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UV-VISIBLE STUDIES OF CHEMICAL BATH DEPOSITED NISE THIN FILMS

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Abstract-NiSe thin films were deposited onto microscope glass slides by chemical bath deposition method. Chemical bath deposition method could be a cost-effective technology for the production of terrestrial photoelectrochemical cells. The films obtained were characterized by UV-Visible spectrophotometer. The values of optical band gap have been determined from the absorption spectra. The deposition was carried out under different deposition times (1, 2 and 3 hours) and bath temperatures (40 and 50 °C). Based on the optical absorbance spectra, all the films exhibited a high absorbance in the visible region. The films deposited at longer time showed higher absorbance values. The band gap values obtained were found to be 2.11-2.52 eV.

Key words – chemical bath deposition, nickel selenide, thin films, UV-visible spectrophotometer, metal chalcogenide.

Introduction

Metal chalcogenides and their mixtures are attractive and useful system for solar energy conversion studies by photoelectrochemical means. Two important factors that should be considered in producing these materials are the band gap energy matching the solar spectrum and the competitiveness of production cost. The rationale for this is that thin films modules are expected to be cheaper to manufacture owing to their reduced material costs, energy costs, handling costs and capital costs. Nickel selenide is a semiconductor which is suitable for applications in solar cells, sensor and laser materials. Films of nickel selenide have previously been prepared by thermal evaporation and chemical bath deposition. Among various other methods, the chemical bath deposition method is found to be a cheap and simple way to deposit metal chalcogenide thin films such as CuS [1], CdS [2], SnS$_2$ [3], CdSe [4], In$_2$S$_3$ [5], ZnS [6], Sb$_2$S$_3$ [7], PbSe [8], CuInSe$_2$ [9], SbCuS [10], Pb$_{1-x}$Fe$_x$S [11],and CuInS$_2$ [12] The properties of materials prepared by the chemical bath deposition method are critically dependent on various preparative parameters such as the pH of the solution, deposition time, bath temperature, complexing agent, concentration of metal and chalcogenide ions.

The present studies are focused on the deposition of NiSe thin films using the chemical bath deposition method. We have demonstrated for the first time to deposit NiSe thin films using Na$_2$EDTA as complexing agent. The depositions were carried out under different deposition times (1, 2 and 3 hours) and bath temperatures (40 and 50 °C). The films were characterized by UV-Visible spectrophotometer. The values of optical band gap have been determined from the absorption spectra.

Material and methods

Microscope glass slides were used as the substrate during deposition process. The substrates were first cleaned in ethanol solution and were subsequently ultrasonically washed with distilled water. Substrates were then dried in an oven at 90 °C. Nickel sulphate, sodium selenite, disodium ethylenediaminetetraacetate and hydrochloric acid of analytical reagent grade were used as received. Aqueous solutions of nickel sulphate, sodium selenite and disodium ethylenediaminetetraacetate were separately prepared before experiment. 25 mL of nickel sulphate (0.3 M) and 25 mL of disodium ethylenediaminetetraacetate (0.3 M) were mixed in a beaker. Then, 25 mL of sodium selenite (0.3 M) was added and the pH of the solution was adjusted to 3 by addition of hydrochloric acid. Substrates were immersed vertically in the beaker. In order to study the optical properties of samples, the films were deposited at different deposition times, ranging from 1 to 3 hours and various bath temperatures (40 and 50 °C). The beaker was not stirred during the film deposition. After deposition, the deposited films were then washed with distilled water and dried in air at room temperature.

The deposited thin films were characterized for optical properties. Absorbance spectra were recorded in the range 350-700 nm by means of Perkin Elmer UV/Vis Lambda 20 spectrophotometer. The film-coated glass substrate was placed across the sample radiation pathway while the uncoated glass substrate was put across the reference path. The absorption data were used for the determination of the band gap energy (E$_g$).

Results and discussions

Fig. 1 indicates absorbance spectra of NiSe thin films which prepared at 40 °C under various deposition periods. We observed that all the samples indicated a high absorbance value in the visible light region. The highest absorbance value is detected for the films prepared for 3 hours as compared with other deposition times as shown in Fig. 1.

In order to determine the band gap of thin films, the equation of Stern was used.

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

where ν is the frequency, h is the Planck's constant, k equals a constant while n carries the value of either 1 (direct transition) or 4 (indirect transition). The plots of $(Ah\nu)^2$ versus photon energy are shown in Fig. 2 in order to investigate the band gap energy for the NiSe films prepared under various deposition periods. Extrapolating the linear-line portion of the plots of $(Ah\nu)^2$ versus $h\nu$ for zero absorption gives the band gap energy (E_g). Based on the **Fig. 2**, the band gap values obtained are 2.39, 2.48 and 2.52 eV for the films deposited for 3, 2 and 1 hour, respectively.

The absorbance spectra of nickel selenide thin films which were deposited at 50 °C at three different deposition times were recorded in the wavelength range of 350 to 700 nm as shown in **Fig. 3**. The films deposited at longer time have high absorbance value while the films deposited at shorter time indicate low absorbance value.

Using optical absorption data, the band gaps were determined from plots of $(Ah\nu)^2$ versus $h\nu$ (**Fig. 4**). The linearity of the plots indicates that the material is of the direct band gap. The energy band gap values are 2.30, 2.11 and 2.20 eV for the films deposited for 3, 2 and 1 hour, respectively.

Conclusion

NiSe thin films have been obtained by chemical bath deposition method in the presence of disodium ethylenediaminetetraacetate. The NiSe thin films deposited at longer time showed higher absorbance value. The energy band gaps obtained were found to be 2.11-2.52 eV.

Acknowledgements

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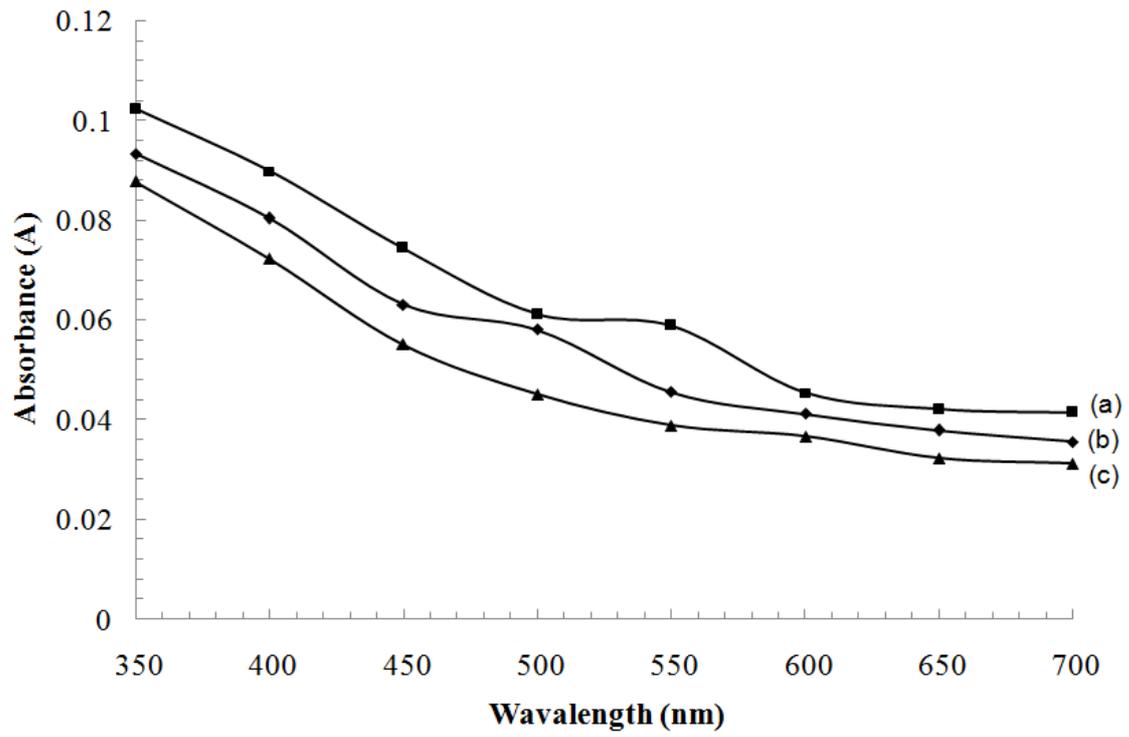
Fig. 1- Absorbance spectra of NiSe thin films deposited at 40 °C under various deposition times. (a) 3 hours (b) 2 hours (c) 1 hour
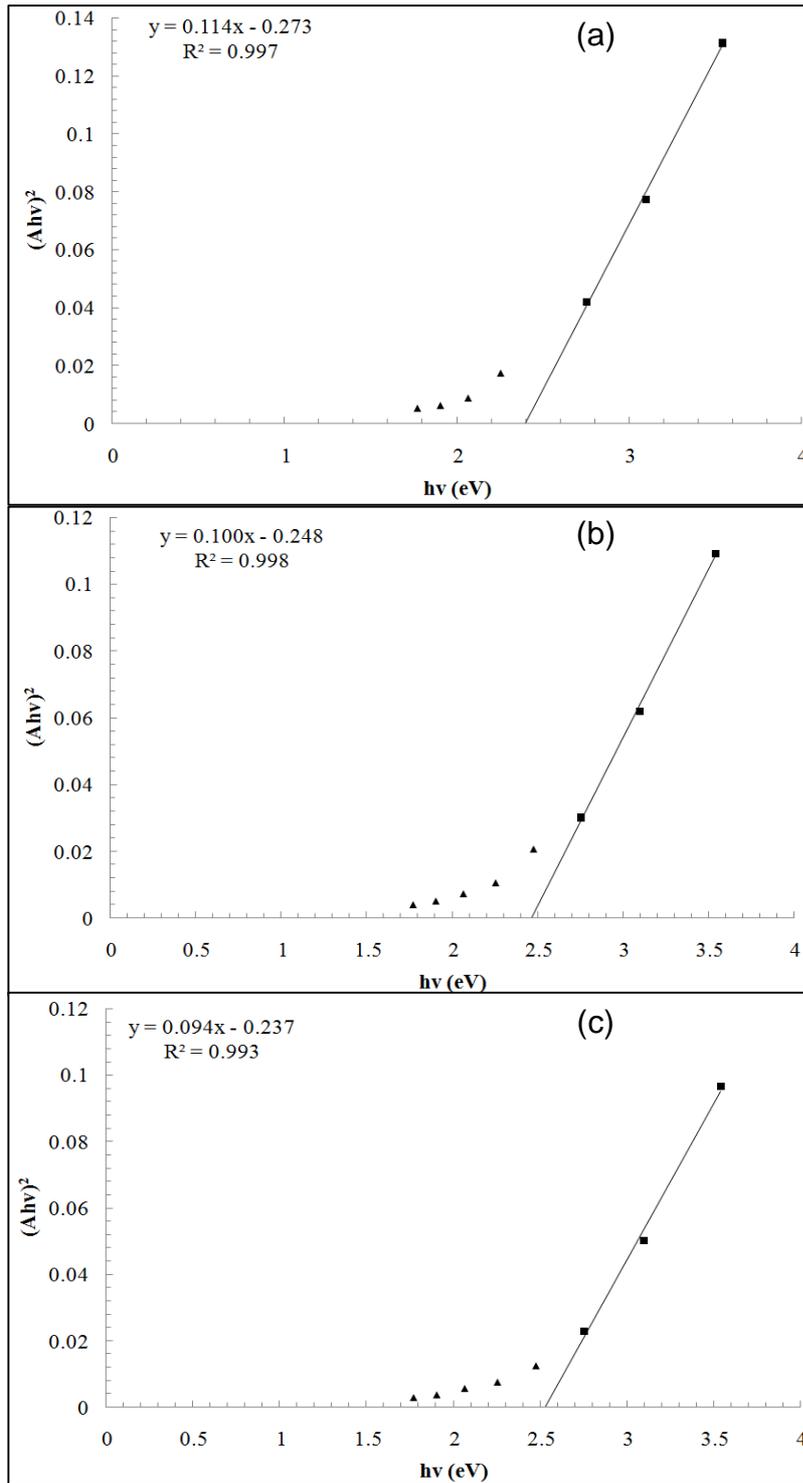
Fig. 2- Plots of $(Ah\nu)^2$ versus $h\nu$ for NiSe thin films deposited at 40 °C under various deposition times. (a) 3 hours (b) 2 hours (c) 1 hour
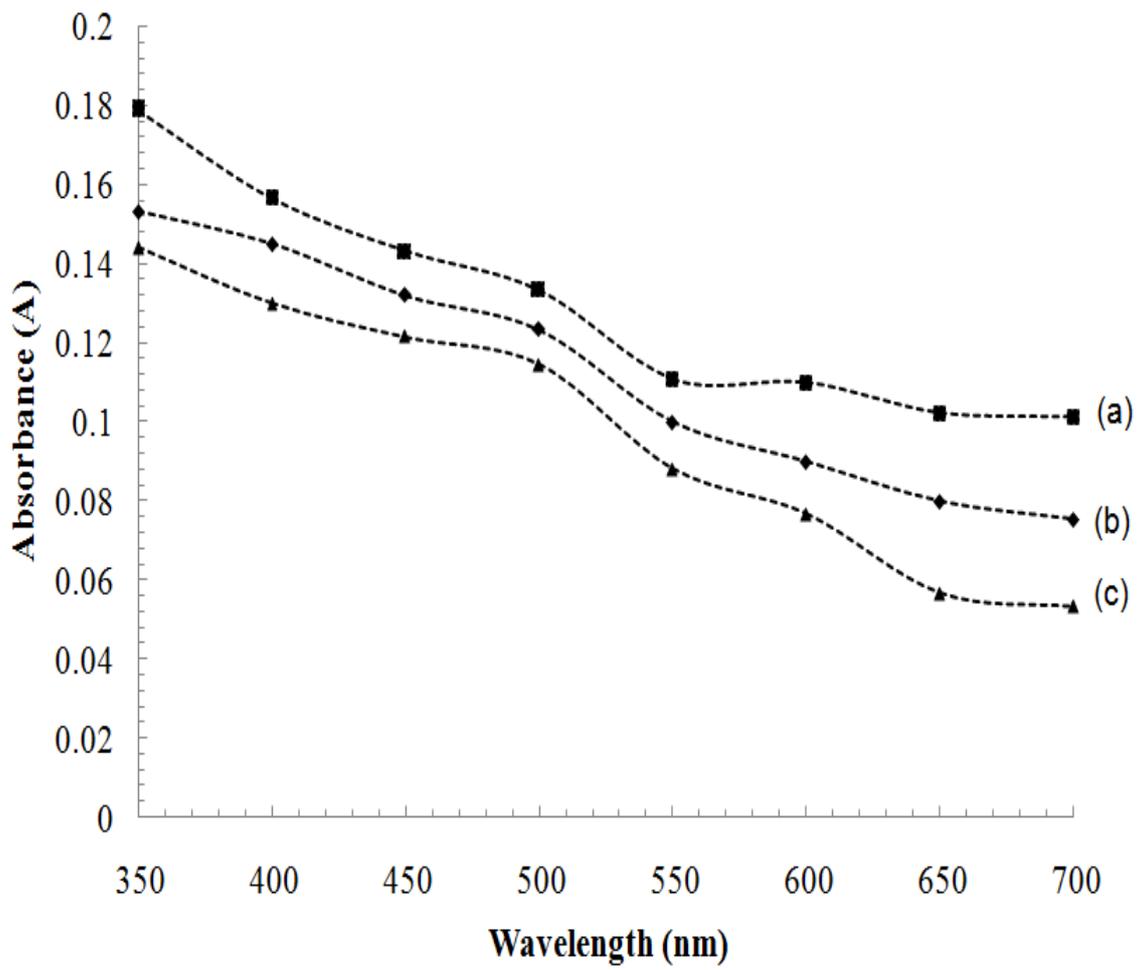
Fig. 3- Absorbance spectra of NiSe thin films deposited at 50 °C under various deposition times. (a) 3 hours (b) 2 hours (c) 1 hour
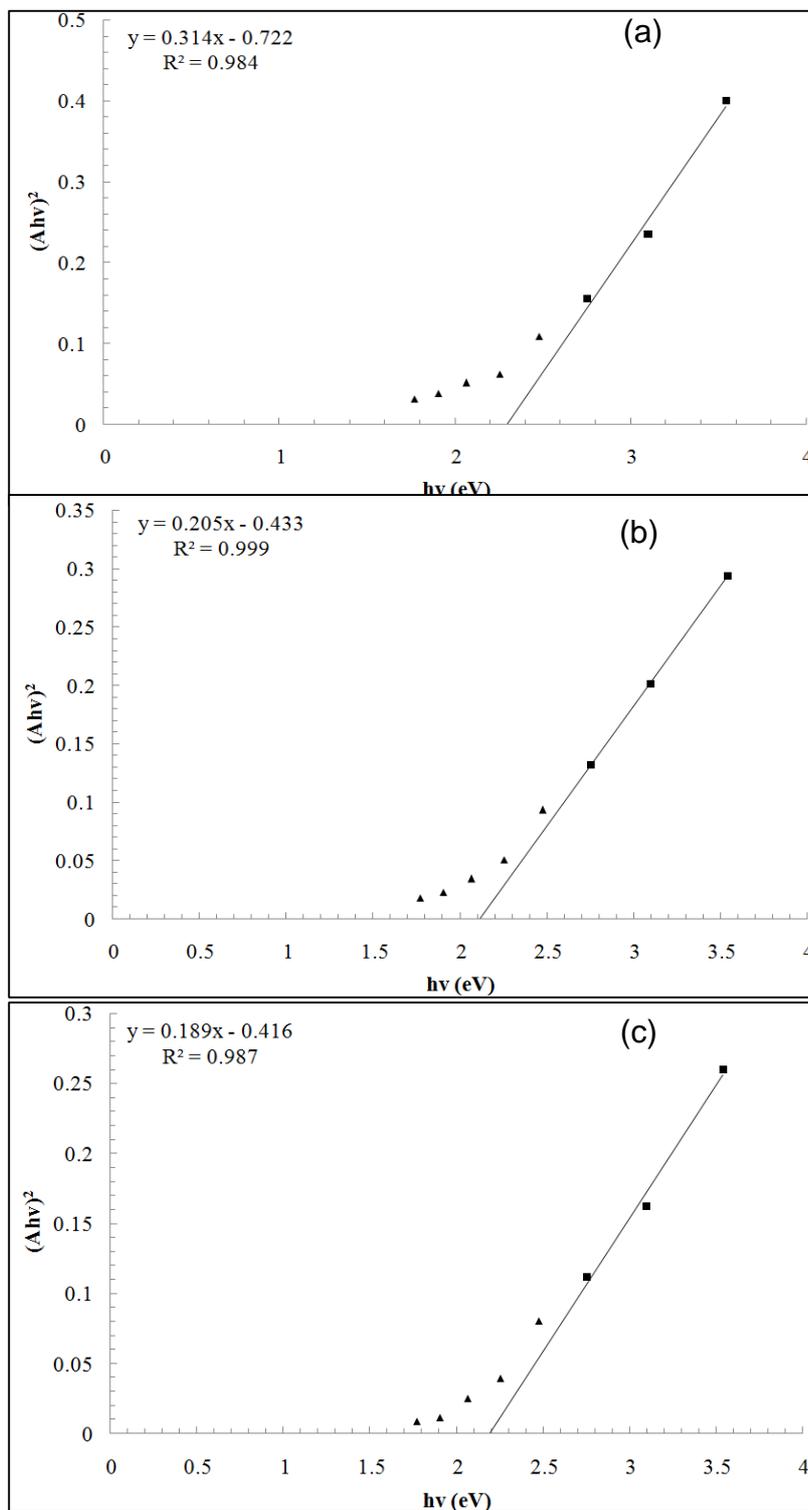
Fig. 4- Plots of $(Ah\nu)^2$ versus $h\nu$ for NiSe thin films deposited at 50 °C under various deposition times. (a) 3 hours (b) 2 hours (c) 1 hour