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Optical and structural properties of CdS films grown by CSVT technique

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CdS films were grown on glass substrates by the close spaced vapor transport technique (CSVT). We deposited two series of samples: a) with a substrate temperature of 150 °C (group A) and b) with a variation of substrate temperature between 200 °C and 550 °C, at intervals of 50 °C (group B). The samples of group A were annealed in N_2 atmosphere, from 200 °C to 400 °C, at intervals of 50 °C. All samples were measured by X-ray diffraction and optical transmission. X-ray diffraction patterns show that the films had a mixture of cubic and hexagonal structure remained unchanged after the thermal annealing, the main phase present was cubic. The energy band gap shows a thermal stability. The substrate temperature has no effect over the crystal structure and band gap energy. Transmittance and X-ray measurements show a thermal stability of the crystal structure and band gap energy.

1 Introduction

The study of the physical properties of CdS films is a subject of current interest. Having a wide fundamental band gap, they have been used in a large variety of applications such as electronic and optoelectronic devices. Techniques of deposit include molecular beam epitaxy, metal organic vapor phase epitaxy, chemical bath deposition and close spaced vapor transport. The II-VI semiconductors present two crystal structures, cubic and hexagonal. The CdS films have a crystal structure that is cubic, hexagonal or a mixture of both structures [1, 2]. One of the problems presented on the determination of the crystal structure is the superposition of the peaks related with the cubic phase and the hexagonal phase. It is evident when the hexagonal phase began to appear due the additional peaks with respect to the cubic phase, but is not clear the presence of the cubic phase. Is necessary to found the existence of the cubic phase by secondary peaks related only with the cubic structure. The optical and structural properties of CdS films are reported by several authors [3, 4]. In this work the influence of annealing temperature and substrate temperature over the structural and optical properties of the CdS films is reported. The films were deposited by CSVT technique.

2 Experiment details

Two CdS film series (group A and B) were deposited on corning glass 7059 substrates. The source material was CdS powder with 99.999% purity from Cerac. Films were evaporated into and evacuated cham-

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ber with a mechanical and turbomolecular pump at 10^{-6} Torr. The growth system consists of the source and substrate separated by a space, and placed between two graphite blocks. The heating of the source and the substrate usually are made by effect joule. We deposited two series of samples. The first samples (group A) were deposited at substrate temperature 150 °C and source temperature 650 °C. After deposition the CdS films were annealed in nitrogen atmosphere in the range 200 to 550 °C, in intervals of 50 °C. The annealing time is one hour and thirty minutes. For the annealing we use a tubular furnace, which can reach a temperature of 800 °C. The group B samples were deposited with a variation of substrate temperature between 200 °C and 550 °C, at intervals of 50 °C. The time of deposition for the two groups of samples was 15 minutes. The transmittance spectra of the films were obtained in the wavelength range from 400 to 1100 nm using Perkin Elmer UV/VIS Lambda 40 spectrometer. X-ray diffraction patterns of the films were obtained with a D8 Advance Bruker diffractometer using CuKα radiation line, with a slit of 0.2 mm. Data were sequentially collected in the range between 20 and 80° (2θ).

3 Results and discussion

Figure 1 shows transmittance spectra of the as grown and annealed CdS films for group A. In this figure, the curves a) and b) correspond to the same sample, as grown and annealed at 450 °C, respectively. It is observed that a significant change in the optical transmittance does not exist. From transmission spectra, the energy vs. squared absorption coefficient (α^2) values were calculated using relation $\alpha = A(h\nu - E_g)^{1/2}$ where α is the material absorption coefficient, A is the Planck constant, ν is the photon frequency and E_g is the gap energy. Figure 2 shows this procedure for the as-grown sample.

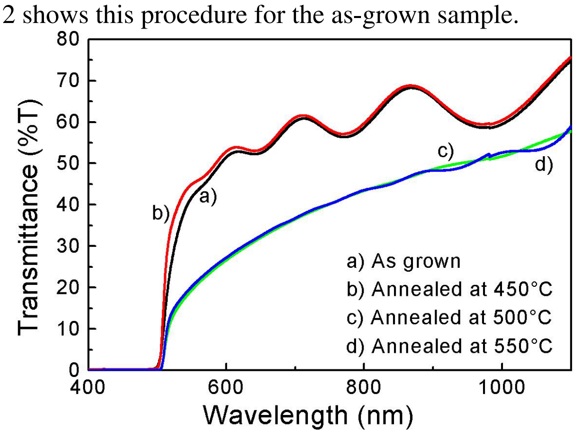

Fig. 1 Transmission spectra of CdS films for group A.

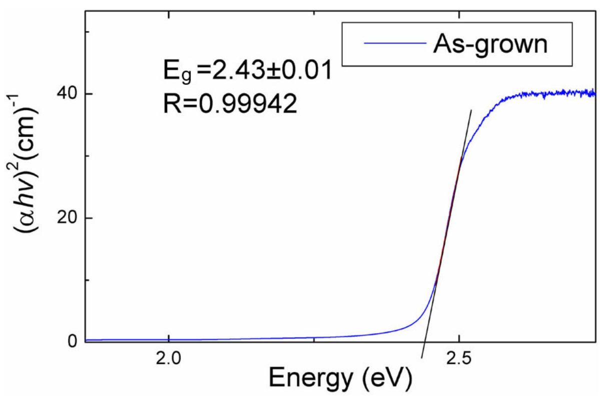

Fig. 2 Curve of $(\alpha h\nu)^2$ vs. $h\nu$ in order to calculate the band gap.

Figure 3 shows the result for band gap energy obtained for the CdS films group A. In these films the energy gap was between 2.43 and 2.44 eV for all samples. It is clear that values stay in the range of cubic phase.

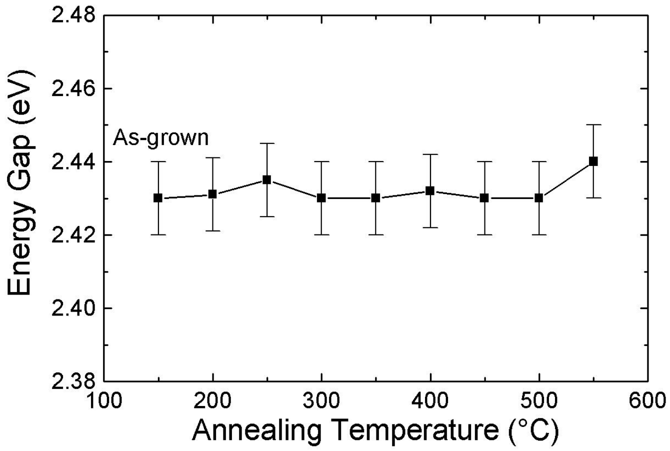

Fig. 3 Energy band gap of as-grown and thermally annealed CdS films.

The spectra transmission of thin films deposited with temperature of substrate presented the same behaviour that films treated thermally. Figure 4 shows the band gap energy for the samples of group B. In this figure variation in the band gap is not observed, this value was between 2.44 and 2.43 eV.

In the bibliography we found a work made by Metin et al. [5], where it is reported that samples deposited by chemical bath the films grew cubical, where the band gap energy reduces its initial value when temperature of treatment is increased. In the samples that we present this change is not observed, and it indicates that the films deposited by CSVT technique are stable in the band gap energy. Diffractogram of CdS as-grown film is represented in Fig. 5, the peaks were indexed using the powder diffraction files (PDF), the numbers were 751545 (hexagonal) and 750581 (cubic). Diffractograms of all thin films with thermal annealing presented the same behaviour at the time of measuring X-ray, the (002), (103) main peaks always appear for all films. Examining the patterns it is concluded that these films treated thermally contain both hexagonal and cubic structure as a mixed.

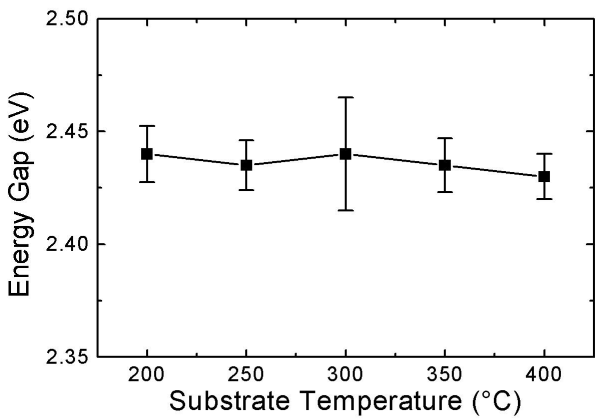

Fig. 4 Energy band gap of samples with substrate temperature.

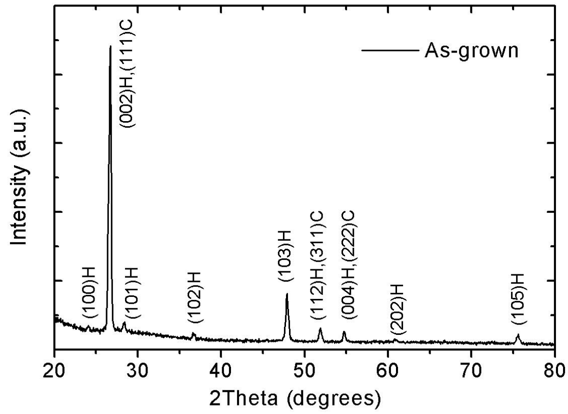

Fig. 5 Typical X-ray diffractogram obtained for CdS thin films deposited by CSVT technique.

4 Conclusions

Two sets of CdS films were grown on glass substrate by CSVT technique. In the group A and B samples, X-ray diffraction patterns of these films indicated that they contain both cubic (zincblende) and hexagonal (wurtzite) structures as a mixture. After thermal annealing in the group A the films do not present change in the structure, for the same group the optical properties of the films no were found affected by thermal annealing. The energy band gap value does not present variation. Taking results of X-ray and optical properties it is demonstrated that deposited films by CSVT are thermally stable.

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