

Effect of Yb^{3+} ions on the morphological and optical properties of electrochemically deposited ZnSe thin films

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Abstract

ZnSe semiconductor thin film were deposited on ITO coated contacting glass substrate together with Yb^{3+} ions by using electrochemical deposition (ECD) technique in an aqueous electrolyte bath at low temperature (50°C). The cyclic voltammetric (CV) and linear sweep voltammetric (LSV) were used to study the electrochemical behavior of $\text{ZnSO}_4/\text{Se}^{2-}$ system on the various concentrations of Yb^{3+} ions in reaction bath. The SEM results revealed that the films having the large number of uniform spherical grains and smooth back ground. Room temperature photoluminescence (PL) spectra was studied that the europium doped as-deposited ZnSe thin films observed a luminescence peak at 410 nm (3.02eV) due to the near band edge emission (NBE) and one broad strong emission peak appeared at 435 nm (2.85eV) and one weak emission peak appeared at 461 nm (2.68eV).

Keywords: Electrochemical deposition, voltammetric, crystalline structure and optical band gap value.

1. Introduction

Zn based nanostructures are widely investigated because of its having interest in the new developments of device applications. In particular, ZnSe based thin films are suitable for the application in thin film solar cells as the window material due to it has some potential applications such as high-density optical storage[1-6], full colour display, light emitting devices,

laser screens and thin film transistor [7-12]. The numbers of well investigated methods are used to high quality of ZnSe thin film deposition such as physical vapor deposition [4], metal organic chemical vapor deposition [5], vacuum deposition [13-20], molecular beam epitaxy [7], vacuum evaporation [8], chemical bath deposition [9], sputtering [10] and electrochemical deposition method [21-26]. Among these, electrochemical deposition technique has emerged as a simple and viable technique which growing well adhere and quality of thin film for the photoelectronic devices. ZnSe thin film formation can be easily controlled by various electrolyte parameters like temperature, solution concentration and also bath pH [27-32]. In general, rare-earth (RE) metals have effective luminescent center for rare earth metals doped semiconductors are due to their well temperature-stable luminescence and involved incompletely filled 4f shells that are well screened and slightly affected by the crystalline field[33-39].

In the present employment, we have examined the deposition of various concentrations of Yb^{3+} ions doped ZnSe thin films on ITO coated conducting glass substrate using electrochemical deposition technique in an aqueous electrolyte medium. The effect Yb^{3+} ions concentration on the morphological and optical properties of ZnSe thin films were studied[40-45].

2. Experimental section

2.1 Materials

Zinc sulphate (ZnSO_4), selenium dioxide (SeO_2) and ytterbium (III) acetate hydrate ($\text{C}_6\text{H}_9\text{YbO}_6 \cdot x\text{H}_2\text{O}$) purchased from sigma-Aldrich and used without any purification.

2.2 Deposition of Yb^{3+} ions doped ZnSe thin films

Eu^{3+} ion doped ZnSe thin films have been deposited on ITO coated conducting glass substrate by electrochemical deposition (ECD) technique with a potentiostatic method from CH instrument USA (model 604E). Electrochemical deposition (ECD) process was done with a five various concentration of Eu solution by using 0.3 M of ZnSO_4 , 0.03 M of SeO_2 and europium (III) acetate hydrate ($\text{C}_6\text{H}_9\text{YbO}_6 \cdot x\text{H}_2\text{O}$). The deposition potential of -700 mV was used with bath temperature and deposition time was maintained at 50°C for 30 min. The deposited Yb^{3+} ion doped ZnSe thin films were taken from bath and washed with double distilled water followed by dried at room temperature and kept in desiccators.

2.3. Characterization techniques

The surface morphology of as-deposited ZnSe thin films was investigated using a Quanta 200 FEGE model scanning electron microscopy (SEM). Room temperature photoluminescence (PL) properties of as-deposited ZnSe thin films were carried out with a Flurospectrometer (FP-5800) spectrograph in range from 300-1100 nm using He-Cd laser as an excitation source.

3. Results and discussion

3.1 Morphological and elemental study

The scanning electron microscopy (SEM) is an exceptional technique to examine microstructure of the thin films. The SEM micrograph of the Yb^{3+} ions doped ZnSe thin films are shown in Figure 1. The concentrations of Eu solution play on important role on the surface morphology of ZnSe thin films. Figure 1 shows SEM image of Yb^{3+} doped ZnSe thin film and it having a uniform and well cover to the substrate surface nicely. This is clearly seen that the film composed of densely packed minute grains. The doping concentrations of Yb^{3+} also affect the surface morphology of electrochemically deposited ZnSe thin film because increases of Yb^{3+}

ions concentration about 2% in the reaction, the ZnSe film has a smooth surface with increase the diameter of spherical grains. The surface morphology of the ZnSe films visibly changed with the concentration of Yb. From this result, we have observed that the present of high selenium stoichiometric in the reaction at higher concentration of Yb ions.

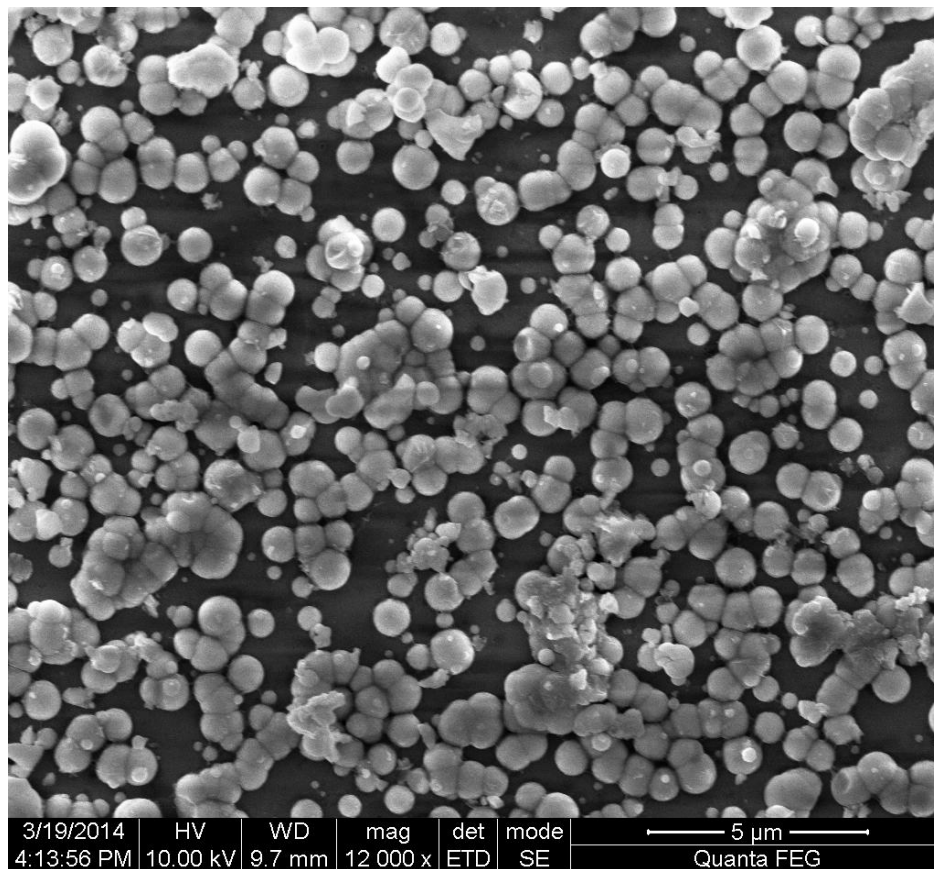


Figure. 1 SEM with EDAX spectra of as-deposited ZnSe thin films

3.2 Photoluminescence study

Typical room temperature photoluminescence spectrums of Eu^{3+} doped ZnSe thin films are shown in Fig. 6. PL spectra of the films were obtained from the excitation wavelength (λ_e) of 371nm. PL spectra of ZnSe:Eu^{3+} thin films consists of one strong emission peaks at 435 nm and two weak emission peak centre at 410 nm and 461 nm. From the Figure 2 it was seen that when Eu ions doped with ZnSe thin film, the very high intense emission peak is observed compared to the other compositions.

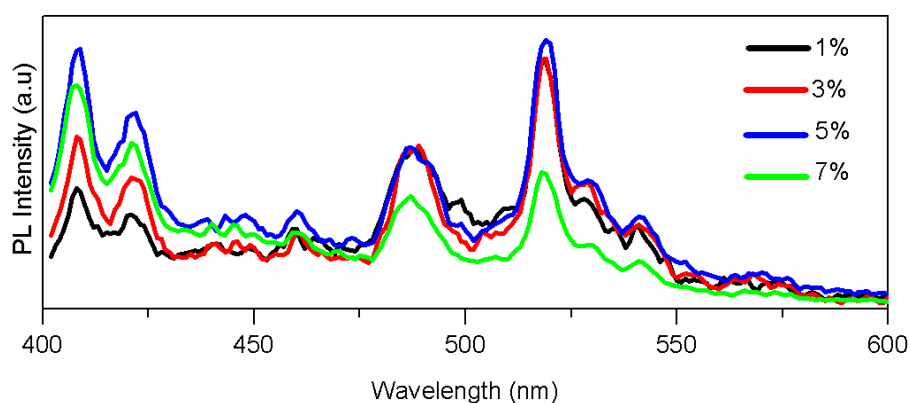


Figure. 2 Photoluminescence spectra of as- deposited ZnSe thin films recorded at room temperature.

4. Conclusions

ZnSe thin films have been successfully deposited on ITO glass substrate by using electrochemical deposition technique at aqueous electrolyte solution with various Yb^{3+} ions. The effects of Yb^{3+} ions concentration on morphological and optical properties of as-deposited ZnSe thin films have been investigated. From the SEM images, as-deposited thin film exhibits the spherical shapes of the grains. Optical band gap energy (E_g) of ZnSe thin film has blue shifted compared to the band gap of bulk ZnSe. The room temperature photoluminescence measurement

shows a strong near band edge emission (NBE) and also broad weak emission. It is confirmed that obtained the spherical shape of ZnSe thin film with presence of few defect.

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