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# Electron transport mechanism of SnIn/c-Si Solar cell

Ahssan humyan saber [1] & Z. T.Mohammed Noori [2] & Kadhim A. Adem [1]
Physics Department / Collage of Science / University of Baghdad [1]
Optics technology Department /Dijllah university Collage [2]

# أليات الانتقالات الالكترونية للخلية الشمسية SnIn/c-Si

احسان حميان صبار ١ & زيدون طارق محمد نوري٢ & كاظم عبد الواحد عادم ١
قسم الفيزياء / كلية العلوم /جامعة بغداد١
كلية دجلة الجامعة الاهلية / قسم تقنيات البصريات ٢

**الخلاصة:**

تم في هذا البحث تصنيع خلية شمسية SnIn/c-Si وذلك بترسيب غشاء من السيلينيوم بسمك 500 nm على ارضية من السليكون البلوري بواسطة التبخير الحراري ودرست الخواص الكهربائية للغشاء التي تتضمن التوصلية المستمرة مع درجات حرارة تلدين مختلفة .
من قياسات التوصيلية المستمرة تم حساب طاقات التنشيط الاولى والثانية ووجد انها تزداد مع زيادة درجات حرارة التلدين من 223-348 K .
القياسات الكهربائية للخلية الشمسية تتضمن قياسات تيار – فولتية عند درجات حرارة التلدين مختلفة. ومن قياسات تيار – فولتية تم حساب الكفاءة للخلية الشمسية ووجد انها تزداد من ( 4.67-1.5 )% بزيادة درجات حرارة التلدين.

## Abstract :

In this research was fabricated SnIn/c-Si Hetrojunction Solar Cell, where SnIn/c-Si heterojunction Solar Cell fabricated by deposition of SnIn film with thickness 500 nm on c-Si by using thermal evaporation. Electrical properties of SnIn thin film include d.c conductivity and Hall effect at different annealing temperature .
From d.c conductivity found the electrical activation energies $Ea_1$ and $Ea_2$ increase with increasing of annealing temperature from 323K to 348K.
From I-V characteristics, measurements efficiency of the found increasing from (1.5 to 4.67)% with increasing of annealing temperature .

**Key words: silicom carbide, Heterojunction solar cell, solar cell**

## Introduction

Recently, high-quality epitaxial growth of SnIn and related materials on (111) oriented Si substrates has been accomplished by incorporating thin intermediate BaF2/CaF2 layers. 1, 2 Heteroepitaxial growth of SnIn on silicon takes advantage of silicon integration technology to obtain inexpensive photonic devices SnIn layers grown heteroepitaxially on Si(111) have been fabricated.[1,4] in this paper we will present deposition SeIn thin film fabricated by the thermal evaporation technique. separated by a junction with a built-in field.

Once separated, they arrive as majority carriers on the opposite sides of the junction. This excess majority carrier concentration is responsible for the creation of voltage across the external circuit. If a load is attached to this circuit a current starts to flow, and useful work[2]. SnIn/c-Si this is solar cell prepared from deposition SnIn over crystal silicon (c-Si) , SnIn alloy ingredient from 50% Sn and 50% In.

## Solar Cell

A solar cell is a large-area p-n junction structure designed to convert the sun light into electric current efficiently. Solar cells use the photovoltaic effect, whereby excess photogenerated minority carriers are influence the performance of the device[3,6]. Figure (1) shows the I-V characteristics of a solar cell in the dark and under illumination.

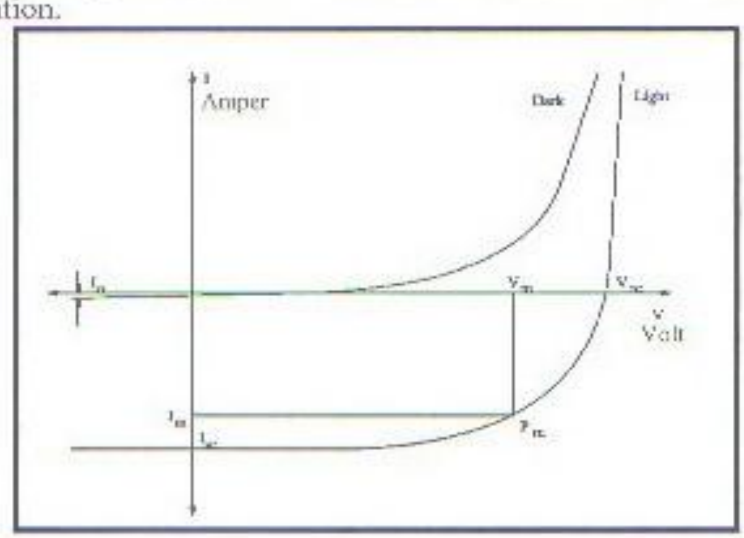


Figure (1) I-V Curve of the Solar Cell in Dark and under Illumination

parameter of interest is the Fill factor given by the relation[3]

$$FF = V_m I_m / V_{oc} I_{sc}$$

The photovoltaic conversion efficiency is another important parameter. It is a measure of the amount of light energy that is converted into electrical energy and is given by.

$$\eta = P_m / P_{in} = FF \times I_{sc} \times V_{oc} / P_{in}$$

where $P_m$ is the area of the maximum power rectangle, and Pin is the incident power[3]

## Experimental Work

Substrates of *n*-type single crystal Si wafers of resistivity 3 (Ω-cm) and orientation (111) were used in the present study. After scribing these wafers into small pieces (typically 1cm x 0.6cm in size), with one surface polished with 2HF: $3HNO_3$: $3CH_3COOH$ mixture (3:5:3) were cleaned ultrasonically by dipping in distilled water, acetone and isopropyl alcohol alternately. After cleaning, the samples were oxidized in dry oxygen [3]. The films of SnIn were prepared by thermal evaporation in vacuum of the order of $10^{-5}$ torr, the rate of evaporation was ≈0.8 nm/min, onto clean silicon mirror-like side substrates at room temperature (~300K). The average thicknesses of the deposits were determined by microbalance method. The maximum error in the determination of thickness was of the order of 10% estimated for the thinnest films (SnIn /Si films of thickness 500 nm). Ohmic contacts of Al Study On the Electrical Properties SnIn /Si Heterojunction aluminum [4] were evaporated on the silicon side and SnIn/Si side.

## Result And Discussion

## D.C conductivity of a-Se layer

The dc conductivity for a-Se films has been studied as a function of 1000/T.

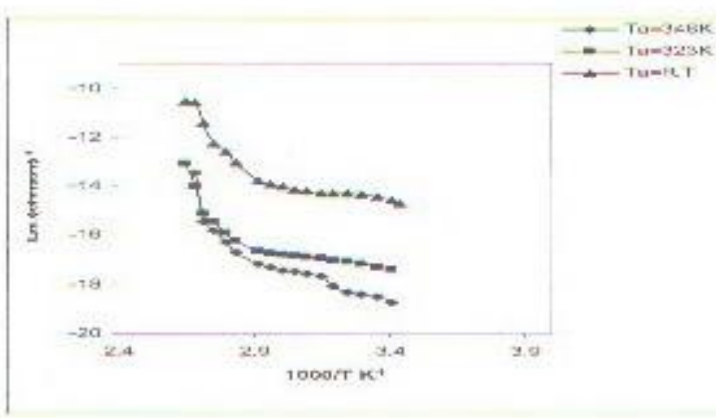


Fig (2) Lnσ as a function of 1000/T for SnIn films

Table(1) DC activation energy

| TaK | $Ea_1$(eV) | Rang Temp. (K) | $Ea_2$(eV) | Rang Temp. (K) |
|---|---|---|---|---|
| 303 | 0.81 | 291-333 | 0.17 | 333-383 |
| 323 | 0.828 | 291-333 | 0.3 | 291-333 |
| 348 | 0.892 | 291-333 | 0.324 | 291-333 |

Table (1) shows the effect of annealing temperatures on ($Ea_1$, $Ea_2$) at ($T_a$=323 and 348K ) for SnIn. It is found that the activation energy tends to increasing with the increasing of the annealing temperature. This increasing is obviously due to the increasing in the energy gap, which may be due to the dense in the V.B &C.B. The effect is shown clearly by the improvement in crystallinity during annealing see Fig.(2).

## I-V characteristics

A typical current-voltage (I-V) characteristic for forward and reverse bias of SnIn/*n*-Si heterojunction is shown in Fig. 3. In the forward bias the current increases exponentially with voltage as expected. But in reverse bias, the current was found to increase slowly with voltage (soft breakdown) and did not show any trend of saturation or sharp breakdown. This could be due to the domination of edge leakage current which is caused by the sharp edge at the periphery of the contact and also due to the generation of excess carriers in the depletion region at higher fields.

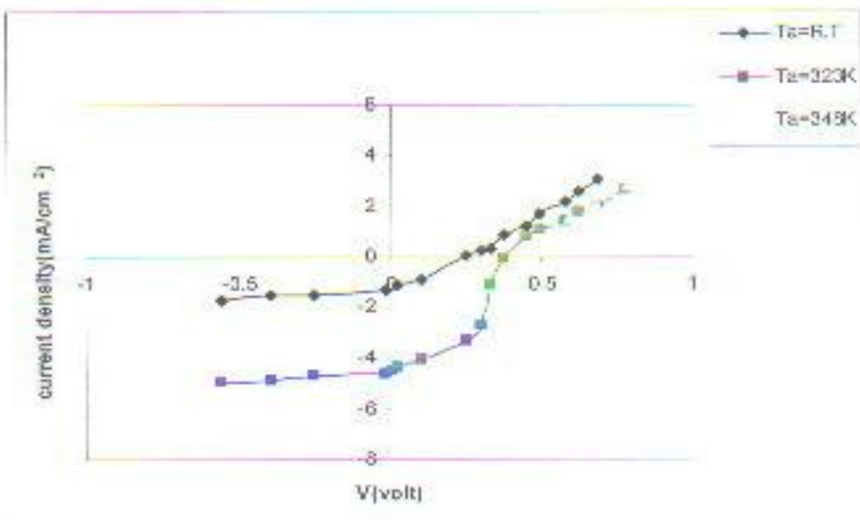


Figure (3): I-V characteristics for SnIn /c-Si heterojunction Solar Cell at forward and reverse bias voltage at different annealing temperatures

Table (2): Values efficiency (η%) for SnIn /c-Si heterojunction Solar Cell with different annealing temperatures

| Ta K | η % |
|---|---|
| R.T | 1.5 |
| 323 | 3.22 |
| 348 | 4.67 |

## Energy Band Diagram for SnIn/c-Se HJs :

To understand adequately the current transport mechanism of heterojunction, the band lineup is necessary. So many investigations on the band lineup of many of HJs were reported [5] .

In our study we suggest the construction of SnIn / Si HJ band lineup with the aid of dc-conductivity, optical energy gap and C-V measurements. At a heterojunction, each of the semiconductor may be doped n-type or p-type, so there are four possible combinations, namely n-N, p-P (isotype)and N-p, P-n (anisotype) junctions, where the capital letter refer to the wider band gap[6,7].

In this work, the heterojunction SnIn/n-Si was formed which is an abrupt heterojunction.

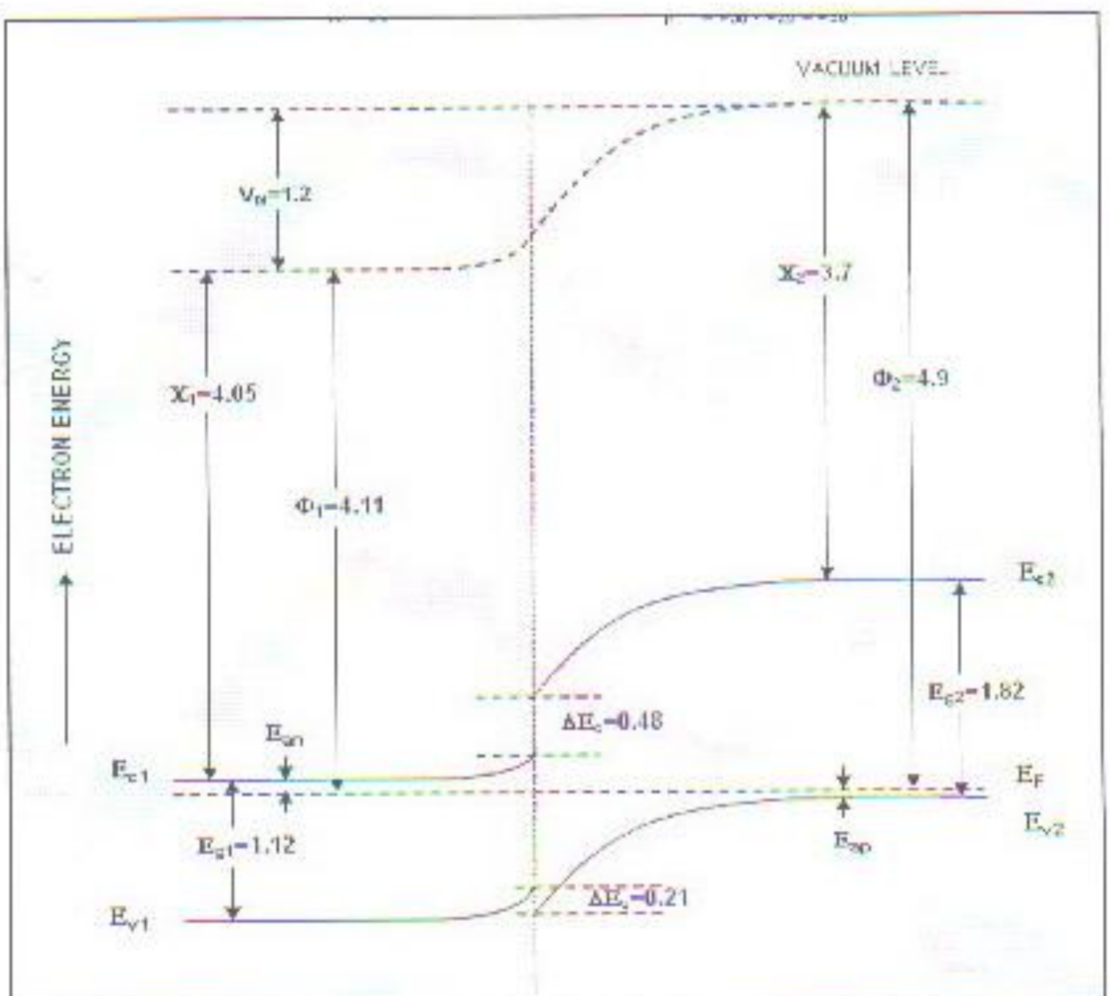


Fig.(4):Energy Band Diagram for SnIn/c-Si Heterojunction Solar Cell

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