INVESTIGATING THE EFFECT OF DIFFERENT PARAMETERS ON THE EFFICIENCY OF GALLIUM ARSENIDE SOLAR CELLS PERFORMANCE USING PC1D SIMULATION

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ABSTRACT

INVESTIGATING THE EFFECT OF DIFFERENT PARAMETERS ON THE EFFICIENCY OF GALLIUM ARSENIDE SOLAR CELLS PERFORMANCE USING PC1D SIMULATION

This study investigates the factors affecting the efficiency of Gallium Arsenide (GaAs) solar cells using PC1D simulation software, in response to the global demand for sustainable energy technologies and the limitations of high-efficiency yet high-cost GaAs solar cells. While GaAs cells offer superior performance in harsh conditions compared to traditional silicon-based cells, their high production cost and complexity hinder widespread adoption. The research focuses on optimizing three main parameters like doping carrier concentration, anti-reflective coating (ARC) materials [Titanium Dioxide (TiO_2), Zinc Oxide (ZnO) and Silicon Nitride (Si_3N_4)] and bulk recombination mechanisms. Using PC1D, findings show that optimal doping concentrations significantly improve the built-in electric field and reduce recombination losses, with peak efficiency achieved at N-type doping of 1×10^{16} cm^{-3} and P-type doping of 1×10^{17} cm^{-3}. Among the ARC materials tested, ZnO produced the highest efficiency of 79.95% due to its suitable refractive index and optimized thickness. Additionally, minimizing bulk recombination through increased base carrier lifetime resulted in an efficiency gain, with the highest observed value of 79.90% at a lifetime of 10,000 µs. In conclusion, this research highlights that strategic optimization of doping, ARC selection and recombination control can substantially enhance GaAs solar cell efficiency, offering valuable insights for making this technology more practical and cost-effective for advanced photovoltaic applications.

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