Electric and Dielectric Properties of Doped Oxide Material for Potential Application

Priti M. Oza

Abstract

This thesis explores the synthesis, characterization, and application of gallium (Ga) and tantalum (Ta) co-doped titanium dioxide (TiO_2) materials. This research investigates the electric and dielectric properties of these doped oxides, with a focus on their potential in enhancing solar cell efficiency and other innovative applications. The study employs various synthesis techniques, including sol-gel and solid-state reactions, to fabricate the materials, followed by comprehensive characterization through X-ray diffraction (XRD), scanning electron microscopy (SEM), and dielectric analysis. The results reveal significant improvements in lattice parameters, dielectric constants, and antimicrobial properties, alongside a detailed simulation of a solar cell based on ${Ti^{4+}}_{1-x}(Ga_{0.5}Ta_{0.5})_x{O_2}^{-2}$, demonstrating its potential for renewable energy applications. The thesis spans 126 pages and includes a thorough literature survey, synthesis methodologies, property analyses, and simulation outcomes, supported by rigorous plagiarism checks showing a similarity index of 5%. A distinctive emphasis of this research lies in its exploration of the application of these doped oxide materials in the ***toy industry***, aligning with the unique focus of the Department of ***Toy Innovation at Children's Research University***. The enhanced electric and dielectric properties of the Ga and Ta co-doped TiO_2 materials offer promising avenues for developing advanced, energy-efficient toys. Specifically, the improved solar cell efficiency can be harnessed to power interactive and educational toys, such as solar-powered remote-control cars (highlighted in the study's figures), fostering sustainable play experiences. Additionally, the antimicrobial properties of these materials, as evidenced by bacterial analysis, suggest their potential use in creating ***hygienic toy*** surfaces, addressing safety concerns for children. By integrating these materials into toy design, this research bridges cutting-edge materials science with practical applications, contributing to the development of ***eco-friendly, durable, and safe toys*** that educate and entertain. This dual focus on renewable energy and ***toy innovation*** underscores the interdisciplinary impact of the study, paving the way for future advancements in both fields.

Synthesis and Characterization of Oxide Material for Solar Cell Application

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Abstract

This thesis explores the development and analysis of nanostructured ceramic oxide materials, specifically focusing on their potential in enhancing solar cell technology. The research investigates the synthesis of In+Ta co-doped rutile TiO_2 and other metal oxide ceramics, such as $Bi_{0.5}A_{0.5}Ti_{1-x}Mn_xO_3$ (A = Na, K, Li), using the solid-state reaction method, emphasizing their structural, morphological, optical, and dielectric properties. The study achieves remarkable outcomes, including a bandgap of approximately 2.95 eV, enabling efficient absorption in the visible light spectrum (λ ~400 nm), and an exceptionally low dielectric loss (down to 10^{-6} at 1 kHz), making these materials promising candidates for high-efficiency, cost-effective solar energy applications. A unique emphasis of this work lies in its exploration of practical applications, particularly in the realm of ***solar cell-based toys***. The developed materials exhibit characteristics ideal for integration into ***educational*** and ***recreational toys***, such as solar-powered model cars, robots, and interactive learning kits. These ***toys***, leveraging the narrow bandgap and enhanced solar efficiency of the synthesized ceramics, can operate effectively under visible light, offering a sustainable and engaging platform to introduce children to renewable energy concepts. The low-cost synthesis method and non-toxic nature of the materials further enhance their suitability for ***toy manufacturing***, aligning with the mission of ***Children's Research University*** to innovate in ***toy science***. Additionally, the thesis proposes future research directions, including the use of alternative synthesis techniques like ball milling and thin film deposition, to refine these materials into nanoscale forms suitable for compact, lightweight toy designs. This work not only advances solar cell technology but also bridges material science with practical, ***child-centric applications***, fostering both technological innovation and educational outreach.