

ABSTRACT BOOK

**13th INTERNATIONAL CONFERENCE ON MATERIALS SCIENCE AND
NANOTECHNOLOGY FOR NEXT GENERATION**

(MSNG2026)

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ADYAMAN UNIVERSITY

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FOREWORD

It is a pleasure for us to offer you Abstracts Book for the 13th international conference on Materials Science and Nanotechnology for Next Generation; MSNG2026. Our goal was to create a scientific platform that introduces the newest results on internationally recognized experts to local students and colleagues and simultaneously displays relevant Turkish achievements to the world. The positive feedback of the community encouraged us to proceed and transform a single event into a conference series. Now, MSNG2026 is honored by the presence of over 150 colleagues from various cities and countries. We stayed true to the original MSNG2026 concept and accepted contributions from all fields of materials science and technology to promote multidisciplinary discussions. The focal points of the conference emerged spontaneously from the submitted abstracts: energy applications, advanced materials, electronic and optoelectronic devices. Further fields of interest include e.g. new advanced and functional materials, advanced-functional composites, biomaterials, smart materials, dielectric materials, optical materials, magnetic materials, organic semiconductors, inorganic semiconductors, electronic materials, graphene, and more. We can offer free publishing of all peer-reviewed proceedings in international journals Materials Science-Poland, Journal of Nanoelectronics and Optoelectronics, Organo Optoelectronics, Journal of Materials and Electronic Devices and provide the participants with all the commodities of a world – class conference. Therefore, we hope that getting first-hand access to so many new results, establishing new connections and enjoying the Adıyaman Turkey ambience will make you feel that your resources were spent well in MSNG2026.

Our warmest thanks go to all invited speakers, authors, and contributors of MSNG2026 for accepting our invitation, visiting Adıyaman and using MSNG2026 as a medium for communicating your research results.

We hope that you will enjoy the conference and look forward to meeting you again in one of the forthcoming MSNG2026 event.

Prof.Dr. Ali Osman AYAŞ & Prof.Dr. Fahrettin YAKUPHANOĞLU
Conference Chairs

INVITED SPEAKER TALKS

13th INTERNATIONAL CONFERENCE ON MATERIALS SCIENCE AND NANOTECHNOLOGY FOR NEXT GENERATION**Rational Design of Nanomaterials for Sustainable Technologies**

Önder Metin*

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The rational design of nanomaterials with precisely engineered composition, morphology, electronic structure, and interfacial properties has emerged as a powerful strategy for addressing some of the most pressing global challenges in sustainable energy, environmental remediation, and healthcare. In this invited lecture, recent advances from my research group on the development of multifunctional nanomaterials for sustainable technologies will be presented, highlighting how fundamental materials design can enable transformative catalytic and biomedical applications.

Firstly, I will focus on the design of advanced nanocatalysts for sustainable energy conversion and green chemical synthesis. Particular emphasis will be placed on semiconductor heterojunctions, plasmonic nanostructures, atomically thin two-dimensional materials, conjugated porous frameworks, and metal-based nanocatalysts engineered to maximize light harvesting, charge separation, and catalytic efficiency. Recent examples will include visible-light-driven transfer hydrogenation, selective photoredox organic transformations and C-H bond functionalization. Fundamental structure–property–performance relationships governing these catalytic systems will be discussed together with mechanistic insights obtained through advanced spectroscopic, electrochemical, and computational investigations.

The second part of my lecture will highlight our recent contributions to sustainable hydrogen technologies, including the development of nanostructured materials for efficient hydrogen production, storage, and utilization. Strategies based on alloy nanoparticles, porous nanomaterials, and multifunctional catalytic architectures will be presented to demonstrate how nanoscale engineering can significantly enhance hydrogen generation kinetics, storage performance, and overall energy efficiency. In addition, recent advances in photo-assisted lithium–oxygen (Li–O₂) batteries will be presented, illustrating how rationally engineered photoactive nanomaterials can reduce charge overpotentials, improve round-trip energy efficiency, and enhance the cycling stability of next-generation energy storage devices.

Finally, the presentation will showcase the expanding role of rationally designed nanomaterials in biomedical applications. Recent studies on functional nanoplateforms for cancer therapy, targeted drug delivery, antimicrobial activity, and bioimaging will illustrate how precise control over nanoscale architecture can simultaneously improve therapeutic efficacy, biocompatibility, and clinical potential.

Overall, this lecture will demonstrate how integrating synthetic chemistry, nanotechnology, catalysis, materials science, and interface engineering provides a versatile platform for developing next-generation functional materials for sustainable energy conversion, advanced energy storage, environmental applications, and human health. The presentation will conclude by discussing future opportunities and emerging directions in the rational design of multifunctional nanomaterials to accelerate the transition toward a sustainable and carbon-neutral future.

I would like to thank to the Scientific and Research Council of Türkiye (TÜBİTAK, Grant No: 124N866, 123Z056, 120Z622), US Airforce office of Scientific Research (AFOSR, Grant No: FA8655-24-1-7386 -P00002) and the Turkish Academy of Sciences for the financial support.

Keywords: Rational design of nanomaterials; Nanocatalysis, Sustainable technologies; Photocatalysis; Hydrogen production and storage; Photo-assisted lithium–oxygen batteries; Biomedical nanomaterials.

Dosimeters in Medical Radiation Applications: From Traditional Systems to New Generation Technologies

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Accurate and reliable dosimetry is essential for ensuring radiation safety, treatment effectiveness, and quality assurance in contemporary medical radiation applications. As the complexity of radiotherapy techniques increases and the use of ionizing radiation becomes more prevalent in diagnostic and interventional procedures, there is a heightened demand for advanced, real-time, and high-sensitivity dosimetry solutions that can improve both patient and occupational safety.

This study aims to conduct a comprehensive evaluation of traditional dosimetry systems including thermoluminescent dosimeters (TLDs), optically stimulated luminescence dosimeters (OSLDs), film dosimeters, and electronic personal dosimeters, focusing on their operational principles, performance characteristics, and clinical limitations. Building on this foundation, the research further investigates next-generation dosimetry technologies with an emphasis on enhancing temporal resolution, sensitivity, and integration into digital healthcare infrastructures.

In this context, innovative approaches such as real-time active dosimetry systems, fiber-optic and semiconductor-based detectors, plastic scintillation technologies, and nanomaterial-enhanced dosimeters are systematically analyzed. Special emphasis is placed on their potential to enable continuous monitoring, remote accessibility, and data-driven decision-making in clinical settings.

Furthermore, the integration of intelligent dosimetry systems with centralized data management platforms and remote monitoring architectures is discussed as a significant advancement toward intelligent radiation safety ecosystems. These innovations are anticipated to greatly improve workflow efficiency, reduce human error, and optimize radiation protection strategies in both routine clinical practice and high-risk exposure scenarios.

In conclusion, this work contributes to the development of next-generation dosimetry frameworks by highlighting scalable, adaptive, and technology-driven solutions that align with the evolving demands of precision medicine and digital health.

This study was supported by the Health Institutes of Türkiye (TÜSEB) under Project No: 48074. The findings will be presented by the project leader on behalf of the project group

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Reverse EXAFS Analysis (REA): From Local Probe to Standalone Crystallographic Tool

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We present Reverse EXAFS Analysis (REA), an innovative, ab initio framework that converts EXAFS from a supplementary local probe into a principal instrument for de novo crystal structure determination. In contrast to traditional approaches that depend on pre-existing structural models or necessitate XRD input, REA operates independently from the outset. By systematically integrating FEFF simulations with a reverse-fitting approach, it immediately retrieves comprehensive crystallographic data, lattice constants, space group, and atomic positions, exclusively from EXAFS oscillations. We confirmed REA on two test systems: LiCrO₂ and CuFeO₂. In CuFeO₂, REA revealed unanticipated phase heterogeneity, detecting secondary phases (CuFe₂O₄ and CuFe₅O₈) that traditional EXAFS analysis had entirely missed [1-3].

This paradigm change creates a new frontier. REA enables accurate structure solving precisely where diffraction fails: in disordered, nanostructured, weakly crystalline, or completely new materials. In essence, we give EXAFS a new role, not merely as a complement to diffraction, but also as a standalone crystallographic approach for the materials that require it the most.

Keywords: EXAFS, Reverse Engineering, Crystal Structure, Synchrotron Techniques

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Engineering Organic π -Frameworks for Optoelectronics and Nanotechnology

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The past century has been the era of mastering chemistry to develop modern functional materials. π -conjugated small molecules and polymers have attracted great attention over the last three decades as functional materials. Owing to their unique features over traditional inorganics and metals, they are envisioned as essential components of next-generation optoelectronics and nanotechnology applications. Our research is focused on designing and building state-of-the-art, high-performance organic optoelectronic materials as well as understanding key structure-property-device relationships. Herein, we describe the molecular design, synthesis, characterization, and device performances of novel solution-processable [1]benzothieno[3,2-b][1]benzothiophene (BTBT)- and indenofluorene (IF)-based n-type organic semiconductors in organic thin-film transistors (OTFTs), BODIPY-based molecular/polymeric semiconductors in OTFTs and bulk-heterojunction photovoltaics (BHJ-OPVs), (non)fluorinated π -conjugated semiconductors for organic surface-enhanced Raman spectroscopy (organic-SERS) platforms, rod-shaped fluorescent molecules with high exciton utilization rates in organic light-emitting diodes (OLEDs), and molecular materials for physically unclonable functions (PUFs) [1-3].

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Engineering Triboelectric Nanogenerators from Fibers to Free-Standing Configurations

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Triboelectric nanogenerators (TENGs) have attracted considerable attention for sustainable energy harvesting in wearable electronics, human-machine interfaces, and self-powered sensing systems; however, challenges associated with scalable architectures and system-level integration still limit broader implementation. This talk introduces a modular and materials-oriented strategy spanning fiber-based, textile-integrated, and free-standing TENG platforms. Initially, fabric-based TENGs composed of silver nanowire-functionalized cotton laminated with thermoplastic polyurethane (TPU) are presented, simultaneously providing washability, Joule heating capability, and energy harvesting performance for human-machine interaction applications [1]. Subsequently, coaxially wet-spun core-shell fibers containing carbon black, silver nanowires, and TPU are developed to realize stretchable and IoT-compatible electronic textiles [2]. Integration of two-dimensional titanium disulfide (TiS₂) nanosheets and their oxidized titanium dioxide (TiO₂) counterparts into the triboelectric sheath demonstrates superior performance for TiO₂-containing fibers (V_{oc} = 55 V, I_{sc} = 690 nA), enabling illumination of 100 LEDs together with machine-learning-assisted tactile sensing for smart glove applications [3]. Simultaneously, optimized silver nanowire electrode networks are implemented in droplet-driven transparent TENG devices for self-powered pH and chemical concentration sensing, while also incorporating heater functionality [4]. For macroscale blue-energy harvesting, buoy-type TENG systems are investigated, producing stable power densities reaching 1.1 W/m² under simulated ocean-wave excitation [5]. Expanding the modular approach, a compact free-standing TENG utilizing oscillating polytetrafluoroethylene (PTFE) marbles inside 3D-printed biodegradable polylactic acid (PLA) channels coupled with aluminum electrodes is introduced; optimization studies identify PLA as the most effective structural material, while stacked configurations achieve an open-circuit voltage of 110 V and peak power of 100 μ W at biologically relevant frequencies [6]. Furthermore, a rolling free-standing triboelectric-electromagnetic hybrid energy harvesting bearing is realized through modular assembly of neodymium magnet-integrated rollers and triboelectric layers, exhibiting effective rotational energy harvesting with outputs up to 0.94 W (EMG) and 0.43 mW (TENG), sufficient for powering 236 LEDs, charging a smartphone through a power-management circuit, and operating temperature and humidity sensors [7]. Collectively, these studies establish a scalable route from fiber-level devices to autonomous energy-harvesting systems through modular engineering and sustainable material selection.

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Overcoming Challenges in Modelling Surface Reactions in Computational Materials Science

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The accurate and efficient theoretical modeling of surface chemical reactions remains a major objective in computational materials science, particularly for energy and environmental applications. While *ab initio* molecular dynamics (AIMD) [1] offers high accuracy by capturing dynamic effects and thermal fluctuations, its severe computational cost restricts simulations to short timescales, making the capture of rare, activated reaction events difficult. Conversely, traditional empirical reactive force fields such as ReaxFF [2] provide high efficiency but suffer from complex parameterization and limited transferability.

In this talk, we present a multi-faceted theoretical and computational strategy designed to balance these computational challenges across diverse catalytic systems. First, we explore the mechanisms of emission-free hydrogen extraction via methane pyrolysis using molten metal alloys (such as Bi-Ni-Cu and Bi-Ni-Al) [3]. Due to the severe convergence issues and static limitations of standard reaction path determination methods such as Nudged Elastic Bands (NEB), we develop and employ our own analysis tools to explore the correlations with the local chemical environment and reaction rates. As a second application, we highlight the evaluation of water-splitting capabilities of magnetic triple alloys (Cu-Cr-Pt). Third, we demonstrate the use of accelerated molecular dynamics and metadynamics [4] to bypass long simulation waiting times, successfully capturing the intermediate steps of ethylene glycol dissociation on metal surfaces. Finally, to bridge the accuracy-cost gap, we introduce our ongoing efforts in building representative datasets from active sampling to train machine-learned interatomic potentials [5]. The talk concludes with a unifying overview of the difficulties of this field and our innovative solutions to its challenging problems.

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Epitaxial Material Engineering of MOVPE-Grown AlN Thin Films for Wide-Bandgap Device Application

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III-nitride semiconductors have attracted considerable attention for advanced electronic and optoelectronic devices, including LEDs, laser diodes, HEMTs, high-power p-n diodes, and Schottky diodes. Among them, aluminum nitride (AlN) is a promising material owing to its wide bandgap of approximately 6.2 eV, high critical electric field, high thermal conductivity, excellent thermal/chemical stability, and suitability for deep-ultraviolet and high-power applications [1].

However, high-quality AlN growth on foreign substrates such as sapphire and Si remains challenging due to lattice mismatch, thermal expansion differences, high growth temperatures, parasitic reactions, and limited surface mobility. Therefore, controlling residual stress, dislocation density, and surface morphology is critical for improving AlN-based device performance [2].

In addition to crystalline quality, controlled electrical conductivity is essential for practical AlN-based devices. Si doping is widely used to achieve n-type conductivity in AlN, but its efficiency is limited by AlN's wide bandgap, high Si donor ionization energy, native defects, and self-compensation effects. Thus, Si incorporation, activation, defect formation, strain evolution, morphology, and optical properties must be optimized together [3].

This presentation focuses on the epitaxial growth, Si doping, and device integration of AlN-based thin films. The effects of MOVPE growth conditions on AlN films grown on sapphire and Si substrates will be discussed. In addition, Si-doped AlN thin films grown on sapphire will be evaluated in terms of SiH₄ flow strategy, Si incorporation, electrical behavior, and Schottky diode performance. Results from XRD, AFM, Raman, UV-Vis-NIR, SIMS, and temperature-dependent I-V measurements demonstrate the potential of Si-doped AlN for optoelectronic and power electronic applications, while highlighting the need for careful optimization of material quality, defect control, and electrical activation.

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Computational core-electron spectroscopies: powerful tools for understanding the electronic structure and dynamics in complex systems

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In this talk I will illustrate the results of computational core-electron spectroscopic studies, namely X-ray Photoemission and X-ray absorption, which are used to probe core and valence electronic excitations and materials structure. Case studies range from medium-sized gas-phase molecules [1] to the surface chemistry and charge dynamics of complex systems such as Au(111) supported 2D systems [2-4]. In the final part of the talk I will illustrate a newly developed computational protocol [5] for the efficient calculation of time-resolved NEXAFS spectra from organic molecules using the ultrafast $\pi\pi^*/n\pi^*$ internal conversion in thymine as a case study. Most of the theoretical work has been carried out in close collaboration with experimental groups of the ELETTRA Synchrotron in Trieste.

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ORAL PRESENTATIONS

Structural, morphological and luminescence properties of Ag-doped SrSiO₃ ceramics

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TL and OSL dosimeters are passive radiation dosimeters based on the excitation of electrons trapped at defect sites within a crystal following the absorption of ionizing radiation [1,2]. TL and OSL techniques have been widely used in many areas, including medical, environmental monitoring, industry, and radiation dosimetry [3]. In this study, Luminescence properties, structural and morphological characteristics of SrSiO₃:Ag ceramics pellet synthesized by the solid state reaction method were investigated. The structural and morphological properties were examined by the XRD and SEM techniques. The XRD results confirmed the successful synthesis of the SrSiO₃ ceramics. In addition, SEM-EDS analysis of the ceramic was performed to characterize its morphological features and elemental composition. TL glow curves of the ceramic was recorded after irradiation a 1 Gy beta dose. Its TL curves exhibited five TL peaks located at 100, 150, 200, 250, and 350 °C. OSL decay curves were recorded the stimulation of CW-OSL after 1 Gy dose. Some basic dosimetric properties such as dose response, reusability, OSL deconvolution analysis were studied.

Keywords: Strontium silicates, Solid state synthesis, Thermoluminescence, Optically Stimulated Luminescence

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A Highly Linear Two-Finger Suspended-Gate Pressure-FET for Urodynamic Pressure Sensing

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Pressure measurement in urodynamic examinations requires a sensor that combines high linearity, low power consumption, and sufficient sensitivity over the clinically relevant range. This study presents a two-finger suspended-gate pressure-sensitive field-effect transistor designed for pressures between 0 and 400 cmH₂O (0–39.23 kPa) [1–3]. The electromechanical model couples a COMSOL Multiphysics simulation of a pressure-sensitive polyimide membrane with a Silvaco ATLAS device simulation. The modeled membrane has an area of 1 $\mu\text{m} \times 1 \mu\text{m}$, a thickness of 20 nm, and an initial air gap of 30 nm. Its simulated center displacement increases to approximately 25 nm at 400 cmH₂O, reducing the effective air gap to 5 nm. These pressure-dependent gaps were transferred to an explicit two-finger NMOS structure having a fixed 50 nm SiO₂ layer, a finger width of 1.5 μm , and a channel length of 0.75 μm . Pressure-induced air-gap modulation shifts the drain-current–gate-voltage transfer characteristic [1,2]. A constant-drain-current readout was therefore employed, in which pressure is obtained from the gate voltage required to maintain a reference current. At $I_D = 2.25 \mu\text{A}$, $V_D = 0.1 \text{ V}$, and a substrate bias of +0.25 V, the model produces a voltage sensitivity of –30.06 mV/kPa and a full-scale gate-voltage change of –1.175 V. The pressure–voltage response achieves $R^2 = 0.999954$ and a best-fit nonlinearity of 0.382% FS, while the intrinsic drain-conduction power is only 0.225 μW . Compared with the preceding model, the optimized configuration improves voltage sensitivity by approximately 30% and reduces nonlinearity by approximately 64%. The results indicate that constant-current gate-voltage tracking is a promising readout strategy for highly linear, low-power urodynamic pressure sensing [2,3]. Future work will focus on fabrication-oriented dimensional optimization, process-variation analysis, and experimental validation.

Keywords: pressure-FET, suspended gate, MEMS pressure sensor, urodynamics, constant-current readout

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Determining the Supercapacitor Performance of the Activated Carbon Produced from Black Carrot

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Activated carbons are the most commonly used active materials for electric double-layer capacitor (EDLC) applications due to their high specific surface area and relatively low cost. Similar to batteries, the material cost is a limiting factor for EDLC applications, therefore this case restricts the use of expensive production processes and precursors. Activated carbons are synthesized from carbon-rich organic materials by heat treatment in an inert atmosphere (carbonization procedure) and physical or chemical activation to increase the specific surface area [1].

Every year tons of biomass waste emerge because of both the production processes and the natural formation. Conversion of biomass waste into materials with high added value is attracting quite attention in recent years. In this context, production of activated carbon from biomass waste is also studied by researchers. Black carrot which is the main ingredient of turnip juice widely produced and consumed in Adana and Çukurova region is also a candidate to be a precursor of activated carbon. In the production of turnip juice, a certain amount of black carrot becomes waste due to the production techniques, and it may be considered suitable for source of activated carbon. In the current study, activated carbon synthesis from black carrot is carried out via $ZnCl_2$ activation process. In order to determine the structural properties to the synthesized activated carbon, analysis methods such as SEM, XRD, BET surface area, Raman, and FTIR spectroscopy tests are used. When it comes to electrochemical properties supercapacitor performance of the electrodes prepared using obtained activated carbon is evaluated via techniques such as cyclic voltammetry, galvanostatic charge-discharge and electrochemical impedance spectroscopy.

After preliminary experiments, supercapacitor electrodes formed by black carrot based activated carbon showed approximately 100 F/g specific capacitance at a current density of 0.1 A/g and 98% capacitance retention upon 3000 cycles of charge and discharge. These results demonstrate the high potential of the current study in supercapacitor applications.

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Structural and Magnetocaloric Features of $\text{PrBa}_{1-x}\text{Ca}_x\text{Mn}_2\text{O}_6$ ($0.6 \leq x \leq 1.0$) Double Perovskite for Magnetic Refrigeration

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As global energy demands increase, refrigeration systems are approaching their maximum efficiency limits while continuing to amplify greenhouse gas emissions [1]. The serious environmental and health risks caused by these methods compel urgent, sustainable alternatives [2, 3]. Magnetic refrigeration appears as a promising green technology to overcome these challenges, offering a more cost-effective, efficient, and eco-friendly solution compared to standard gas-compression cooling. This alternative system relies on the magnetocaloric effect, which can be explained by the temperature change when a material is exposed to an applied magnetic field. This cooling mechanism depends on the specific compound chosen, with the magnetic phase transition temperature and magnetic entropy change. To explore these features, this study investigates the magnetic and magnetocaloric behavior of the double perovskite compounds $\text{PrBa}_{1-x}\text{Ca}_x\text{Mn}_2\text{O}_6$, ($x = 0.6, 0.7, 0.8$, and 1.0) synthesized by the sol-gel method. At room-temperature, X-ray diffraction and Scanning Electron Microscopy with Energy-Dispersive X-ray Spectroscopy were utilized for structural, morphological, and elemental analyses of these compounds. Magnetic analysis through temperature-dependent and field-dependent magnetization measurements exhibits a ferromagnetic to paramagnetic phase transition changes between 40 and 140 K. Furthermore, the materials demonstrates a maximum magnetic entropy change of 1.72 to $3.34 \text{ J kg}^{-1}\text{K}^{-1}$ under an external applied magnetic field of 5 T . These findings show that the synthesized compounds are proper candidates for magnetic cooling applications in the low-temperature regime.

Keywords: Magnetocaloric effect; magnetic cooling systems; Double Perovskite; affordable and clean energy

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Critical Behavior and Magnetic Exchange Interactions in Double Perovskites: An Iterative Modified Arrott Plot and Kouvel-Fisher Analysis

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The growing demand for sustainable refrigeration technologies has driven extensive research into advanced magnetocaloric materials with tunable phase transition features. While conventional Arrott plots offer a primary qualitative hint of magnetic phase transitions, employing an iterative Modified Arrott Plot technique provides a significantly more rigorous analytical framework. By integrating a self-consistent [1] iterative algorithm, computational approach in this study systematically extracts critical parameters such as spontaneous magnetization and inverse initial susceptibility directly from high isothermal datasets without relying on arbitrary assumptions. Beyond eliminating manual curve-fitting ambiguities, this feedback loop captures refined shifts in magnetic ordering that stem from competing ferromagnetic and antiferromagnetic interactions within complex lattices. Coupling these iterated results with the Kouvel-Fisher [2] method further ensures exceptional internal consistency when determining precise critical exponents and transition temperatures. Furthermore, mapping the scaling behavior and analyzing the reliability of the derived exponents against standard universality classes clarifies on the microscopic nature of magnetic exchange. Ultimately, this methodology allows for a reliable evaluation of underlying exchange mechanisms, elevating the precision of magnetocaloric research and paving the way for optimized material design in future solid-state cooling applications.

Keywords: Magnetocaloric effect; Modified Arrott Plot; Spontaneous Magnetization; Computational Methods

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Electromagnetic Wave Absorption Performance of Electrically Tunable MoS₂@PANI/GE/MnO₂ Asymmetric Solid-State Cells

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Reconfigurable and electrochemically tunable microwave absorbers have gained critical importance for next-generation smart electronic systems and the defence industry [1]. In this work, asymmetric solid-state cells comprising a molybdenum disulfide (MoS₂)@Polyaniline (PANI) working electrode, a polyvinyl alcohol (PVA) + potassium hydroxide (KOH) gel electrolyte (GE), and a manganese dioxide (MnO₂) counter electrode were designed to evaluate their dynamic electromagnetic wave absorption properties under external electric fields (-100 V/cm to +100 V/cm) in the 8–12 GHz (X-band) range [2]. Five devices with systematically varied MoS₂:PANI mass ratios (100:0, 75:25, 50:50, 25:75, and 0:100%) were evaluated to elucidate the interplay between active ionic modulation and intrinsic dielectric loss.

Experimental results demonstrate that the pure MoS₂ cell (Device I) exhibits superior tunable characteristics, where applied electric fields enhance interfacial polarization via electric double-layer formation, improving the reflection loss (S₁₁) from -9 dB to -30 dB at 9.2 GHz [3]. Incorporating 25% PANI (Device II) established a continuous conductive network that boosted baseline absorption. At a 50:50 ratio (Device III), a polarity-dependent binary switching behavior emerged, where negative electric fields activated PANI doping, splitting the absorption states. Increasing the PANI fraction to 75% (Device IV) yielded peak attenuation, achieving an outstanding reflection loss of -36 dB at 9.3 GHz under -100 V/cm. Finally, the pure PANI device (Device V) showed threshold-controlled single-polarity switching at -100 V/cm. Across all devices, microwave attenuation was overwhelmingly driven by dielectric absorption shielding effectiveness (SE_A), while reflection (SE_R) remained below 0.5 dB. This study demonstrates a robust pathway to tailor tunable versus static microwave absorbers by adjusting 2D semiconductor/conducting polymer ratios in asymmetric architectures.

Keywords: Tunable Microwave Absorbers, MoS₂, Electrochemical Tuning, Asymmetric Solid-State Cell.

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Site-Selective Tuning of Magnetic Anisotropy in Monolayer Fe₃GaTe₂ via Fe Vacancies and Ru/Os Substitution

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Two-dimensional van der Waals ferromagnets such as Fe₃GaTe₂ are promising platforms for spintronic devices, yet their practical use requires controllable magnetic anisotropy [1]. Here, Fe vacancies and isovalent 4d/5d substitutions in monolayer Fe₃GaTe₂ are investigated using spin-polarized density functional theory including spin-orbit coupling. PAW-PBE+D3(BJ) calculations employed 2×2 supercells.

Following the total-energy-difference approach [2], the magnetocrystalline anisotropy energy (MAE) was defined as $E[100] - E[001]$; positive and negative values therefore indicate [001] out-of-plane and [100] in-plane easy axes, respectively. The pristine monolayer exhibits an MAE of 4.690 meV. Fe vacancies at either inequivalent site reverse the easy axis, producing MAEs of -4.888 and -5.366 meV.

Ru substitution preserves perpendicular anisotropy at both Fe sites, while Ru at Fe-II increases the MAE to 6.184 meV, 31.9% above the pristine value. Os is strongly site selective: Os at Fe-I yields -1.227 meV and an in-plane easy axis, whereas Os at Fe-II gives +3.160 meV and retains out-of-plane anisotropy. Atom-resolved spin-orbit energy analysis at Fe-I indicates that the Ru–Os contrast arises from competing dopant/Fe and Te contributions rather than atomic number alone.

These results identify Fe-site occupancy as a microscopic control parameter for the magnitude and sign of MAE in monolayer Fe₃GaTe₂. Fe vacancies enable easy-axis switching, whereas site-selective Ru/Os substitution offers a route to tune perpendicular anisotropy for low-dimensional spintronic applications.

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Investigation of Laser Photonic Sensor and Optical Properties

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In this study, CdO-doped ZnO powder samples were synthesized via the hydrothermal method using cadmium acetate and zinc acetate. X-ray diffraction (XRD) analysis was performed to determine the crystal structures of the synthesized samples. Subsequently, the optical properties of the powder samples were investigated to determine their optical band gap energies. CdO doping was carried out at ZnO:CdO molar ratios of 1:0.01, 1:0.2, 1:0.5, and 1:1. Among the CdO-doped ZnO samples, the lowest optical band gap energy was observed for the 1:1 CdO-doped ZnO sample, with a value of 2.97 eV, whereas the highest optical band gap energy was observed for the 1:0.2 CdO-doped ZnO sample, with a value of 3.19 eV [1,2].

Finally, scanning electron microscopy (SEM) analyses were performed to investigate the morphological changes induced by CdO doping. The obtained results confirmed that the crystal structures and band gap energies of the synthesized samples were consistent with those reported in the literature. It was determined that these materials have potential applications in various optoelectronic devices, including solar cells, transparent conductive electrodes, photodetectors, and phototransistors.

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Comprehensive Optoelectronic and Photodetectivity Profile of a Silicon Solar Cell under 370–1100 nm spectral range by Advanced Fytronix Photoreponse Systems

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This study presents an in-depth optoelectronic and phototransient analyses of a silicon (Si) photovoltaic cell from 370 to 1100 nm spectral range. To elucidate both the temporal kinetics and steady-state optical response, systematic current-voltage (I–V) loops, time-resolved current (I–t) profiling, and dynamic photoresponse times (rise/decay dynamics) were evaluated by photoresponsivity (R–t) and temporal specific detectivity (D*–t) characteristics.

To further unpack the wavelength-dependent charge collection efficiencies, spectral distributions including current-wavelength (I– λ), photoresponse-wavelength, spectral responsivity (R– λ), and spectral specific detectivity (D*– λ) were analyzed. The empirical results demonstrate strong photon harvesting capability, rapid switching speeds, and exceptionally stable photo-generated current across the near-ultraviolet, visible, and near-infrared bands. Beyond conventional light-to-electricity power conversion, these findings showcase the dual functionality of silicon solar cells as high-sensitivity, broad-spectrum photodetectors suitable for next-generation optoelectronic system integration.

Keywords: Silicon photovoltaics, Spectral responsivity (R), Specific detectivity (D*), Transient photoresponse

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Optical Characterization and Thickness Optimization of CaF₂ Thin Films on Al₂O₃ for 3–5 μ m Anti-Reflectance Applications

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In this study, CaF₂ thin films with different thicknesses were deposited onto an Al₂O₃ (sapphire) substrate, and the anti-reflectance (AR) properties of the resulting structure were investigated in the wavelength range of 3000–5000 nm. The CaF₂ film thicknesses were varied as 580, 610, 668.83, 720, and 800 nm. Among these thicknesses, 668.83 nm was selected as the target film thickness.

The wavelength-dependent refractive indices of the Al₂O₃ and CaF₂ materials indicate that both materials exhibit dispersion behavior in the infrared region. Since CaF₂ has a lower refractive index than Al₂O₃, it provides a more favorable optical impedance transition between the substrate and the surrounding medium, thereby contributing to a reduction in surface reflection. The reflectance curves obtained for the different CaF₂ film thicknesses demonstrate that changing the film thickness significantly affects the optical interference conditions within the 3000–5000 nm wavelength range. As the CaF₂ thickness changes, the position and spectral distribution of the reflectance minima also shift, allowing the operating wavelength region of the anti-reflective effect to be controlled. The curve corresponding to the target thickness of 668.83 nm represents a critical design point for achieving low reflectance in the 3–5 μ m spectral region. Consistent with the reflectance behavior, significant changes in the transmittance values are also observed. In wavelength regions where the reflectance decreases, the transmittance increases to approximately 98–99%. This result indicates that the CaF₂ film reduces the surface reflection of the Al₂O₃ substrate, thereby enhancing optical transmission.

In conclusion, the results demonstrate that the CaF₂ film thickness is an important parameter for controlling the anti-reflective performance in the 3000–5000 nm wavelength range when CaF₂ thin films with different thicknesses are deposited onto an Al₂O₃ sapphire substrate. The 668.83 nm CaF₂ film thickness was selected as the target thickness for the intended AR design, and this thickness provides a suitable coating configuration for achieving low reflectance and high transmittance in the 3–5 μ m MWIR region.

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Design Strategies for Next-Generation Liquid Crystal Mesogens: From Molecular Engineering to Supramolecular Functional Materials

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The rational design of liquid crystal mesogens has evolved beyond the synthesis of new molecular structures toward the development of functional materials with tailored thermal, optical, and dielectric properties. This presentation highlights contemporary molecular engineering strategies for next-generation thermotropic liquid crystals, focusing on carbamate-based architectures, cholesterol-derived mesogens, and hydrogen-bonded supramolecular systems. As a representative example, the synthesis of cholesteryl 4-ethylpiperazine-1-carboxylate (Cho-Etp) is presented to demonstrate the incorporation of heterocyclic functionality into a cholesteryl carbamate framework through the reaction of cholesteryl chloroformate with ethyl piperazine. The synthesized mesogen was structurally characterized by FTIR and ¹H NMR spectroscopy, while its thermal transitions and mesomorphic behavior were investigated using differential scanning calorimetry (DSC) and polarized optical microscopy (POM). Temperature-dependent dielectric properties were further examined by impedance spectroscopy to evaluate molecular polarization and relaxation behavior. Building upon this molecular design concept, recent approaches involving chalcone-containing mesogens, carbamate derivatives, hydrogen-bonded liquid crystalline assemblies, and polymer-supported supramolecular systems are discussed to illustrate how molecular architecture and intermolecular interactions can be systematically manipulated to tune mesophase stability and functional properties. These strategies provide a versatile framework for developing advanced liquid crystalline materials for dielectric, electro-optic, photonic, and responsive soft-matter applications [1-3].

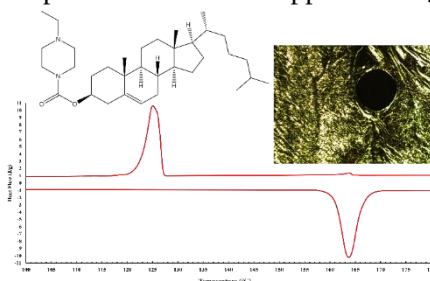


Figure 1: Thermal properties and molecular representation of Cho-Etp

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Density Functional Theory Investigation of the Structural and Electronic Properties of the Pt₃Ni (111) Surface

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Platinum–nickel (Pt–Ni) alloys are widely investigated as catalytic materials because Ni incorporation can modify the structural and electronic properties of Pt-based systems [1]. In this study, the structural and magnetic properties of bulk Pt₃Ni were investigated using spin-polarized density functional theory calculations within the Quantum ESPRESSO package and the Perdew–Burke–Ernzerhof generalized-gradient approximation [2]. A 108-atom Pt₃Ni supercell containing 81 Pt and 27 Ni atoms was constructed as a 3×3×3 replication of the four-atom Pt₃Ni unit cell. Brillouin-zone sampling was systematically examined using 1×1×1, 2×2×2, and 3×3×3 k-point meshes. Initial 1×1×1 (Γ-point) cell optimization reduced the calculated pressure from approximately –269 kbar to –0.51 kbar at celldm(1) ≈ 21.819 bohr. However, evaluation of the same configuration with a 2×2×2 k-point mesh yielded approximately –64.5 kbar, demonstrating a pronounced sensitivity of the equilibrium cell to k-point sampling. Subsequent 2×2×2 calculations identified celldm(1) = 21.6528 bohr as a near-equilibrium configuration, yielding a pressure of approximately +1.34 kbar and a total magnetization of approximately 34.7 μB per 108-atom cell. Final bulk calculations were therefore performed using a 3×3×3 k-point mesh, with wavefunction and charge-density cutoffs of 40 and 320 Ry, respectively. Following final bulk optimization, the converged Pt₃Ni structure will be used as the crystallographic reference for constructing a Pt₃Ni surface slab, establishing a consistent bulk-to-surface framework for subsequent surface relaxation, electronic-structure, adsorption, and reaction-mechanism studies.

Keywords: Density functional theory, Pt₃Ni, Pt–Ni alloy, surface relaxation, projected density of states, d-band center, catalysis.

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Development of PdCo-Modified NiFe₂O₄/Carbon Nanocomposites for Hydrogen and Oxygen Evolution Reactions

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The development of economically viable and highly active bifunctional electrocatalysts is essential for advancing alkaline water electrolysis as a sustainable route for hydrogen generation [1]. In this work, PdCo-modified NiFe₂O₄/carbon black nanocomposites were prepared through a combination of sol–gel and polyol synthesis techniques [2]. Their electrocatalytic activities toward the hydrogen evolution reaction (HER) and oxygen evolution reaction (OER) were investigated in 1 M KOH electrolyte at ambient temperature. Transmission electron microscopy (TEM) revealed a uniform distribution of PdCo nanoparticles across the carbon support. The average PdCo particle size was approximately 6 nm, whereas the NiFe₂O₄ particles remained smaller than 50 nm. Among the prepared samples, the PdCo₅+(NiFe₂O₄)₉₅/C nanocomposite displayed the most desirable microstructure and was therefore selected for comprehensive electrochemical characterization. The optimized catalyst delivered a HER onset potential of 59 mV versus the reversible hydrogen electrode (RHE) and required an overpotential of 250 mV to achieve a current density of 50 mA cm⁻², demonstrating favorable catalytic performance at elevated current densities relative to commercial Pt/C. During OER measurements, the catalyst exhibited an onset potential of 1.57 V versus RHE and an overpotential of approximately 1.59 V at 50 mA cm⁻². These findings indicate that PdCo/NiFe₂O₄/C nanocomposites possess promising bifunctional electrocatalytic properties for alkaline water splitting. Nevertheless, additional optimization of the catalyst composition and interfacial charge-transfer characteristics is necessary to further decrease the operating overpotential and enhance overall electrochemical efficiency.

Keywords: PdCo; NiFe₂O₄; HER; OER; ORR.

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Nanoscale Dynamics of Methylene Blue at the PD-1/SHP2 Interface: Evidence for Non-Specific Protein–Protein Interaction Disruption

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The clinical success of monoclonal antibodies targeting the extracellular PD-1/PD-L1 checkpoint has transformed cancer immunotherapy; however, resistance, immune-related toxicity, limited tumor penetration, and prolonged systemic exposure continue to motivate complementary small-molecule strategies. The intracellular recruitment of Src homology 2 domain-containing protein tyrosine phosphatase 2 (SHP2/PTPN11) to phosphorylated motifs in the PD-1 cytoplasmic tail represents a compelling but pharmacologically challenging point of intervention because it links checkpoint engagement to T-cell exhaustion. Methylene blue (MB), a clinically used phenothiazinium dye, has been proposed as a small-molecule modulator of the PD-1/SHP2 interaction, with preclinical studies suggesting reduced SHP2 recruitment, restoration of cytotoxic T-cell activity, and suppression of tumor growth [1]. Nevertheless, its classification as a target-selective PD-1/SHP2 inhibitor remains controversial, as MB has also been reported to inhibit structurally unrelated protein–protein interactions within overlapping low-micromolar ranges [2]. This critical narrative review evaluates the mechanistic biology of the PD-1/SHP2 signalosome and examines evidence supporting and challenging MB as a selective intracellular checkpoint modulator. Integration of the bidentate “anchor-and-switch” model of SHP2 activation with MB’s planar, cationic, redox-active, and optically active chemical properties suggests that its activity may involve broad physicochemical PPI-interference mechanisms, including surface masking, aggregation-related behavior, redox-linked effects, or assay interference, in addition to or instead of selective interfacial target engagement. Therefore, MB is best interpreted as a biologically active mechanistic probe for intracellular checkpoint modulation rather than a fully validated selective PD-1/SHP2 inhibitor. Orthogonal structural, biophysical, and functional validation will be essential to distinguish genuine target engagement from dye-class chemical or assay-related artifacts and to guide the rational development of next-generation small-molecule checkpoint modulators.

Keywords: Methylene Blue, PD-1/SHP2 Interaction, Protein–Protein Interaction, Small-Molecule Checkpoint Modulators, PAINS, Nanoscale Interactions

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Effect of Nitrogen Content on the Optical and Structural Properties of TiN Thin Films Deposited by DC Reactive Magnetron Sputtering

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In this study, TiN thin films were deposited on glass substrates using the DC reactive magnetron sputtering method at different nitrogen (N₂) flow ratios. The characterization of the deposited TiN films was carried out using optical and Raman spectroscopy techniques. The spectrophotometric measurements revealed that the optical transmittance of the films in the visible region decreased with increasing nitrogen content. The optical band gap values of the films were calculated using the derivative method, and an increase from 2.51 eV to 2.67 eV was observed with increasing nitrogen ratio. The observed Raman spectra correspond to the characteristic TiN modes, namely the second-order acoustic (2A) transverse optical (TO), combined acoustic-optical (A+O), and second-order optical (2O) modes centered at approximately 395 cm⁻¹, 542 cm⁻¹, 776 cm⁻¹, and 944-987 cm⁻¹, respectively. Additionally, a distinct second-order acoustic feature is detected at approximately 459 cm⁻¹. With increasing nitrogen content, a significant enhancement in Raman band intensities was observed, while no considerable shift in the band positions was detected. These changes indicate that the nitrogen ratio has an influence on the structural ordering, crystallization behavior, and defect structure of TiN thin films. The obtained results demonstrate that the nitrogen gas ratio, as one of the key deposition parameters, plays an important role in controlling not only the optical properties but also the structural characteristics of TiN thin films.

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Carbon Black-Supported Multifunctional Pd–Ni Nanoparticles: Magnetic Behavior and Electrocatalytic Activity

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Pd-Ni nanoparticles (NPs) exhibit enhanced magnetic and electrochemical properties that can be adjusted depending on size, shape, composition, and surface characteristics. There are a wide range applications of Pd-Ni NPs, especially in energy, environmental, and advanced materials technologies [1, 2]. In this study, Pd-Ni NPs were successfully synthesized using a modified polyol method and subsequently supported on carbon black (CB) to enhance their electrocatalytic activity. X-ray diffraction and Rietveld refinement analyses revealed that the NPs formed single phase face centered cubic crystal structure and have exhibit crystal sizes of 4.93 nm. Scanning electron microscopy images show that the average particle size of the NPs is below 10 nm. Pd-Ni NPs performances toward the hydrogen evolution (HER), oxygen reduction (ORR), and oxygen evolution (OER) reactions were evaluated by linear sweep voltammetry and cyclic voltammetry. Thus, in the HER activity of CB-supported NPs, the onset potential and 10 mA cm⁻² overpotential values were obtained as 48 mV and 76.7 mV vs. RHE, respectively. In the OER activity, the onset potential and 50 mA cm⁻² overpotential values were calculated as 1.53 V and 1.65 V vs. RHE, respectively. Furthermore, in ORR activity performed under oxygen gas, the onset potential and overpotential were determined as 710 mV and 730 mV vs. RHE, respectively. The blocking temperature was determined to be approximately 25 K from the magnetization-temperature curves. Accordingly, the NPs exhibit ferromagnetic behavior at low temperatures and gradually transition to a superparamagnetic state with increasing temperature. From the magnetization-magnetic field results, the maximum saturation magnetization was calculated to be 11.3 emu/g at 5 K, decreasing to 0.93 emu/g at 320 K. The coercive field was measured as 767.5 Oe at 5 K and 14.1 Oe at 320 K. These results indicate that the material exhibits ferromagnetic behavior at low temperatures, while its magnetic response evolves toward a paramagnetic state as the temperature increases.

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Thermodynamic and Mass Balance Simulation Analysis of a Tower-Type Concentrating Solar Power (CSP) Plant

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The simultaneous production of electricity and freshwater through concentrating solar power (CSP) plants equipped with thermal energy storage offers considerable energy and economic advantages in areas characterized by high levels of direct solar radiation and convenient access to seawater [1]. Studies conducted on this topic have yielded promising results [2-3]. From this perspective this study investigates the thermodynamic and mass balance dynamics of a 1.4 MW capacity plant. Within the scope of the research, an 8760-hour simulation model was developed in the MATLAB environment to evaluate the effects of thermal power obtained from the solar field on the receiver, the charge/discharge mechanisms of the Thermal Energy Storage (TES) system, and the performance of wet/dry cooling systems. For system optimization, a Proportional-Integral-Derivative (PID) controller was utilized; the fluid mass flow rate was dynamically adjusted to successfully stabilize the target fluid temperature of 550°C, reducing the PID error RMS value from 15.2°C to 8.7°C. The analysis results demonstrate that the established analytical model meets the thermodynamic criteria with high accuracy and enhances the system's adaptation to environmental conditions. This developed model provides a significant contribution to the CSP technologies literature by offering a scalable infrastructure suitable for future Direct Steam Generation (DSG) integrations and dynamic optical efficiency optimizations.

Keywords: Concentrated Solar Power (CSP), Thermal Energy Storage (TES), PID Control, MATLAB Simulation, Solar Tower.

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Engineering Band Gap through BaTiO₃- PCL/PVC Nanocomposites: A Study of Optical, Structural, Morphological, and Thermal Properties

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This study aims to investigate the effect of different barium titanate (BaTiO₃) nanocomposite contents on the structural, optical, and thermal properties of PCL/PVC blend polymer matrices. The structural and optical properties of PCL/PVC blend/BaTiO₃ nanocomposites were characterized by X-ray diffraction(XRD), Fourier Transform Infrared Spectroscopy (FT-IR) and Ultraviolet Spectrometry (UV-Vis). Thermal properties were investigated by performing Differential Scanning Calorimetry (DSC) analyses.

Polyvinyl chloride (PVC) was employed as the polymer matrix, methyl ethyl ketone (MEK) as the solvent, and BaTiO₃ nanoparticles (99.9% purity) as the ceramic filler. The PCL/PVC blend exhibits an amorphous structure. With the incorporation of BaTiO₃, distinct diffraction peaks corresponding to the perovskite phase (e.g., (100), (101), (200), (211), and (220)) emerge and sharpen, indicating successful embedding and crystallization of BaTiO₃ within the polymer matrix. This suggests that the bandgap energy (E_g) of the blend sample is approximately 5.03 eV, however, upon BaTiO₃ incorporation, the material exhibited semiconducting behavior, and with increasing additive concentration, the forbidden energy gap was observed to decrease progressively, reaching as low as 2.5 eV. The thermogravimetric (TG) curves of PCL/PVC blend and PCL/PVC/BaTiO₃ composites reveal a clear improvement in thermal stability with increasing BaTiO₃ content. The pure PVC blend begins its major decomposition around 284 °C, corresponding to the onset of dehydrochlorination a typical degradation process for PCL/PVC. As BaTiO₃ nanoparticles are incorporated (10–50 wt%), the initial degradation temperature shifts slightly to higher values, and the residual mass at 435 °C increases from 78% (blend) to 53% (50% BaTiO₃). Endothermic peaks observed from DSC curves indicated that thermal stability was increased with the addition of BaTiO₃. The ATR-FTIR spectrum of the PCL/PVC blend exhibited the characteristic absorption bands associated with both polymer components. The bands observed at 2943 and 2864 cm⁻¹ were assigned to the aliphatic C–H stretching vibrations, predominantly arising from the –CH₂– groups of both PCL and PVC chains.

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Innovating for Tomorrow: Strategic Vision in Next-Generation Materials and Manufacturing

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The translation of tailored nanoscale architectures into commercial functional hardware requires overcoming systemic barriers between molecular synthesis and high-throughput production lines. This work introduces an integrated manufacturing taxonomy designed to incorporate engineered quantum dots, functionalized 2D heterostructures [1], and adaptive phase-change nanomaterials into solid-state electronic and optoelectronic products [2]. By employing a multitier interface control protocol [1], we address the critical degradation of electrical conductivity and mechanical stability that typically occurs during the transfer from lab-scale synthesis to continuous roll-to-roll and additive fabrication workflows. Automated in-line metrology and machine-learning-assisted defect recognition are implemented to maintain structural fidelity across macroscopic device dimensions [3]. The proposed framework establishes a verifiable pathway for scaling functionalized nanomaterials into high-value consumer technologies, high-density energy storage units [4], and real-time structural health sensors without sacrificing nanoscale-specific physical properties.

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Effect of Growth Temperature and Substrate on the Electrochemical Performance of Manganese Oxide Thin Films Grown by RF Reactive Sputtering

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In this study, undoped MnO₂ thin films were grown on carbon cloth (CC) and ITO substrates at room temperature (RT), 100°C, and 150°C via reactive RF magnetron sputtering [1], and the effects of growth temperature and substrate type on electrochemical performance were investigated using cyclic voltammetry (CV) and galvanostatic charge-discharge (GCD) measurements. At all growth temperatures, CC substrates exhibited significantly higher performance than ITO, with the best result obtained for the CC film grown at 100°C (~4.65 mF cm⁻²). SEM images confirmed that this sample possessed a denser and more homogeneous nanosheet structure, consistent with previously reported MnO₂ nanosheet arrays grown on carbon cloth [2]. Furthermore, all applied annealing treatments were found to degrade performance, an effect attributed to macro-cracks formed within the film and in agreement with literature reports on the adverse impact of thermal annealing on MnO₂-based electrodes [3]. These findings indicate that CC substrates combined with low-to-moderate growth temperatures are more suitable for the development of flexible MnO₂-based supercapacitor electrodes.

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Role of Ag Precursor Stacking Sequence in Enhancing the Properties of CZTS Thin-Film Photodetectors

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Cu₂ZnSnS₄ (CZTS) is a promising earth-abundant, non-toxic, and low-cost semiconductor for optoelectronic and photovoltaic applications owing to its suitable direct band gap and high absorption coefficient [1,2]. However, its practical performance is limited by intrinsic defects and poor crystallinity. Elemental substitution has emerged as an effective strategy to improve the structural and electronic properties of CZTS [3]. In this study, the effects of Ag incorporation on the structural, morphological, optical, and photodetection properties of Cu₂ZnSnS₄ (CZTS) thin films were investigated. The Ag-doped CZTS thin films were fabricated by magnetron sputtering and subsequently sulfurized using a rapid thermal processing (RTP) system using different precursor stacking configurations: ZnS/Cu/Sn/Cu (CZTS-I), ZnS/Cu/Sn/Cu/Ag (CZTS-II), ZnS/Cu/Sn/Ag/Cu (CZTS-III), ZnS/Cu/Ag/Sn/Cu (CZTS-IV), ZnS/Ag/Cu/Sn/Cu (CZTS-V), and Ag/ZnS/Cu/Sn/Cu (CZTS-VI). XRD and Raman analyses confirmed the successful formation of kesterite CZTS, while Ag incorporation significantly influenced the crystal structure and lattice properties. Raman spectroscopy confirmed the formation of the kesterite CZTS phase and showed that the Cu₂SnS₃ (CTS) secondary phase present in the undoped film was effectively suppressed after Ag incorporation. SEM analysis revealed improved grain growth and denser film morphology. The optical band gap increased from 1.44 eV for the undoped CZTS film to 1.54 eV for CZTS-V, indicating that Ag incorporation modifies the electronic structure. Photoluminescence measurements showed an emission peak around 1.37 eV associated with donor–acceptor pair recombination, while CZTS-IV exhibited the highest PL intensity, suggesting reduced non-radiative recombination. In addition, the Urbach energy decreased with optimized Ag positioning, reaching a minimum value of 279 meV for CZTS-IV, which reflects improved structural order. Current–voltage measurements demonstrated linear ohmic behavior under both dark and illuminated conditions. The CZTS-IV photodetector achieved the fastest response with rise and fall times of 11 ms, whereas CZTS-II exhibited the highest responsivity (2.40 mA/W), specific detectivity (3.4×10^8 Jones), and external quantum efficiency (0.662) under blue-light illumination. The results demonstrate that both Ag incorporation and precursor stacking sequence play a critical role in controlling film growth, defect density, and photodetector performance, highlighting the potential of Ag-doped CZTS thin films for high-performance visible-light optoelectronic devices.

Keywords: Ag doped CZTS (ACZTS), Sputtering, Thin-film photodetector, RTP

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Optimization of TMIn Flow for Enhanced Structural and Surface Quality of InGaAs Layers in QCL Heterostructures

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Quantum cascade lasers (QCLs) are semiconductor light sources whose performance strongly depends on the precise control of layer composition, crystalline quality, and heterointerface properties within the active-region structure [1,2]. In InGaAs/InAlAs-based QCL heterostructures, optimization of the epitaxial growth conditions is therefore essential to obtain high-quality layers with suitable lattice matching and well-controlled interfaces [3,4].

In this study, the effect of trimethylindium (TMIn) flow rate on the structural and surface properties of InGaAs layers was systematically investigated to determine suitable growth conditions for QCL heterostructures. Six samples were grown under identical growth temperature, TMGa flow, and AsH₃ flow conditions, while only the TMIn flow rate was varied. The resulting layers were characterized by X-ray diffraction (XRD) and atomic force microscopy (AFM) to evaluate variations in In incorporation, crystalline quality, lattice matching, and surface morphology.

XRD measurements revealed a systematic change in the InGaAs diffraction peak position with increasing TMIn flow, together with lower FWHM values at intermediate flow conditions. AFM measurements similarly indicated improved surface morphology and reduced roughness within an intermediate TMIn flow range, whereas higher and lower flow conditions resulted in comparatively rougher surfaces.

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Growth-Temperature Dependence of Si δ -Doped $\text{Al}_x\text{Ga}_{1-x}\text{As}$ for GaAs-Based Laser Diode Structures

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Recent developments in GaAs-based laser diodes have increasingly focused on the optimization of epitaxial heterostructures to improve device performance. In InGaAs/AlGaAs laser structures, AlGaAs plays an essential role in carrier transport and optical confinement, while its electrical properties are strongly influenced by Al composition and doping conditions [1,2]. Previous studies have further demonstrated that the carrier concentration in Si-doped $\text{Al}_x\text{Ga}_{1-x}\text{As}$ is highly sensitive to epitaxial growth conditions, including growth temperature and δ -doping parameters [2,3]. Therefore, precise control of the epitaxial growth parameters of doped $\text{Al}_x\text{Ga}_{1-x}\text{As}$ layers is important for the further development of efficient laser diode structures.

In this study, the influence of growth temperature on Si δ -doped $\text{Al}_x\text{Ga}_{1-x}\text{As}$ was investigated. The layers were epitaxially grown on undoped GaAs substrates by metal-organic chemical vapor deposition (MOCVD) at 600, 650, and 700 °C, while the precursor flow rates, reactor pressure, and growth duration were maintained constant to isolate the effect of growth temperature. The structural, electrical, and optical properties of the grown layers were evaluated using high-resolution X-ray diffraction (HRXRD), Hall-effect measurements, photoluminescence (PL), Raman spectroscopy, and spectroscopic ellipsometry. HRXRD and Hall-effect measurements revealed a clear growth-temperature-dependent trade-off between Al incorporation and electrically active carrier concentration, with the Al composition decreasing while the carrier concentration increased as the growth temperature was raised. This variation in Al composition also affected the optical and lattice properties of the layers, as evidenced by systematic shifts in the PL and Raman spectra. In addition, the optical quality of the layers was observed to deteriorate with increasing growth temperature. Consistently, spectroscopic ellipsometry showed corresponding changes in the wavelength-dependent refractive index (n) and extinction coefficient (k), demonstrating the strong influence of growth temperature on the structural, electrical, and optical properties of the $\text{Al}_x\text{Ga}_{1-x}\text{As}$ layers.

The combined characterization provides insight into the growth-temperature dependence of Si δ -doped $\text{Al}_x\text{Ga}_{1-x}\text{As}$ and contributes to the optimization of AlGaAs epitaxial layers for GaAs-based laser diode structures.

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Electrochemical study of a multiphase Pt, Co, Ni ternary nanoalloy as ORR Catalyst

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Proton Exchange Membrane Fuel Cells, utilizing in great extent Pt based catalysts in its MEA layers [1]. On the other hand due to scarcity and high price of Pt, forming nanoalloys with cheaper transition metals is one of the most promising techniques to obtain efficient and cheap PEM-FC catalyst materials [2]. Polyol method is a robust and well-known technique to synthesize single phase, binary and ternary nanoalloys [3]. Whereas, especially during ternary catalyst synthesis, additional phases may appear in particle matrix. In this presentation electrochemical study of a ternary metal nanoalloy of Pt, Ni and Co is made. Multiphase nature of the nanoalloy determined with XRD method. Cyclic voltametry and linear sweep voltametry (LSV) measurements made using a 3 M KCl Ag/AgCl reference electrode, 0,1963 cm² graphite working electrode and 1 cm² Pt-plate counter electrode set and a Gamry potentiostat. Considering LSV for oxygen reduction reaction region, onset potential was determined as -120 mV (vs. Ag/AgCl) and overpotential at -520 mV (vs. Ag/AgCl) and minimum current measured is 6.87 mA at overpotential.

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Effect of Sputtering Pressure on Surface Morphology and Magnetic Domain Evolution of DC Magnetron-Sputtered Ni₅₂Mn₃₃Ga₁₅ Thin Films Deposited on Glass Substrates

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In this study, 100 nm Ni₅₂Mn₃₃Ga₁₅ thin films were deposited on glass substrates by DC magnetron sputtering under Ar working pressures of 4–15 mTorr while maintaining constant deposition parameters. Surface morphology and magnetic domain evolution were investigated by Atomic Force Microscopy (AFM) and Magnetic Force Microscopy (MFM), respectively. Surface roughness was quantitatively evaluated using the arithmetic average roughness (R_a), root mean square roughness (R_q), and maximum height (R_z).

The AFM results revealed that increasing the sputtering pressure significantly increased the surface roughness, with R_a rising from 1.5 nm at 4 mTorr to 5.8 nm at 15 mTorr, accompanied by corresponding increases in R_q and R_z . Three-dimensional AFM images confirmed the transition from smooth and compact surfaces to coarse island-like morphologies with increasing pressure, which is attributed to reduced adatom mobility during film growth.

MFM measurements showed that the magnetic domain configuration also depends on the sputtering pressure. While films deposited at low pressures exhibited weak magnetic contrast, intermediate pressures produced more distinct magnetic domains. At higher pressures, increased surface roughness resulted in less uniform magnetic domain distributions, suggesting enhanced domain-wall pinning and local magnetostatic variations. The close agreement between AFM and MFM observations demonstrates that sputtering pressure effectively controls both surface evolution and nanoscale magnetic behavior. These findings provide useful insight into optimizing Ni-Mn-Ga Heusler alloy thin films for magnetic and spintronic applications [1].

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Magnetic Transition and Magnetocaloric Response of $\text{La}_{0.6}\text{Eu}_{0.1}\text{Sr}_{0.2}\text{Ca}_{0.1}\text{MnO}_3$ Manganite

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Magnetic refrigeration (MR) utilizes the temperature change induced in a magnetic material by an applied magnetic field, known as the magnetocaloric effect (MCE), and offers an energy-efficient and environmentally friendly alternative to conventional cooling technologies [1]. The operating temperature range strongly governs the choice of magnetocaloric material for MR applications. Among the various material classes, perovskite manganites are particularly attractive due to their tunable magnetic transition temperature and magnetocaloric response through chemical substitution, as well as their low cost, chemical stability, and low magnetic hysteresis [1, 2]. In this study, we investigated the structural, magnetic, and magnetocaloric properties of $\text{La}_{0.6}\text{Eu}_{0.1}\text{Sr}_{0.2}\text{Ca}_{0.1}\text{MnO}_3$ manganite synthesized by the sol–gel method. The structural properties of the sample were characterized by using X-ray diffraction (XRD). The surface morphology and elemental composition were examined by scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDS). The temperature and magnetic field dependent magnetization measurements were performed using a Physical Property Measurement System (PPMS). The $\text{La}_{0.6}\text{Eu}_{0.1}\text{Sr}_{0.2}\text{Ca}_{0.1}\text{MnO}_3$ manganite undergoes a second order ferromagnetic to paramagnetic phase transition at 282.7 K. Under a magnetic field change of 5 T, the maximum magnetic entropy change ($-\Delta S_M^{\text{max}}$) and the relative cooling power (RCP) of the $\text{La}_{0.6}\text{Eu}_{0.1}\text{Sr}_{0.2}\text{Ca}_{0.1}\text{MnO}_3$ sample were calculated to be 5.42 Jkg⁻¹K⁻¹ and 248.2 Jkg⁻¹, respectively. The observed magnetocaloric response near room temperature suggests that $\text{La}_{0.6}\text{Eu}_{0.1}\text{Sr}_{0.2}\text{Ca}_{0.1}\text{MnO}_3$ could be a promising candidate for near-room-temperature magnetic refrigeration applications.

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Effects of Ge and Sn Doping on the Photovoltaic Performance of CsSiF₃ Perovskite Solar Cells

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The increasing global energy demand and associated environmental concerns have intensified the search for efficient and sustainable renewable energy technologies. Halide perovskites have attracted considerable attention for photovoltaic applications owing to their tunable band gaps, strong optical absorption, favorable charge-carrier transport properties, and potential for low-cost fabrication [1]. In particular, compositional engineering through elemental substitution provides an effective strategy for tailoring the structural, electronic, mechanical, and optical properties of perovskite absorbers. In this study, first-principles density functional theory (DFT) calculations were performed to investigate the effects of Ge and Sn doping on the structural, electronic, elastic, and optical properties of CsSiF₃ over doping concentrations ranging from 0 to 100%. The calculated elastic properties indicate that the investigated compositions satisfy the relevant mechanical stability criteria. Electronic structure calculations show that pristine CsSiF₃ exhibits a direct band gap of approximately 1.1 eV, suggesting its potential for photovoltaic applications. The total density of states (TDOS) and charge-density-difference analyses further provide insight into the contributions of the constituent atoms to the electronic states and charge redistribution within the material. To evaluate the photovoltaic potential of the investigated absorber compositions, a lead-free perovskite solar cell with the FTO/TiO₂/CsSiF₃/Spiro-OMeTAD/Au architecture was modeled using SCAPS-1D [2]. The effects of the absorber composition and charge-transport layers on device performance were systematically examined. Among the investigated Ge-doped compositions, 50% Ge doping provided the best photovoltaic performance, yielding a power conversion efficiency (PCE) of 29.29%, an open-circuit voltage (V_{OC}) of 1.44 V, a short-circuit current density (J_{SC}) of 34.95 mA cm⁻², and a fill factor (FF) of 54.55%. For Sn doping, the 50% composition exhibited the highest performance, with a PCE of 30.00%, V_{OC} of 0.98 V, J_{SC} of 37.10 mA cm⁻², and FF of 77.60%. These findings demonstrate that compositional engineering through Ge and Sn substitution can effectively tune the optoelectronic properties of CsSiF₃ and improve its photovoltaic performance, highlighting doped CsSiF₃ as a promising lead-free absorber material for next-generation perovskite solar cells.

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Keywords: CsSiF₃, DFT, Doped, Electronic, Optic, SCAPS-1D, Solar cells

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The Preparation of PVA based nanofibers by Electrospinning System

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Electrospinning of poly(vinyl alcohol) (PVA)-based nanofibers is one of the fundamental nanotechnology methods that has received considerable attention in the literature due to its properties, high surface area, biocompatible structure, and water solubility. In the electrospinning process of PVA solution, parameters such as voltage, flow rate, distance, and concentration are crucial in influencing fiber diameter and beading. Electrospinning can fabricate polymeric fibers ranging from the micro- to the nanoscale. It is an easy, simple, and low-cost technique that does not require heat, an important factor for sensitive compounds. Additionally, it is important to add PVA with other polymers and nanomaterials to improve its mechanical strength, water resistance or functionality. Poly(vinyl alcohol) (PVA) is one of the most studied polymers in the literature for nanofiber production by electrospinning, thanks to its water solubility, biocompatibility, non-toxic and high film-forming ability. To improve the electrical conductivity and mechanical properties of PVA, doped structures are widely investigated for many applications such as photocatalytic treatment, antibacterial surface applications, and drug delivery systems [1-3].

Keywords: PVA, Electrospinning, nanofiber

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Mg-Al LDH/g-C₃N₄ Hybrid Nanomaterials for Next-Generation Biodegradable Food Packaging

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The present work explores the development of multifunctional chitosan-based films, which have gained significant attention in sustainable food-packaging applications due to the ability of nanoparticle incorporation to overcome their inherent mechanical and barrier limitations [1, 2]. To leverage the synergistic advantages of two-dimensional (2D) layered structures, a 2D/2D hybrid system was obtained by integrating graphitic carbon nitride (g-C₃N₄) with magnesium–aluminum layered double hydroxide (Mg-Al LDH) [3]. This hybrid nanostructure was subsequently introduced into the chitosan matrix at different concentrations (0, 0.25, 0.5, 0.75, and 1 wt%) to evaluate its multifunctional enhancements. The incorporation of the hybrid nanostructure was investigated as a strategy for tailoring the physicochemical and functional properties of the resulting films. Accordingly, the prepared nanocomposite films were systematically evaluated in terms of their mechanical performance, thermal stability, barrier behavior, and bioactive characteristics. The application of the developed films contributed to maintaining the quality of the packaged fruits throughout storage. While the firmness of the untreated samples declined to approximately 6 N, the film containing 1 wt% of the hybrid nanostructure (KFGL100) limited fruit weight loss to approximately 23%. The improved performance was attributed to the synergistic interaction between the Mg-Al LDH/g-C₃N₄ hybrid structure and the chitosan matrix, which contributed to the formation of a more effective barrier structure within the chitosan matrix. Overall, the developed chitosan-based nanocomposite films demonstrate considerable potential as sustainable and multifunctional materials for active food-packaging applications. The work presented in this abstract is based on a manuscript currently under consideration for publication.

Keywords: Biopolymers, Food Packaging, Chitosan, g-C₃N₄, Mg-Al LDH, 2D/2D Nanocomposites.

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Exceptional UV Shielding Properties of Corn Starch-Based Polymer Composite Films Modified with Mg-Al LDH/g-C₃N₄ Nanostructures

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The development of biopolymer-based nanocomposites with advanced optical barrier properties has attracted a lot of attention in the domain of sustainable packaging and protective film applications [1-3]. In this study, the UV-Vis absorbance, transmittance and overall UV protection efficiency of corn starch based polymer composite films incorporated with different concentrations (0%, 0.25%, 0.5%, 0.75% and 1%) of a binary Mg-Al LDH/g-C₃N₄ nanostructure system were investigated. Spectroscopic analysis showed that the successful integration of the nanostructures into the polymer matrix significantly modified the optical properties of the films. UV-Vis absorbance spectra showed a linear increase with concentration at all wavelengths, particularly in the UV region (200–400 nm). Importantly, the addition of 1% Mg-Al LDH/g-C₃N₄ enhanced the UV absorbance at 300 nm with about 180% higher than the neat corn starch film (CSGL0), which indicated a strongly photon absorption ability. The composite films were transparent in the visible light spectrum (400–800 nm), with transmittance at 600 nm decreasing from about 85% (neat film) to near 62% (1% modified film) proportionally, but the outstanding UV shielding performance was their defining characteristic. The binary nanoparticle system synergistically enhanced the protective barrier capabilities at all high energy light spectrums. The quantitative UV shielding analysis showed that the blocking of UVC, UVB, UVA, and High Blue Energy Light (HBEL) was improved continuously with increasing additive concentration. The highest efficiency of shielding was obtained in the 1% modified composite (CSGL100) as compared to the pristine film. These results verify that the Mg-Al LDH/g-C₃N₄ binary system is a very effective method for preparing biodegradable polymer films with high UV and blue light shielding properties.

Keywords: UV-Shielding, Biopolymers, Corn Starch, g-C₃N₄, Mg-Al LDH, 2D/2D Nanocomposites.

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Optical and Photocatalytic Properties of Composition-Controlled NiCoFe₂O₄ Nanoparticles

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Spinel Ni_xCo_{1-x}Fe₂O₄ (x: 0.25, 0.50, and 0.75) nanoparticles (NPs) is an important nano-structured magnetic material because adjusting the nickel (x) and cobalt ratio fine-tunes its magnetic, electrical, and catalytic properties for advanced tech and environmental uses [1] with different Ni/Co ratios were synthesized to investigate the effect of composition on their optical and photocatalytic properties [2]. The samples, namely Ni_{0.25}Co_{0.75}Fe₂O₄ (NCF-1), Ni_{0.50}Co_{0.50}Fe₂O₄ (NCF-2), and Ni_{0.75}Co_{0.25}Fe₂O₄ (NCF-3), were evaluated for the degradation of 10 ppm methylene blue (MB) solution under UV–Vis irradiation for 180 min. The degradation efficiencies were determined to be 78.9%, 51.8%, and 44.3% for NCF-1, NCF-2, and NCF-3, respectively, indicating that the photocatalytic activity strongly depends on the Ni/Co ratio. The optical band gap energies, estimated from UV–Vis absorption spectra using Tauc equation with indirect allowed electronic transition, were calculated as 1.813, 1.811 and 1.807 eV for NCF-1, NCF-2 and NCF-3, respectively. Although the band gap values were very close to each other, the photocatalytic performance varied considerably, suggesting that compositional modification plays a important role in determining photocatalytic efficiency. Among the synthesized NPs, the Co-rich NCF-1 sample exhibited the highest photocatalytic activity toward MB degradation. These findings demonstrate that tuning the Ni/Co ratio is an effective strategy for optimizing the optical response and photocatalytic performance of spinel NiCoFe₂O₄ NPs. The obtained results indicate that Co-rich NiCoFe₂O₄ NPs are promising photocatalysts for the removal of organic dye pollutants from aqueous environments.

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Optical and Raman Characterization of Ga₂O₃ Thin Films Grown at Different Oxygen Ratios by RF Magnetron Sputtering

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In this study, Ga₂O₃ thin films were grown by RF magnetron sputtering in an Ar/O₂ atmosphere with different oxygen ratios (0–5%) and subsequently annealed in air at 850 °C for 1.5 h. The optical and vibrational properties of the as-deposited and annealed films were investigated using UV–Vis and Raman spectroscopy. All samples exhibited a distinct absorption edge in the UV region, while the transmittance values were generally above 95% at wavelengths longer than approximately 300 nm. In addition, the effects of oxygen ratio and annealing on the optical band gap were evaluated [1].

Raman spectra of the as-deposited samples showed bands at approximately 430 and 573 cm⁻¹, associated with α-Ga₂O₃ [2]. After annealing, characteristic β-Ga₂O₃ modes became more pronounced, including GaO₆ octahedral vibrations in the 300–500 cm⁻¹ range, GaO₄ tetrahedral vibrations in the 600–700 cm⁻¹ range, and a characteristic high-frequency mode near 766 cm⁻¹. These results indicate that annealing promotes structural rearrangement and the formation of the β-Ga₂O₃ phase. Overall, oxygen ratio and annealing play an important role in determining the optical and vibrational properties of Ga₂O₃ thin films, demonstrating their potential for solar-blind UV photodetector and optoelectronic applications[2-4].

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A viable asymmetric molecular engineering for extremely high solubility and green solvent processed organic field-effect transistors

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Developing novel structural engineering strategies to solubilize high-mobility organic semiconductors is essential for enabling green-solvent processing, sustainable device fabrication, and tailored molecular properties.[1,2] Here, we report a viable asymmetric functionalization strategy to synthesize monocarbonyl [1]benzothieno[3,2-b][2]benzothiophene (BTBT) derivatives on a gram scale via a two-step, transition-metal-free protocol. The resulting asymmetric functionalization yields an unprecedented room-temperature solubility of up to 176.0 mg·mL⁻¹ the highest reported to date for high-performance organic semiconductors. Single-crystal X-ray diffraction reveals a herringbone packing motif stabilized by multiple edge-to-face interactions and nonclassical hydrogen bonds featuring the carbonyl moiety, while antiparallel backbone arrangements facilitate strong face-to-face π - π stacking. The synthesized mono(alkyl-aryl)carbonyl-BTBT derivative, m-C6PhCO-BTBT, enables stable formulations in eco-friendly solvents such as acetone and ethanol. Solution-processed, p-channel top-contact/bottom-gate organic field-effect transistors (OFETs) fabricated under ambient conditions exhibit high charge carrier mobilities up to 1.87 cm²·V⁻¹·s⁻¹ ($\mu_{\text{eff}} \approx 0.4$ cm²/V·s; Ion/Ioff ≈ 107 –108), representing one of the highest OFET performances recorded for green-solvent processing. Hansen Solubility Parameter (HSP) analysis, integrated with Scatchard–Hildebrand regular solution theory and single-crystal packing calculations, elucidates the thermodynamic origin of this exceptional solubility by establishing precise relationships between molecular structure, interaction energy densities, cohesive energetics, and solute–solvent interaction distances (Ra) This work demonstrates that tuning the solute–solvent interaction distance in HSP space is pivotal for optimizing thin-film morphology and provides a general design framework for green-solvent-processable π -conjugated materials in sustainable optoelectronics and bioelectronics.

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Comparative Analysis of Structural and Magnetic Behaviour in $\text{Co}_{1-x}\text{Y}_x$ ($\text{Y} = \text{Cu}$ and Gd) Magnetic Nanoparticles Synthesized by the Polyol Process

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Cobalt-based magnetic nanoparticles have attracted considerable attention for spintronic devices and high-density magnetic data storage because their saturation magnetization (M_s), remanent magnetization (M_r), coercivity (H_c), effective magnetic anisotropy (K_{eff}) and thermal stability can be tailored through compositional and structural modifications [1-3]. In this study, the structural, morphological, and magnetic properties of $\text{Co}_{1-x}\text{Y}_x$ ($\text{Y} = \text{Cu}$ and Gd ; $x = 0.05, 0.10$, and 0.15) nanoparticles synthesized by the polyol method were comparatively investigated. X-ray diffraction analyses revealed the coexistence of face-centred cubic (fcc) and hexagonal close-packed (hcp) Co phases, with the dopant type and concentration significantly influencing phase stability, crystallite size, and lattice strain. Cu incorporation progressively reduced the crystallite size, promoted grain refinement, and favoured the stabilization of the fcc phase. In contrast, Gd incorporation caused pronounced lattice distortions and expansion along the c-axis of the hexagonal phase, contributing to its structural stabilization. Scanning electron microscopy showed that Cu doping produced relatively compact and uniform nanoparticles with reduced agglomeration, whereas increasing Gd content resulted in more porous and fragmented morphologies. The magnetic measurements demonstrated distinctly different effects for the two dopants. The $\text{Co}_{0.90}\text{Cu}_{0.10}$ sample exhibited the highest M_s , reaching $100.10 \text{ emu g}^{-1}$ at 10 K and 99.97 emu g^{-1} at 300 K, together with enhanced magnetic blocking and thermal stability. This behaviour was associated with improved structural coherence, grain refinement, and reduced surface-spin disorder. Conversely, increasing Gd concentration caused a marked reduction in M_s , M_r , H_c , and K_{eff} . At 15% Gd, the M_s decreased to 10.94 emu g^{-1} at 10 K and 9.13 emu g^{-1} at 300 K, indicating weakened ferromagnetic exchange interactions and a progressive transition towards superparamagnetic behaviour. These findings demonstrate that Cu doping enhances ferromagnetic interactions and thermal stability at an optimum concentration, whereas Gd doping promotes magnetic softening and spin relaxation.

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CÜNAM: A National Research Infrastructure for Epitaxy, Semiconductor, Photonic, and Advanced Material Technologies

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Semiconductor, photonic, epitaxial, and advanced material technologies are key enablers for a wide range of strategic applications, including defense, communications, sensing, imaging, energy, and environmental monitoring. Building sustainable research and development capacity in these fields requires not only highly qualified human resources but also an integrated research infrastructure capable of combining epitaxial material growth, thin-film deposition, fabrication, characterization, and device-oriented research. CÜNAM–Sivas Cumhuriyet University Nanophotonics Application and Research Center operates as a national research infrastructure with a multidisciplinary research framework focused on epitaxy, semiconductor technologies, photonics, and advanced materials.

A major strength of CÜNAM is its capability in the development of semiconductor materials and heterostructures through epitaxial growth technologies. The Center’s research activities encompass quantum cascade lasers, SWIR/e-SWIR photodetectors, tandem solar cells, vertical-cavity surface-emitting lasers (VCSELs), ultraviolet and blue light-emitting diodes (LEDs), ultra-wide-bandgap semiconductors, supercapacitors, optical coatings, and thin-film technologies. Its MOCVD, CVD, and sputtering systems support the development of advanced epitaxial layers, heterostructures, and functional thin films, while characterization techniques including HR-XRD, AFM, photoluminescence and Raman spectroscopy, Hall measurements, and ECV provide comprehensive structural, optical, and electrical evaluation. This integrated infrastructure enables research extending from fundamental material and epitaxy studies to advanced semiconductor structures and optoelectronic device technologies.

Another core component of CÜNAM’s national research infrastructure mission is the development of highly qualified human resources and the transfer of technological know-how. Researchers from different disciplines, together with undergraduate and graduate students, actively participate in research activities, supporting hands-on training in epitaxy, semiconductor processing, characterization, and advanced material technologies. National and international R&D projects, as well as collaborations with universities, research institutions, and industrial partners, further strengthen the Center’s role within the broader semiconductor and photonics research ecosystem.

This presentation will provide an overview of CÜNAM’s capabilities as a national research infrastructure, with particular emphasis on epitaxial growth, semiconductor and photonic technologies, advanced materials, characterization infrastructure, and human resource development. Selected R&D activities will be used to illustrate the Center’s integrated approach, spanning epitaxial material and heterostructure development, structural, optical and electrical characterization, and optoelectronic technologies. The contribution of CÜNAM’s infrastructure, scientific expertise, and accumulated know-how to strengthening Türkiye’s research and technological capacity in epitaxy, semiconductors, photonics, and advanced materials, together with its future research perspective, will also be discussed.

Optical Band Gap Determination and Photocatalytic Degradation of Methylene Blue over Ru-Co₃O₄ Nanostructures

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Co₃O₄ is a versatile transition metal oxide with applications in energy storage, electrocatalysis, photocatalysis, gas sensors, and environmental remediation. However, its poor electrical conductivity limits its practical performance [1, 2]. Therefore, Ru was introduced to improve its electrocatalytic activity and durability. Ru is one of the most efficient OER catalysts, but its high cost limits large scale applications [3]. By combining Ru with Co₃O₄, it is possible to achieve a catalyst that offers high catalytic activity, improved conductivity, enhanced durability, and reduced Ru consumption. In this work, Ru-Co₃O₄ nanostructures were synthesized using a modified polyol assisted route followed by ultrasonic assisted Ru incorporation. XRD analysis showed that the obtained Ru-Co₃O₄ possessed a cubic structure with the Fd-3m space group. SEM analysis revealed the formation of nanosized particles with average particle size of 25.17 nm, while EDS confirmed the successful incorporation of approximately 1 wt.% Ru into the Co₃O₄ structure. Electrochemical measurements demonstrated that Ru-Co₃O₄ reached a current density of 10 mA cm⁻² at 1.51 V, compared with 1.54 V for pristine Co₃O₄. In addition, the Ru-Co₃O₄ catalyst demonstrated a lower Tafel slope of 107 mV dec⁻¹ than Co₃O₄ (145 mV dec⁻¹), indicating enhanced OER kinetics. After 20 h of chronoamperometric testing, Ru-Co₃O₄ retained 82% of its initial current, whereas Co₃O₄ retained only 60%, demonstrating the enhanced durability of the Ru-Co₃O₄ catalyst. This work explores the photocatalytic performance of Ru-Co₃O₄ toward methylene blue degradation in addition to its OER activity. The incorporation of Ru significantly improved the photocatalytic activity of Co₃O₄, resulting in approximately 72% degradation of methylene blue under UV irradiation in the presence of H₂O₂ after 240 min. UV-Vis analysis revealed that Co₃O₄ and Ru-Co₃O₄ exhibited nearly identical direct optical band gap values of approximately 1.80 eV.

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Zr-Doped WO₃: A Better Photocatalyst for Dye Degradation

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Tungsten trioxide (WO₃) is a well-established visible-light-responsive semiconductor photocatalyst with an intrinsic band gap of 2.6–2.8 eV; however, its practical application in wastewater treatment is severely hindered by rapid photogenerated electron–hole recombination and a relatively low specific surface area, both of which limit the generation of reactive oxygen species and the overall photocatalytic efficiency [1,2]. Although various modification strategies have been explored to overcome these drawbacks, the photocatalytic performance of Zr⁴⁺-doped WO₃ toward azo dye degradation, particularly Congo Red (CR) removal under visible-light irradiation, remains largely unexplored. Although Zr⁴⁺-doped WO₃ nanoparticles have recently been reported for other applications, demonstrating that Zr incorporation can modify the structural and physicochemical properties of WO₃ [3], its role in enhancing the visible-light-driven photocatalytic degradation of azo dyes has not yet been systematically investigated.

In this study, we address this research gap by incorporating Zr⁴⁺ ions into the WO₃ lattice via a facile hydrothermal route, exploiting the ability of Zr⁴⁺ incorporation to modify the defect structure and electronic properties of the host material while simultaneously inhibiting crystal growth and potentially increasing the specific surface area. A systematic series of Zr⁴⁺-doped WO₃ samples (0–10 mol%) was synthesized and thoroughly characterized by XRD, FTIR, UV–Vis diffuse reflectance spectroscopy, and BET surface area analysis. Zr⁴⁺ incorporation was confirmed by a reduction in crystallite size from 38.6 to 29.4 nm, a narrowing of the optical band gap from 2.62 to 2.55 eV, and a 69.6% enhancement in specific surface area (18.4 → 31.2 m²/g). The 5 mol% Zr-WO₃ catalyst exhibited the optimum photocatalytic activity, achieving 94.2% degradation of Congo Red (CR) within 120 min under visible-light irradiation ($\lambda > 420$ nm)—a 1.62-fold improvement over bare WO₃. Operational parameters were systematically optimized, yielding optimal conditions of pH 5, a catalyst dose of 1.0 g/L, and an initial CR concentration of 20 mg/L. The degradation kinetics followed a pseudo-first-order Langmuir–Hinshelwood model, and Arrhenius analysis across 25–55°C yielded an activation energy of 18.6 kJ/mol, indicative of a diffusion-controlled photocatalytic mechanism with a low energy barrier. This work presents a systematic investigation of Zr⁴⁺-doped WO₃ as a photocatalyst for azo dye remediation and demonstrates its strong potential for visible-light-driven wastewater treatment applications.

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Correlation Between the Structural, Magnetic and Magnetocaloric Properties of Sol–Gel Synthesized $\text{La}_{0.7}\text{Ca}_{0.27}\text{Na}_{0.03}\text{MnO}_3$ Perovskite Manganite

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Magnetic refrigeration technology, based on the magnetocaloric effect (MCE), has emerged as a promising and environmentally friendly alternative to conventional gas-compression refrigeration due to its high energy efficiency and the elimination of greenhouse gas emissions. Among various magnetocaloric materials, perovskite manganites have attracted considerable attention because of their remarkable magnetic and magnetocaloric properties near room temperature. In this study, the structural, magnetic, and magnetocaloric properties of $\text{La}_{0.7}\text{Ca}_{0.27}\text{Na}_{0.03}\text{MnO}_3$ were systematically investigated. The sample was synthesized using the sol–gel method. The crystal structure, surface morphology, and elemental composition were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), and energy-dispersive X-ray spectroscopy (EDS), respectively. XRD analysis confirmed that the sample crystallized in a single-phase orthorhombic perovskite structure with the Pnma space group, while EDS analysis verified the expected elemental composition. Temperature-dependent magnetization measurements revealed a Curie temperature (T_C) of 309 K. The maximum magnetic entropy change ($-\Delta S_M$) reached $6.34 \text{ J kg}^{-1} \text{ K}^{-1}$ under an applied magnetic field change of 5 T, while the relative cooling power (RCP) calculated to be 233 J kg^{-1} . Furthermore, Arrott plot analysis confirmed a second-order magnetic phase transition, indicating high magnetic reversibility with negligible hysteresis, which is highly desirable for efficient magnetic refrigeration. These findings demonstrate that $\text{La}_{0.7}\text{Ca}_{0.27}\text{Na}_{0.03}\text{MnO}_3$ exhibits favorable magnetocaloric performance near room temperature and is a promising candidate for next-generation magnetic refrigeration applications.

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DFT and XRD Investigation of Quantum Chemical, Topological, and Optoelectronic Properties of a Novel Quinoline-Derived Cadmium(II) Complex

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The theoretical and experimental design of quinoline-based metal complexes with tunable electronic properties is of great importance for optoelectronic devices and functional materials [1, 2]. In this study, a novel cadmium(II) complex incorporating a methyl 6-quinolyl ether ligand was synthesized, and its geometric structure was elucidated by single-crystal X-ray diffraction (XRD), revealing crystallization in the triclinic P-1 space group. Density Functional Theory (DFT) calculations at the B3LYP/LanL2DZ level were performed to investigate the electronic structure and spectroscopic behavior (FT-IR, UV-Vis, NMR) of the complex. Frontier molecular orbital (FMO) analysis yielded a HOMO-LUMO energy gap of **3.67 eV**, indicating that the complex possesses moderate electronic stability and significant potential for intramolecular charge transfer. TD-DFT calculations supporting the optical properties successfully explained the nature of the absorption bands observed in the experimental UV-Vis spectrum. Furthermore, advanced topological analyses such as QTAIM, RDG, DORI, and NBO, alongside MEP, ELF, and LOL mapping, were utilized to understand crystal packing and electronic charge distribution [3]. The strong agreement between experimental and theoretical findings reveals the structure-property relationships of quinoline-based Cd(II) coordination compounds, providing a valuable theoretical framework for optical materials science.

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Comparative First-Principles Study of the Electronic, Vibrational, and Carrier–Phonon Scattering Properties of Monolayer WSe₂ and ZrSe₂

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In this study, the electronic structures, vibrational properties, densities of states, and carrier–phonon interaction characteristics of monolayer tungsten diselenide (WSe₂) and monolayer zirconium diselenide (ZrSe₂), two important members of the two-dimensional transition-metal dichalcogenide family with potential applications in electronics and nanoelectronics, were investigated comparatively. The calculations were performed within the framework of density functional theory using Quantum ESPRESSO and the EPW (Electron–Phonon Wannier) package integrated with it [1]. The electronic band structures of the materials were calculated using both the PBE (Perdew–Burke–Ernzerhof) and HSE (Heyd–Scuseria–Ernzerhof) exchange–correlation functionals, and both materials were found to have indirect band gaps. For WSe₂, the valence-band maximum is located at the K point, whereas the conduction-band minimum occurs at the Q point along the K– Γ direction. For ZrSe₂, the corresponding extrema are located at the Γ and M points, respectively. The band-gap energies were calculated to be 1.64 eV for WSe₂ and 0.33 eV for ZrSe₂ in PBE approximation [2]. Effective masses were calculated from the electronic band structures, and the effective mass of ZrSe₂ was found to be significantly anisotropic around the M point. To investigate the vibrational properties, phonon dispersion relations were calculated. No imaginary frequencies were observed, indicating that both materials are dynamically stable within the harmonic approximation. In WSe₂, a phonon band gap was observed between the acoustic and optical branches, whereas no such gap was found in ZrSe₂. Carrier–phonon interactions are important for investigating the carrier transport properties of these materials and identifying the dominant transport limiting phonon modes. Using the EPW package, carrier–phonon scattering rates were calculated over a wide temperature range of 100–500 K as functions of carrier energy and were decomposed according to individual vibrational modes. The results were found to be generally consistent with the values reported in the available literature.

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Optimization of AsH₃ Flow Rate for High-Quality MOCVD-Grown n-InGaAs/InP Epitaxial Layers

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Indium gallium arsenide (InGaAs) is an important III–V semiconductor material for high-speed optoelectronic devices, infrared photodetectors, and high-frequency applications, where device performance strongly depends on crystal quality, surface morphology, and electrical transport properties. Precise control of growth parameters is therefore essential for obtaining high-quality epitaxial layers [1]. Among the growth parameters in metal-organic chemical vapor deposition (MOCVD), the arsine (AsH₃) flow rate plays a critical role by modifying the V/III ratio, surface reaction kinetics, and adatom incorporation processes[2-4]. In this study, n-In_{0.53}Ga_{0.47}As epitaxial layers were grown on (100)-oriented InP substrates by MOCVD using trimethylindium (TMIn), trimethylgallium (TMGa), and AsH₃ as precursor gases in addition to SiH₄ at constant in order to grow n-type dopant layers. The growth temperature and reactor pressure were maintained at 620 °C and 1800 mbar, respectively, while the AsH₃ flow rate was varied from 126 to 148 and then to 190 sccm. The structural, morphological, and electrical properties of the layers were characterized using high-resolution X-ray diffraction (HRXRD), atomic force microscopy (AFM), and Hall-effect measurement system. The In_{0.53}Ga_{0.47}As layers adjusted a lattice-matched composition with the InP substrate during growth. HRXRD fitting observed In compositions of 0.534, 0.533, and 0.537 for samples A, B, and C, respectively, confirming that the In composition remained close to the lattice-matched value of 0.53 despite the variation in AsH₃ flow rate. Since the bond energy of In-As is stronger than that of Ga-As, increasing the AsH₃ resulting in a slight increase of In composition of sample C [5]. Increasing the AsH₃ flow rate also resulted in a decrease in layer thickness, indicating an influence of the group-V supply on the growth rate. AFM measurements revealed terrace-like surface morphologies with low RMS roughness values of 0.16, 0.12, and 0.15 nm for samples A, B, and C, respectively. The electrical characterization showed that the electron mobility increased from approximately 1470 to 1910 cm²/V·s as the AsH₃ flow increased, while the carrier concentration observed results between 8.55-9.25 × 10¹⁸ cm⁻³. Although the highest electron mobility was obtained at the highest AsH₃ flow rate, while the V/III ratio increased with the increase of AsH₃ flow rate resulting in a degradation in the crystal quality under this condition [6]. Considering the structural, morphological, and electrical properties together, an AsH₃ flow rate of 148 sccm provided the most favorable growth condition for high-quality n-In_{0.53}Ga_{0.47}As/InP epitaxial layers under the investigated MOCVD parameters.

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Impact of Annealing Atmosphere on Properties of CZTSSe Thin Films: Experimental and SCAPS-1D Analysis

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With the increasing global population and the continuous rise in energy consumption, the need for alternative and sustainable energy sources is becoming increasingly critical [1]. In this context, thin-film based solar cells are attracting great interest due to their environmental advantages and high energy conversion potential. Copper Zinc Tin Sulfur Selenium ($\text{Cu}_2\text{ZnSn}(\text{S},\text{Se})_4$, **CZTSSe**) stands out as a promising semiconductor material for photovoltaic applications thanks to its high optical absorption coefficient ($\geq 10^4 \text{ cm}^{-1}$), abundant components, non-toxicity, and suitable direct band gap (1.0 - 1.6 eV) [2-3].

In this study, $\text{Cu}_2\text{ZnSn}(\text{S},\text{Se})_4$ thin films were successfully deposited on glass substrates by single-target magnetron sputtering and subsequently post-annealed at 500 °C under various chalcogenization environments, namely Ar-only, S-only, Se-only, and S-Se mixed atmospheres. The influence of these processing parameters on the structural, morphological, optical, and electrical properties of the films was systematically investigated. EDX results showed Cu-rich behavior in Ar, S and Se samples, whereas (S+Se) films exhibited a Cu-poor and Zn-rich composition. XRD analysis confirmed CZTSSe phase formation, with the (112) preferential peak shifting toward higher angles in S-rich conditions and lower angles in Se-rich conditions, indicating compositional tuning. Notably, the S+Se environment exhibited the highest crystallite size ($D=34.22 \text{ nm}$ for (CZTSSe 500-(S+Se)), reflecting improved crystalline and structural quality. Raman spectroscopy confirmed phase purity in all chalcogenized (S, Se, and (S+Se)) samples, while Cu_2Sn (S, Se)₃ (CTS(e)) secondary phases were detected in Ar environment films. SEM analysis revealed significant changes in surface morphology. Optical studies showed tunable band gaps ranging from 1.00 to 1.45 eV depending on the environment. Hall effect measurements confirmed improved electrical properties in all chalcogenized samples, with Se-only conditions showing the best performance. Furthermore, SCAPS-1D simulations were performed using a Glass/Mo/CZTSSe/CdS/AZO/Ag device structure, demonstrating promising photovoltaic behavior that all device structures exhibit promising photovoltaic behavior, with the Se-only configuration achieving the (CZTSSe-500-Se), with the highest efficiency (5.44 %), fill factor ($\text{FF}= 63.58\%$), and short-circuit current density ($\text{J}_{\text{sc}}= 15.71 \text{ mA/cm}^2$), along with a comparatively lower open-circuit voltage ($\text{V}_{\text{oc}} = 540 \text{ mV}$). Overall, these results demonstrate that controlled chalcogenization and annealing play a crucial role in optimizing CZTSSe thin films for high-efficiency thin-film solar cell applications.

Keywords: CZTSSe thin film solar cells. SCAPS-1D Simulation. Annealing environment, Rapid thermal annealing (RTA).

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Temperature Difference and MHD Effects on Nanofluid Hydrodynamics and Heat Transfer

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In this study, the flow and heat transfer of CuO-water nanofluid in a channel under an external magnetic field were numerically analyzed using ANSYS Fluent, with particular focus on the temperature difference (ΔT). The geometry was divided into five parts to obtain a more uniform mesh structure. Simulations were conducted at $Re = 1000$, with inlet temperatures of $T_i = 50, 60, \text{ and } 70^\circ\text{C}$ and a constant wall temperature of $T_w = 30^\circ\text{C}$. The effects of magnetic field and nanoparticle concentration were examined for various Hartmann numbers and volume fractions. Velocity, pressure, temperature, and local Nusselt number variations are presented graphically.

The key findings indicate that increasing ΔT significantly reduces velocity and pressure due to the inverse relationship between temperature and viscosity/density. Higher Ha numbers and nanoparticle fractions further decrease velocity while enhancing temperature (via Joule heating) and local Nusselt numbers. However, ΔT was found to have a negligible effect on heat transfer, as local Nusselt numbers showed no significant variation across different ΔT values.

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Tuning Electromagnetic Wave Attenuation via Electric Field in PANI@MoS₂/GE/ PANI@MoS₂ Symmetric Devices

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The rapid proliferation of wireless communication systems and high-frequency electronic technologies has intensified the need for adaptive electromagnetic interference (EMI) shielding materials capable of dynamically controlling electromagnetic wave propagation. In this study, an electrically tunable electromagnetic attenuation device based on a symmetric PANI@MoS₂/gel electrolyte (GE)/PANI@MoS₂ architecture is developed. The device exploits the coupled electrical and electromagnetic responses of polyaniline-functionalized MoS₂ hybrid electrodes, while the gel electrolyte enables reversible modulation of the charge distribution under an externally applied electric field. The electromagnetic shielding and attenuation characteristics were systematically investigated as a function of the applied electric field over the 8-12 GHz frequency range. The results demonstrate that the electromagnetic response of the device can be actively regulated through electric-field-induced changes in charge transport, interfacial polarization, and dielectric relaxation processes within the PANI@MoS₂ and the interface between PANI@MoS₂ and gel electrolyte. In particular, the applied electric field modifies the balance between electromagnetic reflection and absorption, providing an effective route for dynamically tuning wave attenuation without altering the physical structure or thickness of the device. The observed behavior is attributed to the synergistic interaction between the conductive PANI network and semiconducting MoS₂ nanosheets, together with field-induced electrochemical charge redistribution at the electrode/gel interfaces. These findings highlight the potential of PANI@MoS₂/GE/PANI@MoS₂ symmetric devices as electrically programmable platforms for adaptive EMI shielding, electromagnetic wave attenuation, and next-generation reconfigurable electromagnetic protection technologies.

Keywords: Tunable Microwave Absorbers, PANI@MoS₂ nanocomposite, Symmetric Solid-State Cell.

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Investigation of Strain Effects in InGaAs/InAlAs Superlattices for Quantum Cascade Laser Structures

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Quantum cascade lasers (QCLs) are unipolar semiconductor lasers whose emission arises from electron transitions between quantized subbands in engineered quantum-well cascades [1]. In InP-based QCLs, InGaAs/InAlAs multilayers define the active-region electronic structure, so precise control of layer thickness, interface quality, and accumulated strain is essential [2,3]. Strain engineering balances opposing layer strains to limit cumulative stress and sustain coherent growth [3].

The investigated heterostructures consisted of ten repetitions of an InGaAs/InAlAs multilayer sequence grown by metal-organic vapor-phase epitaxy (MOVPE) on InP substrates. The growth temperature, AsH₃ flow rate, nominal alloy compositions, and number of repetitions were kept constant, while the growth durations of the InGaAs and InAlAs layers were varied. S2 and S3 were designed with the same InGaAs-to-InAlAs growth-time ratio, with all layer growth durations in S3 reduced by half relative to S2, whereas S1 employed equal InGaAs and InAlAs growth durations and represented a distinct thickness-balance condition. This design enabled the influence of layer-thickness configuration and superlattice period to be examined under different nominal strain conditions.

HRXRD analysis confirmed systematic differences in the superlattice periods and provided the structural basis for comparing samples designed with different nominal strain conditions. AFM measurements revealed smooth, step-like surface morphologies with sub-nanometre roughness for all structures; strain-related variations in surface morphology have also been reported for InGaAs-based heterostructures [4]. Room-temperature Raman spectra exhibited the characteristic InAs-like, GaAs-like LO, and AlAs-like LO phonon modes of the InGaAs/InAlAs heterostructures. Changes in the phonon peak positions were examined in relation to the nominal strain conditions, providing a complementary assessment of the strain-dependent vibrational response. The S2–S3 comparison is particularly informative because these structures were designed under similar nominal strain-compensation conditions while exhibiting markedly different superlattice periods, enabling the influence of period scaling on structural, morphological, and vibrational properties to be evaluated.

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Green Synthesis of Pd Nanoparticles Using Olives Leaves Extract: Investigation of Structural and Catalytic Properties

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Hydrogen technology stands out as one of the most promising future energy solutions due to its zero carbon emissions, potential to reduce fossil fuel dependence, ability to store energy for long periods, transport it over long distances, and enable the production of more efficient and cleaner vehicles, thereby decreasing external dependency. In this context, the development of environmentally friendly catalysts for clean and efficient energy systems is of great importance. This study aims to produce palladium–cobalt (Pd–Co) bimetallic nanoparticles (NPs) via a green synthesis method. Olive leaves were shade-dried and used to prepare an aqueous extract containing *Olea europaea* compounds, which served as the reducing agent. Pd–Co NPs were obtained by single-step co-reduction of Pd(acac)₂ and Co(acac)₂ (1:1 molar ratio) with the plant extract under an inert atmosphere. As the as-synthesized product was poorly crystalline, the powder was calcined at 500 °C. X-ray diffraction of the calcined sample revealed a two-phase structure composed of tetragonal PdO and spinel Co₃O₄. Scanning electron microscopy analysis indicated an average particle size of approximately 17 nm, and energy-dispersive X-ray spectroscopy confirmed the presence of both Pd and Co. The results demonstrate that low-cost, environmentally friendly Pd–Co NPs can be successfully synthesized via green synthesis, with strong potential for application as catalysts in hydrogen technologies.

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Development of Next-Generation Dosimeter Systems for Use in Medical Radiation Applications

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Cancer remains one of the leading causes of death worldwide. Radiotherapy is an essential component of cancer treatment for most patients. Approximately 50% of cancer patients undergo radiotherapy as part of their treatment. However, one of the most significant challenges that radiotherapy faces is to deliver the prescribed radiation dose to the target tumour while minimizing radiation exposure to surrounding healthy tissues [1]. Consequently, remote dose monitoring using active (in vivo) dosimetry plays an important role by providing real-time or near-real-time data about the actual dose delivered to the patient, improving the accuracy, reliability, and safety of radiotherapy treatment [2].

Numerous active dosimeters have been developed, each with its advantages and some limitations. Among these, RADFET (Radiation-Sensitive Field Effect Transistor) dosimeters combine high sensitivity, low power consumption, compact dimensions, and compatibility with modern microprocessor-based systems. Nevertheless, their clinical performance remains affected by radiation-induced drift, signal fading, temperature dependence, angular dependence, low-dose uncertainty, and calibration requirements [3].

This study will present the conceptual design of a next-generation active dosimetry platform intended for millimeter-scale radiotherapy applications where treatment fields may be smaller than 4×4 cm². The proposed system integrates a RADFET sensor with a Bluetooth Low Energy (BLE) ESP32-based Internet of Things (IoT) system to establish wireless communication, a cloud platform incorporating AI-assisted dose analysis, and a clinician-oriented remote monitoring interface. The system is designed to support real-time dosimetry, non-destructive electrical readout, and software-based compensation for temperature drift and signal fading through anomaly detection algorithms. Calibration is planned to be performed through accredited secondary standard laboratories to ensure traceability to international standards. These improvements are expected to facilitate real-time dose verification and support adaptive radiotherapy while contributing to improved patient safety. The proposed system uniquely combines RADFET sensing, BLE-enabled IoT communication, AI-assisted signal correction, and cloud-based adaptive radiotherapy support within a single wireless dosimetry platform. Future experimental validation will evaluate dosimetric accuracy, system stability, and clinical feasibility.

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2.5D Printing of Red and Green InP-Based QDs Using Maskless Lithography

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InP-based QDs have emerged as environmentally friendly wavelength-conversion materials for next-generation displays and solid-state lighting. However, conventional deposition techniques, such as spin coating and inkjet printing, offer limited flexibility for fabricating high-resolution, 3D color-conversion architectures.^[1] Here, we present a maskless digital light processing (DLP)-based 2.5D printing strategy for the direct fabrication of patterned InP QD nanocomposites with programmable geometry and spatial distribution.

Red- and green-emitting InP QDs dispersed in a photocurable resin were sequentially printed onto glass substrates to demonstrate high-resolution multicolor patterning. The printable nanocomposite resin contained 1.3 wt% native-ligand-capped InP QDs, and 125 μ L of resin was used for each fabrication. Photopolymerization was carried out at 70% LED intensity with exposure times ranging from 2 to 5 min, followed by methanol development to remove uncured resin. This process produced well-defined 2.5D microstructures with a minimum lateral feature size of approximately 35 μ m, demonstrating precise spatial control over individual QD patterns.

As a proof of concept, red InP QD nanocomposites were also directly printed onto PMMA substrates, demonstrating the compatibility of the printing process with polymeric light-guiding components. Such architectures provide a promising route toward integrating printed QD wavelength converters with optical waveguides for solid-state lighting.

The capability to independently print red and green QD architectures provides a versatile route for spectral engineering of blue LED emission. By tailoring the geometry, position, and relative distribution of the printed QD structures, the spectral output and correlated color temperature can be tuned to meet the requirements of diverse applications, including human-centric lighting, horticultural illumination, mini-/micro-LED color converters, and other solid-state lighting technologies. The presented maskless DLP approach establishes a scalable and flexible platform for manufacturing high-resolution, environmentally friendly QD-based photonic devices.

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Physical Characterization of Nanostructured CdO Thin Films Grown by SILAR Method

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Transparent Conductive Oxide (TCO) thin films function as essential components in modern optoelectronic and photovoltaic devices due to their unique combination of optical transparency and electrical conductivity. Among these, cadmium oxide (CdO) thin films stand out as compelling candidates for transparent electrodes, owing to their favorable bandgap, high visible clarity, and low electrical resistivity. To obtain these films, the Successive Ionic Layer Adsorption and Reaction (SILAR) technique offers an effective route characterized by low processing temperatures, reproducibility, and scalability over large substrate areas. In this study, nanostructured CdO thin films were grown on glass substrates via the SILAR method using different anionic solution temperatures (50, 60, and 70 °C). The film thickness was evaluated through the gravimetric weight-difference approach, where an increase in anionic solution temperature was found to yield thicker films. A systematic assessment was conducted to elucidate how the anionic solution temperature governs the structural, morphological, optical, and electrical behaviors of the prepared CdO thin films. X-ray diffraction (XRD) patterns indicated that the obtained CdO films were amorphous. Field emission scanning electron microscopy (FE-SEM) analyses revealed a tight, dense surface arrangement of particles. UV-Vis spectrophotometry was used to determine the fundamental optical constants. In the visible region (400–700 nm), optical transmittance values ranged from 55% to 95%. The refractive index values in this range were determined to be between 1.30 and 2.20. The optical energy bandgap of CdO thin films was determined to be between 2.72 and 3.10 eV using the Tauc method. Hall effect measurements revealed that the CdO thin films exhibited n-type electrical conductivity. Overall, the findings suggest that variations in the anionic bath temperature significantly influence the physical attributes of SILAR-deposited CdO films, highlighting their potential application as transparent layers in solar energy technologies. The analyses revealed that the investigated physical parameters strongly depend on the anionic bath temperature. Consequently, the CdO thin films obtained in this study are considered to be promising candidates for photovoltaic solar cell applications.

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Growth and Characterization of SiH₄-Controlled In_xAl_{1-x}As Layers for Application in QCL Injector Regions

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Quantum cascade lasers (QCLs) in the mid-wave infrared (MWIR, 3-7 μm) and long-wave infrared (LWIR, 8-12 μm) regions have attracted increasing interest for applications including infrared countermeasures, free-space communications, and chemical and biological sensing. However, the growth of QCL structures remains a challenging task because their active regions consist of hundreds of ultrathin epitaxial layers, requiring precise control of alloy composition, layer thickness, heterointerface quality, and doping [1]. In InP-based QCLs, the InGaAs/InAlAs material system is widely used as the quantum-well/barrier system. The doping level of the injector is also an important parameter because it affects carrier transport and the operating range of the QCL.

In this study, n-type In_xAl_{1-x}As layers were grown on InP substrates by metal-organic vapor-phase epitaxy (MOVPE) using different SiH₄ flow conditions. Previous studies have shown that growth conditions, such as the V/III ratio and Si incorporation can strongly influence the structural, optical, and electrical properties of InAlAs layers for QCL structures [2,3,4]. Therefore, the effect of SiH₄ flow on the electrical properties of InAlAs, particularly carrier concentration and electron mobility, was investigated together with its structural and optical properties. Hall Effect measurements were used to determine the carrier concentration and mobility, while high-resolution X-ray diffraction (HRXRD) was used to evaluate the alloy composition, layer thickness, and crystalline quality. Raman spectroscopy was additionally performed to examine the vibrational characteristics of the InAlAs layers and to provide complementary information regarding alloy composition and material quality.

By correlating the electrical properties with the structural and optical characteristics, this study aims to improve the understanding of Si incorporation and its influence on carrier transport and material quality. The results are expected to provide a basis for selecting suitable doping and growth conditions for InAlAs layers prior to their integration into InGaAs/InAlAs QCL structures and future injector doping optimization.

Acknowledgments

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Composition-Controlled Pd–Co Alloy Nanoparticles with Tunable Structural and Magnetic Properties

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Alloying noble metals with low-cost 3d transition metals (such as Fe, Co, Ni, and Cu) is an effective strategy for improving structural properties, controlling magnetic behavior, and developing materials for magnetic sensing and magnetic data storage applications [1]. In this study, Pd_{0.2}Co_{0.8} nanoparticles (NPs) were synthesized using a modified polyol method by annealing at 160 °C for 1 h in the presence of polyvinylpyrrolidone as a stabilizing agent [2]. X-ray diffraction and Rietveld refinement analyses confirmed that all synthesized samples crystallized in a face-centered cubic structure with the Fm-3m space group, indicating the successful formation of the Pd–Co alloy phase. SEM analysis revealed nearly spherical NPs with sizes in the nanometer range. Among the synthesized samples, Pd_{0.2}Co_{0.8} exhibited a crystallite size of 8 nm and an average particle size of 16.7 nm. Its magnetic properties were investigated over the temperature range of 5–300 K under applied magnetic fields of up to ±5 T. The M–H hysteresis curves confirmed ferromagnetic behavior, with a saturation magnetization of 3.40 emu/g, a coercivity of 192.5 Oe, and a remanent magnetization of 0.21 emu/g. These findings demonstrate that the Pd_{0.2}Co_{0.8} alloy nanoparticles possess well-defined structural characteristics and favorable magnetic properties, highlighting their potential for future magnetic nanomaterial applications.

Keywords: PdCo NPs, XRD, Rietveld refinement, SEM, Magnetic properties

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Development of an α -Ketoglutaric Acid-Functionalized $\text{Fe}_3\text{O}_4@\text{Silica}$ Nanocarrier Platform for Magnetically Targeted Paclitaxel and Docetaxel Delivery and *In Vitro* Evaluation of Anticancer Potential

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Taxanes, including paclitaxel and docetaxel, commonly used in breast cancer treatment, have significant therapeutic limitations due to their low aqueous solubility, limited targeting capacity, and systemic toxicity, despite their strong anticancer activity [1]. The present study aims to develop a magnetically controlled and α -ketoglutaric acid (α -KG)-modified $\text{Fe}_3\text{O}_4@\text{SiO}_2$ -based nanocarrier platform in order to overcome relative limitations. In the system that has been designed, the magnetic core of Fe_3O_4 is intended to provide magnetic orientation, while the silica coating aims to increase the chemical stability and surface functionalizability of the nanoparticles [2]. The synthesis of Fe_3O_4 nanoparticles was achieved through a controlled chemical precipitation process, subsequently followed by silica coating using TEOS and surface amination using APTES. Consequently, α -KG was immobilized onto the nanoparticle surface, and paclitaxel and docetaxel were separately loaded onto the nanocarrier system. The loading efficiency, encapsulation rate, and *in vitro* drug release profiles of the obtained nanocarriers were determined, while their physicochemical properties were characterised using DLS, zeta potential, FTIR, XRD, BET, and SEM/TEM analyses. The present study will entail the performance of biological evaluations in MCF-7 and triple-negative MDA-MB-231 breast cancer cells. The examination will encompass cellular viability, intracellular uptake, ROS levels, and magnetic targeting capacity. The potential contribution of α -KG to ferroptosis will be investigated through inhibition experiments using Ferrostatin-1, and the relationship between the observed cytotoxic activity and the ferroptotic mechanism will be evaluated [3]. The hypothesis is that the developed platform will demonstrate the capability to facilitate the controlled and magnetically targeted delivery of taxanes, and that this will result in the activation of an alternative cellular death mechanism via α -KG. It is hypothesised that the study will facilitate the development of more selective and effective nanotherapeutic systems for breast cancer by presenting an innovative approach that combines magnetically targeted drug delivery and ferroptosis-based cancer nanotechnology.

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Experimental Investigation of Curvature-Induced Performance Changes in Flexible Photovoltaic Modules under Simultaneous Outdoor Measurements

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Flexible photovoltaic (PV) modules offer important advantages for curved roofs, vehicle surfaces, portable systems, and other applications in which conventional rigid modules are difficult to install [1]. However, bending a flexible module changes its geometric orientation and may influence its electrical response through nonuniform irradiance, local mechanical strain, and temperature-dependent effects. This study presents an experimental framework for evaluating curvature-induced performance changes in flexible PV modules under real outdoor conditions. Two nominally identical flexible modules were operated simultaneously: one was maintained in a flat configuration as the reference, whereas the second was fixed at a prescribed curvature. Synchronous electrical and environmental measurements were used to minimize the uncertainty caused by short-term variations in solar irradiance and ambient conditions [2]. The comparison is based on instantaneous power, energy yield, the curved-to-flat power ratio, and percentage power deviation. The measurements are also grouped according to irradiance level to determine whether the influence of curvature varies with operating conditions. A paired statistical analysis is proposed because every curved-module observation has a time-matched flat-module reference. This approach separates the device-level effect associated with the curved installation from common environmental fluctuations more effectively than measurements performed on different days. The resulting methodology provides a practical basis for quantifying the electromechanical response of flexible PV modules without requiring a controlled solar simulator. It can support curvature-aware module selection, installation design, and the development of data-driven performance models for flexible solar-energy systems [3].

Keywords: flexible photovoltaic module; curvature; mechanical deformation; outdoor measurement; energy materials

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Effect of Ag doping on YBCO Superconductors

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High-temperature superconductors have become an important research topic in magnetic levitation applications, energy transmission systems and electronic technologies due to their ability to operate at liquid nitrogen temperatures [1]. $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$ (YBCO) is one of the most prominent and extensively studied superconductors among these materials due to its high critical temperature and superior superconducting properties [2]. This study investigates the effect of Ag doping on the structural, magnetic and electrical properties of YBCO superconductors. Undoped, 1 and 2 wt% Ag doped YBCO samples were synthesized using the sol-gel method [3]. The phase structures of the obtained samples were determined by X-ray Diffraction (XRD). Their structural properties and elemental compositions were examined using Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray Spectroscopy (EDS), respectively. In addition, the superconducting properties of the samples were investigated through magnetization-temperature (M-T) and magnetization-magnetic field (M-H) measurements.

The results indicate that Ag doping significantly affects the structural, magnetic and electrical properties of YBCO. Furthermore, M-T and M-H measurements were conducted to evaluate the superconducting properties of the samples and to examine the influence of Ag doping on the performance of YBCO superconductors.

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The Effect of Layer Arrangement on the Properties of CdS/ZnS Multilayer Thin Films Deposited by CBD

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ZnS and CdS are among the most extensively studied II–VI semiconductor materials for photovoltaic, optoelectronic, and photodetector applications due to their wide band gaps, high optical transparency, and favorable electronic properties (Geremew & Abza, 2020). In particular, ZnS/CdS multilayer thin films have attracted considerable attention because of their enhanced interfacial characteristics and their potential to improve charge transport and device performance (Wang et al., 2014).

In this study, nine-layer ZnS/CdS and CdS/ZnS thin films were fabricated on glass substrates by the chemical bath deposition (CBD) method in order to investigate the effect of deposition sequence on film properties and to evaluate their potential for optoelectronic device applications. The structural, morphological, and optical properties of the films were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), and UV–Vis spectroscopy, and the influence of the stacking order on the multilayer structure was examined. The results are discussed in terms of the suitability of these multilayer structures for optoelectronic devices.

Keywords: ZnS/CdS, CdS/ZnS, Chemical Bath Deposition, Multilayer Thin Films

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Green Synthesis of Pure and Boron-Doped TiO₂ Nanoparticles Synthesized via Sambucus nigra Extract and Photocatalytic Degradation of Tetracycline

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In this study, pure and boron (B)-doped titanium dioxide (TiO₂) nanoparticles were successfully produced using elderberry (*Sambucus nigra*) plant extract via green synthesis. Unlike traditional chemical reduction methods, this approach eliminates the need for high temperatures and toxic reagents, offering an environmentally friendly and cost-effective production protocol [1]. The structural, morphological, and optical properties of the synthesized nanomaterials were analyzed using X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM), and Fourier Transform Infrared Spectroscopy (FTIR) techniques, respectively. The photocatalytic performance of the produced nanoparticles was tested by the photodegradation of tetracycline antibiotic under ultraviolet (UV) light, which triggers the development of antibiotic-resistant bacteria (ARB) when released into the environment [2]. A comparison of the obtained results shows that boron-doped TiO₂ exhibits more effective photocatalytic activity. These results demonstrate that photocatalysts obtained through green synthesis offer a sustainable alternative for removing pharmaceutical waste from water [3].

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Luminescence investigations on lanthanide doped CaB₄O₇ phosphorsT. C. Kutuk^{1*}, V. Altunal², and H. Ozturk¹¹*Department of Physics, Osmaniye Korkut Ata University, Osmaniye, TÜRKİYE*²*Physics Department, Cukurova University, Adana, Turkey****Corresponding e-mail:** tufancagri@hotmail.com

Reliable and accurate measurement of exposure to ionizing radiation is of great importance for personal, environmental, medical, and industrial dosimetry applications. In this context, thermoluminescence (TL) and optically stimulated luminescence (OSL) based passive dosimeters are widely preferred due to their high sensitivity, ability to measure over wide dose ranges, near tissue equivalence properties, and reusability. In recent years, boron-based compounds have become an important research area in dosimetric material development studies thanks to their high structural stability, low effective atomic numbers, and the ability to effectively control luminescence properties through doping [1–3].

In this study, doped and undoped CaB₄O₇ luminescence phosphors were synthesized using the solid-state reaction method, and their structural, morphological, and luminescence properties were investigated in detail. Phase analyses of the synthesized samples were performed using X-ray diffraction (XRD), and morphological characterization was performed using scanning electron microscopy (SEM). XRD analyses showed that all CaB₄O₇ samples, both doped and undoped, were successfully synthesized in the target crystalline phase. The luminescence performance of the samples was evaluated using TL and OSL techniques. In single doping studies, it was determined that Ce doping significantly improved the dosimetric performance by increasing the luminescence efficiency of the main matrix. Li co-doped as a charge compensator to eliminate the charge imbalance caused by Ce³⁺ ions was added, and further increases in TL and OSL signals were obtained at appropriate Ce/Li doping concentrations. Additionally, Tb and Dy ions were included as tertiary doping elements, and it was determined that both doping elements synergistically interacted with Ce, increasing the luminescence signals by approximately one order of magnitude. Concentration quenching studies were performed for each doping system, and optimum doping ratios were determined. The results obtained revealed that phosphors with compositions of CaB₄O₇:Ce(0.7%),Tb(0.5%),Li(5%) and CaB₄O₇:Ce(0.7%),Dy(0.1%), Li(5%) are promising candidate materials with high potential for TL and OSL-based ionizing radiation dosimetry applications.

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Microhardness Properties of Graphene-Doped YBCO Superconductors

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YBa₂Cu₃O_(7-δ) remains one of the most important high-temperature superconductors; however, its functional performance in technology is known to largely depend on phase stability, grain coupling, and mechanical integrity [1]. In this study, YBCO superconductors produced by sol-gel and electrospinning methods were investigated by correlating their structural, morphological, superconducting, and micromechanical properties. For electrospinning, the effects of PVP concentration, applied voltage, and flow rate on the precursor fiber morphology were systematically investigated, and the most stable bead-free morphology was obtained using 35% weight PVP at 18 kV and 0.6 mL h⁻¹. The YBCO superconductors maintained the orthorhombic Y123 structure and exhibited superconducting transition onset temperatures up to 93.60 K with transition widths of approximately 2.65–3.47 K. The YBCO sample obtained by electrospinning showed a similar initial temperature of 93.36 K [2]. The mechanical response was investigated in more detail by Vickers microhardness measurements under loads of 0.3, 0.5, and 1.0 kgf. Vickers microhardness values (HV), calculated as the ratio of the applied load to the pyramidal contact area of the indentation by placing a diamond pyramid, were compared for all samples [3]. Elastic parameters such as elastic modulus (E), yield strength (Y), fracture toughness (K_I), and brittleness index (B_i) were examined. The results show that YBCO optimization cannot be based solely on the superconducting transition temperature; morphology, grain linkage, dopant distribution, and micromechanical stability must be considered together. This study provides a pioneering and practical framework for adapting YBCO-based superconductors for mechanically more reliable and functionally more stable applications.

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Luminescence investigations of BeO ceramics produced by green synthesis

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Beryllium oxide (BeO) ceramics have attracted significant interest in the field of radiation dosimetry since the 1950s due to their unique combination of physical, chemical, and luminescence properties [1]. However, the potential toxicity risk that may arise during the processing and transportation of BeO powders is a significant factor limiting the practical applications of this material [2,3]. In this study, BeO nanoceramics were synthesized using an environmentally friendly green synthesis method and then converted into pellet form, thereby reducing the risks associated with direct exposure to fine BeO powders.

The green synthesis process was carried out using green tea extract as a biologically derived reaction medium, and beryllium sulfate was chosen as the Be source. The structural, morphological, and luminescence properties of the obtained BeO ceramics were systematically investigated using X-ray diffraction (XRD), scanning electron microscopy and energy dispersive X-ray spectroscopy (SEM/EDS), thermoluminescence (TL), and optically stimulated luminescence (OSL) techniques. XRD analyses confirmed the successful synthesis of phase-pure BeO nanoceramics crystallized in a hexagonal wurtzite structure. SEM observations showed that the synthesized powders exhibited a relatively homogeneous nanostructure, and the sintering process increased the density of the material, resulting in the formation of compact pellets with a smooth surface and significantly reduced porosity. TL glow curves exhibited four different trapping-related properties, maximizing at approximately 200, 280, 425, and 525 °C, indicating the presence of multiple thermally activated charge trapping levels within the BeO lattice. OSL decay curves were successfully characterized by the superposition of two- and three-component exponential functions. Furthermore, TL measurements performed after OSL readout (TL-after-OSL) revealed a residual TL signal, indicating the presence of deeper trapping centers that are weakly or completely insensitive to optical stimulation. Dosimetric characterization exhibited a linear luminescence dose response in the 0.2–50 Gy dose range. BeO ceramic pellets also demonstrated good reusability over ten consecutive irradiation-readout cycles and exhibited negligible signal attenuation within the first 24 hours after irradiation. Overall, the results show that BeO nanophosphors can be successfully produced using a green synthesis approach with a biologically derived extract, reducing the need for conventional chemical reagents. The wide linear dose range, low short-term extinction, good reusability, and strong OSL response observed in this study demonstrate that green synthesized BeO nanoceramics are promising candidates for OSL-based radiation dosimetry applications.

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First Principles Investigation of ScAuPb Half-Heusler Alloy: Mechanical, Vibrational, Electronic and Optical Properties

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Employing first-principles calculations, this work comprehensively examines the structural, elastic, electronic, optical, vibrational, and thermodynamic properties of ScAuPb half-Heusler alloy. To establish the ground-state structural configuration of ScAuPb compound, total-energy calculations were carried out for three possible phases (α , β , γ) across a range of unit-cell volumes. The obtained total energy–volume data for each phase were fitted to the Birch-Murnaghan equation of state to extract the equilibrium structural parameters, including the lattice constant, bulk modulus, and its pressure derivative. Among the three configurations, the γ -phase was found to possess the lowest total energy, indicating that it represents the energetically most stable phase of ScAuPb. The mechanical stability of the γ -phase was confirmed through the calculated elastic constants, which fulfill the Born stability criteria. In addition, the phonon dispersion curves exhibit no imaginary frequencies, verifying its lattice dynamical stability. The thermodynamic properties of γ phase, such as the heat capacity, entropy and free energy were calculated based on the phonon dispersion spectra using Phonopy code. To obtain a more accurate description of the electronic and optical properties in the γ -phase, calculations were performed using both the standard PBE and the HSE06 functionals. The HSE06 approach revealed that ScAuPb possesses an indirect band gap of 0.212 eV with the valence band maximum located at the Γ point and the conduction band minimum at the X point, indicating narrow-gap semiconducting behavior at γ -phase. Various optical parameters, such as the, dielectric function, refractive index, reflectivity, extinction coefficient, absorption coefficient and energy loss function, have been analyzed across an incident photon energy range of 0-20 eV.

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**Strain Effects on the Structural, Elastic, Electronic,
and Optical Properties of the KSiF₃**

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The abundant and increasing need for energy conversion and optoelectronic applications has stimulated a lot of interest in perovskite-type compounds. Among them, halide perovskites with the general formula ABX₃ have attracted considerable interest because their structures are flexible and their electronic and optical properties can be readily tuned. Because these materials are tunable and well-suited to electromagnetic radiation, they are ideal candidates for photovoltaic and optoelectronic devices [1-3]. Strain engineering is the best way to tailor functional materials without altering their chemical composition, and it offers many opportunities to develop future optoelectronic and photovoltaic devices based on fluorine-based perovskites. In this study, the influence of strain on the structural, elastic, electronic, and optical properties of KSiF₃ fluoroperovskite is investigated in the framework of density functional theory (DFT). The tensile and compressional strains are applied from 5% to +5% to understand the response of the material to strain. The structural and elastic properties of KSiF₃ can be shown to be stable in the strain range, and its elastic response is affected by the deformation of the lattice. The electronic structure calculations show that KSiF₃ remains semiconducting over the strain range, and the band gap can be modified by lattice compression and expansion. The electronic tunability is induced by the strain, and the optical response changes significantly. These results clearly indicate that strain engineering is effective in tuning the electronic and optical properties of KSiF₃ while maintaining its mechanical stability. Thus, KSiF₃ may be a potential fluoroperovskite platform for strain-tuning optoelectronic and photovoltaic applications.

Keywords: KSiF₃, DFT, Strain, Elastic, Electronic, Optic

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Electrical Characterization of an AAO-Based GEM Detector

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Gas Electron Multiplier (GEM) detectors are widely used in high-energy physics, medical imaging, and radiation measurement systems. Continuous efforts are being made to achieve higher spatial resolution, improved electrical performance, and novel fabrication techniques [1,2]. In this context, Anodic Aluminum Oxide (AAO) membranes with highly ordered nanoporous structures have emerged as a promising alternative to conventional polymer-based amplification elements [3-5]. Owing to their high pore density, regular channel geometry, and controllable micro/nanoscale structural properties, AAO-based structures have attracted considerable interest for next-generation gaseous radiation detectors.

In this study, the electrical characterization of a GEM-like detector prototype based on an aluminum-coated AAO membrane was performed. A detector structure incorporating a 50 µm thick nanoporous AAO membrane was fabricated and experimentally investigated. The electrical behavior of the detector was evaluated under different operating voltages. The response of the detector and its operational stability were examined in order to assess the feasibility of AAO-based structures for gaseous radiation detector applications.

The obtained results demonstrated that the AAO-based structure exhibits stable electrical behavior under applied voltage and operates with low leakage current. Numerical analyses revealed that the nanoporous architecture contributes to local electric field enhancement, which may support electron transport processes within the detector. These findings provide important insights into the feasibility of employing AAO-based nanoporous structures in GEM-like gaseous detectors and suggest a promising approach for the development of highly granular, compact, and radiation-resistant detector systems.

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Synthesis of Calcium Phosphates from Oyster Shell Powder of a Cardiidae Species via Mechanochemical Precipitation

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The physical and biological evaluation of materials, including synthesis, optimization, characterization, *in vitro-in vivo* testing, and investigation of host–material interactions is essential for determining their suitability and long-term performance in biological tissues. Previous studies have consistently shown that biomaterials should be in harmony with the surrounding biological tissue, as they are in direct contact with the host tissue following implantation. Hydroxyapatite ($\text{Ca}_{10}(\text{PO}_4)_6\text{OH}_2$, HAp) has a high affinity for hard tissues so, it can promote bone formation in diseased or damaged areas while minimizing adverse biological responses. Thus, HAp is widely used in bone implant and bone cement applications due to its chemical and biological similarity to natural bone tissue [1]. Although various methods are available for the chemical synthesis of HAp using different reactants, these synthesis processes may be complicated or raise concerns regarding biological safety. For these reasons, natural bioceramics can also be obtained through the calcination of biological sources, such as animal bones, fish waste, and seashells [2].

The present study aimed to synthesize calcium phosphates from the oyster shell of a Cardiidae species using a mechanochemical precipitation method. The resulting powders were then sintered at different temperatures (1000 °C and 1250 °C) to investigate the effect of sintering temperature on their structural characteristics. The samples were characterized using ATR-FTIR, SEM/EDX, and XRD techniques. Subsequently, their *in vitro* bioactivity and biodegradation properties were also evaluated.

The structure of the oyster shell powder was preserved after sintering at 1000 °C; however, at 1250 °C, the powder exhibited a more spherical morphology and stronger interparticle bonding. These structural features were associated with very good *in vitro* bioactivity. Overall, these findings suggest that the resulting materials may have considerable potential for clinical applications, particularly as implant materials and in tissue-engineering applications.

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Investigation of the Structural, Morphological, and Optical Properties of PANI-Doped ZnO Nanocomposites Synthesized by the Hydrothermal Method

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In this study, undoped Zinc Oxide (ZnO) and ZnO/PANI nanocomposites doped with Polyaniline (PANI) at different molar ratios (10%, 20%, 40%, and 80%) were synthesized using the hydrothermal method. The physical properties of the obtained materials were characterized by X-Ray Diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR / ATR-IR), Scanning Electron Microscopy (SEM), and UV-Vis Spectroscopy. XRD analyses confirmed the wurtzite crystal structure of pure ZnO. With increasing PANI content, a decrease in diffraction peak intensities and peak broadening were observed due to the amorphous nature of the polymer. In the ATR-IR/FTIR spectra, Zn–O bond vibrations and the characteristic benzenoid and quinoid ring stretching bands associated with PANI were identified [1]. Changes in the intensities and frequencies of these bands with the addition of PANI revealed interactions between the constituent components. SEM surface images showed that the formation of granular and fibrous structures increased with increasing PANI content, resulting in a more porous and agglomerated morphology in the composites. According to the results of UV-Vis spectroscopy and Tauc band gap analyses, the addition of PANI affected the optical absorption properties and altered the optical band gap of the nanocomposites [2].

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The Effect of Low-Level Bipartite Doping on the Morphological and Magnetocaloric Properties of La-Mn-O Perovskite Manganite

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This study investigates how the systematic substitution of Ba and Pb at the A-site, and Cu at the B-site, induces significant modifications in the structural, morphological, and magnetic properties of LaMnO₃ perovskite manganites. In particular, Curie temperature (T_C) and isothermal magnetic entropy ($-\Delta S_M$) change significantly. Three distinct compositions, namely La_{0.70}Ba_{0.30}MnO₃, La_{0.65}Ba_{0.30}Pb_{0.05}MnO₃, and La_{0.65}Ba_{0.30}Pb_{0.05}Mn_{0.9}Cu_{0.1}O₃, were successfully synthesized via the sol-gel method and sintered in air at 1100°C for 24 hours. The crystallographic and morphological properties of the fabricated samples were characterized using X-ray diffraction (XRD) and scanning electron microscopy (SEM). XRD analysis confirms that all samples stabilize in a rhombohedral structure belonging to the R-3c space group. Microstructural evaluations from SEM images reveal a distinct change in the particle size distribution, with average grain sizes determined as ~350 nm, ~550 nm, and ~250 nm for the respective compositions. The magnetic behavior was systematically evaluated using a Magnetic Property Measurement System (MPMS). The experimental results demonstrate that both the T_C and $-\Delta S_M$ are highly sensitive to the dual-site doping strategy. The T_C values were tuned to 340 K, 350 K, and 314 K, respectively. Notably, the Cu-doped sample successfully shifts the transition temperature toward the room-temperature region (314 K). Furthermore, under an external magnetic field change of 1 T, the maximum magnetic entropy changes were calculated as 1.46 J/kgK, 1.51 J/kgK, and 0.97 J/kgK, respectively. We believe that efforts can contribute to the theoretical understanding of the magnetocaloric effect in La-Mn-O₃ compounds. Especially it is revealed that T_C and $-\Delta S_M$ values are very sensitive to doping. It has been shown that ionic radius of the A-site and B-site in La-Mn-O₃ (ABO₃) play a decisive role in determining magnetic properties.

Keywords: Perovskite manganite; magnetocaloric effect, sol-gel method

Effect of Nitrogen Annealing on the Structural, Optical and Electrical Properties of CdTe Thin Films Deposited on Different Substrates by Chemical Bath Deposition

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CdTe is an important II–VI semiconductor material widely used in photovoltaic and optoelectronic applications due to its suitable band gap and high absorption coefficient. In this study, CdTe thin films were deposited on glass and ITO-coated glass substrates by the Chemical Bath Deposition (CBD) method. The deposited films were subsequently annealed in a nitrogen atmosphere at 150°C and 250°C.

The structural, morphological, optical and electrical properties of the films were investigated using X-ray diffraction (XRD), scanning electron microscopy (SEM), UV–Vis spectroscopy and Hall effect measurements. Particular attention was given to the influence of substrate type and nitrogen annealing on the crystal structure, surface morphology, optical characteristics and charge transport properties of the CdTe thin films.

This study aims to provide a better understanding of the combined effects of substrate selection and nitrogen annealing conditions on CBD-grown CdTe thin films and to evaluate their potential for photovoltaic and optoelectronic applications.

Keywords: CdTe, Chemical Bath Deposition, Nitrogen Annealing, Substrate Effect, Hall Effect.

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Comparative TCAD Analysis of Superlattice Buffer Layers in High-Indium e-SWIR Photodetectors

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Pushing standard short-wave infrared detection into the extended-SWIR (e-SWIR) spectrum covering wavelengths up to $2.5\ \mu\text{m}$ unlocks vastly superior capabilities for advanced low-light imaging and specialized spectroscopy. To achieve e-SWIR sensitivity using Indium Gallium Arsenide (InGaAs) photodetectors, the Indium concentration must be heavily increased to form $\text{In}_{0.83}\text{GaAs}$ effectively narrowing the bandgap to capture these longer wavelengths. While Indium Phosphide (InP) provides the optimal substrate foundation, growing this high-Indium layer directly on InP causes a severe $\sim 2.0\%$ lattice mismatch. The resulting interfacial strain generates threading dislocations that act as non-radiative generation-recombination centers, critically inflating dark current and degrading device sensitivity.

To overcome these material limitations, this study utilizes Silvaco TCAD finite-element modeling to evaluate the integration of graded InGaAs/InAlAs superlattice layers. Three photodetector architectures are comparatively analyzed: (1) a baseline unbuffered $\text{In}_{0.83}\text{GaAs}$ layer grown directly on an InP substrate; (2) an intermediate architecture featuring a single graded InGaAs/InAlAs superlattice transition layer; and (3) an advanced configuration incorporating two InGaAs/InAlAs superlattices with graded InGaAs layers.

Evaluating key metrics including dark current, steady-state photocurrent, recombination profiles, spatial photogeneration, and photon absorption simulations reveal the unbuffered model fails due to structural mismatch, yielding dominant non-radiative recombination and maximized dark current. Conversely, incorporating superlattices accommodates this mismatch and optimizes heterojunction bandgap curving. This continuous energy band grading filters threading dislocations and establishes a precisely tuned electron barrier that suppresses thermionic emission and non-radiative recombination without sacrificing carrier sweep-out efficiency. Ultimately, these superlattice-enhanced architectures successfully manage interfacial strain, secure localized photogeneration, and yield the lowest simulated dark current densities, confirming superlattice bandgap engineering as a fundamental requirement for optimizing high-performance e-SWIR photodetectors.

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POSTER PRESENTATIONS

Thickness-Dependent Optoelectronic and Interfacial Response of ETL-Free and CdS-Based AgBiS₂ Solar Cells

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The role of the electron transport layer (ETL) in AgBiS₂ thin-film solar cells was investigated by comparative SCAPS-1D simulations of two device architectures, an ETL-free configuration (FTO/AgBiS₂/Au, D0) and a CdS-containing counterpart (FTO/CdS/AgBiS₂/Au, D1). Silver bismuth sulfide has recently attracted growing interest as a low-toxicity absorber material with a direct bandgap near 1.3 eV and an absorption coefficient above 10⁵ cm⁻¹, which makes it a strong candidate for scalable and environmentally benign photovoltaic applications [1]. Although CdS has been widely employed as the standard buffer layer in chalcogenide devices, a direct comparison between CdS-based and ETL-free AgBiS₂ configurations under identical simulation conditions has not been reported [2]. In the present work, both structures were analyzed through current–voltage, capacitance–voltage, external quantum efficiency, spectral responsivity, frequency-dependent conductance and impedance measurements under AM1.5G illumination. The AgBiS₂ absorber thickness was varied from 100 to 1000 nm in both devices and the CdS buffer thickness in D1 was independently swept from 50 to 250 nm. Additional simulations were performed under three distinct illumination conditions, namely 1-Sun (AM1.5G), a broad white spectrum (300–1300 nm) and a narrow visible spectrum (400–800 nm), in order to further probe the optical and interfacial contributions to the device response. The insertion of the CdS buffer left the open-circuit voltage essentially unchanged at 0.917 V and produced a modest gain in fill factor from 82.31% to 83.64%, while the short-circuit current density decreased from 30.885 to 27.478 mA/cm². Impedance and conductance analyses consistently showed a larger and more complex electrical response for the CdS-containing device under all illumination conditions studied, which is consistent with a coupled contribution of short-wavelength optical attenuation and modified interfacial transport at the CdS/AgBiS₂ boundary [3]. These findings identify CdS as an interfacial modifier rather than a universally beneficial electron transport layer for AgBiS₂ solar cells and support the ETL-free FTO/AgBiS₂/Au architecture as a viable route for low-cost and Cd-free thin-film photovoltaic devices.

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Impact of ALD-Deposited ZnO Interlayer on the Dielectric Response and Electric Modulus of Al/p-Si Junctions

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In this study, Al/ZnO/p-Si heterojunction photodiodes were fabricated by depositing a 5 nm-thick ZnO interlayer on p-type Si (100) substrates via atomic layer deposition (ALD), followed by thermal evaporation of Al top contacts. The frequency- and voltage-dependent dielectric and electrical properties of the devices were systematically investigated through admittance spectroscopy ($Y = G + j\omega C$) over a wide frequency range (1 kHz–1 MHz) and bias window (–2 to +2 V). The capacitance–voltage (C–V) and conductance–voltage (G–V) characteristics revealed a strong frequency dispersion, particularly at low frequencies, which is attributed to the contribution of interface trap states (D_{it}) located at the ZnO/p-Si interface that can follow the AC signal at low frequencies but fail to respond at higher ones [1-2]. To fully elucidate the polarization and charge transport mechanisms, key dielectric parameters such as the real (ϵ') and imaginary (ϵ'') components of the complex permittivity, dielectric loss ($\tan \delta$), and the electric modulus (M' and M'') were derived from the admittance data. The ϵ' -frequency plots exhibited a sharp decrease at lower frequencies, characteristic of Maxwell-Wagner interfacial polarization arising from charge accumulation at the heterointerface, whereas ϵ'' spectra displayed distinct loss peaks indicating trap-assisted relaxation processes [3]. Cole-Cole plots further illustrated asymmetric arc patterns, evidencing the distributed relaxation times associated with hopping conduction via oxygen vacancies within the ALD-grown ZnO layer [4]. These comprehensive admittance and dielectric spectroscopy results not only provide profound insights into the interfacial quality, trap state dynamics, and relaxation phenomena of the ALD-fabricated ZnO/p-Si heterostructure but also demonstrate its strong high-frequency optoelectronic device applications.

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Electrospun YBCO Superconductors: From Precursor Nanofibers to Functional Superconducting Structures

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YBCO is a high-temperature superconductor whose performance depends on the complex relationship between crystal structure, oxygen stoichiometry, grain linkage, secondary phases, and process-dependent morphology [1]. This study presents a review-oriented overview of current strategies used to shape YBCO, focusing particularly on graphene doping and electrospinning-based nanofibers. Graphene and borophene-type dopants are considered promising because their high surface areas and unique electronic structures can alter grain boundary regions, intergranular transport, and magnetic flux retention; however, their beneficial effects are largely dependent on concentration, dispersion, and compatibility with the Y123 matrix. Over- or under-dispersed dopants can instead lead to secondary phases or weaken intergranular linkage. On the other hand, electrospinning offers a way to produce YBCO precursor fibers with high aspect ratio and controllable microstructure. Polymer concentration, solution viscosity, applied voltage, flow rate, and needle-collector distance determine jet stability, bead formation, fiber continuity, and diameter distribution [2, 3]. Continuous and homogeneous precursor fibers are particularly important because subsequent calcination and sintering can transform the initial nanoscale morphology into superconducting structures whose electrical behavior remains sensitive to porosity, oxygen distribution, and weak linkages at the grain boundary. Phase purity, morphology, dopant distribution, heat treatment, and superconducting transition properties must be considered together. This overview highlights the main opportunities and limitations of electrospinning coupled to the development of next-generation YBCO superconductors with improved functional applicability.

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Density Functional Theory Analysis of a Novel Naphthalene-Carboxylic-Acid Interfacial Material for Organic Photovoltaic Cells

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In this study, the functional organic semiconductor 4-(4-butoxy-N-(4-butoxyphenyl)anilino)naphthalene-1-carboxylic acid and its derivatives, not previously investigated in the literature, are employed for the first time as an interfacial layer in organic photovoltaic (OPV) cells. In the first stage, the energy levels of this interfacial material are theoretically calculated using Density Functional Theory (DFT), determining the Highest Occupied Molecular Orbital (HOMO) and Lowest Unoccupied Molecular Orbital (LUMO) values. Geometry optimization is performed at the B3LYP/6-31G(d,p) level in ORCA 6.1.1, followed by single-point frontier-orbital energy calculations at the CAM-B3LYP/6-311+G(d,p) level, since this long-range-corrected functional more accurately describes the donor-acceptor charge-transfer character arising from the triarylamine donor unit and the carboxylic-acid anchoring group [1,2]. Vibrational frequency analysis confirms that the optimized geometry corresponds to a true minimum on the potential energy surface. The calculated HOMO/LUMO levels are used to evaluate the energetic alignment of the interfacial material with the ITO electrode work function and with the donor/acceptor active-layer levels, providing a theoretical basis for the interlayer's expected role in improving hole injection and charge-transport properties at the ITO/active-layer interface of OPV devices [3].

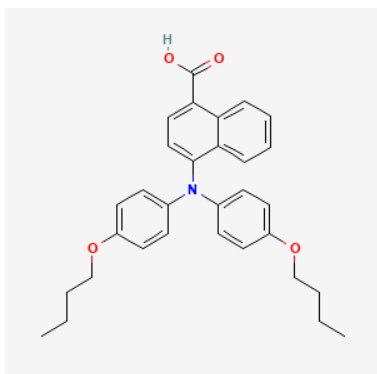


Figure 1. Chemical structure of organic semiconductor 4-(4-butoxy-N-(4-butoxyphenyl)anilino)naphthalene-1-carboxylic acid from PubChem[4]

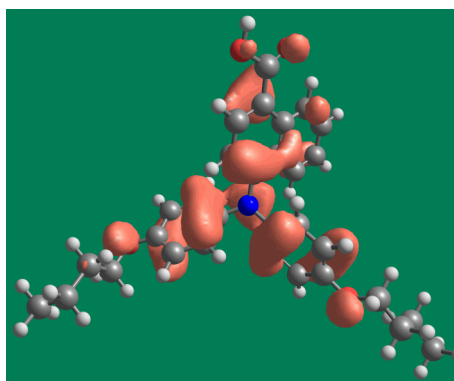


Figure 2. HOMO of the naphthalene-carboxylic-acid interlayer.

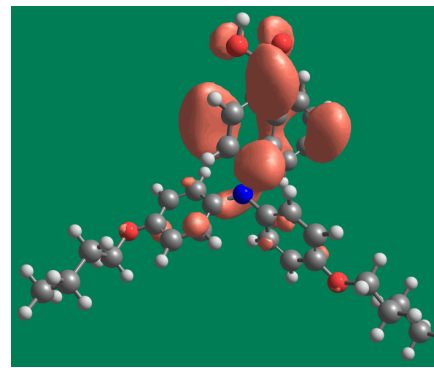


Figure 3. LUMO of the naphthalene-carboxylic-acid interlayer.

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The initial three-dimensional geometry of the interfacial molecule was generated from its SMILES representation and pre-optimized using the MMFF94 force field in RDKit. All quantum-chemical calculations were performed with the ORCA 6.1.1 program package: geometry optimization and vibrational frequency analysis were carried out at the B3LYP/6-31G(d,p) level, followed by single-point frontier-orbital (HOMO/LUMO) calculations at the CAM-B3LYP/6-311+G(d,p) level, both accelerated using the RIJCOSX approximation with the def2/J auxiliary basis. Molecular orbital isosurfaces (Figures 2-3) were generated with ORCA's orca_plot and orca_2mkl utilities and visualized in Chemcraft.

Table 1. Comparison of the organic semiconductor 4-(4-butoxy-N-(4-butoxyphenyl)anilino)naphthalene-1-carboxylic acid by ORCA 6.1.1 program package: geometry optimization and vibrational frequency analysis were carried out at the B3LYP/6-31G(d,p) level, followed by single-point frontier-orbital (HOMO/LUMO) calculations at the CAM-B3LYP/6-311+G(d,p) level.

Functions	HOMO (eV)	LUMO (eV)	Gap (eV)
CAM-B3LYP/6-311+G(d,p)	-6.445	-0.937	5.508
B3LYP/6-311+G(d,p)	-5.098	-1.939	3.160

To assess the functional dependence of the calculated frontier-orbital energies, an additional single-point calculation was performed at the B3LYP/6-311+G(d,p) level on the identical B3LYP/6-31G(d,p)-optimized geometry. This benchmark yielded a HOMO-LUMO gap of 3.16 eV (HOMO = -5.10 eV, LUMO = -1.94 eV), markedly narrower than the 5.51 eV gap obtained at the CAM-B3LYP/6-311+G(d,p) level (HOMO = -6.45 eV, LUMO = -0.94 eV). The ~2.35 eV widening upon inclusion of long-range Hartree-Fock exchange is consistent with the well-documented tendency of conventional hybrid functionals such as B3LYP to underestimate frontier-orbital gaps in donor-acceptor pi-conjugated systems owing to self-interaction (delocalization) error, an effect substantially mitigated by the range-separated exchange treatment in CAM-B3LYP. The B3LYP-level gap falls within the range typically reported for triarylamine-based donor-acceptor chromophores, corroborating the physical plausibility of the optimized ground-state geometry, whereas the CAM-B3LYP value is regarded as the more appropriate descriptor of the charge-transfer character intrinsic to the donor-acceptor architecture of the title interlayer.

Keywords: Density Functional Theory, HOMO-LUMO, Interfacial Layer, Organic Photovoltaic Cells, Triarylamine, Naphthalene Carboxylic Acid, CAM-B3LYP.

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The Effect of Adding Waste Slag on the Mechanical and Wear Behavior of EPDM/CaCO₃-Slag Composites

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This study investigated the mechanical and wear properties of EPDM rubber composites containing different mineral fillers. The composites were produced by homogeneously mixing EPDM rubber compound with CaCO₃ and waste slag fillers in an open mixer, followed by vulcanization. EPDM/50CaCO₃ and EPDM/20CaCO₃/30Slag composites were evaluated in this study [1][2]. In the composite using CaCO₃ and waste slag together, tensile strength decreased by 3.2%, while elongation at break increased by 8.9%. Permanent deformation decreased by 24.8%, while elasticity increased by 7.1%. Furthermore, tear strength increased by 61.8%, and wear decreased by 43.5%. The results show that the combined use of CaCO₃ and waste slag is effective in improving the tear and wear performance of EPDM composites.

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Novel 1,4-Dihydropyridine Bioactive Scaffolds: Microwave-Assisted Synthesis and Evaluation of Dual α -Glucosidase Inhibitory and Antioxidant Activities

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1,4-Dihydropyridines (1,4-DHPs) represent a privileged class of nitrogen-containing heterocycles essential to numerous pharmacological agents [1]. Overcoming the limitations of conventional synthesis, microwave-assisted multicomponent reactions (MCRs) provide a highly efficient, eco-friendly approach that accelerates reaction times and maximizes atom economy [2]. Herein, a series of novel 1,4-DHP derivatives were strategically synthesized via a rapid microwave-assisted protocol. To assess their potential as targeted therapeutic agents, the compounds were systematically evaluated for *in vitro* dual biological activities. Anti-diabetic efficacy was determined via α -glucosidase inhibition assays, alongside radical scavenging tests for antioxidant capacity. Remarkably, several candidates exhibited α -glucosidase inhibitory activities substantially more potent than the clinical standard, Acarbose [3], while simultaneously demonstrating exceptional antioxidant properties. This eco-friendly synthetic route successfully yielded highly potent, dual-action bioactive agents. These striking biological profiles strongly indicate that the synthesized 1,4-DHP scaffolds hold immense promise for future nanomedicine and advanced biomaterial applications.

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Hydrogen-Bonded Cholesteryl Carbamate–Imidazole/Poly(styrene-co-maleic acid) Supramolecular Liquid Crystalline Polymer Complexes

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Supramolecular hydrogen-bonded liquid crystalline polymers provide an effective strategy for combining the processability of polymeric materials with the anisotropic properties of liquid crystal mesogens. In this study, hydrolyzed poly (styrene-co-maleic acid) (PSMA) was employed as a hydrogen bond donor polymer and complexed with a cholesteryl carbamate–imidazole mesogen (Cho-Imi) through reversible hydrogen bonding interactions. Supramolecular complexes were prepared at different polymer-to-mesogen molar ratios to investigate the influence of composition on liquid crystalline organization.

The synthesized mesogen and supramolecular complexes were characterized by Fourier Transform Infrared (FTIR) spectroscopy and proton Nuclear Magnetic Resonance (¹H NMR) spectroscopy. Thermal transitions and mesomorphic behavior were investigated using Differential Scanning Calorimetry (DSC) and Polarized Optical Microscopy (POM). The combined experimental approach is intended to establish structure–property relationships between hydrogen-bond density, mesomorphic organization in polymeric liquid crystalline systems. The proposed supramolecular design offers a modular platform for the development of responsive liquid crystalline polymers with potential applications in dielectric materials, electro-optic devices, adaptive coatings, and functional soft-matter systems [1-3].

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Theoretical Analysis of CaF₂ Thin-Film Antireflectance Coatings on Sapphire in the 900–3000 nm

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The primary purpose of antireflection (AR) coatings is to reduce reflection losses at optical surfaces and thereby increase the amount of light transmitted through the surface. Particularly for optical materials with a high refractive index, such as sapphire, a significant amount of light can be reflected at the air–substrate interface due to the refractive index mismatch. In this study, the theoretical antireflection behavior of a single-layer CaF₂ thin-film coating on a sapphire substrate was investigated over the wavelength range of 900–3000 nm, with the optical performance specifically targeted at a wavelength of 1630 nm.

In the theoretical calculations, CaF₂ film thicknesses of 180, 210, 283.91, 320, and 380 nm were considered. The results demonstrate that varying the film thickness significantly shifts the wavelength at which the minimum reflectance and the corresponding maximum transmittance occur. For the investigated film thicknesses, the characteristic reflectance minima were obtained at approximately 1033.1, 1206.1, 1630.8, 1844.1, and 2189.9 nm, respectively. These results demonstrate that the CaF₂ film thickness is a critical parameter in determining the operating wavelength of the antireflection coating. Considering the target wavelength of 1630 nm, the optimum film thickness was determined to be 283.91 nm. At this thickness, the CaF₂ coating exhibits a minimum reflectance at approximately 1630.8 nm, demonstrating optical behavior that closely matches the targeted operating wavelength. Consequently, the 283.91 nm-thick CaF₂ thin-film coating provides a suitable single-layer antireflection coating design for optical systems operating around 1630 nm by reducing reflection losses at the sapphire surface and enhancing light transmission.

Acknowledgement: This study was supported by the Scientific Research Projects (BAP) Coordination Unit of Karamanoğlu Mehmetbey University under Project No. 08-M-26.

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Synthesis and Mesomorphic Characterization of a Novel Cholesteryl-Based Chalcone Liquid Crystal Mesogen

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A new cholesterol-based chalcone liquid crystalline mesogen was synthesized to investigate the influence of a conjugated chalcone moiety on the mesomorphic behavior of chiral liquid crystals. The target compound, 4-cinnamoylphenyl cholesteryl carbonate, was prepared through the reaction of cholesteryl chloroformate with 1-(4-hydroxyphenyl)-3-phenylprop-2-en-1-one in the presence of triethylamine under mild conditions. The intermediate chalcone was synthesized by Claisen–Schmidt condensation of 4-hydroxyacetophenone and benzaldehyde. The molecular structures of both the intermediate and the final mesogen were confirmed by Fourier Transform Infrared (FTIR) spectroscopy and proton Nuclear Magnetic Resonance (¹H-NMR) spectroscopy. Mesomorphic properties were investigated using Differential Scanning Calorimetry (DSC) and Polarized Optical Microscopy (POM). Thermal analyses demonstrated liquid crystalline behavior, while POM revealed the formation of a chiral mesophase during cooling. The synthesized compound exhibited an isotropic-to-cholesteric transition followed by crystallization, indicating that incorporation of the chalcone unit preserves the liquid crystalline characteristics of the cholesterol-based mesogen while introducing an extended conjugated aromatic system. These findings demonstrate that chalcone-functionalized cholesterol derivatives are promising candidates for advanced thermotropic liquid crystalline materials with potential applications in optical materials, photonic devices, and display Technologies [1,2].

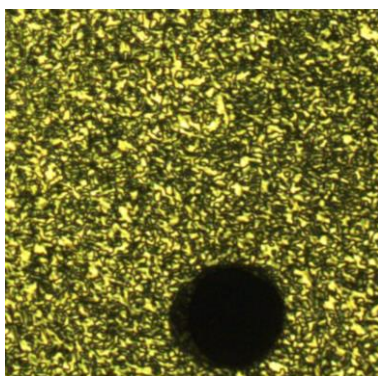


Figure 1 Nematic phase of 4-cinnamoylphenyl Cholesteryl carbonate

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Green Synthesis Method for Industrial Coffee Waste-Based Activated Carbon/ Fe_3O_4 Nanocomposites and Their Applications in Waste Dye Adsorption

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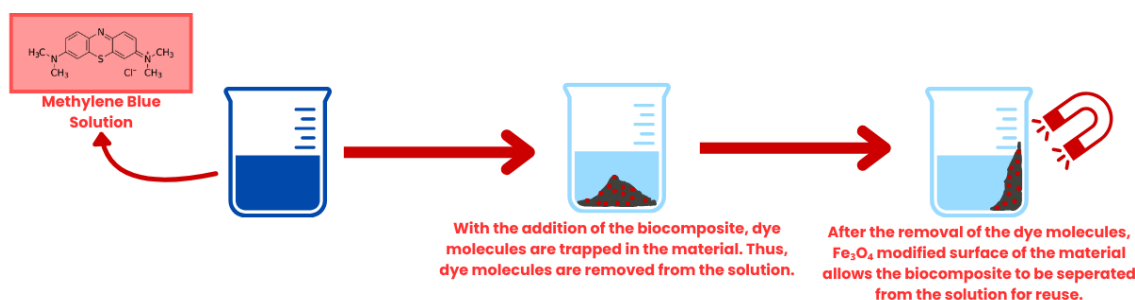
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Organic dyes discharged from the textile, paper, leather, and food industries pose serious environmental and health risks due to their toxic effects. Among available treatment approaches, adsorption is a preferred treatment method for its low cost and simplicity. However, conventional carbon-based adsorbents are difficult to separate from treated water, limiting their reusability and overall efficiency.

This project offers a sustainable magnetic material that combines biochar derived from spent coffee grounds with Fe_3O_4 nanoparticles produced via a green synthesis route. Spent coffee grounds were first converted into a biochar using KOH-assisted pyrolysis, thus yielding a porous material capable of strong interactions with dye molecules. Fe_3O_4 nanoparticles were then co-precipitated [1] onto this carbon matrix, giving the composite magnetic separability for easy recovery and reuse.

The resulting nanocomposite was characterized using SEM, FTIR, XRD, and BET analyses. Its dye-removal performance was evaluated through an ultrasound-assisted adsorption process, which combines surface adsorption with sonolysis [2] to enhance degradation efficiency, targeting over 90% dye removal. Testing spans a range of pH, temperature, and initial dye concentrations. Reusability across multiple adsorption–desorption cycles and performance relative to commercial activated carbon is also assessed as key success criteria.



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Effect of Silane-Treated and Untreated Micronized Glass Fiber on the Rheological, Mechanical, and Tribological Properties of EPDM/CaCO₃ Composites

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In this study, the rheological and mechanical properties of micronized glass fiber-reinforced EPDM/CaCO₃ composites with and without silane treatment were investigated. For this purpose, EPDM/CaCO₃ rubber, an EPDM composite containing 12 wt% untreated micronized glass fiber (EPDM/CaCO₃/12MGF), and an EPDM composite containing 12 wt% silane-treated micronized glass fiber (EPDM/CaCO₃/12SMGF) were compounded using a laboratory-scale Banbury mixer. The rheological and viscosity properties of the compounds were characterized by moving die rheometer (MDR) and Mooney viscosity measurements. Following press vulcanization and preparation of the test specimens, tensile properties, including tensile strength and elongation at break, were determined. In addition, density and hardness measurements were performed to evaluate the physical properties of the composites. The experimental results revealed that the incorporation of micronized glass fiber into EPDM increased the maximum torque (MH), whereas the silane treatment had no significant effect on the rheological properties. The addition of micronized glass fiber decreased the tensile strength of EPDM by 21.5%; however, silane treatment increased the tensile strength by 5.8% compared with the untreated glass fiber-filled composite. The tensile stress at 100% elongation (modulus) increased by 19% with the incorporation of micronized glass fiber and by a further 26% following silane treatment. The incorporation of micronized glass fiber resulted in reductions in permanent set, elasticity, and tear strength. The addition of untreated micronized glass fiber improved the abrasion resistance of EPDM by 5.4%, while the incorporation of silane-treated micronized glass fiber resulted in an approximately 34.7% reduction in abrasion volume loss. Overall, the use of silane-treated micronized glass fiber improved the performance of EPDM composites, demonstrating its potential as an alternative to conventional glass fiber reinforcements in high-value-added rubber composite applications.

Keywords: EPDM; micronized glass fiber; silane treatment; moving die rheometry; abrasion

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Optimization of Nitrogen-doped Ga₂O₃ Films Produced by Magnetron Sputtering Method

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In this study, Ga₂O₃ films were produced on glass substrates using radio frequency (RF) magnetron deposition at different nitrogen concentrations (0%, 30%, and 60%). The produced films were then annealed at 550 °C to investigate changes in their structural and optical properties. Structural analyses were performed using X-ray diffraction (XRD) to characterize the crystal structures of the films, and surface morphology was detailed using scanning electron microscopy (SEM). Optical properties were determined using UV-Vis spectrophotometers to define energy band gaps. The energy band gaps for the unannealed films were measured as 4.843, 4.806, and 4.806 eV, respectively, while these values decreased to 4.843, 4.715, and 4.715 eV after annealing. For unannealed samples, the film thicknesses were found to be 329.9 nm for 0% nitrogen, 289.5 nm for 30% nitrogen, and 268.3 nm for 60% nitrogen. For films annealed at 550 degrees, the thicknesses were found to be 319.7 nm for 0% nitrogen, 286.0 nm for 30% nitrogen, and 256.8 nm for 60% nitrogen. It was observed that the thickness of the films decreased with the effect of annealing.

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Design-Structure-Performance Relationships in Polymer Matrix Hybrid Composite Bone Plates: A Critical Review

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Metallic bone fixation plates provide reliable fracture stabilization; however, their high stiffness relative to cortical bone may alter physiological load sharing and contribute to stress shielding. Polymer matrix hybrid composites offer a tunable alternative because matrix chemistry, reinforcement type, hybrid architecture, stacking sequence, and processing route can be adjusted to balance stiffness and structural reliability. This critical review evaluates reported relationships between material design, laminate architecture, manufacturing quality, and performance in polymer-based composite systems proposed for bone fixation. Carbon/flax epoxy and bio-epoxy laminates show high load-bearing capability, with tensile moduli of approximately 37.6-42 GPa and tensile strengths of about 340-400 MPa [1,2]. Lower-stiffness hybrids can approach the mechanical range of cortical bone; flax/basalt epoxy laminates have exhibited a tensile modulus of 13.88 GPa and a tensile strength of 133.3 MPa [3]. The literature further indicates that ply position and hybrid architecture strongly affect tensile, flexural, interlaminar, and impact responses [4]. Vacuum-assisted processing influences void formation, impregnation, and fiber-matrix bonding, while hydroxyapatite-based modifications may improve interfacial, viscoelastic, and bioactivity-related behavior when dispersion is adequately controlled [5]. Overall, composite bone plate suitability is governed not by maximum stiffness or strength alone, but by a balance of stiffness compatibility, fracture stability, fatigue and impact resistance, interfacial integrity, and processing quality. Key research needs include standardized plate-level testing, evaluation of screw-hole-induced damage, long-term cyclic loading under physiological environments, and integrated mechanical, thermal, microstructural, and biological characterization.

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Improving the Performance of PEO-Based Solid Electrolytes with Environmentally Friendly DOBHTP Plasticizer for Solid-State Lithium Batteries

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In this study, an environmentally friendly, phthalate-free plasticizer, commercial DOBHTP, was incorporated into polyethylene oxide (PEO)-based flexible solid macromolecules to fabricate solid-state lithium battery electrolytes. Compared to conventional commercial plasticizers such as diisononyl phthalate (DINP) and di-2-ethylhexyl phthalate (DEHP), DOBHTP demonstrated superior plasticizing efficiency, accelerated processing desiccation, and a reduced melting temperature. When blended with the PEO/lithium-salt matrix, the rapid thermal transition of the DOBHTP commercial mixture significantly lowered processing energy consumption. Electrochemical characterization of the resulting membranes (thicknesses of 100 μm and 132 μm) was conducted via cyclic voltammetry (Figure 1). These findings indicate that the integration of DOBHTP into PEO-based solid electrolytes is a highly promising strategy for optimizing electrochemical performance [1,2].

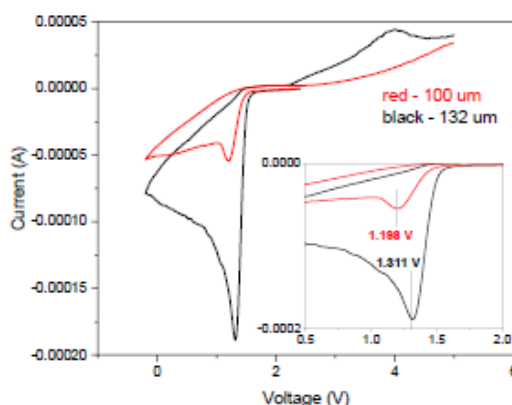


Figure 1. Cyclic voltammetry of DOBHTP-doped electrolytes with different thicknesses (100 μm and 132 μm)

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DFT and TD-DFT Investigation of the OLED Properties of a Triazole-Based Molecule

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Triazoles are important compounds with potential for use in organic light-emitting diodes (OLEDs). Triazole-based ligands can play important roles in energy transfer mechanisms. This property also has a positive effect on the energy efficiency of phosphorescent materials used in OLEDs. Triazole-containing complexes generally provide higher light and quantum efficiencies, thereby increasing the energy efficiency of OLED technologies [1]. In this study, the OLED behavior of the molecule 4-(benzylideneamino)-5-propyl-2,4-dihydro-[1,2,4]triazol-3-one was determined following the determination of quantum chemical parameters via DFT and TD-DFT calculations.

The three-dimensional ground-state (S_0) geometries of the molecule were optimized using the Gaussian 09W [2] software package and the B3LYP [3] hybrid functional. To determine their electronic and optoelectronic properties, E_{HOMO} , E_{LUMO} , E_{gap} , dipole moment (μ), polarization (α), hyperpolarization (β), electron/hole rearrangement energies (λ_e , λ_h), adiabatic/vertical ionization potentials (IP_a , IP_v), adiabatic/vertical electron affinities (EA_a , EA_v), chemical hardness (η) and softness (σ) values, and boundary orbital shapes were obtained; subsequently, the energies of the molecules under investigation in the S_0 , S_1 , and T_1 states, the oscillator force (f), and the transition energy (E_{ex}) were calculated at the TD-DFT level. Based on the results obtained, the emission values and TADF parameters of the studied molecules were determined. The OLED behaviors were investigated using the parameters obtained in this study. It was determined that the material cannot be used as an HTL, ETL, or direct emitter but is suitable as a host material; based on the results, recommendations were made to improve the efficiency of the OLED device, and an example design was presented.

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Growth and Optical Characterization of Sapphire/NiO/Ga₂O₃ and Sapphire/Ga₂O₃/NiO Heterostructures for Solar-Blind UV Photodetectors

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Solar-blind ultraviolet (UV) photodetectors have attracted considerable attention owing to their potential applications in environmental monitoring, flame detection, space communications, and defense technologies. Among wide-bandgap semiconductor materials, Ga₂O₃ has emerged as a promising candidate for solar-blind UV photodetectors because of its large bandgap, high transparency, and excellent chemical and thermal stability. However, the realization of high-performance Ga₂O₃-based photodetectors requires the formation of high-quality heterojunctions with suitable p-type oxide semiconductors.

In this study, Sapphire/NiO/Ga₂O₃ and Sapphire/Ga₂O₃/NiO heterostructures were fabricated using the radio-frequency (RF) magnetron sputtering technique. The thicknesses of the NiO and Ga₂O₃ films were precisely controlled using a quartz crystal microbalance (QCM) during deposition, resulting in film thicknesses of 250 nm and 125 nm, respectively. The influence of the layer sequence on the optical properties of the heterostructures was systematically investigated. Structural and optical characterizations were carried out to evaluate the quality of the deposited thin films and heterojunctions. The optical properties, including transmittance, absorbance, and optical bandgap, were analyzed and compared for both heterostructure configurations. The obtained results demonstrate that the deposition sequence significantly affects the optical behavior of the heterostructures, indicating its importance in the design and optimization of oxide-based solar-blind UV photodetectors. The findings provide valuable insight into the development of high-performance NiO/Ga₂O₃ heterojunction devices fabricated by RF magnetron sputtering and contribute to the advancement of solar-blind UV photodetection technologies.

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Density Functional Theory Investigation of Adsorption Mechanisms and Electronic Properties on Pd-Co Surfaces

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Transition metal alloys, particularly palladium-cobalt (Pd-Co) systems, are promising electrocatalysts due to their tunable electronic and surface properties. In this study, spin-polarized density functional theory calculations were performed using Quantum ESPRESSO with the PBE functional and PAW pseudopotentials to investigate H, 2H, and O adsorption on a Pd-Co surface [1]. The calculated magnetic moments were 20.24, 19.32, and 19.35 μB for H-, 2H-, and O-covered slabs, respectively. The optimized 2H structure consisted of two separated H atoms adsorbed at neighboring Co-centered sites, indicating a dissociative hydrogen adsorption pathway. Projected density-of-states and d-band analyses revealed adsorbate-dependent electronic redistribution near the Fermi level, highlighting the role of Pd-Co hybridization in surface reactivity [2]. Experimentally, Pd_{0.4}Co_{0.6} nanoparticles exhibited an FCC crystal structure with the Fm-3m space group and a lattice parameter of $a = b = c = 3.9909 \text{ \AA}$, with an average particle size of approximately 8 nm. Electrochemical measurements demonstrated bifunctional catalytic activity. For HER, an onset potential of 12 mV vs. RHE and an overpotential of 62 mV at 50 mA cm⁻² were obtained. For OER, an onset potential of 1.595 V vs. RHE and an overpotential of 1659 mV at 50 mA cm⁻² were observed. Overall, the combined theoretical and experimental results demonstrate that Pd-Co alloying strongly influences adsorption, electronic structure, and electrocatalytic activity, highlighting the potential of Pd-Co nanoparticles as bifunctional electrocatalysts.

Keywords: Density Functional Theory, Pd-Co Alloy, Surface Adsorption, Magnetic Moment, d-Band Center, Electrocatalysis.

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Effect of Magnetic Field on the Confinement Potential and Total Optical Absorption of a Symmetric Hyperbolic Quantum Well

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This study presents a theoretical investigation of the effects of an applied magnetic field on the confinement potential and optical absorption properties of a symmetric hyperbolic quantum well heterostructure. The electronic structure is obtained by solving the Schrödinger equation within the effective mass approximation using a numerical diagonalization method. Particular attention is given to the evolution of the hyperbolic confinement potential under different magnetic field strengths and its influence on the total optical absorption coefficient (TOAC) associated with intersubband transitions between the lowest confined electronic states. The results show that the applied magnetic field enhances electron localization within the quantum well and modifies the effective confinement experienced by the electrons. As the magnetic field strength increases, the intersubband transition energies increase due to magnetic localization, leading to a pronounced blueshift of the TOAC resonance peaks. These results demonstrate that the magnetic field provides an effective external control parameter for tuning the electronic confinement and optical response of the symmetric hyperbolic quantum well. The resulting tunability could be useful for the design of magnetically controlled terahertz and infrared optoelectronic devices.

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Effect of Superlattice Period Number on the Structural, Optical, and Surface Properties of $\text{In}_{0.68}\text{Ga}_{0.32}\text{As}/\text{In}_{0.21}\text{Al}_{0.79}\text{As}$ Heterostructures

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Quantum cascade lasers (QCLs) are semiconductor light sources based on precisely engineered multilayer heterostructures, where structural quality and layer control are important for device performance [1]. In InGaAs/InAlAs-based QCL structures, superlattice growth requires careful optimization because periodicity, strain balance, and interface quality strongly affect the multilayer structure [2,3].

In this study, the effect of superlattice (SL) period number on the structural, optical, and surface properties of $\text{In}_{0.68}\text{Ga}_{0.32}\text{As}/\text{In}_{0.21}\text{Al}_{0.79}\text{As}$ heterostructures was investigated. Four samples containing 5, 20, 30, and 50 SL periods were grown under comparable epitaxial conditions. In-situ reflectance, high-resolution X-ray diffraction (XRD), spectroscopic reflectance, Raman spectroscopy, and microscopy were used to evaluate structural periodicity, optical response, lattice-related characteristics, and surface morphology. Wang et al. reported that well-resolved XRD satellite peaks and interference fringes in InAlAs/InGaAs superlattices are associated with good reproducibility of the superlattice periods [4].

In-situ reflectance measurements showed periodic oscillations for the 30- and 50-period structures, whereas similar features were not clearly resolved for the 5- and 20-period samples. These findings indicate that the optical response of repeated InGaAs/InAlAs layers becomes more clearly observable with increasing SL period number and may support the optimization of QCL epitaxial structures.

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Synthesis and Thermal Degradation Kinetics of 2,2,2-Trifluoroethyl Methacrylate/Ethyl Methacrylate-Based Copolymer/TiO₂ Nanocomposites

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Fluorinated methacrylate based polymers have attracted interest in the development of functional polymeric materials due to the unique properties conferred by their fluorine containing groups. In particular, the synthesis and properties of 2,2,2-trifluoroethyl methacrylate (TFEMA) based polymers have been investigated in the literature [1]. The incorporation of nanoscale inorganic fillers into the polymer matrix can contribute to improved thermal stability through polymer/nanoparticle interactions. Indeed, it has been reported that TiO₂ nanoparticles alter the thermal degradation behavior of methacrylate based polymers and affect their thermal stability [2].

In this study, the aim was to synthesize a copolymer based on TFEMA and ethyl methacrylate (EMA) and to investigate the effect of nano TiO₂ addition on the copolymer's thermal properties and degradation kinetics. The P(TFEMA-co-EMA) copolymer was synthesized via free-radical polymerization at 70 °C for 18 hours using benzoyl peroxide as the initiator. The structural characterization of the copolymer was performed using FT-IR and ¹H-NMR spectroscopy. A nanocomposite was prepared by adding 10% (by weight) of nano TiO₂ to the copolymer. The TGA results demonstrated that the incorporation of nano TiO₂ enhanced the thermal stability of the copolymer and increased its initial degradation temperature. The thermal behavior of the pure copolymer and the nanocomposite containing 10% nano TiO₂ was investigated by thermogravimetric analysis (TGA) conducted at different heating rates. In addition, the activation energies associated with thermal degradation were determined using the Flynn-Wall-Ozawa (FWO) and Kissinger-Akahira-Sunose (KAS) isoconversional methods. Overall, the findings indicate that P(TFEMA-co-EMA)/nano TiO₂ nanocomposites have potential for applications requiring enhanced thermal stability.

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Luminescence Properties of Fluorine and Phosphorus Doped LiAlO₂ Ceramics Synthesized by Green Synthesis

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The aim of this study was to develop LiAlO₂-based luminescent materials through a green synthesis approach. Plant-derived green tea extract was used in the synthesis process. To enhance luminescence characteristics of the undoped LiAlO₂, fluorine (F) and phosphorus (P) elements were doped into the host material with different dopant concentrations. The crystal structures, morphological properties and elemental compositions of the synthesized undoped and doped samples were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), and energy-dispersive X-ray spectroscopy (EDS) techniques, respectively. The results showed that the target aluminate phases were successfully synthesized and the prepared samples exhibited characteristic structural/morphological properties. Luminescence behavior and dosimetric potential of the products were investigated by Thermoluminescence (TL) and optically stimulated luminescence (OSL) methods. While the TL glow curve from undoped LiAlO₂ sample was found to be combined four peaks ranging from 30 °C to 450 °C, for the F and P-doped LiAlO₂ samples, TL glow curves exhibited three peaks, first one is low sensitive shallow peak located approximately 90 °C, the second peak is shoulder peak at nearly 175 °C, and the third peak is dosimetric peak located at 240 °C, respectively. OSL decay curve of the F and P-doped LiAlO₂ sample was found to originate from two exponential decay functions, first one is fast component with 0.45 s lifetime, and the second one is relatively slow component with 3.45 s lifetime. Furthermore, detailed kinetic analyses were carried out using TL glow curve deconvolution techniques. Individual trapping centers contributing to the TL response were identified, and the corresponding kinetic parameters, including activation energy, frequency factor, and kinetic order, were determined. The trap distributions and recombination processes were investigated to better understand the luminescence mechanisms of the synthesized materials. The results demonstrated that LiAlO₂-based luminescent ceramics can be successfully produced via a green synthesis method and that their dosimetric performance can be further improved through suitable doping strategies. This study reveals that LiAlO₂ materials prepared with an environmentally friendly synthesis approach can be considered among the potential candidates for radiation dosimetry applications.

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Epitaxial Growth of High-Indium Content InGaAs Layers via MOVPE for Extended-SWIR Applications

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The extended short-wave infrared (extended-SWIR) spectral region is an important area of interest for applications such as imaging, optical sensing, spectroscopy, and remote sensing. InGaAs is a suitable material system for extending the detection range beyond the conventional SWIR region because its bandgap can be reduced by increasing the indium content [1]. However, increasing the In concentration also changes the lattice parameter of InGaAs, leading to a larger lattice mismatch with the InP substrate and directly affecting the structural properties of the epitaxial layers.

In this study, In_xGa_{1-x}As layers with indium compositions of x=0.53, 0.57, 0.60, 0.64, and 0.68 were grown to investigate the effect of increasing In concentration on their structural properties. The samples were characterized by high-resolution X-ray diffraction (HR-XRD). The obtained 2θ-ω diffraction patterns showed a systematic shift of the InGaAs-related diffraction peak toward lower 2θ values with increasing In concentration. This behavior is consistent with the increase in the lattice parameter of InGaAs associated with higher In incorporation [2]. While the In_{0.53}Ga_{0.47}As structure exhibits a response close to the lattice-matched composition with InP, the separation between the epilayer and InP substrate peaks becomes more pronounced as the In concentration increases. This evolution indicates the controlled variation of the InGaAs alloy composition throughout the sample series.

The results show that systematically increasing the In content leads to a clear structural evolution in the InGaAs layers. This approach can contribute to the development of InGaAs-based material structures aimed at bandgap reduction and extension of the spectral response toward the e-SWIR region.

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Optical and Catalytic Evaluation of Ni₂FeO₄ Nanoparticles for Efficient Dye Degradation and Water Oxidation

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In this study, Ni₂FeO₄ nanoparticles (NPs) was successfully synthesized using the sol–gel method followed by calcination at 500°C for 4 h and sintering processes at 800°C for 12 h to improve crystallinity and phase formation [1]. X-ray diffraction (XRD) analysis confirmed the successful formation of the crystalline Ni₂FeO₄ structure without the appearance of noticeable secondary phases, indicating the high purity of the synthesized material. The surface morphology and particle size distribution were analyzed using scanning electron microscopy (SEM). SEM images revealed that the Ni₂FeO₄ NPs exhibited a relatively homogeneous distribution with slight agglomeration, which can be associated with the thermal treatment stages during synthesis. The average particle size was calculated from SEM micrographs using the ImageJ software and determined to be approximately 80 nm. Photocatalysis degraation of Metylene Blue under UV light performed and 91% was deaggated upto 180 mins. Following, indirect and direct bandgap of the Ni₂FeO₄ NPs were calculated to be ~1.72 and ~1.85 eV, respectively. Oxygen evolution reaction (OER) activities were determined using cyclic voltametry and linear sweep voltametry methods. A disting oxygen adsorption region were observed in between 1.35–1.48 V vs. RHE. The onset potential and over potential at 10 mA cm⁻² of OER performance were found to be 1.50 and 0.31 V vs. RHE, respectively. These findings suggest that the synthesized material may be a promising candidate for future catalytic, electrochemical, and functional material applications.

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First Report on the Green Synthesis of Silver Nanoparticles Using *Magnolia Grandiflora* Leaf Extract as a Sustainable Biogenic Reducing Agent

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Silver nanoparticles (AgNPs) exhibit distinctive nanoscale optical properties arising from localized surface plasmon resonance (LSPR), making them promising for plasmonic, sensing, photonic, and optoelectronic applications [1-2]. In this study, AgNPs were synthesized via a simple and environmentally sustainable green route using an aqueous extract of shade-dried *Magnolia grandiflora* leaves as a biological reducing and stabilizing medium. A 0.1 mM AgNO₃ solution was added dropwise to a 1% (w/v) leaf extract maintained at 70 °C under continuous stirring, and nanoparticle formation was evaluated by UV–Vis absorption spectroscopy over 350–700 nm without sample dilution. The original leaf extract showed no distinct absorption maximum in the investigated visible region, whereas the AgNP-containing solution exhibited a pronounced and broad absorption band centered at approximately 440 nm. The emergence of this band was attributed to the LSPR of metallic silver nanostructures and provides clear spectroscopic evidence of AgNP formation. The LSPR maximum was slightly red-shifted relative to previously reported values of approximately 417–425 nm for *Magnolia grandiflora*-mediated AgNPs [3-4]. This shift, together with the broad plasmonic profile, may reflect differences in nanoparticle characteristics, interparticle interactions, surface-bound phytochemicals, and the local dielectric environment [5-6]; however, these contributions cannot be distinguished by UV–Vis spectroscopy alone. The results demonstrate that aqueous *Magnolia grandiflora* leaf extract provides an effective and sustainable platform for producing silver nanostructures with a well-defined plasmonic response. Further structural and morphological characterization will enable correlation of the observed LSPR behavior with the physicochemical properties of the synthesized AgNPs.

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Investigation of the Properties of Waste Mullite Powder Reinforced EPDM Composites

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In this study, the effects of waste mullite powder addition on the rheological, physical, and mechanical properties of Ethylene Propylene Diene Monomer (EPDM) rubber composites were investigated. For this purpose, EPDM composites containing mullite at ratios of 5 phr (EPDM/5M) and 15 phr (EPDM/15M) were homogeneously mixed using a laboratory-type banbury mixer and converted into uncured compounds. Following the production of test plates via press vulcanization, moving die rheometer (MDR) and Mooney viscosity tests were performed to determine the rheological properties of the mixtures. While the mechanical properties of the composites were characterized by tensile, tear, and hardness (Shore A) tests, their physical and dynamic properties were determined through density, compression set, elasticity, and abrasion tests. As a result of the experimental studies, it was determined that the addition of 5 phr mullite to the EPDM matrix increased the maximum torque (MH) value by 12.4%, thereby enhancing the crosslink density and hardness within the material structure. It was observed that the 5 phr mullite reinforcement increased the tensile strength by 3.5% and the 100% modulus (M100) by 12.3%, whereas increasing the filler content to 15 phr resulted in a 12.6% decrease in tensile strength. With the addition of mullite, the compression set values of the composites improved, dropping from 12.85% to 11.96 levels. The abrasion loss was reduced by 33.6% with the addition of 5 phr mullite and by 27.1% with the 15 phr addition to the EPDM rubber (indicating an increase in abrasion resistance).

The obtained results revealed that mullite, possessing high hardness, thermal stability, and chemical resistance properties, can be utilized as an effective functional filler in EPDM composites through appropriate surface modification, and presents significant potential particularly for industrial rubber applications where abrasion resistance is critical.

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Effect of Silane-Modified Mullite and 2Si69 Coupling Agent on the Cure Characteristics, Mechanical Properties and Wear Performance of EPDM Composites

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Ethylene propylene diene monomer (EPDM) rubber is widely employed in sealing and automotive applications owing to its excellent weather resistance and elasticity. However, improvements in wear resistance and mechanical performance are often required for demanding service conditions [1-2]. In this study, the effects of silane-modified mullite (M-S) and an additional 2Si69 coupling agent on the cure characteristics, mechanical properties and wear behavior of EPDM composites were investigated. Three formulations, namely neat EPDM, EPDM containing 5 phr silane-modified mullite (EPDM/5M-S) and EPDM reinforced with 5 phr mullite together with 2 phr Si69 (EPDM/2Si69/5M), were prepared and characterized.

The incorporation of silane-modified mullite reduced the minimum rheometer torque (ML) from 2.79 dNm to 1.73 dNm (38.0%) and compound viscosity from 126.8 MU to 108.9 MU (14.1%), indicating improved processability. The maximum torque (MH) increased from 19.16 dNm to 21.02 dNm (9.7%) with the addition of Si69, suggesting enhanced rubber–filler interaction. Shore A hardness increased from 67 to 69 for both filled compounds. The tensile strength reached 20.9 MPa for EPDM/5M-S, corresponding to a 5.6% increase compared with neat EPDM, whereas the Si69-containing composite exhibited a tensile strength of 17.6 MPa. Elongation at break increased from 258% to 299% (15.9%) with silane-modified mullite and remained at 263% after Si69 addition. The tear strength increased from 57.11 N/mm to 61.02 N/mm (6.8%) with Si69. Abrasion volume decreased from 135.39 mm³ for neat EPDM to 99.91 mm³ (26.2%) and 101.31 mm³ (25.2%) for EPDM/5M-S and EPDM/2Si69/5M, respectively.

The results demonstrate that silane-modified mullite significantly improves processability and wear resistance, while the incorporation of Si69 further enhances the cure characteristics and tear strength. The developed EPDM composites exhibit improved performance and are promising candidates for applications requiring high wear resistance and mechanical durability.

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Re-modeling S-doped Li_3P for solid-state electrolyte in battery systems: stronger bonds and thermodynamic reinforcement via computationally guided simulation

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Solid-state lithium-ion batteries depend critically on electrolyte frameworks that remain structurally robust and thermodynamically stable under operating conditions. In this work, the structural integrity and thermodynamic stability of hexagonal lithium phosphide Li_3P (*space group* $P6_3/mmc$, *No. 194*) [1] and its sulfur-substituted derivative $\text{Li}_{3-x}\text{S}_x\text{P}$ are investigated by first-principles density functional theory (DFT) calculations within the generalized gradient approximation (GGA-PBE) [2], as implemented in the Quantum ESPRESSO package and code [3]. Convergence was ensured using a 60 Ry plane-wave cutoff and a $14 \times 14 \times 12$ Monkhorst–Pack k-point grid, with the host treated by both ultrasoft (USPP) pseudopotentials. The optimized lattice parameters of pristine Li_3P ($a = b = 4.145 \text{ \AA}$, $c = 7.402 \text{ \AA}$, $V_0 = 116.087 \text{ \AA}^3$, shortest Li–P bond = $2.393 \text{ \AA}$), confirming the layered Li–P framework favorable for ionic transport. Cohesive-energy analysis yields large negative values for both systems, establishing their thermodynamic stability. Notably, the cohesive energy per atom increases in magnitude from -2.404 eV in pristine Li_3P to -2.466 eV upon sulfur incorporation, a gain of 0.062 eV/atom that signals enhanced thermodynamic stability driven by the stronger, more covalent Li–S interactions relative to Li–P bonds. These results demonstrate that controlled sulfur substitution reinforces the bonding framework of Li_3P while preserving its structural features, offering a viable design strategy for mechanically and thermodynamically durable solid-state electrolytes.

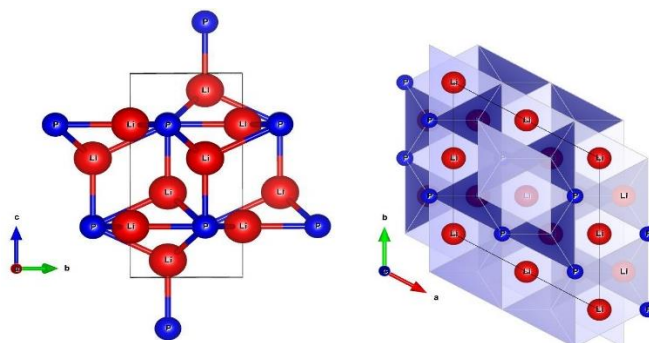


Figure 1. Design of Li_3P with unit cell and supercell systems

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Optimization of AsH₃ Flow Rate for High-Quality MOCVD-Grown n-InGaAs/InP Epitaxial Layers

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InGaAs/InP epitaxial structures are of significant interest for infrared and optoelectronic applications due to their favorable electronic and optical properties[1]. Therefore, precise control of the growth conditions is crucial for achieving high-quality epitaxial layers. Among the various parameters governing MOCVD growth, the arsine (AsH₃) flow rate is particularly important, as it influences the V/III ratio, surface reaction kinetics, and the incorporation behavior of adatoms[2]. In this study, the effect of AsH₃ flow rate on the structural, surface, and electrical properties of n-InGaAs/InP epitaxial layers grown by metal-organic chemical vapor deposition (MOCVD) was investigated. Three samples were grown on (100)-oriented InP substrates at 620 °C and 1800 mbar, with AsH₃ flow rates of 126, 148, and 190 sccm while the other growth parameters were kept constant. The structural properties and layer parameters were investigated by high-resolution X-ray diffraction (HRXRD) and GlobalFit analysis, while surface morphology and electrical properties were evaluated using atomic force microscopy (AFM) and Hall effect measurements, respectively. The In compositions obtained from GlobalFit analysis were 0.534, 0.533, and 0.537 for the three samples, respectively, remaining close to the lattice-matched composition of In_{0.53}Ga_{0.47}As. The layer thickness decreased from 135 to 120 nm with increasing AsH₃ flow rate. On the other hand, AFM measurements showed smooth, terrace-like surfaces with RMS roughness values of 0.16, 0.12, and 0.15 nm, respectively. The sample grown at 148 sccm exhibited the lowest surface roughness, while the electron mobility increased with AsH₃ flow rate and reached 1910 cm²/V·s at 190 sccm. These results demonstrate that the AsH₃ flow rate strongly influences the growth characteristics and electrical transport properties of InGaAs/InP epitaxial layers[3]. Among the investigated conditions, 148 sccm provided the most favorable surface morphology and structural characteristics.

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Numerical Analysis of p-Type Diffusion Depth on InGaAs/InP SPAD Characteristics Using Silvaco TCAD

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Single-photon avalanche diodes (SPADs) are the key detector technology for telecom-wavelength photon counting, enabling applications such as quantum key distribution, LiDAR and 3D imaging, and time-resolved spectroscopy[1]. Among these, In_{0.53}Ga_{0.47}As/InP SPADs operated in Geiger mode are the most practical choice in 0.9–1.6 μm range due to their room-temperature operation and low cost compared to superconducting detectors [2]. However, achieving high detection performance requires careful electric-field engineering, where a sufficiently high field must be maintained in the InP multiplication layer to enable avalanche multiplication while minimizing the field in the InGaAs absorption layer to suppress tunneling-induced dark counts.

In the planar separate absorption, grading, charge, and multiplication (SAGCM) architecture, this field balance is set largely by the p-type (Zn) diffusion front in the top InP cap layer, which defines the junction position and therefore the effective multiplication-region width [3]. In this work, the influence of the diffusion front depth; 0.5, 0.75, 1.0, 1.25, and 1.5 μm , at a fixed surface doping concentration of $1 \times 10^{18} \text{ cm}^{-3}$ is investigated using two-dimensional numerical simulations in Silvaco TCAD. For each structure, we analyze the electric field distribution, the punch-through voltage (V_{pt}), and the breakdown voltage (V_{br}), under dark and illuminated conditions. These findings provide a quantitative design guideline for the Zn diffusion step in planar InGaAs/InP SPAD fabrication.

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Solution Combustion Synthesis of Alkaline Earth Borate Phosphors for Dosimetric Applications

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In this study, boron-based tetraborate compounds MgB₄O₇, SrB₄O₇, BaB₄O₇, and CaB₄O₇ were synthesized using the solution combustion synthesis (SCS) route to investigate luminescence performance for radiation dosimetry. Preliminary luminescence observations indicated that the CaB₄O₇ matrix exhibited the most pronounced and optimizable thermoluminescence (TL) and optically stimulated luminescence (OSL) signals. Consequently, the synthesis parameters of CaB₄O₇ were systematically optimized by varying the urea-to-boric acid molar ratios (including 1:2, 2:1, and 4:1) to investigate fuel-to-oxidizer stoichiometry effects on crystallization, morphology, and trapping dynamics. The phase purity, crystalline structure, surface morphology, and elemental stoichiometry of the synthesized powders were characterized using X-ray diffraction (XRD), scanning electron microscopy (SEM), and energy-dispersive X-ray spectroscopy (EDS). Luminescence properties were studied using TL glow curves, continuous-wave OSL (CW-OSL), and TL after OSL (residual TL) measurements to probe both shallow and deep trapping centers as well as optical depletion behavior. The results demonstrated that the urea/boric acid ratio significantly influences defect distributions, grain connectivity, and luminescence yields. In particular, the sample synthesized with an optimized stoichiometric balance exhibited enhanced TL/OSL sensitivity, high pellet integrity, and reproducible residual TL characteristics. In comparison to other compositions, the 4:1 ratio sample yielded superior TL and OSL responses. The recorded TL glow curve revealed a prominent peak near 150°C with high sensitivity, accompanied by a shoulder peak at around 230°C and a high-temperature peak of substantial sensitivity at approximately 300°C. Overall, these findings highlight the viability of combustion-synthesized as an efficient candidate material for radiation measurements. Conducted to determine the primary candidate matrix for subsequent doping investigations, this study revealed superior luminescence and structural performance at a 4:1 ratio; hence, further synthesis and development of this optimized candidate will continue.

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Melt-Spun Recycled Polyethylene terephthalate Multifilaments Containing Transition Metal Oxide for Multifunctional Applications

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The development of sustainable and multifunctional polymeric fibers has become increasingly important for advancing high-performance textile applications while supporting circular economy initiatives. The increasing demand for sustainable textile materials has accelerated the use of recycled polyethylene terephthalate (r-PET) in fiber production. In this study, recycled polyethylene terephthalate (r-PET) was compounded with copper oxide (CuO) masterbatch and processed into multifilament yarns through melt spinning to produce fibers with enhanced functionality. The morphological, mechanical, and antibacterial properties of the resulting yarns were evaluated and compared with those of neat r-PET yarns. Morphology and the dispersion of CuO particles were characterized using microscopic techniques. The mechanical performance of the multifilaments was assessed through tensile testing according to ISO 2062 protocol [1]. In addition, the antibacterial activity of the CuO-containing yarns was examined against *Staphylococcus Aureus* (ATCC 6538) according to ASTM 2149 method [2] to evaluate their potential for functional textile applications.

The results demonstrate that transition metal oxide incorporation provided a promising strategy for developing multifunctional r-PET multifilaments with balanced mechanical performance and added bioactive functionality. These sustainable yarns exhibit significant potential for use in technical textiles, medical and healthcare products, protective clothing, sportswear, filtration media, and other value-added applications requiring durable materials with antimicrobial properties. This work highlights the potential of combining recycled poly(ethylene terephthalate) with transition metal oxides through conventional melt-spinning technology to produce environmentally responsible, multifunctional textile materials for next-generation applications.

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Ball-Milled Recycled PET/Slag and PET/Clinker Composite Materials: Synthesis, Characterization, and Dye Adsorption Performance

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Adsorption is one of the most economical methods for removing dyestuffs from wastewater [1]. In recent years, the research and development of adsorbent composite material systems that are economic, easily manufacturable, and based on recycled products have gained significant importance in adsorption studies [1]. Non-biodegradable waste PET water bottles cause environmental pollution worldwide [2]. In this study, for the removal of Basic Yellow 28 (BY28) dyestuff from wastewater, single adsorbent systems of recycled PET water bottles, blast furnace slag, and clinker were utilized, alongside their binary composite adsorbent material systems. These binary composites were prepared at weight percentages of 70:30 (PET:Slag, PET:Clinker) and 50:50 (PET:Slag, PET:Clinker) using a simple ball-milling method. Characterizations of both pure and composite adsorbents before and after BY28 adsorption were performed using FTIR/ATR and SEM. The optimum adsorbent dosage, optimum pH, and pH_{pzc} were determined for each adsorbent. Adsorption studies were conducted at $pH=9$ and $25\text{ }^{\circ}\text{C}$, at Basic Yellow 28 dyestuff concentrations of 25, 50, and 100 ppm at a wavelength of 466 nm. The equilibrium time for adsorption was found to be 30 minutes. Freundlich, Langmuir, Dubinin-Radushkevich, Temkin, and Flory-Huggins isotherms were applied. According to the Langmuir isotherm, the q_{max} values were found to be 12.56 mg/g for PET. For Slag, Clinker, and the binary composite adsorbents PET:Slag (70:30 wt.%), PET:Slag (50:50 wt.%), PET:Clinker (70:30 wt.%), and PET:Clinker (50:50 wt.%), the values were calculated as 45.5 mg/g, 59 mg/g, 30 mg/g, 12 mg/g, 135 mg/g, and 162 mg/g, respectively. The obtained results demonstrated that the composite adsorbent material systems, formed by adding Slag and Clinker individually to the PET adsorbent at various weight percentages, increased the maximum adsorption capacity of PET for Basic Yellow 28 dyestuff. Furthermore, the binary composite adsorbent material systems formed with clinker exhibited a higher efficiency compared to those formed with slag under identical conditions. Through this study, the production of waste PET water bottle-based composite adsorbent material systems via a simple manufacturing method not only ensured the disposal of PET water bottle wastes but also yielded highly effective new composite adsorbent materials.

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Rheological Behavior and Modulation of Biomineralization in Injectable Bioactive Glass Bone Grafts via Incorporation of a Therapeutic Agent

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Injectable bone graft putties offer a minimally invasive approach to bone regeneration [1]. First introduced by Hench et al. in 1969, bioactive glasses (BGs) are inorganic alloplastic bone grafts uniquely capable of directly bonding with hard tissues [2,3] This study developed a composite putty system using different sized melt-quenched 45S5 BGs dispersed within a polyethylene glycol (PEG) and glycerol carrier matrix. To explore localized pharmacological interventions, a clinically approved therapeutic agent, typically used for systemic bone loss treatment, was incorporated into the putties at varying concentrations (up to 10 wt.%). This research comprehensively evaluates the combined influence of this therapeutic agent on both the rheological flow properties and the *in vitro* bioactivity dynamics of the grafts.

Rheological analyses utilizing mathematical modeling revealed that all baseline putties exhibited favorable viscoelastic and pseudoplastic behavior. Crucially, the incorporation of the therapeutic agent successfully preserved an injectability rate of over 98%, indicating excellent clinical applicability. However, the presence of the agent actively modified the flow behavior, shifting it towards a more Newtonian profile and reducing both viscosity at higher drug contents. Concurrently, *in vitro* bioactivity assessments during Simulated Body Fluid (SBF) incubation demonstrated that while base putties formed a standard apatite layer, the drug-loaded formulations exhibited a distinct dual-phase biomineralization. The active agent uniquely induced the co-precipitation of crystalline calcite alongside apatite, enhancing overall surface crystallinity by approximately 30% and rapidly altering local ion release kinetics. Among all tested samples, those containing smaller-sized BG particles with a lower therapeutic agent concentration exhibited the most optimal balance of ideal flowability and enhanced bioactivity. These findings highlight that integrating this therapeutic agent actively modulates biomimetic mineralization while maintaining the critical rheological parameters necessary for advanced, injectable bone tissue engineering applications

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Effects of Polyethylene Glycol (PEG) Additives with Different Molecular Weights on the Rheological and Physical Properties of EPDM Rubber

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In this study, the effects of polyethylene glycol (PEG) additives with different molecular weights on the rheological and physical properties of EPDM rubber were investigated. For this purpose, rubber compounds were prepared by incorporating PEG 2000, PEG 4000, and PEG 6000 into a base EPDM formulation. The rheological properties, Mooney viscosity, density, and Shore A hardness of the prepared compounds were determined. According to the rheological test results, the minimum torque (ML) increased by 8.5%, 16.1%, and 30.8% with the incorporation of PEG 2000, PEG 4000, and PEG 6000, respectively, compared with the unmodified EPDM compound. The maximum torque (MH) decreased by 3.0% and 0.4% with the addition of PEG 2000 and PEG 4000, respectively, while a 7.8% decrease was observed with PEG 6000. The T90 cure time increased by 2.1%, 8.5%, and 66.9% with the incorporation of PEG 2000, PEG 4000, and PEG 6000, respectively. Mooney viscosity increased by 2.6%, 4.6%, and 8.6%, respectively. Shore A hardness remained unchanged with PEG 2000, whereas a 1.4% increase was observed with both PEG 4000 and PEG 6000. The results demonstrate that increasing the molecular weight of PEG has a significant effect on the rheological behavior and curing characteristics of EPDM rubber. In particular, the increase in T90 and Mooney viscosity with increasing PEG molecular weight indicates that the molecular weight of PEG plays an important role in determining the processing and vulcanization behavior of EPDM compounds.

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Investigation of the Potential Use of Recycled Lithium-Ion Battery Powder as a Functional Filler in Chloroprene Rubber (CR) Composites

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With the increasing widespread use of electric vehicles, portable electronic devices, and energy storage systems, the amount of end-of-life lithium-ion batteries is growing every year. This has made the sustainable and value-added utilization of battery powder, known as “black mass,” obtained from battery recycling processes and containing graphite, carbon, and various metal compounds, an important research topic. In this study, the potential use of recycled lithium-ion battery powder as an alternative filler in chloroprene rubber (CR) compounds was investigated. For this purpose, rubber compounds were prepared by incorporating different amounts of battery powder into a base CR formulation. The rheological properties, Mooney viscosity, density, and Shore A hardness values of the prepared compounds were determined. In addition, the effects of battery powder incorporation on the flame-retardant and electrical properties were investigated. The results showed that the incorporation of battery powder increased the rheological values and Mooney viscosity of the CR compounds. In contrast, a decrease in mechanical and certain physical properties was observed with the addition of battery powder. Nevertheless, the effect of battery powder on the electrical and flame-retardant properties demonstrated promising potential for its evaluation as a functional filler. The study reveals that the reuse of recycled lithium-ion battery powder in the rubber industry may provide a viable alternative for converting waste into value-added applications and supporting circular economy and sustainable material development approaches.

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Machine Learning Informatics for Targeted Glioblastoma Photodynamic Therapy using optimized Yb/Er doped Upconversion Nanomaterials: A Multi-Photosensitizer Theranostic Framework

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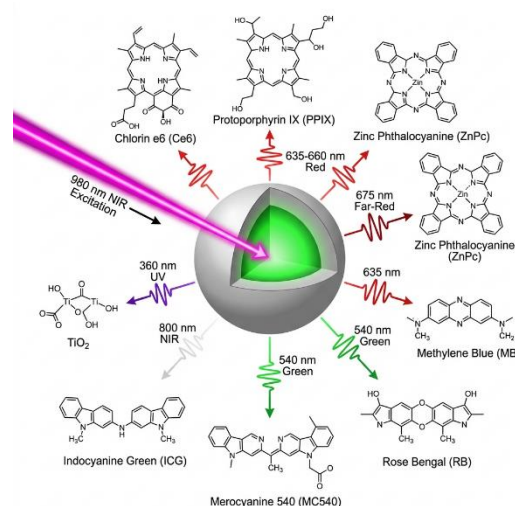
Glioblastoma Multiforme (GBM) remains a lethal primary brain tumor due to micro-invasive infiltration and poor light penetration in cranial tissue (<2-3 mm). In the scope of nanomedicine and nanobiotechnology, lanthanide-doped upconversion luminescent nanomaterials offer an unprecedented non-invasive therapeutic platform. These smart functional biomaterials convert deep-penetrating 980 nm near-infrared (NIR) light into visible/UV emissions in situ, activating bound photosensitizers to generate cytotoxic reactive oxygen species (ROS) [1]. However, optimizing host lattice composition, dopant ratios, and particle size for diverse photosensitizer Q-bands remains unstandardized. This study establishes a machine learning informatics framework and suitability matrix for tailoring smart upconversion nanostructures across 9 biomedical photosensitizers (Chlorin e6, PPIX, ZnPC, Methylene Blue, Rose Bengal, MC540, Hypericin, ICG, and TiO₂) for targeted brain cancer therapy. We constructed a dataset of 1,710 formulation-photosensitizer pairs evaluated across a published 190 UCNP host lattices dataset[2]. Five domain-physics features were engineered: Spectral Overlap Integral (J_{PS}), Blood-Brain Barrier (BBB) Transcytosis Size Penalty (W_{BBB}), Effective Atomic Number (Z_{eff}), and Cross-Relaxation Index (CR_{idx}). The machine learning regressors were benchmarked using 80/20 train/test splits with SHAP explainability. Extra Trees Regressor achieved top predictive accuracy (Test R₂ = 0.9485, RMSE = 0.6842), followed by Gradient Boosting (R₂ = 0.9272) and XGBoost (R₂ = 0.9104). This work provides a validated nanobiotechnology blueprint for designing BBB-permeable smart functional nanomaterials, advancing precision nanomedicine for deep-seated brain tumor therapy.

Graphical Abstract

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Systematic Investigation of Structural, Morphological, and Magnetic Properties in Doped Perovskite Manganite

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This study reports on the systematic investigation of the structural, morphological, and magnetic properties of $\text{La}_{0.67}\text{Ba}_{0.33}\text{MnO}_3$, $\text{La}_{0.67}\text{Ba}_{0.23}\text{Na}_{0.10}\text{MnO}_3$ and $\text{La}_{0.67}\text{Ba}_{0.18}\text{Na}_{0.15}\text{MnO}_3$ perovskite manganites synthesized via a sol-gel method, focusing on the concurrent effects of monovalent (Na^{1+}) co-substitution. X-ray diffraction (XRD) analysis confirms the single-phase formation of the perovskite structure for all compositions, stabilizing in a rhombohedral symmetry with the R-3c space group. Microstructural and surface topography evaluations, conducted via scanning electron microscopy (SEM) and atomic force microscopy (AFM), reveal a pronounced grain growth evolution as a function of Na content. Statistical particle size distribution analysis yields average values of 414 nm, 772 nm, and 855 nm for the samples respectively, indicating an accelerated coalescence driven by chemical modification. Magnetic measurements demonstrate that this systematic reduction in grain boundary density, coupled with lattice tuning, directly governs the magnetic phase transition behavior. The Curie transition temperatures (T_C), marking the ferromagnetic-to-paramagnetic phase transition, were determined as 332 K, 339 K, and 335 K for the respective compositions. The initial enhancement of T_C to 339 K is ascribed to the optimization of the $\text{Mn}^{3+}/\text{Mn}^{4+}$ ratio via monovalent substitution, which strengthens the double-exchange interaction mechanism [1]. These results highlight the potential of managing the $\text{Ba}^{2+}/\text{Na}^{1+}$ ratio to simultaneously control the microstructure and phase transition characteristics in LaMnO_3 -based systems for prospective room-temperature technological applications [2,3].

Keywords: Perovskite manganite, sol-gel method, Curie temperature

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Photocatalytic Degradation of Methylene Blue Using a $\text{Co}_3\text{O}_4\text{-Bi}_2\text{O}_3$ Composite Synthesized by Solid-State Reaction

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Photocatalysis plays a significant role in the degradation of industrial dye pollutants into less harmful or mineralized products through light-driven chemical processes [1]. Upon light irradiation, photocatalytic materials generate electron-hole pairs, which can participate in the formation of reactive species responsible for the degradation of organic pollutants [2]. In this study, a bismuth-cobalt oxide material was synthesized by a solid-state reaction method, and its photocatalytic activity toward methylene blue (MB) degradation was investigated. The material was initially calcined at 600 °C for 4 h and subsequently sintered at 800 °C for 12 h. Rietveld refinement of the X-ray diffraction data revealed a dual-phase structure consisting of 42 wt% Co_3O_4 (space group $Fd-3m$, lattice parameter $a = b = c = 8.0806 \text{ Å}$) and 58 wt% Bi_2O_3 (space group $I23$, lattice parameter $a = b = c = 10.1113 \text{ Å}$). The average crystallite size was estimated to be approximately 62 nm using the Scherrer equation. Scanning electron microscopy and energy-dispersive X-ray spectroscopy analysis revealed a relatively homogeneous and impurity free microstructure. UV-vis spectrophotometric analysis demonstrated that 88% of MB was degraded from a 10 ppm solution after 180 min of UV irradiation. These results demonstrate that the synthesized $\text{Co}_3\text{O}_4\text{-Bi}_2\text{O}_3$ material exhibits promising photocatalytic activity for the degradation of methylene blue under UV irradiation.

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Passive Thermal Runaway Mitigation in UAV Battery Packs via FGM Cell HoldersR. Demir^{1,2*}, B. Yurtsever³, R.N. Mutlu⁴, N.U. Bakoğlu⁵ and M. Aydın⁶¹*Department of Aeronautical Engineering, Graduate School of Natural and Applied Sciences, Erciyes University, Kayseri, Türkiye*²*ASPİLSAN Energy Inc., Kayseri, Türkiye*³*ASPİLSAN Energy Inc., Kayseri, Türkiye*⁴*ASPİLSAN Energy Inc., Kayseri, Türkiye*⁵*ASPİLSAN Energy Inc., Kayseri, Türkiye*⁶*Department of Aeronautical Engineering, Graduate School of Natural and Applied Sciences, Erciyes University, Kayseri, Türkiye****Corresponding e-mail:** resul.demir@aspilsan.com

In mission-specific (one-way attack) UAVs Batteries, Battery Management Systems (BMS) are frequently omitted to minimize payload weight and architectural complexity. However, this approach complicates the management of inherent thermal runaway (TR) and propagation (TRP) risks associated with high-energy-density Nickel-Manganese-Cobalt (NMC) lithium-ion cells. In NMC chemistries, triggers such as overcharge, overheating, or mechanical impact can induce an internal short circuit and subsequent uncontrolled exothermic chemical degradation, initiating a TR event. Such an event can generate surface temperatures of 700°C-800°C and jet-fires exceeding 1000°C, which, without active protection, can trigger cascading thermal propagation and catastrophic full-pack failure [1-2].

To passively overcome this thermal management challenge and introduce a novel application to the literature, this study utilizes high-performance Aspilsan INR18650A28 cells in a 6S3P configuration, paired with a newly developed three-zone Step-wise Functionally Graded Material (FGM) cell holder (3 mm layer thickness). The architecture incorporates a mica top layer to deflect direct jet-fires, a silica aerogel blanket middle layer equipped with structural stoppers to ensure optimum insulation thickness and block radial heat transfer, and a CF-PEEK basal layer engineered to withstand severe flight loads [2-3].

The proposed FGM holder physically halts single-cell TR propagation by suppressing radial heat transfer, protecting adjacent cells. In a worst-case full-pack TR scenario, while the basal matrix undergoes thermal degradation, the inorganic mica and aerogel frameworks retain their structural integrity. This significantly delays heat flux toward the UAV fuselage, granting vital operational time-to-failure margins for the UAV to complete its terminal trajectory.

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