The Effect of Different Concentrations of CuO on Solar Cell Performance

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Abstract:

CuO solar cells fabricated from polymer, with different CuO concentrations ranged from (0.3 to 0.25) mg/mL were prepared. It was found that increasing CuO concentration increases efficiency. This can be explained on the basis of the relation between current and concentration of CuO. In this work it is found that there is a sudden increase in the efficiency of the cell at concentrations of (0.28 and 0.25) this is explained by the same mechanism of Mott Insulator of super conductivity. It assumes the existence of narrow energy band in the energy gap; thus the shift of Fermi Level affects the efficiency.

Key words: solar cell, copper oxide, efficiency, concentration, energy gap

1. Introduction

Energy problem is one of the challenging problems facing modern civilization, petroleum energy was found to cause severe pollution, with limited abundance
[1].This forces scientists to search for better sustainable permanent, pollution free source. The most popular one, which satisfy these needs are the solar energy .Solar energy, can be converted to heat or electric energy [2]. Electric conversion is preferable, as for as electric energy is widely used.
Solar cells can be divided into the inorganic type or the organic type, according to the materials used. Inorganic materials commonly used in solar cells are semiconductor silicon (monocrystalline, polycrystalline, amorphous, complex) and compound semiconductors (GaAs, $CuInSe_2$, CdTe, InP). Silicon solar cells (monocrystalline silicon, polycrystalline silicon, amorphous silicon) have relatively higher photoelectric conversion efficiency, but the cost is also high and the preparation process is complex. In addition, the batteries made from multi-compound materials, such as inorganic salts, including gallium arsenide, cadmium sulphide, and copper indium selenium, contain cadmium and other toxic elements, as well as indium, selenium, and other rare elements, and therefore they are inferior in security and price [3].Materials commonly used in organic solar cells are organic semiconductors (zinc phthalocyanine, polyaniline, poly *p*-phenylene vinylene, etc.). There are also other photochemical solar cells using nano-TiO_2. Solar cells made from functional polymer materials are presently still in the early stage of research and development and are characterized by low conversion efficiency and short service life [4].Oxide semiconductors are one of the alternatives to silicon solar cells, and copper oxides such as CuO and Cu_2o are one of the candidate materials. The features of copper oxide semiconductors are relatively higher optical absorption, low cost of raw materials and non- toxicity. CuO and Cu_2o are p-type semiconductors with band gap energies of 1.5eV and 2 eV, respectively, which are close to the ideal energy gap of 1.4 eV for solar cells and allows for good solar spectral absorption. The highest efficiency of ˷ 2% for cu_2o solar cells has been obtained by using the high

temperature annealing method .cu_2o/Zno thin film solar cells have also been studied and reported however, the solar cells with CuO/ZnO structure have not widely fabricated and studied. Copper oxide (CuO) is metal oxide material that has been substantially explored for furious fields of applications. As a p-type semiconductor having narrow band gab of (1.35eV), CuO has great potential as a field emitter, catalyst and as a gas sensing medium. The physiochemical properties of CuO such as the photoconductivity and photochemistry can be tolerated for fabricating optical switches and solar. The Cu_2o is of low cost, non toxic, available. The efficiency is about 9-1190, it has band gap of 2 eV , which is suitable for solar energy 1-2 eV .conversion which needs band gap in this range[5].Due to these features of CuO, this wane is concerned with studying the performance of CuO solar cell having different concentrations. This is done in section (2) which describes materials and methods. Sections (3) and (4) are devoted for discussion and conclusion.

2. Materials and methods

The materials used in fabricating solar cell consists of ITO glass which act as a substrate on which was Deposited (MEH-PPV) polymer with concentration of 0.2 mg/mL another layer from copper oxide with concentration of 0.3 mg/mL was deposited on the polymer , aluminium was putted   on copper oxide to represent the anode while ITO cathode , six cell with different concentrations   (0.3,0.29,0.28,0.27,0.26 and 0.25) mg/mL of copper oxide was fabricated by adding certain value of ethanol ,also for doping the polymer was added the chloroform. The devices were characterized by ultra violet visible spectroscopy. Also our apparatus include voltmeter, ammeter, rheostat and light source lamp. Cell was offered to light and the different readings of voltmeter and ammeter were taken by using rheostat.

The efficiency of the solar cell is given by

$$\eta = \frac{I_m V_m}{p_{in}} \quad = \frac{I_m V_m}{I_{sc} A} \tag{1}$$

Where

$$I_m = \frac{V_m I_o q}{A_o kT} e^{\frac{qV_m}{A_o kT}}$$

$$I_o = A_o \left(\frac{D_e}{L_e N_A} + \frac{D_h}{Lh N_D} \right) q n_i^2$$

For : $D_e = 0$ $N_D = n_i$ (where no acceptors exists)

$$I_o = \frac{A_o D_h}{Lh} q n_i \tag{2}$$

AL

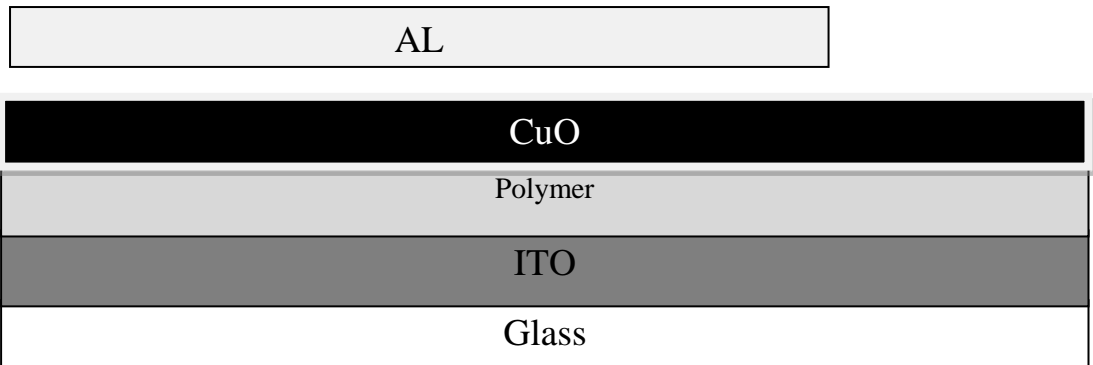| CuO |
|---|
| Polymer |
| ITO |
| Glass |

Fig (1) show the structure of polymer solar cell when adding CuO
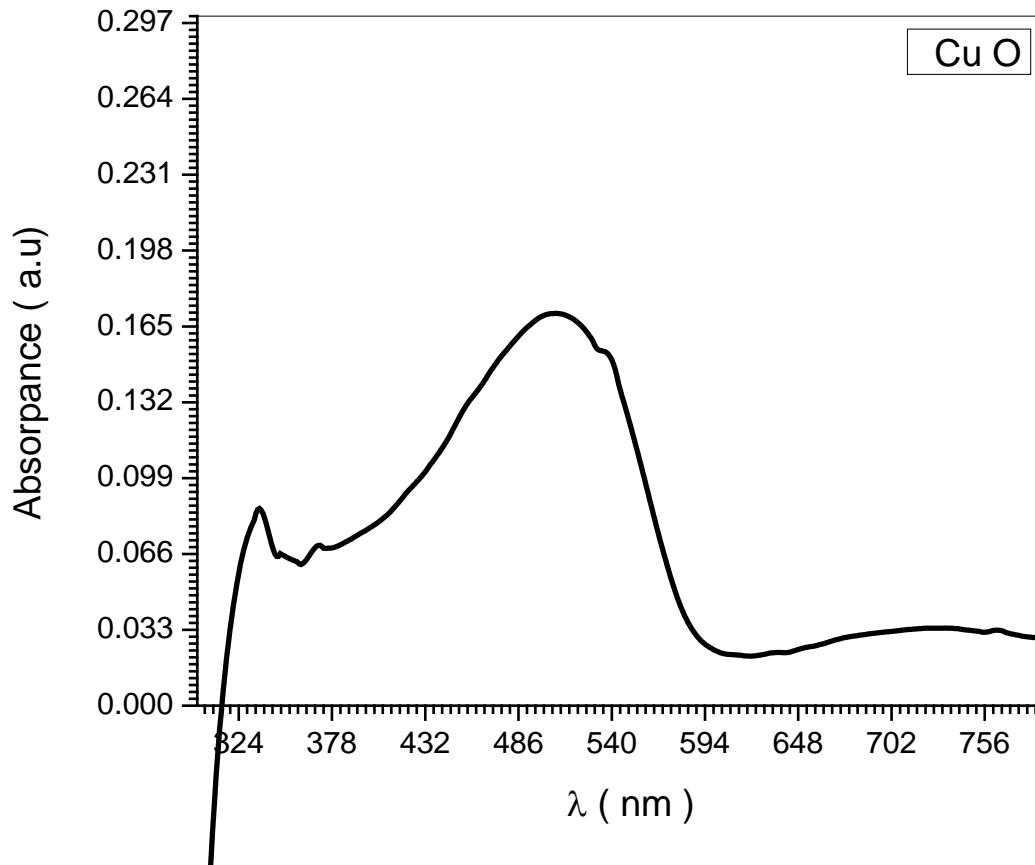
3. Results

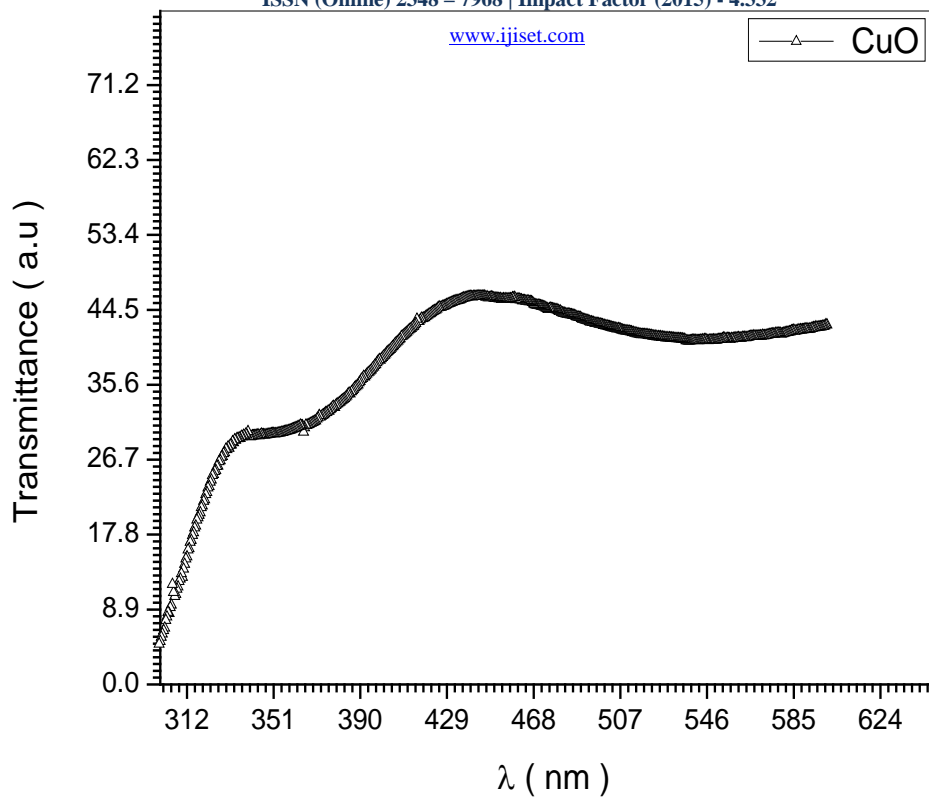Fig (2) UV-visible absorption spectra of thin films
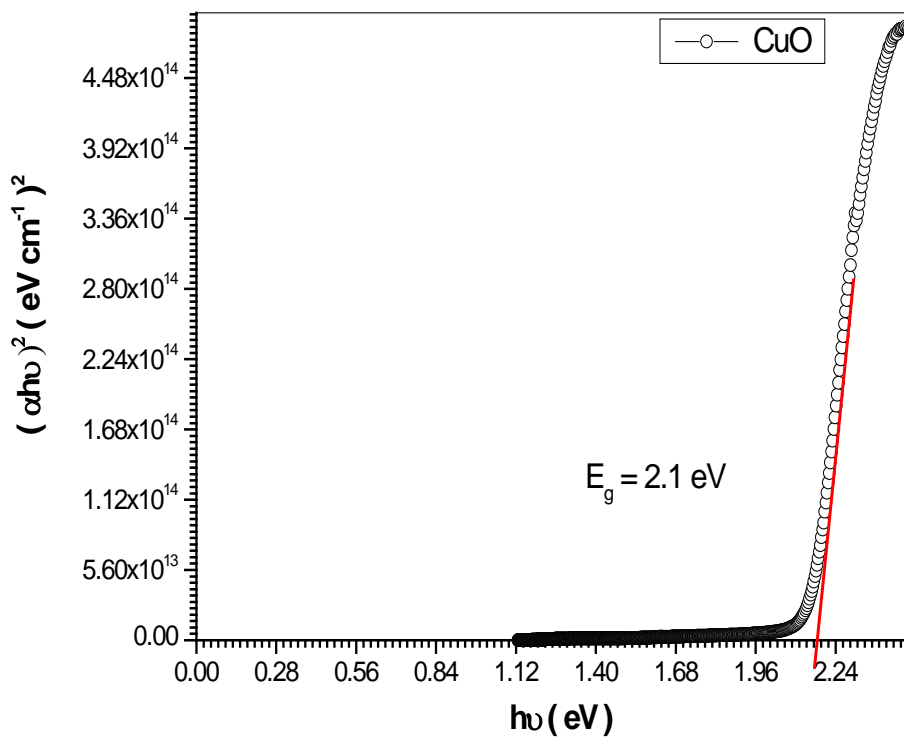
Fig (3) Transmittance spectrum of CuO

Fig (4) is plot, which shows $(\alpha h\nu)^2$ versus $h\nu$ for the CuO.
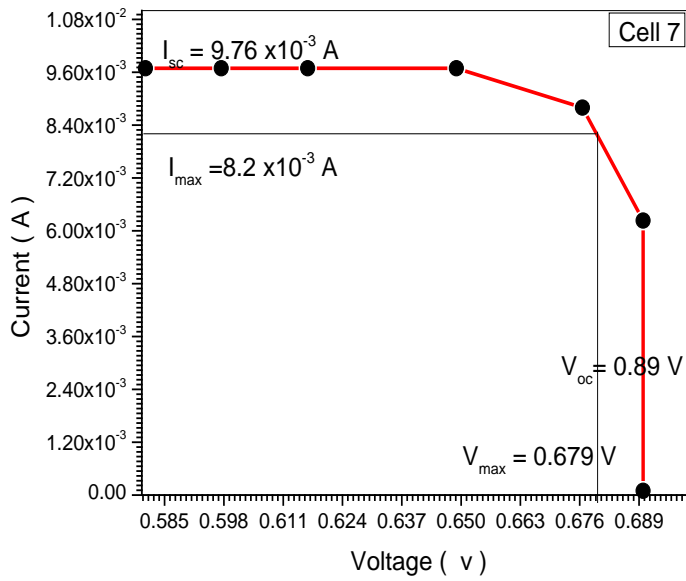
Fig (5) the relation between voltage and current for copper oxide cell with concentration of 0.3 mg/mL

Fig (6) the relation between voltage and current for copper oxide cell with concentration of 0.29 mg/mL

Fig(7) the relation between voltage and current for copper oxide cell with concentration of 0.28 mg/mL
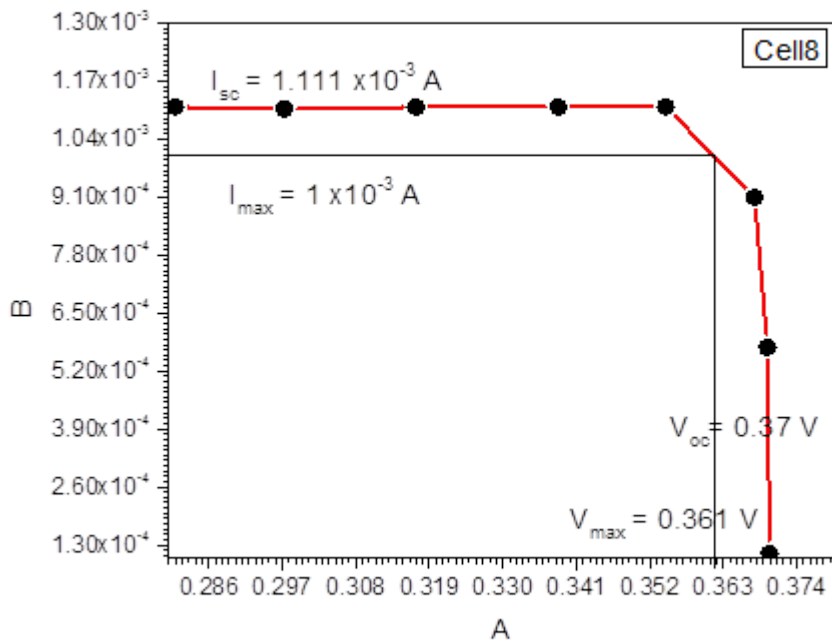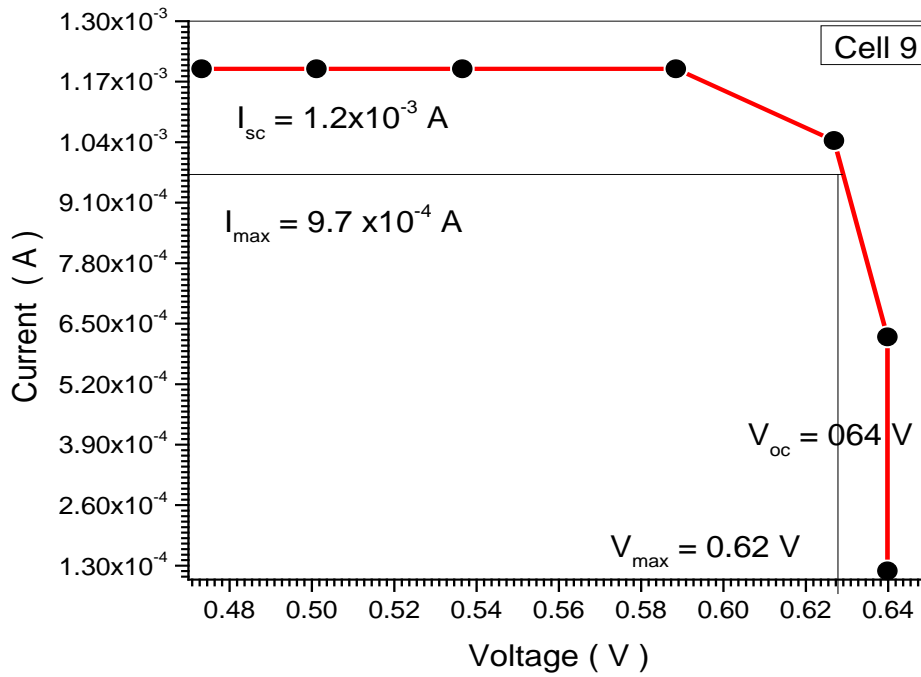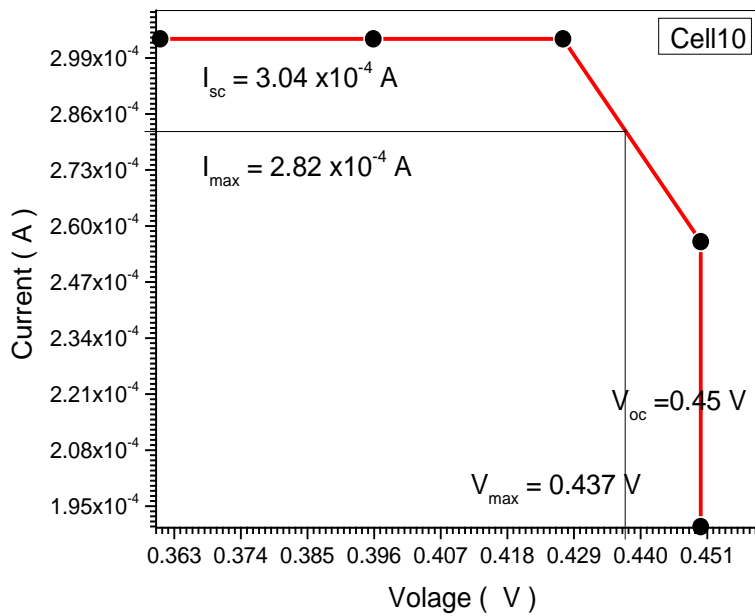

Fig (8) the relation between voltage and current for copper oxide cell with concentration of 0.27 mg/mL
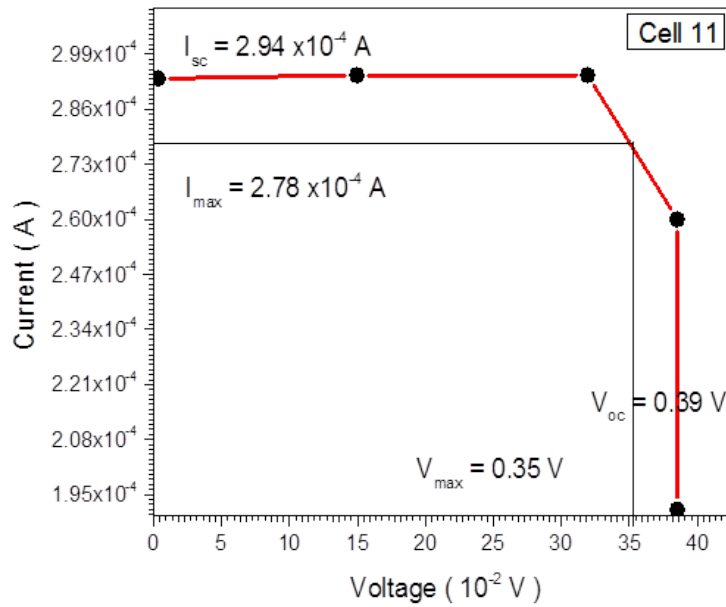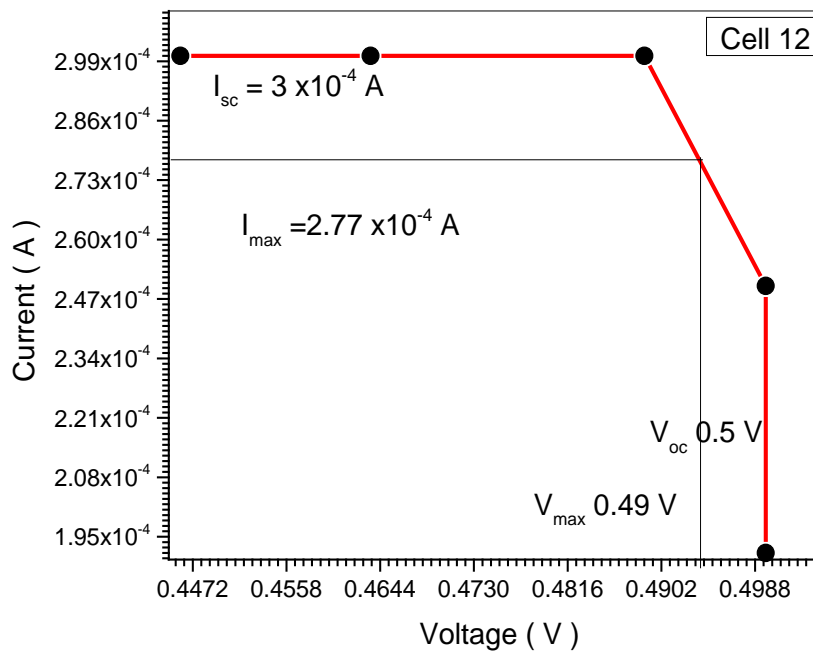
Fig (9) the relation between voltage and current for copper oxide cell with concentration of 0.26 mg/mL

Fig(10) the relation between voltage and current for copper oxide cell with concentration of 0.25 mg/mL

Table (1) show the voltmeter and ammeter readings (CuO) cell with concentration of 0.3 mg/mL

V(volt)	I(A)
0.36993	1.10557E-4
0.36964	5.72962E-4
0.36769	9.09736E-4
0.3544	0.00111
0.33832	0.00111
0.31697	0.00111
0.29728	0.00111
0.28094	0.00111

Table (2) show the voltmeter and ammeter readings (CuO) cell with concentration of 0.29 mg/mL

V(volt)	I(A)
0.6899	9.67742E-5
0.6899	0.00623
0.67661	0.0088
0.64897	0.00969
0.61638	0.00969
0.59742	0.00969
0.58081	0.00969

Table (3) show the voltmeter and ammeter readings (CuO) cell with concentration of 0.28 mg/mL

V(volt)	I(A)
0.63983	1.18651E-4
0.63983	6.21525E-4
0.62685	0.00104
0.58843	0.0012
0.53655	0.0012
0.50111	0.0012
0.4732	0.0012

Table (4) show the voltmeter and ammeter readings (CuO) cell with concentration of 0.27mg/mL

V(volt)	I(A)
0.44993	1.90246E-4
0.44993	2.5637E-4
0.42719	3.03419E-4
0.39587	3.03419E-4
0.36067	3.03419E-4

Table (5) show the voltmeter and ammeter readings (CuO) cell with concentration of 0.26mg/mL

V(volt)	I(A)
0.32091	2.93284E-4
14.9363	2.94094E-4
31.91526	2.94094E-4
38.50361	2.60029E-4
38.50361	1.91443E-4

Table (6) show the voltmeter and ammeter readings (CuO) cell with concentration of 0.25mg/mL

V(volt)	I(A)
0.49978	1.91443E-4
0.49978	2.49859E-4
0.48864	3.00182E-4
0.46352	3.00182E-4
0.44607	3.00182E-4

Table (7) Cu O

Cell No	Concentration of CuO	Isc	Imax	V_{oc}	V_{max}
7	0.3	9.76×10^{-3}	8.2×10^{-3}	0.89	0.679
8	0.29	1.111×10^{-3}	1×10^{-3}	0.37	0.361
9	0.28	1.2×10^{-3}	9.7×10^{-4}	0.64	0.62
10	0.27	3.04×10^{-4}	2.82×10^{-4}	0.45	0.437
11	0.26	2.94×10^{-4}	2.78×10^{-4}	0.39	0.35
12	0.25	3×10^{-4}	2.77×10^{-4}	0.5	0.49

Table (8)

Cell No	Concentration of CuO	A/cm^2	J_{sc}	FF	ɳ %
7	0.3	6.25	15.6×10^{-4}	0.64	88.86×10^{-5}
8	0.29	6.25	17.7×10^{-5}	0.88	5.77×10^{-5}
9	0.28	6.25	19.2×10^{-5}	0.78	9.58×10^{-5}
10	0.27	6.25	4.8×10^{-5}	0.90	1.96×10^{-5}
11	0.26	6.25	4.7×10^{-5}	0.85	1.55×10^{-5}
12	0.25	6.25	4.8×10^{-5}	0.90	2.17×10^{-5}

4. Discussion

According to fig (2) the absorption is m at wave length 515.5 nm which corresponds to the energy gap 2.4 eV This value conforms with the energy gap value obtained directly from the intercept of curve tangent with the energy axis , where E_g=2.1 eV . This value agrees with the range of CuO energy gap values (1.3-2 eV).When Fermi level exists in the band gap between donor and upper band the efficiencies of CuO solar cells decrease as concentrations decrease, where the efficiencies assumes the values , 8.886×10^{-4},5.77×10^{-5},1.96×10^{-5}, 1.55×10^{-5} for concentrations   , 0.3, 0.29, 0.27, 0.26 respectively. This agree with the theoretical relations (1) and (2) where the decrease of concentration n decreases free carriers concentration thus decreasing the efficiency .However for the concentrations 0.28 and 0.25 the efficiencies 9.58×10^{-5} and 2.17×10^{-5} show abrupt increase. This can be explained by a mechanism similar to that used to explain the mechanism by which Mott insulator is converted to a super conductor. Here we assume the existence of narrow energy band inside the energy gap. upon decreasing CuO concentration Fermi level, which separates conduction band and valence band moves down ward till it enters the sub band which splited into conduction band and valence band with no energy gap thus increases suddenly the value at 0.28 to be 9.58×10^{-5}, upon decreasing n to become 0.27 and 0.26 the Femi level leave the sub band to the lower energy gap thus decreases to 1.96×10^{-5}, 1.55×10^{-5} again. when n is decreased to 0.25 the Fermi level move down again to enter the main valence (lower) band , where it split it to conduction band and valence band , with no band gap which leads to sudden increase of current and thus efficiency.

5. Conclusion

The efficiency of CuO solar cell can be increased by changing concentration of CuO. One can also change the efficiency by controlling the Fermi level position also.

References

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