EFFECT OF SUBSTRATE TEMPERATURE ON PHYSICAL PROPERTIES OF NANOSTRUCTURED CDS THIN FILMS PREPARED BY SPRAY PYROLYSIS TECHNIQUE

N. Memarian, S. M. Rozati
Solar Cell Lab., Department of Physics, University of Guilan, 41335, Iran.
smrozati@guilan.ac.ir

Introduction

Cadmium sulfide (CdS) is a compound semiconductor comprising of group II-VI elements. CdS has a relatively wide band gap (E_g= 2.42 eV). and possesses n-type semiconductor characteristics [1].These properties make it a very desirable window layer for many heterojunction thin film solar cells such as those based on Cu_2S , CdTe , $CuInSe_2$. CdS films have been produced by different methods such as vacuum evaporation , chemical bath deposition (CBD) and spray pyrolysis.

Spray pyrolysis technique has several advantages such as low cost, non-vacuum and simplicity [2]. The aim of this work is to produce nanostructuerd CdS thin films by a spray pyrolysis technique and investigating the effect of substrate temperature on physical properties of the films.

Experimental details

CdS thin films were prepared by spraying an aqueous solution of cadmium chloride ($CdCl_2$) and thiourea ($(NH_2)_2CS$), on glass substrates. 100cc of aqueous solution at 0.005 M concentration with the Cd: S ratio of 1:1.5 was used as starting solution. The substrate temperature temperaturehas changed ranging from 300^0 C to550^0C in steps of 50^0C.

Uniformly grown CdS thin films were obtained by rotating substrates at 10 rpm (rotate per minute). Other deposition parameters were kept constant as follow: the distance between the spray nozzle and the substrate 35 cm, gas flow rate 2.5 bars.

Optical transmittance of films was obtained from Carry 100 Varian double beam spectrophotometer with respect to air as baseline reference. The SEM images of films were taken by a scanning electron microscope LEO 1430 VP. The I/V characteristics of the films have been performed by RH 2010 van der Pauw and Hall effect measurement system (Phys. Tech.).

Results and discussion

The substrate temperature seems to be one of the most important parameters affecting the physical properties of thin films in spray pyrolysis technique[3,4]. Films deposited at low temperatures (below 300^0C) are foggy in appearance, while those deposited at high temperatures are usually transparentand thin [5].

The transmission spectra in visible and ultraviolet regions have been depicted in Fig. 1 for the set of CdS films studied. From the data one can see that all films exhibit a strong UV sharp edge and that the transmittance in the visible range varied from 56% to 86% as substrate temperature increased from 300^0 C to 550^0 C.

At low temperature, 300^0C, the temperature is not enough for the complete pyrolysis reaction so organic solvent is already in the layer. And the structure is not formed yet.

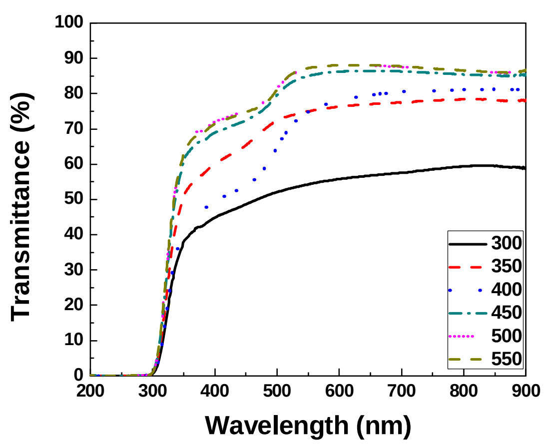

Fig. 1: Transmittance spectra of CdS thin films deposited at different substrate temperatures.

The surface morphology of the films was investigated by SEM images. SEM micrographs are shown in Fig.2.

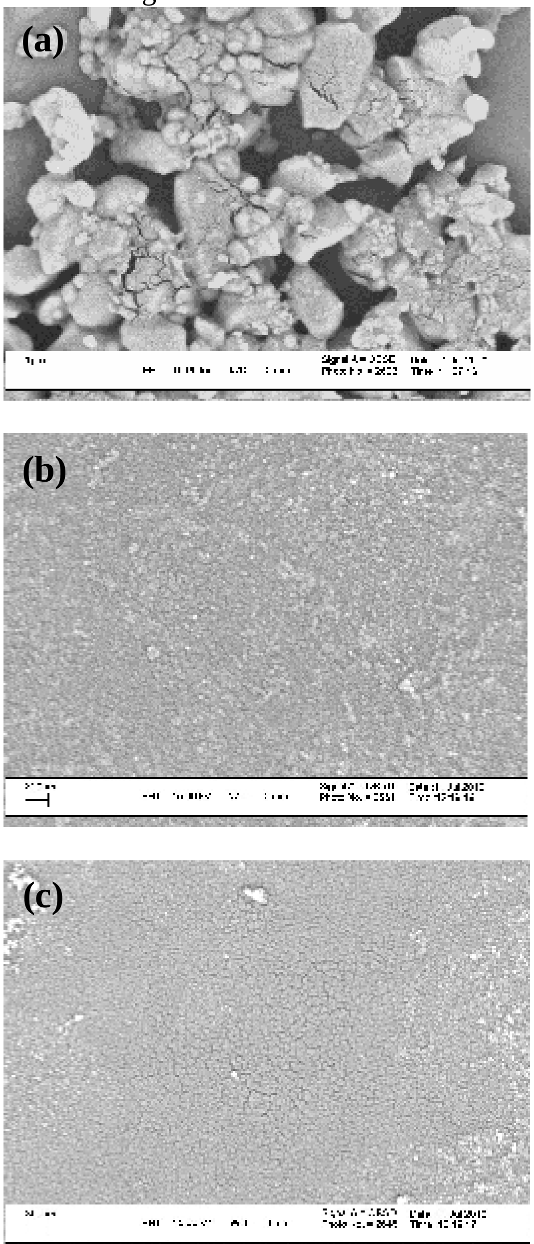

Fig. 2: SEM images of nanostructured CdS thin films at different substrate temperatures.(a) 300^0C, (b) 350^0C, (c) 500^0C.

From SEM images the grain size values of the CdS films deposited at temperatures between 300-400^0C are found and for films deposited at temperatures above 450^0C surface are very smooth and no granule structure was found. As can be seen from fig. 2 (a) for the film which is deposited at 330^0C, film is not homogeneous and it seems that film is powdery. The average grain size of the films deposited at 350^0C is about 65 nm. When the substrate temperature increased to 400^0C the size of grains are about 42 nm. No cluster formation is observed and the grains appear homogenous and uniform suggesting that there was a uniform nucleation throughout the substrate surface.

In order to investigate the electrical properties, I/V characteristics of the films were carried out. The resistance of prepared films was estimated by using of the I/V plots which were linear. As Table1 demonstrates, the resistance value has decreased when substrate temperature is changed from 300^0C to 350^0C and then with the increasing substrate temperature there isan increase in resistance.

Table 1: Resistance values of CdS thin films.

T_s (^{0}C)	300	350	400	450	500	550
R_{sh} (MΩ)	1.19×10^3	21	30.8	40.6	59.2	80.1

T_s – Substrate temperature; R_{sh} – Sheet resistance

Conclusion

The effect of substrate temperature on the physical properties of nanostructured CdS thin films was investigated. The morphological analysis authenticated the evolution in the surface microstructures as a function of substrate temperature.

From optical, electrical and microstructural analysis it has found that optimum substrate temperature is 350^0C. These unique properties demonstrate that CdS films are suitable for window layer application in CdS/CdTe solar cells.

References

1. Atay F., Kose S., 2003 Material Letters, **57** 3461.
2. N. Memarian, S.M. Rozati, E. Elangovan, E. Fortunato, Phys. Status Solidi C. **C7,9**,2277-2281,(2010).
3. S.M. Rozati, F. Zarenejad, N. Memarian, Thin Solid Films. Accepted to published (online in sciencedirect.com), (2011).
4. S.M. Rozati, Sh. Akesteh, Cryst. Res. Technol. **43**, 273-275, (2008).
5. Sharma, R.K., Jain, K., 2003 Current Applied physics, **3** 199.