

Comparative Analysis in Morphology of Lead Sulfide (Pbs) and Cadmium Sulfide (Cds) Thin Film

Hemendra Kumar

M. M. H. College, Ghaziabad, U.P. India.

DOI: <https://doi.org/10.57067/ir.v2.i7.661>

Abstract

In this work metal sulfide (PbS) and cadmium sulfide (CdS) thin films were developed by the chemical bath deposition (CBD) technique. The PbS films showed a polycrystalline structure related to the galena cubic phase. The surface morphology of the PbS and cadmium sulfide films was analyzed by scanning electron microscopy (SEM), which evidenced a gradual coverage of the surface of grain structure. Successive ionic layer adsorption and reaction (SILAR) methods are involved in forming of thin film deposition technique. This work reveals that thin film prepared by adhesive process of atom by atom or molecule by molecule. The PbS and CdS films were developed on a glass substrate separately. The surface morphology of the prepared PbS and CdS films were investigated using scanning electron microscopy (SEM), which revealed progressive coverage of the substrate surface by the grain-like structure.

Keywords: CdS thin film, PbS thin film, SEM.

Introduction

Lead is a soft, dense and malleable metal with a low melting point. It is a poor conductor of electricity and heat. Thin film of a p-type semiconductor material such as PbS is applicable for solar cell [1]. PbS is a plenty element on the earth has emerged as a promising element in photo voltaic application. In PbS semiconductor material positive charge carriers are in majority form. The narrow band gap is present in this type semiconductor material. The motion of charge carriers are confined due to narrow band gap resulting quantum confinement is present. For the manufacturing of PbS thin film lead acetate provides lead ion. The sulfur ion is found by thiourea. Many scientists are worked on photovoltaic cells [2]. Ahmed. S and S.T. Navale [3,4] found the band gap of PbS semiconductor 0.37-0.41 eV at room temperature. T. Abza and coworkers [5,6] got 2.42eV band gap for cadmium sulfide semiconductor. The fabrication

Corresponding Author: Hemendra Kumar

Email: hemendra.babloo@gmail.com

Received 10 May, 2025; Accepted 02 June, 2025. Available online: 30 July, 2025.

Published by SAFE. (Society for Academic Facilitation and Extension)

[This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License](#)



technique chemical bath deposition method is followed by M. Ortega-Lopéz [7] for making thin films. H. Kumar and coworkers [8,9] are also use this technique for making of CdS and PbS thin film. Y.F. Nicolau [10] explained the manufacturing process in which adsorption takes place. CdS is second and fourth group element having wide energy band gap. The large energy gap materials are useful for optoelectronic devices. The characteristics of n-type semiconductors are observed in cadmium sulfide material. J. Kundu, [11] worked on wide energy gap materials and found CdS heterojunction structure play an important role which provides good performance in visible light. A. García-Barrientos and O. Echendu [12, 13] worked on thin film heterojunction solar cell using as n-type buffer layer, H. Kumar and others [14], were prepared ZnS/CdS/ZnS quantum well structures. K. Hasanirukh [15] was studying light-emitting devices. There are many techniques to manufacturing thin films such as CBD method [16, 17], the vacuum deposition method [18,19], electrodeposition [13,20]. But chemical bath deposition method gives more advantages than other methods. CdS thin films deposited by chemical bath depositions are normally found to have high resistivity [21]. 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.

Preparation method of thin films

PbS thin film was making in same way as ZnO thin film prepared by our work group [22]. In this process amazing phenomena take place in which adhesive of molecules arranged in a manner that is called successive ionic layer adsorption and reaction (SILAR) methods. Initially we taken 0.08 M molarity solution of Pb (CH₃COO)₂·3H₂O solution. This solution is prepared by mixing 5gm of Pb (CH₃COO)₂ with 200 ml doubled distilled. Similarly, 1.3M molarity solution prepared by mixing of 5gm thiourea [SC(NH₂)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 double distilled water vessel. In this process loosely bound atoms are washed away over the thin film surface, and we get fine thin films. The chemical reaction takes place during the developing of thin film described by [23]. In this process lead acetate dissolves in water and makes tri hydrate compound which react with sodium hydroxide and forms hydroxide. This lead hydroxide provides lead ion (Pb²⁺) and two hydroxide ions (2OH⁻). These two hydroxide ions with thiocarbamide provides sulfur ion (S²⁻)-

. In this mechanism these lead ion and sulfur ion are responsible for developing thin film of PbS.

Firstly, we make cadmium sulfate solution of 0.24 N normality by mixing of 5 g of crystalline CdSO_4 in 200 mL of double-distilled water this solution heated at 70°C with stirring regularly. Similarly 0.66 N Normality thiocarbamide solutions prepared by mixing of 5 g thiocarbamide was dissolved in 100 mL of double-distilled water. 20 mL (NH_4OH) solution was added to the CdSO_4 solution with stirring at decreasing temperature. All these solutions were mixed up then 60 mL of thiocarbamide solution having 0.66 N Normality was mixed in prepared mixture with regularly stirring. Finally, this solution became in yellowish colour. This solution is ready for deposition. The temperature of final solution sustained 40°C to 45°C . The cleaned substrate glass slide immersed into solution for 40 minutes, and then it is taken out from the solution and dipped into distilled water. In this process loosely bound ions washed away from the thin film surface and got a fine CdS thin film, which is characterized by Scanning Electron Microscopy. Second observation taken at room temperature slide immersed into this solution for 24 hours. After this time second slide taken out from the solution and washed with doubled distilled water for getting fine CdS thin film. Analysis of reaction was explained by H.Kumar and others [08]. In whole process, chemical reaction takes place many steps. Equilibrium equation of chemical reaction is described following. When thiocarbamide and cadmium sulfate mixed with sodium hydroxide resultant compound are carbamide (urea) and ammonium sulfate and important compound cadmium sulfide are obtained. This CdS agent is deposited on glass substrate in form of thin film.

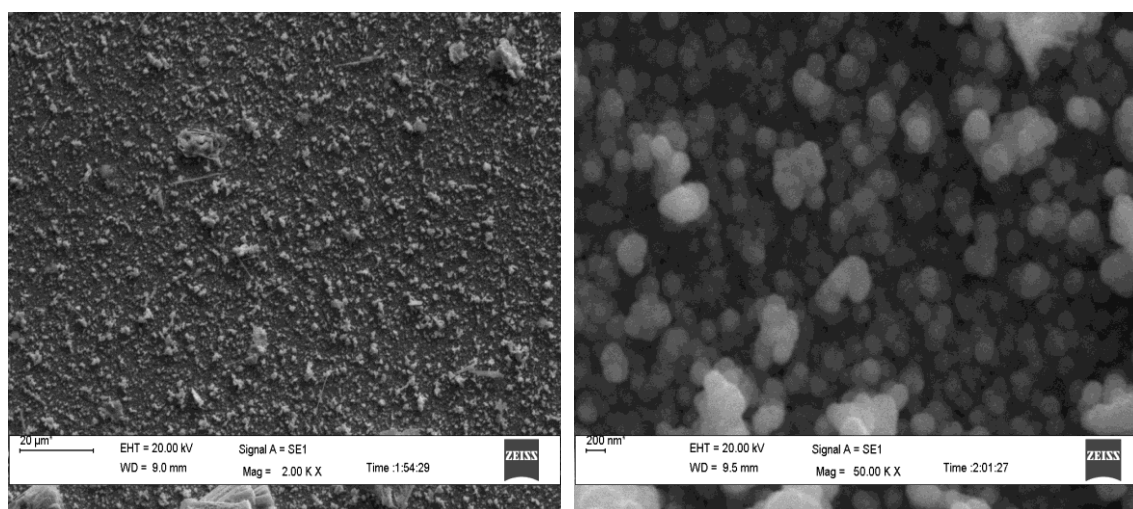
PbS Surface image

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 forms 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 1 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 1(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 1(b) got when magnification adjust at 50.00 KX with 20,00 kV EHT. Figure 1(c) was taken at 20,00 kV EHT and magnification factor is 30.00 KX. shows uniformly individual clusters are distributed over all

of PbS films. Figure 1(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 1(c) revealed that the clusters are constituted by nanocrystalline grains over the surface.

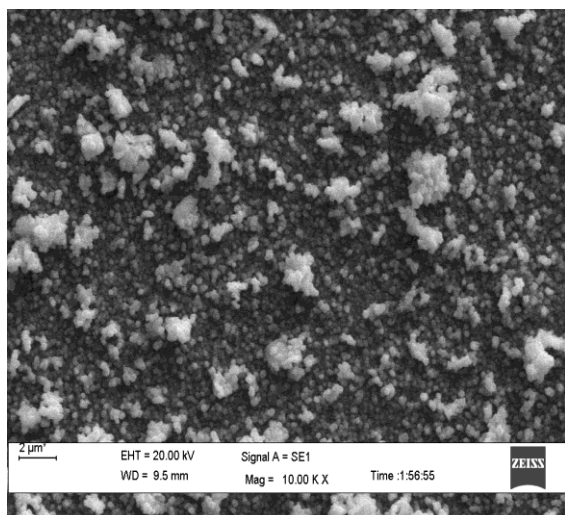
CdS Surface Image

Surface image and Grain structure of CdS thin film disclosed that it is grow a very compact and smooth form. SEM image showed that it is having continuous surface layer with small uniform grains. From the SEM image it is clear that there are minimal cracks or pinholes when deposited properly by chemical bath deposition method. The surface images, morphology of both slides are shown in figure 2 and figure 3. Morphology was explained by H.Kumar and others [08]. The temperature of solution sustained at 400C for making film substrate dipped in solution for 40 minutes. Another film was prepared at room temperature by immersed substrate in solution for 24 hours. Both are shown with porous structure. Figure2 and Figure3are captured at 20.0Kv EHT with magnification factor2.0 KX. These figures disclose that images were composed of aggregated particles with porous structure. By the analysis of images it is clear that the size of pores decreases as the immersed time increases. Spherical growth of nano crystal particles appeared in surface images. This nano cluster type particle was separately distributed on glass substrate surface disclosed by Figures 2(a) and 3(a).The discrimination in clearness and fine image can be understood on the basis of deposition take place at more temperature than room temperature. It is clear that compactness of the atoms of Cd and S are increases and roughness decreases with dipping time increases. The geometrical shape of CdS nanoparticle presented in nano length is observed by Fig. 2(c) and 3(c).

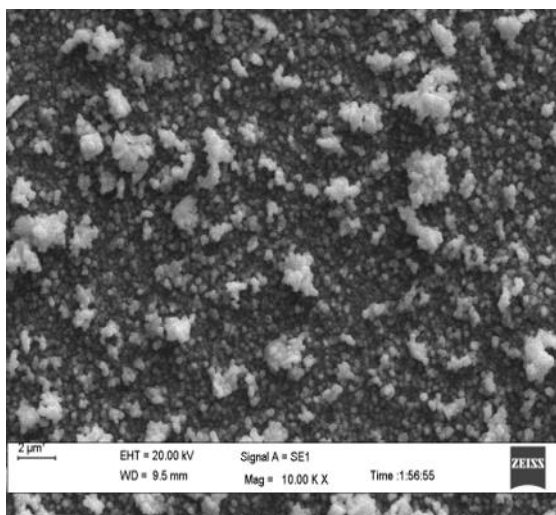


Figure;1(a) SEM image of PbS thin film

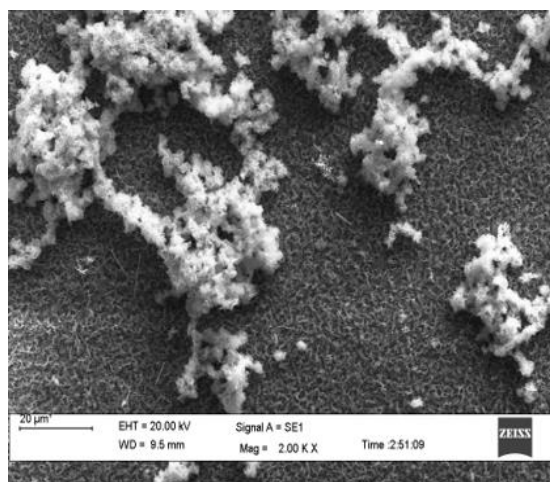
Figure;1(b) SEM image of PbS thin film



Figure;1(a) SEM image of PbS thin film



Figure;1(b) SEM image of PbS thin film



Figure;2(a) SEM image of CdS thin film

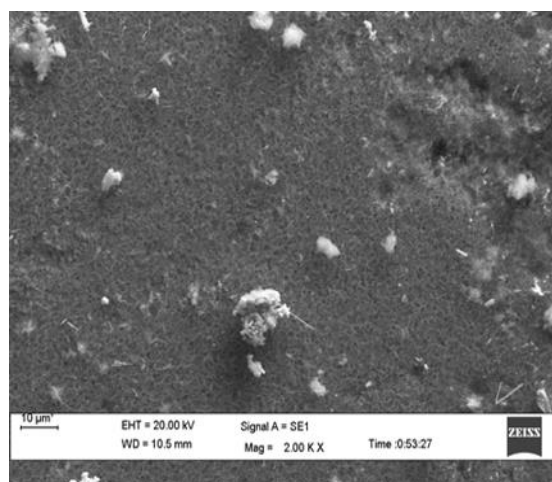


Figure3(a) SEM image of CdS thin film

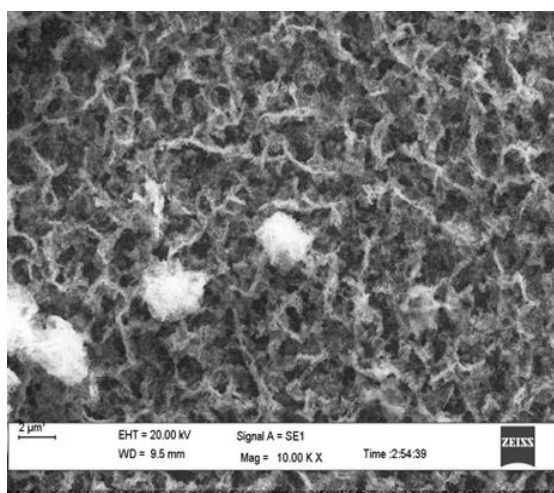


Figure2(b) SEM image of CdS thin film

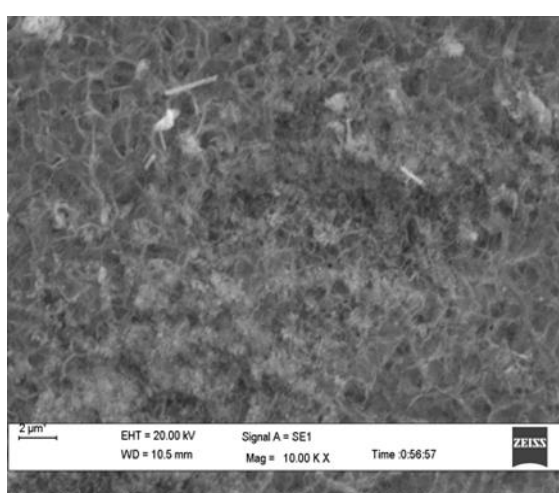


Figure3(b) SEM image of CdS thin film

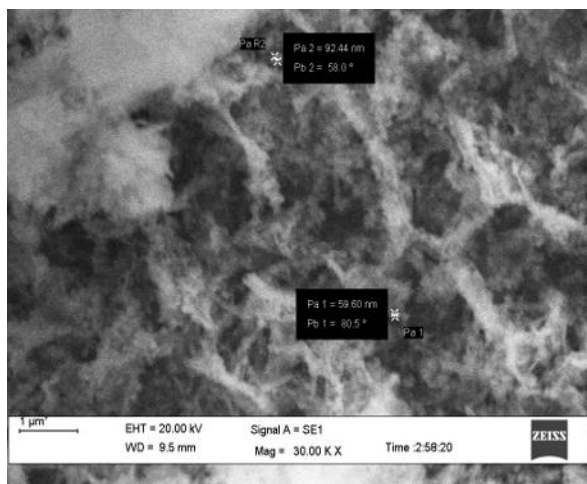


Figure 2(c) SEM image of CdS thin film

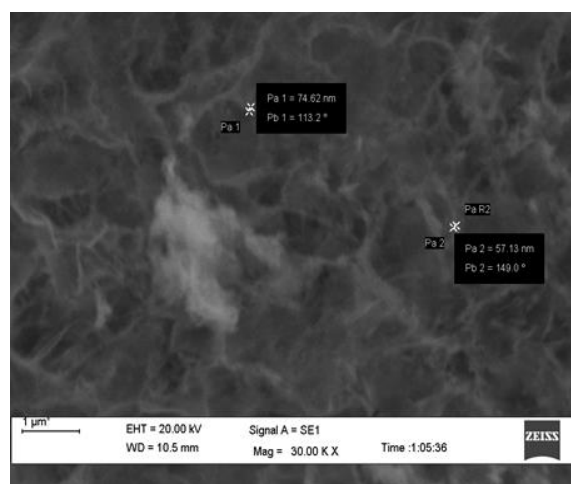


Figure3(c) SEM image of CdS thin film

Conclusion

Nano crystalline film of lead sulfide is successfully developed on substrate by CBD method. A good quality thin film is found by this process. The great sticking properties of PbS particles are obtained. A well-defined granular structure with some porosity is found in thin film. Figure (1a,b,c,d) revealed that the shape of particles are found spherical with uniform size distributed on substrate surface. Characterization of PbS thin film produced by chemical bath deposition at room temperature also explained [24]. CdS can be crystalline in both cubic and hexagonal structures depending on the synthesis procedures and the thermal and chemical treatments [25,26]. The morphology of cadmium sulfide (CdS) thin films can be described as polycrystalline grains shown in figure 2(a). Figure 3(a) appears on the smooth surface of thin film. Figure 2(b) reveals the continuous surfaces image of cadmium sulfide thin film, From the SEM image figure 3(b) appears thread weaving or tailored structure. Figure 2(c) and figure 3(c) appear pores model.

Acknowledgement

The authors sincerely thank JNU Delhi for providing the SEM facilities.

References:

[1] V. Manthina, J.P Correa-Baena, G. Liu, A.G. Agrios, ZnO – TiO₂ Nano Composite Films For Highlight Harvesting Efficiency and Fast Electron Transport In Dyesensitized Solar Cells , J.Phys.Chem.C 116 (2012) 23864.

- [2] M. Afzaal, P. O'Brien, J. Mater. Chem. 16, pp 1597 (2006).
- [3] Ahmed.S. Obaid Preparation of chemically deposited thin films of CdS/PbS solar cell. Superlattices and Microstructures, 52(4): pp 816-823 (2012).
- [4] S.T. Navale Facile method of preparation of PbS films for NO₂ detection. RSC Advances, 5: pp 6518-6527 (2014).
- [5] T. Abza, F. K. Ampong, F. G. Hone, I. Nkrumah, R. K. Nkum, and F. Boakye, "A new route for the synthesis of CdS thin films from acidic chemical baths," International Journal of 5in Films Science and Technology, vol. 6, no. 2, pp. 67–71, 2017.
- [6] T. Abza, F. K. Ampong, F. G. Hone, R. K. Nkum, and F. Boakye, "Preparation of cadmium zinc sulfide (Cd_{1-x}Zn_xS) thin films from acidic chemical baths," 5in Solid Films, vol. 666, pp. 28–33, 2018.
- [7] M. Ortega-Lopéz, A. Avila-García, M.L. Albor-Aguilera, V.M. SánchezResendiz, Improved efficiency of the chemical bath deposition method during growth of ZnO thin films, Mater. Res. Bull. 38 (2010) 1241-1248.
- [8] H. Kumar, S. Gangwar, S. P. Singh, K. Yadav, Investigation of morphology of CdS thin film prepared by CBD method SRJIS, Vol.-12/80 Nov.-Dec.(2023).
- [9] H.Kumar, S.Gangwar, S.P.Singh, K.Kumar, (CASIRJ),IRJCAC, Vol.- 14, Issue-12 (2023)
- [10] Y.F. Nicolau, Solution deposition of thin solid compound films by a successive ionic-layer absorption and reaction process, Applications of Surface Science 22/23 (1985) 1061-1074
- [11] J. Kundu, B. K. Satpathy, and D. Pradhan, "Compositioncontrolled CdS/ZnS heterostructure nanocomposites for efficient visible light photocatalytic hydrogen generation," Industrial & Engineering Chemistry Research, vol. 58, no. 51, pp. 22709–22717, 2019.
- [12] A. Garc'ia-Barrientos, H. Gomez-Pozos, E. Villicaña-Ortiz, and L. Cruz-Netro, "Comparative study of CdS and CdS/ZnS thin films deposited by CBD as a buffer layer solar cell," Microscopy and Microanalysis, vol. 24, no. S1, pp. 1548-1549, 2018.
- [13] O. Echendu and I. Dharmadasa, "Graded-bandgap solar cells using all-electrodeposited ZnS, CdS and CdTe thin-films," Energies, vol. 8, no. 5, pp. 4416–4435, 2015.

- [14] H. Kumar, A. Kumari, and R. R. Singh, "Tunable narrow emission in ZnS/CdS/ZnS quantum well structures prepared by aqueous route," *Optical Materials*, vol. 69, pp. 23–29, 2017.
- [15] K. Hasanirrok and A. Asgari, "Modeling and studying of white light emitting diodes based on CdS/ZnS spherical quantum dots," *Optical Materials*, vol. 81, pp. 129–133, 2018.
- [16] I. O. Oladeji and L. Chow, "Synthesis and processing of CdS/ ZnS multilayer films for solar cell application," *Thin Solid Films*, vol. 474, no. 1-2, pp. 77–83, 2005.
- [17] X. Wang and W. Zhang, "Chemical depositing of CdS/ZnS composition nanostructure modified TiO₂ thin film," *Chalcogenide Letters*, vol. 11, no. 8, pp. 389–395, 2014.
- [18] N. Dahbi and D.-E. Arafah, "Photoluminescence characteristics of ZnS/CdS/ZnS window multilayer thin film for solar cell applications," *Energy Procedia*, vol. 18, pp. 1446– 1451, 2012.
- [19] N. Dahbi and D.-E. Arafah, "Characterization and processing of CdS/ZnS thin layer films deposited onto quartz for solar cell applications," *Energy Procedia*, vol. 18, pp. 85–90, 2012.
- [20] E. Okechukwu and D. Okoli, "Optical and structural properties of electrodeposited CdS/ZnS compound thin films and their possible applications," *Journal of Materials Sciences and Applications*, vol. 1, no. 6, pp. 282–291, 2015
- [21] O D Melo, L Hernandez, O Zelaya-Angel, R Lozada-Morales, M Bercerril and E Vasco *Appl. Phys. Lett.* vol. 65 pp. 1278, 1994
- [22] H.Kumar, S.Gangwar, S.P.Singh,K.Kumar ,Fabrication of ZnO Thin film using chemical bath deposition method. *IJRAR* , Vol.-9,Issue-4 ,Dec. (2022).
- [23] R. Palomino Merino, O. Portillo Moreno, L.A. Chaltel Lima, R. Gutierrez Pérez, M. De Icaza Herrera, V. Castaño, *Journal of Nanomaterials* pp. 1-6 (2013), (article ID 507647).
- [24] Kul, M. Characterization of PbS Film Produced By Chemical Bath Deposition At Room Temperature. *Eskişehir Tech. Univ. J. Sci. Technol. B- Theor. Sci.*, 7, pp 46–5 (2019).
- [25] F. T. Munna, P. Chelvanathan, K. Sobayel et al., "Effect of zinc doping on the optoelectronic properties of cadmium sulphide (CdS) thin films deposited by chemical bath deposition by utilising an alternative sulphur precursor," *Optik*, vol. 218, Article ID 165197, 2020.

[26] J. Kim, C. R. Lee, V. K. Arepalli, S.-J. Kim, W.-J. Lee, and Y.-D. Chung, “Role of hydrazine in the enhanced growth of zinc sulfide thin films using chemical bath deposition for Cu (In,Ga)Se₂ solar cell application,” *Materials Science in Semiconductor Processing*, vol. 105, Article ID 104729, 2020