

Correlation Between Surface Images of ZnO and PbS Thin Film

¹Hemendra Kumar, ²Shailendra Gangwar ³Sanjeet Pratap Singh*
M. M. H. College Ghaziabad, U. P. India.

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Abstract

Zinc oxide consists of amazing physical and chemical properties. The bottom up approach is implemented for developing thin films. Adhesives occur at room temperature in which atom by atom is stacked. In various fields are covered by such type materials as emitters, electronic devices, sensors, transducers, solar cells. ZnO thin film is used in. Lead sulfide (PbS) thin film was deposited on the glass substrate. This metal sulfide as PbS thin film was prepared chemical bath deposition (CBD) method. The PbS thin film showed a polycrystalline structure related to the galena cubic phase. In this work characterization of the sample is done by XRD and SEM technique.

Keywords: ZnO thin film, PbS thin film, SEM, XRD.

Introduction

Zinc Oxide (ZnO) is a compound in which IInd and VIth group elements participate. Lead is a soft, dense and malleable metal which has low melting point. PbS is a poor conductor of electricity and heat. In Zinc oxide largely ionic bond plays crucial role ($Zn^{2+}O^{2-}$) with corresponding radii of 0.074nm for Zn^{2+} and 0.140nm for O^{2-} . These properties are responsible for the preferential formation of Wurtzite rather than Zinc blende structure [1]. Zinc oxide thin film behaves as a semiconductor having wide band gap. PbS is a p-type semiconductor in which carriers are hole in majority. This material has its narrow band gap that has range is 0.37-0.41 eV at 300K [2,3]. The presentation of narrow band gap in material probed towards quantum confinement. Lead acetate was used as lead precursor and thiourea was used for sulfur source for deposition of PbS thin films. The native doping of the semiconductor due to oxygen vacancies or zinc interstitials is n-type behavior [4]. Cause of narrow band gap It is attractive for different applications such as solar cells [3-5], gas sensors [6-9], electronic devices [10-11]. Different methods are applicable for synthesis of zinc oxide

Corresponding Author: **Hemendra Kumar**

Email: hemendra.babloo@gmail.com

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thin film such as solgel [12], pulsed laser deposition [13], chemical bath deposition [14]. A Successive ionic layer adsorption and reaction [SILAR] method [15] is easier and low-cost method for deposition of thin film. Zinc oxide thin films play important roles in solar cells, ZnO thin films are harvesting solar energy from the sunlight.

Procedure

A glass substrate cleaned and rinsed with distilled water. Without annealing SILAR method is use for depositing the zinc oxide thin film. Precursor for zinc oxide can be made by zinc salt compound such as zinc nitrate, zinc chloride and zinc sulphate [16-20], ethylene glycol was used as other additive compound which acts as a binder and form zinc complex compound and provides desired homogeneous compound. 2 gm zinc sulphate and 20 ml NH_4OH with 20ml distilled water and ethylene glycol takes as precursor materials in this work. The cleaned glass substrate immersed into prepared solution for 20 seconds, after this substrate immersed into second vessels of distilled water for 02 seconds. Then this substrate immersed into third vessels of ethylene glycol for 2 minutes, finally this substrate immersed into fourth vessels of distilled water for 02 seconds. This one cycle repeated 70 times then a transparent thin film deposited on the substrate. For the preparation of thin film given steps are follow.1-the concentration of the precursor materials are taken differently and observation recorded.2-, the experiments are carried out by varying the number of cycles.3- the immersing time of substrate into solution are recorded differently.4- all the experiments are performed at room temperature and without annealing of any precursors materials. Initially zinc sulphate was taken with NH_4OH in the ratio 1:20 and added 20ml distilled water into it, resulting solution appear transparently. The substrate immersed in this solution and followed one cycle covering four steps with equal time intervals of 10 seconds. In this procedure 50 cycles have been carried out but there were no thin film deposited on the substrate. Increasing the concentration of zinc sulphate deposition rate is increase. It is clear from observation if the number of cycle's increases, the thickness of zinc oxide thin film also increases. When the substrate is immersed in zinc sulphate precursor for more time and then in distilled water for short time and finally immersed in ethylene glycol for time to exceed than ZnSO_4 , resulting to thin film deposition rate increases. For the manufacturing of PbS thin film we take 0.08 M molarity solution of Pb (CH_3COO)₂·3H₂O. This solution prepared by mixing 5gm of Pb (CH_3COO)₂ with 200 ml doubled distilled. Similarly 1.3M molarity solution prepared by mixing of 5gm thiourea [$\text{SC}(\text{NH}_2)_2$] with 50 ml doubled distilled water. 20 ml NaOH mixed in prepared both solutions. This solution is ready

for deposition. At room temperature cleaned glass substrate was put in growth solution for 24 hours. After this substrate was taken out from growth solution and put into doubled distilled water vessel. In this process loosely bound atoms are washed away over the thin film surface and we get fine thin film. When glass slide dipped in zinc sulphate (ZnSO_4) with deionized water produces zinc complex mixed ammonium hydroxide. The ions of stabilized zinc complex are adsorbed at the substrate surface due to attractive forces that may be due to cohesive forces, Vander Waals forces or chemical attraction forces [21]. The substrate or glass slide dipped in second vessel filled with distilled water, the second bath serves to decompose $[\text{Zn}(\text{NH}_3)_4]^{2+}$ in water forming $\text{Zn}(\text{OH})_2$. The substrate dipped in third vessel containing glycol, zinc hydroxide transformed into the zinc oxide. When substrate dipped in fourth vessel filled with distilled water for short time, the loosely attached atoms in the process of adhesion removed from substrate and fine thin film deposited on the substrate

Surface images of ZnO and PbS

From figure 2(a),2(d) it is clear that variation in solution density is vary surface image. Small grains of various size at different level is observed reporting by figure 2(b). In figure2(c) the grain boundaries are observed and some pores are also appeared in surface images of zinc oxide thin film. Figure 2(a) Model : SNE-4500M, Date : 6/24/2022 3:54:48 PM ,Time : 15:54:48.2882169 ,File Name : C:\Users\Admin\Desktop\Glass slide\sec_ 15 kV_SE_HighVac_x2.5K __9.jpg, Discription : Tabletop SEM, Aceleated Voltage : 15 kV, Magnification : x2.5K , Emission Current : 110uA, Detector Mode : SED, Vacuum Mode : High Vacuum, Scan Speed : [Running Info], Focus : 1997, Magnification , x2.5K . Figure2(b) [Image Info],Model : SNE-4500M,Date : 6/24/2022 4:14:05 PM,Time : 16:14:05.4991095,File Name : C:\Users\Admin\Desktop\Glass slide\sec_ 15 kV_SE_HighVac_x3.0K __16.jpg,Discription : Tabletop SEM,Aceleated Voltage : 15 kV,Magnification : x3.0K,Emission Current : 110uA,Detector Mode : SED,Vacuum Mode : High Vacuum,Scan Speed : [Running Info],Focus : 1929,Magnification : x3.0K, r Level : 0,Image Size : 480,480,Paint Area : 1,0.75,ImmediatePaint : True,Frame Si

A Grain Shape of PbS thin film reveals a more porous or clustered surface structure. From the SEM images it is clear that it is frequently forming uniform grain gatherings. This image also showed an island-like formation in which adhesive molecules appear as larger spherical and irregular crystallite across the substrate. Figure 3 gives the structural images of PbS thin film as nano crystalline, which was investigated by using of scanning electron microscopy

(SEM) tools. Uniform and sticking quality of lead sulfide film was obtained. Figure 3(a) taken at 20,00 kV EHT in present of 2.00 KX magnification parameter. Homogeneous and smooth film is observed that was excellently covered to the substrate. Figure 3(b) got when magnification adjust at 50.00 KX with 20,00 kV EHT. Figure 3(c) was taken at 20,00 kV EHT and magnification factor is 30.00 KX. shows the uniformly individual clusters are distributed over all of PbS films. Figure 3(d) explained that the surface of the deposited film loose compact structure, taken at 20,00 kV EHT and magnification is 10.00 KX. Figure 3(c) revealed that the clusters are constituted by nanocrystalline grains over the surface.

XRD for ZnO The XRD pattern of ZnO thin film is shown in figure 1. XRD spectrum explains the normalized mass concentration. Glass slide number 1482 taken as the value of HV [KV] AT 15.0 kev and mag. 2000x and WD mm as 10.0 mm shown in figure 1(a). In glass slide number 1482 at two places naming glass slide 2061 and glass slide 2062, the normalized mass concentration of zinc in percentage are 80.88 and 77.24 respectively. Hence the average normalized mass concentration of zinc in thin film is 79.06. The spectrum details of thin film taken by XRD are given in Table 1 and spectrum shown in figure 1(a). Glass slide 1481 taken as the value of HV [KV] at 15.0 kev and mag. 5000x and WD mm as 10.0 mm shown in figure 1(b). In glass slide 1481 taken a point naming 2060, its spectrum also shown in figure 1(b), spectrum details are given in Table 2. The crystalline sizes of thin films are calculated using Scherrer formula: $D = 0.9\lambda / \beta \cos\theta$

Table;1, Normalized mass concentration [%] of glass slide 1482

Spectrum	C	Si	S	Ca	Zn
Glass slide 2061	1.78	6.51	8.64	2.19	80.88
Glass slide 2062	2.13	8.27	8.11	4.25	77.24
Mean	1.95	7.39	8.37	3.22	79.06
Sigma	0.25	1.25	0.37	1.45	2.58
Sigma Mean	0.18	0.88	0.26	1.03	1.82

Table 2; The details of spectrum of glass slide 1481 are given below

Spectrum	C	S	Zn
Glass slide 2060	5.17	8.52	86.31

Summary

As the concentration of precursors increases beyond a threshold value, the thin film deposition starts. The thickness of thin film deposited is directly proportional to the frequency of cycle of steps. The deposition of thin film is directly proportional to the time duration of immersed substrate in glycol. SEM analysis reveals the surface morphology of thin films. This thin film acts as the n- type semiconductor and plays an important role for harvesting energy from sunlight and improves the efficiency of solar cells. Figure 3(a,b,c,d) revealed that the shape of particles is found spherical with uniform size distributed on substrate surface for PbS thin film.

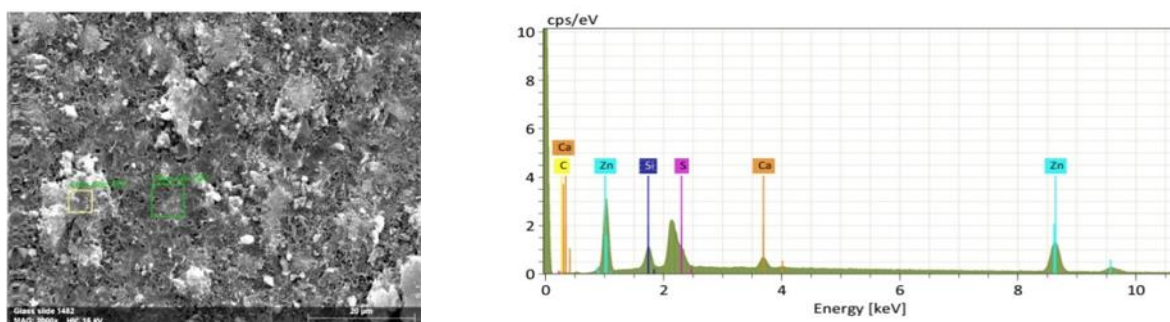


Figure1(a)

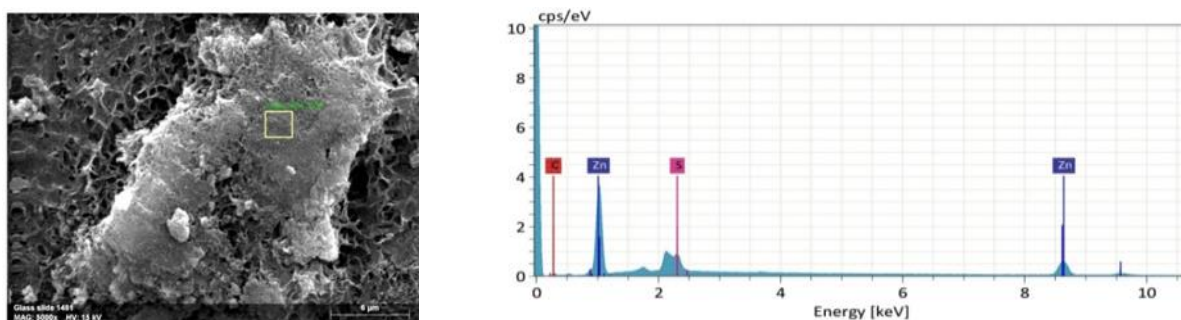
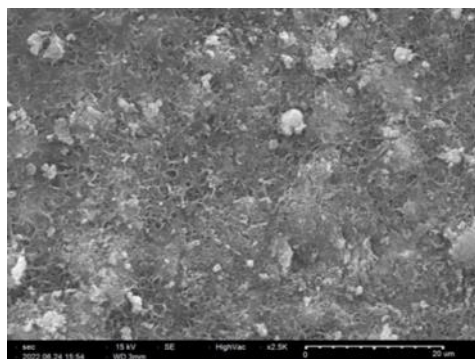


Figure 1(b)



Figure; 2(a) ZnO image

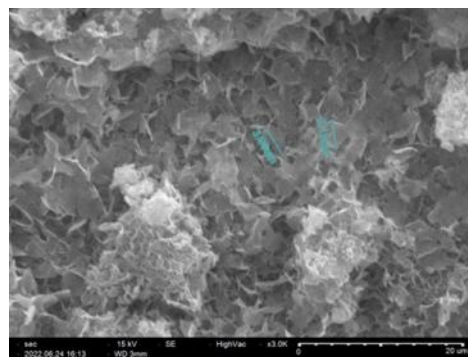


Figure 2(b) ZnO image

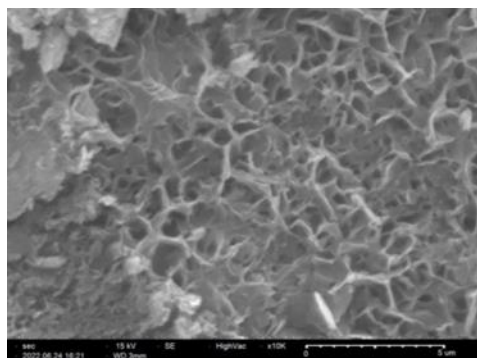


Figure 2(c) ZnO image

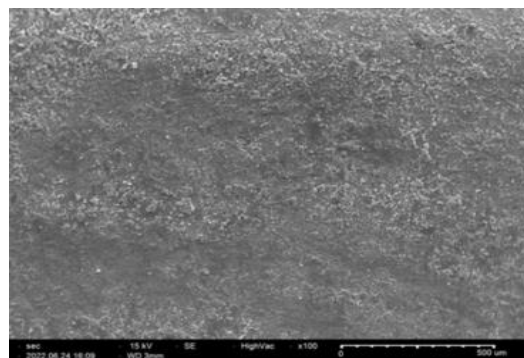
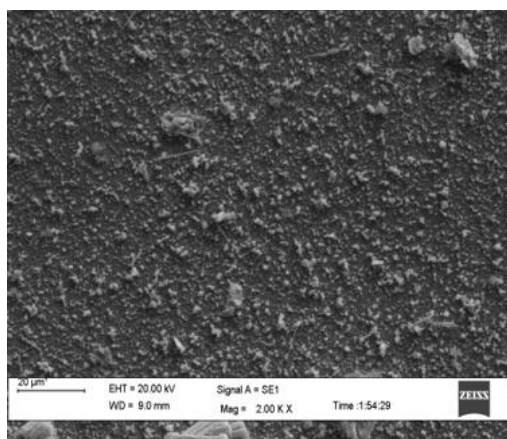
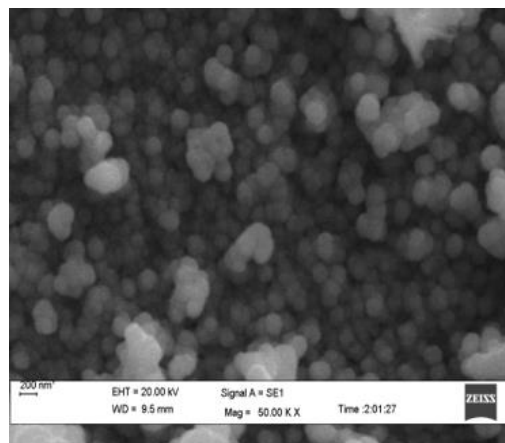


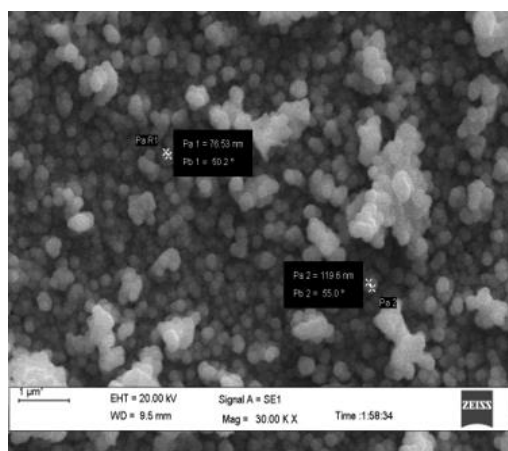
Figure 2(d) ZnO image



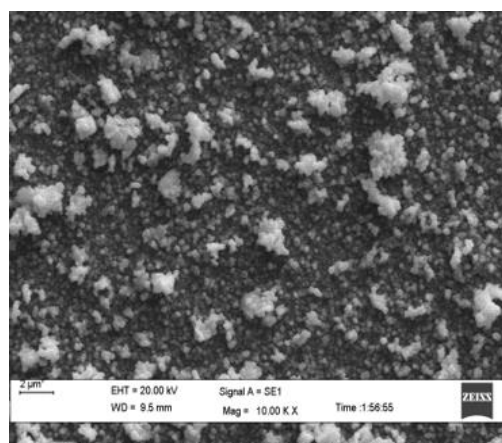
Figure;3(a) SEM image of PbS thin film



Figure;3(b) SEM image of PbS thin film



Figure;3(c) SEM image of PbS thin film



Figure;3(d) SEM image of PbS thin film

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