Journal of Engineering and Applied Sciences 13 (22): 9689-9692, 2018
ISSN: 1816-949X

Study the Influence of Antimony Trioxide (Sb_2O_3) on Optical Properties of (PVA-PVP) Composites

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Abstract: In this study, the effect of adding antimony trioxide (Sb_2O_3) on optical properties of (PVA-PVP) has been studied. Samples have been deposited by adding different concentration Sb_2O_3 by using casting method. Absorbance and transmittance spectra has been recorded in the wavelength range 250-1100 nm. The outcome display that the transmittance decreased as Sb_2O_3 content increased. Optical constants of PVA-PVP-Sb_2O_3 composites increase with the increasing of Sb_2O_3 content. The energy band gap of PVA-PVP-Sb_2O_3 composites decreased as the Sb_2O_3 content increased.

Key words: PVA-PVP, antimony trioxide, optical properties, composites, transmittance, samples

INTRODUCTION

Polymers have gained much attention in electrical and electronic applications. Polymers have diverse features, like easy processing, non-cost-effective, elasticity, high durability and perfect mechanical quality. In the microelectronics manufacturing, polymers are used in the photolithography process (Alias *et al*., 2013). Preparation of (PVA) film offers a combination of excellent properties, along with insoluble in cold water and organic solvent (Callister, 2003). Optical spectroscopy gives an outstanding feature to determine materials band structure. Moreover, difference in electronic band structure can be inspected by optical spectroscopy (Nathan *et al*., 2015). Polyvinyl alcohol has gained interest because of their applications in optical devices. PVA is a water soluble polymer. Moreover, PVA is also virulent, high dielectric strength and convenient charge storage capacity (Abass *et al*., 2017). In this study, we focused on optical properties of (PVA-PVP-Sb_2O_3) composites.

MATERIALS AND METHODS

The composite consisting of (Polyvinyl Alcohol (PVA) (90 wt.%) and Polyvinylpyrrolidone (PVP) (10 wt.%) in re-distilled water, the solution was mixed with the help of magnetic stirrer mixing in order to obtain clear solution. Antimony trioxide was used as a doping agent (2 and 4%) weight percentage. Casting technique was used to obtain films of these composite. Optical properties of deposit films were measured using UV-Vis-NIR spectrophotometer (UV/1800/Shimadzu spectrophoto meter Japan) (Tauc, 1974):

$$C_p = \frac{\varepsilon'\varepsilon_o A}{d} \quad (1)$$

Where:

- C_p = Capacitance
- ε_o = Free space permittivity
- A = Surface area of deposited film and
- d = Thickness of the deposited film

whereas for dielectric loss ε" can be calculated using expression (Tauc, 1974):

$$\tan\delta = \frac{Ip}{Iq} = \frac{\varepsilon''}{\varepsilon'} \quad (2)$$

where, tanδ is dissipation factor. AC conductivity (σ_{ac}) can be estimated by the this expression (Tauc, 1974):

$$\sigma_{a.c} = \omega\varepsilon_o\varepsilon'' \quad (3)$$

where, $\sigma_{a.c}$ represents A.C conductivity of polymer.

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RESULTS AND DISCUSSION

The effect of antimony trioxide (Sb_2O_3) on absorbance of (PVA-PVP) composite with wavelength range (200-1100) nm was displayed in Fig. 1. The absorbance of (PVA-PVP) composite has increased as Sb_2O_3, content increased. This behavior related to the increase in charge carriers (Pankove, 1971).

Figure 2 shows optical transmittance spectra versus incident wavelength for PVA-PVP-Sb_2O_3 film. It can see observe from this figure that the transmittance decreased with increasing of concentration of Sb_2O_3.

The absorption coefficient (α) of (PVA-PVP-Sb_2O_3) composites is given by using the following equation (Hamdalla *et al*., 2015):

$$\alpha = 2.303A/d \quad (4)$$

Where:

A = Absorbance of composites and
d = Sample thickness

The absorption coefficient (α) of deposited films has been calculated from Eq. 1. Figure 3 depicts the relationship between the absorption coefficient and photon energy which refer to the increase of α with increasing of Sb_2O_3 concentration. The increase of absorption coefficient could be referred to increase in light absorption (Alwan, 2010). The values of α are less than 10^4 cm^{-1} which means that the deposited films have indirect transition as illustrated in Fig. 3.

The energy band gap E_g for the film deposited in this study was calculated by using relation (Hamad *et al*., 2014):

$$\alpha = C\left(h\upsilon - E_g\right)^m / h\upsilon \quad (5)$$

Where:

h = Incident energy of photon
E_g = Optical energy band gap, constant
m = The power coefficient depends on the nature of the transitions

m = 2 and 3 for indirect allowed and forbidden transition, respectively (Habubi *et al*., 2010).

Figure 4 depicts the relation between $(ahv)^{1/2}$ of deposited film versus photon energy. Figure 4 illustrate that energy gap decreased with increasing of Sb_2O_3 content. The optical energy gap decreased from 5 eV for pure PVA-PVP films to 4.8 eV for 4% Sb_2O_3. This is possibly due to increase absorption coefficient as a result of introducing dopant atoms and hence, E_g will be decreasing.

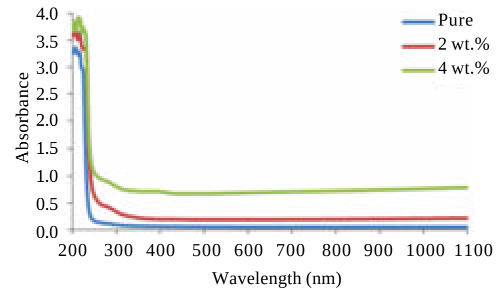

Fig. 1: Absorbance against wavelength of (PVA-PVP-Sb_2O_3) composites

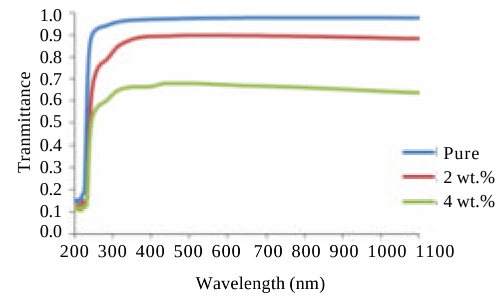

Fig. 2: Transmittance against wavelength of (PVA-PVP-Sb_2O_3) composites

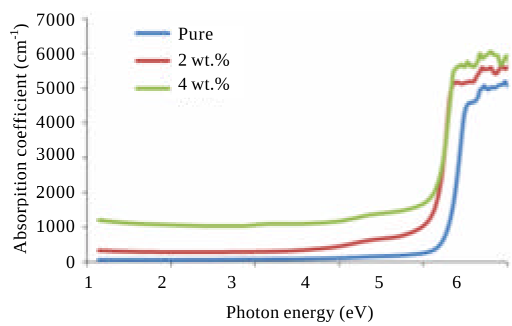

Fig. 3: Absorption coefficient against photon energy

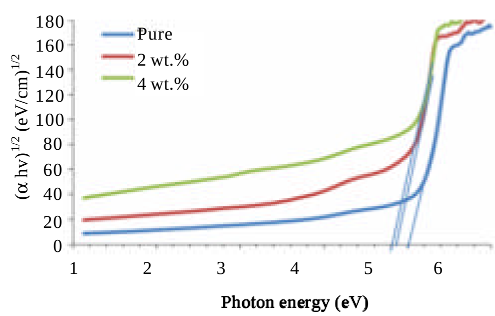

Fig. 4: $(\alpha h\upsilon)^{1/2}$ against photon energy of deposited film

The relation between $(ahv)^{1/3}$ versus photon energy is illustrated in Fig. 5. From these results, it can be noticed that there is a decrease in energy gap as (Sb_2O_3)

Table 1: Energy gap values obtained of the deposited films

Antimony trioxide (wt.%)	E_g (eV) Allowed	Forbidden
0	5.00	4.70
2	4.88	4.40
4	4.80	4.30

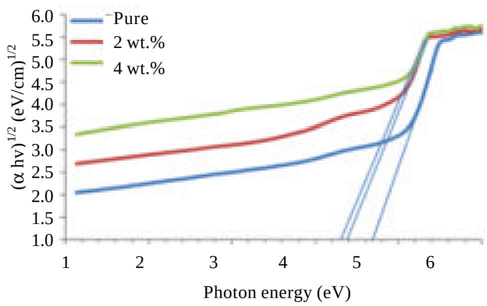

Fig. 5: $(\alpha h\upsilon)^{1/3}$ against photon energy of deposited films

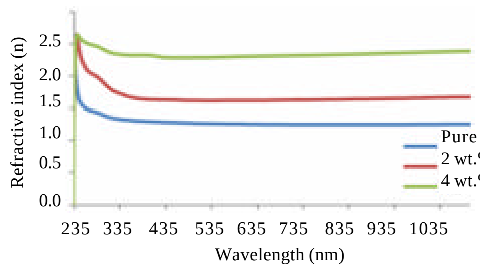

Fig. 6: Refractive index versus wavelength of the deposited films

content increased. This could be referred to the production of site levels inside the forbidden gap, the transition allows two steps of behavior that include electron transition from valence band to local levels of conduction band as doping percent increase. The values of allowed and forbidden energy gap were shown in Table 1.

The refractive index (n) is remarkable parameter of optical materials. Thus, it is substantial in locating optical constants of films. The refractive index of deposited films was estimated from the relation (Hamad *et al*., 2014):

$$n = \left[\left(\frac{4R}{(R-1)^2}\right)-K^2\right]^{1/2} + \frac{(R+1)}{(R-1)} \quad (6)$$

Where:

R = The reflectance

k = The extinction coefficient ($k = \alpha\lambda/4\pi$)

The n and k values versus wavelength was shown in Fig. 6 and 7, respectively for all samples before and after

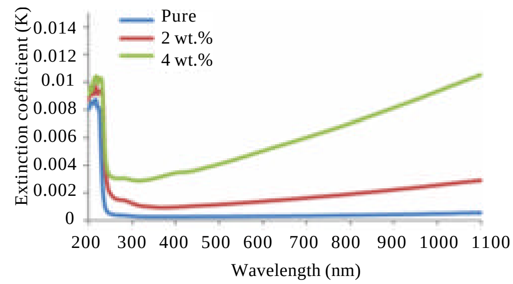

Fig. 7: Extinction coefficient versus wavelength of deposited films

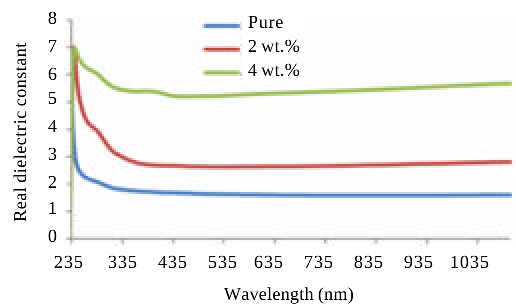

Fig. 8: Real part of dielectric constant against wavelength of the deposited films

being doped. n and k values increased with increasing of Sb_2O_3 content, this result agrees with the previous work (Habubi *et al*., 2010; Tintu *et al*., 2010). Such behavior corresponds to the density of absorbing centers such as impurity absorption, excitation transition and other defects in the crystal lattice dependent on the conditions of sample preparation.

The real and imaginary of dielectric (ε_1 and ε_2) can be calculated by using equations (Mohammed *et al*., 2017):

$$\varepsilon = \varepsilon_1 - i\varepsilon_2 \quad (7)$$

$$\varepsilon_1 = n^2 - k^2 \quad (8)$$

$$\varepsilon_2 = 2nk \quad (9)$$

Figure 8 and 9 illustrate the relation between real and imaginary parts of dielectric constants against wavelength at different Sb_2O_3 content. From these figures, ε_1 and ε_2 increase with the increasing of concentration of Sb_2O_3. It can be concluded that differences of ε_1 rely on (n^2) while ε_2 depends on (k) values which was related to the differences in absorption coefficients (Abass and Latif, 2016).

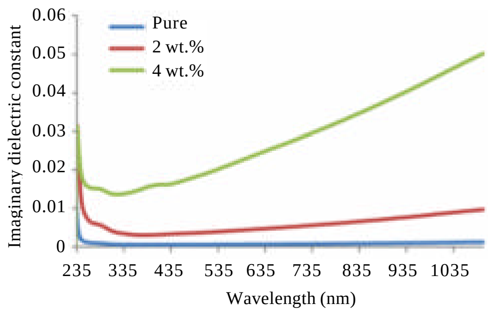

Fig. 9: Imaginary part of dielectric constant against wavelength of the deposited films

CONCLUSION

The absorbance of PVA-PVP-Sb_2O_3 composite increased with increasing of the antimony trioxide (Sb_2O_3) concentration while the transmittance decreased. The optical constants increased with antimony trioxide content .The energy band gap deposited films was decreased with increasing of Sb_2O_3 percentage.

ACKNOWLEDGMENT

The scientist want to say thanks to Mustansiriyah University and Babylon University for their help in the present research.

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