

# An experimental investigation of spin-on doping optimization for enhanced electrical characteristics in silicon homojunction solar cells: Proof of concept

## Abstract

The pursuit of enhancing the performance of silicon-based solar cells is pivotal for the progression of solar photovoltaics as the most potential renewable energy technologies. Despite the existence of sophisticated methods like diffusion and ion implantation for doping phosphorus into p-type silicon wafers in the semiconductor industry, there is a compelling need to research spin-on doping techniques, especially in the context of tandem devices, where fabricating the bottom cell demands meticulous control over conditions. The primary challenge with existing silicon cell fabrication methods lies in their complexity, cost, and environmental concerns. Thus, this research focuses on the optimization of parameters, such as, deposition of the spin on doping layer, emitter thickness ( $X_j$ ), and dopant concentration ( $N_D$ ) to maximize solar cell efficiency. We utilized both fabrication and simulation techniques to delve into these factors. Employing silicon wafer thickness of 625  $\mu\text{m}$ , the study explored the effects of altering the count of dopant layers through the spin-on dopant (SOD) technique in the device fabrication. Interestingly, the increase of the dopant layers from 1 to 4 enhances efficiency, whereby, further addition of 6 and 8 layers worsens both series and shunt resistances, affecting the solar cell performance. The peak efficiency of 11.75 % achieved in fabrication of 4 layers dopant. By using device simulation with wxAMPS to perform a combinatorial analysis of  $X_j$  and  $N_D$ , we further identified the optimal conditions for an emitter to achieve peak performance. Altering  $X_j$  between 0.05  $\mu\text{m}$  and 10  $\mu\text{m}$  and adjusting  $N_D$  from  $1\text{e}+15 \text{ cm}^{-3}$  to  $9\text{e}+15 \text{ cm}^{-3}$ , we found that maximum efficiency of 14.18 % was attained for  $X_j = 1 \mu\text{m}$  and  $N_D = 9\text{e}+15 \text{ cm}^{-3}$ . This research addresses a crucial knowledge gap, providing insights for creating more efficient, cost-effective, and flexible silicon solar cells, thereby enhancing their viability as a sustainable energy source.

## Keywords

Efficiency; Emitter thickness; Energy; Homojunction; Series resistance; Shunt resistance; Silicon; Solar cell; Spin on doping