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Effect of Ph on Selected Properties of Nise Thin Film Deposited By Chemical Bath Technique

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Abstract: *The influence of pH on some selected properties of Nikel Selenide (NiSe) thin films deposited using the chemical bath technique was studied. The values of some selected optical properties were obtained from the transmission spectra. Our results indicates that pH has some influence on some of this properties. The result revealed that as the pH increases, the bandgap decreases. The recorded band gap lies between 2.60eV-2.99eV, while index of refraction lies in the range of 1.28 – 2.33. The dielectric constant were also found to vary with bath pH. From the findings of this current research and report of similar works, it can be deduced that NiSe thin films would have high potential as buffer layers in heterojunction solar cell.*
Keywords: *Nickel Selenide, absorption coefficient, refractive index, chemical bath, dielectric constant, bandgap*

I. Introduction

Over the years, semiconductors has gained wide usage in the fabrication of many devices. Though, silicon – based technology is by far the most advanced amongst semiconductor technology, there has been an increasing interest in the use of binary chalcogenides composites like CdSe, CuSe, CdS etc. This composites possess properties which are to some extent non-existence in silicon. This fact among others has led to increased interest in the study of binary semiconductors for possible applications in electronic, electrical, optoelectronics and in photovoltaic applications. Many researches [1- 6, 7] etc have been carried on Nickel selenides and sulphides deposited using various techniques. However in this paper we prepare NiSe thin film by chemical bath method and study the effect of pH time on some selected properties of the films using PVA as the complexing agent in an alkaline medium.

II. Experimental

The glass slides used as the substrate with dimension of 16mm x 30mm were dipped in HnO_3 for 24 hours then washed and rinsed with distilled water and dried ultrasonically in order to remove any dirt. The reaction baths for the deposition of NiSe thin films contain 5 ml, 1 M $NiCl_2$, 10 ml, 25% NH_3, 8ml, 1 M Na_2SeSO_3 and 40 ml of PVA put in that order in 80ml beaker at pH of 8.1, 9.2, 10.00 and 10.5 by adding proper amount of alkaline. Deposition was allowed to take place at a temperature of 60^O C. Thereafter, the glass slides were removed from the beaker, washed with distilled water and allowed to dry in the air. One of the films was annealed at 100^oC. Structural analysis was performed using X-ray diffractometer with CuKα radiation (λ=1.542Å). The film surface morphology was analysed using scanning electron microscope, while the transmittance measurements in the visible and near- infrared region were performed at room temperature using spectrophotometer (PMQ-H) at wavelength of 100- 1200nm from where some optical properties of the films were derived.

III. Results And Discussion

Figures 1a and b show the Scanning electron micrographs of the as-deposited NiSe films and the film annealed at100^o C. A close observation of the two micrographs indicates that homogeneity and crystallanity of the films increased with post deposition annealing. The SEM equally show clearer grains and well defined grain boundaries with rougher boundaries. The X-ray diffraction pattern of the as- deposited film is shown in figure 2. The pattern shows that film has preferred orientation along (111) plane. Other peaks observed are (031), (231), (0321) and (413) at 2θ values of 33.36^o, 40.49^o, 41.81^o and 61.82^o respectively. These peaks are however of less intensity than the peak at $2\theta = 22.0^o$ having reflection to (111) plane. The grain sizes were calculated using the Scherrer's formula [8,9,10-12]

$$D = \frac{k\lambda}{\beta \cos\theta} \quad (1)$$

Where k is a constant called the shape factor with an approximate value of 0.94, λ is the wavelength of the X-ray radiation used, β is the full-width at half-maximum (FWHM) of the (111) diffraction as expressed in radians and θ is the diffraction angle.

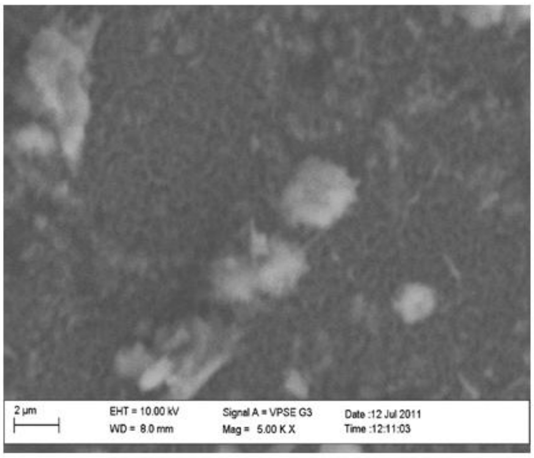


Fig.1a: SEM of as-deposited NiSe film

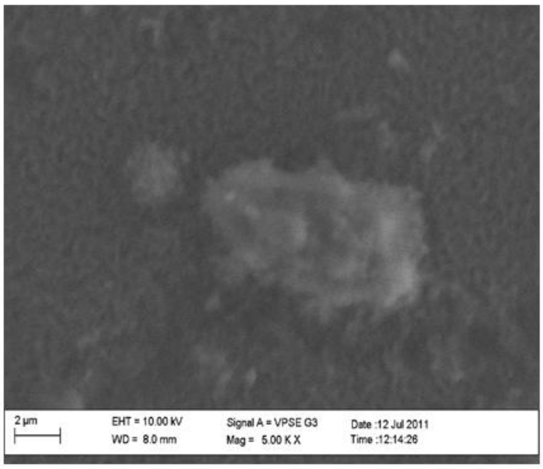


Fig.1b- SEM of NiSe film annealed at 100° C

Figure 3 shows the plot of transmittance against wavelength for NiSe thin films deposited at different bath pH. The plot shows that the films were highly transparent in the UV-region irrespective of the value of the pH. The plots indicate that as the pH decreases, the transmittance tends to increase with highest transmittance of about 81% is recorded by film deposited at pH of 8.1.

The optical absorption studies have guide to a variety of interesting thin film parameters. Usually the optical properties of the thin film are different from those of the bulk [9,13-16]. The optical absorption of NiSe thin film was studied in the wavelength range of 100 – 1200 nm. The variation of absorption coefficient against photon energy is shown in figure 4, for films deposited adifferent bath pH while the absorption spectra was analysed using the relation [4, 17, 18,19]

$$\alpha = \frac{A(h\nu - Eg)^n}{h\nu} \qquad (2)$$

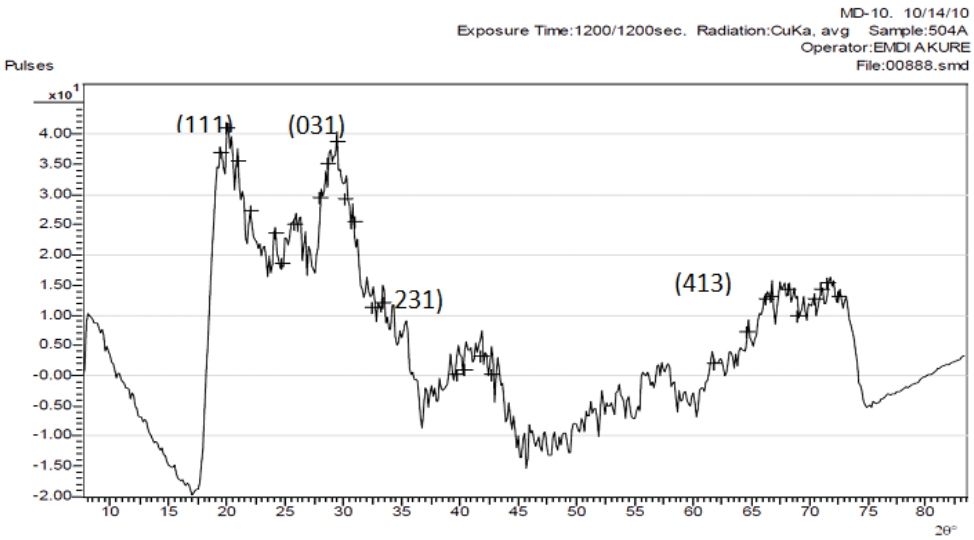


Fig.2 – XRD pattern of NiSe thin film

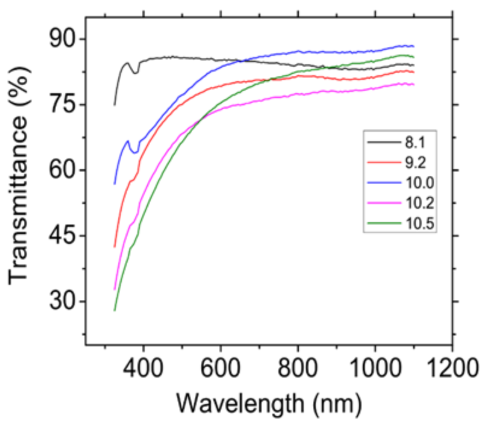


Fig. 3: Plot of Transmittance against wavelength

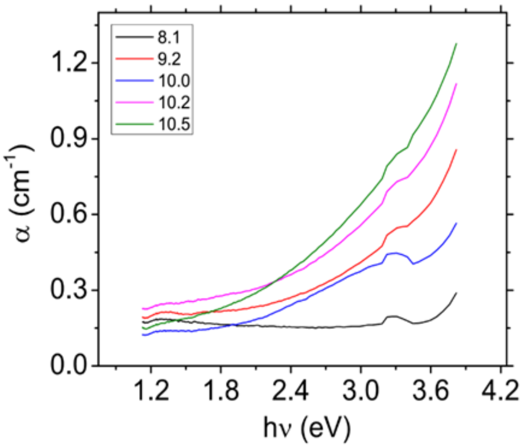


Fig. 4: Plot of absorption coefficient against photon energy

Where hv is the photon energy, E_g is the optical band gap energy. A is a constant and n =1/2 or 2 for allowed direct and allowed indirect transitions respectively. The plot of $(\alpha h\nu)^2$against hv is displayed in figure 4 for NiSe thin film at different pH. The recorded direct band gap energy are in the range of 2.60 – 2.99 eV. The trend indicates that as the pH decreases, the bandgap increases. This could be attributed to structural transformation, increasing grain size and roughening of the film. The trend could also be linked to the fact at lower pH, coalescence of the grains becomes less [8,20]. As pH increases, the concentration of free metal ions decreases, leading to decrease in the deposition rate and an increase in terminal thickness of the film provided the OH^- take part in complex formation.

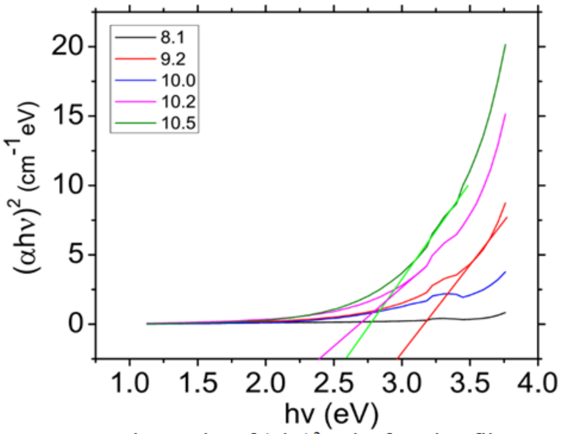


Fig. 5- Plot of $(\alpha h\upsilon)^2$ vs hυ for NiSe films at Different pH

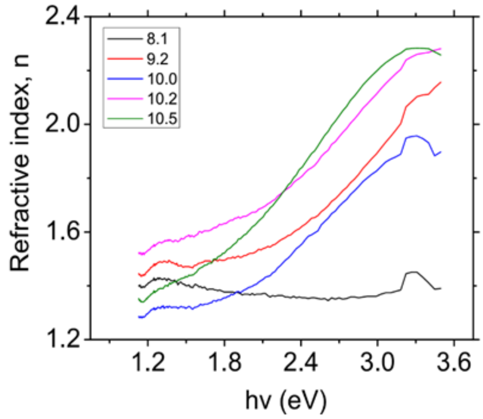
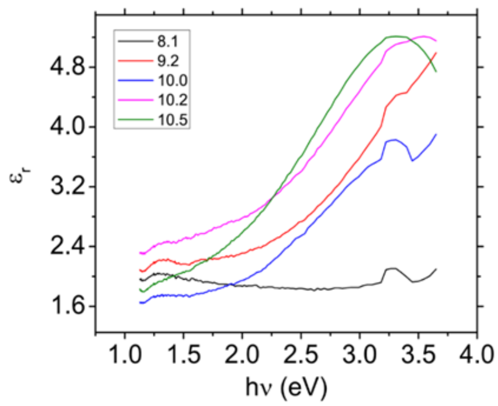
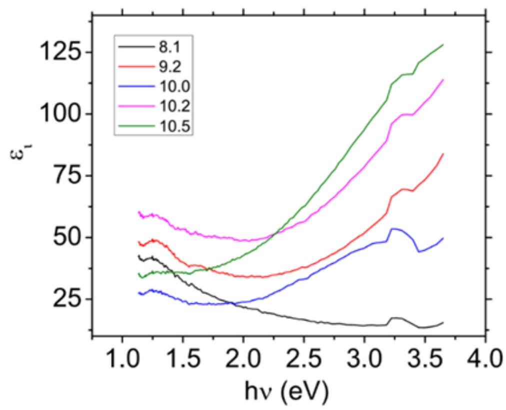


Fig.6 – Plot of n vs hυ for NiSe at different pH

The plot of refractive index, n, against photon energy is displayed in figure 6. The plot reveals that the film deposited at the highest pH has the greatest value of the index of refraction. However, for all the films, the index of refraction increases with increasing photon energy except for the film deposited at the lowest pH. The values of index of refraction lies in the range of 1.28 – 2.33. These values are in the range reported by other authors in the literature [19,21]. Figures 7a and 7b show the plot of real and imaginary dielectric constant against photon energy for the NiSe films deposited at different bath pH respectively. The plot reveals that the real ($\epsilon_{r)}$ part of the dielectric constant increases sharply with increase in photon energy whereas the imaginary ($\epsilon_{i)}$ part increases slowly in the lower region but increase sharply in the higher energy region. The results indicates that in NiSe thin films, the loss factor increases with increase in photon energy.





In this communication, we have successfully grown NiSe thin film at different bath pH in order to investigate the effect of pH on some properties of the film using the chemical bath technique. Film properties like transmittance, absorption coefficient, bandgap, index refraction and the dielectric constant were studied. Our results indicate that pH has some influence on some of these properties. The result revealed that as the pH increases, the bandgap decreases. The recorded band gap lies between 2.60eV-2.99eV, while index of refraction lies in the range of 1.28 – 2.33. The dielectric constant were also found to vary with bath pH. From the findings of this current research and report of similar works, it can be deduced that NiSe thin films would have high potential as buffer layers in heterojunction solar cell and other device applications.

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