Optical Properties of ZnTe Thin Films Prepared By Chemical Spray Pyrolysis

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Abstract

Thin films of ZnTe have been prepared by the method of chemical spray pyrolysis .The absorption and transmissions spectra are recorded in the range 400-900nm.The spectral dependences of absorption coefficient were calculated from transmission spectra. The allowed direct and optical band gap energy has been evaluated from $(\alpha h\nu)^2$ vs. $(h\nu)$ plots. The optical constants such as extinction coefficient(k)and refractive index (n) have been evaluated.

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. . $900-400$

.$(h\nu)$ $(\alpha h\nu)^2$

.(n) (k)

Keywords:Thin films,Pyrolysis Technique, Transmission Spectra, Absorption Coefficient

Introduction

There is much current interest in Π-VI binary compounds semiconductors for use in a variety of solid –state devices. One of these compounds is Zinc Telluride which is an important semiconductor material for the development of various modern technologies of solid state devices (blue light emitting diodes, laser diodes, solar cells, microwave devices,etc…)[1,2].Also operated at the temperature of liquid nitrogen,ZnTe is promising compound for devices used in tetrahertz regime[2,3].The study of the optical properties of solid state material is interesting for many reasons. Firstly, the use of materials in optical applications such as interference filters, optical fibers, and reflective coatings requires accurate knowledge of their optical constants over a wide range of wavelength.Secondly,the optical properties of all materials may be related to their atomic structure, electronic band structure. Thus the study of optical constants, enable correlation to be made with the band structures derived by other methods [4],a variety of methods have been developed for the preparation of ZnTe thin films such as physical vapor deposition under vaccum, molecular beam epitaxy, organo-metallic chemical vapor deposition solution grouth, spray

pyrolysis,etc[5].Among these methods spray pyrolysis is economical,

versatile and simple. So it can be used for the preparation of a large number of deferent types of thin films, some of which can not be prepared by other methods. Thin films prepared in this method may not be of a very high quality, but are suitable for the studies carried out in this work. In this method it is also possible to prepare mixed thin films of two or more compound where mixing is perfect since the compounds are mixed in their solution forms. The method of chemical spray pyrolysis is also suitable for the preparation of doped thin films where the percentage of doping materials may be very accurately determined [6].

Experimental

The experimental set up, the spray nozzle and other experimental details are demonstrated elsewhere[7].ZnTe films were deposited by spraying 0.1 molar aqueous solution of Zinc Chloride and Tellurium Dioxide in the required proportion on a glass substrate(Bk-7) maintained at 500k.Nitrogen was used as a carrier gas with a constant flow rate of 30 ml/min.In particular experiment, the Zn:Te ratio was (1:1).The clear white solution is sprayed on preheated borosilicate crown glass substrate to about 500k.The spraying processes is about 5 sec.The period between spraying processes is about 1 min.this period is enough to avoid excessive cooling of glass substrates. In order to

get uniform thin films, the height of the spraying nozzle adjusted to 30 cm. The rate of the deposition was 1 nm/sec,and number of spraying was 100. All thin films prepared by spray pyrolysis were quite uniform, free of pin holes, well fixed on the substrates.

The film thickness was measured via laser interferometer method. All films had nearly equal thickness 500 nm .

Optical measurements on the thin films are carried out using a recording uv-visible double beam spectrophotometer. The transmission ratio is obtained by placing two thin films of different thicknesses at the two windows of the spectrophotometer, the thinner one in front of the reference beam. This automatically eliminates the reflection effects [6].Neglecting reflection effects; absorption coefficient is determined by the well-known relationship [5].

$$\alpha = \frac{1}{d} \ln \frac{1}{T} \dots\dots\dots\dots(1)$$

Where d and T represent the film thickness and transmission coefficient, respectively.

Results and Discussion

By studying optical properties (transmission and absorption spectra, refraction index dispersion)of ZnTe films, very valuable information can be obtained about energy band-gap, characteristics of optical transitions,etc[2].The optical transmission spectra as a function of wavelength in the range of 400-900nm were measured for different samples.Fig.1 shows transmissions spectra for as deposited ZnTe film.

With the aid of Eqn. (1), the absorption coefficient of ZnTe thin film has been

calculated. Note that eqn.(1) is correct only when absorption coefficient is not exceeding 10^4 cm^{-1} when thin film thickness (d=1μm).In that case R can be neglected.Fig.2 shows absorption spectrum of ZnTe thin film.

Generally, the pure compounds in thin films are characterized by a sharp absorption edges at photon energies which correspond to the forbidden energy gap of respective semiconductors [5].On the other hand a slow increases of absorption coefficient with photon energy indicates a large concentration of structural defects especially Zn vacancies [2].

The extinction coefficient (k) was calculated from the relation.

$$k = \frac{\ln\left(\frac{1}{T}\right)\lambda}{4\pi d} \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

The refractive index was calculated from relation.

$$n = \left[\left(\frac{1+R}{1-R}\right)^2 - \left(k^2 + 1\right)\right]^{\frac{1}{2}} + \frac{1+R}{1-R}$$
…(3)

The dependence of extinction coefficient (k) on the wavelength for as-deposited ZnTe thin film is shown in Fig.3

The calculated values of n and k for ZnTe films were plotted as a function of incident wavelength .The value of refractive index n is found to be decrease slowly with increase of wavelength.

It is known that if the multiple reflections are neglected the

transmittance (T) of the film is given by:

$$T = \left(1 - R^2\right)\exp(-A) \quad _{.(4)}$$

Where R is the reflectance and A is the absorbance,R can be determined from measurements of both T&A using eq.(4).Which can be rewritten in the form:

$$R = 1 - \left[T\exp(\alpha d)\right]^{\frac{1}{2}} \ldots (5)$$

Fig.4 shows the variations reflectance with incident wavelength for ZnTe thin film.

The absorption coefficient (α) is related to the band gap (Eg) by using the relation[8].

$$\alpha = \frac{\left(h\nu - Eg\right)^{\frac{1}{2}}}{h\nu} \quad \ldots\ldots (4)$$

Fig.5 shows the plot of $(\alpha h\nu)^2$ versus (hν) of ZnTe films. The optical band gap values were obtained by extrapolating the linear portion of plot of $(\alpha h\nu)^2$ versus hν to α equal zero. The band gap value of the film is found to be 1.90 eV.Rusu[2] showed that the values of energy gap for ZnTe thin films prepared by vacuum thermal evaporation ranged between 1.70 and 2.40 eV.

Conclusions

The studied ZnTe thin films deposited by chemical spray pyrolysis onto preheated glass substrate to 500k revealed good uniformity and homogeneousity.The calculated optical constants can be correlated to the electronic band structure. The value of the energy gap, calculated from

absorption spectra, is acceptable agreement with an earlier report.

References

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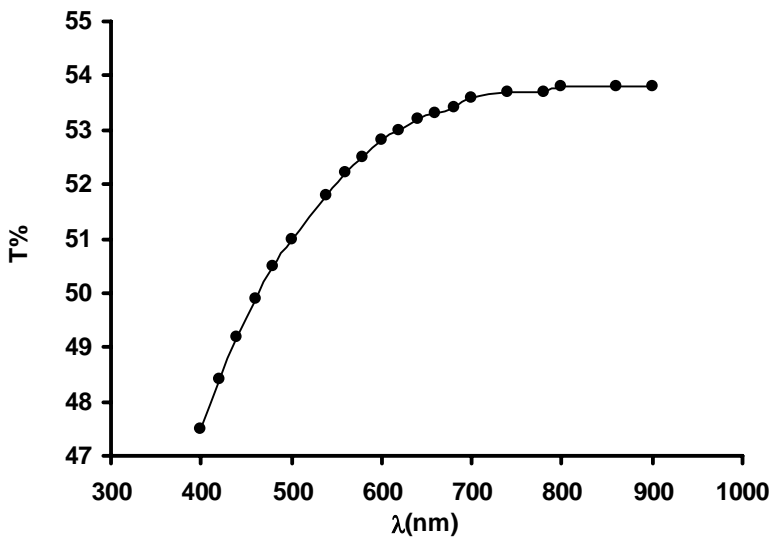[8] J.I.Pankov, Optical Processes in Semiconductors,Prentice-Hall,New Jersey(1971).
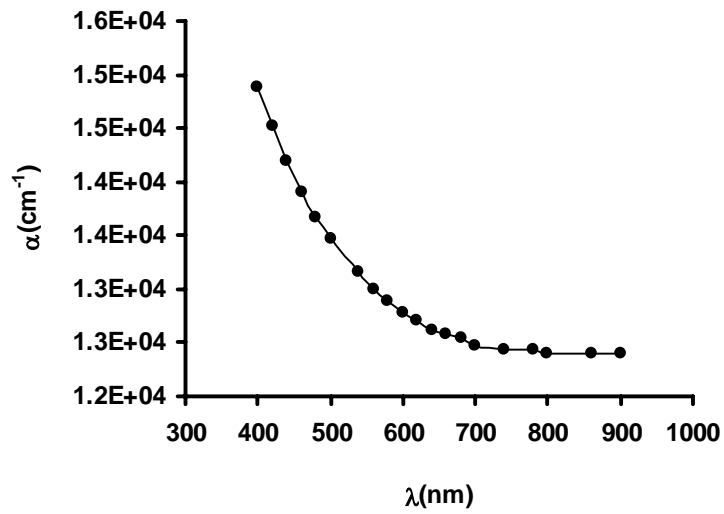

Fig.1:measured data of transmis

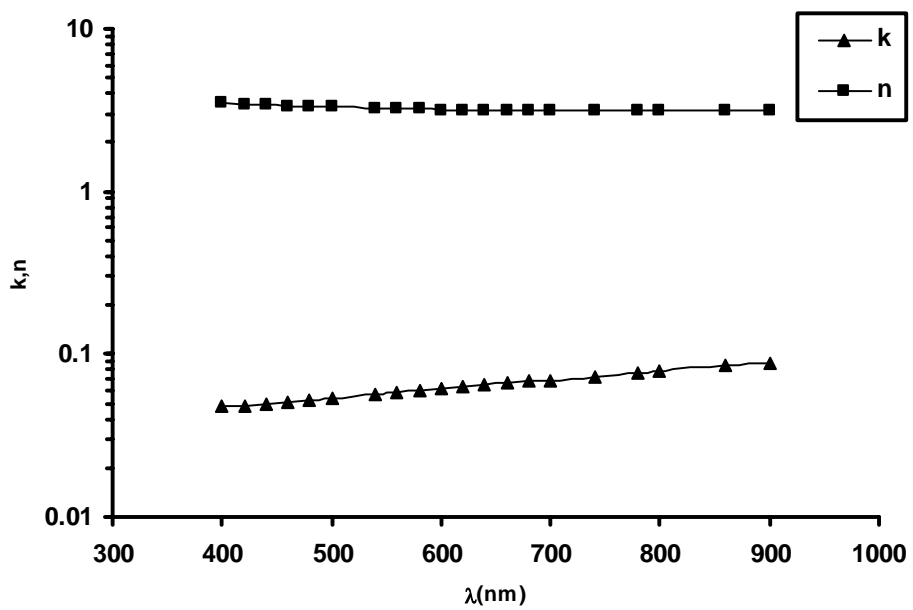**Fig.2:Absorption coefficient vs. wavelength for ZnTe thin film.**

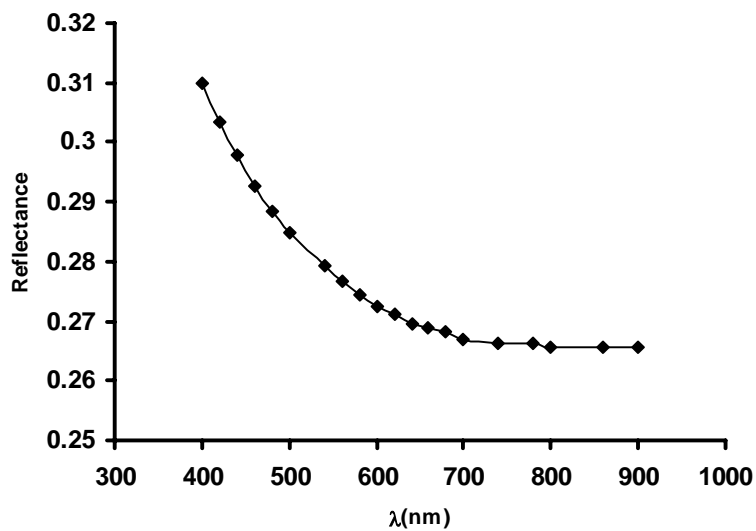**Fig.3:Spectral dependence of n & k on wavelength for as deposited ZnTe thin film.**
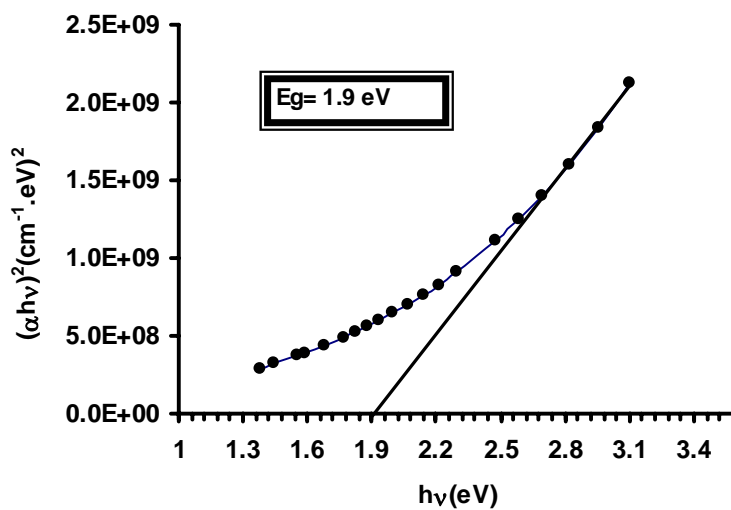
Fig.4:reflectance of ZnTe thin film as a function of wavelength

Fig.5:$(\alpha h\nu)^2$ vs. energy photon for ZnTe thin film.