INTERNATIONAL JOURNAL OF ADVANCED RESEARCH IN ENGINEERING AND TECHNOLOGY (IJARET)

ISSN 0976 - 6480 (Print)
ISSN 0976 - 6499 (Online)
Volume 4, Issue 7, November - December 2013, pp. 297-301
© IAEME: www.iaeme.com/ijaret.asp
Journal Impact Factor (2013): 5.8376 (Calculated by GISI)
www.jifactor.com

IJARET
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FABRICATION OF AGAL/SI SOLAR CELL

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ABSTRACT

The structural, optical and photoelectrical properties of fabricated diffusion heterojunction (HJ) solar cell, from n-type c-Si wafer of [400] direction with Boron, has been studied. AgAl alloys was used because of its properties that affect as a good connection materials. TiO_2 has been used as a reflecting layer to increase the absorption radiation.

The HJ has direct allowed energy gap equal to 3.1 eV. The c-Si/B HJ solar cell yielded has an active area conversion efficiency of 16.4% with an open circuit voltage of (V_{oc}) 0.592V, short circuit current (I_{sc}) of 2.042mA, fill factor (F.F) of 0.682 and η% =10.54.

Key words: Heterojunction, Agal, Solar Cell Efficiency, Optical Properties.

INTRODUCTION

Recently, heterojunction (HJ) silicon based solar cells were under intensive investigations as a technological alternative to c-Si solar cells with diffused p-n junctions since they are combining the low cost and low temperature processes of a-Si:H deposition coupled with the high efficiency and high stability of c-Si[1].

We choice Ag-Al alloy as an electrical connections for the following reasons:

1. The influence of Ag on the properties of Al rich Al-Ag alloys is particularly intriguing because Ag does not affect the Al lattice parameter[2].
2. There is interdiffusion between Ag and Al to lead to greater intermixing because extrapolation of higher temperature diffusion data to room temperature suggested that interdiffusion might occur at R.T.[3].

3. There is stability for metal-metal interface, in particular, interfaces between aluminum and various transition metals play an important role in applications as catalysts, metallization layers in semiconductor devices, and thin films for magnetic data storage[4].

X-ray Diffraction (XRD): was used to the position and intensity of diffracted intensity spectra versus Bragg's angle, gives information on the crystal structure such as phase crystalline, polycrystalline, amorphous, grain size, and lattice parameter.

The inter planer distance d (hkl) for different planes was measured by Bragg's law[5]:

$$2d\sin\theta = n\lambda \qquad (1)$$

Where n is the reflection order.

The optical absorption spectrum used to determine the optical energy gap and the absorption coefficient. We employed Tauc formula equation[6]:

$$\alpha h\nu = B\,(h\nu - E_g^{opt})^{1/r} \qquad (2)$$

Where, B is a constant inversely proportional to amorphousity, hν is the photon energy (eV), E_g^{opt} is the optical energy gap (eV), and r is constant and may take values 2, 3,1/2, 3/2 depending on the material and the type of the optical transition. There are two types of the optical transitions, direct and indirect transition, according to the type of materials.

The values of $(\alpha h\nu)^2$ plotted against photon energy (hν), the straight lines portion extrapolated to zero and the values, which obtained, represented the optical energy gap for direct transition.

In the absence of recombination or generation of carriers in the depletion region, J_R is voltage independent and is equal to the short-circuit photocurrent density (J_{SC}) [7].

The open-circuit voltage V_{oc} across the heterojunction (i.e. for J=0) can process in terms of J_R and J_S as follows:

$$V_{oc} = k_B T/e \ln(1 + J_R/J_S) \qquad (3)$$

The fill factor is defined as:

$$F.F = \frac{V_m I_m}{V_{oc} I_{sc}} \qquad (4)$$

Where: $V_m I_m$ present the maximum power P_m.

$$\eta = \frac{P_m}{P_{in}} x100\% \qquad (5)$$

EXPERIMENTAL PARTS

N-type single crystal wafer has been cleaned, The p-n heterojunction have been prepared by coated boron layer of 1.5μm thickness on n-Si wafer by plating the wafer in vacuum France to get the diffusion junction, the AgAl alloy has been use as grid electrode, deposited as a thin films on the back of the Si-wafer for all the cell area, using thermal evaporation method at pressure about $2x10^{-5}$

Torr in vacuum, with rate of deposition 8.5°A/sec, using Coating unit Edward type (E306A), while on the front of the cell it has been deposited using the mask to get the connection grid of the cell, then we evaporated the TiO_2 thin films at 470 C to get the antireflection layer.
The structures of the alloy and deposited films have been examined by XRD methods using siemens x-ray diffractometer system.

The optical energy gap has been determined to study the optical properties of single crystal n-Si/B heterojunction have been characterized using equation(2).
The short circuit current (I_{sc}), the open circuit voltage (V_{oc}), filling factor, and the efficiency were measured using QuickSun Solar Simulator-Version7.1.9.

RESULTS AND DISCUSSION

We divided the x-ray diffraction pattern into two parts A and B because of the great difference in intensity values between that of c-Si wafer and c-Si/B heterojunction. Part A of the figures illustrated that silicon substrate which has single crystal structure in nature at the direction [400] ,we can observe that it belong to the Si at (2Ɵ=69.1°) as shown in the fig.(1-a).

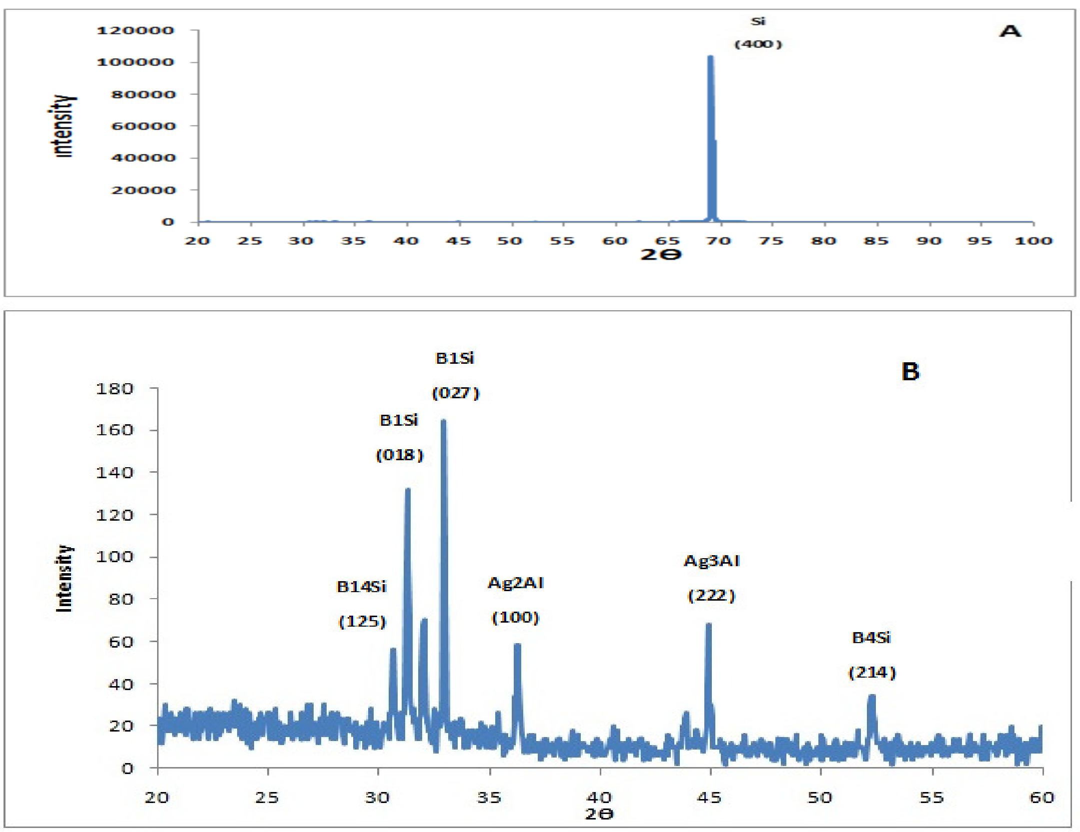

Figure (1): Present the X-ray diffraction pattern of Si and n-Si/B heterojunction

Part B of the Fig.(1) shows that there was an diffusion process between n-Si substrate and boron p-type layers, which presented in the reflected diffraction angles at (2Ɵ=30.65°, 31.3 °, 32.05 °, 32.95 °) , revealed that there was present of B-Si bonding in the formed c-Si/B heterojunction, which illustrated that there was boron inclusion with the silicon wafer.

Whereas, the diffraction angles which belong to AgAl films that has been used for electrical connection, present at (Ө=36.3^o and 44.9^o).

The optical energy gap values (E_g^{opt}) for c-Si/B heterojunction has been determined to find the type of the optical transition by plotting $(\alpha h\nu)^2$ versus photon energy (hν) and select the optimum linear part. It was found that the relation for r=1/2 yields linear dependence, which describes the allowed direct transition. It determined by the extrapolation of the portion at (α=0) as shown in Fig.(2).

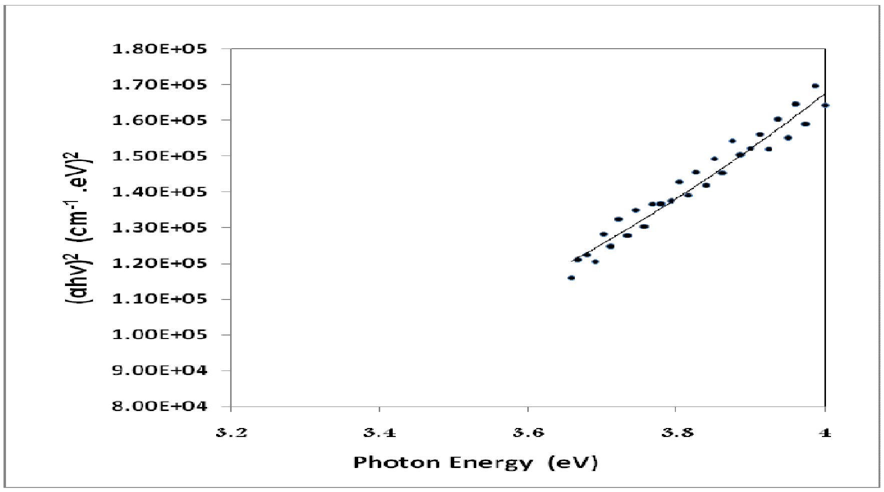

Figure (2): Present (αhν)^2 as a function of photon energy (eV) of n-Si/B heterojunction

The deduced values of HJ optical band gap has been evaluated from figure (2), its equal to 3.1eV. This values lease than that of single crystal silicon wafer which has direct energy gap equal to 3.4eV, because of the diffusion of boron layer with the substrate. Besides, the band gap narrowing is usually observed with increasing the interaction of boron layer of the heterojunction. The solar cell parameters, short circuit current density I_{sc}, open circuit voltage V_{oc}, and the maximum out putted power (P_m), were listed in table (1).

Table (1) electrical parameters of fabricated n-Si/B heterojunction solar cell

P_m(W)	I_m(A)	V_m(V)	V_{oc}(V)	I_{SC}(mA)	F.F%	η%
0.82	1.801	0.458	0.592	2.042	0.682	10.54

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تصنيع الخلية الشمسية AgAl

الخلاصة:

تم دراسة الخصائص التركيبية , الضوئية والكهروضوئية للخلية الشمسية ذات المفرق الهجيني المصنعة من الوصلة الانتشارية للسليكون السالب مع البورون الموجب الشحنة , واستخدام سبيكة AgAl للتوصيلا ت الكهربائية , بسبب ماتمتلكه من خصائص مميزة.

ان المفرق له فجوة طاقة مسموحة مباشرة قيمتها 3.1 الكترون-فولت.

ان قيمة فولتية الدائرة المفتوحة تساوي 0.592 V وتيار القصر 2.042 mA وعامل الملئ 0.682 والكفاءة كانت 10.54% .