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Theoretical design and performance of $In_xGa_{1-x}N$ single junction solar cell

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ABSTRACT

The insertion of optimized Window and a back surface field (BSF) layers on an $In_xGa_{1-x}N$ p-n basic single junction (BSJ) solar cell is the chief reason behind the reduction of front and back recombination. In this context, this work is focused on the selection of the suitable parameters including the indium (*In*) content, thickness and doping concentration for the $In_xGa_{1-x}N$ inserted layers, that gives the best photovoltaic performances. At this aim, numerical simulations were performed using the computational numerical modeling TCAD *Silvaco-Atlas* to design, optimize the $In_xGa_{1-x}N$ BSJ and extract the above Window and BSF parameters that enhance the BSJ performances. A short circuit current density (J_{sc}) of 26.15 mA/cm^2, an open circuit voltage (V_{oc}) value of 0.904 V and a fill factor (*FF*) value of 79.67 % are obtained under AM1.5G illumination, exhibiting a maximum conversion efficiency (η) of 19.62 %. Other parameters like the external quantum efficiency (EQE), electric field developed, the current density-voltage (J-V) and the power density-voltage (P-V) characteristics are also calculated and plotted for the designed solar cell.

1. Introduction

As the demand of energy and emphasis on environmental protection increase, solar energy is expected to become the major energy source [1]. Solar cells still remain the best way yet determined to harness energy from the sun, which is literally the unlimited source of renewable and clean energy [2]. To attain the expected breakthrough of photovoltaic technology as a competitive energy source against fossil fuels, the cell higher conversion efficiency, low cost and stability are the main factors [3]. Several materials were utilized to perform solar cells, the most common material used for the production of photovoltaic cells is silicon which is now approaching his theoretical maximum efficiency [4,5].

III-V group materials have been widely used for tandem solar cells for the space application, such as *GaAs* stacked with *InGaP* and *Ge*. The toxicity of arsenic in *GaAs*, the *InGaP* low resistance against irradiation damage and the indirect bandgap of the *Ge* are the biggest barriers of these materials [3]. *InGaN* is an alternative photovoltaic material, it has become a promising candidate for high-efficiency solar cells due to its attractive features. Among these, the following are of most interesting: First, the direct band gap lying from 0.7 eV (*InN*, in the near IR) to 3.4 eV (*GaN*, in the mid-UV), which can absorb the full

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