Study of n/p solar cell based on ITO/Si Heterojunction

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Introduction

Transparent conductive oxides (TCO) are remarkablematerials in many fields. The existence of their dualproperty, electrical conductivity and transparency in thevisible, in addition to mechanical durability, including flexibility, makes them ideal candidates for applicationsin optoelectronics, photovoltaic or even as electro-chromic windows[1]. They can become conductive (of typen for example: ZnO, ITO..and type p: NiO, SnO)[2]Theuse of TCO in heterojunction C-Si solar cells as transparent electrodes, and as n or p type layers in a solarcell is an economically viable photovoltaic technology[3].Among n type TCO are tin doped Indium oxide (ITO isformed from indium oxide (In2O3) and a few atomicpercentages in tin (Sn), generally 10 %), which is themost used on an industrial large scale since it is non-toxic,good cost and abundance[4]. In this paper presented thestudy simulation of ITO /Si heterojunction solar cellsusing the simulation program Silvaco-Atlas that are usedas optical window also used as electrodes for a solar cell.

Theoretical Study

The ATLAS device simulator, by Silvaco international, is a computer program, which uses solid-state physics and numerical analysis to simulate the behavior and characteristics of electrical devices [5]. In this chapter, the ATLAS simulator is used to study n/p solar cells based on conductive oxide /Si heterojunction. The studied cell is ITO/Si. Figure.1:

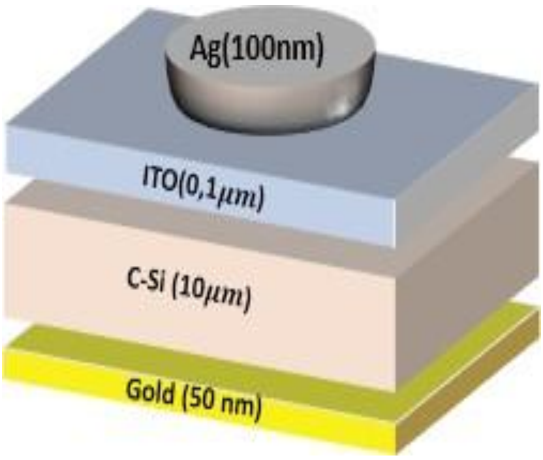

Figure.1: The structure of ITO/Si solar cell.

Results and Discussion

We notice that this study is carried out in the ideal case byomitting defects in the ITO (n-type)/Si (p-type) solar cell. The first structure named structure 1 is presented, in which the cathode material is the silver. We have tried to improve structure 1 to structure 2 in which a SiO_2 anti- reflecting (AR) layer is added on the top of the cell and the silver cathode is replaced by three transparentconductor ITO

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cathode .by comparing the two structures indeed there is improvement in Jsc unlike Voc and FF that increase a little. Structure 2 exhibits a conversionefficiency of 3.14% better than 0.85% of structure 1. These values are in the experimental range (earlymeasurement without any optimized conditions). In second section, we study the thickness effect of the C-Si p-layer. The layer thickness is varied from 10 μm to 500 μm using structure 2. Significant increase is noticed in Jsc. All the other parameters also increase the significant increase in Jsc is related to the absorption with the augmentation of the p-layer thickness but without exceeding the free carrier diffusion length and the efficiency increase from 3.14% to 7.9 %. The p-type C-Si layer thickness is kept at 500 µm and thickness of ITO ranges from 0.1 to 1µm it is observed that Voc remains constant during the simulation process the efficiency enhances from 7.9% to 9.45%. The little increaseremarked in is because the ITO is characterized by transparency and then absorbs in the UV and generates few carriers. In third section, the doping of the two layer of the cell is augmented and in addition, a back doping in the Si region is inserted. A benefit effect of the doping is observed in FF and Voc. The best efficiency is 17.24 % using a back doping. In section fourth the effect of anode work function is studied the work function anode contact is changed from 5.23 eV to 5.8 eV, taking into account the precedent optimum parameters of thicknesses and doping. It is observed that all outputs improve little a bit with the increase of the anode and the reached efficiency is 18.39%. In final section, we suggest the formation of a buffer layer between the ITO and Si region littleamelioration is noticed in all outputs parameters of the solar cell are summarized: J_{SC}=35.01 $mA.cm^{-2}$, Voc=0.665V, FF=0.832, η =19.39 %.

Conclusion

In this paper, we have successfully simulated solar cells based on ITO /Si using Silvaco-Atlas software. Manyimprovements have been made (thickness, doping, work function of anode, buffer layer). Before optimizations, theconversion efficiency was 0.85% optimization process efficiency reached 19.39%.

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