

SYNTHESIS AND CHARACTERIZATION OF ZINC SULFIDE FILMS ON FTO GLASS

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Zinc sulfide (ZnS) is a non-toxic, abundant semiconductor characterized by a wide direct band gap (3.65 eV) and excellent chemical stability against oxidation and hydrolysis [1]. Due to its unique optoelectronic properties, ZnS is widely utilized in solar cells, sensors, and light-emitting devices, while also serving as an efficient photocatalyst for the degradation of organic water contaminants [2]. Structurally, ZnS exists in two primary phases: the low-temperature stable zinc blende and the high-temperature wurtzite [3]. The aim of this work was to synthesize ZnS films on FTO glass using the Successive Ionic Layer Adsorption and Reaction (SILAR) method and to characterize them via X-ray diffraction (XRD), Grazing Incidence XRD (GIXRD), SEM, and EDX analysis. The deposition involved immersing a cleaned FTO substrate in a cationic precursor (0.1 M ZnCl₂) for 30 s, followed by an anionic precursor (0.1 M Na₂S) for 30 s, with intermediate rinsing in distilled water for 20 s. The process was performed in steps of 10 cycles up to a total of 40 cycles, with intermediate annealing after every 10-cycle increment to enhance film stability. XRD analysis identified a cubic ZnS phase (PDF No. 80-20) alongside SnO₂ (PDF No. 46-1088) from the substrate surface, with ZnS peaks observed at $2\theta = 28.28^\circ$, 48.23° , and 56.57° . As the number of deposition cycles increased, the intensity of the ZnS peaks also increased. Parallel analysis using GIXRD confirmed consistent ZnS peaks; however, the SnO₂ substrate peaks were not detected in several diffractograms when using the grazing incidence method. In the 40-cycle sample, the SnO₂ phase was entirely absent, indicating that the film thickness was sufficient to fully mask the surface of FTO substrate. SEM imaging revealed a clear evolution of the surface morphology as a function of the cycle count and thermal treatment. At 10 SILAR cycles, the unheated film exhibited a highly porous and fragmented structure consisting of loose aggregates with significant voids. Thermal treatment initiated the densification process, where particles began to rearrange into larger clusters. As the deposition progressed to 20 and 30 SILAR cycles, a distinct granular morphology emerged, characterized by more uniform and well-defined grains. By 40 SILAR cycles, the film reached its peak density and surface homogeneity, forming a continuous layer where individual grains merged to minimize porosity. These findings were further supported by EDX analysis, which showed the Sn signal from the FTO glass dropping to just 0.88 % at 40 SILAR cycles, while Zn and S concentrations reached 29.75 % and 19.22 %, respectively, confirming the formation of a dense, chemically mature, and uniform ZnS thin film.

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- [1] S. A. Saah, P. O. Sakyi, N. O. Boadi, F. A. Tiekou, and A. K. Boampong, "Solventless Synthesis of Zinc Sulphide Nanoparticles from Zinc Bis(diethyldithiocarbamate) as a Single Source Precursor," *ChemistryOpen*, vol. 13, no. 6, p. e202400050, May 2024, doi: 10.1002/open.202400050.
- [2] N. Kaur et al., "A review on Zinc sulphide nanoparticles: from synthesis, properties to applications," *Journal of Bioelectronics and Nanotechnology*, vol. 1, no. 1, Jan. 2016, doi: 10.13188/2475-224x.1000006.
- [3] A. Chakrabarti and E. Alessandri, "Syntheses, properties, and applications of ZNS-Based Nanomaterials," *Applied Nano*, vol. 5, no. 3, pp. 116–142, Aug. 2024, doi: 10.3390/applnano5030010.