Structural and Optical Properties of Sn doped ZnS Thin Films Synthesized by Chemical Bath Deposition Method

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Abstract

Transparent and well adhered Sn doped ZnS films have been synthesized on glass substrates by the chemical bath deposition (CBD) process. An analysis derived from XRD pattern revealed the presence of cubic structure in the Sn:ZnS thin films, with an impurity phase corresponding to the insertion of Sn ions in interstitial sites or defects of the lattice. The atomic ratio of Sn in ZnS films have been confirmed by EDX spectra. Changes in the optical properties of the films have been observed due to incorporation of Sn by UV-Vis-Nir Spectrophotometer analysis.

Keywords: CBD, Sn:ZnS thin films, XRD, EDX, UV-Vis-Nir Spectrophotometer

1.Introduction

ZnS is an important semiconductor compound of the II–VI group with excellent physical properties and wide band-gap energy of 3.54 eV at 300 K. It has a high refractive index (2.35 at 632 nm)[1]. The material has huge potential application in both bulk and thin film form in various photovoltaic and optoelectronic devices [3] The chemical bath deposition (CBD) method has been conveniently used for the doping of several compounds. However, there are few reports for the specific deposition of Sn doped ZnS films by this method. Sn doped ZnS films by the CBD method with alkaline reaction solutions was reported in Ref. [2].

2. Experimental Technique

Zinc sulfide thin films have been deposited on soda lime glass substrates. The chemical bath containing zinc chloride [$ZnCl_2$: 0.2 M], thiourea [$(CSNH_2)_2$: 0.2 M],ammonia solution [NH_4OH] and stannous chloride[$SnCl_2.2H_2O$: 0.1M].30 ml of $ZnCl_2$ solution was putted firstly and stirred with a magnetic stirrer, then 30 ml of thiourea was added and stirred for several minutes. There after ammonium hydroxide solution was added to the mixture, under stirring, to get a clear and homogeneous solution, and finally 20 ml of $SnCl_2.2H_2O$ was added for Sn doped films. The PH of the solution was 9-10. Glass substrates were then placed vertically in the beaker. The substrates were kept in the solution at 75°C for 30 minutes under continuous stirring.

3. Results and Discussion

Structural Properties

Fig. 1 shows the XRD pattern of five samples undoped ZnS, 20% Sn:ZnS, 25% Sn:ZnS , 30% Sn:ZnS , 35% Sn:ZnS thin films respectively for 2θ values in the range of 20^0 to 70^0. Good crystallinity with (111) and (222) peaks at 27.9^0, 57.7^0 ensure the zinc blende (cubic) structure of ZnS(JCPDS No. 05-0566). Another peak of SnS with (102) plane at 42.4^0 is present here (JCPDS No. 73-1859). This has been found because may be some Sn molecule have produced SnS and replaced as a single crystal on the film.Crystallite size, dislocation density and microstrain have been calculated using Scherrer's formula(Table 1).The EDX spectra of five samples have been shown in Fig. 2 (a-e). From this spectra it has been observed that the atomic(%) of Sn L according to doping ratio for Undoped ZnS : 0.00%, 20%Sn:ZnS:21.60%, 25%Sn:ZnS: 22.11%, 30% Sn:ZnS : 29.34%, 35% Sn:ZnS : 35.75% respectively.

Optical Properties

The transmittance values for all samples are lower in the region of 300 to 370 nm (UV region) shown in Fig. 3(a). Transmittance gets much higher value in the region of 380 nm to 750 nm (visible region) and then fall from the region of 750 nm to 1000 nm. After that a slightly high response again in the region of 1000 nm to 2500 nm (infrared region).

The optical band gap have been calculated for five samples separately and shown in Fig. 3(b-f).Band gap are increasing up to 30% Sn doping. For 35% Sn:ZnS band gap has fallen to 3.52 eV which is below undoped ZnS thin film.

4. Conclusion

ZnS and Sn:ZnS thin films have been deposited successfully using Chemical Bath Deposition (CBD) technique.The structural and optical results reveal that Sn doped ZnS thin film would be an effective material for buffer layer in thin film solar cell as their increasing band gap than undoped ZnS.

References

[1] A.H. Eid et al ; Journal of Applied Sciences Research, 6(6): 777-784, 2010 © 2010, INSInet Publication
[2] Ayan Mukherjeea, et al ; Materials Research. DOI: http://dx.doi.org/10.1590/1980-5373-MR-2016-0628
[3] Shinde MS et al; Indian Journal of Pure & Applied Physics. 2011;49(11):765-768.

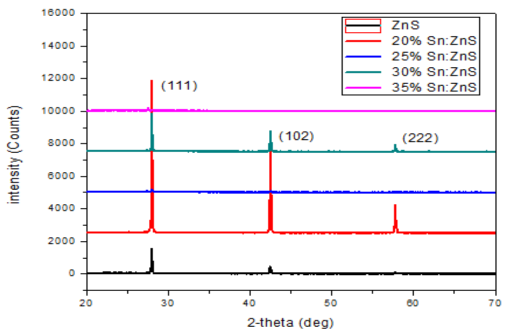


Fig.1: XRD pattern for different of ZnS and Sn:ZnS Sn:ZnS thin films.

Sample Name	Strong Peak	FWHM (deg)	2θ	Crystallite Size, D(nm)	Strain, ε	Dislocation Density, δ (m^{-2})
Undoped ZnS	(111)	0.073	27.9^0	112.098	3.09×10^{-4}	7.95888×10^{13}
20% Sn:ZnS	(111)	0.060	27.9^0	136.378	2.54×10^{-4}	5.37661×10^{13}
25% Sn:ZnS	(111)	0.047	27.9^0	174.100	2.05×10^{-4}	3.2991×10^{13}
30% Sn:ZnS	(111)	0.056	27.9^0	146.119	2.44×10^{-4}	4.68363×10^{13}
35% Sn:ZnS	(111)	0.065	27.5^0	122.207	2.84×10^{-4}	6.69587×10^{13}

Table 1: Crystallite size, Dislocation Density and Strain

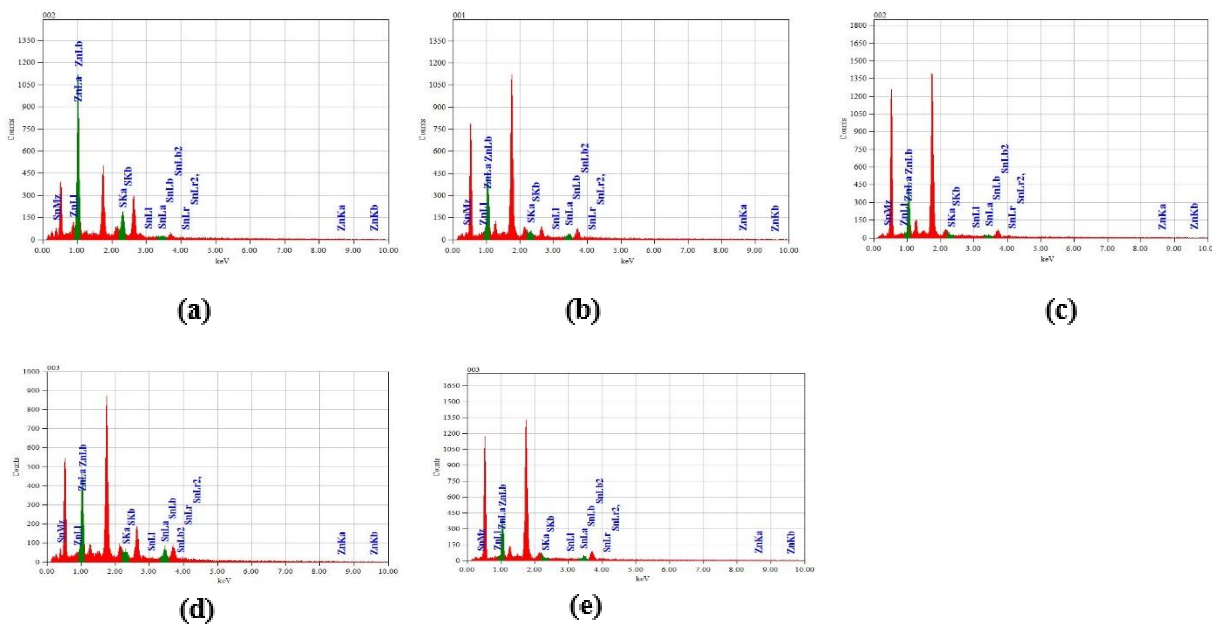
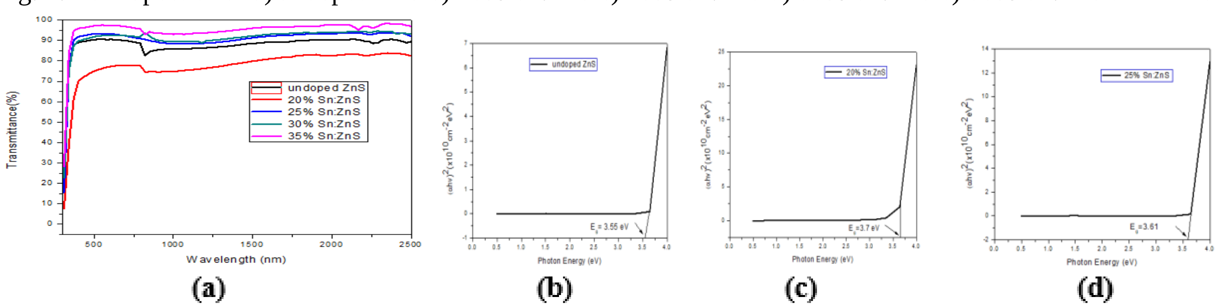


Fig. 2: EdX Spectra for a)Undoped ZnS b) 20% Sn:ZnS c) 25% Sn:ZnS d) 30% Sn:ZnS e) 35% Sn:ZnS thin films



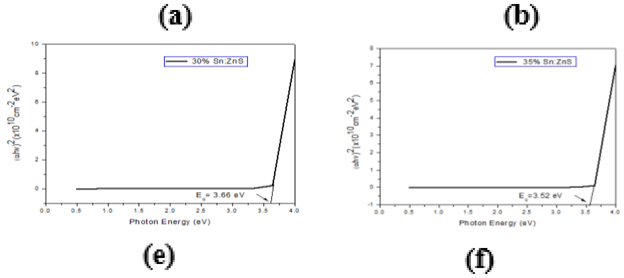


Fig.3: a) Transmittance (%) Spectra for undoped and Sn:ZnS thin films; optical band gap for b)undoped Zns c) 20% Sn:ZnS d) 25% Sn:ZnS e) 30% Sn:ZnS f) 35% Sn:ZnS thin films