element of the CPA technique is the stretcher-compressor system. Large spectral bandwidth pulses are stretched up to few-hundred picoseconds – few-nanosecond pulse duration in an optical stretcher with diffraction gratings that produce a positive group delay dispersion. The laser stretched pulses intensity is by 4-5 orders of magnitude lower compared to femtosecond pulses intensity. This way, laser pulses can be safely amplified up to hundreds of Joules pulse energy. After amplification, laser pulses are re-compressed in a temporal compressor with a negative group delay dispersion. To get the re-compressed pulse duration close to the initial one, special techniques were developed in order to preserve the laser pulse bandwidth and to compensate for spectral phase distortions. High laser field intensity can be reached by tightly focusing high power femtosecond pulses. Amplified pulses wavefront correction using adaptive optics is currently used to focus the laser beam in a few-micrometer diameter spot.

Recently, the limits of 10 PW peak power [3] and 10^23 W/cm^2 intensity in a tightly focused laser beam [4] were exceeded. More than 10^{12} intensity contrast of femtosecond pulses is required for experiments performed at such high intensity levels of radiation.

To reach the target of 100 PW peak power and more than 10^24 W/cm^2 focused femtosecond pulse intensity, many efforts are being made in the worldwide scientific community of researchers and engineers working in the laser field. These advances are leading to exciting applications in basic and applied research, such as laser particle acceleration, attosecond science, ultra-intense laser fields, nuclear physics, laser fusion.

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Ultrafast Laser 3D and Volume Processing: Principles and Applications

Koji SUGIOKA

[1]RIKEN Center for Advanced Photonics, RIKEN, Wako, Saitama 351-0198, Japan

Corresponding author: ksugioka@riken.jp

The rapid development of ultrafast laser has revolutionized materials processing due to its unique characteristics of ultrashort pulse width and extremely high peak intensity [1]. Importantly, the high peak intensity allows nonlinear interactions such as multiphoton absorption and tunneling ionization to be induced in transparent materials, enabling internal modification [2]. The modifications include changes of refractive index and birefringence. These changes induce no visible (no shape) change, so that they can be categorized to undeformative processing, in other words, zero processing. The local modification can also enhance the glass ability in chemical etch rate. The confined modification inside glasses with focused laser beam translation (laser direct-write) followed by chemical wet etching allows the fabrication with high precision of various three-dimensionally (3D) embedded hollow structures with applications to fabrication of microfluidic and lab-on-a-chip devices. Meanwhile, ultrafast laser direct-write ablation of glass immersed in water can also create the 3D embedded hollow structures based on the nonlinear absorption. They are a subtractive processing since the laser-exposed areas are selectively removed. Besides glasses, polymers are excellent materials for many applications in terms of transparency, chemical stability and flexible design. Two-photon polymerization (TPP) using the ultrafast laser successfully fabricated 3D polymer structures with a size below the diffraction limit. When applied to photocurable resin or epoxy-negative tone photoresist, this technology is categorized to an additive processing. This technology can be further extended to 3D printing of other materials such as metals, glass, and protein. Flexible micro and nanoprocessing with respect to structure, function, and scale is then possible by ultrafast lasers with accurate control on all 3D environments for both inorganic and organic materials by either undeformative, subtractive or additive technologies. Combination of each technology, so called, hybrid ultrafast laser 3D processing, further enhance the performance to diversify geometries of the fabricated 3D micro and nanostrucstures with enhanced functionalities [3].

In this lecture, fundamentals of ultrafast laser 3D and volume processing are first briefly explained. Then, the phenomena induced by ultrafast laser pulses inside transparent materials such as glasses and photoresists are comprehensively reviewed with relevant applications to fabrication of some 3D microdevices. Hybrid ultrafast laser 3D processing is also introduced to offer rapid prototyping technologies for the fabrication of functional micro and nanodevices.

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Photonic micro and nanostructures for integrated optics and quantum sources

Marian ZAMFIRESCU[1], Nicu SCĂRIȘOREANU[1], Raluca IVAN[1], Eliseia PETRE[1], Luiza STÎNGESCU[1]

[1]INFLPR, Atomistilor 409, Magurele, RO-077125, ROMANIA

Corresponding author: marian.zamfirescu@inflpr.ro

Optical microcavities (MS) are possible candidates for entangled photon pair sources that can be integrated in optical chips [1,2]. In this work, we introduce the physics of optical MC heterostructure, the recent progress, and their applications in the field of quantum sources. We discuss a particular design of MC based on ZnO. Due to its high excitonic binding energy of 60 MeV, the ZnO excitons can survive at room temperature. The excitons coupled with the cavity resonance allow for polaritonic scattering in the semiconductor microstructure and emission of entangled photons [4,5]. The strong coupling between the cavity's photons and ZnO excitons gives rise to the polaritonic states in the microcavity. The dispersion curve of the polaritons in the cavity is numerically studied from angle resolved reflectance, for different detuning parameters between the cavity and exciton resonance. Experimentally, a ZnO cavity have been produce by Pulse Laser Deposition (PLD). The reflectance and photoluminescence spectra of the sample were measured at room. The polaritonic branches and their anti-crossing were observed in our sample from the angle resolved spectra of ZnO-based microcavity. The parametric polaritonic scattering mechanisms in such structures and possible configuration for generation of entangled photon pair sources from ZnO microcavities are discussed. Also, the application of MC in quantum technologies are presented, as well as some designs for their integration with optical chips and fibre optical systems.

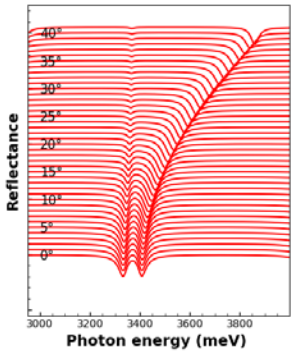

Fig. 1. Angle resolved reflectance from a typical microcavity in strong coupling regime.

Acknowledgement: This work was supported by a grant of the Ministry of Research, Innovation and Digitization, CNCS - UEFISCDI, project number PN-III-P4-PCE-2021-1710, within PNCDI III.

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Ultrafast non-diffractive beams with tunable dispersion; opportunities for smart laser material processing

Razvan STOIAN[1]

[1]Laboratoire Hubert Curien, CNRS UMR 5516, Université Jean Monnet, St. Etienne, France

Corresponding author: razvan.stoian@univ-st-etienne.fr.

The lecture will follow the latest developments in ultrafast laser micro- and nano-processing using engineered beams. It will summarize the major achievements in the quest for optical resolution [1]. The talk will focus on a specific class of beams with non-diffractive properties and the possibility to perform spatial, temporal or vectorial manipulation in order to achieve a significant level of process control. Examples will be given to their specific interaction with matter and their capability to structure materials on extreme scales. A dynamic time-resolved view of the structuring process will be given, emphasizing the potential for feedback and control. Their capacity to modify matter in a user-defined way and on the smallest scales is an essential brick into smart laser material processing.

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Pulsed laser deposition of oxide materials: Fundamental aspects probed by ablation plume analysis

Thomas LIPPERT[1,2,3]

[1]Division for Research with Neutrons and Muons, Paul Scherrer Institute, 5232 Villigen, Switzerland

[2]International Institute for Carbon-Neutral Energy Research (WPI-I2CNER), Kyushu University, Fukuoka 819-0395, Japan

[3]Laboratory of Inorganic Chemistry, Department of Chemistry and Applied Biosciences, ETH Züürich, 8093 Züürich, Switzerland

Corresponding author: thomas.lippert@psi.ch

Thin films of organic, polymeric, biological, and inorganic thin films are utilized in many applications, e.g. catalysis, microelectronics, sensors, food industry, tools, optics, decorative coatings, and renewable energy applications, etc.. The preparation of these thin films can be achieved with a variety of tools, ranging e.g. from chemical to physical vapor deposition methods (PVD). One PVD method which is used extensively in research, especially for oxides, but recently also in industry in pulsed laser deposition (PLD). PLD can be divided into 3 steps, i.e. laser ablation and plasma formation, plasma expansion, and film growth. Different processes associated to these steps can have a pronounced influence on the film growth and film composition, i.e. properties. It is noteworthy, that it is often assumed, without further analysis, that the films will have automatically the same composition as the target, which is not really the case. I will show, that all steps and the associated parameter, such as background gas type and pressure, target composition, and substrate type and temperature have a pronounced effect on the PLD process, and therefore on the film composition and properties. One approach to probe the PLD process (in-situ) is ablation plume analysis and the expansion dynamics of laser induced plasmas has received considerable attention in the last 30 years due to its importance for the basic understanding of materials removal by laser ablation as well as laser-materials processing and thin film deposition. Some problems associated with PLD, e.g. differences in composition between targets and thin films, nonhomogenous composition of the thin films, and deviation of the film thickness for substrates greater than around 1 cm2, are most likely related to the ablation plume. A detailed study of the ablation plume can therefore help to understand whether and how these problems can be overcome. We apply space-, angle-, and energy-resolved plasma mass spectrometry, space- and angle-resolved ion probe measurements, and spectral- and time-resolved plasma imaging in the same PLD chamber, that is equipped with a special designed substrate system to analyse the thin films composition for various deposition angles. To analyse the influence of the applied elements, a variety of different target compositions are utilized. We would like to highlight here some of the most important findings related to the film composition, while the thickness related variations are mostly related to the well-known forward peaked nature of the ablation plume. The sum of all these effects suggests, that in many cases it can be difficult and time-consuming to find conditions to achieve the desired film composition (properties).

Understanding the atmospheric pressure plasma processes: from plasma diagnostics to plasma chemistry

Anton Nikiforov[1], Mikhail Gromov[1], Georgios D. Stefanidis[2,3], Michalis Poupouzas[4], Tomas Markevicius[1], Ana Sobota[4], Uros Cvelbar[5], Rino Morent[1]

[1] Department of Applied Physics, Ghent University, Sint-Pietersnieuwstraat 41, 9000, Ghent, Belgium
[2] School of Chemical Engineering, National Technical University of Athens, Iroon Polytechniou 9, 15780, Athens, Greece
[3] Laboratory for Chemical Technology, Ghent University, Tech Lane Ghent Science Park 125, B-9052, Gent, Belgium
[4] Department of Applied Physics, EPG, Eindhoven University of Technology, 5600 MB Eindhoven, The Netherlands
[5] Jožef Stefan Institute, Department of Surface Engineering and Optoelectronics, Jamova cesta 39, 1000 Ljubljana, Slovenia

Corresponding author: anton.nikiforov@ugent.be

Non-thermal plasmas (NTPs) at atmospheric pressure provide a unique possibility to initiate various chemical processes at low temperatures otherwise requiring elevated temperature and/or presence of catalysts. In that regard, NTPs can be considered as chemical reactors where plasma-generated species can transform feedstocks to desirable valuable products. The pathways of plasma chemical processes can be substantially different from conventional chemistry and control over the reaction pathways can be achieved through detailed plasma diagnostics of the gas phase.

Here, an overview of the main methods of species detection including emission spectroscopy, actinometry, laser spectroscopy and scattering is given with a focus on relevant applications of NTPs in the energy sector and surface treatment. The advantages and limitations of the methods are discussed and analysed with some examples of practical implementations for pulsed plasmas and RF discharges.

Among different NTPs, the role of pulsed discharges in chemical processes is demonstrated for reforming natural gas and heavy hydrocarbons to more valuable compounds, C_2H_4 and hydrogen. The kinetics of the electrons and gas heating are analysed based on a combination of passive and active plasma diagnostics. It is shown that strong gas heating during the discharge phase is responsible for almost complete CH_4 dissociation and production of C_2H_2 and atomic H which can be utilized for *in-situ* ethylene synthesis as the most valuable product. The concept of natural gas reforming is demonstrated based on various methods of plasma diagnostics.

The approach of the use an NTPs as a source of chemically active species is further elaborated through the use of RF plasma as a source of atomic oxygen for contactless cleaning of cultural heritage objects. The mechanisms of oxygen dissociation are proposed based on laser spectroscopy of the main species present in the plasma region. The effect of possible air diffusion in the region of the discharge is discussed and methods to prevent the air back diffusion are proposed. The concept of atomic oxygen beam generated by NTP is applied for cleaning various samples relevant to the field of cultural heritage.

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INDUSTRIAL WORKSHOP

10 years of CETAL – contributions to industrial research in Romania

Marian ZAMFIRESCU[1], Andrei POPESCU[1], Emanuel AXENTE[1], Sandel SIMION[1], Felix SIMA[1]

[1]INFLPR, Atomistilor 409, Magurele, RO-077125, ROMANIA

Corresponding author: marian.zamfirescu@inflpr.ro

The Center for Advanced Laser Technologies (CETAL) is the most important research infrastructure in the field of laser-based technologies in Romania, realized with national investment funds. Established in 2014, CETAL is a unique laser research center in Southeast Europe.

The main objective of CETAL is to develop and transfer laser technologies to the Romanian industry. From this perspective, it operates as a research infrastructure of national interest. Shortly after its establishment, the young team of researchers at CETAL managed to develop laser techniques for additive manufacturing of 3D metal parts, with applications in the aerospace and biomedical industries; high-resolution 3D laser lithography techniques for the manufacture of micro- and nanostructures, with applications in tissue engineering, integrated optics, and photonics; optical fiber-based sensors for distributed sensing, with applications in structural health monitoring, sustainable environment monitoring, and space-borne systems; manufacturing techniques and characterization of microfluidic structures for lab-on-a-chip devices with biomedical and nanomedicine applications; and fabrication methods of 3D microstructured targets for interaction with high-intensity laser pulses.

The PW laser facility at CETAL is part of the strategy for the development of high-power lasers in Romania and was created simultaneously with the birth of the ELI-NP project. At the CETAL-PW laser, experiments for laser-driven particle acceleration are carried out for the simulation of cosmic rays and evaluations of materials irradiated by ionizing radiation in extreme conditions. Experiments are also developed to evaluate the biological effects of FLASH-RT radiation induced by VHEE obtained by PW laser-driven electron acceleration in gas. Fundamental physics experiments, such as plasma physics induced by high-intensity laser pulses and optical pulse compression experiments for the development of future generations of high-power lasers, are performed at the CETAL-PW facility, including the preparation of future experiments for the ELI-NP laser.

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The national platform for semiconductor technologies

Adrian DINESCU[1], Andrei AVRAM[1], Radu POPA[1], Octavian BUIU[1]

[1]IMT Bucharest, 126A Erou Iancu Nicolae street, Voluntari, RO-077190, ROMANIA

Corresponding author: andrei.avram@imt.ro

The current European and international pace can be met only by reinforcing the achievements in technologies with high application potential targeting high value-added products, addressing a well-defined market segment. Therefore, the efficient pathway is to resolutely capitalize on best-proven competencies in discerningly selected fields of advanced technologies that address the observed barriers and are in line with the international trends. In this respect, and in alignment with the Smart Specialization priorities as emphasized in the National Strategy for Research, Innovation and Specialization (SNCSI 2022-2027), the National Platform for Semiconductor Technologies (NPST) aims to engage the most relevant Romanian public RDI actors in a coherent, large-scale project in the strategic field of semiconductor technologies. This field is recognized as a critical driver for the successful implementation of EU industrial policies while supporting Digitization and green deal initiatives. The project also addresses one major weakness of the Romanian RD&I ecosystem: the chronic fragmentation of the ecosystem. This problem prevents reaching the critical mass in terms of capabilities, competencies, and resources, as well as addressing, in a coherent manner, the needs of the industrial actors. Reducing this knowledge and capabilities fragmentation also simplifies and renders efficiency to the contact between the RDI system and the industrial beneficiaries.

The focus of the NPST initiative is to speed up the transformation of the multitude of low-TRL, advanced technology research outputs into industrial level, validation-ready components and systems by employing suitable wafer integration semiconductor processes. This transformation will be implemented through the development of pilot line facilities, using state of the art equipment, that will enable the transfer of the R&DI outputs towards industrial partners, ready for launching new products on the market.

NPST is currently the only national level active initiative aiming at implementing a consolidated set of actions that are designed to offer a coherent solution for the development of a complete and effective value chain in the field of microelectronics – from concept development to small scale production and transfer to industry. These are achieved by reaching a high level of convergence of complementary infrastructure, technologies, human resources, and know-how developed independently over the last 30 years by each of the consortium members, and on the other hand, a unified effort to revitalize the microelectronics industry in Romania and contribute to the European key strategic value chains.

IREPA LASER, serving industry for 40 years in the field of material processing by laser beam

Eric FOGARASSY[1], Jean-Paul GAUFILLET[1], Didier BOISSELIER[1]

[1]IREPA LASER, Pole API, 320 Bld Sebastien BRANT, F-67400 ILLKIRCH, FRANCE

Corresponding author: Eric.Fogarassy@unistra.fr

IREPA LASER is a cooperative company (statutes: Collective Interest Cooperative Society) which develops innovative manufacturing solutions and supports their operational implementation in the industry. IREPA LASER is a major French player that supports technological and environmental transitions through innovation and its technology transfer capabilities. Its multidisciplinary positioning in laser processes, materials and power photonic systems allows it to offer original solutions to industrial companies that want to integrate laser technology into their production process.

In line with the requirements of its customers, R&D partnerships with suppliers of lasers, associated optical systems and academic research allow IREPA LASER to maintain this high level of excellence in its own areas of expertise.

IREPA LASER's service offer and activity is structured around four major business areas of expertise and a machine park comprising more than 20 lasers installed on industrial machines and allowing it to go as far as pilot production or pre-series.

	Laser welding	Additive manufacturing	Surface functionalization	Laser safety
Innovation offer	R&D partnership in B2B or collaborative R&D via European-type projects			
Manufacturing offer	Adaptation of mature laser processes, feasibility study, proof of concept, technical advice, etc.			Machine installation safety audit
Academy offer	Training in laser processes. Certified training organization			Training of certified laser safety operators

table. 1 Service offer and activity at IREPA LASER

In its activities, IREPA LASER has developed real expertise with a pragmatic approach to make these innovative solutions industrially viable. This approach to democratizing laser processes is recognized by IREPA LASER's customers, giving it a strong position in the field of technology transfer, particularly thanks to innovative solutions, some of which are patented. These new developments often originate within the framework of European projects, which have punctuated the existence of IREPA LASER. And this desire to cooperate with other European laboratories and companies is part of the DNA of our company.

40 years of experience, 50 people, 4.5 M€ turnover, 75% industrial B2B development contracts mainly with major accounts in the automotive, aeronautics and space sectors, creator of innovative startups and spin-offs, 5 active patents.

C400 PHOTOPLASMAT - industrial research capabilities in the context of the POCIDIF program

Nicu Doinel SCARISOREANU[1]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: nicu.scarisoreanu@inflpr.ro

The C400 PHOTOPLASMAT Department – "Innovation Center in Photonics and Plasma for Advanced Materials and Technologie" is a research infrastructure of INFLPR whose unique feature lies in the integration of laser/plasma/radiation advanced materials processing systems, characterization facilities and prototyping systems in a technological flow at industrial production standards. The main feature of C400 PHOTOPLASMAT is to obtain scientific products and technologies with a high degree of maturity, thus facilitating the technology transfer to beneficiaries interested in mass production. Unique national/international characteristics include:

• Laser/plasma processing technologies for advanced materials on large area -200 mm (8") or more: magnetron sputtering, electron beam evaporation, atmospheric pressure plasma deposition system, surface functionalization systems;
• Technologies for the production and testing of biomaterials at industrial standards;
• Equipment for dedicated physical-chemical property characterization: high-resolution transmission electron microscopy (HR-TEM), systems for X-ray, optical, electrical, surface analysis, etc.;
• Integration technologies into functional test and prototyping devices with diameters up to 200 mm (8") and industrial standards: FIB (focused ion beam), PL (photolithography), EBL (electron beam lithography), sensor testing systems, etc.

By developing this research-development chain at an industrial level, the needs for innovation of national private companies and even external ones will be met with high accuracy and within a time frame appropriate for technology transfer, thus assisting our partners in obtaining/tailoring the final high-added value products.

Development of laser welding technologies for semiconducting materials

Marcel VARLAN[1]

[1]"MICRO NANO TECH" SRL, 75A Cuza Voda str., Bucharest, ROMANIA

Corresponding author: marcel.varlan@micronanotech.com

The Romanian company „MICRO NANO TECH„ S.R.L., specialized in the production of high precision electronic components, such as nano and micro wires, micro coils and sensors, aims to develop its own laser microprocessing direction, with the final goal to offer on the market products with improved technical characteristics at the lowest possible cost for Romanian and international economic operators. The entity strives to solve challenges within miniaturisation project customers with a team of enthusiastic and
experienced engineers who can find solutions to the finest challenges by developing technologies, prototyping, equipment manufacturing and mass production.

To achieve this goal, the company will collaborate with INFLPR [1], the Romanian authority in the field of laser processing of materials, for the joint development of a pilot multifunctional laser processing system for precision cutting of silicon wafers, FeSi microwires and microwelding of Cu.

Semiconductors are integral to the inner workings of medical devices, helping to drive conductivity between a non-conductor and a conductor to control the flow of electricity. In turn, the assembly process to create an ideal semiconductor is incredibly detailed, especially as the trend is to create devices with ever-smaller dimensions. With the rapid miniaturization of semiconductors to fit into these ever-smaller devices, the role of lasers in processing semiconductor materials has become perfectly integrated. Laser technology is commonly used in semiconductor manufacturing because it enables multiple types of processing, including cutting, welding, coating removal and marking due to its precise, versatile and high power density energy beam.

The development of laser welding for semiconductors has been driven by the need
for precise, clean, and efficient joining methods, particularly in the fabrication of microelectronics and medical devices. Semiconducting materials are often sensitive to heat, which can cause damage or alter their properties. Laser welding offers precise control over the heat input, allowing for minimal thermal stress on the semiconductor components. Advanced laser systems incorporate features such as pulsed lasers, which deliver energy in short bursts, minimizing heat-affected zones and ensuring precise control over the welding process.

One of MICRO NANO TECH's main areas of activity is the production of microcoils and the production of microwires that go into them. The company produces such devices for national and international customers in the automotive and automation industries. To produce the product, a Cu microwire with a diameter < 100 μm and a core made of a FeSi microwire with a diameter of 100-200 μm is used for the winding (fig.1). The two microwires require processing: the winding must be welded at the ends to a Si coated Cu support, and the core must be cut accurately, without burrs or deformations, it is extremely important that the edges retain their shape, and the material does not coagulate at the end forming a hemisphere.

At present cuts are made using conventional processing methods involving tools with Wolfram Carbide cutting edges. This technology is technologically outdated, as the life of a tool knife is very limited, processing only about 200 cutting operations. The company currently produces hundreds of micro reels per day, and the long-term goal is to increase production to thousands of micro reels per day, making the process inefficient. The implementation of laser processing technologies allows for increased efficiency in the manufacturing process and its automation which ensures a high degree of repeatability and versatility.

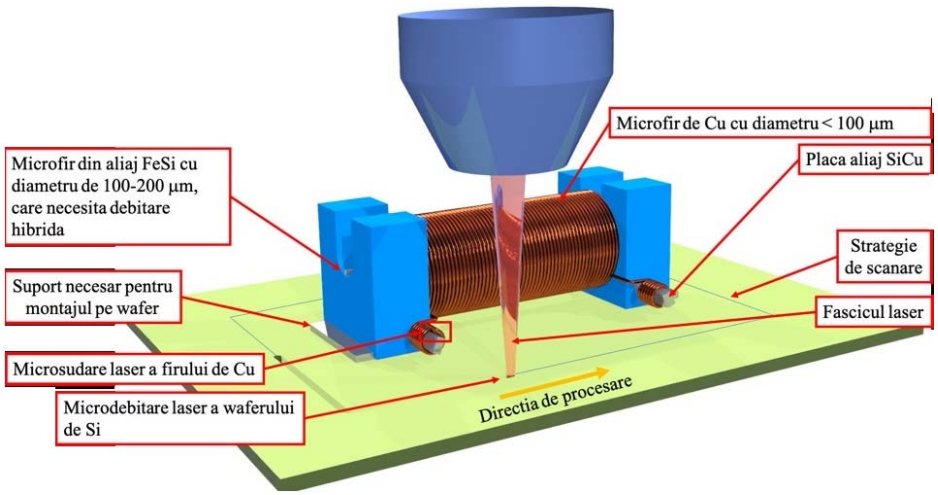

Fig. 1 Microcoil with Cu winding and FeSI core, mounted on Si support.

In semiconductor production, there are different cutting steps, such as cutting wafers from crystal blocks and templates from foils. The use of lasers for cutting ensures that chips are cut cleanly so that they fit with high precision into the final device. Using laser sources the shapes of semiconductor materials can achieve geometric complexities impossible to achieve using other cutting methods [2]. The advantages of cutting silicon wafers using this method are no tool wear, non-contact processing, reduced material loss around the processed edges and high processing efficiency, resulting in higher processing yield [3].

Laser welding is a fast process, particularly when compared to traditional methods such as soldering or adhesive bonding. This high-speed capability makes it suitable for high-volume manufacturing processes in semiconductor fabrication. Additionally, advancements in automation and robotics have enabled the integration of laser welding systems into automated production lines, further enhancing productivity and consistency.

[1] https://iclpr-st.inflpr.ro/, INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA.
[2] “Introduction to laser machining of semiconductors.” Accessed: Oct. 10, 2023. [Online]. Available: http://www.aml.engineering.columbia.edu/ntm/level1/ch05/html/l1c05s04.html.
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Development of periodic microstructures by laser processing of silicon

Cosmin-Dumitru IOANEȘ

INNO Robotics SRL, 212, Traian Vuia street, Cluj-Napoca, ROMANIA

Corresponding author: cosmin.ioanes@inno-robotics.com

INNO Robotics is a fully Romanian privately owned company, currently one of the largest integrators of automated solutions with industrial robots in Romania. As a new company on the market, INNO Robotics has built step by step an attractive portfolio of products and services and has earned the credibility of its customers. From consulting of the automation solution to concept development, design, manufacturing, installation, training, warranty, maintenance, offering customers turnkey solutions. With a team of forty employees with extensive experience in the field of automation, INNO Robotics focuses on European expansion and beyond.

With the achievement of these goals, solid partnerships have been established with important industrial companies such as the aeronautical industry, the automotive industry, the electronics industry, processing industries by different processes (welding, deburring, machine tending, palletizing and manufacturing various processes).

The main automation applications are focused in the areas of robotic welding, palletizing and CNC tending. INNO Robotics is launching new products on the market strengthening its expertise also in industrial automation for marking and laser welding.

Innovation is at the core of every concept.

System integrator of laser processing technologies

Octavian STOCKLOSA[1], Radu -Gabriel SANDU[1], Andrei-Alexandru MIHAI[1]

[1]EAST ELECTRIC, 256 Basarabia Boulevard, Bucharest, RO-030352, ROMANIA

Corresponding author: octavian.stocklosa@eastelectric.ro

Laser welding is becoming widely used in many industrial applications. This paper reviews recent research conducted on the performance, potential and problems of laser processing. Common defects that occur in laser beam processing are discussed and possible solutions proposed. Methods of welding process efficiency improvement are analyzed.

Focused on enhancing the efficiency and reliability of battery pack manufacturing, East Electric strives to achieve better solutions with the help of advanced joining technologies. East Electric's work on selecting laser sources, engineering control systems, implementing stringent safety protocols, and delivering automation applications tailored to the industry needs helps achieving an optimized system design answering the industry's increased need of better high powers solutions.

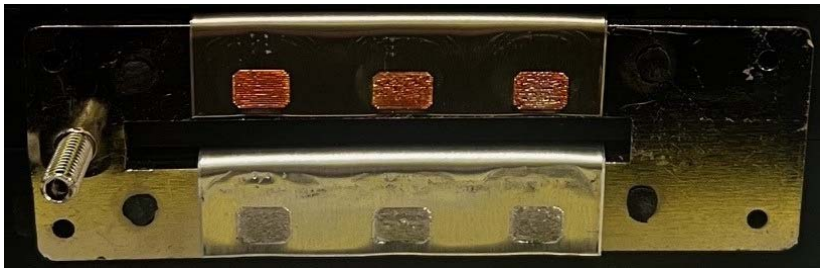


Fig. 1 Example of laser welding application using different materials and thickness.

Through iterative prototyping and rigorous testing, East Electric demonstrates the feasibility and efficacy of laser welding technology in battery manufacturing.[1] The resulting prototype exhibits superior precision, minimized heat-affected zones, and enhanced throughput, surpassing traditional welding methods and meeting stringent industry standards.

In this paper we will review results achieved and further paths analyzed towards the goal of improving laser processing techniques for joining different materials.

[1]https://eastelectric.ro/

CETAL expertise in technological transfer

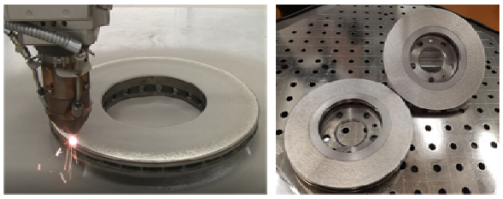
Diana CHIOIBASU[1], Sabin MIHAI[1], Andrei POPESCU[1], Ion N. MIHAILESCU[1]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: diana.chioibasu@inflpr.ro

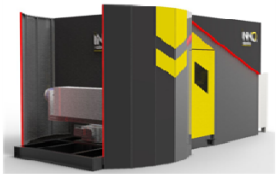
In the last 5 years, the research team of the LaMP laboratory in CETAL has focused its attention on the development of innovative laser processing technologies to be implemented on the production lines of industrial partners. The presentation will address the most important achievements of the center in the last 5 years: • laser cladding of brake discs to improve the physical-mechanical properties; • additive manufacturing of medical implants; • laser welding for: contacts of electrical energy storage systems, elements of the thermal management system of motor vehicles, structural components of civil constructions, plates of the stators of electric motors, metal systems for the evacuation of combustion compounds. For each technology developed, integrated pilot systems were designed, fully automated and customized according to the requirements imposed by the beneficiary. The reached technology readiness levels varied between 6 and 9.

Stainless Steel Laser Welding



Laser Cladding With Metallic Materials

Laser Welding For Electrical Batteries



Laser Welding For Automotive Components

Acknowledgement: This work was supported by a grant of the Ministry of Research, Innovation and Digitization, CCCDI – UEFISCDI, project number PN-III-P2-2.1-PTE-2021-0670, within PNCDI III (PTE88/2022) and Romanian National Core Program LAPLAS VII-contract no. 30N/2023.

Development of a water monitoring sensor in collaboration with BEIA Consult International

Mihai ȘERBĂNESCU[1*], Andreea GROZA[2]

[1]CETAL INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

[2] LAB 260, INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

[*]Corresponding author: mihai.serbanescu@inflpr.ro

The optical sensors are demanded as innovative green technology for environmental applications due to their sensitivity, in-situ detection and real time monitoring. Such devices are ease to use, friendly with nature and reliable in collecting data on long periods of time.

The present results are related to the development of a compact, portable and affordable device for detection of organic compounds from water, namely NO_2 and NO_3. The detection in real time of their concentration above the normal values is essential for the life on underwater living organism. The working principle of this system is related to the detection of the absorption of radiation transmitted through the contaminated liquid medium in the range of 200 - 400 nm of the electromagnetic spectrum. By reference to the uncontaminated environment, the low transmission of radiation at predetermined wavelengths indicates the presence of various contaminants.

The system made in collaboration with BEIA Consult International is composed of a network of discrete optical radiation sources that work successively, a detection system, a collector enclosure for the liquid analysis, a water pumping system for collecting and evacuating the samples, an electronic system for command and control, a wireless system, a software for controlling the electronic system and recording data, a database.

Acknowledgement: This work was supported by a grant of the Ministry of Research, Innovation and Digitization, CNCS/CCCDI –UEFISCDI, project number ERANET-MARTERA-iPREMAS-2, within PNCDI III and support of National Interest Infrastructure facility IOSIN – CETAL at INFLPR.

Harnessing semiconductor-based sensors, advanced predictive analytics, and automation for enhanced biosecurity and agricultural productivity

Marius HĂRĂTĂU[1]

[1]INFOSEC CENTER SRL, IAȘI, șos. PĂCURARI, nr. 157, RO-700544, ROMANIA
Corresponding author: mharatau@infoseccenter.ro

The agricultural sector is undergoing a significant transformation, driven by advancements in technology that promise to enhance productivity and biosecurity. This paper explores the integration of semiconductor-based sensors, advanced predictive analytics, and automation in agriculture.

One such initiative is the SIMADCA project (Monitoring and Alarm System with Applications in Agriculture for Determining Water Contaminations), which aims to improve agriculture through the deployment of smart sensors and data analytics. Salehin et al. (2021) discuss the use of various sensors to detect pests in crops and automatically alert farmers, showcasing the efficiency of crop pest detection through **IoT automation[2]** systems in agriculture.

Predictive analytics in agriculture leverages machine learning, big data, and prediction algorithms to forecast crop yields, optimize resource usage, and enhance biosecurity measures, Gupta et al. (2021) outline how sensor technology has revolutionized traditional agriculture by integrating **predictive analytics[3]** and automation for optimal crop and soil management.

Biosecurity in agriculture is enhanced through advanced monitoring systems that detect diseases and contaminants early. Optimizing agricultural productivity involves the use of technology to predict yields, monitor crop development, and manage resources efficiently. Poblete-Echeverría & Fuentes (2020) discuss how research and innovation in sensor technology can accelerate the **adoption of digital tools[4]** in agriculture.

Water monitoring in agriculture is crucial for optimizing irrigation and ensuring efficient water use. Semiconductor-based sensors play a significant role in this area by providing accurate and real-time data on various water parameters. Additionally, multimodal sensor chips can measure water content and nutrient concentration in soil simultaneously, enhancing precision agriculture practices using **Machine Learning in Agricultural Monitoring[5]**.

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The development of innovation: integrating process design into research

Dorin Aurelian IUSCU[1]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: aurelian.iuscu@sfb.ro

The integration of Design for Six Sigma (DFSS) and Design of Experiments (DOE) into research processes significantly enhances innovation and operational excellence. DFSS is crucial in the initial phases of product or process development, focusing on meeting all quality specifications through thoughtful design rather than subsequent modifications. This approach ensures high-quality, high-performance outcomes from the outset.

Conversely, DOE serves as a robust statistical tool that systematically explores the interactions between different factors affecting a process. It facilitates the identification of critical variables and allows for process design optimization by conducting experiments that are both efficient and informative.

Together, DFSS and DOE offer a structured, rigorous approach to research and development. This combination not only streamlines the development process, reducing both time and costs, but also maximizes the overall quality and efficiency of the outcomes. The synergy between these methodologies revolutionizes traditional research approaches, driving forward innovations that adhere to the highest standards of operational excellence.

A semi-analytical method for temperature prediction at baseplate level for D.E.D.

Petru-Vlad TOMA[1,2], Vaibhav NAIN[3], Andrei C. POPESCU[1], Didier BOISSELIER[3]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125

[2]University of Bucharest, Faculty of Physics, 405 Atomistilor street, Magurele, RO-077125

[3]IREPA LASER, Pole API, 320 Bld Sebastien BRANT, F-67400 ILLKIRCH, FRANCE

Corresponding author: vlad.toma@inflpr.ro

During the fast prototyping and testing, characteristic to the field of additive manufacturing, the ability to quickly asses and discard bad processing parameters is paramount. Traditionally, this task was accomplished using finite element simulations (F.E.M.), which are rather slow. Pivotal work has already been done in order to speed-up the F.E.M. approach [1], however this comes at the expense of accuracy. Ideally, we'd like an analytical solution for the temperature field, however given the complex dynamics taking place on very short time-scales make the partial differential equations which govern the process into an intractable problem.

However, during the D.E.D. process, it is often the case that a baseplate is used, typically in the shape of a rectangular parallelepiped. The substrate is often dominant in mass and volume, and while it is only interacting with the printed part via one surface, it cannot be neglected and thus it consumes a great deal of computing power when simulating the process using the F.E.M. method. We've managed to speed up this class of F.E.M. simulations by analytically solving the temperature evolution in the baseplate separately, dividing our domain as presented in **Fig. 1**, where the blue region is solved via F.E.M., while the red region is solved analytically.

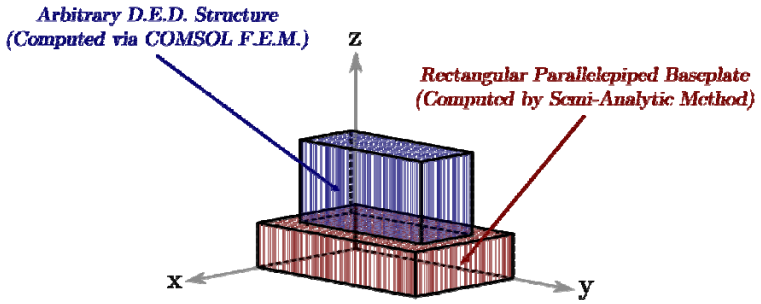

Fig. 1 Distribution of domains between the analytical solution and F.E.M. numerical solution.

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PLENARY LECTURES

Renewable electricity driven chemical conversion: Novel pathways provided by plasma enhanced chemistry

Richard van de SANDEN[1,2]

[1]DIFFER, P.O. Box 6336, 5600 HH Eindhoven, The Netherlands,
[2]Eindhoven Institute for Renewable Energy Systems (EIRES) and Department of Applied Physics, Eindhoven University of Technology, Eindhoven, The Netherlands

Corresponding author: m.c.m.vandesanden@differ.nl

In a circular CO_2 neutral society, the direct electrification of chemical conversion processes is one of the biggest challenges to achieve deep decarbonisation after 2030. The re-use of (air captured) carbon dioxide, the end product of the oxidation of dense energy carriers, for synthetic fuels and chemicals is required. Also, in this context, nitrogen fixation in the form of NH_3 or NO_x is unquestionably one of the most important chemical conversion processes. This electricity driven chemical conversion processes are also needed to mitigate intermittency of renewable energy sources by providing seasonal storage, as well as non-fossil based feedstock for the chemical industry.

The use of electrons, from renewable electricity, or photons, directly from the sun, provide scientific and technological opportunities to develop novel pathways for chemical conversion. In this talk, after an introduction to the challenges facing the world in the next decades, I will discuss the opportunities of using plasmas, powered by renewable electricity, for scalable gas conversion of stable key molecules such as CO_2 and N_2. In particular, I will address the use of microwave generated plasma to dissociate CO_2 into CO and O_2, the formation of NO_x from N_2/O_2 mixtures and the possible, often claimed, role of nonequilibrium vibrational kinetics in these conversion processes. An outlook on potential gamechanging application of non-thermal plasma, next to the use as a high temperature heating source, and in combination with catalyst, will be discussed.

Photonic processing of transition metal oxide nanostructures

Najma KHATOON, Binod SUBEDI, Madhu GAIRE, Sijun LUO, Sepideh KHALILI, Douglas B. CHRISEY

Dept. of Physics and Engineering Physics, Tulane University, New Orleans, LA. 70118

Corresponding author: dchrisey@tulane.edu

Nanostructured transition metal oxide-graphitic oxide nanocomposite thin films with a large specific surface area are preferable for practical device applications in energy conversion/storage, perovskite solar cells and for flexible electronics applications. This presentation will give a review of a novel approach to the instantaneous photoinitiated synthesis of mixed anatase-rutile nanocrystalline TiO_2 thin films, and other transition metals, e.g., TM: Co, Fe, Ni, Mn, with a three-dimensional nanostructure through pulsed white light irradiation of photosensitive TM-organic precursor films. High wall-plug efficiency-pulsed photonic irradiation (xenon flash lamp, pulse width of 1.93 ms, fluence of 4.5-8.5 J/cm^2 and frequency of 1.2 Hz) of wide wavelength range (280 nm -1100 nm) is used herein for scalable photonic processing. Pulsed photoinitiated pyrolysis of thin films (20 and 80 nm thickness) initiates generation and no-radiative recombination of photo electron-hole pairs which results into instantaneous self-assembly and crystallization of graphitic oxides-coated TM-O_2 nanograins.

The refractive index of the films is determined by ellipsometry to be 1.92 +/- 0.08 at 650 nm, which is indication of high refractive material with anti-reflective properties We controlled the amount of graphitic oxide by employing oxygen plasma cleaning following pulsed photothermal treatment. The enhanced optical transparency of the as-prepared thin films was observed before (91.1%) and after (91.3%) thermal processing. Moreover, the increase in sheet resistance (14.54 +/- 1.11 W/□ to 28.90 +/- 2.24 W /□) was observed on removal of graphitic oxide. Tunability of TiO_2 phase composition was observed with the photonic irradiation fluence. The increase in bandgap and sheet resistance for films as-processed through photonic curing and after carbon removal is comparable to traditionally high temperature processed TiO_2 thin films and offers the distinct advantages of scalable manufacturing, low-temperature processing, simultaneous bilayer fabrication, and in situ formation of removable carbon nanocomposites. Raman spectroscopy of TiO_2/graphite shows the E_g peak, characteristic of anatase phase titania, increases in intensity with higher photonic irradiation fluence, suggesting increased crystallinity through higher fluence processing. Film thickness and dendrite density is shown to increase with precursor concentration in the printed ink. The as-prepared MnO-graphitic oxide thin film electrodes exhibit excellent electrochemical performance and an ultra-long lifetime by retaining 90% of the initial capacitance even after 100,000 GCD cycles at constant areal current density of 0.4 mA/cm^2. We attribute this excellent lifetime performance to the conductive reduced graphitic oxide, synergistic effects of carbon composite and the metal oxides, and the unique porous nanostructure. Such highly porous morphology also enhances the structural stability of the electrode by buffering the volume changes during the redox processes. The porous morphology TM thin films cured via photonic curing makes this process a promising route to make TM oxides-based perovskite supercapacitors. The porous morphology will aid the fast-redox processes and intercalation process for perovskite oxides. This photoinitiated nanofabrication technology opens a promising way for the low-cost and high-throughput manufacturing of nanostructured metal oxides for energy storage/conversion hybrid devices. As reported TiO_2, Co_3O_4, and Fe_2O_3 thin films along with our future work on photo-rechargeable perovskite oxides materials through photonic cured represents a promising new method for the low-cost and high-throughput manufacturing of nanostructured metal oxide thin films for sustainable energy applications. Moreover, the ability of photonic curing to process high temperature materials on low-temperature substrates signifies its potential application in foldable and wearable consumer electronic devices which require continuous energy supply while going through physical deformation.

State of art of experiments versus theory in the interaction of high-intensity laser radiation with matter: novel aspects and new possibilities

Inam MIRZA[1], Vladimir P. ZHUKOV[1,2,3], Alexander V. BULGAKOV[1], Thibault J.-Y. DERRIEN[1], Martin ZUKERSTEIN[1], Yuri P. MESHCHERYAKOV[4], Nadezhda M. BULGAKOVA[1]

[1]HiLASE Centre, Institute of Physics ASCR, Za Radnicí 828, 25241 Dolni Brezany, Czech Republic
[2]Federal Research Center for Information and Computational Technologies, 6 Lavrentyev Ave., 630090 Novosibirsk, Russia
[3]Novosibirsk State Technical University, 20 Karl Marx Ave., Novosibirsk 630073, Russia
[4]Design and Technology Division of Lavrentyev Institute of Hydrodynamics SB RAS, Novosibirsk 630090, Russia

Corresponding author: bulgakova@fzu.cz

When high-power laser pulses act on a solid material, being focused on the surface or inside the bulk, they trigger a large body of processes occurring simultaneously and/or sequentially. These processes often bring the matter to a non-equilibrium state and change its optical and thermodynamic properties and morphology. At ultrashort laser pulses, some material properties start to change swiftly already at the femtosecond time scale, exhibiting strong variation of material optical response. Diagnostics tools to directly follow the complexity of the processes at such ultrashort scales are limited, giving valuable but incomplete information that must be analyzed and properly understood. In such circumstances, theoretical analysis and computer simulations are of high importance for achieving understanding and controlling the laser excitation processes.

In this talk, an overview of our studies on high-power laser action on materials of different kinds, both on surfaces and volume, will be given in which theory and experiment are synergistically linked. The progress in physics (as well as in the other sciences) is conditioned by a close interaction between experiment and theory [1]. The following topics on linking between experimental observation and theoretical description and interpretation will be discussed: laser-induced solid-solid phase transformation of nanostructured materials [2], formation of plasma in air [3] and bandgap solids [4] and its implications for material processing, dynamics of the electron plasma and a role of stresses upon volumetric modification of optical glasses [5]. Finally, the importance of studies of ultrashort processes on the level of quantum simulations will be addressed [6].

Acknowledgement. The work was supported by Operational Programme Johannes Amos Comenius financed by European Structural and Investment Funds and the Czech Ministry of Education, Youth and Sports (Project No. SENDISO -CZ.02.01.01/00/22_008/0004596).

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INVITED LECTURES

Laser-induced breakdown spectroscopy in combination with artificial intelligence for understanding and predicting corrosion in metals

Yongfeng LU[*,1], Lei LIU[1], Xi HUANG[1], Haoyu DONG[1], Aofei MAO[1], Peizi LI[1], Bai CUI[2], and Jean-Francois SILVAIN[3]

[1]Department of Electrical and Computer Engineering, University of Nebraska, Lincoln, NE 68588, USA.
[2]Department of Mechanical and Materials Engineering, University of Nebraska, Lincoln, NE 68588, USA.
[3]CNRS, University of Bordeaux; Bordeaux I.N.P., ICMCB, UMR 5026, F-33608 Pessac, France.

Corresponding author: ylu2@unl.edu

The 5xxx series aluminum (Al) – magnesium (Mg) alloys are extensively used in marine transportation and ships due to their high strength-to-weight ratios and great corrosion resistance properties. However, material degradation of the 5xxx alloys occurs over time after exposure to environments at elevated temperatures, referred as sensitization. Sensitization is characterized by β-phase (Mg_2Al_3) precipitates along the grain boundaries, which increases the susceptibility to intergranular corrosion (IGC) and stress corrosion cracking (SCC). Therefore, it is important to assess the degree of sensitization (DoS) in modern ships, whose structures are primarily made of Al-Mg alloys, to determine whether they have reached a DoS threshold that may require maintenance or repair activities. In this study, laser-induced breakdown spectroscopy (LIBS) with in combination with artificial intelligence was successfully developed to assess the DoS levels of the 5xxx alloys. The schematic of the technology using LIBS for Al alloy sensitization assessment is shown in **Fig. 1**.

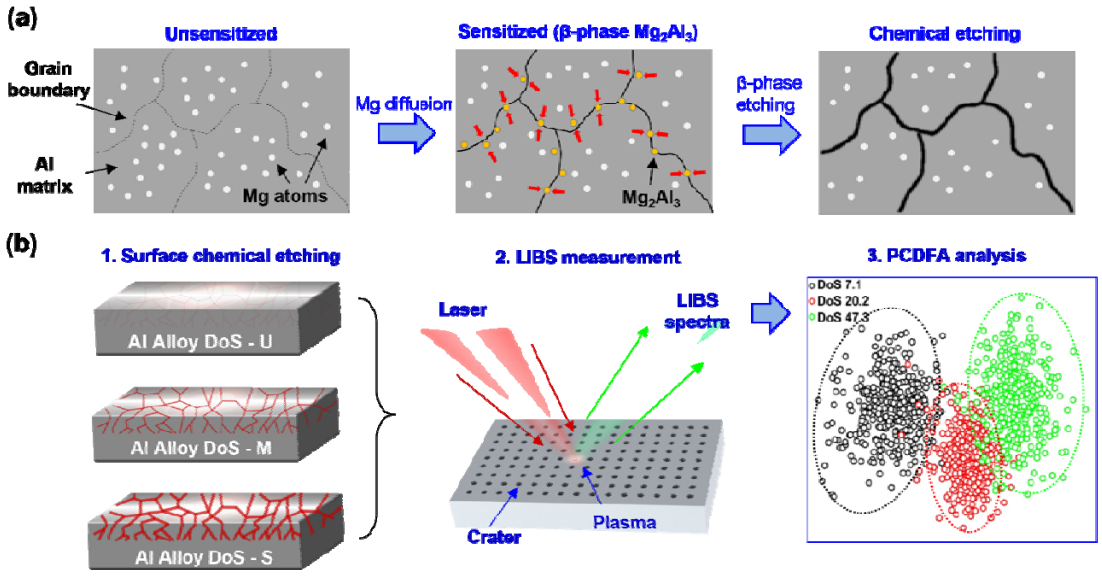

Fig. 1 (a) Schematic of the microstructures and spatial concentration variations of Mg in unsensitized, sensitized (β-phase precipitates), and chemically etched (preferred β-phase etching) in an Al-Mg alloy; (b) Overview of the proposed technology for sensitization assessment, including chemical etching of Al-Mg alloy with different DoS values, to induce Mg concentration variation correlated with the DoS values, subsequent LIBS measurements to probe the Mg concentration variations, and LIBS spectra processing by PC-DFA for DoS classification and prediction.

Additive manufacturing of porous carbon electrodes for supercapacitors

Quentin BAUERLIN[1,2,3], Bénédicte RETY[1,2,3], Adrian BEDA[1,2,3], Arnaud SPANGENBERG[1,2], Camélia MATEI GHIMBEU[1,2,3]

[1]Institut de Science des Matériaux de Mulhouse, UMR 7361 CNRS-Université de Haute Alsace, Mulhouse, FRANCE,
[2]Université de Strasbourg, FRANCE
[3]Réseau sur le Stockage Electrochimique de l'Energie (RS2E), CNRS FR3459, Amiens Cedex, France

Corresponding author: camelia.ghimbeu@uha.fr, Arnaud.spangenberg@uha.fr

Structuring objects from carbonaceous materials poses major challenges and is still relatively uncommon. The scientific literature describes a few manufacturing methods, but these remain complex and require several steps. An innovative approach that is becoming increasingly widespread is additive manufacturing, which makes it easy to create a variety of objects with different shapes [1]. In this project, the focus is on the employ of digital light processing (DLP) and volumetric printing as complementary techniques to achieve carbon structures with tuned properties. The advantage of latter approach relies on the use of a dose of 3D light applied to a volume of photoresist, enabling rapid, layer-free printing of centimetre-sized structures. As shown in **Fig. 1**, the aim is to develop photosensitive formulations compatible with these techniques to create complex carbon structures, such as custom electrodes exempt of binders, to be integrated in energy storage devices. The properties of carbon objects can vary considerably depending on a number of manufacturing factors (formulation of resin, printing conditions and pyrolysis step). Therefore, the properties of these carbon objects such as structure, composition, texture, morphology, are tuned and their electrochemical properties evaluated in order to improve the performance of the manufactured objects [2-3]. Several applications, particularly in the energy sector, are conceivable. The primary aim is to design electrodes that can be integrated into a supercapacitor to improve energy storage performance.

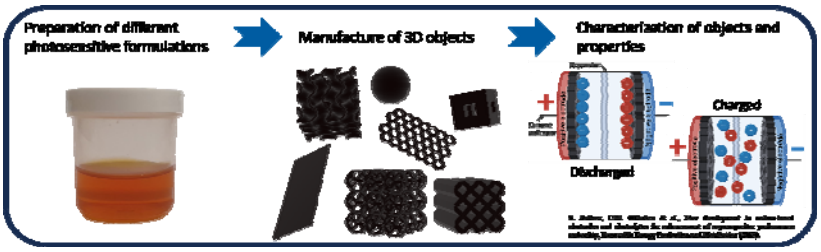

Fig. 1 Global outline of the subject.

Acknowledgement: The authors thank RS2E and the French Ministry of Higher Education and Research for their financial support via the French National Research Agency (STORE-EX Labex Project ANR-10-LABX-76-01; France 2030 – Project Mat-Light 4.0 – ANR-21-EXES-0012).

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Macro-scale microfabrication of 3D structures by nano-scale internal processing in glass

Ya CHENG[1,2]

[1]The Extreme Optoelectromechanics Laboratory (XXL), School of Physics and Electronic Science, East China Normal University
[2]State Key Laboratory of High Field Laser Physics and CAS Center for Excellence in Ultra-intense Laser Science, Shanghai Institute of Optics and Fine Mechanics (SIOM), Chinese Academy of Sciences (CAS), Shanghai 201800, China

Corresponding author: ya.cheng@siom.ac.cn

Over the past decades, ultrafast laser internal modification has become a widely adopted approach to enable three-dimensional (3D) micromachining of transparent materials into sophisticated structures and devices with the extreme geometrical flexibility. Owing to the linear diffraction and nonlinear self-focusing effects, it is extremely challenging to maintain the high longitudinal resolution when focusing deeply into the transparent substrates for achieving macro-scale microfabrication, i.e., fabrication of objects of centimeter-level heights without sacrificing the micrometer-scale resolution. We overcome this tremendous difficulty using loosely focused picosecond laser pulses, which, surprisingly, offer focal-volume-invariant modification deeply inside fused silica glass and give rise to the formation of extended nano-cracks preferentially oriented along the laser scan direction [1,2]. Ultrafast pump-probe microscopy is employed to investigate the complex spatiotemporal dynamics of fused silica glass exposed to loosely focused laser pulses with femtosecond and picosecond durations, pinpointing an exceptional incubation effect in the picosecond regime which enables highly localized concentration of the laser energy well beyond the diffraction limit of light. We further show that the combination of these two advantages, depth-insensitive focusing and extended nano-cracks, uniquely allows efficient macro-scale microfabrication as demanded by various applications such as 3D glass printing and flow chemistry [3].

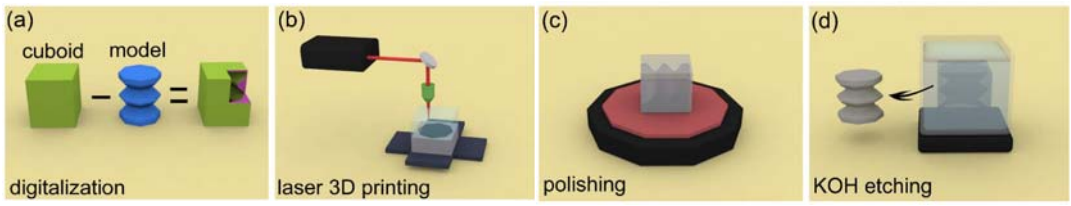

Fig. 1 The ultrafast laser 3D printing process in glass.

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Plasma research and technology development in response to selected societal challenges

Klaus-Dieter WELTMANN, Thomas VON WOEDTKE, Jürgen KOLB, Ronny BRANDENBURG

INP Leibniz Institute for Plasma Science and Technologies e.V., Felix-Hausdorff-Str. 2, 17489 Greifswald, Germany

Corresponding author: weltmann@inp-greifswald.de

Rapid advances in plasma research and technology have continued to position themselves as promising solutions to various societal challenges in recent years.
In the field of energy, plasma technologies offer innovative solutions for sustainable energy generation and storage. In addition, plasma technologies could contribute to environmental sustainability in the future, such as in the areas of biomass processing [1], agriculture and water treatment [2,3]. Plasma medicine offers great potential in the field of wound healing and cancer treatment. Plasma-based technologies are also increasingly finding their way into everyday clinical practice [4,5,6].

The interdisciplinary nature of plasma technologies makes them an integral part of the search for a sustainable and technologically advanced future. In this lecture, selected developments in plasma research and their applications for solving specific social problems will be presented.

Acknowledgement: *Sincere gratitude for the support and contributions goes to the various sources associated with this work.*

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Plasma based strategies for the degradation of perfluoroalkyl substances

Martina VAROTTO[1], Mubbshir SALEEM[1], Giulia TOMEI[1], Enzo MENNA[1], Ester MAROTTA[1]

[1]Department of Chemical Sciences, University of Padova, via Marzolo 1, 35131 Padova, Italy

Corresponding author: ester.marotta@unipd.it

Application of transient spark/streamer discharges in contact with liquid turned out to be very effective in the degradation of long chain perfluoroalkyl substances (PFAS) [1,2]. However, when the contaminants concentration is in the order of hundreds of ng/L or μg/L, as is typically the case in groundwater, the energy cost to sustain the plasma process can be too high. The most widely applied technique for the removal of PFAS from groundwater in drinking water plants is indeed adsorption on Granular Activated Carbon (GAC), a procedure considered easier and cheaper [3]. Based on these considerations, a more convenient strategy to apply plasma for the removal of PFAS could consist in the introduction of a pre-concentration step to optimize the ratio between the mass of the removed contaminants per unit of applied energy or in the direct treatment of exhausted GAC. The last approach is meant to be an alternative to the thermal treatment for GAC regeneration, that could avoid loss of carbon, changes in the porous structure of the material with the consequent decrease of its adsorption capacity and release of fluorinated compounds in air.

GAC samples saturated with perfluorooctanoic acid (PFOA) or perfluorobutanoic acid (PFBA) submerged in a little volume of water were thus treated in a multipin self-pulsing discharge reactor, developed in our laboratory and previously proven to be effective in the degradation of PFOA dissolved in water. Two different electrode configurations and both positive and negative polarities of the voltage for the generation of plasma were tested.

After the treatment, GAC were subjected to desorption by solvent and the obtained solution was analyzed by LC/ESI-MS to estimate the percentage of perfluorocarboxylic acid still adsorbed on GAC after the plasma treatment and to detect and quantify the adsorbed degradation products. The same analysis was carried out on the water in which GAC were submerged during the treatment; moreover, dissolved fluoride ions were quantified by means of an ion-selective electrode. GACs were also characterized by thermogravimetric analysis (TGA), both before and after the plasma treatment.

The obtained results will be presented and discussed with particular attention to the effectiveness of the process and to the chemical characterization procedures applied.

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Characterisation of atmospheric pressure plasma jets in contact with liquids, chemistry in liquids and applications in biomedicine and agriculture

Nevena PUAČ[1], Neda BABUCIĆ[1], Anđelija MARKOVIĆ[1], Olivera JOVANOVIĆ[1], Arian MORINA[2], Gordana MALOVIĆ[1], Nikola ŠKORO[1]

[1]Institute of Physics, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia

[2]Faculty of Science and Natural Resources, University of Malaysia Sabah, 88400 Kota Kinabalu, Malaysia

Corresponding author: nevena@ipb.ac.rs

In the last two decades applications of cold plasmas in the fields of Plasma Medicine and Plasma Agriculture have driven the development of non-equilibrium plasma sources that operate at atmospheric pressure [1]. Their rich plasma chemistry, with ample amounts of Reactive Oxygen and Nitrogen Species (RONS), is responsible for triggering various mechanisms and effects in cells. The application of cold plasmas can be direct, when discharge is in the contact with the cells, and indirect, through application of Plasma Activated Liquids (PALs). In the latter case the main species interacting with cells are long-living RONS. When aqueous solutions (water, cell medium, saline solution etc.) are exposed to cold plasma, reactions occurring in the gaseous phase and at the gas-liquid interface, introduce short and long-living RONS, such as OH, O, O_3, H_2O_2, NO_2^-, NO_3^-, into the aqueous phase [2].

We have used several configurations of Atmospheric Pressure Plasma Jets (APPJ) that were powered by power supplies with frequencies ranging from kHz to GHz and with different electrode geometries. Each of these APPJs were chosen depending on the application and characterized in detail by optical emission spectroscopy, electrical characterization, ICCD imaging, mass spectrometry etc. The applications of these APPJs include direct and indirect treatment of plant cells, cancer cells, bacteria biofilm, suspension of bacteria, production of Plasma Activated Water/Medium for wound healing/anticancer vaccines etc. [3-5]. Also, in order to test the toxicity of PAW we have used a model plant *Lemna minor* and investigated the influence of the various concentrations of PAW on plant growth and amount of chlorophyl in the plant.

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Investigation of electric fields at sub-atomic resolution with the STEM

Jörg K.N. LINDNER, Maja GROLL, Julius BÜRGER

Nanopatterning, Nanoanalysis & Photonic Materials Group, Dept. of Physics, Paderborn University, 33098 Paderborn, Germany

Corresponding author: lindner@physik.upb.de

With the advent of correctors for electron optical lenses the resolution of scanning transmission electron microscopes (STEM) has dropped to significantly less than one angstrom even at small acceleration voltages. This allows to investigate even beam sensitive materials at a resolution much better than the typical bonding length in solids. Thus, not only the position of atoms can be determined at unprecedented accuracy, but also the atomic potential between the nuclei of a solid becomes "visible". The Coulomb interaction between beam electrons and the specimen potential leads to a lateral momentum transfer onto the beam electrons which can be determined by means of either pixelated or segmented bright-field STEM detectors. In the first case the technique is called 4D-STEM, because at each image pixel a full diffraction pattern is recorded, while in the second case the technique is called differential phase contrast (DPC) imaging, both having advantages and disadvantages. Both techniques allow to observe light atoms, which are typically hardly visible using conventional STEM techniques, but both techniques are at the same time prone to residual lens errors and misalignments [1]. From maps of the interatomic electric fields the local charge distribution can be calculated using Gauss' law. For this to be accurate, many conditions need to be fulfilled, starting with a very small specimen thickness to suppress dynamical diffraction effects. In this presentation, we will therefore focus on experimental and theoretical DPC investigations of 2D materials, in particular transition metal dichalcogenides such as WSe_2 [2]. It will be demonstrated that even in a film as thin as a single molecule, dynamical diffraction effects need to be taken into account for achieving reliable charge density maps. The charge state and substitutional decoration of vacancy clusters in 2D-WSe_2 will be discussed.

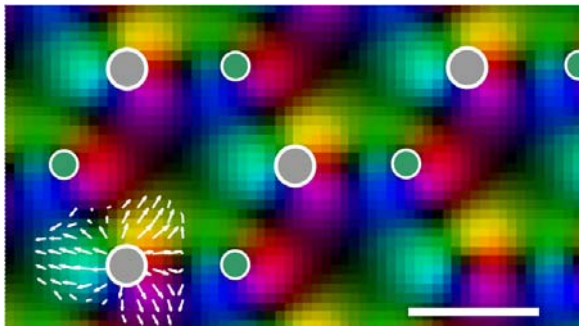

Fig. 1 DPC-STEM image of the interatomic electric field distribution in a pristine WSe_2 monolayer with central W and Se atomic positions marked in grey and in green, respectively. Colours represent the direction and strength of electric fields, partially also indicated by vectors. The scale bar is 2 Å.

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Tuning plasma CVD film properties in unusual manners

Masaharu SHIRATANI, Kunihiro KAMATAKI,

Naho ITAGAKI, Naoto YAMASHITA, Kazunori KOGA

Kyushu University, 744 Motooka, Fukuoka, 819-0395, JAPAN

Corresponding author: siratani@ed.kyushu-u.ac.jp

Low-temperature plasma technology has been put to practical use in various applications such as etching, deposition, and surface modification. In recent years, the development and practical applications of plasma-assisted atomic layer etching (PEALE) and plasma-assisted atomic layer deposition (PEALD) have been particularly remarkable. In this talk, we focus on plasma chemical vapor deposition (CVD), which we have been working on over 40 years. In particular, we explain how innovative and unique material properties can be achieved by tuning the properties of plasma CVD films in unusual manners [1-6]. Conventional methods adjust process parameters such as temperature, pressure, and gas flow rate. Unconventional approaches explore other avenues to achieve required film properties. Three such approaches are presented here: first, control through unconventional plasma generation, which encompasses pulsed plasmas, amplitude-modulated RF discharge plasmas, and arbitrary waveform excitation plasmas; second, control of film contamination due to nanoparticles growing in the plasma; and third, interface tuning by means of buffer layers formation based on unconventional parameters. For instance, a-C:H hard masks require plasma CVD at low temperatures to achieve stresses below 3 GPa, mass density above 2.3 g/cm^3, and deposition rate above 200 nm/min. In particular, reducing the residual stress of a-C:H films with high hardness has been an important issue for many years. We have succeeded in reducing the stress of a-C:H films by 35% by incorporating carbon nanoparticles (CNPs) in the buffer layer with a coverage of 8.9% [6]. Finally, we briefly show that process analysis using machine learning is an important direction for future thin film deposition.

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A Monte Carlo formulation for nanosecond discharges

Tiago C. DIAS, Vasco GUERRA

Instituto de Plasmas e Fusão Nuclear, Instituto Superior Técnico, Universidade de Lisboa, Portugal

Corresponding author: vguerra@tecnico.ulisboa.pt

Nanosecond discharges are very interesting for a variety of applications, as their short voltage raise times and high peak values effectively generate different transient active species. Their control and optimization relies on combined experimental and modelling efforts. However, the simulation of nanosecond discharges often relies on assumptions and approximations that were not systematically investigated, most commonly the two-term expansion of the electron Boltzmann equation, isotropic electron scattering, the local field (LFA) and the local energy (LEA) approximations, and the separation of the time-scales of the different kinetics. Since nanosecond discharges are characterized by high values and fast-varying reduced electric field (*E/N*), the validity of these assumptions must be carefully evaluated.

In this work we develop a rigorous mathematical framework to study nanosecond discharges based on Monte Carlo (MC) methods, that allows to assess the common approximations and benchmark different models. The formulation capitalizes on the LisbOn Kinetics Monte Carlo solver (LoKI-MC) [1,2] and stochastically solves the temporal evolution of both the electron [1,2] and heavy-particle kinetics [3], describing in a fully coupled way their mutual influence. Figure 1 shows illustrates the influence of the LFA and LEA in a nanosecond pulsed discharge in air at p=10 Torr, assuming a peak value of *E/N* of 300 Td at 2.5 ns and vanishing after ~30 ns, and reveals that these approximations may impact on the description of the plasma chemistry.

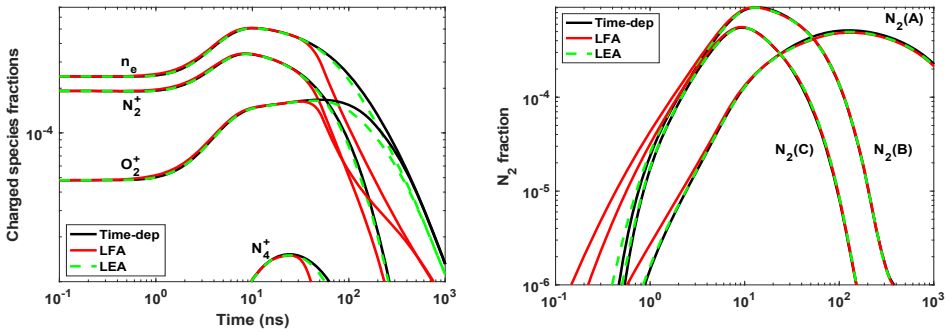

Fig. 1. Time-evolution of representative charged (left) and neutral (right) species for a nanosecond discharge in air at p=10 Torr: (—) exact MC solution; (—) local field approximation; (—) local energy approximation

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Bacterial nanocellulose nanocomposites for medical applications

Andrea ZILLE[1], Cátia ALVES[1], Liliana MELRO[1],Jorge PADRÂO[1], Marta FERNANDES[1], António J.SALGADO[2,3], Diego MOLDES[4]

[1]Centre for Textile Science and Technology (2C2T), University of Minho, Campus de Azurém, 4800-058, Guimarães, Portugal

[2] Life and Health Sciences Research Institute (ICVS), University of Minho, Campus de Gualtar, 4701-057 Braga, Portugal.

[3] ICVS/3B's, PT Government Associate Laboratory, Braga, Guimarães, Portugal

[4]CINTECX, Dep. of Chemical Engineering, Universidade de Vigo, Campus Universitario as Lagoas–Marcosende, 36310 Vigo, Spain

Corresponding author: azille@det.uminho.pt

Bacterial nanocellulose (BNC) is a biopolymer made entirely out of pure cellulose nanofibers [1]. It is ideal as a medical material due to its fibrous configuration, mechanical flexibility, high crystallinity, lightweight density, improved tensile strength, and biodegradability [2]. The presence of hydroxyl groups in its structure makes it a remarkable material for surface functionalization, acting as a binder for carbon-based materials [3]. Biocompatibility and lack of toxicity are two essential features of BNC that are essential for medical implants [4]. Examples of implants are surgical hernia meshes and implantable felts for microvascular decompression. However, the porosity of BNC is inadequate to allow the permeability of leukocytes, fibroblasts, and the setup of blood vessels and collagen essential for adequate healing. Thus, a pattern can be designed on this biopolymer (**Fig. 1**a) using a laser or a template during its production. Furthermore, the lack of antimicrobial activity can be overcome by the functionalization of antimicrobial metal- or organic-based nanoparticles such as lignin (**Fig. 1**b). Cold plasma pretreatment has recently been applied as a green and clean pretreatment to different cellulose substrates to modify their surface-characterizations.

Therefore, in this study, we report a simple atmospheric air DBD plasma (**Fig. 1**c) activation and etching pretreatment approach for maximizing the surface roughness of the BNC to improve the hernia-mesh tissue inclusion and improve the immobilization onto the BNC nanofibrous of lignin nanoparticle.

Fig. 1 (a) BNC with a porous pattern; (b) BNC functionalized with lignin; (c) Semi-industrial atmospheric DBD plasma prototype.

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Electrochemical Anodisation on Bioimplants from Titanium Alloys to Control Fibroblast and Osteoblast Attachment

Achim Walter HASSEL[1,2], Dominik KNAPIC[1], Andrei Ionut MARDARE[1],

Wiktor Luczak[2], Christoph KLEBER[2]

[1]Institute of Chemical Technology of Inorganic Materials, Johannes Kepler University Linz, 4040 Linz, Austria

[2]Danube Private University, Krems an der Donau, Austria

Corresponding author: achimwalter.hassel@jku.at

Titanium and its alloys are frequently used as medical implant materials. Titanium is a very ignoble metal that readily reacts with oxygen from air or with water to form a thin, nanometre thick titanium oxide film that prevents further reaction. This reaction is solely due to the chemical gradient between the oxygen containing environment and the pure metal. A further increase in the oxide thickness becomes possible when an electrical field is applied e.g. during anodization. This results in a thermally activated, field assisted process that is described by the high field model of oxide growth. This way it is possible to form oxide films which are several tenths to a few hundreds of nanometres thick, visible by the colour of the oxide film. Mechanically machined titanium implants are rather flat and do not provide significant structures for human cell adherence. Using femtosecond pulsed laser processing it is possible to form laser induced periodic surface structures (LIPSS) which allow controlling the surface features such as roughness, periodic length, height, microscopic and nanoscopic structure. In all these cases the forming oxides are just generated by the chemical gradient which leaves space for the chemical weak points.

One of the reasons for the high biocompatibility of titanium is the relative permittivity number of its oxide that is similar to that of adsorbed water. Water has a rather high relative permittivity number but when being adsorbed the contribution of the molecule rotation is lost and the permittivity decreases accordingly. Aiming for an optimisation of the surface structure and properties requires tuning several experimental parameters such as laser power, pulse duration, laser focussing, electrolyte for anodization, pH value, chemical composition of the electrolyte, temperature, anodization type (potentiodynamic, scan rate, potentiostatic), anodization potential etc. Therefore, the pure number of combinations seem to be too high for a regular one by one approach. To overcome this problem the combined surface modification was performed in a combinatorial approach [1]. Titanium samples were processed by a fs-laser with well-defined parameters. Small areas of these substrates were then addressed by a versatile electrochemical tool the so-called flow type scanning droplet cell microscope FT-SDCM. In different spots on the same substrate the electrochemical parameters were varied. The entire sample was then subjected to a cell culture experiment with fibroblasts or osteoblasts. Evaluation was concluded using scanning electron microscopy to quantify the number of adhering cells. Examples should illustrate the performance of this method.

The Micra is a leadless pace maker that is placed inside the heart. With time it may be overgrown by fibroblasts, which ensures a safe positioning. However, in case of a required replacement such as low battery conditions after a few years, the Micra may be completely encapsulated into the tissue. Making it impossible to remove it with a catheter. A proper modification of the titanium casing of the Micra based on

a well-chosen experimental setting allows today to divide the surface into two distinct regions [2]. The lower part is fibroblast affine and will be well integrated into the tissue. Two fibroblast-rejecting rings however, ensure that the upper part cannot be overgrown and in this way the device remains accessible [3].

Different parameters have to be chosen to control the attachment of bone forming cells the so-called osteoblasts. Depending on the application either a partial rejection or a full integration is intended. For orthopaedic bone screws it is important if the head of the screw is not overgrown so that it remains accessible to a screw driver even after weeks or months in the human body [4]. This allows also a minimally invasive removal at the end of its use time. For dental implants on the other hand the goal is obviously to optimize the osseointegration [5]. Here, different processing steps were successfully developed which results in implants with faster osteoblast seeding and stronger bone implant binding [6].

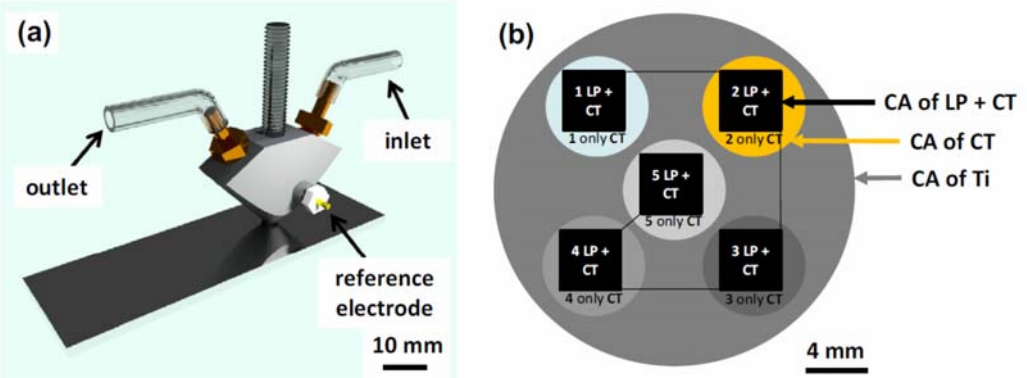

Fig. 1 Scheme of combinatorial experimentation

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Ultrashort pulsed laser engineering of biomimetic surfaces

Emmanuel STRATAKIS[1,2]

[1]Institute of Electronic Structure and Laser (IESL), Foundation for Research and Technology (FORTH), Greece

[2]Physics Department, University of Crete, Greece

Corresponding author: stratak@iesl.forth.gr

The fabrication of artificial biomimetic surfaces via femtosecond laser processing is presented. Metallic, semiconductor and dielectric surfaces were irradiated and Laser Induced Surface Structures (LIPSS) were observed in each type of material. In particular, femtosecond laser pulses with linear, circular, radialor azimuthal polarization states were used for structuring steel, silicon and fused silica surfaces. Experimental results showed that the direction of LIPSS in each case proved to be dependent on the laser beam polarisation. A complete study was carried out for the investigation of LIPSS dependence on fluence and the number of pulses per spot for variable beam polarization states and irradiation strategies, allowing the production of new and more complex surface structures. Furthermore, we present a novel way to control and modulate the different LIPSS morphologies and geometries. Moreover, large area surfaces were fabricated, tailored with various micro-and/or nano- structures bearing great structural resemblance to surfaces found in nature such as the lotus leaf, shark skin and butterfly Greta Oto wing. Those bioinspired surfaces manifest remarkable optical and wetting properties, which were attributed to the specific surface morphology. Thus, femtosecond laser processing can be a novel and one single-step method for the fabrication of functional surfaces on almost all classes of solid materials.

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Laser-generated electromagnetic pulses and applications for different laser pulse scenarios

Fabrizio CONSOLI

ENEA, Nuclear Department, Centro Ricerche Frascati, Via E. Fermi 45, 00044 Frascati ITALY

Corresponding author: fabrizio.consoli@enea.it

Transient electromagnetic fields in the radiofrequency-microwave range are commonly generated in experiments where high energy and high-power lasers interact with matter. These electromagnetic pulses (EMPs) depend on laser energy and intensity [1] (see **Fig. 1**). They can get a significant amount of the laser energy and reach intensities that can make them a potential serious danger for personnel and for electronic devices placed inside and outside the experimental vacuum chamber. This motivates research activities on mitigation of these EMPs for the operation of existing and future laser facilities for inertial confinement fusion and laser-plasma acceleration.

Recently, the insight and the understanding of the physical sources of these EMPs [1-3] has triggered the use of these mechanisms for application to multidisciplinary fields. They involve the generation of transient magnetic and electric fields of very high intensity, of traveling waves in helicoidal structures for ion acceleration and conditioning, of terahertz waves.

In this work we will give an up-to-date presentation of the laser-generated EMP sources, focusing on related applications for laser pulses with duration spanning from nanosecond down to femtosecond duration.

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A control-oriented approach to disruption prediction with a view on thereactor

Riccardo ROSSI[1], Michela GELFUSA[1], Teddy CRACIUNESCU[2] and Andrea MURARI[3,4] on behalf of JET Contributors* and the EUROfusion Tokamak Exploitation Team**

[1]Department of Industrial Engineering, University of Rome "Tor Vergata", Via del Politecnico 1, 00133, Rome, Italy

[2]National Institute for Laser, Plasma and Radiation Physics, Magurele-Bucharest, Romania

[3]Consorzio RFX (CNR, ENEA, INFN, University of Padova, Acciaierie Venete SpA), C.so Stati Uniti 4, 35127 Padova, Italy

[4]Istituto per la Scienza e la Tecnologia dei Plasmi, CNR, Padova, Italy

* See the author list of "Overview of T and D-T results in JET with ITER-like wall" by CF Maggi et al. to bepublished in Nuclear Fusion Special Issue: Overview and Summary Papers from the 29th Fusion Energy Conference (London, UK, 16-21 October 2023)
** See the author list of "Progress on an exhaust solution for a reactor using EUROfusion multi-machines capabilities" by E. Joffrin et al. to be published in Nuclear Fusion Special Issue: Overview and Summary Papers from the 29th Fusion Energy Conference (London, UK, 16-21 October 2023).
Corresponding author: gelfusa@ing.uniroma2.it

The long term goal of thermonuclear fusion consists of producing electricity from the coalescence of light nuclei in the laboratory. This is expected to be achieved by producing the fourth state of matter, in the form of high temperature plasmas. The most established route to fusion envisages the confinement of such plasmas with high magnetic fields in toroidal vacuum vessels. The best magnetic configuration remains the tokamak. Disruptions are catastrophic forms of collapse that have afflicted all tokomaks everoperated and remain one of the main potential showstoppers on the route to developing a commercial reactor. Reliable observers are a prerequisite to the deployment of anyrealistic strategy of countermeasures to avoid and/or mitigate disruptions. To complement under development principle models of the dynamics leading to disruptions, in the past decades empirical predictors have been extensively studied.

In metallic machines, such as JET with the new ITER Like Wall, most disruptions are preceded or caused by specific radiation anomalies. Deploying new tomographic and analysis methods to study about two thousand JET discharges, covering the complete set of isotopic compositions from hydrogen to full tritium and D-T, the nature of the various forms of collapse has been investigate din detail. The interactions between the radiation anomalies and the main magnetic and kinetic profiles allow determining the sequence of events leading to the breakdown of the magnetic configuration. A new approach to proximity detection has been developed, which permits to determine both the time interval to and the probability of an incoming disruption. This information is estimated with adaptive, real time compatible techniques. The performances of the developed predictors would meet ITER requirements and they are expected to be easily transferrable to larger devices, because they rely only on normalized quantities, form factors, and established physical/empirical scaling laws. The obtained results therefore indicate that state aware prediction and control tools can be developed, to deploy sufficiently performing real time strategies of disruption avoidance and prevention, with realistic requirements for the actuators of the next generation of devices.

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Laser-induced heating decimated luminescence nanothermometry using robust LaOF:Yb^{3+}, Er^{3+} upconversion nanophosphors

Hendrik C. SWART[1], Govind B. NAIR[1]

[1]Department of Physics, University of the Free State, Bloemfontein, South Africa

Corresponding author:swarthc@ufs.ac.za

A microwave-assisted hydrothermal route was used to synthesize LaOF:0.05 Yb^{3+}, x Er^{3+} ($0.001 \leq x \leq 0.05$) upconversion nanoparticles (UCNPs). Luminescence nanothermometers based on LaOF:Yb^{3+},Er^{3+} UCNPs were also investigated. Laser-induced heating is a bothersome factor that can lead to the degradation of several temperature-sensing probes. One way to eliminate this influence on the thermal readouts is to identify the critical point of the laser power that produces undesirable effects on the probe and operate the laser excitation source at safe levels below this point. Unfortunately, most luminescent probes must be pumped by lasers operating at alarming power levels that can either disintegrate the probe or produce counterfactual results. The fluorescence intensity ratio (FIR) of the UCNPs was recorded using the visible (red) and near-infrared (NIR) regions, at different temperatures. The impact of laser-heating on the UCNPs was prevented by identifying the optimal operating conditions of the laser that could be used to record the FIRs without compromising the integrity of the UCNPs. The behaviour of the UCNPs against the laser exposure time and power was analysed to recognize the critical point of the laser power, below which laser-heating of the UCNPs was negligible. In this scenario, LaOF: Yb^{3+}, Er^{3+} UCNPs proved to be a highly sensitive and durable temperature sensing probe that can operate efficiently at low laser powers. Up to power densities below 18 W/cm^2, the laser-induced heating was easily nullified from the thermal readouts of this temperature sensor, thus, preventing the need for temperature calibrations in the measurements. The LaOF: Yb^{3+}, Er^{3+} UCNPs demonstrated consistent thermal readouts with impeccable accuracies at low laser power density (6.91 W/cm^2). These UCNPs exhibited remarkable durability and reusability over multiple thermal cycles. The impressive relative and absolute sensitivities, and noteworthy temperature resolution of the LaOF:Yb^{3+},Er^{3+} UCNPs indicates their potential for luminescence nanothermometry applications. This approach can be perceived as a benchmark for testing luminescent materials using nanothermometry.

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Growth and characterization of rare-earth doped fluorides crystals for UV applications

Marius STEF[1], Gabriel BUSE[2], Philippe VEBER[1], Daniel VIZMAN[1]

[1]West University of Timisoara, Faculty ov Physics, Bd. V.Parvan 4, Timisoara

[2]West University of Timisoara, ICAM, Bd. V.Parvan 4, Timisoara

Corresponding author: daniel.vizman@e-uvt.ro

Doped fluoride (MeF_2: Me = Ca, Sr, Ba) crystals have been widely studied in order to find new scintillator and laser materials. Rare-earth (RE) ion-doped fluorides (MeF_2), due to their optical properties, have been studied for various applications [1]. In this work we present some characteristics of the CaF_2 and BaF_2 crystals doped with different concentration of ErF_3 and YbF_3. The crystals were grown using the vertical Bridgman technique. In a typical growth the precursors and dopants in the form of powders were heated in a pure graphite crucible to the melting temperature using a shaped graphite heater in vacuum. Transparent crystals, approximate to 5-6 cm in length, approximate to 10 mm in diameter, were obtained (**Fig. 1**).

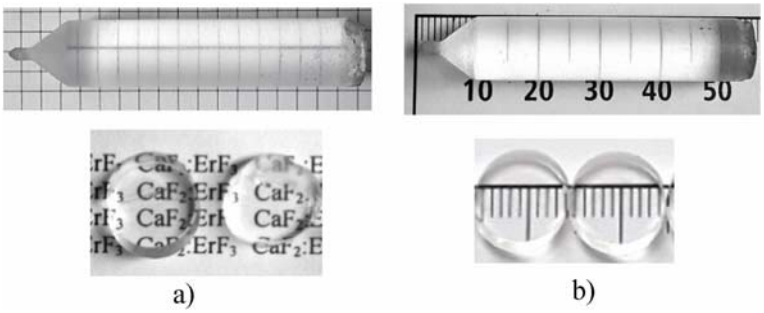

Fig. 1. Erbium doped CaF_2 (a) and BaF_2 single crystals (b).

One of the interesting result we found is that for the Er^{3+} ions doped BaF_2 crystals apart from the green and red emissions, arising under excitation at 378 nm, a new UV emission band centered at 321 nm (corresponding to the $^2P_{3/2} \rightarrow {}^4I_{15/2}$ transition) was observed under excitation at 290 nm. This emission was not reported before. The new UV luminescence can be related to the Er^{3+} isolated centers that predominates at low dopant concentration. This emission makes from Er^{3+} ions doped BaF_2 crystals a good candidate for UV applications. The difficulty elements of this issue are connected to the obtaining good quality crystals, with a low number of defects (dislocations, cracks, impurities, etc.) and with a uniform distribution of laser active centers along the crystals.

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Plasma sputtering onto polyols for the synthesis of electrocatalytic nanomaterials used in renewable H_2 storage and fuel cells

Amaël CAILLARD[1], Soumya ATMANE[1], Aïssatou DIOP[1], Aryan ARYAN[1], Loic GIMENEZ[1], Pascal BRAULT[1], Anne-Lise THOMANN[1], Pascal ANDREAZZA[2], Corinne BOUILLET[3], Karine DE OLIVEIRA VIGIER[4], Christophe COUTANCEAU[4]

[1]GREMI UMR7344, Université d'Orléans, CNRS, 14 rue d'Issoudun, 45067 ORLEANS cedex 2, France

[2] ICMN, UMR 7374, Université d'Orléans, CNRS, 1b rue de la Férollerie, F-45071 Orléans, France

[3] MACLE-CVL, UAR 2590, CNRS, 1b rue de la Férollerie, F-45071 Orléans, France

[4] IC2MP, Université de Poitiers, CNRS, 4 rue Michel Brunet, 86022 Poitiers, France

Corresponding author: amael.caillard@univ-orleans.fr

Nanoparticles (NPs) are widely used in nanostructured materials for electrochemical energy conversion and storage devices especially for emerging the expected renewable hydrogen economy. Chemical or physical processes can be used to manufacture NPs. The chemical methods are very versatile in terms of controlling NPs shape/size but requires additives as stabilization agents, which generate by-products difficult to remove and NPs with limited purity. In contrast, physical methods as magnetron sputtering on solid substrates avoid the use of additives, allowing the production of pure metallic NPs but are not always adapted to produce large amount of materials. In order to make the magnetron sputtering process suitable with conventional liquid ink preparation techniques used for electrochemical devices, we recently reported the synthesis of Pt NPs over a host liquid substrate (glycerol) that sustains low pressures [1]. This new interdisciplinary synthesized method for chemists and physicists was opened in order to tailor the physiochemical properties of NPs for advanced properties and applications. Our current research is focused on the synthesis of bi-, tri-, and multi-elemental metallic nanocatalysts (as Pt, Ru, Ag, ZrO_x, TiO_x, PtAg, PtRu, $PtTiO_x$ and $PtRuSnO_x$) necessary for electrochemical reaction occurring in hydrogen storage or fuel cells and on the rational design of these NPs which could offer new possibilities and tunable properties for a larger range of applications. First results combining experimental and numerical molecular dynamics (MD) studies highlighted that the NPs diffusion in the liquid phase depends on the associated kinetic energy of atoms when arriving on the liquid surface and so the plasma / liquid interaction properties [1]. The present talk aims to investigate the influence of the sputtering and the gas phase parameters on the NP properties using direct current magnetron sputtering (DCMS) and pulsed DC magnetron sputtering (p-DCMS). The interaction between the plasma and the polyethylene glycol (PEG) liquid and the gas phase properties will be discussed using mass spectrometer and energy flux probe giving us access to total energy influx incoming onto the liquid and to the gas phase composition. These results will be correlated to the NPs physical properties obtained by X-ray diffraction/scattering (XRD, WAXS/SAXS) and high-resolution transmission electron microscopy (HRTEM) or by MD, enabling us a better understanding of the NPs growth phenomena on and at the liquid surface or in the liquid phase. Finally, the sputtering period and the temperature of PEG related to the plasma energy influx incoming onto the surface appears to be key parameters (as previously observed [2]) for controlling the growing mechanism and the NPs properties.

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ORAL PRESENTATIONS

Electrochemical investigations of high entropy alloy thin films grown by pulsed laser deposition

Doina CRACIUN[1], Gabriela DORCIOMAN[1], Petronela GAROI[1], Julia Claudia MIRZA-ROSCA[2,3], Victor GEANTĂ[4], Ionelia VOICULESCU[4], Liviu BADEA[5,6], Valentin CRĂCIUN[1,7]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA
[2]Mechanical Eng. Dept., University of Las Palmas de Gran Canaria, 35017 Las Palmas de Gran Canaria, Spain
[3]Materials Engineering and Welding Department, Transilvania University of Brasov, 500036 Brasov, Romania
[4]Faculty of Material Science and Engineering, Polytechnic University of Bucharest, 313 Splaiul Independenței Avenue, 060042 Bucharest, Romania
[5]Faculty of Physics, University of Bucharest, 405 Atomiștilor Street, 077125 Măgurele, Romania
[6]National R&D Institute for Non-Ferrous and Rare Metals, Pantelimon, Romania
[7]Extreme Light Infrastructure for Nuclear Physics, 30 Reactorului Street, 077125 Măgurele, Romania)

Corresponding author: valentin.craciun@inflpr.ro

We synthesized high entropy alloy (HEA) thin films with the aid of the Pulsed Laser Deposition (PLD) technique starting from three AlCoCrFeNix targets with Ni molar ratio x of 0.2 (HEA2), 1.2 (HEA6) and 2.0 (HEA10). Depositions were performed either in residual vacuum (10^{-7} mbar) or under N_2 (10^{-4} mbar, films denoted as HEN) at room temperature on Si wafers and highly polished Ti substrates. The films structure, investigated by grazing incidence X-ray diffraction, was a mixture of FCC and BCC phases, although the targets for x=2 and x=2.o were pure BCC and FCC, respectively. The chemical composition, obtained by energy dispersion X-ray spectroscopy (EDS), was quite similar to that of the used targets. Films deposited under N_2 contained up to 6-13 at. % nitrogen in a metallic nitride compound as shown by X-ray photoelectron spectroscopy (XPS) analysis.

The electrochemical behaviour of HEA and HEN films under simulated physiological conditions was investigated by Open Circuit Potent (OCP) – for 24h and Electrochemical Impedance Spectroscopy (EIS) – at 10 mV and frequencies in the range 10^{-1} – 10^{+5} Hz. The solution used in experiments was a simulated body fluid. AC impedance data were collected at different potentials using a PAR 263A potentiostat coupled with a PAR 5210 lock-in amplifier. NanoIndentation (NI) and scratch tests have been also performed using a Brucker system. The results showed that films deposited under nitrogen exhibited a higher density and hardness than films deposited under vacuum.

Overall, HEN6 films exhibited the best corrosion behavior among the investigated films. It was noticed that for 24 hours of immersion in SBF solution, this film was also a physical barrier to the corrosion process, not only the chemical one [1].

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Cu/In thin films grown using co-evaporation

Lehlohonolo Eric MAKOLOANE[1], Shaun CRONJE[1], Hendrik Christoffel SWART[1],

Jacobus Johannes TERBLANS[1]

[1]University of the Free State, 205 Nelson Mandela, Bloemfontein, 9300, SOUTH AFRICA

Corresponding author: TerblansJJ@ufs.ac.za

Thin film alloys of Cu/In were prepared by co-evaporation utilising an Electron Beam Physical Vapor Deposition (EBPVD) system equipped with dual electron beams. The films were grown on a SiO_2 substrate, and the In concentration in the deposition vapour was varied from 10 to 90 at%. Precise control over the In concentration was achieved by regulating the deposition rates of In and Cu, accomplished through the manipulation of the beam currents of each respective beam. Surface topography characterisation of the film alloys was performed using Scanning Electron Microscopy (SEM).

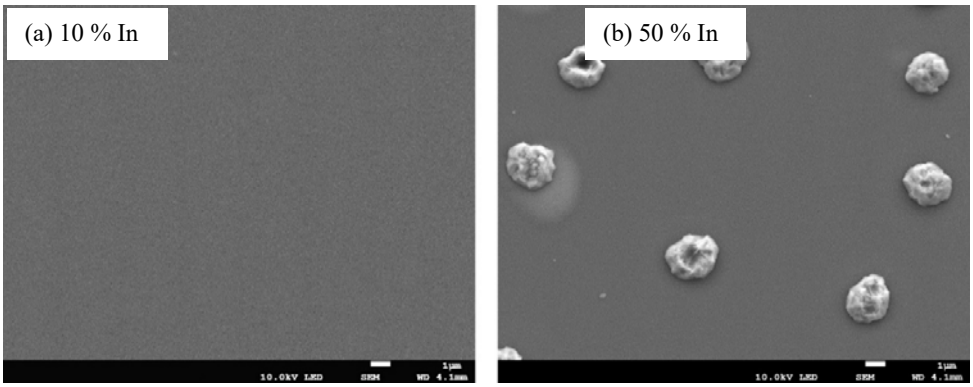

Fig. 1 SEM images of (a) 10 at% In thin film with smooth, featureless surface and a (b) 50 at% In sample with imposed In-rich particle-like features onto a smooth background film.

The SEM images showed that films with an In content of less than 30 at% formed smooth, featureless surfaces, suggesting a homogeneous distribution of In and Cu in the as-deposited layers. For films containing 30 at% In, a grain-like structure was observed. Beyond 30 at% In in the vapour, particle-like features are formed on top of a smooth background film. The sizes of the particle-like features increase as In concentration in the vapour increases. Fig 1 shows the particle-like features that form on the surface when the deposition vapour contains 50 at% In. Energy-Dispersive X-ray Spectroscopy (EDS) analysis of particle-like features indicated that it is rich in In with a composition of 61 at% In to 39 at% Cu. In contrast, the smooth background film is rich in Cu (37 at% In to 63 at% Cu).

Buried depressed-cladding waveguides realized in Nd:YAG ceramics with high-repetition rate picosecond-laser pulses

Gabriela CROITORU[1], Florin JIPA[2], Nicolaie PAVEL[1]

[1]National Institute for Laser, Plasma and Radiation Physics, Laboratory of Solid-State Quantum Electronics, Magurele 077125, Ilfov, Romania

[2]National Institute for Laser, Plasma and Radiation Physics, Center for Advanced Laser Technology, Photonic Investigations Laboratory - PhIL, Magurele 077125, Ilfov, Romania

Corresponding author: gabriela.croitoru@inflpr.ro

Waveguide structures are the building blocks for various integrated optical devices, such as amplifiers and waveguides lasers, beam splitters, modulators, directional couplers or polarizers. Such structures provide light confinement and propagation within a μm-scale volume by means of total internal reflection [1,2]. In dielectric materials, this confinement offers a great number of possibilities to realize laser sources with small footprint, high optical gain, low threshold of emission and good thermal management in respect with their bulk counterparts. For crystalline and ceramic materials, waveguiding is commonly realized in the volume confined between the written tracks (the so-called Type II waveguides), with double-wall or more complex structures [3].

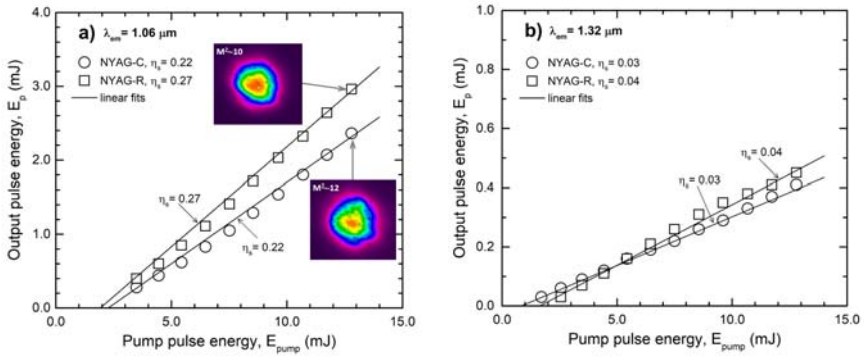

Fig. 1. a) The laser pulse energy, E_p at 1.06 μm vs. pump pulse energy, E_{pump}; OCM with T= 0.05; λ_{em}: wavelength of emission. The laser beam distributions are shown at the maximum E_p. **b)** The laser pulse energy, E_p at 1.32 μm versus E_{pump}; OCM with T= 0.03.

In this work we are reporting on the realization of buried depressed-cladding waveguides in a 1.1-at.% Nd:YAG ceramic medium by picosecond (ps)-laser beam writing. Laser emission performances were investigated under the pump with fiber-coupled diode lasers. For quasi-continuous-wave pumping, a circular waveguide with 100 μm diameter yielded laser pulses at 1.06 μm with energy E_p= 2.4 mJ for the pump energy E_{pump}= 12.8 mJ at 807 nm (corresponding to an overall optical-to-optical efficiency η_o of 0.19); the slope efficiency η_s was 0.22. Continuous-wave output power of 0.35 W with η_o= 0.09 was obtained from the same waveguide; η_s amounted to 0.12. The circular waveguide yielded laser pulses at 1.32 μm with 0.4 mJ energy for the same E_{pump} at 807 nm (corresponding to η_o of 0.03); slope efficiency η_s was 0.03.

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Analysis of mechanical energy deposited by laser-induced breakdown in gas

Prathika Prathap SHETTY[1], Steve RUDZ[1], Jean-Luc HANUS[2], Stéphane PELLERIN[1], Jean-Marc BAUCHIRE[1]

[1] GREMI, UMR 7344, CNRS/University of Orléans, F-45067 Orleans Cedex 2 & F-18020 Bourges Cedex, France
[2] LaMé, EA 7494, INSA CVL/Univ. Orléans/Univ. Tours, F-18020, Bourges Cedex, France
Corresponding author: prathika-prathap.shetty@univ-orleans.fr

Ignition by laser breakdown offers numerous benefits over conventional igniting techniques like electrical breakdown of spark type [1], exploding wires [2], etc. Greater control over the position and timing of the deposited energy is one of the many significant advantages. Using this approach to ignite a reactive mixture necessitates a thorough understanding of the characterization of deposited energy.

Two different forms of energy are produced when laser breakdown occurs: mechanical and thermal. The study aims to trace the blast wave produced during laser breakdown in different gases to characterize the mechanical energy deposited. The breakdown was performed using Q-switched Nd: Yag laser with following properties: the laser beam wavelength is λ = 532 nm, the pulse duration is τ = 5 ns, the beam diameter is D = 9 mm, and the beam quality factor is M^2 = 1.5. Blast waves are produced by laser breakdown in argon, air, CO_2 at various pressures (250 mbar, 500 mbar, 1000 mbar, 1500 mbar) and incident laser energies (15 mJ, 30 mJ, 60 mJ, 100 mJ, 200 mJ). A high-speed camera (Photron Fastcam SA5) records the pictures of the blast wave created by laser breakdown. Shadowgraph technique is used. The blast wave visualization is depicted in Figure 1.

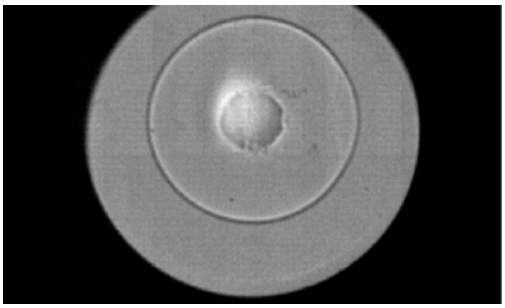

Fig. 1 Blast wave formed due to laser-induced breakdown at E_{inc}= 100 mJ and P_0= 1000 mbar in Compressed Air, Δt= 5.6805 μs

The blast wave trajectory as a function of time is extracted by processing the captured image data. The mechanical energy is then calculated by optimizing the acquired data using the Jones model [3], taking into consideration cylindrical geometry as discussed in [4].

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Laser ignition of H_2/air mixtures by a high-peak power passively Q-switched Nd:YAG/Cr^{4+}:YAG laser

Oana-Valeria GRIGORE, Gabriela CROITORU, George STANCIU, Alexandru CRACIUN, Nicolaie PAVEL

National Institute for Laser, Plasma and Radiation Physics, Laboratory of Solid-State Quantum Electronics
Magurele 077125, Ilfov, Romania

Corresponding author: nicolaie.pavel @inflpr.ro

Sustained research has been done in the last decades on the ignition of various fuel mixtures with lasers [1-3]. Advanced technologies have led to the realization of compact lasers, with dimensions similar to those of a classic spark plug and which can withstand high pressures and temperatures; these devices were used in the operation only with laser spark plugs of internal combustion engines. On the other hand, the use of hydrogen (H_2) as fuel presents numerous advantages [4]. Its combustion results in an exhaust consisting mainly of water and traces of nitrogen oxides, making it a cleaner fuel compared to other conventional fuels due to the absence of CO_2 emissions. Furthermore, H_2 presents a high caloric value and generates significantly more energy than conventional fuels.

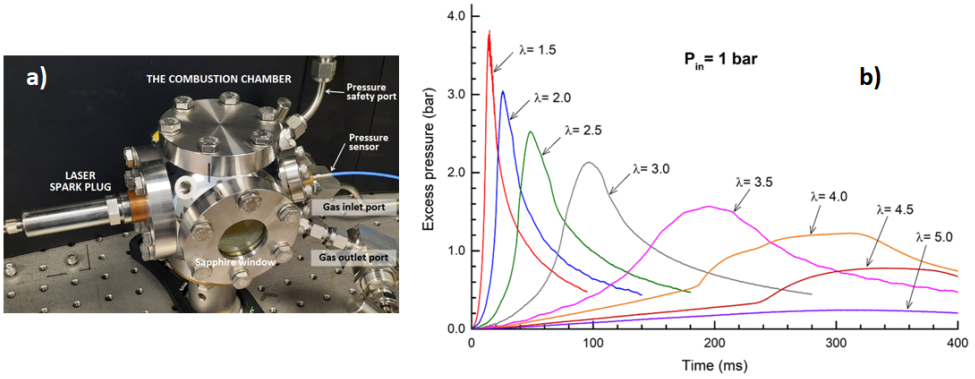

Fig. 1 a) The constant-volume combustion chamber and a single-beam laser spark plug.
b) Pressure history in CVCC for LI of H_2/air mixtures with various λ at P_{in}= 1 bar; single-point, single-pulse LI.

In this work, we are reporting the characteristics of laser ignition (LI) of H_2/air mixtures within a static, constant-volume combustion chamber (CVCC), using compact, spark-plug like Nd:YAG/Cr^{4+}:YAG lasers developed in our laboratory (**Fig. 1**a). LI was conducted at a single point as well as in four points, with precise timing achieved through two laser modes operation: delivering a single laser pulse and operating in pulse-burst mode, emitting trains of up to five laser pulses. Experiments covered a wide range of relative equivalence ratios (λ= 1.5 to 5.0) at 1 bar initial pressure (example in **Fig. 1**b) and extended to 9 bar. The results provide an insight into the features of LI of H_2/air mixtures and the use of LI technique in hydrogen-powered reciprocating engines.

Acknowledgement: This work was financed by project 30/2022 PN-III-P4-PCE-2021-0519, CNCS-UEFISCDI and partially supported by program NUCLEU-LAPLAS VII 30N/2023, Ministry of Research, Innovation and Digitization, Romania.

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Iron oxide nanoparticles synthesized by laser pyrolysis using exotic sensitizers

Florian DUMITRACHE[1], Iulia Ioana LUNGU[1], Claudiu FLEACA[1], Anca CRIVEANU[1], Lavinia GAVRILA[1], Evghenii GONCEARENCO[1], Iuliana MORJAN[1], Angela STAICU[1], Mihaela BALAS[2], Bogdan Stefan VASILE[3], Vlad SOCOLIUC[4,5]

[1]Lasers Department, National Institute for Lasers, Plasma and Radiation Physics, 409 Atomistilor St., Magurele, RO-077125, ROMANIA

[2] Department of Biochemistry and Molecular Biology, Faculty of Biology, University of Bucharest, 91-95 Splaiul Independentei, 050095, Bucharest, ROMANIA

[3] Department of Science and Engineering of Oxide Materials and Nanomaterials, University Politehnica of Bucharest, Gh. Polizu St. 1-7, 060042, Bucharest, ROMANIA

[4] Politehnica University of Timisoara, Research Centre for Complex Fluids Systems Engineering, 1 M. Viteazu Ave., Timisoara, ROMANIA

[5] Romanian Academy-Timisoara Branch, Centre for Fundamental and Advanced Technical Research, 24 Mihai Viteazu Ave., Timisoara, ROMANIA

Corresponding author: iulia.lungu@inflpr.ro

Iron oxide nanoparticles with mean size less than 8 nm have unique benefits for theranostic applications superparamagnetic properties, excellent biocompatibility combined with cellular internalisation, as well as hydrophilic and functionalization features. The NPs synthesized by laser pyrolysis may come with additional properties: high saturation magnetization (up to 110 emu/g), superficial functional groups, externally NPs size control (from 2 nm to 15 nm), and a narrow size distribution. Common mixture flows of iron pentacarbonyl vapours and oxygen donor molecules (O_2 or N_2O) were used as precursors and in this situation for an efficient CO_2 laser energy transfer it is mandatory to introduce a sensitizer – a molecular species with an appropriate adsorption at laser wavelength, such as ethylene (an unsaturated hydrocarbon) or sulphur hexafluoride. Each common sensitizer comes with drawbacks due to their minimal decompositions, thus C, S and/or F impurities could drastically decrease the dispersion tendency in aqueous solution, and also their biocompatibility. Here, we present new alternative solutions to by-pass the above-mentioned impurifications. Different oxygenated organic small molecules were used: isopropanol, ethanol, and formic acid, all of them without unsaturated C=C bonds and for this reason they induce reduced carbon impurification during their oxidative decomposition. Synthesis experiments using such different sensitizer molecules were performed trying to maintain the other important parameters at constant values: total flow, ratio between iron pentacarbonyl and oxygen flows, temperature and pressure, in order to analyse and to choose the proper sensitizer for our biomedical purposes. Thermal treatments were also performed at different temperatures (up to 500°C) in order to improve the crystalline and magnetization features. The treatment samples and the as synthesized ones were analysed by XRD, SEM-EDX, TEM, XPS, and also magnetic measurements at room temperature. Their stability in water-based suspensions was investigated using DLS measurements performed at different time intervals. Moreover, it was improved by adding biocompatible stabilizers, such as: dextran, chitosan, and CMC-Na. Regarding their potential biomedical applications, these stabilized NPs were further functionalized with cisplatin and their cytotoxicity was tested on both diploid and tumoral cell lines.

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Degradation study of carbamazepine in aqueous medium under non-thermal plasma oxidation process

Manoj P. RAYAROTH[1,2], Dunpin HONG[1*], Olivier AUBRY[1], Hervé RABAT[1], Pascal BRAULT[1]

[1]GREMI, UMR 7344, CNRS, Université d'Orléans, 45067 Orléans, France
[2] Department of Environmental Science, School of Science, GITAM (Deemed to Be) University, Visakhapatnam, 530045, India.

*Corresponding author: dunpin.hong@univ-orleans.fr

Water pollution by different kinds of pharmaceutical pollutants has increased the demand for proper treatment methods all over the world. The objective of the study was to propose a proper treatment technique for the decontamination of pharmaceutical-contaminated water by using a Non-thermal plasma (NTP) since it is a promising oxidation technique used in recent years for the removal of micropollutants [1]. Carbamazepine (CBZ) is selected as the model compound, as it is detected in various water resources [2]. The dielectric barrier discharge on the surface of a water sample containing 25 $mg.L^{-1}$ of the CBZ resulted in more than 90% of the removal with an energy yield of 0.19 $g.(kWh)^{-1}$. The applied voltage amplitude significantly affected the removal efficiency and the energy yield. Indeed, the degradation efficiency was 55%, 70%, and 72% respectively with an applied voltage of 8, 10, and 12 kV for a given treatment time of 20 minutes in a pure water matrix. The water matrices containing inorganic anions such as chloride and carbonate ions reduced the removal efficiency by scavenging the reactive species. Accordingly, a reduction in the removal efficiency was observed in tap water (Fig.1). The product analysis using LC-MS revealed that both reactive oxygen and nitrogen species are taking part in the reaction process which yields many intermediate products including aromatic nitro-products. This study concluded that NTP is effectively degrading CBZ in both pure and tap water, but special attention must be given to the changes in the water quality parameters (pH, conductivity, and nitrate/nitrite ions) and the fate of nitro products.

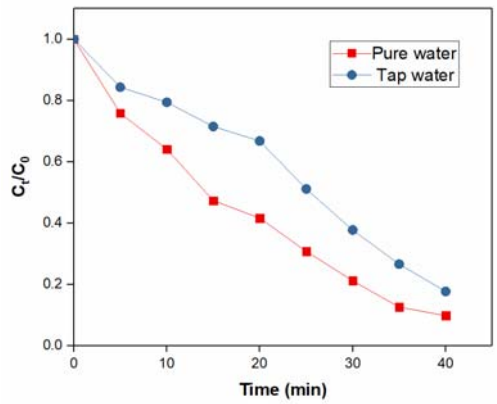

Fig. 1 Degradation of CBZ in pure and Tap water: Needle to liquid surface distance 3.5 mm, HV = 10 kV, Frequency = 500 Hz, $[CBZ]_0$ = 25 $mg.L^{-1}$

Acknowledgment: This work has been supported by Conseil Régional Centre-Val de Loire with grant #2021-00144786 for project Perturb'Eau.

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Degradation of herbicides in water using non-thermal plasmas (NTP) at atmospheric pressure

Cyrine BEN OTHMEN[1], Maxime WARTEL[1], Sylvain ISENI[1], Stéphane PELLERIN[1]

[1] *GREMI, UMR 7344 CNRS/University of Orléans, Orléans/ Bourges, France*
Corresponding author: cyrine.ben-othmen@univ-orleans.fr

Excessive pesticides application in agriculture leads to pollution of both surface water and groundwater. While conventional methods used in wastewater treatment plants remain partially effective for persistent organic pollutants (POPs), advanced oxidation processes are employed to more efficiently degrade these contaminants [1].

Among the advanced oxidation processes (AOP), the use of plasma has already proven its potential to degrade persistent organic pollutants [2,3]. Thus, this research focuses on the degradation by non-thermal plasmas (NTP) at atmospheric pressure of the herbicides present in the water.

The main goal of the first part of this study is to perform a comparative analysis of the efficiency of three plasma reactors at atmospheric pressure (Glidarc, DBD and plasma jet) in terms of the production of key reactive species, such as hydrogen peroxide or acids/bases derived from nitrogen generated in Plasma Activated Distilled Water (PADW). Chemical analysis (spectrophotometry/UV-visible colorimetry) is performed. Additionally, the energy efficiency of each plasma reactor is characterized.

The second part of this work is dedicated to testing the capacity of the chosen plasma reactor to treat a target herbicide.

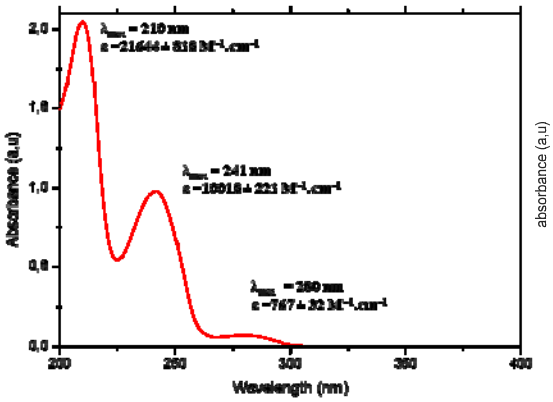

Fig. 1: Absorption spectrum of chlortoluron at 98.7 µmol.L^{-1} (before plasma treatment)

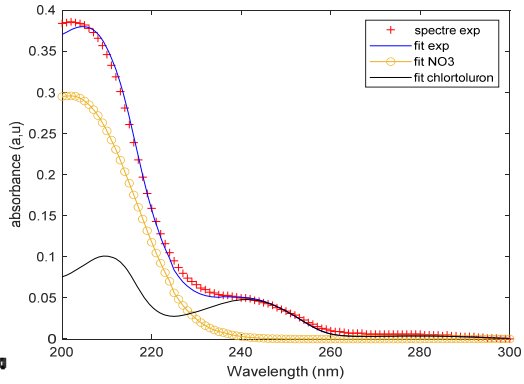

Fig. 2: Comparison of experimental spectra, global fit, nitrate ion fit and chlortoluron fit for chlortoluron solution treated by plasma jet (t= 20 min, V=50 mL and [chlortoluron]= 98.7 µmol.L^{-1})

Acknowledgement: The authors are grateful to François Faubert for his guidance and experience with the gas chromatography-mass spectrometry technique.

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Effects of plasma activated water treatment on plants

Alexandru MANDICI[1], Anca MIRON[1], Craita ROSU, Dragos ASTANEI[2], Oana BENIUGA[2], Radu BURLICA[2]

[1]Grigore T Popa Univ Med & Pharm, Dept Pharmacognosy Phytotherapy, 16 Univ Str, Iasi 700115, ROMANIA

[2]Gheorghe Asachi Tech Univ, Dept Electrical Engineering, 71 D Mangeron Blvd, Iasi 700050, ROMANIA

Corresponding author: radu.burlica@tuiasi.ro

The present study aimed to investigate the effects of non-thermal plasma activated water (PAW) on biological subjects such as *Triticum aestivum* L. cv. Glosa sprouts and on morphological, physiological, biochemical parameters and yield of *Lactuca sativa.* For both cases the seeds have been treated with plasma activated water obtained un an electrochemical reactor with a T geometry with atomized water with 2 inlets and one outlet. The inlet ports were used for water and air inlet and the water was sprayed directed into the plasma generated by an HV pulse electrical discharge. The PAW obtained was collected at the outlet port.

In the case of *Lactuca sativa* the results showed that the treatments with PAW have positive effects on the length of radicle and hypocotyls of lettuce, the chlorophyll content was significantly increased and also the foliar weight. *Lactuca sativa* plants cultivated in a greenhouse was irrigated with PAW until maturity. The dry weight was significantly higher for the lettuce treated with PAW at 60 days after transplanting -Fig.1.

In the case of *Triticum aestivum* L. cv. Glosa sprouts two types of PAW were generated by exposing distilled water to high voltage electric discharge, similar as in the previous case. Wheat caryopses were treated either with PAW (25 mg/L NO_3^-, 4 mg/L NO_2^-, and 6 mg/L H_2O_2). The germination rate, growth parameters, protein, photosynthetic pigments, and total phenolic contents, antioxidant activity of free and bound phenolic fractions, and activity of antioxidant enzymes were evaluated.

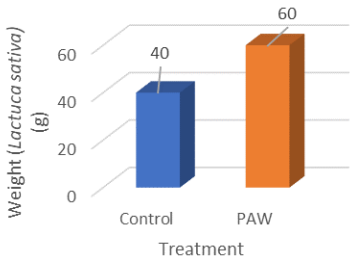

Fig. 1 Weight of *Lactuca sativa* treated with PAW

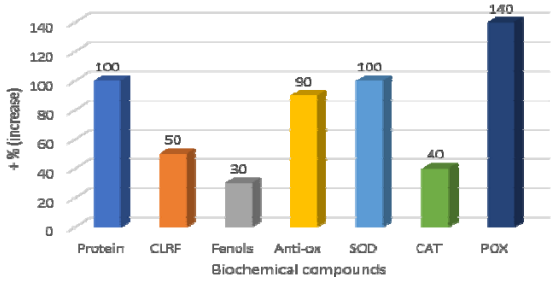

Fig. 2 Wheat Biochemical compounds variation with PAW

The exposure to PAW increases the quality of *Triticum aestivum* L. cv. Glosa sprouts.

Acknowledgment: This paper was supported by Gheorghe Asachi Technical University of Iasi, Romania.

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Influence of plasma treated water on bovine serum albumin thermal aggregation

Stefana SIMON[1], Ilarion MIHAILA[2], Ioana Cristina GERBER[2], Valentin POHOATA[1], Ionut TOPALA[1]

[1]*Iasi Plasma Advanced Research Center (IPARC), Faculty of Physics, Alexandru Ioan Cuza University of Iasi, Iasi 700506, Romania*

[2]*Integrated Center of Environmental Science Studies in the North-Eastern Development Region (CERNESIM), Alexandru Ioan Cuza University of Iasi, Iasi 700506, Romania*

Corresponding author: stefana.simon@student.uaic.ro

Atmospheric pressure plasma sources have long been of interest in medicine. The wide range of plasma uses in medicine, biology, and food processing has motivated studies on the molecular processes of plasma interaction with biological structures, such as proteins [1].

In this study, a filamentary dielectric barrier discharge in air was utilized as a plasma source to treat ultrapure and distilled water for 1, 2, 3, and 5 minutes. The plasma source consists of two electrodes, one with 9 stainless steel pins and the other circular aluminum electrode, covered by a glass Pietri vessel acting as dielectric barrier. The discharge was operated in air at atmospheric pressure, with an excitation frequency of 50 Hz and 15 kV sinusoidal applied voltage. The treated water was stored at room temperature and used to prepare protein solutions at a concentration of 1 mg/ml. The kinetics of protein aggregation was investigated using laser light (337 nm) scattering, photomultiplier detection and an oscilloscope to monitor the scattered signal during sample heating. The samples were heated for 30 min using an electric oven and the temperature was measured with a thermistor, every 30 s.

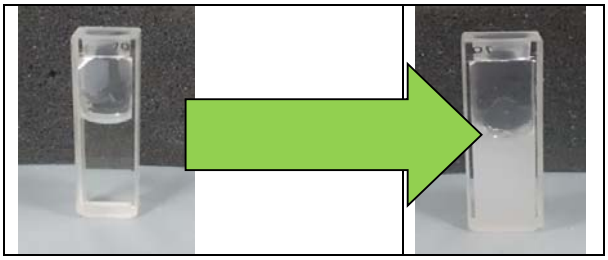

Fig.1. Comparison of the control protein solution (left) and the heated protein solution after 30 minutes (right).

The representation of the scattering signal amplitude as a function of solution temperature is an indication of the protein thermal aggregation phenomenon. We observed that if plasma treated water is used as solvent to prepare protein solutions, for plasma exposure durations longer than 1 min, the protein aggregation process no longer occurs. We explain this behavior by the change in pH of the solution and the generation of free radicals, i.e. reactive oxygen and nitrogen species [2-3]. Moreover, the effect is still present 30 days after water plasma treatment.

Keywords: Dielectric Barrier Discharge (DBD), aggregation, Bovine Serum Albumin (BSA)

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On the oxidation processes during the deposition of selected oxynitride system

Stefan Andrei IRIMICIUC[1,2], Sergii CHERTOPALOV[1], Michal NOVOTNY[1], Ladislav FEKETE[1], Stanislav CICHON[1], Valentin CRACIUN[2,3], Jan LANCOK[1]

[1]Institute of Physics of the Czech Academy of Sciences, Na Slovance 1999/2, Prague, Czech Republic

[2]National Institute for Laser, Plasma and Radiation Physics – NILPRP, 409 Atomistilor Street, Bucharest, Romania

[3]Extreme Light Infrastructure for Nuclear Physics, IFIN-HH, Magurele, Romania

Corresponding author: stefan.irimiciuc@inflpr.ro

The recent developments at the European level saw a shift in the legislation regarding the manufacturing process and raised new challenges concerning existent upscaling strategies. As such, the industrialization of certain thin film technologies aims to incorporate automatization and machine learning aided procedures. For application with direct impact in the energy sector Pulsed Laser Deposition (PLD) has been promoted as extraordinary flexible tool for generating wide range of nanoscale materials with controllable properties. In this paper, oxidation process occurring during the deposition of selected oxynitride systems (TiO_xN_y, ZrO_xN_y, MnO_xN_y) will be discussed. Because band gap tailoring for the oxynitrides is achieved by balancing the ratio between the nitride and oxide phases, a bottom-up approach is proposed for the characterization of the deposition process coupled with material characterization which will link the production process with the resulted material thus promote the development of plasma-thin film relationships, essential in upscaling PLD technology.

Angle-resolved electrical investigations coupled optical emission spectroscopy were used to investigate the deposition process. The oxidation processes are investigated in a wide range of conditions for both metallic and nitride plasmas. A clear signature in the charge particle density distribution is identified for gas phase oxidation processed involving. Complementary, time-resolved electrical and optical investigation revealed a complex dynamic of a two-temperature plasma with peculiar angular structuring and oxide molecule formation in gas phase.

To reflect the particularities of the PLD, on and off axis deposition geometries were implemented to investigate the role of charge kinetic energy on the defect and oxynitride phase formation. The deposited films were investigated using several surface analysis techniques such as Atomic Force Microscopy (AFM), Scanning Electron Microscopy (SEM), X-ray Diffraction (XRD), X-ray Photoelectron Spectroscopy (XPS) and electrical measurements. Finally, some correlations are proposed between the selected plasma properties and physical properties of the film. The optimum deposition conditions are discussed in the context of tailoring the properties oxynitride coatings via plasma monitoring tools.

Acknowledgement: This work was supported by the European Union and the Czech Ministry of Education, Youth and Sports (Project: MSCA Fellowships CZ FZU II - CZ.02.01.01/00/22_010/ 0008124) and the NATO grant SPS MYP G6153.

Mass spectrometry as tool for analysis of gaseous inclusion releases from thin films by laser induced ablation respectively laser induced desorption

Andreea GROZA[1*], Corneliu POROSNICU[1], Sasa-Alexandra YEHIA-ALEXE[1,2], Mihai SERBANESCU[1], Maria Elena ZARIF[1,3], Bogdan BITA[1,2], Paul DINCA[1], Bogdan BUTOI[1], Cornel STAICU[1]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA
[2]Faculty of Physics, University of Bucharest, 405 Atomistilor street, Magurele, RO-077125, ROMANIA
[3]Department of Science and Engineering of Oxide Materials and Nanomaterials, Faculty of Applied Chemistry and Materials Science, University Politehnica of Bucharest, 1-7 Gheorghe Polizu Street, sector 1, Bucharest, RO-011061, ROMANIA

[*]Corresponding author: andreea.groza@inflpr.ro

Mass spectrometry is an analytical method used for the detection of chemical elements or compounds with high detection accuracy. Depending on the intended application, it can be coupled with other analysis methods.

One of the most extensive research topics in recent decades is thermonuclear fusion due to its great potential to provide an alternative source of energy. The main fuels used in thermonuclear reactors are hydrogen isotopes, namely deuterium and tritium. An important problem regarding their use on a small or large scale (for example, the International Thermonuclear Experimental Reactor - ITER), is the penetration of these isotopes into materials and devices relevant to fusion technology [1].

The study of the incorporation, retention, and release of hydrogen isotopes by mass spectrometry is an important issue in the field of nuclear fusion materials research [1,2]. Thermal desorption spectrometry represents the "gold" method with 100% detection efficiency in the quantification of hydrogen isotopes retention and release [2] with a detection limit of 10^{11} molecules. Recently [1-3], laser induced ablation and laser induced desorption, coupled with mass spectrometry are intensively studied for extraction, detection, and quantification of hydrogen isotopes released from materials used *in situ* in nuclear fusion reactor with detection errors below 15% comparative to thermal desorption spectrometry [3].

In this context, our latest spectral studies on the release of deuterium atoms from thin or thick layers of beryllium, boron, or aluminum will be exhibited. Also, remarks on the use of thermal desorption spectrometry, laser induced ablation, and laser induced desorption mass spectrometry techniques will be presented [3]. For example, the efficiency in the detection of deuterium atoms (at/m^2) in Be layers varies between 100% for thermal desorption spectrometry (4 x 10^{17} D/m^2) and 1.3% (4 x 10^{15} D/m^2) for laser induced desorption mass spectrometry. For laser induced ablation mass spectrometry the efficiency in deuterium atoms detection in Be layers is 85% (3,4 x 10^{17} D/m^2) as function of laser parameters and experimental conditions. It results that the detection limit of our method is 4 x 10^{15} D/m^2.

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Angular distribution of species in pulsed electron beam deposition of $Ba_xSr_{1-x}TiO_3$

Daniela DOBRIN[1], Ion BURDUCEA[2], Decebal IANCU[2], Cristina BURDUCEA[2], Florin GHERENDI[1], Magdalena NISTOR[1]

[1]National Institute for Lasers, Plasma and Radiation Physics (INFLPR), 409 Atomistilor street, Magurele, RO-077125, ROMANIA

[2] "Horia Hulubei" National Institute for Research & Development in Physics and Nuclear Engineering, 30 Reactorului street, Magurele, RO-077125, ROMANIA

Corresponding author: daniela.dobrin@inflpr.ro, magda.nistor@inflpr.ro

The precise control of film stoichiometry is of crucial importance in order to attain the desired functional properties in metal oxide thin films and heterostructures for various applications, regardless of the film growth method [1]. For example, the multicomponent oxide $Ba_xSr_{1-x}TiO_3$ (BST) exhibits tunable dielectric, electrical, and ferroelectric properties depending on the barium/strontium ratio, which requires the control of the thin film composition [2].

Pulsed Electron Beam Deposition (PED) is a versatile technique based on ablation plasma for the growth of thin films of complex composition with tunable properties owing to the stoichiometric transfer of elements from a target to the film. PED method has been typically used to grow thin films on planar substrates and only a few papers have studied the angular dependence of ablation plasma species and determined the film thickness profile [3].

In this work we investigate the angular thickness and composition profiles of thin films obtained by irradiating a $Ba_xSr_{1-x}TiO_3$ (x=0.2, BST) target with a pulsed electron beam, based on the model used for PLD and presented in reference [4]. BST thin films, grown either in argon or oxygen background gases at a pressure of about 10^{-2} mbar and room temperature were analyzed by Rutherford backscattering spectrometry (RBS) at different substrate angular positions along the major and minor axes of the film. A "semi-sphere" holder was used, resulting in a fixed target to substrate distance of about 40 mm. The film thickness profiles have forward shaped peaks, with measurable thickness up to 80-90° for major axis and up to 25° for minor axis, presenting similar trend for both argon and oxygen background gas. The analysis of the congruent transfer of the elements from the target as a function of the angle showed that the film composition is not uniform over this wide angular range and differs with respect of the ablated target depending on the element used and on background gas.

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Complex oxides thin films integration in devices and evaluation of their functional properties

Mihai ZAMFIR[1], Valentin ION[1], Anca NITESCU[1], Isabela BANCU[1], Florin ANDREI[1], Nicu SCARISOREANU[1],

[1]INFLPR, 409 Atomistilor Street, Magurele, RO-077125, ROMANIA

Corresponding author: mihai.zamfir@inflpr.ro

Advanced materials, particularly complex oxides, defined as oxides with more than one cation, have attracted attention for a wide range of potential applications due to their exotic physical properties. Adjusting the intrinsic structural, topographical and stoichiometric features through various ways, is used for improvement of the functional properties of complex oxide materials such as photoelectrochemical (PEC) activity or dielectric/ferroic ones. Here, we present the fabrication of LaFeO3 perovskite thin films via pulsed laser deposition technique and their photoelectrochemical/electrical performances as a function of the layer's thickness and fine structural/compositional variations along the film/substrate interface. The variation of the structural parameters with the film's thickness and oxygen content of epitaxial $LaFeO_3$ (LFO) thin films, together with the appearance of self-assembled nanodomains for film's thicknesses higher than 14 nm, is highlighted. Moreover, for instance, heterostructures based on these materials, which in general are insulators with wide-bandgaps, exhibit novel properties such as interfacial conductivity due to a confined two-dimensional electron gas (2DEG). The origin of the 2DEG emergence is highly debated and different mechanisms have been proposed to explain its origin. Here we report also results on a complex oxide heterostructure based on LFO/STO architecture and the measurement of the 2DEG and we propose a model to explain the emergence of the 2DEG on devices fabricated using FIB lithography.

Acknowledgement: This work was performed using C400 PHOTOPLASMAT facilities acquired within the POC153/2016 IN2-FOTOPLASMAT project.

Integration of PECVD growth processes of carbon materials in the development of devices based on metal oxides

Octavian-Gabriel SIMIONESCU[1], Cosmin ROMANIȚAN[1], Oana BRÎNCOVEANU[1], Marius STOIAN[1], Octavian LIGOR[1], Cristina PACHIU[1], Silviu VULPE[1], Florin NĂSTASE[1]

[1] National Institute for Research and Development in Microtechnologies – IMT Bucharest, 126A Erou Iancu Nicolae, 077190 Voluntari, ROMANIA

Corresponding author: octavian.simionescu@imt.ro

Carbon nanostructures are used as electrodes in various applications due to their excellent electrical and thermal conductivity. In most cases, they are transferred or grown on an insulating substrate that has the role of shielding the rest of the device. Very few studies focus on carbonaceous material–oxide heterostructures and the use of ultrathin oxide films as an active material in conjunction with carbonaceous materials. This is largely due to the major differences between their growth processes, especially the high temperatures in the synthesis processes of carbonaceous materials, and the incompatibilities that can occur between the materials.

For the present study, both thin films of compact/bulk nanocrystalline graphite (bulk-NCG) and graphite/graphene nanowalls (GNW) were grown via plasma-enhanced chemical vapor deposition (PECVD) to be studied in conjunction with oxides developed by atomic layer deposition (ALD) and RF magnetron sputtering. The main purpose of this work is to determine the compatibility of the deposition methods (*i.e.*, PECVD/ALD and PECVD/RF magnetron sputtering), and also of the carbonic materials with the studied oxides. The structural, morphological, and electrical properties of the oxides were investigated via grazing incidence X-ray diffraction, X-ray reflectivity, atomic force microscopy (AFM), scanning electron microscopy (SEM), and I-V plots, while the carbonic layers were investigated through Raman spectroscopy, AFM, SEM, and four-point probe measurements.

The integration of the PECVD growth process of carbonaceous materials at high temperatures with the deposition processes of metal oxides by ALD and RF magnetron sputtering presents both benefits, by improving the crystallinity of the oxides in-situ, but also disadvantages regarding surface modification and loss of adhesion. Zr-doped HfO_2 films grown by ALD were successfully integrated with carbonic films grown by PECVD at a temperature of 750 °C, obtaining oxides with a superior crystallinity. From the preliminary integration tests of the carbonic films with the vanadium oxide films developed by RF magnetron sputtering, the two processes/materials appear to be incompatible up until this point. The integrity of the V_2O_5 films is compromised following its exposure to high temperatures, the oxide diffusing on the surface and forming centers of tens-hundreds of nanometers in size.

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Unlocking the versatility of in-situ transmission electron microscopy with broad range of imaging techniques

Ondrej BACO[1]

[1]Thermo Fisher Scientific, Vlastimila Pecha 1282/12, Brno 627 00, Czech Republic

Corresponding author: ondrej.baco@thermofisher.com

In-situ transmission electron microscopy (TEM) has emerged as a powerful tool for investigating dynamic processes and material behaviors at the nanoscale. This talk aims to explore the versatility of in-situ TEM by showcasing a broad range of imaging techniques that enable real-time observations and analysis of dynamic phenomena. By utilizing in-situ studies, researchers can gain unprecedented insights into the structural, chemical, and mechanical properties of materials under various environmental conditions, such as temperature, pressure, and electrical fields.

Highlighted in this talk will be the recent developments in in-situ TEM field as well as aberration corrected environmental TEM. The presentation will cover the advancements in imaging techniques which enable low dose atomic resolution observations of dynamic phenomena. Examples of results which will be presented include almost real-time energy-dispersive x-ray spectroscopy study of melting nanoparticles, benzene rings capturing by zeolite [1], moving magnetic domains by changing the external magnetic field and many others.

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Valve metals thin film combinatorial library screening for defect engineering of composite anodic memristors

Andrei Ionut MARDARE, Ivana ZRINSKI, Dominik KNAPIC, Achim Walter HASSEL

Institute of Chemical Technology of Inorganic Materials, Johannes Kepler University Linz, 4040 Linz, Austria

Corresponding author: andrei.mardare@jku.at

Screening of thin film combinatorial libraries in search of alloys with improved properties is a modern high throughput approach involved in the discovery of new 2D materials. Combinations between physical vapor deposition techniques and electrochemical surface treatment is gaining a lot of momentum today due to the increased driving force towards industrial implementation of electrochemical approaches in the electronics fabrication. Thin anodic oxide films of valve metals (Al, Hf, Ta, Ti, Nb, Zr) have shown remarkable performances as memristive elements. Exceeding most limits of conventional memory technology, the memristors are mainly recognized as resistive random access memories (ReRAMs), the data storage being related to a non-volatile change in the material resistance. The switching between a high resistance state (HRS) and a low resistance state (LRS) depends on the selection of electrodes and active (oxide) layers. This generally impacts the conductive pathways (filaments) formation, which is mediated by oxygen vacancies and/or cations, and their field-activated movement inside the oxide. Even though for research purposes the synthesis of such oxide layers is commonly done by atomic layer deposition or sputtering, the electrochemical anodization process should not be neglected. This is a faster, less complex and inexpensive method, with precise composition and oxide thickness control through electrochemical parameters. The value of this approach is clearly emphasized by its continuous industrial implementation in various sectors.

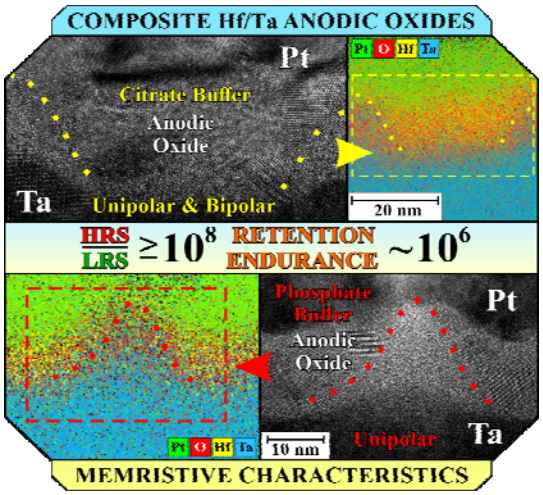

Fig. 1 Anodic memristor grown on Hf/Ta wedge library showing intrinsic nanostructuring of the mixed oxide.

It was already demonstrated that the performance of many anodic memristors obtained from pure valve metals can be improved by carefully selecting the anodization electrolyte or other electrochemical parameters [1-3]. These play a crucial role in positioning and sizing of conductive filaments within the oxide. This approach

directly leads to defect-engineered memristors fabrication, which is nowadays a major motivation for investigating devices based on mixed oxides formed in different electrolytes. Predicting the position and shape/thickness of a conducting filament may eventually lead to enhanced device stability and resistive states control.

The current work is focused on the behaviour of anodic memristors grown from ultra-thin Hf superimposed on Ta films as illustrated in **Fig. 1** [4-6]. The main idea linked to the control of resistive filaments is based on the particularities of the anodization process, when the interface between both oxides is dynamically changing. In situ oxide self-nanostructuring is already known for various superimposed valve metals, including Hf and Ta. Their anodization leads to nanoscale oxide columns ("fingers") formation, when a metal producing a more resistive oxide is superimposed on a metal producing a less resistive one. This phenomenon results from the ionic current preferring the less resistive paths, enhancing the growth of the correspondent oxide. In the current work, anodization of Hf/Ta system leads to this effect since HfO2 is the more resistive oxide. The boundary between Hf and Ta oxides may influence the conductive pathways required for the memristive effect, thus being most relevant for fabrication of highly stable and forming-free memristors. Additionally, the use of superimposed films with gradient but complementary thicknesses allows investigating the ideal Hf/Ta ratios for which the best memristive behavior is obtained. Additionally, the characteristics of the Hf-Ta-based composite memristors are compared to the ones obtained from anodization of Hf-Ta combinatorial libraries. The co-sputtering of Hf and Ta leads to a mixture of the parent metal alloy which is anodized in a final step. This approach leads to a different behavior of the memristors, due to their mixed oxide nature. However, an intrinsic defect engineering process was identified by the composition of the parent metal alloys, where crystalline Hf oxide clusters were embedded in an amorphous Ta oxide matrix.

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Nanostructured composite coatings fabricated by advanced laser processing to target resistant superbugs

Rodica CRISTESCU[1], Irina Gabriela NEGUT[1], Anita Ioana VISAN[1], Gabriela Corina DORCIOMAN[1], Consuela Elena MATEI[1], Dan Eduard MIHAIESCU[2], Marcela POPA[3], Carmen Mariana CHIFIRIUC[3,4], Roger J. NARAYAN[5], Douglas B. CHRISEY[6]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA
[2]Faculty of Applied Chemistry and Materials Science, Department of Organic Chemistry "Costin Nenitescu," University "Politehnica" Bucharest, 1-7 Polizu Street, Bucharest, RO-011061, ROMANIA
[3]Research Institute of the University of Bucharest–ICUB, University of Bucharest, 90-92 Panduri Road, RO-050657, Bucharest, ROMANIA
[4]Faculty of Biology, Microbiology-Immunology Department, University of Bucharest, 91–95 Splaiul Independenței Street, Bucharest, RO-050095, ROMANIA
[5]Joint Department of Biomedical Engineering, University of North Carolina, Chapel Hill, NC 27599, and North Carolina State University, Raleigh, NC 27695, USA
[6]Department of Physics and Engineering Physics, Tulane University, 6823 St. Charles Avenue, New Orleans, LA 70118, USA

Corresponding author: rodica.cristescu@inflpr.ro

Antimicrobials are effective treatments that target a variety of disease-causing microorganisms, including fungi, bacteria, viruses, and parasites. Many of these treatments have become ineffective in recent years as “superbug” pathogens have evolved and acquired resistance to the available antimicrobials. The growth of antimicrobial resistance (AMR), which contributes to almost five million deaths per year, has deepened the demand for the rapid discovery of novel antimicrobial agents. Herein, we report on the successful fabrication of nanostructured composite coatings consisting of nanoencapsulated antimicrobial peptides in mesoporous biopolymeric/magnetic nanoparticles via the Matrix Assisted Pulsed Laser Evaporation (MAPLE) technique as a potential therapeutic strategy to fight the emerging antimicrobial resistant threat. The characterization of the nanocoatings included SEM, AFM, and TEM to evaluate the coating uniformity and nanoparticle shape; chemical investigation of the target starting materials and coatings was performed by FT-IR to validate the functional groups and chemical bonding. The antimicrobial activity was evaluated on ESKAPE "superbug" pathogens in planktonic and biofilm growth states using culture-dependent qualitative and quantitative methods. The cyto and biocompatibility of the obtained composite nanocoatings were also investigated. These studies indicate that the mesoporous biopolymeric/magnetic nanoparticle composite nanocoatings that were deposited using MAPLE are biocompatible and able to release the nanoencapsulated antimicrobial peptides in an active form. These coatings may be used to eradicate drug-resistant biofilm-associated nosocomial infections associated with medical implants, medical devices, and other biomaterials.

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Simple and doped biological hydroxyapatite coatings with antimicrobial activity: a step forward to preliminary *in vivo* testing

Liviu DUTA[1], George E. STAN[2], Valentina GRUMEZESCU[1], Gabriela DORCIOMAN[1], Geanina POPESCU-PELIN[1], Irina ZGURA[2], Johny NEAMTU[3], Florin MICULESCU[4], Ali Oguz ER[5], Carmen CHIFIRIUC[6]

[1]National Institute for Lasers, Plasma and Radiation Physics, Magurele, 077125, ROMANIA
[2]National Institute of Materials Physics, Magurele, 077125, ROMANIA
[3]Faculty of Pharmacy, University of Medicine & Pharmacy, Craiova, 200349, ROMANIA
[4]Faculty of Materials Science and Engineering, Politehnica University of Bucharest, Bucharest, 060042, ROMANIA
[5]Department of Physics and Astronomy, Western Kentucky University, Bowling Green, KY 42101, USA
[6]Department of Microbiology, Faculty of Biology, University of Bucharest, Bucharest, 060101, ROMANIA

Corresponding author: liviu.duta@inflpr.ro

We report on the synthesis by Pulsed Laser Deposition of simple and doped hydroxyapatite (HA) coatings derived from rich, renewable, and cheap biological resources (i.e., animal and fish bones, and/or sea-shells – BioHA). The impact of various doping agents on the physical-chemical, mechanical, and biological properties of the structures was evaluated. Following validation through *in vitro* tests, the BioHA coatings were preliminarily investigated *in vivo*, by insertion into rabbits' femoral condyles.

Morphological investigations revealed rough and irregular surfaces, which were demonstrated to facilitate a good adhesion of cells and anchorage of implants in-situ. Structural analyses demonstrated that the synthesized BioHA coatings consisted of a hexagonal HA phase. Compositional examination indicated the presence of trace elements commonly found in the composition of bone mineral phase, along with a quasi-stoichiometric target-to-substrate transfer. This is consistent with the inherent biological nature of the pristine materials. The IR spectra highlighted the main bands characteristic of phosphate groups, which corresponded to a HA-type structure. Furthermore, following just three days of immersion in simulated body fluid, the IR spectra exhibited a remarkable growth of a biomimetic apatitic layer. This was indicative for a high biomineralization capacity of the synthesized coatings. The inferred bonding strength adherence values were superior to the threshold imposed by international standard that regulate coatings for load-bearing implants. The synthesized layers demonstrated low cytotoxicity on osteoblast cell lines, corroborated with a prolonged antimicrobial biofilm activity. The bone density measurements of the functionalized implants, conducted at either 4 or 9 weeks, revealed values superior to those of the control group. The inferred detachment force values for the functionalized implants were ~2 times higher than those recorded for the control group. When referring to longer implantation time periods, the extraction test results revealed enhanced bonding strength values (~5 times higher) for the functionalized implants compared to identical structures corresponding to a 4-week implantation period.

The combined characteristics of these bioinspired HA materials, corroborated with their low-cost fabrication from sustainable sources, could recommend them as suitable alternatives to synthetic HA for the fabrication of the next generation of implant coatings.

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Two photon polymerization of SU-8 scaffolds for cancer research: cell motility aimed at understanding cancer invasiveness

Alexandra BRAN[1], Stefana OROBETI[1,2], Florin JIPA[1], Emanuel AXENTE[1], Livia Elena SIMA[2],Felix SIMA[1,3], Koji SUGIOKA[3]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA
[2]Institute of Biochemistry of Romanian Academy, 296 Splaiul Independentei, sector 6, Bucharest, 060031, ROMANIA
[3]RIKEN Center for Advanced Photonics, 2-1 Hirosawa, Wako, Saitama 351-0198, JAPAN

Corresponding author: alexandra.bran@inflpr.ro, felix.sima@inflpr.ro

Cell interaction with tumor environment strongly influences cancer metastasis, supporting cancer cells spreading and migration to distant tissues. Melanoma cancer cells are known to exhibit a higher motility on collagen-coated substrates as compared to non-functionalized surfaces. We demonstrated that both spreading area and cellular velocity of melanoma A375 cancer cells are increased on collagen-coated cover glass (Fig. 1(a)) as compared to bare cover glass (Fig. 1(b)).

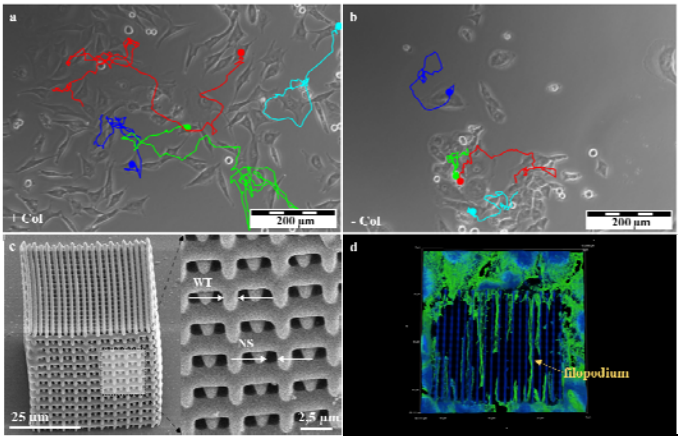

Fig. 1 Time-lapse microscope images of A375 melanoma cancer cell motility on (a) collagen-coated cover glass vs (b) bare cover glass, with an increased spreading area for treated substrate. (c) Scanning electron microscope images of SU-8 scaffolds, with narrow space (NS) and scanning line width (WT) parameters shown. (d) NS acts as confined space for invasiveness studies, where multiple filopodia are observed to penetrate into the scaffold

Further, two-photon polymerization (TPP) of a negative tone SU-8 photoresist was employed to achieve 3D polymeric scaffolds with micrometric dimensions to mimic architectural tumor micro-environment and to evaluate cancer cell invasive potential. In this study, a Nanoscribe Photonic Professional platform which employs a femtosecond laser beam was used to build 50×50×50 μm^3 scaffolds in SU-8 photoresist (Fig. 1(c)). The polymerized line (WT) and the narrow space (NS) between two adjacent lines were adjusted by varying the scanning speed and laser power in order to create porous structures with sub-micrometric dimensions. We detected that melanoma cancer cells are then capable to develop multiple filopodia that unidirectionally penetrated the scaffold (Fig. 1(d)). By quantifying the invasive behavior of filopodia penetrating the polymeric pores we correlate cancer cell motility in unrestricted environment with cell invasiveness potential in confined spaces under physiologically and architecturally relevant conditions.

Oxide thin films obtained on large areas through PLD

Mihai SOPRONYI[1], Nicu SCARISOREANU[1], Valentin ION[1],
Mihai ZAMFIR[1], Luiza STINGESCU[1], Florin ANDREI[1]

[1]INFLPR, 409 Atomistilor Street, Magurele, RO-077125, ROMANIA

Corresponding author: mihai.sopronyi@inflpr.ro

Oxide thin films were fabricated on large Si (100) substrates, with diameters of either 100 mm (4 inches) or 200 mm (8 inches), utilizing a Pulsed Laser Deposition (PLD) technique under optimized conditions, which included an O_2 partial pressure of 0.1 mbar or a high vacuum environment, alongside varying substrate temperatures ranging from 500°C to 800°C. Profilometric and spectrometric ellipsometry analyses confirmed that the resultant coatings exhibited a uniformity within 1σ for 90% of the substrate surface, with deviations maintained below 3%. Comprehensive characterization of the thin films was conducted using techniques such as tribo-nano-indentation, X-Ray Diffraction (XRD), Scanning Electron Microscopy (SEM), and Energy-Dispersive X-ray Spectroscopy (EDX). Additionally, the distinctive configuration of the deposition apparatus (Solmates SMP 800) facilitated the production of thin films characterized by a notably low cluster density in their morphology. This attribute renders the films applicable across a diverse spectrum of uses, encompassing mechanical and corrosion-resistant coatings, insulators, capacitors, catalytic processes, and absorptive applications.

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Optical modulator based on surface plasmon resonance structure containing As_2S_3 film

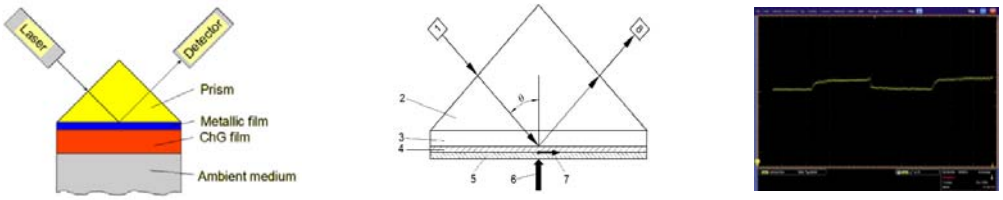
Aurelian POPESCU, Dan SAVASTRU

National Research and Development Institute for Optoelectronics INOE 2000, 409 Atomistilor str., Magurele, RO-077125, ROMANIA

Corresponding author: apopescu@inoe.ro

There is a large interest for metal-insulator structures as they support surface plasmon-polariton resonance (SPR) which may confine the light near surface at dimensions shorter than the wavelength. This phenomenon led very soon to the development of plasmonic sensors, the results being particularly impressive in the case of the biological selective sensors [1]. Chalcogenide amorphous films like As_2S_3 used in SPR configuration has been proposed as promising media for active plasmonic devices [2].

This report proposes the investigation of the light reflectance for a four layers SPR structure. The structure includes: coupling prism made of BK7 glass (1) – metal film made of gold (2) – amorphous As_2S_3 film (3) – air (4) (**Fig. 1**a). The amorphous As_2S_3 film due to high refractive index of 2.5 constitutes plasmonic waveguide which may support several modes depending on thickness. Numerical simulations for the reflectivity R(angle) are provided in MATLAB by using Jones-matrix formalism. As the calculations shown, for some As_2S_3 film thicknesses specific waveguide mode can be resonance coupled. Due to strong interaction the light intensity is absorbed and the reflectance R is near zero. For example, for As_2S_3 films with thickness of 600 nm only TM4 mode can be coupled but TM1, TM2, TM3 can't. The resonance angle changes are large, up to one degree for quite small 1% change of the amorphous film refractive index.



a) b) c)

Fig.1. Characteristics of four layers SPR structure: **a)** SPR structure; **b)** 1- prism, 2 - immersion oil, 3 - grass slide, 4 - gold film 5 - As_2S_3 amorphous film, 6 - irradiation beam; 7 - generated surface wave; **c)** experimentally measured changes of light reflectance due to film irradiation.

An experimental setup corresponding to theoretical structure was mounted as shown in **Fig. 1**b. The polarized laser beam 1 of He-Ne laser was directed to the glass coupling prism 2 made BK7. The polarization of the laser corresponds to TM modes. The plasmonic chipset consists of a glass slide 3 on the front of which thin gold film 4 (50 nm thickness) was deposited by e-beam sputtering. Over the gold film, an amorphous chalcogenide As_2S_3 film 5 was deposited by thermal evaporation in vacuum. This chipset was attached with the back side to the BK7 prism by using immersion oil (not shown) with the refractive index equal to the prism refractive index. Optically, the glass slide 3 forms with the prism 2 a single component called "prism" in the theoretical model of **Fig. 1**a.

The reflection beam of He-Ne laser was monitored by photodetector 8 during the irradiation by CW, 514 nm argon laser. The green laser beam of power 30 mW was modulated by shutter. The signal on the oscilloscope has the shape presented in **Fig. 1**c. The DC intensity of the reflected signal keeps the value even after the irradiation has stopped. The DC intensity can be restored by irradiation with perpendicular polarization. The proof of concept of new class of photonic modulator/memory based on SPR structures containing amorphous As_2S_3 films was experimentally demonstrated.

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Gas sensing investigations using polyaniline-coated chemoresistive sensors exposed to electron beam irradiation

Felicia IACOB[1,2], Ana-Maria POPA[1,2], Andrei STOCHIOIU[1,2], Luiza-Izabela TODERAŞCU[1], Oana GHERASIM[1], Vlad-Andrei ANTOHE[2], Elena MANAILA[1], Gabriela CRACIUN[1], Gabriel SOCOL[1], Iulia ANTOHE[1,3,*]

[1]National Institute for Laser, Plasma and Radiation Physics (INFLPR), Atomiştilor Street 409, 077125 Măgurele, Ilfov, Romania
[2]Faculty of Physics, Research and Development Center for Materials and Electronic & Optoelectronic Devices (MDEO), University of Bucharest, Atomiştilor Street 405, 077125 Măgurele, Ilfov, Romania
[3]Academy of Romanian Scientists (AOSR), Ilfov 3, 050094 Bucharest, Romania

*Corresponding authors: iulia.antohe@inflpr.ro; gabriel.socol@inflpr.ro

In this research work, the effect of different doses of electron beam irradiation on the gas sensing properties of polyaniline (PANI) film-based chemiresistor-type sensors for methane (CH_4) sensing applications has been reported. The PANI sensing film was synthesized by the chemical oxidative polymerization method directly onto the sensor gold-interdigitated electrodes [1]. The obtained PANI-coated sensors were firstly used to detect CH_4 concentrations ranging from 1 to 100 ppm and afterward were subjected to electron beam irradiation at the irradiation doses of 50, 100, 150, 200 and 250 kGy. Irradiation was performed in atmospheric conditions and at room temperature of 25°C using the electron linear accelerator of 5.5 MeV, ALID 7 from the National Institute for Laser, Plasma and Radiation Physics, Magurele, Romania [2]. The nominal values of the electron beam parameters were: energy of 5.5 MeV, peak current of 130 mA, output power of 134 W, pulse duration of 3.75 μs and pulse repetition frequency of 50 Hz [3]. The irradiated PANI-coated sensors were subsequently employed to detect the same CH_4 concentrations. Hence, sensor performance parameters (i.e. sensitivity, limit of detection, response time, recovery time, etc.) for all prepared samples were determined.

Moreover, the structural and morphological properties of these PANI films were also characterized by scanning electron microscopy (SEM) and X-ray photoelectron spectroscopy (XPS) measurements before and after electron beam irradiation. In conclusion, the effect of electron beam irradiation causes both chain scission and cross-linking processes in PANI, dependent on the irradiation dose, affecting further the sensor performance parameters.

Keywords: polyaniline, conductive polymer, chemiresistive gas sensors, electron beam irradiation

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Creation of a versatile platform for gamma imaging and medical applications based on electron acceleration at ELI-NP

Ovidiu TESILEANU[1], Georgiana GIUBEGA[1,2], Yoshihide NAKAMIYA[1], Liviu NEAGU[1,2], Madalin ROSU[1], Gabriel COJOCARU[1,2], Andrei BERCEANU[1], Alexandru BALACEANU[3], Madalina DOBRE[3], Ioana FIDEL[1,5], Flanish D'SOUZA[1], Edward HERMANN[6], Marian NEAGU[6], Monica MIREA[6], Florin NEGOITA[1,3], Laura NITA[4], Jian Fuh ONG[1], Stefan POPA[1], Vanessa PHUNG[1], Mihai RISCA[1], Gabriel SULIMAN[4,1], Lucian TUDOR[1], Adrian VODA[1], Catalin VANCEA[3], Mihai IOVEA[6]

[1] Extreme Light Infrastructure – Nuclear Physics, "Horia Hulubei" National R&D Institute for Physics and Nuclear Engineering (IFIN-HH), 30 Reactorului Street, Magurele, Romania

[2] CETAL, National Institute for Lasers, Plasma and Radiation Physics, Magurele, Romania

[3] Department of Nuclear Physics, "Horia Hulubei" National R&D Institute for Physics and Nuclear Engineering (IFIN-HH), 30 Reactorului St., Magurele 077125, Romania

[4] POLITEHNICA Bucuresti, Physics Department, 060042 Bucharest, Romania

[5] ISDS, University of Bucharest, 36-46 Bd Elisabeta, Bucharest, 050107, Romania

[6] AccentPro2000 SRL-R&D Company, 25A Marasesti St., Magurele 077125, Ilfov, Romania

Corresponding author: ovidiu.tesileanu@eli-np.ro

The Extreme Light Infrastructure – Nuclear Physics (ELI-NP) facility in Romania has begun operation as a user facility, and the laser-wakefield acceleration of electrons (LWFA) [1, 2] opens the perspective for experiments relevant in both fundamental science and applications [3], raising interest among the users. The extremely short duration of the gamma pulses generated through Bremsstrahlung from the LWFA electrons, translating into high gamma photon flux and dose rate, enables, industrial imaging and tomography of moving objects and the study of FLASH effects on biological cells irradiated at ultra-high dose rates [4].

We will present the first steps taken at ELI-NP, at the 100TW and 1PW laser pulse output power levels, in the development of a flexible platform for the applications of LWFA electrons in the imaging and medical fields. These include the design, construction and experimental testing of setups for electron acceleration, electron beam conditioning, Bremsstrahlung photon sources and irradiation of biological cells.

The preliminary results from experiments include the gamma ray imagining application and the tests of a proof-of-concept magnetic lens assembly for accelerated electrons.

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Investigating the impact of proton beams on human cancer cells using Geant-4 DNA simulation

Tatiana TOZAR[1,2], Cristina MARIN[1], Andi Sebastian CUCOANES[1], Violeta IANCU[1]

[1] ELI-NP, "Horia Hulubei" National Institute for Physics and Nuclear Engineering, 30 Reactorului street, Magurele, RO-077125, ROMANIA

[2]National Institute for Laser, Plasma, and Radiation Physics, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: tatiana.tozar@eli-np.ro

Cancer incidence remains a significant global health challenge, with an increasing need for advanced treatment options to improve patient outcomes. Proton beam therapy has emerged as a promising treatment option, providing increased precision in targeting tumours while reducing damage to surrounding healthy tissues. Understanding the effects of radiation on human cells is critical for improving treatment protocols, maximizing therapeutic benefits, and ensuring the long-term health of cancer patients after therapy. Accurate simulations, like those provided by Geant-4 DNA, are critical for understanding the complex interactions between proton beams and sub-cellular structures.

This study is focused on the investigation of the effects of proton beams with energies ranging from 150 keV to 60 MeV on human fibroblast cells. Fibroblasts are fundamental in maintaining tissue structure and function, making them a suitable cell type for studying the radiation response. The Geant4-DNA toolkit was employed for simulating cancer cell geometries, integrating accurate representations of the physical, physicochemical, and chemical stages occurring post-irradiation, including radiolytic processes. The output of the simulation was the quantification of early DNA damage, such as single and double strand breaks. These damages arise from energy deposition or DNA interaction with free radicals. The results for DNA double strand breaks are in good agreement with experimental data and previously published simulation data. In addition, the results of the simulations yield parameters easy to be compared with experimental data, such as survival curves or number of gH2AX foci.

In conclusion, the presented research underlines the important role of Geant-4 DNA simulations in clarifying the complex interactions between protons and human cells. It reveals dose-response relationships, highlighting potential patterns in the cellular damage inflicted by protons across a broad energy spectrum. These findings can contribute to a broader understanding of radiation effects on biological systems, with implications for medical applications and safety regulations.

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Coherent transition radiation imaging of the high intensity focused laser pulses

Constantin DIPLASU[1], Razvan UNGUREANU[1], Georgiana GIUBEGA[1,2], Gabriel COJOCARU[1,2], Septimiu BALASCUTA[2]

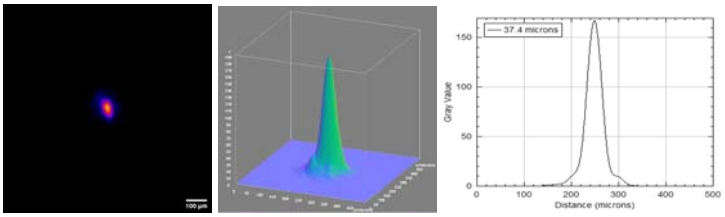
[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

[2]IFIN-HH, ELI-NP department, 30 Reactorului, Măgurele, 077125, Romania

Corresponding author: constantin.diplasu@inflpr.ro

Coherent Transition Radiation (CTR) is emitted when relativistic electron beams, accelerated by an intense laser pulse focused on a solid target, exit from the solid target into vacuum [1]. One of the very interesting aspects of CTR is that it allows to measure the transverse size of the electron bunches, in the few micrometers regime, by imaging (in the far field) the source target. Hence, **it allows to directly measure the high-intensity laser pattern from which the electrons are born**.

Laser pulses with energy in the range 1.4 ÷ 5.1 J (in the laser bay) were used to produce CTR from the rear surface of relatively thick targets: Aluminium 70 μm thick foils and Titanium 25 μm thick foils. Focal spot classically measured with an optical microscope is presented in **Fig. 1** and a few examples of CTR images obtained from Al targets at various laser energies are presented in Fig. 2.



(a) (b) (c)

Fig. 1. Focal spot classically measured with the focus microscope (a) Image of the focal spot; (b) 3D spatial profile of the focal spot; (c) 2D profiles of the focus on two orthogonal directions

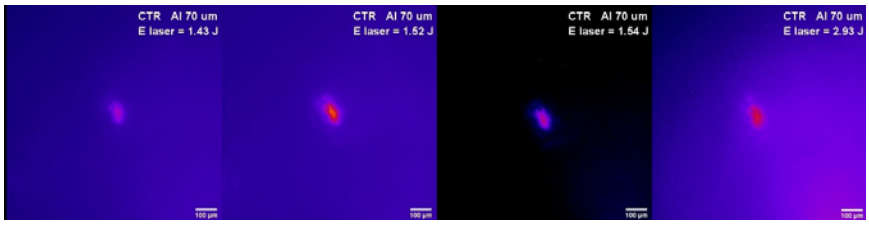


Fig. 2. CTR images recorded from Al foil at various laser energies

One can easily observe that the focus (measured at low energy) and CTR profiles are very similar, which demonstrate that CTR imaging could be considered a reliable method to directly measure the high-intensity laser focuses at full power.

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Symposium of High Power Lasers Network

Simulating the focusing of laser-plasma accelerated particle beams

Laura Anamaria NIȚĂ[1], Michaela ARNOLD[2], Cătălin M. TICOȘ[1,3]

[1]National University of Science and Technology Politehnica Bucharest, Splaiul Independentei no. 313, RO-060042, Bucharest, Romania

[2]Institut fur Kernphysik, Technische Universitat Darmstadt, Schlossgartenstr. 9,64289 Darmstadt, Germany

[3]Extreme Light Infrastructure - Nuclear Physics (ELI-NP), "Horia Hulubei" National Institute for Physics and Nuclear Engineering (IFIN-HH), 30 Reactorului Street, RO-077125 Bucharest-Măgurele, Romania

Corresponding author: laura_anamaria.nita@upb.com

The interest in laser-plasma accelerated particle beams with potential application in the biomedical field is rapidly growing [1, 2]. The future use of such beams greatly depends on the development of specially designed focusing and beam transport systems that can control the delivery of the beam with a predefined set of parameters [3]. Some of the main issues that need to be addressed, particularly for the case of ultra-short accelerated hadrons, are the broad energy spectrum and the high angular divergence.

Here we present simulation-based studies which aim to understand the focusing effects of various beam steering elements such as coils, dipoles, quadrupoles and their combinations on laser-plasma accelerated particle beams. The proposed beamline configurations are being analyzed in terms of collection efficiency by varying the position, dimension and geometry of the magnetic elements, as well as the mean focusing distance and profile of the beam.

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Qualification of spiral phase plates for high power laser systems

Vicentiu IANCU[1,2], Razvan UNGUREANU[3], Cristina GHEORGHIU[1], Ioan DANCUS[1], Dan MATEI[1], Daniel URSESCU[1,2]

[1] Extreme Light Infrastructure (ELI-NP) & Horia Hulubei National Institute for R & D in Physics and Nuclear Engineering (IFIN-HH), Str. Reactorului No.30, 077125, Magurele, Romania
[2] Faculty of Physics, University of Bucharest, Magurele, 077125, Ilfov, Romania
[3] Center for Advanced Laser Technologies (CETAL), National Institute for Laser, Plasma and Radiation Physics (INFLPR), Str. Atomistilor No.409, 077125, Magurele, Romania

Corresponding author: vicentiu.iancu@eli-np.ro

The application of light beams exhibiting Orbital Angular Momentum (OAM), commonly known as optical vortices (OV), has led to notable progress in various fields, such as optical metrology and the exploration of new interactions between light and matter. Despite the emergence of several techniques for generating and detecting structured light beams, including those with OAM, accurately characterizing these beams—especially in terms of their amplitude, wavefront, and mode content—remains a challenging and unresolved issue.

The high-power laser system (HPLS) at ELI-NP [1] will be able to produce focused intensities of up to few $I_0 \sim 1\times10^{23}\mathrm{Wcm}^{-2}$. Therefore, increase availability and access to such spatially and temporally ultra-intense laser solutions provides an opportunity to produce and inevitable to implement in any experiment optical vortices.

In this research, we introduce a method for precisely measuring full aperture phase discontinuities using a Shack-Hartmann wavefront sensor and an optical profilometer, as illustrated in **Fig. 1**. OV beams were generated by employing spiral phase plates (SPPs), already used in the first user experiments campaign at ELI-NP [2]. The wavefront was characterized by measuring the transmitted or reflected wavefront with the detector positioned in the relay imaging plane across a 70mm aperture, utilizing a flat mirror with a central hole.

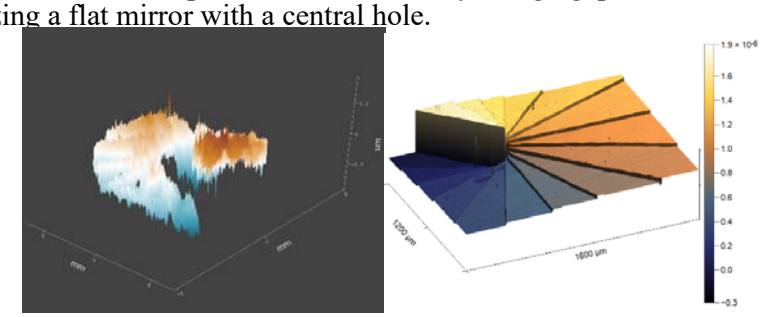

Fig. 1 (Left) Measured 3D full-aperture (80.64 mm x 108.96 mm) helical wavefront produced by a 6" spiral phase plate with topological order ℓ=1) with a high resolution wavefront sensor, and (Right) real-time profilometer measurement of a 10 mm^2 x 10 mm^2 optical profile image after data post-processing.

The experimental setup demonstrated the capability to distinguish between the 16 steps of the helical phase plate, and reconstruct the low order aberrations introduced by the wavefront. The obtained results were combined with measurements from a non-contact optical profilometer, thus offering an alternative to conventional measurement methods.

The approach based on the characterized large aperture helical phase plate make possible continuous operation of HPLS to deliver hollow ultra-short laser pulses [2], for ion acceleration experiments [3].

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Betatron oscillations in LWFA with periodic plasma density profile

Rareș IOVĂNESCU[1,2], Radu P. DAIA[2], Emil I. SLUSANȘCHI[2], Cătălin M. TICOȘ[1,2]

[1] Extreme Light Infrastructure – Nuclear Physics, 'Horia Hulubei' National Institute for Physics and Nuclear Engineering, Măgurele-Bucharest, Romania

[2] Politehnica University of Bucharest, Bucharest, Romania

Corresponding author: rares.iovanescu@eli-np.ro

Laser wakefield acceleration (LWFA) has proved to be a reliable mechanism for accelerating electrons to GeV-order energies over a distance of few cm [1]. Moreover, it is widely used also as an x-rays and gamma rays generator [2,3]. The transversal oscillations of electrons in the bubble are called betatron oscillations and the flux of photons emitted constitute the betatron radiation.

We use 2D PIC simulations to investigate the betatron oscillations in a periodic plasma density profile using a laser with intensity $4\times10^{21}W/cm^2$ and a spot with diameter 25μm. We a take sinusoidal variation for the plasma profiles such as $7\times10^{18}(1+0.3*\sin(2\pi x/x_0))cm^{-3}$, with x_0 either 40 μm or 60 μm, $2\times10^{18}(1+0.5*\sin(2\pi x/x_0))cm^{-3}$, $6\times10^{18}(1+0.6*\sin(2\pi x/x_0))cm^{-3}$, with x_0=100 μm. The variable size of the bubble causes a change of the total ionic charge inside it, leading to a variation in the acceleration of the electrons, whose maximum energies are sampled at 250 fs intervals. An image of the bubble is presented in **Fig. 1** where we can see the injection of electrons and their subsequent oscillations. The impact of the plasma profile on the betatron oscillations is investigated while we compute the average radiated power, the total radiated energy, the critical energy and the wiggler strength parameter.

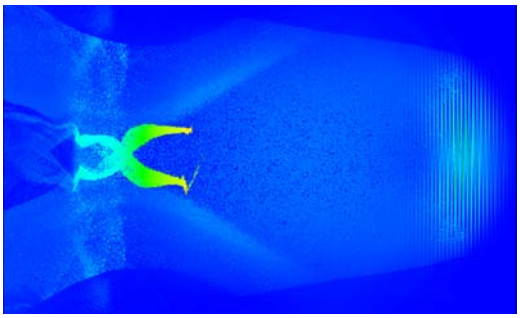

Fig. 1 The bubble obtained for a plasma density $2e^{18}(1+0.5*\sin(2\pi x/x_0))cm^{-3}$ after 900fs and with x_0=100μm, shows a strong injection of electrons which perform high amplitude betatron oscillations.

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Solving Ill-posed inverse problems with physics-informed neural networks for the understanding and control of tokamak plasmas

Riccardo ROSSI[1], Michela GELFUSA[1], Teddy CRACIUNESCU[2], Ivan WYSS[1] and Andrea MURARI[3,4], on behalf of JET Contributors* and WPTE team[§]

[1]Department of Industrial Engineering, University of Rome "Tor Vergata", Via del Politecnico 1, 00133, Rome, Italy
[2]National Institute for Laser, Plasma and Radiation Physics, Magurele-Bucharest, Romania
[3]Consorzio RFX (CNR, ENEA, INFN, University of Padova, Acciaierie Venete SpA), C.so Stati Uniti 4, 35127 Padova, Italy
4Istituto per la Scienza e la Tecnologia dei Plasmi, CNR, Padova, Italy
[*] See the author list of "Overview of T and D-T results in JET with ITER-like wall" by CF Maggi et al. to be published in Nuclear Fusion Special Issue
[§]See the author list of "Progress on an exhaust solution for a reactor using EUROfusion multi-machines capabilities" by E. Joffrin et al. to be published in Nuclear Fusion Special Issue: Overview and Summary Papers from the 29th Fusion Energy Conference (London, UK, 16-21 October 2023)

Corresponding author r.rossi@ing.uniroma2.it

Traditionally, in thermonuclear fusion the methods utilised to analyse the data, to formulate hypotheses, or to develop models suffer from a fundamental dichotomy: they are based on either numerical simulations or purely data-driven tools. The results of both approaches have substantial drawbacks when investigating complex systems such as tokamak plasmas. Physics-informed neural networks (PINNs) are a new machine learning approach, explicitly conceived to combine both previous knowledge in mathematical form (for example established theories or conservation laws) and experimental data in the same model building process. More technically, PINNs are a specific type of universal function approximators, which can include in the learning process the knowledge of any physical laws governing the process described by the given database. PINNs can therefore alleviate the limitations of both the accuracy of the laws and the quality of the data, exploiting their synergy.

Advanced diagnostic techniques in tokamak reactors are fundamental to understand the physics, validate models, develop new ones, and advance and implement control strategies for correct execution of the discharges. Unfortunately, many diagnostics rely on the external measurement of the plasma variables, requiring the solution of severely ill-posed inverse problems to obtain information about local internal quantities. The lack of local internal measurements implies that the nuclear fusion scientific community had to develop strategies to reconstruct the local variables by using advanced inversion techniques. This is the case of the magnetic topology, the tomographies, the video cameras and the neutron spectra. However, traditional inversion techniques are usually limited by various assumptions that are required to render the inversion algorithms stable and reliable. Unfortunately, these hypotheses are true as first approximations at best, while if one is interested in extracting more physically meaningful information, more detailed reconstruction should be performed.

This contribution introduces a novel approach, employing PINNs for the solution of the aforementioned delicate inversion problems. The authors propose innovative solutions to enhance the accuracy of existing methods by incorporating physics-based models, adopting multi-diagnostics approaches, and employing time-resolved reconstructions. The developed learning algorithms provide better generalization capability (including transfer from one experimental setting to another) and better capability to handle data sparsity (low amount of training examples) and can be applied to some of the major issues of the tokamak configuration such as disruptions and plasma wall interactions.

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Neural networks for turbulent transport prediction in a simplified model of tokamak plasmas

Ligia Maria POMÂRJANSCHI[1,2], Dragoș Iustin PALADE[1,2]

[1] National Institute for Laser, Plasma and Radiation Physics, 409 Atomistilor street, Magurele, RO-077125, ROMANIA
[2] Faculty of Physics, University of Bucharest, 405 Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: ligia.pomarjanschi@inflpr.ro

We explore the method of using neural networks (NNs) for turbulent transport prediction in a simplified model of tokamak plasmas [1]. The NNs are trained on a database obtained via test-particle simulations of a transport model in the slab-geometrical approximation. The database consists of a five-dimensional input of transport model parameters and the radial diffusion coefficient as output [2]. The structural details of the method are presented below, in Fig. 1.

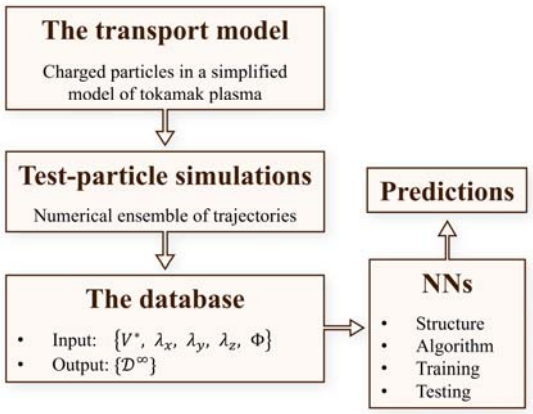

Fig. 1 Schematic preview of the NN building components and structure of the approach used in this work.

The NNs display fast and efficient convergence, a validation error below 2%, and predictions that are in excellent agreement with the real data, obtained orders of magnitude faster than test-particle simulations. In comparison to a spline interpolation, the NN outperforms, exhibiting better predicting and extrapolating capabilities. We demonstrate the preciseness and efficiency of this method as a proof-of-concept, establishing a promising approach for future, more comprehensive research on the use of NNs for transport predictions in tokamak plasmas.

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A perturbative description of photoionization, electron angular distribution and spin polarization. Application: C III ion

Cristian IORGA[1], Viorica STANCALIE[1]

[1]National Institute for Laser, Plasma, and Radiation Physics, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: iorga.cristian@inflpr.ro

This work presents an extended Fano model [1] incorporating multiple discrete quasi-bound levels within the continua in conjuncture with the density matrix formalism [2] to provide the differential photoionization cross section and spin polarization of photoelectrons. The aim of this approach is to provide a simple, yet efficient, implementation of discrete-continuum configuration interaction method as an improvement over the independent processes and isolated resonances approximation [3-5]. The basis wave functions describing the structure of C III ion are constructed using a single model-potential based on the Dirac-Fock-Slater iteration and the free electron states are calculated within distorted-wave approximation by using the Flexible Atomic Code [6]. The present results are necessary for understanding the different contributions of closely-lying initial energy levels to photoelectron spectra and total yield in the case of photoionization with ultra-short laser pulses.

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W dust synthesis by sputtering in Deuterium dominated discharges

Tomy ACSENTE[1], Cornel STAICU[1], Veronica SATULU[1], Gheorghe DINESCU[1]

[1]National Institute for Laser, Plasma and Radiation Physics, 409 Atomistilor str., Magurele, RO-077125, ROMANIA

Corresponding author: tomy@infim.ro

Magnetron sputtering combined with gas aggregation (MSGA) is a plasma-based technique for the synthesis of nanoparticles based on condensation in an inert gas flow (Ar) of the metallic vapours obtained from a magnetron discharge [1]. In this work, we will present the synthesis by MSGA of W nanoparticles (W NPs) in a discharge dominated by a light gas like D_2 mixed with small amounts of Ar and air. Synthesis of the W NPs in such experimental conditions may be relevant for processes where tungsten material is in contact with plasmas, specifically in fusion applications. Thus, in nuclear fusion reactors, tungsten is the material used for the divertor [2]. W dust is expected to occur [3] when the divertor is operated in a plasma detached regime, obtained by injecting small amounts of inert gases in the discharge [4]. In our study, we point to the influence of the MSGA process parameters over the W dust synthesis rate, morphology (SEM results), chemical composition (XPS results) and D retention (by TDS-thermal desorption spectrometry). The following process parameters are varied: D_2/Ar ratio (17:3, 9:1 and 19:1), the aggregation length (75-135 mm), the power applied to discharge (70-130 W), and the amount of air injected in discharge (0.5-10 %). SEM images reveal for all samples that the W dust consists of agglomerates (30-90 nm) of W NPs (6-20 nm). These dimensions depend on the experimental conditions. Both the synthesis rate and the D retention depend mainly on the D_2 content in discharge and the aggregation length. It is important to note that D retention increases when the experimental conditions lead to a decrease in the W dust synthesis rate. These observations suggest that fuel retention can have significant values when nanometric dust of W is produced, even at very low concentrations of Ar in the discharge. Also, the intentional introduction of residual amounts of air in the discharge led to a counterintuitive increase in D retention. This suggests a possible stimulation of the nuclear fuel incorporation in the W dust when it is accompanied by the interaction with air, due to unwanted but possible leaks in the fusion reactor main chamber [5].

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Synthesis and modelling of Sm^{2+} doped phosphors in luminescent solar concentrator devices

Lucas Johannes Bartel ERASMUS[1], Jacobus Johannes TERBLANS[1], Hendrik Christoffel SWART[1]

[1]University of the Free State, 205 Nelson Mandela Drive, Park West, Bloemfontein, 9300, SOUTH AFRICA

Corresponding author: erasmuslb@ufs.ac.za

This study evaluates the use of phosphor materials in luminescent solar concentrators (LSCs). An LSC is a device used as a large-area solar radiation collector that converts and emits radiation and directs the radiation to photovoltaic cells located on the small side area of the device. Fig. 1 (a) illustrates that a basic LSC consists of a transparent waveguide with embedded luminescent material and a strategically placed photovoltaic cell on the edge. The large area of the waveguide collects a portion of the solar radiation, while the luminescent material absorbs this energy and reemits it at longer wavelengths. Internal reflection directs the emitted photons towards smaller areas on the sides where the photovoltaic cells are used to convert the concentrated radiation into electricity. This results in a concentration of solar energy with a resulting geometric gain since a large collection area is coupled to a limited photovoltaic cell area [1].

a) b)

Fig. 1 (a) Edge-on schematics explaining the basic principle of a luminescent solar concentrator. (b) Image of the optimised device excited with ultraviolet radiation.

For this study, strontium borate doped with samarium and europium was considered for incorporation into a polystyrene waveguide [2]. Fig. 1 (b) shows the resulting LSC device under ultraviolet excitation. The optical properties of the device were characterised by using setups that allowed the study of the intensity and angle of the light exiting from the edges of the device under different excitation positions and angles. These results agreed with the data obtained from a ray-tracing model that was developed using the geometrical and optical properties of the optimised device [3]. Modelling estimates the optical efficiency of this device at 1.3 % (λ_{ex} = 325 nm).

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Complex oxide-based thin films for photoelectrochemical water-splitting applications

Florin ANDREI[1], Valentin ION[1], Ruxandra BIRJEGA[1], Nicu Doinel SCARISOREANU[1]

[1]National Institute for Laser, Plasma and Radiation Physics, Magurele, Bucharest, Romania, Fotoplasmat Center (C400) and Laser Department, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: florin.andrei@inflpr.ro

Photocatalysis is considered the key of solving energy generation and environmental pollution problems since it can use sunlight. Perovskites are intensively studied as photocatalysts, for several reactions including the water splitting reaction. Adjusting the intrinsic structural, topographical and stoichiometric properties through various ways is used for improving the photoelectrochemical (PEC) activity of complex oxide materials. Here, we present the fabrication of perovskite thin films via PLD and their photoelectrochemical performances as a function of the layer's thickness and deposition pressure. The variation of the structural parameters with the film's thickness and oxygen content of epitaxial $LaFeO_3$ (LFO) thin films, together with the appearance of self-assembled nanodomains for film's thicknesses higher than 14 nm, is highlighted. The strain induced in the material structure appears as an effect of the discrepancy between the lattice constants of the material and the substrate. Using Nb:$SrTiO_3$ as conductive substrate and 0.5 M NaOH aqueous solution for PEC measurements, the dependence of the photocurrent density and the onset potential on the structural, topographical and optical features exhibited by the photoelectrodes based on complex oxides are carried out by means of the X-ray diffraction, high-resolution transmission electron microscopy and ellipsometry. The potentiodynamic PEC analysis has revealed the highest photocurrent density $J_{photocurrent}$ values (up to 1.2 mA/cm^2) with excellent stability over time, for the thinnest LFO/Nb:$SrTiO_3$ sample prepared at 0.6 mbar O_2, both cathodic and anodic behavior being noticed. The photocurrent density can be further improved by using a multilayer photoelectrode based on LFO and BFO materials. Most importantly, perovskite-based thin films show unbiased hydrogen evolution from water, as determined by gas chromatography under constant illumination.

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Transparent and black zinc oxide thin films growth through oxygen control in the pulsed electron beam deposition method

Magdalena NISTOR[1], Florin GHERENDI[1*], Daniela DOBRIN[1], Jacques PERRIERE[2,3]

[1]National Institute for Lasers, Plasma and Radiation Physics, (INFLPR), 409 Atomistilor street, Magurele, RO-077125, ROMANIA

[2] Sorbonne Universités, UPMC Univ Paris 06, UMR 7588, INSP, F-75005, Paris, France

[3] CNRS, UMR 7588, INSP, F-75005, Paris, France

Corresponding author: *florin.gherendi@inflpr.ro; magda.nistor@inflpr.ro

The Pulsed Electron Beam Deposition (PED) is an ablation plasma deposition technique that can be used for the growth of complex composition thin films, grace to the stoichiometric transfer of elements from a target to the film. PED has some similar features with the commonly used Pulsed Laser Deposition (PLD) but, while PLD uses a nanosecond UV laser, PED uses a polyenergetic intense pulsed electron beam, having enough energy to melt, vaporize and ablate, generating an ablation plasma from the target. A particularity of the PED method consists in the facile tuning of the deposition parameters (gas pressure and energy of the species), allowing the control of the films composition, morphology, thickness, and physical properties [1].

As a thin film, zinc oxide is a n-type transparent semiconductor, which has attracted substantial research in recent years. Due to its physical and chemical properties, it can be used for various applications, such as solar cells, optoelectronic devices, gas sensors, photocatalysis, etc. Although transparent and crystalline zinc oxide films can be obtained by the most part of the growth methods, black and amorphous zinc oxide films are not usually observed and investigated.

In this work we report on the investigation of PED obtained black ZnO thin films in comparison to the transparent ones, in terms of composition, structure, electrical, optical and near-surface properties, as a function of the oxygen deficiency [1]. The films were grown at 300º C on c-cut sapphire single crystal substrates, using a slight variation of argon pressure in PED from 9×10^{-3} mbar (LP) to 2×10^{-2} mbar (HP). These growth conditions lead to the formation of amorphous oxygen deficient ($ZnO_{0.85}$) black thin film in the LP case, and crystalline, stoichiometric (ZnO) and transparent films in HP conditions. Both films present structural disorder (amorphous vs. polycrystalline) and high densities of carriers, leading to a temperature-dependent resistivity behaviour that is characteristic to disordered metal oxide systems. Due to the oxygen deficiency, the black ZnO thin films present an enhanced absorption in the visible and near-infrared spectrum, which enables the extension of their range of applications from transparent electronics to solar absorbers and photocatalysis.

Acknowledgement: This work was supported by Romanian Ministry of Research, Innovation and Digitization under National Core Program LAPLAS VI – contract no. 16/201 and National Core Program LAPLAS VII – contract no. 30N/2023-2026

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Formation of controllable diffusion barrier layer on the surface of polydimethylsiloxane films by infrared laser irradiation

Hung Quoc TRAN[1], Asad ur REHMAN[2], Philippe FIOUX[1], Aissam AIROUDJ[1], Thierry VANDAMME[2], Valeriy LUCHNIKOV[1]

[1]IS2M - Institut de Science des Matériaux de Mulhouse, CNRS LRC 7361, 68057 Mulhouse, France.

[2]INSERM, Regenerative Nanomedicine UMR 1260, Centre de Recherche en Biomédecine de Strasbourg (CRBS), Université de Strasbourg, F-67000 Strasbourg, France

Corresponding author: valeriy.luchnikov@uha.fr

Developing diffusion barrier layer on material interfaces has potential applications in various fields like packaging materials, pharmaceuticals, chemical filtration, microelectronics, medical devices. Although numerous physical and chemical methods have been proposed to generate the diffusion barrier layer, the complexity of fabrication techniques and high manufacturing costs limit their practical utility. Here, we propose an innovative approach to fabricate the diffusion barrier layer by irradiating poly(dimethylsiloxane) (PDMS) with a mid-infrared ((λ=10.6μm) CO2 laser. This process directly creates a diffusion barrier layer on the PDMS surface by forming heavily crosslinked network in the polymer matrix. The optimal irradiation conditions were investigated by modulating the defocusing distance, laser power, and number of scanning passes. The barrier thickness can reach up to 70 μm as observed by scanning electron microscope (SEM). The attenuated total reflectance (ATR), electron dispersive X-ray (EDX), and X-ray photoelectron spectroscopy (XPS) analyses collectively confirmed the formation of the SiOx structure on the modified surface, based on the decreased methyl group signal, and the increased oxygen/silicon ratio. The diffusion test with the model drugs (Rhodamine B and Donepezil) demonstrated that the modified surface exhibits effective diffusion barrier properties and that the rate of drug diffusion through the modified barrier layer can be controlled by optimization of the irradiation parameters. This novel approach provides the possibility to develop a controllable diffusion barrier layer in a biocompatible polymer with perspective applications in the fields of pharmaceuticals, packing materials, and medical devices.

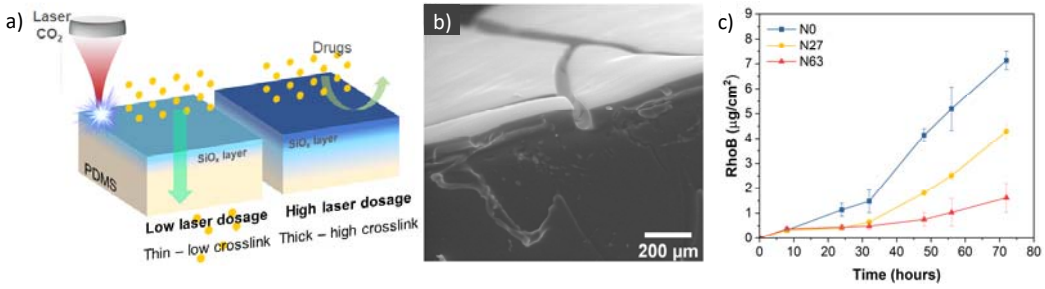

Fig. 1 a) Schematic representation of diffusion barrier layer, b) SEM image of the barrier layer interface on sample N45 c) Cumulative diffusion of Rhodamine B through the diffusion barrier layer (N0, N27 and N63)

Acknowledgement: This research was funded by the French National Research Agency (ANR) through the LABRICON project (Grant number ANR-20-CE19-0006).

POSTER PRESENTATIONS

Topic 1. Fundamentals, diagnostics and modelling in laser, plasma and radiation physics

Wave propagation modeling: An approach using geometrical optics

Alexandru CRACIUN[1,2]

[1]National Institute for Laser, Plasma and Radiation Physics, Laboratory of Solid-State Quantum Electronics, Atomistilor 409, Magurele 077125, Ilfov, Romania
[2]Doctoral School of Physics, University of Bucharest, Atomistilor 405, Magurele 077125, Ilfov, Romania

Corresponding author: alexandru.craciun@inflpr.com

Ray-Tracing is mostly used nowadays for the design and optimization of optical systems as well as for short-distance propagation through reflective/refractive optical elements. For long-distance propagation in free-space, physical optics is often preferred as the influence of diffraction effects becomes more pronounced, also strong aberrations lead to the formation of caustics and interference between the waves originating from different parts of the beam. However, the numerical complexity in physical optics simulations is *nlogn* due to the usage of fast Fourier transforms, whereas it is *n* for geometrical optics-based simulations [1]. Physical optics simulations often require dense sampling for non-collimated beams [2] or in the presence of significant aberrations. In this presentation, a wave propagation model based on geometrical optics, capable of handling interference effects, will be introduced together with its advantages and disadvantages in comparison with physical optics models.

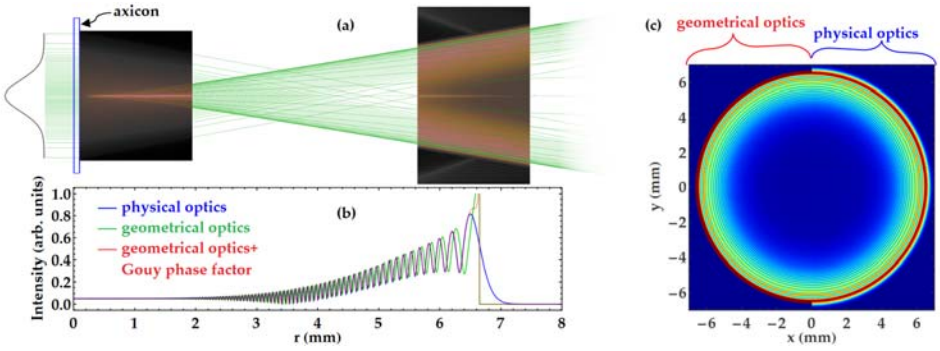

Fig. 1 **(a)** Propagation of the Gaussian beam (mm) longitudinal view. **(b)** Radial intensity profile of the beam at 500 mm from the axicon that was computed using physical optics (blue), geometric optics (green), and geometrical optics considering the additional Gouy phase along the ray. **(c)** Transverse profile of the beam at 500 mm from the axicon both physical optics (right) and geometrical optics (left).

The presented example involves a rounded-tip axicon with a physical angle of 2 degrees. Axicons produce a conical superposition of waves, forming a Bessel beam in the near field and a ring-shaped beam in the far field (**Fig. 1**). Manufacturing an ideal axicon with a perfectly conical shape is not possible. The rounded tip of practical axicons acts as a lens, scattering the waves and creating an interference pattern. The wave propagation modeling program can detect instances where radiation scattered from different regions of the input plane falls on the same point on the output plane, allowing for the coherent addition of these waves. A novel aspect in our approach is the identification of a Gouy phase variation along the ray, determined from geometrical optics related quantities. This phenomenon occurs when the beamlet associated with a ray traverses a focal point.

This work was financed by the Romanian Ministry of Research, Innovation and Digitization, Program NUCLEU - LAPLAS VII 30N/2023.

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The efficiency of spherical solid target compression via multiple laser beams.

Alexei ZUBAREV[1], Marina CUZMINSCHI[2] , Ana-Maria IORDACHE[3], Ștefan-Marian IORDACHE[3]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

[1]IFIN-HH, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

[3]INOE 2000, Atomistilor 409, Măgurele, 077125, România

Corresponding author: alxzubarev@gmail.com

Laser-driven controlled nuclear fusion is considered a good alternative to magnetic confinement-controlled fusion reactors because they are of the same safety level, are low-radiative, require a small amount of fuel, and can be an abundant energy source. In addition, inertial fusion reactors can be easily integrated into the existing energy distribution systems and are much more scalable [1]. The main task in the field of inertial fusion is to increase laser radiation transfer to nuclear fuel. Nanostructured targets significantly improve the performance of laser-driven installations [2].

In this work, we investigated different nanostructured targets and analyzed the confinement efficiency and target heating. Numerical simulations were implemented using the radiation-hydrodynamic software FLASH [3]. We put in evidence growing of instabilities in the target and their influence on the target confinement. We confirm that using a shell with a high atomic number significantly improves confinement efficiency and determine its optimal thickness. The result presented in this woek are obtained using numeriacal simulations.

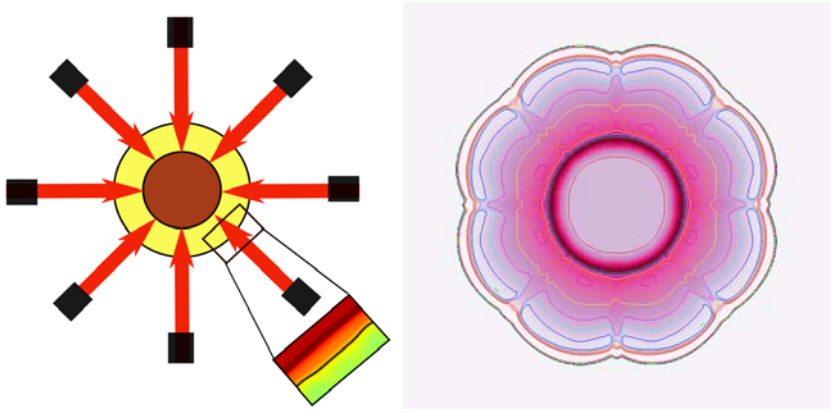

Fig. 1 Scheme of a typical targe for a direct laser-driven inertial fusion with nuclear combustion core and metalic shell. Inset pesents electron density distribution on the surface of metallic shell generated upon the laser infuluience. Black line corresponds to margin of critical density region (Left). Preplasma temperature and density distribution in the irradiated target (right).

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The analytical Fokker-Planck-Cattaneo model for ultra-short laser pulse heating of dielectrics

Mihai OANE[1], Claudiu HAPENCIUC[1], Gerarldine M. STANCIU[2], Cristian N. MIHĂILESCU[1], Natalia MIHĂILESCU[1], Dolis L. CRISTINA[2]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA
[2]"Prof. Dr. Alexandru Obregia" Clinical Psychiatric Hospital, 10-12 Berceni Str., Bucharest, Romania.

Corresponding author: mihai.oane@inflpr.ro

In the two-temperature model, firstly proposed by Anisimov [1], the thermal fields are usually defined by two-coupled diffusion equations describing the electron and phonon heat conduction, respectively. The two equations are connected by an "electron-phonon coupling constant" term. The classical model proposed by Fourier over 200 years ago in order to describe the conduction of heat turns out to fail in some situations that are more and more frequent nowadays, for example those that involve short heating periods or extremely low temperatures. Cattaneo introduced the thermal relaxation time in order to provide a model that generalizes the one by Fourier. This led to a hyperbolic equation for the temperature, introducing the idea of thermal waves and finite propagation time. Ultrafast thermal phenomena during femtosecond laser pulse heating of solids, first of all of dielectrics, were analytically developed using a new mathematical method based upon the two-temperature model via the Cattaneo approach. A straightforward but powerful mathematical formalism is proposed to evaluate the spatial and temporal profiles of electron temperature under the irradiation with a single Gaussian femtosecond laser pulse. An illustrative example was selected: a sapphire target under femtosecond laser pulse irradiation. The proposed model can be used to guide and design experimental activities, i.e. parameters optimization before conducting real-time experiments of ultra-short laser pulses - dielectrics interaction. The Cattaneo approach proved appropriate to describe the thermal field in laser-dielectrics interaction at intensities up to 10^{15} W/cm^2, as major relativistic effects usually occur for higher intensities. The applications domain is vast, extending from industry, medicine, fundamental research, to military utilizations. The present work could be considered a generalization from metal targets [2, 3] to dielectric one. In order to find out free electron density a Fokker-Planck model was applied. After that in order to solve the Cattaneo version of heat equation we used a state of the art method for partial derivative equations with boundary conditions. 3D thermal fields versus space-time are obtain and compared with the Fourier case applied to metals.

Acknowledgement: This research was supported by the Romanian Ministry of Research, Innovation and Digitization under Romanian National Core Program LAPLAS VII (NUCLEU) – contract no. 30N/2023.

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Time series analysis for fusion plasma disruption prediction studies

Teddy CRACIUNESCU[1], Andrea MURARI[2,3], Riccardo ROSSI[4], Michela GELFUSA[4] on behalf of JET Contributors* and the EUROfusion Tokamak Exploitation Team**

[1]National Institute for Laser, Plasma and Radiation Physics, Magurele-Bucharest, Romania

[2]Consorzio RFX (CNR, ENEA, INFN, University of Padova, Acciaierie Venete SpA), C.so Stati Uniti 4, 35127 Padova, Italy

[3]Istituto per la Scienza e la Tecnologia dei Plasmi, CNR, Padova, Italy

[4]Department of Industrial Engineering, University of Rome "Tor Vergata", Via del Politecnico 1, 00133, Rome, Italy

[*]See the author list of "Overview of JET results for optimising ITER operation" by J. Mailloux et al. published on Nuclear Fusion, 62 042026 (doi:10.1088/1741-4326/ac47b4)

[**]See author list of "Progress on an exhaust solution for a reactor using EUROfusion multi-machines capabilities" by E.Joffrin et al. to be published in Nuclear Fusion Special Issue: Overview and Summary Papers from the 29th Fusion Energy Conference (London, UK, 16-21 October 2023)

Corresponding author: teddy.craciunescu@inflpr.ro

Tokamak plasmas are very complex systems, from both a technological and physical point of view. They are kept well out of thermodynamic equilibrium by continuous injection of material and megawatts of power.

One of the major issues on the route of a commercial tokamak reactor is related to the various instabilities, which develop naturally and so far, unavoidably. Even relatively small instabilities can grow, interact and lead to a rapid loss of the stored thermal and magnetic energy. These rapid global collapses of the configuration are called disruptions and can cause harmful effects on the plasma facing components. Disruptions may also be accompanied by the generation of runaway electrons, which could also lead to severe accidents such as the melting of the first wall or leaks in water cooling circuits. Therefore, preventing disruptions or, at least, mitigating their detrimental effects is extremely important.

A series of methods based on the time series analysis of the main plasma diagnostic signals have been implemented to determine when significant changes in the plasma dynamics of the tokamak configuration occur, indicating the onset of drifts towards the plasma disruption. The dynamical changes can be detected by monitoring only global signals such as the plasma current or the locked mode amplitude. The evolution of dynamical measures like the embedding dimension, the recurrence properties or the transition to the chaotic regime may provide the necessary information to detect the onset of the process leading to disruptions. Abrupt changes of statistical properties of the measured data, associated with the onset of the processes leading to disruptions, can be detected also by using concept drift methods. These methods may help the identification of significantly more appropriate training sets for various kinds of disruption predictors. Some of these methods presented may also be implemented as stand-alone disruption predictors for real time deployment.

Acknowledgment: This work has been carried out within the framework of the EUROfusion Consortium, funded by the European Union via the Euratom Research and Training Programme (Grant Agreement No 101052200 — EUROfusion). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.

Investigation of electric arcs ignited by FOD for high power aeronautic conditions

Cathy ROND[1], Dunpin HONG[2], Hervé RABAT[2], Cyril VAN DE STEEN[3], Hugo MEUNIER[4], Thierry LEBEY[3]

[1]Institut Clément Ader, INSA Toulouse, CNRS UMR 5312, 3 rue Caroline Aigle, 31400 Toulouse, FRANCE
[2] GREMI, UMR 7344, CNRS, Université d'Orléans, 45067 Orléans, France
[3] SafranTech, Safran Group, 1 Rue louis Bélriot, 31702 Blagnac, France
ue louis Bélriot, 31702 Blagnac, France
[4]Safran Electronic and Power, Safran Group, 271 rue de Château Musset, 79180 Chauray

Corresponding author: dunpin.hong@univ-orleans.fr

For sustainability concerns, more electric aircrafts are being developed with the final goal of evolving towards all-electric aircrafts. As a consequence, aircrafts will use more electric power than current ones, requiring for example to operate at high DC voltage levels (>1 kV). These modifications lead to a higher risk of electric arc appearance, which can be dangerous [1]. Few works have reported arc study for DC conditions, especially for high power conditions [2], so prevention and detection of default arcs require a better understanding of their behavior.

This work reports investigations of DC electric arcs in high power aeronautic conditions for two supply voltages (800 V_{DC} and 540 V_{DC}), current intensities from 120 to 250 A and durations of about hundreds of ms. Figure 1 presents the experimental setup and illustrates the four different diagnostics that have been performed simultaneously. Electric arcs are ignited by a metal wire (Cu or Sn) simulating Foreign Object Debris (FOD) that shorts out two aluminum busbars separated by 5 mm.

Measurements of the current and voltage waveforms of the arc provide the electrical properties and the injected energy. Fast camera (Photron SA4) videos characterize the displacement and the elongation of the arc. Optical emission spectroscopy (Ocean optics HR2000CG–UV-NIR spectrometer) reports mainly the emission of metallic lines (Al, Cu and Ag) and few ionic lines (Al^+ and Ag^+) can be observed. Spectral radiation is obtained by using two joulemeters (XPLF12, from Gentec Electro-Optics) equipped with filters. First results report that the radiation is higher in the UV range. We observe that the radiative energy is proportional to the supplied electrical energy and represents about 30% of this injected energy.

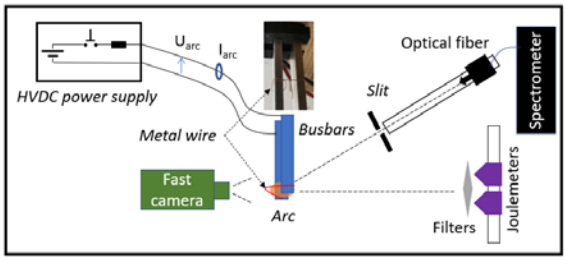

Fig. 1 Experimental set up (top view)

Acknowledgment: The authors thank Frédéric Canevet and Valentin Detambel (Safran SEP) for technical support and the French "Association Arc Electrique" for partial funding of this work.

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Identification of molecular tungsten ionic species in plasma by mass spectra fitting

Cristina CRACIUN[1,2], Silviu Daniel STOICA [1], Bogdana Maria MITU [1], Tomy ACSENTE [1], Gheorghe DINESCU [1,2]

[1] National Institute for Lasers, Plasma and Radiation Physics, 409 Atomistilor Str., 077125 Magurele, Ilfov, Romania;
[2] Doctoral School of Physics, Faculty of Physics, University of Bucharest, 405 Atomistilor Str., 077125 Magurele, Ilfov, Romania

Corresponding author: cristina.craciun@inflpr.ro

The identification of Tungsten species released from the W walls in plasma is of high interest for surface engineering and fusion technology. Herewith, we report mass spectrometry analysis of a magnetron sputtering plasma in contact with a tungsten surface and the development of a procedure for fitting mass spectra affected by instrumental limitations such as widening of peaks at high mass, superposition of adjacent peaks and peaks displacement on the mass scale. The presented procedure implied the determination of a peak profile function suitable to describe the shape of the experimentally recorded peaks, mass calibration, and simultaneously fitting of superposed peaks. We show that the peak shapes are well described by a convolution between a gaussian and a modified top-hat function. Representative mass spectra recorded from a plasma generated by a magnetron discharge with a W target in a mixture of hydrogen and argon, and in the presence of foreign gases as N_2 and O_2, for the mass range 170-250 amu, are presented in Figure 1.

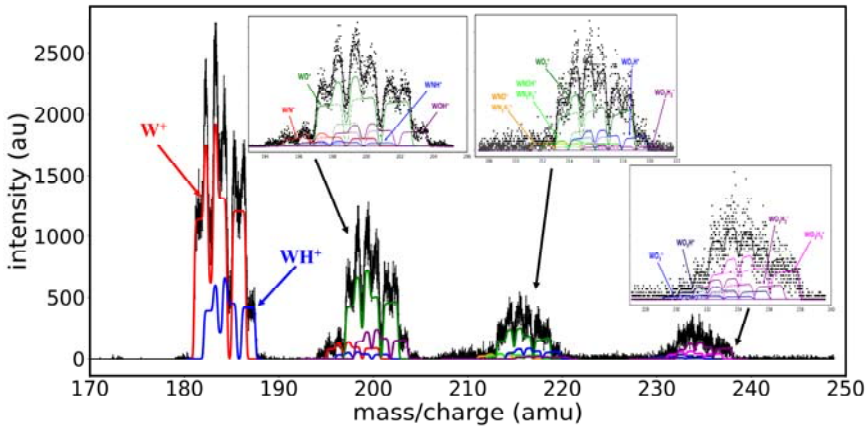

Fig. 1. Mass spectra of magnetron discharge with W target, generated in Ar/H_2 in presence of N_2 or O_2impurities, recorded in the mass region 170 – 250 amu: black points and lines - experimental data, colored lines – fitting results

We identified and reported for the first time [1,2] a diverse variety of tungsten molecular ionic species having the form $WH_xN_yO_z^+$ (x=0-3; y=0-2; z=0-3). The occurrence of these species might significantly influence the Tokamak plasma modeling studies, species transport, and W dust formation in fusion and laboratory discharges.

Acknowledgment: This work has been carried out within the framework of the EUROfusion Consortium, funded by the European Union via the Euratom Research and Training Programme (Grant Agreement No 101052200 — EUROfusion). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.

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A laboratory platform for studying rotational dust flows in a plasma crystal irradiated by a 10 keVelectron beam

Dorina TICOS[1], Adrian SCURTU[1], Maria Luiza MITU[1], Corneliu POROSNICU[1], Catalin M. TICOS[1,2]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

[2]ELI-NP IFIN-HH, 30 Reactorului street, Magurele, RO-077125, ROMANIA

Corresponding author: dorina.toader@inflpr.ro

A laboratory platform [1] has been designed and built for the irradiation of a plasma crystal (PC) with an electron beam (e-beam) having an energy around 10 keV and a current of tens of milliamperes. The pulsed e-beam collimated to a few millimeter-size spot is aimed at a crystal made of dust particles levitated in a radio-frequency (RF) plasma. The platform consists of three vacuum chambers connected in-line, each with different utility: one for generating free electrons in a pulsed hollow anode Penning discharge, another for the extraction and acceleration of electrons at ≈ 10 kV and for focusing the e-beam in the magnetic field of a pair of circular coils [2], and the last one for producing PCs above a RF-driven electrode. The main challenge is to obtain both a stable e-beam and PC by insuring appropriate gas pressures, given that the e-beam is formed in high vacuum (10^{-4} Torr), while the PC is produced at much higher pressures (10^{-1} Torr). The main diagnostics include a high speed camera, a Faraday cup and a Langmuir probe. One application concerned with the creation of a pair of dust flow vortices by the drag force of the e-beam acting on the strongly coupled dust particles are presented. The dust flow can become turbulent as demonstrated by the energy spectrum, featuring vortices at different space scales.

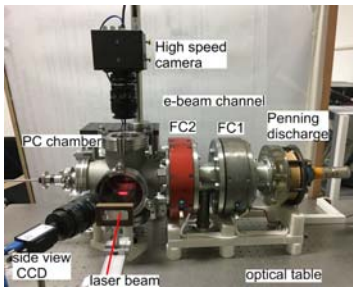

Fig. 1 The laboratory platform for studying rotational dust flows in a PC irradiated by a ≈ 10 keV

Acknowledgment: The authors acknowledge the support from the Ministry of Research, Innovation and Digitization from contract PN LAPLAS VI,VII 16N, 30 N (2018-2023).

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Manipulation of microparticle in radio-frequency (RF) plasma

Maria Luiza MITU[1], Dorina TICOŞ[1], Nicoleta UDREA[1], Adrian SCURTU[1], Corneliu POROŞNICU[1], Cătălin Mihai TICOŞ[1, 2]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

[2]IFIN-HH, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: maria.mitu@inflpr.ro

The experimental study of the rotation and stability of clusters consisting of varying numbers (5, 9, 10) of micron-sized, charged dust particles suspended in a horizontal plane was conducted in an inductively coupled dusty plasma. In our experiment, a pulsed electron beam with an energy ranging from 9 to 13 keV was used to rotate and manipulate the dust clusters [1,2]. The cluster is strongly coupled, confined within a potential well, and restrained to move in a circular path by the electron beam [3]. The action of the electron drag force induces the increasing of the cluster rotation speed with the energy of the electron beam. The rotational properties such as cluster radius, the angular velocity and the unwrapped rotational angle of each dust particle are investigated. The rotation patterns are found to depend, on the number of microparticles, crystal structure and electron beam energy. Intershell rotation appears for the 9 microparticle cluster at a beam energy between 10 and 12 keV, while for an electron beam energy of 13 keV the stick-slip effect appears and a metastable state of the dust cluster can be observed for a short period of time. For the 10 microparticles cluster the intershell effect is limited for a 10 keV electron beam. When increasing the electron beam energy up to 12 keV, the 10 microparticles cluster exhibits a stick-slip effect between shells. The angular velocity increases linearly as the electron beam energy increases for the outer particles in the cluster, while for the inner particles the angular velocity increases irregularly in time.

Acknowledgement: This research was supported by Romanian Ministry of Research, Innovation and Digitization under Romanian National Nucleu Program LAPLAS VII, Contract No. 30N/2023.

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Stretching and compression of double dusty plasma vortex

Adrian SCURTU[1], Nicoleta UDREA[1], Dorina TICOŞ[1], Maria Luiza MITU[1], Catalin Mihai TICOŞ[1,2], Corneliu POROŞNICU[1]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

[2]IFIN-HH, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: nicoleta.udrea@inflpr.ro

The numerous applications that complex plasmas target (astrophysics, plasma fusion [1], industry [2], etc.) are driving up interest in them. This paper describes an experimental study of a crystal that levitates in an RF plasma and interacts with a gas jet. The crystal has two vortexes made of spherical microparticles. The neutral pushing force causes the crystal to be displaced in the direction of the jet propagation while retaining its vortex structure. The crystal shift also involves a change of its shape, especially at the level of the two vortexes. One vortex is stretched, and the other one is compressed. The crystal's length remains relatively constant at 12 ± mm throughout all three phases of shape modification, which is due to the preservation of ion drag forces and electric forces. The orderly structure of the crystal lasts until the particles begin to fall on the bottom electrode. The changing of the vorticity in the crystal regions can be attributed to the neutral push force [3].

Acknowledgement: This research was supported by Romanian Ministry of Research, Innovation and Digitization under Romanian National Nucleu Program LAPLAS VII, Contract No. 30N/2023.

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Intense pulsed plasma jets to split CO_2

Adrian SCURTU[1], Dorina TICOS[2], Corneliu POROSNICU[1], Maria Luiza MITU[1], Constantin DIPLASU[1], Nicoleta UDREA[1], Catalin Mihai TICOS[1]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: adrian.scurtu@inflpr.ro, dorina.toader@inflpr.ro

The coaxial gun was utilized to produce a pulsed plasma discharge in order to investigate the splitting of CO_2 [1]. The voltage applied ranged from 1 to 2 kV, while the peak discharge current varied between 7 and 14 kA. The plasma was propelled from the gun at a speed of a few kilometers per second, with electron temperatures ranging from 11 to 14 electron volts and peak electron densities of approximately 2.4 x 10^21 particles per cubic meter. A series of spectroscopic measurements were conducted on a plasma plume generated at pressures ranging from 1 to 5 Torr, which revealed the presence of oxygen and CO, resulting from the dissociation of CO2. The observation of more intense spectral lines and the emergence of new oxygen lines, as a result of higher discharge current, suggests the presence of more dissociation channels as it can be seen in figure 1.

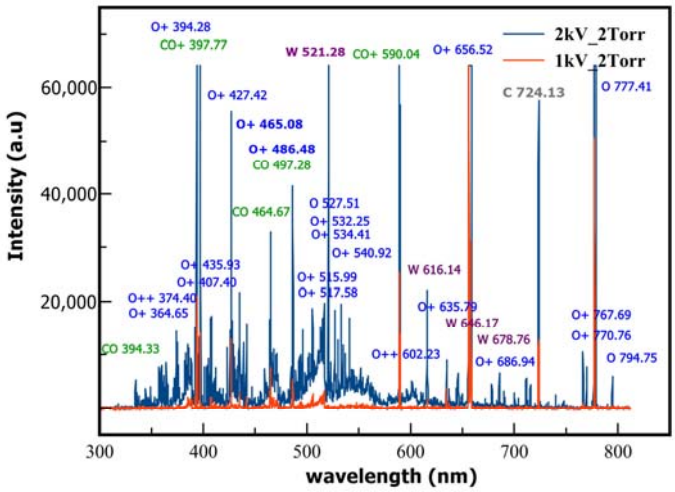

Fig. 1. Full emission spectra captured for two discharge voltages, 1 kV (in red) and 2 kV (in blue), at a CO_2 pressure of 2 Torr [1].

The main candidate mechanism of molecules dissociation is direct electron impact. Estimates of dissociation rates are made based on the measured plasma parameters and interaction cross-sections available in the literature. The potential application of this technique was explored for future Mars missions, where the coaxial plasma gun running in the atmosphere could produce oxygen at a rate of over 100 g/h in a highly repetitive regime.

Acknowledgment: This research was supported (or financed) by the Romanian Ministry of Research, Innovation, and Digitization under Romanian National Core Program LAPLAS VII—contract no. 30N/2023 and SUPERCELL—contract no. 734 PED/2022.

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The study of hydrogen isotopes retention and release in boron and boron/deuterium composite layer using an *ab initio* approach

Bianca-Georgiana ŞOLOMONEA[1,2], George-Alexandru NEMNEŞ[2,3,4], Călin-Andrei PANTIŞ-SIMUŢ[2,3,4], Paul DINCA[1], Corneliu STAICU[1,2], Corneliu POROŞNICU[1]

[1] National Institute for Laser, Plasma and Radiation Physics (INFLPR), Atomiştilor Street 409, 077125 Măgurele, Ilfov, Romania

[2] Faculty of Physics, University of Bucharest, Atomistilor 405, Magurele-Ilfov 077125, Romania

[3]Research Institute of the University of Bucharest (ICUB), Mihail Kogalniceanu Blvd 36-46, Bucharest 050107, Romania

[4]Horia Hulubei National Institute for Physics and Nuclear Engineering, Reactorului 30, Magurele-Ilfov 077125, Romania

Corresponding author: corneliu.porosnicu@inflpr.ro

Controlling the isotopes retention in fusion reactors, such as the proposed International Thermonuclear Experimental Reactor (ITER) is crucial for the operating regime, lifetime and conditioning of the reactor inner wall. The high affinity of boron with respect to certain elements, such as oxygen, nitrogen and carbon [1], makes it promising to be taken into account as plasma facing material (PFM). The boronization process is to be used in order to reduce the impurities from the residual gas and PFM's, and to lower the energy required for plasma ignition [2]. Here, the boron structures are studied from both the experimental and theoretical points of view. The activation energies of hydrogen isotopes for certain reactions, such as: diffusion, trapping and detrapping are determined.

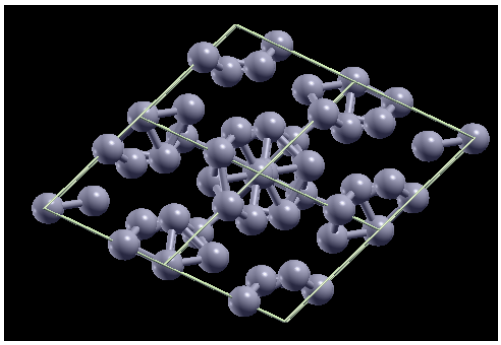

Fig. 1 The α-boron crystalline structure studied using density functional theory.

The structure of boron and boron-deuterium thin films, its electronic properties, and the molecular dynamics are determined by *ab-initio* calculations using the density functional theory (DFT) implemented in the SIESTA code. The boron properties were first determined by analyzing the periodic crystalline boron structure and ~~the~~ computations of the activation energies of hydrogen isotopes were performed. Supplementary, the Nudged Elastic Band (NEB) method was employed for a proper determination of the activation energies for the processes mentioned above. In addition, the amorphous boron is studied the results are correlated with the experimental ones.

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Quantum spectral model applied on the solar data investigation in 2.4-14 microns range for H-I

Diana-Rodica CONSTANTIN[1], Liliana PREDA[2], Mark RUSHTON[3],

Dumitru POPESCU[4], Valentin Ioan NICULESCU[5]

[1,3]INSTITUTUL ASTRONOMIC AL ACADEMIEI ROMANE, 5 Cutitul de Argint street, Bucuresti, RO-040557, ROMANIA

[2]UNIVERSITATEA POLITEHNICA BUCURESTI, 313 Splaiul Independentei street, Bucuresti, RO-060042, ROMANIA

[4]ISMMA, 13 Calea 13 Septembrie street, Bucuresti, RO-050711, ROMANIA

[5]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: ghe12constantin@yahoo.com

We work in frame of the quantum spectral model (QS-Model) for H-I spectrum [1]. The model is applied to the Brackett-Humphreys spectral series to theoretically establish the width of the multiplets and the wavelength position of the maximum of the spectral line in fine structure approximation [1-2] which gives the location of the multiplet lines. After that the results are validated using NIST database for which there are available data, i.e. for multiplets Brackett_1-2 and Pfund_1. Then we compare these results to data from ACE for these common multiplets (existing in both NIST/ACE databases). The QS-Model is applied to the rest of the multiplets in ACE and we make an estimate of the multiplet width and the position of the maximum peak in the spectral composition of the ACE multiplets. Futher, using this model, we perform an analysis of data in this range for solar observations that relate to the hydrogen spectral series in both the Bohr and fine structure approximations. Conclusions are given regarding the quality of solar spectral data.

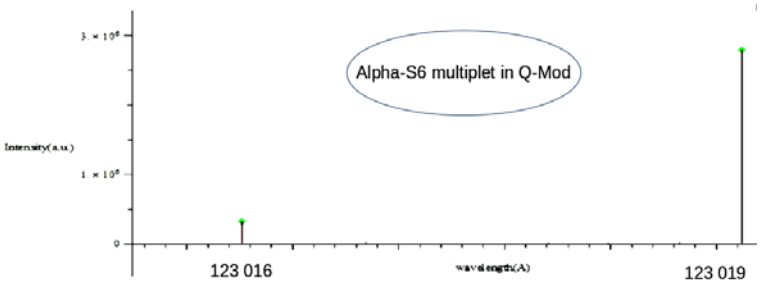

Fig. 1 A plot of H-I α-multiplet edges in fine structure approximation for the sixth spectral series in (λ,I)-space.

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Topic 2. Advances in optics, laser and photonics

Nd:LYSB as a new laser and nonlinear optical crystal grown by the Czochralski method

Lucian GHEORGHE[1], Alin BROASCA[1], Madalin GRECULEASA[1,2], Flavius VOICU[1], Stefania HAU[1], Cristina GHEORGHE[1], George STANCIU[1], Gabriela CROITORU[1], Nicolaie PAVEL[1]

[1]National Institute for Laser, Plasma and Radiation Physics, 409 Atomistilor, 077125 Magurele, Romania

[2]Doctoral School of Physics, Faculty of Physics, University of Bucharest, 405 Atomistilor, 077125 Magurele, Romania

Corresponding author: lucian.gheorghe@inflpr.ro

In the last years, the pursuit of new nonlinear optical (NLO) and/or laser crystals has attracted more and more interest in the scientific community, due to their key role in the emergence of optoelectronic and photonic technologies. Herein, we report on the crystal growth by the Czochralski method of a new NLO and laser $La_xY_yNd_zSc_{4-x-y-z}(BO_3)_4$ - Nd:LYSB borate crystal. Because of the incongruent melting of LYSB-type compounds, the growth by the Czochralski method is difficult and requires a compositional refinement of the starting melt composition, optimization of the growth parameters, and also the use of a particular thermal setup. Fig. 1a presents the photo of the Nd:LYSB crystal grown from the starting melt composition $La_{0.725}Nd_{0.05}Y_{0.475}Sc_{2.75}(BO_3)_4$. The grown crystal has a huntite-type structure (trigonal structure, space group *R32*), thus allowing $\chi^{(2)}$ effects. The chemical composition of the grown crystal was determined to be $La_{0.783}Nd_{0.039}Y_{0.354}Sc_{2.824}(BO_3)_4$, corresponding to an Nd^{3+} doping concentration of 3.9 at.%. The spectroscopic investigations were carried out at room and cryogenic (10K) temperatures. The best laser emission performances at 1.06 µm were obtained for a 2.45 mm thick crystal sample oriented perpendicular to the easy cleavage plane (101). The optical pumping was performed using a fiber-coupled laser diode with emission centered at 808 nm in the quasi-continuous-wave (quasi-CW) regime. The laser operated with a high slope efficiency (η_{sa}) of 0.63 when an extraction mirror with transmission T = 0.20 at 1.06 µm was employed (Fig. 1b). These preliminary results are very promising for a newly developed crystal, currently under development.

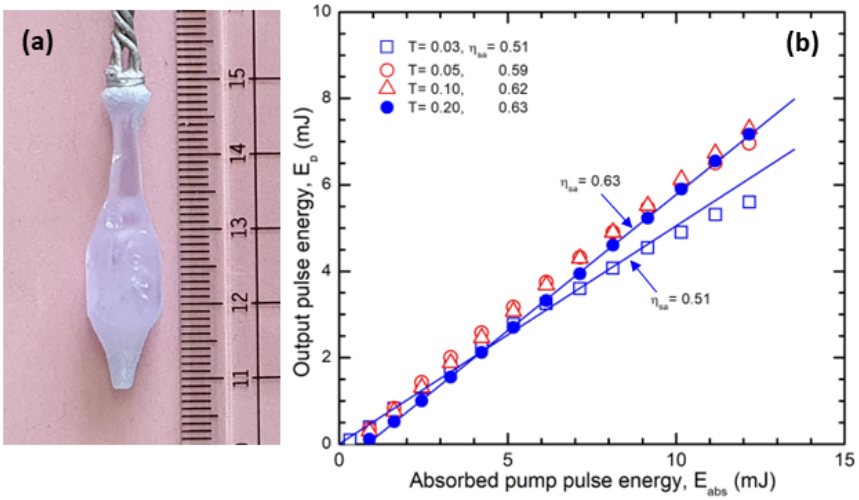

Fig. 1 Photo of the as-grown Nd:LYSB crystal (a) and quasi-CW laser emission performances at 1.06 µm of the Nd:LYSB crystal (b).

Acknowledgment: This work was financed by the Romanian Ministry of Research, Innovation and Digitization through project 30N/2023 within program NUCLEU-LAPLAS VII.

LGYSB:Nd - a new laser crystal with enhanced performance for high-efficiency laser applications in the near-infrared region

Alin BROASCA[1], Madalin GRECULEASA[1,2], Flavius VOICU[1], Stefania HAU[1], Cristina GHEORGHE[1], Gabriela CROITORU[1], Nicolaie PAVEL[1], Lucian GHEORGHE[1]

[1]National Institute for Laser, Plasma and Radiation Physics, 409 Atomistilor, 077125 Magurele, Romania
[2]Doctoral School of Physics, Faculty of Physics, University of Bucharest, 405 Atomistilor, 077125 Magurele, Romania

Corresponding author: alin.broasca@inflpr.ro

Three incongruent melting $La_wNd_xGd_yY_zSc_{4-w-x-y-z}(BO_3)_4$ - LGYSB:Nd crystals, with different Y concentrations (z = 0.15, 0.05, and 0.025) and the same Nd doping concentration of 5 at.% (x = 0.05) in the starting compounds, have been grown by the Czochralski method, for the first time to our knowledge. The grown crystals shared the same optimal growth parameters, namely a pulling rate of 2 mm/h and a rotation rate of 8 rpm. Figure 1a shows the best quality grown crystal. The LGYSB:Nd-type crystals exhibit an acentric structure similar to that of the natural mineral huntite $CaMg_3(CO_3)_4$, with space group *R32*. The composition of the LGYSB:Nd_3 (z = 0.025) crystal grown from the starting melt composition $La_{0.628}Gd_{0.547}Y_{0.025}Nd_{0.05}Sc_{2.75}(BO_3)_4$ was measured by ICP-MS method and it was found to be $La_{0.6794}Gd_{0.4105}Y_{0.0178}Nd_{0.0381}Sc_{2.8542}(BO_3)_4$. The optical transmission spectrum was measured in the range of 200 - 2000 nm. The absorption cross-section at 808 nm in σ-polarization was determined to be 1.18×10^{-19} cm^2 for the LGYSB:Nd_3 crystal. The 10K absorption spectra revealed that Nd^{3+} ions occupy only La^{3+} cationic sites in the LGYSB host matrix. The emission cross-section at 1064 nm in σ-polarization was determined to be $\sigma_{em}(\sigma) = 1.74 \times 10^{-19}$ cm^2 for LGYSB:Nd_3 crystal. The fluorescence lifetime was found to be τ = 115 μs for all the LGYSB:Nd crystals. The LGYSB:Nd_3 laser operated at the emission wavelength of 1062 nm with very high slope efficiencies of η_{sa} = 0.74 (**Fig. 1**b) and η_{sa} = 0.64 (**Fig. 1**c) in quasi-cw and cw regimes, respectively.

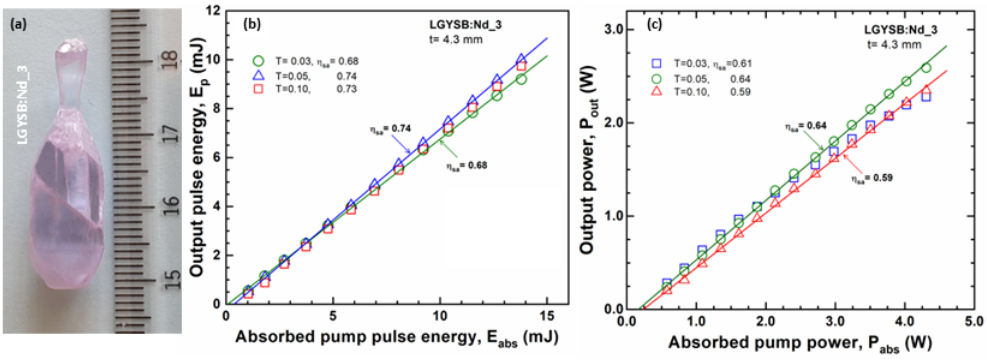

Fig. 1 As-grown LGYSB:Nd_3 crystal (a), laser pulse energy, E_p versus absorbed energy of the pump pulse, E_{abs}, and (c) output power, P_{out} versus absorbed pump power, P_{abs} for LGYSB:Nd_3 crystal. The near-field distribution of the laser beam is shown in the figure inset, at the highest output level.

Acknowledgment: This work was financed by the Romanian Ministry of Research, Innovation and Digitization, through project 30N/2023 within program NUCLEU LAPLAS VII.

Crystal growth and characterization of Nd:LGSB as bifunctional laser and nonlinear optical crystals

Madalin GRECULEASA[1,2], Alin BROASCA[1], Flavius VOICU[1], Cristina GHEORGHE[1], Stefania HAU[1], George STANCIU[1], Catalina-Alice BRANDUS[1], Nicolaie PAVEL[1], Lucian GHEORGHE[1]

[1]National Institute for Laser, Plasma and Radiation Physics, 409 Atomistilor, 077125 Magurele, Romania
[2]Doctoral School of Physics, Faculty of Physics, University of Bucharest, 405 Atomistilor, 077125 Magurele, Romania

Corresponding author: madalin.greculeasa@inflpr.ro

Currently, many researches are focused on the development of new bifunctional laser and nonlinear optical (NLO) or on improving existing ones based on new concepts. Very recently, our group has developed Czochralski-grown $La_xGd_yNd_zSc_{4-x-y-z}(BO_3)_4$ (LGSB:Nd) bifunctional crystals [1-3], as very promising active media for the construction of highly efficient lasers in the near-infrared (NIR) domain, as well as compact visible (VIS) lasers based on self-frequency doubling (SFD) processes. Considering the incongruent melting of LGSB:Nd crystals, the starting melt compositions and the pulling and rotation rates were optimized. Also, a special thermal setup was engineered to grow LGSB:Nd-type crystals by the Czochralski crystal growth method. High optical quality LGSB:Nd crystals doped with various concentrations of Nd^{3+} ions (2.3, 3.5, and 4.6 at.%) were grown by the Czochralski method, for the first time according to our knowledge. The as-grown crystals are shown in Fig. 1.

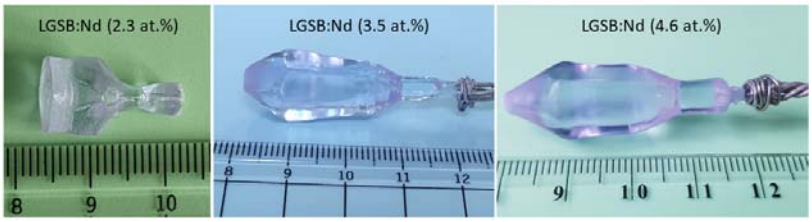

Fig. 1. Photos of Czochralski-grown Nd:LGSB-type crystals.

The structural and optical properties of the grown crystals as well as their laser performances were evaluated. The obtained results prove their favorable intrinsic properties to generate laser emission in the NIR domain (~ 1 μm) with very high efficiencies. A high slope efficiency of 0.73 was obtained for the LGSB:Nd (4.6 at.%) crystal in quasi-continuous-wave (quasi-CW) operation. The main NLO properties of all grown crystals were found to be similar to those of undoped LGSB crystal [3]. Preliminary SFD experiments were also carried out. In the case of the LGSB:Nd (3.5 at.%) crystal, a green (~ 530 nm) SFD power of 48 mW was achieved.

Acknowledgement: This work was financed by the Romanian Ministry of Research, Innovation and Digitization through project 30N/2023 within program NUCLEU-LAPLAS VII.

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Growth and spectroscopic properties of $Ca_3(Ta,Ga)_5O_{12}:Pr^{3+}$ single crystal

Flavius VOICU[1], Lucian GHEORGHE[1], Cristina GHEORGHE [1], Stefania HAU[1], Madalin GRECULEASA[1,2], Alin BROASCA[1], George STANCIU[1], Monica ENCULESCU[3]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA
[2]Doctoral School of Physics, University of Bucharest, Faculty of Physics, 405 Atomistilor street, Magurele, RO- 077125, ROMANIA
[3]National Institute of Materials Physics, 405A Atomistilor street, Magurele, RO- 077125, ROMANIA

Corresponding author: flavius.voicu@inflpr.ro

Structurally disordered Pr^{3+}-doped $Ca_3(Ta,Ga)_5O_{12}$ - Pr:CTGG single crystal [1] was grown for the first time by the Czochralski technique and its spectroscopic properties were investigated. Modified Judd-Ofelt analysis was applied to determine the spectroscopic and laser emission characteristics. Based on the absorption and emission spectra at low temperature, the partial energy levels of Pr^{3+} ions have been obtained and a multicenter structure of the optical spectra was highlighted. The electron-phonon interactions were also observed in the emission spectra corresponding to the $^3P_0 \rightarrow {}^3H_4$ transition under different excitation wavelengths. The fluorescence decays of the $^3P_0$ and $^1D_2$ levels were measured. The emission cross-sections corresponding to the $^3P_0 \rightarrow {}^3H_4$ and $^3P_0 \rightarrow {}^3F_2$ transitions, quantum efficiency, gain bandwidth, and optical gain were determined. The obtained results indicate that the Pr:CTGG crystal has a high potential for obtaining efficient laser emission in the blue and red domains.

Fig. 1. As-grown Pr:CTGG single crystal. The inset shows a polished crystal sample cut from the grown crystal.

Acknowledgment: This work was financed by the Romanian Ministry of Research, Innovation and Digitization through project 30N/2023 within program NUCLEU-LAPLAS VII.

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Multilayered $Y_2O_3/RE^{3+}:Y_2O_3$ (RE= Nd, Yb) transparent ceramics: Fabrication process and laser performances

George STANCIU[1], Flavius VOICU[1], Cristina TIHON[1], Ana-Maria VOICULESCU[1], Stefania HAU[1], Cristina GHEORGHE[1], Gabriela CROITORU[1], Lucian GHEORGHE[1], Nicolaie PAVEL[1]

[1]National Institute for Laser, Plasma and Radiation Physics, Laboratory of Solid-State Quantum Electronics Magurele 077125, Ilfov, Romania

Corresponding author: george.stanciu@inflpr.ro

Composite active media were initially produced by bonding single crystals of different compositions. This approach can bond components with flat surfaces, and special techniques must be used to obtain a final bonded structure strong enough for high-power laser applications. In contrast, polycrystalline ceramics offer greater flexibility in the design of composite media because they are made from powders, and their composition can be easily adjusted. In recent years, composite ceramics have emerged as a new type of active medium. Also, composite ceramics allow better control of thermal effects in the gain medium during laser operation due to the gradient distribution of laser-active ions in the host materials [1,2].

In this work, $Nd:Y_2O_3$ and $Yb:Y_2O_3$ composite ceramics with graded doping profile of Nd^{3+} or Yb^{3+} ions were obtained by solid-state reaction and multi-step sintering method. The phase structure, microstructure, optical properties, and laser performances of the obtained ceramic samples were systematically investigated.

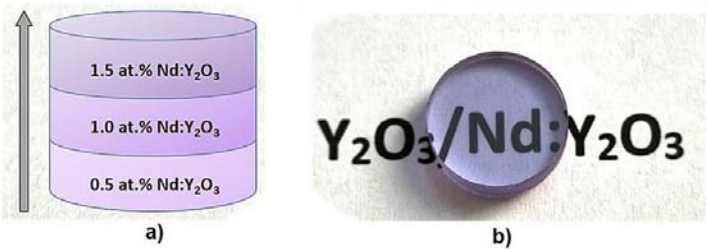

Fig. 1 a) Schematic of a $Nd:Y_2O_3$ ceramics with graded doping profile (the sample has three layers with increased Nd concentration). **b)** Image of 0.5-at.% $Nd:Y_2O_3$/1.0-at.% $Nd:Y_2O_3$/1.5-at.% $Nd:Y_2O_3$ ceramic sample (thickness of 3 mm) obtained in our laboratory.

A scheme of a composite $Nd:Y_2O_3$ ceramic medium is presented in Fig. 1a, consisting of three layers with different Nd doping, 0.5-at.% Nd/1.0-at.% Nd/1.5-at.% Nd; such a structure allows to control the distribution of the pump radiation absorbed in the laser medium and thus of the thermal effects. The obtained $Nd:Y_2O_3$ ceramic sample is shown in Fig. 1b. The structural investigation concluded that all sintered ceramics were well crystallized and similar to the standard cubic Y_2O_3 phase (Ia-3 space group) with no impurity phases. The microstructure of the ceramics showed good homogeneity, with an average grain size of about 20 µm; no pores were observed at grain boundaries or within the grains, indicating that the samples have a fully dense structure. High transmittance up to 80% at the 1.0 µm wavelength was measured for all sintered ceramics. Laser emission at 1.0 µm is under investigation, using the pump with fiber-coupled diode lasers. Other structures consisting of two layers with different Nd or Yb doping, or including one layer of undoped Y_2O_3 for improved thermal management, will be discussed.

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Excited-state absorption of Er^{3+} in Y_2O_3 transparent ceramics

Octavian TOMA[1], George STANCIU[1], Ana-Maria VOICULESCU[1]

[1]National Institute for Laser, Plasma and Radiation Physics, 409 Atomistilor Street, Magurele, RO-077125, ROMANIA

Corresponding author: octavian.toma@inflpr.ro

The low phonon energy of Y_2O_3 as well as its favorable chemical, mechanical and thermal properties makes this oxide a desirable host for lanthanide trivalent ions for various applications. Er:Y_2O_3 in particular is a valuable laser material for 3-μm [1] and eye-safe laser emission [2]; upconversion-emitting Er:Y_2O_3 has applications in medicine and biology [3]. Quantitative characterization of the excited-state absorption (ESA) processes in Er:Y_2O_3 will therefore provide valuable data for the design of the radiation-emitting devices for such applications.

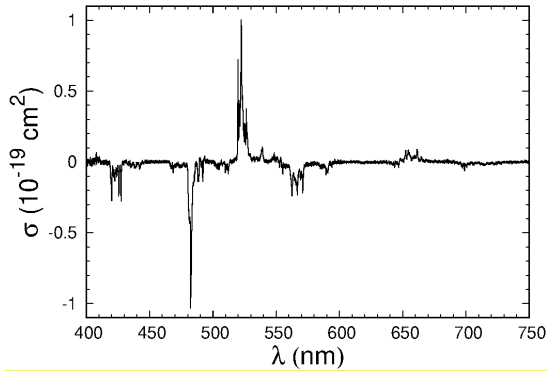

Fig. 1 ESA spectrum of Er:Y_2O_3, calibrated in cross-section units. Up: lines corresponding to ground-state absorption; down: lines corresponding to ESA.

In this work, polycrystalline Er(0.5 at. %):Y_2O_3 transparent ceramics were obtained by solid-state reaction and multi-step sintering method starting from commercial high-purity micropowders of Y_2O_3 and Er_2O_3, with sintering additives La_2O_3 and ZrO_2. ESA spectra were recorded in the spectral range 400 - 750 nm using a pump-probe setup. The transitions corresponding to various lines are identified and discussed. The spectra are calibrated in units of absorption cross-section. The cross-sections of the ESA transitions are calculated, separating them from those of the overlapping ground-state absorption transitions.

Acknowledgement: This work was supported by program NUCLEU-LAPLAS VII 30N/2023, Ministry of Research, Innovation and Digitization, Romania.

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Fabrication of high aspect ratio microstructures in photosensitive glasses by picosecond laser beam processing

Florin JIPA[1], Laura IONEL[2], Gianina POPESCU-PELIN[2], Alexandra BRAN[1], Emanuel AXENTE[1], Koji SUGIOKA[3], Felix SIMA[1,3]

[1]National Institute for Laser, Plasma and Radiation Physics (INFLPR)- Center for Advanced Laser Technology, Photonic Investigations Laboratory – PhIL, 409 Atomistilor, Magurele 077125, Romania
[2]National Institute for Laser, Plasma and Radiation Physics (INFLPR) – Laser Department 409 Atomistilor, Magurele 077125, Romania
3- RIKEN Center for Advanced Photonics, 2-1 Hirosawa, Wako, Saitama, 351-0198, Japan

Corresponding author: florin.jipa@inflpr.ro

The laser induced voxel in a material represents the volume in which the laser beam energy is confined using optical systems such as microscope objectives or lenses. Although its theoretical size is given by the numerical aperture value of the optical system, there are other factors such as the laser beam properties or the environment refractive index that influence this value.

In this study, we demonstrate experimentally the controlled variation of voxel size by changing the laser beam diameter before the focusing optics, with a high impact on the resolution of the fabricated structures. Spatial distribution and position of the voxel were evidenced in Foturan photosensitive glass (PG) after laser irradiation of parallel structures at different beam sizes and energies using a high repetition rate picosecond (ps) laser-assisted etching (PLAE) method [1,2]. Inscribed structures with variable aspect ratio from 1:3 up to 1:30 were fabricated in PG volume using a single optical system.

The ability to control voxel characteristics without replacing focusing optical components can be highly beneficial for material processing, enabling the creation of structures with different aspect ratios. This method offers numerous advantages for optimizing the microfabrication process of microfluidic devices in PG on large areas.

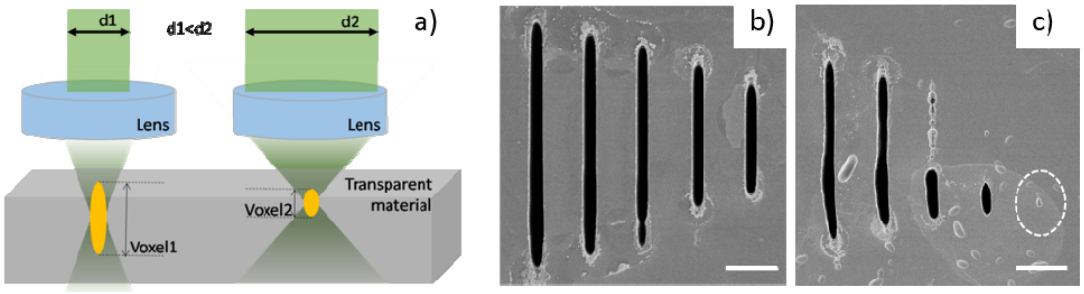

Fig.1. Voxel size variation in relation with laser beam diameter. a) Sketch of the voxel size in transparent materials; Embedded channels fabricated in Foturan glass by varying the picosecond laser beam diameter before the lens b) 3,5 mm (d1) and c) 11 mm (d2). The laser power was varied from 600 mW to 200 mW with 100 mW step in both configurations. The white dash circle from c) indicate the under-modification energy threshold. The scale bar is 100 µm.

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Effect of varied beam diameter of picosecond laser on Foturan glass volume microprocessing

Laura IONEL[1], Florin JIPA[1], Alexandra BRAN[1], Emanuel AXENTE[1], Felix SIMA[1,2], Koji SUGIOKA[2]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

[2] RIKEN Center for Advanced Photonics, Wako, Japan

Corresponding author: laura.ionel@inflpr.ro

Currently, lot of efforts are focused to optimize the laser fabrication processes developing innovative and high-efficient methods able to improve the micro and nanoprocessing performances [1, 2]. The present work investigates the picosecond laser processing effect in Foturan photosensitive glass when varying the incident laser beam diameter pointing out its benefits in focusing system optimization process. To this end, specific focusing laser configurations have been designed using raytracing models and an analysis protocol has been developed in the lens focusing region in order to describe the focal point displacement occurring at the variation of the incident laser beam diameter. The numerically simulated results were explained in association with Rayleigh length and found to be in good agreement with the experimental data obtained at well-defined conditions. Specifically, it was found that the hollow micro-structures developed by thermal treatment and chemical etching after laser irradiation were significantly displaced along the propagation direction when the incident beam diameter varied in the range of 1-3.5 times (figure 1). This approach aims to bring an essential contribution to the field of ultrashort pulse lasers micro and nanoprocessing in glass materials proving that the laser beam focus position and its size can be precisely controlled with high resolution by varying the incident laser beam diameter in predefined conditions.

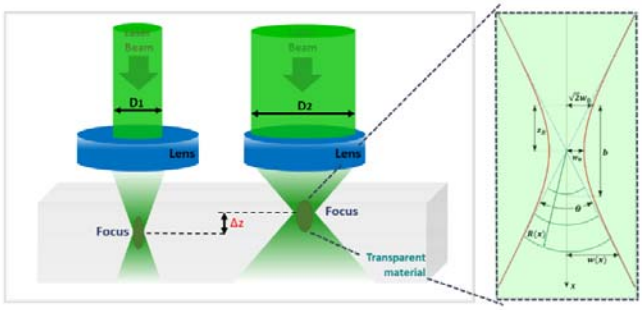

Fig. 1. Conceptual representation of the laser beam focalization in Foturan glass, showing the focal distance change (Δz) induced by the expanded diameter of collimated laser beam to provide the Rayleigh range z_R and the confocal parameter b (R(x) - radius of the curvature of the wavefront, w(x) - the gaussian spot size, θ – full divergence angle)

Acknowledgement: The research is supported by the Romanian Ministry of Research, Innovation and Digitization under Romanian National Nucleu Program LAPLAS VII – contract no. 30N/2023 and UEFISCDI PCE8/2021.

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Influence of illumination with c.w. laser light at 532 nm on transmittance and light emission of Rhodamine 610 in DNA-CTMA matrix

Adrian PETRIS[1], Petronela GHEORGHE[1], Ileana RAU[2]

[1]National Institute for Laser, Plasma and Radiation Physics, 409 Atomistilor Street, 077125 Magurele, ROMANIA

[2]National University of Science and Technology POLITEHNICA Bucharest, Faculty of Chemical Engineering and Biotechnologies, 1-7 Polizu Str., 011061 Bucharest, ROMANIA

Corresponding author: adrian.petris@inflpr.ro

The deoxyribonucleic acid (DNA) biopolymer is a novel natural optical material, which is usually obtained from the residues of the food processing industry. It is studied intensively in recent years due to its promising applications in organic photonics and organic electronics [1-12]. The large transparency of the DNA biopolymer in visible and near-infrared spectral domains and its functionalization with the cetyltrimethylammonium chloride (CTMA) surfactant, which ensures its solubility in many organic solvents, make the DNA-CTMA matrix a suitable host for many photosensitive molecules, the resulted compound being an attractive photonic material with tunable optical properties.

We present our recent results obtained in the study of the influence of illumination with continuous wave (c.w.) laser light at 532 nm on transmittance and on light emission of Rhodamine 610 (Rh610) embedded in the DNA-CTMA matrix and, for comparison, of Rh610 alone. The laser light at this wavelength is frequently used to excite the photoluminescence of Rh610 in laser oscillators and amplifiers based on this dye.

The obtained results revealed the beneficial influence of the DNA-CTMA matrix on light emission in Rh610 [6,10,11].

Acknowledgment: The support of the Romanian Ministry of Research, Innovation and Digitization, Nucleus Programme LAPLAS VII, Contract nr. 30N /2023 is gratefully acknowledged.

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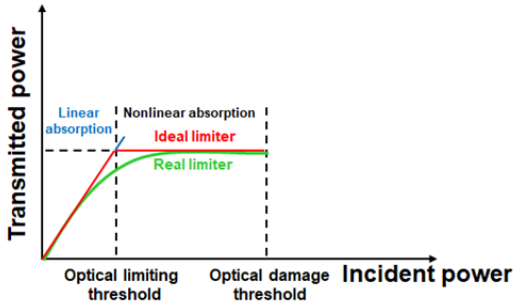
Study of optical limiting properties in DNA-based materials functionalized with natural dyes

Petronela GHEORGHE[1], Adrian PETRIS[1], Mirela ANTON[1]

[11]National Institute for Laser, Plasma and Radiation Physics, 409 Atomistilor Street, 077125 Magurele, ROMANIA

Corresponding author: petronela.gheorghe@inflpr.ro

Lasers, which are now widely used in many applications, can represent a potential hazard to the eyes and other sensitive optical and optoelectronic devices due to laser-induced damage. Therefore, the protection measures against their high-intensity radiation are extremely important. Optical limiting is the phenomenon of reducing the optical transmission of a material with increasing laser power/fluence [1-3].



Optical limiting functionality

For the ideal OL the transmitted power/intensity has a linear increase for incident power/intensity up to the OL threshold, remaining constant after this. For a real OL, the transmitted power/intensity depends nonlinearly on the incident one, being described by a saturation curve.

In this work, we study the optical limiting potential of a new class of deoxyribonucleic acid (DNA) bio-polymer functionalized with natural dyes by the Intensity-scan (I-scan) [4-7] in the NIR spectral domain at the wavelength of 1550 nm, which is important in telecommunications. The optical transmittance value, in the linear regime, the OL threshold, and the saturation intensity of the nonlinear transmission curves were determined. The influence of DNA biopolymer and of natural dye concentration on the limiting optical properties of the investigated biomaterials is also reported and discussed. Our results indicate the positive influence of DNA, which incorporates natural dyes, on the optical limiting functionality. This study revealed the potential for optical limiting of the investigated class of new biomaterials with photonic applications.

Acknowledgment: This work was supported by a grant from the Romanian Ministry of Research, Innovation and Digitization, CNCS - UEFISCDI, project number PN-III-PI-l.1-TE-2021-1546, within PNCDI III and by Project 30N/2023 within program NUCLEU LAPLAS VII.

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Optical fiber gratings optimized for ionizing radiation sensing and security applications

Andrei STANCALIE[1], Razvan MIHALCEA[1], Daniel IGHIGEANU[1], Daniel NEGUT[2], Mihai STRATICIUC[2], Agostino IADICCICO[3], Flavio ESPOSITO[3], Mateusz SMIETANA[4], Jan MRAZEK[5]

[1] Center for Advanced Laser Technologies, INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

[2]"Horia Hulubei" National Institute for R&D in Physics and Nuclear Engineering, Magurele RO-077125, Romania

[3]Department of Engineering, University of Naples "Parthenope", 80143 Naples, Italy

[4]Warsaw University of Technology, Institute of Microelectronics and Optoelectronics, 00-662 Warsaw, Poland

[5]Insittute of Photonics and Electronics of the Czech Academy of Sciences, 182 00 Prague, Czechia

Corresponding author: andrei.stancalie@inflpr.ro

Depending on optical fibers composition, such as pure-silica core, doped/co-doped core or cladding regions, fiber-based platforms such as fiber Bragg or long period gratings (LPG) demonstrated their capacity to provide, in real time, essential information on the ionizing radiation parameters (e.g. accumulated dose) while operating in high energy radiation fields [1][2]. In this work, we report a comparative study of LPG fabricated by electric-arc discharge (EAD) in radiation hardened fibers (pure-silica core, F-doped cladding), B-Ge-doped core as well as optimized fibers by scintillating materials dopants, providing ultra-high sensitivity, for low dose-rates, suitable even for medical applications. While the evaluation is assessed by using three types of radiation sources, namely, a 'GC-5000' Co-60 source, a 3 MeV protons accelerator and a 5.5 MeV electrons accelerator, we report for the first time to our knowledge, the resonance wavelength's dose-rate dependency of a doped single-ended LPG while subjected to 60-Co gamma radiation up to ~4.5 kGy total absorbed dose (Fig.1).

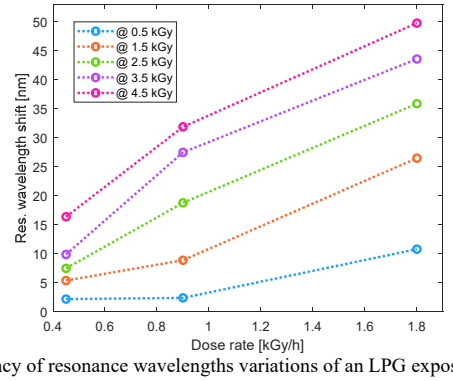

Fig. 1 Dose-rate dependency of resonance wavelengths variations of an LPG exposed to a Co-60 gamma source

Acknowledgment: We acknowledge the support of UEFISCDI funded project 666PED/2022 "MEMOIR" and National Interest Infrastructure facility IOSIN – CETAL at INFLPR.

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Experimental setup for encryption – compression and decryption – decompression of data

Cristian UDREA[1], Tatiana TOZAR[1], Petre Catalin LOGOFATU[†]

[1]National Institute for Laser, Plasma, and Radiation Physics, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: cristian.udrea@inflpr.ro

Recent advancements in holography and imaging technologies have revolutionized the efficiency and precision of capturing multidimensional data. Digital holography has successfully used compressive sensing and Fourier transform techniques to effectively capture complex details of three-dimensional objects and generate reference waves for interference. While Fourier transform is employed for data encoding and compression, offering moderate compression power, its key advantage lies in its ability to encode data efficiently with minimal loss. Additionally, it is a widely adopted method in signal processing and image compression.

However, there is a notable advantage in physically encrypting data over manual or digital computations, providing an added layer of security for sensitive information. Physical encryption offers enhanced resistance against hacking or interception compared to digital methods. This encryption method accommodates various types of input data, whether it's a note, image, or diagram, without requiring specialized training from the operator. Real-time encoding is feasible, although it may necessitate the message data to conform to specific physical criteria, such as transparency, dimensional requirements, and high contrast. Here, we present two complementary experimental setups, illustrated in Fig 1.

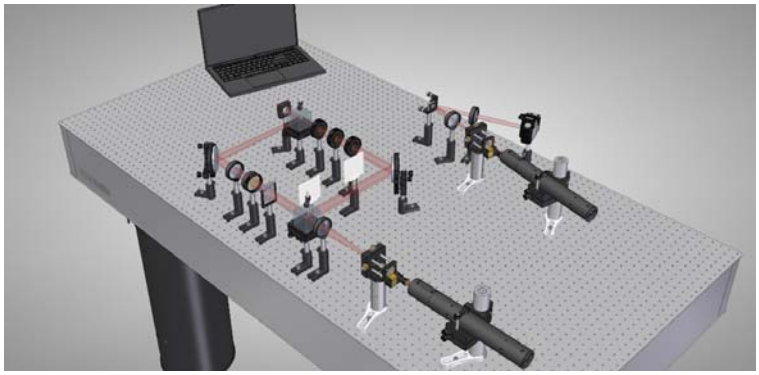

Fig. 1 Experimental set-up for encryption and decryption.

This setup is dedicated to encryption, transforming the message data into a predefined physical format, while the second setup focuses on decryption, reversing the process to reveal the original message. Both setups operate in real-time, enabling swift and efficient communication through coded messages.

Acknowledgement: This work was carried out under the contract PN-III-P2-2.1-PED-2021-1939, funded by the Romanian Ministry of Research, Innovation and Digitization.

Optical cryptographic communications with non-identical chaotic laser systems

Ionut -Relu ANDREI[1], Sandel SIMION[2], Florin GAROI[1], Mircea BULINSKI[3], Mihai BONI[1], Mihail Lucian PASCU[1]

[1] Lasers Department, INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

[2]Center for Advanced Laser Technologies, INFLPR, 409 Atomistilor street, 077125 Magurele, RO-077125, ROMANIA

[3] Faculty of Physics, University of Bucharest, 405 Atomistilor street, Magurele, ROMANIA

Corresponding author: ionut.andrei@inflpr.ro

We report on secure data transmission achieved using chaotic lasers with different external cavity geometries, employing the chaotic masking (CMS) method based on subcarrier (SM) and phase (RF) modulations of the chaotic optical carrier [1,2]. Two chaotic semiconductor lasers, each with similar multimode emission spectra and self-optical feedback provided by ring (master) and linear (slave) external cavities respectively, were optically coupled and chaotically synchronized into a master-slave scheme (**Fig. 1**a). The transmitted message (m_T) frequency modulates (FM) the radio frequency (RF) signal, which in turn modulates the master chaotic carrier's phase. Leveraging the robustness of the encryption method used and the synchronization characteristics of the two lasers, decryption (m_R) is performed by simply monitoring the radio frequency (power) spectrum of the slave emission (**Fig. 1**b) [3].

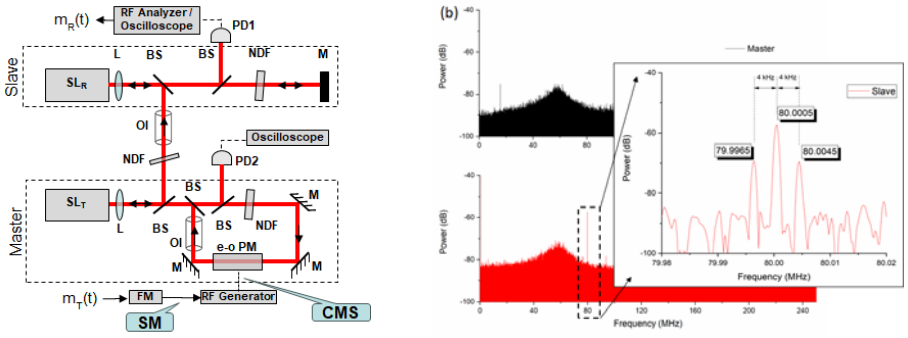

Fig. 1 Chaotic laser systems. (a) Master – Slave optical coupling scheme. (b) Power spectra associated to intensity time series; the inset, detail of slave spectrum around the RF frequency, f_{RF}= 80 MHz, which shows the subcarrier modulation of the RF carrier, f_{FM}= 4 kHz; SLt, and SLr, solitary transmitter, and receiver lasers; L, collimation lens system; BS, beam splitter; NDF, neutral density filter; M, mirror; PD, amplified photodetector; OI, optical isolator; e-o PM, electro-optic phase modulator; FM, frequency subcarrier modulation (SM); RF, frequency chaotic carrier modulation; $m_T(t)$ and $m_R(t)$, transmitted, and received messages.

The results enable us to comprehend the mechanisms underlying chaotic encryption of the optical information, which relies on the optical and chaotic synchronization characteristics of two, non-identical chaotic lasers, coupled with the application of subcarrier and phase modulation techniques.

Acknowledgment: This work was supported by grants of the Ministry of Research, Innovation and Digitization and CCCDI-UEFISCDI, project number PN-III-P2-2.1-PED-2019-5283, and Nucleu Program LAPLAS VII nr. 30N/2023.

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Topic 3. New trends in thin films and nanomaterials synthesis and processing

Biphasic calcium phosphate based coatings synthetized by c-PLD for bone tissue treatment

Gianina POPESCU-PELIN[1], Cristian BUTNARU[1], Izabela JINGA[1], Livia SIMA[2], Marioara CHIRITOIU[2], Gabriela CHIRITOIU[2], Felix SIMA[1], Gabriel SOCOL[1]

[1] National Institute for Lasers, Plasma and Radiation Physics, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

[2] Institute of Biochemistry of the Romanian Academy, 296 Splaiul Independentei, Bucharest, RO- 060031, ROMANIA

Corresponding author: gianina.popescu@inflpr.ro

We report on the development of novel coatings with improved composition and structure that enhance bone structure restoring properties of titanium (Ti) implants. Ti implants functionalized with Se and Sr doped HA/β-TCP coatings (HA/β-TCP:Se/Sr) were achieved by combinatorial pulsed laser deposition (c-PLD) technique in order to identify the optimum elemental composition with respect to their biological performances.

FTIR evaluation of HA/β-TCP:Se/Sr samples offered information's about the functional groups and covalent bonding and confirmed the stoichiometric transfer of compounds. The elemental composition of the as-deposited coatings was determined from EDS and XPS measurements and pointed out the Se and Sr dopants content. The morphological features and the crystalline state of the as-deposited coatings were evaluated by scanning electron microscopy (SEM) and X-ray diffraction (XRD) analyses, respectively. The cytotoxicity, viability and proliferation of HA/β-TCP:Se/Sr were evaluated in order to establish the optimal Se/Sr ratio for which the proliferation of osteoblasts precursors is ensured. The ELISA measurements showed that M2 polarization of mouse primary macrophages is diminished on HA/β-TCP coated Ti. Moreover, an attenuation of inflammatory response on areas with increased Se content was observed.

The aim of this study was to fabricate metallic implantable devices covered with thin films of HA/β-TCP:Se/Sr composite designed for bone tissue therapy.

Physicochemical investigations of strontium-doped calcium phosphate/chitosan composite films deposited by plasma and laser techniques

Maria-Elena ZARIF[1,2], Bogdan BITA[1,3], Sasa Alexandra YEHIA-ALEXE[1,3], Irina NEGUT[1], Andreea GROZA[1,*]

[1]National Institute for Lasers, Plasma and Radiation Physics, 077125 Măgurele, Romania;

[2]Faculty of Chemical Engineering and Biotechnologies, University Politehnica of Bucharest, 011061 Bucharest, Romania;

[3]Faculty of Physics, University of Bucharest, 077125 Măgurele, Romania

[*]Corresponding author: andreea.groza@inflpr.ro

In this work, we report the deposition of Sr-doped calcium phosphate/chitosan composites layers on Si substrates by combining two deposition techniques, namely radio-frequency magnetron sputtering and matrix-assisted pulsed laser evaporation (see **Fig. 1**.). The calcium phosphates layers were deposited at different substrate temperatures, ranged between the room temperature (unheated substrate) and 400 °C, using an homemade oven [1].

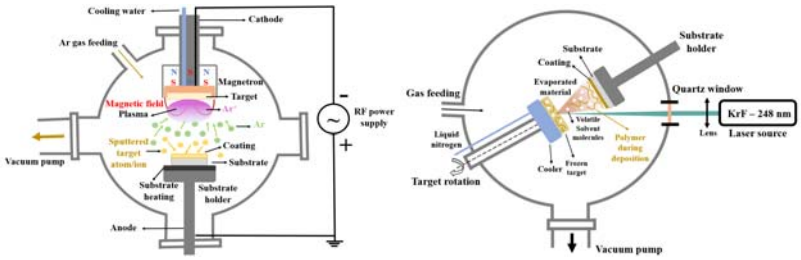

Fig. 1 Schematic representation of RF-MS (a) and MAPLE (b) experimental setup [2]

The surface morphology and the elemental composition were evaluated by Scanning Electron Microscopy and Energy Dispersive X-Ray Spectroscopy. A grain-like morphology was observed for the lowest substrate temperatures and microchannel structures for the highest substrate temperature. The (Ca+Sr)/P ratio revealed that during the RF-MS deposition, tetra calcium phosphate (TTCP) was formed. These results were also confirmed by the Fourier Transform Infrared Spectroscopy investigation. The peak fitting analysis revealed peaks corresponding to apatite structures and TTCP. The spectra also revealed the presence of absorption bands characteristic for the chemical functional groups of chitosan. The mass spectrometry coupled with laser induced ablation highlighted the molecular ions characteristic to calcium phosphates and chitosan compounds.

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Application of doped hydroxyapatite coatings via MAPLE deposition for bone tissue engineering

Diana-Elena RADULESCU[1], Bogdan Stefan VASILE[1, 2], Ecaterina ANDRONESCU[1], Otilia Ruxandra VASILE[1], Roxana Doina TRUSCA[1], Iulian BOERASU[3], Simona BRAJNICOV[3]

[1] Department of Science and Engineering of Oxide Materials and Nanomaterials, Faculty of Chemical Engineering and Biotechnologies, National University of Science and Technology Polytechnica Bucharest, 011061 Bucharest, Romania

[2]Advanced Research Center for Innovative Materials, Products and Processes, National University of Science and Technology Polytechnica Bucharest, 011061 Bucharest, Romania

[3] National Institute for Laser, Plasma and Radiation Physics, 077125, Magurele, Romania

Corresponding author: otilia.vasile@upb.ro

Over the last few years, the development of novel materials has gained significant interest from researchers worldwide, focusing on the synthesis of materials to possess superior biological properties. In this regard, bone tissue engineering focuses on obtaining materials with enhanced biological and mechanical properties. Considering these aspects, hydroxyapatite is the most studied biomaterial due to its biological properties, similarity with the native osseous tissue, osteoinductivity, and osseointegration. Furthermore, this ceramic material also presents several drawbacks such as corrosion, release of toxic ions, and wear. In this direction, several studies highlighted the possibility of improving their properties and surpassing possible disadvantages that may appear during application in the biomedical field. The ideal solution is to obtain hydroxyapatite from natural sources, which is known to retain trace elements such as Na^+, F^-, Zn^{2+}, K^+, Mg^{2+}, Si^{2+}, and CO_3^{2-} that mimic the native apatite from the human bone. The use of HA from natural sources is an environmentally friendly, sustainable, and economical process [1]. This ceramic also presents the capacity to substitute doping ions at the PO_4^{3-}, Ca^{2+}, and OH^- sites of its lattice, which is the essential characteristic in the increase in biological performance of HA after implantation. In this study, Mg-doped hydroxyapatite was obtained from natural sources in different concentrations (1% and 5%). Furthermore, the developed materials were deposited through Matrix-Assisted Pulsed Laser Evaporation (MAPLE) on a titanium substrate (> 99% Ti). To assess the successful deposition, Scanning Electron Microscopy was performed.

Acknowledgement: This work is supported by Ministry of Research, Innovation, Digitization from Romania by PN-III-P2-2.1-PED-2021-0627 (Contract No. 519PED/2022)

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Nanostructured coatings with applications in hard tissue engineering

Valentina GRUMEZESCU[1], Ștefan Andrei IRIMICIUC[1], Oana GHERASIM[1],
Alexandru Mihai GRUMEZESCU[2], Bogdan Ștefan VASILE[2],
Bianca GĂLĂȚEANU[3], Ariana HUDIȚĂ[3]

[1] National Institute for Lasers, Plasma and Radiation Physics, 077125 Magurele, Romania;
[2] Politehnica University of Bucharest, 011061 Bucharest, Romania;
[3]Department of Biochemistry and Molecular Biology, Faculty of Biology, University of Bucharest, 050095 Bucharest, Romania;

Corresponding author: valentina.grumezescu@inflpr.ro

Considering the diversity and complexity of orthopedic conditions, surgical intervention on hard tissues has emerged in the last years. Given the bioinertness and microbial susceptibility of conventional implantable devices, researchers, engineers and clinicians seek for efficient alternatives to develop tailored biomaterials to replace, restore, or regenerate the injured tissues.

Protective and tunable coatings represent an attractive and challenging selection for improving the biofunctional performances of metallic devices used for the restoration or replacement of bone tissue. In this study, innovative thin films based on hydroxyapatite doped with silver are proposed as multifunctional coatings for hard tissue implants. The composite nano-coatings, grown by pulsed laser deposition technique, presented superior biological performance, showing excellent biocompatibility with human pre-osteoblasts, as well as remarkable hemocompatibility, with no negative impact on blood components. The good biocompatibility and antimicrobial efficiency of herein developed nanotextured thin films confirmed their promising use in hard tissue engineering applications.

Generating thick titanium oxide layer on the surface of titanium using a new microwave discharge method

Marian MOGILDEA[1], George MOGILDEA[1], Sorin I. ZGURA[1], Valentin CRACIUN[2], Petronela PREPELITA[2], Natalia MIHAILESCU[2]

[1]Institute of Space Science - INFLPR, RO-077125, Bucharest-Magurele, ROMANIA
[2] National Institute for Laser, Plasma and Radiation Physics, 409 Atomistilor st., Magurele, RO-077125, ROMANIA

Corresponding author: george_mogildea@spacescience.ro

The research explores the generation of a titanium oxide layer on the surface of a titanium wire using a new microwave discharge based method [1]. The interaction process between microwaves and a Ti wire is the starting point for plasma ignition, which will result in titanium oxide formation [2]. The experiment was conducted in air at normal pressure. During the interaction process, metallic ions and gas ions were generated and the electronic temperature of the plasma, determined using optical emission spectroscopy method was up to reached 48000 K. The SEM analysis of the surface of the titanium wire exposed at microwaves highlighted that during interaction process oxide nanoparticles were generated (Fig.1). At the used magnification of 60K one can clearly see that the nanoparticles dimensions are smaller than 100 nm. Using this simple microwave discharge method one can improve the antibacterial activity of titanium implants by covering them with a thin layer of titanium oxide [3].

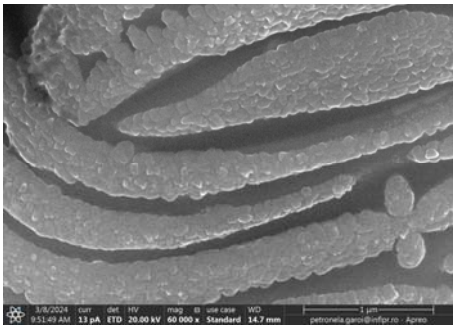

Fig. 1 SEM image of the titanium wire irradiated with microwaves.

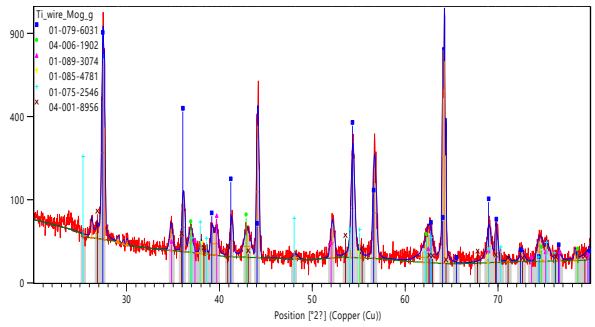

Fig.2 XRD analysis of the titanium oxide thick titanium oxide layer from surface of the titanium wire: 01-079-6031-TiO_2, 04-006-1902, 01-089-3074, 01-075-2546-TiO, 01-085-4781- Ti.

Acknowledgement: This work was supported by grants of the Ministry of Scientific Research, Innovation and Digitization project codes PN-III-P2-2.1-PED-2021-0957 and Nucleu programme - LAPLAS VII, no. 30N/2023.

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Fabrication and characterization of poly(ε-caprolactone) films for applications in biliary stents

Simona BRAJNICOV[1], Antoniu MOLDOVAN[1], Iulian BOERASU[1], Adrian BERCEA[1], Alexandra PALLA-PAPAVLU[1]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: alexandra.papavlu@inflpr.ro

In the present day, there is a substantial demand for the production of medical devices intended for applications in regenerative medicine, which aligns with the advancement of personalized medicine. Within this context, the technology behind biliary stents emerges as a crucial element contributing to the achievement of successful liver transplantation procedures and facilitating rapid patient recovery. Although there are currently numerous options available for biliary stents in terms of materials, designs, and biological functions, these stents still have some drawbacks. These drawbacks include issues such as displacement of the stent after implantation, clogging of the internal biliary stent due to factors like biofilm formation, salt clusters, and lipid attachment, as well as the potential proliferation of bacteria. Herein, we report on the manufacture of a new design of polycaprolactone-based biliary stent device, completely resorbable, intended primarily to support bile duct functions in the post-liver transplant period.

Within this context, we present the results of a study investigating the effects of the experimental parameters on the morphological characteristics of Polycaprolactone (PCL) thin films produced through spin coating and matrix-assisted pulsed laser evaporation (MAPLE). The polymer coatings obtained in this manner are characterized for their structural, morphological, and compositional attributes using techniques such as XRD, AFM, SEM, Raman, and FTIR. Additionally, the phenomenon of PCL layer detachment from the deposition substrate will be discussed. Lastly, laser-induced periodic surface structures were obtained in the polycaprolactone free-standing membrane layers by irradiation with linearly polarized radiation.

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Fabrication and characterization of polymer-graphene films for applications in resistive sensors

Simona BRAJNICOV[1], Antoniu MOLDOVAN[1], Adrian BERCEA[1], Alexandra PALLA-PAPAVLU[1]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: alexandra.papavlu@inflpr.ro

Currently, one of the major global concerns is represented by the challenges in the field of agriculture, with a focus on the need to efficiently manage agricultural resources and minimize environmental impact. Sensors play a crucial role in transforming traditional agriculture into an efficient and sustainable domain. In the context of modern agriculture, these devices have become indispensable tools, providing detailed and real-time information on soil conditions, water quality, and crop status. In this study we have.

This study presents the fabrication and characterization of polymer-graphene films designed for use in resistive sensors. Leveraging the electrical properties of graphene and the flexibility of polymer matrices, we have developed a novel composite material that exhibits enhanced sensitivity and stability under a range of environmental conditions.

The fabrication process employed laser-based methods, i.e., matrix-assisted pulsed laser evaporation and laser-induced forward transfer methods to integrate graphene flakes into a polymer base, creating a homogenous composite film. Various concentrations of graphene were explored to optimize the electrical conductivity and mechanical properties of the films.

Our results indicate that the incorporation of graphene significantly improves the electrical conductivity of the polymer films without compromising their flexibility and mechanical strength. The optimal graphene concentration was found to provide a balance between conductivity and material integrity, making these films suitable for high-performance resistive sensors. Furthermore, the polymer-graphene films demonstrated excellent sensitivity to changes in temperature and humidity, highlighting their potential for environmental sensing applications.

Acknowledgement: This research was supported by Romanian Ministry of Research, Innovation and Digitization under Romanian National Core Program LAPLAS VII – contract no. 30N/2023.

Development of a room temperature chemoresistive ammonia gas sensor

Ana-Maria POPA[1,2], Felicia IACOB[1,2], Andrei STOCHIOIU[1,2], Luiza-Izabela TODERAŞCU[1], Vlad-Andrei ANTOHE[2], Gabriel SOCOL[1] and Iulia ANTOHE[1,3,*]

[1]National Institute for Laser, Plasma and Radiation Physics (INFLPR), Atomiştilor Street 409, 077125 Măgurele, Ilfov, Romania
[2]Faculty of Physics, Research and Development Center for Materials and Electronic & Optoelectronic Devices (MDEO), University of Bucharest, Atomiştilor Street 405, 077125 Măgurele, Ilfov, Romania
[3]Academy of Romanian Scientists (AOSR), Ilfov 3, 050044 Bucharest, Romania

*Corresponding authors: iulia.antohe@inflpr.ro; gabriel.socol@inflpr.ro

Gas detection is important for many industries, such as industrial safety, environmental monitoring, and healthcare. Ensuring workplace safety, managing emissions and recognizing possible hazards all depend on the quick and precise detection of various gases, including ammonia (NH_3) [1]. Due to their great sensitivity, quick reaction time, and adaptability, chemiresistive sensors based on conductive polymers (i.e. polyaniline, polypyrrole, etc) have become very promising instruments for NH_3 detection at room temperature [2].

In this study, polyaniline (PANi) and polypyrrole (PPy) conductive polymers were chosen for their remarkable affinity for NH_3 gas [3, 4]. Both polymers were synthesized via chemical polymerization of their monomer directly on the interdigitated gold electrodes and have been further characterized by scanning electron microscopy (SEM) and X-ray photoelectron spectroscopy (XPS) to provide morphological and chemical insights. Moreover, the prepared sensor was electrically characterized using an in-house gas testing setup. The electrical properties of the sensor inside the gas chamber were investigated using a source-meter while it was directly exposed to various analyte concentrations ranging from 1 to 100 ppm.

Finally, the data analysis showed that the proposed sensors exhibit good sensitivity and selectivity to the analyte, having a stable response over time. Response time and recovery time were calculated as the time to reach 90% of the final resistance in the presence and absence of the target gas, respectively. The limit of detection (LOD) for both types of sensors was found to be below 1 ppm.

Keywords: polyaniline, polypyrrole, conductive polymers, chemiresistive gas sensors

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Synthesis and characterization of modified TiO_2 nanomaterials for sensor applications

Evghenii GONCEARENCO[1], Monica SCARISOREANU[1], Iuliana MORJAN[1], Elena DUTU[1], Anca Daniela CRIVEANU[1], Ana-Maria BANICI[1], Claudiu Teodor FLEACA[1], Cristian VIESPE[1], Mihai PAUNICA[1], Valentin TEODORESCU[2]

[1] National Institute for Lasers, Plasma and Radiation Physics, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

[2]National Institute of Materials Physics, 405 A Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: monica.scarisoreanu@inflpr.ro

This work presents the preparation of W and V co-doped TiO_2 nanoparticles (W:TiO_2 and W:V:TiO_2) using laser pyrolysis technique followed by their modification with noble metals Au or Ag using chemical impregnation method. Due to its superior chemical and physical characteristics, TiO_2 is the most significant component, while when doped or loaded, the surface area and defect density are expected to be higher than in the bulk material, contributing to increased sensing activity. For this reason, morpho-structural properties of the obtained decorated nanopowders have been characterized by complementary technics. According to the phase composition results, the anatase phase predominates (95%) over the rutile phase, exhibiting an average particle size ranging between 25-30 nm. The TiO_2 based nanomaterials were supplementary modified by noble metals deposition showing Au particles larger than 15 nm and spherical Ag crystallites with a diameter between 3 and 5 nm (Fig.1) which display a higher specific surface area (3-5 times).

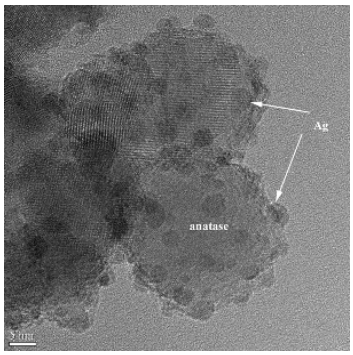

Fig. 1 HRTEM image for the TiO_2 based sample loaded with Ag

The sensing properties of the nanopowders were tested as nanocomposite layers of SAW (Surface Acoustic Wave) sensors, at different concentrations of CH_4. For the nanocomposite layers, PEI (polyethyleneimine) polymer and each type of nanopowders synthetized were deposited by spin coating on the sensor surface. The results proven that adding noble metals on the surface of the oxide semiconductors nanoparticles was an effective strategy to enhance sensitivities of the sensors, especially if Ag is used.

Acknowledgement: This research was supported (or financed) by Romanian Ministry of Research, Innovation and Digitization under Romanian National Nucleu Program LAPLAS VII – contract no. 30N/2023.

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Hybrids of organic conjugated systems and inorganic semiconducting nanostructures for electronic devices

Marcela SOCOL[1*], Nicoleta PREDA[1**], Andreea COSTAS[1], Gabriela PETRE[1,2], Anca STANCULESCU[1], Sorina IFTIMIE[2], Gianina POPESCU-PELIN[3], Gabriel SOCOL[3]

[1]National Institute of Material Physics, 405A Atomistilor Street, 077125, Magurele, Romania
[2]University of Bucharest, Faculty of Physics, 405 Atomistilor Street, PO Box MG-11, 077125, Magurele, Romania
[3]National Institute for Lasers, Plasma and Radiation Physics, 409 Atomistilor Street, 077125, Magurele, Romania

Corresponding author: marcela.socol@infim.ro, nicol@infim.ro

Over the past two decades, new hybrid materials and architectures have been developed in order to address solutions to the emerging issues from the technological domains of greatest interest including electronics, clean energy or environmental remediation. Organic conjugated systems such as polymers, small molecules, macrocyclic compounds, etc. have features like low processing temperatures, high absorption coefficients, mechanical flexibility, compatibility with plastic substrates (even on large area) that make them suitable for the integration in electronics devices [1]. Inorganic semiconductors such as metal oxides, metal sulphides, etc. can be easily engineered by various wet and dry pathways to yield functional nanostructures with tailored properties [2, 3]. Thus, organic-inorganic composites can be obtained by embedding inorganic nanoparticles in an organic layer, these hybrid materials combining in a synergetic manner the properties of both organic and inorganic components. Matrix assisted pulsed laser evaporation (MAPLE) is a laser-processing technique that allows the deposition of hybrid composite layers on various substrates, even on plastics, making this approach very attractive for flexible electronics [4]. In the present study, thin films containing organic conjugated compounds and inorganic semiconducting nanoparticles were deposited by MAPLE, the obtained hybrid materials being characterized by morphological, structural, optical and electrical point-of-view. The impact of the type and amount of inorganic semiconducting particles added in the organic conjugated compound on the properties of the obtained hybrid films were assessed. The work proves that MAPLE can be regarded as a viable approach for designing hybrid thin films with tuned properties, further these being used in the development of electronic devices (photovoltaic cells, field effect transistors, etc.) on rigid and flexible substrates.

Acknowledgement: This work was supported by a grant of the Ministry of Research, Innovation and Digitization, CNCS - UEFISCDI, project number PN-III-P4-PCE-2021-1131, within PNCDI III.

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Polycrystalline Terfenol-D thin films grown by pulsed laser deposition

Valentin ION[1], Isabela-Elena BANCU[1], Florin ANDREI[1], Luiza-Maria STINGESCU[1], Nicu Doinel SCARISOREANU[1]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: valentin.ion@inflpr.ro

Magnetostriction is an interesting phenomenon specific for ferromagnetic materials and it is evidenced by the ability of some materials to convert the magnetic energy into mechanical energy. Terfenol-D is a compound that possesses giant magnetostriction along <111> crystallographic direction under the action of an external magnetic field at room temperature [1-3].

Given the composition of this material ($Tb_{0.3}Dy_{0.7}Fe_2$) finding a suitable experimental route to grow good quality thin films is a challenge. In the present paper work, we report the parametric study and growth properties of polycrystalline Terfenol-D thin films using the Pulsed Laser Deposition (PLD) technique on Pt/Si substrates.

The Terfenol D polycrystalline structure was highlighted using X-ray diffraction, and the ap-pearance of its specific (111) plane was noted. The thickness of the prepared films and the nature of the interface between the substrate-film were evaluated by SEM in cross-section. The electrical properties and the transitory behaviour as a function of temperature were also presented. Finally, the magnetoresistance variation with the applied magnetic field and the mechanical properties of Terfenol-D films were investigated using the LakeShore HMS 8425 cryostat cryostat and Nano indentation systems.

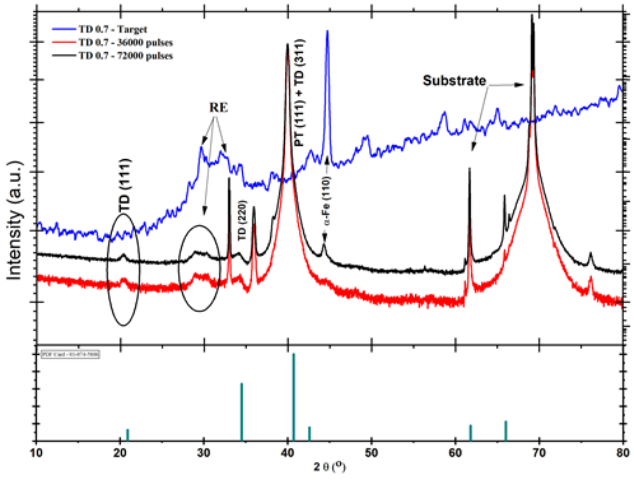

Fig. 1 XRD patterns of TD 0.7 films deposited at 36000 and 72000 pulses.

Acknowledgment: This work was supported by a grant of the Ministry of Research, Innovation and Digitization, CNCS - UEFISCDI, project number PN-III-P4-ID-PCE-2020-2921, within PNCDI III.

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Heterojunction solar cell based on p-type metal oxides

Andrei STOCHIOIU[1,2], Ștefan ANTOHE[2], Ana-Maria BĂNICI[1], Gianina POPESCU-PELIN[1], Gabriel SOCOL[1]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

[2]Faculty of Physics, University of Bucharest, 077125 Măgurele, Romania

Corresponding author: andrei.stochioiu@inflpr.ro

At present, inorganic semiconducting materials are the most economical and viable source for the renewable energy industry. The present work deals with the morphological and optical characterization of p-type copper oxide (CuO) and other oxides such as: zinc oxide (ZnO), nickel oxide (NiO), titanium dioxide (TiO_2) thin films fabricated by succesive thermal vacuum deposition (TVE) of pure metal on fluorine-doped tin oxide (FTO) glass followed by oxidation through thermal annealing. As a whole, the above inorganic composite materials can be applied in photovoltaic cells. An attempt has been made to study structural, morphological and absorption characteristics of individual films and the final structure as a whole using state of the art techniques like X-ray diffraction (XRD), scanning electron microscopy (SEM), atomic force microscopy (AFM) and UV-Vis spectroscopy. The energy band gaps of resulting oxides have also been calculated and discussed based on the UV-Vis spectroscopy measurements.

New ways of manufacturing solar cells that can scale-up to large volumes and low cost are required; here, the widely available transition metal oxide based materials can play a decisive role due to their low cost and simple scale-up to large volume production. Futhermore, this work attempts to simplify fabrication through the use of just one fabrication step (TVE) and one processing step (thermal annealing) for all oxides. Other thin-film fabrication methods have also been used for comparison, such as pulsed laser deposition (PLD), DC magnetron sputtering and spin-coating.

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Transition metal oxide – carbon-based nanomaterials photocatalyst layers synthesized by laser techniques

Raluca IVAN[1,2], Iuliana URZICA[2], Stefan ANTOHE[1], Angel PÉREZ del PINO[3], Eniko GYÖRGY[2,3]

[1]University of Bucharest, Faculty of Physics, 405 Atomistilor street, Magurele, RO-077125, ROMANIA
[2]National Institute for Lasers, Plasma and Radiation Physics, 409 Atomistilor street, Magurele, RO-077125, ROMANIA
[3]Institute of Materials Science of Barcelona (ICMAB CSIC), 08193 Bellaterra, Barcelona, Spania

Corresponding author: raluca.ivan@inflpr.ro

In the last decade, environmental pollution, especially water contamination, has become the focus of world attention, clean water being one of the most important and scarcest resources. Due to the growing population and industrialisation, excessive release of toxic organic compounds as dyes and pharmaceutical products, the contamination of water resources occurs at an accelerated rate globally. Unfortunately, discharge of these contaminants into aquatic environment leads to hazardous mixtures affects the ecosystem and leads to health problems. Various techniques have been developed for wastewater treatment. Among them, methods based on photocatalytic processes represent a promising solution, being a "green" technology for decomposing organic pollutants.

TiO_2, ZnO, FeOx, and MgO semiconductor photocatalysts are the most widely investigated [1, 2]. However, the main drawback of transition metal oxide semiconductor materials is their relatively large band gap, reducing the optical absorption range to the UV domain and the high recombination rate of the photogenerated electron-holes pairs. In order to suppress the recombination of photogenerated carries we mixed semiconductor materials with carbon-based nanomaterials as graphene-like reduced graphene oxide [3] and carbon nanotubes [4]. Both reduced graphene oxide and carbon nanotubes are good electron conductors, contributing to the separation of photogenerated charge carriers, and improving the photocatalytic efficiency of the hybrid layers.

A laser technique was used for the synthesis and deposition of hybrid layers, called matrix assisted pulsed laser evaporation. The technique consists in the irradiation of dispersion containing the initial materials, which are previously cooled down until solidification. The morphology, structure and chemical composition of the synthesised layers were investigated and correlated with their photocatalytic performances.

Keywords: photocatalysis, laser technique, thin films, semiconductor materials

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Photoluminescence of ZnO heterostructures at room temperature

Eliseia PETRE[1], Raluca IVAN[1], Luiza STINGESCU[1], Marian ZAMFIRESCU[1], Nicu SCĂRIȘOREANU[1]

[1]INFLPR, Atomistilor 409, Magurele, RO-077125, ROMANIA

Corresponding author: eliseia.petre@inflpr.ro

Zinc oxide, the most common II-O semiconductor, thermodynamically stable in wurtzite phase, is a material with considerable potential for a variety of next-generation applications because of its unique properties such as high excitonic binding energy, that make possible the excitonic emission at room temperature [1]. The main goal of this study was to investigate the exciton-phonon interaction and exciton localization in ZnO-based heterostructures [2], in order to evaluate the quality of the ZnO films as candidate for future photonic devices.

To accomplish this aim, ZnO samples were grown by pulsed laser deposition (PLD), and investigated using photoluminescence (PL) spectroscopy at room temperature. The samples were irradiated by the third harmonic of Nd:YAG pulsed laser source with excitation wavelength λ = 355 nm, pulse duration σ = 5 ps and 500 kHz repetition rate. The photoluminescence spectra showed a principal emission band at 375 nm specific to the free-excitonic in ZnO at room temperature, as well as secondary band at 387 nm specific to the acceptor-bound excitons [3,4].

The study was completed by the PL dependence on the excitation power in order to evidence the kinetic of emissions bands as function of laser power. The quality of deposited samples was confirmed from other complementary techniques such as AFM, SEM, XRD.

Overall, this study helps to evaluate the excitonic emission of the ZnO heterostructures as intermediate step in developing applications in the field of integrated quantum sources at room temperature.

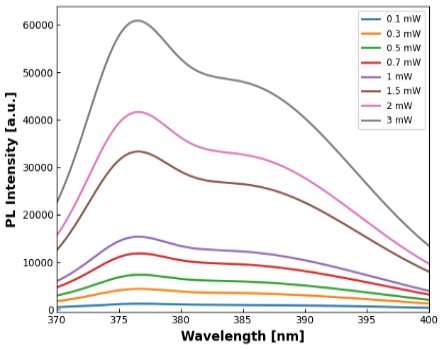

Fig. 1. Power dependent PL spectra of ZnO heterostructures at room temperature

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Structural characterization and luminescence spectroscopy of *in situ* Er, Yb-codoped $SrTiO_3$ ceramics

Cristina TIHON[1], Catalina STANCIU[1], Stefania HAU[1], George STANCIU[1]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: cristina.matei@inflpr.ro

Er^{3+}/Yb^{3+}-codoped strontium titanate nanopowders and dense ceramics were successfully prepared via an optimized acetate-nitrate sol-gel protocole. The structure, morphology, and optical properties, such as excitation spectra at λ_{em} = 548 nm, up-conversion luminescence spectra, and luminescence kinetics were investigated with the concentrations of Er^{3+} and Yb^{3+} added to $SrTiO_3$. $Sr_{1-3(x+y)/2}Er_xYb_yTiO_3$ (x = 0.01 and y = 0.01, 0.03, 0.05, 0.07) and (x = 0.01, 0.03, 0.05, 0.07 and y = 0.01). The ceramics with these compositions show pure perovskite structure, homogeneous morphology, and high up-conversion performance. These properties increase with increase of the Er^{3+} and Yb^{3+} doping levels of $SrTiO_3$. The results of analyses and measurements reveal that Er^{3+} and Yb^{3+} doped $SrTiO_3$ solid solutions are efficient for visible (green and red) emission when pumping into the infrared and can have applications in optical devices working in this domain.

Strontium titanate ($SrTiO_3$) is a material with a perovskite structure, a good chemical stability and remarkable dielectric and optical properties as optical transparency in the visible range. By dopind $SrTiO_3$ with trivalent rare earth ions such as Er^{3+} and Yb^{3+} with role of absorption and/or emission centers, the up-conversion phosphors can be improved. The Er^{3+} ion is the most efficient ion for up-conversion because the metastable levels $^4I_{9/2}$ and $^4I_{11/2}$ of Er^{3+} can be populated by high-power 800 nm and 980 nm laser diodes. Yb^{3+} has high absorption cross-section around 980 nm, efficient energy transfer from Yb^{3+} to other rare earth ions when is used as codopant, and thus increases the optical pump efficiency of doped host matrix. The use of codopants Er^{3+} and Yb^{3+} enhances the visible up-conversion emissions of $SrTiO_3$. The choice of the methods for synthesis of inorganic materials with well defined morphologies is very important due to the strong dependence between optical properties and structure of materials. Er,Yb-doped $SrTiO_3$ was prepared by various methods, as: conventional solid state reaction route [1], hydrothermal method [2], the citric sol-gel route [3], polymeric precursor method [4], and in a molten NaCl flux [5]. To obtain highly homogenous distribution of erbium and ytterbium in the structure of $SrTiO_3$, we propose an approach that consists in the use of acetate sol-gel chemistry for the fabrication of $Sr_{1-3(x+y)/2}Er_xYb_yTiO_3$ (x = 0.01 and y = 0.01, 0.03, 0.05, 0.07) powders and cereamics.

To characterize the crystalline structure of $Sr_{1-3(x+y)/2}Er_xYb_yTiO_3$ (x = 0.01, y = 0.01-0.07 and, x = 0.01-0.07, y = 0.01), XRD analyses of the calcined powders at 1000 ºC, 2h have been carried out, as shown in Fig. 1.

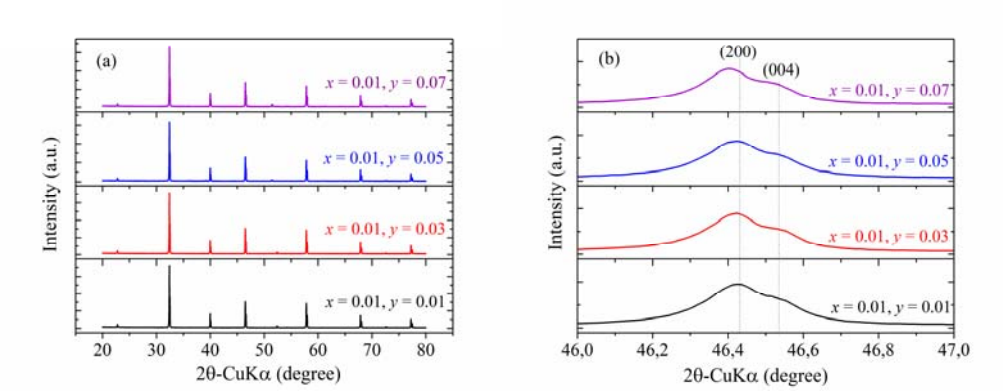

Fig. 1 X-ray diffraction spectra for $Sr_{1-3(x+y)/2}Er_xYb_yTiO_3$ powders calcined at 1000 °C, 2h in air: XRD patterns (a) and detail (b) for $x = 0.01$, $y = 0.01$-0.07.

The DRX and SEM analyses demonstrated that nanometric powders with chemically homogeneous microstructure were obtained, whose average size decreases with the increased amount of added dopants (Er^{3+} and Yb^{3+}). Top-conversion luminescence spectra of Er^{3+} and Yb^{3+} doped $SrTiO_3$ show the transitions from the $^2H_{11/2}$, $^4S_{3/2}$ and $^4F_{9/2}$ excited states to the $^4I_{15/2}$ ground state. The most intense peak is the one in green, from 550 nm. The corresponding CIE coordinates for Er^{3+} and Yb^{3+} codoped $SrTiO_3$ ceramic samples, obtained at an excitation wavelength of 973 nm, vary in the green range. The lifetime of the $^4S_{3/2}$ level decreases with increasing of dopant Yb^{3+} concentration. These results demonstrate the possibility of manufacturing Er^{3+} and Yb^{3+} codoped $SrTiO_3$ ceramics for applications in up-conversion phosphors, detectors for infrared radiation.

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Perovskite thin films ferroelectric domain analysis

Ioan-Mihail GHIȚIU[1,2], George Alexandru NEMNEȘ[2], Mihai ZAMFIR[1], Valentin ION[1], Nicu SCĂRIȘOREANU[1]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

[2]Faculty of Physics, University of Bucharest, Magurele, RO-077125, ROMANIA

Corresponding author: ioan.ghitiu@inflpr.ro

Application-driven optimization of a nanostructured material's properties has become an essential aspect of research and development, with doping and strain engineering being the primary techniques. Both of these led to advancements in varied fields, from bringing crucial improvements in the development of halide perovskite photovoltaics [1], to yielding significant enhancements of critical temperatures in superconductors [2] or efficiency increases in photoelectrocatalytic processes [3]. In the case of multiferroic materials, well represented by the perovskite material class, these techniques also change the energy landscape of the order parameters, thus being able to induce complex domain structures and profound changes in the behaviour of the material. Moreover, they may promote generally insignificant phenomena, such as the flexoelectric effect [4], to the forefront, opening the way for new applications and opportunities.

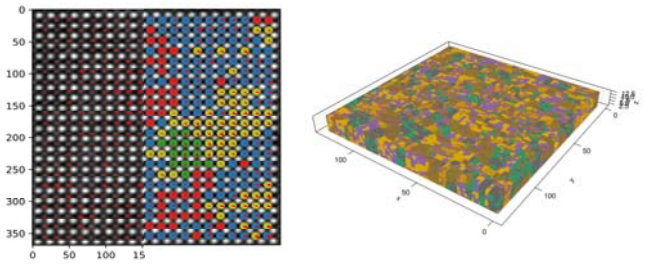

Fig. 1.STEM atomic displacements and K-means predicted domains (left), Phase Field simulations of ferroelectric domains (right)

To investigate such behaviour, computational modelling coupled with high resolution microscopy techniques has become crucial. Phase field simulations, in particular, offer a powerful approach to understand the formation and dynamics of ferroelectric domains under external influences. In this work the authors investigate the effects of strain and electric boundary conditions on perovskite systems, using a code built upon the semi-implicit time dependent Ginzburg-Landau formalism [5]. These results are then compared with S/TEM analyses of thin films deposited through the Pulsed Laser Deposition method. Through the integration of STEM microscopy observations and phase field simulations, this research unveils novel insights into the influence of external factors on domain dynamics, paving the way for tailored engineering strategies.

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The role of rare earth Y-dopant on the optical properties of $BiFeO_3$ thin films

Valentin ION[1], Florin ANDREI[1], Nicu Doinel SCARISOREANU[1]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: valentin.ion@inflpr.ro

The most promising approaches for harvesting solar energy are photovoltaics and photo catalysis applications. In the Photocatalytic used for pollutant degradation or photocatalytic water splitting the oxide semiconductors, such as TiO_2 or ZnO [1], have been proven as efficient photocatalysts agent but those oxide semiconductors are greatly limited for practical applications because due their wide band gap can absorb about of 5% of sunlight in the ultraviolet region. A route to absorb more light is to tune the band gap of materials. One of the classes of materials with tunable band gap are multiferroic materials. Multiferroic BiFeO3 is known to exhibit ferromagnetism (FM) at room temperature (RT), with high ferroelectric (FE) Curie point (Tc ~ 1,103 K) [2] and low the band gap for ferroelectric oxides [3]. The origin of lower band gap (Eg=2.74 eV) come from structural properties of BFO. The rhombohedral unit cell of $BiFeO_3$ is formed by two blocks of pseudo cubic perovskite unit cells connected along their diagonal direction [111] and the wide bandgap of $BiFeO_3$ is a result of the transition metal–oxygen along the [111] axis bonds at B sites [4]. The value of band gap can be lower more by strain induced by chemical doping of BFO with rare earth elements (Lanthanum, Yttrium).

In this work we report the effect on optical properties by doping the $BiFeO_3$ with different percent of Yttrium. The optical investigation was done by spectroscopic ellipsometry in the 250-1700 nm (0.72-4.96 eV) range of wavelength, with a step of 2 nm at 60-700 angle of beam incidence. The calculation of optical constants (refractive index and extinction coefficients) was done by V-VASE32 software. The values of optical band gap extracted from Tauc plot and the lower value was Eg=2.05 eV in case of $BiFeO_3$ doped with 3% yttrium.

Acknowledgement: This research was funded by UEFISCDI, through the PN-III-P4-PCE-2021-1906 PCE97/2022 project.

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Complementary surface investigation of large area $Ba_xSr_{1-x}TiO_3$ thin films grown by pulsed electron beam deposition

Daniela DOBRIN, Florin GHERENDI, Magdalena NISTOR

National Institute for Lasers, Plasma and Radiation Physics (INFLPR), 409 Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: daniela.dobrin@inflpr.ro; magda.nistor@inflpr.ro

The perovskite ferroelectric oxide $Ba_xSr_{1-x}TiO_3$ (BST) is widely used as a tunable dielectric material in microwave capacitors, surface and bulk acoustic waveguides and resonators. Due to its complex oxide nature, the physical properties of this material are dependent on the control of stoichiometry during the thin film deposition, in particular to the A/B ratio in the ABO_3 perovskite lattice of BST films.

In a complementary abstract at this conference we presented the angular thickness and composition profiles of $Ba_xSr_{1-x}TiO_3$ thin films grown by pulsed electron beam deposition (PED) at 10^{-2} mbar pressure in argon or oxygen background gases and room temperature [1, 2]. Large area thin films were analyzed by Rutherford backscattering spectrometry (RBS) at different substrate angular positions using the approach already established for pulsed laser deposition (PLD) [3]. The analysis of the congruent transfer of elements from the target as a function of the angle revealed that the film composition may not be uniform up to 80-90° with respect to the ablated target. The mass of the element used and the background gas appear to play a significant role in determining the angular thickness and composition profiles of films grown by PED. This is similar to the effect seen in the PLD growth [3].

Herein, we present complementary investigations of the surface composition of the BST thin films performed by using X-ray photoelectron spectroscopy (XPS) as function of the angular position. High resolution core-level (Ba 3d, Sr 3d, Ti 2p and O 1s) spectra were recorded on the Thermo Scientific ESCALAB Xi+ spectrometer using monochromatic Al K_α (1486.6 eV) radiation. XPS measurements are surface-sensitive and only probe the top 5 - 10 nm of a film in respect with the RBS that probes in-depth thickness. A comparison between the surface composition obtained by XPS and volume sensitive compositional analysis by RBS is presented for a wide range of angles. The observed variation in the B/A ratio at the surface layer may, at least in part, be associated with different surface terminations, point defects and particularities of the growth method, PED or PLD [4].

Acknowledgement: The Romanian Ministry of Research, Innovation and Digitization under National Core Program LAPLAS VII – contract no. 30N/2023-2026 is acknowledged.

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Temperature influence in PLD / VLS growing processes

Razvan MIHALCEA[1], Marius DUMITRU[1], Aurelian MARCU[1]

[1]NILPRP, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: aurelian.marcu@inflpr.ro

Nanostructures are becoming building blocks for the modern devices fabrication so structure control is essential in determining the device performances. Using a bottom-up catalytic approach based on Pulsed Laser Deposition (PLD) and Vapour-Liquid-Solid (VLS) methods, oxide nanostructures could be grown from the laser ablation plume, using chemically inert liquid droplet (e.g. gold) catalyst. While in the wet chemistry approach there are numerous studies of morphology control, based on the chemical reactions and surface charges [1,2], there are considerably less investigations on the laser based approach [3], in spite of the considerable better performances of the method in terms of potential surface contamination and structural properties. Within the laser based growing process, ambient temperature is a critical parameter, insuring on one side the liquid faze of the catalyst and on the other side controling particle surface diffusion on the deposition substrate. Thus, if a mild decrease in the particle mobility could induce a structure conicity through the so called 'tapering' effect, a more significant decrease of the mobility (corroborated with a 'strong' particle incident flux) could overcame the catalyst based growing (maximal) speed (within the catalyst droplets) producing a combined VLS and Vapour-Solid-Solid (VSS) grow, further affecting nanostructure growing morphology. In such a 'mixed growing process', grown nanostructures section will no longer be (fully) determined by the catalyst droplet geometry, but by the crystalline structure of the grown crystal, and, in **Fig. 1** is exemplified the ZnO nanowire growing morphology for several ambient temperatures.

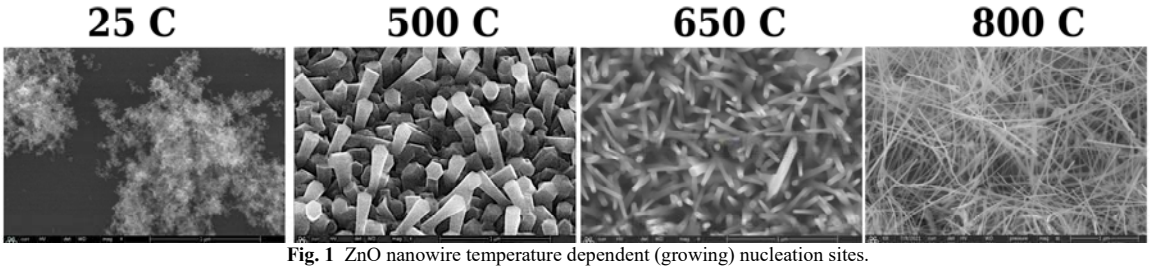

Fig. 1 ZnO nanowire temperature dependent (growing) nucleation sites.

Some theoretical consideration on the growing processes for understanding and potentially controlling the grown morphologies are also included.

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On the production of high entropy alloys by physical deposition methods

Stefan IRIMICIUC[1,2], Valentina GRUMEZESCU[2], Sergiu VATAVU[3], Sergii CHERTOPALOV[1], Stanislav CICHOŇ[1], Petr HRUŠKA[1], Jan LANCOK[1]

[1]Institute of Physics of the Czech Academy of Sciences, Na Slovance 1999/2, Prague, Czech Republic

[2]National Institute for Laser, Plasma and Radiation Physics – NILPRP, 409 Atomistilor Street, Bucharest, Romania
[3]Moldova State University, Alexei Mateevici St 60, Chișinău, Moldova

Corresponding author: valentina.grumezescu@inflpr.ro

High Entropy Alloys (HEAs) represent a relatively novel and intriguing class of materials that have garnered significant attention in materials science and engineering over the past few decades. HEAs are characterized by the presence of multiple principal elements in roughly equal proportions and are the first major result of the involvement of machine learning algorithms and AI in the development of new materials. The unique composition gives HEAs their name, as they exhibit a high degree of configurational entropy due to the large number of elements in the alloy.

The proposed approach uses various combinations of HEAs (e.g., HfNbTaVZr, HfNbTaTiZr, FeCoNiCuTi, FeCoNiCrAl) and oxides (e.g., CuO, ZrO, TiO) fillers are to be tested, analysed, for microwave (MW) and IR absorbers. This technological pursuit is particularly crucial in the context of a rapidly evolving environment characterized by the exponential growth in computational power and the emergence of AI-controlled systems, defining the era of the 4th Industrial Revolution or Industry 4.0.

HEAs coating were produced by pulsed laser ablation and magnetron sputtering. The depositions were performed using a Nd: YAG laser operated at 266 nm on FuSi and MgO (100) substrates. The films were prepared under diverse experimental conditions: substrate temperature variations (up to 500°C), working atmospheres (Ar, N and O_2 atmospheres up to 20 Pa), and laser fluences (2-10 J/cm^2). Alternatively, magnetron sputtering was employed, variation in discharge power, Ar pressure and deposition time were the chosen control parameters for the deposited films. The production of the HEA films was monitored in situ by optical emission spectroscopy to analyze the composition of the plasma and the fluctuations that can appear during deposition.

The deposited films were investigated using several surface analysis techniques such as Atomic Force Microscopy (AFM), Scanning Electron Microscopy (SEM), X-ray Diffraction (XRD), X-ray Photoelectron Spectroscopy (XPS) and electrical measurements. Finally, an optimization procedure was developed to corelate the deposition conditions with the physical properties of the films.

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Physical properties of AZO thin films prepared by the Pulsed Laser Deposition (PLD) technique

Elena-Isabela BANCU[1,2*], Florin ANDREI[1], Mihai-Robert ZAMFIR[1], Valentin ION[1], Sorina IFTIMIE[2], Nicu Dorinel SCĂRIȘOREANU[1], Ștefan ANTOHE[2,3]

[1]National Institute for Laser, Plasma and Radiation Physics, Str. Atomistilor nr. 409, Magurele 077125, Romania
[2]Faculty of Physics, University of Bucharest, 405 Atomistilor Street, 077125 Magurele, Romania
[3] Academy of Romanian Scientists, Ilfov St 3, Bucharest 050045, ROMANIA

Corresponding author: elena.bancu@inflpr.ro

In recent years, the electronic and optoelectronic industry has experienced accelerated development, leading to integrating transparent conducting oxides (TCO) into a wide range of devices [1,2]. Currently, Indium Tin Oxide (ITO) is the most popular TCO, used as transparent electrodes in many applications such as photovoltaic solar cells, light emitting diodes, OLEDs, touch screens, and so on. ITO presents several physical drawbacks, including chemical instability, poor mechanical properties, toxicity, inferior crystallinity quality at low temperatures, and indium migration into the active layer during the device's operation. An available alternative for replacing ITO is zinc oxide (ZnO) due to its excellent physical properties and low production cost. ZnO is an n-type semiconductor that belongs to the A_{II}-B_{IV} group of compounds. This material exhibits good optical and electrical properties combined with a direct bandgap (3.37 eV) at room temperature, low toxicity, and mechanical and chemical stability. [3]

Therefore, this study aimed to analyze how some of the physical properties of AZO films deposited by the Pulsed Laser Deposition (PLD) technique with an Nd: YAG (266 nm) laser change when the pressure of the working gas changes. AZO films were deposited onto silicon and glass substrate at 300 °C. After deposition, the structural proprieties of AZO films were analyzed using X-ray diffraction (XRD) measurements. The optical characterization of the samples was carried out using spectroscopic ellipsometry (SE) and UV-VIS-NIR spectrophotometry in the spectral range of 300-1700 nm. The morphology of the films was studied using an atomic force microscope (AFM), and finally, the electrical characterization was performed using the four-point probe technique. The structural characterization shows that all the AZO films present the (002) diffraction peaks specific to the wurtzite structure. Moreover, the transmission of the samples across the entire visible spectrum exceeded 80%.

Keywords: Transparent conductive oxides (TCO), AZO Thin Films, PLD

Acknowledgment: Part of this work was performed using C400 PHOTOPLASMAT facilities acquired within the POC153/2016 IN2-FOTOPLASMAT project.

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A new microwave-induced plasma method to generate ZnO nanopowders

George MOGILDEA[1], Marian MOGILDEA[1], Gabriel CHIRITOI[1], Cristian Dumitru IONESCU[1], Valentin CRACIUN[2], Petronela PREPELITA[2], Natalia MIHAILESCU[2]

[1]Institute of Space Science - INFLPR, RO-077125, Bucharest-Magurele, ROMANIA
[2] National Institute for Laser, Plasma and Radiation Physics, 409 Atomistilor st., Magurele, RO-077125, ROMANIA

Corresponding author: marian_mogildea@spacescience.ro

The paper presents a new method to generating zinc oxide (ZnO) nanopowders. Using a commercial microwave source (2.45 GHz frequency with 800 W RF power) coupled with a TM_{011} cylindrical cavity was obtained a microwave generator [1]. In center of the cylindrical cavity, a zinc metallic wire was introduced. During interaction process between metallic wire and microwaves a plasma was initiated (**Fig. 1**) and the metallic wire was vaporized. The metal vapors were condensed on a Si substrate placed inside of the cavity and the cavity walls. The experiment was conducted in air at normal pressure. SEM analysis (Fig.2) of the Si substrate deposited with metallic nanoparticles revealed that the size of the metallic nanoparticles is below 1 μm [2]. The XRD analysis was showed that during plasma generation was formed particles ZnO very crystalline.
This method can used in medical domain to produce ZnO nanopowders for contrast substances [3].

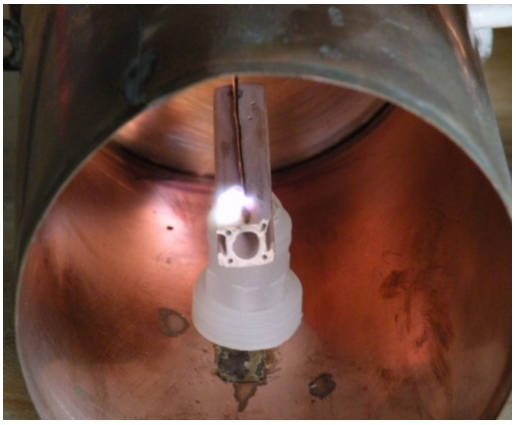

Fig. 1 The image of plasma generated during interaction between microwaves and Zn wire

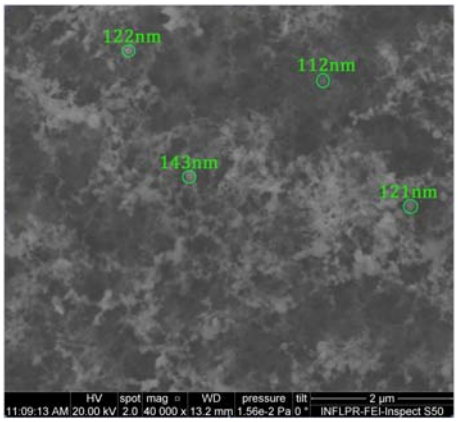

Fig. 2 The SEM image of ZnO nanoparticles

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Synthesis of boron nanoparticles through magnetron sputtering gas aggregation

Tomy ACSENTE[1], Alexandra Ioana SCĂRLĂTESCU[1,2], Veronica SĂTULU[1], Elena MATEI[3], Gheorghe DINESCU[1,2]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

[2]Faculty of Physics, University of Bucharest, 405 Atomistilor street, Magurele, RO-077125, ROMANIA

[3]National Institute for Materials Physics, 405 Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: dinescug@infim.ro

Boron (B) holds significant promise across a range of technologies, including nuclear fusion as coatings for W plasma-facing components [1]. This study reports for the first time the synthesis of B nanoparticles (BNPs) using magnetron sputtering gas aggregation (MSGA) technique [2], based on the condensation in an inert gas flow of the supersaturated vapors obtained from a B target of a magnetron discharge. In this study, Ar and Kr were used as working gases, and small amounts (around 3%) of reactive gases (O_2, N_2, or H_2) were used to emphasize their possible effect on the BNPs synthesis. Sputtering was performed using RF power supply (130W, 13.56 MHz), at a pressure of 80 Pa in MSGA chamber. The BNPs were collected on substrates and analyzed through SEM and XPS. SEM images revealed a small number of 10-100 nm isolated BNPs when Ar, Kr and mixtures with H_2 or N_2 were used, while XPS spectra certified the B presence.

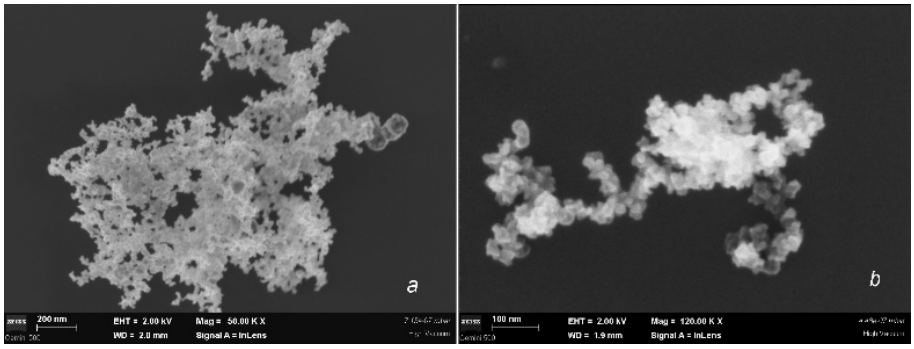

Fig. 1 (a) Boron nanoparticles obtained in MSGA adding small amounts of O_2 to Ar (a) and Kr (b).

We noted that, in comparison with other gases, the addition of O_2 leads to formation of a higher amount of agglomerated B NPs (see Fig.1) collected on substrates, with an increased content of B in particles. This suggests a nucleation mechanism based on B-O dimmers with possible contribution of enhanced sputtering from the oxidized target.

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Formation and properties of Be dust produced in off-normal (air and water leaks) conditions like in the fusion reactors

Cristian P. LUNGU[1], Corneliu POROSNICU[1], Bogdan BUTOI[1], Paul DINCA[1], Cornel STAICU[1], Oana POMPILIAN[1]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: cristian.lungu@inflpr.ro

The presence of dust in core plasma pollution with impurities originated because of the vaporization of some "particulates that might have been produced by blistering or abrasion of wall in previous discharges" [1] must be related to the safety and performance of the fusion machine operation [2]. In this work, we addressed the issue of air and water leaks over the dust production of beryllium to improve the prediction of Be dust generation. Using an arching procedure, beryllium dust was obtained starting from a beryllium target in Ar buffer gas and addition of deuterium, water, and air. The dust shape and size obtained were similar with the ones collected from the JET machine.

In order to produce dust particles was used an DC / pulsed reactor working in a mixture of Ar and deuterium gas. The air and water vapors were added into the reactor. An arc discharge was ignited between a 1 inch Be plate and a 1 mm in diameter W tip.

Operating parameters were: i) the pressure of gas mixture was between 1- 10 mbar, ii) electrical parameters: 1-100 A, 100 -1000 V, iii) obtained dust sizes: 0.5 -100 µm.

During discharges, optical emission spectra were recorded using an OMA spectrometer, in the visible range of 300 to 900 nm. The image of the discharge was collected using a fi 50mm, 100 mm focal distance lens on a screen situated at 200 mm distance. Were highlighted emission lines of ArI, Dα, Dβ , N2, Be II. It was observed that the ratio of Dα/Ar intensity drastically increases in the middle of the distance between Be anode and the W tip cathode.

Using a INSPEC scanning electron microscope, the size and morphology of the dust particle were characterized. Particle sizes were in the range of 1 to 30 nm and the particles shapes were like those collected from Jet.

By a Thermal Desorption System developed at NILPRP, the behavior of different dust powders prepared in air and water vapors mixtures were studied. Was observed a D release at temperatures of 405 ^{0}C, an increase in the release temperature being observed when the dust was prepared in the water environment, the presence of nitrogen, leading to this effect. The incorporation of deuterium into the produced Be dust was proved. Higher content of BeO, H_2O, N_2, $Be(OH)_2$ were found for samples prepared when water was added in the reaction chamber, and also Be, O_2 and Be_3N_2 for samples prepared in air environment.

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Exploring metal nanoparticle synthesis through laser ablation in liquid

Alexandru-Mihai IAMANDI[1,2*], Nicu Dorinel SCĂRIȘOREANU[1], Mihai-Robert ZAMFIR[1], Liviu – Daniel GHICULESCU[2]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

[2] Universitatea Politehnica din București, Splaiul Independenței 313 · 021 402 9100, Romania

Corresponding author: alexandru.iamandi@inflpr.ro

Metallic nanoparticles hold significant importance across diverse industrial sectors owing to their distinctive attributes, including a high surface area-to-volume ratio and remarkable catalytic prowess. These nanoparticles find extensive application in catalysis, electronics, and biomedicine, where they contribute to heightened efficiency and performance. Notably, in catalysis, metallic nanoparticles serve as highly efficient catalysts, expediting crucial chemical reactions pivotal to industrial processes [1]. Furthermore, their superior conductivity and optical properties empower advancements in electronics, facilitating the creation of cutting-edge devices with enhanced functionality and reduced size [2]. Pulsed laser ablation (PLA) in liquid environments holds promise for the fabrication of various nanoparticles (NPs) and nanostructures (NS). Globally, there is a growing demand for the production of metal nanoparticles, such as gold, silver, and nickel, for the manufacturing of sensors, optical and magnetic devices and [2].

This study outlines the principle of nanoparticle synthesis using a series of solid targets (Nickel, Terfenol 0.6 and 0.7, TiO_2, silver) and presents various experimental results obtained. For the experiments, wavelengths of 1064, 532, and 355nm were used, with a pulse frequency of 10 Hz and an ablation time of 20 minutes, corresponding to 12,000 pulses. As liquid suspensions, ultrapure water, ultrapure water + 5 mlM NaCl, and ultrapure water + 10 mlM NaCl were used. From the DLS data, the analyzed samples showed standard deviations of sizes, on average ranging from 15 to 100nm, indicating a narrow distribution of nanoparticles and excellent stability. From the zeta potential, it is observed that the analyzed particles have anionic (Zeta Potential greater than 30 mV) or cationic (Zeta Potential less than 30mV) character. From the data obtained through atomic force microscopy, nanoparticles with sizes ranging from 10-40 nm and a maximum height of 100nm were identified. From the data obtained through SEM, uneven distributions of both dispersed and agglomerated nanoparticles with sizes ranging from 7-170 nm can be observed.

Therefore, this study aims to identify the optimal parameters for obtaining nanoparticles with optimal characteristics for sensor and catalytic applications and to optimize the laser ablation process in liquid to ensure the repeatability of the obtained samples.

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Laser pyrolysis synthesized C-SiC composite nanoparticles for CMCNa stabilized aqueous nanofluids

Lavinia GAVRILA-FLORESCU[1], Iulia LUNGU [1], Florian DUMITRACHE[1], Evghenii GONCEARENCO[1], Anca CRIVEANU[1], Iuliana MORJAN[1], Claudiu FLEACA[1]

[1]INFLPR, 409 Atomistilor Street, Magurele, RO-077125, ROMANIA

Corresponding author: lavinia.gavrila@inflpr.ro

C-based composite nanoparticles with various silicon content (as SiC) were synthesized by laser pyrolysis technique from acetylene with small amount of silane. SiH_4 has also the role of infrared laser energy transfer agent even at low concentrations. X-ray diffractograms indicated the presence of turbostratic carbon and silicon carbide phases in those nanocomposites. Scanning electron microscopy images revealed the presence of aggregated nanoparticles. Energy Dispersive X-ray Spectroscopy (EDS) measurements shown a majority presence of carbon. A direct correlation between EDS-extracted C/Si atomic ratio in the nanoparticles and the same atomic ratio from the gas precursors flows was observed. Due to their post-synthesis exposure to air, the oxygen presence in small amount in those nanocomposites was detected, signaling the formation of surface carbon oxygenated groups and SiO_x. X-ray Photoelectron Spectroscopy (XPS) revealed the presence of C=C, C-Si, C-O, C=O, Si-O bonds in the samples, confirming this superficial oxidation. Water-based stable black nanofluids were obtained from these nanopowders at three different concentrations (0.5, 0.75 and 1 g/l) using Na carboxymethylcellulose as polyanionic hydrophylic agent in the presence of intense horn sonication. Negative Zeta potential values lower than -40 mV of these nanofluids indicated their stability due to their component particles electrostatic repulsion, while their hydrodynamic sizes measured by Dynamic Light Scattering were generally ~ 200 nm.

Acknowledgement: This work was supported by the Romanian Ministry of Research, Innovation and Digitization under Romanian National Nucleu Program LAPLAS VII – contract no. 30N/2023.

Topic 4. Modern applications in environment, life sciences and energy

Polypyrrole-tungsten oxide nanocomposites fabrication via PLD for ammonia sensing

Mihaela FILIPESCU[1], Stefan DOBRESCU[1,2], Adrian Ionut BERCEA[1], Anca Florina NITESCU[1], Valentina MARASCU[1], Simona BRAJNICOV[1], Alexandra PALLA-PAPAVLU[1], Maria DINESCU[1]

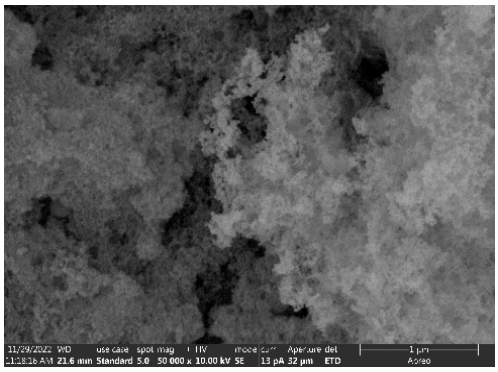
[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA
[2]University of Bucharest, 077125 Magurele, ROMANIA

Corresponding author: mihaela.filipescu@inflpr.ro

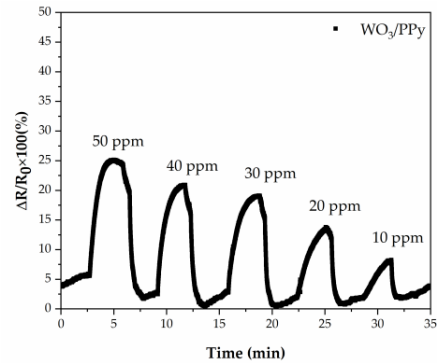
This study introduces a highly sensitive ammonia gas sensor based on nanocomposites of tungsten trioxide and polypyrrole (WO_3/PPy). The synthesis of the WO_3/PPy nanocomposite involves pulsed laser deposition (PLD) and matrix-assisted pulsed laser evaporation (MAPLE) techniques. The nanocomposite is fabricated through a layer-by-layer deposition process, where a thin layer of PPy is alternately deposited onto a mesoporous layer of WO_3.

Comprehensive characterization techniques, including X-ray diffraction, FTIR, scanning electron microscopy, and water contact angle measurements, are employed to analyze the as-prepared layers. The gas-sensing properties of the WO_3/PPy nanocomposite layers are systematically investigated upon exposure to ammonia gas.

The results indicate that the WO_3/PPy nanocomposite sensor outperforms the pure PPy and WO_3 counterparts in terms of detection limit, response, response/recovery time, and repeatability. This improvement in gas-sensing properties is attributed to the unique interactions at the p-n heterojunction formed between the n-type WO_3 and p-type PPy. Furthermore, the enhanced surface area of the WO_3/PPy nanocomposite (Fig. 1a), achieved through PLD and MAPLE synthesis techniques, contributes to its exceptional gas-sensing performance at room temperature (Fig. 1b).



(a)



(b)

Fig. 1 (a) SEM image of PPy/WO_3 structure (b) Time dependent response obtained at 22±1°C of a sensor with WO_3/PPy active layer.

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Pd/SnO_2 bilayers obtained by PLD for SAW hydrogen sensors

Mihai PAUNICA[1,2], Izabela CONSTANTINOIU[1], Cristian VIESPE[1]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA
[2]Faculty of Medical Engineering, National University of Science and Technology POLITEHNICA Bucharest, RO-060042, ROMANIA

Corresponding author: cristian.viespe@inflpr.ro

For hydrogen detection, surface acoustic wave (SAW) sensors with different morphologies of the sensitive layers were developed. Taking into account that a large specific surface of a material leads to greater interaction between gas molecules and sensitive layer, thin films with different degrees porosities were developed by pulsed laser deposition (PLD) method.

SnO_2 is one of the most used oxide semiconductor material as sensitive element in gas sensing, but its big disadvantage is the low selectivity for certain gases. It is known that Pd is an element with an increased selectivity for hydrogen, because it has the ability to dissociate the hydrogen molecule, thus increasing the sensitivity of the sensor for hydrogen. Combining the increased sensitivity of SnO_2 and the selectivity for hydrogen of Pd, bilayers for SAW sensors were developed.

The performances of these sensors were also optimized by controlling the porosity of the layers, which was achieved by varying the oxygen pressure in the deposition chamber as follows: 100, 400 and 700 mTorr.

The morphology of the layers was analysed by scanning electron microscopy and the sensor tests at different hydrogen concentrations to observe the influence of oxygen pressure on sensor performance. Tests were also carried out for nitrogen, oxygen and carbon dioxide, in order to establish their selectivity to hydrogen.

The final results showed that the sensitivity of the sensors increases with the porosity, the best results, 0.21 Hz/ppm sensitivity and a limit of detection of 142 ppm at hydrogen tests, being obtained by the sensor with both sensitive layers deposited at 700 mTorr. Also, the sensors with double sensitive layers of SnO_2 and Pd showed selectivity for hydrogen, while the sensor with SnO_2 only layer had the best result for carbon dioxide.

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A portable, fast and sensitive plasmonic sensor for pesticide and heavy metal detection

Iulia ANTOHE[1,3], Ana-Maria POPA[1,2], Felicia IACOB[1,2], Luiza-Izabela TODERAŞCU[1], Oana GHERASIM[1], Bianca ŞOLOMONEA[1], Vlad-Andrei ANTOHE[2], and Gabriel SOCOL[1]

[1]National Institute for Laser, Plasma and Radiation Physics (INFLPR), Atomiştilor Street 409, 077125 Măgurele, Ilfov, Romania
[2]Faculty of Physics, Research and Development Center for Materials and Electronic & Optoelectronic Devices (MDEO), University of Bucharest, Atomiştilor Street 405, 077125 Măgurele, Ilfov, Romania
[3]Academy of Romanian Scientists (AOSR), Ilfov 3, 050094 Bucharest, Romania

Corresponding authors: iulia.antohe@inflpr.ro; gabriel.socol@inflpr.ro

Heavy metals and persistent organic pollutants are nowadays excessively present in the water environment, leading to water pollution and serious threats to public health [1].

Several analytical methods, including electrochemistry, fluorescence, chromatography, mass spectrometry, or atomic absorption spectrometry, have been applied for the detection of such environmentally hazardous materials. Among them, the fiber optic–-surface plasmon resonance (FO-SPR) technique stands out since it provides label-free, real-time, fast and sensitive measurements, requiring minimal sample consumption [2]. Hence, FO-SPR has been widely employed to investigate water pollution and analyze the water treatment process. Most environmental pollutants can be determined by the FO-SPR sensing system using the appropriate surface modification [3].

In this work, results on the fabrication and characterization of such FO-SPR sensors were reported. Moreover, we used these sensors for rapid and sensitive detection of heavy metals (i.e. cobalt, cadmium, zinc, copper) [4] and pesticides (4-nitrophenol) [5] in water samples. In the first scenario, the FO-SPR sensor was coated successively with different plasmonic materials (i.e. gold, platinum, palladium) and different polymers (i.e. polyaniline, chitosan, etc) specific for the above-mentioned heavy metals.

In the second scenario, the FO-SPR sensor was coated with a polyaniline/platinum bilayer and used for 4-nitrophenol detection, demonstrating a sensor limit of detection in the low pM concentrations range.

In conclusion, the FO-SPR sensors are amongst the most versatile tools, and their use might be extended to almost all types of pollutants present in water.

Keywords: plasmonic materials, fiber optic-surface plasmon resonance sensors, polymers, pesticides, heavy metals

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Improving plasmonic-based virus detection using artificial intelligence solutions

Iulia ANTOHE[1,2], Bianca ŞOLOMONEA[1,2] and Gabriel SOCOL[1]

[1]National Institute for Laser, Plasma and Radiation Physics (INFLPR), Atomiştilor Street 409, 077125 Măgurele, Ilfov, Romania
[2]Academy of Romanian Scientists (AOSR), Ilfov 3, 050094 Bucharest, Romania

Corresponding author: iulia.antohe@inflpr.ro

The worldwide impact of coronavirus disease 2019 (COVID-19) especially on public health has accentuated the need for fast and simple viral diagnostic approaches. In this context, plasmonic-based sensing might control the infectious disease threat by appropriate virus monitoring [1]. Hence, fiber-optic surface plasmon resonance systems allow on-site strategies to complement traditional diagnostic methods based on the polymerase chain reaction (PCR) and enzyme-linked immunosorbent assays (ELISA) [2].

However, to unlock the FO-SPR system's real potential, the design of novel functionalization strategies for effective coverage of the bioreceptor while ensuring the affinity towards the target viral nucleic acids or proteins is essential [3]. The integration of artificial intelligence (AI) algorithms with FO-SPR might enhance the sensors' performance by sorting the output signals, detecting fouling and interferences, choosing the appropriate bioreceptors, and automating the entire sensing process.

Herein, we present preliminary results about using AI for data processing and for the selection of the appropriate aptamer-based bioreptors to be immobilized on the FO-SPR sensor surface for specific SAR-Cov-2 spike glycoprotein detection. In conclusion, AI can improve FO-SPR data analysis and can enhance the detection and quantification of target analytes by selecting suitable bioreceptors.

Keywords: plasmonics, fiber optic-surface plasmon resonance sensors, artificial intelligence, SARS-CoV-2 coronavirus, experimental design

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Synthesis and characterization of high-sensitivity DLC-like SAW sensors for gas sensing applications

Veronica SATULU[1], Bogdana MITU[1], Cristian VIESPE[1], Gheorghe DINESCU[1]

[1] National Institute for Laser, Plasma and Radiation Physics - 409 Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: mitu.bogdana@inflpr.ro

The use of diamond-like carbon (DLC) based sensors has become increasingly popular, particularly in environments where the detection of toxic gases and monitoring of air quality is essential. As such, this contribution aims to evaluate the gas sensing capabilities of DLC-based sensors response to various gases at room temperature. To achieve this objective, DLC thin films were synthesized onto the quartz surface acoustic wave (SAW) sensor substrate through plasma-enhanced chemical vapor deposition technique (PECVD) starting from methane (CH_4) as precursor in the presence of Ar and introducing various reactive gases, such as nitrogen (N_2) and hydrogen (H_2). The capacitively coupled discharge was ignited via an RF power supply (13.56 MHz) at power ranging from 50 to 100 W using a shower-like active electrode, while the substrate was placed on the grounded electrode, leading to deposition rates adjusted in accordance with the gas mixture and RF power used. The obtained DLC-like thin films were subjected to multiple characterization techniques to understand their properties and gas sensing behaviour. The topography investigations using Atomic Force Microscopy (AFM) revealed that the active surface of the sensors had a smooth surface, while the morphology of the DLC SAW sensors evaluated through scanning electron microscopy (SEM) analysis showed a uniform and dense structure. X-ray diffraction (XRD) analysis was utilized to assess the crystalline nature of the investigated samples, exposing an amorphous structure in the DLC-like thin films obtained under all investigated conditions. X-ray Photoelectron Spectroscopy (XPS) analysis indicated that the DLC thin films primarily consisted of a combination of sp^2 and sp^3 hybridized carbon atoms, with their proportions varying depending on the gas admixture utilized during synthesis. The sensors' gas sensing capabilities were evaluated by exposing them to H_2S, and H_2, at room temperature, and their performance with respect to various concentrations of these gases is reported. Overall, the study offers valuable insights into the behaviour and performance of DLC-based sensors, which can contribute to the development of more advanced and reliable gas sensing technologies.

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Self-assembled carbon nanostructured carpets as microporous layers in proton exchange membranes fuel cells

Ion SANDU[1], Bogdan Ionut BIŢĂ[1], Ana Violeta FILIP[1], Adriana BALAN [2], Anca NEDELCEA[1], Alexandra Maria Isabel TREFILOV[1]

[1] National Institute for Laser, Plasma and Radiation Physics - INFLPR, 409 Atomistilor Street, Magurele-Ilfov, RO-077125, Romania

[2]University of Bucharest, Faculty of Physics, 3Nano-SAE Research Center, 405 Atomistilor Street, Magurele-Ilfov, Romania

Corresponding author: alexandra.trefilov@inflpr.ro

The microporous layers (MPL) are key components of the proton exchange membrane fuel cell (PEMFC) in water-gas management. The MPL require specific properties, such as hydrophobicity, good chemical and mechanical stability, durability, and high electrical conductivity. In the present article, we propose a self-assembled MPL architecture that builds up as a distinct layer on the surface of the carbon paper while remaining in close contact with it, assuring a homogeneous distribution of nano and micropores, and a remarkable hydrophobicity of the film. The synthesis method is simple, similar to the Langmuir-Blodgett technique: the polyaromatic hydrocarbon components enable the carbon powders to form a fluffy carpet onto the water surface which is subsequently transferred onto the carbon paper as a homogeneous thick film (d ~ 10 μm). Two types of carbon were tested: Vulcan XC 72R and carbon nanoparticles synthesized by laser pyrolysis technique. The mean size of the nano/micro pores can be tuned by compressing the produced carbon film onto the water surface. Platinum ink, used as a fuel cell catalyst, was sprayed directly onto the MPLs and incorporated into the FC assembly by hot pressing against a polymer membrane. This formed the membrane electrode assembly and gas diffusion layers. The integrated PEMFCs were tested in a single-cell configuration, showing power performance comparable to industrial-quality membrane assemblies, with elevated power density (400 mW/cm^2) and impeccable fuel crossover for a low-cost system.

Acknowledgement: This work was supported by Romanian Ministry of Research, Innovation and Digitization under the Romanian National Nucleu Program LAPLAS VII – contract no. 30N/2023; Program I—Development of the National R&D System, Subprogram 1.2 – Institutional Performance – Projects for Excellence Financing in RDI, contract no. 13PFE/2021.

New microporous layer architecture based on N-doped carbon nanowalls for proton exchange membranes fuel cells

Alexandra M.I. TREFILOV[1], Adriana Elena BĂLAN[2], Bogdan Ionut BIŢĂ[1], Sorin VIZIREANU[1], Anca NEDELCEA[1], Ana V. FILIP[1], Bogdan A. SAVA[1]

[1]National Institute for Laser, Plasma and Radiation Physics, 409 Atomistilor Str., Măgurele, Ilfov, RO-077125, Romania

[2]University of Bucharest, Faculty of Physics, 3Nano-SAE Research Center, 405 Atomistilor Str., Măgurele, Ilfov, RO-077125, Romania

Corresponding author: alexandra.trefilov@inflpr.ro

The cathode microporous layer (MPL), as one of the key components of the proton exchange membrane fuel cell (PEM-FC), requires specialized carbon materials to realize the two-phase flow and inter-facial effects. In this respect, we designed a novel MPL based on super-hydrophobic nitrogen doped carbon nano-walls (CNW). Employing radio-frequency plasma enhanced chemical vapor deposition techniques directly on carbon paper we produced high quality microporous layers (Fig. 1.) at competitive yield-to cost ratio with distinctive MPL properties: high porosity, good stability, considerably durability, high hydrophobicity and substantial conductivity[1]. Platinum-ink, serving as fuel cell catalyst, was directly sprayed on the MPLs and incorporated in the FC assembly by hot-pressing against a polymeric membrane to form the membrane-electrode assembly (MEA) and gas diffusion layers (GDLs). The integrated PEM-FCs were tested in a single cell PEM-FC on a BT-112 Single Cell Test System, showing power performance comparable to industrial quality membrane assemblies (350 mW/cm^2 at 80 °C and 80% relative humidity), with elevated working potential (0.99 V) and impeccable fuel crossover for a low-cost system.

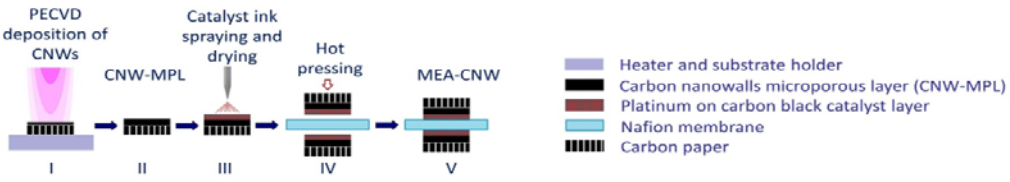

Fig. 1. Graphic illustration of the MEA fabrication: (I) N-doped CNW deposition on the carbon paper by PECVD techniques; (II) gas diffusion layer composed of CNW as MPL and carbon paper; (III) catalyst layer deposition by spraying the platinum ink on top of the MPL; (IV) hot pressing the two catalyst-loaded GDLs against Nafion- proton exchange membrane; (V) MEA_CNW ready for tests.

Acknowledgement: This work was supported by Romanian Ministry of Research, Innovation and Digitization under the Romanian National Nucleu Program LAPLAS VII – contract no. 30N/2023; Program I—Development of the National R&D System, Subprogram 1.2 – Institutional Performance – Projects for Excellence Financing in RDI, contract no. 13PFE/2021.

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CVD grown Graphene/Nafion composite membranes characterization for fuel cells applications

Daniela ION-EBRASU[1], Elena CARCADEA[1], Bogdan Stefan VASILE[2],

Adrian Ionut NICOARA[3], Iulian BOERASU[4]

[1]National Institute for Cryogenics and Isotopic Technologies ICSI-Rm. Valcea, ICSI Energy, Uzinei Str. no. 4, 240050, Ramnicu Valcea, Romania, Ramnicu Valcea, Romania
[2] Advanced Research Center for Innovative Materials, Products and Processes, National University of Science and Technology Polytechnica Bucharest, 011061 Bucharest, Romania
[3] Department of Science and Engineering of Oxide Materials and Nanomaterials, Faculty of Chemical Engineering and Biotechnologies, National Polytechnic University of Science and Technology of Bucharest, 011061 Bucharest, Romania
[4] National Research Center for Micro and Nanomaterials, National Polytechnic University of Science and Technology of Bucharest, 011061 Bucharest, Romania

Corresponding author: bogdan.vasile@upb.ro

Our paper addresses an enormous need for more efficient energy systems such as fuel cells and electrolysers production based on 2D graphene. In this paper is investigated the influence of single and few (2-3) layers graphene grown by chemical vapor deposition (CVD) towards electrical and electrochemical performances of the modified Nafion 115. The number of graphene layers was adjusted from 5 to 15 minutes time of reaction, using methane as carbon source during the CVD process on cooper foil substrate catalyst. The graphene transfer on the polymeric membrane was carried out using roll-to-roll method, by using a thermal release tape applied directly on the graphene layer. The increase of graphene layers deposited on the Nafion 115 was put in evidence by the decrease of transmittance obtained by UV-Vis spectroscopy (Figure 1). Further, Raman spectroscopy analysis, as well as scanning electron microscopy (SEM) were carried out to understand the structure of the samples. Moreover, there were obtained membranes with increased water uptake (WU), ion exchange capacity (IEC) and in plane proton conductivity measured by electrochemical impedance spectroscopy (EIS). At a temperature of 25°C and fully hydrated conditions, a value of 195 $mS \cdot cm^{-1}$ corresponding to composite membranes with graphene obtained after 10 minutes time of CVD growing, can be achieved. For higher graphene loadings, the proton conductivity decreases, which may be due to the excess amount of graphene, hindering and disrupting proton pathway.

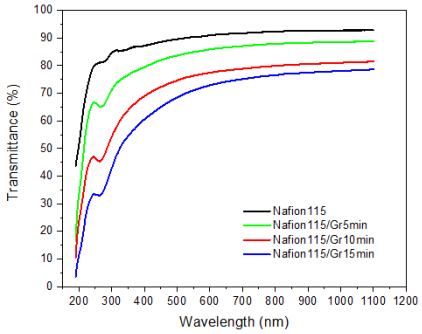

Fig. 1 UV-Vis Spectroscopy Characterization

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[1] Daniela Ion-Ebrașu, Radu Dorin Andrei, Stanică Enache, Simona Căprărescu, Constantin Cătălin Negrilă, Cătălin Jianu, Adrian Enache, Iulian Boerașu, Elena Carcadea, Mihai Varlam, Bogdan Ștefan Vasile, Jianwei Ren, *Materials* **14** (17), 2021, 4952

Impact of hole transport layer thickness on the performance of ternary organic solar cells

Maria-Luiza STÎNGESCU[1, 2], Alina RADU[1, 2], Cristina CRĂCIUN[1, 2], Mihai-Robert ZAMFIR[1], Adrian RADU[2], Sorina IFTIMIE[2], Nicu Doinel SCĂRIȘOREANU[1], Ștefan ANTOHE[2,3]

[1] INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA
[2] Univ Bucharest, Fac Phys, Dept Elect Solid State Phys & Biophys, 405 Atomistilor St. POB MG-11, Bucharest, ROMANIA
[3] Acad Romanian Scientists, Ilfov St 3, Bucharest 050045, ROMANIA

Corresponding author: maria.stingescu@infpr.ro

In the last decade, organic solar cells have been intensively studied due to several key features, including their light weight, flexibility, potential for large-scale production, reproducibility, and ease of processing from solution without requiring a high vacuum. These characteristics result in decreased fabrication costs compared to inorganic-based technologies. Furthermore, amidst the sharp rise in energy demand in recent years, organic photovoltaic cells have emerged as promising candidates to mitigate the negative effects of fuel consumption, thus attracting significant attention. Efforts have been made to achieve high performance and long-term stability in organic solar cells, with some studies reporting conversion efficiencies exceeding 18%. [1] However, further improvements are still necessary. [2, 3] One promising approach involves adding a third component to the bulk heterojunction (BHJ) structure, which can function as either a second donor or a second acceptor. [4] This addition has been shown to improve the short-circuit current (J_{SC}) and open-circuit voltage (V_{OC}), reduce energy losses, facilitate charge transport, and enhance stability. The concept of ternary organic solar cells has the potential to broaden the absorption range, improve blend morphology, and tune exciton splitting and charge extraction. Therefore, the current study proposes to investigate the impact of the thickness of the hole transporting layer (PEDOT:PSS) on the photovoltaic properties of the solar cells based on a ternary blend between the well-known donor polymer Regioregular poly(3-hexylthiophene-2,5-diyl) (P3HT) and two non-fullerene acceptors named Y7 (BTP-4Cl) and 1-10 Phenanthroline.

Acknowledgement: This work was performed using C400 PHOTOPLASMAT facilities acquired within the POC153/2016 IN2-FOTOPLASMAT project.

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Hot probe technique for thin films Seebeck coefficient measurement

Claudiu. L. HAPENCIUC[1], Mihai OANE[1], Anita VISAN[1], Carmen RISTOSCU[1],
Theodorian BORCA-TASCIUC[2], Ion N. MIHAILESCU[1]

[1)] National Institute for Laser, Plasma and Radiation Physics, 409 Atomistilor St., Magurele RO-77125, Romania

[2)] Mechanical Aerospace and Nuclear Engineering Department, Rensselaer Polytechnic Institute,
110 8th St., Troy, New York 12180-3590, USA

Corresponding author: ion.mihailescu@inflpr.ro

A new experimental method using a 50 microns diameter hand fabricated hot probe from Pt90/10Rh alloyis proposed to measure Seebeck coefficient of thin films deposited onto electrically insulated substrates. By variance to the classical measuring methods, which resorts to a heater-heat sink ensemble instrumented with thermocouples orbased upon heated metallic rods with built-in thermocouples or microfabricated structures the proposed method is fast, reliable and easy to implement. A thermal model for heat transfer inside the probe and to the sample was developed to simulate the corresponding temperature distributions. Computation showed that the ratio of the probe temperature rise in the contact point to the average temperature variation behaves basically independent on electrical current and film-substrate properties. Moreover, the contact radius and thermal contact resistance should not be necessary known butonly the pairs that are fitting the best the probe thermal resistance in contact with the film substrate. This brings a great simplification to the AFM based hot probe methods which previously determines these two parameters by calibration of the two substrates with known thermal conductivity. These values can be further used to evaluate the Seebeck coefficient of the sample of a macroscopic probe, within 1% precision. The method was validated by measuring the Seebeck coefficient on several reference samples.

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Surface tension driven phenomena by vapor migration between binary droplets

Ionuț-Petrișor UNGUREANU[1], Mihai BONI[1], Ionuț Relu ANDREI[1], Mihail-Lucian PASCU[1]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: ionut.ungureanu@inflpr.ro

The interaction of fluids in microgravity is governed by surface tension phenomena, resulting in distinct behaviours compared to those observed under Earth's laboratory conditions [1]. In the presence of gravity, the evaporation of droplets has a significant influence on surface tension behaviour. This phenomenon is impacted by natural convection [2] and droplet geometry [3].

Preliminary investigations were undertaken to analyse surface tension variation in 1g terrestrial gravity conditions, focusing on vapor migration dynamics and diffusion rates at the interaction between two droplets in view of experiments on droplets coalescence set out to be performed aboard the International Space Station (ISS).

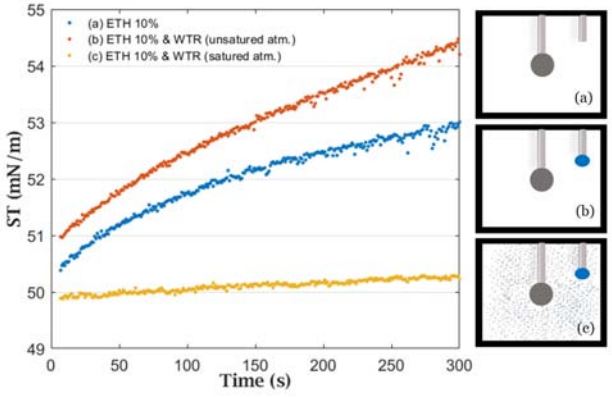

Fig. 1 Surface tension behaviour of a 10 % ethanol drop (V=12 µl) (a) without presence of other drop, (b) in the proximity of a water drop in unsaturated atmosphere, (c) saturated atmosphere.

This paper investigates the impact of vapor migration between two pendant droplets of ultrapure water and 10% (v/v) ethanol (solution in water) under different atmospheric saturation conditions on the surface tension behaviour at $T = 22.1 \pm 0.5$ °C. These studies conducted in 1g environments explore vapor migration dynamics and diffusion rates between droplets, revealing that the presence of a neighbouring droplet with a different surface tension alters evaporation rates, droplet geometry, and surface tension. The study highlights the modification of surface tension by vapor interactions without droplets direct contact and will help droplets coalescence understanding in microgravity conditions.

Acknowledgement: This work was supported by the Romanian Ministry of Research, Innovation, and Digitization through the Nucleu Program LAPLAS VII, contract no. 30N/2023.

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Drop coalescence – Sky is NOT the limit

Mihai BONI[1], Mihail L. PASCU[1,2], Ionut R. ANDREI[1], Ionut P. UNGUREANU[1], Benedikt J. SCHMIDT[3], Ilia ROISMAN[3], Jeanette HUSSONG[3], Stephen GAROFF[4], Mugurel BALAN[5], Sebastien VINCENT-BONNIEU[6]

[1]INFLPR, 409 Atomistilor, Magurele, 077125, ROMANIA
[2]AOSR, 3 Ilfov, Bucharest, 050044, ROMANIA
[3]TU Darmstadt – SLA, 19 Flughafenstr, 64347, Griesheim, GERMANY
[4]CMU, 5000 Forbes Avenue, 15213, Pittsburgh, SUA
[5]RISE, 405 Atomistilor, Magurele, 077125, ROMANIA
[6]ESA, 19 Keplerlaan 1, 2201 AZ Noordwijk, NEDERLANDS

Corresponding author: mihai.boni@inflpr.ro

The DropCoal project, short form for "*Setup for investigation of drops coalescence in view of medical applications"*, will study droplet coalescence in low-gravity environment of the International Space Station during 6 months.

This project focuses on measuring coalescence time, coalescence type, and coalescence process kinematics using large, spherical drops to visualize micro-scale mechanisms in microgravity. By varying collision velocities, drop diameter ratio, and liquid combinations, the payload (Fig. 1) use a high-speed video system to observe phenomena challenging to replicate on Earth due to small drop sizes and complex collision conditions [1].

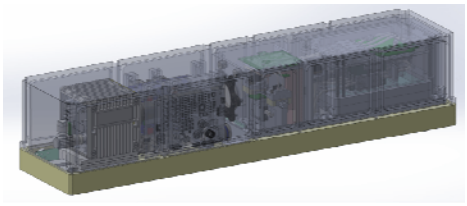

Fig. 1 The 3D model of the DropCoal set-up that will be hosted on Europe's Columbus module in the ICE Cube facility.

This paper outlines four years of intensive work on the preparation of an ESA mission, presents the experimental scientific requirements, unveils the insights of the developed cutting-edge hardware device and explores the bottlenecks encountered during the project implementations and their innovative solutions.

The results will give insights in understanding raindrop and cloud formation, as well as fuel combustion, all of which are crucial for space exploration. They also have a significant impact on the administration of medicine to astronauts during lengthy and far-reaching space missions [2].

The project represents a significant step forward in addressing fundamental challenges in fluid dynamics under microgravity and this is *Rocket Science*, indeed, pushing the boundaries of knowledge for both space exploration and terrestrial applications.

Acknowledgement: This research was funded by the Romanian Ministry of Research, Innovation, and Digitization under the Nucleu Program LAPLAS VII—contract no. 30N/2023 and by European Space Agency.

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Spectral studies for detecting nitrate and nitrite compounds in water

Mihai SERBANESCU[1], Andreea GROZA[1], Bogdan BITA[1,2], Sasa-Alexandra YEHIA-ALEXE[1,2], Maria Elena ZARIF[1,3]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA
[2]Faculty of Physics, University of Bucharest, 405 Atomistilor street, Magurele, RO-077125, ROMANIA
[3]Department of Science and Engineering of Oxide Materials and Nanomaterials, Faculty of Applied Chemistry and Materials Science, University Politehnica of Bucharest, 1-7 Gheorghe Polizu Street, sector 1, Bucuresti, RO-011061, ROMANIA

*Corresponding author: mihai.serbanescu@inflpr.ro

The development of novel optical sensors for nitrate and nitrite concentration measurements in water is of high interest in the context of the present water pollution [1].

The detection of nitrogen-based compounds, respectively nitrate and nitrites can be achieved by spectral methods considering their properties of absorbing the UV radiation in the 190-400 nm range. Ultraviolet radiation can be provided by spectral lamps, electroluminescent emitting diodes or laser diodes that emit broad spectrum radiation respectively a narrow spectrum radiation. The detection of ultraviolet radiation is performed with the help of optical systems with high sensitivity response in the ultraviolet range such as optical spectrometers or photodetectors [1, 2].

The present study explores the utilization of optical spectral methods and colorimetric methods for an *in-situ* and enhanced detection of the nitrate and nitrite concentrations in water. For example, by using photodiodes, and long optical path of the liquid sample enclosure in comparison with UV-Vis optical spectrometers the nitrite concentration detection was improved ten times (from 10 mg/L dissolved $NaNO_2$ to 1 mg/L $NaNO_2$) respectively two times (from 10 mg/L dissolved $NaNO_3$ to 5 mg/L $NaNO_3$).

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Novel hybrid nanofluids from laser pyrolysis synthesized silicon nanoparticles and single walled carbon nanohorns

Claudiu Teodor FLEACĂ[1], Florian DUMITRACHE[1], Iulia LUNGU[1], Lavinia GAVRILĂ-FLORESCU[1], Ana-Maria BĂNICI[1], Marius DUMITRU[1], Ioan GHIŢIU[1], Gabriela HUMINIC[2], Angel HUMINIC[2]

[1]INFLPR, 409 Atomistilor street, RO-077125, Magurele, ROMANIA

[2]Transilvania University of Brasov, Mechanical Engineering Department, 29 Eroilor bd., 500036, Brasov, ROMANIA

Corresponding author: dumitracheflorian@yahoo.com

Hybrid nanofluids are modern nanofluids containing two different types of nanoparticles dispersed in a conventional base liquid, usually presenting better performances than pure heat transfer fluids or the monocomponent nanofluids [1]. One important class of these nanofluids is that which contains carbon nanomaterialsas one of the components, such as carbon nanotubes, graphenes, etc. [2]. An emerging application of these nanofluids is their use as working fluids in solar collectors for fossil-fuel free energy generation [3]. We synthesized first the Si nanoparticles by infrared laser pyrolysis at 250 mbar pressure and 350 W laser power using 20 sccm silane inner flow surrounded by Ar inert flowintroduced with a two-nozzle injector (0.9 mm inner diameter). The Si nanoparticles were characterized by XRD, TEM, SEM and EDS analyses, showing a mean crystallite diameter of 20.7 nm and an aggregated round morphology. The nanofluids (having total nanoparticle concentrations of 0.05, 0.075 and 0.1 wt.%) were prepared by mixing equal quantities of Si nanopowders and commercial single-walled carbon nanohorns (SWCNHs) aggregates black particles (around 100 nm in size) with low viscosity sodium carboxymethylcellulose (0.04 wt.%) as hydrophilizing agent and dispersing themin distilled water using a vibrating rod and strong horn ultrasonication for one hour under cooling water bath. The resulted nanofluids stability was confirmed by their negative values of the Zeta potential and by their average hydrodinamic sizes under 500 nm determined by Dynamic Light Scattering (DLS) analyses. The nanofluids presented higher thermal conductivity than pure water, increasing with the nanoparticles concentrations. These properties recommend those nanofluids for applications in the field of heat transfer agents.

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Bio-functionalization study of doped titanium dioxide nanoparticles synthesized by laser pyrolysis

Anca Daniela CRIVEANU[1], Monica SCARISOREANU[1], Iulia LUNGU[1], Lavinia GAVRILA[1], Florian DUMITRACHE[1], Iuliana MORJAN[1], Mihaela BALAS[2], Andra DINACHE[1]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA
[2]Univ Bucharest, Fac Biol, Dept Biochem & Mol Biol, 91-95 Splaiul Independentei, Bucharest 050095, Romania

Corresponding author: anca.criveanu@inflpr.ro

Titanium dioxide nanoparticles were synthesized by laser pyrolysis using $TiCl_4$ as the TiO_2 source. In this process, it was used a CO_2 laser and ethylene as sensitizer. During the synthesis, iron, zinc or tin dopants were used, obtaining nanoparticles with improved properties. To get rid of impurities, it is calcined at a temperature of 450 ºC. After being characterized with the established analyses, XRD, EDX, XPS, the nanoparticles were stabilized and functionalized with polymers and 5-flouracil and analyzed by DLS, FTIR.

Three types of nanoparticles doped with tin, zinc and iron are used and stabilized with three types of polymers: l-3,4-dihydroxyphenylalanine, carboxymethylcellulose sodium and chitosan. During the functionalization of nanoparticles their dimensions improved from 490-3875 nm in water to 100-300 nm. In the case of L-dopa, the dimensions are generally 140 nm. The nanoparticles obtained by laser pyrolysis synthesis are also compared with commercial Degussa P25 sample.

The stabilized and functionalized nanoparticle solutions were tested in vitro to see the toxicity of TiO_2 nanoparticles doped with different elements. The cell viability is at a level close to that of the control for the tested cells.

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Nano-silver embedded coatings for metallic implants

Oana GHERASIM[1], Gianina POPESCU-PELIN[1], Valentina GRUMEZESCU[1], Alexandru Mihai GRUMEZESCU[2,3], Bogdan Ștefan VASILE[2], Roxana Cristina POPESCU[2,4], Alina Maria HOLBAN[3,5], Marcela SOCOL[6], Gabriel SOCOL[1]

[1] National Institute for Laser, Plasma and Radiation Physics, 409 Atomistilor Street, 077125 Magurele, ROMANIA
[2] National University of Science and Technology POLITEHNICA Bucharest, 313 Independentei Lane, 060042 Bucharest, ROMANIA
[3] Research Institute of the University of Bucharest, 90-92 Panduri Road, 050657 Bucharest, ROMANIA
[4] "Horia Hulubei" National Institute of Physics and Nuclear Engineering, 30 Reactorului Street, 077125 Magurele, ROMANIA
[5] University of Bucharest, 1-3 Portocalelor Lane, 077206 Bucharest, ROMANIA
[6] National Institute of Materials Physics, 405A Atomistilor Street, 077125 Magurele, ROMANIA

Corresponding author: oana.gherasim@inflpr.ro

As the surface characteristics of metallic implants strongly impact overall biofunctional outcomes, their modification with bioactive coatings is a topical concern of the healthcare practice. Nanostructured coatings able to prevent or limit microbial contamination and colonization, while stimulating osteogenic events, represent prospective candidates for the infection-free and boosted osseointegration of metallic devices.

In this respect, we herein evaluate the ability of laser-processed nano-silver embedded hydroxyapatite coatings to modulate the opportunistic infection and regenerative ability of implantable metallic devices. Phytochemicals-conjugated silver nanoparticles, with core/shell spherical morphology, were synthesized by classical and ultrasound-assisted chemical reduction. Uniform and nanorough compact coatings, obtained by matrix-assisted pulsed laser evaporation technique, exhibited important and sustained inhibitory effects against bacterial biofilms, with more prominent effects for composites embedded with conventionally synthesized nano-silver. Moreover, the high biocompatibility and osteogenic ability, demonstrated on osteoblast-like cells, confirmed the successful fabrication of anti-biofilm and osteoinductive nanostructured coatings for metallic implants.

Picosecond laser processing of TiAl6V4 dental abutments surfaces: an *in vitro* cells response study

Emanuel AXENTE*[1], Paula FLORIAN[1,2], Madalina ICRIVERZI[1,2], Florin JIPA[1], Gianina POPESCU-PELIN[1], Raluca IVAN[1], Petronela GAROI[1], Dragos BUDEI[3], Koji SUGIOKA[4], and Felix SIMA*[1,4]

[1]National Institute for Laser, Plasma and Radiation Physics (INFLPR), 409 Atomistilor, Magurele 077125, Romania
[2]Institute of Biochemistry of the Romanian Academy, 296 Splaiul Independentei, Bucharest 060031, Romania
[3]Dentix Millennium SRL, 087153 Giurgiu, Romania
[4]RIKEN Center for Advanced Photonics, 2-1 Hirosawa, Wako, Saitama, 351-0198, Japan

Corresponding authors: *emanuel.axente@inflpr.ro, felix.sima@inflpr.ro

Ultrafast laser materials processing is a powerful tool for the fabrication of micro- and nanostructures on large surfaces. Due to the high versatility of the experimental parameters, various materials could be easily processed, and thus the creation of new functionalities by nanotexturing became available [1,2]. Although Titanium and its alloys are generally used for the manufacturing of dental implant abutments, they are typically susceptible to bacterial infection. Being in close contact with the soft surrounding tissue, their surface may be functionalized in order to improve connective tissue cells adhesion while preventing bacterial penetration at the interface. Here we present the possibility to generate laser-induced periodic surface structures (LIPSS) on TiAl6V4 surfaces, in a contamination-free approach [3]. Primary human gingival epithelial cells (hGEpiCs) and gingival fibroblast cells (hGFCs) behavior in response to laser-textured TiAl6V4 surfaces is evaluated to assess samples biocompatibility. It is demonstrated that such surfaces are beneficial to improve adhesion of both hGEpiCs and hGFCs while minimizing the risk of bacterial infection.

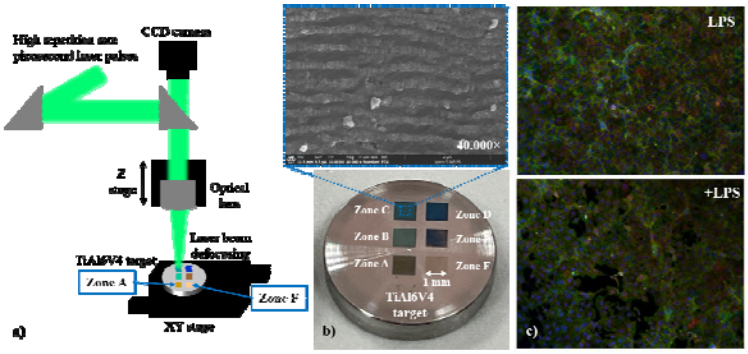

Fig. 1 (a) Setup for laser-texturing. (b) Image of TiAl6V4 irradiated with different laser doses and SEM image of the Zone C (used for cell cultures). (c) Immunofluorescence images of hGEpiCs in contact with laser processed TiAl6V4, in the presence (+LPS) or absence (-LPS) of an inflammatory process. Proteins visualization: actin (green), vinculin (red), nucleus (Hoechst-blue).

Acknowledgement: This work was supported by POC 361 project (SMIS 122040) and by Romanian Ministry of Education and Research, under Romanian National Nucleu Programme LAPLAS VII. We acknowledge the support of National Interest Infrastructure facility IOSIN – CETAL at INFLPR.

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Application of Raman spectroscopy for *in vivo* periodontal disease monitoring

Catalin LUCULESCU[1], Eduard GATIN[2], Ana-Maria IORDACHE[3], Stefan-Marian IORDACHE[3]

[1] INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA
[2] University of Medicine "Carol Davila", Eroii Sanitari 8, Bucharest, ROMANIA;
[3] Optospintronics Department, National Institute of R&D in Optoelectronics INOE 2000, 409Atomistilor, 077125, Magurele, ROMANIA

Corresponding author: catalin.luculescu@inflpr.ro

The intent of this survey was to investigate the quality of the alveolar bone by revealing the different phases for calcified tissues independent of the medical history of the patient in relation to periodontal disease by means of Raman spectroscopy and then to correlate the results by suggesting a possible mechanism for the medical impairment. The investigation was mainly based on Raman spectroscopy that was performed in vivo during surgery for a group of 10 patients (**Fig. 1**). We attempted to carry out an in vivo characterization of mineralization processes by Raman spectroscopy in patients with or without periodontitis. By doing so, we try to analyse the mineralization products and to provide some insight into the related mechanism [1-4]. The full potential of Raman technique as a promising tool for biomedical analysis and clinical diagnostics was compared with data obtained from histological analyses and histomorphometry. Our attempt is another step toward developing and bringing the Raman spectroscopy method to the clinics as the end or final users.

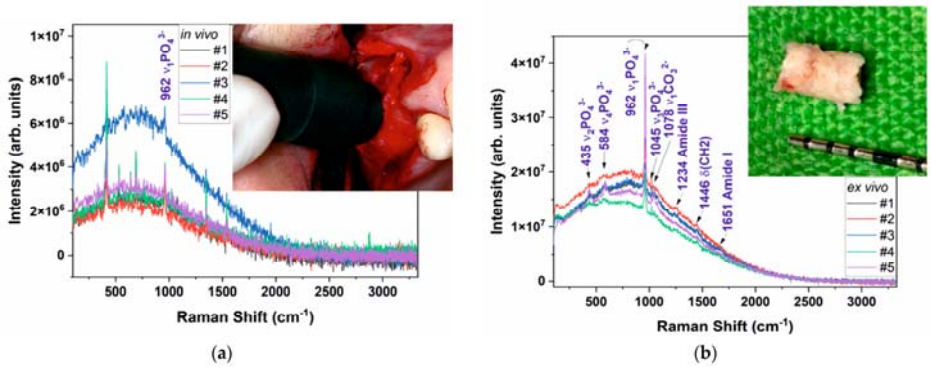

Fig. 1 Raman spectra in 100–3300 cm^{-1} range acquired in vivo (a) and ex vivo (b) for all patients. The insets are showing the Raman probe head during in vivo acquisition (a) and bone sample collected from patient #3 for ex vivo investigation.[2]

Acknowledgement: C. Luculescu was supported by the Core Program LAPLAS VII—contract No. 30N/2023 funded by the Romanian Ministry of Research, Innovation and Digitization and he acknowledges the support of National Interest Infrastructure facility IOSIN – CETAL at INFLPR.

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Plasma treatments for the improvement of the antibacterial properties of wound dressings

Sorin VIZIREANU[1], Veronica SATULU[1], Cristian STANCU[1], Valentina MARASCU[1], Anca BONCIU[1], Gheorghe DINESCU[1], Denis PANAITESCU[2], Adriana FRONE[2], Valentin RADITOIU[2], Cristian NICOLAE[2], Mădălina OPRICĂ[2], Brânduşa LIXANDRU[3], Cristin COMAN[3]

[1] INFLPR-National Institute for Laser, Plasma and Radiation Physics, 409 Atomistilor street, Magurele, RO-077125, Romania
[2] National Institute for Research and Development in Chemistry and Petrochemistry, 202 Splaiul Independentei, 060021 Bucharest, Romania
[3] Cantacuzino National Medical-Military Institute for Research and Development, 103 Spl. Independentei, 050096 Bucharest, Romania

Corresponding author:sorin.vizireanu@inflpr.ro

Plasma treatments are often used in biology and medical applications, in particular for the fabrication of new antibacterial patches. Previously, we obtained promising results for biopolymers modified with ZnO nanoparticles [1] by atmospheric pressure plasma, for nanocellulose functionalized [2] by submerged liquid plasma treatments and oxidation of cellulose [3] by chemical routes.

In the present study we treated poly(3-hydroxybutyrate) (PHB) commercial biopolymers foils by plasma to obtain uniform and antibacterial coatings through a spraying process. As bactericidal agent we used curcumins and activated nanocellulose suspensions. The activated nanocellulose suspensions were obtained by combing plasma in liquid treatments in the presence of oxidizing agents.

The changes induced by the plasma treatments in the biopolymer foils and the functionalization of the nanocellulose due to the coupled plasma and chemical treatments were investigated by X-ray photoelectron spectroscopy, contact angle measurements, thermogravimetric analysis, Fourier-transform infrared spectroscopy and scanning electron microscopy. Finally, the patches obtained by spraying functionalized nanocellulose with or without a bactericidal agent on the biopolymer foil treated or untreated with plasma were characterized from the point of view of morphology, wettability, surface chemistry and antibacterial activity. The obtained results showed that the plasma treatments led to new characteristics for the materials and ensured uniform layers of nanocellulose/antibacterial agent on the surface of the plasma treated biopolymer after spraying. The new patches are promising materials for biomedical applications.

Acknowledgement: This work was supported by supported by a grant of the Ministry of Research, Innovation and Digitization, CCCDI - UEFISCDI, project number PN-III-P2-2.1-PED-2021-2559 (BIOPLASM) and Romanian National Core Program LAPLAS VII – contract no. 30N/2023.

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A new generation of antimicrobial implant via plasma surface treatment for -NH_2 formation

Bogdan BUTOI[1], Mohadeseh ZARE[2], Veronica SATULU[1], Corneliu POROSNICU[1], Artemis STAMBOULIS[2], Ion MIHAILESCU[1]

[1]INFLPR, 409 Atomistilor Street, Magurele, RO-077125, ROMANIA
[2] School of Metallurgy and Materials, Biomaterials Research Group, University of Birmingham Edgbaston, Birmingham B152TT, UK

Corresponding author: Bogdan.butoi@inflpr.ro

Rejection of orthopaedic and other implants because of various infections is still a solid challenge, primarily caused by biofilms formation on surfaces. Our aim is to develop prosthetic titanium implants with enhanced antimicrobial properties by immobilizing antimicrobial peptides, thereby reducing rejection rates, addressing a critical aspect of orthopaedic implantology. We address this issue by focusing on the modification of medical-grade titanium substrates to incorporate functional primary amine groups (-NH_2) which act as anchors for attachment of Antimicrobial Peptides (AMPs). To reach this purpose, the KR-12 peptide, derived from LL-37, has been utilized as AMPs demonstrating antimicrobial properties and promoting cell proliferation.

A plasma custom-built treatment reactor consisting of a 300 cm^3 glass chamber, preliminary and turbomolecular pumping systems, vacuum gauge, mobile electrodes, and multiple power supplies (DC, RF, pulsed DC), has been used to introduce primary amine groups onto titanium substrates. Optimisation of the influence of power supply type (DC, RF, pulsed DC) and experimental parameters (like pressure, time, and N/H gas ratio), in respect with the concentration of incorporated -NH_2 groups was performed. The working pressure was varied between 10^{-3}mbar and 1mbar, overall plasma power (for all power supply types) from 10 to 80W and time from 30 to 1800 seconds. The introduction of primary amine groups was monitored by X-ray Photoelectron Spectroscopy (XPS). Antibacterial activity of surface functionalized with the anchored peptide KR-12 was tested in vitro against *Staphylococcus aureus* and *Escherichia coli.*

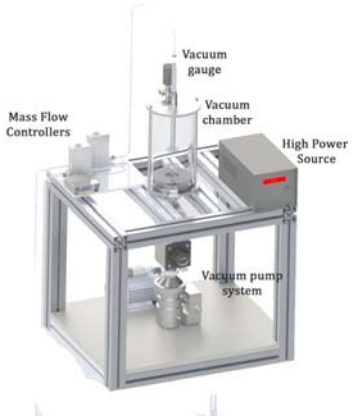

Fig. 1 Schematic representation of the plasma treatment setup

Cell behaviour modulation by hybrid zwitterionic coatings modified polydimethylsiloxane (PDMS) interfaces for implant application

Madalina ICRIVERZI[1], Paula Ecaterina FLORIAN[1], Cristian MUNTEANU[1], Livia Elena SIMA[1], Anca BONCIU[2], Nicoleta DUMITRESCU[2], Laurentiu RUSEN[2], Anca ROSEANU[1], Valentina DINCA[2]

[1]Institute of Biochemistry of the Romanian Academy IBAR, Sple Independentei 296, 060031, Bucharest, Romania
[2]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: valentina.dinca@inflpr.ro

In this work, results regarding polydimethylsiloxane (PDMS) modified interfaces by the use of zwitterionic polymers, their physical-chemical characteristics and *in vitro* effect on cell behaviour are presented. Improved efficiency of implanted devices for better biocompatibility and minimized adverse responses were developed based on Matrix-Assisted Laser Evaporation (MAPLE) laser technique. Adhesion and proliferation of human macrophages and human normal fibroblasts grown on modified surfaces and coated with antifibrotic and anti-inflammatory active compound were reduced as compared to unmodified scaffold. Moreover, the laser-processed surfaces modulated cytokine response in both local and systemic *in vitro* cell culture inflammatory models as well as reduced cell expression of pro-fibrotic markers.

Our findings evidenced the potential of MAPLE-modified interfaces to develop PDMS-hybrid zwitterionic coated implants to mitigate foreign body response and thus to be used in the biomedical field.

Acknowledgement: This research was funded by a grant of the Romanian Ministry of Education and Research, project number project PN-III-P4-ID-PCE-2020-2375. P.F., M.I., C.M. L.E.S and A.R. acknowledge and thank the partial support of Research Program of the Institute of Biochemistry of the Romanian Academy.

Novel designed structured PDMS microtopography modulates *in vitro* cell behaviour and bacteria growth

Valentina DINCA[1], Andreea NEGRESCU[2], Simona NISTORESCU[1], Anca BONCIU[1], Nicoleta DUMITRESCU[1], Iuliana URZICA[1], Laurentiu RUSEN[1], Anisoara CIMPEAN[2]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

[2]Faculty of Biology, University of Bucharest, 050095 Bucharest, ROMANIA

Corresponding author: valentina.dinca@inflpr.ro

Formation of scar tissue commonly known as a fibrotic capsule, occurs at cell-implant interface and around the implanted biomaterial and represents one of the most common causes for device failure. In this work, our approach was to tailor topographically polydimethylsiloxane (PDMS) surface by replication using laser designed moulds in order to modulate fibroblasts and immune cell function towards creating a pro-healing environment.

Macrophages and fibroblasts were cultured on structured PDMS surfaces and compared to smooth surface. Cell attachment, proliferation and cytotoxicity, in addition to immunofluorescence staining, SEM imaging, and cytokine determination were performed. The structured PDMS surfaces promoted cell adhesion, proliferation and survival. Vinculin and collagen 1 were up-regulated in macrophages on microstructured surfaces.

This study represents a novel approach to the development of microtopography based prosthetic implant surfaces which were demonstrated to attenuate the acute in vitro foreign body reaction (FBR) to silicone.

The antimicrobial effect of the PDMS surfaces was evaluated against three different standard strains namely Staphylococcus aureus ATCC 25923 (S. aureus), Escherichia coli ATCC 25922 (E. coli), and Candida albicans ATCC 1-234 (C. albicans). Overall, our results suggested that the structured PDMS surface led to an altered biological behaviour of fibroblasts and a reduced inflammatory response, turning the present study into a novel approach for obtaining an attenuated in vitro FBR response to silicone through the development of microstructured topography prosthetic implant surfaces.

Acknowledgement: This research was funded by a grant of the Romanian Ministry of Education and Research, project number project PN-III-P4-ID-PCE-2020-2375.

Bio-platforms engineered by laser based method (MAPLE) with tailored antibacterial and antitumor activity

Laurenţiu RUSEN[1], Luminiţa Nicoleta DUMITRESCU[1], Mădălina ICRIVERZI[2], Paula FLORIAN[2], Anca BONCIU[1], Cristian MUNTEANU[2], Antoniu MOLDOVAN[1], Anca ROȘEANU[2], Livia Elena SIMA[2], Valentina DINCĂ[1]

[1]INFLPR, 409 Atomistilor Street, Magurele, RO-077125, ROMANIA
[2]Institute of Biochemistry of the Romanian Academy, 060031 Bucharest, ROMANIA

Corresponding author: laurentiu.rusen@inflpr.ro

The following work presents the results obtained during the design of an experimental prototype for a new generation of responsive hybrid smart platforms engineered by laser method, Matrix Assisted Pulsed Laser Evaporation - MAPLE. In order to obtain the desired platforms, a new multi-target support for MAPLE experiments has been designed, developed and preliminarily tested in order to obtain the necessary surface coverage. The platforms obtained from different polymers and co-polymers were characterized morphologically and structurally by Scanning Electron Microscopy (SEM), FTIR, Atomic Force Microscopy (AFM), and contact angle measurements in order to have an insight of the physical/chemical/wetting properties. The platforms obtained exhibit antibacterial and antitumor dual activity, addressing the current needs for research studies and medical applications (e.g. tunable interfaces for basic cell, development of next-generation precision platform for drug testing, research controlled drug delivery).

The results obtained show that the platform is designed / tuned for tumor and bacteria microenvironment-active/triggered drugs/bioactive compounds release. The dependence of antitumor capacity of the platforms on cell line studied as well as their biological functionality was validated by evaluation of cell viability/proliferation and morphological analysis.

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Laser irradiated chlorpromazine: A novel compound in targeted molecular therapy

Ana-Maria UDREA[1,2], Florin BALEA[1], Mihaela BALAS[3], Adriana SMARANDACHE[1], Ionut Relu ANDREI[1], Madalina Andreea BADEA[2,3], Mihail-Lucian PASCU[1], and Angela STAICU[1]

[1] INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA
[2] ICUB, University of Bucharest, 91–95, Splaiul Independentei, Bucharest, RO-050095 ROMANIA
[3]Faculty of Biology, University of Bucharest, 91-95 Splaiul Independentei, Bucharest, RO-050095, ROMANIA

Corresponding author: ana.udrea@inflpr.ro

Cancer stood out as the primary cause of global mortality, with breast cancer emerging as the most prevalent type [1]. Conventional treatments for breast cancer involve chemotherapy, radiation, surgery, or a combination of these therapies. Present study aims to address the existing gap in cancer research by proposing a novel approach for breast cancer treatment. Through the integration of *in silico* techniques, laser radiation, HPLC-MS studies, and *in vitro* validation, this research introduces an innovative strategy for repositioning medications in cancer treatment. Chlorpromazine undergoes irradiation using a pulsed laser beam (10 ns) with an average pulse energy of 6.5 mJ at a wavelength of 266 nm and a pulse repetition rate of 10 pps for various durations. Following the laser irradiation protocol, HPLC-MS analysis is employed to identify the photoproducts. Molecular docking assay is used to predict the biological activity of chlorpromazine and the identified photoproducts. The focus is on the evaluation of their interactions with different receptors recognized in targeted molecular therapy. The cytotoxic effect is evaluated through several in vitro approaches, including the MTS assay and fluorescent labeling of F-actin filaments (Figure 1).

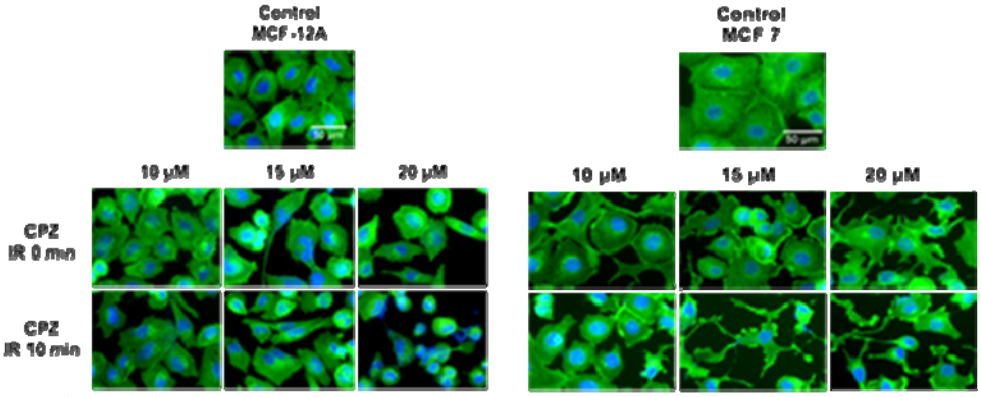

Fig. 1 Fluorescent labeling of F-actin filaments present in MCF-12A and MCF-7 cells. The scale bar represents 50 µm.

Predictions suggest that chlorpromazine photoproducts, generated through laser irradiation, exhibit enhanced biological activity in comparison with chlorpromazine. Moreover, in vitro studies indicate that irradiated chlorpromazine demonstrates a greater cancer-inhibitory effect compared to the non-irradiated drug.

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Porphyrin-loaded nanoparticles for cancer photodynamic therapy

Angela STAICU[1], Mihaela BALAS[2], Andra DINACHE[1], Ana-Maria UDREA[1], Simona NISTORESCU[1,2], Adriana SMARANDACHE[1], Mihaela Andreea BADEA[2], Iulia LUNGU[1], Florian DUMITRACHE[1], Petronela PREPELITA[1]

[1]INFLPR, 409 AtomistilorStr., 077125 Magurele, Ilfov, ROMANIA
[2]Faculty of Biology, University of Bucharest, 91-95 SplaiulIndependentei, 050095 Bucharest, ROMANIA

Corresponding author: angela.staicu@inflpr.ro

The utilization of nanocarriers for targeted delivery of photosensitizers presents a promising approach for enhancing the efficacy of cancer photodynamic therapy (PDT)[1–3].This study explores the photodynamic effect of titanium and iron oxide nanoparticles conjugated with porphyrin derivatives. The efficiency of porphyrin loading onto the nanocarriers was evaluated using UV-Vis absorption and FTIR spectroscopy, while singlet oxygen generation was quantified through analysis of singlet oxygen phosphorescence characteristics at 1270 nm. Morphological characterization of the complexes was conducted using Scanning Electron Microscopy and Dynamic Light Scattering. The investigation focused on human cutaneous melanoma cells exposed to irradiation with 1 mW/cm² blue light. Biological assays revealed a potent anticancer effect of the nanocomplexes, evidenced by inhibition of tumor cell proliferation, reduced cell adhesion, and induction of cell death through ROS generation under light exposure (**Fig. 1**). Pharmacokinetic predictions of the porphyrins supplemented these biological tests. Notably, the observed photodynamic effect demonstrated higher efficacy in melanoma cells compared to non-tumor cell lines, indicating promising potential for cancer selectivity in PDT targeting melanoma.

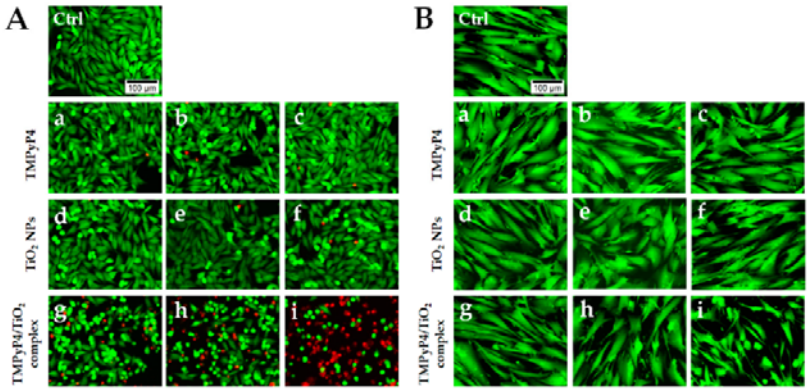

Fig. 1 LIVE/DEAD staining on treated Mel-Juso (A), and CCD-1070Sk cells (B) after light irradiation for 7.5 min. Cells were treated with different concentrations of TMPyP4, TiO_2 NPs and TMPyP4/TiO_2 complex.

Acknowledgement: This work was supported by the Romanian Ministry of Research, Innovation, and Digitization through the Nucleu Program LAPLAS VII, contract no. 30N/2023 and CNCS-UEFISCDI by PN-III-P1-1.1-PD-2021-0225 project.

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Utilizing laser technology to create emulsions as drug delivery systems

Andra DINACHE[1], Adriana SMARANDACHE[1], Iuliana URZICA[1], Ionut ANDREI[1], Angela STAICU[1]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: andra.dinache@inflpr.ro

Continuous research efforts aim to enhance the existing treatments and innovate drug delivery systems (DDS) to address cytostatic toxicity, reduce damage to healthy cells, and combat cancer cells' multidrug resistance. Several DDS are currently under investigation, including nanoemulsions (NE), nanoparticles (NP), nanocrystals, liposomal carriers, and micelles.

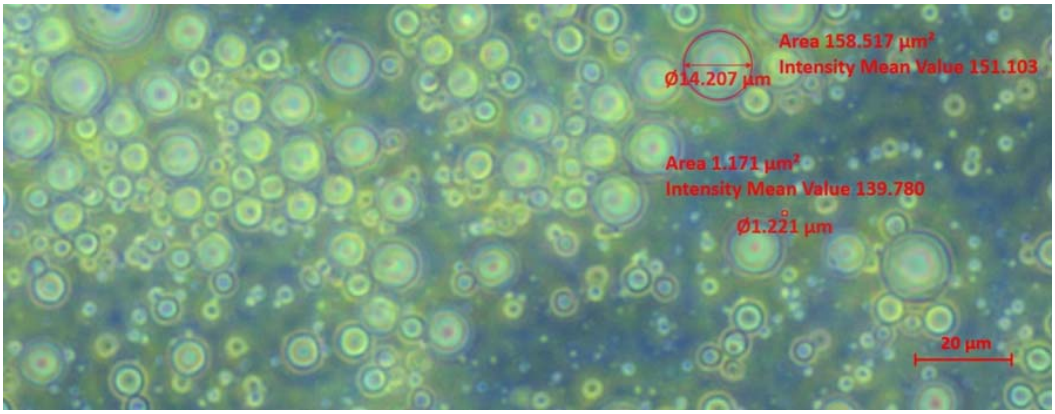

Fig. 1 Optical microscopy image (20X magnification) of an emulsion containing Doxorubicin and TMPyP in water and vitamin A, 1:1 ratio.

We utilized a laser-assisted method to generate NE as DDS. Studies included generation of emulsions containing different drugs: antisclerotics (Sodium tetradecyl sulphate), cytostatics (Cisplatin, Idarubicin, Doxorubicin), photosensitizers (TMPyP - meso-Tetra (N-methyl-4-pyridyl) porphine tetra tosylate). NP were also incorporated to assess their effect on emulsions' stability.

This method involves a double-syringe system that allows setting the volumes of the solutions, mixing speed, and number of mixing cycles. Afterwards, the resulting emulsion is exposed to laser radiation, at specific energy and wavelength, which decreases the size of droplets, producing an emulsion with nano-/micro-droplets. The interaction of the laser radiation with the emulsion is unresonant, the effect being of mechanical nature. The energy of laser radiation fractures the emulsions' droplets, generating new smaller droplets. These observations were made based on optical microscopy and dynamic light scattering (DLS) analyses, as well as surface tension measurements, UV-Vis reflectance and FTIR spectroscopy studies of the generated emulsions before and after exposure to laser radiation.

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Degradation of sulfonamide antibiotics in water by plasma-ozonation

Florin BILEA[1], Corina BRADU[2], Marius CICIRMA[1], Monica MAGUREANU[1]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA
[2]Faculty of Biology, University of Bucharest, Splaiul Independenței Str. 91–95, 050095 Bucharest, Romania

Corresponding author: monimag@gmail.com

Acceleration and spreading of water pollution caused by the release of various hazardous chemicals represent a growing concern [1]. The situation is particularly alarming in case of water contamination with antibiotics, due to their role in the promotion and spread of antimicrobial resistance [2]. The inability of conventional treatment methods to efficiently remove these chemicals prompted research into alternative techniques, such as the advanced oxidation processes (AOPs), among which non-thermal plasma [3]. Sulfamethoxazole (SMX), a bacteriostatic antibiotic belonging to the sulfonamide class, was selected as target pollutant. SMX inhibits bacterial growth by interfering with folate production and, implicitly, with specific metabolic processes. A similar mode of action of SMX in plants was reported: by disrupting the folate biosynthetic pathway, it adversely affects every process in plants [4,5].

This work presents the degradation of SMX in water using a plasma-ozonation system based on a pulsed corona discharge in contact with liquid [6]. **Fig. 1**A shows that large concentrations of SMX (0.5 mM) can be removed after about 20 min treatment with an input power of 5 W. The mineralization is much slower, and formation of degradation intermediates may represent a problem, as in all AOPs. Irrigation of tomato seeds with SMX-containing water greatly inhibits plant growth (Fig.1B). However, plasma-ozonation treatment could diminish or completely eliminate the herbicidal effect caused by the antibiotic, showing that the remaining degradation products were no longer harmful to plants, while the plasma generated species present in solution stimulate plant growth.

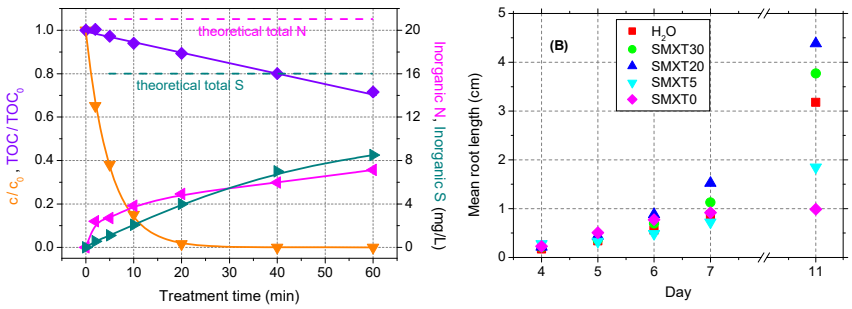

Fig. 1 (A) SMX degradation, and mineralization of carbon, nitrogen and sulphur as a function of input energy; (B) – Mean root length of the tomato plants irrigated with SMX-containing water (untreated and treated) from the 4th up to the 11th day of cultivation.

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Biological efficient decontamination of large fluid volumes via combined action of UVC radiation and metamaterials

Sinziana ANGHEL [1,2], Carmen RISTOSCU [2], Anita VISAN[2], Gianina POPESCU-PELIN[2], Nicolae A. ENAKI[3], Ion MUNTEANU[3], Ion N. MIHAILESCU[2]

[1]Faculty of Physics, University of Bucharest, Magurele, Ilfov, RO-077125 Romania
[2] Laser-Surface-Plasma Interactions Laboratory, National Institute for Lasers, Plasma and Radiation Physics (INFLPR), Romania
[3] Quantum Optics and Kinetic Processes Laboratory, Institute of Applied Physics, Moldova State University, 5 Academiei str., Chișinău MD2028, Republic of Moldova

Corresponding author: sanziana.anghel@inflpr.ro

Pathogens annihilation is reported in fluid fluxes under pulsed laser UVC (100-280) nm irradiation during the transit through metamaterials (small spheres, optical fibres and/or crushed fragments) structures. Super-packed smaller in-between large metamaterial spheres and fibres were prepared and studied for enhanced depollution of large fluid fluxes (water, blood, plasma blood, air and gases). Cultures of Candida Albicans, were used in biological tests due to resemblance and often superior resistance to important pathogens. 248 nm pulse KrF* excimer radiation was directed through a tubular structure filled up with metamaterials, either (i) (0.1–0.5) mm quartz spheres, (ii) (2–5) mm crushed quartz particles or (iii) 1 mm diameter optical fibre fragments and contaminated fluids in transit. A good contact between the metamaterial elements (spheres, optical fibres and/or crushed elements) is reached, so that the light is “confined” and dispersed via evanescent waves inside an extended volume of circulating fluids. Experimental conditions have been selected to insure a minimal (0 transmission of radiation) which is complete absorbed inside crossed-volumes and induce accelerated decontamination, leading to the partial and, under optimum conditions, sometimes complete elimination of pathogens. These results open, in our opinion, the perspective for the fabrication of an inexpensive and easy-to-monitor UVC LEDs for efficient fluids decontamination. A challenge is therefore raised for the design and development of UVC LED systems for efficient decontamination of fluids using optical resonances between metamaterial elements of different sizes (packings).

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Seed germination and early growth of *Triticum aestivum L. cv. Glosa* treated with atmospheric pressure plasma jet

Cristian STANCU[1], Catalin Ionut CONSTANTIN[1], Oana VENAT[2], Roxana CICEOI[2], Bogdana MITU[1]

[1]National Institute for Laser, Plasma and Radiation Physics, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

[2]Research Center for Studies of Food Quality and Agricultural Products, University of Agronomic Sciences and Veterinary Medicine of Bucharest (USAMVB), ROMANIA

Corresponding author: mitu.bogdana@inflpr.ro

Plasma treatment is a promising technique for enhancing seed germination and plant growth due to its potential to improve seed viability and reduce pathogens load and is increasingly considered as an alternative to the traditional pre-sowing seed treatments in the agriculture field.

The present study evaluates the effects induces by plasma treatment on the germination and early development of *Triticum aestivum L. cv. Glosa* seeds. The seeds (50 g, equivalent to approximately 1500 seeds) were placed into a fluidized bed reactor fed with compressed air to ensure the seeds movement. Plasma treatment was conducted by a filamentary RF plasma jet generated in Ar and injected with nitrogen. The treatment time was chosen in the range 4 – 10 min. The seeds were afterwards placed in Petri plates and kept at 22°C, half day light program in growth chamber. The biometric indices refer to number of germinated seeds, roots number, roots length and sprouts lengths.

The results evidence that the germination rate is increasing from 92.5% for the control to 95% for 10 minutes plasma treatment. The control also had the lowest roots average length – 136.95 mm, while seeds treated for 7 minutes shown the roots length with more than 20% longer, reaching 167.63 mm. For the sprout's length, the same evolution was observed, with the control showing the lowest growth - 28.72 mm and the plasma treated for 7 minutes with the highest growth 36.56 mm. These preliminary results show that atmospheric pressure plasma treatment have a positive effect on seeds germination and growth, when compared with untreated seeds. Further experiments are undergoing in order to determine the optimum treatment conditions with respect to germination and growth under

Keywords: Triticum aestivum, RF plasma treatment, seed germination, root growth, plant height

Acknowledgement: This work is part of program Ader 2.1.7. - Research on the use of plasma technologies in pests and diseases of stored agricultural products and evaluation of its effects on seeds and plants, for sustainable and quality productions

Food webs in sinking-cave streams

Octavian PACIOGLU, Daniela FLOREA, Iris M. TUSA

National Institute of Research and Development for Biological Sciences, 296 Splaiul Independentei street, Bucharest, Romania

Corresponding author: octavian.pacioglu@incdsb.ro

Subterranean streams represent unique heterotrophic ecosystems, usually supported by organic matter imported from the surface. Traditionally, the biological communities from subterranean streams were characterized as simple associations, with low diversity and species abundance, comprising mostly aquatic invertebrates connected by few trophic links compared with those of the surface.
Combining the most recent predictions of Ecological Stoichiometry and the Metabolic Theory of Ecology, here we present a theoretical framework aiming to explain the patterns observed along the surface–subterranean continuum in streams. It is predicted that the main factors constraining the structure and functioning of communities and food webs are the decline in the quantity and diversity of basal resources along this gradient, along with nutrients availability in water that affects food quality. With increasing availability of dissolved nutrients in water, sinking-cave streams are hypothesized to fluctuate between being N and/ or P co-limited to C-limited.

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Topic 5. Innovative technologies for sustainable future

Pr^{3+} ions doped $Ca_3(M,Ga)_5O_{12}$ (M^{5+} = Nb, Ta) garnet phosphors as new optical temperature sensors

Cristina GHEORGHE[1*], Stefania HAU[1], George STANCIU[1], Daniel AVRAM[1], Alin BROASCA[1], Lucian GHEORGHE[1]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

Corresponding author: cristina.gheorghe@inflpr.ro

Pr^{3+}-doped $Ca_3(Nb,Ga)_5O_{12}$ (Pr:CNGG) and $Ca_3(Ta,Ga)_5O_{12}$ (Pr:CTGG) phosphors with garnet structure have been systematically investigated as optical thermometric materials for potential applications in the field of sensing technology, for the first time to our knowledge. The ceramic samples of Pr:CNGG and Pr:CTGG with different concentrations of Pr^{3+} ions have been obtained by the solid-state reaction method. A comparative analysis to evidence the influence of the position of the inter-valence charge transfer (IVCT) states on the excited-state dynamics of Pr^{3+} ions in CNGG and CTGG materials is presented. The optical thermometric properties of the Pr:CNGG and Pr:CTGG samples were studied. The luminescence thermal quenching mechanisms of the $^3P_0$ and $^1D_2$ levels were investigated in detail based on the luminescence intensity ratio (LIR) of $^1D_2 \rightarrow {}^3H_4$ / $^3P_0 \rightarrow {}^3H_4$ (I_{606}/I_{487}) transitions over an extended temperature range (10 - 700 K). The maximum relative sensitivities (**Fig. 1**) were determined to be 1.64 % K^{-1} at 10 K for 7 at.% Pr:CTGG and 2.4 % K^{-1} at 430 K for 1 at.% Pr:CNGG, thus proving their potential as high-sensitivity temperature sensors in cryogenic and high-temperature domains, respectively.

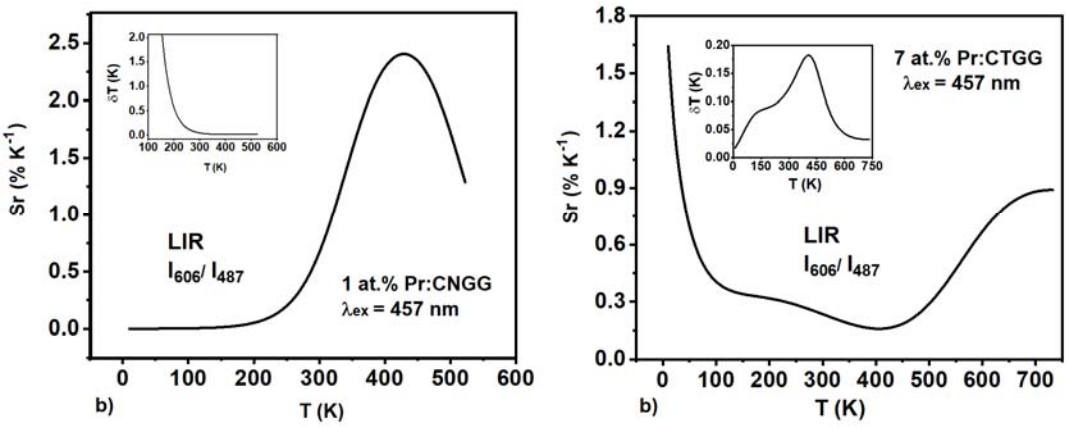

Fig. 1 Relative thermal sensitivity curve Sr (b) as a function of temperature for 1at% Pr:CNGG (a) and 7 at% Pr:CTGG (b) phosphors.

Acknowledgment: This work was supported by the Romanian Ministry of Research, Innovation and Digitization through project 30N/2023 within program NUCLEU LAPLAS VII.

Novel $SrLaGaO_4$: Er^{3+} perovskite phosphor for optical thermometry

Ana-Maria VOICULESCU[1], Stefania HAU[1], George STANCIU[1], Cristina GHEORGHE[1]

[1]National Institute for Laser, Plasma and Radiation Physics, 409 Atomistilor Street, Magurele 077125, Ilfov, Romania

Corresponding author: ana.voiculescu@inflpr.ro

To discover the potential as a temperature sensor of Er^{3+}:$SrLaGaO_4$ (SLGO) phosphor, the temperature-dependent up-conversion (UC) luminescence of Er^{3+} ions was investigated. The UC luminescence spectra of the $^2H_{11/2}$ and $^4S_{3/2}$ thermally coupled energy levels (TCL) of Er^{3+} ions in Eu: SLGO were monitored between 300-673 K under the infrared excitation wavelength.

A series of x at. % Er^{3+}-doped $SrLaGaO_4$ (x = 0.1, 1, 2, 3, 4, 5) ceramic phosphors have been prepared by the solid-state reaction method. The phase structure of the obtained ceramics was identified by X-ray diffraction (XRD). No additional peaks are found, indicating that even high Er^{3+} doping concentrations do not change significantly the structure of $SrLaGaO_4$ ceramics. Fig. 1(a) shows the UC emission spectra of the sample under a 973 nm diode laser excitation with the pumping power of 1.5 W. The UC luminescent spectra of all the samples exhibit two strong green emission bands: (1) green emission band between 515 - 539 nm assigned to $^2H_{11/2} \rightarrow {}^4I_{15/2}$ transitions, (2) the intense green emission band between 539 - 565 nm attributed to $^4S_{3/2} \rightarrow {}^4I_{15/2}$ transitions.

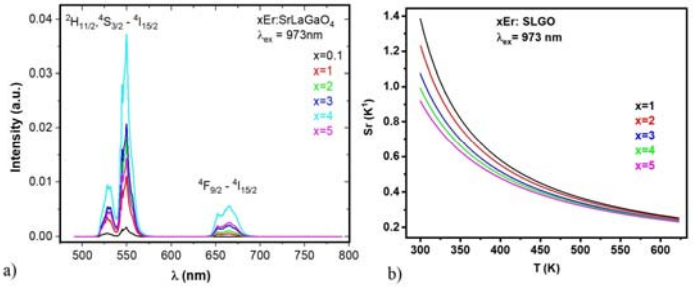

Fig. 1. Up-conversion luminescence of xEr: SrlaGaO4 samples in the green and red domains under 973 nm excitation (a) calculated plots of Sr values function of temperature (b).

The intensity of UC green emission increases with increasing Er^{3+} concentration up to 4 at. %, then the intensity decreases at higher Er concentration due to concentration-quenching effect [1]. To evaluate the thermometer performance, the relative thermal sensitivity was calculated using the luminescence ratio of intensities (LIR) of ($^2H_{11/2}$ / $^4S_{3/2}$) levels for all Er^{3+} concentrations. The value of relative thermal sensitivity S_r decreases gradually both with temperature and with concentration of Er ions Fig.1(b). The maximum value of relative thermal sensitivity (Sr) of 1.37 % K^{-1} is obtained for 1Er at 300 K. The results indicate that 1Er: SLGO phosphor can be considered a promising candidate for optical temperature sensor.

Acknowledgment: This work was supported by the Romanian Ministry of Research, Innovation and Digitization through the program NUCLEU LAPLAS VII, contract number 30N/2023

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Narrow-band red-emitting Eu^{3+}: $SrLaGaO_4$ phosphor as a potential temperature sensor

Ana-Maria VOICULESCU[1], Stefania HAU[1], George STANCIU[1], Cristina GHEORGHE[1]

[1]National Institute for Laser, Plasma and Radiation Physics, 409 Atomistilor Street, Magurele 077125, Ilfov, Romania

Corresponding author: ana.voiculescu@inflpr.ro

Strontium lanthanum gallate ($SrLaGaO_4$ - SLO) ceramic phosphors doped with x at.% Eu^{3+} ions (x = 0.1, 1, 3, 5, 10, 15, 20, 30) were obtained by the solid-state reaction method. The XRD analysis indicates that all the sintered samples are well crystallized with a pure tetragonal structure. The emission spectra of the xEu: SLO ceramic phosphors, under blue or UV excitation wavelengths, show that the maximum relative emission intensity corresponding to the hypersensitive $^5D_0 \rightarrow {}^7F_2$ transition at 620 nm was found for x = 10 with a full width at half maximum (FWHM) of ~7 nm (at 300 K). The cross-relaxation and energy migration processes between Eu^{3+} ions in the 10Eu: SLO sample are negligible and do not contribute to the quenching of the $^5D_0$ emitting level. The asymmetry parameter (the ratio between the $^5D_0 \rightarrow {}^7F_2$ and $^5D_0 \rightarrow {}^7F_1$ transitions) and the critical distance between Eu^{3+} ions allowed obtaining a good color purity of the red emission (88 %) for the 10Eu: SLO phosphor. Based on the luminescence ratio of intensities (LIR) regarding the $^5D_0 \rightarrow {}^7F_2$ and $^5D_0 \rightarrow {}^7F_1$ transitions the relative sensitivity parameter (Sr) was determined for all Eu concentrations and the maximum values were between 0.43 % K^{-1} at 10 K (for 5Eu) and 0.45 % K^{-1} at 450 K (1Eu).

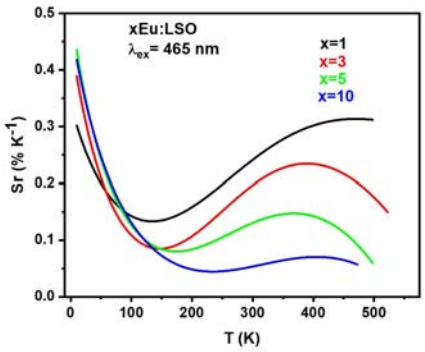

Fig. 1. The calculated curves of relative sensitivity Sr of Eu^{3+} in xEu: SLO ceramic phosphors (x = 1, 3, 5, and 10).

These results suggest that Eu: SLO phosphor is a versatile material that could be operated as a temperature sensor over a wide range of temperatures, as well as a narrow-band red-emitting phosphor for phosphor-converted white light-emitting diodes (pc-WLEDs).

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3D lithography for stimuli actuated micro/nanostructures

Bogdan Stefanita CALIN[1], Roxana POPESCU[2, 3], Eugenia TANASA[2], Irina PAUN[1, 2]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA
[2] University POLITEHNICA of Bucharest, 303 Independentei Road, Bucharest, ROMANIA
[3]IFIN-HH, 30 Reactorului Street, Magurele, ROMANIA

Corresponding author: irina.paun@inflpr.ro

We will present the most recent research on laser 3D and 4D printing of micro-nanostructures for tissue engineering applications. First, we will make an overview on laser 3D printing of backbone micro/nanostructures where the seeded cells attach, proliferate and differentiate towards the formation of new tissues. Then, we go from 3D towards laser 4D printing of micro/nanostructures that control cellular processes by stimulation using topographical, mechanical, chemical, electric and/or magnetic stimuli.

For each type of stimulus, a particular application will be presented, such as controlling the cells proliferation and avoiding the formation of a necrotic core (via topographic stimulation), controlling the cellular adhesion (via topographical stimulation), supporting the cells differentiation by cells' nuclei deformation (via mechanical stimulation), improving the osteogenesis (by chemical and magnetic stimulation), controlling the drug delivery (by electric stimulation) and fastening the processes of tissue formation (via magnetic stimulation).

The advantages of laser 3D over 4D printing of micro-nanostructures for biomedical applications will be emphasized. Special attention will be dedicated to 3D and 4D printing by laser direct writing via two photon polymerization (LDW via TPP) technique [1-3].

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[2] Paun I.A, Calin BS, Popescu RC, Tanasa E, Moldovan A Laser Direct Writing of Dual-Scale 3D Structures for Cell Repelling at High Cellular Density INTERNATIONAL JOURNAL OF MOLECULAR SCIENCES **3**(6) 3247 DOI10.3390/ijms2306 WOS:000775310000001 (2022)
[3] Paun I. A.; Mustaciosu C.C.; Mihailescu M.; Calin B.S.; Sandu A.M. Magnetically-driven 2D cells organization on superparamagnetic micromagnets fabricated by laser direct writing SCIENTIFIC REPORTS **10**(1) DOI 10.1038/s41598-020-73414-4 WOS 000577151500013 (2020).

Reverse engineering by laser 3D printing: a new route for biomimetics

Irina PAUN[1, 2], Bogdan Stefanita CALIN[1], Roxana POPESCU[2, 3], Eugenia TANASA[2], Antoniu MOLDOVAN[1]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA
[2] University POLITEHNICA of Bucharest, 303 Independentei Road, Bucharest, ROMANIA
[3]IFIN-HH, 30 Reactorului Street, Magurele, ROMANIA

Corresponding author: irina.paun@inflpr.ro

Nature offers unique examples that can inspire us to produce artificial systems that mimic the structure and specific even functions of complex living organisms. These biomimetic systems can potentially resolve complex issues encountered in diverse scientific domains. In line with this "biomimetic approach", the last years emerged the concept of "reverse engineering", which means the extraction of a minimal set of design parameters from biological structures for obtaining a biofunctional mimicry.

Here, we report the use of reverse engineering for reproducing, with tens of nm spatial accuracy, ultrastructural details of insects' compound eyes. Generally, the insects' eyes consist in arrays of ommatidia, each measuring tens of micrometers in diameter and that are covered with pillar-like structures with submicrometric heights and periodicities, known as "corneal nipples". Here, we present the design and laser fabrication of 3D biomimetic structures that closely reproduce the insects' compound eyes and partially possess their biofunctionality. Our structures were fabricated by laser direct writing via two photon polymerization (LDW via TPP) of Ip-Dip photocompatible photopolymer. LDW via TPP is a sort of laser 3D printing having nanometric spatial accuracy and full reproducibility of the imprinted structures [1-3]. By optimizing the computer aided design and the laser writing parameters (laser power, scanning speed), we obtained 3D structures very similar with the compound eyes of specific insects, with deviations regarding ommatidia diameters, heights and periodicities of the corneal nipples, all less than 5%. Given this close mimicry of the laser-imprinted structures, we expected that they possess specific properties of the insects' compound eyes, among which we particularly explored their optical properties and behaviour.

In all, these preliminary results open up promising routes for accurate, low cost and easy-to-use laser 3D printing technologies for obtaining diverse physiologically relevant biomimetic structures with significant potential for various applications.

[1] Calin, B.S.; Paun, I.A. A Review on Stimuli-Actuated 3D Micro/Nanostructures for Tissue Engineering and the Potential of Laser-Direct Writing via Two-Photon Polymerization for Structure Fabrication. Int. J. Mol. Sci. **23**, 14270. DOI: 10.3390/ijms232214270 (2022)
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Laser micro-marking of Ti and TiAlV dental implants

Radu UDREA[1,4], Doina CRACIUN[2], Gabriela DORCIOMAN[2], Petronela GAROI[2],
Silvia A. SAVENCU[1], Mihai N. SELAGEA[1],
Dragos BUDEI[3], Valentina GRUMEZESCU[2], Liviu BADEA[4,5], Valentin CRĂCIUN[2,6]

[1]APEL LASER SRL, 15 Vintilă Mihăilescu Street, 077135 Bucharest, ROMANIA
[2]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA
[3]DENTIX MILLENNIUM SRL, 15A Magnoliei Street, Sabareni, Giurgiu, ROMANIA
[4]Faculty of Physics, University of Bucharest, 405 Atomiștilor Street, 077125 Măgurele, ROMANIA
[5]National R&D Institute for Non-Ferrous and Rare Metals, Pantelimon, ROMANIA
[6]Extreme Light Infrastructure for Nuclear Physics, 30 Reactorului Street, 077125 Măgurele, ROMANIA

Corresponding author: radu.udrea@inflpr.ro

The manufacturing of dental implants from Ti and Ti-based alloys such TiAlV is one of the major fields of biomedical engineering with a history of more than 50 years. Implants can last for more than 25 years if properly fitted and respecting the oral hygiene rules. The rate of success for dental implants can be higher than 95%. An important characteristic of these implants is their traceability. First, the knowledge of the producer's name ensures the adequate quality of medical implants, which are manufactured from known origin raw materials. Secondly, if a systemic problem is found with a lot of implants, then corrective measures could be immediately and efficiently taken for all patients that received those implants. This also ensures that clinical studies about the quality of the implants, their side effects and contra-indications could be easily performed, evaluated, and finally archived. The traceability of implants can be obtained by directly marking the products (and not only the package) with a specific alpha-numeric code or serial number. Considering these facts, we investigated the laser marking of Ti and TiAlV dental implants. Laser marking is a mature technology having many advantages and being biocompatible. Using a Coherent PowerLine Pico system (equipped with a Coherent RapidNX laser source: fundamental center wavelength: 1064.5 ±0.5 nm, repetition rate: 50 kHz to 1 MHz, output energy: 7 µJ at 1064nm, 1 MHz) we marked both flat medical-grade Ti samples and Ti implants.

We first investigated the laser system parameters (wavelength, pulse duration, focusing, fluence, gas atmosphere, repetition rate) that will make the process fast and economically viable. The laser processed surface exhibits different optical properties than the rest of the medical device and these changes should be observed either by the naked eye or a simple magnifying glass. Secondly, we investigated the laser marked area characteristics to observe changes in surface morphology, structure, chemical composition, corrosion resistance, mechanical properties and biocompatibility. The laser irradiated area was investigated using scanning electron microscopy, grazing incidence X-ray diffraction, X-ray photoelectron spectroscopy, nanoindentation, Open Circuit Potential (OCP) and Electrochemical Impedance Spectroscopy. The results showed that the laser marked area contains a higher percentage of TiO_2 than the initial surface, which increases the wettability, corrosion resistance and biocompatibility.

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Aloe vera-based coatings fabrication and characterization of essential oil influence on the coatings' composition, degradation, and *in vitro* evaluation of the composite material

Anita I. VISAN[1], Carmen G. RISTOSCU[1], George STAN[2], Teddy TITE[2], Gabriel SOCOL[1], Rodica CRISTESCU[1], Gianina F. PELIN-POPESCU[1], Izabela L. TODERASCU[1], Consuela E. MATEI[1], Mirela POPA[3], Carmen CHIFIRIUC [3,4]

[1]National Institute for Laser, Plasma and Radiation Physics, 077125 Magurele, Ilfov, Romania

[2]National Institute for Materials Physics

[3] Department of Microbiology, Faculty of Biology, University of Bucharest, 060101 Bucharest, Romania

[4] Earth, Environmental and Life Sciences Division, Research Institute of the University of Bucharest, 050567 Bucharest, Romania.

Corresponding author: anita.visan@inflpr.ro

We report the synthesis of apatite-lignin-aloe vera (Ap/Lig/AV) coatings using the Matrix Assisted Pulsed Laser Evaporation (MAPLE) technique. We have used natural and renewable materials, lignin and aloe vera plant extract respectively, as a safer and more eco-friendly alternative to synthetic antibiotics that are currently in use. This approach not only offers infection prevention but also helps to combat the alarming phenomenon of primary and secondary resistance to conventional drugs, which is a major public health concern.

The study demonstrated that the chemical functions and stoichiometry of the deposited material remained intact. When the essential oil amount equals that of organic material, a uniform and homogeneous distribution of the material is achieved.

All the coatings used in the study were hydrophilic and showed improved cellular viability when cultured with cancerous Mg 63-cells. The composite structures demonstrated significant antimicrobial activity against both Gram-positive and Gram-negative bacteria such as Escherichia coli and Staphylococcus aureus, as well as Candida albicans fungus. The use of these naturally-derived products is cost-effective and offers an attractive solution for creating biodegradable thin films with antibacterial, antioxidant, and anti-inflammatory properties.

Acknowledgment: The authors acknowledge the financial support of the Romanian Ministry of Education and Research, CNCS-UEFISCDI, project number PN-III-P4-ID-PCE-2020-2273, PN-III-P4-ID-PCE-2020- 2030 within PNCDI III and the Romanian National Nucleu Program LAPLAS VII—contract no. 30N/2023.

Enhancing surface characteristics of glass and stainless steel through atmospheric-pressure air dielectric barrier discharge (DBD) plasma treatment

Aymane NAJAH[1], François FAUBERT[1], Isabelle GERAUD-GRENIER[1], Stéphane PELLERIN[1], Pascal ANDREAZZA[2]

[1] GREMI, UMR7344 CNRS/ Université d'Orléans, Bourges, 18000, France
[2] ICMN, UMR7374 CNRS/ Université d'Orléans, Orléans, 45000, France

Corresponding author: aymane.najah@univ-orleans.fr

Glass and stainless steel are integral materials across a wide array of applications, spanning from household items to high-tech industries such as optics, automotive, aerospace, etc. The surface properties of these materials play a pivotal role in determining their functionality and efficiency, making surface modification a key area of interest. Various methods exist for altering surface properties, with functionalization techniques being particularly noteworthy. Among these techniques, low-temperature plasma treatments emerge as a highly promising avenue for enhancing and fine-tuning surface characteristics.

This study endeavors to investigate the effects of atmospheric-pressure dielectric barrier discharge (DBD) plasma treatment on the surface properties of borosilicate glass and stainless steel, with a sinusoidal voltage source. Specifically, our research delves into a comprehensive parametric analysis, exploring the influence of varying DBD plasma treatment durations and powers on surface characteristics. Through systematic experimentation, we meticulously assess alterations in surface hydrophilicity using water contact angle measurements, correlating these changes with treatment duration (fig 1) and DBD power levels. Additionally, employing X-ray photoelectron spectroscopy (XPS), we investigate the chemical transformations occurring at the interface of the treated stainless steel and borosilicate glass surfaces. Interesting observations include variations in metal oxide compositions (as depicted in Fig. 2) and other chemical changes induced by the DBD treatment are present.

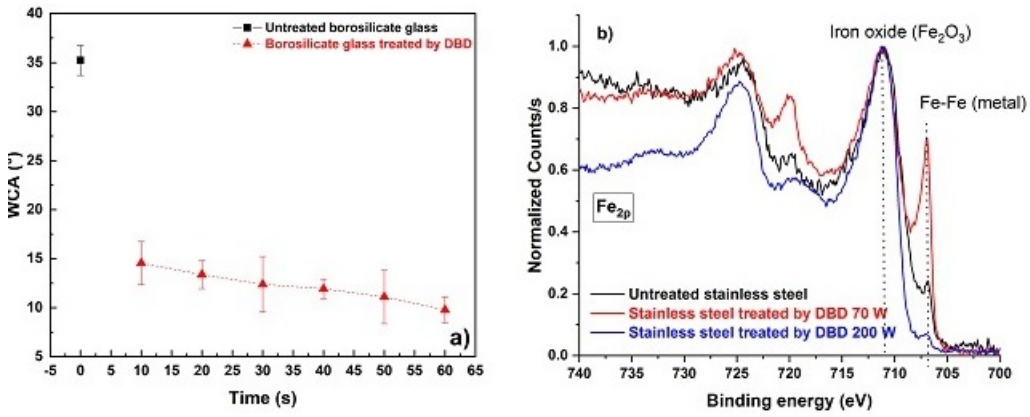

Fig. 1. **a.** variations of water contact angle (WCA) with respect to the DBD plasma treatment time of glass, **b.** XPS analysis of stainless steel treated by DBD plasma treatment at different powers.

New composite materials based on WO_3 nanoparticles with high x-ray attenuation factor

Marian MOGILDEA[1], George MOGILDEA[1], Doina CRACIUN[2], Natalia MIHAILESCU[2], Petronela PREPELITA[2], Marian C. BAZAVAN[3], Vasile BERCU[3], Leonard C. GEBAC[3], Raluca MAIER[4], Bogdan S. VASILE[5], Valentin CRACIUN[2,6,*]

[1]ISS, 409 Atomistilor street, Magurele, RO-077125, ROMANIA
[2]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA
[3]Univ. of Bucharest, Physics Faculty, 407 Atomistilor street, Magurele RO-077125, ROMANIA
[4]Romanian Research & Development Institute for Gas Turbines – Bucharest, ROMANIA
[5]National University of Science and Technology Politehnica of Bucharest, 060042 Bucharest, ROMANIA
[6]Extreme Light Infrastructure for Nuclear Physics, 30 Reactorului Street, 077125 Măgurele, ROMANIA

Corresponding author: valentin.craciun@inflpr.ro

A new carbon reinforced composite material, which exhibited a high X-ray attenuation factor has been synthesized. Such materials are very useful for use in commercial applications where X-ray screening is required. Using a new synthesizing method [1] based on high intensity microwave vaporization of a thin tungsten wire, a thin layer of crystalline tungsten oxide, WO_3, nanoparticles was deposited directly on the surface of a classic composite material. The nanoparticles synthesis method is based on the direct absorption of microwaves by a metallic wire to generate a high temperature plasma in an oxygen containing atmosphere, which then condenses on a substrate. During microwave discharge the value of the electronic temperature of the plasma reached up to 4 eV and generated tungsten oxide nanocrystals with dimension between 2 nm to 100 nm as measured with the aid of scanning and transmission electron microscopes (TEM, see **Fig. 1**). Grazing incidence X-ray diffraction, X-ray photoelectron spectroscopy, scanning electron microscopy (SEM) and TEM investigations showed that the nanoparticles were single crystal, stoichiometric WO_3. To determine the X-ray attenuation factor of the new composite material we prepared two samples, which contained layers of tungsten oxide nanoparticles of 2 μm and 21 μm thickness, respectively. After preparation, the samples attenuation factor was measured using a Leybold X-ray apparatus and a photon flux with energies between 20 KeV and 32 KeV. We observed that these samples attenuated 10 % and 60 % of the X ray photons flux [2].

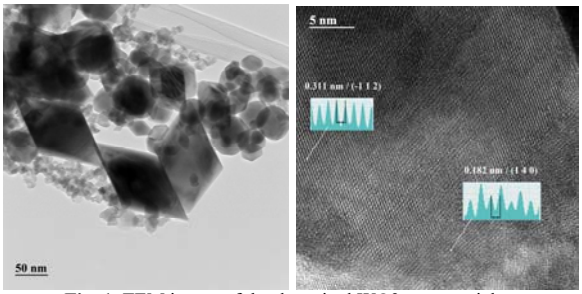

Fig. 1. TEM image of the deposited WO3 nanoparticles.

Acknowledgement: This research was funded by the Romanian Ministry of Research, Innovation and Digitization, UEFISCDI, under projects PCE104/2022, PED599/2022, Project NUCLEU LAPLAS VII no. 30N/2023, PN 23 21 01 05, and the IOSIN funds for research infrastructures of national interest. Additional support came from Extreme Light Infrastructure Nuclear Physics (ELI-NP) Phase II, a project co-financed by the Romanian Government and the European Union through the Europe-an Regional Development Fund and the Competitiveness Operational Programme (1/07.07.2016, COP, ID 1334).

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Ultrasound assisted synthesis and characterization of hydroxyapatite/β-cyclodextrin composite as additive for tanning industry

Elisa DUMBRAVA[1,2,3], Ilaria QUARATESI[2], Petre CHIPURICI[3], Adrian BERCEA[1], Mohamed Yassine ZAKI[4], Andrei CUCOS[5], Miruna S. STAN[6], Genoveva BURCA[7], Elena BADEA[2,8]

[1] National Institute for Laser, Plasma & Radiation Physics (INFLPR), Atomistilor Street, No. 409, 077125, Măgurele, Romania.
[2]National Research and Development Institute for Textile and Leather - Research Institute for Leather and Footwear (INCDTP-ICPI), Ion Minulescu Str. 93, 031215, Bucharest, Romania.
[3]National University of Science and Technology POLITECHNIC Bucharest, Faculty of Chemical Engineering and Biotechnology, Department of Bioresources and Polymer Science, 313 Splaiul Indipendentei 060042, Bucharest, Romania.
[4]Laboratory of Complex Heterostructures and Multifunctional Materials, National institute of Materials Physics, Strada Atomiștilor 405A, 077125, Măgurele, Romania.
[5]Institutul Naţional de Cercetare - Dezvoltare pentru Inginerie Electrică INCDIE ICPE-CA, Splaiul Unirii 313, 030138, Bucharest, Romania.
[6] Department of Microbiology and Biochemistry, Research Institute of the University of Bucharest-ICUB, 050567 Bucharest, Romania.
[7]Diamond Light Source Ltd, Harwell Science & Innovation Campus, Chilton, Didcot, Oxon, OX11 0DE, United Kingdom.
[8]Department of Chemistry, Faculty of Sciences, University of Craiova, Calea Bucuresti Str. 107 I, 200512 Craiova, Romania.

Corresponding author: dumbrava.elisa@gmail.com

The environmental impact of the leather industry is one of the main problems it faces. Large amounts of energy, chemicals, and water are required, and all of these could have a detrimental effect on the ecosystem. The aim of our research has been the development of non-toxic and biodegradable additives that confer leather properties such as antimicrobial activity, flame retardancy, breathability using ultrasounds (US), a novel clean, green technology [1]. Hydroxyapatite (HAp) is an excellent candidate for the synthesis of such additives due to its high biocompatibility, antimicrobial activity and fire resistance [2]. However, HAp has the tendency to agglomerate and become larger than the hides' pores (≈10 μm), thus lowering penetration and treatment effectiveness [3]. The use of macrocyclic derivatives such as cyclodextrins (CDs) to improve HAp solubility and binding to collagen matrix represents a valid choice as they are reasonably cheap, biodegradable and already produced on industrial scale [4]. We, therefore tested the synthesis of HAp/β-CD composites by using US. The process parameters, i.e., time, amplitude and HAp/β-CD ratio was varied to obtain hybrid particles with suitable size and stability. The average size of the composites was measured by Dynamic Light Scattering (DLS) and their stability was evaluated by the Z-potential. The molecular profile, composition, thermal stability and morphology of composites were investigated by FTIR-ATR spectroscopy, XRD, TG/DTG and SEM. The complete set of results lead to the assumption of a coordination-type interaction between the -OH groups in β-CD and the Ca^{2+} ions in HAp, through electrostatic and/or hydrogen-bond interactions. The composites were also shown not to be cytotoxic. Fire retardancy was tested on leather treated with one of the HAp/β-CD composite.

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Symposium of High Power Lasers Network

Target neutralization current as source of EMP emission in laser particle acceleration processes

Aurelian MARCU[1], Mihai STAFE[2], Mihai SERBANESCU[1], Andreea GROZA[1], Georgiana GIUBEGA[1], Constantin DIPLASU[1], Constantin NEGUTU[2], Nicolae N. PUSCAS[2]

[1]National Istitute for Laser Plasma and Radiation Physics, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

[2] University "Politehnica" of Bucharest, Spl. Independentei 313, RO-060042, Bucharest, ROMANIA

Corresponding author: aurelian.marcu@inflpr.ro

High power pulsed lasers are increasingly used as effective tools to achieve particle acceleration. However, real-time particle characterization (without affecting accelerated particle beam) and strong electro-magnetic pulse (EMP) emission during the particle acceleration process (known to affect sensitive electronic equipment) are two critical challenges in real applications. Using CETAL - 1 PW laser facility from NILPRP in particle acceleration from different thin metallic targets, we recorded similar dependences of the laser accelerated electron energies and generated EMP amplitude on target thickness, resistivity, and mass number of the target material, and consequently a quasi-linear inter-dependence between them (Fig. 1).

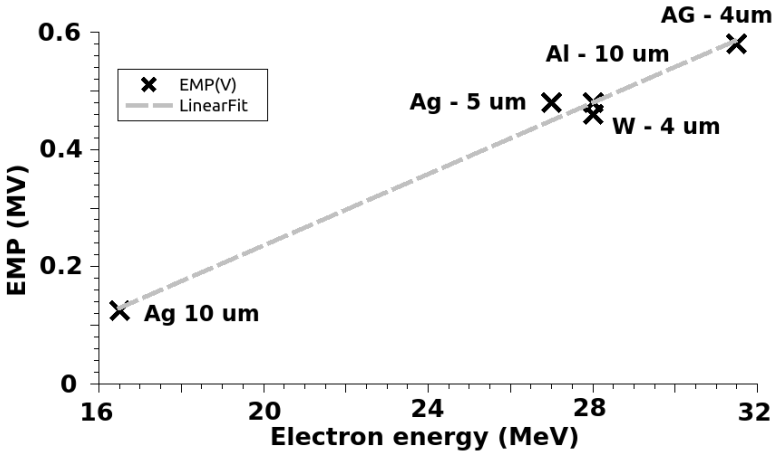

Fig. 1 Experimental correlation between (recorded) electron maximal energy and EMP (mediated) low frequencies amplitude .

We propose here an analytical model for the Ghz band EMP emission which considers as the EMP main source target neutralization current flowing through the target-stalk, under the Coulombian field of the positive charge accumulated on the irradiated spot after the electron acceleration from the target back-side. The good agreement between the experimental and simulated EMP spectra supports the possibility to employ GHz range EMP spectra to perform non-invasive real-time characterization of laser plasma accelerated particles.

Acknowledgement: For this research, we acknowledge funds from ELI-RO 13/2021, ELI-RO 11/2020 and ELI-RO 17/2016 projects and support of National Interest Infrastructure facility IOSIN-CETAL from NILPRP.

Development of gas jet multiplexer for high-peak-power laser interactions

Alexandru MIHALCEA[1,3], Razvan UNGUREANU[1], Gabriel COJOCARU[1,2], Mihai SERBANESCU[1], Georgiana GIUBEGA[1,2], Constantin DIPLASU[1], Aurelian MARCU[1], Sandel SIMION[1]

[1]Center for Advanced Laser Technologies (CETAL), National Institute for Laser, Plasma and Radiation Physics (INFLPR), Atomistilor 409, 077125 Magurele, Ilfov, Romania

[2]Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering, ELI-NP department, 30 Reactorului, Măgurele, 077125, ROMANIA

[3]Doctoral School of Electronics, Telecommunications & Information Technology, National University of Science and Technology POLITEHNICA Bucharest, 1-3 Iuliu Maniu Bd., 061071, Bucharest, Romania

Corresponding author: alexandru.mihalcea@inflpr.ro

In the world of high-peak-intensity laser pulse interaction with gas experiments, the adequate design of the experimental setup represents one of the key factors for a successful beam time session. One important parameter consists of the vacuum time recovery after releasing the high-backing pressure gas inside the chamber, which may limit the interactions repetition rate compared to the laser maximal repetition rate, also swapping components under extreme pressure levels at high repetition rates is very difficult to achieve.

To overcome such bottlenecks, we are developing a device for continuum gas-target delivery inside a vacuum chamber with the preliminary design presented in Fig. 1. To evaluate the performances of the new gas valve several simulations were initiated to study the pressure (starting from 10^{-7}mbar) changes inside the vacuum chamber during injection and mixing of the gases as function of their backing pressures and the output area in balance with the actual pumping rates possibilities. The manufacturing of the device requires processes such as electrical discharge machining (EDM) and femtosecond pulse macro-processing in order to obtain the specific geometry.

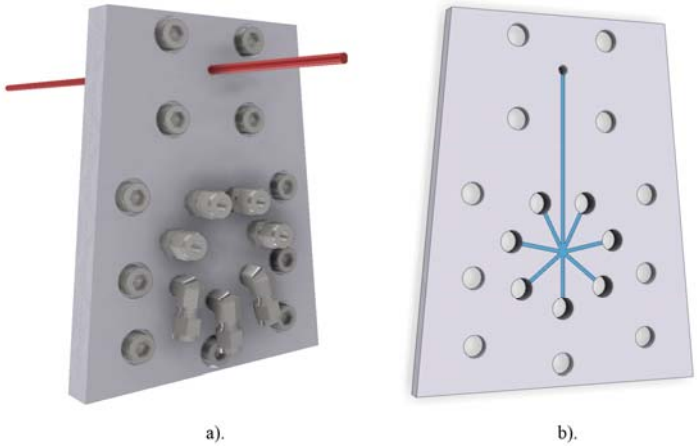

Fig. 1 (a) Partially assembled stack with multiple gas inputs
(b) Single plate highlighting the gas channels and mixing chamber

Acknowledgement: The team acknowledge the support of National Interest Infrastructure facility IOSIN – CETAL at INFLPR, and project: ELI-RO 01/2023.

Secondary sources optimized by extreme intensity lasers at the interaction with micro-cones

Olimpia BUDRIGĂ[1], Emmanuel D'HUMIÈRES[2], Aurora BUDRIGĂ[3], Laura Emilia IONEL[1], Kazuo A. TANAKA[4,5]

[1]INFLPR, 409 Atomistilor Street, Magurele RO-077125, ROMANIA

[2]Université de Bordeaux-CNRS-CEA, CELIA, Domaine du Haut Carre 43, Pierre Noailles Street, Talence 33405, FRANCE

3Braila County Emergency Clinical Hospital, 1 Pietatii Street, Braila 810249, ROMANIA

[4]ELI-NP, 30 Reactorului Street, Magurele-Bucharest RO-077125, ROMANIA
[5]Institute of Laser Engineering, Osaka University, Yamada-oka 2-6, Suita, Osaka 565-0871, JAPAN

Corresponding author: olimpia.budriga@inflpr.ro

Extreme intensities above 10^{23} W/cm^2 are envisaged to be achieved at the ELI-NP facility [1]. We show that the interaction of a laser with an intensity of 10^{23} W/cm^2 (the normalized laser field amplitude $a_0 = 215$) and 5×10^{23} W/cm^2 ($a_0 = 481$) with a plastic micro-cone target can lead to direct laser acceleration of electrons, proton shock acceleration and γ photon creation by performing three-dimensional Particle-in-Cell simulations using the SMILEI code [2]. Figure 1 shows the proton energy spectrum for micro-cones with different tip diameters compared with the case of a foil with a thickness of 1 μm for $a_0 = 215$ (see where a_0 is not specified in the legend) at the simulation time of 100 fs. As depicted in Figure 1, the graphics for the micro-cones have a plateau for high proton energies which is a characteristic of ion acceleration by a shock wave. Also, it is noticeable that for a laser intensity of 5×10^{23} W/cm^2 and using micro-cones we can obtain protons accelerated to a highest energy twice the maximum energy reached by the protons in the case of a foil.

We conclude that a plastic micro-cone is a very good candidate to be used for secondary sources optimization at the interaction with ultra-high intensities pulses that will be available at ELI-NP.

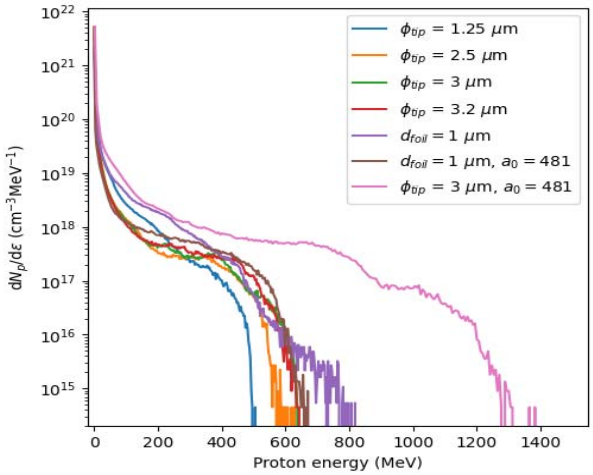

Fig 1. Proton energy spectrum for micro-cones with different tip diameters, the foil with the thickness of 1 μm for $a_0 = 215$ (everywhere where *a0* is not specified in the legend) and $a_0 = 481$ at the simulation time of 100 fs.

Acknowledgement: This research was supported by the Romanian Ministry of Research, Innovation and Digitization under Romanian National Nucleu Program LAPLAS VII contract No. 30N/2023. This work was partially supported by JSPS Core-to-Core Program, grant number JPJSCCA20230003.

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Pioneering FLASH irradiation experiments with laser-driven electrons: Insights from cell co-culture investigations

Georgiana GIUBEGA[1,2], Constantin DIPLASU[1], Gabriel COJOCARU[1,2], Razvan UNGUREANU[1], Stefana OROBETI[1,3], Livia Elena SIMA[3], Ioana POROSNICU[1], Cosmin DOBREA[1], Mihai SERBANESCU[1], Alexandru MIHALCEA[1], Elena STANCU[1], Cristina Elena STAICU[1], Florin JIPA[1], Alexandra BRAN[1], Emanuel AXENTE[1], Simion SANDEL[1], Marian ZAMFIRESCU[1], Ion TISEANU[1], Felix SIMA[1]

[1]CETAL, National Institute for Laser, Plasma and Radiation Physics, 409 Atomistilor street, Magurele, RO-077125, ROMANIA
[2]ELI-NP, "Horia Hulubei" National R&D Institute for Physics and Nuclear Engineering, Romania
[3] Department of Molecular Cell Biology, Institute of Biochemistry of Romanian Academy, 296 Splaiul Independentei, Romania

Corresponding author: georgiana.giubega@inflpr.ro

FLASH irradiation, characterized by ultra-high dose rates, holds promise in revolutionizing cancer therapy by potentially enhancing treatment efficacy while minimizing damage to healthy tissues. Despite its potential, practical implementation of FLASH therapy has been limited, with most studies confined to theoretical investigation. Thus, we are excited to report the first in vitro experiments utilizing laser-driven electron beams for FLASH irradiation [1]. This represents a significant step towards translating theoretical concepts into tangible applications in cancer treatment. Healthy NHEM melanocyte cells and A375 melanoma cells have been simultaneously exposed to laser-accelerated electrons. Various methods were employed to measure the doses absorbed by the cells (see **Fig. 1**), facilitating the correlation between the received dose and cellular response.

The experiments were conducted at CETAL-PW lab from INFLPR, Romania, equipped with a Ti:Sa PW class laser (800 nm, 25 fs, 25 J, 0.1Hz) which has demonstrated electron acceleration in the very high energy electron (VHEE) in recent years [2]. We detail the experimental setup, laser-plasma parameters, diagnostics utilized for beam characterization and methodologies employed for determining absorbed doses in this study.

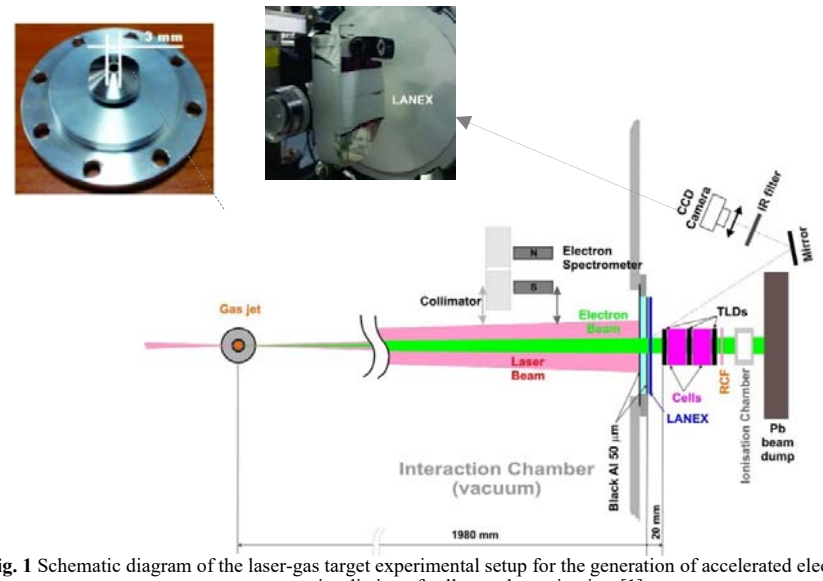

Fig. 1 Schematic diagram of the laser-gas target experimental setup for the generation of accelerated electron beams and the irradiation of cell co-cultures in vitro [1].

Acknowledgement: This research was supported by IFA (Institute of Atomic Physics) through ELI-RO_2020_11 Project, No. 01/2020 and by National Interest Infrastructure facility IOSIN – CETAL at INFLPR.

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Radiation resilience: Assessing the stability of pharmaceuticals in complex radiation field

Adriana SMARANDACHE[1], Viorel NASTASA[2], Angela STAICU[1], Mihail Lucian PASCU[1, 3], Ralf MÖLLER[4]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA
[2]ELI-NP, IFIN-HH, 30 Reactorului street, Magurele, RO-077125, ROMANIA
[3]Faculty of Physics, University of Bucharest, 405 Atomistilor street, Magurele, RO-077125, ROMANIA
[4]German Aerospace Center (DLR e.V.), Linder Hoehe, Cologne (Köln) 51147, GERMANY

Corresponding author: adriana.smarandache@inflpr.ro

The preservation of pharmaceutical stability during extended spaceflight is paramount given the unique environmental challenges inherent to space travel. Ensuring the integrity of astronaut medications is imperative to sustain their health and well-being throughout prolonged missions [1].

The aim of this work was to assess the stability of three antibiotics (Rifampicin, Nalidixic acid, and Spectinomycin) subsequent their exposure to radiation in two distinct experiments. In the first one, gamma radiation of up to 204 kGy doses from an encapsulated ^{60}Co source have been applied to samples. In the second experiment, the medicines were exposed to secondary radiation generated by the high-power laser's (~10 PW, 250J, 25fs) interaction with a solid target at Extreme Light Infrastructure - Nuclear Physics facility (ELI-NP, Romania). The high power short-pulse lasers are able to produce a variety of secondary radiation, from relativistic electrons and multi-MeV/nucleon ions to relatively large intensity X-rays and γ-rays [2]. UV-Vis and FTIR spectroscopy were used to analyse the chemical modifications of the medicines triggered by γ-rays and a more complex radiation field. Antibiotics exposed to radiation in the two experimental settings undergo distinct chemical changes, with both the UV-Vis absorption spectra and the vibrational spectra exhibiting distinct features ((**Fig. 1**).

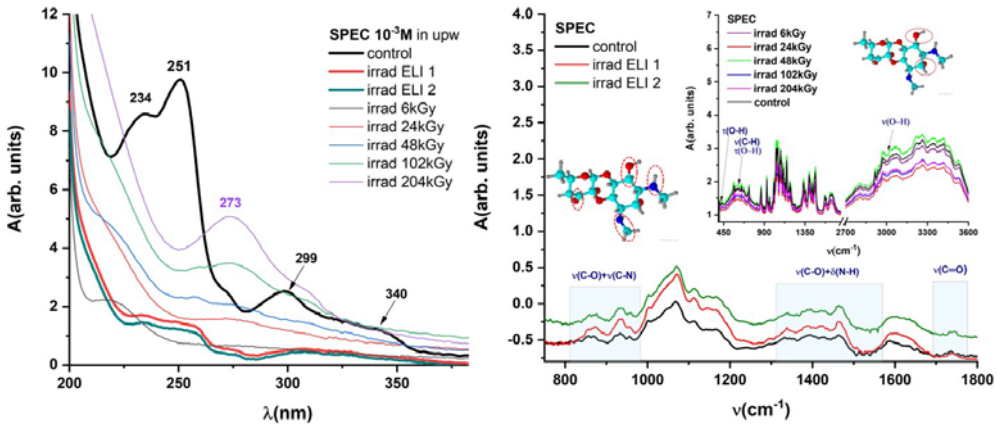

Fig. 1 (a) UV-Vis and (b) FTIR spectra of Spectinomycin.

Acknowledgement: This research was funded by the Romanian Ministry of Research, Innovation, and Digitization under the Nucleu Program LAPLAS VII—contract no. 30N/2023.

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Comparative analysis of the influences of electron and gamma radiation on FBG sensors created in conventional and radiation-hardened optical fibers using a variety of approaches

Razvan MIHALCEA[1], Andrei STANCALIE[1], Daniel IGHIGEANU[1], Daniel NEGUT[2]

[1]INFLPR, 409 Atomistilor street, Magurele, RO-077125, ROMANIA

[2]IFIN-HH Reactorului street, Magurele, RO-077125, ROMANIA

Corresponding author: razvan.mihalcea@inflpr.ro

In this work, we report the results on the gamma (GC-5000 CO^{60} irradiator) and electron (linear accelerator 2MW peak power, 5.5 MeV electrons energy) radiation exposure of fiber Bragg gratings (FBG) inscribed within both standard and radiation-hardened optical fibers, by two types of fabrication methods. By subjecting FBG up to a total accumulated radiation doses of 120 kGy and by monitoring their real-time responses, the research focuses twofold: i) the radiation tolerance of these components, particularly in terms of radiation induced attenuation (RIA) ii) direct correlations of the main spectral parameters, such as resonance wavelength, with the accumulated dose. Furthermore in Fig.1, the investigation explores how factors such as fiber type, radiation type, and fabrication technique affect the Bragg wavelength shift (BWS), spanning from 10 pm to 120 pm [1]. Noteworthy is the examination of protective coatings on the grating region, focusing on their impact when subjected to electron radiation-induced effects, as compared to gamma radiation-induced spectral changes.

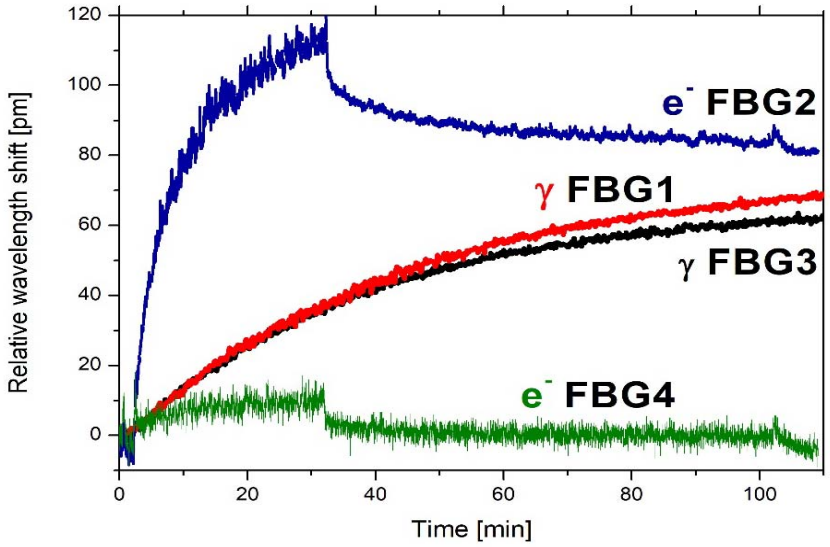

Fig. 1 The relative wavelength shift of four FBG sensors for two different types of radiation.

Acknowledgement: We acknowledge the support of UEFISCDI funded project 666PED/2022 "MEMOIR" and Romanian Ministry of Research and Innovation funded project IOSIN/2023.

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Thermal lensing monitoring using wavefront sensor in Ti:sapphire laser amplifier

Razvan UNGUREANU[1], Alexandru MIHALCEA[1], Gabriel COJOCARU[1,2], Mihai SERBANESCU[1], Georgiana GIUBEGA[1,2], Constantin DIPLASU[1], Aurelian MARCU[1], Sandel SIMION[1]

[1]Center for Advanced Laser Technologies (CETAL), National Institute for Laser, Plasma and Radiation Physics (INFLPR), Atomistilor 409, 077125 Magurele, Ilfov, Romania

[2]Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering, ELI-NP department, 30 Reactorului, Măgurele, 077125, ROMANIA

Corresponding author: razvan.ungureanu@inflpr.ro

In high-power laser amplifiers, like those using Ti:Sapphire crystals, non-uniform heating creates variations in the refractive index across the crystal [1]. This effect, known as thermal lensing, becomes more pronounced as the average optical power absorbed in crystal increases. This study investigated the thermal effects caused by a Ti:Sapphire crystal in a chirped pulse amplification (CPA) system pumped with nanosecond green pulses at a 1 kHz repetition rate. To understand how different factors affect the crystal's heat load, the key parameters were adjusted: the average pumping power and the coolant water temperature. The measurements were performed using a probe beam that overlapped the pump through the crystal sent at a slightly different incidence angle. A commercial wavefront sensor (SID4-HR from Phasics) was used to analyze the resulting interferogram in order to extract important information about the wavefront, such as its radius of curvature (Fig. 1) and the distortions quantified by the Zernike coefficients. This approach could be exploited as a sensitive tool for monitoring how the thermal lensing and other effects like photoelasticity are producing wavefront modification inside the multi-pass amplifiers pumped with high energy pulses at lower repetition rates are producing wavefront modification inside the chirped pulse amplification laser resulting in further shot-to-shot peak irradiance instabilities.

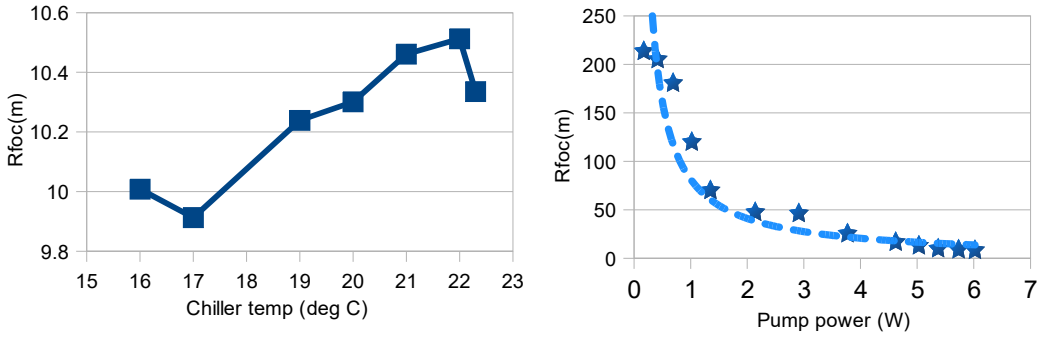

Fig. 1. Measured wavefront radius of curvature variation with circulating water temperature for the pump power of 5 W (Left) and wavefront radius of curvature variation with the pump power at circulating water temperature of 20 degree (Right) .

Acknowledgement: The team acknowledge the support of National Interest Infrastructure facility IOSIN – CETAL at INFLPR, and projects: ELI-RO 11/2020, ELI-RO 01/2023, PCCF-2016 8/2018 and PCE 58/2022.

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Beam particle steering and focusing system for high energy laser-plasma accelerated protons

Mircea PĂTRĂȘCOIU[1,2,3], Bogdan DIACONESCU[1], Dan Gabriel GHIȚĂ[1], Grigore O. DONȚU[3], Lucian TUDOR[1], Cătălin M. TICOȘ[12]

[1]Extreme Light Infrastructure-Nuclear Physics (ELI-NP), IFIN-HH, Măgurele, RO-077125, ROMANIA
[2]Engineering and Applications of Lasers and Accelerators Doctoral School (SDIALA), National University of Science and Technology Politehnica of Bucharest, 313 Splaiul Independentei, Bucharest RO-060042 Romania
[3]Department of Mechatronics and Precision Mechanics, National University of Science and Technology Politehnica of Bucharest, 313 Splaiul Independentei, Bucharest RO-060042 Romania

Corresponding author: mircea.patrascoiu@eli-np.ro

A high energy proton beam transport and focusing line shown in Fig. 1 is simulated in SIMION for proton energies between 70-120 MeV emitted in a cone with 4 degrees spatial dispersion. The line includes 2 dipoles, 3 quadrupoles and a slit featuring a total transmission efficiency of 60%. The setup shows good focusing capabilities, bunching most of the particles in a limited region of only 16 by 13 mm. The high energy protons are considered to be emitted from a solid target interacting with an ultra-high-power laser. Applications of proton beam transport and focusing lines are in proton radiography, material irradiation for spallation and hadron therapy [1, 2].

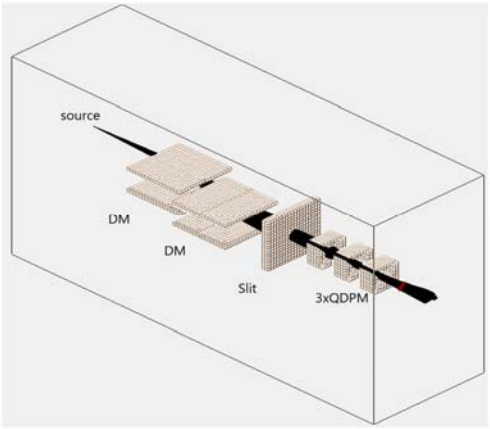

Fig. 1 Setup overview of the proton beam steering system employing 2 dipole magnets (DP), a slit and 3 quadrupole magnets (QDPM).

Acknowledgment: This work was supported by the PN 23 21 01 05 contract financed by the Romanian Ministry of Research, Innovation and Digitization, and the IOSIN funds for research infrastructures of national interest.

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