Highly Precise Optoelectronic Properties of GaSe/p-Si Thin Films Deposited Solar Cells

Ihab H. Naeim and A. A. El-Amin

Abstract— In this paper, light-sensitive materials have been used to produce a solar cell that is suitable for practical applications. A gallium selenide thin film (GaSe/p-Si) was deposited on a glass substrate by chemical bath evaporation (CBD) at room temperature. The Ga and Se sources were $GaSO_4$ and Na_2SeSO_3. NaOH was used as the finishing agent. The deposited samples were annealed in ovens at temperatures of 200 °C, 300 °C, 400 °C, and 500 °C. Absorption, transmission, and photoconductivity of light by the two-point probe method in which sample is mixed with an optical band gap spectrophotometer (GENESYS 10S Model UV-VIS), and two copper wires (electrodes) are fixed using a silver paint. It was confirmed that, in the case of a deposited film are annealed at temperature of 200 °C, 300 °C, 400 °C and 500 °C, an annealing treatment was performed in an amount of about 2.8 eV, a band gap of 2.87 eV, 3.03 eV, and 3.01 eV. When the substrate temperature raises from 200 °C to 500 °C the band spacing energy increases slightly. Although it shows a normal change in the blue color, the dark current from the photographic sample increases linearly when electric field temperature is applied. The first one is large and the second one is lower, which is an indicator of positive photoconductivity.

Index Terms— Optoelectronic properties , Chemical Bath Deposition , thin film , Solar cells.

1 Introduction

THERE is considerable interest in materials containing selenium. Group II-VI semiconductor materials such as gallium selenide, cadmium selenide, or copper and indium diselenide are materials that can be used for various applications from solid state lasers to solar cells. In many cases compounds are required as high quality thin films and techniques such as metal organic chemical vapor deposition (MOCVD) are used for deposition. Recently there has been considerable interest in the synthesis of materials such as CdSe in the form of isolated nanometer particles exhibiting quantum confinement effects. In this article we will briefly explain the use and potential usage of these compounds.

Compounds II-VI Compound semiconductors have attracted a lot of attention in recent decades due to potential applications in optoelectronic devices, solar cells, IR detectors, lasers and other fields. Gallium selenide is a known II-VI semiconductor composite material. It has a cubic and / or hexagonal crystal structure, has an optical bandgap in the range 2.6 to 3.1 eV, has a resistivity on the order of 104 to 1012 ohm-cm, a yellow- Orange color [1]. Various techniques have been used to prepare GaSe / p-Si thin films, including electrode location technology [2-4], organic chemical vapor deposition [5-6], gas condensation [5-6] Thermal evaporation [9-10], vacuum deposition [11], chemical bath deposition (CBD) [17/12], molecular beam epitaxy [18]], followed by Ionic layer Adsorption and Reaction [19], cyclic voltammeter method [20] Such Among the various other methods, Chemical Bath Deposition is found to be simple, convenient, cost effective, and capable of producing uniform and homogeneous thin films to industrial scale. In the present work, GaSe/p-Si thin films were deposited on glass substrates using the Chemical Bath Deposition (CBD) technique. The deposited films were annealed and Characterized for their Optical and Electrical properties.

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2 Experimental Work

A thin layer of gallium selenide (GaSe/p-Si) was deposited on a commercial glass slide (25×75×2 mm^2) using Bath Chemical Deposition (CBD) technology. All chemicals used were of analytical quality. Prior to deposition, the slides were rinsed with distilled water, washed with surfactant and then rinsed with distilled water. Slide glass is again degreased with ethanol, rinsed with distilled water and then dried in an oven. This process has been done to ensure an essentially clean surface for the formation of nucleation centers necessary for the deposition of thin layers.

Deposition was carried out by placing 20 ml (1M) of gallium sulfate in 60 ml of glass beaker and adding 20 ml of NaOH with constant stirring. Addition of excess NaOH decreased the concentration of Ga^{2+}. 3 ml (1M) of Na_2SeSO_3 as selenium source (Se) was slowly added to the mixture. The resulting solution was made up to 70 ml with distilled water and stirred with a glass rod for several minutes. The pH of the mixture was maintained at 12 ±

1.65 and bath alkalinity was checked. A clean glass slide was inserted into the bath and held vertically in a synthetic foam blanket. The deposit was allowed to proceed for 48 hours at room temperature after which the coated slide was removed from the bath, rinsed with distilled water and air dried. The coated slides were annealed in ovens at temperatures of 200° C, 300° C. and 400° C. Using a spectrophotometer (GENESYS 10S Model UV-VIS) for the optical band gap, characterized by measurement of light absorption and transmission, photoconductivity was measured using a two-point probe method, Two copper wires are fixed) sample. A DC power supply, a pico amp meter (Keithley Model 6487) and a sample film were connected in series. The dark current of the sample was measured by covering the sample with a black box and measuring the photocurrent by focusing the filtered white light from a tungsten lamp (400 W) through the window onto the sample. It is in transparent glass. Field dependent darkness and photocurrent were measured using a pico ammeter by varying the applied and corresponding currents in the circuit.

High purity gallium (99.999%), selenium (99.999%), zirconium, selenium and iodine compounds were absorbed in a vacuum-sealed quartz ampule under vacuum of 4×10^{-3} Pa.) And iodine (99.99%) were prepared. Production of gallium selenide A gallium selenide compound was prepared at 1148 K using iodine as a reactant. In this study, the substrate was silicon (100) and glass, which was used to deposit a thin layer of gallium selenide. The silicon wafer is thoroughly rinsed with double distilled water and then treated with methanol to remove organic contaminants.

3 Results And Discussion

Thin GaSe/p-Si deposition occurs when the ion products of Ga^{2+} and Se^{2-} ions exceed the GaSe/p-Si solubility product. Control of Ga^{2+} and Se^{2-} ions in the bath controls the precipitation rate. The formula of the film formation and deposition process is given as follows [15].

Hydrolysis of sodium selenosulfate (Na2SeSO3) in Se2- ion bath is shown by the following reaction:

$$Na_2SeSO_3 + OH^{-1} \rightleftharpoons Na_2SO_4 + HSe^- \quad (1)$$

$$HSe^- + OH^{-1} \rightleftharpoons H_2O + Se^{2-} \quad (2)$$

The reaction between Ga^{2+} and NaOH takes place through:

$$(Ga)_2SO_4 + 2NaOH \rightleftharpoons 2(GaOH) + Na_2SO_4 \quad (3)$$

When the NaOH is added to the Ga_2+ salt solution, the $Ga(OH)_2$ begin to precipitate when the solubility product (SP) of $Ga(OH)_2$ is exceeded, i.e

$$Ga^{2+} + 2OH^- \rightleftharpoons Ga(OH)_2 \quad (4)$$

The GaOH precipitate dissolves in excess NaOH solution to form the complex sodium gallium hydroxide $Na_4Ga(OH)_6$ as follows:

$$Ga^{1+} + 2NaOH^- \rightleftharpoons NaGa(OH)_2 \quad (5)$$

$$2NaGa(OH)_2 \rightleftharpoons Na + HGa + OH + H_2O \quad (6)$$

Finally, the GaSe/p-Si thin film formation takes place through:

$$HGaO_2^- + HSe^- \rightleftharpoons GaSe/p\text{-}Si + 2OH^- \quad (7)$$

Fig. 1 shows a light absorption spectrum of an electrolytically deposited gallium selenium film in a visible region on an ITO substrate. The spectrum shows that the main absorption takes place in the wavelength range from 350 to 450 nm, but in the wavelength range from 450 to 550 nm additional absorption is also observed. This suggests that the transition between the valence band and the ionized donor, or the transition between the ionized acceptor and the conduction band occurs in the lower region, whereas the interband transition occurs in the high photon energy region are doing. [15]. The absorption data was further used to calculate the bandgap energy of the gallium selenide film.

Drawing. Figure 2 shows a plot of the bandgap width of GaSe / p-Si deposited thin films and annealed thin films at different temperatures (ie 200° C, 300° C, 400° C and 500 ° C) with $Vs(\alpha h\nu)^2$. The energy bandwidth is estimated by extrapolating the right part of the curve for the zero absorption coefficient value giving the absorbed energy corresponding to the band gap energy. The estimated band spacing is 2.8 eV, 2.87 eV, 3.03 eV and 3.01 eV for the deposited film and the film is annealed at temperatures of 200° C., 300° C, 400° C, and 500° C. It was the band gap energy increases slightly as the substrate temperature rises from 200° C to 500° C, and shows a blue color change of normal volume value and the film anneals, 0.22 eV, 0.27 eV, 0.38 eV and 0.35 eV are GaSe/p-Si [15], and could be attributed to size quantization leading to quantum confinement of GaSe/p-Si thin film [26].

Fig. 3 shows the current path (dark and photograph) as a function of the applied electric field used to analyze the photoconductivity of a GaSe/p-Si thin film annealed at 300° C. 'Darkness increases linearly with the applied electric field, but the first charge is large and the second charge is smaller. This is an indicator of positive photoconductivity caused by the generation of mobile charge carriers. Absorption of photons occurs. This is consistent with the result of [27]. Irradiation creates electron-hole

pairs, holes neutralize the grain boundary repulsion potential, resulting in an exponential increase in electron mobility, resulting in high photocurrent during irradiation, so it is strong against thin layers It can be used in combination with a low dark current film [6] that produces photosensitivity.

The stochastic defect of group II samples is the Se gap and can be interpreted from the activation energy of 1000/T for 1000 diagrams (Fig. 4). This observation that the material with abundant and abundant Ga film Se gap of activation (about 26 meV) remains p-type is consistent with observation of Se-deficient GaSe / p-Si sample.

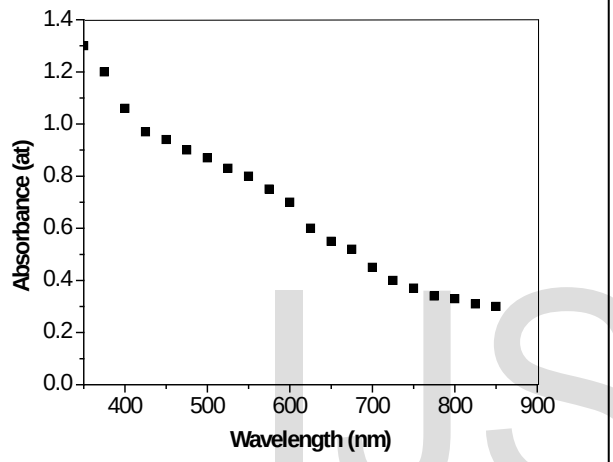

Fig. 1. Plot absorbance against wavelength for gallium selenide thin film.

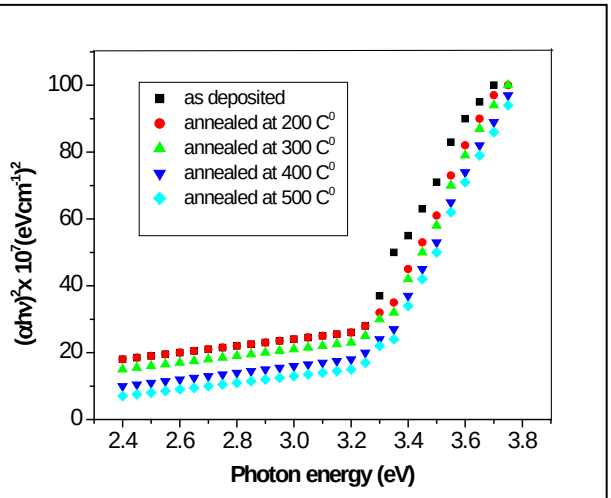

Fig. 2. Absorption coefficients Vs photon energy of GaSe/p-Si thin films annealed at different Temperatures.

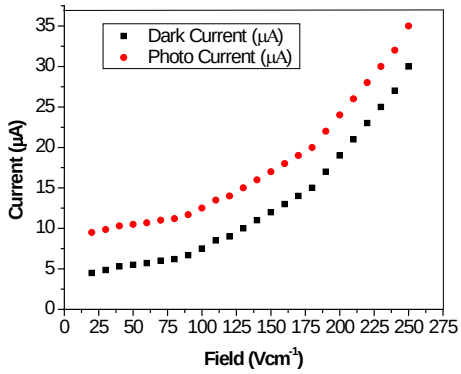

Fig. 3. Photoconductivity study of GaSe/p-Si thin films.

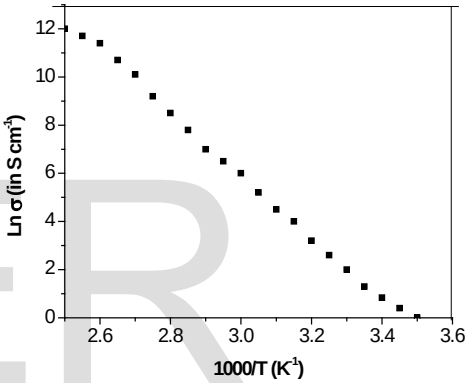

Fig. 4. ln σ versus 1000/T graphs of GaSe/p-Si thin films.

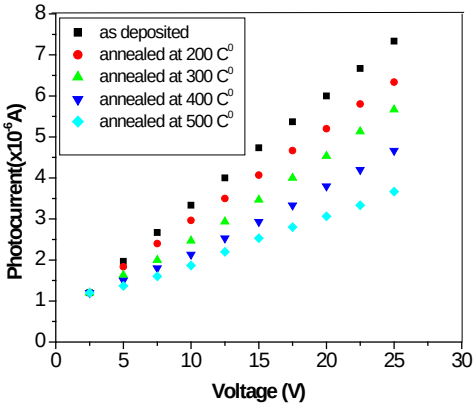

Fig. 5 Photocurrent–voltage characteristics of GaSe/p-Si films annealed at different temperature.

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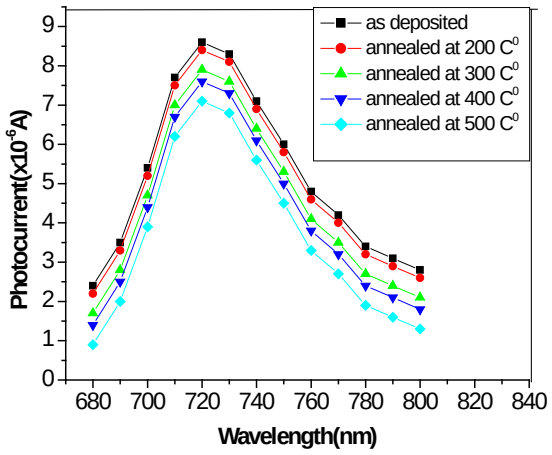

Fig. 6. Photocurrent–spectra of GaSe/p-Si thin films annealed at different Temperatures.

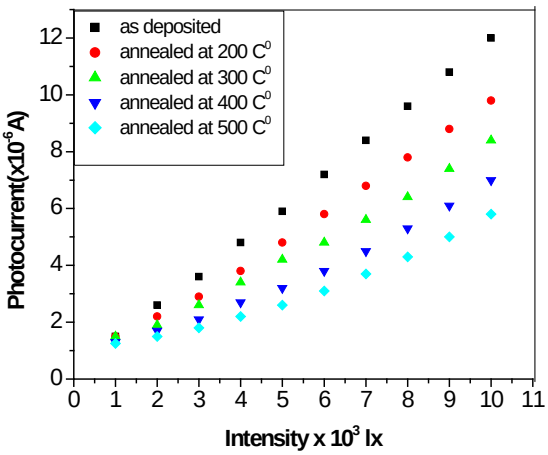

Fig. 7. Photocurrent–illumination characteristics GaSe/p-Si thin films annealed at different Temperatures.

The variation of photocurrent with applied voltage in CGSe films is shown in Fig. 5. The photocurrent increases with an increase in voltage. Similar behavior of the photocurrent has been reported by Shahidi et al. [28].

Photocurrent spectra of GaSe /p-Si films deposited at different duty cycles are shown in FIG. The photocurrent spectrum shows a peak near the absorption edge, and it is also observed by Rose [29]. The band gap of the GaSe/p-Si film determined from the spectral response is 1.67 eV. This is in good agreement with the band gap value obtained from the light absorption measurement. Photocurrents traveling in the short wavelength region may be due to high absorption coefficients and only surface regions with shorter defect states are excited. In the high wavelength region, the radiation is only partly absorbed, resulting in a photocurrent lower than the peak. The tail of the spectrum spanning up to 1200 nm is due to the direct excitation of carriers from the defect level. Similar results have been reported for GaSe/p-Si films by several researchers [30].

Fig. 7 shows the variation of photocurrent with light intensity of GaSe/p-Si films annealed at different temperature. The photocurrent is found to increase with an increase of temperature due to increase in light intensity.

4 Conclusion

A thin GaSe/p-Si film was deposited on a glass substrate using bath chemical vapor deposition (CBD) technology. The coated slides were baked in ovens at temperatures of 200° C, 300° C, 400° C, and 500° C. Then characterized in terms of optical and electrical properties. The annealing of the film causes a red shift of 0.22 eV, 0.27 eV, 0.38 eV and 0.35 eV in the optical spectrum with respect to the mass of the GaSe/p-Si characteristic and this was attributed to size quantization leading to quantum confinement of GaSe/p-Si thin film and the photo and dark currents were observed to increase linearly with the applied electric field, but the former being large and the latter is less, which is an indication of positive photoconductivity caused by the generation of mobile charge carriers produced by absorption of photons. The photocurrent also increases with an increase in voltage. The photoconductor results indicate that the films could be used in photoconductor operating in the near infrared region. The photocurrent spectra show a peak near the absorption edge. The band gap of GaSe/p-Si films determined from the spectral response is 1.67 eV. The photocurrent is found to increase with an increase of temperature due to increase in light intensity.

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