PC1D SIMULATION ON VARIOUS ANTIREFLECTION COATING (ARC) AND DOPING OPTIMIZATION IN SILICON SOLAR CELL

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ABSTRACT

PC1D SIMULATION ON VARIOUS ANTIREFLECTION COATING (ARC) AND DOPING OPTIMIZATION IN SILICON SOLAR CELL

The solar installation sector has experienced a 24% annual growth rate over the past decade, driven by nanotechnology. However, challenges persist such as insufficient light energy conversion due to reflection loss on silicon surfaces, and limited efficiency of conventional solar cells that only convert about 30% of sunlight into power. This study investigates the optimization of doping levels and antireflection coating (ARC) materials to address these issues and achieve higher efficiency in silicon-based solar cells using PC1D simulation software. The goal of this research is to analyze various ARC materials, such as Si_3N_4, ZnO, TiO_2, SiO_2, ZnS, and SiC, focusing on their refractive index and thickness to minimize reflectance and maximize absorption energy. Simultaneously, the impact of different doping concentrations in n-type and p-type semiconductor regions is studied to identify optimal electrical performance at the p-n junction. Simulation results indicate that Si_3N_4 and ZnO ARCs exhibit maximum efficiency, around 23%, with moderate doping concentrations (10^{17} cm^{-3}), while over-doping leads to efficiency losses due to increased carrier recombination. Key output parameters like open-circuit voltage (V_oc), short-circuit current (I_sc), fill factor (FF), and maximum power (P_max) were measured for performance comparison. The findings reveal that careful selection and optimization of ARC material and doping concentration are critical to enhancing solar cell performance and encouraging cost-effective, high-efficiency photovoltaic technologies.

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