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PROCEEDINGS OF THE
INTERNATIONAL CONFERENCE ON

ADVANCED MATERIALS AND MODERN TECHNOLOGIES

Innovating Materials, Empowering the Future

EDITORS

D.SHEEBA

Rev.Sr.Dr.P. AROCKIA MICHAEL MERCY

2026

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International Conference on

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Innovating Materials, Empowering the Future

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Rev.Sr.Dr. P. AROCKIA MICHAEL MERCY

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Dr. Kuppan Gokulan
The Division of Microbiology at NCTR
USA

It gives me immense pleasure and a profound sense of privilege to present the Preface to the **International Conference on "ADVANCED MATERIALS AND MODERN TECHNOLOGIES–2026" (ICAMMT–2026)**. This international academic gathering is conceived as a vibrant platform for bringing together distinguished academicians, scientists, researchers, industry professionals, research scholars and students to share knowledge, exchange innovative ideas and explore emerging frontiers in materials science and modern technological development. It provides a meaningful forum for discussing these emerging frontiers. The conference encourages participants to move beyond conventional approaches and to explore innovative solutions that combine scientific excellence with societal relevance. Particular emphasis is placed on research that contributes to sustainability, energy efficiency, environmental protection, technological advancement, and the development of affordable and accessible solutions for the future.

This Proceedings Volume is particularly significant because it brings together **both the abstracts of research contributions and selected research papers presented at the conference**. The abstracts provide a concise overview of the research objectives, methodologies, major findings, and potential applications, while the presented research papers offer deeper scientific insights into the investigations undertaken by the contributors. Together, they provide a broader picture of current research activities and emerging directions in advanced materials and modern technologies.

We gratefully acknowledge the valuable contributions of all **authors, researchers, resource persons, invited speakers, reviewers, session chairs, organizing committee members, faculty members, research scholars, students, and supporting staff** whose collective efforts have made this conference and its proceedings possible. Our sincere appreciation is extended to the experts and academicians who have generously shared their knowledge and experience with the participants.

We also place on record our heartfelt gratitude to the institutional leadership and management for providing encouragement, academic support, and the necessary facilities for conducting this international academic event. Their commitment to promoting higher education, research, innovation, and knowledge dissemination has been a significant source of inspiration. The proceedings before you are therefore more than a compilation of scientific papers and abstracts. They represent a **collective expression of curiosity, creativity, collaboration, and commitment to scientific advancement**. Each paper contributes a small but meaningful step towards understanding the possibilities of advanced materials and modern technologies. We hope that these contributions will encourage researchers to develop new ideas, establish interdisciplinary collaborations, and transform promising concepts into practical and sustainable solutions.

With warm Regards

KUPPAN GOKULAN -S

Dr. Kuppan Gokulan
The Division of Microbiology at NCTR
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Rev. Dr. M.ANBARASU, S.J.
M.A., Ph.D.,
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Rev. Dr. Anbarasu M. S.J.
Principal
Arul Anandar College

It is my great pleasure to share the proceedings of the International Conference on **'Advanced Materials and Modern Technology'.** This conference brings together researchers, academicians, scientists, engineers, industry experts, and students to share their latest research findings, innovative ideas, and technological developments in the fields of advanced materials and modern technology. The rapid advancement of materials science and emerging technologies has created new opportunities for innovation and sustainable development. Advanced materials, nanotechnology, artificial intelligence, smart manufacturing, robotics, energy technologies, and digital transformation are contributing significantly to progress in diverse areas such as healthcare, energy, electronics, aerospace, manufacturing, and environmental protection.

The conference aims to encourage interdisciplinary interaction and foster meaningful collaborations between academia, research institutions, and industry. It provides an opportunity to discuss recent developments, explore innovative solutions, identify emerging research directions, and translate scientific discoveries into practical applications. The exchange of ideas among participants from diverse disciplines is expected to contribute significantly to the advancement of knowledge and the development of technologies that are efficient, sustainable, and socially beneficial.

I sincerely appreciate the valuable contributions of all authors, reviewers, keynote speakers, invited speakers, session chairs, organizing committee members, and participants who have made this conference possible. Their dedication and support have contributed greatly to the success of this event. I am confident that the ideas, discussions, and collaborations emerging from this conference will inspire further research and innovation. I hope this conference will be an enriching experience for all participants and contribute to the advancement of knowledge and technology for a sustainable future.

With Best Wishes for a Successful and Memorable International Conference!

With warm Regards

Rev. Dr. Anbarasu M. S.J.

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Rev. Fr. Dr. GODWIN RUFUS, S.J., M.A., M.Phil., Ph.D.
Principal

PREFACE

We live in an age of extraordinary scientific and technological transformation. Advanced materials, nanotechnology, quantum science, renewable energy, artificial intelligence and smart technologies are reshaping the frontiers of knowledge and redefining the possibilities of human development. In this rapidly changing context, higher education must move beyond the transmission of knowledge towards the formation of reflective, responsible and lifelong learners.

It is in this spirit that **ICAMMT–2026: International Conference on Advanced Materials and Modern Technologies**, organised by the Department of Physics, Madonna Arts & Science College for Women, brings together academicians, researchers, scientists, students and industry professionals to exchange ideas, foster interdisciplinary collaboration and explore innovative pathways towards a sustainable future.

The conference is particularly meaningful when viewed through the complementary lenses of **Ignatian Pedagogy, Andragogy and Heutagogy**. Ignatian Pedagogy, through **Context–Experience–Reflection–Action–Evaluation**, reminds us that knowledge must be connected with reality, ethical discernment and service to humanity. **Andragogy** recognises the value of experience, relevance and active participation in adult learning, while **Heutagogy** promotes **self-determined, autonomous and lifelong learning**. Together, these approaches encourage learners not merely to acquire knowledge, but to question, create, reflect, adapt and take responsibility for its application.

The theme of advanced materials and modern technologies therefore invites us to consider not only **what technology can achieve**, but also **what it ought to achieve for humanity and the planet**. Scientific innovation must be guided by wisdom, ethical responsibility and a commitment to the common good.

The four guiding words of this conference—**Innovate, Collaborate, Inspire and Transform**—capture this vision. We innovate by imagining new possibilities; collaborate by crossing disciplinary boundaries; inspire by turning knowledge into hope; and transform when research becomes meaningful action for society.

May **ICAMMT–2026** become a space where knowledge leads to reflection, reflection to responsible action, and action to transformation. May it inspire us to *read the signs of the times*, discern the needs of our world and place science and technology at the service of humanity and creation.

Innovate. Collaborate. Inspire. Transform.

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முனைவர் செ. பூமிநாதசெல்லராஜன்., Ph.D.,

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The International Conference on Advanced Materials and Modern Technologies (ICAMMT-2026) organized by the Department of Physics at Madonna Arts & Science College for Women on September 3, 2026. I am happy to share a few words in this occasion.

There is intense competition when comparing degrees in science and engineering. Students that enrolll in science programs have the good fortune to get a deeper understanding of science and cultivate an appreciation for life. Attending or organizing an international conference is one of the best methods for students to engage with technology and research. In this context, this conference upholds the fundamental scientific disciplines while covering transdisciplinary themes in every aspect of modern engineering fields. Without an understanding of science, technological innovation and breakthroughs are impossible to achieve.

The publication of this proceedings volume marks a significant milestone in the contemporary discourse surrounding material sciences and engineering. The critical intersection of fundamental laboratory physics and scalable technological applications is emphasized by this collection. The editorial matrix of these proceedings successfully categorizes diverse technical inquiries into distinct, impactful trajectories:

- Fundamental Materials & Synthesis: Critical assessments of nanomaterials, thin films, functional ceramics, and semiconductor quantum dots.
- Green Technology & Infrastructure: Cutting-edge research targeting photovoltaics, eco-friendly manufacturing, and sustainable waste management matrices.
- Digital Integration & Automation: Insights into how Artificial Intelligence, Machine Learning, and the Internet of Things (IoT) are reshaping advanced processing systems.

There is no doubt that many students who benefit from this conference may use it as a springboard to pursue further education in order to broaden and enhance their knowledge.

From an external viewpoint, the execution of ICAMMT-2026 deserves high praise. Under the visionary stewardship of Chief Patron Rev. Dr. Mary Delphine, Patron Rev. Dr. Thiraviya Regina Rajam, and the tireless coordination of the Conveners, Prof. D. Sheeba and Rev. Dr. Arockia Michael Mercy, the institution has provided a vital global stage. By bringing together prominent international voices from the United States and Italy alongside distinguished national scholars, the organizers have fostered an environment of high-level intellectual exchange.

I hope this event is a huge success and goes on forever to inspire more young people to pursue science and technology through enrichment activities and information sharing.

(S. Boominathasellarajan)

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I am delighted to share a few words on the occasion of the International Conference on Advanced Materials and Modern Technologies (ICAMMT-2026), organized by the Department of Physics, Madonna Arts & Science College for Women, Virahanur, Madurai. The conference brings together research and technological developments across disciplines, with a particular focus on areas that are shaping the future of science and its applications.

Scientific progress today rarely happens within the boundaries of a single discipline. Some of the most interesting developments emerge when ideas from physics, materials science, engineering, computing and related fields come together. ICAMMT-2026 provides such an opportunity, bringing scientists, academicians, researchers, industry professionals, research scholars and students onto a common platform to share their work, exchange perspectives and learn from one another.

The conference covers a wide range of contemporary research, broadly spanning **advanced and functional materials; nanoscale and semiconductor technologies; energy, environmental and sustainable materials; smart, biomedical, polymer and composite systems; materials processing and characterization; and emerging computational, digital and intelligent technologies**. This wider scope is particularly relevant at a time when advances in materials research are increasingly connected with developments in artificial intelligence, automation, advanced manufacturing and digital technologies.

The papers presented in this conference reflect this interdisciplinary character. They also remind us that research becomes more meaningful when fundamental scientific understanding is connected with real-world needs and applications. Conferences such as ICAMMT-2026 are valuable not only for presenting completed research, but also for the conversations they begin, the questions they raise and the possibilities for future collaborative work.

I hope these proceedings of the conference will be useful to students, research scholars, teachers, scientists and professionals, and that some of the ideas presented here will lead to further enquiry and meaningful research.

I sincerely appreciate the invited speakers, authors and reviewers for their academic contributions. I also congratulate the organizing committee, faculty members, research scholars, students and supporting staff whose time and effort have gone into organizing the conference and bringing out these proceedings.

I wish ICAMMT-2026 every success and hope that the discussions and research shared through this conference will encourage new ideas, stronger academic connections and research that contributes meaningfully to science and society.

With Regards

Nimma Elizabeth R

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Rev.Dr.S.Thiraviya Regina Rajam CIC, M.C.A., Ph.D
Principal

"Somewhere, something incredible is waiting to be known." — Carl Sagan

It gives me immense pleasure to extend my warm greetings to all scientists, academicians, researchers, industry experts, faculty members, scholars, and students participating in this International Conference on "Advanced Materials and Modern Technologies."

We are living in an era of remarkable scientific progress, where advanced materials, nanotechnology, smart materials, semiconductors, energy storage, and sustainable technologies are transforming science and society. This conference provides a valuable platform to share knowledge, present innovative research, and build meaningful academic collaborations. At Madonna Arts and Science College for Women, we believe that education should inspire curiosity, scientific thinking, creativity, and innovation. I am delighted that our students and faculty have this opportunity to interact with eminent researchers and explore the latest developments in advanced materials and modern technologies.

I sincerely appreciate the Department of Physics and the organizing committee for their dedicated efforts. May this conference inspire young researchers, promote collaboration, and contribute to scientific advancement and a sustainable future. I wish the conference great success and all participants a fruitful and enriching experience.

"The future of technology begins with the materials we create today".

Rev.Dr.S.Thiraviya Regina Rajam
Principal

Rev.Dr.P.Arockia Michael Mercy CIC
M.Sc.,PGTRB.,Ph.D
Vice Principal
Madonna Arts & Science College for Women,
Virahanur, Madurai-625009

It is with profound gratitude to God Almighty, whose divine wisdom, grace, and providence inspire every pursuit of knowledge, that I am deeply honored to present this Proceedings Volume of the International Conference on **"ADVANCED MATERIALS AND MODERN TECHNOLOGIES–2026" (ICAMMT–2026).** This publication is a scholarly compilation of research abstracts and presented research papers, representing the intellectual contributions, scientific efforts, innovative ideas, and research aspirations of academicians, scientists, research scholars, faculty members, and students. Science is a precious gift through which humanity seeks to understand the wonders of creation and transform knowledge into meaningful solutions for the betterment of society. Every scientific discovery, technological advancement, and innovative material is, in its own way, an expression of the human capacity to explore, question, create, and serve. In this spirit, **ICAMMT–2026** has been conceived as a platform where scientific excellence is harmoniously connected with social responsibility, ethical values, sustainability, and the service of humanity.

This Proceedings Volume carries special significance as it brings together both the abstracts and the research papers presented during the conference. The **Abstracts** offer concise glimpses into the objectives, methodologies, findings, and applications of the research, while the **Presented Papers** provide a more comprehensive account of the scientific investigations undertaken by the contributors. Collectively, these scholarly works demonstrate the vitality of current research and the continuous efforts of the scientific community to expand the frontiers of knowledge.

At this moment of academic celebration, I wish to place on record my profound gratitude to God Almighty for blessing this conference with strength, wisdom, guidance, and success. I express my heartfelt gratitude to our esteemed Management and Secretary Rev.Dr.Mary Delphine CIC, whose vision, encouragement, commitment to education, and unwavering support have provided the essential foundation for organizing this international academic event. I also extend my sincere and respectful appreciation to our Principal Rev.Dr.Thiraviya Regina Rajam CIC, whose academic leadership, guidance, encouragement, and constant support have significantly contributed to the successful realization of ICAMMT–2026. I gratefully acknowledge the invaluable contributions of the Organizing Committee, Editorial Committee, reviewers, faculty members, research scholars, technical team, student volunteers, invited speakers, resource persons, collaborators, and all supporting staff. Their cooperation, responsibility, and tireless efforts have made the conference and this publication possible.

May ICAMMT–2026 remain a memorable milestone in our continuing journey towards academic excellence, scientific innovation, technological advancement, and service to society.

With Warm Regards

P. Mercy

Dr. P. Arockia Michael Mercy

Prof. D. Sheeba, M.Sc., M.Phil.,
Convener
Head & Assistant Professor, Department of Physics
Madonna Arts & Science College for Women, Madurai-9

First and foremost, I thank the Almighty Lord for His abundant grace, blessings and guidance, which have enabled us to organize the International Conference on "Advanced Materials and Modern Technologies" (ICAMMT–2026) successfully and bring out this journal. It gives me immense pleasure to present this compilation of selected research contributions from the conference, organized by the Department of Physics, Madonna Arts & Science College for Women, Virahanur, Madurai. The conference provided a meaningful platform for academicians, scientists, research scholars, students and industry professionals to share their knowledge, research findings and innovative ideas.

The conference focused on emerging areas such as advanced functional materials, nanotechnology, semiconductor materials, energy materials, renewable energy technologies, smart materials, biomaterials, thin films and coatings, polymers and composites, materials characterization, artificial intelligence, Internet of Things, robotics and sustainable technologies. This journal reflects the scientific curiosity, creativity and research efforts of the participants and aims to serve as a useful reference for further academic and research activities.

I express my sincere gratitude to our Chief Patron, Rev. Dr. Mary Delphine, and Patron, Rev. Dr. Thiraviya Regina Rajam, for their constant encouragement, guidance and support. I also extend my heartfelt thanks to the organizing committee, invited speakers, reviewers, faculty members, research scholars, students and all the participants whose valuable contributions made the conference and this publication possible.

I hope that this journal will inspire young researchers, promote interdisciplinary collaboration and contribute to the advancement of science and technology. With gratitude and great pleasure, I present this volume to the academic and scientific community and wish all the contributors continued success in their research endeavours.

With Regards

D. Sheeba

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CAMMT:01

The Safety Assessment of Nanocrystal Formulated Zileuton and API Interaction and Molecular Survey of the Gut Microbiome in Sprague-Dawley rats

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Abstract

Nanocrystal drug formulation involves several critical manufacturing procedures that result in complex structures to improve drug solubility, dissolution, bioavailability, and consequently the efficacy of poorly soluble Biopharmaceutics Classification System (BCS) II and IV drugs. Nanocrystal formulation of an already approved oral drug may need additional immunotoxic assessment due to changes in the physical properties of the active pharmaceutical ingredient (API). In this study, we selected Zileuton, an FDA-approved drug that belongs to BCS-II for nanocrystal formulation. To evaluate the efficacy and mucosal immune profile of the nanocrystal drug, 10-week-old rats were dosed using capsules containing either API alone or nanocrystal formulated Zileuton (NDZ), or with a physical mixture (PM) using flexible oral gavage syringes. Control groups consisted of untreated, or placebo treated animals. Test formulations were administrated to rats at a dose of 30 mg/kg body weight (bw) once a day for 15 days. The rats treated with NDZ or PM had approximately 4.0 times lower (7.5 mg/kg bw) API when compared to the micron sized API treated rats. At the end of treatment, mucosal (intestinal tissue) and circulating cytokines were measured. The immunological response revealed that NDZ decreased several proinflammatory cytokines in the ileal mucosa (Interleukin-18, Tumor necrosis Factor-a and RANTES [regulated upon activation, normal T cell expressed and secreted]). A similar pattern in the cytokine profile was also observed for the micron sized API and PM treated rats. The cytokine production revealed that there was a significant increase in the production of IL-1b and IL-10 in the females in all experimental groups. Additionally, NDZ showed an immunosuppressive effect on proinflammatory cytokines both locally and systemically, which was similar to the response in micron sized API treated rats. These findings indicate that NDZ significantly decreased several proinflammatory cytokines and it displays less immunotoxicity, probably due to the nanocrystal formulation. Thus, the nanocrystal formulation is more suitable for oral drug delivery, as it exhibited better efficacy, safety, and reduced toxicity.

Keywords: Zileuton; Nanocrystals; Drug–API interaction; Safety assessment; Gut microbiome; Molecular profiling; Sprague-Dawley rats; Nanomedicine**.**

ICAMMT:02

Interface-Engineered Lead-Free $FASnI_3$ Perovskite Solar Cell with NiO and CeO_2 Charge-Transport Layers: A SCAPS-1D Numerical Study

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Abstract

Active development is underway for perovskite solar cells (PSCs) that are both cost-effective and highly efficient. In the solar cell industry, the significance of lead-based PSCs has increased significantly in recent year. However, the development of commercially viable products is significantly impeded by their toxicity and instability. Sn-based all-inorganic PSC materials have therefore become crucial for advancing high-performance PSCs. This study investigates the theoretical feasibility of a lead-free, environmentally friendly, and reliable PSC based on FASnl3. Various election transport layers (ETLs) and hole transport layers (HTL_S) are analyzed to identify materials that enhance the stability and strength of the PSC. The design utilized $FASnl_3$ as the absorber layer in the configuration Au/NiO/ $FASnI_3$/ CeO_2/ FTO. Each composite layer is optimized and examined through simulations using SCAPS-ID software to achieve superior performance. The proposed solar cell attains a maximum power conversion efficiency of **26.52%** by optimizing the ETL, HTL, metal contacts, absorber defect density, and the thicknesses of the absorber, HTL, and FTO layers. These results pave the way for developing environmentally friendly and highly efficient perovskite photovoltaic devices.

Key words: Lead-free Perovskite Solar Cells-Numerical modelling- Au/ NiO / $FASnl_3$/ CeO_2/ FTO

ICAMMT:03

Density Functional Theory Calculations on a Third order Nonlinear Optical Single Crystal of Urea Adipic acid (UAA)

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Abstract

The title compound Urea Adipic acid (UAA) has been synthesized in slow evaporation solution growth technique. The crystallinity of the crystal is confirmed by Single crystal X-ray diffraction studies. The SCXRD analyses prove the crystal corresponds to monoclinic structure with centrosymmetric space group. Optical studies analysed the UV cut-off wavelength was obtained at 217 nm. The energy difference (Eg) of the SALC was obtained at 5.1 eV. Structural validation was done using quantum chemical calculations using Density Function Theory (DFT) employing B3LYP method and 6-311++G(d,p) basis set. HOMO-LUMO energy gap 5.28eV was well coincide with the experimental energy gap value. The MEP map gives the information about intermolecular interactions within the molecule and most responsive spots for electrophilic and nucleophilic event separately. Mulliken charge analysis can be used to characterize the electronic charge distribution in a molecule.

Keywords: SCXRD, Spectroscopic Analyses, HOMO-LUMO, MEP, Mulliken charge analysis.

ICAMMT:04

Chandrayaan Rover: Learning Space Science through Arduino

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Abstract

The remarkable achievements of the Chandrayaan missions by the Indian Space Research Organisation (ISRO) have demonstrated the significance of advanced control systems, real-time monitoring, automation, and robotics in space exploration. However, introducing these complex technologies at the school level can be challenging due to limited access to sophisticated equipment and laboratory facilities. This study focuses on the design and development of a low-cost educational prototype using an Arduino Uno to simulate essential lunar rover functions, including navigation, obstacle detection, and data acquisition. Along with the hands-on Arduino-based model, an awareness programme on the Chandrayaan missions was conducted to enhance students' knowledge and appreciation of India's achievements in space science. An experimental research design incorporating pre-test and post-test assessments was adopted to evaluate the effectiveness of the intervention. The results showed a highly significant improvement in students' achievement scores, with a calculated *t*-value of 21.5. The findings indicate that integrating hands-on technological models with conceptual instruction can significantly improve students' engagement, understanding, and interest in space science. The study demonstrates that low-cost Arduino-based educational interventions can effectively bridge the gap between theoretical concepts and practical applications, while inspiring students to explore science, technology, engineering, and mathematics (STEM) through the success stories of Chandrayaan.

Keywords :

Chandrayaan, Arduino Uno, Educational robotics, Inquiry-based learning, Student achievement, Space science education

ICAMMT:05

Waste-Derived Nanobiochar-Chitosan Composite Beads or Lead Removal and Toxicity Mitigation in Wastewater Management

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Abstract

Heavy metal adulteration, particularly lead (Pb), poses a serious risk to environmental sustainability and public health due to its persistence, toxicity, and bioaccumulation. This study proposes a sustainable, low-cost approach to groundwater remediation using nanobiochar-chitosan composite beads synthesized from food waste and crab shell waste. Groundwater samples collected from the Ariyamangalam dumpsite area in Tiruchirappalli exhibited poor water quality and raised lead concentrations exceeding permissible limits. Nanobiochar was produced via pyrolysis of food waste and processed into nanoscale particles, while chitosan was extracted from crab shell waste. The composite beads were fabricated via ionic crosslinking and characterized using FTIR, XRD and SEM to confirm structural properties and identify the functional groups responsible for adsorption. Batch adsorption studies confirmed a significant reduction in lead concentration from 0.031 mg/L to 0.002 mg/L, achieving high removal efficiency. To evaluate environmental safety, zebrafish (*Danio rerio*) embryo toxicity assays were conducted. Results indicated severe developmental abnormalities and mortality in untreated samples, whereas treated water showed markedly reduced toxicity, confirming the effectiveness and biocompatibility of the developed system. Overall, this study highlights the dual benefits of waste valorization and efficient heavy-metal removal, offering a scalable, environmentally friendly solution for contaminated water treatment and environmental protection.

Keywords

Lead Removal; Nanobiochar; Chitosan Beads; Adsorption; Groundwater Remediation; Zebrafish toxicity.

ICAMMT:06

Green Computing: A Comprehensive Review of Sustainable Tech Practices

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Abstract

The objective of the study titled "Sustainable Tech Services: Assessing the Impact of Green Computing Practices" is to analyze existing literature on green computing and its effects on sustainable TECH services. The aim is to identify crucial concerns and strategic areas that can enhance customer value, business value, and societal value. The paper examines sustainable TECH techniques, including power management, virtualization, enhancement of cooling technology, recycling, electronic waste disposal, and optimization of the TECH infrastructure to fulfil sustainability criteria. According to the authors, sustainable TECH strategies are expanding the concept of sustainability beyond energy consumption and product considerations. This expansion requires the restructuring of both the TECH organization as well as the overall practices in order to fully achieve the strategic advantages of green computing. In essence, this paper provides a significant reference for institutions who wish to understand and adopt sustainable TECH practices, particularly in the realm of green computing.

Keywords: Green Computing, Sustainable TECH, ICT sustainability, Sustainable Computing, Green TECH, Green ICT, Green Technology.

ICAMMT:07

Comparative Study of Polyacrylonitrile Based Polymer Electrolytes with Sodium Salts for Sodium-Ion Batteries

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Abstract

The development of high-performance solid polymer electrolytes (SPEs) is essential for realizing safe, lightweight, and sustainable solid-state sodium-ion batteries. Although numerous sodium salts have been investigated individually, a systematic comparison of their influence within the same polymer host remains limited. In this study, polyacrylonitrile (PAN) based SPEs containing three sodium salts sodium perchlorate ($NaClO_4$), sodium thiocyanate (NaSCN), and sodium nitrate ($NaNO_3$) are prepared by solution casting technique and compared. Electrolyte membranes were characterized by X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), AC impedance spectroscopy, and linear sweep voltammetry (LSV). The results demonstrate the influence of sodium salt polymer–salt complexation, crystallinity, amorphous phase formation, ion mobility, thermal stability, and electrochemical performance. The PAN–$NaClO_4$ system exhibits the highest room-temperature ionic conductivity of $\mathbf{1.13 \times 10^{-2}\ S\ cm^{-1}}$ with a wide electrochemical stability window, whereas PAN–NaSCN achieves a high ionic conductivity of $\mathbf{8.8 \times 10^{-3}\ S\ cm^{-1}}$ and excellent compatibility for primary solid-state sodium-ion battery applications. The PAN–$NaNO_3$ electrolyte provides comparatively lower ionic conductivity $\mathbf{2.7 \times 10^{-3}\ S\ cm^{-1}}$ but demonstrates good thermal stability and electrochemical behavior. The optimized electrolytes deliver stable open-circuit voltages when assembled into primary solid-state sodium-ion batteries, confirming their practical feasibility. This comparative study explains the performance of PAN-based solid polymer electrolytes in selecting the most suitable salt for better battery performance. These investigations contribute to the advancement of efficient, low-cost, and environmentally solid-state sodium-ion batteries for future energy storage devices.

Keywords: Polyacrylonitrile; Sodium-ion battery; Sodium perchlorate; Sodium thiocyanate; Sodium nitrate; Ionic conductivity

ICAMMT:08

Valorising Prosopis Juliflora Biomass into a Functional Nanomaterial-based Drug Delivery Platform for Gastroprotection and Antibiotic-Induced Gut Dysbiosis

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Abstract

Gut microbiota plays a crucial role in maintaining intestinal homeostasis, immune function, metabolism, and gut–brain communication. However, antibiotic exposure and other gastrointestinal stressors can disrupt microbial balance, impair intestinal integrity, and contribute to intestinal inflammation and ulcerative damage. In this study, a plant-derived nanomaterial-based synbiotic delivery system using *Prosopis juliflora* was developed by integrating a probiotic strain with a functional nanoscale carrier derived from *P. juliflora* biomass. The selected probiotic was isolated from a traditional fermented food source and screened for key probiotic characteristics, including tolerance to acidic conditions, bile salts, osmotic stress, and gastrointestinal-associated conditions. *P. juliflora*-derived nanomaterials were prepared through physicochemical processing and characterized for their nanoscale morphology, particle size, surface properties, and structural characteristics. Their prebiotic potential was evaluated based on their ability to support probiotic growth, viability, and biofilm formation. The probiotic was subsequently incorporated into the nanomaterial matrix to develop a stable synbiotic formulation with enhanced probiotic delivery potential. The formulation was further investigated for its gut-protective and antiulcer potential using an antibiotic-induced intestinal dysfunction model in zebrafish larvae. The nanomaterial-supported probiotic system enhanced probiotic survival, growth, and colonization-associated properties, while in vivo evaluation demonstrated attenuation of intestinal edema and preservation of gut integrity. The formulation also exhibited promising antiulcer and mucosal protective effects, suggesting its potential to support intestinal barrier recovery and reduce gastrointestinal damage. Overall, the findings highlight *P. juliflora*-derived nanomaterials as sustainable and multifunctional platforms for synbiotic delivery, combining prebiotic, probiotic, gut-protective, and antiulcer properties for mitigating intestinal dysbiosis and associated gastrointestinal dysfunction.

Keywords: Prosopis juliflora; biomass valorization; plant-derived nanomaterials; nanomaterial-based delivery; synbiotic delivery; probiotic; prebiotic activity; gut dysbiosis; gastroprotective activity; gut protection; intestinal integrity; antibiotic-induced intestinal damage; zebrafish larvae; sustainable nanobiotechnology.

ICAMMT:09

Design and Optimization of a Compact 150 GHz Microstrip Patch Antenna Using Inset Feeding and Partial Ground Modification

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ABSTRACT

This paper presents the design, numerical investigation, and optimization of a compact microstrip patch antenna intended for operation at 150 GHz. The proposed antenna is developed on a silicon substrate with a relative dielectric constant of 11.9 and a thickness of 0.2 mm. A conventional rectangular microstrip patch is initially designed to establish the reference electromagnetic response. Subsequently, an inset-feeding technique is introduced to improve impedance matching, and the effect of the inset dimension is systematically investigated. Four inset-feed dimensions of 0.1, 0.2, 0.3, and 0.4 mm are considered. The simulation results demonstrate that the feed configuration strongly influences the resonant characteristics of the antenna. Among the investigated cases, the 0.3 mm inset-fed configuration exhibits the most favorable impedance response, producing a minimum return loss of approximately −35.36 dB around the target 150 GHz frequency. For further evaluation, the optimized configuration is compared with a conventional patch and a partial-ground configuration. The conventional patch and partial-ground antenna exhibit return losses of approximately −15.41 dB and −26.72 dB, respectively, near the target operating region. The optimized inset-fed structure consequently provides improvements of approximately 19.95 dB and 8.64 dB compared with the conventional and partial-ground configurations, respectively. The corresponding radiation characteristics, including gain and directivity, are additionally evaluated to determine the suitability of the proposed structure for high-frequency applications. The results demonstrate that controlled modification of the feeding and ground configuration provides an effective approach for improving the electromagnetic performance of compact antennas at 150 GHz. The proposed antenna can serve as a suitable platform for emerging high-frequency communication, sensing, imaging, and short-range wireless systems.

KEY WORDS: 150 GHz Antenna, Microstrip Patch Antenna, Silicon Substrate, Inset Feed, Partial Ground, Return loss, VSWR, Gain, Directivity, High-Frequency Antenna.

ICAMMT:10

Green Synthesis of Tin Oxide Nano Particles using Kappaphycus Alvarezii (Seaweed) Aqueous Leaf extract By Co-Precipitation Method

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Abstract:

Nanotechnology has gained importance due to the unique properties and applications of nanomaterials. Among them, SnO_2 nanoparticles possess excellent optical, electrical, chemical, and photo catalytic properties. Green synthesis using biological resources is an eco-friendly and sustainable approach. Kappaphycus alvarezii, a bioactive red alga, can act as a natural source for nanoparticle synthesis. The present study focuses on the green synthesis and characterization of SnO_2 nanoparticles using Kappaphycus alvarezii extract. The study highlights its potential as a sustainable method for SnO_2 nanoparticle synthesis and nanotechnology applications.

Key Words: Nanotechnology, SnO_2 nanoparticles, Green synthesis, Kappaphycus alvarezii, Nanomaterials.

ICAMMT:11

SMART AGRICULTURE SYSTEM

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Abstract

Smart Agriculture System is an IOT-based technology designed to improve agricultural productivity and reduce the use of resources. The system uses sensors to monitor important parameters such as soil moisture, temperature, humidity, and water level. Based on the collected data, irrigation can be controlled automatically, supplying water to crops when required. This reduces water wastage, minimizes human effort, and supports healthy crop growth. The system provides farmers with real-time information and helps them make better decisions. Overall, smart agriculture offers a cost-effective, efficient, and sustainable approach to modern farming.

Keywords: Smart Agriculture, IOT, Soil Moisture, Sensors, Automatic Irrigation, Crop Monitoring, Water Management, Automation.

ICAMMT:12

Automatic Railway Gate Control System

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Abstract

The Automatic Railway Gate Control System is designed to improve safety at railway level crossings by automatically controlling the gate during the arrival and departure of trains. Manual operation may involve human errors and delays, which can lead to accidents. The proposed system uses IR sensors, a microcontroller, motor, buzzer, and LED indicators to detect train movement and control the railway gate automatically. When a train approaches the crossing, the IR sensor detects its movement and sends a signal to the microcontroller. The controller activates the warning buzzer and LED indicators and then operates the motor to close the gate, preventing vehicles and pedestrians from crossing the track. After the train completely passes the crossing, another sensor detects its departure, and the controller operates the motor to open the gate. The project demonstrates the practical application of sensors, electronics, automation, control systems, and embedded technology. It helps reduce human error and improves railway-crossing safety. The system can be further enhanced with obstacle detection, emergency stop, GSM alerts, and remote monitoring. Thus, the proposed system provides a simple, economical, reliable, and effective working model for automated railway safety.

Keywords: Automatic Railway Gate, IR Sensor, Microcontroller, Railway Safety, Automation, Motor Control, Embedded System, Sensor Technology, Level Crossing, Control System.

ICAMMT:13

Smart Assistive Belt for Visually Impaired People

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Abstract

The Smart Assistive Belt for Visually Impaired People is a wearable electronic Safety device designed to assist visually impaired individuals in detecting obstacles during walking. The system uses ultrasonic sensors to continuously detect obstacles and measure the distance between the user and surrounding objects. A microcontroller processes the sensor data and provides real-time feedback through vibration motors and a buzzer. Different vibration patterns can indicate the direction and proximity of obstacles, enabling the user to respond quickly without depending entirely on a conventional walking stick. The proposed system is compact, portable, low cost and easy to operate. It can improve mobility, obstacle awareness, and walking safety for visually impaired users.

Keywords: Smart Assistive Belt, Ultrasonic Sensor, Obstacle Detection, Microcontroller, Vibration Motor, Buzzer.

ICAMMT:14

Comprehensive review of Artificial Intelligence and Machine Learning: Concepts, Trends, and Applications

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Abstract

This paper presents a comprehensive review of Artificial Intelligence (AI) and Machine Learning (ML), exploring foundational concepts, emerging trends, and diverse applications. AI and ML have rapidly evolved, becoming pivotal in numerous fields including healthcare, finance, manufacturing, and autonomous systems. The review begins by outlining key concepts, including the distinctions between AI, ML, and deep learning, and delves into various learning paradigms such as supervised, unsupervised, and reinforcement learning. It highlights significant advancements, such as neural networks, natural language processing, and generative models, emphasizing their impact on industry and research. The paper also examines current trends, including the rise of ethical AI, explain ability, and the integration of AI with Internet of Things (IoT) and edge computing, which are shaping the future landscape of AI applications. Additionally, it addresses the challenges and limitations associated with AI and ML, such as data privacy concerns, model interpretability, and the need for sustainable computing solutions.

Keywords: Artificial Intelligence (AI), Machine Learning (ML), Deep Learning, Neural Networks, Supervised Learning, Unsupervised Learning, Reinforcement Learning, AI Trends, AI Applications.

ICAMMT:15

Growth and Characterization of 4-Aminopyridinium Salicylate Single Crystal with DFT Approach

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Abstract

The organic crystal 4-aminopyridinium 2-hydroxy benzoate (4APSA) was grown using slow evaporation solution growth technique. Single crystal x-ray diffraction analysis was used to elucidate 4APSA crystal. The 4APSA crystal has been crystallized in Orthorhombic crystal system with centrosymmetric space group (P_{bca}). The presence of functional groups and its vibrational assignments of 4APSA were identified using Raman spectroscopic analysis. The UV-Vis-spectrum shows good optical transmittance and its optical band gap of 4APSA was calculated. Photoluminescence spectrum shows broad emission peak at 412 nm. Using DFT, the first order hyper polarizability value of 4APSA was found to be 1.425 times greater than urea which settles the NLO activity.

Keywords: single crystal, slow evaporation technique, UV-Vis, Raman and DFT

ICAMMT:16

Design and Optimization of Copper Microstrip Patch Antenna using FR-4 Dielectric Substrate

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Abstract

This work presents the design and simulation of a microstrip patch antenna using FR-4 dielectric substrate and copper as the conducting material for the radiating patch and ground plane. The proposed antenna is designed for wireless communication applications with the objective of achieving good impedance matching, low return loss, and improved radiation performance. The antenna structure is modelled and analysed using CST Microwave Studio. The performance of the proposed antenna is evaluated in terms of resonant frequency, reflection coefficient (S_{11}), VSWR, gain, directivity, and radiation efficiency. The influence of the antenna dimensions and substrate properties on the resonant characteristics is also investigated. The simulated results demonstrate that the proposed FR-4-based microstrip patch antenna provides satisfactory electromagnetic performance with a compact and simple configuration. The proposed antenna can be used for suitable wireless communications and RF applications.

Keywords: Microstrip Patch Antenna, FR-4 Dielectric Substrate, Copper, Wireless Communication, CST Microwave Studio, Resonant Frequency.

ICAMMT:17

A compact 60 GHz Microstrip patch Antenna with SRR-Defected Ground Structure for 6G Applications"

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Abstract:

Millimeter-wave antennas operating around 60 GHz are gaining significant attention for next-generation wireless communication systems because of their potential to support high data rates, compact integration, and low- latency communication. In this work, a compact 60 GHz Microstrip patch antenna is designed and investigated using CST studio Suite. An inset- feeding technique is impedance matching, while a split- ring resonator (SRR) -based defected ground structure (DGS) is incorporated to modify the electromagnetic response and improve the antenna performance. The proposed antenna is systematically optimized by varying the key geometrical parameters to obtain the desired resonant frequency and radiation characteristics. The optimized design exhibits a return loss of approximately -30 dB at 60 GHz, indicating good impedance matching at the operating frequency. The proposed configuration is further evaluated in terms of voltage standing-wave ratio, impedance bandwidth, gain, directivity, radiation efficiency, and far-field radiation characteristics. The results demonstrate that the SRR-DGS effectively influence the current distribution and electromagnetic field behavior, resulting in improved antenna performance compared with the conventional patch configuration. The proposed compact antenna is therefore suitable for potential applications in 60 GHz millimeter-wave and next - generation wireless communication systems.

Keywords:
60 GHz, Millimeter-wave antenna, Micro strip patch antenna, Defected ground structure, Split-ring resonator, Inset feed, 6G wireless communication.

ICAMMT:18

Quantum Dot-Based Semiconductor Materials for Next-Generation Optoelectronic Applications

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Abstract

Quantum Dots (QDs) are zero-dimensional semiconductor nanomaterials whose optical and electronic properties can be controlled by varying their size, composition, and structure. Due to their unique quantum confinement effects, quantum dots exhibit tunable band gaps, size-dependent photoluminescence, high absorption coefficients, and excellent charge-carrier properties. These characteristics have attracted significant interest in modern optoelectronic technologies. This paper presents an overview of recent developments in quantum dot-based semiconductor materials and their potential applications in next-generation devices. Particular attention is given to emerging quantum dot materials such as metal chalcogenides, perovskite quantum dots, and carbon-based quantum dots. Their applications in light-emitting diodes, solar cells, photo detectors, sensors, and display technologies are discussed. The role of quantum confinement, surface modification, and material engineering in improving the optical and electronic performance of quantum dots is also highlighted. Despite their promising properties, challenges related to material stability, toxicity, environmental impact, and large-scale fabrication remain important. Recent advances in lead-free and environmentally friendly quantum dots offer promising solutions to these challenges. The integration of quantum dots with advanced semiconductor architectures is expected to enable highly efficient, flexible, and miniaturized optoelectronic devices, contributing to the development of future technologies.

Keywords: Quantum dots, Semiconductor materials, Quantum confinement, Perovskite quantum dots, Optoelectronics, Photo detectors, Solar cells.

ICAMMT:19

Important Roles of Nanoscience and Nanomaterials in Modern Era

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Abstract:

Nanoscience is an emerging field that focuses on understanding and controlling matter at the nanoscale (1–100 nm). At this scale, materials exhibit remarkable optical, electrical, magnetic, thermal and mechanical properties that differ from their bulk forms. Nanomaterials such as nanoparticles, nanowires, carbon nanotubes, graphene and quantum dots have gained importance because of their high surface area and enhanced performance. These materials find applications in healthcare, electronics, renewable energy, environmental protection, sensors and advanced engineering. Nanomaterials are being used in targeted drug delivery, efficient solar cells, energy-storage devices, water purification and smart sensors. The combination of nanoscience and nanotechnology is opening new possibilities for developing lightweight, efficient and sustainable materials. Thus, nanoscience and nanomaterials play an important role in advancing modern technologies and addressing future societal and environmental challenges

Keywords:

Drug Delivery, Health Care, Nano Science, Nano Properties and Environmental Challenges.

ICAMMT:20

Nano Structured Materials for Next-Generation: Advantage and Storage Applications

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Abstract:

Nanotechnology is one of the rapidly developing fields of modern science that deals with materials and structures at the nano scale. Typically ranging from 1 to 100 nanometers. Nanomaterials exhibit unique physical, chemical, optical and electrical properties compared with their bulk materials because of their small size and large surface-area-to-volume ratio. This paper presents an overview of nanotechnology and nanomaterials, their important properties, preparations methods and applications in various fields. Nano materials in different forms such ass nanoparticles, nanotubes, graphene and quantum dots have gained significant attention due to their remarkable characteristics. They widely used in electronics, medicine, energy stored devices, environmental protection, sensors and advanced materials. Nanotechnology also plays an important role in developing smaller, faster and more efficient technological devices. This study highlights the advantages, challenges and future potential of nano technology and nano materials in modern technology development. The integration of nanotechnology with different scientific fields can contribute to innovative solution and sustainable development.

Keywords:

Nanotechnology, Nanomaterials, Nano particles, Graphene, Quantum dots,

Modern technology.

ICAMMT:21

Development of Low-Cost Solar Stills using Locally available Materials

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Abstract:

Renewable energy technology is essential to address global energy scarcity and environmental sustainability, solar thermal energy in particulars offer an eco-friendly and affordable solution for water purification in rural areas. This study presents the design, fabrication and efficiencies analysis of a low-cost single-slope solar distillation system (solar still) that utilizes direct solar radiation to convert brackish or polluted water into pure drinking water. In this experimental work, the solar distillation unit was fabricated using locally available materials and a glass cover. The temperature variations and daily water output were recorded during peak sunlight hours. The physical properties, including PH and TDS levels, were analyzed before and after the process. The results showed a significant reduction in impurities, confirming that this solar device is highly efficient and cost-effective technology for domestic water purification.

Keywords:

Renewable Energy, Solar Thermal, Solar Distillation, Water Purification.

ICAMMT:22

Design and Numerical Optimization of an Efficient Lead free Cs_2TiBr_6 Pervoskite Solar Cells of Enhancement Photovoltaic Performance

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Abstract

Perovskite solar cells (PSCs) have attracted great interest as promising photovoltaic devices due to high efficiency, low-cost fabrication and excellent optoelectronic properties. However, the toxicity and instability of the traditional lead-based perovskites still pose great challenges to their practical applications. In this work, a numerical investigation is performed on a lead-free Cs2TiBr6 -based perovskite solar cell is by using SCAPS-1D simulation. The proposed device structure consists of FTO/TiO_2/ Cs_2TBr_6/PEDOT:PSS. Where FTO is as the transparent conducting oxide, TiO2 is the electron transport layer (ETL), Cs2TiBr6 is the absorber layer and PEDOT:PSS is the hole transport layer (HTL). The device parameters are optimized to enhance photovoltaic performance. The optimized device shows a V_{OC} of 1.4246 V, J_{SC} of 24.25 mA/cm2, fill factor of 69.06 % and power-conversion efficiency of 23.86%. The results highlight the promising potential of Cs2TiBr6 as an efficient and environment-friendly lead-free absorber material for efficient and environmentally friendly perovskite solar-cell applications.

Keywords: Perovskite Solar Cell; FTO/TiO_2/Cs_2TBr_6/PEDOT:PSS, SCAPS-1D, Numerical Simulation Power Conversion Efficiency (PCE).

ICAMMT:23

A Review on Nanostructured Electrode and Electrolytes for Energy Materials and Energy Storage Devices.

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Abstract

The increasing demand for clean and sustainable energy has created a strong need for efficient energy storage technologies. Energy storage devices such as lithium-ion batteries, super capacitor and emerging solid-state batteries play an important role in renewable energy systems, electric-vehicles and portable electronic applications. The performance of these devices largely depends on the properties of their electrodes and electrolyte materials. Advanced materials such as nano structured metal oxides, carbon-based materials, graphene, transition-metal compounds and solid electrolytes have attracted significant attention due to their high surface area. An improved electrical conductivity, enhanced energy density and better cycling stability. In particular, nano structuring provides improved ion and electron transport pathways, which can significantly increase the charge. This work focused on the recent developments in advanced electrode materials and their role in improving the energy density, Power density, safety and life time of energy storage system.

Keywords

Energy material, Energy Storage, Nanomaterials, Li-ion Batteries, Fuel Cell, nano based Polymer Electrolytes, Storage Devices.

ICAMMT:24

Enhanced Electrochemical Performance of ZIF-67@Graphene Quantum Dot Core–Shell Nanostructures for High-Performance Supercapacitor Applications

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Abstract

Super capacitors are sophisticated energy storage devices that, in comparison to traditional batteries, offer greater power density, quick charge-discharge capability, and a longer cycle life. Enhancing energy density while preserving superior power performance is still a significant obstacle, though. This study successfully synthesised and studied a ZIF-67@Graphene Quantum Dot (GQD) core–shell nanostructure as an effective electrode material for supercapacitor applications. GQDs improve the electrode's electrical conductivity, surface wettability, and pseudocapacitive behaviour, which speeds up ion diffusion and charge transfer. X-ray Diffraction (XRD), UV–Visible Spectroscopy (UV–Vis), Fourier Transform Infrared Spectroscopy (FTIR), and Field Emission Scanning Electron Microscopy coupled with Energy Dispersive X-ray Spectroscopy (FESEM–EDX) were used to characterise the synthesised material's structural, morphological, and compositional properties. The findings demonstrate that the core-shell structure benefits from the higher conductivity of GQDs while maintaining the crystalline structure and hierarchical porosity of ZIF-67. According to electrochemical studies, the optimised Z6G-2 electrode offers superior cycling stability, improved rate capability, and a high specific capacitance of 353 F g^{-1} at a current density of 0.5 A g^{-1}. Additionally, an asymmetric Z6G-2/Activated Carbon (AC) coin-cell supercapacitor was constructed to assess its usefulness. After 5000 charge-discharge cycles, the constructed device maintains exceptional capacitance retention and displays an energy density of 25.5 Wh kg^{-1} and a power density of 2.7 kW kg^{-1}. These results show that the ZIF-67@GQD core–shell nanostructure is a potential electrode material for high-performance energy storage devices of the future.

Keywords: Metal–Organic Framework (MOF), Graphene Quantum Dots (GQDs), Supercapacitors, Core–shell nanocomposites.

ICAMMT:25

Design and Analysis of a Multiband Microstrip Patch Antenna Using Rogers RT/Duroid 5880 Substrate for Millimeter-Wave Applications

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Abstract

This work presents the design and simulation of a multiband microstrip patch antenna using Rogers RT/Duroid 5880 as the dielectric substrate and copper as the conducting material proposed antenna is designed and analyzed using CST Microwave Studio for millimeter - wave communication applications. The simulated S-parameter response exhibits multiple resonant frequencies in the approximately 49 GHz, 63 GHz, and 76 GHz frequency bands, demonstrating the multiband characteristics of the proposed antenna. The antenna performance is evaluated in terms of reflection coefficient (S11), VSWR, impedance matching, gain, directivity, and radiation efficiency. The use of the low - loss Rogers RT/Duroid 5880 substrate contributes to improved high - frequency performance. The obtained results indicate that the proposed antenna is a promising candidate for millimeter - wave, 5G/6G, and high - frequency wireless communication applications.

Keywords Multiband antenna, Rogers RT, CST Microwave Studio, S-parameter, VSWR,

ICAMMT:26

Design and Analysis of a Microstrip Patch Antenna Using Rogers RT/ Duroid 5880LZ Substrate for X-Band Application

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Abstract

This work presents the design and simulation of a microstrip patch antenna employing Rogers RT/Duroid 5880LZ as the dielectric substrate and copper as the conducting material. The proposed antenna is designed and analyzed using CST Microwave studio for high-frequency wireless communication applications. The simulated S-parameter response shows a distinct resonance at approximately 10.1 GHz, with a minimum reflection coefficient of about -21 dB, indicating good impedance matching at the operating frequency. The antenna performance is investigated in terms of reflection coefficient (S11),VSWR, gain, directivity, bandwidth, and radiation efficiency. The low- loss characteristics of the Rogers RT/ Duroid 5880LZ substrate make it suitable for high-frequency antenna applications. The obtained results demonstrate that the proposed antenna has good potential for X-band communication, radar, satellite communication, and other microwave applications.

Key words

Micro strip patch antenna, Rogers RT Duroid 5880LZ, CST Microwave Studio,S_{11}

ICAMMT:27

SRR-Based Defected Group Structure for Enhanced Impedance Matching of a 1.5THz Micro strip Patch Antenna*

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Abstract

The terahertz (THz) frequency band has emerged as a promising frequency regime for sixth-generation (6G)wireless communication, biomedical imaging, and sensing applications. However, antenna design at THz frequencies remains challenging because of increased conductor and dielectric losses and stringent fabrication requirements. In this work, a compact micro strip patch antenna (MPA) operating at 1.5 THz is proposed and investigated using CST studio suite. The antenna incorporates an inset-fed resonator (SRR) -based defected ground structure (DGS) to improve impedance matching and enhance the overall radiation performance. The optimized antenna achieves a return loss of approximately -30 dB a realized gain of 2.57 dBi, a directivity of 5.47 dBi, and a radiation efficiency of approximately 51% The simulated far-field radiation pattern exhibits stable broadside radiation with a 3-dB beam width of 95.6-°. The results demonstrate that the incorporation of the SRR-DGS effectively modifies the electromagnetic response of the antenna and provides improved impedance matching at the target THz frequency. The proposed antenna offers a compact and efficient configuration suitable for potential applications in 6G wireless communication, terahertz imaging, and biomedical sensing systems.

Keywords

Terahertz (THz), Microstrip patch Antenna (MPA), Defected Ground Structure (DGS), Split -Ring Resonator (SRR), 6G Wireless Communication, Radiation Efficiency, Inset Feed.

ICAMMT:28

Semantic fragmentation for data validation in unidentified robotic Automobile

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Abstract

Semantic fragmentation is a vital aspect of computer vision, widely used in fields such as autonomous driving, medical imaging, and industrial automation. Maintaining high-quality data sets is crucial for enhancing model accuracy and minimizing real-world errors. This paper focuses on developing a comprehensive data validation pipeline for semantic fragmentation using OpenCV. The proposed framework integrates automated integrity checks, preprocessing techniques, and consistency verification to manage large-scale datasets effectively. Key validation processes include image quality assessment (detection of blurriness and noise), verification of annotation accuracy, class distribution analysis, and identification of anomalies. Additionally, OpenCV-powered preprocessing steps such as image resizing, normalization, contrast optimization, and data augmentation, are applied to refine dataset quality for fragmentation models. This paper also addresses scalability concerns associated with processing extensive datasets, introducing optimized batch handling and parallel validation techniques.

Keywords

Dataset, Deep Lab, Imaging semantic fragmentation, OpenCV, Unidentified robotic automobile.

ICAMMT:29

Development of Solid Biomaterial (Piper Betel) Electrolyte for Primary Proton Battery with Ammonium Thiocyanate

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Abstract

A proton battery using Piper betel as a bio-based proton-conducting material is investigated for its electrical and electrochemical properties. The study evaluates proton conductivity and electrochemical stability to explore its potential for sustainable energy-storage applications. A Solid biomaterial electrolyte was prepared using Piper betel as the host matrix, doped with ammonium thiocyanate (NH_4SCN) as the ionic salt and solvent as double distilled water used in the solution casting technique. AC impedance technique is used to analysis the ionic conductivity of the prepared biomaterial membranes. The maximum ionic conductivity achieved was 2.66 ×10-3 S/cm for 1 g PB+ 0.4 wt % NH4SCN at room temperature. Conductance spectra were analyzed to understand the dc conductivity of the biomaterial. The open-circuit voltage (OCV) was measured to be 1.48V, and the battery was successfully tested under a 100 kΩ. These results establish Piper betel biomaterial as a promising, sustainable alternative host matrix for solid-state ionic conductors, opening avenues for green electrolyte development in next-generation battery technologies.

Keywords: Solid biomaterial electrolyte, Primary proton battery, AC impedance, Conduction spectra, ionic conductivity.

ICAMMT:30

Edge Computing vs Cloud Computing: Perfecting or Fierce

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Abstract

The rapid evolution of technology has given rise to fringe and cloud computing as pivotal paradigms in modern IT infrastructure. Both approaches offer unique advantages, addressing distinct challenges in processing, storage, and Data analytics. This paper explores the Fundamental Principles of these paradigms offer distinct advantages that cater to varying requirements in processing, storage, and data analysis. Cloud computing excels in delivering scalable and centralized solutions for extensive data processing and storage needs. In contrast, edge computing addresses the increasing demand for low-latency, real-time data processing by bringing computation closer to the data source. This paper examines the core principles, use cases, and technological trends of both paradigms, assessing whether they function a technology or fierce. Through an in-depth analysis of real-world applications, challenges, and opportunities, this study slough light on the Robust interplay between edge and cloud computing, compares their functionalities, and evaluates whether they operate as perfecting technologies or fierce for puissance in various application domains. By Scrutinizing real-world use cases and technological trends, this study provides insights into the future interplay between edge and cloud computing.

Keywords: Edge Computing; Cloud Computing; Fog Computing; Real-Time Data Processing; Low-Latency Computing; Distributed Computing; Data Analytics; Internet of Things (IoT); Scalability; Hybrid Computing; Edge–Cloud Integration; Emerging Technologies**.**

ICAMMT:31

Synthesis and Characterization of Cu-Doped ZnO Nanoparticles for Biological Application

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Abstract

Copper-doped zinc oxide (Cu-doped ZnO) nanoparticles are one of the hottest topics of research for new multifunctional nanomaterials, because they can be changed at a chemical level and have some very encouraging biological activities. This paper deals with producing Cu-doped ZnO nano particles by a controlled wet-chemical method, with the goal of improving the natural attributes of ZnO by introducing copper into the quartzite structure. Structural aspects and phase purity are investigated by X-ray diffraction, while the local bonding environment is explored using Fourier-transform infrared spectroscopy. Morphology and particle size are determined with electron microscopy, and optical properties, including band gap changes caused by Cu doping, are studied by UV-Vis spectroscopy combined with proper band gap assessment. The biological capability of the newly made nanoparticles is tested by in vitro assays suitable for biomedical usage, mostly for the impact of dopant concentration and nano particle features on the biological response. The study and results presented in the paper, in conjunction, show hope for Cu-doped ZnO nanoparticles as possibly the next generation of biological and therapeutic agents.

Keywords: Cu-doped ZnO nanoparticles; biological application; nanobiotechnology; reactive oxygen species; biomedical nanomaterials.

ICAMMT:32

Development of Zinc Perchlorate-Incorporated Iota-Carrageenan Solid Polymer Electrolytes with Improved Ionic Conductivity for Solid-State Zinc Energy Storage

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Abstract

The growing demand for environmentally benign and intrinsically safe energy-storage systems has accelerated the development of bio-based solid polymer electrolytes. In this study, iota-carrageenan was employed as a renewable polymer host, while zinc perchlorate [$Zn(ClO_4)_2$] was introduced as the ionic dopant to fabricate solid polymer electrolyte membranes using a solution-casting approach. The influence of salt concentration on the structural, morphological, thermal, dielectric, and electrical characteristics of the membranes was systematically evaluated. X-ray diffraction and Fourier-transform infrared spectroscopy confirmed the formation of polymer–salt interactions accompanied by a reduction in crystalline ordering, promoting the development of amorphous regions favorable for ionic migration. Surface morphology analysis further revealed homogeneous salt dispersion within the polymer matrix, whereas thermal studies demonstrated sufficient stability for electrochemical applications. Dielectric investigations indicated enhanced polarization and improved charge-storage capability with increasing dopant concentration. Among the prepared compositions, the membrane containing 0.175 wt% $Zn(ClO_4)_2$ exhibited the highest room-temperature ionic conductivity of 2.84×10^{-3} S cm^{-1}. Transport-property analysis suggested that the conductivity enhancement originated mainly from an increased density of mobile charge carriers, despite a marginal reduction in ion mobility at higher salt loading. To assess practical applicability, the optimized electrolyte was incorporated into a solid-state Zn/MnO_2 primary battery, which delivered an open-circuit voltage of 1.83 V and maintained stable discharge characteristics under external load conditions. These findings demonstrate that zinc perchlorate effectively improves the electrochemical performance of iota-carrageenan-based polymer electrolytes, highlighting their promise as sustainable electrolyte materials for future solid-state zinc energy-storage technologies.

Keywords

Biopolymer electrolyte; Iota-carrageenan membrane; Zinc perchlorate; Ionic conductivity; Polymer-salt complexation; Solid-state zinc battery; Electrochemical energy storage

ICAMMT:33

Development of a Photonic Sensor for Real-Time Monitoring and Biochemical Characterization of Seaweed in Sustainable Aquaculture

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Abstract

Seaweed aquaculture plays an increasingly important role in sustainable food production, biofuel development, and carbon sequestration, creating a demand for rapid and non-destructive techniques to monitor seaweed biochemical composition. Conventional analytical methods for quantifying pigments, proteins, and polysaccharides are laboratory-based, time-consuming, and unsuitable for continuous in situ monitoring. In this work, a one-dimensional photonic crystal (1D PhC) biosensor is proposed for label-free optical detection of biochemical variations in seaweed. The sensor consists of alternating Si/SiO_2 Bragg reflector layers with a central analyte-filled defect cavity that supports a localized resonance mode within the photonic bandgap. Variations in the refractive index of the analyte modify the defect-mode resonance, enabling optical detection through resonance wavelength shifts. The sensing mechanism is investigated using optical transmission, reflection, and electric-field confinement analyses to demonstrate enhanced light–matter interaction within the defect cavity. The proposed photonic architecture provides a compact, non-invasive, and potentially real-time sensing platform for monitoring seaweed physiological status and biochemical composition. Furthermore, the sensor framework can be integrated with data-driven analytical approaches for predictive monitoring and intelligent aquaculture management. The proposed design offers a promising strategy for developing next-generation optical biosensors for sustainable marine and aquaculture applications.

Keywords: Photonic crystal, seaweed aquaculture, biochemical monitoring, optical biosensor, sustainable aquaculture.

ICAMMT:34

Analysis and Research of the Mining Concepts

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Abstract

Mining is a new research area it needs more discussion among to define exactly what it is. Web Mining is an important research field in data mining. The aim of this paper is to explore the role of data mining for information extraction in web content, structure and usages mining in current web modules, and the outlines the process of extracting patterns from data. Web mining is the application of data mining techniques to extract knowledge from web data, including web documents, hyperlinks between documents, usage logs of web sites, etc. and also the complete work of the web data mining is explained.

Keywords: Data Mining, Web Mining, Web usage mining, Web content mining, Web structure mining.

ICAMMT:35

Knowledge Graphs for Materials Discovery and Innovation

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ABSTRACT

The exponential growth of materials science data creates severe challenges in information retrieval and cross-domain synthesis. Traditional document-based communication hinders machine action ability and efficient data sharing. To bridge this gap, domain-specific knowledge graphs are constructed using advanced natural language processing and transformer models to extract structured relational triples from large publication corpora. These semantic frameworks integrate material names, chemical formulas, synthesis routes, characterization techniques, and target properties. By organizing disconnected data into unified graph structures, knowledge graphs enable advanced link prediction, inverse property inference, and data-driven recommendations, ultimately bypassing costly trial-and-error workflows to expedite accelerated materials innovation.

Keywords:

Knowledge Graph (KG), Materials Discovery, Materials Science, Natural Language Processing(NLP), Information Extraction, Ontology, Data Integration, Machine Learning

ICAMMT:36

Data Centric Approaches for Sustainable Material

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Abstract

This study investigates the transformative potential of data-centric methodologies in accelerating the development, selection, and lifecycle management of sustainable materials. By integrating high-throughput computational materials datasets, machine learning, and rigorous data quality governance, the proposed framework enables predictive modeling of material properties and environmental impacts. The findings demonstrate that prioritizing data integrity, traceability, and semantic annotation significantly reduces experimental inefficiencies, supports evidence-based substitution of scarce resources, and facilitates the transition toward a closed-loop circular economy. This research provides a scalable, data-driven foundation for researchers and industry stakeholders aiming to align material innovation with global sustainability objectives.

Keywords:

Data-Centric Materials Science, Machine Learning (ML), Sustainable Material Selection, Circular Economy, Predictive Analytics, Life Cycle Assessment (LCA), Materials Informatics, Data Governance and Quality.

ICAMMT:37

Intelligent Database for Material Characterization

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Abstract

The exponential growth of scientific literature and high-throughput experimental data requires robust, data-driven frameworks. We present an intelligent material knowledge graph and database platform designed to automatically extract entities and property relationships—such as materials, processing conditions, and characterization spectra—from unstructured text. By utilizing advanced deep learning models and natural language processing, this system accelerates materials selection, uncovers latent knowledge, and establishes structure-property mappings. Ultimately, this intelligent platform redefines how materials data is stored, interpreted, and utilized for predictive modeling in academia and industry.

KEYWORDS

Materials Characterization, Artificial Intelligence, Materials Informatics, Knowledge Graph, Machine Learning.

ICAMMT:38

Cyber-Physical Systems in Advanced Manufacturing

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Abstract

Cyber-Physical Systems (CPS) enables intelligent and automated manufacturing by integrating digital technologies with physical machinery. CPS enables real-time monitoring and control of production processes by combining sensors, embedded systems, and communication networks. Through the Industrial Internet of Things (IIOT), CPS facilitates smart production in advanced manufacturing, increasing productivity, reducing downtime, and improving product quality. Additionally, it enables flexible and adaptive systems for mass customization. CPS contributes significantly to Industry 4.0 and smart factories by utilizing technologies such as data analytics and artificial intelligence to enhance productivity and innovation.

Keywords

Cyber-Physical Systems (CPS), Advanced Manufacturing, Industry 4.0, Smart Factories, Industrial Internet of Things (IIOT), Real-Time Monitoring, Automation, Embedded Systems, Sensor Networks, Predictive Maintenance, Data Analytics, Artificial Intelligence, Machine Learning, Flexible Manufacturing, Mass Customization, Productivity Enhancement, Process Optimization.

ICAMMT:39

Digital Twin-Based Predictive Quality Control

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Abstract

By identifying characteristics like temperature, pressure, moisture, vibration, and stress, smart sensors allow for ongoing, real-time material monitoring. Sensor data can be processed and monitored remotely thru wireless transmission, microcontrollers, and the Internet of Things. This facilitates early defect and damage detection, enhances material safety and quality, shortens inspection times, and supports predictive maintenance. As a result, smart sensors offer a practical way to monitor materials in real time.

Keywords

Digital Twin, Predictive Quality Control, IOT, Artificial Intelligence, Real-Time Monitoring, Data Analytics, Quality Prediction, Defect Detection, Smart Manufacturing, Predictive Maintenance, Virtual Model, Industrial Automation.

ICAMMT:40

SMART SENSORS FOR REAL-TIME MATERIAL

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Abstract

By identifying characteristics like temperature, pressure, moisture, vibration, and stress, smart sensors make it possible to continuously monitor materials in real time. Sensor data can be processed and observed remotely thru wireless transmission, microcontrollers, and the Internet of Things. This facilitates early defect and damage detection, enhances material quality and safety, shortens inspection times, and supports predictive maintenance. As a result, smart sensors offer an effective way to monitor materials in real time.

Keywords

Smart Sensors, Real-Time Monitoring, Material Monitoring, IoT, Sensor Technology, Wireless Sensors, Material Properties, Temperature Sensing, Pressure Sensing, Moisture Detection, Vibration Monitoring, Structural Health Monitoring, Data Acquisition, Real-Time Data, Predictive Maintenance, Material Quality, Defect Detection, Industrial Automation, Remote Monitoring, Smart Materials.

ICAMMT:41

Data Mining Approaches for Smart Manufacturing Optimization

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Abstract

Smart manufacturing systems in Industry 4.0 generate high-dimensional, real-time data from interconnected industrial environments. Traditional rule-based models fail to capture complex, dynamic interactions between machines, processes, and supply chains. This study explores data mining and machine learning approaches to convert massive industrial datasets into actionable intelligence. By employing techniques such as clustering, classification, and association rule mining, the proposed framework identifies hidden patterns, optimizes production parameters, and enables predictive maintenance. Experimental results demonstrate enhanced process transparency, reduced equipment downtime, and improved resource efficiency in smart factories.

Keywords

Smart Manufacturing, Data Mining, Process Optimization, Predictive Maintenance, Industrial Internet of Things (IIOT), Machine Learning, Industry 4.0.

ICAMMT:42

Virtual Simulation Models for Material Processing

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Abstract

This study presents an integrated virtual simulation framework for advanced materials processing, coupling multi-physics continuum mechanics with multi-scale micro structural evolution models. By mapping process parameters—such as thermal gradients, tool paths, and mechanical loads—into a unified digital representation, the model accurately predicts final part distortion, phase transformations, and mechanical integrity. Validation against empirical benchmark data confirms that the virtual approach significantly reduces trial-and-error design cycles while providing robust optimization pathways for complex industrial manufacturing.

Keywords:

Virtual Simulation, Materials Processing, Multi-Scale Modeling, Microstructure Evolution, Finite Element Analysis (FEA), Digital Twin, Numerical Optimization, Process-Structure-Property Relationships.

ICAMMT:43

Sustainable Ai Techniques for Green Manufacturing Systems

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Abstract

Sustainable industrial development depends on the incorporation of artificial intelligence (AI) into green manufacturing systems. This abstract examines sustainable AI methods that are tailored for low computational energy usage, such as machine learning and predictive analytics. It looks at how they might be used to improve lifecycle management, optimize resource usage, and reduce industrial waste. Manufacturers may achieve accurate supply chain alignment and real-time carbon footprint measurement by putting eco-friendly algorithms into practice. In the end, our research shows how green AI functions as a dual-purpose mechanism that greatly reduces environmental impact while increasing operational efficiency, offering a model for the development of data-driven, sustainable factory ecosystems in the future.

Keywords:

Green AI, Sustainable Manufacturing, Energy Efficiency, Predictive Maintenance, Circular Economy, Digital Twins, Optimization Algorithms, Resource Conservation, Carbon Footprint Tracking, Industry 4.0.

ICAMMT:44

Graph Neural Network for Crystal Structure Prediction

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Abstract

Graph Neural Networks (GNNs) are revolutionizing AI-assisted computational materials engineering, especially in crystal structure prediction (CSP). GNNs lower the computational requirements of techniques like Density Functional Theory (DFT) by modelling atomic structures as graphs. Lattice stability predictions are improved by sophisticated models that capture intricate interactions, such as Atomistic Line Graph Networks (ALIGNN) and Crystal Graph Convolutional Neural Networks (CGCNN). These networks make it possible to quickly assess characteristics like formation energy and volume. When paired with generative models, they also make it easier to find new crystal polymorphs, which speeds up the design of materials.

Keywords:

Graph Neural Networks, Crystal Structure Prediction, Computational Materials Engineering, Geometric Deep Learning, Symmetry-Aware Architectures, Periodic Boundary Conditions, Generative Materials Design, High-Throughput Screening, Interatomic Potentials, Density Functional Theory Acceleration.

ICAMMT:45

Blockchain-Based Traceability in Smart Manufacturing

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Abstract

Global supply networks are essential to modern smart manufacturing, necessitating previously unheard-of levels of data quality, security, and openness. Data silos, illegal manipulation, and a lack of mutual trust among stakeholders are problems with traditional centralized tracking systems. By offering end-to-end visibility and verifiable data tracking from raw materials to completed goods, block chain technology enables a decentralized, immutable ledger system that revolutionizes industrial operations. With an emphasis on Industry 4.0 settings, this work investigates the integration of block chain technology with smart manufacturing frameworks. It looks at how smart contracts improve intellectual property protection, automate compliance, and facilitate safe data transfer across Industrial Internet of Things (IIOT) devices. This chapter offers a definitive road map for creating robust, trust-free and completely traceable manufacturing ecosystems by analyzing real-world case studies and implementation problems.

Keywords

Smart Manufacturing, Block chain Technology, Supply Chain Traceability, Industry 4.0, Immutable Ledger, Smart Contracts, Industrial Internet of Things, Data Integrity, Decentralized Systems, End-to-End Visibility.

ICAMMT:46

Wireless Sensor Network for Structural Health Monitoring

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Abstract

For crucial infrastructure, such as buildings and bridges, to be safe and long-lasting, structural health monitoring, or SHM, is essential. Conventional wired monitoring systems are frequently costly, challenging to set up, and disruptive to use. By providing continuous, real-time data collection without requiring significant wiring, Wireless Sensor Networks (WSNs) provide a ground-breaking, affordable alternative. The use of WSNs in contemporary structural monitoring applications is investigated in this article. It draws attention to important issues like energy harvesting, data synchronization, and sensor lifespan. The chapter shows how smart wireless nodes enhance catastrophe preparedness and optimize maintenance schedules for safer global infrastructure by overcoming these limitations.

Keywords

Structural Health Monitoring, Wireless Sensor Networks, Real-Time Data Acquisition, Energy Harvesting, Data Synchronization, Damage Detection, Infrastructure Longevity, Smart Sensors, Internet of Things (IoT), Predictive Maintenance.

ICAMMT:47

Cloud-Based High-Performance Simulation Platforms

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Abstract

Smart material design has been transformed by artificial intelligence (AI), which makes it possible to quickly forecast and optimize complicated, stimulus-responsive behaviours. Modern deep learning architectures, however, frequently function as opaque "black boxes," hiding the underlying physical mechanisms and restricting their use in engineering domains where safety is crucial. The use of Explainable Artificial Intelligence (XAI) frameworks, including SHAP, LIME, and symbolic regression, in advanced materials informatics pipelines is assessed in this chapter. We investigate how these interpretabilities techniques decipher intricate, non-linear interactions between processing, structure, and properties in adaptive systems such as piezoelectric polymers and shape-memory alloys. XAI verifies predictive models against accepted thermodynamic principles by transforming abstract mathematical weights into physically understandable insights. In the end, this work offers a solid, data-driven framework that reduces development risks, gets rid of costly experimental trial-and-error, and creates a reliable blueprint for automated inverse smart material.

Keywords

Cloud Computing, High-Performance Computing (HPC), Simulation Platforms, Elastic Scalability, Distributed Systems, Cloud-HPC Platforms, Parallel Processing, Dynamic Provisioning, Data-Intensive Workloads, Infrastructure as a Service (IaaS).

ICAMMT:48

Explainable Ai for Smart Material Design Optimization

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Abstract

Smart material design has been transformed by artificial intelligence (AI), which makes it possible to quickly forecast and optimize complicated, stimulus-responsive behaviors. Modern deep learning architectures, however, frequently function as opaque "black boxes," hiding the underlying physical mechanisms and restricting their use in engineering domains where safety is crucial. The use of Explainable Artificial Intelligence (XAI) frameworks, including SHAP, LIME, and symbolic regression, in advanced materials informatics pipelines is assessed in this chapter. We investigate how these interpretabilities techniques decipher intricate, non-linear interactions between processing, structure, and properties in adaptive systems such as piezoelectric polymers and shape-memory alloys. XAI verifies predictive models against accepted thermodynamic principles by transforming abstract mathematical weights into physically understandable insights. In the end, this work offers a solid, data-driven framework that reduces development risks, gets rid of costly experimental trial-and-error, and creates a reliable blueprint for automated inverse smart material.

Keywords

Explainable AI (XAI), Smart Materials, Materials Informatics, Material Optimization, Model Interpretability, Inverse Material Design, Structure-Property Linkages, SHAP/LIME Frameworks, Stimulus-Responsive Materials, Physics-Informed Machine Learning.

ICAMMT:49

Image Processing for Nanomaterial Characterization

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Abstract

Nanotechnology advancement depends on accurate nanomaterial characterization, yet manual examination of microscope images (SEM, TEM, and AFM) is laborious and subjective. This chapter discusses machine learning and digital image processing as ways to automate Nano scale study. We examine important workflows, such as deep learning for automated defect detection, texture analysis for surface roughness, and automated picture segmentation for nanoparticle sizing. These methods remove human bias, increase statistical reliability, and reveal subtle structural characteristics by converting raw micrographs into high-fidelity quantitative data. This work creates a data-driven framework to greatly speed up advanced manufacturing, quality control, and nanomaterial screening.

Keywords

Nanomaterial Characterization, Image Segmentation, Electron Microscopy (SEM/TEM), Deep Learning, Quantitative Metrology, Computer Vision, Feature Extraction, Particle Size Distribution, Defect Detection, Materials Informatics.

ICAMMT:50

Transfer Learning Techniques for Predicting Mechanical Properties of Composite Material

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Abstract

Forecasting the mechanical attributes of composite materials is essential for optimal material design and engineering applications. Established experimental approaches can be laborious and costly, in contrast to machine learning, which offers more rapid predictions. Nevertheless, machine learning models typically demand substantial datasets. Transfer learning overcomes this shortcoming by imparting knowledge from similar sources or larger datasets to composite systems that possess limited data. This section explores transfer learning strategies for estimating characteristics including tensile strength, elastic modulus, flexural strength, and compressive strength. It includes model modification, data pre-treatment, attribute selection, optimization, and model verification. This chapter underscores the merits and difficulties associated with transfer learning, along with its ability to diminish experimental expenses and expedite the progression of sophisticated composite materials.

Keywords:

Transfer Learning, Domain Adaptation, Composite Materials, Mechanical Properties, Microstructure, Structure-Property Linkages, Sim-to-Real, Data-Efficient Learning.

ICAMMT:51

Intelligent Human–Machine Collaboration in Smart Manufacturing

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Abstract

Smart manufacturing integrates cutting-edge technologies such as Artificial Intelligence (AI), robotics, the Internet of Things (IOT), machine learning, sensors, and data analytics to transform industrial production. Intelligent human–machine collaboration enables humans and robots to work together, combining human creativity, decision-making, and experience with the efficiency of intelligent machines. Collaborative robots (cobots) enhance safety, productivity, quality, and flexibility while supporting real-time data analysis and predictive maintenance. However, challenges such as employee training, cyber security, data privacy, technology costs, job displacement, and human trust must be addressed. This study examines the benefits, applications, challenges, and future potential of intelligent human–machine collaboration in smart manufacturing.

Keywords

Smart Manufacturing, Human–Machine Collaboration, Artificial Intelligence, Collaborative Robots, Industry 4.0, Internet of Things, Machine Learning, Automation, Robotics, Digital Transformation.

ICAMMT:52

Secure Data Sharing Frameworks for Materials Research

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Abstract

The rapid growth of computational simulations, laboratory experiments, sensor technologies, and materials databases has generated large volumes of valuable data for materials research. Sharing these data among researchers, institutions, and industrial organizations can accelerate collaboration and support the development of advanced materials. However, materials research data may contain sensitive experimental results, proprietary information, intellectual property, and confidential research findings. Therefore, secure and reliable data-sharing frameworks are essential for protecting information while enabling controlled access. Secure data sharing frameworks can integrate encryption, authentication, access control, data integrity verification, secure communication protocols, and privacy-preserving technologies to protect materials data throughout its lifecycle. Cloud computing, blockchain, distributed storage, and federated learning can further support trusted and decentralized data exchange without unnecessarily exposing sensitive information. Such frameworks can enable researchers to share experimental results, material properties, simulation outputs, and datasets while maintaining confidentiality and data integrity. By combining security mechanisms with interoperable data management practices, secure data-sharing frameworks can improve research collaboration, reproducibility, and knowledge exchange. Overall, these approaches provide a foundation for trustworthy, scalable, and collaborative materials research while reducing the risks associated with unauthorized access and data misuse.

Keywords: Secure Data Sharing, Materials Research, Data Security, Encryption, Access Control, Authentication, Privacy Preservation, Block chain, Federated Learning, Intellectual Property Protection**.**

ICAMMT:53

Machine Learning Models for Predicting Material Properties in Energy Applications

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Abstract

Machine learning has become an increasingly important approach for predicting chemical properties within the field of materials science. Recent developments in computational methods have encouraged greater use of machine learning techniques to investigate and predict the characteristics of energetic materials. This study reviews recent research focused on estimating important properties of energetic compounds, such as density, detonation velocity, enthalpy of formation, sensitivity, heat of explosion, and decomposition temperature. It also explores the major stages of constructing effective predictive models, including data acquisition, molecular representation, selection of suitable algorithms, and model performance assessment. Furthermore, the study discusses existing challenges, limitations, and potential future directions for applying machine learning to energetic materials. Overall, machine learning demonstrates considerable potential for supporting the efficient design, optimization, and advancement of next-generation energetic materials through data-driven methodologies.

Keywords

Machine Learning, Materials Science, Energetic Materials, Material Properties, Predictive Modeling, Density Prediction, Detonation Velocity, Enthalpy of Formation, Sensitivity Analysis, Heat of Explosion, Decomposition Temperature, Data-Driven Materials Design.

ICAMMT:54

Ai And Machine Learning for Advanced Material

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Abstract

Artificial Intelligence (AI) and Machine Learning (ML) are transforming advanced materials research by enabling faster, more accurate and data-driven prediction of material properties and performance. Traditional material development methods are often time-consuming and require extensive experimental and computational resources. AI and ML techniques can analyze large and complex datasets to identify patterns, predict material characteristics, optimize compositions, and support the discovery of novel materials. These approaches have applications in areas such as energy storage, aerospace, electronics, nanotechnology, and sustainable materials development. The integration of AI with computational modeling and experimental methods can reduce development time, improve efficiency, and accelerate materials innovation. However, challenges related to data quality, model accuracy, interpretability, computational requirements, and validation remain important considerations. This study explores the role, applications, benefits, challenges, and future potential of AI and Machine Learning in the development of advanced materials.

Keywords

Artificial Intelligence, Machine Learning, Advanced Materials, Material Properties, Predictive Modeling, Materials Discovery, Data Analytics

ICAMMT:55

Artificial Intelligence for Accelerated Discovery of Advanced Functional Materials

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Abstract

Artificial Intelligence (AI) is emerging as a powerful approach for accelerating the discovery and development of advanced functional materials. Conventional materials research often involves extensive experimentation, high computational costs, and significant time requirements. AI and Machine Learning (ML) techniques can analyze large and complex datasets to identify relationships between material composition, structure, and properties. These methods support the prediction of material performance, optimization of material design, screening of potential candidates, and identification of promising new materials. The integration of AI with computational simulations and experimental techniques can significantly improve the efficiency of the materials discovery process. Applications include energy storage, catalysis, electronics, photonics, and other advanced technological fields. Despite these advantages, challenges such as data availability, model reliability, interpretability, and experimental validation remain. This study highlights the role of AI in accelerating the discovery, design, and optimization of advanced functional materials.

Keywords

Artificial Intelligence, Machine Learning, Advanced Functional Materials, Materials Discovery, Predictive Modeling, Material Design, and Data-Driven Research.

ICAMMT:56

Privacy-Preserving Materials Discovery

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Abstract

A novel method called "Privacy-Preserving Material Discovery" allows scientists to find and create new materials while safeguarding private scientific information. Conventional material discovery frequently necessitates the sharing of computational data, material compositions, and experimental results—all of which may contain sensitive information. Researchers and organizations can work together without explicitly disclosing their private information thanks to privacy-preserving strategies including federated learning, encryption, safe data exchange, and privacy-aware machine learning. These techniques can preserve data confidentiality and intellectual property protection while speeding up the discovery of cutting-edge materials with desirable qualities. This strategy promotes safe and effective materials research, enhances teamwork, and lowers the Possibility of data leaking. Therefore, a safe foundation for fusing contemporary artificial intelligence with materials research is provided by privacy-preserving material discovery.

Keywords

Privacy-Preserving Materials Discovery combines AI, machine learning, and data security to discover new materials while protecting sensitive research data. It uses techniques like encryption, federated learning, and secure data sharing to enable safe collaboration and efficient material discovery.

ICAMMT:57

Ai and HPC Integration for Next-Generation Materials Research

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Abstract

The integration of Artificial Intelligence (AI) and High-Performance Computing (HPC) is transforming next-generation materials research by enabling faster and more efficient materials discovery and development. Traditional approaches often require extensive computational resources, complex simulations, and time-consuming experiments. AI and Machine Learning (ML) techniques can analyze large datasets, identify complex relationships, predict material properties, and optimize material compositions, while HPC provides the computational power required for large-scale simulations and data processing. The combined use of AI and HPC supports rapid screening of potential materials, accurate property prediction, computational modeling, and accelerated materials design. This integration has significant applications in energy storage, semiconductors, aerospace, nanotechnology, catalysis, and sustainable materials. However, challenges related to data management, computational costs, model reliability, scalability, and validation must be addressed. This study highlights the role of AI-HPC integration in accelerating materials research and developing innovative materials for future technological applications.

Keywords

Artificial Intelligence, High-Performance Computing, Machine Learning, Next-Generation Materials, Materials Discovery, Computational Materials Science, Materials Design, Data Analytics.

ICAMMT:58

Federated Learning for Privacy-Preserving Materials Discovery

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Abstract

Federated Learning (FL) is an emerging Artificial Intelligence (AI) approach that enables collaborative materials discovery while preserving the privacy of sensitive data. Conventional materials research often requires organizations to share experimental results and computational datasets, which may raise concerns regarding data confidentiality, intellectual property, and security. Federated Learning addresses these challenges by allowing multiple institutions or research facilities to train Machine Learning (ML) models collaboratively without directly exchanging their raw data. Instead, model updates are shared and aggregated to develop a common predictive model. This approach can support the prediction of material properties, identification of promising materials, and optimization of material designs while maintaining data privacy. Federated Learning has potential applications in advanced materials research, energy storage, pharmaceuticals, nanotechnology, and industrial materials development. However, challenges such as communication costs, data heterogeneity, model security, and computational complexity need to be considered. This study examines the role and potential of Federated Learning in enabling secure, collaborative, and privacy-preserving materials discovery.

Keywords: Federated Learning, Privacy Preservation, Artificial Intelligence, Machine Learning, Materials Discovery, Data Security, Material Properties, Collaborative Research.

ICAMMT:59

Reinforcement Learning for Autonomous Materials Discovery

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Abstract

Reinforcement Learning (RL) is gaining importance as an Artificial Intelligence (AI) approach for improving the speed and efficiency of materials discovery. Conventional materials development generally requires numerous experiments, complex simulations, and repeated optimization, making the process costly and time-consuming. RL can enable intelligent systems to learn from interactions with simulated or experimental environments and identify material candidates that satisfy specific performance requirements. When integrated with Machine Learning models, materials databases, computational simulations, and automated laboratory techniques, RL can efficiently explore extensive material design spaces and recommend promising candidates. This approach has potential applications in energy storage, catalysis, electronics, aerospace, and sustainable material development. However, issues such as limited training data, computational demands, exploration strategies, model accuracy, and experimental verification must be addressed. The application of RL can therefore contribute to more autonomous, efficient, and data-driven materials discovery and development.

Keywords:

Reinforcement Learning, Artificial Intelligence, Autonomous Materials Discovery, Machine Learning, Materials Science, Materials Optimization, Materials Design, Property Prediction, Automated Experimentation, Computational Materials Science.

ICAMMT:60

Cyber-Physical Security in Smart Manufacturing Systems

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Abstract

Smart manufacturing systems integrate physical machines, sensors, industrial control systems, and digital technologies to improve production efficiency and automation. However, the connection between physical and cyber environments creates security risks such as unauthorized access, data theft, malware attacks, and manipulation of industrial processes. Cyber-physical security focuses on protecting both digital networks and physical manufacturing equipment from these threats. Technologies such as artificial intelligence, machine learning, real-time monitoring, secure communication, and intrusion detection systems help identify and prevent cyber-attacks. Strong authentication, continuous monitoring, and automated threat detection can improve the safety, reliability, and productivity of smart factories. Therefore, cyber-physical security is essential for building secure, resilient, and trustworthy smart manufacturing systems.

Keywords

Cyber-Physical Systems, Smart Manufacturing, Cyber security, Industrial Control Systems, Internet of Things (IOT), Artificial Intelligence, Machine Learning, Data Security, Threat Detection, Industrial Automation.

ICAMMT:61

Discovery of Advanced Functional Materials

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Abstract

Advanced functional materials are specially designed to exhibit enhanced mechanical, optical, chemical, electrical, and physical properties, making them important in modern science and technology. The discovery and development of these materials have become essential for addressing the growing demands of various technological fields. Nanomaterial's, smart materials, grapheme, semiconductors, and biomaterials are widely utilized in areas such as electronics, energy storage, healthcare, aerospace, and environmental applications. Current research focuses on developing materials that are stronger, lighter, more efficient, durable, and environmentally sustainable. The advancement of functional materials therefore plays a significant role in enabling innovative technologies, improving industrial performance, and supporting sustainable solutions for enhancing human life.

Keywords

Advanced Functional Materials, Nanomaterial's, Smart Materials, Grapheme, Semiconductors, Biomaterials, Energy Storage, Sustainable Materials, Materials Science, and Innovative Technologies.

ICAMMT:62

Explainable Computer Vision for Industrial Materials Inspection

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Abstract

Industrial materials inspection is an essential process for ensuring product quality, structural reliability, and manufacturing safety. Traditional inspection methods often depend on manual observation or conventional computer vision techniques, which may require considerable time and can be affected by human error. Recent developments in artificial intelligence and deep learning have enabled computer vision systems to automatically identify defects and irregularities in industrial materials. However, many advanced deep learning models operate as black-box systems, making it difficult for engineers and quality-control personnel to understand the reasons behind their predictions. Explainable Computer Vision addresses this limitation by providing interpretable information about how and why a vision model reaches a particular inspection decision. Techniques such as Grad-CAM, saliency maps, attention mechanisms, and feature visualization can highlight important regions associated with defects such as cracks, scratches, corrosion, surface irregularities, and structural damage. This approach improves transparency, reliability, and user confidence in automated inspection systems. The integration of explainable artificial intelligence with computer vision can therefore support more accurate, trustworthy, and efficient industrial materials inspection while assisting experts in making informed quality-control decisions.

Keywords

Explainable Artificial Intelligence, Computer Vision, Industrial Materials, Defect Detection, Deep Learning, Quality Inspection, Image Processing, Grad-CAM, Surface Defect Detection, Automated Inspection

ICAMMT:63

Automated Defect Classification using Deep Neural Networks

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Abstract

Automated defect classification plays a significant role in modern industrial inspection by improving product quality, manufacturing efficiency, and process reliability. Conventional inspection methods often depend on manual examination, which can be time-consuming, inconsistent, and prone to human error. The development of deep neural networks has enabled automated systems to identify and classify material defects from images with high accuracy. Deep learning architectures can automatically extract meaningful features from inspection images and distinguish between different types of defects, including cracks, scratches, corrosion, surface irregularities, and structural damage. Convolutional Neural Networks (CNNs) are particularly effective for visual defect classification because they can learn complex patterns and spatial features directly from image data. The proposed approach involves image acquisition, preprocessing, feature learning, model training, and defect classification. By reducing dependence on manual inspection, deep neural networks can provide faster, more consistent, and scalable quality-control solutions for industrial applications. Such automated classification systems can support early defect detection, minimize production losses, and improve the overall reliability of industrial materials inspection.

Keywords

Automated Defect Classification, Deep Neural Networks, Deep Learning, Convolutional Neural Networks, Industrial Inspection, Defect Detection, Image Processing, Material Inspection, Quality Control, Computer Vision.

ICAMMT:64

Parallel Computing Approaches for Molecular Dynamics Simulations

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Abstract

Molecular dynamics simulations are widely used to investigate the structural, thermodynamic, and dynamic behavior of materials and molecular systems at the atomic level. However, the large number of particles and computationally intensive interactions involved in these simulations can require substantial processing time and computational resources. Parallel computing provides an effective approach to overcome these limitations by distributing computational tasks across multiple processors or computing units. Various parallelization strategies, including domain decomposition, particle decomposition, and task-based parallelism, can be employed to improve the performance and scalability of molecular dynamics simulations. High-performance computing architectures, graphics processing units, and distributed computing frameworks further enable the efficient execution of large-scale simulations. Parallel algorithms can significantly reduce simulation time while maintaining computational accuracy and enabling the study of complex molecular systems. This approach is particularly valuable in materials science, chemistry, nanotechnology, drug discovery, and computational physics. The integration of advanced parallel computing techniques with molecular dynamics can therefore support faster simulations, efficient resource utilization, and the investigation of increasingly complex molecular and material systems.

Keywords

Parallel Computing, Molecular Dynamics, High-Performance Computing, Domain Decomposition, Parallel Algorithms, GPU Computing, Distributed Computing, Molecular Simulation, Computational Materials Science, Scalability

ICAMMT:65

Multi-Source Data Fusion for Materials Performance Prediction

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Abstract

Materials performance prediction plays an important role in the development of advanced materials for engineering, energy, manufacturing, and other applications. However, materials data are often collected from different sources, including experimental measurements, computational simulations, material databases, sensor systems, and published literature. These data may vary in format, scale, accuracy, and completeness, making it difficult to obtain reliable predictions using a single data source. **Multi-source data fusion** provides an effective approach for integrating heterogeneous materials data and extracting meaningful information for predictive modeling. This approach combines data preprocessing, feature extraction, data alignment, fusion techniques, and machine learning algorithms to establish relationships between material composition, structure, processing conditions, and performance characteristics. By integrating complementary information from multiple sources, data fusion can improve prediction accuracy, reduce uncertainty, and support the identification of important material properties. The proposed approach can be applied to predict mechanical, thermal, electrical, chemical, and energy-related material performance. It also supports faster material screening and reduces the dependence on repeated experimental testing. Overall, multi-source data fusion offers a scalable and intelligent framework for improving materials performance prediction and accelerating data-driven materials discovery.

Keywords

Multi-Source Data Fusion, Materials Performance Prediction, Materials Informatics, Machine Learning, Data Integration, Heterogeneous Data, Feature Extraction, Materials Databases, Predictive Modeling, Materials Discovery.

ICAMMT:66

SCAPS-1D-Based Design of a High-Performance Lead-Free $Cu/MoO_3/FAPbI_3/WS_2/FTO$ Perovskite Solar Cell through Interface and Defect Engineering

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Abstract

Perovskite solar cells (PSCs) have attracted significant attention due to their high power-conversion efficiency and low fabrication cost. Although remarkable progress has been achieved, further improvement in device efficiency and stability remains essential for large-scale commercialization. In this work, a high-performance PSC based on $FAPbI_3$ as the absorber layer is numerically investigated using the SCAPS-1D simulation software. The effects of WS_2 as the electron transport layer (ETL) and MoO_3 as the hole transport layer (HTL) are analyzed to enhance charge transport and suppress carrier recombination. The proposed device structure consists of $Cu/MoO_3/FAPbI_3/WS_2/FTO$. The influence of absorber thickness, defect density, transport-layer properties, and back-contact material is systematically optimized to achieve superior photovoltaic performance. After optimization of all device parameters, the proposed solar cell exhibits a maximum power-conversion efficiency of approximately 24%, along with improved open-circuit voltage, short-circuit current density, and fill factor. These findings demonstrate that the $Cu/MoO_3/FAPbI_3/WS_2/FTO$ architecture is a promising candidate for the development of efficient and stable perovskite solar cells.

Keywords: Perovskite solar cells; $FAPbI_3$; SCAPS-1D; WS_2 electron transport layer; MoO_3 hole transport layer; photovoltaic performance; defect density; absorber thickness; charge transport; carrier recombination; power conversion efficiency.

ICAMMT:67

Synthesis and Characterization of Cobalt Tungstate ($Cowo_4$) for Super capacitor Application

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Abstract

Batteries, with their high energy capacity, are considered as one of the most common storage devices. However, their low power density makes them unsuitable for applications with high power impulses. Compared to batteries, supercapacitors also known as ultracapacitor and electrochemical capacitors, offer much higher charge-discharge rates ranging from seconds to minutes, as well as high power and moderate energy density. The capacitors have low voltage limits. These components are the choice over the regular type of capacitors since they feature higher power density. These components consume less power and are absolutely safe and easy to operate.

Among tremendous tested metal oxide tested as electrode materials for SCs, bimetallic oxides, especially metal tungstates and molybdates with large *C*s capacitance, good rate capability, and appropriate cycle performance, which ultimately provide superior supercapacitor performance, are suitable compounds. Metal tungstates are known to act as efficient materials for construction of SC electrodes because of appropriate faradaic activity, low cost, natural abundance, and environmental friendliness. Furthermore, metal tungstates, especially metal tungstates, are of interest due to their high theoretical capacitance for use as active electrode materials in supercapacitors. However, the real capacitance of metal tungstates is much lower than their theoretical capacitance.

Keywords

Bimetallic oxides, metal tungstates, molybdates, faradaic activity, $CoWO4$ nanoparticles, $CoCl2.6H2O$ and $Na2WO4.4H2O$, polyvinylidene difluoride, N- Methyl Pyrrolidone.

ICAMMT:68

Advanced Device Engineering and Performance Optimization of FTO/TiO_2/$MAPbI_3$/NiO/Au Perovskite Solar Cells Using SCAPS-1D

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Abstract

Perovskite solar cells (PSCs) are widely studied as promising photovoltaic devices because of their strong light absorption and favorable optoelectronic properties. In this work, the performance of a methyl ammonium lead iodide ($MAPbI_3$)-based perovskite solar cell was numerically investigated using SCAPS-1D. The proposed device consists of an FTO/TiO_2/$MAPbI_3$/NiO structure, where FTO acts as the transparent conducting layer, TiO_2 as the electron transport layer, $MAPbI_3$ as the absorber, and NiO as the hole transport layer. The effect of $MAPbI_3$ absorber thickness on the photovoltaic performance was investigated by evaluating the open-circuit voltage (Voc), short-circuit current density (Jsc), fill factor (FF), and power conversion efficiency (PCE). The absorber thickness was varied while the other device parameters were maintained at their selected values. A thickness of 1200 nm for $MAPbI_3$ was found to provide the best simulated performance, while the TiO_2 and NiO thicknesses were maintained at 50 nm. Under AM1.5G illumination at 300 K, the optimized device achieved a maximum simulated PCE of 23.31%. The results indicate that careful selection of the absorber thickness can improve the photovoltaic performance of the proposed $MAPbI_3$-based perovskite solar cell and demonstrate the usefulness of SCAPS-1D for numerical device optimization.

Keywords

$MAPbI_3$ perovskite solar cell; SCAPS-1D; TiO_2 electron transport layer; NiO hole transport layer; absorber thickness; photovoltaic performance; power conversion efficiency; short-circuit current density; open-circuit voltage; fill factor; numerical simulation; device optimization.

ICAMMT:69

SCAPS -1D-Based Numerical Optimization $MApbl_3$ Perovskite Solar Cells of Enhancement Photovoltaic Performance

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Abstract

Pervoskite solar cells (PSCs)have attracted significant attention due to their high-power conversion efficiency and low fabrication cost. In this work, a numerical simulation of a lead-based perovskite solar cell with the structure FTO/CeO_2/$MAPbI_3$/CuI/Au was carried out using SCAPS-1D software. CeO_2 was used as the electron transport layer (ETL), $MAPbI_3$ as the absorber layer, and CuI as the hole transport layer (HTL). The effects of key device parameters, including layer thickness, defect density, and material properties, were analyzed to improve th e photovoltaic performance. The optimized device exhibited enhanced values of open-circuit voltage (Voc), short-circuit current density (Jsc), fill factor (FF), and power conversion efficiency (PCE). The simulation results demonstrate that the selected device configuration is a promising candidate for efficient perovskite solar cells and provides useful guidance for future experimental.

Keywords

Perovskite solar cells; $MAPbI_3$; SCAPS-1D; CeO_2 electron transport layer; CuI hole transport layer; absorber thickness; defect density; photovoltaic performance; power conversion efficiency; numerical simulation; device optimization.

ICAMMT:70

Performance evaluation of single chamber microbial fuel cells using different nanofillers based electrolytes in three different substrates: A comparative study

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Abstract

Performances of single chamber microbial fuel cell (SCMFC) can be evaluated with four different electrolytes based on different nanofillers in sulfonated chitosan/PEO matrix. The four electrolytes were based on different nano fillers such as sulfonated montmorillonite, sulfonated silicon dioxide, slfonated graphene oxide and sulfonated silicon dioxide with heteropoly acids was prepared by solvent casting technique. Among the four electrolytes sulfonated silicon dioxide with PWA shows the maximum power density compare with other polymer electrolyte. The device was operated at anaerobic condition at varying time duration in three different substrates (synthetic sea water, waste water and glucose fed waste water). The performance was evaluated by characterizing the voltage, current and power density. The maximum value of the power density is 863 mW/cm2 (at 990 mA/cm2) for the PWA doped electrolytes. Thus, this study has demonstrated such that the fabricated MFC can be used for electrical energy generation in glucose fed waste water.

Keywords

Microbial fuel cell, Sulfonation, Power density, Current density, Bipolymer; Functionalization; Power density.

ICAMMT:71

SCAPS -1D-Based Numerical Optimization MApbl3 Perovskite solar cells of Enhancement photovoltaic performance

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Abstract

Perovskite solar cells (PSCs) with high efficiency, low cost, and improved environmental compatibility have attracted significant attention in recent years. However, the toxicity and instability associated with conventional lead-based perovskites remain major challenges for their practical commercialization. In this context, lead-free double perovskite materials have emerged as prmising alternatives for developing environmentally friendly photovoltaic devices. This work investigates the theoretical feasibility of a lead-free and stable Cs_2Ptl_6-based perovskite solar cell incorporating CUL as the hole transport layer (HTL) and CeO_2 as the electron transport layer (ETL). The proposed device architecture consists of Au/CuI/ Cs_2Ptl_6/CeO_2/FTO, where Cs_2Ptl_6 is considered as the photoactive absorber layer. The photovoltaic performance of the proposed device is systematically analyzed using SCAPS-1D numerical simulation by optimizing the absorber layer, HTL, ETL, metal contact, defect density, and layer thicknesses. The incorporation of Cs_2Ptl_6 as the HTL is investigated to facilitate efficient hole extraction and transport, while CeO_2 is employed as the ETL to promote selective electron extraction and reduce carrier recombination. The optimized device demonstrates promising photovoltaic performance, highlighting the potential of the Au/CuI/ Cs_2Ptl_6/CeO_2/FTO material combination for lead-free and environmentally friendly solar cell applications. These findings provide a theoretical basis for the development of efficient and stable Cs_2Ptl_6 based perovskite photovoltaic devices.

Keywords

Lead-free perovskite solar cell; Au/CuI/Cs_2Ptl_6/CeO_2/FTO SCAPS-1D; Numerical simulation.

ICAMMT:72

Design and Performance Analysis of a Broadband Photonic Crystal-Based Terahertz Antenna for Pharmaceutical Material Characterization and Biomedical Sensing

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Abstract

Terahertz (THz) technology offers considerable potential for rapid and non-destructive pharmaceutical material characterization and biomedical sensing. This study presents the design and numerical investigation of a broadband photonic-crystal (PC)-based THz microstrip antenna employing a polyimide substrate periodically engineered with air cavities. The proposed PC configuration is introduced to modify surface-wave propagation and electromagnetic-field confinement, thereby improving the radiation and impedance characteristics of the antenna. A systematic parametric analysis is performed by varying the PBG diameter, air-hole radius, and substrate height. The optimized PBG diameter of **20 µm** produces a minimum reflection coefficient of approximately **−45 dB** near **301 GHz**, while the optimized **5 µm PBG hole radius** achieves approximately **−49.6 dB** at **301.1 GHz**. Substrate-height optimization further demonstrates that an **8 µm substrate height** provides a gain of **6.9189 dB**, directivity of **6.2221 dB**, and radiation efficiency of **96.82%**, with an impedance bandwidth of **6.6332 GHz** over **300.6030–307.2362 GHz**. These results demonstrate that PC engineering provides an effective approach for controlling THz antenna resonance, impedance matching, and radiation performance. The optimized architecture offers a promising electromagnetic platform for future non-invasive pharmaceutical material characterization, drug-formulation analysis, and biomedical sensing, subject to experimental validation using representative pharmaceutical and biological samples.

Keywords: Terahertz antenna; photonic crystal; polyimide substrate; broadband antenna; biomedical sensing; pharmaceutical analysis; biosensing; tissue and drug characterization

ICAMMT:73

Green Synthesis, Characterization, and Biological Evaluation of Undoped, Ag-Doped, And Fe-Doped Copper Nanoparticles

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Abstract

Copper nanoparticles (CuNPs) have attracted considerable interest due to their low cost, high electrical conductivity, catalytic properties, and potential biological applications. In the present study, undoped, Ag-doped, and Fe-doped CuNPs were synthesized via a green route using *Moringa oleifera* leaf extract as a natural reducing and stabilizing agent. The synthesized nanoparticles were characterized using UV–Visible spectroscopy, X-ray diffraction (XRD), scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy (SEM–EDX), and Fourier-transform infrared spectroscopy (FTIR). UV-Visible analysis revealed surface plasmon resonance peaks at 585 nm for undoped CuNPs, 565 nm for Ag-doped CuNPs, and 605 nm for Fe-doped CuNPs, indicating changes in optical properties upon metal doping. XRD analysis confirmed a face-centered cubic (FCC) crystalline structure, with a reduction in crystallite size from approximately 28 nm for undoped CuNPs to 24–26 nm for doped samples. SEM analysis showed predominantly quasi-spherical nanoparticles with sizes ranging from 25 to 45 nm, while EDX confirmed the presence of Cu along with Ag or Fe in the respective samples. FTIR results indicated the involvement of plant-derived functional groups in nanoparticle formation and stabilization. Biological evaluation demonstrated concentration-dependent antimicrobial and antioxidant activities, with doped nanoparticles exhibiting enhanced performance compared with undoped CuNPs. Among the tested samples, Ag-doped CuNPs showed the highest activity, followed by Fe-doped and undoped CuNPs. These findings demonstrate that *M. oleifera*-mediated synthesis provides a simple and environmentally friendly approach for producing CuNPs with improved physicochemical and biological properties, highlighting their potential for pharmaceutical and biomedical applications.

Keywords

Green synthesis; CuNPs; Metal doping; Optical properties; Antimicrobial activity; Antioxidant activity.

ICAMMT:74

SCAPS-1D-Based Optimization of an Efficient Lead-Free Cs_2TiBr_6 Perovskite Solar Cell with $CuSbS_2$/ZnSe Transport Layers

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Abstract

Lead-free perovskite solar cells (PSCs) have emerged as promising alternatives to conventional lead-based photovoltaic devices owing to growing concerns regarding toxicity and environmental sustainability. In this study, the photovoltaic performance of an all-inorganic, lead-free Cs_2TiBr_6 perovskite solar cell is systematically investigated using the SCAPS-1D numerical simulation tool. A device architecture of Au/$CuSbS_2$/Cs_2TiBr_6/ZnSe/FTO is proposed, in which Cs_2TiBr_6 serves as the absorber layer, $CuSbS_2$ acts as the hole transport layer (HTL), and ZnSe functions as the electron transport layer (ETL). The device parameters are systematically optimized to enhance carrier generation and extraction while minimizing bulk and interfacial recombination losses. The effects of the absorber and transport-layer properties on the photovoltaic response are evaluated to identify suitable conditions for improved device performance. Following optimization, the proposed device achieves a maximum power conversion efficiency (PCE) of 20.12%, demonstrating the potential of Cs_2TiBr_6 as a lead-free absorber for next-generation photovoltaic applications. The optimized device architecture provides an effective combination of suitable charge-transport layers and absorber properties, contributing to improved charge separation and collection. These results demonstrate that Cs_2TiBr_6-based perovskite solar cells can provide a promising pathway toward efficient, environmentally friendly, and potentially stable photovoltaic technologies. The findings obtained from the SCAPS-1D analysis offer useful theoretical guidance for the further development and experimental realization of high-performance lead-free perovskite solar cells.

Keywords:
Lead-free perovskite solar cell; Cs_2TiBr_6; SCAPS-1D; $CuSbS_2$; ZnSe; Numerical simulation; Device optimization; Power conversion efficiency**.**

ICAMMT:75

Convolutional Neural Networks

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Abstract

Artificial Intelligence (AI) has emerged as a fundamental technology in modern computing, transforming various domains such as healthcare, finance, robotics, autonomous systems, and cybersecurity. Among the major AI techniques, Convolutional Neural Networks (CNNs) have gained significant importance due to their ability to perform high-dimensional data analysis and automated feature extraction. CNNs are a specialized class of deep neural networks (DNNs) extensively used for image classification, object detection, facial recognition, speech processing, natural language processing (NLP), and genomic sequence analysis, including DNA sequence classification. This paper presents a comprehensive technical overview of CNNs and their applications in computer vision and image recognition. It initially explains the fundamental architecture of CNNs, including convolutional layers, pooling layers, feature maps, activation functions, fully connected layers, and backpropagation-based optimization techniques. The convolution operation plays a crucial role in extractinfg spatial and hierarchical features from input data, while activation functions such as ReLU (Rectified Linear Unit) introduce non-linearity into the neural network. Furthermore, the paper examines several influential CNN architectures, including LeNet, AlexNet, VGGNet, ResNet, and InceptionNet. These architectures demonstrate progressive improvements in computational efficiency, feature representation, network depth, and classification accuracy. The study also compares their architectural characteristics, performance, and practical applications. Overall, CNNs provide an efficient and scalable framework for automated visual feature extraction and high-accuracy image recognition, making them a key component of modern deep learning systems.

Keywords: Artificial Intelligence (AI); Convolutional Neural Networks (CNNs); Deep Learning; Deep Neural Networks (DNNs); Computer Vision; Image Recognition; Image Classification; Feature Extraction; Convolutional Layers; Pooling Layers; ReLU Activation; Backpropagation; LeNet; AlexNet; VGGNet; ResNet; InceptionNet.

ICAMMT:76

Explainable Artificial Intelligence: An Expanded Taxonomy by Mechanism and Interpretability Perspectives

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Abstract

Explainable Artificial Intelligence (XAI) has emerged as a critical area of research to address the opacity of modern machine learning models, with deep neural networks being a major focus. While numerous surveys of XAI exist, many either focus narrowly on specific techniques or lack a unifying structure that connects diverse approaches into a coherent framework. This paper presents a comprehensive literature review that consolidates both widely adopted and less commonly discussed XAI methods, including perturbation and gradient based explainers, dimensionality reduction techniques, counterfactual frameworks, and attribution methods. We adopt the well-established taxonomy in literature, which categorizes XAI approaches into scoop based, complexity based, model based, and methodology based classes, and extend it in two important ways: (i) by introducing finer operational subcategories (e.g., gradient vs. perturbation based, model specific vs. model agnostic), and (ii) by introducing a complementary interpretability level distinction that categorizes explanations as structural, semantic, or behavioural according to the level at which understanding is achieved. For each method, we summarize its underlying principles and highlight reported strengths and limitations, enabling readers to understand both the technical foundations and the trade-offs involved. By structuring the field into this extended taxonomy, the survey provides a road map for new researchers entering XAI and offers a reference point for identifying gaps where novel approaches can be developed.

Keywords:

Machine learning, Explainable AI

ICAMMT:77

A Study on Web Personalization Using Web Usage Mining

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Abstract

Web is an enormous store house of Information. Web Mining is an upcoming trend which serves as per the user requirements. It has many in types. Web Usage mining is to discover interesting user navigation patterns and can be applied to many real-world problems, such as improving website/pages, making additional customer behavior studies etc. Personalization is a subclass of information filtering system that seeks to predict the ratings or preferences that a user would give to an item; they have not yet considered using a model built from the characteristics of the item. This proposed system uses information such as profile info, time being spent by the user, preferences from log file then process the selected info and then improvise the user's recommendation as per the results.

Keywords

Web Mining; Web Usage Mining; User Navigation Patterns; Personalization; Information Filtering; User Preferences; User Profiling; Web Log Analysis; Customer Behavior Analysis; Recommendation Systems; User Behavior Prediction; Personalized Recommendations**.**

ICAMMT:78

Computational Design of Stable and High-Performance Lead-Free Cs_2TiBr_6 Perovskite Solar Cells through Multilayer Interface Engineering

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Abstract

Perovskite solar cells (PSCs) have attracted significant attention due to their high-power conversion efficiency and low fabrication cost. In this work, a lead-free perovskite solar cell is designed and numerically analyzed using SCAPS-1D. The proposed device consists of Au/CuO / Cs_2TiBr_6/ CeO_2/ FTO layers, where CeO_2 acts as the electron transport layer (ETL), Cs_2TiBr_6 serves as the absorber layer, and CuO functions as the hole transport layer (HTL). The device performance is optimized by varying the thickness and electrical properties of the individual layers. The optimized device achieves a maximum power conversion efficiency (PCE) of 20.60%. The obtained results indicate that the Au/CuO / Cs_2TiBr_6/ CeO_2/ FTO structure is a promising configuration for developing efficient and environmentally friendly lead-free perovskite solar cells.

Keywords: Lead-free Perovskite Solar cell, SCAPS-1D, Cs_2TiBr_6, CeO_2, CuO, FTO, Numerical simulation.

ICAMMT:79

Molarity-Driven Tuning of Structural, Optical and Gas-Sensing Properties of CeO_2 Thin Films by Nebulizer-Assisted Spray Pyrolysis

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Abstract

Cerium oxide (CeO_2) thin films were deposited on glass substrates by nebulizer-assisted spray pyrolysis at 450 °C using precursor molarities of 0.05, 0.075, 0.10, and 0.125 M. The influence of molarity on the structural, morphological, optical, photoluminescence, and NH_3 gas-sensing properties was systematically investigated. X-ray diffraction (XRD) confirmed the formation of a polycrystalline cubic fluorite structure with preferential orientation along the (111) plane and improved crystallinity with increasing molarity. FESEM analysis revealed molarity-dependent changes in surface morphology, including grain growth and increased surface roughness. UV–Vis studies showed good optical transparency, with variations in optical band gap attributed to changes in crystallite size and defect states. Photoluminescence (PL) analysis indicated the presence of defect-related emission, particularly oxygen vacancies. NH_3 sensing measurements demonstrated enhanced response at room temperature for the optimized precursor molarity, which was attributed to the favourable surface morphology and increased oxygen-vacancy-related active sites. These results demonstrate that precursor molarity effectively controls the physicochemical properties and gas-sensing performance of CeO_2 thin films, making them promising candidates for room-temperature NH_3 sensing applications.

Keywords: CeO_2 thin films; Nebulizer-assisted spray pyrolysis; Precursor molarity; Oxygen vacancies; Photoluminescence; NH_3 gas sensing; Room-temperature sensor.

ICAMMT:80

SCAPS-1D-Based Design and Multivariable Optimization of a Lead-Free FTO/CeO_2/$FASnI_3$/$CuSbS_2$ Perovskite Solar Cell"

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Abstract

Lead-free tin halide perovskites are attractive candidates for next-generation photovoltaic devices because they avoid the use of lead while retaining a band gap suitable for efficient solar-energy conversion. In this work, a qaàmultilayer FTO/CeO2/ $FASnI_3$/ $CuSbS_2$ photovoltaic structure is investigated numerically using the Solar Cell Capacitance Simulator in One Dimension (SCAPS-1D The $FASnI_3$ absorber thickness is 1.45 μm, while CeO_2 and $CuSbS_2$ are used as electron- and hole-transport layers, respectively. The model specifies a 0.45 μm CeO_2 layer, a 55 μm $CuSbS_2$ layer and a 0.40 μm FTO layer. The simulated J–V output shown in the supplied result gives Jsc = 28.032727 mA cm^{-2}, FF = 21.26%, and η = 21.98%; the displayed Voc is 3.6878 V. Although the reported efficiency is internally consistent with the displayed Jsc, Voc and FF through the standard efficiency relationship, the 3.6878 V open-circuit voltage is physically inconsistent with a 1.45 eV $FASnI_3$ absorber and must be independently verified in SCAPS before the result is used in a journal submission. The study therefore presents the uploaded model as a reproducible simulation configuration, identifies the principal charge-transport and recombination considerations, and proposes a validation and optimization pathway focused on absorber thickness, transport-layer thickness, doping, defect density, interface recombination, and contact properties

Keywords: $FASnI_3$; lead-freeperovskite; $CuSbS_2$; CeO_2; FTO; SCAPS-1D; numerical simulation; photovoltaic performance

ICAMMT:81

Energy Storage and Conversion Green and Sustainable Materials for Emerging Energy Storage Technologies

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Abstract

The growing demand for renewable and clean energy has increased the need for efficient energy storage and conversion technologies. Green and sustainable materials, including biomass-derived carbon, biodegradable polymers, graphene-based materials, and metal oxides, are being developed for advanced batteries, super capacitors and fuel cells. These materials can help improve energy efficiency while reducing environmental impact and dependence on non-renewable resources. The selection and performance of these materials are important for developing safe, low-cost and environmentally friendly energy-storage systems.

Mathematics provides useful tools for analyzing and optimizing emerging energy-storage technologies. Mathematical modelling, statistical methods, optimization techniques and numerical analysis can be used to study parameters such as energy density, power density, charging and discharging rates, efficiency and material performance. By applying mathematical approaches, suitable materials and operating conditions can be identified more effectively. Thus, the integration of mathematics with green materials research can contribute to the development of efficient, sustainable and reliable energy-storage and conversion systems.

Keywords

Energy storage, Energy conversion, green materials, Sustainable materials, Batteries, Super capacitors, Mathematical modelling, Optimization, Energy density, Power density, Renewable energy and Sustainable technology.

ICAMMT:82

PEROVSKITE AND SOLAR-CELL MATERIALS

Interface Engineering of Perovskite Solar Cells Using Advanced Charge-Transport Materials for Enhanced Device Performance

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Abstract

Perovskite solar cells(PSCs) face performance limits due to energy barriers, trap states, and non-radiative recombination at the interfaces between the light absorber and charge-transport layers. Interface engineering uses advanced electron-and hole transport materials, chemical dopants, and molecular interlayers to fix these flaws. These changes smooth energy levels, stop ion movement, and lock defects in place. This leads to better charge movement and higher stability.

Keywords

Perovskite solar cells, Interface engineering, Charge-transport materials, Defect passivation, Energy-level alignment, Recombination reduction.

ICAMMT:83

Semiconductor, Optoelectronic and Photonic Materials

Interface Engineering of Semiconductor Nanocomposites for Enhanced Photocatalytic and Optoelectronic Performance

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Abstract

Semiconductor optoelectronic and photonic materials play an important role in modern energy, sensing and communication technologies. Among them, semiconductor nanocomposites show enhanced photocatalytic and optoelectronic performance due to their tunable electronic structure and improved interfacial properties. Interface engineering helps optimize charge transfer, light absorption and recombination processes, leading to better efficiency. From an applied mathematics viewpoint, charge carrier dynamics, photon interactions and diffusion-reaction processes can be modeled using differential equations and numerical techniques.

Mathematical formulations such as continuity equations, Poisson's equation and rate equation are used to study charge transport and recombination behavior. Interface effects like band alignment and heterojunctions are analyzed using boundary value problems and simulations. Numerical methods, including finite difference and finite element techniques, help predict system performance. This integration of mathematics and material science supports the design of efficient nanocomposites for applications like solar cells, photodetectors, and environmental remediation.

Keywords

Semiconductor Nanocomposites; interface Engineering; photocatalysis; optoelectronics; Applied Mathematics; Differential Equations; Numerical methods.

ICAMMT:84

Smart Materials and Intelligent Technologies for Next-Generation Biomedical Applications: A Review

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Abstract

Smart materials and intelligent technologies are emerging as promising approaches for advanced biomedical applications due to their ability to respond dynamically to environmental and physiological stimuli. This review highlights stimuli-responsive materials, including shape-memory polymers, hydrogels, liquid-crystal elastomers, smart composites, and shape-memory alloys, along with recent advances in 3D/4D printing and artificial intelligence (AI). Their applications in drug delivery, tissue engineering, regenerative medicine, biosensing, wound management, and minimally invasive implants are discussed. The review also examines key challenges, including biocompatibility, mechanical reliability, manufacturing scalability, standardization, and clinical validation. The integration of smart materials, 4D printing, biosensors, and AI offers significant potential for developing adaptive, personalized, and multifunctional biomedical systems.

Keywords

Smart materials; Stimuli-responsive materials; 4D printing; Artificial intelligence; Biomedical applications; Tissue engineering; Drug delivery; Biosensors; Personalized medicine.

ICAMMT:85

SCAPS-1D Simulation and Optimization of a High-Efficiency Lead-Free Cs_2TiBr_6 Perovskite Solar Cell with $CuSbS_2$/ZnO Transport Layers

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Abstract

Perovskite solar cells (PSCs) have attracted significant attention due to their high-power conversion efficiency and low fabrication cost. However, the toxicity and poor long-term stability of lead-based perovskite materials remain major obstacles to their commercial application. Therefore, the development of lead-free, environmentally friendly, and stable perovskite solar cells has become an important research focus. In this work, a lead-free all-inorganic Cs_2TiBr_6 perovskite absorber is employed to investigate the performance of a perovskite solar cell. Different transport layer materials are analysed to identify the most suitable combination for achieving high efficiency and stability. The proposed device structure consists of Au/$CuSbS_2$/Cs_2TiBr_6/ZnO/FTO, where $CuSbS_2$ is used as the hole transport layer (HTL), ZnO as the electron transport layer, Cs_2TiBr_6 as the absorber layer, and FTO as the transparent conducting oxide. The device performance is theoretically evaluated and optimized using the SCAPS-1D simulation software by varying the thickness, defect density, and doping concentration of the functional layers. The optimized device demonstrates excellent photovoltaic performance with enhanced power conversion efficiency, indicating that the Au/$CuSbS_2$/Cs_2TiBr_6/ZnO/FTO architecture is a promising candidate for Keywords Lead-free perovskite solar cell · Numerical simulation efficient, stable, and eco-friendly lead-free perovskite solar cells. The findings provide useful guidance for the future development of high-performance inorganic perovskite photovoltaic devices Utilizing SCAPS1D software to achieve elevated performance A maximum power-conversion efficiency of 21.44% is Achieved for the proposed solar cell through optimization of ETL, HTL,Back metal materials defect density of the absorber and the thickness of the absorber HTL,and FT. This result will pave for developing eco-friendly and highly efficient perovskite photovoltaic device.

Keywords

Lead-free perovskite solar cells; Cs_2TiBr_6; SCAPS-1D; Numerical simulation; $CuSbS_2$; ZnO; Device optimization; Power conversion efficiency.

ICAMMT:86

Nano-Size Cathode Materials for Lithium - Ion batteries

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Abstract

One of the foremost challenges of the twenty-first century is the development of efficient and sustainable energy storage systems. In response to the growing demands of modern society, it is imperative to design low-cost and environmentally friendly energy conversion and storage technologies. Rechargeable lithium-ion batteries have emerged as the most suitable solution, replacing conventional systems such as alkaline, Ni-Cd, and lead-acid batteries across diverse applications ranging from microelectronics to aerospace. In this work, various metal-ion doped $LiMn_2O_4$ spinel structures were synthesized and characterized to evaluate their potential as cathode materials. Morphological studies using SEM and TEM revealed that the $LiMn_{1.9}Al_{0.1}O_4$ compound exhibits spherical grain size with uniform morphology and an average particle size of approximately 50 nm, the smallest among the synthesized samples. Electrochemical impedance spectroscopy (EIS) confirmed superior kinetic properties, with $LiMn_{1.9}Al_{0.1}O_4$ demonstrating the lowest charge-transfer resistance ($R\_CT \approx 130\ \Omega$) compared to $LiMn_2O_4$ and $LiMn_{1.9}Ni_{0.1}O_4$. Cyclic voltammetry studies identified two anodic peaks at 4.1 V and 4.4 V, and two cathodic peaks at 3.75 V and 4.3 V, corresponding to lithium intercalation and de-intercalation processes.

The improved electrochemical performance and favorable morphology of $LiMn_{1.9}Al_{0.1}O_4$ highlight its potential as a promising cathode material for next-generation lithium-ion batteries, offering enhanced energy storage capabilities and long-term stability.

Keywords

Lithium-ion batteries, Spinel cathode materials, Al-doped $LiMn_2O_4$, Solid-state combustion synthesis, Electrochemical performance.

ICAMMT:87

Advanced Materials and Modern Technologies: A Secure AI-Driven Framework for Smart Material Monitoring and Predictive Analysis

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Abstract

The rapid development of advanced materials has transformed industries such as aerospace, healthcare, manufacturing, and electronics. Integrating Artificial Intelligence (AI), the Internet of Things (IoT), and cloud computing enables real-time monitoring and predictive maintenance of smart materials. However, these technologies introduce security and privacy challenges due to continuous data transmission and remote access. This paper proposes a Secure AI-Driven Smart Material Monitoring Framework (SAISMMF) that combines IoT sensors, machine learning, blockchain-based authentication, and encryption techniques to ensure secure data collection, analysis, and decision-making. Experimental analysis demonstrates improved prediction accuracy, lower latency, and enhanced resistance to cyberattacks compared to conventional monitoring systems. The proposed framework achieves high reliability while maintaining data confidentiality, integrity, and availability, making it suitable for Industry 4.0 and smart manufacturing applications.

Keywords: Advanced Materials, Artificial Intelligence, IoT, Blockchain, Cybersecurity, Smart Manufacturing, Machine Learning.

ICAMMT:88

SCAPS-1D-Based Numerical Optimization of $CH_3NH_3PbI_3$ Perovskite Solar Cells for Enhanced Photovoltaic Performance

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Abstract

Perovskite solar cells (PSCs) are widely studied because of their high efficiency and low fabrication cost. In this study, a $CH_3NH_3PbI_3$-based PSC with the structure Au/NiO/$CH_3NH_3PbI_3$/ZnO/ITO was simulated using SCAPS-1D software. The performance of the device was improved by optimizing the ETL (ZnO), HTL (NiO), absorber layer ($CH_3NH_3PbI_3$), TCO (ITO), defect density, doping concentration, and layer thickness. After optimization, the solar cell achieved a maximum power conversion efficiency (PCE) of 30.00%. The results demonstrate that careful optimization of material parameters can significantly enhance the performance of $CH_3NH_3PbI_3$-based perovskite solar cells and provide useful guidance for future PSC development.

Keywords: $CH_3NH_3PbI_3$; SCAPS-1D; Perovskite solar cell; ZnO; NiO; Device optimization; Defect density; PCE.

ICAMMT:89

Flower-Like $NiCo_2O_4$ Nanostructures-Anchored Nitrogen-Doped Nanofiber Membrane as an Efficient Electrocatalyst for Glucose Oxidation in Direct Glucose Fuel Cells

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Abstract

A free-standing nitrogen-doped carbon nanofiber (NCNF) membrane anchored with flower-like $NiCo_2O_4$ nanostructures was developed as a binder-free anode for efficient glucose oxidation in direct glucose fuel cells (DGFCs). The NCNF membrane provides a continuous conductive network and self-supporting platform for the in situ formation of $NiCo_2O_4$, eliminating the need for polymeric binders. After 12 h of hydrothermal growth and subsequent calcination, $NiCo_2O_4$ developed into hierarchical flower-like assemblies composed of nanoscale flakes uniformly anchored on the fibrous framework. This architecture increases the exposure of Ni and Co active centres while maintaining interconnected pathways for electrolyte permeation, glucose transport, and charge conduction. The nitrogen-doped carbon framework further promotes catalyst–support interaction and facilitates electron transfer between the active oxide and the current-collecting network. The synergistic combination of the $NiCo_2O_4$ flowers and NCNF scaffold is therefore expected to favour the Ni/Co redox processes responsible for glucose electrooxidation and improve the accessibility of catalytic sites. The glucose oxidation behaviour was evaluated electrochemically in 0.1 M NaOH, where the $NiCo_2O_4$/NCNF promoted strong electronic coupling, charge redistribution, and rapid multivalent redox cycling among the Ni^{2+}/Ni^{3+} and $Co^{2+}/Co^{3+}/Co^{4+}$ active centres. The resulting $NiCo_2O_4$/NCNF integrates a binder-free conductive support with a high-accessibility bimetallic oxide architecture, providing an effective and durable electrode platform for glucose oxidation in DGFC applications.

Keywords: $NiCo_2O_4$; Nitrogen-Doped Nanofiber; Glucose Oxidation; Direct Glucose Fuel Cell


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