Influence of the Deposition Time on the Structure and Optical Properties of Indium Sulfide Films (In_2S_3)

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Abstract – The process of synthesis of indium sulphide (In_2S_3) semiconductor thin films by a chemical synthesis method was done. The acetic acid has been used as a complexing agent. Ivestigations of thin films properties were carried out by using X-ray powder diffraction, scanning eletron microscopy, optical spectroscopy. The phase composition, optical transmission and absorption spectra of In_2S_3 films were studied. The value of bang gap energy has been experimentally determined from spectral dependences of optical transmission of In_2S_3 films, and ranges from 2,31 to 2,55 eV.

Key words – indium sulfide, chemical deposition, semiconductor films, thin films, structure and morphology of thin films.

I. Introduction

Mass production of thin-film devices are allowed only when the methods for their preparation are technologically simple, low-cost, flexible in managing properties with high reproducibility obtained materials.

Increased interest is observed in semiconductor materials of the group A^3B^6 with their subsequent application in the optoelectronic, photoelectric industry and photoelectrochemical solar cells [1,2]. One of the promising candidates for replacing cadmium sulfide is chemically deposited films of sulfide indium. In_2S_3 – n-type semiconductor with bandgap width (2.0-2.8 eV) [2,3], which is a non-toxic material and can be used as a buffer layer in Cadmium-Indium Sulfide (CIS) solar cells.

II. Experimental

The working solution for synthesis In_2S_3 films was prepared by mixing indium sulfate ($C(In_2(SO_4)_3)$ = 0,01 M), acetic acid ($C(CH_3COOH)$ = 0,1 M), as a complexing agent and thioacetamide ($C(CH_3CSNH_2)$ = 0,2 M), as sulphating agent [3-8]. Deposition time was from 10 to 45 min.; temperature – 65 ^oC. As substrates, pre-prepared plates 18 × 18 mm from an optically homogeneous glass with a thickness of 0.2 mm were used. The resulting films were solid.

The investigation of surface morphology of the films was carried out using a raster electron microscope REM-106Y equipped with a system for microanalysis The optical transmission spectra of In_2S_3 films were obtained for wavelengths from 340 to 900 nm on spectrophotometer Xion 500 «Dr. Lange». A comparative signal was passed through glass substrates identical to the substrates, used for the investigated films. The phase composition of the In_2S_3 films and structures was investigated by X-ray powder diffraction (diffractometer DRON-3.0, CoKα-radiation). Primary processing of the experimental diffraction data in order to identify the phases was made using the PowderCell program [4]. Optimum exposure for each of the samples was selected.

III. Results and discussion

According to the results of X-ray diffraction analysis of samples In_2S_3 films obtained at a temperature of 65 ° C., was established that all samples consist of α-In_2S_3, β-In_2S_3, or their mixture. That's because their theoretical difractograms are similar.

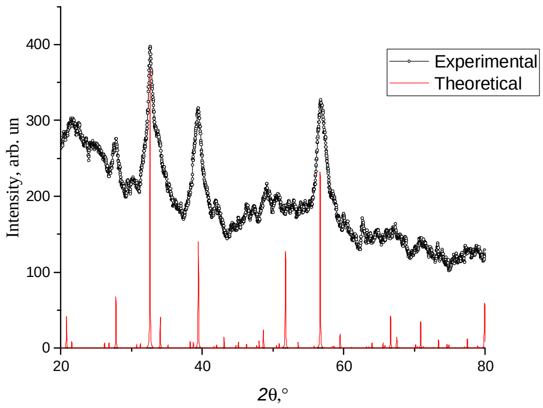


Fig. 1 X-ray diffractogram of In_2S_3 film.

The optical spectrum of light transmission T (λ) of In_2S_3 film for wavelengths from 340 to 900 nm was investigated (Fig. 2). The growth of light transmission begins in the area 360-380 nm. With increasing in the duration of the synthesis of light transmittance gradually decreases due to an increase in their thickness. The spectral dependences of the absorption of the In_2S_3 in $(\alpha \cdot h\nu)^2$ vs. $h\nu$ coordinates allow determining the fundamental absorption edges.

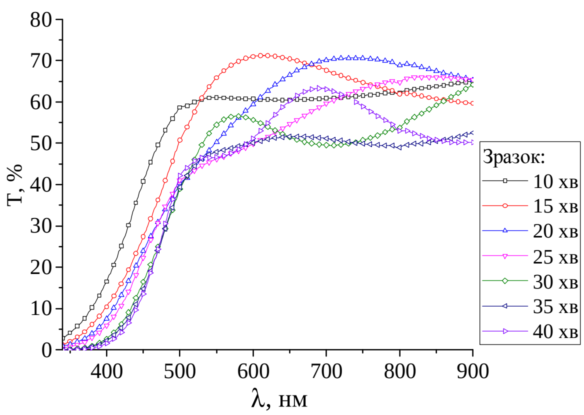


Fig. 2 The spectral dependences of optical transmission of In_2S_3 films.

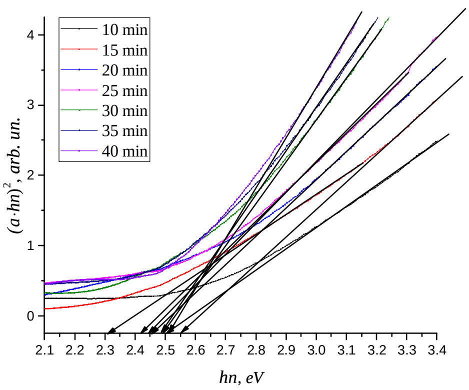


Fig. 3 Plot of $(\alpha \cdot h\nu)^2$ vs. $h\nu$ (b).

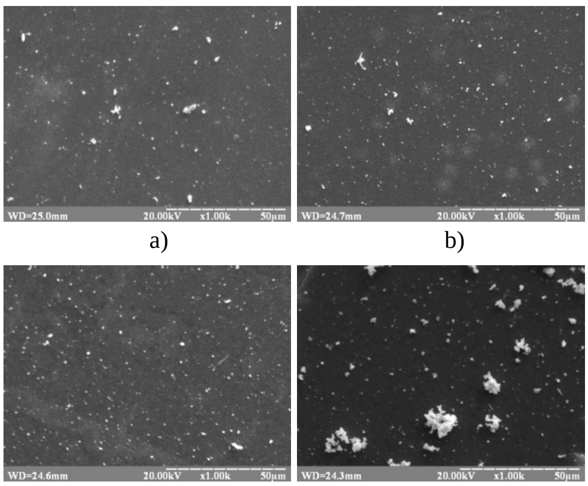
The optical band gaps of the films (Fig. 3) are localized in the ranges 2,31-2,55 eV, which is in good agreement with literature data for films of indium sulfide, deposited by chemical methods. [3,4].

TABLE 1

RESULTS OF THIN FILMS MICROANALYSIS

Deposition time, min.	Content In, at.%	Content S, at.%	In/S
10	43.812	56.188	1.283
15	40.125	59.875	1.492
20	41.891	58.109	1.387
25	41.844	58.156	1.390
30	41.734	58.266	1.396
35	42.013	57.987	1.380
40	43.052	56.948	1.323

The surface of In_2S_3 films (Fig.4 a – d) is smooth and homogeneous, solid, completely covering the surface of the substrate. With the increase duration of synthesis there is a change in color from yellow lemon to orange. The duration of the process also affects the thickness and thickness defects obtained films. More inclusions of approximately the same color, the number of which increases over time.



a) b) c) d)

Fig. 4 Surface morphology of the In_2S_3 films, deposited for a) 10 min; b) 20 min; c) 30 min; d) 40 min.

Conclusion

The possibility of the synthesis of films by chemical precipitation using acetate acid, as complexing, indium sulfate, as a donor of Indium ions and thioacetamide as a sulfating agent [1-4, 5-9], has been confirmed. In this paper, the synthesis and properties of thin films of indium sulfide were studied.

The influence of the deposition time on the surface morphology and the coefficients of light transmission has been investigated. The value of bang gap energy has been experimentally determined (2,31-2,55 eV). The atomic composition and phase composition of films are determined. It has been established that the quality of films is very dependent on mixing and constant temperature control. At low mixing speed, a precipitate is formed on the substrate surface.

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