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Efficient Solar Cells via Green, And Sustainable Coating Technique

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Abstract

Metal Oxide Semiconductor, MOS, solar cells of low cost and stable unit proficiency was established. Solar cells with sol gel SiO2 deposited by spin coating technique were discussed. The sol gel layer is prepared via greener methodology at optimum economic impact as promising and sustainable source of energy. The I–V characteristic of the sample solar cell at different time was investigated. The Photovoltaic performance and optical properties of the resulted cells were recorded and found confident. The green and sustainable context of the method was pronounced and pointed out. These techniques were found useful and inspiring for large scale manufacturing. The procedure, that obeying the commands of sustainability and cope with the principles of green chemistry, was found as ecofriendly-, productive-, applicable-, and sustainable-technique.

"Keywords: Green Chemistry; Sustainability; Solar Cell; Photovoltaic; Thin film"

1. Introduction

The principal of the semiconductor solar cell is the PN junction of the absorbent layer, which converts the photons into electron-hole pairs. The Charge transfer (CT) process involves electronic transfer inside the absorbent molecules form the highest occupied molecular orbital (HOMO) to the lowest unoccupied ones (LUMO). These Charge Transfers are responsible for the absorption of green, renewable, and sustainable source of energy titled solar energy. The main principle of the absorption processes are chemical formulation constitutes the photosensitizing absorbent layer [1-3]. These light absorbing materials of solar cells, p-doped semiconductors, were usually constructed via electronic structures that maximized the absorption of direct sun light. The whole process starts with photons that have higher energies than the forbidden band that emits. These energies can control the valence electrons that occur.

The cost of solar cells is still an important issue in the photovoltaic manufacturing and application. Great efforts were reported to prepare solar cells of high economic impact with optimum proficiency [4, 5]. The reported predisposition steps used to form a PN junction were carried out at high temperature and time consuming procedure. Consequently, competitive alternatives were studied to employ simpler and more economic MOS structure with lower temperature fabrication and higher cost advantage. [6]. Moreover, the important advantage of MOS solar cells is compatible with CMOS technology. Therefore, MOS structure is a cost competitive option for silicon solar cells.

Owing to excellent homogeneity, ease of composition control, low heat treatment temperature, and film uniformity over large area, the sol gel technique is extensively applied to deposit thin films for various applications [7–10].

Moreover, Traditional practices in this important industrial field urged researchers to design green and sustainable methodologies that satisfy marketing standards with optimum environmental impact [11, 12].

In the current study, sol gel spin coating was adopted to deposit SiO_2 layers of MOS solar cells through greener and more sustainable manner and the properties of the prepared MOS solar cells were investigated. Also, the green context and the concept of sustainability of the whole process was highly prominent due to simplicity, low thermal budget,

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applicability, low cost, high proficiency and productivity, and high atom economy [13].

2. Experimental

General

All reagents were purchased from, Merck Serono Egypt, in Cairo, and were used without further purification. Solvents were of analytical grade.

The Thin film solar cell modules are delicate and complex systems with various functional modules requiring unique solar materials to perform the solar energy conversion process. It is always useful to look for all kinds of advanced solar materials offering superior performance to improve the energy conversion efficiency of all equipment. The MOS solar cells used in this study were fabricated on a p-type Si (100) substrate. The resistivity of the Si substrate used in this study is between 1 and 10 ohm cm. Sol-gel solutions were prepared by acid catalysed hydrolysis of Tetra Ethyl Ortho Silicate (TEOS) in an alcoholic solution [14-20]. The solution was diluted with water and aged. The wet silica thin film was spin-coated on Si substrate and then dried at 600° C. Finally, the sol-gel SiO2 layer was heated at 4500° C for different time (60-90-120-150=180) min. The course of the process for preparing the sol-gel coating was achieved by centrifugation.

After these treatments, Aluminium electrodes were produced by thermal evaporation. Aluminium has also been used as a back contact.

In addition, this study points out that MOS solar cells do not use antireflection coatings, rear electric fields, or textured surfaces [21-28]. The structural and chemical composition characteristics of the sol-gel-derived SiO2 layer were characterized by scanning electron microscopy (SEM). Current-voltage measurements (IV) were performed using an HP 4140 BpA / DC voltage source meter under AM 1.5 illumination (100 mW /cm2) at 25° C. In addition, all conversion efficiencies were reported in this study as a function of total area.

Optical transmittance spectra of thin films specimens with different time of semiconductor oxide were carried out at RT using Perkin-Elmer Lambda 800-UV-VIS spectrophotometer connected with Phillips computer [29-35].

3. Results and Discussion

The I–V characteristic of the fabricated 0.5 × 0.5 cm2 solar cell is shown in Fig. 1. The photocurrent density of the cell is high up to 32.83 mA/cm2 at AM1.5 illumination (100 mW/cm2) at room temperature at time of semiconductor oxides but the photocurrent density of the cell is low up to 22.72 mA/cm^2.

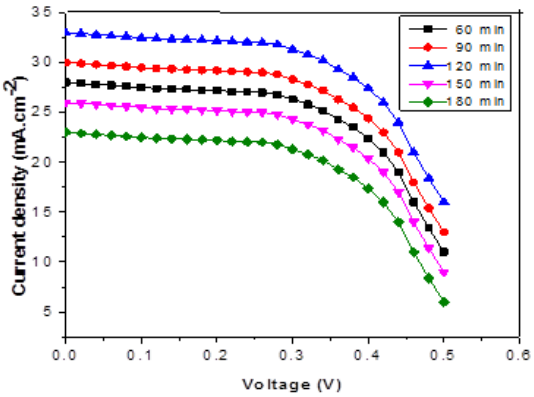

Fig.1 I–V characteristic of the sample solar cell at different time

This result confirms that film has well adhesive and highly conductive, and are very suitable for free carrier at 120 min in thin film solar cells. So the highly-conductive improved the hole collected ability and reduce the barrier height to enhance the overall power conversion efficiency, and the photovoltaic parameters are listed in Table 1. This, intern, declare the green context and sustainable impact of the current method.

Table 1: Photovoltaic performance and optical properties of cells.

Sample	J (mA.cm^{-2})	V_{oc}	E_g	S (μV/K^{-1})	σ (S·m^{-1})	ρ (ohm.m)
60 min	28.22	0.56	2.0	19	80	4.0
90 m	30.15	0.57	1.95	21	82	4.25
120 m	32.82	0.59	1.9	16	84	3.65
150 m	26.35	0.54	2.22	24	77	4.4
180m	22.72	0.52	2.3	28	75	4.7

The band gap (Eg) was calculated from the equation of αhν = K(hν −Eg)n/2 [30], where hν is photon energy, n and K are constants, and n is equal to 1 for direct-band gap cells. The value of Eg was determined by extrapolating the linear portion of the plots of (αhν)2 versus hν to α = 0 on the hν axis. The plots of (αhν)2 versus hν for the solar thin films were shown in Fig. 2.

The Eg value of the solar film depends on the time of semiconductor oxides. The sharp absorption edges of other solar films at the different time of semiconductor oxides were characteristic of homogeneous phases. Their Eg values of the solar thin film, deposited at 120 min, Eg ≈ 1.9 eV were related with the solar film. Therefore, the quality of solar films can be estimated from their optical properties.

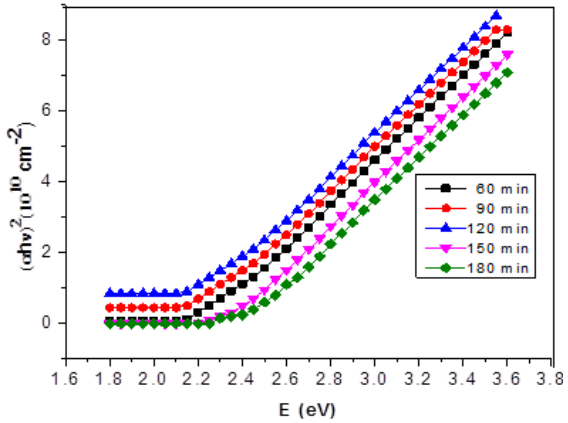

Fig.2 (αhν)2 versus photon energy hν for specimen thin films.

Fig. 3 displays the time oxides dependence of Seebeck coefficient of solar cells at room temperature.

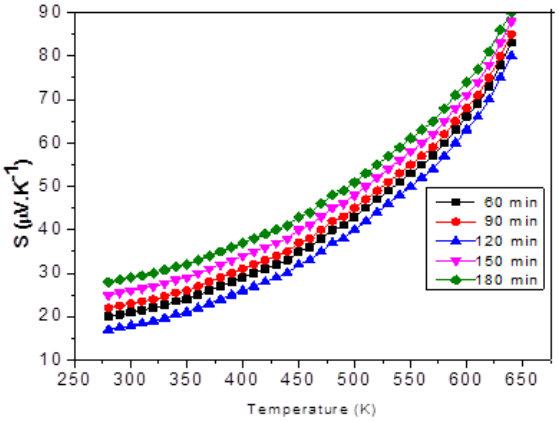

Fig.3. Temperature dependences of Seebeck Coefficient of samples

As the time oxide increases, the Seebeck coefficient decreases slightly but the low results at time oxide of 120 min. This might be caused by the gradually increasing carrier density of the samples with the decrease of time oxidation.

At room temperature, the values of Seebeck coefficient for at 120 min are relatively low, about 16 μV/K-1. However, as the time increases, the values increase evidently for all the samples. The Seebeck coefficients are 28 μV/K-1 for time equal to 180 min. As a consequence, in the studies system, the optical band gap reduces gradually, the electrical conductivity increases dramatically and the Seebeck coefficient decreases slightly with increasing time oxidation. It is likely that lattice distortions and additional holes introduced to the improved conductivity and the decreased band gap and Seebeck coefficient.

As shown in Fig. 4, σ increases to some degree and then inversely decreases with the increasing time oxidation. Remarkably, at 120 min result σ for solar cell reaching 84 S·m−1 at room temperature, which is about 180 min that of result 75 S·m−1.

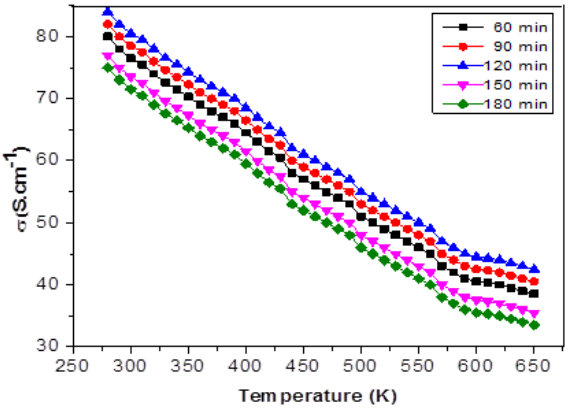

Fig. 4: Temp. Dependence of the electrical conductivity of samples

It may be attributed to the creation of holes and conversion of electrically insulating paths to electrically conducting paths. This feature is consistent with the interpretation that holes conductivity comes from the time oxidation.

In Fig. 5, the quantum efficiency spectra of the solar cell are measured from time of oxidation 60 min to180 min. The cell design is based on the common substrate structure. Spectral Responses in Quantum Efficiency of Emerging Kesterite Thin-Film Solar Cells. The preparation of solar cells by this way gives as a transparent conductive window layer. The spectral responses of this sample were characterized in the range of 400–1200 nm with lamp

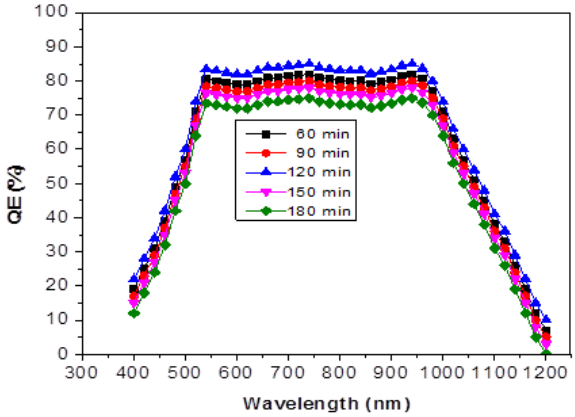

Fig.5: Quantum efficiency (QE) of specimen solar cells.

In the wavelength region 400–500 nm, measured spectral responses from the devices demonstrate typical layer response. Above 500 nm, the measured spectral response is limited by the band gap of cells. Overall reduction in the quantum efficiency in Fig. 5 is due to the grid shading and front surface reflection

as described. Between 300 and 500 nm, the widely accepted loss mechanisms in quantum efficiency are cells absorption. So we can show spectral response from the device.

Figure 6 shows the time oxidation dependence of the resistivity of samples prepared from 60-180 min . At 140 min, impurity phases and imperfections of the samples decrease. Thus, the resistivity of samples was dropping with them. However, at 140 min the resistivity equal to 3.65 ohm m and at 180 min the resistivity equal to 4.7 ohm. m. Since grain boundary makes a significant contribution to electro-conductibility of specimens, the grain growth reduces the grain boundary, cuts the conducting path and increases the resistivity.

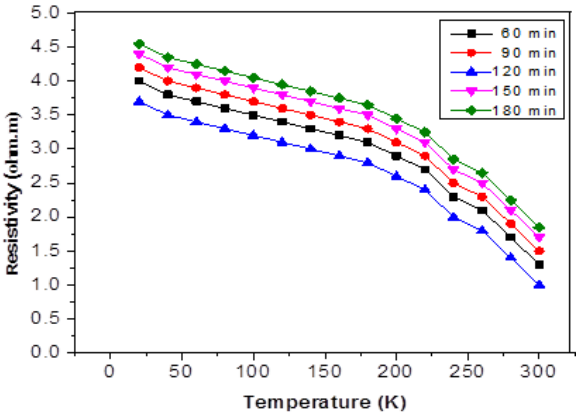

Fig.6: Temp. dependence of the resistivity of samples prepared.

Herein, the basic band diagram and working principle of a typical thin-film semiconductor solar cell are addressed, and some recent developments of solar materials and technologies thin film photovoltaic cells are reviewed. These new fabrications and new solar materials can improve photovoltaic efficiency and reduce manufacturing cost, including thin films deposited by metal-oxide-semiconductor.

The main absorbing materials of solar cells (p-doped semiconductors have optimal electronic structures to maximize the absorption of solar energy. The whole process starts with photons that have higher energies than the forbidden band that emits. These energies can control the valence electrons that occur. The cost of production of solar cells is still an important issue in the photovoltaic application. The predisposition and drive in steps used to form a p–n junction are high temperature and long term processes. Thus an alternative to the diffused p–n junction structure for solar cells is to use a simple MOS structure.

The photocurrent density of the cell is high up to 32.83 mA/cm2 at AM1.5 illumination (100 mW/cm^2) at room temperature at time of semiconductor oxides but the photocurrent density of the cell is low up to 22.72 mA/cm^2.

The sharp absorption edges of other solar films at the different time of semiconductor oxides were characteristic of homogeneous phases. Their Eg values of the solar thin film, deposited at 120 min, Eg ≈ 1.9 eV were related with the solar film. Therefore, the quality of solar films can be estimated from their optical properties.

Since grain boundary makes a significant contribution to electro conductibility of specimens, the grain growth reduces the grain boundary, cuts the conducting path and increases the resistivity.

Conclusion

Metal Oxide Semiconductor solar cell of low cost and stable unit proficiency was constructed via sol gel (SiO_2) spin coating technique. The sol gel layer was synthesized employing greener methodology at optimum economic impact. The I–V characteristics of the sample solar cell at different time, the photovoltaic performance, and optical properties of the resulted solar cell were evaluated and found efficient, productive, promising, and applicable. The green context and sustainable impacts of the methodology were clear enough, and highly marked, hence, inspiring for large scale manufacturing, obeying the commands of sustainability, and copping with the principles of green chemistry.

Conflicts of interest

The authors declare no conflict of interest

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