The role of Ag layer in the optical properties of CdS thin film

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CdS and CdS capped with Ag thin layer thin films were organized by chemical bath deposition technique. Cadmium chloride and thiouria were used as precursors material to deposited CdS film at 80 C. after deposition of CdS film, it dipped in Ag NPs. precursors for one hour at 50 C to coated it surface by Ag layer. In this paper, we examined the absorbance in the range between 300 and 1100 nm. The direct and indirect band gaps were calculated with the Tauc method, yielding values of 1.97 to 2.46 eV. Resulting noticeable decreasing in band gaps with the presence of Ag layer.

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1. Introduction

The development of nanostructured semiconductor materials over many decades, as well as their possession of unique and distinctive properties, has led to their use in many different applications [1].

CdS, a II-VI group semiconductor, is a yellow inorganic compound, employed in industry as a yellow pigment, it has thermal stability, good chemical stability and it is easily soluble in acid solution but not soluble in water [2]. It used as N-type semiconductor, has Bohr radius of 2.4 nm2 [3,4], has two common crystal structures with direct band gaps (Eg at 300 K): hexagonal (wurtzite) phase with 2.26 - 2.5 eV and cubic (sphalerite) phase with 3.5 eV [3,5].

CdS is a promising material that is widely used in optoelectronic device technologies, including optical filters, photosensors, gas sensors, and most notably solar cells [6-9].

CdS has been extensively studied and prepared using a variety of techniques, including chemical bath deposition (CBD), chemical vapor deposition (CVD), electrodeposition, electron beam evaporation, spray pyrolysis, pulsed direct current (DC) magnetron sputtering, pH-controlled growth solution, molecular beam epitaxy (MBE), spin-coating, and successive ionic layer adsorption and desorption[10-12].

Anyhow, CdS is a health risk material upon direct contact. This health risk could be reduced if this material is coated with a innocuous one upon direct contact. Therefore, we chose silver (Ag) as a coating for CdS thin films, which has no negative effects on humans [13].

In the present work, we have fabricated CdS and CdS/Ag thin films by chemical bath deposition. We performed a comparative study for optical properties before and after Ag layer deposition on the surface of CdS film, highlighting how the strong reduction in energy gap and increasing in absorption.

2. Experimental

CBD was used to develop CdS and CdS/Ag thin films on a glass substrate. The CdS solution contains the following reactive substances: cadmium chloride ($CdCl_2$), ammonium acetate, ammonia, thiourea [$(NH_2)_2CS$], and deionized water in a 100 ml beaker. For two hours,

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the bath was kept at a constant temperature of 80 °C. The thin films were formed by immersing a clean glass substrate slide in the solution. The CdS thin films were then allowed to dry at room temperature before being immersed in a silver ion solution composed of silver nitrate (AgNO3), tri sodium citrate, and deionized water in a 100 ml beaker. For one hour, the bath was maintained at a constant temperature of 50 °C. The deposited films were homogeneous in thickness and had excellent adherence to the substrate, however their color darkened after Ag deposition. The thin films' X-ray diffraction (XRD) spectra were acquired to determine their crystalline structure. The thin films' optical absorption spectra were determined. Scanning electron microscopy (SEM) was used to examine the morphology using a NanoSEM instrument.

3. Results and discussions

The Field Emission Scanning Electron Microscope (FESEM) was used to study the particle size and morphology of a CdS thin film. The FESEM picture of the CdS thin film was shown in Fig. 1. The FESEM image clearly demonstrates that the thin film surface was smooth and contains spherically formed grains. The surface was coated in grains of uniform size. The thin sheets exhibit no cracks or holes.

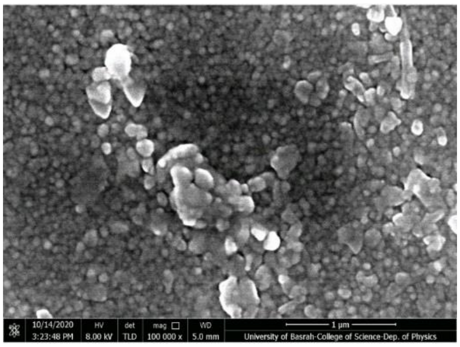

Fig. 1. CdS thin film FESEM micrograph.

Fig. 2 illustrates the X-ray diffractogram of a CdS thin sheet. The peaks in the Figure have been compared to the normal cubic structure of CdS. The XRD patterns indicate that the CdS film was composed of nanoparticles. The peak intensity at 2=26.7 was greater than the other peaks, confirming the formation of thin films along this plane. There were no detection of peaks resultant from impurities that suggestion the great purity of produced matter. The intensity of the peaks was quite an indication of the well crystalline nature of the prepared nanoparticles.

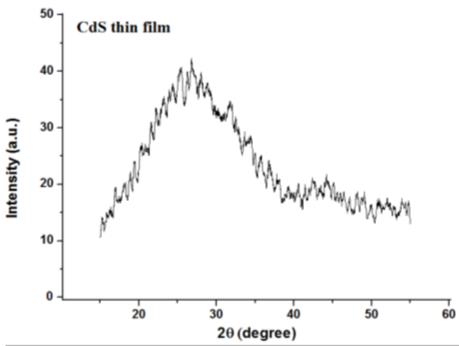

Fig. 2. CdS thin film X-ray diffraction pattern.

At room temperature, absorption measurements between 300 and 1000 nm were made. The absorption spectra of the thin films demonstrate a significant absorption in the ultraviolet area and a high transmission in the visible and infrared regions, as shown in Fig. 3.

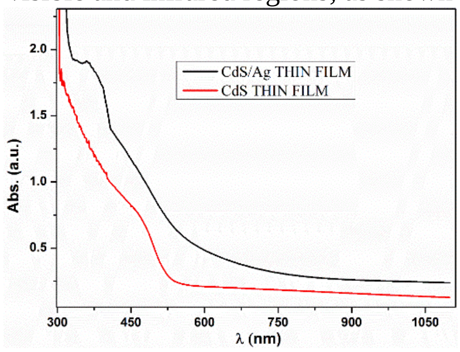

Fig. 3. Spectrum of absorption of CdS and CdS/Ag thin films.

The direct band gap energy (Eg) of CdS and CdS/Ag thin films was determined using the Tauc plot of **(**αhν)^2 versus photon energy (hν), as illustrated in Fig. 4. The pure CdS film's respectable band gap was 2.46 eV and that of ref [14], which lowers to 2.33 eV [13] following the deposition of an Ag thin film on the surface of CdS.

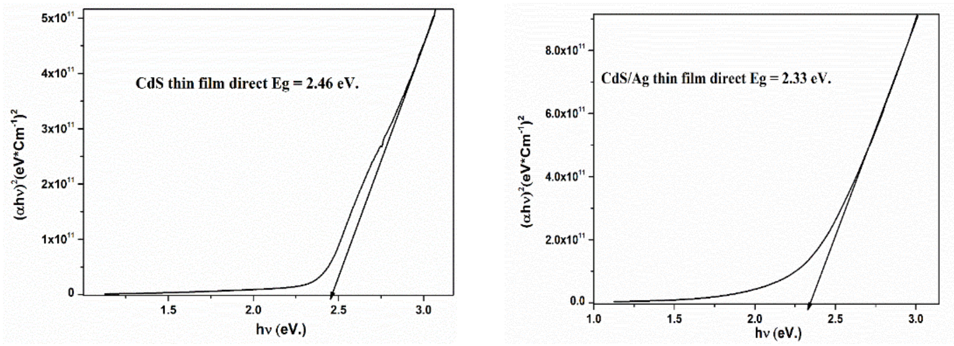

Fig. 4. Direct Band gaps of CdS and CdS/Ag thin films.

The indirect bandgaps for CdS and CdS/Ag thin films were obtained as a function of *hv* in Figure .5 . Rendering to interrupt of the finest fitting of line in the x-axis, indirect bandgaps have been intended from figure. It had been noticed that the indirect bandgap values for CdS and CdS/Ag were 2.25 eV and 1.97 eV, respectively.

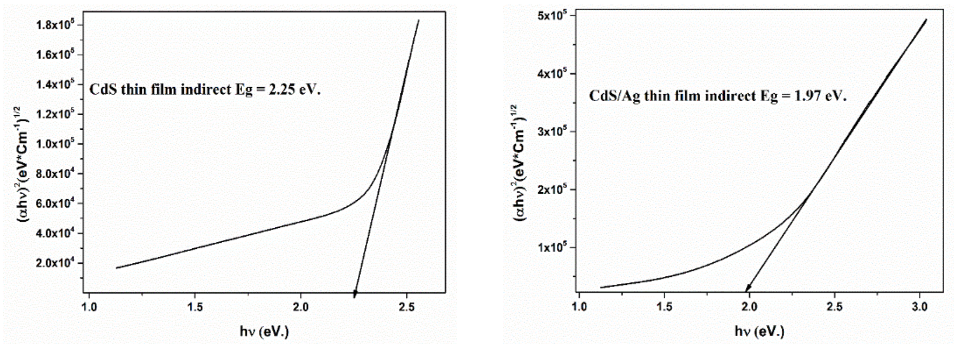

Fig. 5. Indirect Band gaps of CdS and CdS/Ag thin films.

4. Conclusion

Chemical bath deposition was used to create nanocrystalline CdS and CdS/Ag thin films. The films were extremely adherent to the substrate. All XRD peaks were found to be associated with CdS films, and no peaks associated with contaminants were identified. We investigated the influence of an Ag layer on the optical characteristics of a CdS thin film. Ag has a lower band gap energy than CdS samples. Ag/CdS is a good contender for the window layer in solar cells based on the absorption measurements.

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