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Electrodeposition Of CdS Thin Films at Various Cathodic Potential Values

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Abstract
The effects of cathodic potential on CdS thin films fabricated by using electrodeposition were investigated in detail. The cathodic potential values were adjusted between -0,55 V and -0,70 V. The structural, optical and morphological properties of the films were analyzed by using X-ray diffraction, ultraviolet-visible spectroscopy and scanning electron microscopy, respectively. Compact films with good crystallinity were obtained at the cathodic potential value of-0,60 V and -0,65 V. Ultraviolet-visible spectroscopy was used for estimating the energy band gap. The energy band gaps varied from 2,03 eV to 2,43 eV.

Keywords: Cadmium sulphide, CdS, Electrodeposition

Introduction

Cadmium sulfide (CdS) is an n-type semiconductor and has a direct optical band gap of about 2.2 eV to 2.6 eV at room temperature. II-VI group metal is known as chalgogenide semiconductor [1]. Surface morphologies of CdS thin films affect their optical properties. This is an important factor for the applications of photovoltaic devices. For this reason, morphology controlled CdS thin film production is technologically important [2, 3, 4]. CdS thin films, thermal evaporation [5], vacuum evaporation [6], chemical vapor deposition [7], electrodeposition [8, 9], RF sputtering [10], chemical spraying [4], sequential ionic layer adsorption and reaction (SILAR) [4], chemical bath storage [11, 4]. Among these methods, electrodeposition stands out as an attractive technique for the preparation of thin films in commercial quantities because it requires relatively inexpensive equipment, allows deposition over large areas, and is easy to control the growth parameters [12, 9].

Material and Method

In this study, CdS thin films were produced on ITO-coated glass substrates by using Chronoamperometer, one of the electrodeposition techniques. A three-electrode galvanostat/potentiostat device was used in the experiments. ITO is used as working electrode, saturated calomel electrode as reference electrode and platinum wire as counter electrode here. 0,1 M $CdCl_2$ and 0,1 M $Na_2S_2O_3$ were dissolved in 100 mL deionized water. The bath temperatures were kept at constant value of 80±2 °C. The solutions pHs were adjusted to 6,5. The experiments were completed in 2400 seconds. Electrochemical deposition system demonstrate in Figure1 was used all experiment. The depositions contexts are shortened in Table 1.

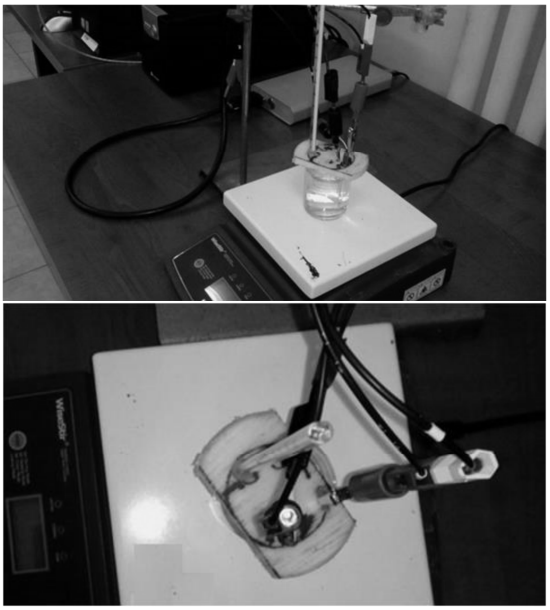

Figure 1: Electrochemical deposition system

Table 1: The deposition conditions of the CdS thin films

Experiments	Concentration of $CdCl_2$ (M)	Concentration of $Na_2S_2O_3$(M)	Deposition time (sec)	Cathodic Potential (V)	Deposition temperature (°C)	pH
D1	0,1	0,1	2400	-0,55	80± 2	6,5
D2	0,1	0,1	2400	-0,60	80 ± 2	6,5
D3	0,1	0,1	2400	-0,65	80± 2	6,5
D4	0,1	0,1	2400	-0,70	80± 2	6,5

The crystallographic properties were analyzed with a PANalytical empyrean X-ray diffractometer. The transmittance and band gaps of the films were investigated by using a JASCO V–530 double-beam uv-vis spectrophotometer. A Zeiss supra 40VP SEM was used to determine surface properties of the films.

The X-ray diffraction patterns of the films

When XRD patterns are examined, it is seen that CdS films can be produced in Figure 2 and Figure 3. It is shown in Figures 2 and 3 that all films produced have peak intensities belonging to the (002) planes. It is understood from Figure 2 that the peak intensity of the (002) plane of the CdS film produced using the -0,65 V value of the cathodic potential is very high. This peak is related to the Cubic structure. XRD analysis of CdS films produced using a cathodic potential of -0,70 V shows the presence of Cadmium and Sulfur peaks. In addition, it is seen that the films produced using the cathodic potential values of -0,55 v and -0,65 V have peaks belonging to the (111) plane. Film thicknesses were determined using the gravimetric method and all films have thicknesses in the range from 500 nm to 650 nm. It was observed that the thickness increased as the cathodic potential value used for the electrodeposition process increased.

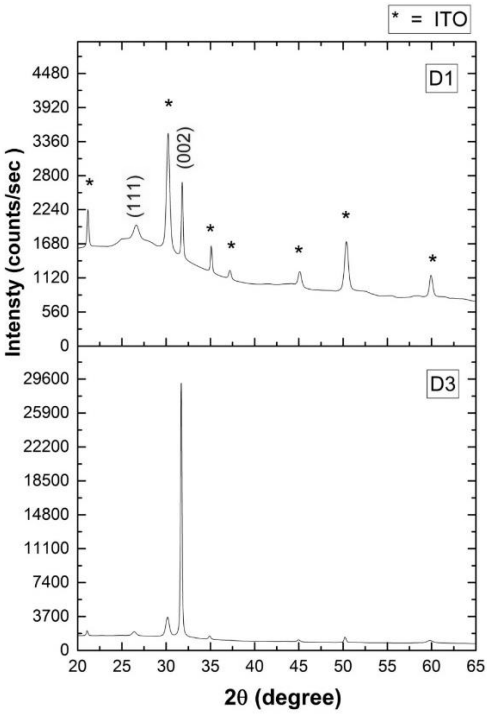

Figure 2

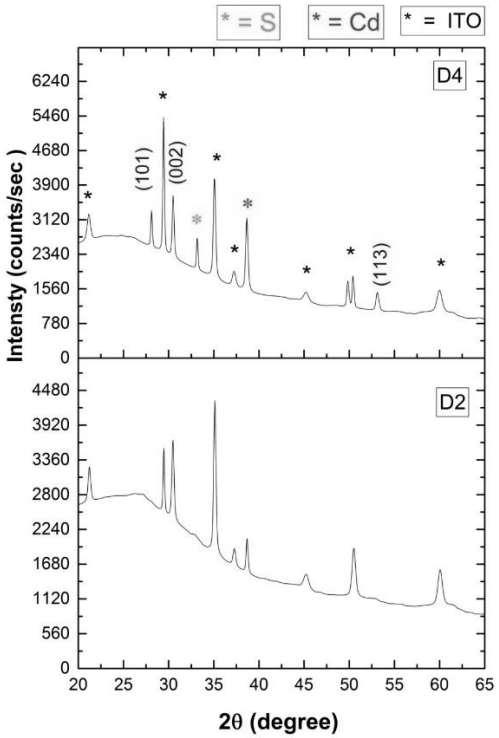

Figure 3

2.2. Optical properties of of the Films

The absorbance measurements versus wavelength were given in Figure4. The Tauc relation given in Equation 1was used to estimate energy band gaps.

$$\alpha h\upsilon = A(h\nu - E_g)^n \quad (1)$$

where hυ is photon energy, A is constant, Eg is optical band gap, n = for direct band gap material

and n = 2 for indirect band gap materials [13]. Figure 5 shows the Tauc plot of CdS films. By using this graph, the forbidden band gap of CdS films was calculated in the range of 2 to 2,43 eV. This value is in good agreement with the literature. The band gaps of the films were affected by the crystal size.

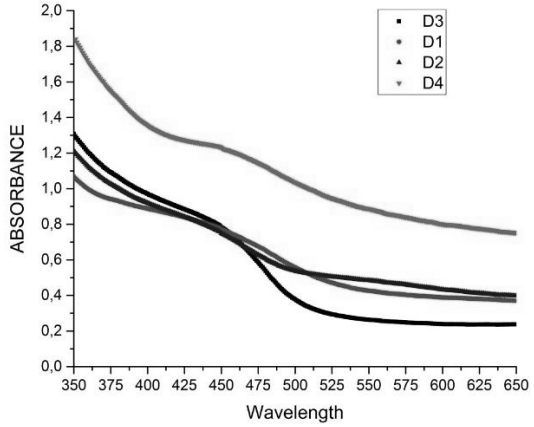

Figure 4 : The absorbance measurements of CdS films

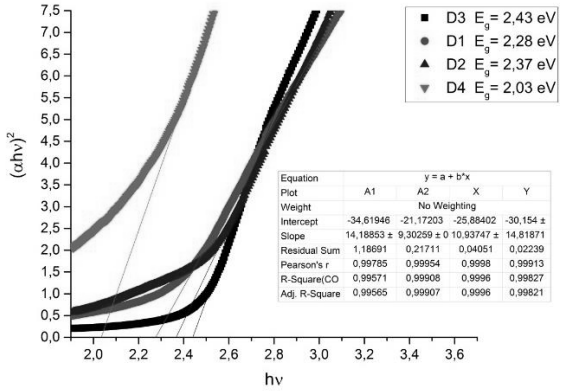

Figure 5 : The Tauc plot of CdS films

2.3 SEM images of the Films

SEM images of the films produced using -0,65 V and -0,70 V cathodic potential, at 30000 times magnification, are given in Figure 6 and Figure 7, respectively. It has been shown from the SEM images that the cathodic potential value has a great influence on the surface morphologies. The surface of the film obtained at -0,65 V is estimated to have relatively low surface roughnesses.

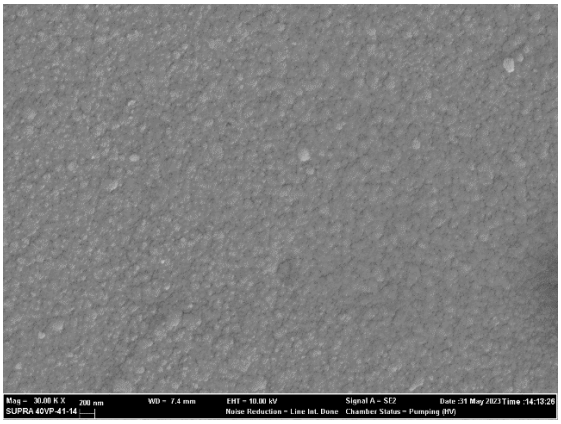

Figure 6: SEM images of the films produced using -0,65 V cathodic potential

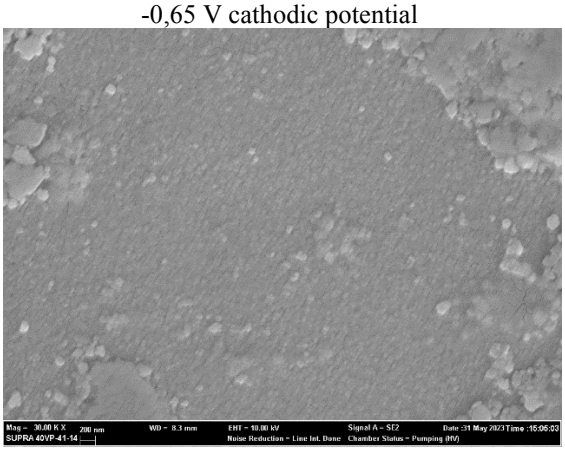

Figure 7 : SEM images of the films produced using -0,70 V cathodic potential

3. Conclusion

In this study, the effects of cathodic potential on electrodeposited CdS thin films were investigated. The XRD results showed that the peak intensity was predominantly high when the cathodic potential was -0,65 V. In addition, XRD results showed that all films formed in cubic crystal structure except the film produced at -0,70 V. The optical properties of the films were analyzed using absorbance measurements. It was observed that the film obtained by using a cathodic potential of -0,65 V showed high transmittance. It was concluded that low surface roughness and good crystallization may cause this result. The energy band gaps of the films range from 2 eV to 2,43 eV and are in agreement with the studies in the literature. As a result, in this study, it is thought that the films produced by keeping the experimental conditions constant and using the -0,65 V cathodic potential are more suitable for the solar cell sub-base.

4. References

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