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Photoluminacence Studies on $Ag_2Se_{0.2}Te_{0.8}$ Thin Films

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Abstract: Semiconducting silver selenide telluride ($Ag_2Se_{0.2}Te_{0.8}$) ternary thin films of different thickness were vacuum deposited on well cleaned glass substrate at a pressure of 2 $x10^{-5}$ mbar and at a deposition rate of 0.2 nm/sec at room temperature. X-ray diffraction studies revealed that thin films of lower thickness were amorphous and at higher thickness they were polycrystalline in nature with orthorhombic structure. The film crystallinity increased with increase of thickness. The PL spectra of $Ag_2Se_{0.2}Te_{0.8}$ bulk and thin films revealed that there is a strong emission band at 751 nm and it is independent of thickness. The topography of the thin film was studied using atomic force microscopy.
Keywords: $Ag_2Se_{0.2}Te_{0.8}$, Thin films, Thermal evaporation, XRD, AFM, Photoluminescence (PL) Spectroscopy.

1. Introduction and Experimental

Ternary and binary silver chalcogenides are I-VI semiconductor compound with wide applications in optoelectronic devices, IR detectors, optical coatings, photoconductive devices, photovoltaic cells etc. [1]. The optical properties of silver chalcogenide thin films were studied using transmittance [2]. Pandiaraman et al [3-4] has reported a changing emission wavelength (red shift) for the thermal evaporated Ag_2Te films in the thickness range 50 to 150 nm and single wavelength emission for Ag_2Se films in the same thickness range. In literature, optical properties of silver chalcogenide thin films are studied widely by transmittance analysis, but only very few works are available on the photoluminescence studies on ternary silver chalcogenide thin films. No studies on $Ag_2Se_{0.2}Te_{0.8}$ films on PL properties are reported. The present study is the determination of the optical constants of thin films of $Ag_2Se_{0.2}Te_{0.8}$ of various thicknesses using PL method in the wavelength range from 310 nm to 800 nm.

Silver selenide telluride ($Ag_2Se_{0.2}Te_{0.8}$) alloy was prepared from a stoichiometric mixture of spectro scopically pure (99.999%) silver, selenium and tellurium. The formation of the bulk $Ag_2Se_{0.2}Te_{0.8}$ has been confirmed by X-ray powder diffraction at room temperature. $Ag_2Se_{0.2}Te_{0.8}$ thin films of thickness 50nm - 320nm were deposited on well cleaned glass substrates of dimensions 0.03x0.02m kept at room temperature

at a pressure of $2x10^{-5}$ mbar and at a deposition rate of 0.2 nm/sec. A digital quartz crystal thickness monitor was used to measure and monitor the thickness of films and their deposition rate. The characterization $Ag_2Se_{0.2}Te_{0.8}$ thin films were carried out using phtoluminence spectrum and X-ray diffraction. The powder X-ray diffraction were recorded in the 2θ range of 10º to 90º using a powder X-ray diffractrometer with Cu-k_α radiation (λ=0.15406nm). The PL spectrum of $Ag_2Se_{0.2}Te_{0.8}$ bulk and films were recorded in the wavelength range of 310 to 800 nm with an excited wavelength 499nm at room temperature and AFM was also recorded.

2. Results and Discussion

2.1 Structural

From Figure (1) it is clear that for films grown with thickness 50 nm, the XRD shows that the films are amorphous. However at 95 nm and 230 nm thicknesses the characteristic peaks tend to appear distinctly with orthorhombic phase. It is observed that the films had prominent and intense peaks at two theta values 29.86, 31.66, 35.36, 38.82, 42.32 and 43.16 degrees.and their planes corresponding to [102], [120], [013], [122], [201] and [032] respectively. These peaks with reduced intensity coincide with the peaks reported for $Ag_2Se_{.3}Te_{.7}$ system in Pearson's XRD standard [5]. By using the Debye-Scherrer's formula [6], the average grain size of $Ag_2Se_{0.2}Te_{0.8}$ is found to be 40 nm.

2.2. Analysis of Photoluminescence Studies

The PL spectra of $Ag_2Se_{0.2}Te_{0.8}$ bulk and thin films of thickness between 90 nm - 320 nm is shown in figure 2. From it is observed that all the spectra revealed an emission peak at 751 nm. The corresponding energy is about 1.65 eV. The intensity of the peak increases with increase in thickness from 140 to 319 and for bulk it is in the order of 1000. It is interesting to note that the emission wavelength does not change with variation in thickness. The FWHM, however, changes denoting the approaching of bulk value with increasing thickness.

The band gap of $Ag_2Se_{0.2}Te_{0.8}$ thin films has varied as revealed in the UV-Vis-NIR studies [2] but these signatures are not present in the emission spectra. This may be due to the screening of certain emissions by dominant species. Here the quantum size effect or solid solution effect is not revealed. This may be due to the dominance of certain emissions independent of thickness in the thickness range studied. As far as emission property is concerned Ag_2Se plays a significant role in the $Ag_2Se_{0.2}Te_{0.8}$ system [3-4]. The presence of grains whose size is in the order of thickness of the films may dominate in the emission intensity leading to single energy emission independent of thickness. The strong peak is attributed to the recombination of free excitons through exciton-exciton collision process [7] due to the 1.65eV (751nm) direct band gap transition of $Ag_2Se_{0.2}Te_{0.8}$, and, therefore indicates good crystallinity of the $Ag_2Se_{0.2}Te_{0.8}$ samples synthesized via thermal evaporation.

Figure 3 shows the typical AFM spectra obtained for film of thickness 95, 150 and 230 nm. The micrographs indicate the modification of morphology and grain size during increase of thickness of this system. The typical grain size around 40 nm is measured for a film of thickness 150 nm. The uniform distributions revealed by the AFM micrographs testify the higher quality of films at higher thicknesses.

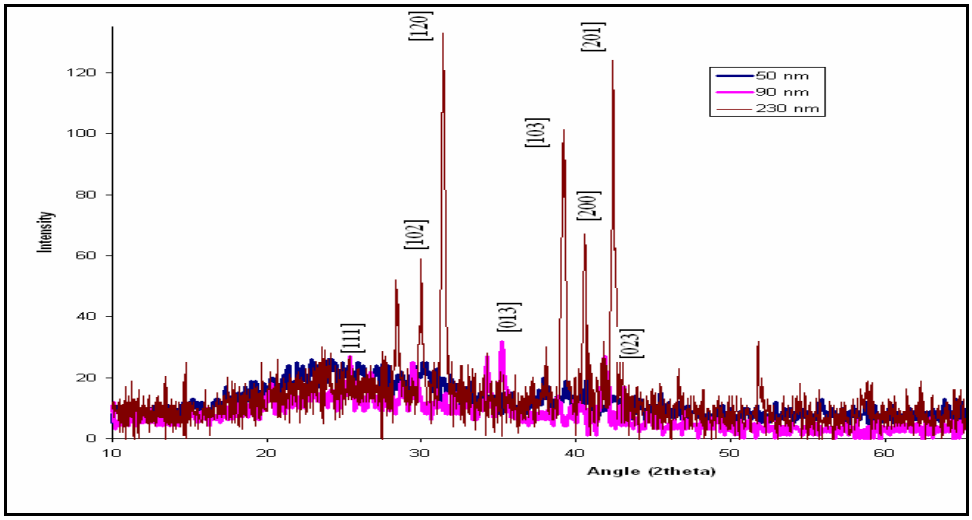


Fig.1. XRD pattern for $Ag_2Se_{0.2}Te_{0.8}$ thin films of thickness 50 nm, 95 nm and 230 nm

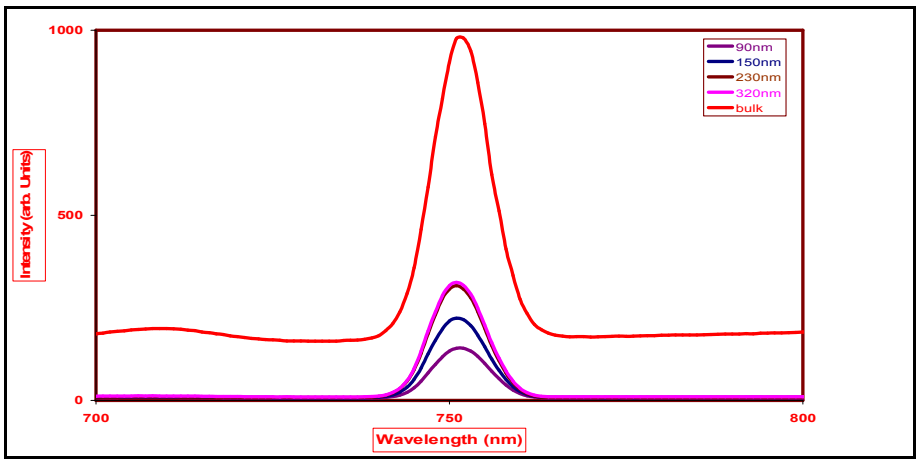
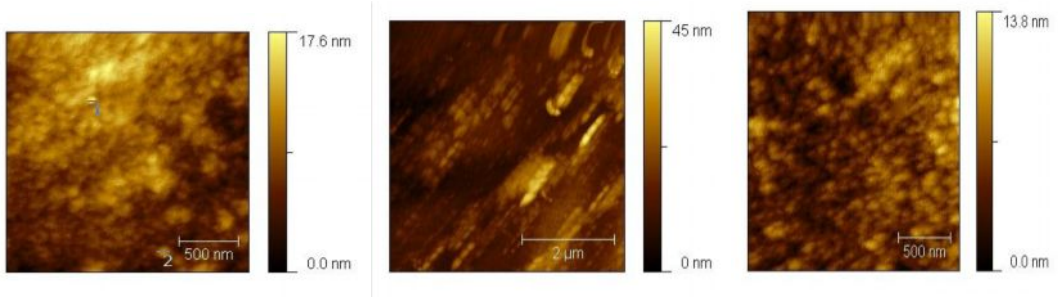


Fig.2.PL spectra of $Ag_2Se_{0.2}Te_{0.8}$ bulk and thin films of thickness



95nm 150nm 230nm

Figure 3 The AFM 2D micrographs obtained for $Ag_2Se_{0.2}Te_{0.8}$ films of various thicknesses.

3. References

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