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Short Communication

Growth and Characterization of PbSe Thin Films Prepared By Chemical Bath Deposition Technique

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Abstract

PbSe thin films were deposited on glass substrate by chemical bath deposition (CBD) technique from the aqueous solutions of lead acetate, selenium sulphate, ammonia, in which ethylene di-amine tetra acetate (EDTA) was employed as complexing agent. The grown films were optically characterized using M501 Single Beam Scanning UV/VIS Spectrophotometer. The result shows that the film has high absorbance in almost regions of electromagnetic spectra with low transmittance and reflectance values in these regions. The calculated value of the film thickness was found to be 1.11285-1.19536μm. This film thickness was also found to depend on the dip time and concentration of EDTA used. The PbSe thin film was found to have band gap energy of 1.0eV, and with high absorption coefficient obtained.

Key words: Lead selenide, absorption coefficient, transmittance, reflectance and band gap energy.

Introduction

In view of the rapid depletion of existing conventional energy resources occasion by high rate of consumption all over the world; it is apparent that mankind is heading towards energy crisis. To avert this likely energy crisis, and further meet up with energy needs of nations, renewable energy resource is the answer. Renewable energy resources are energy resources that are derived from wind, hydro, solar, biomass, geothermal, tidal and ocean. Among these wide range of energy resources, solar energy is certainly is the most attractive because it is abundant and environmental friendly. But the major challenge is how to harness this nature provision and put it in a form that will be useful. To convert this solar energy into other useful forms of energy like electrical energy an intervening system like photovoltaic device is needed. For efficient photovoltaic conversion of solar energy into electricity, a semiconductor material with desirable properties with low band gap energy, high absorption coefficient and reflectivity are needed for the fabrication of the solar cells. PbSe thin film had been prepared by other researches using methods like chemical bath deposition[1], electrochemical atomic layer epitaxy[2], photochemical[3], molecular beam epitaxy[4] and pulsed laser deposition[5].

In this paper, lead selenide (PbSe) semiconductor was grown and characterized. This semiconductor has potential application in solar cell production[6-8].

Material and Methods

Lead selenide (PbSe) thin films were prepared on glass substrate using the chemical bath deposition technique from the aqueous solutions of lead acetate, selenium sulphate, ammonia solution, and in which ethylene diamine tetra acetate (EDTA) was employed as a complexing agent. The step by step process involved in the deposition is as follows; The glass slides which served as substrates, the beaker(bath) and strirrer were first degreased in diluted hydrochloric acid for 24 hours , removed, wash with detergent and rinsed with distilled water. The essence is to ensure a clean surface necessary for the formation of thin film. The bath was prepared by sequential addition of 5ml 1M lead acetate, 5ml of 1M EDTA, 5ml of ammonia solution and 5ml of 1M selenium sulphate. The solution formed was stirred for 5 minutes before distilled water was used to make up the solution to 50ml mark on the beaker. The resultant solution was again stirred before the substrate was clamped vertically into the bath using synthetic foam as cover to prevent unwanted particles from entering the solution. The whole set-up was allowed to stand for 8 hours after which the substrate was removed, rinsed with distilled water and dried in open air.

In order to observe the effect of EDTA and dip time on the thickness of the deposited PbSe thin film, the procedure was repeated various volumes (2ml, 4ml, 6ml ,8ml 10ml) of EDTA used and the slides labeled S_1, S_2, S_3, S_4, and S_5 respectively while other parameters remains constant. Also , different dip times (2hrs, 4hrs, 6hrs, 8hrs and 10hrs) were observed with slides labeled S6, S7, S8, S9 , S10 respectively while other parameters remains constant. At the end of each process, the slide was removed and treated as earlier mentioned. The slides were found to be coated with thin films of PbSe with colour grayish in appearance. The M501 Single Beam Scanning UV/VIS Spectrophotometer was used to determine the absorbance of the deposited films. Other quantities like transmittance, reflectance[9], absorption coefficient, band gap energy and thickness of the films were obtained using the under listed equations.

The transmittance was calculated using;

$T = 10-A$ (1)

where T is the transmittance and A is the absorbance. For the absorption coefficient the formula used is;

$\alpha = A/\lambda$ (2)

where A is the absorbance and λ is the wavelength of incident radiation. The optical thickness of the film was calculated using the relation;

$t = \ln(1/T)/\alpha$ (3)

where t is the film thickness, T is the transmittance and α is the absorption coefficient.

The band gap energy was obtained from the plot of absorption coefficient squared against the photon energy. The point where the extrapolated straight part of the graph meets the photo energy axis is the band gap energy value.

Results and Discussion

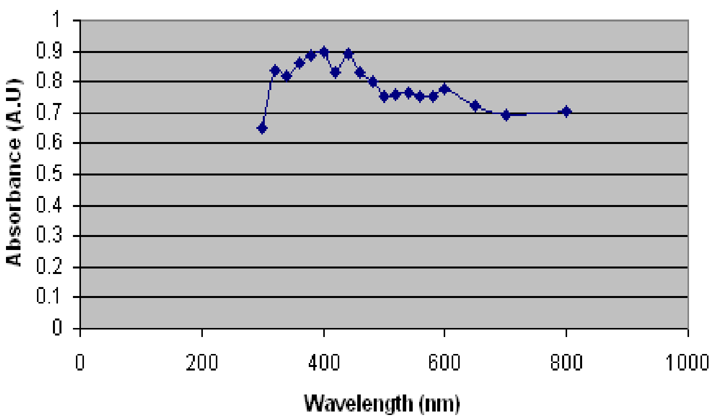

Figure-1
Plot of Absorbance against the wavelength

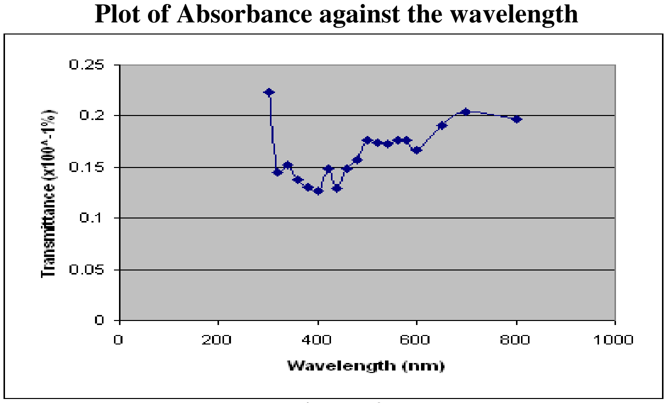

Figure-2
Plot of Transmittance against Wavelength

The transmittance spectrum of the PbSe thin film is shown in figure 2. The transmittance was found to be generally low in almost all the regions of the electromagnetic spectrum. This is an indication that the material can serve as a good absorber of solar radiation.

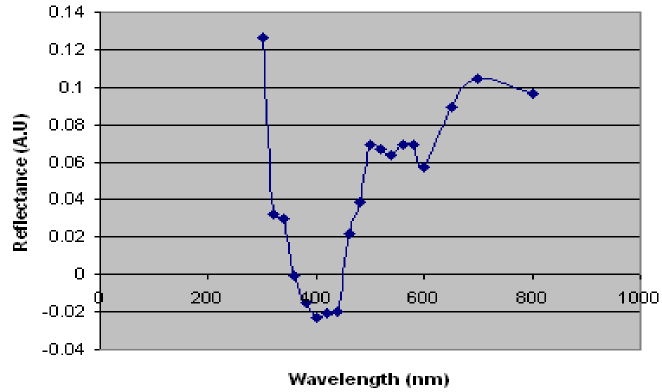

Figure-3
The Reflectance Spectrum of PbSe thin film

The plot of reflectance against the wavelength is also illustrated in figure 3. From the graph, it could be seen that PbSe thin film has poor reflectance value. This means that the material can be used for anti-reflection coatings on window glass, video screen, camera lenses, and even in photovoltaic devices like solar cells. This will protect the cell and decreases reflective loss on the cell surface.

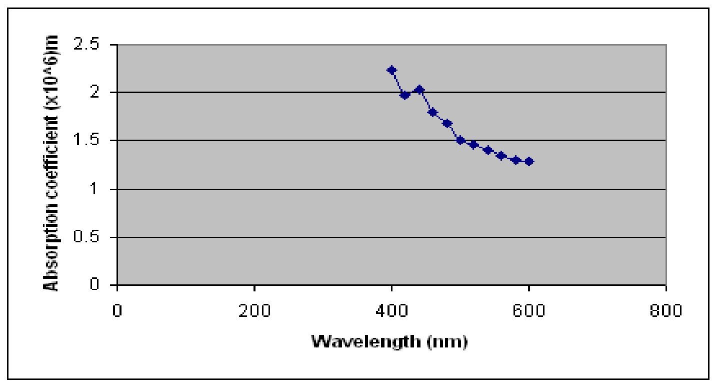

Figure-4
Plot of Absorption coefficient against the Wavelength

The graph 4 shows that the PbSe thin film has high absorption coefficient which decreases as the wavelength of incident radiation increases. This high value of absorption coefficient from UV region to visible region makes the semiconductor a good candidate for solar cells fabrication.

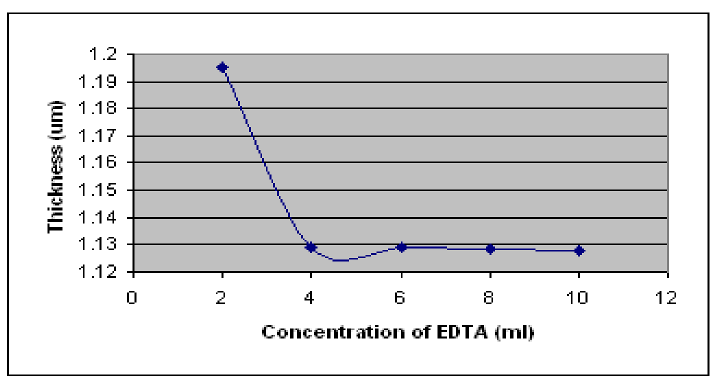

Figure-5
Variation of film thickness with the Concentration of EDTA

The variation of the film thickness with the concentration of complexing agent is shown in figure 5. From the figure, it was observed that as the concentration of the complexing agent increases in the bath the thickness of the film decreases until optimum deposition was achieved beyond which the thickness of the film remains fairly constant.

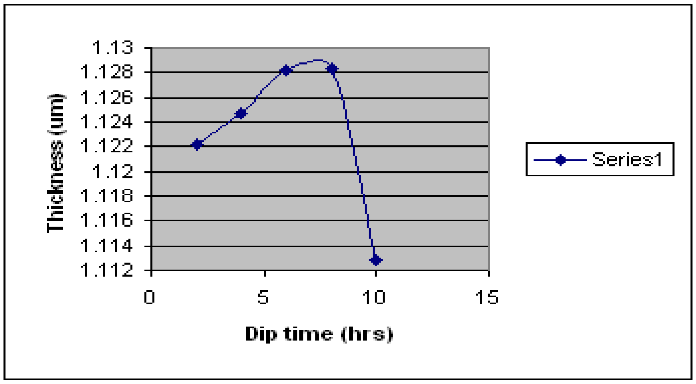

Figure-6
The Plot of film thickness with Dip time

The effect of dip time on the film thickness was also studied. From the figure, it was observed that as the film thickness increases, there was also increase in the dip time until optimum deposition was reached beyond which increase in thickness led to decrease in film thickness.

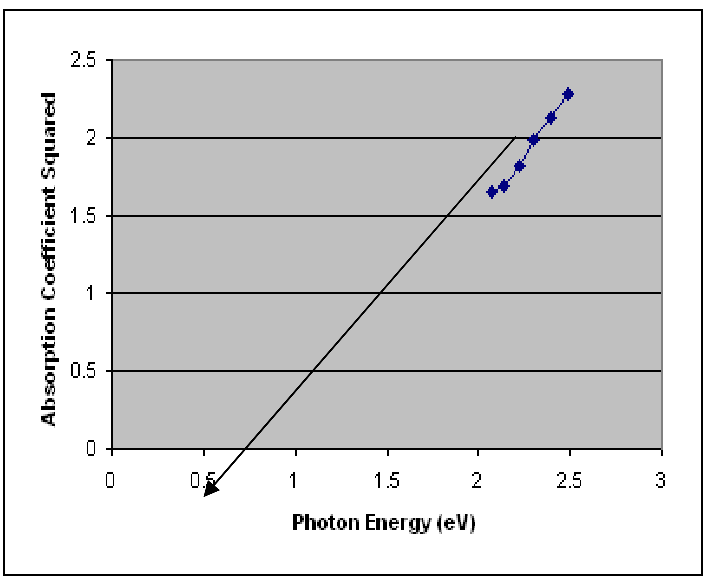

Figure-7
The plot of Absorption coefficient squared against Photon energy

The band gap energy of PbSe thin film was found to be 1.0 eV. This is seen from the plot of absorption coefficient squared against the photon energy as illustrated in figure 7. This value of 1.0 eV was obtained by extrapolating the straight portion of the graph to intercept the Photon energy axis. This value compares favourably with values 1.3eV and 1.58-2.20eV reported by other researches [10-11]. Thin films of II-VI compounds and other related compounds [12-20] have also been investigated based due to the above studied desirable properties and application in science and technology.

Conclusion

Thin films of PbSe have been successful grown using a chemical bath deposition (CBD) technique from the aqueous solution of lead acetate, selenium sulphate, ammonia solution and in which ethylene diamine tetra acetate (EDTA) was used as a complexing agent. The optical characterization carried out on the films show that the film has band gap energy of 1.0eV. The film also shows high absorbance, low transmittance and reflectance of incident radiation. The results also show that the thickness of the film is a function of bath parameters like dip time and the concentration of complexing agent used. All these properties make the material to be a good candidate for opto-electronic and photovoltaic applications.

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