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Characteristics of thin film solar cells as the future energy

Mariam Tawfik Hussein, Mona Ahmed Abd El-Samie, Nada Ashraf Ahmed, Nada Essam kamal, Hoda Sherif Bakr, Hager Ashraf Ahmed, Yara Salah El-din Abdel Fattah.
Faculty of Education Ain Shams University, Bachelor of Science and Education.
Supervisor: Prof. Dr. Adly Hassan Imam Ammar "Solid State Physics".

Abstract:

Unclean energy has become undesirable, as it pollutes the environment such as coal and petroleum so the whole world turned to using clean, renewable and sustainable energy. Therefore, this project was done to design a solar cell through thermal evaporation that works as an energy source.

Through smelting, copper indium diselenide duo were prepared from their basic elements with a high degree of purity.

Then CuInSe2 thin film was deposited using thermal evaporation procedure. Indexing the CuInSe2/n-Si heterojunction's dark and illumination I-V characteristics curve was done at room temperature. The photovoltaic (PV) properties and several parameters of the Au/CuInSe2/n-Si/Al device have been obtained from the white light's illumination conditions. Solar cell efficiency is equal to 5.7% .

The future belongs to the CuInSe2 solar cell.

أصبحت الطاقة غير النظيفة ،تلوث البيئة، وغير مرغوب فيها مثل الفحم والبترول لذلك أتجه العالم كله إلى استخدام طاقة نظيفة متجددة مستدامة لذلك تم عمل هذا المشروع لتصميم خلية شمسية عن طريق التبخير الحراري تعمل كمصدر للطاقة.

تم تحضير السيلينيوم والانديوم والنحاس من خلال عملية الصهر من عناصرها الأولية بدرجة عالية من النقاء .

ثم ترسيب اغشيه رقيقه من ثنائي السيلينيوم والانديوم والنحاس على حامله من السيلكون الإحادى من النوع السالب بطريقه التبخير الحرارى . تم قياس منحنيات الجهد والتيار في الظلام والاضاءة ومن خلال هذا الجهد والتيار لهذه الخلية (Au / CuInSe2/ n–Si / Al)

تم تعيين كفاءة الخلية ،وجد إنها تساوي ٥,٧٪ .

Key Words: CuInSe2, Solar cell, thin films, photovoltaic.

1. Introduction:

A p-n junction that made of silicon (Si), gallium arsenide, or another material is the solar cell. Electrons in the valence band of a solar cell gain sufficient energy to move to the conduction band upon exposure to solar radiation, resulting in the formation of electron-hole pairs.

After circling the external circuit and returning to the p-side of the junction, the electrons from the n-side of the junction merge with the holes to close the current path [1].

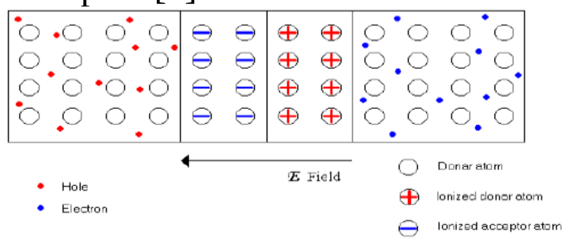


Fig.1 illustrateS the P-N junction without applied voltage.

The increase in voltage causes electrons to move from the junction's n-side to the p-side. The movement of holes from the junction's p-side to n-side also occurs alongside with an increase in voltage. The concentration gradient between the two sides of the terminals is the result of this. Charge carriers will move from areas of higher concentration to areas of lower concentration as a result of the concentration gradient. The current flowing across the circuit is caused by the movement of charge carriers inside the P-N junction.

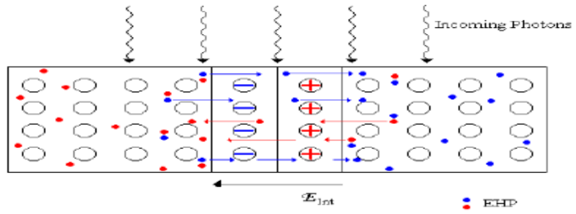


Fig.2 show P–N junction under illumination.

A thin film is made up of thin layers of material with thicknesses ranging from one micron to a nano meter. The difference between thick coating and thin film depositions is made by the thickness of layers deposited. It should be mentioned that thick coating deals with the deposition of particles, whereas thin film deposition deals with the deposition of individual atoms or molecules on the surface. Depending on the desired qualities, a thin film can be created with either an inhomogeneous or homogeneous composition [2].

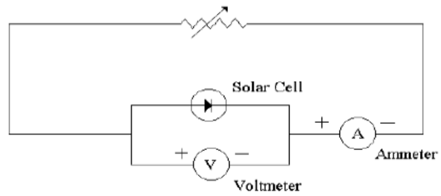


Fig.3.a

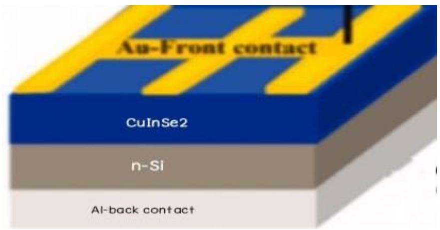


Fig.3.b

Fig.3 shows the circuit and configuration of the cell that determine I-V characteristics of solar cell

Because of its exceptional radiation stability, (copper indium diselenide) is a promising material for thin-film solar cells [3].
$CuInSe_2$ is a semiconducting compound from the chalcopyrite I–III–VI2 family. The chalcopyrite structure can be understood in terms of two interpenetrating sub-lattices, one of which is occupied by the I–III atomic positions, that function as cations, and the other as sub-lattice [4].
$CuInSe_2$ films have exceptional material properties such as band gap,

absorbance coefficient, and minority carrier diffusion length, which make them ideal for solar applications.
They can be made with n- and p-type conductivity, hence this material has both homo- and hetero-junction potential[5].
Konovalov examines the relationship . between the lattice constant and energy gap of isovalent chalcopyrite materials as well as the material needs for CuInSe2 solar cell[6].
Numerous methods, including vacuum evaporation, two-stage sputtering, and molecular beam epitaxy, have been used to create thin films of copper indium diselenide [7].
More homogeneous and larger area CuInSe2 thin films have been produced by a closed space vapour transport technique.[8]
In comparison to MBE and MOCVD films, hot wall formed CdTe thin films demonstrated better luminous properties [9].
CuInSe2 thin film was used to deposit stoichiometric to prepare clean, renewable, sustainable solar cell (Au/CuInSe2/n–Si/Al).

2.The Theoretical Framework:

The middle area that contains the electric field is known as the space charge area or the depletion region as shown in Fig. 1. Owing to the electric field, electrons and holes undergo a drift current. The equilibrium is established when the drift current is exactly equal to the diffusion current. The net current flow is zero. Thus, the total current density for either electron or hole is as follows:

$$J_{nTotol} = J_{nDrift} + J_{nDiff} \quad (1)$$
$$J_{pTotol} = J_{pDrift} + J_{pDiff}$$

The current densities given by:

$$J_n = qn\mu_n E + qD_n \frac{dn(x)}{dx} \quad (2)$$
$$J_p = qp\mu_p E - qD_p \frac{dn(x)}{dx}$$

Where p and n are electron and hole concentrations. The drift Mobility is μ. Electric field is E. The diffusion coefficients are Dp and Dn.
Diffusion and drift currents are added to determine the overall current with diffusion current predominating.
Current is the same magnitude of the drift current's absolute value during equilibrium diffusion.
The diffusion current under forward bias can be given by:

The total current is the diffusion current minus the absolute value of the drift current, so the drift current is in the

$$I_{diff} = \left|I_{drift}\right| e^{qV/kT} \quad (3)$$

opposite direction; the current is given by:

$$I = I_0\left(e^{qV/kT} - 1\right) \quad (4)$$

The product of the voltage and current are the power output of the cell.
The quality of a cell is given by the fill factor ff.

The fill factor is the ratio of the maximum power of open circuit voltage and
short circuit current.

$$ff = \frac{I_M V_M}{I_{SC} V_{OC}} \quad (5)$$

Typical values of the fill factor range from 0.75 to 0.85.
If the I–V curve were in rectangle shape the fill factor would be 1.
The measure of the maximum power over the input power is called the efficiency.

$$\eta = \frac{P_{out}}{P_{in}} \quad (6)$$

When the sun perpendicular to a solar cell's surface the value of E is the solar constant and it is average value is approximately $1 kw/m^2$.
then the efficiency can be written as :

$$\eta = \frac{ff \cdot I_{SC} V_{OC}}{E \cdot A} \quad (7)$$

3.Methods of Research and the tools used:

3.1 Preparation of Copper indium selenium as a bulk:

The first ingot of the CuInSe2 material was made using stoichiometric proportions of 99.999 present pure copper (Cu), indium (In), and selenium (Se).
Under vacuum, the mixture was enclosed inside a quartz tube.
The quartz tube was gradually heated to 20 °C every hour. It takes 48 h to achieve full homogeneity when the melt is kept at 750 °C.
After that, the tube cooled at a rate of 7°C/h to prevent cracking from the melt's thermal expansion during solidification.

3.2 Preparation of Copper indium selenium as a thin film:

Using a heat resistant filament coil around a quartz crucible or a metal boat, thermal evaporation can create thin films from pure elements, alloys, and compounds based on their melting or sublimation points. The material qualities and substrate conditions have an impact on the formed films' shape.
Under a high vacuum(2×10^4 pa) coating unit model was used to coat CuInSe2 thin films on the substrate surface. **(**Edwards E306 A) [10].
Nippon Mining Co provides the n-type Si (100) single crystal wafers with a carrier concentration of $10^{22} m^{-3}$. Area is $2 cm^2$, thickness is 450 micro meters and The degree of vaporization is 2 Angstroms per second were etched and cleaned using the CP4 solution (HF: HNO3: CH3COOH in a 1:6:1) ratio.
Silicon wafers were etched, then they were washed with distilled water and ethyl alcohol. After being cleaned and etched, CuInSe2 thin films were coated on silicon wafers from the front side using the traditional thermal evaporation method.
Gold mesh coated the over layer of CuInSe2 to serve as an ohmic electrode

and Aluminium layer coated in front of layer of cell.

4.Results and Discussion of Research:

4.1Dark current-voltage characteristics:

To investigate the junction qualities were constructed current–voltage characteristics I–V. Measurements of electric characteristics I–V usually become the valuable source of information about Junction properties, rectification ratio RR, diode quality Factor n, reverse saturation current (I°), Series (R*s*)and Shunt (R*sh*) resistances.

The analysis of I–V characteristics is also valuable for identifying the transport mechanisms, which is conduction control. The current–voltage properties of the deposited onto n-Si at the temperature of 300K in CuInSe2 Films with thickness 55 nm are presented on fig.4.a .

The curves demonstrate a diode-like behaviour in a forward and reverse direction with positive potential on cell .

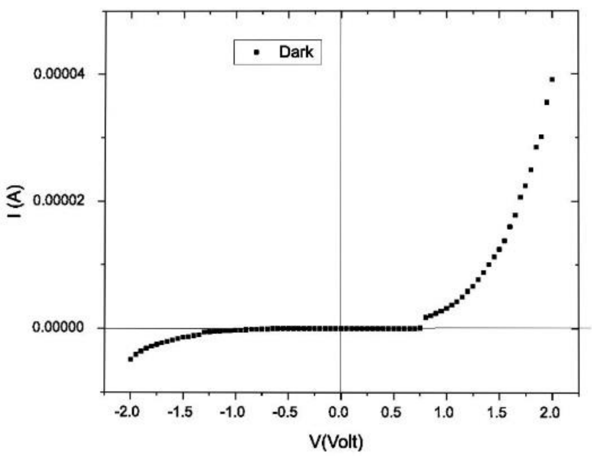
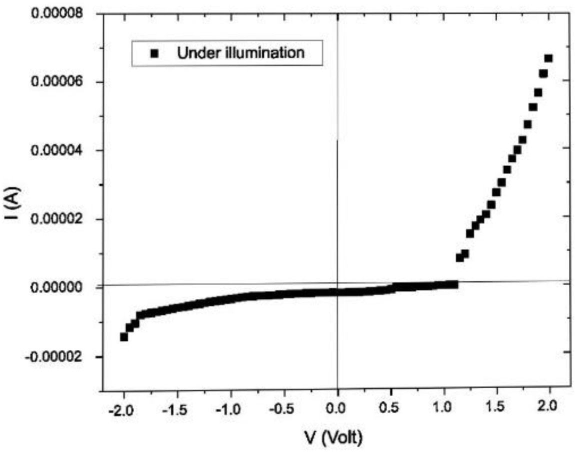


Fig.4.a Study I-V characteristics of Solar cell in dark with forward and reverse direction.

4.2 Illumination current–voltage characteristics:

The behavior of diode under illumination



with forward and reverse direction is shown in Fig.4.b

Fig.4.b I–V characteristics of solar cell under illumination with forward and reverse.

Fig.5 Illustrates ln(I) against the voltage of solar cell, at 1.5V and RR =9.29

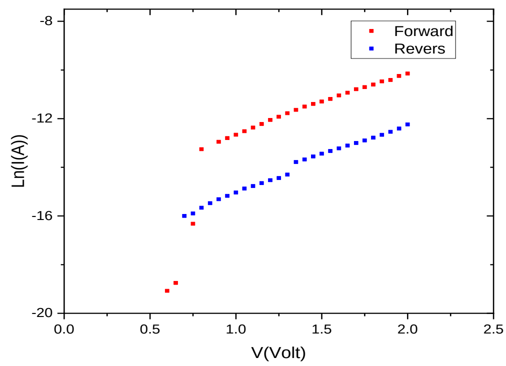


Fig.5 study I–V characteristics for the junction at low voltage with forward and reverse direction.

Fig.6 shows the I–V curves with higher current through the voltage range because direction. of the light generated carriers. The open-Circuit Voltage (Voc) is higher under illumination because of the presence of light generated current.

Short-Circuit Current (Isc) is the maximum current at zero voltage.it's only achievable under illumination.

From Fig.6 we calculate the solar cell parameters such as:

Voc =0.567 volt, , Isc =2.349×10^(-7)A, and η=5.7%.

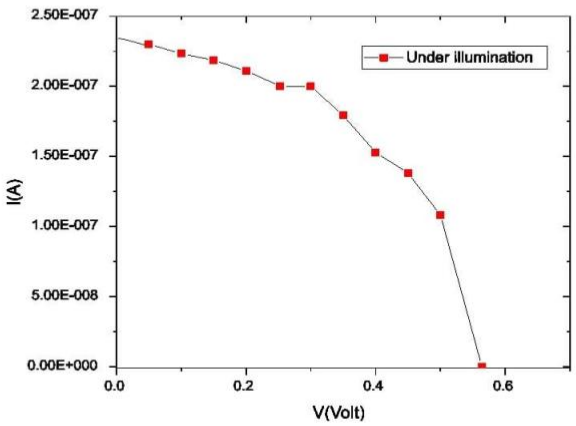


Fig.6 study I–V characteristics for the junction under illumination.

5. Conclusion:

I-V characteristics of solar cell (Au /CuInSe2/n–Si/Al) in dark have diode like behaviour.

Gold , Copper Indium diselenide, n-Silicon and Aluminium photovoltaic device was prepared and determine the parameters of photovoltaic. The goal of the cell is producing clean, renewable and sustainable energy from sunlight.

The values of Voltage open circuit (Voc) , Short circuit current density (Isc) , fill factor (ff) and efficiency (η) were calculated: Voc = 0.567 v, Isc=2.349×10^(-7)A, ff= 0.85 and η=5.7 %

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