Chemical bath deposition of NiSe thin films from alkaline solutions using triethanolamine as complexing agent

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ABSTRACT

The nickel selenide thin films were prepared onto microscope glass slides by chemical bath deposition technique. The X-ray diffraction and scanning electron microscopy have been used for their structural and morphological characterization. The X-ray diffraction result shows that thin films have a polycrystalline and rhombohedral structure. The scanning electron microscopy micrograph shows the thin films cover the glass substrate completely and consisted of irregular shaped grains. The optical properties of thin films were determined from analysis of measured absorbance spectrum. The nickel selenide thin films exhibited direct band gap transition with band gap energy of 1.8 eV.

Key words: chemical bath deposition, nickel selenide, photovoltaic cells, thin films.

INTRODUCTION

In the past several years, synthesis and physical characterization of thin film semiconductors have attracted significant interest. They have a wide variety of applications such as solar cells[1-3], electroluminescent devices, photoconductors, sensor and infrared detector devices. Chemical bath deposition method has been used for the deposition of thin films of sulphides[4-6] and selenides[7-9]. However, there is no literature review for the preparation of NiSe thin film using chemical bath deposition method so far. The basic principal involved in chemical bath deposition technique is the controlled precipitation of the desired compound from a solution of its constituents. This requires the ionic product must exceed the solubility product. The use of complexing agent is very common in the preparation of thin films. Many researchers use various complexing agents such as sodium citrate[10], ammonia[11], triethanolamine[12] and disodium ethylene diamine tetra-acetate[13] during deposition of thin films.

In the present investigation, thin films of NiSe were prepared from an alkaline bath using $NiSO_4$ and Na_2SeO_3 acted as a source of nickel and selenide ion, respectively. The triethanolamine $[N(CH_2CH_2OH)_3]$ was used as a complexing agent during deposition process. The nickel selenide thin film characterization including structural, morphological and optical was presented.

MATERIAL AND METHODS

All the chemicals used in the present investigation were analytical reagent grade. All the solutions were prepared by dissolving appropriate quantity of materials into deionized water. The microscope glass slide was used as the substrate in this study. In order to remove the oily substance from the surface, the glass slides were washed using ethanol for 10 min and finally ultrasonically cleaned with deionized water for 15 min. A 10 ml of triethanolamine (3.75 M) and 25 ml nickel sulphate (0.3 M) was added to 25 ml of sodium selenosulphate (0.3 M) and the resultant solution was stirred to get homogeneous solution in a beaker. The pH of chemical bath was adjusted to 11 by adding sodium hydroxide (NaOH). The glass slide was then placed vertically inside this beaker without disturbing it. The beaker was placed in a water bath at the desired temperature (50 °C). After completion of film deposition (3 h), the glass slide was removed from the beaker, washed well with deionized water and dried in desiccator.

X-ray diffraction of sample was recorded by using a Philips PM 11730 diffractometer with CuK_{α} (λ=0.15418 nm) radiation. The thin film surfaces were analyzed by scanning electron microscopy (JEOL, JSM-6400). Optical characterization of the deposited thin films was obtained using a Perkin Elmer UV/Vis Lambda 20 Spectrophotometer in the wavelength range 320 to 800 nm. An uncoated glass slide was used as reference to standardize the results.

RESULTS AND DISCUSSION

The examination of crystal structure of the thin film was carried out using X-ray diffraction (XRD) technique. The XRD pattern of the NiSe thin film is shown in Fig. 1. The well defined (300), (021), (211) and (131) planes are observed in the XRD pattern. The nickel selenide thin films are polycrystalline. All of the diffraction peaks can be attributed to rhombohedral structure of NiSe thin film. The single phase thin film exhibited the observed *d*-spacing values is in good agreement with JCPDS (reference code: 00-018-0887) data[14]. The lattice parameters are a=10.01 Å, b=10.01 Å and c=3.32 Å.

The surface morphology of sample was investigated using scanning electron microscopy (SEM). Figure 2 shows the SEM micrograph of NiSe thin film deposited on the microscope glass slide at 1000x magnification. The thin film is composed of largely irregular-shaped grains of diameter 1-10 µm. This is due to several crystallites grouped together to form larger grains. Also, the grains tend to cover the substrate completely.

The absorbance spectrum of the film was taken by using UV-Vis Spectrophotometer between 320 and 800 nm. Fig. 3 shows the absorbance spectrum of nickel selenide thin film. It is observed that the absorption is high at lower wavelength (320 nm) and decreases sharply below a certain wavelength for NiSe thin film.

For the determination of band gap of the compound semiconductor, the best method is to study the absorption of the sample through the measurement of absorbance spectra. To decide the band gap energy, the following equation[15] is calculated.

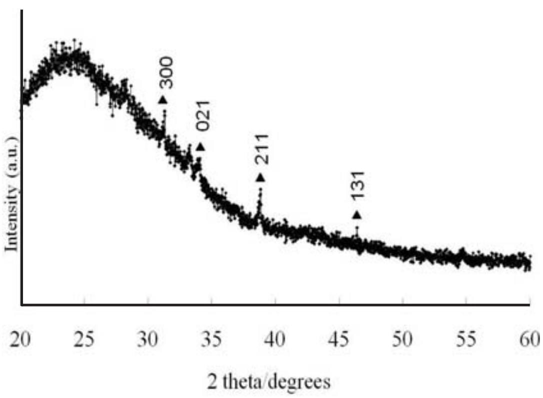

Fig. 1: X-ray diffraction pattern of NiSe thin films deposited by chemical bath deposition method

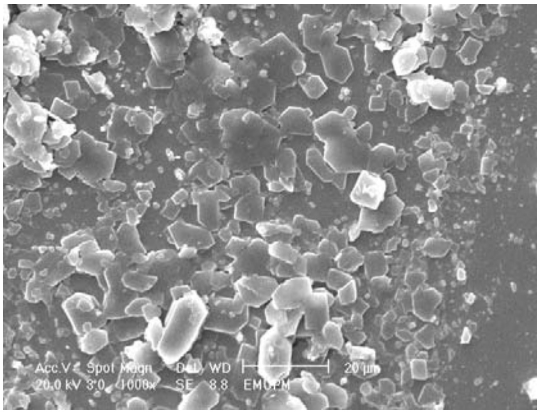

Fig. 2: The SEM micrograph of NiSe thin films deposited by chemical bath deposition method

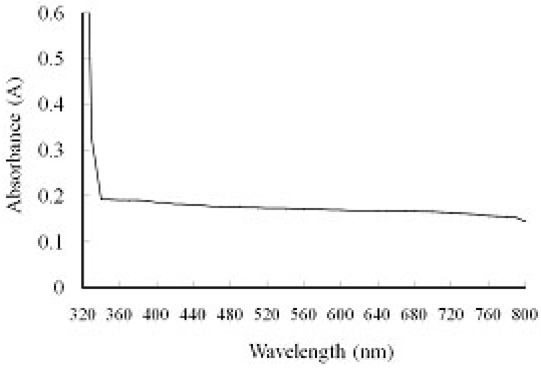

Fig. 3: Absorbance spectrum for the NiSe thin films deposited by chemical bath deposition method

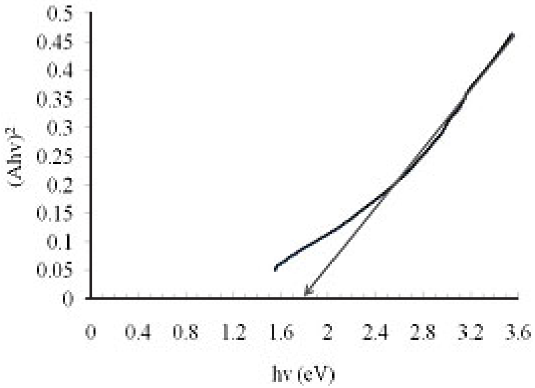

Fig. 4: Plot of (*Ahv*)^2 versus *hv* for the NiSe thin films deposited by chemical bath deposition method

$$A = \frac{[k\left(hv - E_g\right)^{n/2}]}{hv}$$

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. The band gap energy was obtained by plotting the straight line between (A*hv*)^2 and *hv* (Fig. 4), by making use of the extrapolation of energy axis. Using this equation, the band gap energy was determined to be approximately 1.8 eV. It is considered as good material for solar cell application due to band gap value closed to solar spectrum. The linear nature of the plots through the absorption range indicated that the chemical bath deposited NiSe thin films had a direct band gap. This band gap value is close to Ni_3Se_2 thin film (1.4 eV) prepared by using electrodeposition technique[16].

CONCLUSIONS

The NiSe thin films have been prepared by the chemical bath deposition technique. Deposition was carried out from aqueous solutions using nickel sulphate and sodium selenosulphate acted as a source of nickel and selenide ion, respectively. The triethanolamine was used as a complexing agent during deposition process. XRD pattern showed that the thin films produced were polycrystalline and had a rhombohedral structure. The SEM micrograph showed the films covered the glass substrate completely and consisted of irregular shaped grains. The nickel selenide thin films exhibited direct band gap transition with band gap energy of 1.8 eV.

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