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INVESTIGATION OF MORPHOLOGY OF CdS THIN FILM PREPARED BY CHEMICAL BATH DEPOSITION METHOD

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Abstract

CdS thin films prepared by chemical bath deposition technique, are characterized using scan electron microscopy. In this observation our object to improve the understanding of the response of mechanisms associated with the formation of CdS thin films. CdS thin film behaves like an effective buffer material for film based poly crystalline solar cells (CdTe). Various type mechanisms are involved in the formation of CdS thin film, in which ion by ion mechanism has an important role in formation of thin film. In this formation glass slide is used as a substrate for deposition of CdS thin film. This work is done in ways, thin film was deposited at 70°C temperature glass substrate immersed into solution for 40 minutes and glass substrate immersed into solution at room temperature for 24 hours.

***Kew words** : CdS thin film ,Scanning Electron Microscopy (SEM),*

Introduction

CdS thin film was deposited on glass substrate using chemical bath deposition technique. Before the deposition of thin film the slides were cleaned properly with the help of ethanol, washed with doubled distilled water. As we know that II–VI compounds have received a lot of attention as optoelectronic materials because of their wide band gap. Cadmium sulfide (CdS) is II–VI compound semiconductors with wide direct bandgaps of 2.42 eV [1, 2]. CdS can crystalline in both cubic and hexagonal structures depending on the synthesis procedures and the thermal and chemical treatments [3, 4]. CdS is recognized as an n-type semiconductor which has been widely used in a variety of applications, such as the window layer in high efficiency solar cells' hetero structures, in optical detectors, optoelectronic devices, light-emitting diodes.

Photonic semiconductor heterojunction has opened up new dimensions in material science and led to exciting new developments in many scientific areas [5,6]. It provides an additional opportunity in the design of semiconductor junction devices due to its controlled impurity doping and the conduction and valence band satiate at the junction [7, 8]. For the extraordinary performance of many important optoelectronic and photocatalytic device applications the heterojunctions provide fundamental platforms. The examples of such devices are lasers, light emitting diodes, solar cells, and high electron mobility transistors [9]. For efficient performance of optoelectronic and photocatalytic applications in the blue or ultraviolet region CdS heterojunction material plays a significant role [10].They can be used as an n-type buffer layer to form thin film heterojunction solar cells [11, 12], quantum wells [13], and light-emitting devices [14]. Different methods have been used to fabricate CdS and heterojunction thin films, e.g., CBD [15, 16], the vacuum deposition method [17,18], electrodeposition [12,19], and others. Deposition (CBD) [20] have been used for forming CdS thin films. Out of these various processes, chemical bath deposition is advantageous due to its low cost and suitability for forming large area thin films. CdS thin films deposited by chemical bath depositions are normally found to have high resistivity [21]. A wide range of study of the formation of conducting CdS during annealing of the chemical bath deposited CdS thin films has been made [22,23]. CBD technique has many benefits such as low cost for equipment and operation, simplicity in operation, low deposition temperature, low energy consumption, and large area deposition in a single procedure.

Experimental Work

Chemical components for depositing CdS thin films are cadmium sulphate, thiourea ($CS(NH_2)_2$) and ammonia water NH_4OH and distilled water. In this work cadmium sulphate is used as a cadmium ion source and thiourea as sulphide ion source. Initially we prepared a cadmium sulphate solution. 5 gm. cadmium sulphate $CdSO_4$ crystalline mix in 200 ml double distilled water and got **M** normality solution of $CdSO_4$. In the second step 5 gram thiourea mixed with 100 ml double distilled water and got **N** normality thiourea solution. We performed the following procedure step by step for deposition of CdS thin film on glass substrate.

1. Taking 200 ml $CdSO_4$ solution of **M** normality and heated up to 70^0 C with steering.

2. 20 ml ammonia NH_4OH solution added in cadmium sulfate solution at a lower temperature of 60^0 C and reached a homogeneous solution.

3. Now slowly slowly added 60 ml **N** normality thiourea solution in solution prepared after second step. Now solution becomes of yellowish colour which indicated the solution is ready for deposition of CdS thin film.

The temperature of the final solution was sustained between 40°C and 45°C. During this a substrate of glass slide was dipped into this solution for 40 minutes. After 40 minutes substrate was taken out from the solution and immersed into a beaker of distilled water to wash loosely bound ions away from the thin film surface and got a fine CdS thin film which was characterized by Scanning Electron Microscopy. When the temperature of this solution reached room temperature a second glass slide was made immersed into this solution for 24 hours. After 24 hours the second slide was taken out from the solution and washed with doubled distilled water for getting fine CdS thin film which was also characterized by Scanning Electron Microscopy. The surface images and morphology of both slides are shown in figure 1 and figure 2.

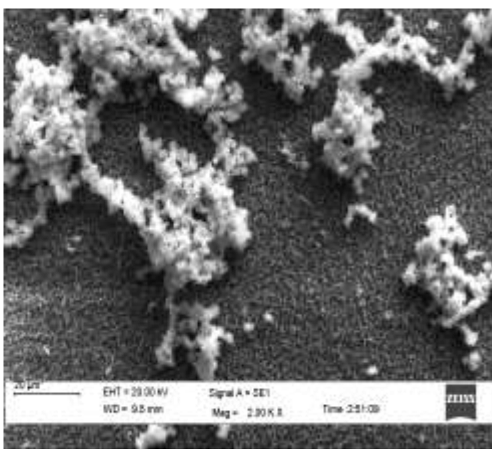

Figure 1(a)

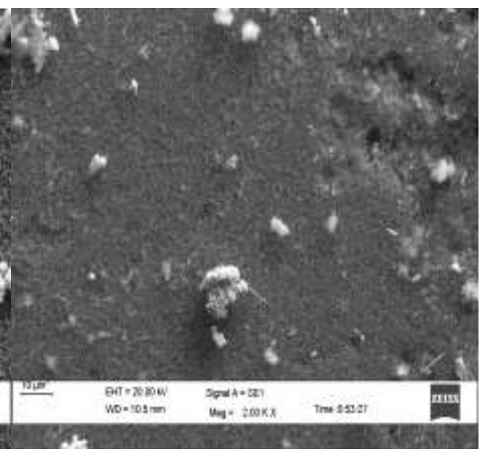

Figure2(a)

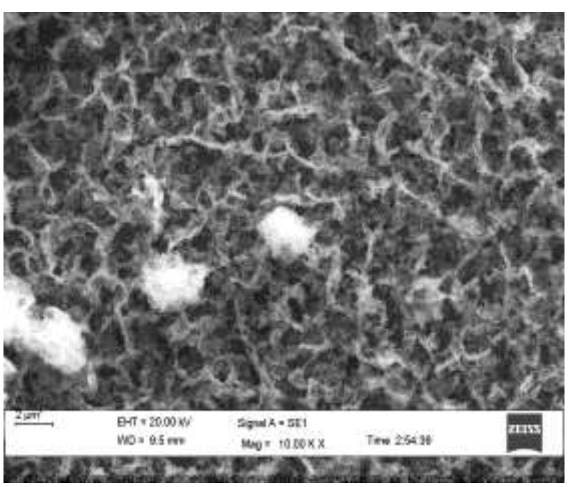

Fig. 1(b)

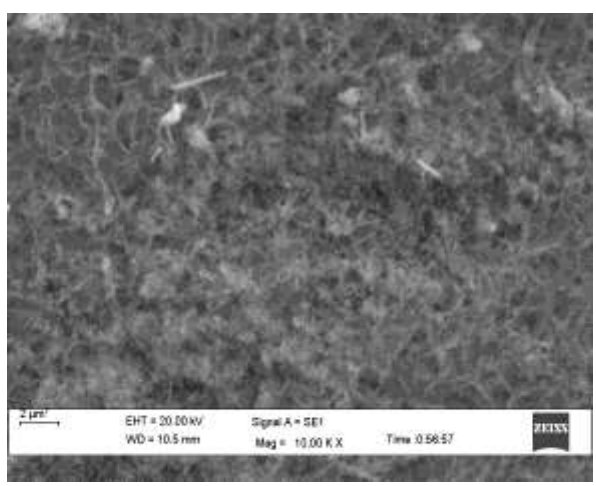

Fig.2(b)

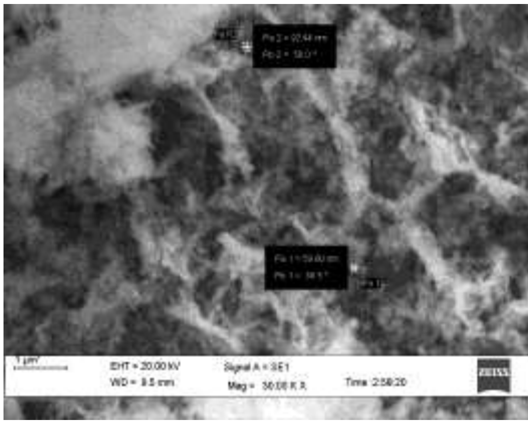

Fig. 1(c)

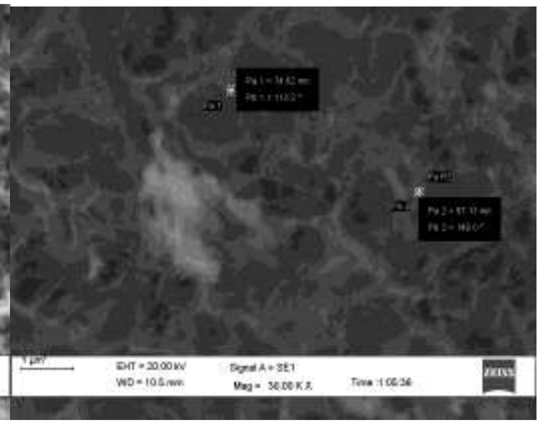

Fig. 2(c)

Result and discussion

Chemical reactions took place in this whole process in different steps. Equilibrium equation of chemical reaction is described in the following equation-

$2CH_4N_2S + 3CdSO_4 + 4NH_4OH \rightarrow 2CH_4N_2O + 3CdS + 2(NH_2)_2SO_4 + 6H_2O$

The growth mechanism can be understood by following chemical reactions

The solution of amino-cadmium complex equilibrium:

$Cd^{2+} + 4NH_3 \rightleftarrows Cd(NH_3)_4^{2+}$ ……………………………………………….(1)

The formation of $Cd(NH_3)_4^{2+}$ prevents the precipitation of Cd $(OH)_2$. Hydrolysis of thiourea in an alkaline medium is shown below-

$(NH_2)_2CS + OH^- \leftrightarrows SH^- + CH_2N_2 + H_2O$………………………………………….(2)

where SH^- ions are in equilibrium with water and give S^{2-} ions according to this equation:

$SH^- + OH^- \leftrightarrows S^{2-} + H_2O$ ……………………………………………………….(3)

Cadmium sulfide formation:

$Cd(NH_3)_4^{2+} + S^{2-} \rightarrow CdS + 4NH_3$ ……………………………………………..(4)

Conclusion

Thin films prepared at 40^0C immersed in solution for 40 minutes and prepared at room temperature immersed in solution for 24 hours are shown with porous structure. As shown in figure 1 and figure 2, CdS thin films at 20.0Kv EHT and at mag= 2.0 KX were composed of aggregated particles with porous structure and it is clear that the size of pores decreases as the immersed time increases. Scanning electron microscopy (SEM) morphology also confirmed the nanocrystalline spherical growth appeared. Figures 1(a) and 2(a) for CdS film confirmed that nano cluster type particle was separately distributed on glass substrate surface. Morphological images shown in figures 1(a),2(a) indicated that clearness and fine image appeared at deposition take place at higher temperature than room temperature. From figure 1(b) and 2(b) it is clear that compactness of the atoms of Cd and S are increases and roughness decreases with dipping time increases. Fig. 1(c) and 2(c) indicates that the geometrical shape of CdS nanoparticle is presented in nano length. Th egeometrical shape of ZnO thin film [24] also resembles with that of CdS

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