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Archives of Physics Research, 2013, 4 (3):7-11
(http://scholarsresearchlibrary.com/archive.html)

Archives of Physics Research
Scholars Research Library
ISSN : 0976-0970
CODEN (USA): APRRC7

Optical study of ZnS Solid thin film prepared by spray pyrolysis technique

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ABSTRACT

Thin film of ZnS is prepared using aqueous solution of zinc acetate & thiourea on the clean glass substrate by using spray pyrolysis method at 350^{0}c. The ZnS film grown is uniform and adherent with high transmittance in the visible region. The optical properties of ZnS thin film are studied using UV- VIS spectrophotometer. Optical absorption measurement in the visible region (380 – 1000nm) were carried out and on the bases of absorption the optical energy band gap is calculated.

Keyword: ZnS thin film, optical properties, spray pyrolysis, solid-state, Spectrophotometer

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INTRODUCTION

Metallic and non metallic compounds are studied in thin films form [1-5]. The element from group II – VI are explore in determination of thin film devices. Several method for depositing ZnS thin film, are available in literature such as vaccum evaporation, sputtering, chemical bath deposition, spray pyrolysis. Absorption edge in ZnS films lies in the UV region. However, In this paper we studied the optical properties of ZnS film prepared by spray pyrolysis method by using UV- VIS Spectrophotometer from its absorption spectrum in the 380 – 1000 nm optical range.

MATERIALS AND METHODS

Biological glass slide is used as a substrate to deposited ZnS thin film, which was cleaned in conc. Nitrate acid, alcohol and distilled water for several times to remove the impurities on the surface of substrate before the deposition.

Aqueous solution of Zinc Acetate (MW 219.49 gm/cc) (0.01N) and Thiourea (MW 76.12 gm/cc) (0.01N) were mixed together in proper ratio. This solution is stirrered for 1 hour on electronic stirrer.

The weight of the glass substrate before spraying & after spraying was measured using electron unipan microbalance of accuracy 10^{-4} gm.

The clean glass substrate is arranged on spray pyrolysis setup consists at hot metal plate on heating coil with controlled variac. This glass substrate is heated at constant suitable temperature (350^{0}c) now the solution sprayed on the glass slide to form ZnS thin film on the glass substrate. After the solution finished the glass substrate was allow to cool up to room temperature. The nature of the deposited thin film was analysis by XRD pattern(fig. 3). The nature of ZnS film is polycrystalline. The zns thin film is then used to study optical properties and energy gap measurement.

After preparation the ZnS thin films by spray pyrolysis technique the optical absorption & percentage transmission were measured by UV – VIS Spectrophotometer Elco (SL- 159) in the wavelength range 380 – 1000 nm.

To determine the band gap of the thin film the equation of stern [6] was used.

$$A = \frac{\left(K(h\nu - Eg)^{\frac{n}{2}}\right)}{h\nu}$$
$$A.h\nu = \left(K(h\nu - Eg)^{\frac{n}{2}}\right)$$
$$(A.h\nu)^2 = K(h\nu - Eg)^n$$

Where ν = the frequency of radiation, h = Planck's constant, K = constant, n =1 for direct band gap material.

A plot of $(A.h\nu)^2$ vs hν is plotted (fig. 2). The absorption coefficient $(A.h\nu)^2$ is linear function of frequency ν. This indicates that the transition is direct transition in ZnS material. Hence, a straight line tangent to a linear portion of$(A.h\nu)^2$ cut hν axis which gives the band gap energy of grown ZnS film in the present study.

RESULTS AND DISCUSSION

Optical absorption & % transmission of the deposited ZnS thin film were obtained in the visible region (380 – 1000nm) on ELCO – SL -159 Spectrophotometer (Table 1)

Transmittance and absorption as function of wavelength are shown in figure 1 which shows high transmission in the visible wavelength and lower transmission at shorter wavelength (UV).

In figure 2 the plot of $(Ah\nu)^2$ verse photon energy (hν) for ZnS thin film shows strong absorption edge in the UV region, at which the curve become straight line extrapolation (linear function of frequency(hν)).

TABLE 1

λ nm	hν eV	A	%T	(Ahν)2
380	3.233	0.052	88.5	0.028261
386	3.183	0.044	90.2	0.01961
392	3.134	0.037	91.6	0.013446
398	3.087	0.037	91.7	0.013043
404	3.041	0.034	92.3	0.010689
410	2.996	0.034	92.3	0.010379
416	2.953	0.037	91.7	0.011939
422	2.911	0.037	91.8	0.011602
428	2.870	0.038	91.5	0.011897
434	2.831	0.037	91.8	0.010969
440	2.792	0.037	91.8	0.010672
446	2.754	0.035	92.1	0.009294
452	2.718	0.037	91.6	0.010113
458	2.682	0.036	91.9	0.009324
464	2.648	0.035	92.2	0.008587
470	2.614	0.031	92.9	0.006566
476	2.581	0.033	92.6	0.007254
482	2.549	0.034	92.3	0.00751
488	2.517	0.034	92.4	0.007326
494	2.487	0.031	92.9	0.005943
500	2.457	0.033	92.6	0.006574
506	2.428	0.031	93	0.005665
512	2.399	0.03	93.3	0.005181
518	2.372	0.029	93.4	0.00473
524	2.344	0.028	93.6	0.004309
530	2.318	0.03	93.2	0.004835
536	2.292	0.029	93	0.004418
542	2.267	0.032	92.9	0.005261
548	2.242	0.031	93	0.00483
554	2.218	0.029	93.5	0.004135
560	2.194	0.028	93.7	0.003773
566	2.170	0.027	93.9	0.003434
572	2.148	0.026	94	0.003118
578	2.125	0.027	93.8	0.003293
584	2.104	0.027	93.8	0.003226

590	2.082	0.026	94	0.002931
596	2.061	0.027	93.9	0.003097
602	2.041	0.03	93.2	0.003748
608	2.021	0.022	95	0.001976
614	2.001	0.027	94	0.002918
620	1.981	0.022	94.9	0.0019
626	1.962	0.032	92.7	0.003944
632	1.944	0.033	92.6	0.004115
638	1.926	0.029	93.3	0.003118
644	1.908	0.026	94	0.00246
650	1.890	0.025	94.3	0.002233
656	1.873	0.021	95.1	0.001547
662	1.856	0.026	94.1	0.002328
668	1.839	0.025	98.9	0.002114
674	1.823	0.021	94.2	0.001465
680	1.807	0.023	94.8	0.001727
686	1.791	0.024	94.6	0.001847
692	1.775	0.024	94.6	0.001815
698	1.760	0.025	94.3	0.001936
704	1.745	0.027	93.9	0.00222
710	1.730	0.027	93.9	0.002183
716	1.716	0.028	93.7	0.002308
722	1.702	0.025	94.3	0.001809
728	1.688	0.026	94	0.001925
734	1.674	0.025	94.3	0.001751
740	1.660	0.025	94.4	0.001723
746	1.647	0.025	94.3	0.001695
752	1.634	0.026	94	0.001804
758	1.621	0.025	94.3	0.001642
764	1.608	0.024	94.6	0.001489
770	1.595	0.024	94.5	0.001466
776	1.583	0.025	94.4	0.001566
782	1.571	0.024	94.6	0.001422
788	1.559	0.024	94.6	0.0014
794	1.547	0.023	94.7	0.001266
800	1.536	0.023	94.8	0.001247
806	1.524	0.026	94.1	0.00157
812	1.513	0.025	94.3	0.001431
818	1.502	0.024	94.5	0.001299
824	1.491	0.024	94.4	0.00128
830	1.480	0.024	94.4	0.001262
836	1.469	0.024	94.4	0.001244
842	1.459	0.024	94.6	0.001226
848	1.449	0.022	94.9	0.001016
854	1.439	0.022	94.9	0.001002
860	1.428	0.022	94.9	0.000988
866	1.419	0.022	95	0.000974
872	1.409	0.022	94.9	0.000961
878	1.399	0.023	94.6	0.001036
884	1.390	0.024	94.6	0.001112
890	1.380	0.025	94.4	0.001191
896	1.371	0.026	94	0.001271
902	1.362	0.026	94.1	0.001254
908	1.353	0.025	94.3	0.001144
914	1.344	0.026	94	0.001221
920	1.335	0.027	93.8	0.0013
926	1.327	0.027	93.9	0.001283
932	1.318	0.027	93.9	0.001267
938	1.310	0.026	94	0.00116
944	1.301	0.025	94.2	0.001058
950	1.293	0.025	94.3	0.001045
956	1.285	0.024	94.5	0.000951
962	1.277	0.023	94.8	0.000863
968	1.269	0.023	94.7	0.000852
974	1.261	0.023	94.8	0.000842
980	1.254	0.021	95.3	0.000693
986	1.246	0.022	95	0.000751
992	1.238	0.022	94.9	0.000742
998	1.231	0.021	95.2	0.000668

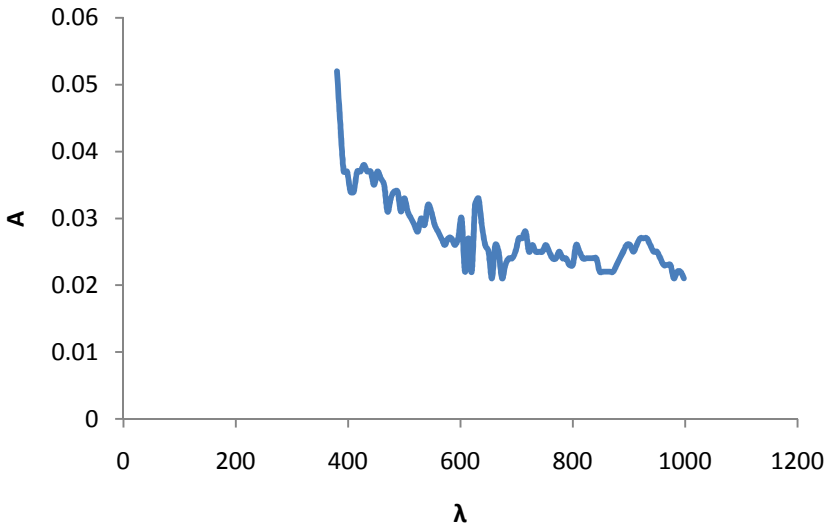

Figure 1 :- (a) absorption (A) vs wavelength (λ)

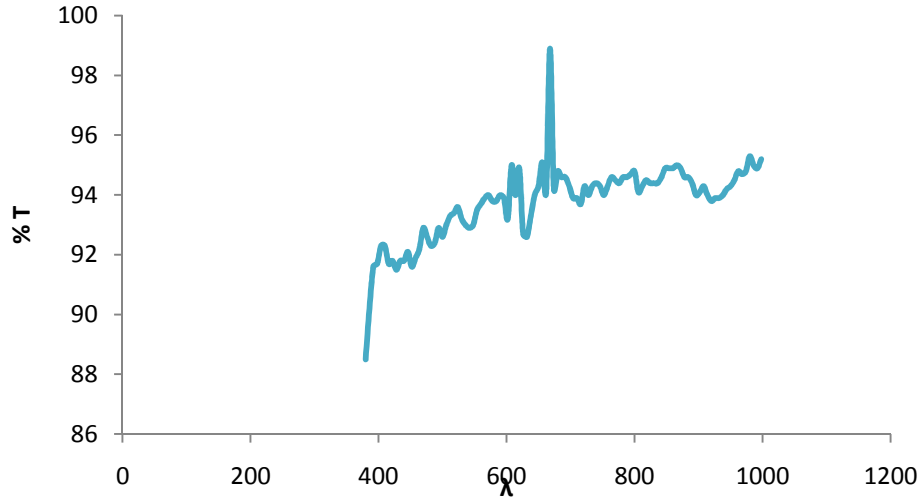

Figure 1:- (b) % transmission (T) vs Wavelength (λ)

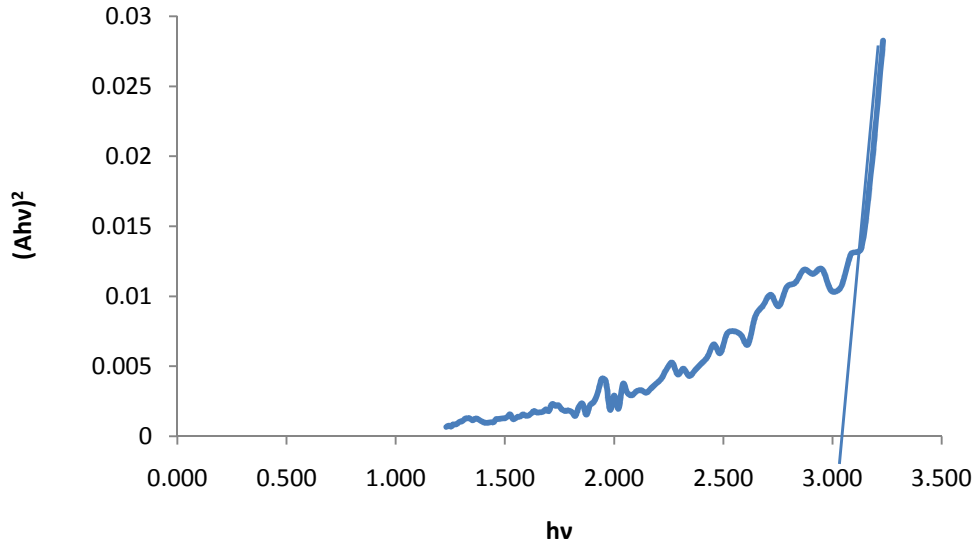

Figure 2 :- $(Ahv)^2$ VS hv

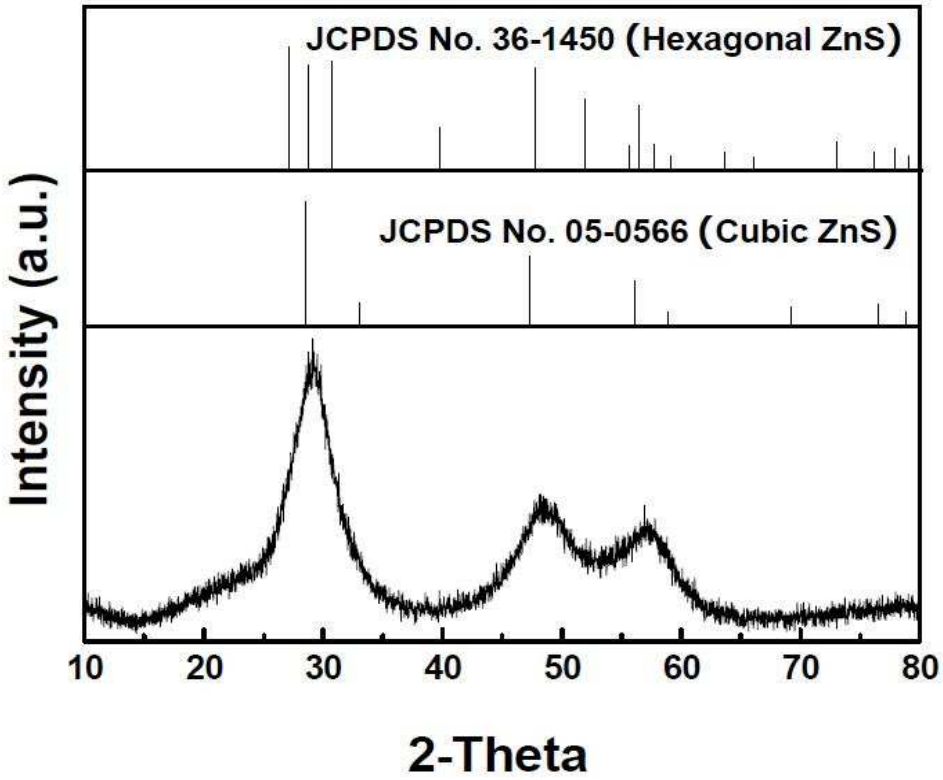

Figure 3 :- XRD pattern of ZnS

CONCULSION

The energy band gap obtained in this work is Eg = 3.2 ev. Which is slightly smaller than those reported in literature [1] (3.6 ev to 4.0 ev). This difference in the result may be due to our optical measurement are in the visible region and close to UV region.

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