

Synthesis of Silver Doped CdSe Thin Film by Triethanolamine Complex Method at Room Temperature

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Abstract: The silver doped thin film of CdSe has been deposited onto clean glass substrate by using chemical bath deposition technique. CdSe thin film doped with silver showed well defined peak with narrow width. From the XRD pattern, it was observed that the deposited thin film has both hexagonal (002) H and cubic phase (111) C with preferred orientation in the (111) direction. Absorption spectra of this film have been recorded using spectrophotometer. The thickness of the film has been determined by gravimetric method. The energy band gap has been calculated using Tauc's method. It is found that energy band gap of Ag doped CdSe thin film is 1.74 eV.

Keywords: Silver doped CdSe thin film, Energy band gap, TEA, Triethanolamine complex

Introduction

Thin films of II-VI compounds have been widely investigated primarily because of their electronic, optical and optoelectronic applications. II-VI compound semiconductors have a band gap between 1-3 eV, which falls in the visible region and these semiconducting materials are used worldwide in optoelectronic devices. CdSe is one of such compound in this group and its physical properties have been constantly investigated during recent years for both fundamental and practical aims. Its interesting properties make them suitable for many potential applications in a variety of solid state devices such as solar cell, high efficiency thin film transistors, light-emitting diodes, electron-beam pumped lasers and electroluminescent devices *etc*¹⁻³.

In the recent years, major attention has been given to the investigation of optical and electrical properties of CdSe thin films in order to improve the performance of the device and also for finding new application⁴⁻⁸. These properties of CdSe are very sensitive to deposition condition and to the technique used. CdSe thin film has been prepared using a variety of methods including sputtering, spray pyrolysis, electro-deposition and thermal evaporation under high vacuum^{9,10}. In view of this, the present study deals with preparation of silver doped of CdSe thin films by Chemical Bath Deposition (CBD) method at room temperature under basic condition on glass substrates. The CBD is considered to be an easy, simple and low cost method.

Experimental

Cadmium sulphate was purchased from LOBA Chemicals. 30% ammonia solution, silver nitrate and triethanolamine were procured from Merck. All chemicals were used as purchased. Sodium selenosulphite (Na_2SeSO_3) was prepared by heating selenium powder with a solution of sodium sulphite (Na_2SO_3) in water at 90°C with constant stirring.

Deposition of CdSe thin film

A 30 mL of 0.5M cadmium sulphate [CdSO_4] solution was mixed with 1 mL of 0.001M AgNO_3 solution. Then 30% ammonia solution was added to this mixture. A white turbidity appears which was dissolved in excess of ammonia solution. After dissolving the turbidity 30 mL of 0.5M sodium selenosulphite was mixed with the solution. With this 30 mL triethanolamine was mixed with constant stirring. Then the solution was transferred to a 250 mL beaker in which glass plate were suspended horizontally. The system was kept at room temperature without disturbing. The Ag doped thin film of CdSe has been deposited on clean glass plate after 48 h.

Characterization

UV-Vis spectra were recorded by using a U-4100 spectrophotometer (Hitachi). X-ray diffraction (XRD) patterns were recorded on SIEMENS D5005 X-ray diffractometer with $\text{Cu K}\alpha$ radiation. The film thickness varied with deposition time. The thickness of the film was measured by weight difference method assuming the density of the deposited film to be same as that of the bulk¹¹.

Results and Discussion

XRD studies

The CdSe thin film doped with silver showed well defined peak with narrow width indicated increase in crystalline nature (Figure 1). The presence of CdSe and AgSe peaks were confirmed by comparing with JCPDS Card No. 019- 0191 for CdSe and JCPDS Card No. 76-0135 for AgSe. The peaks positions due to CdSe and AgSe were also shown in the XRD pattern. From the XRD pattern, it was observed that the deposited thin film has both hexagonal (002) H and cubic phase (111) C with preferred orientation in the (111) direction.

Optical properties

The absorption spectra of CdSe thin film have been recorded over wavelength range 400 to 850 nm using a U-4100 spectrophotometer at room temperature. Figure 2 shows the absorption spectra of Ag doped CdSe thin film.

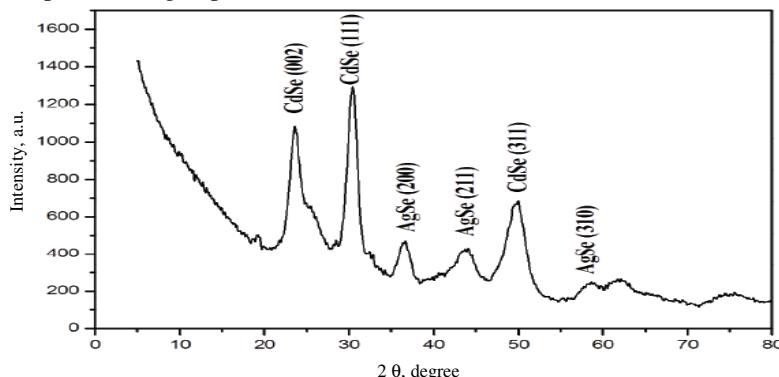


Figure 1. X-Ray diffraction pattern of Ag doped CdSe thin film

It is observed that the absorption coefficient is high at lower wavelength and decreases sharply below a certain wavelength for CdSe thin film. The energy band gap was determined using absorption spectra with the help of Tauc relation¹². Using this relation, a graph is plotted between the square of ($\alpha h\nu$) and $h\nu$ to obtain a straight line (Figure 3). The extrapolation of straight line to $(\alpha h\nu)^2 = 0$ axis gives the value of the band gap. The energy band gap of this sample is 1.74 eV which is smaller than the CdSe thin film prepared without doping and nearly the bulk value. The observation was also supported by the XRD results which indicated the increase in crystalline size as compared to as deposited CdSe thin film.

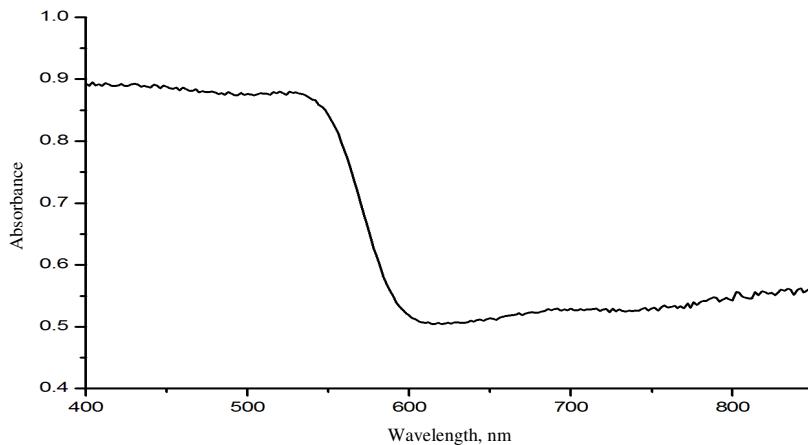


Figure 2. Absorption spectra of Ag doped CdSe thin film

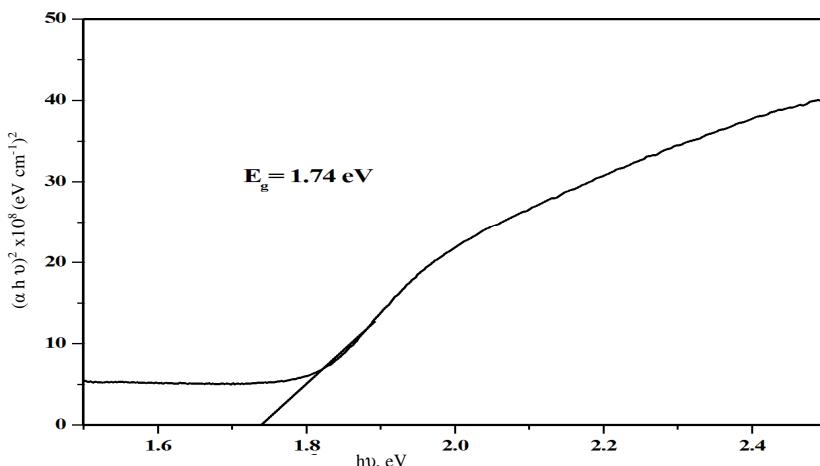


Figure 3. Plot of energy band gap $(\alpha h\nu)^2$ vs. photon energy($h\nu$) of Ag-doped CdSe thin film

Surface morphology and elemental analysis

The EDX and SEM micrographs were shown in Figure 4 and 5. The EDX analysis showed the presence of Ag atom in the deposited CdSe thin film. Also it was seen that due to silver doping the film became nonstoichiometric with Cd:Se ratio 57.04:42.54. The atomic percentage of silver was found to be of 0.42%.

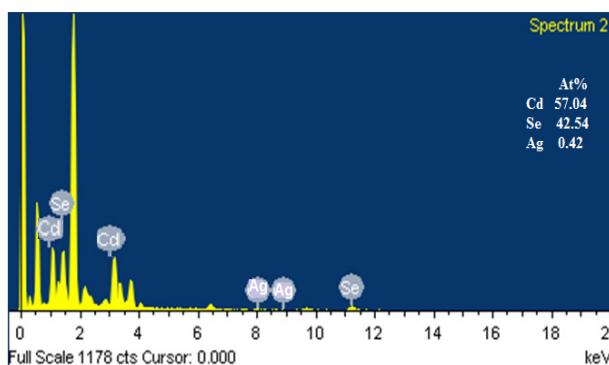


Figure 4. EDX spectrum of Ag doped CdSe thin film

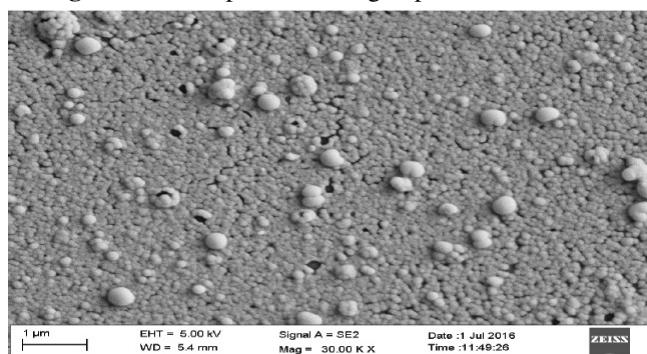


Figure 5. SEM micrograph of Ag doped CdSe thin film

Conclusion

The XRD study of silver doped CdSe thin film at room temperature revealed that the film has cubic phase with (111) plane as the preferred orientation. Doping of silver did not cause any phase changes but improved crystallinity as compared to the undoped room temperature deposited CdSe thin film¹¹. The band gap energy decreased from 2.35 eV to 1.74 eV after silver doping. The presence of silver in the CdSe thin film was confirmed by EDX analysis.

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