Abstract Book

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The Abstracts are presented in the authors original forms

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DELAYED ABSTRACTS

Key Invited

Electromagnetism of Functional Biomaterials

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The multidisciplinary field of electro-mechano-biology (EMB) requires the combined efforts of biologists, material scientists, physicists, and engineers. This is in part due to the great morphological complexity of the cellular system. The emergence of EMB was boosted by numerical simulations, which allow envisioning both fundamental discoveries for cell migration and deformation in microfluidic constrictions over a broad range of time and length scales, and technologies for cancer treatment and drug delivery vehicles. Although a few mechanisms by which cells can be electrodeformed are identified, a few recent papers highlight the potential of multiscale and multiphysics simulations that contain elements of stochasticity in heterogeneous systems to analyze the role of forces and deformation in biological systems [1-2]. These considerations make an exploration of the theoretical and phenomenological aspects of electromagnetism of functional bionanomaterials a well-motivated direction to pursue. In the EMB of cells and tissues, what matters is the range of characteristic timescales of delayed motion, which limits the applicability of electromagnetic fields. In [3], we have recently considered the role of these short- and long-term timescales in building spring-dashpot network models of cell architecture to provide a framework for studying the creep and strain relaxation of a single nucleated cell.

With this motivation, in this talk, we want to review the recent efforts of my lab and others on a very old problem, namely, how to use electricity to study and control the mechanical properties of functional biomaterials. We first briefly review results from the literature on the basic core-shell model of an individual cell as an integrated whole, and then shift the focus to relevant equations for computing the Maxwell stress tensor to interpret the cross-properties between electrical and mechanical phenomena of materials. After a brief overview of the constraints and limitations imposed by the continuum EMB analysis of cells, we report on several recent advances in EMB development for characterizing the electric behavior of two organelles depending on the scale length, for discussing prolate-oblate morphology change of a reference cell as a function of the electromagnetic frequency, and for modeling the electromechanically induced cell membrane and nuclear envelope rupture. Some other interrelated purposes are to discuss the key successes and limitations of this versatile approach to analyzing cell electromechanics. Next, we identify several subjects in EMB that are significant for the scientific community, to deepen the electromechanical analysis in each of these areas.

Acknowledgment

The development of the ideas presented in this study is based on work done with E. Sabri.

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BROAD BAND FREQUENCY MEASUREMENTS OF ADVANCED MATERIALS

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Abstract: The dielectric response of materials provides information about the orientational adjustment of dipoles and the translational adjustment of mobile charges present in a dielectric medium in response to an applied electric field. Microwave and terahertz dielectric spectroscopy of ferroelectrics and related materials enables the independent determination of the dielectric permittivity and loss in the dispersion region, as well as the parameters of the soft modes related to phase transitions. Besides scientific purposes, microwave dielectric measurements are of increasing importance in telecommunications-related applications and the design of microwave circuit components. These applications include imaging radars, guidance systems, surveillance and secure communications. The magnetic properties are also of crucial importance. Dielectric and magnetic parameters fully characterize the manner in which electromagnetic waves propagate within the medium. The difficulties of making measurements on a wide range of materials over a wide frequency (and temperature) range have led to the development of various direct and indirect methods. At microwave frequencies, the direct single-frequency methods were enriched in the recent years with more convenient broad band frequency domain dielectric spectroscopy (FDDS), time – domain spectroscopy (TDS), Fourier transform spectroscopy (FTS). Computer controlled spectrometers are now the norm in dielectric spectroscopy. Computers allow the computation of electromagnetic fields in entirely new measurement geometries and the use of numerical analysis in the direct measurement process. The use of such spectrometers is now one of the most fruitful factors in new approaches to microwave dielectric spectroscopy. Each investigator employs the method adequate for the size and shape of a sample. The most important problem now is the rigorous mathematical solution of the microwave interaction with the samples in various geometries. Although there is now complete overlap and coverage of the radio frequency to the infrared band, the different experimental methods based on coaxial, waveguide, and resonator and free–space technique are still divided and will be presented. Examples of various materials, such as ferroelectric, relaxor, dipolar glasses and other materials dielectric spectroscopy results will be presented.

Keywords: Dielectric materials, broad band dielectric spectroscopy

Innovations for Neuromorphic Computer: Insulators, Semiconductors and Superconductors for Base Elements of Brain-Inspired Neural Networks

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Abstract: With the growing energy demands of modern computers based on the von Neumann architecture, the need for more energy-efficient computing solutions has become increasingly urgent. This challenge has stimulated a shift toward non–von Neumann computing paradigms, particularly those inspired by the brain's neural network architecture. Artificial neural networks (ANNs), which emulate the structure and function of biological neurons and synapses, have gained significant attention in this context. These networks require innovative functional nanostructures designed using advanced insulating, semiconducting, and superconducting materials, offering the potential for dramatic reductions in energy consumption and addressing key limitations of conventional von Neumann systems.

In this work, we present the results of modeling, design, and investigation of artificial neurons and synapses based on smart functional nanostructures composed of hybrid layered superconductor/insulator and superconductor/magnetic metamaterial systems. The results highlight their potential in superconducting spintronics and their promise for enabling a new generation of energy-efficient computing technologies.

Keywords: Insulator, Spintronics, Neuromorphic Computing, Artificial Neural Networks, Hybrid Nanostructures.

Advanced Nanomaterials-Based Sensing Platforms for Enhanced Situational Awareness Using Augmented Artificial Intelligence

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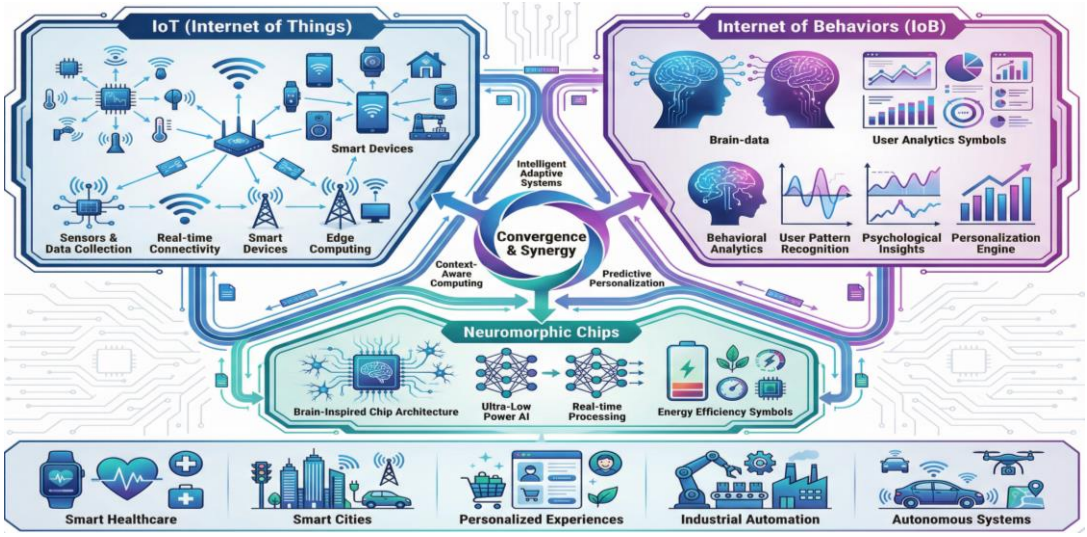
Abstract: The rapid convergence of nanotechnology, artificial intelligence (AI), and advanced materials science is revolutionizing sensing technologies, giving rise to platforms with unprecedented precision, adaptability, and intelligence. Once confined to narrow functions, traditional sensors are being reimagined as multifunctional, autonomous systems capable of thriving across diverse domains—from biomedical diagnostics and environmental monitoring to aerospace and defense. Quantum sensors, leveraging entanglement and coherence, achieve ultra-sensitive measurements of time, gravity, and magnetic fields, pushing far beyond classical limits. Bio-inspired and bio-integrated sensors, meanwhile, harness living systems or synthetic analogues to enable real-time, noninvasive physiological monitoring, driving breakthroughs in personalized healthcare and human–machine symbiosis. The infusion of AI and edge computing equips sensors with on-device intelligence, empowering context-aware decision-making, predictive analytics, and self-calibration in dynamic environments. Advances in flexible, stretchable, and self-healing materials further enhance adaptability to unconventional surfaces and extreme conditions, while energy-harvesting solutions address power constraints by enabling self-sustained operation. Together, these innovations redefine sensing as an active, networked capability rather than a passive data-collection tool, fostering the emergence of "cognitive sensing ecosystems" that autonomously learn, adapt, and evolve. Looking ahead, futuristic sensors will shape resilient societies, sustainable industries, and secure infrastructure, while simultaneously raising pressing questions about ethics, privacy, and governance. Although the full potential may await the advent of artificial general intelligence (AGI), these technologies, including neuromorphic ones, by literally sensing the unseen future, herald a new era of intelligence-driven interaction among humans, machines, and the environment.

Keywords: AI, AGI, Neuromorphic, Sensors, Edge computing, Dielectric, Energy, Biomedical

Schematics



Resent Progress on the Research and Development for Practical Application of HDD-Type Ultra-High Density Ferroelectric Data Storage

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Abstract: We have proposed ferroelectric recording using scanning nonlinear dielectric constant microscopy (SNDM) as a next-generation ultra-high-density information recording method (SNDM probe memory) [1]. To date, we have confirmed extremely high recording densities and high-speed write characteristics using $LiTaO_3$ single-crystal media.

In this paper, we present the resent progress on the research and development for practical application of HDD-type SNDM probe memory.

Fist topic is "Non-Contact Heat Assisted Ferroelectric Reading (HAFeR)". Recently, we proposed a HAFeR method as a technique to dramatically increase the read speed [2]. However, all these fundamental data were obtained with the SNDM probe tip in contact with the ferroelectric recording medium. Considering the practical implementation of HDD-type SNDM probe memory, it is self-evident that a non-contact method, similar to magnetic HDDs, is essential. Calculations using data from previously obtained temperature dependence of both linear and nonlinear dielectric constants suggest that even if a gap forms between the tip and sample, the SNDM signal is expected to increase proportionally to $(Tc-T)^{-1.5}$. Experimentally, the HAFeR effect was confirmed for gap within the tip radius (approximately 30 nm). Since the gap length at the practical implementation stage of SNDM probe memory is expected to be 1 nm or less, it was found that the same HAFeR effect as during contact can realistically be obtained.

Second topic is "Shingled Dielectric Recording". Compared to magnetic recording, dielectric recording inherently allows for smaller bit formation, but in magnetic HDDs, where forming a single small polarization reversal dot is relatively difficult, the shingled recording technique is used to enhance recording density. We believe that applying this technique to dielectric recording could enable simpler and higher-density recording. Therefore, we have conducted a preliminary experimental study on shingled dielectric recording. Shingled recordings on a single track and triple track have been conducted. In particular, in the triple track case, extremely small dot formation was confirmed relative to the set pitch width, confirming that the shingled recording technique is an effective method for achieving high-density recording in dielectric recording as well.

Keywords: Scanning nonlinear dielectric microscopy, Ferroelectric data storage, SNDM probe memory

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Methods for creating submicron structures by direct laser writing

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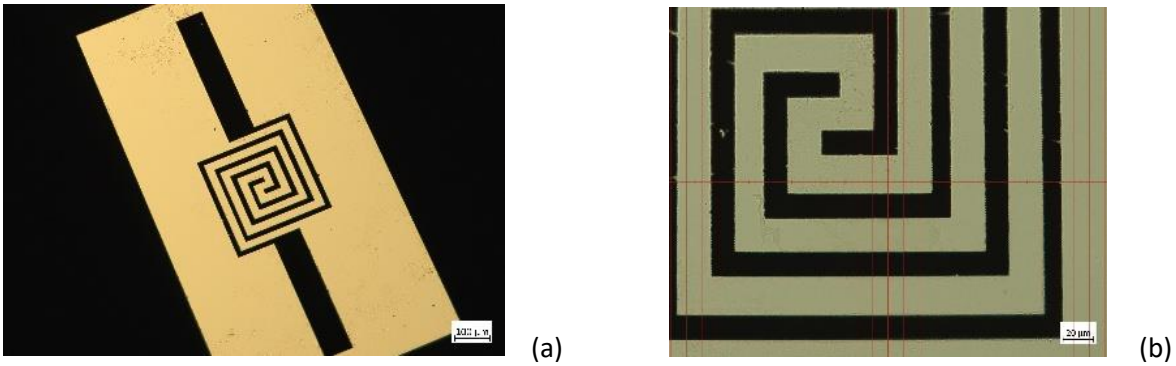
Abstract: Today, direct laser recording technology is gaining significant popularity in the field of optoelectronics for creating high-quality diffractive optical elements on substrates of arbitrary sizes. It allows one to quickly form optical elements for various purposes, namely angular scales, limbs and diffractive elements without the use of phototemplates, which allows you to speed up the manufacturing process and improve the quality of the structures. Direct laser recording technology is based on scanning and exposing the surface of the substrate covered with a photoresist layer to a focused amplitude-modulated laser beam. Technological equipment for direct laser recording can be created using laser recording stations, which were used in the technological process of manufacturing compact discs. The optical system of the laser recording station uses a focusing lens with a numerical aperture of 0.70-0.95, located on piezoactuator of the laser beam automatic focusing system. The use of a high-aperture lens will allow focusing of the laser beam to submicron sizes. To record two-dimensional images at the laser recording station, an angular reference encoder is used to form sector marks with a resolution P, which is selected according to the substrate diameter D so that the D/P ratio is 0.7–1.2 μm. The size of the elements formed in the process of direct laser recording is significantly influenced by the characteristics of laser radiation, such as the intensity distribution of the focused laser beam, scanning speed and focusing accuracy. Of fundamental importance for the formation of submicron structures is the use of nonlinear interaction of the laser with a photosensitive material, which allows one to bypass the limitations in resolution, which are determined by the Rayleigh criterion. Experimental studies of direct laser recording have shown the possibility of creating images with high resolution (Fig. 1).



(a) (b)

Figure 1. An optical image of representative metal structures fabricated by direct laser recording. The length of the scale bar is 100 μm in (a) and 20 μm in (b).

Keywords: direct laser recording, diffractive optical elements, laser recording station, photosensitive material

Phonons, polarons and Raman scattering in layered quantum crystalline materials

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Abstract: The fundamental theory of spatially extended optical vibrational excitations, their interaction with charge carriers and the resulting polaron phenomena in multi-layer quantum crystalline materials is overviewed [1]. One of the most significant manifestations of the potential theory in multilayer planar systems and the theory of collective states in such systems is the theoretical prediction − followed by the experimental detection − of the phenomenon of propagation in superlattices of vibrational excitations of a new type, called Spatially Extended Interface Polaritons. On the grounds of the quantum theory of potential and image forces in multilayer planar systems, the dielectric function of quantum insulators is derived. Based on the quantum theory of electron emission from the 'metal–dielectric' structure in strong electric fields, the thermoautoelectronic emission in 'metal–dielectric' structures is understood as a manifestation of the quantum nature of image forces under conditions close to atomic electric fields. The behavior of the magneto-polaron resonances as a function of the phonon symmetry inherent in monolayer Transition Metal Dichalcogenides (TMDs) is unveiled [2]. Several avoided-crossing points of energy branches assisted by an optical phonon in the MP spectrum, superposition of the electron and hole states in the emerging excitations, and their impact on optical transitions in various scattering configurations are specific for these two-dimensional quantum crystalline materials [3]. The magneto-polaron resonant scattering in a monolayer TMD is explored as a function of the laser intensity and the magnetic field. The magneto-polaron resonant Raman intensity manifests three resonant splittings of double avoided-crossing levels. Three magneto-polaron excitation branches occur by virtue of the coupling of electron and hole Landau levels to an out-of-plane A_1 optical phonon mode. The energy gaps at the anticrossing points in the magneto-polaron Raman spectrum are determined for various electron and hole deformation potential constants. The derived resonant magneto-polaron Raman efficiency as a function of the magnetic field allow for exploring the relative contribution of the conduction and valence bands in TMDs to the formation of magneto-polaron excitation branches [4]. The obtained results provide a background for on-demand engineering of the optical spectra, polaron states, and transport processes in layered quantum crystalline materials towards applications in the emerging technologies encompassing artificial intelligence, quantum computing, nanotechnology, advanced materials. The support from the National Agency for Research and Development (Republic of Moldova) through the Project "ReBRAIN" no. 25.80013.5007.07RE is gratefully acknowledged.

Keywords: Phonons, Polarons, Raman scattering, Layered quantum crystalline materials, TMDs

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Carbon Nanomaterials as Dielectric-Active Interfaces

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Abstract: Carbon nanomaterials have emerged as highly versatile interface components in electronic and photoelectrochemical (PEC) devices, where their role extends well beyond electrical conductivity. In this contribution, we show how graphene oxide, carbon nanodots, and graphitic carbon nitride act as dielectric-active interfacial materials, governing polarization phenomena, charge separation, and chaqJl extraction at semiconductor junctions. By tailoring surface chemistry, defect density, and nanostructure morphology, carbon nanostructures enable precise modulation of the local dielectric environment at carbon-semiconductor and electrode-electrolyte interfaces.

Focusing on hybrid systems based on metal oxides, polymer semiconductors, and two-dimensional materials, we demonstrate how carbon-derived interfaces influence interfacial electric fields and band alignment, thereby enhancing charge extraction and suppressing recombination pathways. The presentation further highlights water-based processing strategies for carbon nanomaterials, enabling the fabrication of sustainable dielectric thin-fihn interfaces with controlled micro structure and func1ional stability.

These results underline the importance of carbon nanomaterials as interfacial dielectric design elements, offering new opportimities for improving efficiency, durability, and scalability in photoelectrochemical energy conversion and advanced electronic devices

Keywords: Carbon Nanostructures, Dielectric Interfaces, Energy and Environmental Applications

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Lead-Free Oxides for Electrial Energy Storage

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Abstract: This work is part of ongoing international research into electrical energy storage, often referred to as the "missing link" of the energy transition. Indeed, as global electricity production is mainly based on fossil fuels that generate CO_2, which causes climate change, the energy transition currently underway around the world aims to promote "green growth" dominated by renewable energies such as wind and solar energy. However, although this new system is carbon-free, it remains at the mercy of the weather, as its energy production varies according to seasons, months, and days, with irregular and unstable efficiency. For these renewable energies to be considered completely reliable primary energy sources, it is necessary to have efficient systems for storing the electrical energy produced, enabling it to be transformed from instantaneous flow energy into available stored energy.

Dielectric capacitors are storage systems that have established themselves as one of the solutions to energy problems due to their advantages, such as environmental friendliness and very fast energy charging and discharging. The capacitor has an infinite lifespan: A Li-Ion battery lasts for 1000 to 3000 cycles, while a dielectric capacitor can undergo millions of charge/discharge cycles without losing its capacity. Finally, capacitors are much more resistant to high voltages and high temperatures than batteries or even supercapacitors, allowing them to operate in extreme temperature environments, such as vehicle engines.

The aim of this work is to contribute to the development of new lead-free oxides for the production of capacitors with high electrical energy storage capacity. Currently, capacitors based on the material $PbZrTiO_3$ (PZT) can store high energy densities, but this oxide contains lead. However, the European RoHS directive, in force since July 1, 2006, bans lead, which is a hazardous substance that must be replaced by other materials that are harmless to health and the environment. Accordingly, it is necessary to implement materials without these prohibited substances, and presenting low losses, high and stable dielectric permittivity in frequency and temperature. Among lead-free oxides, the perovskite material $SrTiO_3$ exhibits low dielectric losses, and its dielectric properties can be improved by substituting Sr^{2+} ions at the A sites with ions of the same valence. In particular, $Sr_{1-x}Ca_xTiO_3$ material with $(0.30 \leq x \leq 0.40)$ presents a rich orthorhombic structural symmetry (Pbcm) evolution, responsible for antiferroelectric (AFE) behavior at room temperature. In this work, we present the dielectric and ferroelectric study of this material in the form of ceramics and thick films in this range of compositions in order to remain close to the possible antiferroelectric (AFE) phase, with the aim of maximizing the stored electrical energy densities and the energy efficiency of the material.

Keywords: Strontium calcium titanate, ceramics, thick films, dielectrics, energy storage capacitors

Invited Papers

Plantar Pressure Measurement Using Sol–Gel Composite Piezoelectric Film Sensors for Prosthetic and Orthotic Fabrication

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Abstract: In the field of prosthetics and orthotics, pressure measurement is performed to evaluate the physical condition of users and to verify the effectiveness of fabricated devices. In particular, in order to prevent discomfort or pain at the interface between the body and the device, it is necessary to adjust the distribution of applied forces according to individual users. Therefore, there is a strong demand for pressure measurement devices that enable simple and practical evaluation.

The pressure sensor is required to be thin and flexible to conform to the curved surfaces of the body and the device. In addition, even if the force distribution is appropriate in a static condition, it can change during motion, creating a need to measure pressure variations during movement. To solve these requirements, we consider piezoelectric sensors based on sol–gel composite films to be an effective solution.

Sol–gel composite piezoelectric thin films are fabricated by dispersing piezoelectric ceramic powder in a sol–gel solution and coating and firing it onto a metal substrate. The films fabricated by spray coating [1] exhibit a porous microstructure, which provides high flexibility. When the film is deposited on thin metal foil substrates, the sensors can be bent, which is a notable characteristic.

In this study, a sensor with a thickness of approximately 0.2 mm fabricated using a sol–gel composite was inserted between an in-shoe insole and the foot, and pressure variations during walking were measured. In general, piezoelectric materials generate a voltage at the moment when strain occurs (i.e., when force is applied); however, because the generated charge is neutralized by externally connected measurement equipment, the voltage rapidly decays. As a result, forces that change slowly over time cannot be measured accurately. To address this issue, we investigated methods based on integrating the output voltage and on solving an inverse problem using frequency response of the sensor. As a result, we obtained measurement results that reasonably represent the variation of forces acting on the plantar surface during walking, indicating that this sensor has strong potential for application in the field of prosthetic and orthotic fabrication.

Keywords: Prosthetics and Orthotics, pressure measurement, Sol-gel composite piezoelectric film

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Tailoring the surface topology, wettability, and optical bandgap of metal oxide films by means of tuning their compositions and technological conditions in spray pyrolysis

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Abstract: Oxide thin films with large band gaps offer a wealth of potential applications across various technological fields in energy, electronics, optoelectronics, and environmental technologies, due to their combination of unique optical and electronic properties [1,2]. Microfluidics is another application filed of metal oxide films, when their wettability can be controlled [8].

Metal oxide thin films are prepared by a variety of technological methods, such as chemical vapor deposition (CVD), magnetron sputtering, atomic layer deposition (ALD), pulsed laser deposition (PLD), spray pyrolysis and many other techniques. Among these techniques, spray pyrolysis has a series of advantages, such as simplicity and cost-effectiveness, versatility, suitability for different substrates, low processing temperatures, ability to efficiently control the film properties.

A comprehensive analysis of relationships between topological features, wettability properties and optical bandgaps on a wide variety of metal oxide semiconductor films prepared by spray pyrolysis on various substrates is performed in this report, which is of especial importance for microfluidic and optoelectronic applications. Several classes of metal oxide materials are in the focus of research, such as $Zn_{1-x}Mg_xO$, $(In_{1-x}Ga_x)_2O_3$, $(In_{1-x}Al_x)_2O_3$, $(Ga_2O_3)_{1-x}(SnO_2)_x$, and $(In_2O_3)_{1-x}(MgO)_x$.

X-ray diffraction (XRD) in combination of energy dispersive x-ray (EDX) analysis demonstrated that the films in these material systems can be produced in the form of solid solutions (alloys) in a certain range of x-value compositions, while they represent nanostructured composite films with a controlled ratio of composite phases, determined by the precursor solutions used. The 3D topography of the prepared films investigated by atomic force microscopy (AFM) image processing was explained in terms of formation of solid solutions and nanocomposite films, composed of nanocrystals with different crystal structure. Particularly, Mg ions are incorporated into the wurtzite $Zn_{1-x}Mg_xO$ structure only at low values of *x*, while a mixture of wurtzite type ZnMgO and cubic type MgO nanocrystallites is produced at high value of *x*, which resulted in increasing the roughness of films with increasing the *x*-value. $(In_{1-x}Ga_x)_2O_3$ films were found to be composed of In_2O_3 nanocrystallites with the *bixbyite* body-centered cubic structure and Ga_2O_3 nanocrystallites with the monoclinic crystal structure. In contrast to the $(In_{1-x}Ga_x)_2O_3$ system consisting of only two phases, a third *$MgIn_2O_4$ phase with spinel structures was found in addition to the* In_2O_3 and MgO phases in films of the $(In_2O_3)_{1-x}(MgO)_x$ system.

The wetting properties and the optical bandgaps of the produced films have been explained in terms of a combined effect of the surface roughness, nature of chemical bonds, nature of the substrate, conditions of thermal treatment and other technological parameters, in the investigated material systems.

Keywords: Metal oxide films, Solid solutions, Composites, Roughness, Wettability, Optical bandgap.

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Emerging Chalcogenides for Sustainable Energy and Environmental Applications

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Abstract: Copper–zinc–tin–sulfide (Cu_2ZnSnS_4, CZTS) kesterites a promising earth-abundant and non-toxic absorber for next-generation thin-film photovoltaics. However, sulfur-based CZTS solar cells remain limited in performance, largely due to intrinsic defects and interfacial recombination losses. Impact of solvent chemistry and extrinsic doping and compositional engineering on the quality of solution-processed CZTS absorbers is revealed [2,3,4,5]. Cd-alloyed CZTS (CZCTS) improves the solar cells efficiencies promoting nearly defect -free due to a quasi-epitaxy between CZCTS and CdS. A synergistic compositional strategy combining silver (Ag) – cadmium (Cd) co-alloying with lithium (Li) doping is introduced to suppress cation disorder, passivate grain-boundary defects, and enhance carrier transport. As a result, champion devices with power conversion efficiency over 10% are obtained, placing it among the highest efficiencies reported for solution-processed, selenium-free CZTS solar cells.

Antimony chalcogenides (Sb_2X_3, where X = S, Se, or S_xSe_{1-x}), as an earth-abundant light-absorbing material class with long-term stability for thin-film photovoltaics, is recognized as promising for emerging inorganic thin-film solar cells Among the Sb_2X_3 family, antimony sulfide (Sb_2S_3) is one of the most attractive materials for thin-film solar cells due to its favorable optoelectronic properties, including a high absorption coefficient ($\alpha > 10^5$ cm^{-1}) and a direct bandgap of around 1.7 eV, while being a binary compound with a single stable phase and earth-abundant elemental composition However, to further develop Sb_2S_3-based solar cells, which are yet less explored among Sb_2X_3, precise control over film deposition parameters, morphology, crystallinity, and defect passivation to optimize charge transport and reduce recombination losses is required, several aspects being presented in this work [6,7].

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Keywords: Cu_2ZnSnS_4, Sb_2S_3, SnS, Solar cells, Chalcogenides, Photovoltaics

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2.

Advanced Functional Materials for Environmental Protection and Electrochemical Sensing

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Abstract: Advanced functional materials play a crucial role in addressing contemporary challenges in environmental protection, energy conversion, and chemical sensing. This presentation highlights recent advances in the synthesis and engineering of zeolite-based materials for environmental applications. Owing to their high surface area and tunable porous structure, zeolites are highly effective for adsorption, catalysis, and pollutant removal from water systems.

In parallel, the fabrication of modified electrodes incorporating these materials represents a promising strategy for the sensitive detection and quantification of pollutants based on their electrochemical behavior. The integration of porous frameworks with conductive substrates enables efficient electrochemical sensing of heavy metals and organic contaminants. Emphasis is placed on scalable synthesis routes, structure–property relationships, and practical environmental applications, contributing to the development of sustainable technologies for environmental monitoring and protection.

Keywords: Functional materials; chemical sensing; pollutants; electrochemical sensing.

Electrospun Piezoelectric Nanofibers for Tissue Engineering Applications

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Abstract: The aim of tissue engineering is to combine cells, scaffolds and growth factors in order to repair, regenerate or replace damaged tissues and organs. Recent advances in biomaterials research have led to the development of smart scaffold systems with controllable and responsive biological functions. Among these systems, piezoelectric materials have attracted particular interest because of their ability to transform mechanical energy into electrical signals. Several load bearing tissues, including bone, tendon and cartilage, that contain large amounts of collagen, exhibit intrinsic piezoelectric behaviour, which enables the generation of electrical signals in response to applying strain and deformation. It is now well recognised that electrically active microenvironments play an important role in regulating cell behaviour and tissue regeneration. Electrospun nanofibrous scaffolds have attracted increasing attention in tissue engineering because they provide a fibrous structure that mimics the native extracellular matrix. Electrospun nanofibers exhibiting piezoelectric behaviour are increasingly being investigated as scaffold materials for tissue engineering, as they combine an extracellular matrix like fibrous structure with the ability to generate electrical stimuli, which plays significant roles in regeneration of defected tissues. This presentation focuses on piezoelectric electrospun nanofibers as functional scaffolds for tissue regeneration. The basic mechanisms responsible for piezoelectricity in polymeric nanofibers are briefly outlined, followed by a discussion of how mechanically induced electrical signals influence cell adhesion, proliferation and differentiation. Recent studies are reviewed to demonstrate the response of particularly bone, neural and musculoskeletal cells to piezoelectric scaffolds, which highlight the potential of piezoelectric electrospun nanofibers as bioactive systems for guiding tissue regeneration.

Keywords: Electrospinning, Scaffold, Piezoelectric materials, Tissue engineering

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Dielectric properties of zirconium oxide containing barium titanate glass-ceramics

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Abstract: The preparation of oxide glasses with high concentration of alkaline and alkaline earth oxides is of both theoretical and practical importance. The obtained materials can subsequently be thermally treated and thus, new functional glass-ceramics with potential for electronic, biomedical and sensor applications can be obtained.
The present study is devoted to the synthesis of bulk glasses in the system $Na_2O/BaO/TiO_2/ZrO_2/B_2O_3/SiO_2/Al_2O_3$ by applying the traditional melt-quenching technique. The as prepared glasses are further subjected to controlled crystallization and thus, glass-ceramics with the desired crystalline phase – barium titanate, $BaTiO_3$ of Zr-substituted barium titanate, $BaTi_{1-x}Zr_xO_3$ are obtained. The phase composition is studied by X-Ray Diffraction (XRD) and reveals the precipitation of Zr-modified $BaTiO_3$. The microstructure is investigated by Scanning Electron Microscopy (SEM) and shows the occurrence of bright crystalline structures containing mainly Ba, Ti and Zr embedded in a dark amorphous matrix. Some of the Zr ions as well as the rest of the elements from the batch composition are detected in the glass matrix. The electric properties are studied by means of Impedance Spectroscopy as a function of frequency and temperature and reveal the occurrence of several relaxor type phase transitions of the Zr-modified $BaTiO_3$.

Keywords: Barium-zirconium titanate, Glass-ceramics, Dielectric properties, Relaxor behaviour

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High-throughput machine learning-guided exploration of chalcogenide materials for resistive switching devices

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Abstract: Chalcogenide glasses have emerged as promising candidates for neuromorphic computing and resistive switching memory devices due to their unique electronic properties and structural flexibility. However, traditional materials discovery approaches are time-consuming and resource-intensive, limiting exploration of the vast compositional space available in these systems. Machine learning (ML) combined with high-throughput (HT) experimental techniques offers a paradigm shift in accelerating the discovery of novel functional materials with targeted properties.

The first step was to establish guiding principles for composition selection. A composition map for ovonic threshold switching (OTS) materials was constructed based on elemental bonding and topological parameters, organizing the Te-based chalcogenide phase space into regions of varying switching probability. Compositions selected from different areas of the map were synthesized and electrically characterized in nanoscale devices, confirming OTS behavior [1]. While map-guided synthesis provides targeted access to individual compositions, covering broad multi-element regions requires a different approach. Magnetron co-sputtering from multiple targets enables the simultaneous synthesis of continuous compositional libraries. Applied to the Si-Ge-Te system, a single combinatorial deposition run covered a broad ternary compositional range, and systematic structural and optical characterization across the library uncovered amorphous compositions beyond the bulk glass formation domain [2].

The compositional and property data generated by combinatorial synthesis provided the foundation for introducing ML into the discovery workflow. An ensemble ML classifier trained on a database of more than 30k chalcogenide compositions using physics-inspired descriptors derived from topological constraint theory, thermodynamic, and elemental attributes achieved ~89% classification accuracy. Combinatorial synthesis data provided experimental validation for the predictions. Applying the same ML framework to optical properties, a model for refractive index prediction was trained on a small dataset of glass compositions, achieving R^2 = 0.90 [3]. The Si-Ge-Te thin films prepared by combinatorial sputtering served as an independent experimental validation set.

Combinatorial synthesis and ML prediction are not independent efforts, they are interconnected. HT experiments provide the training data and experimental validation for ML models, while ML predictions direct synthesis toward the most promising compositional regions, reducing the number of experiments required to identify functional materials for resistive switching and selector applications.

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Nanocluster-Driven Topology as a Unifying Parameter of Physical Properties in Chalcogenide Glasses

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Abstract Amorphous chalcogenide glasses exhibit a wide spectrum of anomalous physical properties, including nonlinear optical response, the boson peak in the low-frequency spectra, non-Debye low-temperature thermal conductivity, complex dielectric relaxation, and pronounced photoinduced structural transformations. Despite decades of research, these phenomena are typically treated independently, and a unified microscopic interpretation remains lacking. In this report, a unified framework based on **nanocluster-driven topology** is proposed. Within this approach, chalcogenide systems such as As–S, Ge–S, and Ge–As–S are considered as structurally heterogeneous media composed of interacting nanoclusters forming medium-range order. These nanoclusters are built from fundamental structural units (AsS_3/SGe_3 pyramids and GeS_4 tetrahedra) and include “rigid”,“soft” and “defect” ring-like configurations; chain-like and branched-like with closed ends, and cage-like configurations. Their topology, connectivity, and spatial distribution define the effective structure of the glass. A key concept of the model is the presence of **"keystone nanoclusters"** [1,2] acting as topological organizing centers that determine the rigidity and stability of the network . Spectroscopic evidence supports this framework. Raman studies of glassy GeS_2 demonstrate the coexistence of nanoclusters related to both α- and β-GeS_2 crystalline phases , indicating mixed medium-range ordering. . In the Raman spectra and differential spectra , characteristic bands correspond to vibrational modes of corner- and edge-sharing GeS_4 tetrahedra [3]. These results reveal that ring-like clusters dominate the structure, while defect-related units, including homopolar Ge–Ge and S–S bonds, emerge depending on preparation conditions such as quenching temperature and cooling rate . This confirms that structurally distinct nanocluster ensembles may exist even in nominally identical compositions. Experimental studies of Ge–As–S glasses further show that systems with identical mean coordination numbers exhibit significantly different nonlinear optical responses (including two-photon absorption), elastic moduli, and density depending on the compositional pathway [4]. Within the proposed framework:

- The spectroscopic and thermometric “**boson peaks”** is interpreted as a manifestation of localized and quasi-localized vibrational modes associated with nanoclusters .
- **Low-temperature thermal anomalies** arise from phonon scattering on nanocluster heterogeneities.
- **Photoinduced effects** are described as light-driven reconfiguration of nanocluster-driven topology and surface relief formation [5].

Keywords: chalcogenide glasses, elastic modulus, density, mean coordination numbers, glass structure, boson peak, low-temperature thermal anomalies, photoinduced effects.

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Silicon nitride ceramic substrates for chip substrate applications

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Abstract: The lecture will give a comprehensive view on innovative developments made in the field of nanocarbons e.g. carbon black, carbon nanotubes (CNTs), graphene added ceramics highlighting the key issues related to integration technology and improvements in the mechanical, tribological or functional properties as a result. Among non-oxide ceramics the silicon nitride based ceramics are well-known as lowdensity materials with high strength and toughness. Silicon nitride, known as a typical dielectric material, is an ideal candidate for several structural applications, even at high temperatures. The addition of graphene or carbon nanotubes to silicon nitride to create ceramic nanocomposites gives rise to promising applications in a wide range of fields such as electronics, biomedical aids, membranes, flexible wearable sensors and actuators, energy systems. It is wellknown that silicon nitride ceramic substrate has excellent insulation performance and good heat dissipation, therefore can be used to manufacture various high-power electrical components, such as power modules, heating modules, etc., effectively ensuring the service life and reliability of electrical equipment. The presentation will show how the use of different reinforcing phases, their dispersion grade, ceramic matrix – CNTs, graphene interphases and sintering methods influence the microstructure and as a result, mechanical properties, electrical, thermal conductivity and tribological properties of the final silicon nitride nanocomposites. The prospective future applications will be also discussed.

Keywords: silicon nitride, carbon nanotube, graphene, substrates

Tailoring dc-tunability properties of functionally graded ceramics by core-shell approach

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Abstract: The nanoscale coating of small particles with materials with different compositions, results in the formation of core-shell structures, is a relatively new and active area of research. The coating changes both the interaction of the particles with environment and their properties. New functionalities can be imparted with the cores depending on the properties of the shell. Using several synthetic approaches, dissimilar materials (metals, semiconductors, ceramics, polymer etc.) can be combined for many different applications in the areas of coating, electronics, catalysis, and drug delivery.

Core-shell particles can be used as building blocks for the fabrication of bulk composite materials with 0-3 connectivity using appropriate densification techniques. The coating prevents percolation even for high-volume fractions of the core phase (>50%), a result not attainable with the conventional preparation routes. The functional properties of composite materials can be modified by changing the shell composition. The coating exerts a significant effect of temperature and frequency dependence of dielectric permittivity. Inorganic composites are usually consolidated by sintering, a process that requires high temperatures. So, the final microstructure and properties will be strongly conditioned by the amount of residual porosity, the occurrence of grain growth and coarsening, the extent of the interdiffusion between the core and shell and the possible formation of the intermediate phases by reaction at phase boundary. These interfaces phenomena can be minimized by using rapid sintering methods, such as sprak plasma sintering (SPS) and field assisted sintering.

In the last years, we focused our attention on preparing and investigating the functional properties of dense composite ceramics obtained from core-shell nanopowders. We passed from magnetoelectric composites to dielectric-ferroelectric composites to understand the role of core-shell structure on the electrical response of ceramics.

This presentation includes different electroceramics prepared from core-shell structures:

(i) Magnetoelectric ceramics (Mag@$BaTiO_3$) where the role of magnetic core and microstructure on the new functional properties were investigated

(ii) Functionally graded ceramics ($BaTiO_3$@$SrTiO_3$) where the role of local composition gradients generated by core-shell structure on the temperature dependence permittivity and tunability were investigated.

Keywords: core-shell structures, dc-tunability, functionally graded ceramics

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Chalcogenide glasses: structural properties and applications in photonics

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Due to their unique properties such as high IR transparency, numerous photoinduced effects, high non-linear optical properties, etc., chalcogenide glasses (CG) are perspective materials for various applications in the modern photonics and nanotechnology. CG are widely used in versatile technological applications for fabrication of optical elements and devices for optoelectronics, holography and information storage media. In present report the investigation results of chalcogenides glasses (CG) structural properties and their applications are reviewed.. EDX, XRD, EXAFS, AFM, SEM techniques and Raman spectroscopy were used as tools in studying the structural properties of CG's. As_2S_3-As_2Se_3, As_2S_3-Sb_2S_3, Ge-As-Se, Ge-As-S, Ge-Sb-Te, Ga-Ge-Te and Ge-S-Ag, Ag–As–S, As_2S_3: Mn chalcogenide glasses. The experimental X-ray diffraction profiles confirmed amorphous nature of studied glasses. Pair distribution functions and RDF were obtained for samples of As-Ge-Se, As-Ge-S, As-Sb-S glasses and Ga-Ge-Te glasses, As-S(Se) glasses doped with Ag, Mn. The addition of silver and germanium does not si gnificantly affect the position of first coordination sphere r_1. Radius of first coordination sphere for As-S-Ag glasses correspond to 2.29A value, for As-Ge-S glasses – 2.25 A and for second coordination sphere – 3.48 A for both glass compositions. Changes of short range order parameters (r_1) of As_2S_3:Mn glasses with Mn concentration were within calculation errors. In the case of As-Sb-S glasses with the increase of Sb content position of first coordination sphere radius is shifted towards the longer distances (from 2.29A to 2.42 A), positions of the second peaks – 3.45-3.54 Å for studied glasses. Compositional changes in As_2S_3-Sb_2S_3 alloys have been observed in the evolution of Raman bands. Raman data show that pseudo-binary As_2S_3–Sb_2S_3 glasses contain different nanophases whose concentration changes along the chosen compositional cross-section. Raman spectra of Ge-As-S samples showed that the backbones of the studied samples consist of $AsS_{3/2}$ pyramidal units, edge- and corner-shared $Ge(S_{1/2})_4$ tetrahedral units. Compositional changes in studied glasses result in the evolution of the observed Raman bands. Such dependences of characteristic constituent Raman bands' intensities showed that Ge-As-S samples contain different nanophases whose concentration is changing along chosen compositional cross-section. For Ag–As–S chalcogenide glasses the main effect that is observed at introduction of silver into nanostructured As_2S_3 glass is the change of the relative concentration of the main and non-stoichiometric molecular structural units. Systematic compositional dependencies of the intensities of the characteristic Raman bands correlate with evolution of concentration of the different structural units in Ge-As-Se, Ge-As-S and Ga-Ge-Te alloys along the studied compositional lines. Observed bands in the Raman spectra of studied glasses show that such glasses contain different nanophases and can be explained in the terms of vibrational modes of the respective binary glasses and films. CG glasses and different structures on their base are promising for application in photonics and optical data storage. Surface patterning using composite nanomultilayer structures on the base of CG by a laser or electron beam with and without chemical etching, attracts high interest. Surface relief holographic diffraction gratings were directly recorded using composite As_2S_3:Ag/Se nano-multilayered structures. Diffraction efficiency values of the recorded gratings in transmission were ~22%. AFM measurements have shown high quality of the recorded gratings relief's. Process of surface relief formation depended on the polarization of recording light beams. Such media are also perspective for the recording of digital holograms. Reviewed investigation results concerning chalcogenide glasses show that chalcogenide glasses are perspective for various applications in photonics.

Keywords: Chalcogenide glasses, structural properties, Raman, optoelectronics and photonics applications

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Regular Papers

Section I

Dielectric materials for electronics and photonics

Invited Papers

Phonon-Plasmonic Bipolaronic Superconductivity in the FeSe/$SrTiO_3$ Quantum Structure

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Abstract: The bipolaron mechanism of experimentally observed high-temperature superconductivity (HTSC) in FeSe monolayers on massive $SrTiO_3$ substrates [1] has been theoretically investigated, based on the exact Hamiltonian of the electron-phonon interaction for multilayer structures [2]. Bipolaronic states arise in FeSe quantum layers due to the interaction of electrons with the electric field of Fuchs-Kliewer surface optical phonons [3] of the strongly polar semiconductor $SrTiO_3$ penetrating into the FeSe monolayer. The effect of doping of a crystalline $SrTiO_3$ substrate with n-type niobium impurities on the critical temperature T_c of HTSC in a monolayer of FeSe is considered. The role of surface polaron plasmons formed in $SrTiO_3$ upon contact with the FeSe quantum layer during the interaction of impurity electrons with surface optical phonons of $SrTiO_3$ is investigated. It is shown that electrons in the quasi-two-dimensional FeSe layer induce an additional polarization potential in the $SrTiO_3$ substrate, which increases the binding energy of bipolarons in the FeSe layer, which leads to an increase in the critical temperature of bipolaronic superconductivity.

Keywords: phonons, plasmons, bipolarons, multilayer structures, high-temperature superconductivity

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Charge Carrier and Optical Properties of porphyrin supported onto multi-walled carbon nanotubes

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Abstract: In this work, we outline the processes of energy transfer and photoinduced electrons that can take place within a composite made of a porphyrin molecule and carbon nanotubes MWNTCs. In this study we discussed the structural, vibrational, and optical properties of porphyrins in the presence of MWNTC, using various spectroscopic analysis techniques such as electronic microscopy, Raman scattering, UV-Vis absorption and Photoluminescence, as well as a numerical simulation by means of SCAPS software that examined photovoltaic properties of the heterojunction ITO/MWNTC and ITO/MWNTC - porphyrin molecule. The obtained results suggest that the use of carbon nanotubes to make MWNTC- porphyrin molecule composite films could provide a good separation of photogenerated charges and enhance their transportleading to efficient composite material that could be used for applications in optoelectronic devices especially in organic photovoltaic devices.

Keywords: Properties of porphyrins and MWNTC, Energy, photovoltaic devices

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Electrochemical and Morphological Characterization of Gold Nanostructures on GaAs

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Abstract: Previous studies have demonstrated that electrochemical nanostructuring of GaAs allows the fabrication of porous structures and nanowires, providing suitable platforms for the deposition of metal nanostructures[1-3]. In the present work, gold nanostructures were formed on GaAs substrates by electrochemical deposition and their morphology was investigated by atomic force microscopy (AFM), which revealed the formation of nanostructured gold films with increased surface roughness compared to sputtered Au films. The electrochemical properties of bulk GaAs and Au-modified GaAs electrodes were studied by cyclic voltammetry. The ferri/ferrocyanide redox system was used as an electrochemical probe to evaluate the electrochemically active surface area of the electrodes. The results indicate differences in the electrochemical response and an increase of the electrochemically active surface area after gold electrodeposition. The obtained results suggest that gold nanostructures on GaAs substrates may represent promising platforms for electrochemical sensing and nanoelectronic applications.

Keywords: Gold nanostructures, porous GaAs; electrodeposition; topology; cyclic voltammetry; electrochemically active surface area.

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Quantitative Phase Imaging by All-Fiber Polarized Digital Holographic Microscopy

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Abstract: In this work, we present an optical fiber-based polarized digital holographic microscopy system designed to improve interferometric stability and measurement precision. The proposed architecture integrates monomode optical fibers into the interferometric setup, forming a compact and robust "all-in-fiber" configuration. This approach minimizes alignment complexity and significantly reduces sensitivity to external disturbances. The system enables non-destructive, label-free imaging of transparent samples, making it particularly suitable for biological and material science applications. Dedicated software tools are developed for data acquisition and numerical reconstruction, allowing accurate phase retrieval and three-dimensional visualization. Experimental results describe the polarization calibration procedure for the developed instrument for estimating the sensitivity for quantitative birefringence measurements. The proposed FO-PDHM system represents a promising platform for advanced interferometric imaging, offering flexibility, precision, and applicability across multidisciplinary research fields.

Keywords: Optical fiber, birefringence imaging, digital holographic microscopy, polarization

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Dielectric Nanoparticles for EMI Shielding Applications

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Abstract: The rapid growth of electronic devices, wireless communication systems, and high-frequency technologies has significantly increased electromagnetic radiation in modern environments, leading to serious electromagnetic interference (EMI) challenges. EMI can disrupt electronic systems, decrease device reliability, and weaken communication networks. As a result, developing efficient, lightweight, and sustainable EMI shielding materials has become a key research focus. While conventional metallic shields provide high electrical conductivity and strong reflection-based shielding, they also have disadvantages, including high density, corrosion susceptibility, and limited design flexibility. Recently, dielectric nanoparticles have become promising components in advanced EMI shielding materials because of their ability to attenuate electromagnetic waves through polarization and dielectric loss mechanisms. Nanomaterials such as SiO_2, TiO_2, $BaTiO_3$, Gd, and ZnO exhibit strong interfacial polarization in response to electromagnetic fields, thereby enabling effective energy dissipation. When integrated into polymer matrices, these nanoparticles enable the fabrication of lightweight nanocomposites with tunable dielectric properties and improved impedance matching. This keynote will discuss recent advancements in designing and engineering dielectric nanoparticle-based composites for EMI shielding applications, with a particular focus on sustainable and bio-based materials. A case study will highlight the development of structural insulated panels made from date palm felt reinforced with functionalized graphene oxide, where agricultural waste fibers are combined with epoxy matrices and graphene nanosheets to produce multifunctional composites. These hybrid materials show improved mechanical strength, enhanced hydrophobicity, and promising electromagnetic shielding capabilities, demonstrating the potential of combining natural fibers with nanomaterials for construction and electronic protection. Finally, future directions for versatile, environmentally friendly EMI shielding materials will be explored, emphasizing nanotechnology's role in tackling the increasing challenges of electromagnetic pollution in modern technological environments.

Keywords: Electromagnetic interference shielding; Graphene nanoparticles; Dielectric nanoparticles.

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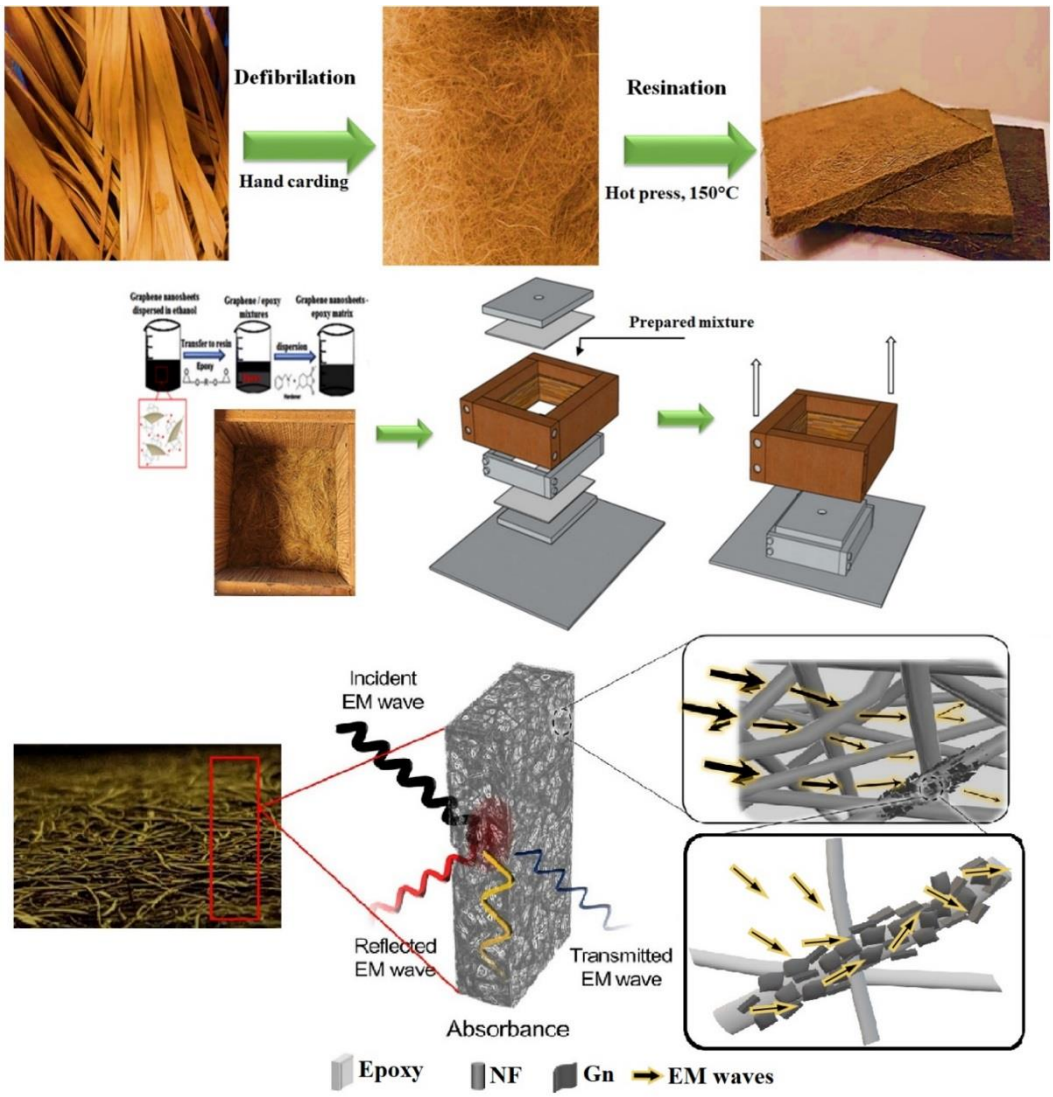

Figure 1: Graphene-based nanocomposite panels manufacturing process for EMI shielding application.

Oral Papers

Structural, Photocatalytic, and Dielectric Properties of Glass-Ceramics

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Abstract: Glass-ceramic materials have attracted significant interest due to their tunable structure and multifunctional properties, making them suitable for advanced technological applications. In this study, glass-ceramics were synthesized using the melt-quenching method followed by controlled heat treatment to induce crystallization. Structural investigations were carried out using X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), and scanning electron microscopy (SEM), revealing the formation of well-dispersed crystalline phases embedded within an amorphous glassy matrix.

The photocatalytic performance of the glass-ceramics was evaluated through the degradation of organic dye under UV and visible light irradiation. The results demonstrate enhanced photocatalytic activity compared to the parent glass, which is attributed to improved charge separation, increased surface reactivity, and the presence of photoactive crystalline phases. Additionally, dielectric measurements performed over a wide frequency and temperature range indicate frequency-dependent dielectric behavior, characterized by high dielectric constant values at low frequencies and reduced dielectric losses at higher frequencies.

The correlation between structural evolution, photocatalytic efficiency, and dielectric properties highlights the crucial role of controlled crystallization in optimizing the functional performance of glass-ceramics. These findings suggest that the developed glass-ceramic systems are promising candidates for multifunctional applications, including photocatalysis, optoelectronic devices, and dielectric components.

Keywords: Glass-ceramics, Structural properties, Photocatalysis, Organic dye degradation, Dielectric behavior.

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Optical, Electrical, and Gas Sensing Properties of ZnO Dielectric Films on Black Silicon Substrates

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Abstract: This work reports a detailed study of the optical, electrical, and gas sensing properties of ZnO dielectric films deposited on black silicon (b-Si) substrates. The b-Si surface was fabricated using reactive ion etching (RIE), enabling the formation of dense, high-aspect-ratio nanostructures that provide strong light trapping and a significantly increased effective surface area. ZnO dielectric films were deposited onto the nanostructured b-Si substrates using the sol–gel method, ensuring good film uniformity and conformal coverage of the textured surface. Optical characterization revealed a pronounced reduction in surface reflectance and enhanced optical absorption over a broad spectral range compared to planar silicon, resulting from the combined effects of the b-Si nanostructure and the ZnO coating. Electrical measurements demonstrated stable dielectric behavior, low leakage currents, and well-defined capacitance–voltage characteristics, indicating high-quality ZnO films and a stable ZnO/b-Si interface. Gas sensing experiments showed a strong, reversible, and reproducible response to nitrogen dioxide (NO_2) at relatively low operating temperatures. The enhanced sensing performance is attributed to the high specific surface area of the RIE-fabricated b-Si, efficient adsorption of NO_2 molecules on the ZnO surface, and effective charge transfer across the ZnO/b-Si heterojunction. These results demonstrate the strong synergistic effect between sol–gel-derived ZnO dielectric films and nanostructured substrate, highlighting the potential of ZnO/b-Si structures for low-power NO_2 gas sensors as well as multifunctional optoelectronic and environmental monitoring applications.

Keywords: Black silicon, Dielectric films, ZnO, Heterojunction, Properties

Geometry-driven dielectric enhancement in $SrTiO_3/BaTiO_3$ superlattices

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Abstract: Ferroelectric/dielectric superlattices constitute ideal systems to investigate the impact of nanoscale domains on dielectric properties at low dimensionality [1, 2]. These superlattices offer great flexibility in terms of design, and their dielectric properties depend on their geometry, defined by the number of periods and the thickness ratio between the ferroelectric and dielectric layers. Enhanced dielectric permittivity of superlattices is attributed to polarization topologies, lattice distortions or interfacial Maxwell-Wagner effects [1 - 4]. Here, we have investigated geometry-driven dielectric and structural evolution in $SrTiO_3/BaTiO_3$ (ST/BT) superlattices grown on (001) $SrTiO_3$ substrates. XRD results demonstrate the successful fabrication of single-phase epitaxial ST/BT superlattices with varying numbers of periods and ST/BT thickness ratios. Reducing the ST layer thickness progressively weakens the satellite peak sharpness and induces strain relaxation. The temperature- and frequency- dependent dielectric behavior of the superlattices as a function of the number of periods and the ferroelectric/dielectric ratio was studied. Increasing the number of periods at fixed composition leads to a pronounced enhancement of dielectric constant (ε_r) while preserving low dielectric loss tangent ($\tan\delta$), illustrated by a $(ST_{12}BT_4)_{50}$ superlattice composed of 12/4 unit-cell ST/BT layers with 50 repetitions, exhibiting $\varepsilon_r \approx 481$ and $\tan\delta \approx 0.018$ at 1 kHz. Further optimization of the superlattice geometry by adjusting the ST/BT thickness ratio enables an even higher dielectric constant, with an $(ST_4BT_4)_{77}$ superlattice reaching $\varepsilon_r \approx 732$ while maintaining a moderate loss tangent ($\tan\delta \approx 0.045$) at 1 kHz. Maxwell-Wagner relaxation, a phenomenon commonly encountered in materials with high dielectric constants, causes a more or less significant drift in dielectric properties depending on frequency and temperature, which is a hindrance for applications such as supercapacitors using superlattices. Adapting the geometry of our superlattices grown on $SrTiO_3$ substrates with a minimum $SrTiO_3$ layer thickness (~ 4 unit cells) is required to suppress Maxwell-Wagner relaxation. These findings highlight the essential role of superlattice geometry in controlling the dielectric response of ST/BT superlattices and achieving optimal performance in the fabrication of low-loss high-k dielectric capacitors.

Keywords: ferroelectric superlattices, strain relaxation, dielectric constant, dielectric loss,

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Dielectric Response and Relaxation Dynamics of GE/P(VDF-TrFE) Nanocomposites: Influence of Graphene Loading and Temperature

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Abstract: Graphene/poly (vinylidene fluoride-trifluoroethylene) [GE/P(VDF-TrFE)] nanocomposites were prepared by mechanical melt mixing, and their dielectric and electrical properties were investigated as functions of graphene content and temperature. The dielectric response of the materials was examined using impedance spectroscopy over a wide frequency range (10^2–10^7 Hz) and over the temperature range 260–380 K. The results show that the dielectric constant increases significantly with graphene loading, reaching its highest value in the composite containing 10 wt.% graphene. At low frequencies (< 1 MHz), the dielectric spectra deviate clearly from ideal Debye behavior, indicating a broad distribution of relaxation times [1,2]. Two relaxation mechanisms were detected in both the P(VDF-TrFE) copolymer matrix and the corresponding nanocomposites. The β-relaxation, observed mainly below the glass transition temperature (T < Tg), is associated with the micro-Brownian motion of polymer chains in the amorphous phase. Conversely, the αc-relaxation appearing above Tg is attributed to molecular motions occurring within the crystalline regions of the copolymer. The dielectric relaxation processes were further interpreted using the Havriliak–Negami model [3]. In addition, morphological observations obtained by scanning electron microscopy and thermal analysis performed by differential scanning calorimetry provide complementary evidence supporting the dielectric behavior of the investigated nanocomposites.

Keywords: P(VDF-TrFE)**,** graphene (GE), Dielectric properties, Relaxation dynamics, Havriliak-Negami

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Tailoring the Properties of CZTS Thin Films through Cation Substitution and Thermal Annealing

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Abstract: Pure sulfide kesterite (Cu_2ZnSnS_4 or CZTS) is a promising absorber material for next-generation photovoltaic (PV) technologies, especially for tandem and indoor applications. These quaternary chalcogenides offer tunable optoelectronic properties, an earth-abundant elemental composition, low cost, and high chemical stability [1]. However, the intrinsic bandgap of CZTS (≈1.5 eV) is suboptimal for tandem and indoor PV applications, which require a wider bandgap in the range of 1.65-1.9 eV. Alloying strategies based on cation substitution provide a flexible approach for engineering the structural, morphological, and optoelectronic properties. In particular, combining Ag alloying with alkaline metal incorporation enables effective tuning of these properties, offering a promising route for bandgap widening and absorber optimization [2,3].

In this study, Ag-alloyed $(Ag,Cu)_2ZnSnS_4$ (ACZTS) thin films were fabricated on SLG/Mo substrates using a chemical solution process based on molecular precursor solutions. The films were deposited by spin coating, followed by drying. After ACZTS film deposition, Na-Li was incorporated by spin-coating an alkali precursor solution onto the absorber, followed by drying. The films were then heat treated under an argon atmosphere with solid sulfur at temperatures between 600 and 660 °C to promote crystallization. Complete solar-cell devices were fabricated using a CdS buffer layer (CBD), ZnO/ITO window layers (sputtering), and Ag front contacts.

The impact of Ag and Na-Li incorporations, as well as heat-treatment temperatures, on the structural, morphological, and optoelectronic properties was systematically investigated. Structural and morphological (SEM/EDS, XRD and Raman) together with optical measurements and current-voltage (J-V) characteristics revealed enhanced grain growth, improved cation stoichiometry, bandgap widening (>1.5 eV) and kesterite crystal structure. The heat treatment temperature was found to strongly influence crystallinity and grain morphology. Na-Li incorporation significantly improves the solar-cells efficiency.

These results highlight ACZTS as a promising wide-bandgap absorber for tandem and indoor photovoltaic applications. Ag alloying and Na-Li co-doping provide complementary strategies to tune the bandgap and crystal structure, while enhancing absorber quality and device performance.

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Keywords: Cu_2ZnSnS_4, Wide bade gap, Solution-processed, indoor photovoltaics, Solar cell.

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Microfabrication of FePt/W/FePt Multilayer Heterostructures via Photolithography for Spintronic Applications

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Abstract: This work reports on the design and microfabrication of magnetic multilayer heterostructures based on FePt thin films, targeting their integration in planar spin valve architectures. A key focus is placed on the development and optimization of a reliable fabrication strategy based entirely on multi-step photolithography, enabling precise pattern definition and alignment at the micrometer scale through the use of dedicated alignment markers.

The proposed technological route allows the sequential definition of the ferromagnetic electrodes and spacer layers while preserving structural integrity and interface quality, which are critical for spin-dependent transport. Compared to electron-beam lithography, photolithography offers clear advantages in terms of scalability, throughput, and compatibility with large-area processing. At the same time, in contrast to approaches based on continuous thin films, the present method enables controlled lateral patterning and device-level integration, which are essential for functional spintronic architectures.

The heterostructures incorporate tungsten (W) as a spacer layer, ensuring efficient magnetic decoupling between the FePt electrodes while maintaining favorable conditions for spin transport phenomena.

The fabricated structures were systematically investigated in terms of their morphological, compositional, and magnetic properties using complementary characterization techniques. The results confirm the successful realization of well-defined multilayer architectures with controlled geometry and material composition, demonstrating the suitability of the proposed fabrication approach for future spintronic device applications. These results highlight the potential of photolithography-based microfabrication as a scalable route toward practical spintronic devices, bridging the gap between fundamental thin film studies and functional device implementation.

Keywords: photolithography; microfabrication, magnetic multilayer heterostructures; FePt thin films.

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Functional properties of $BaTiO_3$-Fe_2O_3 magnetoelectric ceramics

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Abstract: These days, a lot of work has gone into designing and controlling the preparation of multifunctional materials to meet the needs of modern technologies. These materials are multi-phase systems where the functional features come from the combination of materials with diverse compositions, interphase interaction, interconnectivity, and the relative size and form of the distinct phases. One of the more interesting types of these materials in the last ten years is multiferroic magnetoelectric composites (ME). These materials have gotten a lot of attention since they can be used in memory elements, transducers, electro-optic devices, and wireless communications.

In the present paper we demonstrate that by changing ratio and sintering strategy in $BaTiO_3$ and Fe_2O_3 phases in composites, the formation of different magnetic phases can be promoted to induce completely different functional properties of the final ceramic composites. The functional properties of $BaTiO_3$-Fe_2O_3 composite ceramics with different ferroelectric/magnetic ratio and densified by Spark Plasma Sintering (SPS) are comparatively analysed and discussed in relationship with their phase composition.

Dielectric properties of the dense ceramics were determined in a wide frequency (1 Hz-1 MHz) and temperature (20-150^{0}C) and discussed in correlation with the sample microstructures, composition and degree of phase connectivity. Thus, at lower temperatures the interfacial polarization between ferroelectric and ferromagnetic phases is predominant, while at room temperature and above it the behaviour strongly depends on the composition: below the percolation threshold the conductivity plateau was not observed even at high temperature, while above percolation the plateau was detected.

Peculiar magnetic properties, including "wasp-waisted" constricted M(H) loops were determined as result of the formation of magnetic phases with contrasting magnetic coercivities (hard/soft phases). First-order-reversal FORC method was employed to determine the Preisach-like distribution over coercivities and interaction fields and detect the new magnetic properties induced by secondary phases. This method allowed detecting magnetic components with contrasting coercivities formed at interfaces, in very small amounts below the XRD detection limits (*e.g.* the transformation of Fe_2O_3/Fe_3O_4 under reducing conditions).

Keywords: magnetoelectric materials, dielectric properties, magnetic characteristics, ferroelectric properties

Acknowledgement: The financial support of the PN IV-P1-PCE-2023-1192 is acknowledged.

Section II

Chalcogenide glasses and wide – gap semiconductors

Invited Papers

Composition–structure–property relationships in amorphous sulfide thin films prepared by RF magnetron co-sputtering

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Abstract: The local atomic structure of amorphous chalcogenides decisively governs their optical properties. In this contribution, we present a systematic composition–structure–property study of amorphous sulfide thin films prepared by radio-frequency magnetron co-sputtering across the GeS_2–Sb_2S_3, Ga_2S_3–Sb_2S_3, and GeS_2–Ga_2S_3 pseudo-binary systems, as well as the pseudo-ternary GeS_2–Ga_2S_3–Sb_2S_3 compositional range. RF magnetron co-sputtering enables the preparation of high-quality amorphous films over broad compositional ranges, including regions prone to crystallization in bulk form. Spectroscopic ellipsometry reveals distinct composition-dependent trends in refractive index and optical bandgap energy. In the GeS_2–Sb_2S_3 and Ga_2S_3–Sb_2S_3 systems, the refractive index increases systematically with increasing Sb_2S_3 content, accompanied by a corresponding decrease in E_g. In contrast, the GeS_2–Ga_2S_3 system exhibits a nearly constant refractive index across a wide compositional range despite variations in bandgap energy. The films exhibit low absorption within the measured infrared spectral range, supporting their relevance for mid-wave and long-wave infrared applications. To clarify the microscopic origin of the observed optical trends, cluster-based density functional theory (DFT) modeling was employed to analyze Raman-active modes of representative structural motifs in Ge–S networks. The calculated spectra for corner- and edge-sharing tetrahedra, homopolar bonds, and ring- and chain-like fragments reproduce the principal experimental features and enable assignment of characteristic vibrational bands to specific local configurations.

Keywords: chalcogenides, RF magnetron co-sputtering, Mid-infrared optics

The influence of a pseudo-randomly polarized beam patterning in nanomultilayer structures based on chalcogenide glasses.

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Abstract: Chalcogenide glasses (ChG) are known to exhibit several photoinduced phenomena, both scalar and vectorial, which are associated with photoinduced structural transformations. Laser processing of nanomultilayer (NML) structures based on chalcogenide glasses [1] for the formation of surface relief in these glass films has been studied. A single Gaussian beam with a spatially variant polarization distribution was employed to generate optical phase surface-relief structures in the form of a diffraction grating [2]. The polarization distribution on the NML surface was recorded using a DPSS laser (single transverse mode, power 100 mW, wavelength $\lambda = 532$ nm) after illumination of a liquid crystal polymer (LCP) depolarizer. The Thorlabs LCP DPP25-A depolarizer [3] was mounted in the optical setup within an expanded, parallel, and polarized laser beam.

A patterned micro-retarder array converts a linearly polarized light beam into a pseudo-randomly polarized beam. The term "pseudo-random" is used because the transmitted beam does not become fully unpolarized; rather, its polarization state is randomized. The laser is then focused onto the NML using a microscope objective, creating a polarization distribution across the sample.

Thus, the optical phase distribution is recorded in the form of a diffraction grating. The setup made it possible to control both the period of the diffraction grating grooves and their orientation. The phase properties of the recorded structures were studied using a polarization digital holographic microscope. The four obtained holograms were processed using LabVIEW software to determine the optical phase of the sample as an indicator of the induced parameters.

Keywords: Chalcogenide glasses, Diffraction grating, Depolarizer, Polarization digital holographic microscope

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Light-induced bleaching and refractive index change in vitreous AsS_3-GeS_4 thin films

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Abstract: Light-induced structural transformations (LIST) in chalcogenide glasses (ChG), discovered about 50 years ago, still remain a unique phenomenon, very large applied but not fully understood. The LIST results in variation of the optical and other properties of ChG when illuminated, which are called either photobleaching (PB) or photodarkening (PD) if the sample optical transmission at a specific wavelength increases or decreases respectively. To date, unambiguity is established that the optical effects at LIST (especially in thin films) are largely associated with glass composition, technology of preparation and post preparation thermal treatment. The present paper is conducted to investigate photoinduced effects in vitreous thin films of the pseudo - binary system AsS_3 - GeS_4, which belong to an intermediate topological phase. Some compositions from these glasses exhibit the advanced degree of structural self-organization (SSO) [1], so we could track whether the SSO influences the photoinduced effects. The AsS_3 - GeS_4 thin films have been prepared via thermal vacuum evaporation of the beforehand synthesized counterpart glassy alloys, onto quartz substrates. We studied the spectral distribution of both optical absorption (α) and refractive index (n) of the films, before and after their exposing to an integral light with $hv > E_g$ and irradiance 39 mW/cm^2. Measurements were performed in the 350 – 1770 nm spectral range, using the Spectroscopic ellipsometry method. To exclude the thermal irreversible phenomena, before measurements all samples have been annealed at 149 ^oC / 24 h. It was found that exposure to light of the examined glasses leads to their photobleaching, with the exception of GeS_4, which darkens slightly. The level of PB strongly depends on the glass composition and spectral range of the probing light. The largest PB has been observed in Ge free films (AsS_3), as well as in films of ternary $As_{11.1}Ge_{11.1}S_{77.8}$, which are known as films with a large degree of SSO [2].
The refractive index (n) follows the usual curves of a normal dispersion, for all samples of AsS_3-GeS_4, materials measured before and after illuminating experiments. It gradually decreases along entirely used spectrum range, as the content of GeS_4 increases, so that the n of Ge free glass (AsS_3) exhibits the highest value, separately among unexposed and exposed samples. Light exposing differently affects the refractive index of films based on the ChG in question, so that in AsS_3, it slightly increases while when the composition of the film changes from Ge-deficient to rich, it imposingly decreases. Thus, an interesting crossover of Δn from positive to negative values occurs, which points to different mechanisms of LIST in germanium-enriched glasses and arsenic enriched one.

Keywords: Chalcogenide glasses, thin films, AsS_3-GeS_4, photoinduced phenomena.

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Glassy quaternary chalcogenides thin films in chemical and optoelectronic transducers

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Abstract: Quaternary chalcogenides are complex either crystalline or vitreous materials, four-elements containing at least one chalcogen (S, Se, Te) combined with other elements, offering tunable electronic, optical, thermal and gas sensing properties. They are of great interest for photovoltaics [1], thermoelectricity [2], optoelectronics [3] and development of chemical transducers [4]. In the present paper an extensive review of the electronic, optical and gas sensing properties of thin films of the quaternary glassy chalcogenide materials is presented and discussed, alongside with the own experimental investigations related to As-Te-Ge-S and Ag : (As-S-Ge) quaternary systems. The glassy thin films of the As-Te-Ge-S system are considered in terms of the experimentally observed pronounced surface phenomena, which largely predetermine usefulness in the development of gas transducers [4]. The synthesis technology of quaternary chalcogenides $As_2Te_{130}Ge_8S_3$, $As_2Te_{13}Ge_8S_3$ as well as the growth of thin films based on them is briefly described. The electrical DC and AC conductivities of these films have been studied in detail dependent on electrode materials, temperature, value and frequency of applied electric field. The deep analysis of spectral distribution of impedance allowed us to establish the main mechanisms of charge transport, which actually occur to depend on the physical and chemical state of the specimen surface. The obtained results clearly demonstrate that the studied chalcogenides can serve as a basis for the development of excellent NO_2 transducers, operable at room temperature by varying the impedance or capacitance, even under conditions of increased humidity of the ambient air with carbon dioxide impurities. As for Ag: (As-S-Ge) quaternary, they exhibit one of the most remarkable properties of chalcogenide glasses, which consists in the possibility of a transition to ionic mechanism charge transport and further to a metallic one. The superionic solid electrolytes based on pseudo-binary glasses $(GeS_4)_x(AsS_3)_{1-x}$ from the intermediate phase (IP) of the As-S-Ge ternary have been fabricated via photo-dissolution (PD) of Ag, and further used as the active parts of the programmable memory cells (PMC). As some compositions from the IP of the studied glassy system exhibits a strong self-organized backbone, the ionic conductivity of solid electrolytes based on them sharply increases that allows the improvement of operating parameters of programmable metallization cells, based on the same.

Keywords: Quaternary chalcogenide glasses, thin films, optoelectronics, chemical transducers.

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Fabrication and structural reconfiguration of nanostructured As-S chalcogenide films via gold nanoparticles and laser processing

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Abstract: Chalcogenide glasses and nanostructured thin films are promising materials for infrared photonics, optical data storage, and reconfigurable devices due to their high optical nonlinearity and pronounced photo-induced structural response [1,2]. Arsenic sulfide (As-S) systems are widely used as a model platform for studying structure-property relationships under external stimuli. However, the mechanisms governing crystallization, light-induced transformations, and mass transport remain incompletely understood [1,3].

Here, we report the fabrication and laser-induced structural reconfiguration of nanostructured As-S films via gold nanoparticle-assisted growth and laser processing, supported by experimental spectroscopy and atomistic modelling. Gold nanoparticle-assisted chemical vapor deposition on Si substrates leads to selective growth of dendrite-like As-S microcrystallites, in contrast to conventional deposition methods. SEM, XRD, EDX, and Raman spectroscopy confirm their crystalline nature [1]. Depending on synthesis conditions, the fabricated structures are composed of either As_4S_5 or As_4S_4 cage-like molecular units, as confirmed by Raman spectroscopy and DFT calculations. Laser illumination of crystallites consisting of As_4S_4 cages induces structural rearrangements and light-induced transformations, whereas uzonite-like structures built from As_4S_5 molecules are found to be resistant to light-induced degradation. In parallel, *in situ* prepared $As_{40}S_{60}$ and $As_{45}S_{55}$ nanolayers were studied under super-bandgap laser irradiation. Synchrotron photoelectron spectroscopy reveals reversible compositional changes during irradiation-annealing cycles, including arsenic surface enrichment. These effect is fully reversible upon thermal annealing [3]. Molecular modelling and DFT calculations suggest that the observed behaviour is governed by realgar-pararealgar-like transitions involving bond breaking, atomic rearrangement, and anisotropic diffusion of As-rich clusters.

Overall, the results demonstrate two complementary routes for tailoring As-S photonic media: nanoparticle-assisted crystallization of metastable phases and reversible laser-driven structural reconfiguration. These findings provide new insight into nanoscale structural dynamics in chalcogenide systems and enable routes toward adaptive infrared photonic materials.

Keywords: As-S chalcogenide, gold NPs, laser induced transformations, Raman spectroscopy, DFT calculations

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Oral Papers

Characterization of Morphological, Optical, and Electrophysical Properties of Cu_2O Thin Films Obtained by RF Sputtering

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Abstract: Metal oxide semiconductors, owing to their versatile electronic properties, are essential materials for a wide range of applications, including photovoltaic and photoelectrochemical cells, photodetectors, and power electronic devices. Their functionality as selective charge transport layers or light absorbers is determined by their electrical conductivity, work function, and band gap. Copper oxide (Cu_2O), a p-type semiconductor with a band gap in the range of 1.9–2.6 eV, has attracted significant attention as a hole transport layer in perovskite solar cells due to its promising efficiency and stability.
In this work, the electrophysical properties of Cu_2O thin films deposited by RF magnetron sputtering are reported. The optical properties and the effect of post-deposition thermal treatment on the morphological and electrical characteristics of the films were investigated. Atomic force microscopy (AFM) analysis revealed an increase in surface roughness with film thickness, from 100 nm to 500 nm. Post-deposition annealing at 400°C for 60 minutes under high vacuum conditions resulted in a significant increase in the contact angle from 102° to 120°, indicating enhanced hydrophobicity. Raman spectroscopy identified characteristic phonon modes at 218 cm^{-1}, 418 cm^{-1}, and 637 cm^{-1}, confirming the formation of the Cu_2O phase, in agreement with X-ray diffraction (XRD) results. Optimization of film thickness and structural and electronic properties, such as grain size and charge carrier mobility, is expected to significantly improve the performance of Cu_2O-based films.

Keywords: Cu_2O, RF magnetron, Raman Spectroscopy, XRD.

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Interface Engineering and Absorber Quality Control in Tin Sulfide-Based Hybrid Photovoltaic Devices

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Abstract: The development of photovoltaic technologies based on earth-abundant and environmentally benign materials is essential for enabling sustainable and large-scale solar energy deployment. Chalcogenide absorbers such as tin monosulfide (SnS) have attracted significant attention due to their suitable band gap, high absorption coefficient, and compatibility with low-cost thin-film processing routes. Nevertheless, the performance of these emerging photovoltaic devices is often limited by challenges related to thin-film crystallization control, unfavorable morphology, interfacial recombination, and inefficient charge transport [1,2].

In this work, hybrid photovoltaic devices incorporating solution-processed absorber layers are investigated with particular emphasis on the role of the electron transport layer (ETL) and absorber–ETL interface engineering. The optimization of ETL properties is shown to strongly influence absorber growth behaviour, crystallographic orientation, surface morphology, optical absorption, and interface quality. These improvements lead to enhanced charge extraction and reduced recombination losses, resulting in significant device performance enhancement.

Through optimized heterojunction design and thin-film growth control, power conversion efficiencies exceeding 3% under standard solar illumination conditions are achieved. Comprehensive structural, morphological, optical, and interfacial analyses provide insight into the relationship between material properties and device operation. This study highlights the critical importance of interface engineering and absorber quality for advancing scalable photovoltaic technologies based on emerging earth-abundant materials.

Keywords: Molecular ink; Interface engineering; Thin-film solar cells; Earth-abundant photovoltaics

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Synthesis of two-dimensional transition metal dichalcogenides and heterostructures by physical vapor deposition

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Abstract: Two-dimensional (2D) transition metal dichalcogenides (TMDs) such as MoS_2 and WS_2 have attracted significant attention as semiconductor thin-film materials for optoelectronics, memristive devices, and energy applications. Their single- or few-layer forms exhibit direct bandgaps, strong light–matter coupling, and bandgap tunability through composition, layer number, and heterostructure engineering, properties inaccessible in their bulk counterparts. A key challenge in translating these materials to applications is achieving scalable, reproducible synthesis of continuous, high-quality films. In the space-confined microreactor method, two substrates are placed face-to-face in a horizontal configuration: the source substrate carries the precursor material, while the blank growth substrate is placed on top. Using a colloidal dispersion of MoS_2 nanoparticles in saline solution as the source material, this horizontal microreactor geometry produces few-layer MoS_2 nanosheets with lateral dimensions of 5-60 μm [1]. Growth proceeds by a Stranski-Krastanov mechanism, generating abundant undercoordinated edge sites well-suited for electrocatalytic applications such as solar water splitting, but yielding discontinuous isolated islands rather than continuous films. Obtaining continuous monolayer TMD films requires a solid thin-film precursor. We show that replacing the colloidal dispersion with a magnetron-sputtered monolayer W thin film as the source material in the same horizontal microreactor geometry enables large-scale synthesis of continuous monolayer WS_2 by low-temperature sulfurization [2]. While the sputtered-precursor approach yields continuous monolayer films, the horizontal reactor geometry is limiting film uniformity over large substrate areas.
By replacing the microreactor with confined-space, we demonstrate the fabrication of high-quality MoS_2/graphene lateral heterostructure memristors [3]. An amorphous MoS_2 precursor is RF-sputtered directly onto CVD few-layer graphene and crystallized by confined-space sulfurization at 800°C, yielding residue-free 3-4 layer MoS_2. The MoS_2/graphene memristors exhibit reproducible non-volatile analogue resistive switching with a SET transition near +6 V and an ON/OFF ratio of ≈2.1, attributed to vacancy-induced Schottky-barrier modulation at the MoS_2/graphene interface. However, in vertical MoS_2/W precursor stacks, we find that sulfurization at 800°C does not produce discrete heterostructures but instead results in vertically graded $W_xMo_{1-x}S_2$ alloy films due to Mo-W interdiffusion at the high processing temperature. To overcome the limitations of physical deposition routes and enable reproducible, 2D material synthesis, we present a custom-designed automated vertical CVD system.

Keywords: MoS_2, WS_2, transition metal dichalcogenides, heterostructures, chemical vapor deposition, microreactor, magnetron sputtering, sulfurization, memristors

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Glass transition temperature of chalcogenides predicted by large neural network models

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Abstract: Chalcogenide glasses are versatile and complex amorphous inorganic materials with exceptional mechanical, thermal and optoelectronic properties. Among their modern technological applications is the integration in storage class memory devices as both phase change memory (PCM) and ovonic threshold selector components (OTS) [1]. The current research is undergoing the transition from the binary 1PCM-1OTS architecture to more performant and scalable selector-only memory structure. The thermal stability against high temperatures is one important requirement for the selector component, ensuring the maintenance of its structural and electrical properties across repeated and prolonged thermal stress [1]. Glass transition is a fundamental glass property taking place in a narrow temperature interval upon incremental heating. It is defined as the endothermic structural transformation from rigid solid glass to viscous supercritical liquid at the viscosity threshold of $\sim 10^{12}$ *Pa·s* and it depends on chemical composition, topological network structure, and heating rate. In this work we build and optimize a complex deep neural network (DNN) trained and tested on glass compositions collected from the SciGlass database [2]. The input features represent statistical functions derived from fundamental physico-chemical attributes of the constituent elements, enabling the model to capture underlying physically meaningful compositional patterns. The robustness of the model was further validated on an additional set of 124 chalcogenide glasses from chemical systems not present in the training set, including compositions with elements absent from the SciGlass collection. We compared our specialized DNN with the multitarget neural network GlassNet [3], currently the largest open model for general glass property prediction. Prediction results showed that our model significantly outperformed GlassNet, achieving a root mean squared error of 38.44°C compared to 99.64°C, due to the ability to generalize to compositions with unseen elements where GlassNet has limitations. Our specialized model provides a reliable, composition-driven tool for rapid screening of chalcogenide glass compositions relevant to memory device applications.

Keywords: Chalcogenide glasses, Glass transition temperature, Deep neural networks

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Structural studies of $(AsSe)_{100-x}$ Ag_x glasses

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Abstract: Chalcogenide glasses of the As–Se system are promising materials for IR photonics due to their wide transmission window, high refractive index and photosensitivity. Silver incorporation is known to enhance nonlinear refractive index, improve physical parameters and modify short-range order in the glass network.

In present work we conducted structural studies of $(AsSe)_{100-x}$ Ag_x compositions, where x = 0, 5, 10, 15, 20, 25. First, the composition of the glasses was verified using energy-dispersive X-ray spectroscopy (EDX) using a Quantax ESPRIT 1.8.5 on FEI NOVA NanoSEM. This was followed by X-ray diffraction (XRD) measurements performed using a Rigaku SmartLab diffractometer in parallel-beam geometry with Cu Kα radiation (λ = 1.5406 Å). Raman spectroscopy measurements were carried out using a LabRAM HR spectrometer (HORIBA Scientific) in backscattering geometry at room temperature.

The obtained diffraction data for the glassy system $(AsSe)_{100-x}$ Ag_x were used to calculate the pair distribution functions (G(r)) (Fig. 1). From the positions of the first and second maxima, the nearest-neighbour distance r_1 and the second-neighbour distance r_2 were determined. For the first coordination sphere, the interatomic distance increased with increasing silver content from 2.48 Å at x = 0 to 2.62 Å at x = 25. The corresponding values for the second coordination sphere changed from 3.69 Å at x = 0 to 3.83 Å at x = 25. The bond angle φ was calculated using the relation: $\varphi = 2 \arcsin (r_2 / 2r_1)$ and changed from 96.14° at x = 0 to 93.93° at x = 25.

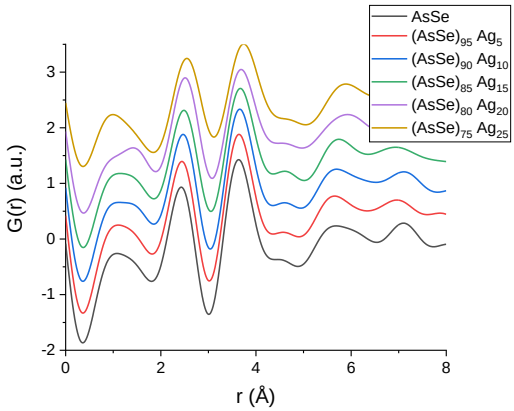

Fig. 1 Pair distribution functions (G(r)) for $(AsSe)_{100-x}$ Ag_x compositions

An increase in silver content leads to a gradual increase of both r_1 and r_2 distances, accompanied by a decrease in the bond angle φ. This behaviour indicates structural rearrangement of the glass network and distortion of the basic $AsSe_3$ pyramidal units due to silver incorporation. The observed bands in the Raman spectra of the studied As-Se-Ag samples show that such glasses contain different nanophases.

Acknowledgements

The work was partially supported by the priority research programme of NAS of Ukraine (0125U000799) and by the National Research Foundation of Ukraine [grant numbers 2025.07/0124]. H. Kochubei acknowledges the support by the project DAAD №57703089 “Sustainable Optical Materials and Methods: Education and Research Infrastructure (SOMMER!)” during a research stay at TU Chemnitz.

Keywords: X-ray diffraction, Raman spectroscopy, As-Se-Ag glasses.

Section III

Dielectric devices for biotechnological and industrial applications

Invited Papers

Induced effects of patterned substrates on the electrical and photo-electrical properties of PTB7-Th:ICBA (1:1, wt.%) bulk-heterojunction solar cells

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Abstract: This work investigates the influence of nano-patterned substrates on the electrical and photoelectrical properties of photovoltaic devices based on PTB7-Th:ICBA (1:1, wt.%) thin films. The devices were fabricated on both flat and nano-patterned substrates prepared by nanoimprint lithography, followed by spin-coating deposition of the active layer. The results indicate that the use of patterned substrates leads to an improvement in several key photovoltaic parameters, including the maximum output power, short-circuit current density, and fill factor. These enhancements are attributed to reduced optical reflection and increased light absorption within the active layer. The morphology, topology, and optical properties of the thin films were investigated using atomic force microscopy, scanning electron microscopy, and optical spectroscopy (absorption measurements). The analyses reveal that the interpenetrating network formed by the regio-regular polymer and the fullerene derivative exhibits a high degree of homogeneity and surface uniformity. All fabrication and characterization processes were carried out under ambient conditions, considering an active device area of 0.4 cm^2.

Keywords: photovoltaic structures, nano-imprinting lithography, PTB7-Th, ICBA

Founding: This research was funded by the Romanian Ministry of Research, Innovation and Digitalization, CNCS-UEFISCDI by project number PN-IV-P7-7.1-PED2024-0884.

In-Vitro Corrosion Performance of Nanocarbon-Reinforced Biodegradable Magnesium-Matrix Composites under Simulated Physiological Conditions

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Abstract: Iron, zinc, and magnesium-based alloys have attracted increasing attention in recent years as biodegradable implant materials. Among them, magnesium and its alloys have emerged as particularly promising candidates due to their excellent biocompatibility, mechanical properties comparable to natural bone, and their ability to gradually degrade in physiological environments[1]. However, their excessively high corrosion rate and associated hydrogen gas evolution under in-vitro and in-vivo conditions remain major challenges limiting their clinical application[2]. Recently, carbon-based nanostructures such as graphene nanosheets (GNS) and carbon nanotubes (CNTs) have gained significant interest in biomedical materials owing to their outstanding mechanical properties, chemical stability, and potential to improve corrosion resistance and surface bioactivity when incorporated into metallic matrices[3]. Nevertheless, the *in-vitro* corrosion behavior of such nanocarbon-reinforced magnesium composites under simulated physiological environments is still not sufficiently understood. In this study, AZ61 magnesium alloy matrix composites reinforced with 0.1, 0.2, and 0.5 wt.% CNT and GNS were fabricated using the powder metallurgy technique. The in-vitro corrosion performance of the composites was evaluated in simulated body fluid at body temperature (37 °C) using potentiodynamic polarization and electrochemical impedance spectroscopy (EIS). Surface morphology and phase evolution before and after corrosion were characterized by scanning electron microscopy coupled with energy-dispersive spectroscopy (SEM–EDS) and X-ray diffraction (XRD). The results demonstrated that optimized nanocarbon reinforcement significantly enhanced corrosion resistance and promoted the formation of more uniform and protective degradation layers under physiological conditions. The composites reinforced with 0.1 wt.% CNT and 0.5 wt.% GNS exhibited the lowest corrosion current densities of 68.94 and 157.70 μA/cm², respectively. Compared to the unreinforced AZ61 alloy, the corrosion resistance increased by approximately eight times. Post-corrosion analyses confirmed improved microstructural stability and controlled degradation behavior, indicating enhanced surface integrity suitable for biodegradable implant applications.

Keywords: Biodegradable magnesium; CNT; Graphene*; In-vitro* corrosion

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Oral Papers

Holographic recording and AFM characterization of diffractive optical elements in azopolymer–Au Nanocomposites

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Abstract. Azopolymer nanocomposites doped with gold nanoparticles represent promising photoresponsive materials for the fabrication of diffractive optical elements due to their strong photoinduced surface mass transport. In this work, diffraction gratings and vortex-type diffractive optical elements were recorded in thin films of azopolymer nanocomposites containing Au nanoparticles, followed by morphological characterization using atomic force microscopy (AFM). AFM analysis revealed well-defined surface relief structures with an average fringe period of approximately 7.5 μm. The influence of recording polarization on surface modulation and diffraction efficiency was investigated in detail for the nanocomposite containing 0.8 μg/ml Au nanoparticles, which exhibited the most stable relief formation. For circular polarization (RLCP), a surface modulation depth of 521 nm was obtained for a film thickness of 990 nm (~52.6% of the film thickness). Under ±45° linear polarization, the relief depth reached 706 nm, while for parallel linear polarization (PP) the modulation increased to 945 nm, corresponding to approximately 95% of the film thickness. The diffraction efficiency (DE) strongly depends on the recording polarization, reaching 37.6% for RLCP, 38.8% for ±45° polarization, and approximately 20% for PP polarization. Vortex diffractive optical elements were also successfully recorded in the nanocomposite films, with a diffraction efficiency of 23% for the 0.8 μg/ml sample, while the highest vortex efficiency of 35.2% was obtained for the sample containing 1.2 μg/ml Au nanoparticles. These results demonstrate the strong influence of nanoparticle concentration and recording polarization on the formation efficiency of diffractive optical elements in azopolymer nanocomposites, highlighting their potential for applications in photonic and structured light devices.

Keywords: Azopolymer nanocomposites; gold nanoparticles; diffractive optical elements; vortex beams; diffraction efficiency; atomic force microscopy; holographic recording; nanophotonics.

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Thick films bazed on *Te-$NaNO_3$* nanocomposites: structure and electrical conductivity

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Abstract:

The *Te-$NaNO_3$*-based nanocomposites were synthesized via a hydrothermal method that consists in dissolving of polycrystalline tellurium powder in diluted nitric acid, followed by its subsequent reducing with sodium dithionite. The yelding solid products, separated by successive filtration, were deposited on flexible paper substrates using the doctor blade method. The fabricated films were dried at room temperature for 24 hours before characterization.The thickness of the films was estimated to be around 35 μm. The structure and morphology of the films were investigated via SEM, EDX and XRD methods, which have revealed the presence of both Te nanowires and *$NaNO_3$* nanoparticles randomly distributed in the films. The functional structures for the study of electroconductivity have been fabricated by depositing the contact aluminium electrodes on top of the films, in a planar arrangement. The electrical conductivity of the films has been studied in the $20 \div 180\ ^oC$ temperature range. It was established an exponential increase of electroconductivity with temperature increases, so that an almost linear dependence of $\ln\sigma$ - 1/T occurs. The relatively low activation energy assessed as 0,14 *eV*, points to the electronic charge transport mechanism via tellurium nanowires network to be the main, with an additional contribution from ionic species originating from *$NaNO_3$* component. Thus, the *Te-$NaNO_3$* nanocomposite-based films emerge as promising materials, which exhibit the both electronic and ionic conductivity.

Keywords: Nanocomposites, *Te-$NaNO_3$*, electrical conductivity, paper substrate

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Direct Electron Beam Patterning of Diffractive Structures in PEPC-SY3 Azopolymer Films

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Abstract: Azopolymers are well known for their ability to record holographic gratings due to photoinduced molecular reorientation and mass transport processes occurring under polarized light irradiation. In particular, the azopolymer PEPC-SY3 exhibits pronounced photoinduced anisotropy, which enables efficient recording of polarization-dependent holographic structures. These unique properties make azopolymers promising materials for the fabrication of diffractive optical elements and polarization-sensitive photonic structures.

In this work, diffraction gratings were fabricated on thin films of the PEPC-SY3 azopolymer using electron beam lithography (EBL), which enables precise control over the geometry and periodicity of the patterned structures. The use of EBL allows direct writing with nanoscale resolution and provides an alternative approach to conventional optical holographic recording techniques. It was shown that the step size is a critical parameter in the EBL recording process, as it directly determines the effective exposure time at each point of the patterned structure.

The obtained results demonstrate that the PEPC-SY3 azopolymer can be effectively structured using EBL, highlighting its potential for the fabrication of high-resolution diffractive elements and integrated photonic components.

Keywords: Azopolymer, Thin films, Electron beam lithography, Diffraction gratings, Photoinduced anisotropy

Enhanced Photocatalytic Performance of Titanium-Phosphate Glasses under Visible-Light Irradiation

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Abstract: This study presents an ongoing investigation into the photocatalytic properties of sodium–barium phosphate glass-ceramics containing titanium. These materials were designed within the phosphate glass system and subsequently subjected to controlled heat treatments in order to promote the formation of crystalline phases within the vitreous matrix.

The introduction of Ti-containing species is expected to enhance photocatalytic activity due to their semiconducting behavior and ability to generate reactive oxygen species under light irradiation. The glass-ceramics were synthesized using the conventional melt-quenching technique, followed by thermal treatments to induce crystallization.

Structural and physicochemical characterizations are being carried out using X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), and thermal analysis to identify phase evolution and structural modifications. Optical properties are also under investigation to determine band gap energy and assess light absorption capability.

Preliminary results indicate the formation of Ti-based crystalline phases embedded in the phosphate glass matrix, which may contribute to improved charge separation and photocatalytic efficiency. Photocatalytic performance is currently being evaluated through the degradation of organic pollutants under UV and/or visible light irradiation.

This ongoing study aims to establish a correlation between composition, microstructure, and photocatalytic performance, with the objective of developing efficient phosphate-based glass-ceramic photocatalysts for environmental remediation applications.

Keywords: Photocatalysis, Glass-ceramics, Phosphate glass system, Titanium-phosphate glass, Photodegradation, Optical properties.

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Raman and DFT simulation spectra of some prevalent herbicide metabolites

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Abstract: The use of pesticides in Europe poses significant environmental and public health challenges, leading to contamination of water sources like rivers and groundwater. Many regions exceed EU pesticide standards, highlighting the need for innovative monitoring methods that can deliver results more quickly than traditional methods, given the impact of pesticides on water quality [1]. Traditional Raman spectroscopy struggles with low sample concentrations but drop coating deposition Raman (DCDR) spectroscopy offers improved sensitivity for detecting weak signals in low-concentration samples [2]. This study investigates the Raman spectra of herbicide metabolites in Danish groundwater using the DCDR technique on gold surfaces. Key compounds examined include the pesticide metabolites Atrazine-2-hydroxy, Atrazine-desethyl, DPC, and 2,6-dichlorobenzamide (BAM). To facilitate rapid identification by this approach, we need to create a database of simulated Raman spectra for these pesticides. The spectra were acquired using a conventional Raman spectrometer (*Horiba LabRAM HR Evolution Spectrometer)*, employing a 50x objective lens at maximum power (17 mW) with a 633 nm and/or 532 nm laser.

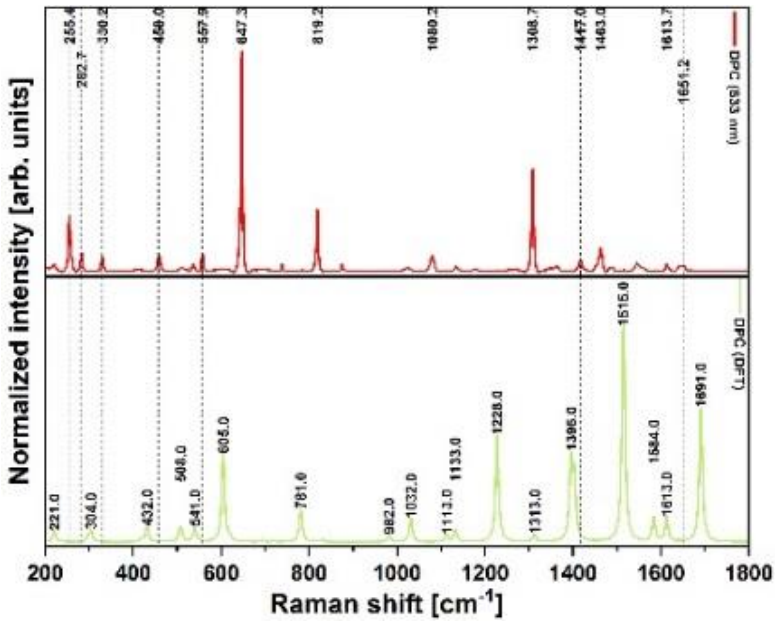

Figure 2: Desphenylchloridazon (DPC) simulated Raman spectra using DFT calculation (To enhance clarity in visual comparisons, dashed vertical lines have been drown from the experimental maxima to the DFT spectra

Keywords: herbicide metabolites, DCDR spectroscopy, DFT simulation

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Interface Engineering of TiO_2/Sb_2S_3 Thin Film Solar Cells Deposited by Spray Pyrolysis

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Abstract: Interface engineering plays a critical role in improving the performance of Sb_2S_3 thin-film solar cells based on earth abundant materials. In this work, the introduction of a zinc oxide (ZnO) thin film as an interlayer between TiO_2 and Sb_2S_3 is proposed to improve the interface quality and facilitate charge transport across the device structure. ZnO is widely used as an electron transport material due to its wide band gap and relatively high electron mobility which may improve the charge extraction and reduce interfacial recombination. The multilayer structure was fabricated using spray pyrolysis deposition. In particular, the spray process was performed under a nitrogen atmosphere using nitrogen gas as the carrier, which avoids possible formation of oxides [2] and better control over the deposition environment and improved film quality. To investigate the role of the interlayer, different ZnO deposition times were tested to tune the thickness of the ZnO layer and evaluate its influence on the properties of the heterostructure. The resulting films were studied through structural, optical, and morphological characterization to better understand how the ZnO interlayer affected the interface between TiO_2 and Sb_2S_3. Attention was given to the influence of the ZnO interlayer on the structural quality and interface properties of the TiO_2/Sb_2S_3 heterostructure.

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Keywords: Interface engineering, solar cells, Sb_2S_3 thin films, Spray pyrolysis

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Simultaneous Removal of Anionic and Cationic Dye Mixtures from Wastewater Using Calcined Zn_2–Al–CO_3 Layered Double Hydroxides

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Abstract: The discharge of wastewater containing dyes from textile, paper, leather, and dyeing industries represents a major environmental problem due to the high stability, toxicity, and persistence of these pollutants in aquatic environments. Industrial effluents frequently contain complex mixtures of anionic and cationic dyes, making their removal by conventional treatment methods particularly challenging. Therefore, the development of efficient and versatile adsorbent materials is essential for wastewater treatment.

In this study, Zn_2–Al–CO_3 layered double hydroxides (LDHs) were synthesized by the coprecipitation method and subsequently calcined to obtain mixed oxides with high specific surface area. These materials were evaluated for the removal of a mixture of anionic and cationic dyes in aqueous solution. A key advantage of calcined LDHs lies in their well-known memory effect, which enables the partial or complete reconstruction of the initial lamellar structure upon contact with water and anionic species present in solution.

The synthesized materials were characterized by X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), and scanning electron microscopy (SEM). XRD results confirmed the transformation of the initial LDH lamellar structure into mixed oxides after calcination, as well as the reappearance of characteristic LDH reflections after reconstruction, indicating the intercalation of anions from the dyes or the reaction medium. FTIR analyses revealed the disappearance of bands associated with interlayer carbonate anions after calcination and their partial reappearance after reconstruction, thereby confirming the rehydration and structural reorganization mechanism. SEM observations showed a porous and heterogeneous morphology favorable for adsorption processes.

Removal performance was investigated by optimizing several operational parameters, including solution pH, adsorbent dosage, and contact time. The results demonstrated that calcined Zn_2–Al–CO_3 LDHs exhibit high efficiency for the simultaneous removal of anionic and cationic dyes, particularly under acidic conditions. This performance is attributed to the combined action of surface adsorption mechanisms for cationic dyes and structural reconstruction of calcined LDHs through intercalation of anionic dyes, highlighting the crucial role of the memory effect in the removal process.

Keywords: Layered double hydroxides (LDHs), Calcined , Memory effect, Structural reconstruction, Adsorption, Mixed dye systems, Anionic and cationic dyes, Wastewater treatment.

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Sensitive photodetector based on transparent oxides

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Abstract: Recently transparent and conductive transparent metal oxide films are receiving more attention because of their properties such as light-emitting semiconductivity, possessing high value of exciton binding energy, etc. Due to these properties the films have been used in varities of applications such as high temperature thermoelectric device fabrication, active emitter in LED and laser diodes, TFT for real-time sensing of gas molecules, acoustic sensors, etc. Being at the beginning of our investigation, our main task consists of obtaining thin metal oxides films (Me_xO_y) (where Me are Sn or Zn) undoped and doped with different additives [1-4]. The thin films were deposited on glass and silicon substrates by spray pyrolysis technique. The specific amount of dopant (In, Mo) influences the conductivity, the transparency and the electrical resistivity of the films.

The microstructure and morphology were studied by XRD, SEM, Raman and AFM techniques. Spectrophotometer UV-VIS in the region of 300-1800 nm was used to study the transmission spectra of the films. Si-SiO_2-Me_xO_y:(In, Mo) structures were prepared and the lateral photoeffect was investigated. Under nonuniform irradiation with a laser beam, a lateral photovoltage (LPV) appeared, with high sensitivity to the spot position on the plane of the metal oxide film. The LPV depends on the conductivity and optical transmittance of the films. The position characteristic shows good linearity and resolution and could be useful for practical applications.

Keywords: Thin films, Spray pyrolysis, Metal oxides, Position sensitive photodetector.

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EMI shielding materials based on Polystyrene/Graphene foam-based composites

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Abstract: Living in the exponential technological growth of electronic devices, including networking devices and antennas, a serious problem of electromagnetic interference (EMI) and radiation comes to light. Recent scientific focus in material science is to develop EMI shielding materials to reflect, absorb, or redirect electromagnetic waves, in order to prevent interference from affecting sensitive equipment. The subject of this work is to develop lightweight polymer foams capable of mitigating electromagnetic interference, based on polystyrene (PS) foam filled with carbonaceous fillers such as graphite and thermally expanded graphene (Gther.exp.). The studied foam-based composites were prepared on a semi-industrial line using conventional CO2 foaming. Structural and shielding characterization was performed using SEM, FTIR-ATR, TGA/DSC, four-probe conductivity, and EMI measurements.
The obtained results point out that carbon-based reinforcements can simultaneously improve the thermal stability, electrical conductivity, and EMI shielding capability of the studied systems, providing a scalable platform for further microstructural and compositional optimization toward higher-performance EMI shields.

Keywords: EMI shielding, polystyrene (PS), thermally expanded graphene, graphite

Section IV

Applications of emerging materials, insulators and devices

Invited Papers

Dielectric Properties of Liquid Water: The Importance of Long-Range Interactions

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Abstract:

The importance of the long-range, in particular the electro-static interactions, is basic knowledge in polar materials. Still many of the recent potential models, used in computer simulations of solids or liquids such as water, are based on local models of the interactions parametrised using machine learning; these kind of Machine Learning Interaction Potentials (MLIPs) have been used in several studies, providing results appearing as satisfactory.

There are recent schemes that include long-range interactions beyond the local ones. One of them is called the Latent Ewald Summation (LES) [1]. It allows the charges being fitted to the energies and forces, without needing the estimation of the atomic "charges" as input parameters to the learning.

Here we investigate the importance the inclusion of the explicit electro-static interactions, using the method LES in MLIPs, on the dielectric properties and the collective dynamics of liquid water, extending our earlier results [2] to the MLIPs, thereby enabling larger systems and longer simulations. Similar to the results reported in Ref [1] and references therein on the dipole-dipole correlations we find a qualitative error appearing at low wave numbers, or large distances in real space; furthermore we discuss the apparent short-coming in the present implementation of the LES that shows up at the very small wave numbers.

Keywords: Machine learning, Dielectric properties, Liquid water, Long-range interactions

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Coupling of Dielectric Barrier Discharge with Fenton's System in Pollution Control of Water Environment

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Abstract: This paper, being based of the own research results of the authors and a comprehensive investigation of available literature and patent information, is focused on analyzing the perspectives of the application of integrated approach for the advanced oxidative degradation of toxic organic pollutants, including micro- and nano-plastics. The authors recognize that the application of the separate treatment methods, especially in case of waters polluted with xenobiotics, persistent organic substances, microplastic particles, etc. is in many cases insufficient and will not allow reaching the target results, when complete decomposition of toxic ingredients to the neutral, simple inorganic salts, gases and water molecules, in needed. One of the promising trends in water treatment is application of combined technologies, providing synergetic effects, often of chemical, physical or biochemical nature, in treating waters containing poisonous pollutants [1]. A review provided in this paper demonstrates the higher efficiency of such integrated approach, coupling two or more treatment technologies. This approach specifically combines the Fenton's system and the "cold plasma" (dielectric barrier discharge - DBD) technology for the degradation of toxic organic pollutants in liquid waste streams. The advantages of Fenton's reaction imply using of environmentally friendly chemicals, whereas the DBD technology provides high treatment efficiency and rate [2,3]. Both technologies are marked with the easy operation and practical implementation. A detailed review is provided on the mechanisms, pathways, properties of generated intermediates and active species, during the advanced oxidation treatments. The advantages and limitations of these methods for treating industrial wastewater and emissions to protect natural ecosystems from the impact of toxic organics and microplastics are highlighted, with the specific focus on the coupled Fenton-DBD systems.

Keywords: Fenton's system, Dielectric barrier discharge, toxic organic pollutants, catalysts, integrated water purification technology, microplastics, aquatic ecosystems.

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Oral Papers

Solubility, Phase Equilibria, and Solid Phase Characterization of Potassium and Sodium Pyrophosphate in Aqueous Solutions over the Temperature Range 298.15–353.15 K

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Abstract: Understanding the phase equilibria and solubility behavior of potassium and sodium pyrophosphate in aqueous systems is of considerable importance for both fundamental and applied aspects of phosphate chemistry [1]. A detailed thermodynamic description of these systems is essential for accurately modeling solid–liquid equilibria and predicting the stability of different solid phases over a wide range of concentrations and temperatures [2]. Such knowledge is particularly relevant for processes involving phosphoric acid and its derivatives, where crystallization, dissolution, and complex formation may significantly affect the overall system behavior [3]. In this study, the solubility of potassium and sodium pyrophosphate was investigated over a temperature range of 298.15 to 353.15 K using equilibrium methods [4]. The results show a temperature-dependent solubility increase for both systems, attributed to enhanced ionic mobility and water activity. X-ray diffraction analysis revealed the formation of distinct phases, $K_2HPO_4 \cdot 3H_2O$ and $Na_2HPO_4 \cdot 7H_2O$, at various temperatures. This crystallization is influenced by specific solution conditions, particularly temperature and ionic strength, which determine the nature of the solid phase. These findings offer valuable insights into the comparative behavior of potassium and sodium pyrophosphate salts, contributing to better process control in the production of phosphoric acid derivatives and supporting the design of more efficient and sustainable industrial systems.

Keywords: pyrophosphate, Solubility, Thermodynamic properties, Water activity, hygrometric method

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Optimizing organosolv extraction of lignin from Rubia waste for textile industry valorization

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Abstract: The composition of lignocellulosic species is complex, consisting of cellulose, hemicellulose, lignin, and various inorganic materials [1]. Separating the three primary biopolymers of lignocellulosic biomass is challenging due to factors such as lignin content, cellulose crystallinity, and water content. Lignin, which constitutes 15 to 30% of lignocellulosic biomass [2], is a crucial component in various industries, including biorefinery, textile, and water treatment, making its valorization critical. The present work aims to valorize the waste generated by the *Rubia tinctorum L.* plant used in the dyeing industry, mainly lignocellulose, that are the raw material for other industries. The composition of lignocellulosic species is complex, consisting of cellulose, hemicellulose, lignin, and various inorganic materials [2]. To achieve effective lignin extraction, environmentally friendly pre-treatment methods have been developed, which produce lignin materials with different physicochemical characteristics [3]. This study focuses on optimizing lignin extraction from the *Rubia tinctorum* L. plant waste using the Organosolv method to valorize the lignin in the textile industry [4]. The Box Behnken Design based on the response surface method was employed, varying three main parameters, organic acid concentration (OA), reaction time (TEM), and solid loading (RML) to determine the optimal conditions for extracting lignin with the highest yield and purity. The optimal conditions are (OA 75%, 0.25 RML, and 3 h TEM), with a yield of 52.23%. The extracted lignin was characterized using the analysis techniques TGA and DSC to study the thermal stability, XRD and SEM were used to study the crystal structure and morphology of lignin, NMR ^{1}H, ^{13}C, FTIR-IR, and UV-Vis spectroscopy to elucidate the lignin structure. In order to compare the different properties of recovered *Rubia* lignin with other common plants such as sugar cane, beets, and paper pulp waste, some applications for finding lignin as a UV protection agent on textiles and a coagulant in water purification stations.

Keywords: Lignin extraction, *Rubia tinctorum L.*, Organosolv method, BBD, RSM.

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Calorimetric Gas Sensors with Catalytic Decomposition of H_2O_2 by MnO_2 Based on Heat Flux Sensors

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Abstract:. In the presented work, the first research attempt was made to create an H_2O_2 gas sensor based on heat flux sensors (HFS). We proceeded from the fact that H_2O_2 gas sensors already exist [1] that operate on the principle of the difference in registered temperatures: one sensor measures the temperature of the H_2O_2 gas, and the other sensor measures the temperature of the catalyst (MnO_2), on which the exothermic reaction of H_2O_2 decomposition with heat release occurs. The temperature difference determines the concentration of H_2O_2 gas. We fabricated an experimental sample of HFS [2-4] using a 10-meter-long, glass-insulated, single-crystal tin-doped bismuth microwire (outer diameter: 20 μm; core diameter: 4 μm). A key factor in this process was the ability to grow the microwire as a single crystal, achieved through a laser-assisted recrystallization technique performed under a strong electric field. The microwire was coiled into a flat spiral and mounted onto a thin copper disk. This sample demonstrated high sensitivity to heat flow, reaching up to 10^{-2} V/W, with a time constant of approximately 0.2 seconds. Polycrystalline bismuth films with thicknesses ranging from 2 to 5 μm were deposited onto mica substrates using a vacuum thermal evaporation technique. Experimental samples of HFS were then fabricated by recrystallizing these films under laser heating in a strong electric field. The MnO_2 catalyst (in powder form or as a film on a thin (d=20 μm) stainless steel substrate) was applied to one side of the HFS, fabricated based on glass-insulated Bi microwire and on Bi films. When such a sensor is placed in an H_2O_2 gas stream, according to the exothermic decomposition reaction, the catalyst heats up, which leads to a heat flux through the HFS and, consequently, to the appearance of a voltage at the sensor output, the magnitude of which was proportional to the H_2O_2 gas concentration. When the fabricated sensors based on Bi microwire and Bi films were placed over a 60 % H_2O_2 solution at room temperature, the output voltage of the sensors was 130 μV and 7 μV, respectively, and decreased as the H2O2 concentration decreased.

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Keywords: Calorimetric gas sensors, MnO_2, Heat flux sensor, Glass-insulated Bi single-crystal microwire, Bi single-crystal film.

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Transforming Clay and Marble Waste into High-Performance Ceramic Membranes for Textile Effluent Microfiltration

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Abstract: This study focuses on the development of an eco-friendly and low-cost flat ceramic microfiltration membrane based on the valorization of marble waste powder and natural clay. The membrane was fabricated and optimized using a statistical experimental design approach (Doehlert matrix) within the framework of response surface methodology, allowing the systematic evaluation of the main processing parameters. The optimized membrane exhibited a favorable combination of mechanical strength, porosity, permeability, and chemical stability, particularly in alkaline environments. When applied to real industrial wastewater, the membrane demonstrated high treatment efficiency, especially in turbidity and organic matter removal. Overall, the results highlight the strong potential of this sustainable ceramic membrane as an effective and environmentally friendly alternative for industrial wastewater treatment applications.

Keywords: Clay, Marble, Ceramic membrane, Microfiltration Optimization, Experimental design.

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Poster session

Tunable Electrical Conductivity and Optical Parameters in Sn-Doped Ga_2O_3 Thin Films for Optoelectronic Applications

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Abstract: Gallium oxide (Ga_2O_3) is an ultra-wide bandgap semiconductor that has attracted significant attention for next-generation power electronics [1], optoelectronic devices [2], and transparent electronic applications [3] due to its exceptional electrical and optical properties. In this study, the electrical and optical properties of Sn-doped Ga_2O_3 thin films (1-3 % in the precursor solution) were systematically investigated. The films were deposited using the spray pyrolysis technique and subsequently thermally annealed in air at 800 °C for 30 minutes in order to improve crystallinity and structural quality. Electrical characterization was carried out using current–voltage (I–V) measurements, while optical properties, including optical transmittance and bandgap energy, were analyzed using UV–Vis spectroscopy. The results indicate that incorporation of Sn into the Ga_2O_3 lattice induces n-type semiconductor behavior through the substitution of Ga^{3+} ions by Sn^{4+} ions, resulting in the generation of additional free electrons. The I–V measurements at 4 V revealed a substantial decrease in resistance with increasing Sn concentration: pure Ga_2O_3 – 17.6 MΩ, 1 % Sn – 2.3 MΩ, 2 % Sn – 700 kΩ, and 3 % Sn – 290 kΩ. Increasing Sn content reduced resistivity and enhanced electrical conductivity while maintaining high optical transparency of approximately 80 % in the visible region. A slight decrease in the optical bandgap with increasing Sn concentration was also observed, indicating modification of the electronic band structure from 4.79 eV to 4.67 eV. These results demonstrate that Sn-doped Ga_2O_3 thin films possess an excellent combination of high electrical conductivity, enhanced carrier mobility, and high optical transparency, highlighting their potential for advanced sensing applications.

Keywords: Ga_2O_3, Sn doped, Band gap, Transmittance, I-V characteristics.

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The impact of green hydrogen on the renewable energy sector

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Abstract: The global energy sector is undergoing a transformative shift from fossil fuels to renewable energy sources, with green hydrogen emerging as a cornerstone of decarbonization strategies. Produced exclusively from renewable energy such as solar, wind, and biomass, green hydrogen not only reduces greenhouse gas emissions but also offers a sustainable solution for addressing energy access challenges in remote and underserved regions. Beyond its environmental benefits, green hydrogen has the potential to revolutionize energy systems by enhancing energy storage, supporting industrial decarbonization, and enabling energy self-sufficiency in areas with limited grid infrastructure.

This study aims to investigate the integration of green hydrogen into localized microgrid systems, proposing a model that combines renewable energy generation, hydrogen production via water electrolysis, advanced storage solutions, and real-time energy applications such as hydrogen fuel cells. The research explores multi-objective optimization techniques to balance energy supply and demand, minimize costs, and reduce carbon footprints. Through detailed simulations and techno-economic analyses, the work evaluates the feasibility and scalability of hydrogen-integrated microgrids, offering practical solutions to renewable intermittency and energy equity. The findings underline green hydrogen's potential to drive sustainable development, facilitate global decarbonization goals, and pave the way for a resilient and inclusive energy future.

Keywords: Green Hydrogen, Renewable Energy Microgrids, Water Electrolysis, Hydrogen Storage, Fuel Cells, Decarbonization

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Electrospun polymer nanofiber-based electromechanically responsive materials

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Abstract: Polyvinylidene fluoride (PVDF) is a crucial piezoelectric electromechanically responsive polymer for a wide range of applications, such as flexible tactile, force and deformation sensors or mechanical energy harvesters. However, the synthesis of PVDF involves the use of per- and polyfluorinated alkyl substances (PFAS), commonly referred to as "forever chemicals". Therefore, the development of alternative environmentally friendly flexible polymer transducer technologies has become an urgent priority [1]. Recently, an electromechanically responsive electrospun laminate approach has been demonstrated [2]. This method can involve various types of polymers, offering significant opportunities for further improvements and the integration of functionalities such as stretchability, biodegradability, or biocompatibility. For such flexible polymer systems, the literature predominantly focuses on the "direct" effect, namely the generation of electrical charge (or voltage) under applied mechanical stress, pressure, or vibration. Here, the converse phenomenon is demonstrated - mechanical deformation induced by an applied electric field. Fibrous samples with a high density of interfaces per unit volume were prepared by electrospinning from different polymers. The standard AixACCT TF2000 analyzer setup allowed characterization of sample polarization, electric-field-induced mechanical deformation, and determination of the electromechanical response nature (electrostrictive or piezoelectric). In several systems, it was also able to induce a piezoelectric-like response using special electrode configurations and high applied voltages.

Keywords: Electromechanically responsive materials, Electrospun polymer nanofibers, Energy harvesting applications

Acknowledgements
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Development of Octacalcium Phosphate/Polymer Bio-Composites for Bone Regeneration

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Abstract: Octacalcium phosphate materials (OCP) find widespread application as synthetic bone grafts owing to their relevant properties. OCP has been identified as a direct precursor of bone apatite crystals during the bone biomineralization process [1]. Consequently, it is extensively used as a bone substitute in various forms, such as granules and three-dimensional scaffolds.

OCP consists of apatite layers interleaved with hydrated layers, which closely mimic the mineral part of natural bone [1]. Its notable advantage lies in its ability to regenerate bone tissue faster and more efficiently than the other calcium phosphate-based materials [2]. Despite these advantages, their limited biodegradability and mechanical properties pose limitations in the orthopedic field. In this perspective, an effective method to enhance these properties involves integrating an organic phase within the OCP inorganic matrix [3].

This study aims to design novel three-dimensional bio-composites combining octacalcium phosphate with polymers, specifically chitosan and alginate. The OCP powders were synthesized at various pH levels, and the OCP composites were functionalized through in-situ precipitation in the presence of the polymer phase. The impact of synthesis conditions (pH, liquid and solid phases, and the polymer content) on OCP phase formation and on the mechanical properties of the composites were investigated. . The *in vitro* bioactivity of the composites was tested by monitoring apatite formation over a 14-day period in simulated body fluid (SBF). The obtained results revealed that pH influenced OCP formation, while the composites maintained a stable OCP composition regardless of polymer content. Mechanical tests demonstrated a significant improvement in strength compared to polymer-free OCP. The immersion of the biocomposites in SBF solution confirmed their bioactivity and biodegradability in vitro. Further biological investigations *in vitro* are needed to evaluate the potential of the formulated materials in orthopedic applications.

Keywords: Octacalcium phosphate, Chitosan, Alginate, Biocomposite.

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Feroelectric and Dielectric Properties of Phosphate Bonded Barium Titanate

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Abstract: Dielectric ceramics have a wide field of applications including, but not limited to capacitors, piezoelectric devices, memory systems, and sensors. While critical to modern day devices, the ceramics are typically prepared using methods that require specific equipment and are very energy intensive – such as spark plasma sintering, microwave sintering or hot pressing. As an alternative to these methods, a new brand of ceramics has emerged: phosphate bonded ceramics (PBCs). PBCs are made by mixing powdered ceramic with aluminum phosphate dissolved in water, and pressed uniaxially. Afterwards, the ceramics are heated up to 300 ^{o}C to speed up the curing process. Main advantage of such ceramics is the ease of preparation. Additionally, no thermal treatment above 300 ^{o}C is performed, which prevents growth of grains and, in case of mixed ceramics, prevents interphasial reactions. However, the ceramics produced typically display lower density, and are more lossy.

In this work, PBCs of barium titanate were prepared and investigated. Three series of samples were prepared at varying pressure during pressing process – one with mean grain size of 700nm, and another with 300nm. A third series of samples was prepared at a constant pressure, but the grains of both sizes were mixed according to the formula x300nm_size_BTO+(1-x)700nm_size_BTO. After sample preparation, measurements of dielectric permittivity and ferroelectric properties were performed.

Keywords: Dielectric materials, barium titanate, phosphate bonded ceramics

Carbon nanotubes - based hybrid composites: size-related effects

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Abstract: The percolation threshold and macroscopic properties of the randomly organized multi-facial media is a problem that was studied for a long time. In modern material science, the main focus is the percolation phenomena in composite with randomly distributed carbon nanoinclusions like graphite nanoplatelets, carbon nanotubes, carbon black, onion-like carbon, etc. The problem is well-studied for the case of one type of inclusions having continuous spatial and angular distribution. However in case of hybrid composites the situation is not so clear. One of the most interesting combinations here is conductive filler of high aspect ratio (like carbon nanotubes) paired with non-conductive counterparts. In this case the second filler only indirectly impacts the overall conductivity.

The present report delivers the Monte Carlo modeling results and their experimental verification of a hybrid CNT-filled composite system with a second inclusion in for of non conductive spherical particles.

Keywords: Carbon nanotubes, hybrid composites, Monte Carlo modeling

Structural studies of As_2S_3:AgI glasses

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Abstract: Chalcogenide glasses are widely used in photonics applications, including IR optics, sensing, optoelectronics, holography, and integrated and fiber platforms. Their optical, electrical and structural properties can be tuned by doping with different modifiers. Silver-containing chalcogenide glasses attract particular interest due to the combination of the wide glass-forming region of the As-S network and the high ionic conductivity of Ag^+ ions. The introduction of AgI into the As_2S_3 matrix enables additional control over the structure and, consequently, the functional properties of the material.

The present work is devoted to the structural investigation of $(As_2S_3)_{95}(AgI)_5$ and $(As_2S_3)_{65}(AgI)_{35}$ glasses in comparison with pure As_2S_3. The samples were studied by X-ray diffraction. Diffraction patterns were recorded using a Rigaku SmartLab diffractometer in parallel-beam geometry with Cu Kα radiation (λ = 1.5406 Å) in the 2θ range from 2° to 120° with a step of 0.05° at room temperature. The obtained diffraction curves confirm the amorphous nature of all investigated samples.

Based on the experimental XRD data, radial distribution functions (RDFs) and short-range order parameters were calculated using the RAD GTK+ software. The positions of the first (r_1) and second (r_2) maxima of the RDF were determined. The bond angle φ was calculated using the relation $\varphi = 2 \arcsin (r_2/ 2r_1)$.

Table 1. Radial distribution functions and short-range order parameters

Composition	r_1	r_2	r_2/r_1	φ
As_2S_3	2.3	3.48	1.51	98.32
$(As_2S_3)_{95}(AgI)_5$	2.31	3.51	1.52	98.88
$(As_2S_3)_{65}(AgI)_{35}$	2.31	3.51	1.52	98.88

Comparison of the short-range order parameters shows that the r_1 and r_2 values for $(As_2S_3)_{95}(AgI)_5$ and $(As_2S_3)_{65}(AgI)_{35}$ are practically identical within the experimental error (±0.01 Å). In the case of pure As_2S_3, a slight shift of r_1 is observed within the error limits. These results indicate that the introduction of AgI does not significantly disturb the short-range order of the As-S network, while structural modifications may occur at longer length scales.

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Keywords: X-ray diffraction, $(As_2S_3)(AgI)$ glasses.

Preparation, Characterization of Silver Nanoparticles and Their Potential Pharmaceutical Applications

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Abstract: The synthesis of nanometer-sized nanoparticles with antibacterial properties is of significant interest for the development of new pharmaceutical products. A key aspect of nanotechnology is the development of rapid and reliable experimental protocols for the synthesis of nanomaterials with controlled chemical composition, size, low polydispersity, and scalability. In this study, a one-step green synthesis route for stable silver nanoparticles (AgNPs) with a narrow size distribution is reported. Silver nitrate was used as the metal precursor, while biocompatible chondroitin sulfate (ChS) served both as a reducing and stabilizing agent. The reaction was carried out in an aqueous medium under continuous stirring at temperatures ranging from 25°C to 80°C. The formation of AgNPs was indicated by a color change from a transparent solution to light red and subsequently to dark reddish-brown. The synthesized nanoparticles were characterized by UV–VIS spectroscopy, transmission electron microscopy (TEM), Fourier transform infrared spectroscopy (FTIR), and dynamic light scattering (DLS). The results confirmed the formation of ChS-coated AgNPs. TEM analysis revealed well-dispersed, spherical nanoparticles with an average size below 20 nm, significantly smaller than the hydrodynamic diameter (~80 nm) obtained by DLS measurements. A characteristic surface plasmon resonance (SPR) peak at approximately 417–420 nm further confirmed nanoparticle formation. Increasing the reaction time from 3 to 24 hours resulted in higher absorption intensity and a slight blue shift of the SPR peak, indicating an increase in nanoparticle concentration and a slight decrease in particle size. The antibacterial activity of the AgNPs was evaluated using the Kirby–Bauer method, demonstrating effective bactericidal activity against *Escherichia coli* and *Staphylococcus aureus*. Determination of the minimum inhibitory concentration (MIC) is currently in progress, with preliminary results obtained

Keywords: AgNPs, UV-VIS Spectroscopy, FTIR, TEM, DLS measurements.

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Synthesis, characterization, and effect of doping on the optical and electrical properties of layered ferroelectric ceramics

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Abstract: Aurivillius phases are layered perovskite-type oxides described by the general formula $A_{n-1}Bi_2Bi_2O_{3n+3}$ where A corresponds to a large cation in 12-fold coordination, while B corresponds to a smaller cation in octahedral (6-fold) coordination [1]. In this study, praseodymium (Pr)-doped $SrBi_2Nb_2O_9$ (x = 0.0, 0.1, 0.2, 0.3, 0.4 and 0.5) ceramics were synthesized via a conventional solid-state reaction using carbonate, oxide, and nitrate precursors dissolved in a citric acid–ethylene glycol solution. X-ray diffraction analysis confirmed that the samples crystallized in the orthorhombic structure typical of $SrBi_2Nb_2O_9$, with a gradual decrease in unit cell volume upon Pr incorporation. FTIR spectroscopy revealed vibrations associated with the NbO_6 octahedra, while photoluminescence measurements confirmed the presence of Pr^{3+} ions. UV-Vis spectroscopy indicated a direct band gap whose value depends on the doping level. The Curie temperature, which remained constant across different frequencies, confirmed the normal ferroelectric behavior of the ceramics. The ferroelectric transition was found to be more sensitive to the Pr substitution site than to its valence, showing no linear correlation with Pr^{3+} concentration. At room temperature, Pr doping did not significantly affect dielectric loss, whereas at elevated temperatures, electrical conduction was dominated by doubly ionized oxygen vacancies and a hopping mechanism [2].

Keywords: Characterization doping ceramics optical conductivity dielectric

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Effect of Deposition Time and Annealing Atmosphere on the Morphological and Physical Properties of SnO_2 Thin Films

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Abstract: Tin oxide **(**SnO_2) thin films were deposited via spray pyrolysis with deposition times of 1–5 min and subjected to post-deposition thermal treatment at 400 °C for 1 h in either vacuum or air to investigate the influence of processing conditions on their morphological, wetting, electrical and optical properties. Atomic force microscopy (AFM) revealed that the surface morphology evolved from smooth, homogeneous films to well-defined granular structures with increasing deposition time. Vacuum-annealed films exhibited a gradual increase in roughness followed by morphological stabilization, whereas air-annealed films displayed more pronounced surface development, with larger grains and higher roughness, indicating enhanced surface diffusion and grain coalescence under oxidizing conditions. Contact angle measurements revealed a transition toward hydrophobic behavior in SnO_2 films subjected to vacuum annealing, in contrast to the typically hydrophilic nature of the glass substrate ($\leq 90°$). SnO_2 thin films prepared by the spray pyrolysis method is typically reported to be hydrophilic [1]. However, the deposited films exhibited hydrophobic behavior, which could be advantageous for SnO_2-based photodetector applications, since hydrophobic surfaces are often associated with improved stability in humid environments. In contrast, air-annealed films exhibited nearly constant hydrophobic wettability, highlighting the combined role of surface topography and chemical composition in determining wetting properties. Optical characterization showed high transparency (80–90%) for all films. The film thickness increased with deposition time, reaching approximately 720 nm, while the refractive index decreased from approximately 2.75 to 1.8 in the 350–800 nm spectral range, in agreement with literature data. These results demonstrate that deposition time and annealing atmosphere are key parameters for controlling the morphological and functional properties of SnO_2 films.

Keywords: SnO_2 thin films, spray pyrolysis, annealing atmosphere, wettability, refractive index, optical properties.

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The structural features of dimorphite thin films grown by thermal evaporation and cathodic magnetron sputtering

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Abstract: Dimorphite (As_4S_3) is a rare arsenic sulfide compound of growing interest for optoelectronic applications. The present work reports the structural characterization of two types of dimorphite thin films prepared by thermal evaporation of As_4S_3 powder and RF magnetron sputtering from a pressed As_4S_3 powder target. The films obtained via thermal evaporation in vacuum ~10^{-5} Torr have been grown onto quartz or titanium (*Ti*) substrates using a quartz crucible, heated by a tungsten coil. The velocity of film growth was controlled varying the temperature of the crucible from 120 to 180 ^oC, which allowed to vary the deposition rates in the range of 0.2÷8 μm/h. The set-up allowed us to grow dimorphite layers with different thickness (0.1÷10 μm) without breaking the vacuum. It was established that As_4S_3 sublimes at a pressure of 10^{-5} Torr and temperature around 120 ^oC. Shown by scanning electron microscopy (SEM), the films obtained via sublimation are fibrillar with a high porosity. The fibrils are randomly distributed and are around 1-2 μm in length. At advanced crucible temperatures dimorphite evaporates and the grown films are dispersive and homogeneous. The X-ray diffraction (XRD) analysis showed that either thin films grown by sublimation or evaporation contain both α and β phases of dimorphite as in the raw material, serving as a source. However, it was pointed out that the ratio β/α concentration strongly depends on the rate of growth, as well as on material and temperature of substrate. Thus, it was found that As_4S_3 thin films obtained via either sublimation or evaporation onto *Ti* substrates contain β-dimorphite in much larger quantities than α-dimorphite, and the ratio β/α tends to increase with increasing evaporation temperature. Sputtered films were deposited at room temperature on quartz and silicon substrates in Ar atmosphere at applied powers of 7 W and 10 W, corresponding to low deposition rates (~0.1÷0.2 μm/h). Films in the thickness range of 60 to 320 nm were obtained, as determined by X-ray reflectometry and spectroscopic ellipsometry. Energy-dispersive X-ray spectroscopy (EDX) indicates near-realgar stoichiometry (As:S ≈ 49:51 at.%), close to realgar (As_4S_4) stoichiometry. Grazing incidence X-ray diffraction (GIXRD) analysis of as-deposited films reveals their polycrystalline structure, cubic As_2O_3 (arsenolite) accompanied by an unknown isostructural cubic phase, its lattice parameter $a \approx 10.936$ Å being smaller (-1.4%) than that of arsenolite (a = 11.088 Å). Post-deposition annealing at 130°C for 120 min in a sulfur atmosphere eliminates the oxide and the unknown cubic phase, as GIXRD analysis reveals. The sulfurized films seem to be composed of a single polycrystalline phase, monoclinic $As_2S_{2.11}$, and a minority amorphous phase. GIXRD diagram of the sputtered target surface shows that it is composed by a balanced mixture of polycrystalline phases, β-As_4S_3 (β-dimorphite) and β-As_4S_4, and a minority amorphous phase. SEM shows smooth films with scattered surface crystallites in as-deposited layers, which are eliminated after sulfurization, consistent with removal of the oxide phases. These results establish the structural baseline for dimorphite thin films prepared by two complementary deposition routes, thermal evaporation and RF magnetron sputtering, and demonstrate that phase composition is governed by deposition rate and substrate properties in evaporated films, while surface oxidation control is the key requirement for phase-pure sputtered films.

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Electrochemical Characterization of Thermally Oxidized Copper

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Abstract: This work aims to compare the electrochemical performance of thermally oxidized copper foil and mesh electrodes, focusing on the effect of morphology on charge storage and mass transport mechanisms. Copper foils [1] and mesh (wire diameter 100 μm, aperture size 180 × 180 μm) were thermally treated at 400 °C for 1 h to form copper oxides layers. Electrochemical properties were assessed through cyclic voltammetry (CV), chronoamperometry, and electrochemical impedance spectroscopy (EIS). Electrochemical measurements were conducted in 0.1 M NaOH electrolyte. Surface morphology was analyzed using scanning electron microscopy (SEM), while phase composition and crystallographic structure were determined by X-ray diffraction (XRD). Cyclic voltammetry data reveals a higher cathodic current response at 300 mV for the mesh compared to the foil oxide, especially at high sweep rates, both electrodes having the same geometrical area (1 cm^2). CV reflects fast charging and surface effects, while chronoamperometry shows the steady-state current, where the signal becomes stable over time and depends mainly on how fast species reach the electrode. The obtained results demonstrate that Cu oxide mesh electrode exhibits a stronger cathodic response and a more pronounced scan rate dependence than Cu oxide foil, indicating a higher electroactive surface area and improved charge transfer properties. These features suggest that the mesh substrate is more suitable for electrochemical applications.

Keywords: Electrochemical impedance, cyclic voltammetry, redox reactions, biosensors, nanomaterials.

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ELECTROSPUN MULTIFUNCTIONAL NANOFIBROUS MATERIALS

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Abstract: Electrospinning is a versatile and widely employed technique for the fabrication of nanofibrous polymeric or semiconductor materials with controlled morphology, high surface-to-volume ratio, and tunable functional properties [1]. ZnO nanofibers fabricated by this method are widely investigated due to the material properties such as electrical, optical, or antibacterial activity, making it suitable for multifunctional applications. Besides ZnO, tin sulfide-based materials, including SnS and SnS_2, have demonstrated promising performance in optoelectronic devices such as photodetectors [2] as well as in photocatalytic processes, particularly in the case of SnS_2 due to its favorable electronic structure [3].

In this study, we report on the fabrication of pure polymer and composite polymer–nanoparticle nanofibers via electrospinning process using a home-made system, and their characterization. The primary objective was to develop uniform nanofibrous mats based on poly(vinyl alcohol) (PVA), ZnO, as well as composite systems incorporating tin sulfide (SnS, SnS_2) nanoparticles, and to investigate the influence of processing parameters and material composition on fiber morphology and functional behavior. To combine antibacterial and photocatalytic functionalities within a single platform, SnS/SnS_2 nanoparticles were added into the PVA/ZnO precursor solution, which was subsequently processed via electrospinning to obtain composite nanofibers or ZnO/SnS (ZnO/SnS_2) heterostructures. The nanofibers were obtained at different voltages ranging from 15 to 25 kV and distances from 8 to 12 cm, followed by an annealing process in order to remove the organic compound. The resulting materials were analyzed in terms of morphology (SEM), composition (EDX), and potential multifunctional performance for application in sensing, filtration, optoelectronics and biomedical engineering.

Keywords: Electrospinning; nanofibers; composite materials; ZnO; chalcogenides

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Structural and electrical properties of $(ZnO)_k \cdot Me_2O_3$ (Me = Al, Ga, In) ceramics activated with halogens and zinc

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Abstract: High-power magnetron sputtering is one of the most reproducible methods for the deposition of ZnO thin films with high structural perfection and low contamination level. The highest film quality requires homogeneous, highly thermally conductive ceramic targets, sintered at extremely high temperatures (1500 °C). Recently, a new low-temperature method for sintering ZnO based on chemical vapor transport (CVT) has been proposed [1, 2]. The sputtering of CVT ZnO targets makes it possible to double the conductivity and structural quality of films [3]. ZnO-based alloys are of considerable practical interest due to the variation of chemical, optical and electrical properties. The aim of the present work is to investigate the structural and electrical properties of $(ZnO)_k \cdot Me_2O_3$ (Me = Al, Ga, In) ceramic alloys and to demonstrate the advantages of CVT based on various halides and Zn excess.
The properties of $(ZnO)_k \cdot Al_2O_3$ alloys with Al concentrations of 2–67 at% have been investigated. The use of HCl-based CVT allows the solubility rate of Al_2O_3 in ZnO to be tripled at 1050 °C. The possibility of increasing ceramics conductivity by four orders of magnitude via Cl activation and Zn excess is demonstrated. Only two phases are observed: ZnO: Al and $ZnAl_2O_4$. The solubility limit of Al is 2 at%. $(ZnO)_k \cdot Ga_2O_3$ alloys with Ga concentrations from 2 to 67 at%, activated in HX, HX + H_2, and HX + H_2 + C media (X = Cl, Br, I), have been obtained. The use of HCl-based CVT allows increasing the solubility rate of Ga_2O_3 in ZnO by 10 times at 1050 °C. The kinetics of HBr- and HI-based CVT are less intense. The conductivity of ceramics can be increased by a factor of 10^3 via stoichiometric deviation. Layered oxides of the $Zn_kGa_2O_{k+3}$ type are not observed. The solubility limit of Ga is about 6 at%. The optimal range of stoichiometric deviation of ceramics has been determined; an excess of Zn beyond optimum promotes the formation of $ZnGa_2O_4$ spinel. Variation in the alloy composition *k* allows the band-gap and resistivity to be tuned over 3.3–4.4 eV and 10^{-3}–10^4 Ω·cm, respectively.
The structural and conducting properties of $(ZnO)_k \cdot In_2O_3$ alloys with In concentrations from 2 to 22 at% have been investigated as well. The major part of In impurity forms layered oxides of the $Zn_kIn_2O_{k+3}$ type, the most stable of which at 950 °C is $Zn_7In_2O_{10}$. The conductivity of ceramics can be increased by four orders of magnitude via halogen activation and stoichiometric deviation. The optimal range of stoichiometric deviation of ceramics has been determined; an excessive Zn content leads to large losses of In in the form of volatile InX halides.

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Keywords: Ceramic magnetron targets, chemical vapor transport, controllable conductivity, ZnO

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DELAYED ABSTRACTS

Super-Radiant Emission Spectra of Tryptophan under UV Exposure for Biomedical Applications

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Abstract: We proposed a model of super radiant Raman scattering with substantial convertion into Stokes for the description of super-radiance in Tryptophan injected into biomolecules proteins. This paper further explores the coherent radiative processes in Tryptophan. We propose a master equation formalism to describe the super-radiation phenomenon, accounting for critical radiation parameters such as pulse duration, field intensity, and resonant frequency. We experimentally characterize the evolution of absorption and emission spectra of Tryptophan under targeted Ultraviolet C (UVC) irradiation. A detailed analysis is provided regarding the wavelength-dependent response and the intensity-driven photochemical alterations of the amino acid. Furthermore, the research investigates the correlation between the electronic relaxation of Tryptophan and the germicidal efficacy of UVC radiation on yeast cultures. By examining the photo-induced damage to protein-based dielectric structures, it is demonstrated that the fundamental role of radiative transitions in determining the stability and biological activity of microorganisms. The findings contribute to the development of advanced photonic tools for biomedical sensing and sterilization technologies.

Keywords: Raman scattering, Ultraviolet-irradiation, Emission spectra, Biomolecules.

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