



Study of Structural Properties of $\text{Ni}_3\text{Pb}_2\text{S}_2$ Films

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ABSTRACT

In this work, X-ray diffraction technique was applied to determine the structure of nickel lead sulphide thin films prepared by chemical bath deposition. The X-ray diffraction patterns reflect that polycrystalline $\text{Ni}_3\text{Pb}_2\text{S}_2$ could be obtained using the method explained. The XRD data show that an increasing the deposition time from 7 to 30 hours resulted in increase in the number of peaks.

Keywords: Thin films, Solar Cell, Chemical Bath Deposition, X-ray Diffraction.

INTRODUCTION

The investigation of the properties of thin films has received great attention all over the world. For example, the obtained films could be characterized by using several techniques such as spectroscopic ellipsometry^{1,2}, Raman Spectroscopy³⁻⁵, electrochemical impedance spectroscopy⁶⁻⁸, profilometer^{9,10}, Rutherford backscattering spectrometry¹¹⁻¹⁴, scanning tunneling microscopy¹⁵⁻¹⁷, and atomic force microscopy¹⁸⁻²⁰. These films exhibit excellent chemical, optical, physical and electrical properties. Therefore, these materials are potential candidate for application in laser, sensors, optoelectronic devices, solar cell, photoconductive, electronic devices and thin film transistors.

In this paper, the structure properties of $\text{Ni}_3\text{Pb}_2\text{S}_2$ films prepared under various deposition

times were studied using X-ray diffraction technique. Deposition was carried out in a chemical bath in the presence of complexing agent at room temperature.

MATERIALS AND METHODS

In this experiment, all the reagents were of analytical grade and de-ionized water (Alpha-Q Millipore) was employed as solvent. The substrates used for the deposition process were indium tin oxide (ITO) coated glass slide. These slides were washed with distilled water, followed by ultrasonic cleaned in acetone solution. During the deposition process, 20 ml of 0.7 M triethanolamine solution (complexing agent) was added into the beaker that contained 25 ml of 0.5 M nickel sulphate and 25 ml of 0.5 M lead nitrate, respectively. Then, 25 ml of 0.5 M of sodium thiosulfate was added into these beakers,

respectively. Lastly, these solutions were mixed together for few minutes. The pH of the mixture was adjusted to 1.4 through the addition of a few drops of hydrochloric acid solution. The glass slides were kept vertically in the beaker. The deposition temperature was room temperature and the deposition time varied between 7-30 hours. After the deposition, these films were washed with distilled water and dried in air.

The structure of the films was studied by X-ray diffraction (XRD) with a PANalytical X-Pert PW 3040 diffractometer equipped with a CuK_α ($\lambda=0.15418$ nm) radiation source. Data were collected by step scanning from 10° to 90° with a step size of 0.026° (2θ).

RESULTS AND DISCUSSION

The X-ray diffraction (XRD) is mostly used in scientific industries, material science and engineering fields for the measurement of compounds. X-ray diffraction has many advantages such as the cheapest technique, x-rays are not absorbed very much by air and the samples need not be in an evacuated chamber. Therefore, this technique was used to investigate the structure of samples by many researchers²¹⁻²⁵. Fig. 1-4 show the films were synthesized for different deposition times. The XRD patterns display that these films are polycrystalline with rhombohedral structure.

Figure 1 shows the XRD pattern for the films deposited for 7 h at room temperature. Identification of the peaks such as (012) and (110) on the X-ray diffraction pattern indicates that less materials could

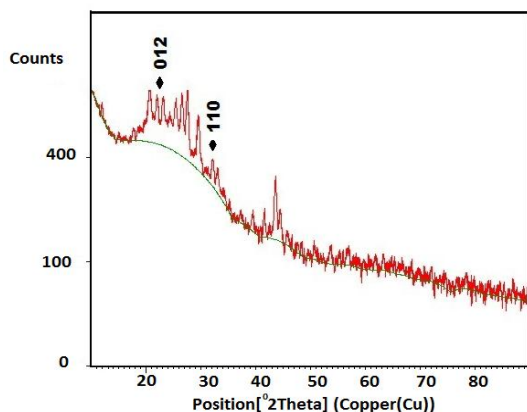


Fig. 1. XRD pattern of thin films prepared for 7 hours.

be deposited onto substrates in shorter deposition time. These peaks were in good agreement with the Joint Committee on Powder Diffraction Standard (JCPDS) data (Reference code: 00-006-0459) belonging to the $\text{Ni}_3\text{Pb}_2\text{S}_2$. Also, XRD pattern displays that the intensities of the signals are rather weak if compared to other samples due to the thin film nature of the samples.

Figure 2 and Figure 3 show the XRD patterns for the films prepared for 9 hours and 26 h, respectively. In these cases, there are three peaks corresponding to the (110), (024) and (300) planes have been observed in both samples. However, comparison between these samples indicates that the intensity of the peaks increased for the films prepared for 26 hours. The observed d -values and standard d -values are shown in Table 1.

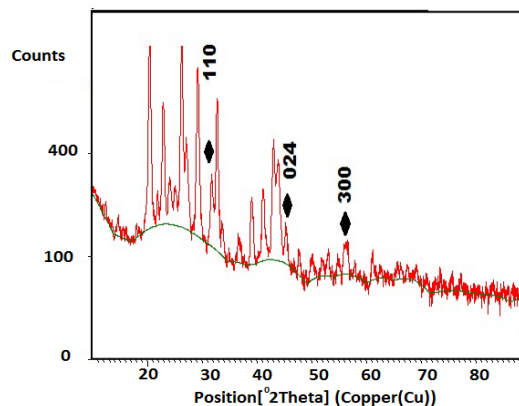


Fig. 2. XRD pattern of thin films prepared for 9 hours.

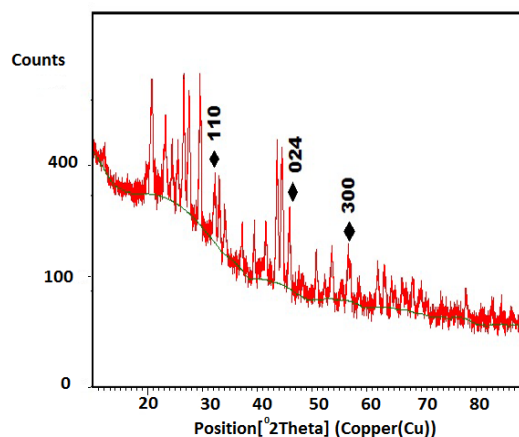
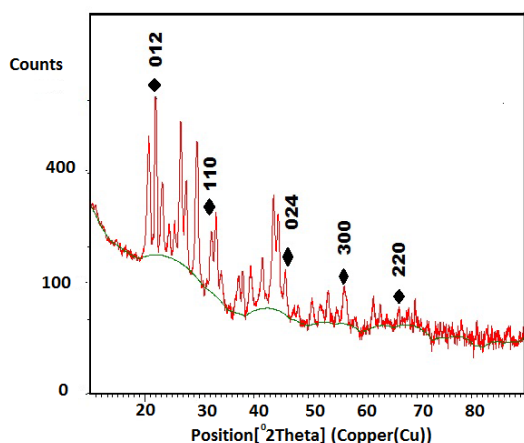


Fig. 3. XRD pattern of thin films prepared for 26 hours.

Table 1: Comparison between observed d -values of $\text{Ni}_3\text{Pb}_2\text{S}_2$ thin films prepared at different deposition times with JCPDS data.

Deposition time (h)	Standard d -values (Å)	Observed d -values (Å)	Plane (hkl)
7	3.97	3.86	012
	2.80	2.78	110
9	2.80	2.81	110
	1.97	2.00	024
	1.61	1.62	300
26	2.80	2.78	110
	1.97	1.96	024
	1.61	1.61	300
30	3.97	3.83	012
	2.80	2.78	110
	1.97	1.98	024
	1.61	1.63	300
	1.39	1.40	220

Figure 4 shows the XRD pattern for the films prepared for 30 hours. The results are well matched with the JCPDS values for $\text{Ni}_3\text{Pb}_2\text{S}_2$. When the deposition time was increased to 30 hours, the intensity and the number of the peaks were

**Fig. 4. XRD pattern of thin films prepared for 30 hours.**

increased. The XRD pattern reflects that the (012), (110), (024), (300) and (220) planes have been deposited.

CONCLUSION

The effect of deposition time on nickel lead sulphide thin films prepared by chemical bath deposition was investigated in this work. X-ray diffraction pattern shows that increasing the deposition time from 7 to 30 hours resulted in increase in the number of peaks and intensity of the $\text{Ni}_3\text{Pb}_2\text{S}_2$ peaks.

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