

The Optical and Electrical Properties of CdSe Thin Films Prepared by CBD Technique

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ABSTRACT

In this work thin films of CdSe were deposited on glass substrate by chemical bath deposition technique at different deposition temperatures 298, 318, and 328 K. The effects of deposition temperature on the optical properties have been studied as well as the effect of annealing at different temperatures (373, 473, 573 and 673 K) for one hour. The optical properties of CdSe were studied from transmittance measurements as a function of a range of wave lengths (320-1000 nm). Optical band gap has been decreased from 2 to 1.7 eV after annealing. CdSe/p-Si was prepared by depositing CdSe film on the p-type Si substrate. The I-V characteristics showed a diode behavior.

Keywords: CdSe, Optical Properties, Thin Films, CBD technique.

CdSe

(CBD)

(CBD) CdSe
(298, 318 and 328 K)
(CdSe) (373, 473, 573 and 673 K)
(320-1000 nm)
CdSe CdSe/p-Si . - 1.7 2
p-type
.I-V
.CBD CdSe :

INTRODUCTION

In recent year major attention is being showed in II-VI Semiconductor compounds because of their specific optoelectronic properties, such as high efficiency of radioactive recombination, high absorption coefficient in the visible and infrared regions of the solar spectrum (Patel *et al.*, 2009), (Sharma *et al.*, 2008), good electrical properties, increased capability in obtaining adjustable n-type or p-type conductivity by doping and direct band-gap (Perez and Arrealas, 2009).

Cadmium Selenide is one of the well known of this group binary compounds as important material because of its containing active regions which can be used to produce light emission. The spectral range (460 – 530) nm and suitable band gap (1.74 eV) (Tamargo ; 2002), can be used for optoelectronic devices such as solar cells (Masumdar and Deshumkh; 2003), (PEC)cells (Gudage *et al.*, 2007) and light emitting diodes ..etc.

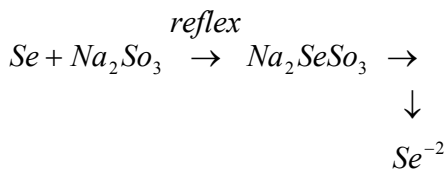
CdSe thin films have been prepared by various film deposition techniques such as sputtering (Moersch *et al.*, 1989), MOCVD (Chae *et al.*, 2006), electron beam evaporation (Murali *et al.*, 2008), photoelectrochemical (Pawar *et al.*, 2006), and chemical bath deposition (CBD) method which is found to be cheap, low deposition temperature and simple way to deposit large area thin film (Kale and Lokhande;2005), (Ezema and Osuji, 2007) and (Elahi and Ghobad, 2008).

In present paper the effect of the preparation conditions on the optical properties of CdSe thin films is investigated. Also a p-n junction had been studied.

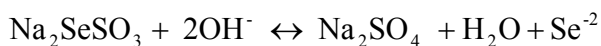
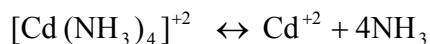
EXPERIMENTAL

Cadmium selenide thin films were deposited on glass substrate by using chemical bath deposition (CBD) technique.

Selenium is not soluble in water in order to create selenium ions. Selenium powder were mixed with solution of sodium sulphite and the solution under reflex condition has been heated for a period between 1-2 hours (Eya, 2006).



(Na₂SeSO₃) mixed with (CdCl₂) and added (NH₃) was used as complex agent in the beaker, after mixing the pH of the solution become ~ 11±1, which is measured by using pH paper which agree with (kale and lokande, 2004).



Substrate cleaning plays an important role in the deposition of thin films. Glass microscope slides cleaned by soap solution and heated in boiled alcohol finally washed by dionized water before use. The glass substrate inclined vertically at 20° angle to the walls of beaker immersed in the solution for a deposition time between (24-72 h). The CdSe thin films were uniform well adherent to the substrates and red-orange in color. CdSe also deposited at different temperatures 298, 318 and 328 K to study the effect of the deposition temperatures on the optical properties of the films. The prepared samples were annealed at 373, 473, 573 and 673 K for one hour in order to study the effect of annealing on the optical properties and of prepared CdSe samples. The spectrum was measured by a spectrophotometer model 721-2000.

The thickness of the films were measured by using the equation:

$$t = \frac{m}{A\rho} \quad \dots(1)$$

t is the film thickness, m is the mass of deposited CdSe, ρ is density of the CdSe = 5.816 g/cm³ and A is the area of sample.

CdSe was deposited by (CBD) on a p-Si substrate. From the I-V Measurements we obtained a diode characteristics and study the mechanism of carrier transport.

RESULT AND DISUSSION

Optical properties

Effect of deposition temperatures:

CdSe thin films were prepared by chemical path deposition at different deposition temperatures 298, 318 and 328 K. Fig.1 shows transmittance spectra, which revealed the films have high transmittance in the near infrared region (700-990 nm) and in the visible region (390 - 770 nm) but the transmittance decreases in the ultraviolet region (350 - 400 nm) of the electromagnetic spectrum. Fig. 2 shows the optical absorbance spectra.

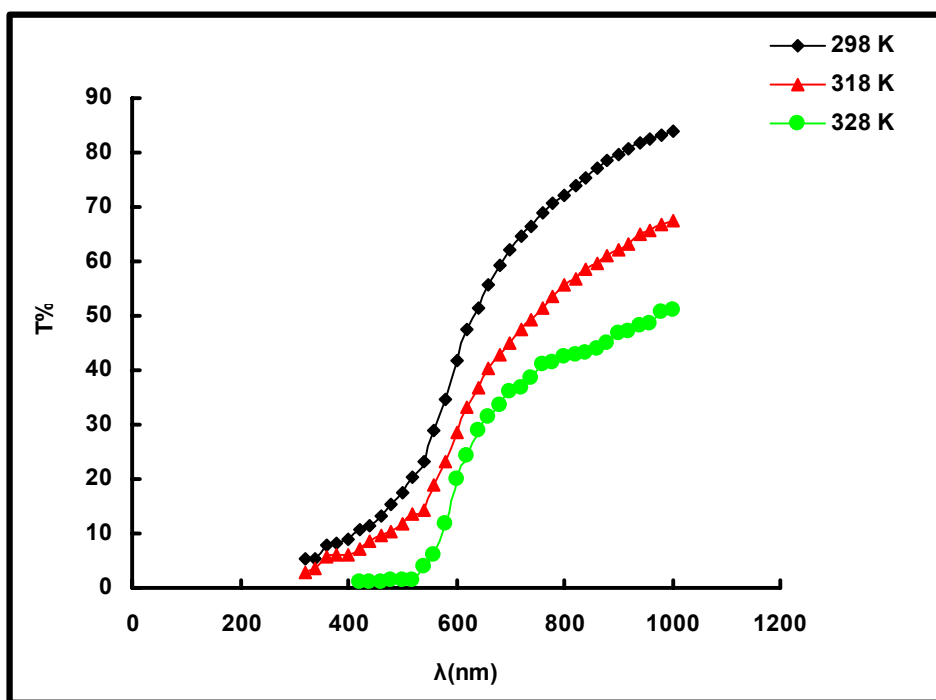


Fig. 1: Transmittance spectra of CdSe thin films deposited at different temperatures.

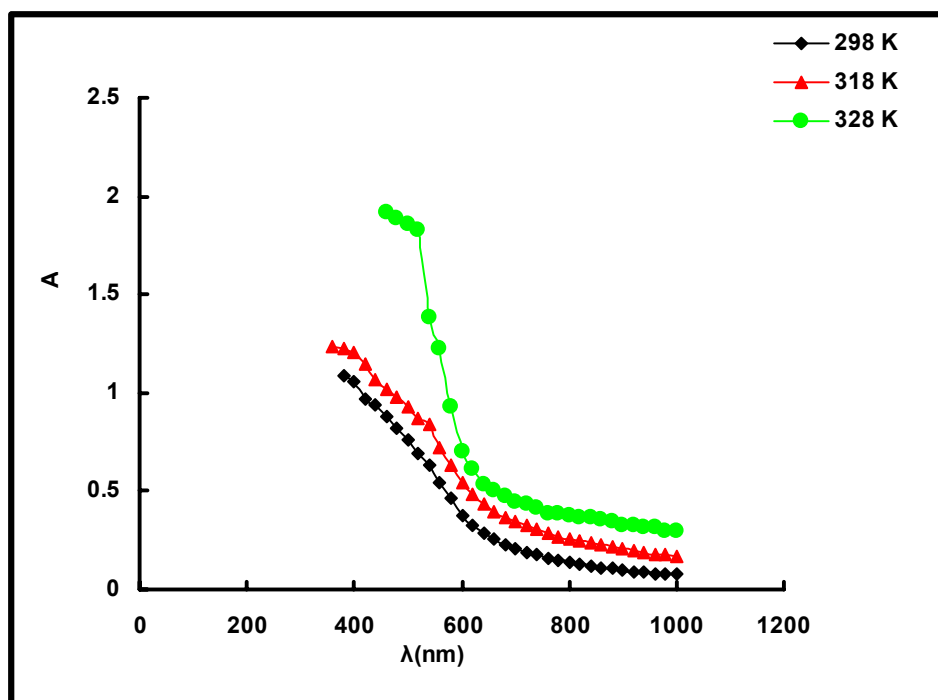
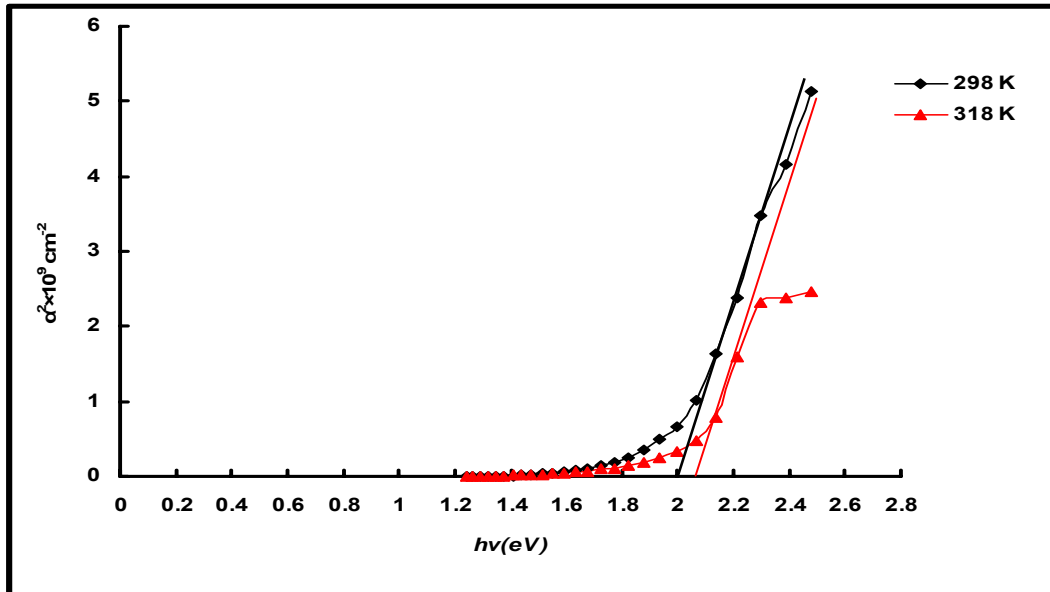
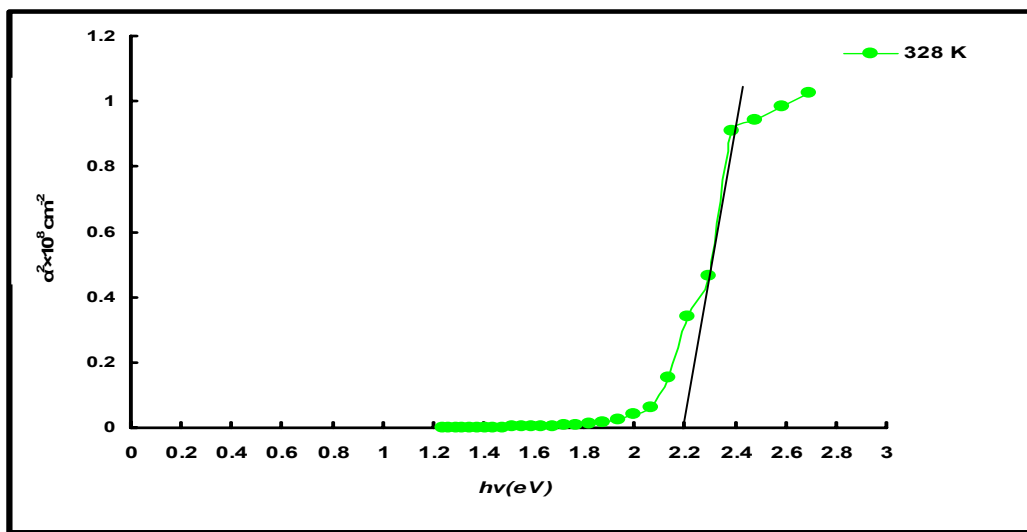


Fig. 2: Absorbance spectra of CdSe thin films deposited at different temperatures.



(a)



(b)

Fig. 3:(a,b) (α^2) ver sus(E) for CdSe thin films at different deposition temperature

Fig.3 shows the relation between the absorption coefficient and the incident photon energy and the extra polation of the linear portion yield a direct band gap (Khoman and Hankare, 2009).

The fundamental absorption which corresponding to the transition from valence to conduction band, by employment on the fig.1 and using the equation (Silverstein and Bassler, 1963):

$$A = \text{Log}(1/T) \quad \dots(2)$$

Where A is absorbance and T is a transmittance can be calculate the absorbance of the films. The band gap of the material can be determined by using the relation between absorption coefficient (α) and the incident photon energy ($h\nu$) as in (Pankove, 1971).

$$\alpha = \beta(h\nu - E_g)^n / h\nu \quad \dots(3)$$

Where β is a constant and the exponent (n) depends on the type of transition have many values (1/2, 2, 3/2 and 3) corresponding to allowed direct, allowed in direct, forbidden direct and forbidden indirect transition, respectively.

Further absorption coefficient (α) can be simplified as (Abbas and Mohamed, 1986)

$$\alpha = 2.303(A - A')/t \quad \dots(4)$$

Where A is absorbance, A' is reflectance, t is thickness of the films which is (0.23, 0.4, 3.7 μm) at different deposition temperatures (298, 318, 328 K) respectively, Fig. (3).

The values of band gap (E_g) determined from the plots of (α^2) versus ($h\nu$) are shown in The linear nature of plot indicates the existence of the direct transition. The optical band gap of CdSe films were found to be in the range (2-2.2 eV) which agrees with earlier investigators report (Kale and Lokhande, 2004), (Eya, 2006) and (Gudage *et al.*, 2009).

Fig. 3 shows that as the deposition temperature increases the band gap of prepared films increases as well (Sharma *et al.*, 2008), this is could be expect due to increase in the deposition rate and decreasing in grain size and probability deposited impurity materials or defects. The thickness of the films is proportional to the temperature of deposition as shown in Fig. 4.

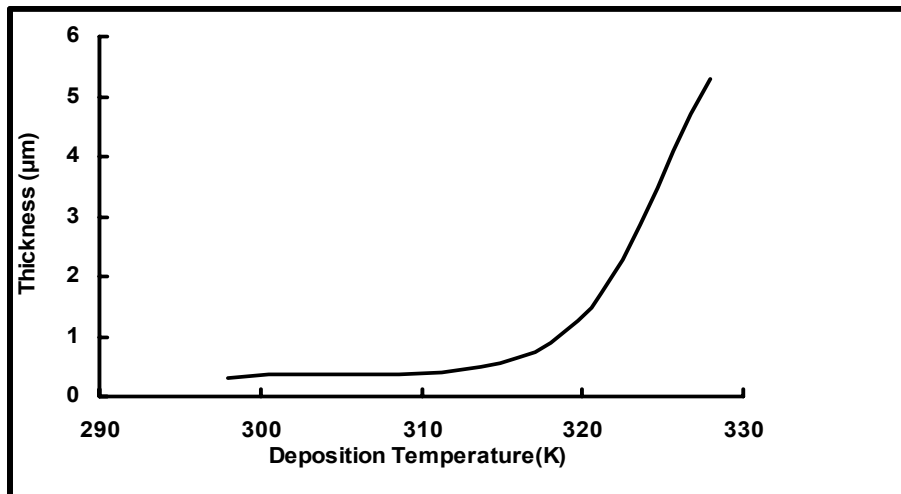


Fig. 4: Thickness of the films versus deposition temperatures.

Effect of annealing temperature on the optical properties

The films show an increase in optical absorption after annealing at (373, 473, 573 and 673 K) for one hour the films exhibits strong red shift in their optical spectra. The increase of annealing temperature caused gradually decrease of the band gap from 2 to 1.7 eV Fig.5 this possibility is due to the increase in grain size. The increase in grain size films decrease the

grain boundaries, and the change in color from red-orange to dark-brown which is in agreement with the reported value by others (Kale and Lokhande, 2004).

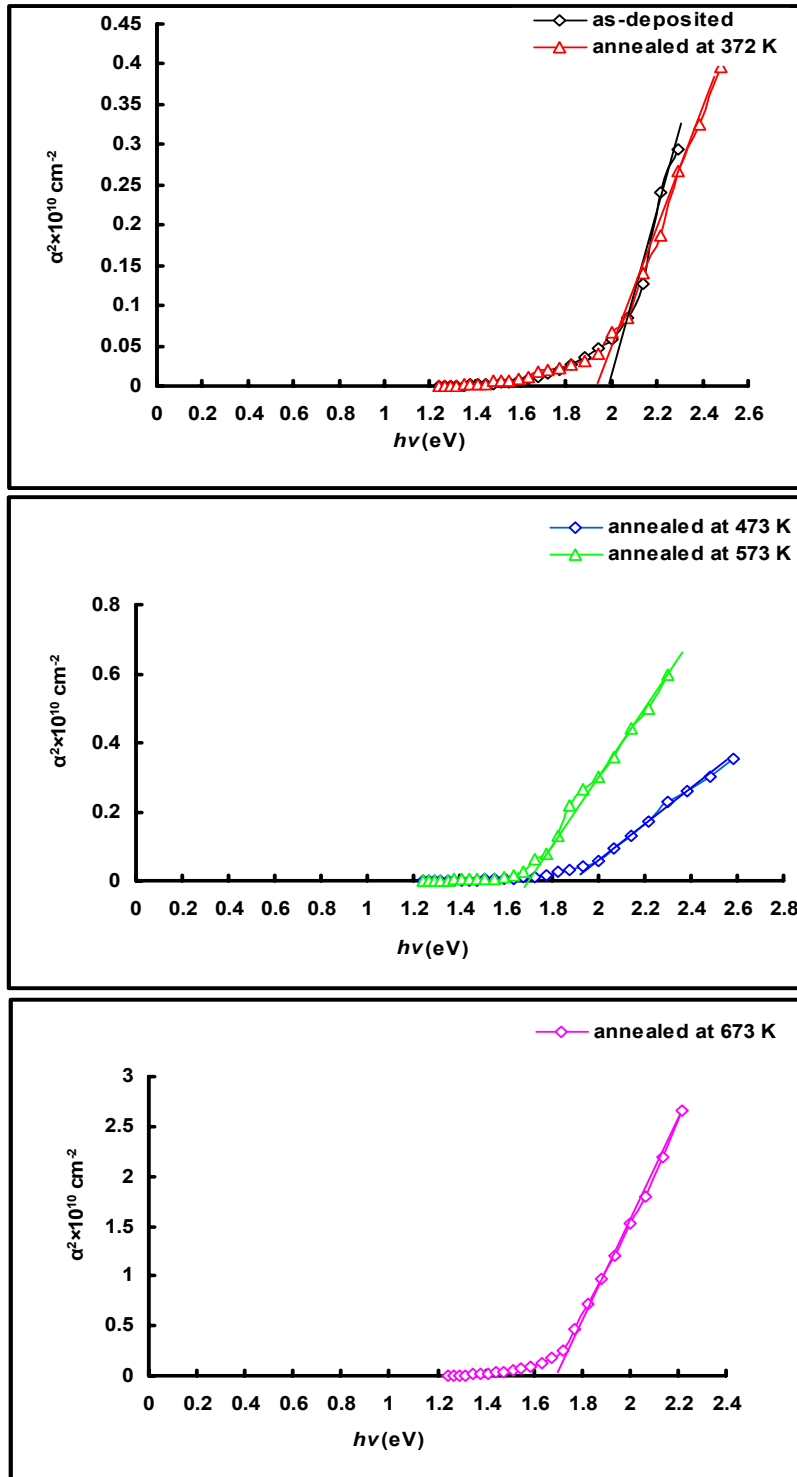


Fig. 5: (α^2) versus ($h\nu$) for CdSe thin films deposited at room temperature and annealing at different temperatures.

Electrical properties

Current–voltage characteristics:

The CdSe film deposited on the silicon substrate as described before to prepare CdSe/Si device and from I-V measurements. It is observed that CdSe/p-Si show a diode behavior as shown in Fig.6. The increase in forward current can be expected due to the decrease in the barrier height.

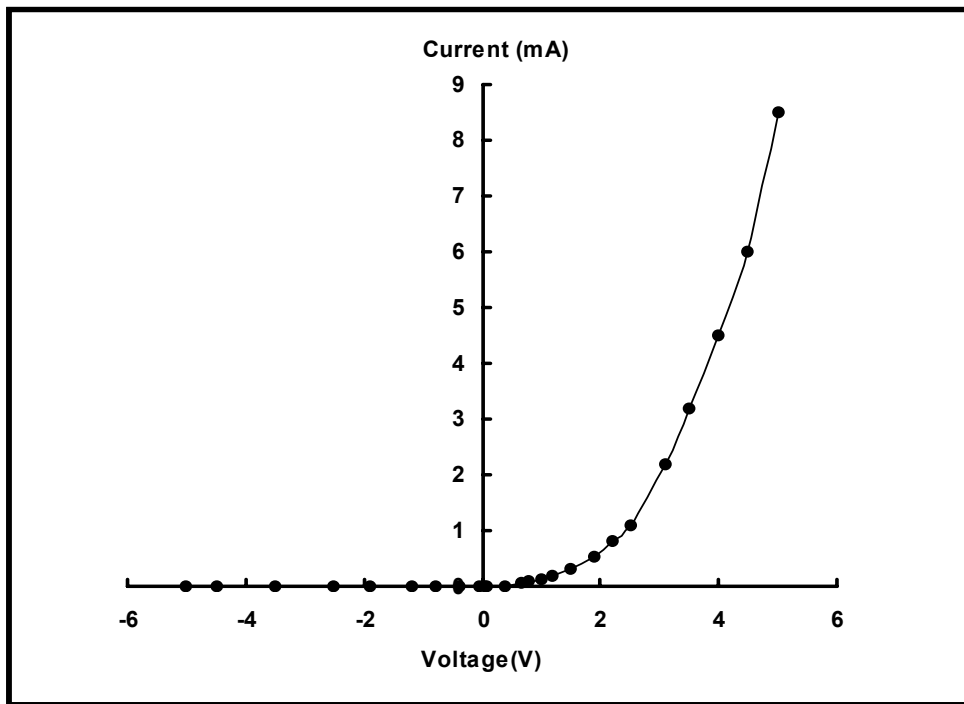


Fig. 6: Current–voltage characteristics of CdSe film.

The logarithm relation between I and V , as shown in Fig.7, appear that a linear relation was obtained and this give an idea that the mechanism of conductivity is by space charge limited current since the value of m in the relation $I \propto V^m$ is equal 2. (Lade *et al.*, 2001)

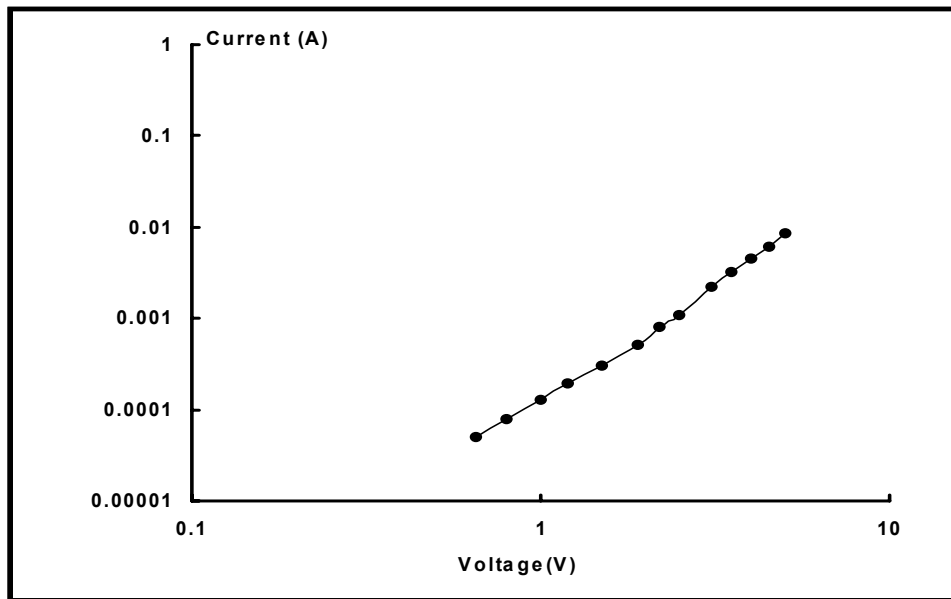


Fig. 7: Current–voltage characteristics of CdSe film in double logarithmic scale.

CONCLUSION

CdSe thin films prepared by (CBD) at different deposition temperatures (298, 318 and 328 K). As the deposition temperature increased the band gap of prepared films increased also, this is due to increase in the deposition rate, and a decrease in grain size. The optical band gap decrease from 2 to 1.7 eV after annealing. CdSe/p-Si device prepared by depositing CdSe film on p-Si substrate, this shows a diode characteristic.

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