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Chemical Bath Deposition of ZnSe Thin Films: SEM and XRD Characterization

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Abstract: ZnSe thin films were deposited on indium tin oxide substrates using the chemical bath deposition technique. The films were obtained in a chemical bath at temperatures of 40, 60 and 80 °C. The structure and surface morphology of the films were studied using X-ray diffraction and scanning electron microscopy, respectively. The X-ray diffraction analysis could be indexed as from the structure of ZnSe. Also, the XRD patterns showed that the most intense peak corresponded to (111) plane. The surface morphology of the films was found to depend chiefly on bath temperature.

Key words: Chemical bath deposition · thin films · Semiconductor · Zinc selenide · Bath temperature

INTRODUCTION

Solar cells are a semiconductor device that converts sunlight into electricity. In recent years, there has been considerable interest in use of thin films in solar cells. A variety of techniques such as chemical bath deposition [1], plasma-enhanced chemical vapour deposition [2], reactive sputter deposition [3], molecular beam epitaxy [4], vacuum evaporation [5], pulsed laser deposition [6], successive ionic layer adsorption and reaction method [7], electrodeposition [8], thermal evaporation [9] and cyclic voltammetry method [10] have been used for deposition of thin films. Among various other methods, the chemical bath deposition method is found to be a cheap and simple way to deposit large area metal chalcogenide thin films such as In_2S_3 [11], CdSe [12], Sb_2S_3 [13], PbS [14], $ZnIn_2Se_4$ [15], $Pb_{1-x}Fe_xS$ [16], $CdS_{1-x}Se_x$ [17], $Zn_xCd_{1-x}S$ [18] and CdZnS [19].

In this work, we investigate the influence of the bath temperature (40-80°C) on the chemical bath deposited ZnSe films. The films have been characterized by X-ray diffraction and scanning electron microscopy for the structural and morphological study, respectively.

Experimental: Indium tin oxide (ITO) glass slides were used as the substrate during the deposition process. The substrates were first cleaned in ethanol then ultrasonically washed with distilled water. Finally, substrates were dried in an oven at 90 °C. Zinc sulphate, sodium selenite, tartaric acid and hydrochloric acid of analytical reagent grade were used as received. Deionized water (Alpha-Q Millipore) with a resistivity of 18.4 MΩcm was used as solvent. Aqueous solutions of zinc sulphate, sodium selenite and tartaric acid were separately prepared before experiment. 25 mL of zinc sulphate (0.15 M) and 25 mL of tartaric acid (0.15 M) were mixed in a beaker. The tartaric acid was served as complexing agent to chelate with Zn^{2+} to obtain Zn-tartaric complex solution. Then, 25 mL of sodium selenite (0.15 M) was added and the pH of the solution was adjusted to 3 by addition of hydrochloric acid using pH meter. Substrates were immersed vertically in the solution. Then, the deposition was conducted at various bath temperatures (40, 60 and 80 °C) in order to investigate the influence of bath temperature on the properties of films. The beaker was not stirred during the thin films deposition. After completion of films deposition (120 min), the deposited films were washed with distilled water and dried in air for further characterization.

X-ray diffraction analysis was carried out, using a Philips PM 11730 diffractometer for the 2θ ranging from 20° to 60° with CuK_α (λ=1.5418 Å) radiation. Surface morphology was studied by JEOL (JSM-6400) scanning electron microscopy operating at an accelerating voltage of 20 kV under 2000X magnification.

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Table 1: Comparison of the theoretical *d*-spacing (Å) data for ZnSe and experimentally observed values from the samples deposited at different chemical bath temperatures

Bath temperature (°C)	*hkl*	d-spacing	
		Obtained value	Standard JCPDS data
40	111	3.20	3.28
60	111	3.21	
	311	1.75	3.28
		1.72	
80	111	3.21	3.28
	220	1.97	2.00
	311	1.75	1.72

RESULTS AND DISCUSSION

Figure 1 shows the X-ray diffraction (XRD) patterns of the films deposited at different bath temperatures ranging from 40 °C to 80 °C. There is only single peak corresponding to (111) plane is obtained for the films prepared at lower bath temperature such as 40 °C. However, as the bath temperature is increased to 60 and 80 °C, the number of ZnSe peak increased to two and three peaks, respectively. These peaks are in a good agreement with the JCPDS (Reference code: 00-002-0479)[20] data for ZnSe as shown in Table 1. On the other hand, we observed that as the bath temperature is increased from 40 to 80 °C, the intensity of the peak corresponding to (111) plane increased. The (111) plane seems dominant at this stage of experiment. The results obtained from X-ray diffraction analysis reveal some interesting nature of the ZnSe materials.

Figure 2 shows the scanning electron microscopy (SEM) micrographs for the films deposited at various bath temperatures. The SEM micrograph of the films deposited at higher bath temperature such as 80°C is shown in Figure 2a.

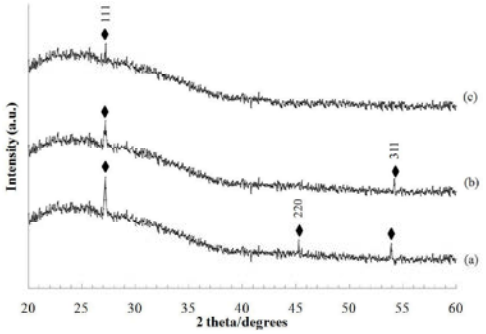

Fig. 1: X-ray diffraction patterns of ZnSe films deposited at different chemical bath temperatures. [(a) 80 °C (b) 60 °C (c) 40 °C] [ZnSe♦]

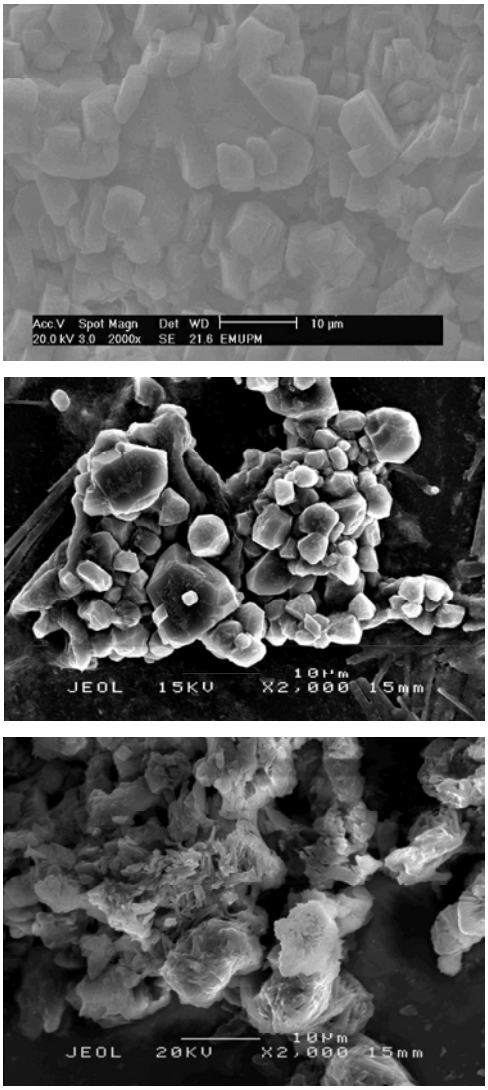

Fig. 2: SEM micrographs of ZnSe films deposited at different chemical bath temperatures. [(a) 80 °C (b) 60 °C (c) 40 °C]

The surface of the indium tin oxide glass substrate is covered completely as can be seen in figure. No pinholes can be observed for these films. The films show more grain formation and well defined particle edges. However, there seems a slight decrease in the number of grains for the films deposited at 40 and 60 °C. The surface of the substrate is not covered completely at these bath temperatures. The grain formation is observed as irregular agglomeration with the grain sizes completely different from each other (2-5 µm). These observations suggest an incomplete nucleation step with irregular growth rate of the grains.

CONCLUSION

ZnSe films have been chemically deposited on indium tin oxide substrates from a chemical bath consisted of zinc sulphate, sodium selenite and tartaric acid solutions. The SEM micrograph shows the surface of the indium tin oxide glass substrate was covered completely for the films deposited at 80 °C. Also, the number of ZnSe peaks increased to three peaks at this bath temperature, which indicated more favorable conditions for the formation of ZnSe films.

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