Characterization and Analysis of Optical Properties of CdS:$CdCl_2$ Thin Film

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ABSTRACT

Using chemical bath deposition (CBD) technique, CdS thin films were prepared on glass substrates. Room temperature photoluminescence analysis in the 400-700 nm emission wavelength ranges for the excitation energies 365nm show the 'well known' green emission band of CdS. The influence of variation of ratio of cadmium and sulphur was studied on the PL emission intensity of CdS thin films. In a selected ratio of cadmium and sulphur for which emission intensity was highest, the effect of $CdCl_2$ concentration on PL emission intensity was studied.

Key words: Photoluminescence studies, chemical bath deposition, thin films, CdS.

INTRODUCTIION

Cadmium sulphide is a suitable window layer for solar cells [1-3] and also finds applications as optical filters and multilayer light emitting diodes [2], photo detectors [3], thin film field effect transistors [3-5], gas sensors [6], and transparent conducting semiconductor for optoelectronic devices [7]. Among the various known methods to synthesis CdS thin films; the reliable, simple and cost effective route is one using the chemical bath deposition (CBD) technique.

The CBD method is based on a controlled precipitation of the material in such a way that the precipitation occurs uniformly onto the substrate [8]. In addition, film formation on the substrate takes place when the ionic product exceeds the solubility product [9]. Regarding the chemical processes of CdS thin films by CBD, the heterogeneous reaction on the substrate surface is limited by the competing homogeneous reaction in solution (which results in precipitation in solution) [10]. Nanocrystalline semiconductors exhibit properties intermediate between the bulk crystals and the molecules [11]. Nanocrystalline CdS thin films are grown on substrates in a solution bath containing cadmium salt and a complexing agent. One of the cadmium salts, either cadmium chloride, cadmium acetate, or cadmium sulfate is used. Wenyi et al. [12] reported on the influence of the growth process on the structural, optical, and electrical properties of CBD CdS films. The surface morphology, structural, and optical properties of CdS thin films depend on the deposition parameters, notably the concentration of the reactants, the pH of the solution, the bath temperature, and the deposition time. In this study, CBD was used to deposit nanocrystalline CdS thin films onto glass substrates. The photoluminescence (PL) studies on the CdS thin films done for

varying concentration of cadmium and sulphate ions and for varying concentration of $CdCl_2$ are reported .

EXPERIMENTAL

Preperation Of Films: Chemical Bath deposition technique was used to deposit films of CdS:$CdCl_2$ on cleaned glass substrates of dimension (24mmX75mm). The glass slides were washed in distilled water and ultrasonically subsequently cleaned in acetone which were dipped vertically into a mixture of solutions of varying concentration of cadmium acetate, Thiourea, Triethanolamine and 30% aqueous ammonia. For preparing doped films, varying concentration of cadmium chloride were mixed to the original mixture. The pH of the solution was observed to be 11.2. The CdS thin films were prepared on glass substrates in the chemical bath at 60°C for 60 minutes. The deposited CdS thin films were rinsed in deionized water, cleaned ultrasonically and then dried in air. The CdS thin films are yellowish and have a good adherence to the glass substrate.

PL emission Spectra : The chemically deposited CdS thin films were uniform and consisted of small nanocrystalline grains. The preparation of CdS thin films by CBD is governed by the chemical reaction within the solution of reactants. It was reported that at lower temperatures the surface of the CdS thin films is rough, but as the temperature remains constant (at 60°C), the film surface becomes more uniform [13].

The photoluminescence (PL) emission spectra of the different CdS films (for various combination of Cd and S) prepared at room temperature under the excitation energy of 365 nm wavelength is presented in fig.-1. The principle of PL measurements is to create carriers by optical excitation with photon energy above the band gap of the films (2.4eV). Electrons and holes relax to their respective ground states in the conduction and valence band. They can then recombine radiatively as most free carrier or excitations. When light energy input is applied to the film there is an electronic transition between two energy levels, E1 & E2 (E2 > E1), with the emission of wavelength λ, where $\frac{hc}{\lambda} = E_2 - E_1$.

Invariably E1 and E2 are part of two groups of energy levels so that instead of a single emission wavelength a band of wavelength is observed [13].

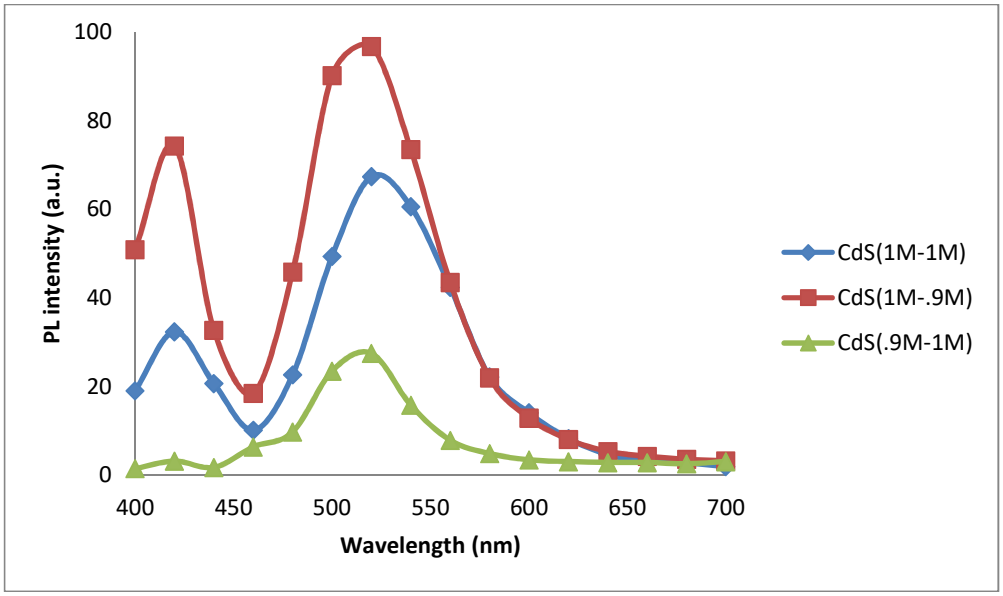

Fig. 1 PL emission spectra for varying concentration of cadmium and sulphur

The highest emission appears at (Cd_1-$S_{0.9}$) concentration and with increase in concentration of sulphur, the intensity of emission spectra is found to decrease. Therefore this concentration was used for the CdS films doped with $CdCl_2$.

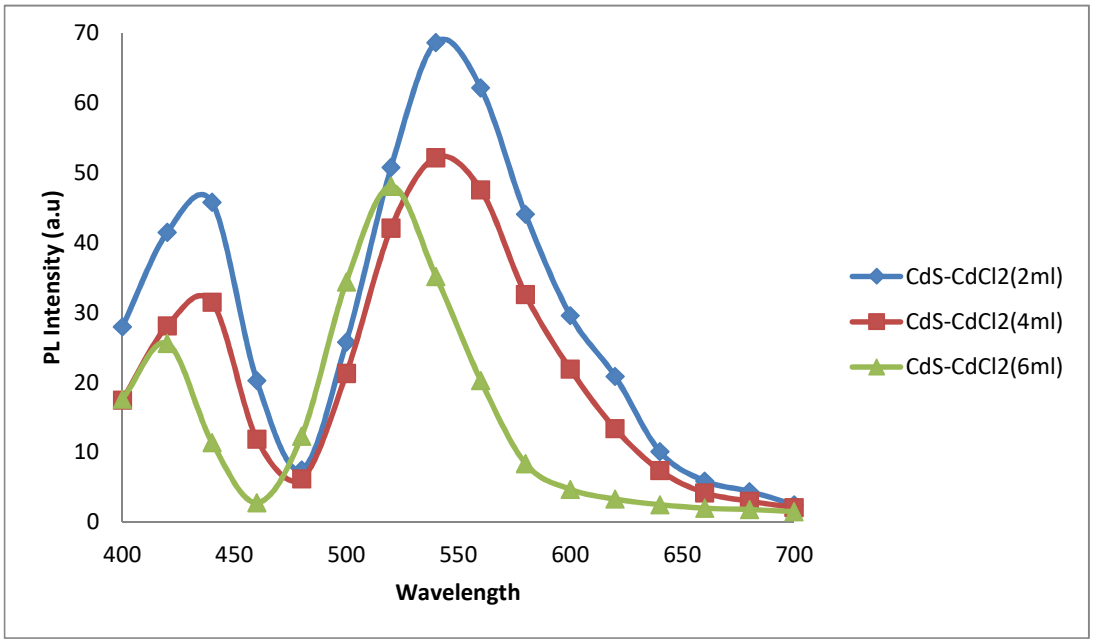

Fig. 2 PL emission spectra of CdS:$CdCl_2$ films with varying concentration of $CdCl_2$.

In fig. 2, PL emission spectra of (Cd_1-$S_{0.9}$) films doped with varying concentration of chlorine is shown. Emission intensity is found to be maximum for 2ml volume of $CdCl_2$ and it decreases as the concentration of $CdCl_2$ increases.

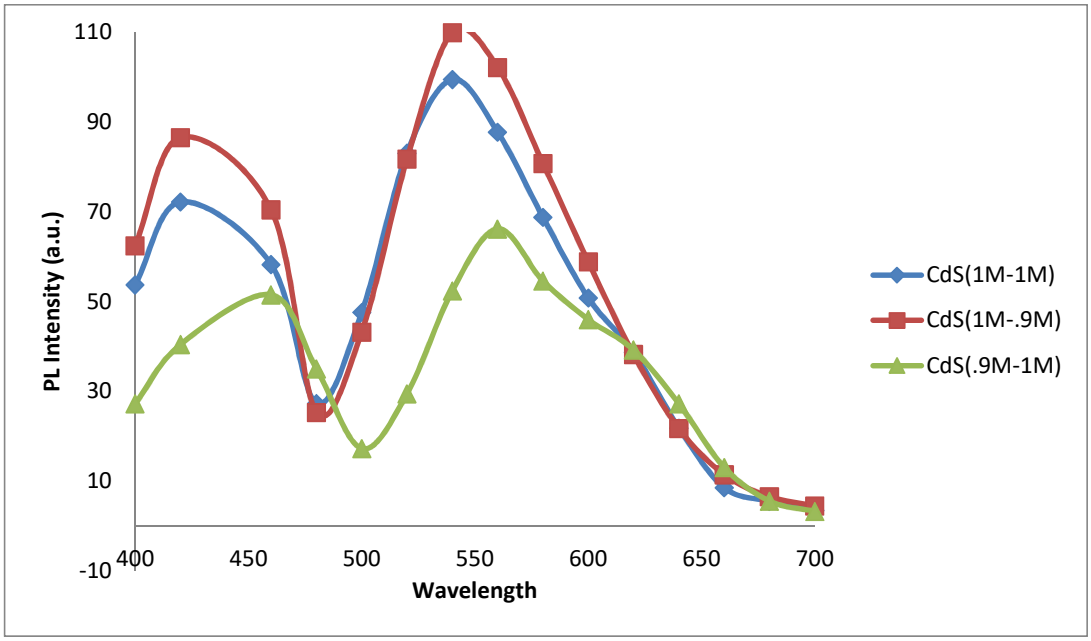

Fig. 3 PL emission spectra for CdS:$CdCl_2$ films with varying concentration of cadmium and sulphur

In fig.3, the PL emission spectra of CdS:$CdCl_2$ films with (2ml $CdCl_2$) and varying concentration of cadmium and sulphur is shown. It can be interpreted from the graph that the intensity of emission spectra is maximum at (Cd_1-$S_{0.9}$) concentration and decreases as the concentration of sulphur increases.

CONCLUSION

Photoluminiscence emission spectra of CdS films with varying concentration of cadmium and sulphur were studied and the PL emission intensity was found to decrease with increasing sulphur concentration. The PL emission intensity was also found to be highest at a particular concentration (2ml) of cadmium chloride.

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