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An Electrical And Structural Studies Of Multilayer Of Cds, Cdte, Cdse And Znse Thin Film Deposited By Thermal Evaporation Method

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Abstract:

Group II-VI materials of periodic table are very suitable for electronics and optoelectronics application. A multilayer thin film is prepared on a chemically cleaned glass substrate by depositing CdS, CdTe, CdSe and ZnSe one after another using Thermal Evaporation Method. The vacuum inside thin film coating unit is maintained at 10^{-6}mbar. The electrical properties of this multilayered thin film have been investigated. The crystal structure and lattice parameter of individual and multilayered film are determined by X-ray diffractograms. The surface morphology of individual film was investigated by SEM analysis.

Keywords: *Thin film, X-ray diffractogram, SEM*

Introduction

Wide – band gap II-VI compounds are applied to optoelectronics devices, especially light-emitting devices in the short-wavelength region of visible light, because of their suitable band gap energies. Wide band gap II-VI semiconductors are in the forefront of materials being studies for blue and green light emitting devices. These compounds have low carrier mobility and relatively high activation energy. CdTe is the widely studied material for thin film solar cells because of its favorable band gap of 1.5 eV. Thin film of Cadmium Sulfide (CdS) is of considerable interest for their efficient use in the fabrication of Solar cell and other optoelectronics devices. Its ideal band gap (2.4eV), high optical absorption and relative ease of deposition have made CdS especially attractive for the preparation of thin film solar cells. The conductivity of undoped CdS films is experimentally controlled by adjusting the rate of deposition and temperature of the substrate. The normal crystal structure of CdS film is hexagonal closed packed (wurtzite).It was also observed that the crystallite size increase with increase of thickness of the film. ZnSe is one of the II-VI semiconductor and it has a direct band gap of 2.8eV, which makes it suitable material for a variety of the optoelectronics application. Thermally evaporated ZnSe thin films deposited on glass substrate in the temperature range 303-623K were polycrystalline in nature, having fcc zincblende structure. ZnSe films deposited by vacuum evaporation have a high resistivity (> $5\times10^{8}\Omega$-cm). CdSe is an important member of II-VI compounds for its direct intrinsic band gap of 1.74eV, which makes it an interesting material for various applications.

The present paper reports Electrical and Structural studies of multilayer of CdTe, CdS, ZnSe and CdSe thin film deposited by thermal evaporation method.

Experimental

Spec pure (99.99%) CdS, ZnSe, CdSe and CdTe in powder form are deposited at different substrate temperature on chemically and ultrasonically cleaned glass substrate with the help of Vico High Vacuum Coating Unit (Vico-16) at a vacuum higher than 10^{-5} Torr, one after another. The source to substrate distance is maintained at 5cm for all the films. The prepared films are annealed in vacuum at different temperature for an hour for electrical characterization. The resistivity of each individual compound and multilayer film is observed from I-V characteristics at different annealing temperature. X-ray diffractrogram of each individual film are taken by using Philips X-ray diffractrometer. Surface morphology of each individual CdTe, CdS, ZnSe and CdSe are investigated by using Scanning Electron Microscope (SEM).

Result And Discussion

Electrical Characterization

The resistivity of each individual CdTe, CdS, ZnSe and CdSe thin films are found using I-V characteristics curve at different annealing temperature (at room temperature, 100°C and 170°C). A graph is plotted between resistivity and annealing temperature, as depicted in Fig1.

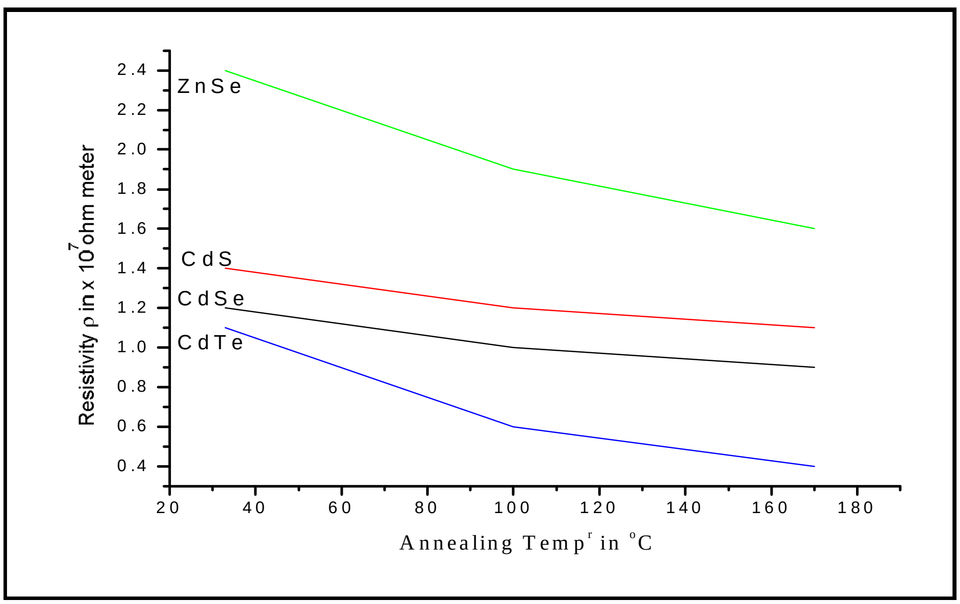

Figure 1: Variation of resistivity with annealing temperature

In the case of multi-layer (CdTe-CdSe-ZnSe-CdS) thin film, annealed at 170°C and exposed at normal light condition the resistance is found as 10.52 KΩ and the dark resistance is found as 10.57 KΩ. On exposing it into sun light for 5 minutes, the multilayer film resistance is found as 9.86 KΩ.

Structural Characterization

The structural analysis of thermally deposited CdTe thin film at substrate temperature 100°C, CdSe thin film at substrate temperature 150°C, ZnSe thin film at substrate temperature 170°C, CdS thin film at substrate temperature 200°C and multilayer thin film of these materials is analyzed by X-ray diffraction technique.

In the case of thermally deposited CdTe thin film at substrate temperature 150°C, the prominent peak in X-ray diffraction pattern is found at 2θ = 25.25° and 45.65°. The film posses fcc zincblende structure when deposited at substrate temperature T_s =423°K. Polycrystalline CdTe film shows the most prominent reflection along [111] direction together with [311] reflection. Figure 2 shows X-ray diffraction pattern of CdTe film deposited at 423°K.

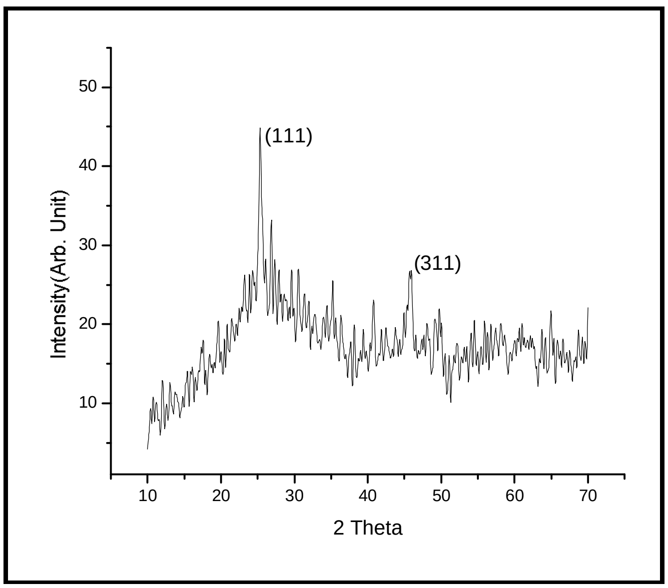

Figure 2: X-ray diffraction pattern of thermally deposited CdTe at T_s =423°K

In the case of thermally deposited CdSe thin film at substrate temperature 160°C, the prominent peak in X-ray diffraction pattern is found at 2θ = 23.75°. Polycrystalline CdSe film shows the most prominent reflection along [111] direction. The film posses cubic wurtzite structure when deposited at T_s =433°K [24] (fig.3)

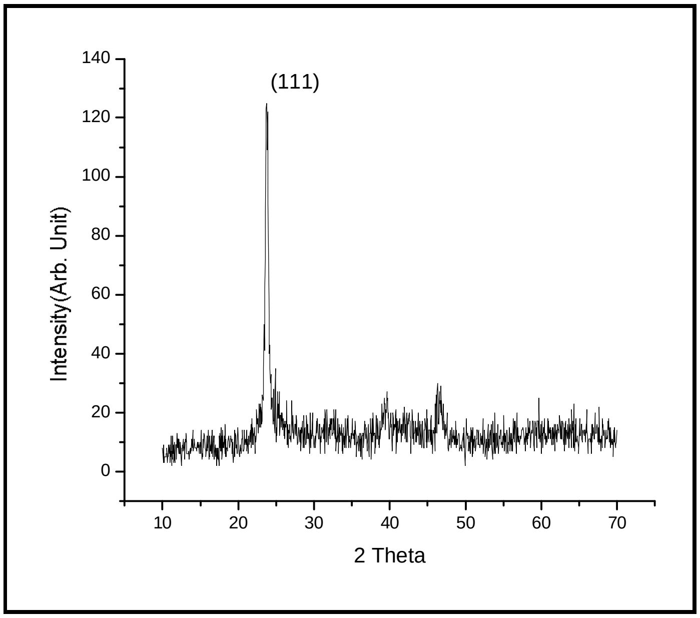

Figure 3: X-ray diffraction pattern of thermally deposited CdSe at T_s =433°K

In the case of thermally deposited ZnSe thin film at substrate temperature 180°C the prominent peak in X-ray diffraction pattern is found at 2θ = 28.6°, which is characterized for the [111] crystallographic planes of the cubic fcc lattice. The film posses cubic wurtzite structure when deposited at T_s =453°K [13] (Fig.4).

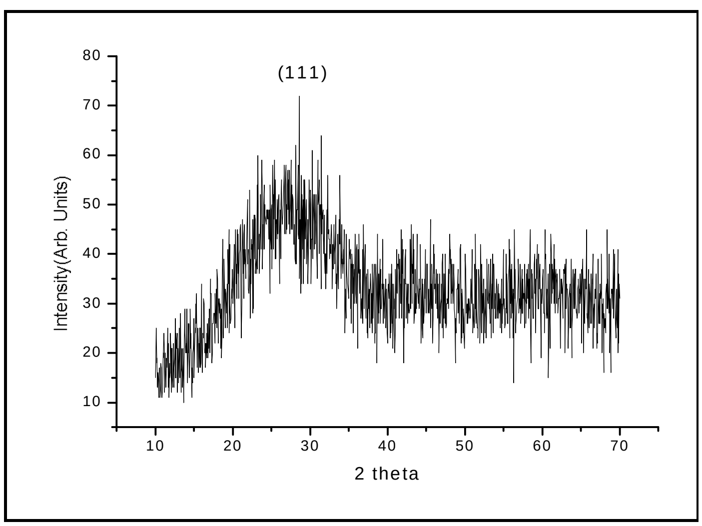

Figure 4: X-ray diffraction pattern of thermally deposited ZnSe at T_s =453°K

The X-ray diffraction pattern of CdTe-CdSe-ZnSe-CdS multilayer thin film is shown in Fig.5. The prominent peak are observed at 2θ = 23.85°, 26.75° and 46°.

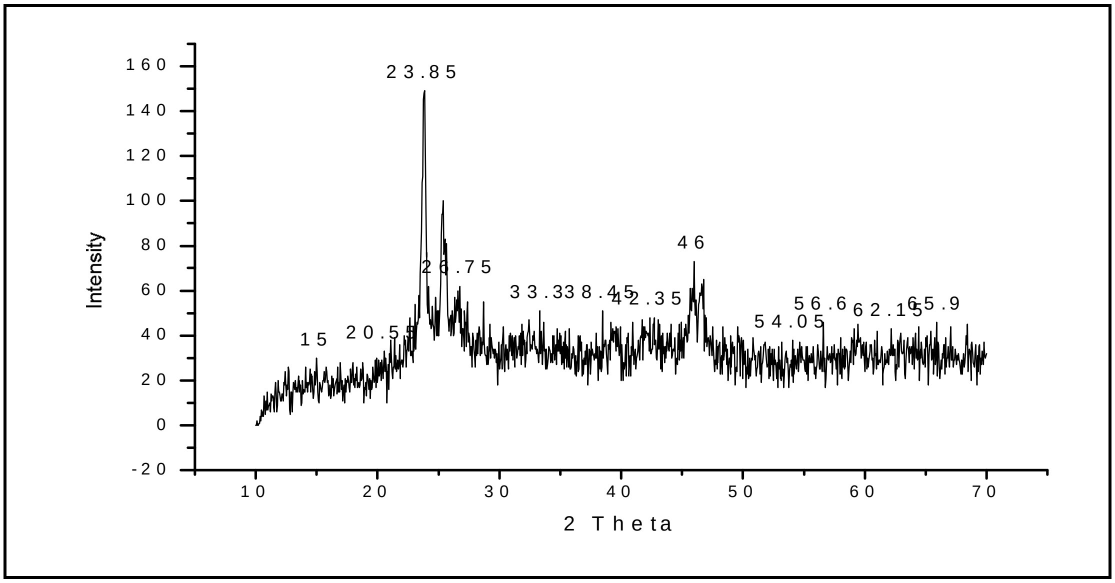

Figure 5: X-ray diffraction pattern of thermally deposited multilayer thin film

The SEM images of thermally deposited CdS film at substrate temperature T_s =473°K is presented in Fig.6. The micrograph shows that CdS film is adherent to the glass substrate, homogeneous and without any crack. They are composed of irregular shaped grain. From the micrograph it can also be conclude that the film is crystalline in nature.

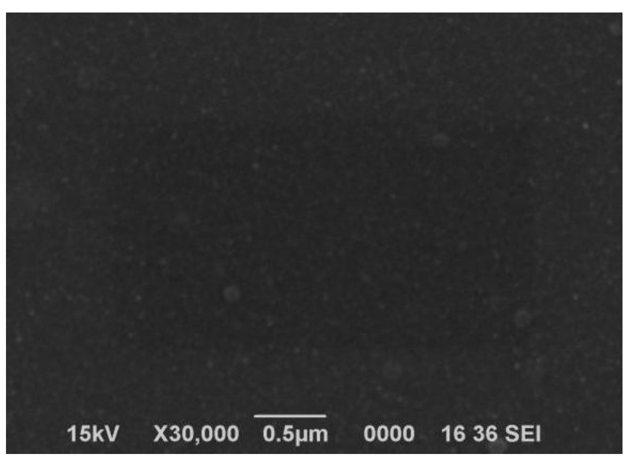

Figure 6: SEM photograph of thermally deposited CdS film
at substrate Temp^r T_S =473°K

The SEM images of thermally deposited CdSe at substrate temperature T_s =433°K is presented in Fig.7. The micrograph shows that the CdSe film is uniform without any crack and peeling. It is also shown from the micrograph that the film is polycrystalline in nature. The film is also composed of irregular shaped grain.

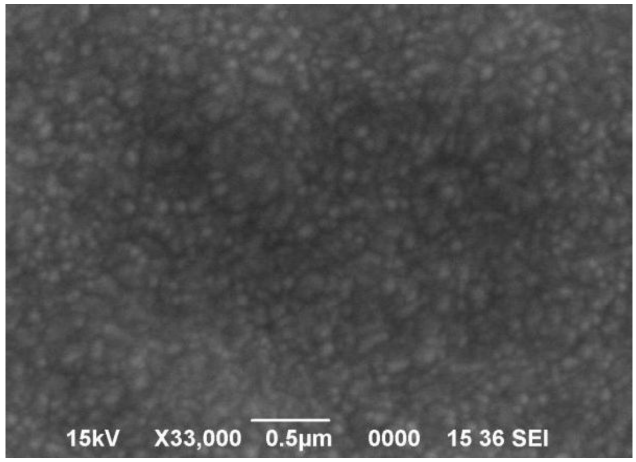

Figure 7: SEM photograph of thermally deposited CdSe film at substrate Temp^r T_s =433°K

The SEM images of CdTe film deposited at substrate temperature T_s =423°K is shown in Fig.8. The particles are uniformly distributed throughout the film with grain size about 0.15µm. The surface of the film is rough and polycrystalline in nature in our investigation.

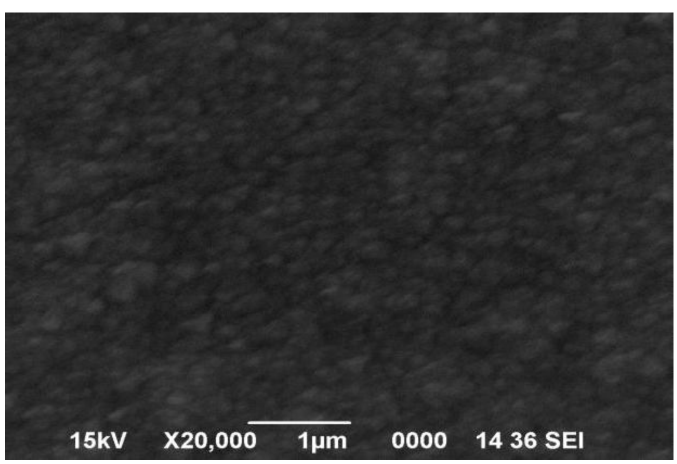

Figure 8: SEM photograph of thermally deposited CdSe film at substrate Temp^r T_s =423°

Conclusion

CdTe-CdSe-ZnSe-CdS films were prepared using thermal evaporation method. It is found that as the annealing temperature of the CdS, CdTe, CdSe and ZnSe film increases the resistivity decreases. On exposing CdS-CdTe-CdSe-ZnSe multilayer thin film in sun light the resistance is abruptly changed, so these materials can be used to form multilayer solar cell. At T_S = 423°K. T_S = 453°K, and T_S = 473°K the CdTe, CdSe and CdS respectively shows the polycrystalline nature. The morphology of the films as studied by SEM is supported by XRD results. This type of result can certainly help in the multilayer device fabrication.

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