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Studies on effect of pH on structural, optical and morphological properties of chemisynthesizedCdSe grains

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Abstract:

Present work describes chemisynthesis of CdSe thin films on stainless steel and fluorine doped tin oxide coated glass substrates. These films are characterized by means of X-ray diffraction (XRD), UV–Visible spectrophotometry, contact angle measurement and field emission scanning electron microscopy (FE-SEM) techniques, to study the effect of pH on the structural, optical, wettability and morphological properties.With change in pH of deposition bath, crystallinity of bath found to be influenced along with phase transformation. Optical studies show band gap energy and absorption edge found to be modulated by pH of bath. Surface morphology of CdSe thin films found to be drastically altered by pH of bath.

Keywords: CdSe, Thin film, pH, XRD, FE-SEM, optical properties.

Introduction

II-VI group compound semiconductors have drawn a great extent of attention from past few decades because of their extensive applications [1, 2]. Cadmium selenide (CdSe) is one of well-known II-VI group semiconductors, which has captivated global researchers due to its appropriate properties. Quantum size effect shown by the CdSenanocrystals is maybe the mainly attractive property [3].s Band gap energy of CdSe (Eg = 1.7eV) is positioned in close proximity of solar spectrum, making it more favorable for various optoelectronic applications, optical sensing agents,laser diodes, photoelectrochemical solar cells, light emitting diodes, photodetectors, photoelectric applications etc [4,5,6,7,8,9]. Researchers used variety of synthesis techniques such as vacuum evaporation [10], successive ionic layer adsorption and reaction [11], spray pyrolysis [12], electrode position [13], pulse plating [14] chemical bath deposition [15] to grow CdSe thin films. Among various methods, chemical bath deposition (CBD) has paramount benefits with other methods as simple, low temperature, no need of conducting substrate, suitable for large area deposition, with no requirement of sophisticated instrumentation. In CBD thin film deposition takes place after supersaturation explicitly when ionic product just go above solubility product [16]. Various preparative parameters like concentrations of precursor solution, temperature, pH etc strongly influence the solubility product of bath consequently controls growth rate of the deposit [17]. pH of deposition bath plays key role in deciding the structural, optical and morphological properties of deposit. Thus in the current investigation, the effect of bath pH on structural, optical, wettability and morphological properties is studied.

Experimental details

Chemical synthesis of CdSe thin films

The CdSe thin films were chemically deposited on the pre-cleaned stainless steel and F:SnO_2 (FTO) coated glass substrates. Since substrate cleaning plays prime role in the deposition process thus all the substrates were cleaned by procedure reported elsewhere [13]. All the chemicals used for deposition process were analytical reagent grade and used with no further purification. Cadmium sulfate ($CdSO_4$) and sodium selenosulphate (Na_2SeSO_3) were used as sources of cation and anion respectively. Cd^{+2}cations were complexed using liquor ammonia. Sodium selenosulphate solution was prepared by dissolving 0.1M selenium (Se) powder in an aqueous solution of 0.5M sodium sulphate (Na_2SO_3), which further refluxed at 85-90°C for 8-9hs. Then this solution was allowed to cool to room temperature and very tiny amount of suspended selenium powder filtered out to get clear solution. Different preparative parameters such as precursor concentrations, deposition temperature and deposition time were optimized with numerous trials and using well known photoelectrochemical method [18].

For chemical bath depositon of CdSe thin films, 0.05 M CdSO4 solution (10ml) was poured into a beaker of 30ml capacity. 30 vol% Liquid ammonia was added drop wise with constant stirring. Initially addition of ammonia to cadmium precursor solution shows formation of milky cadmium hydroxide $Cd(OH)_2$ precipitate , which entirely dissolves after extra adding up of ammonia solution. Finally, 0.05 M Na_2SeSO_3 solution (10ml) was poured to the same. A substrate was kept 15-20° slanted to the wall of beaker. The temperature of bath was maintained at 85°C. pH of bath was varied 11, 11.5, 12 and 12.5(±0.2) with addition of appropriate amount of ammonia. After 8hs, substrates were removed, repeatedly rinsed in doubly distilled water, dried and stored in sealed box for further study.

Characterizations

The study of structural properties of CdSe thin films was carried out using Philips X-ray diffractometer PW-3710 with Cu Kα source (λ=1.54Å) in the 2θ range from 10◦ to100◦. The optical absorption study was carried out inthe wavelength range 300–900 nm using a UV spectrophotometer UV-1800 SHIMADZU. The contact angle measurements were done using by Rame-Hart USA equipment equipped with a CCD camera to study the solid –liquid interface. The JEOLJSM 6360 unit was used for surface morphological study.