ANALYSIS OF SILICON SOLAR CELL PARAMETER USING PC1D SIMULATION

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ABSTRACT

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The increasing demand for renewable energy and the environmental impact of fossil fuels have led to growing interest in improving silicon solar cell efficiency, which is often limited by structural and material parameters. The effect of several parameters which are absorber layer thickness, emitter doping, anti-reflective coating (Si_3N_4) and back surface field (BSF) concentration were investigated. A simulation-based method using PC1D software was employed, allowing detailed modelling of one-dimensional solar cell structures under controlled variations of each parameter while keeping others constant. By simulating this parameter in PC1D simulation, this study aims to understand their impact on performance metrics such as short circuit current (I_{SC}), open circuit voltage (V_{OC}), maximum power (P_{max}), fill factor (FF) and efficiency (η). The results showed that the highest efficiency of 23.06% was achieved with a 74.257nm Si_3N_4 anti-reflective coating. Additionally, a 200μm absorber layer yielded 22.63% efficiency, while 2×10^{16} cm^{-3} emitter doping and 3×10^{17} cm^{-3} back surface field concentration produced 22.61% and 22.59% efficiency, respectively. These findings confirm that precise optimization of physical and doping parameters can significantly improve solar cell performance, supporting both theoretical expectations and previous literature. The simulation also highlights the effectiveness of PC1D as a low-cost, time-efficient tool for photovoltaic research, providing results that closely align with real-world behavior. Overall, this study provides valuable design insights for enhancing the efficiency of silicon-based solar cells and contributes to the advancement of sustainable and high-performance photovoltaic technologies.

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