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Design and Fabrication Heterojunction Solarcell of Si-CdS-ZnO Thin Film

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Cadmium sulphide (CdS) is a prominent candidate to be used a buffer layer in Si based solar cell. In this study, absorber layer parameters thickness have been investigated by (SCAPS) to find out the higher conversion. Moreover, it is found that J_{sc},V_{oc}, η is increased for the absorber layer thickness of 500-600 nm and quantum efficiency is nearly overlap after the 600 nm thickness of the Si absorber layer. In addition, it is revealed that the highest efficiency cell can be achieved with the absorber layer thickness of 600 nm. From the simulation results, numerous influences of absorber layer are investigated in Si/CdS/ZnO solar cell which can lead to the fabrication of high efficiency devices. Experimentally the designed cell fabricated and the electrical properties measured also J_{sc} ,V_{oc} (with lower values) as Si thickness increased until 600 nm. And best efficiency value calculated was 8.9%.

Keywords: Zinc oxide, Solar cell, Film thickness, Layer, Simulation.

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1. INTRODUCTION

Buffer layer is an intermediate layer film between the absorber and window layers with two main objectives, to provide structural stability to the device and to fix the electrostatic conditions inside the absorber layer [1]. Meanwhile, it will have to make good p-n junction with the p-type absorber layer for the electrical conduction and to allow the transmission of photons into the absorber layer to generate electron-hole pair [2].

Simulation of thin film solar cells has become increasingly mature and complex over the last two decades. A number of simulation packages have been developed at universities or research institutes and use atypically available at no cost and without support .This group of programs includes AMPS-ID,SCAPS-ID,PC-ID,ASA ,and AFORS-HET [3]. Among these programs is SCAPS-ID that used in this work, SCAPS-ID ,an acronym for "Solar Cell Capacitance Simulator One Dimension" , is a windows application program, developed at the University of Gent with Lab Windows/CVI of National Instruments under Mars Burgelman[4]. This program is designed basically for the simulation and studying the properties of the photonic devices [5]. In this work we did a simulation using (SCAPS) on Si/CdS/ZnO thin film solar cell, and then experimentally prepared using CVD method. The main focus is to find out the best electrical performances of the thin film solar cells with Si/CdS/ZnO. Moreover, the effects of various thicknesses of Si have been investigated for the Si/CdS/ZnO structured solar cells.

2. EXPERIMENTAL DETAILES

The DC electrical characteristics of thin film heterojunction solar cells (Si/CdS/ZnO) can be investigated with SCAPS ID. We have used SCAPS- program to study the dependence of absorber layer thickness for Si thin films solar cells. We demonstrated the effect of absorber thickness on the solar cell parameters like open circuit voltage (Voc),short circuit current density (Jsc), conversion efficiency (η) and the quantum efficiency (QE). The best electrical performance for CdS and Si solar cells can also be simulated. SCAPS is used to imitate and investigate all the available research-level Si/CdS solar cells with various buffer layers. In the simulation, n-type ZnO,CdS and p-type Si layer parameters are emphasized to investigate the benefits of using CdS as buffer layer in Si solar cells and comparative study with Si/CdS structure. By incorporating the various material parameters into SCAPS for all of the analysis aspects, changes in the values for efficiency, open circuit voltage, short circuit current, fill factor and the quantum efficiency (QE).

The preparation process is included by depositing Al layer (back contact) on glass substrate and followed by depositing p-type Si layer on the substrate with Chemical Vapor Deposition (CVD) method. the buffer layer is also deposited on the Si solar cell with thickness (0.5μm) after that, the window layer Zinc Oxide ZnO is deposited on CdS buffer layer with thickness (1μm) also by CVD. Schematic structure of the solar cell given in Fig 1.

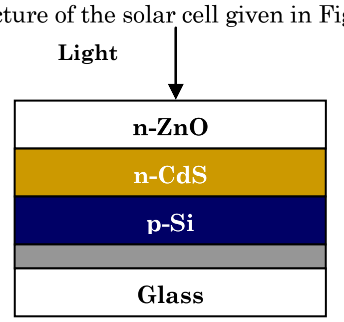

Fig. 1 – Schematic structure of Si solar cell with CdS buffer layer

Electrical measuring done of the sample at illumination then with 100 mw/cm^2 on input power 100 volt.

3. RESULTS AND DISCUSSION

Solar cell of Si/CdS/ZnO designed and using SCAPS program used for simulation of the expected characteristics, QE and efficiency values. Fig.2 shows the J-V characteristics for Si solar cell with SCAPS program. The corresponding solar cell parameters are recorded in table 1.

Fig.2 and table 1 shows that the efficiency increases as Si thickness increase and saturates after 600 nm. The optimum conversion efficiency is about 10.7 % at 600 nm Si thickness.

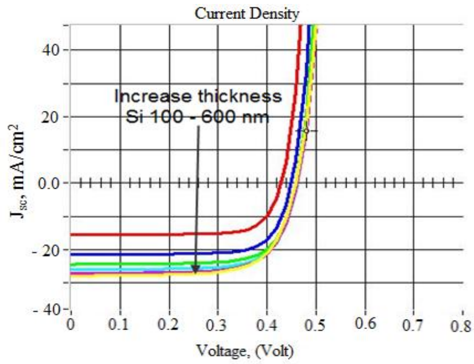

Fig. 2 - J-V spectra for different Si thickness

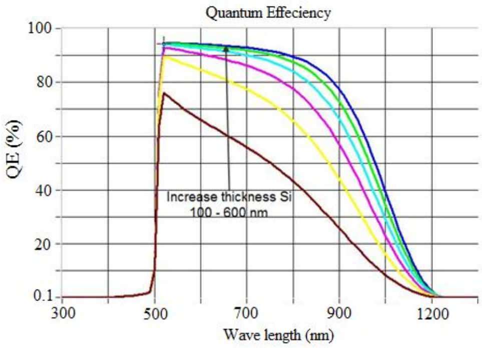

Fig. 3 - J-V spectra for different Si thickness in the Fabricated solar cell

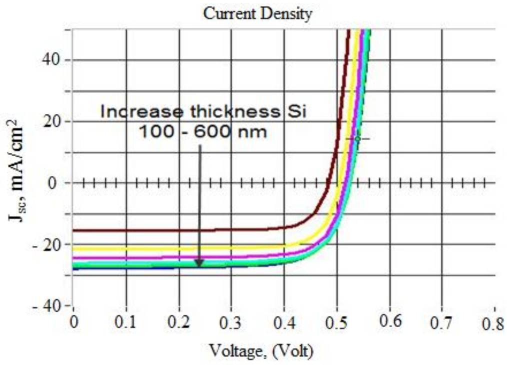

Fig. 4 – Simulated QE spectra for different Si thickness

Fig.4 shows the simulated quantum efficiency (QE) spectra for different Si thickness which shows that at higher thickness of Si more photons absorbed, which improves the overall efficiency of the device.

The fabricated solar cell for this work is Si/CdS/ZnO, the J-V characteristics for Si solar cell is shown in fig.3 and the solar cell parameters are recorded in table 2.

It is clear from fig.4 and table 2 that values of V_{oc}, J_{sc} of the solar cell parameters increase as Si thickness increase, The conversion efficiency increased until the thickness reached at around 600 nm. Further increase in the thickness of the films does not show any improvement in the efficiency. The optimum conversion efficiency is nearly 9 % observed. Also it is appear that the efficiency increases as the thickness increase and saturates after 400 nm which is shown in fig.4.

Fig.5 shows that the Variation in the V_{oc}, J_{sc} and efficiency as a function of Si thickness.

The conversion efficiency (η%) of the Si solar cell is calculated from the relation [6].

$$\eta = \left[\frac{I_{sc}V_{oc}FF}{P_{h\nu}}\right]\times 100\% \quad (1)$$

where $P_{h\nu}$ is the power density of the incident radiation.. The fill factor (FF) which is a measure of the ideality of the system, is calculated from the relation [7].

$$FF = \left[\frac{I_m V_m}{I_{sc}V_{oc}}\right]\times 100\%, \quad (2)$$

Where I_m and V_m are, respectively the current density and voltage obtained at maximum power point on the photovoltaic power output curve. The fill factor values obtained are in agreement with the theoretical of Si solar cell.

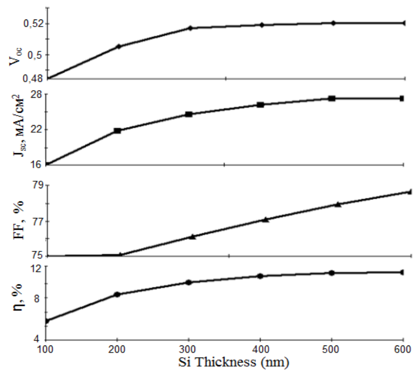

Fig. 5 - Variation in the V_{oc}, J_{sc} and efficiency as a function of thickness

Table 1 – Solar cell parameters using SCAPS program with thickness of CdS (0.5μm) and ZnO thickness (1μm)

V_{oc}, Volt	J_{sc}, mA/cm^2	FF, %	η, %	Si thickness, nm
0.52	27.2	74.2	10.7	600
0.52	27.18	74.3	10.6	500
0.519	26.11	75.51	10.3	400
0.517	24.44	76.68	9.7	300
0.505	21.515	77.71	8.5	200
0.484	15.48	78.59	5.9	100

Table 2 – Fabricated solar cell parameters with thickness of CdS (0.5μm) and ZnO thickness (1μm)

V_{oc},Volt	J_{sc}, mA/cm^2	FF, %	η, %	Si thickness, nm
0.462	27.2	71.01	8.97	600
0.462	27.13	71.02	8.92	500
0.46	26.07	72.15	8.71	400
0.458	24.39	73.28	8.23	300
0.451	21.47	74.47	7.21	200
0.430	15.45	75.42	5.01	100

The QE spectra for different Si thickness shows that higher thickness absorbs more photons which improves the overall efficiency of the device and it is nearly overlap after the 600 nm thickness of the Si absorber layer as shown in fig. 6.

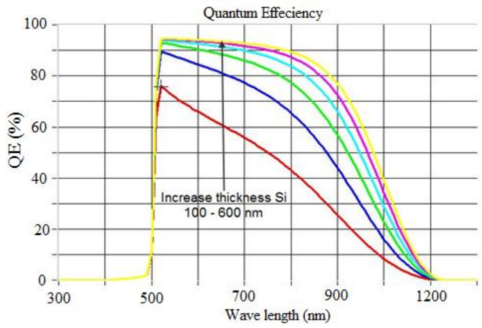

Fig. 6 - Practical QE spectra for different Si thickness

4. CONCLUSIONS

From this numerical analysis of heterojunction-solar cells with Si and CdS buffer layers, electrical performances for the Si/CdS/ZnO solar cells have been investigated in terms of absorber layer thickness. The increasing of Si absorber layer thickness results in higher Jsc, Voc and η also yields better performance. A new challenge to fabricate large-area p-Si/ n-ZnO thin film photovoltaic has been opened up by transferring the new device structure case developed in SCAPS.

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