Optical Absorption in $\text{V}_2\text{O}_5$-$\text{Bi}_2\text{O}_3$ Evaporated Thin Film

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ABSTRACT

Optical absorption of amorphous $\text{V}_2\text{O}_5$-$\text{Bi}_2\text{O}_3$ thin film prepared by thermal evaporation technique has been studied in the wave length range 200 to 800 nm. It is found that the fundamental optical absorption edge rather sharp as in crystalline materials. It is also found that the optical energy gap $E_{\text{OPT}}$ is about 4.07 eV and the mechanism of transition is direct forbidden transition.

Key Words: OPT absorption, vanadat-Bismuth, thin films.

INTRODUCTION

Studying optical absorption particularly the shape and shift of the absorption edge, is a very useful technique for understanding the basic mechanism of optically–induced transitions in crystalline and non-crystalline materials, as well as providing information about the band structure. The basic principal behind the technique depends on the absorption of photons with energies greater than the band gap energy by carries undergoing transitions from occupied states in the conduction band. Two kinds of optical transitions may occur at the fundamental edge in these materials: direct and indirect. In a direct transition, the electron wave vector remains the same (there is no photon interaction), whereas in an indirect transition the cooperation of photon is necessary for conserving momentum and the electrons wave vector changes during transition. It has been suggested by Davis and Mott $^1$ that for direct transitions the following equation may be used to relate the absorption coefficient to photon energy

$$\alpha(\omega) = \beta \left(\frac{\hbar \omega - E_{\text{OPT}}}{\hbar \omega}\right)^n$$  \hspace{1cm} ...(1)

Where $\omega$ is the angular frequency of incident radiation, $B$ is constant, $E_{\text{OPT}}$ is the optical energy gap and $n$ is an exponent which takes values $1, 2, \frac{3}{2}, \frac{1}{3}, \frac{1}{2}$ depending on whether the transitions are allowed or forbidden. A similar equations with $n=2$ was suggested by Tauc et al $^2$, which offers the best fit to optical absorption data in many amorphous semiconductors.
EXPERIMENTAL

Thin samples of 70% V_2O_5 - 30%Bi_2O_3 were prepared by thermal evaporation using coating system model (MECA2000 78540 Vernouillet). The film was deposited at a rate of 9.8 Å/sec on cleaned corning 7059 glass substrates held at 29°C at a residual pressure of approximately 6 x 10^-6 mbar. Tungsten boat was used for the evaporation. The film thickness was monitored by using a quartz crystal unites. The absorption spectrum was recorded with UV/visible spectrometer (model CECIL_CE 5501).

RESULTS AND DISCUSSION

The recorded absorption spectrum is shown in Fig1. The ratio \( \frac{V^+4}{V^{5-}} \) could be responsible for the conducting mechanism. In order to examine

![Fig 1. Absorption of spectrum as a function of wavelength for 70% V_2O_5 - 30%Bi_2O_3 film.](image)

![Fig 2. Variation of (αhω)^3 against photon energy hω for 70% V_2O_5 - 30%Bi_2O_3 film.](image)
equation 1 and to evaluate the exponent n, graphs of $(\alpha h\omega)^n$ versus $h\omega$ were plotted with different values of $n$. $\alpha(\omega)$ was calculated from the following relation:

$$\alpha(\omega) = \frac{1}{d} \ln \frac{I_0}{I_t}$$  \hspace{1cm} \text{(2)}$$

Where $I_0$ and $I_t$ are the intensities of the incident and transmitted beams, respectively, and $d$ is the film thickness. It was found that $n=\frac{3}{3}$ gives the best linear fit in the higher absorption region. Fig. 2 shows the variation of $(\alpha h\omega)^n$ versus $h\omega$ for the film 45.3nm thick; $E_{OPT}$ is obtained by plotting the linear portion in Fig. 2 on the $h\omega$ axis. Value of $B$ in equation (1) can be obtained from the slope of the curve in Fig 2. The result in Fig 1 also follows the Urbach law:

$$\alpha(\omega) = C \exp \left( \frac{h\omega}{\Delta E} \right)$$  \hspace{1cm} \text{(3)}$$

Where $\Delta E$ is the extent of band tailing due to presence of localized states, arising from long-rang order.

As can be seen from Fig 3 the $E_{OPT}$ is equal to about 4.07(eV) and the value of $B$ in equation (1) is found to be about 5.4 (eV$^{-1}$ cm$^{-1}$). Fig 4 shows that

![Graph 1](image1.png)

**Fig3.** $E_{OPT}$ can be obtained by plotting the linear portion in Fig 2.

![Graph 2](image2.png)

**Fig4.** Variation of the $\ln(\alpha)$ versus photon energy $h\omega$. 

The energy band gaps of V$_2$O$_5$-Bi$_2$O$_3$ thin film chalcogenide glasses have been studied at room temperature and normal pressure. The reflections spectra of these glasses are recorded by Spectrophotometer in the wave length region from 200 to 800 nm. From the analysis of the reflection spectra the optical energy band gap is determined. It is also found that the optical energy gap $E_{opt}$ is about 4.07 eV and the mechanism of transition is direct forbidden transition. It will be necessary to conduct thermo power and ESR experiments to verify this tentative conclusion.