

5th INTERNATIONAL CONFERENCE ON
EMERGING TRENDS IN PHYSICS
10th-12th FEBRUARY, 2026

ABSTRACT BOOK

Organized by
Department of Physics
Lahore College for Women University,
Lahore Pakistan
in collaboration with
NILOP, Islamabad, Pakistan

With Compliments



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**5th International Conference On
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In Collaboration With NILOP, Islamabad**



CONFERENCE REPORT

The 5th International Conference on Emerging Trends in Physics was held on 10th to 12th Feb. 2026, at Lahore College for Women University (LCWU), Lahore. The conference was organized by the Department of Physics in collaboration with the National Institute of Lasers and Optronics (NILOP), Islamabad.

The opening ceremony, held at Iqra Auditorium, was inaugurated by the Patron-in-Chief, Vice Chancellor Prof. Dr. Uzma Quraishi. In her inaugural address, she emphasized the importance of strengthening research culture, promoting innovation, and fostering international collaboration to address emerging scientific and technological challenges.

The ceremony was graced by the Chief Guest, Prof. Dr. Shazia Bashir, Vice Chancellor of Government College Women University Sialkot, and Prof. Dr. Manzoor Ikram, Conference Co-Chair, Director General NILOP, Pakistan Atomic Energy Commission, Islamabad, co-chair Prof. Dr. Zohra Nazir Kayani and Conference chair & Chairperson Department of Physics Prof. Dr. Safia Anjum welcomed the participants and outlined the conference objectives, emphasizing the importance of fostering collaboration, strengthening research networks, and encouraging young researchers to engage in emerging areas of physics.

Heartfelt appreciation is also extended to the National Institute of Laser and Optronics (NILOP) for their valuable collaboration and technical support, which greatly strengthened the academics quality of this conference. Their commitment to research and innovation has been truly inspiring.

Gratitude is further expressed to the Punjab Higher Education Commission (PHEC) for their generous funding and support. Their dedication to promoting research, academic excellence, and knowledge sharing played a vital role in the success of this conference.

Conference Chair Prof. Dr. Safia Anjum, in her concluding remarks, stated that on behalf of the organizing committee, sincere gratitude is extended to the Vice Chancellor for her continuous support, encouragement, and visionary leadership, which made the conference possible. She emphasized that the guidance, confidence, and unwavering support provided throughout the planning and execution phases played a crucial role in the successful organization of the event.

The 3-Days conference brought together more than 300 national and international participants, including researchers, faculty members, and scholars from universities and research institutions across Pakistan, as well as invited speakers from the United States, United Kingdom, China, Saudi Arabia were in person and Italy & Ireland were online. The strong participation reflected the growing global interest in emerging areas of physics and interdisciplinary research.

This conference featured about 80 talks in which 30 were keynote lectures and 50 were oral talks. Side by side 40 posters were presented from different universities of Pakistan.

The closing ceremony concluded with the distribution of shields and certificates among speakers, members of Alberuni Physics Society and members of the organizing committee. The gold, silver and Bronzes medals were distributed among the winners of posters. Prof. Dr. Safia Anjum (conference Chair) appreciated the collaborative efforts and emphasized the importance of such conferences in strengthening research culture among national and international institutions.

Sincere appreciation is also extended to the Estate Office, Purchase Office, Treasurer's Office, Chief Warden, and Director IT for their valuable administrative, logistical, financial, residential, and technical support throughout the conference. Their cooperation and timely assistance played a crucial role in ensuring the smooth organization and successful execution of all conference activities.





5th International Conference On
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DAY 1



Patron In Chief
Prof. Dr. Uzam Qureshi
 Vice Chancellor,
 LCWU, Lahore



Chief Guest
Prof. Dr. Shazia Bashir
 Vice Chancellor,
 GCWU, Sialkot



Conference Chair
Prof. Dr. Safia Anjum
 Chairperson of Physics
 Dept, LCWU



Guest of Honors
Prof. Dr. Iqrar Ahmad Khan
 Chairperson PHEC, Lahore.



Conference Co-Chair
Prof. Dr. Manzoor Ikram
 Director General,
 NILOP, Islamabad



Keynote Speaker
Dr. Sami ul Haq
 NILOP, Islamabad



Keynote Speaker
Dr. Attah Ul Allah Shah
 NILOP, Islamabad



Keynote Speaker
Dr. Izhar Ahmad
 NILOP, Islamabad



Dr. Muhammad Saleem
 Director Nilop,
 Islamabad



Dr. Sadiq Nawaz Khan
 NILOP, Islamabad



Keynote Speaker
Dr Shabnam Jabeen
 University of Maryland



Prof. Dr Arifa Tahir
 Chairperson, Environmental
 Sciences, LCWU



Dr. Zaheer Hussain Shah
 Dean Graduate Studies,
 UMT, Lahore

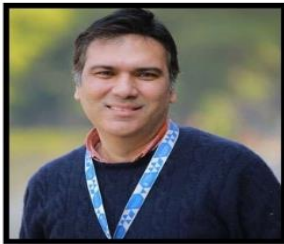


Prof. Dr. Farzana Rashid
 Chairperson Zoology
 Dept. LCWU, Lahore





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DAY 2



Prof. Dr. Riaz Ahmed
 Professor Emeritus, Physics
 Department, GCU, Lahore



Prof. Dr. Rehana Zia
 EX- HOD Physics Dept,
 LCWU Lahore



Prof. Dr. Khurum Siraj
 Director of Laser and Optronics
 Center, UET, Lahore.



Prof. Dr. M. Shahid Rafique
 Dean of Faculty and
 Natural Sciences, UET,
 Lahore



Dr. Khurum Saleem Joya
 Intel Islamic Univ,
 Madina, Saudi Arabia



Dr. Naveed Afzal
 CASP, GCU,
 Lahore, Pakistan



Dr. Mohsin Nazir
 Chairperson Software
 Engineering, LCWU



Dr. M. Shahbaz Anwar
 University of
 Cambridge, UK



Dr. Sidra Maryam
 Tyndall National
 Institute, University
 College cork, Ireland



Dr. M. Yasin Naz
 University of Agriculture
 Faisalabad, Pakistan



Dr. Shahid Idrees
 National Astronomical
 Observatories, Chinese
 Academy of Sciences, China



Dr. Nuaman Sarwar Qureshi
 Chairperson, Physics
 Department, GCU, Lahore



Dr Gohar Abbas
 Physics Dept.
 GCU, lahore



Dr. Jamil Alvi
 Physics Department,
 COMSATS, Lahore



Dr. Laila Zafar
 Physics Department,
 FCCU, Lahore



Dr. Eng. Waseem Amin
 Institute of Metallurgy and
 Materials Engineering
 PU, Lahore



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DAY 2



Dr. Zafar Iqbal
 Physics Dept.
 GCU, Lahore



Dr. Wajeaha Shahid
 University of Lahore,
 Lahore, Pakistan.



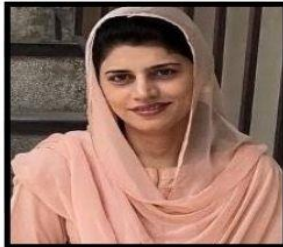
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 Chairperson, Physics
 Dept,PU Lahore



Dr. Javed Afzal
 Chairperson Dept og
 Physics, Govt Islamia
 college, Civil Lines



Dr. Waqas
 Riphah Unievrsity,
 Lahore.



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 Physics Dept,
 GCU, Lahore.



Eng. Waseem Ashraf
 Dept of Electronics,
 GCU, Lahore



Dr. Rehana Kausar
 Chemistry Dept
 LCWU, Lahore.



Dr. Zafar Iqbal
 Physics Dept.
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 Dept. LCWU, Lahore



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 Dept. LCWU, Lahore



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Ms. Tahreem Tayyab
 PhD Scholar, Physics
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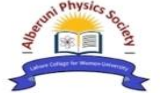
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Ms. Amina Amanat
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DAY 2



Mr. Musab Hammas Khan
 University Degli Studi Di
 Salero, Italy



Ms. Hira
 UMT Lahore



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Mr. Asif Bilal
 Zoology Dept., University of
 Okara, Okara



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Ms. Aqsa Ali
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 PhD Scholar, Physics
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 LCWU, Lahore



Ms. Hina Imtiaz
 Phd Scholar, LCWU



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DAY 2



Ms. Saman Muntaz
 PhD Scholar, Physics
 Dept. LCWU, Lahore



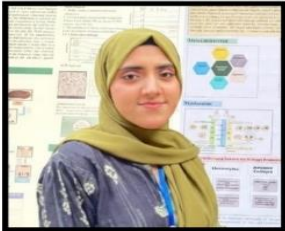
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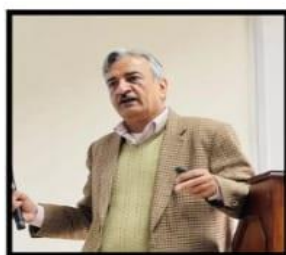


Ms. Laiba Mehmood
 CASP, GCU,
 Lahore





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DAY 3



Prof. Dr. Riaz Ahmed
 Professor Emeritus, Physics
 Department, GCU, Lahore



Prof. Dr. Rozina Chaudhry
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 College Gulberg Lahore



Prof. Dr. Shabnam Jabeen
 MaryLand
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 Centre of Excellence in
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Prof. Dr. Shamaila Shahzadi
 Physics Dept.
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Prof. Dr. Abdul Ghaffar
 Agriculture University,
 Faisalabad, Lahore, Pakistan



Dr. Bilal Tahir
 Khwaja Fareed University,
 Raheem Yaar Khan



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Dr. Saman Iqbal
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Dr. Saba Gondal
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DAY 3



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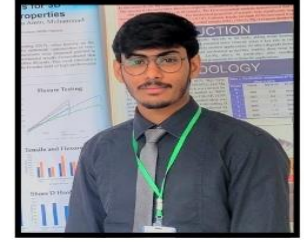
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Ms. Rabia Kanwal
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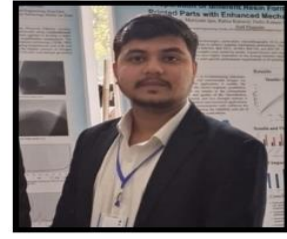
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Mr. Umar Farooq Atta
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Biodegradable Electronic Materials Enabling Transient and Environmentally Responsible Technologies

Muhammad Bilal Tahir

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ABSTRACT

The growing dependence on electronic technologies has intensified concerns related to electronic waste, resource depletion, and long-term environmental impact. In this context, biodegradable electronic materials offer a promising route toward transient and environmentally responsible technologies by enabling devices that perform reliably during operation and subsequently degrade into benign by-products. This presentation focuses on recent progress in biodegradable electronic materials and their role in redefining the life cycle of next-generation electronic systems. Key material classes, including biodegradable conductors, semiconductors, substrates, and dielectric layers, are discussed with emphasis on their physical properties, charge transport behavior, mechanical robustness, and controlled degradation mechanisms. The interplay between material chemistry, device architecture, and environmental conditions is examined to highlight performance–lifetime optimization in transient electronics. Representative applications such as temporary biomedical implants, disposable environmental sensors, and short-lifetime Internet-of-Things devices are presented to demonstrate how biodegradable materials enable functionality while minimizing ecological footprint. By integrating environmental responsibility directly into materials design, biodegradable electronics challenge the conventional paradigm of permanence in electronic systems. The talk underscores how materials physics and device engineering can collectively contribute to sustainable technological development, positioning biodegradable electronic materials as key enablers of transient technologies aligned with circular economy principles.

Keywords: Biodegradable electronics; Sustainable materials; Environmental responsibility; Electronic waste

Structural, Electronic, and Optical Study of Zn: MgO Compositions by Computational and Experimental Approach

Prof. Dr. Zaheer Hussain Shah

Department of Physics, SSC, University of Management and Technology, Lahore

ABSTRACT

The electronic, optical, and thermoelectric behaviours of Zn-doped MgO compositions were investigated in this study. The density of states analysis revealed that O-p and Mg-s orbitals mainly contribute to the valence band in pure MgO, while Zn doping induces strong hybridization between O-p and Mg-s orbitals, leading to a reduction in the band gap. The BoltzTraP package was used to study the thermoelectric properties of both pure and Zn-doped MgO. X-ray diffraction analysis confirmed the FCC crystal structure of the synthesized materials, with no evidence of secondary phases. The results also showed that the optical band gap decreased upon Zn doping, indicating improved optical properties. Overall, the findings demonstrate that Zn doping enhances the thermoelectric and optical properties of MgO, making it a potential material for thermoelectric and optoelectronic applications.

Optical Properties of Layered Structures on Incoherent Substrates

Afaq Ahmad, Hasnain Ahmad Zia

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ABSTRACT

The matrices describe the transformation of two plane waves traveling in opposite directions between the films and their propagation within the thin layers. Multiple reflections inside thin films lead to interference effects in the transmission and reflection coefficients. To suppress interference in a thick layer, Harbecke's approach is employed. Based on this method, a transmittance formula is derived for a layered structure with an incoherent substrate, which is essential for the design of optical devices. The resulting expression is simpler and more straightforward than existing approaches in the literature.

Ion Implantation in Different Materials for Technological Applications

Naveed Afzal

Centre for Advanced Studies in Physics, Government College University, Lahore

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ABSTRACT

surface modification technique widely used to tailor the structural, mechanical, optical, and electrical properties of different materials. In this work, the effects of ion implantation in three major classes of materials — metals/alloys, semiconductors, and polymers — are discussed with an emphasis on technological applications. In the case of metals, carbon ion implantation in aluminum significantly enhanced its surface hardness and corrosion resistance, while argon ion implantation in Ti6Al4V alloy improved the corrosion resistance of the alloy due to the formation of ion-induced surface nanostructures. For semiconductors, ion implantation in ZnS, NiO, and ZnO was employed to investigate modifications in their optical and electrical properties for photodetection application. Finally, ion implantation in polymeric PTFE (Teflon) was investigated for triboelectric nanogenerator (TENG) applications, where gold ion implantation significantly enhanced its triboelectric performance. These results demonstrated that ion implantation is an effective approach for tuning the material properties across diverse material systems for advanced technological applications.

Structural Exploration and Expected values of Topological Indices of Square-Hexagonal T_{2,3} Kink Chains for Advanced Engineering Applications

Dr. Salma Kanwal

Department of Mathematics, LCWU, Lahore

ABSTRACT

Square-hexagonal kink chains offer a compelling balance between geometric regularity and topological complexity, making them valuable models for studying molecular diversity in chemical graph theory. These structures, composed of alternating square and hexagonal polygons, introduce angular distortions and connectivity variations that significantly influence properties such as electronic behavior, entropy, and mechanical stability, characteristics relevant to graphene derivatives and polycyclic hydrocarbons. This work focuses on kink chains of type

T_{2,3}, for which we construct four structural configurations by systematic polygonal attachments. We calculate exact expressions of expected values using a probabilistic vertex-weighting approach for these indices. Numerical evaluation, graphical visualization, and analytical comparison reveal trends and extremal indices across configurations. These findings deepen our understanding of how kink topology influences both exact and expected topological descriptors.

Surface Modes on Hexagonal Boron Nitride Platforms for Waveguiding and Sensing Applications

Prof. Dr. Abdul Ghaffar

Department of Physics, University of Agriculture Faisalabad, 38040, Pakistan.

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ABSTRACT

In this research work, the propagation characteristics of electromagnetic (EM) surface waves supported by hexagonal boron nitride (h-BN)-based structures are analyzed. The optical response of h-BN is modeled using the Drude model. The transverse magnetic (TM) and transverse electric (TE) polarized surface waves are investigated both analytically and numerically. At the interface of the h-BN-based planar structures, appropriate boundary conditions are applied to derive the characteristic equation governing the electromagnetic surface waves. Key surface wave properties, including the dispersion relation, effective mode index, phase speed, propagation length, and field profiles, are calculated numerically. All numerical computations are performed using the Mathematica software package. The main motivation of the proposed work is to examine the propagation of surface waves along the interface between hexagonal boron nitride and various partnering materials, including indium antimonide, vanadium dioxide, chiral materials, and hyperbolic materials. The proposed h-BN-based structures provide active tunability of electromagnetic surface waves. This research has potential applications in the design of thermo-optical waveguides, near-field communication devices, imaging systems, thermo-optical sensors, chiral sensors, and chemical sensors.

Experimental Quantum Optics with Neutral Atoms

Dr Sadiq Nawaz Khan

NILOP, Pakistan

ABSTRACT

Quantum technologies are entering different industries at an increasing pace, replacing their classical counterparts. Many platforms are being used for the realization of these quantum technology applications. One of these platforms is the neutral atoms vapor cell, which with the help of tunable diode lasers, offers a cheap and convenient alternative to the other platforms. In this talk I will discuss our recent achievements in the field of quantum technology based on neutral atoms. I will discuss quantum Sensing of magnetic field using the electromagnetically induced transparency and grating employing both the transmission spectrum and the dispersion spectrum.

Role of dielectric tensor components on plasma waves and surface waves.

Gohar Abbas

Physics department, GCU, Lahore

ABSTRACT

The dielectric tensor provides the fundamental electrodynamic response of a plasma medium and plays a central role in determining the propagation characteristics of both bulk and surface plasma waves. In this talk, we examine how individual components of the dielectric tensor govern the dispersion and stability properties of electromagnetic and electrostatic modes in magnetized and unmagnetized plasmas. We demonstrate how different tensor components contribute distinctly to longitudinal and transverse wave modes and surface magnetoplasmon polariton waves. Particular emphasis is placed on the role of off-diagonal elements in magnetized plasmas, which lead to mode coupling. The analysis highlights how variations in plasma parameters alter the dielectric response and consequently reshape dispersion characteristics and instability thresholds. These results are relevant to space plasmas, laboratory magnetized plasmas, and semiconductor plasma systems where surface and collective excitations play an essential role.

Thermal plasma treatment of zirconium for surface structuring**Dr Asma Hayat***CASP, GCU. Lahore***ABSTRACT**

The thermal plasma setup was designed, fabricated, and successfully established. The effects of thermal plasma treatment on the surface morphological, compositional, electrical, mechanical, and wettability properties of zirconium (Zr) have been investigated. The Zr targets were treated with atmospheric Ar thermal plasma at different Ar flow rates ranging from 10 to 25 L/min and under different treatment times starting from 10 to 25 min. Scanning electron microscope (SEM) and optical analyses reveal the growth of various kinds of surface structures, such as microrods, flakes, pores, cracks, dendrites, agglomerates, and ridges on treated Zr. This growth is explainable on the basis of ion-induced localized heating, melting, collisional sputtering, Coulomb explosion, and thermal spike model. It was observed that both the size and number density of flakes decrease from 8 to 5 μm and 87×10^6 to $37 \times 10^6 \text{ cm}^{-2}$ with increasing Ar flow rate and treatment time. The electrical conductivity has been decreased, while hardness and wettability of Zr are increased after treatment.

100 Years of Quantum**Dr. Shabnam Jabeen***University of Maryland, Maryland, USA***ABSTRACT**

From Foundations to the Future A century ago, quantum mechanics revolutionized our understanding of nature, reshaping physics from the atomic scale to the structure of matter itself. What began with Planck and Einstein evolved into a framework that not only explained the microscopic world but also enabled the First Quantum Revolution — giving rise to semiconductors, lasers, medical imaging, and the modern information age. Today, we are entering the Second Quantum Revolution. Quantum computing, sensing, communication, and encryption are transforming fundamental principles into powerful technologies. At the same time, new insights suggest deep connections between quantum information, gravity, black holes, and even the emergence of spacetime from entanglement. Quantum ideas are also extending into biology and broader questions about life and reality. Reflecting on a century of discovery, this talk explores how quantum science continues to redefine our understanding of the universe —

and how the next generation can help shape its future.

How Does the Sun Act as a “Villain” for Our Technology?

Dr. Shahid Idrees

National Astronomical Observatories, Chinese Academy of Sciences, China

ABSTRACT

Modern life depends on technologies that operate in (or signal through) near-Earth space—satellites, GPS/GNSS navigation, radio communications, and even ground-based power grids. These systems can be disturbed by space weather, a set of conditions driven by solar activity such as flares, coronal mass ejections (CMEs), and energetic particles. In this invited talk (aimed at Bachelor’s students), I will first build an intuitive foundation: what the Sun is, why magnetic fields dominate solar activity, and how magnetic reconnection rapidly releases stored magnetic energy to produce flares and CMEs. I will then connect this physics to real-world impacts, including radio blackouts, GPS errors due to ionospheric disturbances, and geomagnetically induced currents that can stress power grids. The talk will highlight a few historical reference events—from the 1859 Carrington event to the 1989 Québec blackout, the 2003 Halloween storms, and the well-known 2012 “near miss”—to show why understanding the Sun is increasingly important for technological resilience. Finally, I will present a simplified, visual case study from my recent *Astrophysical Journal* work on Active Region 13229, where interactions between coronal loops and filaments reorganize magnetic connectivity and help form a longer filament system—processes that are closely related to eruption and space-weather drivers.

Breaking Energy Barriers in Picosecond DPSSL Technology—A 1.28- Joule Laser System

Izhar Ahmad¹, Kashif Raza¹, Hamid Ahmad Khan¹, Sabih D Khan¹, Dr. Naveed Anjum², Arslan Shahzad¹, M. Ahsan Mahmood¹, Muhammad Saif¹, Muhammad Mumtaz¹, Dr. Muhammad Saleem¹, Ashiq Hussain Dogar¹, and Dr. Manzoor Ikram¹

¹*National Institute of Lasers and Optronics College, Pakistan Institute of Engineering and Applied Sciences, 45650, Islamabad, Pakistan*

²*Optics Laboratories, 45650, Islamabad*

Presenter: Izhar Ahmad

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ABSTRACT

Picosecond lasers have wide-range of applications in the industry, defense, satellite laser ranging, medical surgery, dermatology, and high-field physics [1]. Conventional high-energy picosecond laser amplifiers are commonly pumped using flash-lamps, which suffer from inherent energy instability, low-rep rate, and higher temporal jitter issues. The diode-pumped solid state (DPSS) laser systems provide a reliable solution of these problems. However, achieving Joule-level energy, or more, in DPSS picosecond lasers, in non-CPA configuration, is a real challenge. Low optical damage threshold, small scale self-focusing, thermal lensing, and non-uniform diode pumping profiles are the major concerns in this regard. In this work, development of an all-diode pumped Nd:YAG laser amplifier delivering 1064-nm wavelength pulses of 1280 mJ energy with 50 international publications with > 1200 citations.

Finite Element Analysis of Metallic Nanostructures for Hyperthermia Treatment of Cancer

Muhammad Yasin Naz, Shazia Shukrullah, Abdul Ghaffar

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ABSTRACT

As a cancer treatment method, hyperthermia involves selectively raising the temperature of affected tissues while protecting nearby healthy tissues. This study investigates the effectiveness of pristine and coated silver, copper, and gold nanostructures such as nanorods, nanospheres, and nano ellipsoids for hyperthermia. Finite element analysis was used to evaluate the performance of uncoated nanostructures versus those with different coating thicknesses. The metallic nanostructures were enclosed within a 500 nm spherical zone of malignant tissue, and their ambient temperature was elevated between 42°C and 46°C. Thermal equilibrium was achieved after 0.1 μ s of heating in the treatment area. Compared to other shapes, nanorods quickly reached the desired temperature. Nanorods with a 1 nm coating responded faster than those with 2 nm and 3 nm coatings. Silver, gold, and copper nanorods reached temperatures of 44.2°C, 43.6°C, and 43.5°C respectively after 0.1 μ s of heating. Gold-coated silver nanorods were found to be the most efficient, reaching the highest temperature of 44.2°C.

Keywords: Finite element analysis; metal nanostructures; nanocoating; hyperthermia; cancer

In-Silico Predictive Modeling of Tumor Protein 53 For Single Nucleotide Polymorphisms And Breast Cancer

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ABSTRACT

TP53 is a protein, also named tumor protein 53, which is highly involved in breast cancer. The objective of this study was to identify non-synonymous SNPs of TP53 and their association with breast cancer using computational analysis. For this purpose, different online tools like SIFT, Polyphen, Polyphen-2, fuNTRp, SNAP2 (to identify pathogenic SNPs), SNP&GO, PhD-SNP, PredictSNP, MAPP, SNAP, MetaSNP, PANTHER (disease associated SNPs), Mu-Pro, I-Mutant, and CONSURF (to check protein stability) were used. Post-translational modifications (PTMs) were detected by Musitedeep, Protein secondary structure by SOPMA, and protein to protein interaction by STRING. Fifty-seven SNPs having rsIDs. The PTMs found were 18 times Phosphorylation, 6 times Acetylation, 6 times Methylation, 1-time SUMOylation, 3-time Hydroxylation, 2-time ubiquitination, and 9-time Glycosylation. The protein secondary structure consisted of Alpha helix (Hh) 78 (19.85%), Extended strand (Ee) 71 (18.07%), Beta turn (Tt) 14 (3.56%) and Random coil (Cc) 230 (58.76%). Protein-protein interaction analysis revealed that it has strong interaction with TP53 has shown interaction with BARD1, AURKA, CDK2, MDM2,

RPA1, EP300, SIRT1, DDX1, and CREBBP with score 0.7 to 0.9. Based on these results, it is concluded that these SNPs found in TP53 are highly involved in breast cancer. Further in vitro and in vivo analysis should be performed to conduct these interactions.

Keywords: TP53, Breast Cancer, Computational Analysis, nsSNPs

Multifunctional Metal Oxide Nanocomposite Electrodes for Energy Storage and Environmental Systems

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ABSTRACT

The development of sustainable and effective electrochemical energy storage systems is required due to the world's rapidly rising energy demand and growing environmental concerns. The UN Sustainable Development Goals SDG 7 (Affordable and Clean Energy) and SDG 12 (Responsible Consumption and Production) are directly related to the design of a metal-oxide-based nanocomposite electrode in this work. A simple, solution-based synthesis method appropriate for scalable processing was used to create the nanocomposite. Surface morphology and microstructural features were investigated using scanning electron microscopy (SEM), and phase composition and crystallographic features were examined using X-ray diffraction (XRD). Chemical bonding and successful composite formation were confirmed using Fourier transform infrared spectroscopy (FTIR). Strong rate performance and a high specific capacitance exceeding 900 F/g at 1 A/g were demonstrated by electrochemical testing in an aqueous electrolyte. Additionally, the electrode showed remarkable cycling durability by retaining more than 90% of its capacitance after 5000 cycles of charge and discharge. The metal oxide, nanocarbon, and polymer components cooperate to facilitate effective charge transport and ion diffusion, which results in the enhanced electrochemical behavior. With future efforts focused on device integration and long-term stability assessment, these results show the potential of metal oxide nanocomposite electrodes for next-generation supercapacitors, scalable energy storage technologies, and environmentally relevant electrochemical applications.

Key words: Metal oxide nanocomposites; MXene; Aqueous electrolyte; Energy Storage; Supercapacitor electrodes; Electrochemical characterization; Sustainable materials

Functionalized Samarium-Doped Bismuth Oxide: A Sol-Gel Approach to Advanced Dielectric and Antibacterial Materials

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ABSTRACT

Multifunctional oxide materials combining electrical and antimicrobial properties are of growing interest for electronics and environmental applications. Samarium-doped bismuth oxide ($\text{Bi}_2\text{O}_3:\text{Sm}$) nanostructures were synthesized via a controlled sol-gel method, yielding homogeneous and crystalline powders. X-ray diffraction (XRD) confirmed phase purity and successful Sm incorporation, while scanning electron microscopy (SEM) revealed agglomerated nanostructures with dopant-dependent morphology. FTIR spectroscopy verified characteristic Bi-O and Sm-O vibrations. Dielectric characterization over 1 kHz–1 MHz showed enhanced dielectric constants

($\epsilon' \approx 110-175$) and low dielectric loss ($\tan \delta \approx 0.02-0.06$) with increasing Sm content, attributed to interfacial polarization and defect-mediated charge transport. Antibacterial activity was tested against *Escherichia coli* and *Staphylococcus aureus*, showing inhibition zones of 12–18 mm compared to 8–10 mm for undoped Bi_2O_4 . These results demonstrate that Sm doping improves both dielectric performance and antibacterial efficiency, making $\text{Bi}_2\text{O}_4:\text{Sm}$ a promising candidate for multifunctional devices and antimicrobial coatings.

Keywords: Samarium-doped bismuth oxide; Sol-gel synthesis; Structural characterization; Dielectric properties; Electrical polarization; Antibacterial activity

Influence of Sm^{+3} substitution on the structural, magnetic and electrochemical properties of M-Type Sr hexaferrites for supercapacitor applications

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ABSTRACT

In this project, samarium-substituted strontium hexaferrites with the formula $\text{SrSm}_x\text{Fe}_{12-x}\text{O}_{19}$ (where x ranges from 0 to 0.5) were synthesized using the sol-gel auto-combustion method. The resulting powders were then sintered at 1200°C for 2 hours. The various properties of the samples, including structural, functional group, morphological, elemental, optical, magnetic, dielectric, and electrochemical characteristics, were examined using X-Ray diffractometer, Fourier transform infrared spectroscopy, scanning electron microscopy, Energy dispersive X-Ray, UV-visible, vibrating sample magnetometer, Inductor capacitor and resistor meter, and cyclic voltammetry, galvanostic charging and discharging. The structural analysis confirmed the formation of a single-phase Magnetoplumbite structure in all samples. The crystallite size decreased with an increase in Sm^{+3} ion concentration. The presence of characteristic bands in the range of $400-760\text{ cm}^{-1}$, corresponding to metal-oxygen stretching and vibrational bonds, was observed. The bandgap increased from 4.26 to 4.40 eV. The magnetic properties exhibited a clear ferromagnetic M-H curve, with the coercivity value increasing and the saturation magnetization decreasing. The dielectric constant and tangential loss of the material both decreased with increasing frequency, while the AC conductivity increased with applied frequency. This behavior is typical of ferrites and can be attributed to the polarization and orientation of dipoles within the material in response to an electric field. The observed increase in dielectric constant at higher frequencies suggests that the material could be useful in high-frequency electronic devices. The specific capacitance increased monotonically up to 167 F.g^{-1} with increasing Sm^{+3} concentration, making the samarium-substituted hexaferrites suitable for high-energy-density charge storage devices such as supercapacitors.

Influence of Laser Irradiation on the structural, dielectrical and electrochemical properties of Ce^{+3} substituted CoFe_2O_4 for supercapacitor applications

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ABSTRACT

This novel work deals with the laser irradiation technique to enhance electrochemical properties for supercapacitor applications. The cerium substituted cobalt ferrite is prepared using auto-combustion method calcinated at 1100°C for 4 hours in air furnace. The sample is then divided into six parts, one is kept un-radiated while other five samples are radiated with 2000 to 6000 pulses using Nd: YAG laser having 130mJ energy, 1064nm wavelength. The structural, morphological and electrochemical properties of samples have been examined using X-Ray Diffractometer (XRD), scanning electron microscopy (SEM), cyclic voltammetry (CV), GCD and EIS respectively. X-ray diffraction pattern indicates the single phase cubic spinel ferrite. The CV and GCD specific capacitance for the optimized sample irradiated by 5000 pulses is 951 F/g at scan rate of 5 mV/s and 1004 F/g at 1A/g having capacitance retention of 93.8% and 92.3 % through CV and GCD respectively. These findings prove that laser irradiation is a good technique for the modification of electrode material for high performance supercapacitor applications.

Investigation of electrochemical properties of nickel tin sulfide based composites synthesized using hydrothermal method for supercapacitor applications

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ABSTRACT

The energy crisis is driving the demand for novel and innovative materials for the development of alternative energy sources. Supercapacitors have attracted great attention because of their high power density and long life cycle. In this work, pure nickel tin sulfide $\text{Ni}_3\text{Sn}_2\text{S}_2$, binary composite $\text{Ni}_3\text{Sn}_2\text{S}_2 / \text{rGO}$ and $\text{Ni}_3\text{Sn}_2\text{S}_2 / \text{rGo/PANI}$ have been prepared via hydrothermal route. The synthesized materials were characterized by XRD, CV, GCD and EIS techniques and investigated its utilization for electrode materials. XRD analysis demonstrate the existence of constituents and their mutual contribution in all the binary composites and in a ternary hybrid material. Electrochemical results have proven that ternary composites $\text{Ni}_3\text{Sn}_2\text{S}_2 / \text{rGo/PANI}$ electrode exhibits an excellent specific capacitance of 742.6 F/g at a scan rate of 0.5 mV/s among all the prepared composite. Hence, analysis have proved that $\text{Ni}_3\text{Sn}_2\text{S}_2 / \text{rGO/PANI}$ ternary hybrid is beneficial electrode material for the utilization of supercapacitor application.

Hydrothermal Synthesis Of Nickel Molybdenum Sulfide-based Composite for High Performance Hybrid-Supercapacitor

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ABSTRACT

The need for energy storage has necessitated extensive study into electrochemical energy storage technologies. Due to their high energy density and high-power density, supercapacitors have become one of them and have attracted a lot of attention. This research work represents the

synthesis of hydrothermally prepared transition metal sulfides pure NiMoS₄, CuS, and a novel composite NiMoS₄/CuS/CNTs and their fabrication of electrodes for supercapacitor applications. The CV manifests that the NiMoS₄, CuS, and NiMoS₄/CuS/CNTs electrodes at the scan rate of 5mV /s have specific capacitance values of 266.03 F/g, 126.79 F/g, and 435.8 F/g respectively. Among all electrodes, NiMoS₄/CuS/CNTs electrode have a greater specific capacitance of 435.08 F/g at 5 mV/s. Through the GCD analysis, NiMoS₄/CuS/CNTs electrode exhibits higher specific capacitance of 202.53 F/g, compared to 130.86 F/g for CuS and 185.00 F/g for NiMoS₄, at 0.5A/g, which specifies that the specific capacitance of the ternary hybrid composite material is significantly boosted. The EIS study depicts that NiMoS₄/CuS/CNTs electrode possess minimum ohmic resistance of 1.08 Ω which attributes to high conductivity. The novel ternary composite NiMoS₄/CuS/CNT electrode is beneficial material in supercapacitor application.

Synthesis of Copper Doped Nickel Oxide through Co-Precipitation Method for Supercapacitors Applications

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ABSTRACT

In this work Copper doped nickel oxide with chemical formula Cu_xNi_{1-x}O (x= 0.00, 0.01, 0.03, 0.05 and 0.07) have been fabricated using co-precipitation method and sintered at 500oC. The structural, morphological, optical, dielectric and electrochemical properties have been studied by X-ray Diffractometer (XRD), Scanning Electron Microscopy (SEM), UVvisible spectroscopy (UV-Vis), Inductor Capacitor Resistor meter (LCR) and Potentiostat/galvanostat respectively. The structural analysis reveals that nickel oxide exhibits face-centered cubic rock salt structure. The crystallite size of nickel oxide nanoparticles is observed between 10-50 nm. The crystallite size increases with increasing copper concentration. The spherical-shaped nanoparticles with definite boundaries having average particles size ranges from 20-100 nm is observed. The optical properties reveals that band gap energy is reduced with increasing doping concentration of Cu²⁺ ions. The optical band gap lies in range of 3.5 eV to 4.0 eV. FTIR spectra shows the main Cu-O bond in range of 400,-500 cm⁻¹ and the Ni-O bond lies in the range of 500-600 cm⁻¹. Dielectric analysis reveals that copper doping enhances the ac conductivity at high frequency. The specific capacitance observed by CV analysis is ~ 867 Fg⁻¹ at 5mVs⁻¹.

Assessment of ZnO and TiO₂ Nanoparticle-Induced DNA Damage and Its Amelioration by Ginger and its bioactive components using the Comet Assay

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ABSTRACT

The current experimental study was designed to assess the genotoxic and systemic toxic effects of Zinc oxide (ZnO) and Titanium dioxide (TiO₂) nanoparticles, both separately and in combination, as well as to look into the possible protective role of ginger and its main bioactive components, 6-gingerol and 6-shogaol. Adult experimental rats were separated into control and treatment groups and exposed to low and high doses of ZnO, TiO₂, and their mixture for an initial period of four weeks to determine nanoparticle-induced toxicity. In order to assess the ameliorative effects of ginger, 6-gingerol, or 6-shogaol, the rats were further subdivided into other groups after this exposure phase. Genotoxicity was assessed using alkaline single-cell gel electrophoresis (comet)

assay, a sensitive method for identifying DNA strand breakage at the cellular level. In comparison to the control group, the nanoparticle-treated groups showed a marked increase in DNA damage, as shown by higher percentage tail DNA, tail length, and olive tail moment during the first four weeks. High-dose and mixed nanoparticle groups showed a more noticeable genotoxic effect, suggesting that ZnO and TiO₂ nanoparticles have a dose-dependent and synergistic effect on genomic integrity. Administration of ginger and its bioactive compounds resulted in a marked reduction in comet assay parameters, demonstrating significant attenuation of nanoparticle-induced DNA damage. Among the treatments, 6-gingerol and 6-shogaol showed comparatively stronger protective effects than crude ginger, suggesting a key role of these phenolic constituents in mitigating oxidative DNA damage. In conclusion, the findings of this study confirm that ZnO and TiO₂ nanoparticles induce significant genotoxicity, particularly when administered in combination, while ginger and its active components exert a protective effect by reducing DNA strand breaks. The comet assay results provide compelling evidence for the antigenotoxic potential of ginger-derived phytochemicals and highlight their possible therapeutic relevance against nanoparticle-induced DNA damage.

Direct correlation between open-circuit voltage and quasi-fermi level splitting in perovskite solar cells: a computational step involving thickness, doping, lifetime, and temperature variations for green solutions

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ABSTRACT

In this study, a 1D perovskite-based solar cell was simulated using COMSOL, incorporating CH₃NH₃GeI₃ (organic-inorganic hybrid) as an absorber layer, SnO₂ as the electron transport layer (ETL), and Cu₂Te as the hole transport layer (HTL). The simulations reveal that reducing the ETL's thickness enhances Gohar Abbas Saba Gondal, Saad Muneers current density (J), although the maximum output power (P_{max}) diminishes with ETL's thickness. Conversely, increasing the absorber layer's thickness boosts open-circuit voltage (V_{oc}) and efficiency, exhibiting direct relation between V_{oc} and quasi-Fermi level splitting. Furthermore, variations in HTL thickness do not significantly affect V_{oc} or P_{max}. Notably, V_{oc} and P_{max} both increase with acceptor density, conversely, increase in donor density leads to declines in both V_{oc} and P_{max}. While extending the electron-hole (e-h) lifetime within the ETL results in marginal efficiency improvements, significant enhancements in the e-h lifetime within the absorber layer substantially improve performance. However, the efficiency remains unaffected by variations in the e-h lifetime of the HTL. Additionally, higher operating temperatures adversely impact device performance, reducing J, V_{oc}, P_{max}, fill factor, and overall efficiency. This study provides critical insights into optimizing material properties and device parameters for experimental applications, underscoring the potential of CH₃NH₃GeI₃-based perovskites as viable candidates for next-generation photovoltaic technologies.

Keywords: COMSOL; Solar energy; Perovskite solar cells; CH₃NH₃GeI₃; Organic in-organic hybrid solar cell

Integration of carbon nanotubes/MXene into Co-doped Ni₉S₈ nanostructures for enhanced energy storage mediated via efficient diffusion dynamics in hybrid supercapacitors

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ABSTRACT

The rising need for sustainable energy has prompted researchers to design efficient electrode materials with exceptional electrochemical capabilities. In this perspective, we report the synthesis of Ni₉S₈ (NS), Co_{0.9}Ni_{8.1}S₈ (Co-NS) and its composites (Co-NS/CNTs and Co-NS/MXene), offering potential breakthroughs in super capacitor technology. Microscopic analysis revealed an intricate network of stem-like structures that enhances the availability of chemically active sites, as evident by surface analysis. Cyclic voltammograms exhibited distinct redox peaks across different scan rates, indicating hybrid electrochemical behavior as analyzed through Dunn's model. Among all the composites, Co-NS/MXene achieved a superior electrochemical performance, attaining a notable specific capacity (Q_{sc}) of 1904 C/g at 5.88 A/g, along with an energy density (E_d) of 119.04 Wh/kg at the power density (P_d) of 1323.52 W/kg. Additionally, after 3000 consecutive charge/discharge cycles, Co-NS/MXene retained 98 % of its original capacity. Furthermore, the electrode exhibited the highest ionic conductivity of 0.46 S/cm, and a high diffusion coefficient of 6.65×10^{-9} cm²/s. An asymmetric supercapacitor device demonstrated a remarkable QSC of 228.70C/g at 3.52 A/g, yielding an E_d of 31.76 Wh/kg at 1764.70 W/ kg of P_d. Collectively, these performance parameters position Co-NS/MXene as a leading contender as an electrode material for next-generation energy harvesting systems.

Keywords: Hybrid-supercapacitors; Composites; Surface analysis; Diffusion coefficient; Energy density; Asymmetric device

Significance of the direct relation between the fill factor and hole transport layer thickness in perovskite-based solar cells for green energies

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ABSTRACT

In response to the growing global energy crisis and environmental degradation, the development of clean, sustainable energy technologies is imperative. Solar energy, with its vast availability and minimal ecological footprint, is a leading candidate. Among the emerging photovoltaic technologies, perovskite solar cells (PSCs) are gaining attention for their tuneable optoelectronic properties and low-cost processing. This study employs a 2D model simulation on COMSOL Multiphysics to investigate two lead-free PSC designs, focusing on structural optimization. Notable results for the ZnSe/BiFeO₃/spiro-OMeTAD cell include a maximum short-circuit current density (J_{sc}) of 9.83 mA cm⁻² and a peak efficiency of 10.72% at 75 nm electron transport layer thickness, open-circuit voltage (V_{oc}) of 2.2 V at 125 nm hole transport layer thickness and fill factor (FF) of 73.77% at 100 nm BFO thickness. For the ZnSe/CsSnI₃/spiro cell, a maximum efficiency of 17.56%, FF of 79.91%, V_{oc} of 1.01 V, and J_{sc} of 28.32 mA cm⁻² were achieved. The study specifically explored the direct relation between the FF and hole transport layer thickness in a perovskite-based green photovoltaic device. These findings highlight the promising potential of leadfree perovskites for efficient, stable, and environmentally benign solar cells. This work supports the advancement of inorganic PSCs, contributing to the global shift toward renewable energy.

Keywords: COMSOL Multiphysics; Perovskite solar cell simulation; BiFeO₃; Lead-free perovskite material; Renewable energy

Scaling an inverse relation between photovoltaic efficiency and donor carrier density for sustainable solar potential in double perovskite-based solar cells

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ABSTRACT

The accelerating climate crisis and the depletion of fossil fuel reserves have made clean energy an unavoidable necessity, creating a strong need for efficient and sustainable solar technologies. This work introduces 2D simulations of lead-free $\text{SnO}_2/\text{Cs}_2\text{AgBiBr}_6/\text{Spiro-OMeTAD}$ (using COMSOL) Perovskite solar cell that integrates $\text{Cs}_2\text{AgBiBr}_6$, a very stable, non-toxic double perovskite. A maximum fill factor of 88.15% was recorded at thicknesses below 500 nm, peak short-circuit current density of 13.30 mA/cm^2 was observed above $\text{Cs}_2\text{AgBiBr}_6$ thickness of 1500 nm, and a maximum efficiency (13.10%) was attained close to an acceptor and donor density of 1×10^{18} and $1 \times 10^{17} \text{ cm}^{-3}$, respectively. Furthermore, results elucidate the scaling of the inverse relationship between photovoltaic efficiency and donor carrier density. $\text{Cs}_2\text{AgBiBr}_6$ stands out as a rare lead-free perovskite that unites efficiency with long-term stability, offering a credible path towards environmentally safe photovoltaics. This study found that by adjusting thickness and carrier concentration helps improve the balance between efficiency and stability in double perovskite devices.

Keywords: COMSOL Multiphysics; Perovskites; Solar cell simulation; Lead-free perovskite material; Renewable energy

Porous NiCo_2S_4 /carbon nanotubes composite engineered for efficient ion transport and durable hybrid supercapacitor performance

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ABSTRACT

The accelerated global energy crisis and environmental degradation resulting from fossil fuel combustion necessitate the rational design of sustainable energy storage systems featuring a synergistically balanced energy-power profile and intrinsically optimized ion-diffusion dynamics. In this pursuit, a series of spinel nickel cobalt sulfide (NiCo_2S_4 , NCS) and its carbon nanotubes (CNTs)-integrated nanocomposites containing 3, 6, and 9% CNTs (designated NCS-1, NCS-2, and NCS-3) were synthesized to engineer superior electrochemical characteristics. X-ray diffraction validated the face-centered cubic structure of NCS, while scanning electron microscopy unveiled rock-like nanostructures that transitioned into a highly porous, interconnected web-like architecture upon CNTs integration, enhancing surface area and charge transport pathways. Cyclic voltammetry profiles exhibited characteristic duck-like shapes, indicative of hybrid capacitive-faradaic behavior predominantly governed by surface-controlled mechanisms, as substantiated by Dunn's analytical model. Galvanostatic charge-discharge evaluations demonstrated an optimized specific capacity (1322.38 C/g) and energy density (91.38 Wh/kg) at 11.76 A/g . Electrochemical impedance spectroscopy further delineated minimal solution and charge transfer resistances in the optimized composite, coupled with superior ionic conductivity ($1.11 \times 10^{-1} \text{ S/cm}$). The galvanostatic intermittent titration technique elucidated critical ion diffusion dynamics, revealing an optimal diffusion coefficient of $5.99 \times 10^{-11} \text{ cm}^2/\text{s}$ for NCS-3. Moreover, a 2-electrode

asymmetric device configuration yielded a specific capacity of 107.68 C/g and an energy storage ability of 13.46 Wh/kg, underscoring the transformative potential of NCS-3 in scalable, high-performance energy storage applications.

Keywords: Carbon nanotubes, Web-like porous morphology, Higher energy density, Diffusion dynamics, Hybrid supercapacitors

Exploring Structural Variations and Topological Descriptors of Square-Hexagonal Kink Chains of Type $T_{2,2}$ in Engineering Applications

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ABSTRACT

Square-hexagonal kink chains, also known as hexagonal kink chains or simply kink chains, are structural configurations used in engineering for various purposes, including materials science, nanotechnology, and mechanics. The square-hexagonal kink chain describes a chain-like structure where the individual units have square and hexagon-like shapes arranged symmetrically. Additionally, there are points in the chain where the linear arrangement deviates or “kinks,” possibly due to structural irregularity. Our objective is to discover three possible arrangements of kinks of type T_2 , depending on the process by which different polygons are attached at different positions, while maintaining the condition of forming a kink at each step. In this work, we calculated Forgotten, Geometric-Arithmetic, Sum-Connectivity, and Atom-Bond Connectivity indices for the kink chains. A comparison between these topological descriptors is provided by computing their numerical values for each kink chain.

Exploring Entropy Measures with Topological Indices on Colorectal Cancer Drugs Using Curvilinear Regression Analysis and Machine Learning Approaches

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ABSTRACT

In this paper, we established a QSPR analysis of colorectal cancer drugs by examining entropy indices and their physical properties to develop a predictive relationship. Through a comprehensive analysis of these drugs, essential insights into their molecular properties were obtained, which are vital for predicting their behavior and effectiveness in treating colorectal cancer. The QSPR study was performed using curvilinear regression models including linear, quadratic, cubic, exponential, and logarithmic models. Additionally, we propose the integration of machine learning (ML) techniques to further enhance predictive accuracy and robustness. By leveraging advanced ML algorithms, we aim to uncover more complex, non-linear relationships between topological indices and drug efficacy, potentially leading to more accurate predictions and better-informed drug design strategies.

Comprehensive physicochemical and electrochemical characterization of praseodymium substituted Ni–ZnO nanocomposites for supercapacitor electrodes

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ABSTRACT

A series of praseodymium substituted nickel zinc oxide nanoparticles with general formula $\text{Pr}_x\text{Ni}_{(0.1-x)}\text{Zn}_{0.9}\text{O}$ at ($x = 0.0, 0.01, 0.02, 0.03, 0.04, 0.05$) have been fabricated using hydrothermal method. The role of Pr^{+3} doping has been investigated comprehensively on structural refinement, surface morphology, functional groups, energy modes of vibrations, presence of mesoporous oxidation states and electrochemical properties. The XRD and Rietveld refinement confirm the formation of single-phase hexagonal wurtzite structure with only one minor secondary phase peak $\text{Pr}_2\text{Zn}_{17}$. The FTIR represents the functional groups of Pr-Ni-Zn-O. The Raman shows the existence of phonon-phonon interaction of all the constituent atoms. BET analysis confirms the well-connected mesoporous. XPS shows the different oxidation states of constituent atoms. The highest gravimetric and areal capacitance are 1142 Fg^{-1} and 4.56 Fcm^{-2} respectively for the sample $\text{Pr} = 0.05$ at lowest scan rate 10 mVs^{-1} . The specific capacitance from GCD is 1602 Fg^{-1} at current density 1 Ag^{-1} . The diffusive and capacitive contribution are 52.5 and 47.5 at 10 mVs^{-1} respectively. On the basis of these outcomes, the current samples may be suggested as an electrode material for supercapacitors.

Instability of Coupled Mode in Semiconductor Plasma Waveguides

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ABSTRACT

Three waves interaction of electrostatic modes in semiconductor plasmas for a cylindrical geometry is presented here. The fields of plasma modes couple through second ordered ponderomotive force. For analytical analysis, we applied quantum Hydrodynamics, Fluid Model for the electrons and holes in semiconductor systems. For convenience we consider only high frequency regimes. We derive and analyze the dispersion relations for the electron plasma wave (EPW), hole plasma wave (HPW), and the excited beat wave. Under phase-matching conditions, the growth rate of the beat wave is evaluated. Numerical simulations demonstrate that the growth rate is enhanced by lower temperatures, higher electron densities, shorter wavelengths, and increased pump wave potentials. These conditions optimize wave coupling and energy transfer, highlighting the role of quantum effects in modulating nonlinear interactions.

Motivation:

Future technology like quantum computers, communication systems, and highly sensitive sensors is mainly dependent upon controlled energy transfer. When waves of energy or signals interact inside the tiny components of a semiconductor, they can create unpredictable, nonlinear effects. This study describes a possible mechanism when a "pump" wave and a "sideband" wave combine to create a powerful new "beat" wave.

Steering the Microstructure of Medium Carbon Steel towards Desired Performance through Heat Treatment

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ABSTRACT

Heat treatment is a crucial process used to alter the mechanical properties of steels by controlled heating and cooling. This study investigates the effect of different heat treatment processes on the mechanical properties of medium carbon steel. Samples of medium carbon steel were subjected to various heat treatments including annealing, normalizing, quenching, and tempering. The treated specimens were then evaluated for changes in mechanical properties such as hardness, tensile strength, ductility, and toughness. The results show that quenching significantly increases hardness and tensile strength but reduces ductility, making the steel more brittle. Annealing improves ductility and machinability while decreasing hardness. Normalizing provides a balanced combination of strength and toughness by refining the grain structure. Tempering after quenching reduces brittleness and improves toughness while maintaining adequate strength. The study concludes that appropriate heat treatment selection allows medium carbon steel to be tailored for specific engineering applications, enhancing its performance and service life.

Key Words: Heat treatment, medium carbon steel, Annealing, Normalizing, Quenching, Tempering, Mechanical properties, Material Science.

Heat Treatment Processes: Enhancing Material Properties for Industrial Applications

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ABSTRACT

Heat treatment is a crucial process in materials science and engineering, involving the controlled heating and cooling of materials to alter their microstructure and achieve desired properties. Our research work provides an overview of the latest advancements in heat treatment processes, including quenching, tempering, annealing, and surface hardening. The topics covered, such as recent developments in heat treatment technologies and industrial applications, seem quite relevant to current research and industry needs. I'd like to suggest adding some specific examples or case studies to illustrate the impact of heat treatment on material properties. Additionally, it would be interesting to explore the challenges and limitations of current heat treatment processes and potential areas for future research. The inclusion of emerging trends and future directions provides a forward-looking perspective on the field. Overall, the ABSTRACT provides a good overview of the scope of heat treatment processes and their significance in materials science and engineering.

From Pixels to Particles: How Additive Manufacturing is Turning Dreams into Reality

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ABSTRACT

Additive manufacturing, commonly referred to as 3D printing (3DP), has ushered in a new era of advanced manufacturing, offering unprecedented design freedom. Traditional manufacturing has always been limited by subtractive processes, leading to material waste and geometric constraints. Additive Manufacturing has transformed this paradigm by leveraging fundamental physics principles, such as phase transformation, laser–matter interaction, and molecular bonding. This paper examines how AM is breaking the barriers of classical engineering. From creating bio-inspired metamaterials that defy standard

strength-to-weight ratios to 3D-printing critical components for aerospace and medical applications, we are no longer limited by manufacturing constraints, but by our conceptual boundaries. This paper highlights the transition of AM from a simple prototyping tool to a transformative production paradigm. The methodology in Additive Manufacturing involves key principles and demonstrates how specific physics techniques are applied, such as phase transformation and laser–matter interaction, to accurately build objects layer by layer, ensuring precise control over material properties. The conclusion summarizes the transformative impact of Additive Manufacturing and highlights how AM has overcome traditional limitations, realizing complex geometric designs and providing groundbreaking solutions in various sectors.

Key Words: Paradigm shift, Geometric Complexity, Material Science, Impact, Zero waste

High-Performance Scientific Data Visualization Using ParaView; Better Visualization, Better Understanding

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ABSTRACT

Scientific and engineering simulations generate large and complex datasets that are often difficult to analyze using conventional numerical methods. Scientific data visualization provides an effective approach to transform such data into meaningful visual representations, enhancing interpretation and insight. ParaView is an open-source, multi-platform visualization software widely used for analyzing large-scale scientific data. This presentation focuses on the capabilities of ParaView for visualizing complex three-dimensional and time-dependent datasets, with particular emphasis on applications in materials science. ParaView supports a wide range of data formats and advanced visualization techniques, including scalar and vector field visualization, contour plots, streamlines, and volume rendering. Its parallel processing architecture enables efficient handling of massive datasets, making it suitable for high-performance computing environments. Through practical workflow discussion and examples from materials science and engineering simulations, this work demonstrates how ParaView improves data analysis, supports informed decision-making, and enhances the communication of scientific results.

How Does Microstructure Control the Properties of a Material

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ABSTRACT

The fundamental properties of engineering materials—strength, ductility, and hardness—are not merely a result of chemical composition but are primarily governed by their internal

microstructure. This presentation explores the critical relationship between microscopic features and macroscopic behavior, focusing on how the arrangement of atoms, grains, and phases dictates a material's industrial utility. Key mechanisms such as grain boundary strengthening, where smaller grain sizes impede dislocation movement to increase yield strength, and precipitation hardening are discussed. By examining how thermal and mechanical processing can “tune” these micro-features, this study highlights the role of the materials engineer as an architect of the internal landscape. Ultimately, understanding microstructural control allows for the development of advanced alloys tailored for high-performance applications, bridging the gap between fundamental science and transformative engineering solutions.

Energy Absorption of Re-Entrant Auxetic Structures Fabricated from Multiple Thermoplastic Materials

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ABSTRACT

Auxetic cellular structures exhibit unique mechanical properties; however, their dynamic impact response remains insufficiently explored. This study examines the energy absorption performance of re-entrant auxetic structures fabricated via Fused Deposition Modeling using Acrylonitrile Butadiene Styrene, Polylactic Acid, and Carbon Fiber Reinforced PLA. Specimens were designed according to ISO 179-1 standards and tested using Charpy impact testing to evaluate impact resistance and fracture behavior. The results demonstrate that auxetic structures significantly enhance impact performance compared to conventional solid designs across all materials. Notably, the Carbon Fiber Reinforced PLA auxetic structure exhibited the highest energy absorption of 1.67 J, compared to 0.19 J for its conventional counterpart. This enhanced performance is attributed to the combined effects of auxetic deformation mechanisms and fiber reinforcement, which enable distributed deformation and delay catastrophic fracture. Overall, the findings highlight the critical role of structural topology in improving energy absorption for advanced protective engineering applications.

Friction Stir Technology: A Solution to Modern Manufacturing Challenges

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ABSTRACT

Friction Stir Technology (FST) is a modern solid-state processing technique that highlights how fundamental physics can be applied to real-world material systems. Unlike traditional welding methods that rely on melting, this process uses friction and mechanical stirring to soften and join materials while they remain in the solid state. The heat produced during the process comes from friction at the tool–material interface and intense plastic deformation, making it an interesting example of thermo–mechanical interaction. These conditions lead to severe material flow and dynamic recrystallization, resulting in refined grain structures and improved mechanical properties. From a physics perspective, friction stir technology involves key concepts such as heat transfer, deformation physics, and non-equilibrium microstructural evolution. Temperature gradients play a crucial role in controlling material behavior and final properties. Recent progress in computational and multiphysics modeling has further improved the understanding of heat generation and material flow during the process. Due to its energy efficiency, absence of melting-

related defects, and strong physical foundation, friction stir technology is gaining importance as an emerging trend that connects materials science with fundamental and applied physics.

How Does Physics Behind Superalloys Help Spacecraft Engine Manufacturing

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ABSTRACT

Spacecraft engines operate under extreme conditions involving ultra-high temperatures, intense mechanical stress, and corrosive environments. Superalloys are a class of advanced materials specifically engineered to withstand these harsh conditions, making them essential for modern spacecraft engine manufacturing. The exceptional performance of superalloys is deeply rooted in fundamental physics principles, including solid-state diffusion, phase stability, creep resistance, and dislocation mechanics. This paper explores how the physics governing superalloys contributes to their superior mechanical strength, thermal stability, and oxidation resistance. Emphasis is placed on phase transformations, precipitation strengthening, and atomic bonding mechanisms that allow these materials to maintain structural integrity at elevated temperatures. Furthermore, the role of microstructural control in enhancing engine efficiency and reliability is discussed. By understanding the physics behind superalloys, engineers can optimize spacecraft engine components to achieve higher performance, longer service life, and improved safety in space missions.

Key Words: Superalloys, Spacecraft Engines, Phase Transformation, High-Temperature Physics, Materials Engineering.

Heat Treatment: A Gateway to Microstructural Control, Leading to Better Performance of Materials

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ABSTRACT

Heat treatment plays a vital role in tailoring the microstructure of engineering materials to achieve desired mechanical and functional properties. By controlling heating, soaking, and cooling cycles, the internal structure of metals can be modified to enhance hardness, strength, ductility, toughness, and dimensional stability. This presentation highlights how different heat treatment techniques—such as annealing, normalizing, quenching, tempering, and advanced processes like austempering—impact microstructural evolution and phase transformations. The relationship between microstructure and material performance is emphasized to show how refined grains, balanced phases, and reduced internal stresses contribute to improved service life and reliability. Through selected examples and comparative analysis, the work demonstrates that heat treatment is not just a finishing step but a strategic tool for optimizing material behavior for specific applications in industries such as automotive, aerospace, construction, and manufacturing. The study concludes that effective microstructural control through heat treatment serves as a gateway to designing high-performance materials that meet modern engineering challenges.

Significance of Length Scales in Scientific Development

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ABSTRACT

From the vast galaxies above us to the tiniest subatomic particles, nature never stops surprising us. Our understanding of the world grows not just by discovering new laws, but by exploring how matter and energy behave differently at different scales. At the macroscopic level, gravity and inertia dominate, shaping the world of classical mechanics. Zooming into the microscopic scale, surface forces, viscosity, and interactions between interfaces take over, guiding fields like microfluidics and biology. At the nanoscale, quantum effects and high surface-to-volume ratios start to control behavior, opening doors to nanotechnology, advanced electronics, and smart materials. At the atomic and subatomic levels, quantum mechanics rules, forming the backbone of solid-state physics and semiconductors. Throughout history, instruments like telescopes, microscopes, and particle accelerators have revealed these hidden scales, sparking major scientific leaps. Examples from materials and engineering—such as grain-size strengthening, nanoscale reactivity, and scale-dependent fluid flow—show how scale shapes practical innovation. Understanding these patterns connects different fields and points the way toward the technologies of tomorrow.

Microstructure Evolution in Metal Additive Manufacturing

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ABSTRACT

Metal additive manufacturing (AM) enables the fabrication of complex metallic components through layer-by-layer melting and solidification of metal powders. The process involves rapid heating and cooling cycles, leading to unique microstructure evolution compared to conventional manufacturing. High cooling rates result in fine grains, cellular or columnar morphologies, and non-equilibrium phases. Directional heat flow during deposition produces anisotropic grain structures and crystallographic textures. Process-induced defects such as porosity and residual stresses also influence material behavior. Post-processing treatments are commonly applied to modify microstructure and improve mechanical properties.

Nanostructured Coatings for Corrosion Resistance

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ABSTRACT

Nanostructured coatings have emerged as a promising solution for corrosion protection in various industries. These coatings, comprising metallic, ceramic, or polymeric nanomaterials, offer enhanced barrier properties and durability. Their unique nanostructure enables improved corrosion resistance, self-healing capabilities, and superhydrophobicity. Nanostructured coatings find applications in aerospace, automotive, and oil & gas sectors, protecting critical components. Key benefits include extended lifespan, reduced maintenance, and improved safety in harsh environments. Challenges remain in scaling up production while maintaining performance and ensuring eco-friendly synthesis. Ongoing research aims to develop advanced nanocoatings with tailored properties for specific industrial needs.

Preparation of Different Resin Formulations for 3D Printed Parts with Enhanced Mechanical Properties

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ABSTRACT

The advancement of additive manufacturing technologies, particularly stereolithography (SLA) and digital light processing (DLP), relies heavily on the optimization of photopolymer resin formulations to achieve superior mechanical performance. This study focuses on the systematic optimization of resin blends by varying the relative proportions of RM-416, RM-322-2, ACOMO, RM-234, and RM-198. A series of resin formulations were prepared and printed in standard shapes for mechanical testing. The samples were tested under tensile, three-point flexural, and impact loading conditions. The experimental results demonstrated that the mechanical properties of the printed parts were highly dependent on the synergy between oligomeric resins and reactive diluents. This work provides a framework for tailoring resin compositions to meet specific performance requirements in 3D printing and contributes to the broader field of high-performance photopolymer development.

Innovation in Nanoscale Materials for Energy, Environment and Economy

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ABSTRACT

With the advent on innovative science, chemical research and technology, nanoscale materials can be engineered and programmed to perform specified function at macro level applications. The innovation in chemical science, nanomaterials, catalysis, and electrochemical processes for Water Splitting has a lead now for solar and chemical energy conversion. These systems can be implemented as surface immobilization along with thin-films for catalytic processes, sensing applications and for energy conversion schemes. We have invented, discovered and developed specialized methods, and exploited various thin-film nanoscale materials for catalytic water splitting, CO₂ reduction, and recently for electrochemical sensing, biomass catalysis and solar energy conversion. Now we implement and developing new methods for making advanced electrofunctional nanomaterials and nanoclusters derived from thin-films molecular assemblies, inorganic nanomaterials and metal-oxides displaying great potential to be used in high performance water splitting catalysis and for chemical energy conversion and storage schemes. In this discussion we also highlight the challenges in chemical energy conversion and the possible way forward.

Optical and Electrochemical Properties of Co–Zn Oxide Thin Films

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Abstract

Co–Zn oxide thin films were prepared by spray pyrolysis to study the effect of composition on their optical and electrochemical properties for energy storage applications. Films with different Co:Zn ratios were characterized using structural, optical, and surface analysis techniques, revealing a transition from crystalline to amorphous phases and a tunable optical band gap with increasing compositional mixing. Electrochemical measurements showed pronounced pseudocapacitive behavior, with the optimal 1:1 Co:Zn composition delivering a high specific capacitance of 1452 F g^{-1} at 1 A g^{-1} . A symmetric supercapacitor device based on this composition achieved an energy density of 54 Wh kg^{-1} at a power density of 800 W kg^{-1} . These results demonstrate the potential of Co–Zn oxide thin films for high-performance energy storage applications.

Exploring structural variations and topological descriptors of squarehexagonal kink chains of type T2,2 in engineering applications

Maham

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ABSTRACT

Abstract Square-hexagonal kink chains, also known as hexagonal kink chains or simply kink chains, are structural configurations used in engineering for various purposes, including material science, nano-technology and mechanics. The square hexagonal kink chain likely describes a chain-like structure where the individual units have square and hexagon-like shapes and are arranged with symmetry. Additionally, there are likely points in the chain where the linear arrangement deviates or kinks, possibly due to some structural irregularity. Our objective is to discover three possible arrangements of kinks of type T2, depending on the process of how different polygons are attached at different places, holding the condition to make a kink at each step. In this work, we have calculated forgotten, geometric-arithmetic, sum-connectivity and atom bond-connectivity indices for the kink chains. A comparison between these topological descriptor is given by computing their numerical values for each kink chain.

Electron Ion Acoustic Shock Structures in Non-thermal and Non-toxic Plasmas

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ABSTARCT

Electron-ion acoustic waves play a key role in understanding nonlinear structures in laboratory and space plasmas, particularly in regions with excess nonthermal particle populations. This work investigates both linear and nonlinear electrostatic waves in generalized unmagnetized plasmas with weak dissipation, cold ions, and Cairns-Tsallis distributed electrons. The reductive perturbation method is used to derive the nonlinear evolution equations governing the formation of solitary and shock structures, such as the Burgers and Korteweg-de Vries-Burgers equations under different sets of stretched coordinates. The analysis shows that the phase velocity and the

change from solitary waves to dissipative shock waves are significantly influenced by nonthermal and nonextensive parameters. The shock potential is reduced by increasing nonextensivity, but its amplitude and steepness are increased by nonthermal effects. The thickness and stability of the shock profile are also controlled by kinematic viscosity. The results demonstrate the presence of rarefactive electrostatic shocks, which are consistent with observations in Earth's superthermal electron-rich magnetospheric environment. The study's findings could improve our understanding of wave-particle interactions in laboratory and astrophysical plasma systems and provide theoretical support for comprehending nonlinear electrostatic phenomena in space plasmas.

Key words: Nonthermal plasma; electron-ion acoustic waves; nonextensive statistics; shock structures; magnetospheric plasmas; KdV-Burgers equation

Laser assisted Absorption and Emission Spectroscopy

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ABSTARCT

Laser-assisted absorption and emission spectroscopy comprises a powerful set of analytical techniques that exploit the unique properties of laser like monochromaticity, high intensity, and directionality. In laser absorption Spectroscopy, we experimentally investigate the atomic structure, and properties of excited states such as photoionization cross section and oscillator strengths of Rydberg transitions. This has been done using selective excitation and precise control over light–matter interactions. The emission spectroscopy, known as Laser Induced Breakdown Spectroscopy (LIBS), employs intense laser pulses to ablate a small amount of material from a sample surface, generating a microplasma. As the plasma cools, excited atoms and ions emit characteristic spectral lines corresponding to their elemental composition. By analyzing these emission lines, LIBS provides rapid, simultaneous multi-elemental analysis with minimal sample preparation. As an analytical tool it is applicable to solids, liquids, and gases and can be performed in situ or in standoff setting.

Development of Laser-based Accelerators in Pakistan

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ABSTARCT

Since the invention of chirped pulse amplification technique in 1985 by Prof. Gerard Mourou and Prof. Dona Strickland (for which they received 2018 Nobel Prize in Physics) the laser intensities are on the increasing trend. This increasing intensity has surpassed the relativistic barrier of 10^{18}W/cm^2 and enabled scientists to create laser-based accelerators all around the World with Europe's flagship facility ELI-NP and US's Lawrence Livermore National Lab taking the lead. Till date highest reported intensity is $1.1 \times 10^{23}\text{W/cm}^2$ achieved by our collaborators in CoReIs, Institute of Basic Science, South Korea, while highest accelerated electron energy is $>9\text{GeV}$ is reported by the US group centered around LBNL/LLNL.

Methane Pyrolysis for Net-Zero Hydrogen

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ABSTARCT

Methane pyrolysis is emerging as a viable route for net-zero hydrogen production, enabling hydrogen generation without carbon dioxide emissions and producing solid carbon as a by-product. In regions facing severe air quality challenges, such low-emission energy pathways are increasingly important. This plenary talk presents a multiphysicsbased investigation of methane pyrolysis using COMSOL Multiphysics to optimize reactor configurations and catalyst performance. A first-order kinetic model for high-temperature methane decomposition is developed and validated using analytically derived conversion data ($x \approx 0.60$). Six simulation models are examined, including heterogeneous reactors, porous catalyst beds, and microreactor designs. A nature-inspired lotus-leaf catalyst architecture enhances mass transfer and mitigates fouling, resulting in an approximate 5% increase in hydrogen yield. The work highlights how clean hydrogen technologies can contribute to sustainable energy transitions and improved air quality in smog affected regions.

High Throughput In-Silico Screening of Metal-Organic Frameworks for Energy Storage devices: Minimizing Wet Lab Redundancy via AI Prediction based on Electrochemical Characterizations of MOFs.

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ABSTARCT

The synthesis and testing of Metal-Organic Frameworks (MOFs) is time and cost consuming that restricts the progress of further energy storage systems. The traditional wet-labor characterization could be often related to low experimental yields due to the complexity of the interaction between material chemistry and electrochemical conditions. The provided work is a prediction along the lines of informatics, which ought to be considered an insilico gatekeeper, which evaluates the work of MOF before committing it to a laboratory. It is based on the fact that a neural network is used in respect to specific structural and experimental characteristics being utilized (central metal, valency, organic ligand, cell assembly, electrode substrates). The model is predictive of the high fidelity electrochemical fingerprints including: (1) the Galvanostatic Charge-Discharge (GCD) profiles at a current density and rate capability trends and (2) Electrochemical Impedance Spectroscopy (EIS) of the Nyquist plot of the internal resistance. This equipment is able to detect the influence of electrode boost and coordination environments that provide a realistic value of specific capacity. This framework can significantly reduce the trial and error synthesis to discover next generation energy storage materials since it allows the researchers to visualize the performance and sieve high probability material by an interface created on Streamlit.

Photocatalytic Degradation of Wastewater Dye Using Cobalt-Doped Tin Oxide Nanoparticles

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ABSTARCT

The efficient removal of toxic dyes from industrial wastewater remains a critical environmental challenge. This study reports the synthesis of cobalt-doped tin oxide nanoparticles ($\text{Co}_x\text{Sn}_{1-x}\text{O}_{2-\delta}$, $x = 0-7\%$) as highly effective solar-driven photocatalysts for wastewater dye degradation. The nanoparticles were prepared via a simple coprecipitation method and exhibited a stable tetragonal crystal structure with reduced crystallite size and induced lattice strain upon cobalt incorporation. Cobalt doping significantly narrowed the optical bandgap from 3.64 eV to 3.04 eV, enabling enhanced visible-light absorption and suppressed electron-hole recombination. As a result, the optimized 7% Co-doped SnO_2 nanoparticles achieved 75% degradation of methylene blue dye under natural sunlight within 150 minutes. The enhanced photocatalytic performance is attributed to improved charge carrier dynamics and increased surface reactivity. These findings highlight cobalt-doped SnO_2 nanoparticles as a low-cost, sunlight-activated, and scalable solution for efficient wastewater dye treatment.

Synthesis and Characterization of mixed metal oxide cathode materials for Sodium-ion Batteries.

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ABSTARCT

In this project mixed metal oxide cathode material with general formula $\text{Na}_{0.67}\text{Fe}_{0.5}\text{Mn}_{0.5-x}\text{M}_x\text{O}_2$ ($\text{M}=\text{Cu, Cr}$ and $x=0.1, 0.3$) have been successfully synthesized using co-precipitation method. The structural, morphological, and electrochemical properties have been studied using XRD, SEM, CV and GCD respectively. XRD analysis confirmed the formation of P2- hexagonal structure which belong to space group P63/mmc. When the material was doped, the lattice parameters a and b decrease while the c parameter increased, this expansion in c-axis lead to more easy diffusion of Na^+ ions in the cathode electrode. Morphological analysis revealed the formation of layered material with doping concentration. Electrochemical analysis exhibited excellent specific capacity of 235.46mAh/g at scan rate of 10, along with high diffusion coefficient of 2.55×10^{-9} (cm^2s^{-1}). The initial discharge capacity of NFM-Cu0.3, is 215.82mAh/g at 0.45C, with a coulombic efficiency of 82.41%. After 30 cycles the discharge capacity decreased to 192mAh/g, with the capacity retention of 88.96%. The results showed that Copper doped NFM exhibited improved rate capabilities and is excellent cathode material for sodium ion batteries.

Comparative Optical Performance of Transition and Post Transition Metal Doped ZnO Nanostructures

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ABSTARCT

Zinc oxide (ZnO) is a wide band-gap semiconductor widely investigated for optoelectronic and anti-reflection coating applications due to its high transparency and tunable optical properties. In this work, a comparative study of the optical performance of pure ZnO and metal-doped ZnO nanostructures was conducted using the sol-gel method. A systematic comparison was performed between post-transition metal-doped ZnO (Al and In) and transition metal-doped ZnO (Co and Mn). UV-Vis analysis revealed that pure ZnO exhibits a wide band gap (~3.2 eV) with strong transparency in the visible region. Post-transition metal doping resulted in slight band-gap widening and a blue shift of the absorption edge, indicating enhanced optical transparency. In contrast, transition metal doping led to band-gap narrowing and a red shift, attributed to defect-induced electronic states. The findings demonstrate that post-transition metal-doped ZnO exhibits superior optical performance compared to transition metal-doped ZnO. This study contributes to the advancement of efficient optical materials for solar energy systems, supporting Sustainable Development Goal 7 (Affordable and Clean Energy) and Sustainable Development Goal 9 (Industry, Innovation and Infrastructure).

Temperature-Dependent Variation in Structural Defects of Metal Doped TiO₂ for Photovoltaics

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ABSTARCT

The rapid increase in severity of energy crisis stimulates speedy development of photovoltaics. TiO₂ nanoparticles have great potential to extract energy from energy sources as there are ultimate uses of TiO₂ nanoparticles in photoanodes of DSSCs. In addition to abundance, accessible synthesis, low-cost and good stability of TiO₂ also show complementary advantages. We have studied the tailoring of structural defects in silver doped TiO₂ as a function of calcination temperature. For this purpose, TiO₂ was doped by silver via sol-gel method by using titanium butoxide and silver nitrate (AgNO₃) as precursors and then calcination was done at three different temperatures; 400°C, 600°C and 1000°C. The XRD pattern revealed the amorphous nature of AgTiO₂ at 400°C and mixed phase (anatase and rutile) at 600°C and 1000°C. The crystallite size of anatase and rutile had increased and decreased by the increase in calcination temperature from 600°C to 1000°C, respectively. The functional groups of Ti-O bond and transitional metal carbonyl that is -CO-Ag linkage was inspected by Fourier transform infrared spectroscopy (FTIR). Photoluminescence emission spectra revealed the temperature dependent variations in deep level emissions (DLE) with the presence of donors as dominating defects (oxygen vacancy defects) due to which n-type semi-conductivity is created in AgTiO₂. The PL intensity of oxygen vacancy defects was increased by increasing calcination from 600°C to 1000°C. The band gap of AgTiO₂ was 3.78eV and 3.72eV at 600°C, respectively and it is decreased by the increase in calcination temperature due to red shift. The decrease in band gap can improve the light absorption of AgTiO₂ into visible region. Hence, the optical properties and structural defects of AgTiO₂ can be enhanced

by increase in calcination temperature, further which can enhance the performance and efficiency of photovoltaics.

Nanostructures at the Frontier of Nanophysics: From Fundamental Phenomena to Advanced Applications

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ABSTARCT

Recent advances in nanophysics have enabled the controlled design and functionalization of low-dimensional nanostructures with tailored physical properties, opening new pathways for both fundamental studies and technological applications. This invited talk presents an integrated overview of nanostructure synthesis, characterization, and application, highlighting recent progress in nanowires, nanotubes, nanoparticles, and thin films fabricated through electrochemical, laser-based, and template-assisted techniques. Emphasis is placed on understanding structure–property relationships at the nanoscale using advanced characterization tools, including atomic force microscopy, electron microscopy, X-ray diffraction, and spectroscopic techniques. The talk discusses how nanoscale geometry, composition, and processing conditions influence physical behavior, enabling tunability for specific functionalities. Selected examples are presented to demonstrate the versatility of engineered nanostructures in applied domains such as biomedical applications, antibacterial activity, sensing platforms, energy devices, and nano-enabled functional coatings. The transition from early stage synthesis to application oriented research is highlighted through collaborative and interdisciplinary efforts spanning multiple research environments. The talk concludes with emerging directions and future challenges in nanophysics, focusing on scalable fabrication, multifunctional integration, and the role of nanostructures in next-generation technologies. This overview aims to provide insight into current trends while outlining opportunities for innovation at the interface of fundamental physics and applied nanotechnology.

Role Of Nanoparticle in Improving Solar Cell Efficiency

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ABSTARCT

The rapid growth in global energy demand has intensified the need for high-efficiency and cost-effective solar energy technologies. Conventional solar cells are limited by optical losses, charge carrier recombination, and inefficient light absorption. In recent years, nanoparticles have emerged as a promising approach to overcome these limitations due to their unique optical, electrical, and surface properties at the nanoscale. This work highlights the role of nanoparticles in enhancing solar cell efficiency through improved light harvesting, charge transport, and interface engineering. Metal nanoparticles such as gold and silver enhance light absorption via surface plasmon resonance, while semiconductor nanoparticles including ZnO and TiO₂ improve electron

transport and reduce recombination losses. Quantum dots enable bandgap tuning and broaden spectral absorption, whereas carbon-based nanomaterials such as graphene enhance electrical conductivity and device stability. The incorporation of nanoparticles in silicon, perovskite, dye-sensitized, and organic solar cells has demonstrated significant improvements in power conversion efficiency and operational stability. Overall, nanoparticle-assisted solar cells represent a promising pathway toward next-generation photovoltaic devices. Continued optimization of nanoparticle size, concentration, and distribution, along with scalable fabrication techniques, will be essential for future commercial applications.

Synthesis and characterization of Praseodymium substituted NiCuO₃ perovskites for supercapacitor applications

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ABSTARCT

In this novel work the praseodymium doped NiCuO₃ based perovskites with general formula Pr_xNi_(1-x)CuO₃ where x = 0.0, 0.01, 0.02, 0.03, 0.04, 0.05 have been synthesized using hydrothermal method. The samples kept in autoclave at 200°C for eighteen hours. The fine homogeneously distributed nanoparticles have been obtained. The structural, morphological, vibrational phonon modes, optical properties and particle size distribution have been investigated using XRD, SEM, Raman and UV visible spectroscopy and nano-zetasizer respectively. The XRD analysis confirms the formation of cubic structure. The formation of well define nano-particles are confirmed from SEM. The bandgap energy increases with increasing Pr⁺³ concentration from 230-3000(nm). The electrochemical analysis shows the best performance for supercapacitors applications due to the incorporation of rare earth Pr⁺³ material which is responsible for introducing more changes in active site.

Micro plasma induced surface processing of metallic alloys for the enhancement of field emission properties

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ABSTARCT

Functionalizing materials surfaces render them more beneficial due to their desirably altered properties. In this regard, various techniques such as laser ablation, ion and plasma-based processing have been intensively reported. Among the plasma-based sources, microplasma has emerged as a useful irradiation source for surface structural, morphological and compositional modifications of the materials due to its unique features such as robustness, operation at high pressure and non-equilibrium chemistry. The present work unveils the potential of micro plasma irradiation induced surface modification of metallic alloys to modify their surfaces for enhanced Field Emission (FE) properties. Ar microplasma irradiation of Brass and Mg alloy has been investigated as a function of treatment time. Optical profilometry analysis has been used to estimate the variation in diameter and depth of irradiated crater. Growth of various kinds of surface

structures such as microscale holes, blisters and micro bumps have been observed using SEM analysis X-Ray Diffraction (XRD) analysis reveals absence of new compositional phase however, variation in peak intensities, crystallite size, dislocation line density, and stress/ strain is observed. The potential of microplasma treated brass to be used as field emission cathode is evident from significantly improved field emission parameters. The correlation of field emission parameters with the structural density, work function and electrical conductivity measurements suggests geometrical field enhancement, increased number of emission sites and enhanced charge transport properties offered by the grown structures

Green Synthesis of ZnO nanoparticles using Nigella sativa seed extract for antibacterial activities

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Department of physics, LCWU, Lahore

ABSTARCT

This Research work presents zinc oxide nanoparticles (NPs) synthesized using Nigella sativa seeds extract, which is an improbable plant with a rich history and religious value. The prepared nanoparticles were characterized by X-ray diffraction (XRD), UV visible spectroscopy, Fourier transform infrared spectroscopy, scanning electron microscopy, and dielectric and antibacterial analysis. The XRD pattern confirms the hexagonal structure and crystallite size increase as the concentration of zinc sulfate increases. UV analysis shows that the absorbance edge lies between 364 and 376 nm, and the band gap increases with an increase in the concentration of zinc sulfate. The active functional group at 432 cm for the Zn-O bond was analyzed through FTIR. Spherical and irregular pore shapes were observed through the SEM analysis. According to the dielectric experiments, the conductivity of the nanoparticles dropped with frequency, while the dielectric constant and dielectric loss increased. The dielectric experiments showed that the ZnO nanoparticles have a much-improved dielectric response, particularly for the high-frequency band. Due to a significant number of oxygen vacancies in the prepared nanoparticles, both rotation direction polarization (RDP) and space charge polarization (SCP), the dielectric characteristics of ZnO nanoparticles, have improved in the frequency range from 20 Hz to 2 MHz The high-valued inhibitory zone confirms the substance's potent antibacterial action.

Theoretical Insights and Experimental Validation: Magnesium Substituted Strontium Oxide Thin Films for Optoelectronics

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ABSTARCT

Strontium oxide and magnesium-doped compositions were analyzed using density functional theory to explore their electronic, thermoelectric, and optical properties. Magnesium-doped SrO thin films with various concentrations were experimentally prepared on silicon substrates

using the sol-gel spin-coating technique. Structural analyses confirmed the stable single-phase cubic crystalline structure, unaffected by doping. Electronic studies revealed a reduced band gap and the formation of states near the Fermi level, improving charge carrier transport. The thermoelectric evaluation indicated enhanced electrical conductivity that observed for pure SrO as $4.42 \times 10^{19} (\Omega \text{ m s})^{-1}$, whereas $9.43 \times 10^{19} (\Omega \text{ m s})^{-1}$ for maximum Mg containing composition. The lowered thermal conductivity is contributing to superior thermoelectric performance. Optical analyses demonstrated improved absorption and reduced optical band gap, affirming enhanced light interaction capabilities. The highest refractive index and real epsilon values were recorded at the higher energy regimes approximately 2.94 and 12.89, respectively, for composition containing maximum dopant content. The optical band gap of SrO was calculated as 2.50 eV and found to decrease with increment of Mg substituting concentration. Experimental results showed strong alignment with theoretical predictions, underscoring the potential of Mg-doped SrO thin films as promising candidates for advanced optoelectronic and thermoelectric applications.

Quantum Cheshire Cat in Atomic Media

Mehwish Nawaz, Rameez ul Islam, Tasawar Abbas, Manzoor Ikram

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ABSTARCT

Quantum Cheshire Cat is a phenomenon where the two physical entities from an object can be separated under certain conditions, for example a cat and its grin can be separated in an interferometric setup. The idea was proposed using photons and its polarization states as cat and its grin, respectively. We suggest an idea to implement the Quantum Cheshire Cat in atomic media. The proposal is based on the time-tested tools of the Bragg regime atom interferometry and can be easily executed under the prevailing cavity quantum electrodynamics (QED) research environment. Our analysis, based on weak measurements, clearly demonstrates that under certain specific pre- and post-selected scenarios, the atom strangely behaves as being in one arm of the interferometer whereas the signatures of its energy levels exist in the other arm simultaneously.

Role of Zn in Tin Oxide-Based Nanoparticles: Investigation of their Physical and Electrochemical Properties for Super-capacitor Application

Fakhra Shahzadi, Prof. Dr. Safia Anjum

Department of Physics, LCWU, Lahore

ABSTARCT

The zinc doped tin oxide nanoparticles with general formula $\text{Zn}_x\text{Sn}_{1-x}\text{O}$ at ($x=0.00, 0.01, 0.03, 0.05, \text{ and } 0.07$) have been prepared by simple and cost effective co-precipitation route. The synthesized nanoparticles have been characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), UV Visible spectroscopy, Fourier transform infrared spectroscopy (FTIR), Cyclic Voltammetry (CV) and Galvanostatic Charge Discharge (GCD) for their structural, surface morphological, optical and electrochemical analysis. The tetragonal rutile structure of the prepared nanoparticles is confirmed by the XRD analysis. The Rietveld refinement have been used to refine

the XRD data and it confirms the tetragonal rutile structure having phase group of P42/mnm of the synthesized material. The dielectric analysis shows that, by increasing the dopant concentration the conductivity increases and there is decrement in the tan loss. From the electrochemical analysis, it have been observed that the capacitance increased by increasing the dopant concentration. So, the synthesized materials are efficient for the energy storage applications such as supercapacitor.

Solvent Polarity Effects on Bioactive Extraction from Biowaste: An FTIR-Based Physicochemical Analysis.

Mamoona

Department of Environmental sciences, LCWU, Lahore

ABSTARCT

Effective management of global biowaste is imperative because conventional methods like landfilling aggravate environmental challenges. In developing countries like Pakistan, such practices are the cause of economic and social problems. The current study investigated the antioxidant properties of extracts obtained from 6 stale vegetables using Soxhlet and maceration techniques after pre-processing of samples, using different polarity solvents. Significant variations in extraction yields and phytochemical composition were observed among different solvents and plant materials. Both Soxhlet and maceration extracts exhibited diverse phytochemical profiles and antioxidant activities, as determined by total phenolic content with *Coriandrum sativum* 20.177 (via Soxhlet extraction) and *Brassica oleracea* var. capitata 72.788 (via Maceration), and DPPH assays showed maximum percentage inhibition of *Brassica oleracea* var. capitata 99.2 (via Soxhlet extraction) and 98.9 (via Maceration). Generally, extracts with ethyl acetate showed maximum extraction of phenolics and antioxidant activity. Statistical analysis revealed a significant positive correlation between total phenolics and antioxidant potential for maceration extracts at the 0.01 level which is < 0.05 . Fourier transform infrared (FTIR) spectroscopy identified numerous functional groups responsible for the detected antioxidant potential. These findings highlight the potential of seasonal vegetables as a rich source of polyphenols, with implications for fighting reactive oxidative stress and their valorization that offers sustainable solutions, aiding both environmental conservation and economic viability.

Probe of Carbon Quantum Dots Synthesized by Microemulsion Route

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ABSTARCT

Ce doped CQDs were developed by using microemulsion technique by varying Ce percentages (1–5 wt.%). X-ray diffraction (XRD) confirmed cubic phase of CQDs. The optical band gap of CQDs decreased with increase in Ce doping. The 5 wt.% Ce doped CQDs turned out to be optimal electrode material for pseudocapacitors. With the increase of Ce doping, the photocatalytic activity and antibacterial activity increased. Ce-doped CQDs can be useful environmental and waste water treatment by purifying environment, degrading contaminations and killing bacteria.

Keywords: Ce; CQDs; photocatalysis; waste water treatment.

Deposition and characterization of Ternary Nanocomposites

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ABSTARCT

InGaZnO was deposited on glass substrate by sol-gel dip coating method. Films were polycrystalline. The SEM showed different grain sizes. These ternary nanocomposites were advantageous for transparent devices and sensors. The magnetic properties confirmed that IGZO has a higher saturation magnetization and low coercivity suitable for spintronics and high-frequency devices.

Keywords: Nanostructures; IGZO; polycrystalline; spintronics.

Er-Doped TiO₂ Photo catalysts with High Optical Transparency

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ABSTARCT

Er-doped TiO₂ thin films (1–5 wt%) were synthesized using the sol–gel dip-coating technique. X-ray diffraction revealed a reduction in crystallite size with increasing Er concentration. UV–visible analysis showed enhanced transparency and a blue shift in the absorption edge, with the optical band gap. Photoluminescence studies indicated suppressed electron–hole recombination, resulting in enhanced visible-light-driven photocatalytic degradation, particularly for the 5 wt% Er-doped sample. Ferromagnetism attributed to Er³⁺ incorporation and defect-mediated interactions. The multifunctional Er-doped TiO₂ thin films may be significant for optoelectronics and photocatalysis.

Keywords: Erbium; titania; optical properties; band gap.

Investigation of Zinc Doped Cobalt Oxide ($Zn_xCo_{1-x}O$) for Supercapacitor Applications

Tahreem Tayyab, Prof. Dr. Safia Anjum

Department of Physics, Lahore college for women University

ABSTARCT

Zn doped cobalt oxide with chemical formula $Zn_xCo_{1-x}O$ having Composition ($x= 0, 0.01, 0.03, 0.05, 0.07$) have been synthesized using Co-precipitation method. The Structure, Morphology, composition, optical properties and electrochemical analysis have been analyzed by X-ray Diffraction (XRD), Scanning electron Microscope (SEM), Fourier transformation infrared Spectroscopy (FTIR) , UV-Visible spectroscopy, Cyclic Voltammetry (CV) and Galvanostatic Charging- Discharging (GCD) techniques. XRD analysis showed the formation of single Cubic Structure of Zn doped Cobalt oxide with crystallite size of 14nm for pure Cobalt oxide and 19nm for 7% zinc-cobalt oxide. Morphological analysis revealed the small needle like spheres. Ftir confirmed the stretching band in range of 500 to 600cm^{-1} might be due to the stretching vibration of metal and oxygen (Co-O). The band gap energy decreases with increase in zinc content. The electrochemical analysis revealed that $Zn_{0.03}Co_{0.97}O$ exhibited the highest specific capacitance value of 636 F/g at 5mVs^{-1} in 0.6M electrolyte solution of KOH. Hence the fabricated Zinc doped cobalt oxide electrodes used as a favourable candidate for supercapacitor and other energy storage devices.

Role of AI in Physics

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ABSTARCT

Artificial Intelligence (AI) has emerged as a powerful tool in physical sciences for managing and analyzing large volumes of data generated from simulations, experiments, and observational systems. This talk highlights the transformative role of AI in accelerating scientific research through pattern recognition, predictive modeling, and automated data analysis. Key applications in materials science, energy and environmental studies, medical physics, and astrophysics are discussed, demonstrating how AI supports the discovery of novel materials, optimization of energy systems, and improved analysis of complex physical phenomena.

The presentation also explores the integration of AI with experimental physics, including the development of smart laboratories and autonomous research processes. It emphasizes the importance of interdisciplinary collaboration and essential skills required for future scientists, while addressing challenges related to model reliability, transparency, and ethical considerations. The talk concludes with a future perspective on AI-assisted research environments that enhance scientific discovery and technological advancement.

Epitaxial Growth of Wide Band Gap GaN-Based DMS Semiconductor for Spintronics

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ABSTARCT

Dilute magnetic semiconductors (DMS) based on wide band gap materials have attracted significant attention for their potential applications in spintronic devices due to their ability to utilize both charge and spin of electrons. This study presents the epitaxial growth of Gallium Nitride (GaN)-based DMS semiconductors, focusing on their structural, magnetic, and electronic properties for spintronic applications. The incorporation of magnetic dopants into GaN aims to achieve room-temperature ferromagnetism while maintaining desirable optical and electrical characteristics of the host semiconductor. Advanced epitaxial growth techniques are employed to ensure high crystalline quality, controlled dopant incorporation, and improved material performance. The research investigates the influence of growth parameters on the structural integrity, magnetic behavior, and carrier transport properties of GaN-based DMS materials. Characterization techniques are used to evaluate crystal structure, surface morphology, and magnetic ordering, highlighting their suitability for spin-based electronic devices. The results demonstrate the potential of GaN-based DMS semiconductors for next-generation spintronic technologies, offering enhanced efficiency, high thermal stability, and improved device functionality. This work contributes to the ongoing development of advanced semiconductor materials for future information processing and quantum technologies.

Halogen Free Energy Storage Devices, e.g., Supercapacitors and batteries

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University Degli Studi Di Salero, Italy

ABSTARCT

The increasing demand for sustainable energy solutions has driven research into innovative energy storage technologies. Halogen-based energy storage devices, including supercapacitors and batteries, have emerged as promising candidates due to their high energy density, power density, and environmental compatibility. This review provides an overview of recent advancements in halogen-based supercapacitors and batteries, focusing on materials, design strategies, and performance metrics. Key developments, challenges, and future directions are discussed, highlighting the potential of these technologies for applications in renewable energy systems, electric vehicles, and portable electronics

Laser induced breakdown spectroscopy of teeth of diabetic patients.

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Abstract:

The present work evaluated the effect of diabetes on the elemental composition of human dental tissues, which consist of enamel, coronal dentine, and cementum. The one-line calibration-free Laser-induced Breakdown Spectroscopy (OL-CFLIBS) approach was used for compositional analysis of three tissues, which were validated with Energy-dispersive X-ray Spectroscopy (EDS). LIBS parameters, plasma temperature and electron number density, were used in OL-CFLIBS. LIBS on diabetic patients' dental tissues yields higher values of plasma parameters (electron number density and plasma frequency) relative to healthy participants. The diabetic tissues exhibited lower concentrations of Zn, Sr, Si, and K, but higher concentrations of Fe and Sn, which is correlated with diabetes. LIBS quantitative findings agreed with EDS for elements (Ca, P, Na) within a relative error of 5%. Clinically, Laser-induced Breakdown Spectroscopy (LIBS) can serve as a diagnostic and preventive tool in dentistry for monitoring trace element content, allowing early intervention and reducing the risk of dental treatment failures in diabetic patients

Key words: LIBS, dental tissues, plasma parameters, elemental detection, EDX.

Voltage-Tunable Atmospheric-Pressure Microplasma: A Versatile Platform for Luminescent Nanodiamond Synthesis

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ABSTRACT

This research aims to investigate the influence of atmospheric pressure Microplasma (APM) voltage on the optical properties of NDs. The APM has dissociated the mixture of ethanol and Argon. The applied voltage varied from 2.5-4.5 kV. SAED (selected area electron diffraction) confirmed the Lonsdaleite structure. NDs (~3nm) were synthesized at an applied voltage of 3.0 kV. Raman analysis confirmed that increased applied voltage enhanced the t-PA (trans-polyacetylene) band with a decrease in the diamond band. FTIR (Fourier Transform Infrared Spectrophotometer) indicated the presence of oxygen-containing functional groups responsible for multiband emissions on the surface of NDs. UV-visible spectra verified absorption from oxygen functional groups. PL (photoluminescence) emission spectra exhibited violet (446 nm), blue (~469 nm), cyan (495 nm), and green (519 nm) emission from surface states. The luminescent NDs offered emerging applications in optoelectronic devices, bioimaging, biosensing, photosensitizers, drug testing, quantum computing, and magnetic sensing.

Keywords: Nanodiamonds; Atmospheric pressure Microplasma; Photoluminescence; surface defects; optoelectronic devices.

The Physicochemical Optimization of Carotenoid Extraction from Agro-Byproducts using Box Behnken

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ABSTARCT

In this study, green extraction (Ultrasonic) and conventional (Soxhlet) extraction methods, utilizing a Box-Behnken design, were optimized to valorize pomegranate (*Punica granatum*) and tomato (*Solanum lycopersicum*) peels. The effectiveness of the extracts was evaluated based on their antioxidant activity using the DPPH (2,2-diphenyl-1-picrylhydrazyl) method. β -carotenoids were characterized using Fourier Transform Infrared Spectroscopy (FTIR) and Liquid Chromatography-Mass Spectrometry (LC-MS/MS). The high amount of extractives highlighted the presence of carotenoids and other phenolic compounds, making pomegranates (*Punica granatum*) and tomatoes (*Solanum lycopersicum*) peels valuable sources of antioxidants. The optimal yield in Soxhlet extraction for tomato peels was 11,616.1 $\mu\text{g/g}$ with 91.6% inhibition at 70 °C for 360 min, while for pomegranate peels it was 11,565.4 $\mu\text{g/g}$ with 93.0% inhibition at 70 °C for 360 min. For ultrasonic-assisted extraction, the optimized yield for pomegranate peels was 14,469.5 $\mu\text{g/g}$ with 99.4% inhibition at 70 °C for 20 min, and for tomato peels it was 13,962.5 $\mu\text{g/g}$ with 93.2% inhibition at 70 °C for 20 min. The highest yield was achieved through ultrasonic-assisted extraction using pomegranate peels. Temperature and solvent ratio were key factors influencing yield. Pearson correlation and ANOVA were performed to assess the effect of the extraction techniques and sample types on radical scavenging activity. The current study demonstrates the simultaneous profiling of β -carotenoid, punicalagin, lutein, and ellagitannin from pomegranate and tomato peels using ultrasonic-assisted extraction coupled with LC-MS/MS, which has not been reported before to the best of our knowledge. This research offers an economically viable strategy for food waste valorization and promotes the sustainable use of pomegranate and tomato peels to attain value-added compounds for food, pharmaceuticals, or other industries.

POSTER PRESENTATION

Synthesis, Characterization and Photocatalytic Activity of $Mg_{1-x}Cu_xO$ Nanoparticles for Wastewater Treatment

Mahrukh Imran, Shafaq Arif

Department of Physics, Lahore College for Women University, Lahore

ABSTARCT

We synthesized $Mg_{1-x}Cu_xO$ ($x = 0, 2\%, 4\%, 6\%$, and 8%) nanoparticles by the coprecipitation method. X-ray diffraction (XRD), Fourier Transform Infrared (FTIR), UV-visible spectroscopy (UV-Visible), scanning electron microscopy (SEM), and photocatalytic studies were carried out to analyze the prepared nanoparticles. The XRD results confirmed the cubic structure of $Mg_{1-x}Cu_xO$ nanoparticles. Moreover, crystallite size, dislocation density, and microstrain were investigated using the Debye-Scherrer method. The UV-visible studies revealed a reduction in optical band gap energy from 5.34 eV to 3.74 eV . The SEM micrographs showed uniformly dispersed spherical nanoparticles with an average diameter of 54.25 nm , increasing with Cu concentration up to 8% . The photocatalytic studies indicated that an 8% Cu dopant concentration reduced the absorption intensity of methylene blue (MB) dye to 31% of its original intensity under sunlight exposure for 120 minutes. Hence, Cu-doped MgO nanoparticles can be used as photocatalysts in industrial applications for water treatment.

Development of Zeolites for Oxygen Concentrators

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ABSTARCT

During the 2019 Corona pandemic, the world faced a severe oxygen supply crisis, and many people lost their lives due to this shortage, especially in developing countries where oxygen production and storage infrastructure was limited. On-site oxygen production offers a practical solution, where zeolites act as molecular sieves, separating O_2 from air. Zeolites are a class of microporous crystalline aluminosilicates composed of corner-sharing three-dimensional $[SiO_4]^{4-}$ and $[AlO_4]^{5-}$ tetrahedra containing various cavities and channels. In Pakistan, reliance on imported zeolites remains high. To address this dependency, this work focuses on the local synthesis of zeolites at the laboratory scale using a hydrothermal synthesis route. Both high-silica and low-silica zeolites were synthesized, and Li^+ ion exchange was performed to improve their adsorption capacity. The Faujasite phase was confirmed by XRD analysis, matching with the commercial zeolite phase.

Development of Eco-friendly Anti-corrosive Epoxy Based Coatings Reinforced with GO coated Chitosan nanoparticles

Shanza Bibi, Dr Ibtisam Riaz

Department of Physics, University of Engineering and Technology, Lahore.

ABSTARCT

Corrosion is a life-threatening industrial problem that causes significant economic losses, safety concerns, and, more importantly, issues in various industrial sectors like construction, chemical processing, and marine engineering. Our research focuses on the production of anticorrosive nanocomposite coatings based on epoxy resin reinforced with graphene oxide (GO) nanoparticles and chitosan nanoparticles (CNPs) to provide protection against corrosion. Epoxy resin was chosen as a primary matrix due to its superior mechanical properties and resistance to chemicals. Graphene oxide (GO) and Chitosan (CH NPs) were selected as nanofillers. Chitosan was chosen based on its biocompatibility and adhesive features, whereas Graphene oxide (GO) was chosen as a barrier enhancer. In this work, GO was prepared through the Modified Hummers' method, and CH NPs through Green Synthesis techniques. The CH/GO nanocomposite was prepared with varying concentrations of GO (0.5% and 1%) by the in situ method. These composites were incorporated into Epoxy Resin at 2wt% and then drop-cast onto substrate sheets. Different characterization methods have been used to determine the structure, morphology, and anticorrosive performance of the hybrid coatings: Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM), and Electrochemical Impedance Spectroscopy (EIS). Analysis revealed that the 1 % GO-CH NPs coating had the highest corrosion resistance with a very high value of impedance, poor porosity, and much better surface morphology when compared to the control.

Green hydrogen technologies: Role of Materials for future advancement

Ghulam Mehdi, Sadia Noor

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ABSTARCT

Green hydrogen serves as a vital gateway to sustainable energy and a cleaner future, helping nations reach 2050 decarbonization goals to combat climate change. While electricity alone cannot meet every need, green hydrogen provides a carbon-free fuel for heavy industries like steel and shipping. It also functions as a large-scale storage solution for extra wind and solar power, making energy systems more reliable and self-sufficient. A variety of production methods are available, ranging from biological and thermochemical processes to advanced electrolysis like Proton Exchange Membrane (PEM) and Solid Oxide systems. Among these, Alkaline Water Electrolysis (AWE) is a leading choice for large scale use, particularly in developing nations like Pakistan, due to its durability, cost-effectiveness, and use of affordable catalysts. However, the progress of these technologies depends on solving key material science challenges. High costs for rare metals like iridium and platinum, along with the need for parts that can withstand corrosive environments, currently slow down production. Future growth must focus on "green production", a strategic shift in manufacturing to improve cell design and create durable, low-cost materials. By combining these material innovations with better infrastructure, we can close the gap between research and commercial use, creating a clear path for a global, zero emission energy transition

First Principles study of CsTiO₃ for structural, electronic, mechanical, and optical properties with Zr and In doped for optoelectronic applications

Tehreem Fatima, Dr. Abdul Waheed Anwar, Abid Ali

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ABSTARCT

Using density functional theory (DFT), we investigated the structural, electronic, mechanical, and optical properties of cubic CsTiO₃ doped with Zr and In at concentrations of 0.25% and 0.50%. Calculations were carried out using the CASTEP code with the GGA-PBE and HSE06 hybrid functionals. Doping with Zr and In significantly reduces the band gap of CsTiO₃, enhancing its electrical conductivity and photovoltaic efficiency. A direct band gap is observed for 0.25% In doping, while indirect band gaps are seen in the pristine and higher-doped systems. Structural parameters and the bulk modulus closely match experimental data. Elastic constants confirm the mechanical stability of all compounds. Optical properties, including the dielectric function, absorption, and refractive index, show strong potential for light harvesting. These results indicate that doped CsTiO₃ perovskites are promising candidates for high-efficiency optoelectronic devices.

Screening the doping effect on structural, tuning band, mechanical, dynamical stability, magnetoelectric and optical responses of halide double perovskites Cs₂XInCl₆ (X=Ag, Na) for next-generation spintronic and optoelectronic devices

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University of Engineering and Technology, Lahore

ABSTARCT

This study comprehensively investigates the properties of halide double perovskites Cs₂XInCl₆ (X=Ag, Na) and their doped variants using DFT. In-site doping with 0.25% Fe, Cr, and Co significantly changes the electrical structure, reducing the band gap from 2.93 eV (pure Cs₂NaInCl₆) to as low as 0.73 eV. All compositions have direct band gaps. Thermodynamic stability is confirmed by the formation and Gibbs free energies, the octahedra, and the tolerance factor, supported by phonon spectra showing only positive frequencies. Temperature-dependent entropy, enthalpy, and heat capacity are studied via the quasi-harmonic Debye model, and elastic constants confirm mechanical stability. Spin-polarized DOS shows spin alpha and beta asymmetry, indicating ferromagnetism in doped samples, while optical properties demonstrate strong UV absorption from 0-30 eV. These materials exhibit potential for spintronic and optoelectronic devices due to their durability and stability.

First principles insight on structural, mechanical stability, magnetic, optical and thermoelectric response of Cs₂ZSbX₆ (Z= Cu, Ag and X= Cl, Br, I) double perovskites for advance Optoelectronic applications

Sagheer Ahmad, Dr. Abdul Waheed Anwar, Bushra Sagheer, Abid Ali, Tehreem Fatima

University of Engineering and Technology, Lahore

ABSTARCT

DFT calculations are carried out to investigate the structural, electronic, mechanical, magnetic, optical, and thermoelectric properties of lead-free double perovskites Cs_2ZSbX_6 ($Z = Ag, Cu$; $X = Cl, Br, I$). All compounds crystallize in a stable cubic $Fm\bar{3}m$ structure and satisfy Born mechanical stability criteria. The calculated bandgap ranges from 0.74 to 1.82 eV indicating suitability for optoelectronic devices. DOS reveals strong hybridization between Ag-4d/Cu-3d and Sb-5s orbitals near the Fermi level. Spin polarized calculations indicate dominant spin up states, confirming intrinsic magnetic behaviour. Optical and thermoelectric investigation demonstrate strong absorption, high optical conductivity and promising ZT values highlighting these materials for optoelectronic properties.

Correlation of Characteristics of bone Tumors with MRI and Histopathological findings

Bushra Sagheer, Dr. Anwar Latif, Sagheer Ahmad, Dr. Abdul Waheed Anwar, Dr. Imran Majeed Khan

University of Engineering and Technology, Lahore

ABSTARCT

Bone tumors are a diverse group of neoplasms with high malignancy potential, and this study aimed to evaluate the correlation between bone tumour characteristics, MRI findings, and histopathological results. A retrospective analysis was conducted on 123 patients at AIMC/Jinnah Hospital, Lahore (2018–2023), using clinical data and imaging modalities including X-ray, CT, MRI, ultrasound, bone scan, and biopsy. Diagnostic accuracy, sensitivity, specificity, and statistical significance were assessed. Histologically, 36.6% cases were primary and 63.4% were secondary bone tumors. MRI showed the highest diagnostic performance with 66.1% sensitivity, 47.3% specificity, and 61.1% diagnostic accuracy compared to other techniques. The findings indicate a strong correlation between MRI and histopathological results, supporting MRI as a primary imaging tool for suspected bone tumors.

Optimization of FeCrB Wear Resistant Coatings

Shehzad Hussain, Muhammad Ismail Ayyan, Saba Sajid, Hafiz Kabeer Raza, Abbas Saeed Hakeem, Muhammad Asif Hussain

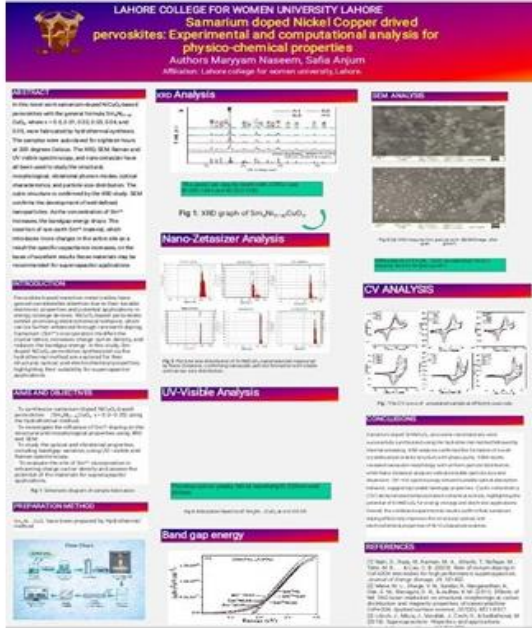
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ABSTARCT

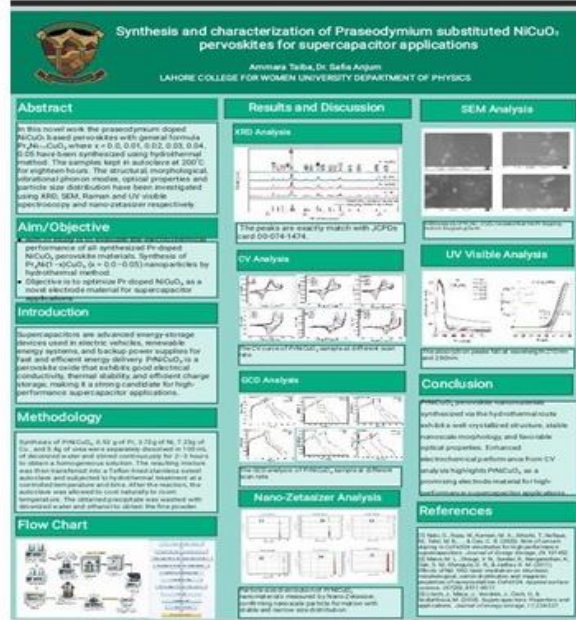
Wire arc spray coatings are crucial for enhancing wear resistance by forming a durable protective layer on surfaces thereby extending the lifespan of different equipment parts. In this work, friction and behavior of wire arc sprayed Iron chromium boron (FeCrB) coatings were studied. The coatings were deposited on mild steel substrates at variable primary pressure, auxiliary pressure, and arc current. The porosity within the coatings was qualitatively and quantitatively evaluated by optical microscopy following by ImageJ analysis. The coatings were also tested for Vickers Hardness. The wear behavior of the coatings was studied in detail by sliding wear tests following ASTM G99 using a ball on disc tribometer with a wear track of 6mm and observed by profilometer. The results showed that higher primary gas pressure improved particle velocity, resulting in denser coatings with lower porosity, high hardness and low wear rate, while lower auxiliary pressure

caused uneven deposition. Moreover, high current led to oxidation and increased porosity. The results of tribometer and profilometer were very well correlated.

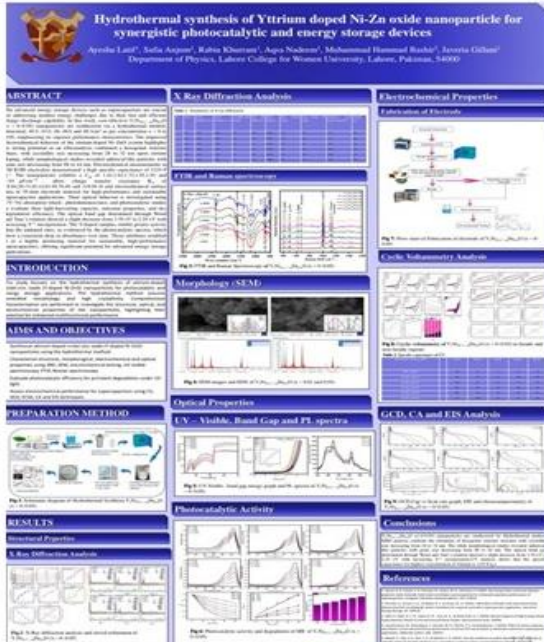
Samarium doped Nickel copper driven perovskites: Experimental and computational analysis physico-chemical properties
 Maryyam Naseem
 Lahore college for women university



Synthesis and characterization of Praseodymium substituted NiCuO₃ perovskites for supercapacitor applications
 Ammara Taiba
 Lahore college for women university



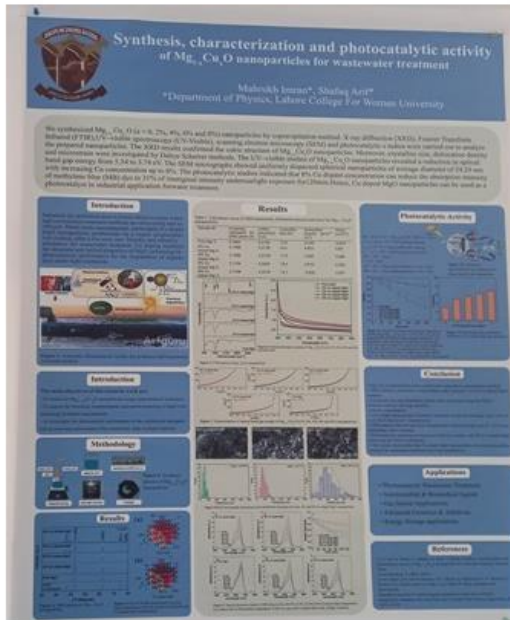
Hydrothermal synthesis of Yttrium doped Ni-Zn oxide nanoparticle for synergistic photocatalytic and energy storage devices
 Ayesha Latif
 Lahore college for women university



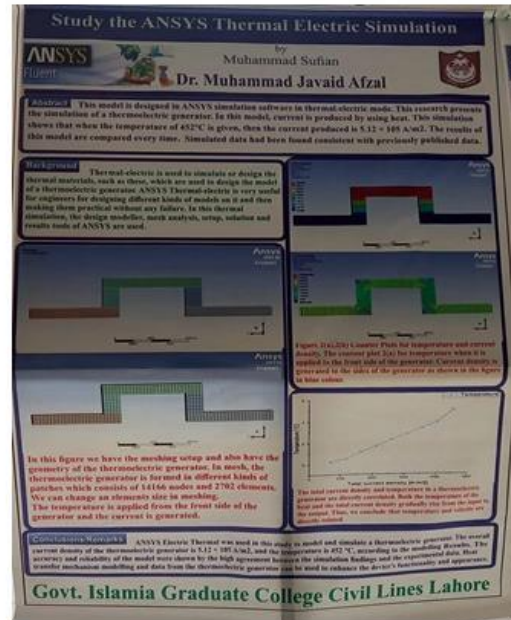
Experimental and theoretical investigation of Gadolinium substituted nickel ferrites for energy storage applications
 Fatima Khalid
 Lahore college for women university



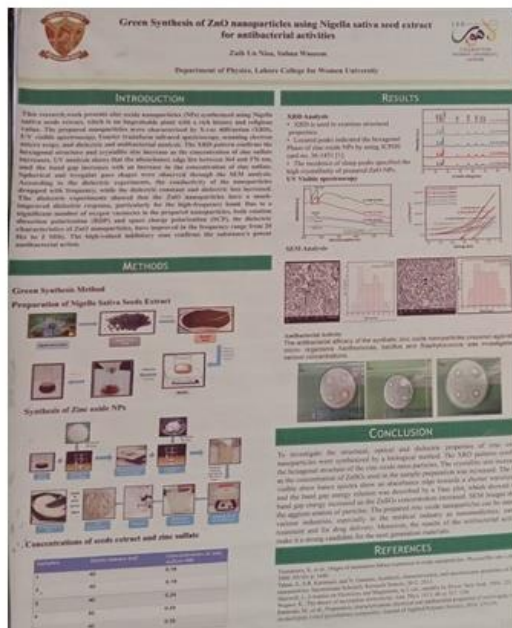
Synthesis characterization and photocatalytic of Mg₂-Cu₂O nanoparticle for wastewater treatment
 Mahrukh Imran, Shafiq Arif
 Lahore college for women university



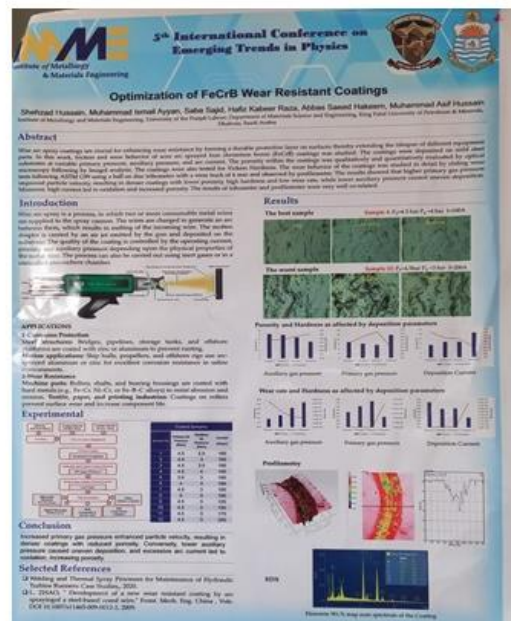
Study the ANSYS Thermal Electric Simulation to analyse the thermoelectric Generator Operations: Generating Current through Heat Absorption
 Muhammad Sufian
 Govt. Islamia graduate college civil line



Green synthesis of ZnO nanoparticles using Nigella sativa seed extract for antibacterial activities
 Zaib ul Nisa
 Lahore college for women university



Optimization of FeCrB wear resistant coating
 Shehzad Hussain, Mr. Muhammad Ismail Ayyar, Ms. Saba Sajid, Abbas Saeed Hakeem, M. Asif Hussain
 University of Punjab



Investigation of InGaZnO nanocomposites for advanced materials
 Zainab Bashir, Aska Nadeem
 Lahore college for women university

Low cost synthesis of MXene Based Bi₂O₃/PPy ternary composites for energy storage applications
 Kashmina Javaid, Iqra Fatima
 Lahore college for women university

Investigation of InGaZnO Nanocomposites for Advanced Materials
 Supervisor: Prof. Dr. Zahra Nasir Kayani, Author: Zainab Bashir, Presented by: Aska Nadeem

Novelty: "This study reports the first-ever investigation of the magnetic properties and detailed dielectric impedance analysis of Sol-gel derived IGZO and IGO nanocomposite thin films."
Objective: "The primary goal is to synthesize cost-effective, high-performance InGaZnO thin films for next-generation optoelectronic, sensing, and spintronic applications."
Experimental Methodology: "The process involves precursor selection, sol-gel synthesis, and dip coating, concluding with annealing at 500°C to achieve high crystallinity and stability."

Results Grid

XRD Analysis

Nanocrystalline XRD Validation
 Successful phase identification of In₂O₃ (25-43 nm) and IGZO (30-38 nm) confirms high-quality, impurity-free nanostructures.

Optical Properties

High Transparency & Bandgap Engineering
 > 60% High Transparency; Films exhibit > 60% transparency
 Direct Bandgap (E_g): Tuned between 3.42 eV and 3.43 eV.

SEM Morphology

Dense Surface Morphology
 SEM analysis reveals uniform surface coverage with porous nanostructures ranging from 22.2 nm to 139 nm.

RTFM Observed

Magnetic Characterization
 IGZO demonstrates superior magnetic properties with saturation magnetization (M_s).

Material Parameters Comparison

Material	Crystallite Size (nm)	Saturation Magnetization (kA/m)
In ₂ O ₃	25-43 nm	9.13 emu/gm
IGZO	30-37 nm	7.93 emu/gm
IGO	40-76 nm	10.83 emu/gm

Applications: "These IGZO thin films are ideal for high-performance transparent electronics, low-power gas sensors, and advanced spintronic devices."
Conclusion: "The study successfully demonstrates that tuning the composition of IGZO nanocomposites significantly enhances their optical transparency and induces room-temperature ferromagnetism."

Low-Cost Synthesis of MXene-Based Bi₂O₃/PPy Ternary Composites for Energy Storage Applications
 Author: Kashmina Javaid, Presenter: Iqra Fatima
 Supervisor: Prof. Dr. Zahra Nasir Kayani Department of Physics, LCWU

Research Foundation & Novelty

Low-cost development of high-performance energy storage materials
 Creating binary and ternary composites to maximize electrochemical activity through synergistic interactions.

First-time synthesis of a Bi₂O₃/MXene/PPy ternary system
 Unique incorporation of post-transition metal Bi₂O₃ into an MXene-polymer matrix.

Simple Solution-Based & In-Situ Polymerization
 A straightforward, low-cost approach using DI water and hydrochloric acid solutions.

Characterization & Performance Results

XRD: Monoclinic Phase & Structural Refinement

SEM: Morphological Confirmation

UV-Vis: Optical Property Investigation

Structural Metrics: Crystallite Size & Specific Surface Area

Sample ID	Crystallite Size (nm)	Specific Surface Area (10 ³ cm ² /g)
BM1 (Binary)	6.01	6.33
BMP3 (Ternary)	5.77	6.61
BMP4 (Ternary)	5.58	6.84

Conclusion & Future Outlook

Enhanced Synergistic Interaction
 The interaction between metal oxide, MXene, and polymer drives superior performance.

Future Application in Advanced Supercapacitors
 This ternary system provides a blueprint for scalable, high-efficiency energy storage devices.

Synergistic Ce-Doped Carbon Quantum Dots: The Future of Energy Storage and Wastewater Treatment
 Ayesha Akram
 Lahore college for women university

Biodegradable Zinc-Magnesium Alloy for Bone Fixation: A Study of Their Structural Integrity, Corrosion Resistance, and Mechanical Properties
 Hina Imtiaz, Madeha Rizvi, Ehtaj Anees, Farooq Bashir, Tauseef Hussain
 Lahore college for women university

Synergistic Ce-Doped Carbon Quantum Dots: The Future of Energy Storage and Wastewater Treatment
 Author: Ayesha Akram, Supervisor: Prof. Dr. Zahra Nasir Kayani, Presenter: Ayesha Akram, Lahore College for Women University & University of the Punjab

Structural & Optical Evolution

Novel Microemulsion Synthesis
 Scalable microemulsion process with multi-walled carbon nanotubes (MWCNTs).
 Multi-walled carbon nanotubes (MWCNTs)
 Ce-Doped Carbon Quantum Dots (1.1 wt% Carbon)

Band Gap & Conductivity Optimization
 Doping reduced the band gap to 2.16 eV while significantly boosting AC conductivity.

Nano-Scale Precision
 XRD confirmed a cubic phase with crystallite sizes ranging from 9.33 to 7.81 nm.

Multifunctional Energy Storage

Record-Breaking Energy Storage

9828.125 F/g Specific Capacitance
11,322 Wh/kg Energy Density

Multifunctional Performance:

Environmental & Bio-Remediation
 Achieved 20.11% dye degradation and up to 25mm bacterial inhibition zones.

EXAMPLE Broad Pathogen Resistance
 Effective against *S. aureus*, *S. enterica*, and *K. pneumoniae* for medical and food-safety use.

Fig 1: XRD and Structural Analysis
Fig 2: Optical and Dielectric Properties
Fig 3: SEM/Morphology
Fig 4: Performance Graphs

Reference: Surfaces and Interfaces 74 (2025)

Biodegradable Zinc-Magnesium Alloy for Bone Fixation: A Study of Their Structural Integrity, Corrosion Resistance, and Mechanical Properties
 Hina Imtiaz, Madeha Rizvi, Ehtaj Anees, Farooq Bashir, Tauseef Hussain
 Lahore College for Women University & University of the Punjab

Abstract
 This research introduces a novel biodegradable zinc-magnesium alloy for bone fixation, designed to overcome the limitations of traditional metallic implants. The alloy, composed of 90% Zn and 10% Mg, was synthesized using a casting method and characterized for its structural integrity, corrosion resistance, and mechanical properties. The study reveals that the alloy exhibits a high tensile strength and excellent ductility, making it suitable for load-bearing applications. Additionally, the alloy shows superior corrosion resistance in simulated body fluids, ensuring long-term stability and biocompatibility. The mechanical properties of the alloy were evaluated using tensile and compression tests, showing a yield strength of approximately 150 MPa and a tensile strength of 250 MPa. The corrosion rate was found to be significantly lower than that of pure zinc, indicating enhanced durability. The alloy's biodegradability was also investigated, showing a controlled degradation rate over time. The study concludes that the zinc-magnesium alloy is a promising candidate for bone fixation, offering a balance of mechanical strength, corrosion resistance, and biodegradability.

01 INTRODUCTION

02 METHODOLOGY

03 RESULT AND DISCUSSION

04 CONCLUSION

05 REFERENCES

06 Electrochemical Analysis

07 Mechanical Properties

08 Biocompatibility

09 SUMMARY

CONCLUSION

CIRCULAR ECONOMY DRIVEN REMOVAL OF MYCOTOXINS THROUGH VALORIZATION OF PHYTOGENIC WASTE
 Ammara Nawaz, Laiba Asif, Dr. Sofi a Nooshen
 Lahore college for women university

Abstract: Mycotoxins are a diverse group of secondary metabolites produced by fungi, which are highly toxic to humans and animals. This study aimed to evaluate the removal of mycotoxins from wheat and maize using natural adsorbents derived from phytogetic waste. The study involved the synthesis of various adsorbents from agricultural waste and their application in the removal of mycotoxins from contaminated samples. The results showed that the synthesized adsorbents were highly effective in removing mycotoxins from the contaminated samples. The study also highlighted the potential of phytogetic waste as a sustainable and cost-effective source of adsorbents for mycotoxin removal. The successful synthesis of microbioderivatives represents a value-added approach to the circular economy, while also serving as an effective strategy for waste minimization and climate change mitigation.

CORRELATION OF CHARACTERISTICS OF BONE TUMORS WITH MRI AND HISTOPATHOLOGICAL FINDINGS
 Bushra Sagheer, Sagheer Ahmad, Dr. Abdul Waheed Anwar
 Supervisors: Prof. Dr. Anwar Latif, Dr. Imran Majeed
 University of engineering and technology

Abstract: Bone tumors are a diverse group of neoplasms with high morbidity and mortality. This study aimed to evaluate the correlation between MRI and histopathological findings in the diagnosis of bone tumors. The study involved the collection of MRI scans and histopathological reports of bone tumor patients. The results showed that MRI findings were highly correlated with histopathological findings. The study also highlighted the importance of MRI in the diagnosis of bone tumors and the need for a multidisciplinary approach in the management of these tumors. The study was conducted in accordance with the ethical guidelines of the Institutional Review Board (IRB) approved by the Department of Radiation Oncology at the University of Engineering and Technology, Lahore. A total of 100 patients were included in the study. The study was conducted from 2018 to 2022. The results of the study are presented in the following tables.

Parameter	Value
Total Patients	100
Male	60
Female	40
Age Group (Mean)	55.2
Location	Metastatic (65%), Primary (35%)
Diagnosis	MRI (95%), Histopathology (5%)

First Principles study of CsTiO₃ for structural, electronic, mechanical, and optical properties with Zr and In doped for optoelectronic applications
 Tehreem Fatima, Dr. Abdul Waheed Anwar, Abid Ali
 University of engineering and technology

Abstract: This study presents the first principles study of CsTiO₃ and its doped variants (Zr and In) for structural, electronic, mechanical, and optical properties. The study was performed using the CASTEP software package. The results show that the doped variants exhibit improved optoelectronic properties compared to the undoped CsTiO₃. The study also highlights the potential of CsTiO₃ and its doped variants as promising materials for optoelectronic applications. The study was conducted in accordance with the ethical guidelines of the Institutional Review Board (IRB) approved by the Department of Physics, University of Engineering and Technology, Lahore, Pakistan. The study was conducted from 2018 to 2022. The results of the study are presented in the following tables.

Property	Value
Bandgap (eV)	2.15
Optical Absorption	High
Mechanical Stability	Good

First Principles Insight On Structural, Mechanical Stability, Magnetic, Optical and Thermoelectric response of Cs₂Zsbx (Z= Cu, Ag And X= Cl, Br, I) Double Perovskites For Advance Optoelectronic Applications
 Sagheer Ahmad, Bushra Sagheer, Abid Ali, Tehreem Fatima
 Supervisor: Dr. Abdul Waheed Anwar
 University of engineering and technology

Abstract: This study presents the first principles insight on the structural, mechanical stability, magnetic, optical, and thermoelectric response of Cs₂Zsbx (Z= Cu, Ag and X= Cl, Br, I) double perovskites. The study was performed using the CASTEP software package. The results show that the double perovskites exhibit improved structural, mechanical, magnetic, optical, and thermoelectric properties compared to the single perovskites. The study also highlights the potential of double perovskites as promising materials for advanced optoelectronic applications. The study was conducted in accordance with the ethical guidelines of the Institutional Review Board (IRB) approved by the Department of Physics, University of Engineering and Technology, Lahore. The study was conducted from 2018 to 2022. The results of the study are presented in the following tables.

Property	Value
Bandgap (eV)	1.8 - 2.2
Magnetic Moment	High
Optical Absorption	High
Thermoelectric Coefficient	High

Synthesis and Investigation of Structural Properties of $La_{1-x}Gd_xFeO_3$
Saira Yaqoob
Lahore college for women university

SYNTHESIS AND INVESTIGATION OF STRUCTURAL PROPERTIES OF $La_{1-x}Gd_xFeO_3$

Abstract: $La_{1-x}Gd_xFeO_3$ was synthesized using the solid state method and XRD analysis confirmed a single phase perovskite structure with slight lattice expansion due to Gd^{3+} substitution at La^{3+} sites, showing that Gd doping influences the structural properties of $LaFeO_3$.

Introduction: $LaFeO_3$ is an important rare earth ferrite due to its structural stability and functional properties. Substitution of La^{3+} with Gd^{3+} is an effective method to tailor its crystal structure. The lattice size difference between La^{3+} and Gd^{3+} leads to lattice distortion. Such structural changes can influence the physical properties of the material. Therefore, $La_{1-x}Gd_xFeO_3$ is studied for potential piezoelectric and magnetic applications.

Methodology: $La_{1-x}Gd_xFeO_3$ samples were synthesized using the solid-state reaction method. High-purity La_2O_3 , Gd_2O_3 and Fe_2O_3 powders were mixed in stoichiometric ratios. The mixed powders were calcined and sintered at high temperatures to form the desired phase. X-ray diffraction (XRD) was used to study crystal structure and lattice parameters. SEM analysis was performed to examine grain size and surface morphology.

Results: SEM images show irregular and agglomerated particles, typical of the solid-state synthesis method. The grains exhibit plate-like and clustered morphology with non-uniform size distribution. Particle size lies in the sub-micron to nanometer range. Clear grain boundaries indicate good crystallinity. Gd doping slightly affects grain size and packing without changing overall morphology.

Discussion: The all sites are irregular in shape and mostly in the 200-500 nm range with some larger agglomerates reaching $\sim 1 \mu m$. Gd doping slightly reduces grain size but does not change the overall particle shape.

Facile and green synthesis of Ag/ZnO heterostructures using Aloe Barbadensis Miller gel extract for enhanced photocatalytic activity
Nawal Ansar, Abeer Jawad, Maria Khizar, Wajeehah Shahid

Facile and green synthesis of Ag/ZnO heterostructures using Aloe Barbadensis Miller gel extract for enhanced photocatalytic activity

Abstract: The present work reports the synthesis of Ag/ZnO heterostructures using Aloe Barbadensis Miller gel extract. The synthesized Ag/ZnO heterostructures were characterized by SEM, EDX, EDS, XRD, and UV-Vis spectroscopy. The Ag/ZnO heterostructures showed enhanced photocatalytic activity under UV light irradiation.

Experimental Procedure: Synthesis of ZnO, Ag, and Ag/ZnO heterostructures. ZnO synthesis: Zn(NO₃)₂·6H₂O and NaOH were dissolved in distilled water. Ag synthesis: AgNO₃ and NaOH were dissolved in distilled water. Ag/ZnO heterostructures synthesis: ZnO and Ag solutions were mixed and Aloe Barbadensis Miller gel extract was added. The mixture was stirred and then dried.

SEM Analysis: SEM images show the morphology of ZnO, Ag, and Ag/ZnO heterostructures. ZnO particles are spherical, Ag particles are rod-like, and Ag/ZnO heterostructures are core-shell structures.

EDX Analysis: EDX spectra show the elemental composition of ZnO, Ag, and Ag/ZnO heterostructures. ZnO contains Zn and O, Ag contains Ag, and Ag/ZnO heterostructures contain Zn, O, and Ag.

EDS Analysis: EDS spectra show the elemental composition of ZnO, Ag, and Ag/ZnO heterostructures. ZnO contains Zn and O, Ag contains Ag, and Ag/ZnO heterostructures contain Zn, O, and Ag.

XRD Analysis: XRD patterns show the crystal structure of ZnO, Ag, and Ag/ZnO heterostructures. ZnO has a hexagonal wurtzite structure, Ag has a face-centered cubic structure, and Ag/ZnO heterostructures have a core-shell structure.

Photocatalytic Activity: Ag/ZnO heterostructures show enhanced photocatalytic activity under UV light irradiation compared to ZnO and Ag.

Preparation of different Resin Formulations for 3D Printed Parts with Enhanced Mechanical Properties
Muhammad Usman, Mariyam Ijaz, Rabia Karwal, Hafiz Kabeeer Raza, Waseem Amin, Muhammad Asif Hussain
Decoding
University of Punjab

Decoding the Physics of Materials Behavior with Machine Learning
Huzefa Ibrahim, Syed Haris Mustafa, and Toseef Ahmad, with supervisor Dr-Ing. Waseem Amin
University of Punjab

Preparation of different Resin Formulations for 3D Printed Parts with Enhanced Mechanical Properties

Abstract: The advancement of additive manufacturing technology, particularly stereolithography (SLA) and digital light processing (DLP), relies heavily on the preparation of photopolymer resin formulations to achieve superior mechanical performance. This study focuses on the systematic optimization of resin formulations for enhanced mechanical properties. The resins were tested by tensile, impact, and flexure testing. The mechanical properties were compared to commercial resins to evaluate the effectiveness of the proposed resin formulations. The mechanical properties of the printed parts were highly dependent on the resin formulation, indicating the potential of the proposed resin formulations for 3D printing and additive manufacturing.

Introduction: Photocrosslinking, or stereolithography (SLA), is a manufacturing technique for producing high-resolution, complex, and customized designs via photopolymerization in the biomedical application. It involves the use of a laser or projector to cure a liquid photopolymer resin, producing solid parts layer by layer. The strength, stiffness, and quality of the fabricated parts are heavily dependent on the resin formulation. This study focuses on long-term tensile and flexure testing to evaluate the mechanical performance of the resin formulations. The study aims to optimize resin formulations by adjusting the resin composition, including the inclusion and use of hardeners in high-performance resin formulations.

Methodology: The study involved the preparation of different resin formulations. The resin formulations were tested by tensile, impact, and flexure testing. The mechanical properties were compared to commercial resins to evaluate the effectiveness of the proposed resin formulations.

Results: Tensile Testing: Graphs showing Tensile Strength (MPa) vs. Displacement (mm) for different resin formulations. Flexure Testing: Graphs showing Flexure Strength (MPa) vs. Displacement (mm) for different resin formulations.

Applications: The resin formulations are suitable for 3D printing of biomedical parts, such as prosthetics, implants, and surgical guides.

Methodology: The study involved the preparation of different resin formulations. The resin formulations were tested by tensile, impact, and flexure testing. The mechanical properties were compared to commercial resins to evaluate the effectiveness of the proposed resin formulations.

Conclusions: The study shows that the proposed resin formulations have enhanced mechanical properties compared to commercial resins. The resin formulations are suitable for 3D printing of biomedical parts.

Decoding the Physics of Materials Behavior with Machine Learning

Institute of Metallurgy & Materials Engineering
Huzefa Ibrahim, Syed Haris Mustafa, Toseef Ahmad
Supervisor: Dr-Ing. Waseem Amin

Introduction
Metallic materials are widely used in engineering for their strength, ductility, and a broad range of applications, such as aerospace, automotive, construction, and energy sectors. Understanding their complex behavior under mechanical, thermal, and environmental loading is crucial in materials science. Traditionally, this has been using complex physical models based on constitutive laws and principles.

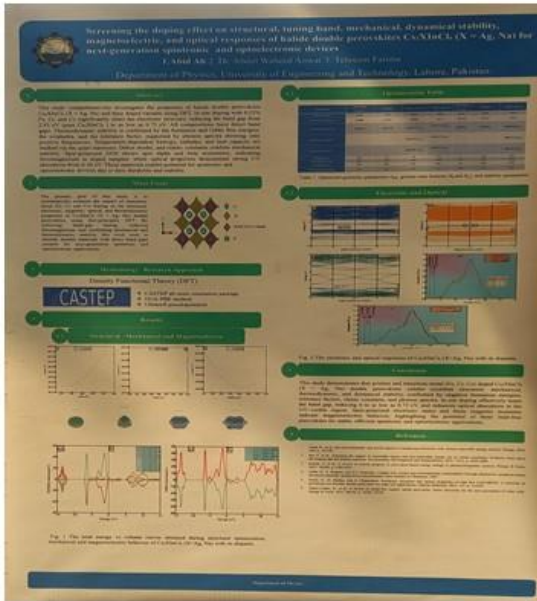
The Traditional Approach
Physics-based models rely on constitutive laws & assumptions, often narrow prior knowledge of physics and complex equations to predict the material responses underlying physics laws and principles.
Challenges:
• Complex, nonlinear equations: $\sigma = E \epsilon$
• Pi-B-II is computationally expensive

Physics-Informed Machine Learning (PIML)
Recent advances in ML extend traditional machine learning by incorporating known physical laws. PIML leverages constitutive relations & boundary conditions to improve the model, the behavior of materials under a wide range of conditions.

Key Benefits of PIML
• **Accuracy & Consistency**
Produces more accurate predictions that respect known physical principles and underlying physics & laws.
• **Improved Interpretability**
Greater insights into the underlying physics and how materials respond to different loads and conditions.
• **Better Generalization**
Models generalize well to unseen loading conditions beyond robust, then, and reliable for real-world.

Comparison of Approaches
Traditional ML models: Accuracy vs. Generalization.
Physics-informed ML models: Accuracy vs. Generalization.

Screening the doping effect on structural tuning band, mechanical, dynamical stability, magnetoelectric, and optical responses of hafnate double perovskites C_2XInCl_6 ($X = Ag, Na$) for next-generation spintronic and optoelectronic devices
 -Abid Ali, Dr. Abdul Waheed Anwar, Tehreen Fatima
 University of engineering and technology



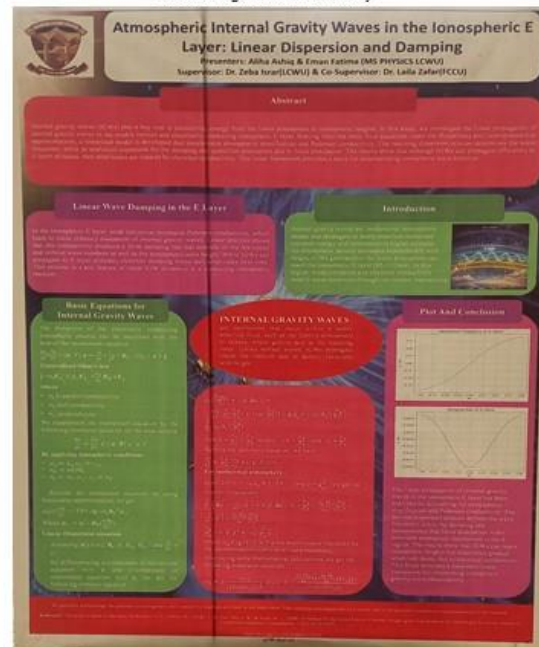
Green Hydrogen Technologies: Role of Materials for Future Advancement
 Ghulam Mehmood, Sadia Noor, Prof. Dr. Mubeen Ali (Supervisor)
 University of Punjab



Structural Study of TiO₂-Doped Zinc Oxide Via Solid State Atmospheric Reaction
 Laiba Mahmood
 Government college university



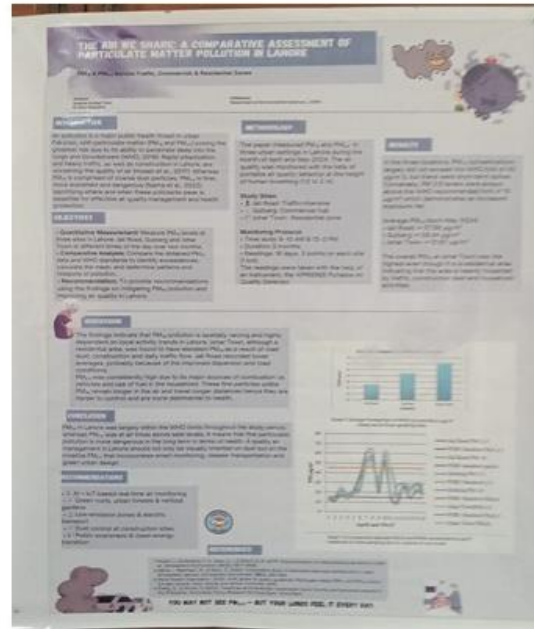
Atmospheric Internal Gravity Waves in the Ionospheric E Layer: Linear Dispersion and Damping
 Aliha Ashiq, Eman Fatima
 Lahore college for women university



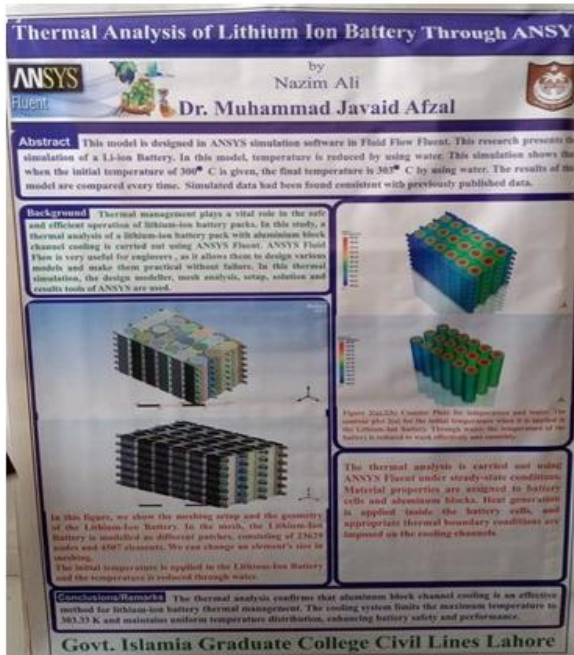
The Impact of XRCC1 Polymorphisms on Thyroid Cancer Susceptibility and Progression
 Aaif Bilal and Fouzia Tanvir
 University of engineering and technology



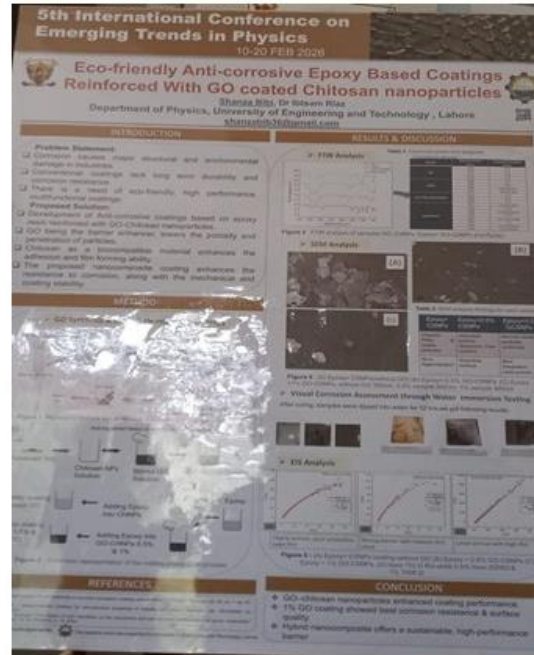
The Air We Share: A Comparative Assessment of Particulate Matter Pollution in Lahore
 Ayesha arshad tarar
 Lahore college for women university



Thermal Analysis of Lithium Ion Battery through ANSYS
 Nazim ali
 Govt Islamia Graduate college civil line



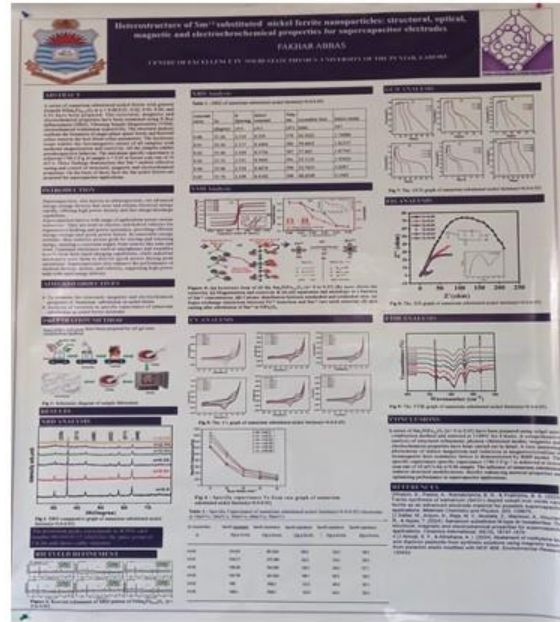
Exo friendly anti corrosive epoxy based coatings reinforced with GO coated Chitosan nanoparticles
 Shanza bibi
 University of engineering and technology



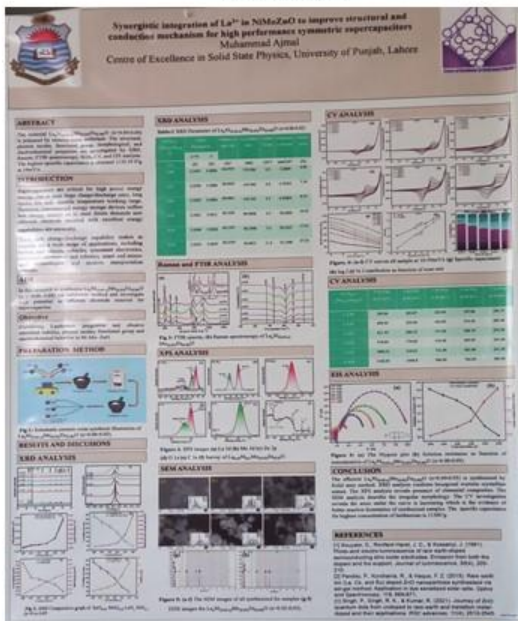
Development of Zeolite for Oxygen Concentrators
 Muhammad Faraz, Umar Atta, Hafiz Kabir Raza, Abbas Saeed
 Hakeem, Muhammad Usman
 University of Punjab



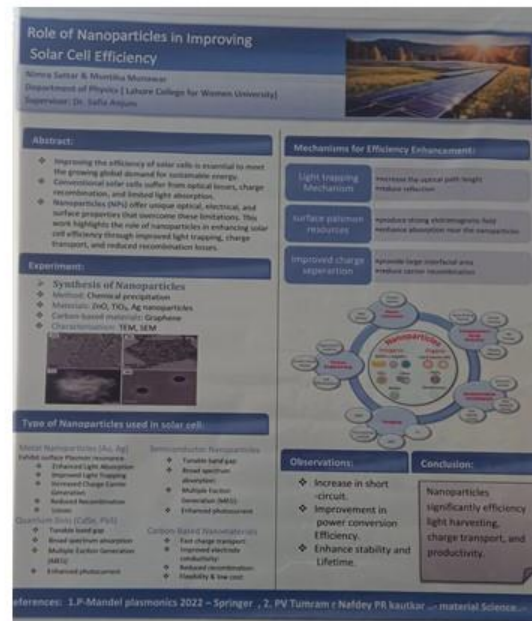
Development of Zeolite for Oxygen Concentrators
 Fakhar Abbas
 University of Punjab



Synergistic integration of La³⁺ in NiMoZnO to improve structural and conduction mechanism for high performance symmetric supercapacitors
 Muhammad Ajmal
 University of Punjab



Role of Nanoparticles in Improving Solar Cell Efficiency
 Nimra Sattar, Mushtaq Musawar
 Lahore college for women university



Recent development in cancer treatment using biomaterials
 Saman Mushtaq, Wajeehah Shahid, Fazal-e-Aleem
 University of Lahore



Recent development in cancer treatment using biomaterials

Samam Mushtaq, Wajeehah Shahid and Fazal-e-Aleem
 Department Of Physics , The University of Lahore , Lahore 54000 , Pakistan



Abstract

Abstract text describing the paper's content.

Introduction

Introduction text discussing the background and objectives of the study.

Types of cancer



Figure 1: Types of cancer [1].

Nanomaterials for cancer treatment

Figure 2: Types and targeted nanoparticles for cancer treatment [2].

Current FDA-approved nanomedicine

Table 1: FDA-approved nanomedicine used in cancer treatment [3].

All in cancer treatment

Figure 3: All in cancer treatment [4].

All in cancer treatment and therapy optimization

Figure 4: Current All in cancer treatment [5].

Quantum computing in cancer treatment

Quantum computing is a field of research that aims to harness the power of quantum mechanics to solve complex problems. In the context of cancer treatment, quantum computing offers several potential applications:

- Drug discovery and optimization:** Quantum computing can be used to simulate the behavior of molecules and predict the effectiveness of different drug combinations.
- Targeted therapy optimization:** Quantum computing can be used to optimize the design of targeted therapies, such as monoclonal antibodies and small molecule inhibitors.
- Personalized medicine:** Quantum computing can be used to analyze large amounts of patient data to identify personalized treatment plans.

Conclusion

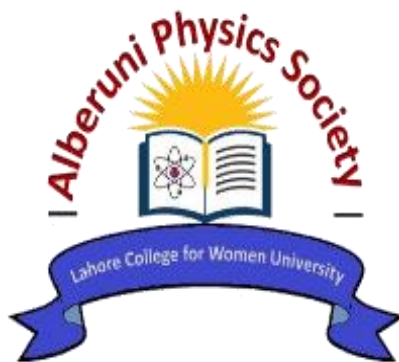
Conclusion text summarizing the findings and future directions of the research.

Literature cited

List of references cited in the paper.

3rd International conference on Emerging Trends in Physics

62



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Miss Shaffan Ayub – BS-Physics

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Miss Moazma Nafees – BS-Physics

Assisted in moderation management and abstract binding



