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Fabrication of Dye Sensitized Solar Cells (DSSC) from Silicon Dioxide at different Temperatures

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Abstract: *In this paper, five samples of dye sensitized solar cells were fabricated from silicon dioxide (SiO_2) and Rose Bangal dye. silicon dioxide was prepared at at different annealing temperatures (300,350,400,450 and 500)^{O}C using hydrothermal method, Rose Bangal dye was extracted and characterized using UV -VIS spectroscopy. the maximum absorbance of Rose Bangal dye is 0.142 (a.u) at wavelengths 642 nm crosponding photon energy 1.9 eV. The absorption coefficient (α) of Rose Bangal dye is 6.51x10^2 cm^{-1} in the visable region and the optical energy gap of Rose Bangal dye is (1.844) eV. The optical energy band gap of silicon dioxide was decreased from (1.976) eV to (1.937) eV when the annealing temperature increase from 300^{O}C to 500^{O}C. the I-V curves were measured for all solar cell samples; the current density increases as the optical energy band gap decrease and then increase the efficiency of solar sell. The current density increases from 3.032 (mA.cm^{-2}) to 4.426 (mA.cm^{-2}) and the efficiency increase from 0.3032% to 1.2100%.*

Keywords*: silicon dioxide, Rose Bangal, solar cell, energy gap, I-V curve and efficiency.*

1. Introduction:

Solar cells are electronic devices which absorb light to generate electricity. This conversion is possible due to the semiconductor materials since they have a low bandgap energy that enables electronic transitions from valence band to conduction band energy levels. This transition can be produced by the absorption of an external photon. Specifically, when a photon is absorbed by a valence band electron, it jumps to the conduction band becoming able to flow through the material. [1,2]. The dye-sensitized solar cells (DSSC) provide a technically and economically credible alternative concept to present day p–n junction photovoltaic devices. These devices are based on the concept of charge separation at an interface of two materials of different conduction mechanism [3,4 and 5]. To date this field has been dominated by solid-state junction devices, usually made of silicon, and profiting from the experience and material availability resulting from the semiconductor industry [6]. The dominance of the photovoltaic field by inorganic solid-state junction devices is now being challenged by the emergence of a third generation of cells [7]. The main parts of DSSCs systems is composed of five elements, the transparent conducting oxides, counter conducting electrodes, the nano-structured wide band gab semiconducting layer, the dye molecules (sensitizer), and the electrolyte Transparent conducting oxides (TCO) coated glass which used as substrate. For high solar cell performance, the substrate must have low sheet resistance and high transparency [8]. The current-voltage, (I-V) characteristics curve define the operating characteristics of an electronic of solar cell. The most important parameters of solar cell can be determined by the I–V characteristic which these parameters include the short-circuit current (Isc), open-circuit voltage (Voc), voltage at maximum power point (Vm), current at maximum power point (Imp) [9]. Silicon dioxide is one of the "building block" for fabrication of semiconductor devices, it can also be an excellent dielectric, It is normally found on a device such as "field oxide" electrically isolating Poly silicon, is also found on the device as a "gate oxide, Silicon dioxide is used in a variety of applications in the electronics and photonics industries, with a corresponding range of desired properties [10, 11] .The aim of this paper is to study I-V characteristics of dye sensitized solar cells fabricated from SiO_2 which prepared at different annealing temperatures and Rose Bangal dyes.

2. Experiential Method

In this study extraction and purification SiO_2 were prepared via a hydrothermal method, 150 grams of sand were collected from Kordofan state and then add 100 ml of HCL (7.1 M) to beaker, the acid is transferred to a magnetic stirrer/ hotplate to dissolve the sand's impurities. After heating, the sand will add slowly as CO_2 will be produced according to the equation

$$\mathrm{CaCO_3\ +\ 2HCL \rightarrow CO_2 + H_2O + CaCL_2}$$

To condense the acid vapor; boiling ask with ice water is placed on the top of the beaker. The heating will have continued until no more bubbles are produced, after that, the acidic sand will wash with water until become gray in color. The pure sand will transfer to filtered paper for drying. Weight the sand crude SiO_2.80 grams of NaOH put in a stainless-steel crucible, and then 60 grams of the crude SiO_2 were added and mixed will, and Heated until becomes liquid and then stiffens again.

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$$2NaOH(l) + SiO_2(s) \rightarrow Na_2SiO_3(s) + H_2O(g)$$

After that quickly remove the mixture from the crucible and put it in a beaker, then added 400 ml of H_2O to dissolve the mixture, Filtrate the mixture using gravity filtration (for 1.5 hours) and Transfer it into glass vessel, and add about 25 ml of 95sulfuric acid drop by drop.

$$2Na(SiO_2) + H_2SO4 \rightarrow 2(SiO_2) + 2Na_2SO_4 + H_2O$$

Filtrate the mixture and wash with water, Excess Silicic acid decomposes to form $SiO_2$and dry it in oven (300, 350,400,450 and 500) OC for 25 min, finally grind it into fine powder and weight. The obtained powder was used with Rose Bangal dye to fabricate dye sensitized Solar Cells (DSSC). The Rose Bangal dye was characterized using UV -VIS spectroscopy. Firstly, clean glass plate of ITO (Indium Tin Oxide) is needed. ITO acts as the first part of the solar cell, the first electrode. The fabrication process started with coating SiO_2 prepared at different temperatures (300,350,400,450 and 500) ^{O}C and Rose Bangal dye of on ITO glass. (ITO +graphite and Iodine) electrode was used to complete the formation of Dye Sensitized Solar Cells (DSSC). Then, the fabricated solar cell inserted in electric circuit containing the voltmeter and Ammeter and a light source Lamp with the intensity radiological Cell was exposed to light and current - voltages were recorded.

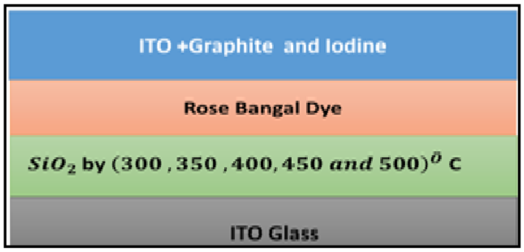

Fig (1) Structure of dye sensitized solar cell fabricated from SiO_2 and Rose Bangal dye

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Fig (2) Setup of experiment

3. Results and Discussion

In this paper, the performance of dye sensitized solar cells fabricated from SiO_2 which prepared at different annealing temperatures (300,350,400,450 and 500) ^{O}C and Rose Bangal dyes were studied. Fig (2) show some optical properties of Rose Bangal dye and optical energy band gap of SiO_2.

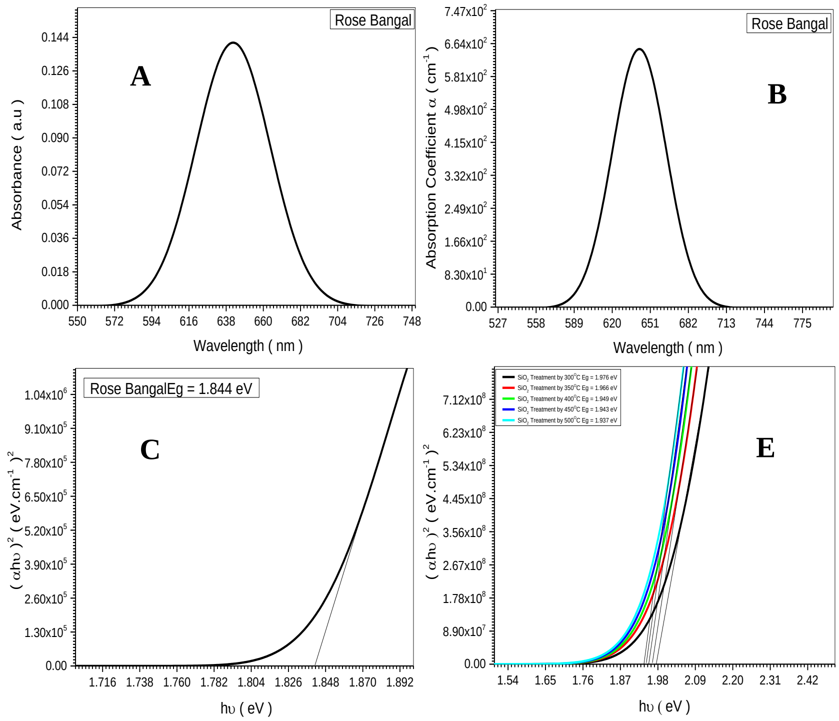

Fig (3) Some optical properties of Rose Bangal Dye, optical energy band gap of SiO_2

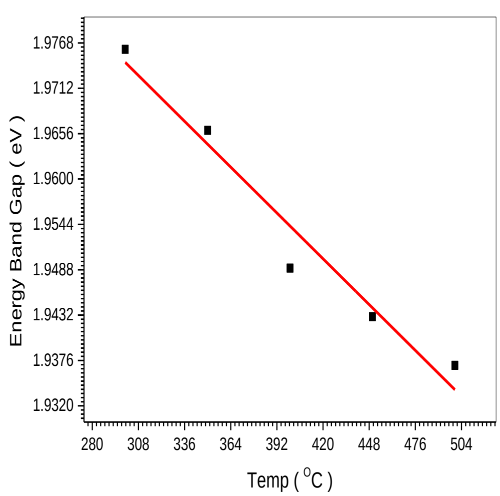

Fig (3) show the relationship between annealing temperature and optical energy band gap

Fig (3-A) shows the relation between absorbance of Rose Bangal and wavelengths , the maximum absorption equal 0.142 (a.u) at wavelengths 642 nm crosponding photon energy 1.9 eV. The absorption coefficient (α) of Rose Bangal dye was shown in fig (3-B) which display that the value of absorption coefficient equal $6.51x10^2$ cm^{-1} in the Visable region (642 nm). Fig(3-C) show the optical energy gap (Eg) of Rose Bangal dye ,the obtained value of Eg of Rose Bangal dye was (1.844) eV. Fig (3-D) display the optical band gap of SiO_2 annealing at different temperatures, the optical energy band gap was decreased from (1.976) eV to (1.937) eV as the annealing temperature increase from 300^OC to 500^OC, all obtained value of Eg within range of semiconductor materials. The relationship between annealing temperature and optical energy band gap of SiO_2 was shown in fig (4). Fig (5) shows the current-voltage characteristics of solar cell ifabricated from SiO_2 and Rose Bangal. All obtained results recorded in table (1).

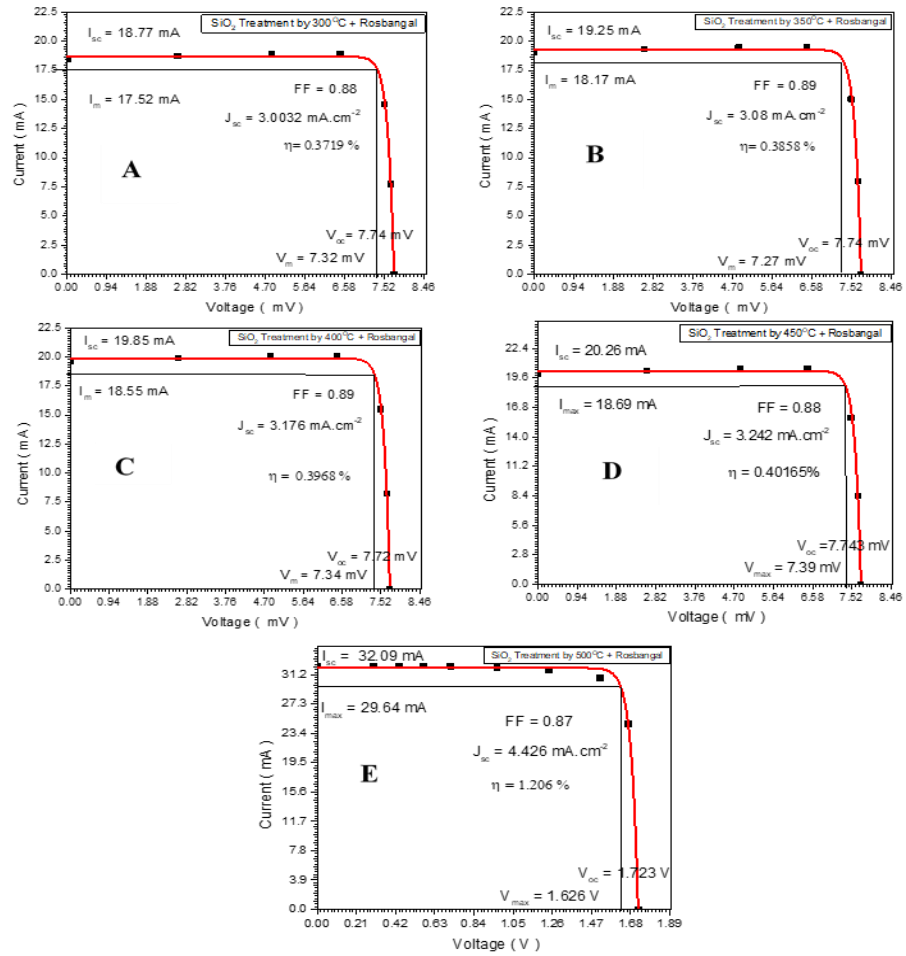

Fig (4) I-V characteristic Dye Sensitized solar cells fabricated from and Rose Bangal dyes

Table (1) I-V characteristics of dye sensitized solar cells fabricated from SiO_2 which prepared at different annealing temperatures (300,350,400,450 and 500) ^{O}C and Rose Bangal dyes.

Sample	**I_{sc} (mA)**	**I_m (mA)**	**V_{oc} (mV)**	**FF**	**η%**	**J_{sc} (mA.cm^{-2})**	**Eg (eV)**
SiO_2 300^{O}C	18.77	17.52	7.74	0.88	0.3032	3.032	1.976
SiO_2 350^{O}C	19.25	18.55	7.74	0.88	0.3858	3.08	1.966
SiO_2 400^{O}C	19.85	18.77	7.74	0.88	0.3968	3.176	1.949
SiO_2 450^{O}C	20.26	18.89	7.74	0.88	0.4016	3.242	1.943
SiO_2 500^{O}C	32.09	29.64	7.74	0.88	1.2100	4.426	1.937

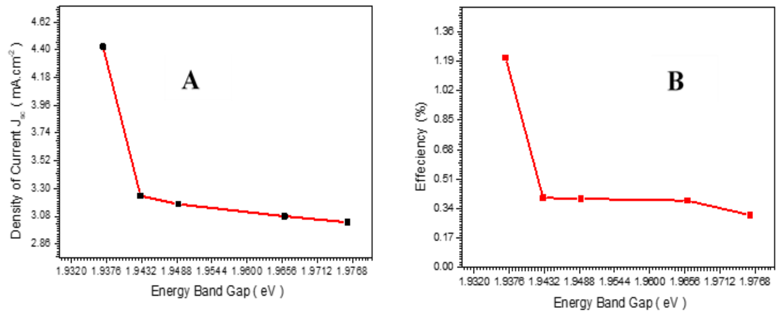

Fig (5) relationship between optical energy band gab of SiO_2 and (A) current density

(B) Efficiency of Dye Sensitized Solar Cells (DSSC)

The fill factor of solar cell (FF) is the ratio of the actual maximum obtainable power to the product of the open circuit voltage and short circuit current. It is evaluating the performance of solar sell, the fill factor of all dye sensitized solar cells fabricated from SiO_2 is 0.88. The measurement was taken from solar cell of and SiO_2 annealing at 300 OC and Rose Bangal samples sample (Isc) is 18.77 mA, (Voc) is 7.74 V and efficiency is 0.3032 %, SiO_2 sample annealing at 350 ^{O}C sample (Isc) is 19.25 mA, (Voc)is 7.74V and e efficiency is 0.3858 %. SiO_2 annealing at 400 ^{O}C (Isc) is19.85 mA, (Voc) is 7.74 V and efficiency is 0.3968 %. SiO_2 annealing at 450 ^{O}C (Isc) is 20.26 mA, (Voc) is 7.74V and efficiency is 0.4016 %, finally, SiO_2 annealing at 500 ^{O}C (Isc)is 32.09 mA, (Voc) is 7.74V and efficiency is 1.21 %.It was noted that the current density increases as the optical energy band gap decrease which increase the photoelectric generation and then increase the efficiency of solar cell.

4.Conclusion

Dye sensitive solar cell was successfully fabircated from Silicon dioxide (SiO_2) in different annealing temperatures (300,350,400,450 and 500)^{O}C and Rose Bangal Dye. It was found that the optictal energy band gap of SiO_2 was decreased when the annealing temperature increase which lead to increase current density and then increase the efficiency of solar sell.

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