Studies on Optical Properties of Thermally Evaporated 50zno-14B_2O_3 -36V_2O_5 Glassy Thin Films

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ABSTRACT
In the present study, the optical properties of 50ZnO-14B_2O_3 -36V_2O_5 glassy thin film is investigated. The glassy thin films of bulk glasses were grown onto glass substrates under vacuum with a thermal evaporation technique. Based on the transmission data obtained from UV-Visible spectra of thin films, the optical constants, absorption coefficient, refractive index on wavelength as well as energy gap are calculated.

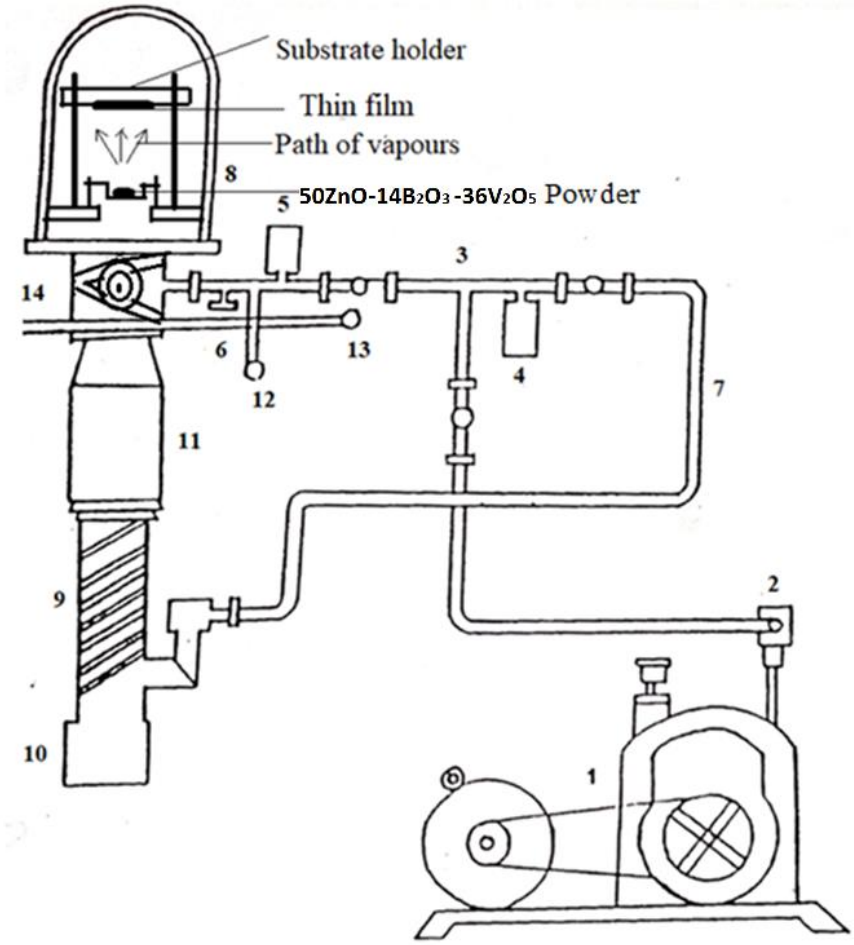
Keywords: Glassy thin films, Thermal evaporation, Absorption coefficient, Refractive index, Optical energy gap.

1. Introduction

The synthesis of glass thin films and the study of their properties have attracted much interest in these years due to their importance in science and technological applications. In the field of semiconductor devices, dielectric glass films have found wide applications as surface passivation layers for active junctions in silicon and as discussion sources into silicon for the fabrication of p–n junctions [1,2]. Advances in new solid electrolytes have led to the development of glass films that are characterized by superionic conduction properties, and exhibit great potential for use in all-solid-state electrochemical devices including micro batteries, sensors, and electrochromic [3-7].

2. Experimental Work

50ZnO-14B_2O_3 -36V_2O_5 glasses were synthesized by the conventional melt-quenching technique. The obtained glass system is ground to fine powder and this powder is used to prepare thin films. 50ZnO-14B_2O_3 -36V_2O_5 thin film was deposited on a glass substrate by thermal evaporation technique (HINDHIVAC Vacuum unit model-12A4). The cleaned substrates after taking out from the oven were placed in the substrate holder in the chamber of the coating unit, Figure 1. half the area of one of the substrates is covered with the mask for thickness measurement. 50ZnO-14B_2O_3 -36V_2O_5 samples in the form of fine powder is taken in a hopper fixed above the molybdenum boat fixed between LT electrodes. When the vacuum was 0.05-0.1 torr, HT cleaning was done. The shutter was placed over the boat and the sample was degassed before evaporation. The sample was evaporated by heating the boat to evaporation temperature by passing a suitable current, 6A through the LT. When the vacuum was of the order of 10^{-5} torr. The 50ZnO-14B_2O_3 -36V_2O_5 powder was made to fall slowly from the spout of the vibrating hopper by giving mechanical vibration. it was evaporated by sublimations. The film was taken out of the chamber after one hour and water circulation continued for 30 minutes after the DC was switched off. Thus the thickness of the obtained thin film is 2918A^0



1. Rotary Pump
2. Magnetic isolation valve
3. Butterfly valve
4. Pirani gauge
5. Pirani gauge II
6. Pinning gauge
7. Backing line
8. Glass or metal bell jar
9. Diffusion pump
10. Diffusion pump heater
11. Liquid air trap
12. Air admittance valve
13. Needle valve
14. Baffle valve

Figure 1: Resistive thermal evaporation unit for deposition of 50ZnO-14B_2O_3 - 36V_2O_5 thin film of thickness 2918A^0

3. Results and discussion

Optical measurements

The transmittance and reflectance spectra of the prepared 50ZnO-14B_2O_3 -36V_2O_5 sample were carried out using a double-beam spectrophotometer in the wavelength range 350 to 800 nm.

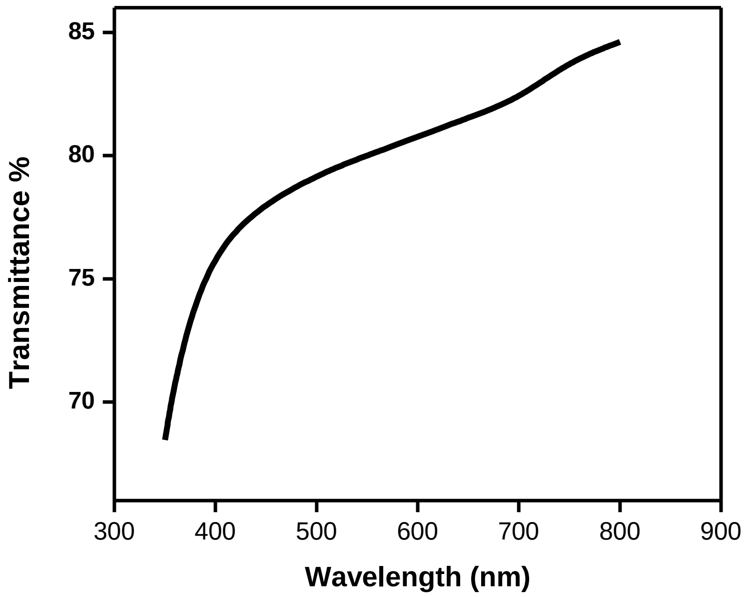


Figure 2. Transmittance spectra of 50ZnO-14B_2O_3 -36V_2O_5 thin film of thickness 2918A^0

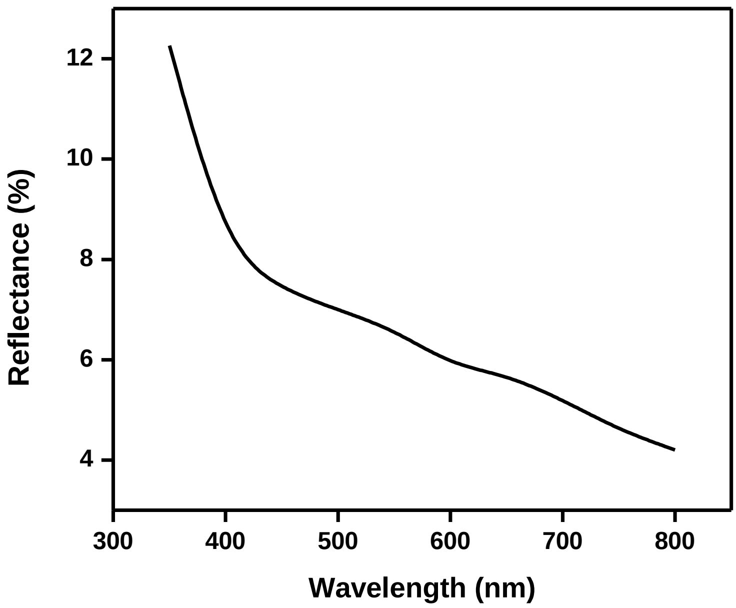


Figure 3. Reflectance spectra of 50ZnO-14B_2O_3 -36V_2O_5 thin film of thickness 2918A^0

Figure 2. shows the variation of transmittance with wavelength for 50ZnO-14B_2O_3 -36V_2O_5 film of thicknesses 2918A^0. The graph shows increased transmittance with an increase in wavelength from 350 to 800 nm. From the transmittance spectra, optical parameters α and E_g have been determined using the formula [8], $\alpha = \frac{2.303}{d}\log(\frac{1}{T})$, where 'd' is the thickness of the film and 'T' is the percentage of transmission. Then the photon energy was calculated using the formula, E = hc / λ, where h= plank's constant = 6.625 x10^{-35} Js, c = Velocity of light = 3 x 10^8 m/sec. λ = wavelength of light in nm.

The values of hγ and $(\alpha h\gamma)^2$ are calculated and shown in Figure 4. The graph is straight except at lower values. The optical band gap energies (E_{opt}) have been evaluated by extrapolating the linear region of the curve to a point $(\alpha h\upsilon)^2 = 0$. It satisfies the relation, $\alpha h\gamma = A\ (hv - E_g)^2$. In this work optical band gap is found to be 3.317 eV.

Figure 3. shows the variation of reflectance with wavelength for $50ZnO\text{-}14B_2O_3\ \text{-}36V_2O_5$ film of thicknesses 2918A^0.

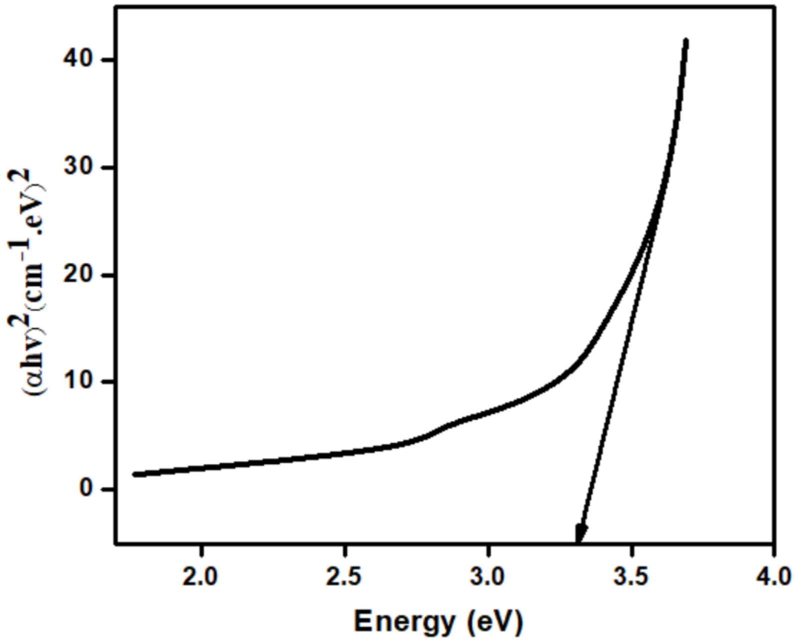


Figure 4. Plot of $(\alpha h\gamma)^2$versus energy for $50ZnO\text{-}14B_2O_3\ \text{-}36V_2O_5$ thin film of thickness 2918A^0

The extinction coefficient k of the thin film was calculated using the formula, $k=\frac{\lambda\alpha}{4\pi}$. The graph shows the extinction coefficient versus wavelength in Figure 5. It indicates that the extinction coefficient increases with an increase in wavelength.

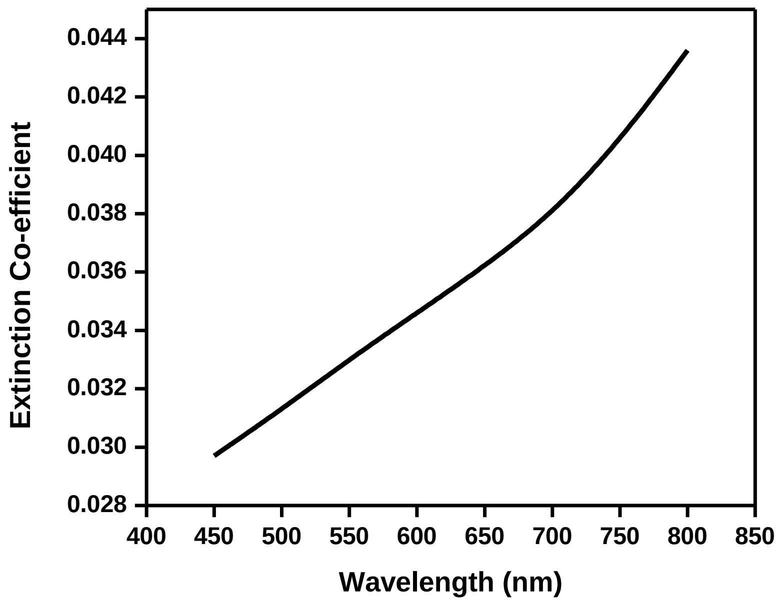


Figure 5. Plot of extinction co-efficient versus wavelength for $50ZnO\text{-}14B_2O_3\ \text{-}36V_2O_5$ thin film of thickness 2918A^0

The refractive index of the $50ZnO\text{-}14B_2O_3\text{-}36V_2O_5$ thin films was calculated by using the results of reflectance and transmittance according to the following relation [9,10], n=$(\frac{1+R}{1-R}) + (\frac{4R}{1-R^2} - K^2)^2$, Where R is the reflectance data, and k is the extinction coefficient. The refractive index as a function of wavelength is shown in Figure 6. The values of the refractive index of $50ZnO\text{-}14B_2O_3\text{-}36V_2O_5$ thin film decrease with an increase in wavelength.

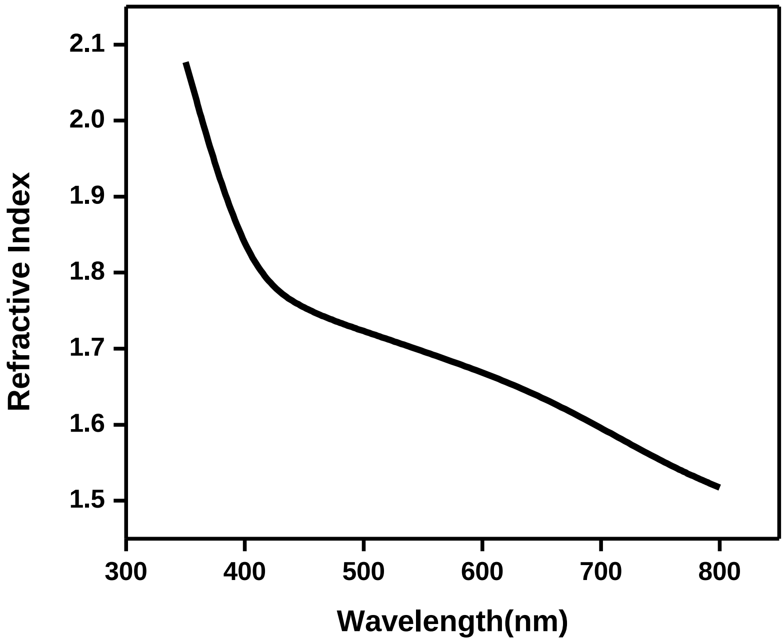


Figure 6. Plot of refractive index versus wavelength for $50ZnO\text{-}14B_2O_3\text{-}36V_2O_5$ thin film of thickness $2918A^0$

The percentage of reflectance(R) was also studied by knowing the optical constants of the films and using in the relation, R = $\frac{(1-n)^2 + k^2}{(1+n)^2 + k^2}$.

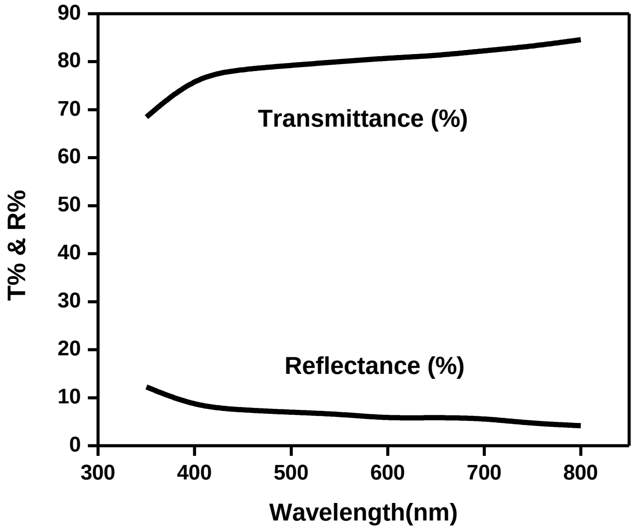


Figure 7. Plot of T% & R% versus wavelength for $50ZnO\text{-}14B_2O_3\text{-}36V_2O_5$ thin film of thickness $2918A^0$

T% and R% Vs Wavelength is plotted in Figure 7. for the wavelength range 350nm- 800 nm. These graphs show that as wavelength increases transmittance increases and reflectance decreases and both values are found to be steady at higher wavelengths.

CONCLUSION

Transmittance increases with wavelength from 350nm to 800 nm. $50ZnO\text{-}14B_2O_3\text{-}36V_2O_5$ thin film exhibits an energy band gap of 3.317 eV, which is important for optoelectronic applications. The refractive index decreases with wavelength. The value of transmittance increases and reflectance decreases with wavelength, the value of transmittance being very much higher than that of reflectance. Both values are found to be almost steady at higher wavelengths.

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