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THE INFLUENCE OF NICKEL ACETATE $NI(CH_3CO_2)_2$ CONCENTRATIONS ON THE OPTICAL PROPERTIES OF COMPOUND (ZINC OXIDE, ALUMINUM OXIDE) BASED ON EPOXY RESIN

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Abstract
Composite thin films are intentionally manufactured media that typically consist of two or three phases, one of which is metallic and the other dielectric. The word "thin films" denotes that it's about composites with a little amount of metal phase. It has been demonstrated in this study the influence of nickel acetate with various ratios (0%, 0.5% ,2% ,5%, 10 %, 12.5 %) on the optical properties of zinc oxide/ aluminum oxide compound based on epoxy resin. The optical characteristics of such as absorption (A), transmission (T), absorption coefficient (α), optical energy gap (Eg) and other optical constant such as refractive index, extinction coefficient, real and imaginary parts of dielectric constant have been investigated. The optical energy gap has been estimated to be 3.39 eV to 2.81 eV.

Keyword: Optical characteristics, epoxy resin, zinc oxide, aluminum oxide, nickel acetate, absorption, transition, dielectric constant.

1.Introduction
Composites materials have gained interest in recent years in science as introduction of materials in transparent polymer matrix, polymeric composites have much attention of researches as advanced technological materials according to their unique optical, electrical and electronic. Mechanical and structural characteristics. These characteristics are obtained from the specific combination of the inherent novel

properties of polymers and metals providing new ideas in physics to explain it[1-6]. Composite thin films are intentionally manufactured media that typically consist of two or three phases, one of which is metallic and the other dielectric. The word "thin films" denotes that it's about composites with a little amount of metal phase (less than 50 at.%) [7]. The composite's structure is a collection of microscale metal beads scattered across the bulk of the dielectric matrix, which is a continuous medium in this case. Because the metal granules and the dielectric layer that separates them have dimensions of only a few micrometers, such materials exhibit quantum phenomena and, above all, electron tunneling. In general Zinc oxide is an n-type semiconductor with wide band gap II-VI compound semiconductor and have a stable wurtzite structure. It has been attracting much attention in research with Aluminum oxide for their potential application in optoelectronic devices photovoltaic cells, gas sensor UV laser, Optical wave guides, Light emitting diodes, catalysts (using zinc oxide as an active channel in invisible thin film transistors) and hydrogen storage devices[8-13]. Composite of Zinc oxide , Aluminum oxide and nickel acetate of epoxy resin are very important scientific and commercial composite .They may be used in various devices as a protective layer and for optoelectronic applications, because of their high durability and according to its excellent properties such as having high dielectric constant, high flexibility as well as their ability to be fabricated at normal temperature and low cost. The aim of the present work is to investigate the optical characteristics of zinc oxide/aluminum oxide compound with different weight ratio's (0%, 0.5% ,2% ,5%, 10 %, 12.5 %) of nickel acetate $Ni(ch_3Co_2)_2$ based on epoxy resin. The optical absorption spectrum is one of the most important tools for understanding band structure, electronic properties and optical constants (refractive and absorption indices) of pure and doped the composite films included absorption (A), transmission (T), absorption coefficient (α) and optical energy gap (Eg). As well as the dielectric constants have been studied.

2.Experimental

This project uses epoxy resin (Mixing ratio: 3:1, Product model: 136-2A, and Product lot number: 20209150). Filler materials included zinc oxide (ZnO), aluminum oxide (AL_2O_3), and nickel acetate ($Ni(CH_3Co_2)_2$. A glass substrate with dimensions of (75mm. x 25mm.x 1mm.) received a multistep solvent cleaning by ultrasonic bath technique; for (5 min.) in isopropyl alcohol, for (5 min.) in acetone, and for (5 min.) in deionized water, followed by one hour of drying in an oven at 90^oC.By mechanical mixing methods, the epoxy resin mixtures were generated in various concentrations (as given in Table 1) of ZnO, AL_2O_3, and Ni $(CH_3Co_2)_2$ as fillers materials, and then the hardener (in a 3:1 epoxy to hardener ratio) was added. The samples were made at room temperature using the coat deposition procedure. Before being measured, the samples were allowed to dry for two days at room temperature, the absorption and transmission spectrums were measured with a UV-VIS spectrophotometer (SHIMADZU, 1800, UV-16, Japan). The variation of absorbance, transmittance and specular absolute reflectance with wavelength of light incident on the films was measured using a UV-VIS spectrophotometer (SHIMADZU, 1800, UV-16, Japan) in the photon wavelength range (300-900) nm. The dependence of absorption coefficient,

(α) on photon energy has been analyzed with existing models to find the nature and extent of the band gap energy (Eg). and other optical constant such as refractive index, extinction coefficient, real and imaginary parts of dielectric constant have been estimated.

Table (1)

Sample.No.	ZnO		Al_2O_3		Ni $(CH_3Co_2)_2$	
	Concen.	(gm)	Concen.	(gm)	Concen.	(gm)
1	0.5 %	0.2	0.5 %	0.2	0 %	0
2	0.5 %	0.2	0.5 %	0.2	0.5 %	0.2
3	0.5 %	0.2	0.5 %	0.2	2 %	0.8
4	0.5 %	0.2	0.5 %	0.2	5 %	2
5	0.5 %	0.2	0.5 %	0.2	10 %	4
6	0.5 %	0.2	0.5 %	0.2	12.5 %	5

The concentrations elements of composites ZnO /Al_2O_3 and $Ni(ch_3Co_2)_2$.

3 – Results and Discussion

3.1. Examining the absorption, reflectance and transmittance spectra of composite ZnO/Al_2O_3/ $Ni(ch_3Co_2)_2$ films.

Analysis of the absorption spectra in the lower energy part gives information about atomic vibrations, while the higher energy part of the spectrum offers knowledge about the electronic states in the atom. The UV-VIS absorbance spectra in the region (300-900) nm. for the composite of ZnO/Al_2O_3 with varying concentrations (0%, 0.5 % ,2 % ,5%, 10 %, 12.5 %) of nickel acetate $Ni(ch_3Co_2)_2$ added at room temperature are shown in Figure (1). It can be observed from the figure that the absorption spectra for all samples decreased with increasing wavelength, while for the mixture films with varying concentrations (0.5 % ,2 % ,5%, 10 %, 12.5 %) of nickel acetate $Ni(ch_3Co_2)_2$,

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the absorption increased with increasing concentration for all films. In the pure sample of ZnO/Al_2O_3 composite the absorption decrease in the region (320 -360) nm. and hence slight change occurs in the beyond wavelength. The presence of nickel acetate in the composite showed a significant change in the absorption in the region (380-420) nm. for different concentration, slight change occurs in absorption in the high wavelengths. The formation of new peaks and the broadening of these peaks with increasing of nickel acetate concentrations gives an indication of change in the composite structure. This phenomenon might be also explained by the accumulation of charge carriers in levels below the conduction beam, which need less energy to transmit to the conduction beam, and is known as the (Moss-Burstein) effect[14]. Increasing the doping ratios improves the area absorption and consequently the amount of photons absorbed in that region, resulting in increased absorption.

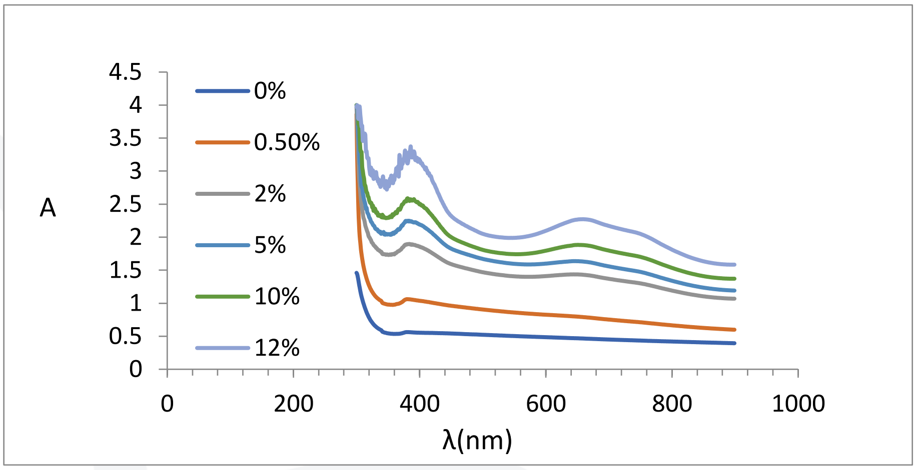

Figure (1) The absorbance spectrum for composite thin films as a function of wavelength.

The optical transmittance spectra of composite ZnO/Al_2O_3 with varying doping ratios (0%, 0.5 % ,2 % ,5%, 10 %, 12.5 %) of $Ni(ch_3Co_2)_2$ as a function of wavelength is shown in Figure (2). The measurements were performed in the wavelength range (of 300-900) nm. It can be noticed that the transmittance intensity increases with increasing of the wavelength, and as the concentration of doped of nickel acetate $Ni(ch_3Co_2)_2$ increases, the transmittance decreases. According to the figures, all distorted films are transparent at wavelengths ranging from (300 to 900) nm and have a high transmittance of up to (87%) percent in the visible range. The increase in doping is accompanied by a minor increase in transmittance. These results agree with the works reported by Luka's [8]. The reason for this behavior is that, the increases of concentration of nickel acetate led to increases the localized state density which reduces the transmittance values. It is also noticed that the composite films after the increase in the percentage of doping have new peaks where appear in the short wavelengths, so higher transmission values in the higher wavelengths of the spectrum.

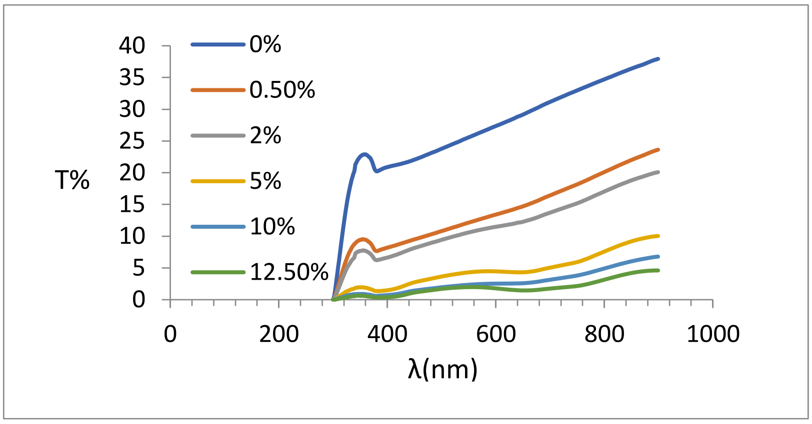

Figure (2) The transmittance spectrum for composite thin films $ZnOAl_2O_3$ $Ni(ch_3Co_2)_2$ at various concentrations as a function of wavelength.

Figure (3) shows the reflectance spectra of composite ZnO/Al_2O_3 with varying doping ratios (0%, 0.5 % ,2 % ,5%, 10 %, 12.5 %) of $Ni(ch_3Co_2)_2$ as a function of wavelength. The reflectance has been determined using the following relationship [15]:-

$$R = 1 - \sqrt{T' \exp(A')} \qquad (1)$$

Where (R) the reflectance, T / Correction factor for Transmittance, A/ Correction factor for Absorbance. When the light radiation passes from one medium in to another having different of refraction some of the light is scattered at the interface between the two media even if both are transparent. thus, higher index of refraction of the solid, greater is the reflectivity. just as the index of refraction of a solid depends on the wavelength of the incident light, so the reflectivity varies with wavelength. As a result, as the wavelength grows, the reflectivity increases, and as the doping increases, the absorption zone expands, increasing the quantity of photons in that region, allowing the film thickness to increase. This behavior may be attributed to the accumulation of charge carriers at levels below the conduction beam, which require more energy for transfer to the conduction beam, and this is known as the effect of Moss_Burstein. Additionally, increasing the distortion may create membrane flaws, which enhances ray scattering and reflection.

3.2. Calculation of the absorption coefficient for the composite $ZnO/Al_2O_3/Ni(ch_3Co_2)_2$ samples.

The absorption coefficient (α) is the ratio of the reduction in excess radiation energy to the unit distance between the wave propagation directions within the medium. The absorption coefficient is affected by the energy of incident photons as well as

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semiconductor features like the energy gap and the type of electronic transitions between the valence and conduction bands. The absorption coefficient (α) of composite films with a concentration difference at room temperature can be determined using the equation below: [16-17]

$I_t = I_o \exp(-\alpha t)$ (2)

Where α is the optical absorption coefficient, it is the thickness of the film, I_t and I_o are the intensity of transmitted light and initial light respectively and

$$\alpha = \frac{2.303}{t} e^{\frac{I0}{I}} = \frac{2.303}{t} A' \quad (3)$$

where A' is the amount of absorbance after correction and (t) the sample thickness. The relationship between the absorbance coefficient and photon energy for films of the compound with varying doping ratios is depicted in the Figure (3). It can be observed from the figure that, When the photon energy is less than (1.5 eV), there is a little increase in the absorption coefficient for all films, while a great increases in the absorption coefficient at the photon energy is more than (1.5 eV) for all concentrations.

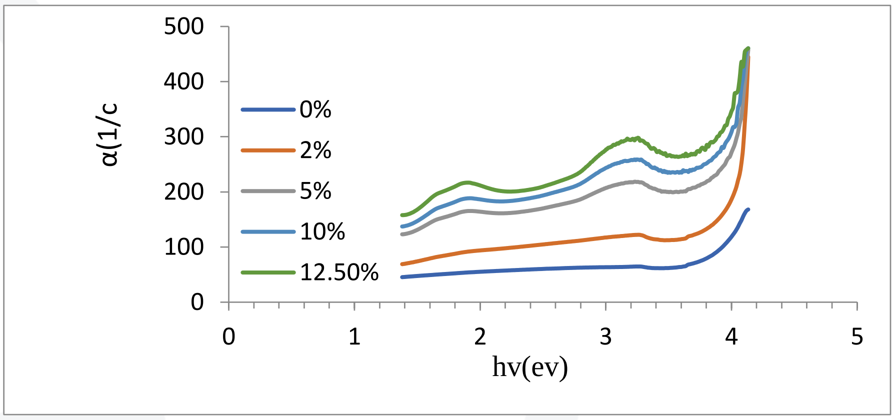

Figure (3) illustrates the absorption coefficient for composite thin films $ZnO/Al_2O_3/Ni(ch_3Co_2)_2$ at various concentrations as a function of photon energy.

This behavior is according to absorption related to the amount of absorbing molecules due to Beer-Lombard relating rising the doping percentage leads to increasing the amount of particles that absorbed light energy via non-bounding electrons. In addition to the number of absorbing molecules as a result of considerable interaction between the composite materials leads to increase the localized state density, these results agree with other workers [18-19].

3.3. Calculation of the optical energy gap (Eg) of the composite ZnO/Al_2O_3 $Ni(ch_3Co_2)_2$ samples.

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The energy gap depends on the kind of transition, and the value of the absorption coefficient plays an essential role in defining the type of transition, studying the value of the absorption coefficient allows us to identify the type of electronic transition. This type of transition is known as direct transmission when the absorption coefficient is ($\alpha \geq 10^4$), but it is known as indirect transmission when the absorption coefficient is ($\alpha \leq 10^4$) From the figure, it is clear that the type of transition in the thin and impregnated films from the composite is a type of direct transmission allowed with it.These transitions can be described by the following equation [20]

$\alpha hv = \beta(hv\text{-}Eg)^r$.............(4)

where β is constant, E_g is the optical energy gap, h is the plank constant, v is the frequency and r is an exponential coefficient with a value of 0.5 for permitted direct transmission and 0 for prohibited direct transmission. The energy gap of composite ZnO/Al_2O_3 with varying doping ratios (0%, 0.5 % ,2 % ,5%, 10 %, 12.5 %) of $Ni(ch_3Co_2)_2$ was determined by drawing the relationship between $(\alpha hv)^{0.5}$ and photon energy are shown in Figure (4) and then extending the straight line from the curve to intersect the photon energy axis at point (0) to obtain the energy gap value for the allowed direct transfer.

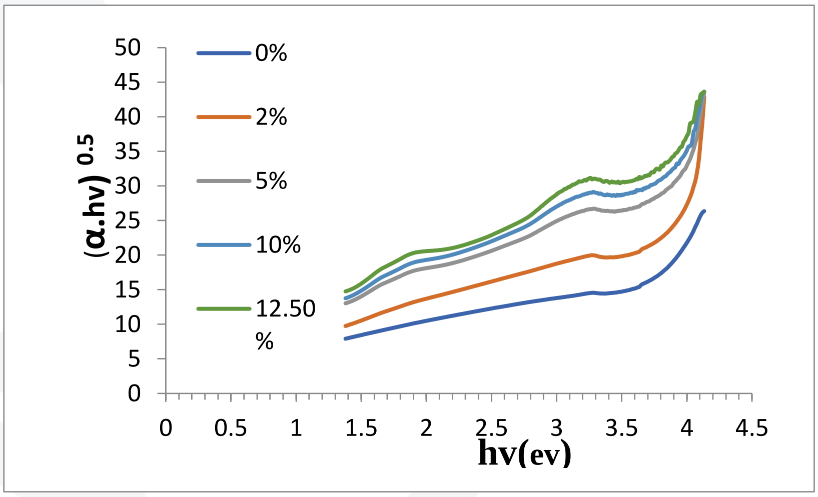

Figure (4) illustrates the relationship between $(\alpha hv)^{0.5}$ and photon energy for composite thin films ZnO/Al_2O_3 /$Ni(ch_3Co_2)_2$ at various concentrations as a function of photon energy.

Figure (4) illustrates the relationship between (α) and photon energy for composite thin films $ZnOAl_2O_3$ $Ni(ch_3Co_2)_2$ at various concentrations as a function of photon energy.it can be seen from figure (4) that, whereas $\alpha(cm^{-1})$ is decreasing with increasing of adding weight ratio. The energy gaps decrease with increase the adding weight ratio. The energy gaps are (3.39 eV ,3.34eV, 3.22 eV, 2.9 eV,2.88 eV and 2.81eV) for adding weight ratio (0%,0.5%,2%,5%,10% and 12.5%) respectively in

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which the weight doping ratio resulting to increase the defects formation and it is believed that be related to the presence of secondary phase to grain boundaries. The factors that, effect on the band gap are grain size, strain and dislocation. The relationship between (E_g) and weight ratio for composite thin films ZnO/Al_2O_3 at various concentrations of $Ni(ch_3Co_2)_2$ as a function of photon energy is shown in Figure (5) .

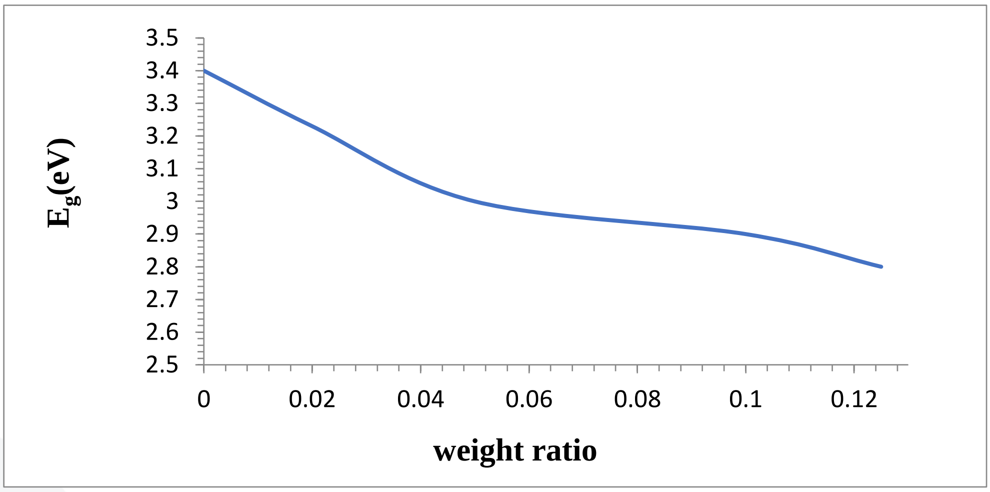

Figure (5) The relationship between (E_g) and weight ratio for composite thin films $ZnOAl_2O_3$ $Ni(ch_3Co_2)_2$ at various concentrations as a function of photon energy.

The optical conductivity (σ_{op}) of the film is related to the absorption coefficient (α) and the velocity of light (C) according to relation:

$$\sigma_{0p} = \frac{\alpha n c}{4\pi} \quad (5)$$

It is noticed that the optical conductivity (σ_{op}) of the composite ZnO/Al_2O_3 with varying doping ratios (0%, 0.5 % ,2 % ,5%, 10 %, 12.5 %) of $Ni(ch_3Co_2)_2$ was increasing with increases the incident photon energy (hν) because this behavior is depending on absorption coefficient.

3-4 Calculation of the extinction coefficient(k) and refractive index(n) of the composite ZnO/Al_2O_3 $Ni(ch_3Co_2)_2$ samples.

The dependence of the extinction coefficient (k) on the wavelength in the range 300-900 nm. of pure and weight ratio for composite films ZnO/Al_2O_3 at various concentrations of $Ni(ch_3Co_2)_2$ are estimated. It's observed that the extinction coefficient for the composite was increased with increasing the wavelength (300-900) nm and with increasing the $Ni(ch_3Co_2)_2$weight ratio, this is according to increase in absorption coefficient, where the extinction coefficient depends on the absorption coefficient by the following relation [21-23].

$$k = \frac{\alpha\lambda}{4\pi} \quad (6)$$

where α is the absorption coefficient.

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The refractive index (n) is a fundamental optical property of nanostructures films, that is directly to the optical, electrical and magnetic properties, as well as it is interesting to investigate the physical and chemical of semiconductor by optical techniques [32]. The refractive index (n) of the composite films were estimated from the absolute values of the absorbance and transmittance of the studying films by the following relation [21-22]

$$n = \left[\frac{1+R}{1-R}\right] + \left[\frac{4R}{(1-R)^2}\, k^2\right] \qquad (7),$$

Where R is the optical reflectance.

The dependence of the extinction coefficient (k) and refractive index (n) of the pure and weight ratio for composite films ZnO/Al_2O_3 at various concentrations of $Ni(ch_3Co_2)_2$ on the incident photon energy (hν) in the range of 300 – 900 nm. Are shown in Figure (6).It is clear from the figure that the extinction coefficient are increase in values with increasing the incident photon energy this is according to the increase in absorption coefficient .

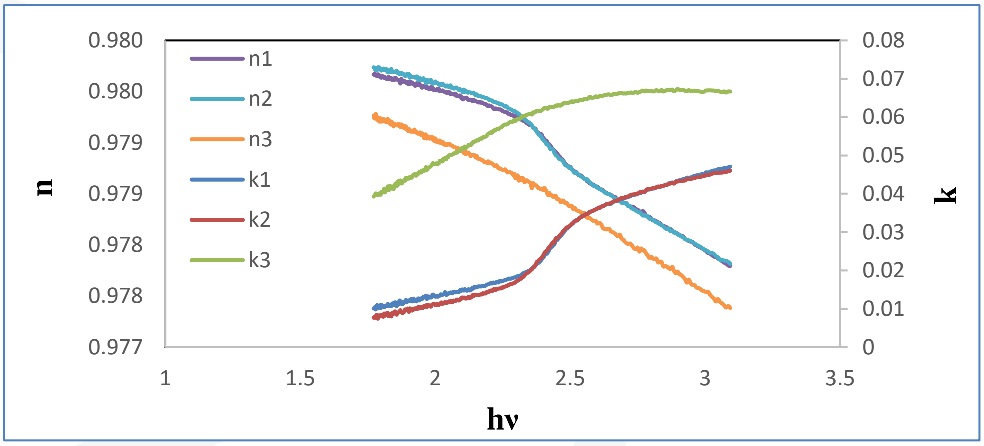

Figure (6) The extinction coefficient and refractive index for composite films ZnO/Al_2O_3 at various concentrations of $Ni(ch_3Co_2)_2$ as a function of photon energy.

The dielectric constant which is consists real part (ε_r) and the imaginary part (ε_i) can be determined by using are the following relations: - [22]

$\varepsilon_r = n^2+k^2$ (8)

$\varepsilon_i = 2nk$ (9)

It is seen that the behavior of real part(ε_r) similar to the behavior of the refractive index (n), because the effect of extinction coefficient is very small which implies to smaller values of (k^2) in comparison with (n^2) but the behavior of imaginary part(ε_i) mainly depends on the variation of extinction coefficient (k) .Also it noticed that ,the values of the real dielectric constant (ε_r) are greater than the imaginary part of dielectric constant (ε_i).

4- Conclusions

In the present work the composite of ZnO/ AL_2O_3, and $Ni(CH_3Co_2)_2$ Material was prepared by mechanical mixing methods, the epoxy resin mixtures were generated in various concentrations of ZnO, AL_2O_3, and Ni $(CH_3Co_2)_2$ as materials, and then the hardener (in a 3:1 epoxy to hardener ratio) was added. The optical characteristics such as absorption (A), transmission (T), absorption coefficient (α) and optical energy gap (Eg). refractive index(n), extinction coefficient (k), real and imaginary parts of dielectric constant have been studied.

The dependence of absorption coefficient, (α) on photon energy has been analyzed with existing models to find the nature and extent of the band gap energy (Eg). and other optical constant such as refractive index, extinction coefficient, real and imaginary parts of dielectric constant have been estimated. The energy gaps are (3.39 eV ,3.34eV, 3.22 eV, 2.9 eV,2.88 eV and 2.81eV) for adding weight ratio (0%,0.5%,2%,5%,10% and 12.5%) respectively.

The extinction coefficient is increase in values with increasing the incident photon energy this is according to the increase in absorption coefficient.

The behavior of real part(ε_r) similar to the behavior of the refractive index (n) and the behavior of imaginary part(ε_i) mainly depends on the variation of extinction coefficient (k). Also, it noticed that, the values of the real dielectric constant (ε_r) are greater than the imaginary part of dielectric constant (ε_i).

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