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Influence of Triethanolamine on the Chemical Bath Deposited NiS Thin Films

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Abstract: Problem statement: Recently, many scientists looking for new chalcogenide materials for the solar cell applications. Nowadays, silicon-based solar cell became dominant products in the market. Because of expensive silicon-based solar cells, scientists hope replaces it with cheaper chalcogenide materials. **Approach:** The binary chalcogenide materials were deposited onto microscope glass slide using simple chemical bath deposition method. Here, we study the influence of complexing agent in the preparation of thin films. The structural and morphological of the deposited films have been studied using X-ray diffraction and scanning electron microscopy, respectively. **Results:** The X-ray diffraction data showed that the films had polycrystalline in nature with hexagonal structure. The films deposited using 0.1 M of triethanolamine showed more NiS peaks and larger grain sizes as compared with 0.05M and 0.2 M triethanolamine based on the X-ray diffraction and scanning electron microscopy analysis, respectively. **Conclusion:** The complexing agent played important role during the deposition process.

Key words: Complexing agent, chemical bath deposition, triethanolamine, thin films, material wastage, cheaper chalcogenide, larger grain sizes, microscope glass slide, X-Ray diffraction, scanning electron microscopy

INTRODUCTION

In recent years, the synthesis and characterization of metal chalcogenide thin films have attracted great attention due to their brilliant applications such as solar cells, sensor and laser materials. Chemical bath deposition method has many benefits such as simple, no requirement of sophisticated instruments, minimum material wastage and easy coating of large surfaces. This method is based on the controlled release of the metal ions and chalcogenide ions in an aqueous bath into which the substrates are immersed. Several authors have reported on the chemical bath deposition of FeS_2 (Anuar *et al*., 2010a), CdS (Cao *et al*., 2010), ZnO (Abdullah *et al*., 2009), In_2S_3 (Asenjo *et al*., 2010), PbSe (Kassim *et al*., 2010), CdSe (Gopakumar *et al*., 2010), SnS (Guneri *et al*., 2010), Cu_4SnS_4 (Anuar *et al*., 2010b), SbCuS (Ekuma *et al*., 2010), $CuInSe_2$ (Hankare *et al*., 2010), $CuBiS_2$ (Sonawane *et al*., 2004) and $Cd_{0.5}Zn_{0.5}Se$ (Kale *et al*., 2007) thin films from aqueous solution. Sometimes, several complexing agents have been utilized in the deposition of thin films such as disodium ethylenediaminetetraacetate, tartaric acid, ammonia, triethanolamine and nitrilotriacetic acid.

In this study, we report for the first time the effects towards the NiS thin films properties by varying the concentrations (0.05-0.2 M) of triethanolamine. The structural and morphological of thin films were investigated.

MATERIALS AND METHODS

Microscope glass slides were used as the substrate during the deposition process. The substrates were first cleaned in ethanol and then ultrasonically washed with distilled water. Finally, substrates were dried in an oven at 90°C. Nickel sulphate, sodium thiosulphate, triethanolamine and hydrochloric acid of analytical reagent grade were used as received. Aqueous solutions of nickel sulphate, sodium thiosulphate and triethanolamine were separately prepared before experiment. 25 mL of nickel sulphate (0.15 M) and 25 mL of triethanolamine (0.05- 0.2 M) were mixed in a beaker. Then, 25 mL of sodium thiosulphate (0.15 M) was added and the pH of the solution was adjusted to 1.5 by addition of hydrochloric acid using pH meter. Substrates were immersed vertically in the solution.

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Then, the beaker was placed in water bath at desired temperature of 80 °C. The beaker was not stirred during the thin films deposition. After completion of films deposition (90 min), the deposited films were washed with distilled water and dried in air.

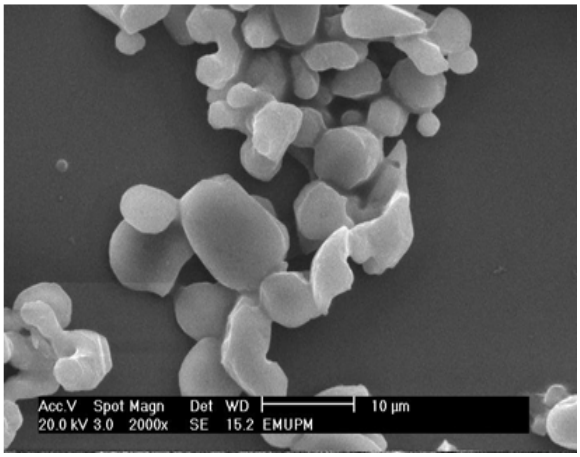
X-ray diffraction analysis was carried out using a Philips PM 11730 diffractometer for the 2θ ranging from 30°-70° with CuKα (λ = 1.5418 Å) radiation. The surface morphology was observed by a scanning electron microscopy (JEOL, JSM-6400). All the samples taken at 20 kV with a 2000 X magnification.

RESULTS

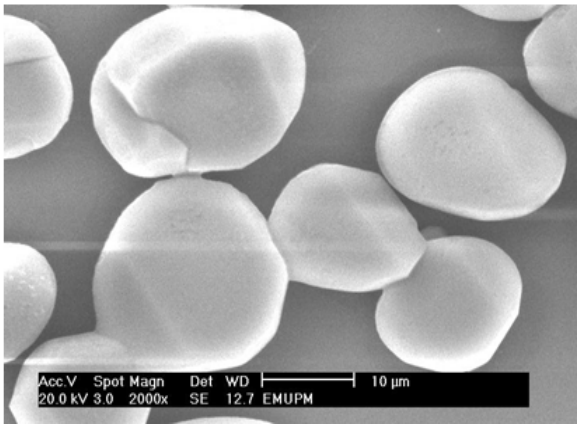
In this study, the structure characterization and surface morphology were performed using the X-ray diffraction and scanning electron microscopy, respectively. Table 1 shows the X-Ray Diffraction (XRD) data of the nickel sulphide thin films deposited at different concentrations of triethanolamine. The results of the experiments showed that the concentration of triethanolamine affect the number of NiS peaks as presented in the Table 1. The XRD data demonstrated that the NiS peaks increased with the rise in concentration of triethanolamine (TEA) up to 0.1 M. Conversely, the NiS peak dropped for the films deposited at higher concentration of TEA (0.2 M). Figure 1 shows the Scanning Electron Microscopy (SEM) micrographs of the chemical bath deposited NiS thin films prepared under various concentrations of triethanolamine. The increase in grain size reached maximum for the films deposited using 0.1 M TEA, then a slightly decreased as the concentration of TEA is further increased to 0.2 M. There was a significant influence of concentration of complexing agent (triethanolamine) on the properties of thin films.

Table .1: Comparison of the JCPDS d-spacing data for nickel sulphide thin films to experimentally observed values for the samples deposited at various concentrations of triethanolamine

Concentration of TEA (M)	2θ (°)	hkl	d-spacing (Å) Observed	JCPDS
0.05	34.4	101	2.56	2.59
	45.5	102	1.98	1.98
0.1	34.4	101	2.57	2.59
	45.7	102	1.99	1.98
	53.6	110	1.72	1.72
	61.1	103	1.53	1.52
0.2	34.4	101	2.57	2.59
	45.7	102	1.99	1.98
	53.0	110	1.72	1.72



(a)



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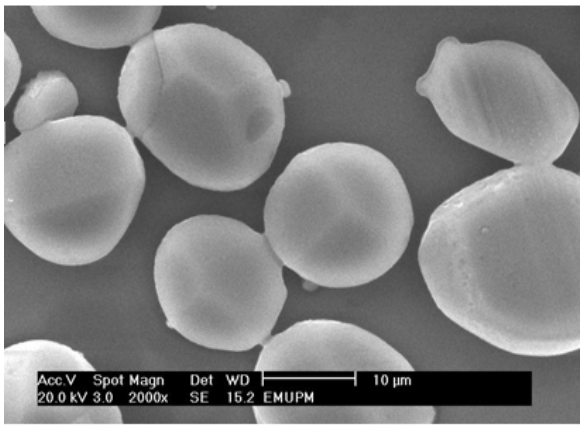

(c)

Fig. 1: Scanning electron microscopy micrograph of NiS thin films prepared at various concentrations of triethanolamine. (a) 0.05M (b) 0.1 M (c) 0.2 M

DISCUSSION

Based on the XRD data obtained, all the samples indicated polycrystalline in nature. There are only two peaks attributable to hexagonal phase of NiS were obtained for the films deposited with 0.05 M TEA. The number of peaks increased to four as the concentration of triethanolamine was increased to 0.1 M. However, as the concentration of triethanolamine was increased further to 0.2 M, the number of peaks decreased to three indicating less favorable conditions for the formation of NiS films. All the peaks matched well with the standard Joint Committee on Powder Diffraction Standard (JCPDS) data (Reference code: 00-065-0830) for hexagonal phase of NiS. For the films deposited using 0.05M of triethanolamine, the growth of the grains was not distributed evenly and focused at certain part of the substrate. The grains were found to be small and the size of the grains varied from 2 to 10 μm. On the other hand, it is observed that the films deposited using 0.1M TEA have larger grain sizes (16-20 μm) as compared with the films deposited using 0.2 M TEA. This is due to the fact that higher concentration of complexing agent hinders the deposition of nickel sulphide thin films. Furthermore, the surface morphology of these films (0.1 M TEA) are becomes more homogeneous. It is found that the films deposited using 0.2 M of triethanolamine is irregular and the sizes of the grains are dissimilar to each other (8-16 μm).

CONCLUSION

NiS thin films were deposited on microscope glass substrate using the chemical bath deposition method. The X-ray diffraction data indicated that the number of peaks increased as the concentration of triethanolamine was increased up to 0.1M. Based on the scanning electron microscopy analysis, the grains were found to be small for the films deposited using 0.05 M TEA. However, the grain size was much bigger for the films prepared using 0.1 and 0.2M of TEA.

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