Computational Study of the Photovoltaic Performance of CdS/Si Solar Cells: Anti-reflective Layers Effect

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Photovoltaic conversion is a photo-electronic process that involves the interaction between a photo and an electron. The subject is to present a study on the physical principle of operation of a photovoltaic cell based on silicon. The external parameters that we have determined from a photovoltaic model are the short-circuit current (J_{sc}), the open-circuit voltage (V_{oc}) and the photovoltaic conversion efficiency (η), we simulate the photovoltaic parameters by the Solar Cell Capacitance Simulator structures (SCAPS-1D) software whose mathematical model is based on solving the equations of Poisson and continuity of electrons and holes. We used two structures to carry out this study, the first ITO/CdS/Si and the second ZnO/Si/CdS, after having noted their current-voltage characteristic (*J-V*). In this paper we studied the effect of the temperature and the doping concentration on the two structures of heterojunction solar cell. The highest performance value for the ZnO/CdS/Si heterojunction solar cell was simulated as 29.3 %. The performance value for the ITO/CdS/Si structure was increased to 29.7 % with the impact of the ITO antireflective layer.

Keywords: Si, CdS, ITO, ZnO, Solar cells, SCAPS-1D.

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1. INTRODUCTION

Solar energy is a clean and renewable source of power that has gained significant attention in recent years as a way to reduce dependence on fossil fuels and combat climate change [1-6]. Among the various types of solar cells available, CdS/Si (cadmium sulfide/silicon) heterojunction solar cells have emerged as a promising option due to their efficiency, cost-effectiveness, and stability [7-10]. A CdS/Si heterojunction solar cell is a type of heterojunction solar cell that utilizes a thin layer of CdS as the light-absorbing material and a layer of silicon as the semiconductor [11]. CdS based solar cells have been used as moisture based electricity generators, photo detector [12], highly sensitive detector for the solar light, dopant free solar cells [12]. The CdS and silicon layers are carefully engineered to form a p-n junction, which allows for efficient conversion of sunlight into electrical energy. The CdS layer absorbs the sunlight and generates electron-hole pairs, which are then separated by the *p-n* junction and collected by the electrodes to generate an electrical current. CdS/Si heterojunction solar cells have achieved efficiencies of up to 12.29 % in laboratory conditions and are relatively low-cost to produce[13]. They also have a good stability. However, CdS is toxic and therefore CdS/Si solar cells are not widely used as compare to other solar cells like CIGS [14-16] or CdTe [17].

In this work, it is provided an in depth acquaintance to the new technological advancement in the field of solar cells. The use of a possible combination of CdS/Si heterojunction with ITO or ZnO is proposed as a probable step to increase the solar cell efficiency above the theoretical limit.

2. NUMERICAL MODELING AND MATERIAL PARAMETERS

The composition of solar cells from right to left, the CdS/Si cells are composed of transparent conductive film (ZnO) or (ITO); absorber layer of s silicon; *n*-type layer of CdS; a substrate made of Mo/glass as shown in the Fig. 1 below. The initial physical parameters of ITO, ZnO, CdS and Si layers simulation are summarized in Table 1.

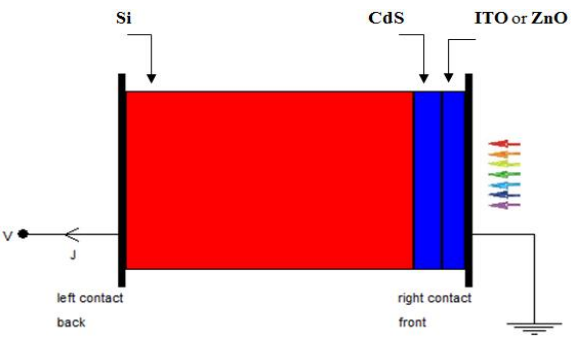

Fig. 1– Structure of Solar cell used for the numerical

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