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Annealing Influence on Nanostructure's Optical Properties CdS Thin Films Prepared by Physical Vapor Deposition Technique

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Abstract

In this work, the influence of the annealing temperature on the optical properties of the thin films Cadmium Sulphide (CdS) has been studied. Thin films of Cadmium Sulphide (CdS) were made using the Physical Vapor Deposition (PVD) method. The optical properties of annealing temperatures (as deposited, 200, 250, and 300℃) were scrupulous. The UV/VIS spectrophotometer investigated optical parameters such as transmission, the coefficient of absorption and energy gap of the films for the range (400-110 nm) as an assignment of the annealing temperature. The optical properties were calculated as a function of annealed temperature: absorption, transmission, reflection, band gap, coefficient of absorption, excitation coefficient and index of refraction.

Keywords: Physical Vapor Deposition, Cadmium sulphide (CdS) films, Annealing Temperature, optical properties.

1. Introduction

The semiconductor manufacturing products now spread throughout the world and penetrate pointedly into the daily life of an epidermal existence. For many semiconductor devices, thin films are well known as stamping for enforcement in abundant physically established profession [1]. Interest in the physical properties of thin films has increased significantly in recent years as new effects may appear in film statements that are not observed in bulk samples [2]. Cadmium sulfide thin film is a suitable n-type semiconductor for an opening layer in solar cells for CdTe/CdS heterojunction [3,4]. Due to its new properties, CdS is a substance material such as photoconductivity, refractive elevation single (2.5) [5]. And its high cognition of electrons [6]. Thin CdS films such as vaporization by vacuum, sputtering, electro-deposition, radio frequency, pulsed laser evaporation, molecular beam epitaxy (MBE) were obtained using several techniques [7]. CdS thin film development was based on organic metal vapor deposition (MOCVD), spray pyrolysis deposition (SPD), close-spaced sublimation (CSS), successive ionic layer adsorption and reaction (SILAR) and chemical bath deposition (CBD) [8]. Physical vapor deposition (PVD) has become an engaging technique due to its naivety, low cost and look high accuracy data technology, with a large surface and large surface deposition at low temperatures [9]. The purpose of this work the effect of annealing on CdS thin film optical parameters.

2. Experimental Method

One of the physical vapor deposition (PVD) combined method is thermal evaporation. This is a form of thin film precipitation on glass substrates, a vacuum technology that stratifies the clothing of pure materials to the surface of multiple materials. The optical properties of PVD CdS thin films are based on the parameters of proportional reactant condensation for chemical reaction, films thickness, aqueous solution PH and annealing temperature. The deposition technique of thermal vacuum evaporation depends on the heating identity. Ultimately, the material vapor precipitates on the cold substratum surface and on the vacuum chamber walls in the form of the thin film. Usually, low pressure is used; approximately (2×10^{-5}) mbar or up to (1.5×10^{-5}) torr, to avoid a vapour-environment response. The mean free way of vapour iotas at these low pressures is the same as the measurements of the vacuum chamber so that these particles go in go in straight lines from the vanishing source towards the substrate. This begins with "shadowing" phenomena with 3D objects, especially in areas that are not opened directly from the (crucible) vanishing source. In addition, the normal vitality of vapour molecules achieving the surface of the substratum is by and large low in warm vanishing strategies (order of kT, i.e. 10ths of eV). At a rate equal to 5.2Å / sec deposition and thickness of 0.5µ is equal in all samples. (0,200,250 and 300) ^{o}C.

3. Results and Discussion

Figure1. Illustrates the transmittance via wavelength; it can be clearly seen that the transmittance of 250^{o}C is higher than the all deposited thin films showing a shift in peak location as the temperature increase. All the films exhibit peaks maxima and minima. This might be due to the high homogeneity of the deposited thin films. Transmittance was given by the proportion of the force of the transmitting rays (IT) through the film to the power of the incident rays (I_o) on it as deposited [10].

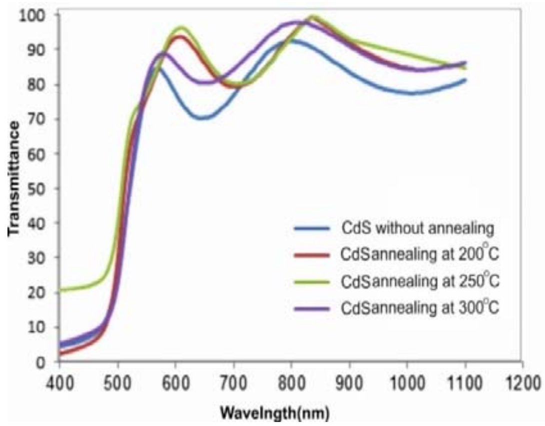

Figure 1. Transmittance versus wavelength different annealing of CdS thin films.

$$T = {}^{I_T}/_{I_0} \quad (1)$$

It is also observed in **Figure 1.** That increasing thermal annealing has a tendency to diminish transmittance in all the range of solar powered light energy. This is as an aftereffect of the development of denser movies in view of water evaporation. This behaviour agrees with the results published by Ezema et al. [11]. **Figure 2.** Shows the relation between absorbance and wavelength. It was observed that absorbance was higher for the untreated one and then began to decrease .This can be explained by the inverse relation between transmittance and absorbance. A can be characterized as the proportion between material absorbed light intensity (I_A) and incident light intensity (I_o).

$$A = {}^{I_A}/_{I_0} \quad (2)$$

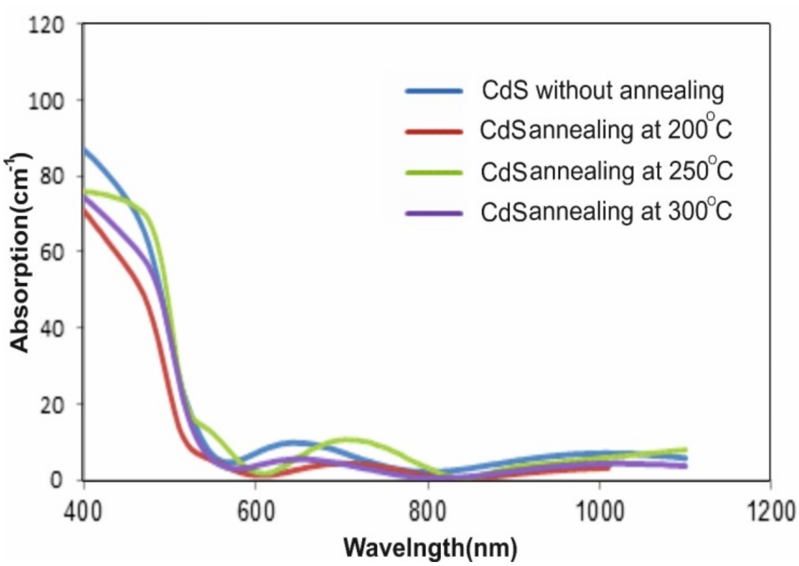

Figure 2. Absorption versus wavelength different annealing of CdS thin films.

The absorbance versus wavelength was plotted for CdS; as-grown and annealed thin films. From the absorbance spectra, it was observed generally that the absorption of films in the VIS area of the solar radiation spectrum decreased with increasing wavelength and film absorption. The sharp absorption edges occurred at wavelengths less than 530 nm and the film-absorption edge shifted slightly to longer wavelengths revise. For optimum absorbance at 140ºC, the highest absorption values were observed in the annealed samples with the critical annealed temperature. They have noted similar behavior in the [12-14]. **Figure 3.** illustrates the relationship between the coefficient of absorption and the energy of the photon. The absorption coefficient value was in the range of 104 cm which predominated the possibility of direct electronic transitions; the absorption edge was shifted to lower photon energy.

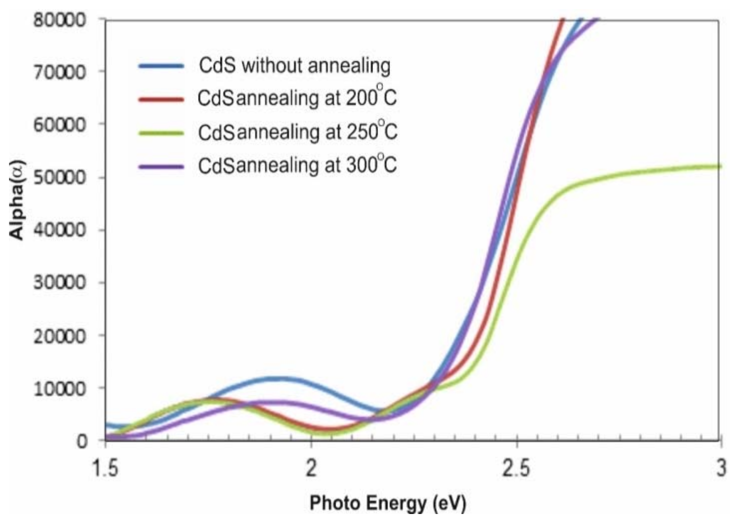

Figure 3. Alpha(α) versus photo Energy different annealing of CdS thin films.

$$(\alpha h\,\nu)^2 = \left(h\,\nu - E_g\right) \quad (3)$$

Where α is the coefficient of absorption, A will be consistent, the energy of the photon and E_g the hole of the band will be consistent. The value of the gap of optical energy using **Figure 4.** Varied from 2.38 to 2.44 eV, the highest value was reinforced at 200ºC for the film. (revise: no verb) Increases in the absorption coefficient with annealing temperature were also observed. The absorption coefficient (α) is related to the extinction coefficient (k) by

$$k = \frac{\alpha\,\lambda}{4\,\pi} \quad (4)$$

Where λ is the wavelength of the electromagnetic wave [15].

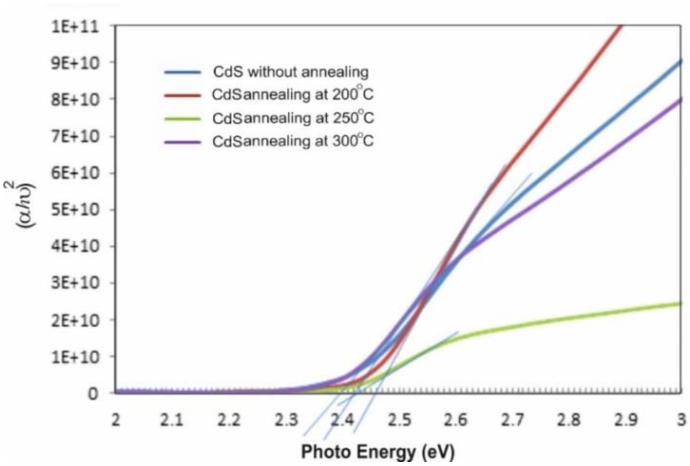

Figure 4. $(\alpha h\upsilon)^2$ versus photon energy different annealing of CdS thin films.

Figure 5. Shows the coefficient of extinction value calculated using the relationship below. In **Figure 5.** It is clear that the coefficient of extinction value increases with the increase in photon energy. At 600 nm of wavelength, the maximum value of k was observed [16].

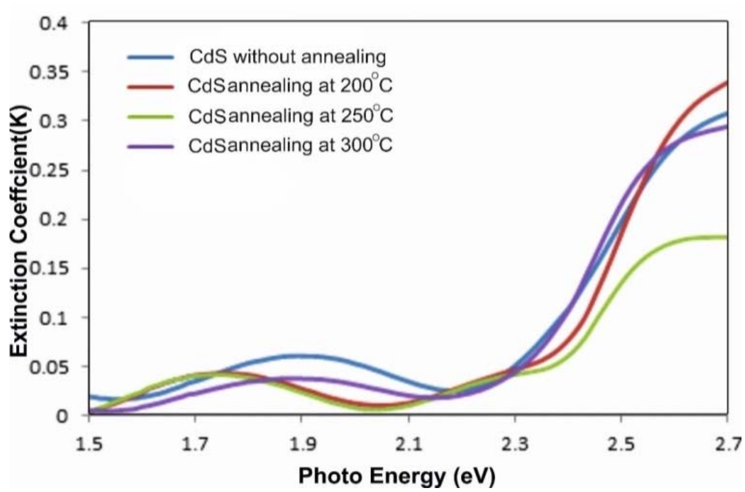

Figure 5. Coefficient of extinction versus various annealing of CdS thin films by Photo Energy.

Figure 6. shows the refractive index value estimated using the following relationship: the ratio represents the refractive index between the speed of light in the vacuum and the speed of the material, and the relationship between the refractive index and the refractive membrane (R) is as follows: [17].

$$R = {[(n-1)^2 + k^2]} \Big/ {[(n+1)^2 + k^2]} \qquad (5)$$

It is crystal clear the highest refractive index value is 200ºC. Similarly, this pattern was observed in the conduct of the annealing refractive index and attributed to denser films resulting from the disappearance of film water particles [18].

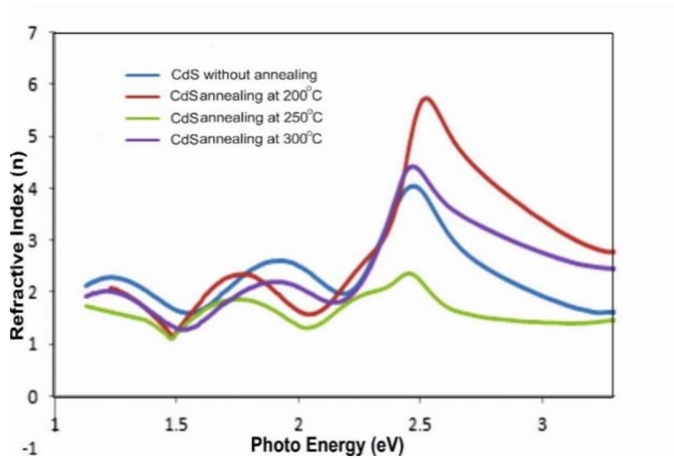

Figure 6. Refractive index versus different annealing of CdS thin films with photon energy.

Figure 7. Shows the relationship between the real part of the dielectric constant and the photon energy. It was observed that the real part of the dielectric constant was higher because the value was higher for the film at 200ºC and then the inverse relationship between them can explain this.

$$\varepsilon_0 = n^2 - k^2 \quad (6)$$

Figure 8. Represents the value of photo-energy optical conductivity without annealing and various degrees of annealing. The relation is used to determine the optical conductivity Where α is the coefficient of absorption and c is the speed of light. The optical conductivity relies immediately on the coefficient of absorption and the increased photon energy that establishes accretion. The optical conductivity value varies from 1.2 to 3eV in photon energy, the elevated value is 200ºC for the film.

$$\sigma = \left({}^{\alpha n c}/_{4\pi}\right) \quad (7)$$

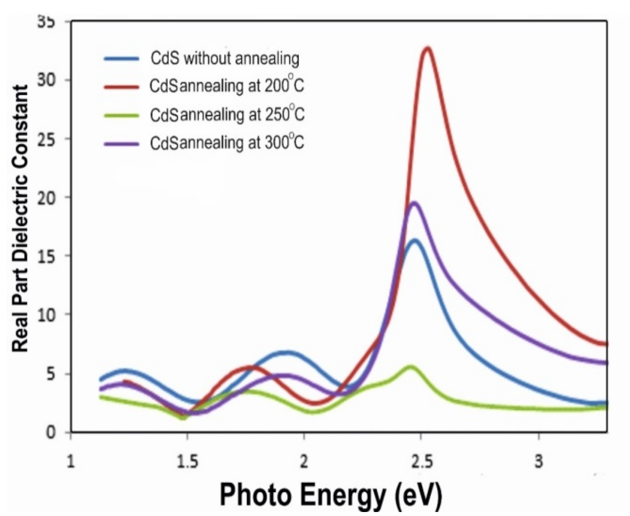

Figure 7. The dielectric constant real part vs photon energy for different CdS thin films annealing.

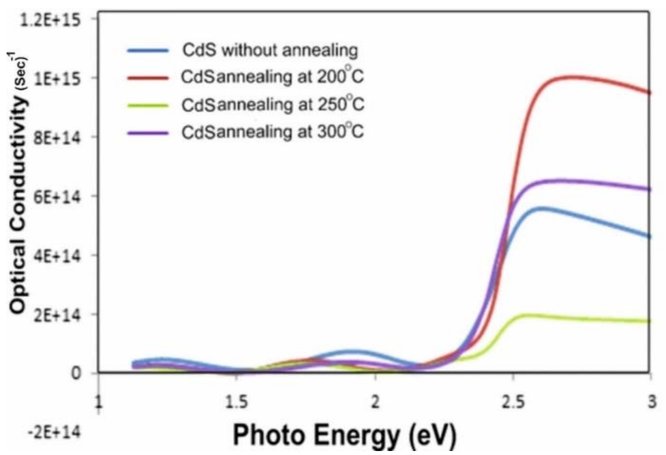

Figure 8. Optical conductivity versus different CdS thin film annealing photon energy.

4. Conclusion

CdS thin film was prepared using the technique of thermal evaporation. From the results, it is concluded that the grain size of the CdS structure was increased by annealing which in turn causes to decrease the energy band gap to be used in IR optoelectronic devices. Annealing is caused to increase the crystallinity of the resulted structures. The optical transmittance varied with the annealing temperature. CdS exhibited characteristics compatible with window material for solar cells and other optoelectronics devices.

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