COOU INTERDISCIPLINARY RESEARCH JOURNAL
FORMERLY ANAMBRA STATE UNIVERSITY

Contents

Published by
School of Postgraduate Studies
Chukwuemeka Odumegwu Ojukwu University
(formerly Anambra State University)

COOU INTERDISCIPLINARY RESEARCH JOURNAL VOL. 1, N0. 1 DECEMBER, 2014

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EDUCATION FOR DEVELOPMENT

Vol.1, No.1 December, 2014

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Vol. 1, No.1
Website: www.ansu.edu.ng/postgraduate

OPTICAL PROPERTIES OF CdSe THINFILMS DEPOSITED BY CHEMICAL BATH DEPOSITION TECHNIQUE

Ezenwaka, Laz, Nwosa, Josiah C., Umeokwonna N.S.,
Department of Industrial Physics, Chukwuemeka Odumegwu Ojukwu University Uli, Anambra State, Nigeria

ABSTRACT

Cadmium selenide thinfilms were deposited on glass substrate using Chemical Bath Deposition (CBD) technique. The effect of pH variation on the optical properties of the film was investigated. The source of Cd^{2+} ion was $CdCl_2$ and sodium selenide supplied the Se^{2-} ions. The optical properties of the deposited CdSe films were analyzed in the UV/VIS/NIR (300- 1100nm). Results of the work show that optical properties viz: absorbance, reflectance, refractive index (η), extinction coefficient(k) of the film are directly proportional to the pH of the solution while transmittance is in inverse proportion.

Keywords: Chemical Bath, Thinfilm, Optical Properties, Semiconductor

INTRODUCTION

The aim of this research is to grow thinfilms of Cadmium selenide by solution growth technique. The effect of pH variation on the optical properties of the films is to be studied and possible applications of the film determined. Recently, thinfilm has drawn major attention and occupied a prominent place in the basic research. The uses of thinfilm semiconductors have found an expanding variety of applications in various electronic and optoelectronic devices[1]. Cadmium selenide thinfilm has widely been studied because of its high absorption coefficient and optimum bandgap energy and has found applications in solar cells, lasers, photoconductors and detectors, light amplifier, Liquid Crystal Displays (LCD), photovoltaic materials etc. CdSe is one of the well-known of this group of II-VI binary semiconducting compounds belonging to the Cadmium chalcogenide family (CdS, CdSe, CdTe) [2]. The methods commonly used for depositing CdSe thinfilms are Chemical Bath Deposition (CBD)[3], vacuum evaporation[4], electro-deposition method[5], spray pyrolysis method[6], thermal evaporation method[7], Successive Ionic Layer Adsorption and Reaction (SILAR)[8]. The chemical bath method CBD has become very popular in recent times especially for thinfilm depositions due to its low cost of fabrication and requires less sophisticated apparatus.

Materials and Methods

Cadmium selenide thinfilms were deposited on glass substrates by the method of Chemical Bath Deposition Technique (CBD). Substrates used in the present work were commercial quality microscopic glass slides, which were first soaked in trioxonitrate (v) acid [HNO_3], washed with detergent, rinsed in distilled water and dried in air. The basic idea of deposition is a reaction between a slowly released selenide ion (Se^{2-}) with metallic Cadmium ion (Cd^{2+}). Sodium selenosulphate (Na_2SeSO_3) served as source of Selenide ion (Se^{2-}) while Cadmium chloride served as source of cadmium ion (Cd^{2+}). The time of deposition was kept constant. Solution of sodium selenosulphate was obtained by adding selenium powder (99% purity) to a hot solution of sodium sulphite. The mixture was stirred for 2.30 hours at 100^o C and filtered. This solution is relatively unstable and therefore it must be freshly prepared prior to thinfilm deposition process. The optimal chemical composition of reaction system for preparation of CdSe thinfilms was obtained by mixing the following solutions; 10 ml of 0.5 M cadmium chloride solution was taken in a 50 ml glass beaker and to it, 2.0 ml of triethanolamine (TEA), and 5 ml of sodium selenosulphate was slowly added with constant stirring. The pH of the solution was varied as shown in table1. Addition of different volumes of NH_4OH was done in order to determine the optimum condition for the deposition of CdSe thinfilm. The solution was stirred for few seconds and glass substrates were inserted vertically at 300K without touching the walls of the beaker with the help of synthetic foam. After deposition, the films were washed with distilled water and dried in air. Optical absorbance and morphological characterization of the films were carried out using, a Janway 6405 UV/VIS spectrophotometer and an Olumpus optical microscope respectively. Optical properties viz: transmittance, reflectance, refractive index (η), extinction coefficient and absorption coefficient, were calculated using appropriate theory.

Table 1: Bath constituents for the deposition of Cadmium Selenide thinfilm

Reaction Baths	pH	$CdCl_2$ Vol. (ml)	Na_2SeSO_3 Vol. (ml)	NH_4OH Vol. (ml)	TEA Vol. (ml)	H_2O Vol. (ml)
Cd_1	11.2	10.0	5.0	5.0	2.0	60.0
Cd_2	11.4	10.0	5.0	10.0	2.0	60.0
Cd_3	11.6	10.0	5.0	15.0	2.0	60.0
Cd_4	11.8	10.0	5.0	20.0	2.0	60.0
Cd_5	12.1	10.0	5.0	25.0	2.0	60.0

THEORY

Calculation of optical properties

Optical properties of the films were calculated using the following formulae:

1: Transmittance

$T = 10^{-A}$

A = absorbance of the film

2: Refractive index (n)

$n = \frac{1+\sqrt{R}}{1-\sqrt{R}}$ [9]

R = reflectance

3: Reflectance

The Reflectance

$R = 1 - (A + T)$ [9]

A = absorbance , T = transmittance

4: Absorption coefficient (α)

$\alpha = \frac{A}{\lambda}$

A = absorbance and λ = wavelength

5: Extinction coefficient (k)

$k = \frac{\alpha\lambda}{4\pi}$ [10]

α = absorption coefficient and λ = wavelength

6: Photon energy (hυ)

E = hυ [11],

h = Planck's constant = 6.63×10^{-34}Js, υ = frequency of photon,

However, $\nu = \frac{c}{\lambda}$

c = velocity of light = 3×10^8m/s and λ = wavelength,

Hence, $E = \frac{hc}{\lambda}$

But, $1eV = 1.602 \times 10^{-19}J$, Planck's constant $h = \frac{6.63\times10^{-34}Js}{1.602\times10^{-19}J} \approx 4.14 \times 10^{-15}eV$

∴ Photon energy $E = \frac{4.14\times10^{-15}eV\times3\times10^{8}m/s}{\lambda(m)} =$ …..eV

RESULTS

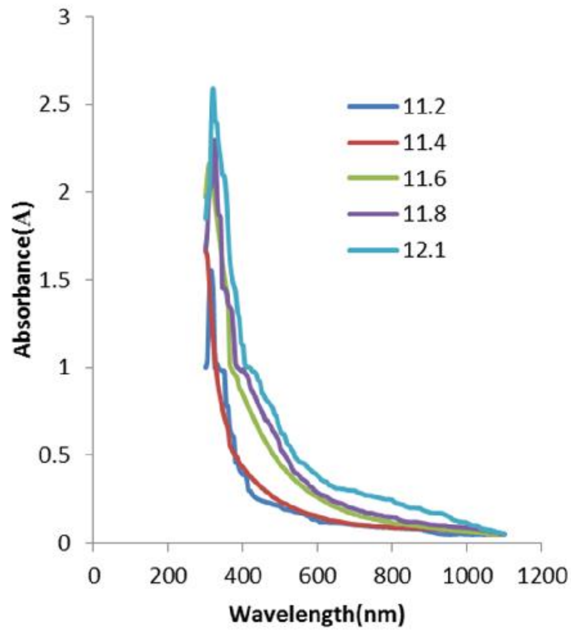

Fig.1: Absorbance versus wavelength for CdSe thinfilm

From fig.1, Absorbance of the films is directly proportional to the pH of the solution.

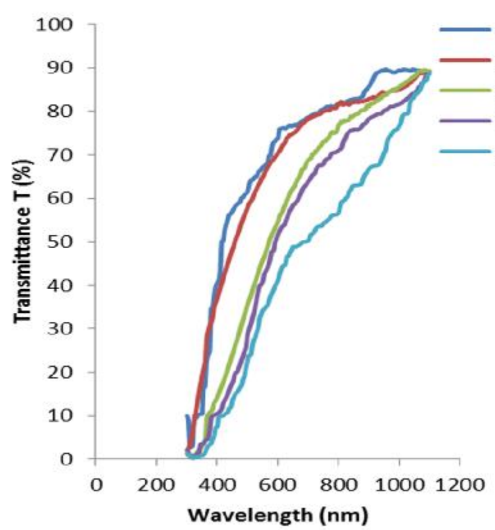

Fig.2: Transmittance versus wavelength for CdSe thinfilm

Transmittance of the films is inversely proportional to the pH of the solution.

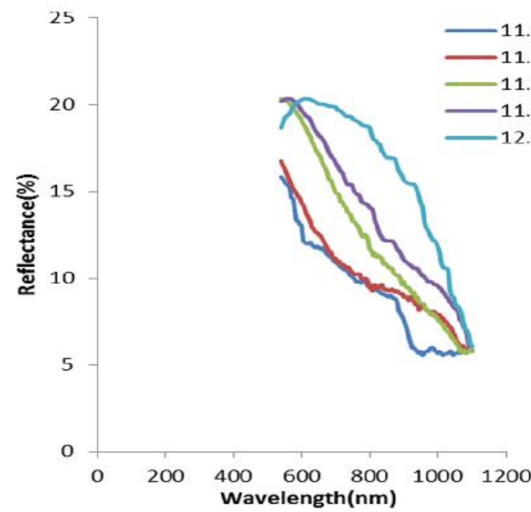

Fig.3: Reflectance versus wavelength for CdSe thinfilm

From fig.3, Reflectance of the films is directly proportional to the pH of the solution.

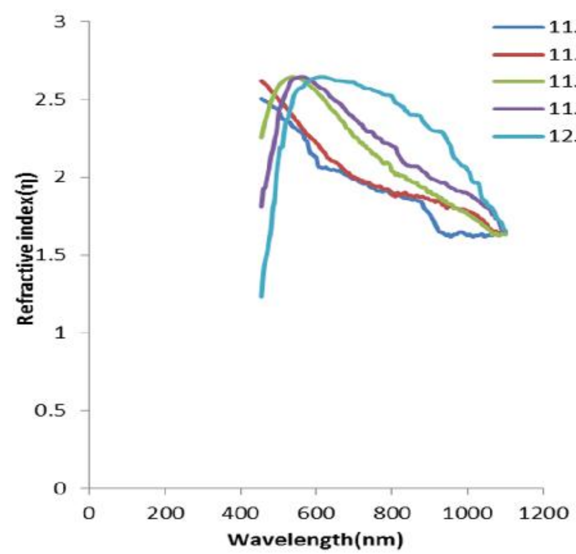

Fig.4: Refractive index versus wavelength for CdSe thinfilm

Refractive index of the films is directly proportional to the pH of the solution.

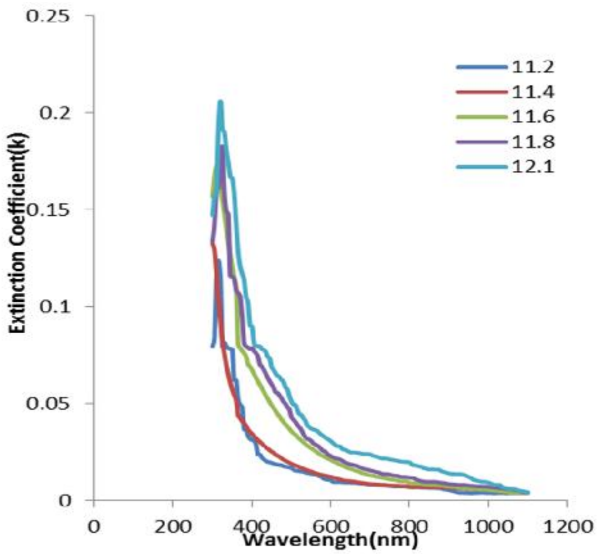

Fig.5: Extinction coefficient versus wavelength for CdSe thinfilm

From fig.5, Extinction Coefficient of the films is directly proportional to the pH of the solution.

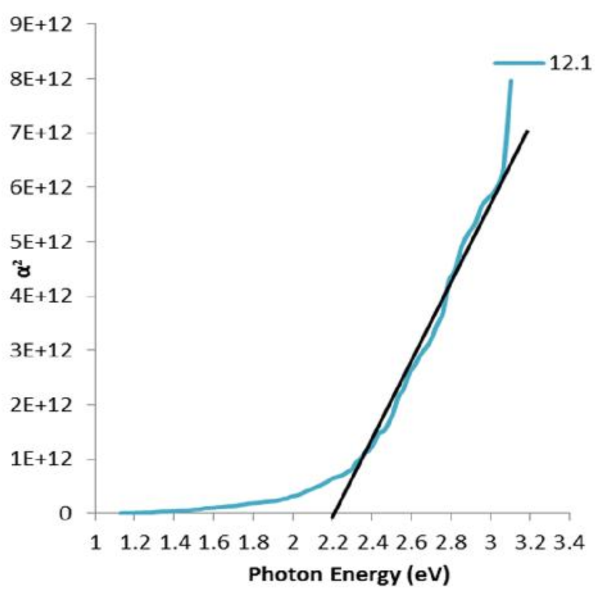

Fig.6: (Absorption Coefficient)² versus Photon Energy for CdSe thinfilm

DISCUSSION

From fig.1, it is observed that the absorbance of the CdSe films is generally low and directly proportional to the pH of the solution. The film has peak absorbance value at the UV region (310-340nm) with CdSe film with pH of 12.1 having the highest value of 2.6 = 26% and the CdSe film with pH of 11.2 having 1.5 at the same spectral region. The absorbance tends to zero in the NIR. This makes the films suitable material for fabrication of solar cells. Result as shown in fig.2, shows that the transmittance is inversely proportional to the pH of the solution. The transmittance increases from zero at UV region to maximum of 88% in NIR (900nm). CdSe film with pH of 11.2 exhibits the highest transmittance of 88% at 900nm and CdSe film with pH of 12.1 having the lowest of 62% all in NIR. The very high transmittance in the visible region makes cadmium selenide films useful aesthetic window glaze materials, solar cell, poultry house window glazing and photothermal application. From fig.3, reflectance of the films is directly proportional to pH of the solution. The films have low reflectance in all the regions with maximum (20%) in visible region and minimumin (6%) in NIR. It could be applicable as anti reflection coating. AS shown in fig. 4, the CdSe thinfilms have high refractive index of 2.5 – 2.6 at the VIS region. The CdSe films with pH of 11.2 and 11.4 have their peak values of 2.5 and 2.6 respectively at 450nm and decreased to minimum at IR region. CdSe film with pH of 12.1 has minimum value of 1.2 at 450nm and peak value of 2.6 at 550nm and then decreased to minimum in NIR. The refractive index of the films is directly proportional to the pH of the solution. Fig.5 reveals that extinction coefficient of the films is directly proportional to the pH of the solution. The films attain their peak values at the UV region with CdSe film of pH 12.1 having the highest value of 0.22 and CdSe film of pH 11.2 having 0.12 at the same electromagnetic spectral of 320nm then tend to zero in NIR. The optical bandgap of the film was determined from the graph of α^2 versus Photon energy ($h\upsilon$) curves shown in fig.6. The linear nature of the plot indicates the existence of the direct transition. The bandgap value was determined by extrapolating the straight portion of the graph to the energy axis at $\alpha^2 = 0$. The bandgap was found to be 2.2eV. which is a wide bandgap. As a result, it could serve as good material for power electronics that can operate faster and at higher temperatures, voltages anf frequencies. It could find good application in high efficiency Light emitting diodes.

CONCLUSION

Cadmium selenide films have been successfully grown using chemical bath deposition technique. The film generally has low absorbance and reflectance in all the regions of electromagnetic spectrum and high transmittance in all the regions. The optical properties viz: absorbance, reflectance, refractive index, and extinction coefficient of the film are directly proportional to the pH of the solution while transmittance is in inverse proportion. The film could be useful in optoelectronics, window glazing, antireflection coating and photothermal application.

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