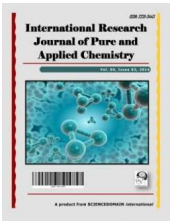

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Preparation of Ternary ($Ni_3Pb_2S_2$) Thin Films by Chemical Bath Deposition Method

S. M. Ho[1*]

[1]Faculty of Science, Technology, Engineering and Mathematics, INTI International University, Putra Nilai, 71800, Negeri Sembilan, Malaysia.

Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

In this work, the synthesis of $Ni_3Pb_2S_2$ thin films using chemical bath deposition method was carried out. The films were deposited onto glass substrate from aqueous solutions in the absence of complexing agent. The atomic force microscopy analysis showed that the non-uniformity surface with island shaped grains. Meanwhile, in optical properties studies, the band gap was calculated to be 1.42 eV, from its UV-Visible absorption spectrum.

Keywords: Thin films; atomic force microscopy; ternary compound; semiconductor.

1. INTRODUCTION

Deposition of binary, ternary and quaternary thin films have been prepared by different deposition methods such as thermal evaporation [1], electron beam evaporation [2,3], successive ionic layer adsorption and reaction [4], chemical bath deposition [5-12], electro deposition [13], vacuum evaporation [14], spray pyrolysis [15] and flash evaporation [16] have been reported by many researchers. These films are attracted great attention from researchers due to they already

**Corresponding author: E-mail: soonmin.ho@newinti.edu.my;*

widely used in electronic and optoelectronic devices. For example, ternary thin films have band gap energy very suitable to the photovoltaic conversion of solar energy. In addition, these compounds are direct band gap semiconductor with a high value of the absorption coefficient. In this study, an investigation of the properties of chemical bath deposited thin films in the absence of complexing agent was reported. The obtained films were characterized using atomic force microscopy and UV-Visible spectrophotometer.

2. MATERIALS AND METHODS

The films were deposited on the microscope glass slide from an acidic solution (pH=1.5) using nickel (II) sulfate, lead (II) nitrate and sodium thiosulfate. The glass slide cleaning process was discussed elsewhere [17]. All the chemicals were prepared in deionized water with a resistivity of 18.2 MΩcm. 20 mL of 0.1 M sodium thiosulfate was placed into separate beakers which contained 20 mL of 0.1 M of nickel (II) sulfate and 20 mL of 0.1 M lead (II) nitrate, respectively. Then, the components of a mixture were physically mixed together under continuous stirring. Lastly, the glass slide was suspended vertically in the solution with the aid of a beaker cover. Thin films were grown on the glass slide in the bath temperature of 70°C. After a deposition time of 60 minutes, the sample was taken out and dried in constant temperature oven at 80°C for 8 hours.

Surface topography was investigated using an atomic force microscopy (Quesant Instrument Corporation, Q-Scope 250) technique. It was operated in contact mode, with a commercial Si_3N_4 cantilever. Optical absorption study was carried out using the Perkin Elmer UV/V is Lambda 20 Spectrophotometer.

3. RESULTS AND DISCUSSION

$Ni_3Pb_2S_2$ thin films were deposited on microscope glass slide using chemical bath deposition method. In this experiment, nickel (II) sulfate, lead (II) nitrate and sodium thiosulfate were the sources of Ni^{2+}, Pb^{2+} and S^{2-} ions, respectively. The chemical bath deposition process is a slow process. The formation of a solid phase from a solution involves two steps, namely nucleation and particle growth. Under the suitable process conditions, nucleation centers took place on the substrate. Here, Pb^{2+}, Ni^{2+} and S^{2-} ions combine to grow up to a certain thickness of the films.

Fig. 1 indicates a three dimensional of atomic force microscopy (AFM) image of $Ni_3Pb_2S_2$ thin films deposited onto glass substrate in the absence of complexing agent. Several small grains are observed to agglomerate and eventually produce a few bigger grains as shown in Fig. 1. The average sizes were observed to be in the range between 0.5 to 1.5 µm. Meanwhile, the thickness of the films was 929.6 nm. On the other hand, the AFM image showed the incomplete surface coverage and randomly distributed on the substrate surface. In other words, the thin films deposition process on substrates depends chiefly on the formation of nucleation sites and subsequent growth of the film from these centers.

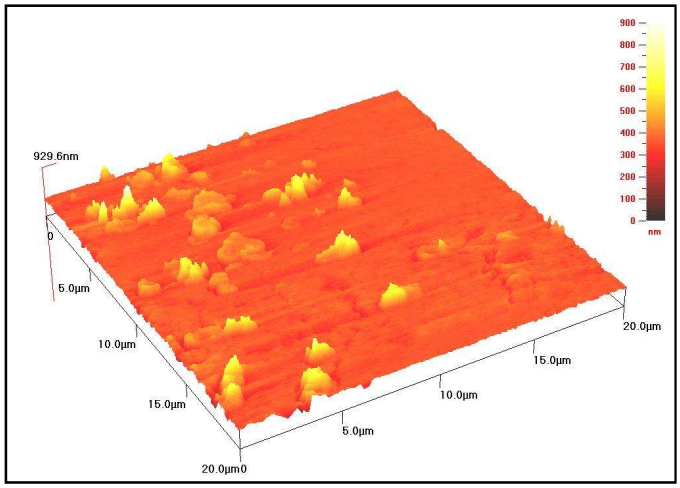

Fig. 1. Atomic force microscopy image of $Ni_3Pb_2S_2$ thin films

The optical property has been carried out in the range 300 to 900 nm using UV-Visible Spectrophotometer. In this work, optical transmittance and absorption spectrum of the films is shown in Fig. 2 and 3, respectively. The transmittance value is observed increase with increasing wavelength from 300 to 900 nm as shown in Fig. 2. On the other hand, the films absorb strongly in the visible regions as shown in Fig. 3. It means that, these compounds could be used in the solar cell applications. During the experiment, the film-coated glass substrate was placed across the sample radiation pathway while the uncoated glass substrate was put across the reference path. Then, the absorption data were used for the determination of the band gap energy as indicated in Equation 1.

$$A = \frac{[k(h\nu - E_g)^{n/2}]}{h\nu} \quad (1)$$

where v is the frequency, h is the Planck's constant, k equals a constant while n carries the value of either 1 or 4. The value of n is 1 and 4 for the direct transition and indirect transition, respectively. Fig. 4 indicates that the plot of $(Ahv)^2$ versus hv for thin films deposited in the absence of complexing agent. The band gap estimate to be 1.42 eV when the linear part is extrapolated to y-axis at $(Ahv)^2=0$.

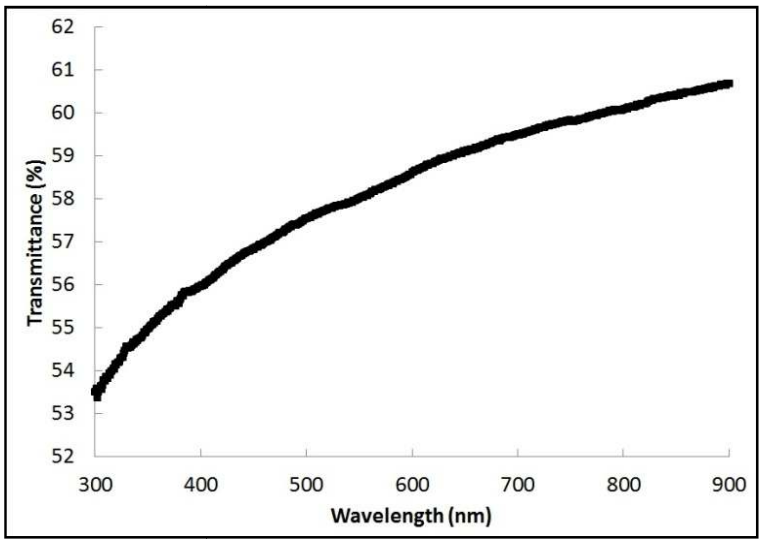

Fig. 2. Transmittance spectrum of $Ni_3Pb_2S_2$ thin films

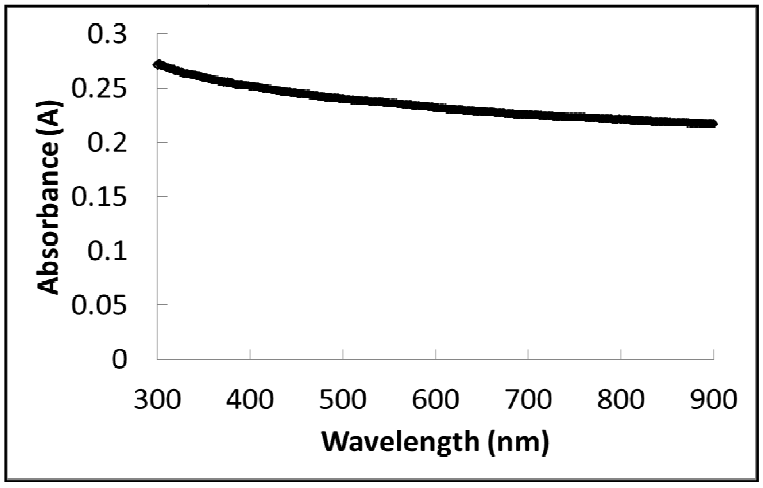

Fig. 3. Optical absorbance versus wavelength of the $Ni_3Pb_2S_2$ thin films

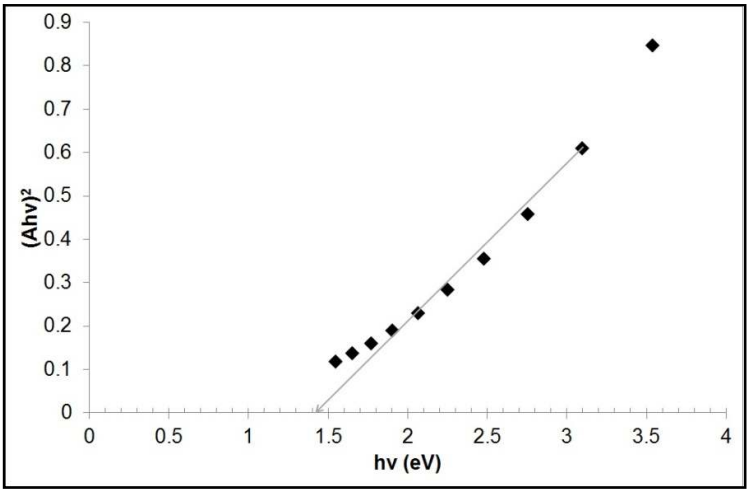

Fig. 4. Plot of $(Ahv)^2$ versus hv for the $Ni_3Pb_2S_2$ thin films

4. CONCLUSION

$Ni_3Pb_2S_2$ thin films with the band gap of 1.42 eV have been successfully deposited by using chemical bath deposition technique. The obtained films showed strong absorption in the visible regions.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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