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P-Cu_2S/n-Si Anisotype Heterojunction Solar Cell

Ali H. Al-Hamdani*, Khaled Z. Yahiya**
& Yasmeen Z.Daood*
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Abstract

An extensive study is presented on photovoltaic devices fabricated by spray pyrolysis method using aqueous solution of $CuCl_2.2H_2O$ onto n-type silicon substrates. The condition of preparation has been optimized to get good photovoltaic characteristics, these include short circuit current I_{SC} of (1.82mA) and open circuit voltage V_{OC} of (0.31mv). The conversion efficiency of the solar cell is equal to (3%) and the fill factor is (0.44).

Keyword: solar cell, fabricated, heterojunction, spray pyrolysis

تصنيع خلية شمسية ذات المفرق الهجين P-Cu_2S/n-Si

الخلاصة

في هذا البحث تم تصنيع نبيطة كهروضوئية باستخدام تقنية الرش الكيميائي الحراري باستخدام المحلول المائي $CuCl_2.2H_2O$ على قواعد سلكونية احادية البلورة. تم دراسة خصائص الخلية الشمسية المصنعة والتي تشمل قياس تيار دائرة القصر وفولتية الدائرة المفتوحة، نلاحظ إن أعلى قيمة لتيار دائرة القصر كان بحدود 1.82mA وفولتية الدائرة المفتوحة 0.31mv . كما تم حساب كفاءة أداء الخلية المصنعة 3% وكذلك حساب عامل الملء للخلية FF=0.44 .

Introduction

Solar cells based on heterojunction are expected to exhibit good performance when strict conditions on the structural and electronic parameters are fulfilled, according to well-established theories.

There has been considerable interest in recent years directed towards the development of heterojunction solar cell[1,2]. Heterojunction in general is defined as the interface between two dissimilar materials in electron affinities, energy band gap and work function. Such heterojunction can be classified as abrupt or graded according to the distances during which the transition from one material to the other is completed near the interface. Another classification of heterojunction depends on the type of conductivity present on either side of the junction. If two semiconductors involved have similar types of conductivity then the junction is called isotype heterojunction otherwise it is called anisotype heterojunction[3,4].

It is interesting to consider various theoretical factors which influence the properties of the grown heteroxpitaxial layers, the three main factors are (i) lattice mismatch. (ii) thermal mismatch. and (iii) interdiffusion[3,5].

In this paper, p-Cu_2S /n-Si heterojunction thin film solar cells have been prepared by spray pyrolysis method. Efficiencies measured for solar cell prepared by this method

* Solar Research Center, Baghdad, Jadriya, P.O.Box 13026 E-Mail Solarenergy_Iraq@Yahoo.Com
** Dept.of Applied Sciences, UOT.

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2412-0758/University of Technology-Iraq, Baghdad, Iraq

under $93mw/cm^2$, tungsten-halogen simulated solar illumination for $1cm^2$.

Experimental

The film of Cu_2S has been prepared by spray pyrolysis technique from a starting solution of 0.1M aqueous solution $CuCl_2.2H_2O$ and thiourea $(NH_2)_2CS$ with an ion solution 1:1.

Single – crystal silicon wafers of n-type with (111) orientation are used as substrates of resistivity 2Ω.cm. Prior to film deposition, the wafers were degreased with ethanol in ultrasonic bath. Native oxides were removed by dilute hydrofluoric acid. The substrate was maintained at 523K , then these films were allowed to cool down to room temperature. At this stage the carriers in the Cu_2S film were confirmed as p-type by thermoelectric effect. Ohmic contacts ware made to the materials forming the heterojuncion by vacuum deposition of 2000! thick aluminum film.

The optical transmittances of the Cu_2S thin films prepared onto glass substrates were measured using spectrophotometer of range (330-900) nm.

The illumination was achieved under simulated AM1 condition ($93mw/cm^2$) by halogen lamp type "Philips", 120W, which is connected to a variac and calibrated by a silicon power meter. The type of conductivity of Cu_2S film was determined using Seabeck measurements.

Results and discussion

The Cu_2S film was found to be p-type by Seebeck effect. The poly crystallinity of grown film was confirmed by X-ray studies[6], fig.(1).

Optical properties:

The transmittance of Cu_2S thin film as a function of wavelength for sample is as shown in fig.(2). It also shows an increase in transmittance with wavelength, to attain the value (550) nm wavelength. Then slight increase is observed beyond this value. Cu_2S films exhibit high transparency in the visible region, about (70%) i.e. Cu_2S film represent window layer for such spectral region[7].

Fig. (3) shows the reflection spectra for Cu_2S film in the range (300-900)nm. Since the reflection depends on the thickness and type of film, the film has a value of reflection(0.21) at ë=550nm .

Optical constant extinction coefficient (k) and refractive index (n) were calculated from the transmission and reflection data and the known film thickness, typical experimental spectral dependences of n and k of films[8].

Fig.(3) shows the variation of in with wavelength, the maximum value attained was (2.1). Fig.(4) shows the variation in k with wavelength, the maximum value obtained is (2.5).

Photoelectronic properties:

The (I-V) characteristics under illuminated of different illuminating powers of the sample is shown in Fig.(6). The sample was illuminated by halogen lamp calibrated at five intensity levels under simulated AM1conditions (93mw/cm2) by using a standard Si power meter. Under certain illuminating power, the sample shows that the photocurrent strongly depends on the bias voltage. From this figure we observe increase in the current value with power density.

Figs.(7and 8) show the photovoltaic performance of Cu_2S/Si hetero-junction. An increase in short circuit current I_{SC} and with different illuminating power density is observed Fig.(7). This gives a good linearity at low levels of illumination. But at high levels, I_{SC} tends to saturate. Fig.(8) shows the open circuit voltage V_{OC} versus different illuminating power densities. The maximum value of V_{OC} is 333mv at 93mw/cm^2 irradiance, which corresponds to AM1 condition. Result for anisotype heterojunction shows a good photovoltaic performance due to anisotype heterojunction formation, which has photovoltaic characteristics better than the result for isotype heterojunction[4,9].

Fig. (9) demonstrates the variation in output power (the power generated by the cell under simulator AM1) versus voltage across the load resistance. This figure reveals that sprayed Cu_2S/Si heterojunction is a suitable device to produce a high efficient solar cell with a conversion efficiency of 3%. The low value of conversion efficiency is probably due to oxide formation at interface [1], which can be avoidable by using inert gas instead of air through the spray process.

Conclusions

Cu_2S films deposited onto n-Si by these simplest chemical spray pyrolysis technique produce anisotype heterojunction solar cell. Results show that this technique is appropriate to fabricate solar cells with a fill factor of (0.44) and conversion efficiency of(3%). These promised right can be improved by using antireflection coating or by using solar cell concentrations.

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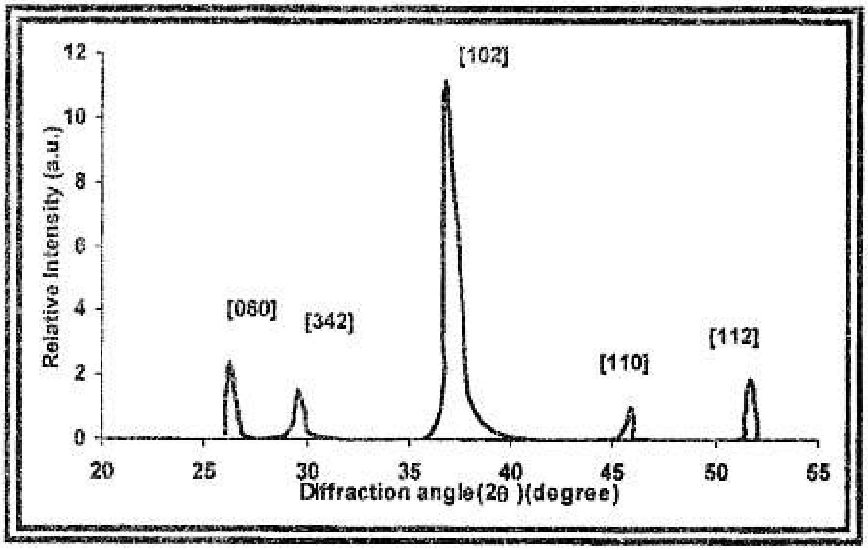

Fig.(1) X-ray diffraction of Cu_2S film grown on Si substrate.

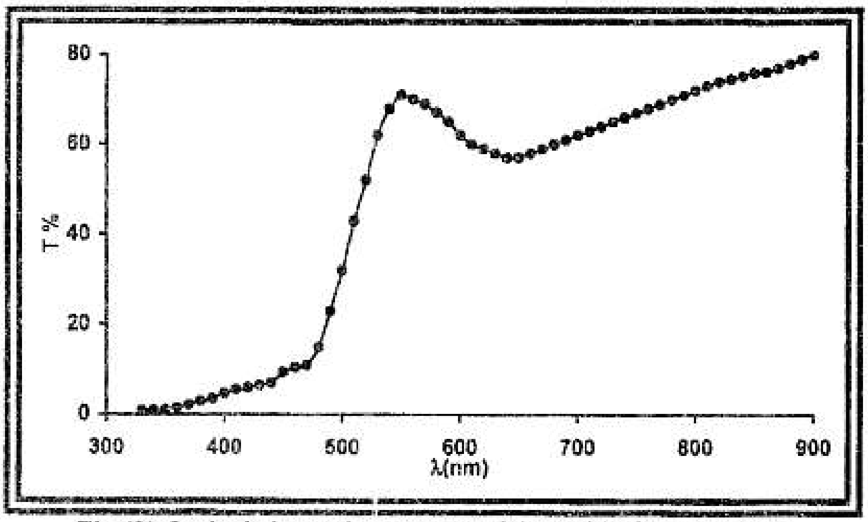

Fig.(2) Optical absorption spectra of Cu_2S thin film on glass.

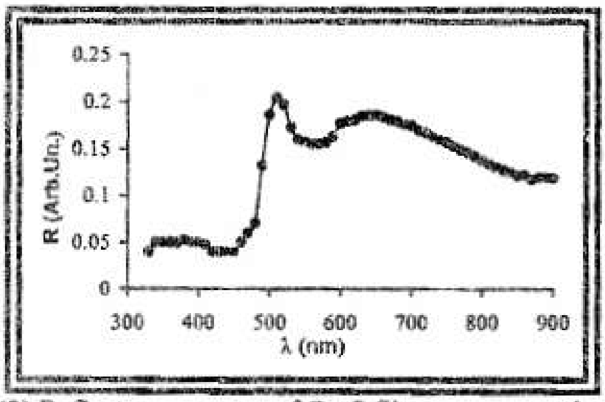

Fig. (3) Reflectance spectra of Cu_2S film versus wavelength.

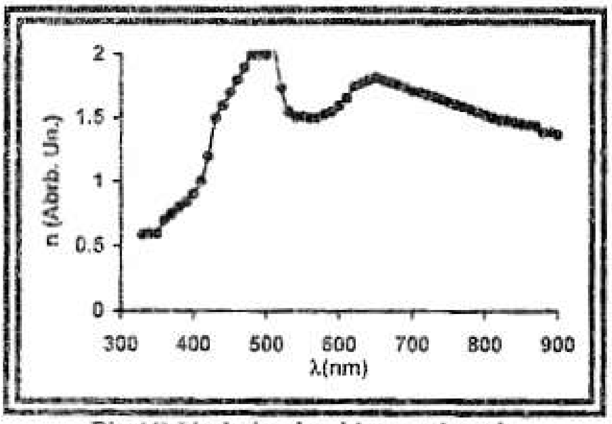

Fig.(4) Variation k with wavelength.

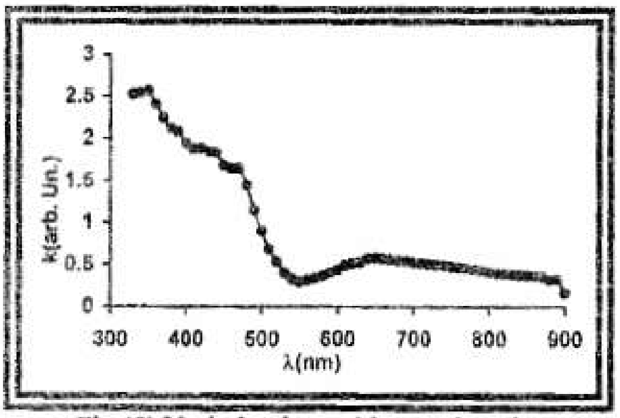

Fig.(5) Variation in n with wavelength.

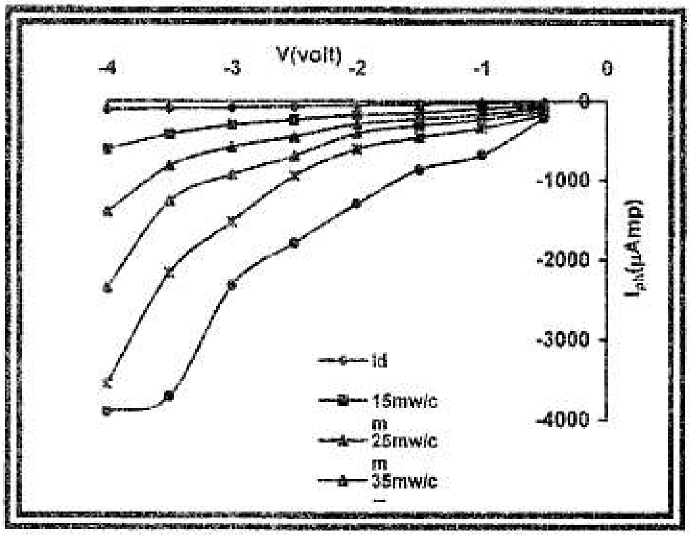

Fig.(6) Illuminated (I-V)characteristics of Cu2S/Si heterojunction under various illuminating power density.

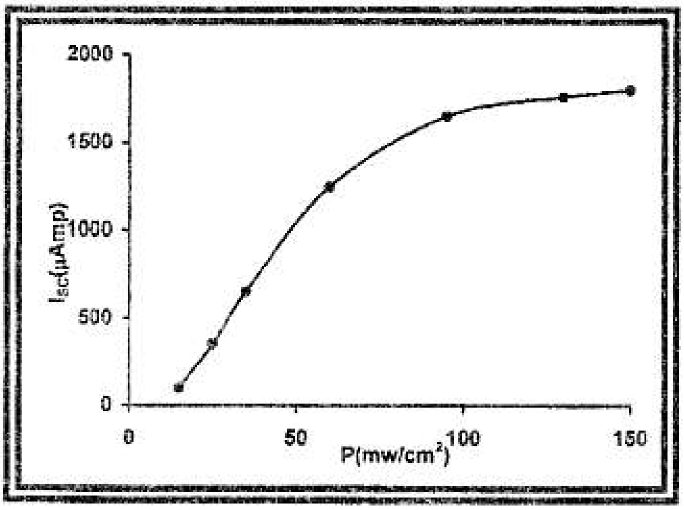

Fig. (7) Short circuit current versus illumination power density.

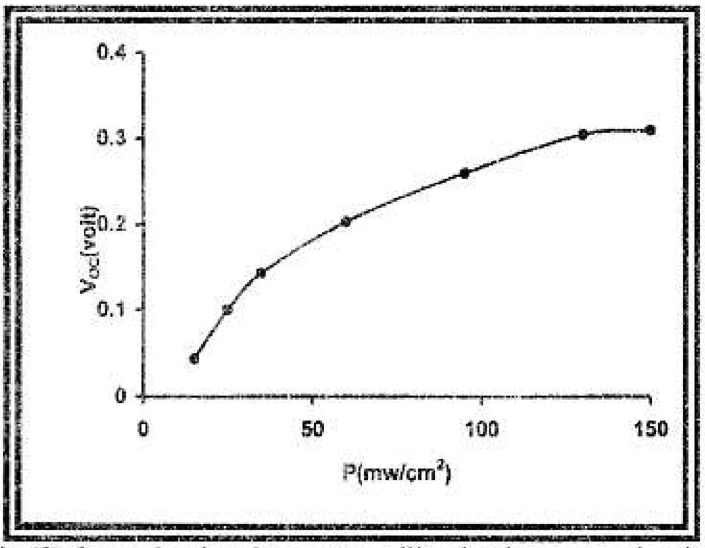

Fig.(8) Open circuit voltage versus illumination power density.

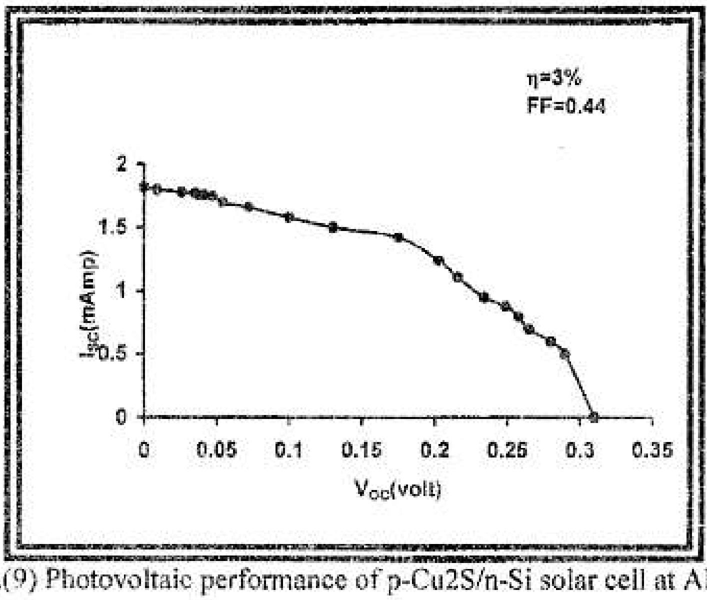

Fig.(9) Photovoltaic performance of p-Cu2S/n-Si solar cell at AM1.