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Optical Properties of Polyvinylpyrrolidone (PVP) Films Doped with Nickel Nitrate ($NiNO_3$)

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Abstract: ***The pure of polyvinylpyrrolidone (PVP) and PVP-$NiNO_3$ composite with different weight percentage of $NiNO_3$ were prepared using casting technique. The optical properties of all samples were studied in the room temperature by using UV-VIS/160/Shimadzu spectrophotometer at (200-800) nm wavelength region. The effects of NiNO3 concentration on the optical properties of (PVP- NiNO3) composites have been investigated. The experimental results show that the samples have indirect transition. The energy band gap decrease with increase the concentration of $NiNO_3$. The optical constants (Refractive index, Extinction coefficient, Real and Imaginary parts of the dielectric constant) showed clear changes with increasing the doping concentrations.***

Keywords: polyvinylpyrrolidone (PVP), polymer, composites.

1. Introduction

The polymer composites have been become very popular in the recent time because of their significant importance in applied as well as basic sciences. The stability of polymer thin films on solid substrates is of great technological importance in applications ranging from protective coatings to paintings, semiconductor, and micro-and optoelectronic[1, 2].

Polymer –inorganic and polymer-polymer interfaces can also have a great impact naval materials[3]. Suitable addition of dopants, blends, or copolymer to the polymer matrix, the electrical, electrochemical and optical properties of these materials could be selectively modified for particular properties in various applications.

The poly vinylpyrrolidone (PVP) has good film-forming and adhesive behavior on many solid substrates and its formed films exhibits good optical quality (high transmission in visible range), and mechanical strength (easy processing) required for application [4]The study of the optical absorption spectra in solids provides essential information about the band structure and the energy gap in the crystalline and noncrystalline materials.

In this work, we prepared polyvinylpyrrolidone thin films with different concentration from Nickel Nitrate $NiNO_3$ to investigate the effect on the dielectric, optical properties of poly vinylpyrrolidone thin film.

2. Experimental Part

The polymer was dissolved in distilled water by using magnetic stirrer in a warmer condition to get homogeneous solution, . gravimetric ratios from $NiNO_3$ (0, 5, 10, 15) wt% were added and mixed for 10 minutes to get more homogenous solution, after which solution was transferred to clean glass Petri dish of (5cm) in diameter placed on plate form. The dried film was then removed easily by using tweezers clamp. The polymer systems were evaluated spectra photo metrically by using UV-VIS/160/Shimadzu spectrophotometer.

3. Results and Discussion

3.1 The Transmittance and Reflectance

Fig 1 shows the transmittance for composite with various photon energy. The composites have been high transmittance in the visible region and decrease with increase photon energy.

Fig 2 shows the reflectance against photon energy for the composites. it can be seen the reflectance is less than 6 %. from fig 2 the reflectance increase with increase photon energy.

Thin films with high transmittance and low reflectance are good material for antireflection coatings of thermal devices[5].

3.2 The Absorption coefficient and energy gap of composite

The optical absorption coefficient (α) which is a function of wavelength can be calculated by using the relation[6] :

$\alpha=2.303A/d$ ………. (1)

Where A: is the absorption of the material, d: the sample thickness

Fig 3 shows the relationship between the absorption coefficients of the composite with photon energy. The absorption coefficient increase with increase the weight percentage of $NiNO_3$ may be due to the absorption by the $NiNO_3$. The absorption coefficient is smaller and stable in the low photon energy because of the scattering of the photon energy.

Analysis of optical absorption spectra could reveal the energy gap E_g between the conduction Band (CD) and the

Valance Band (VB) due to direct and indirect transition of both crystalline and amorphous materials.

The energy band gap E_g for the film deposited in this paper was calculated by using relation [7, 8]:

$$\alpha = B\,(h\upsilon - E_g)^{m}/h\upsilon \ldots\ldots\ldots\ldots\ldots (2)$$

Where:
$h\upsilon$ = The energy of the incidence photon, h = the Planck constant, E_g = the optical energy band gap, B = a constant, m is the power coefficient depends on the nature of the transitions, i. e. , m = 1/2, 2/3, 2or 3 for direct allowed, direct forbidden, indirect allowed and indirect forbidden respectively. The indirect optical band gap can be evaluated from the linear plots of $(\alpha h\upsilon)^{1/2}$ versus $h\upsilon$ as illustrated in Fig 4, the energy gab values dependence in general on the crystal structure of the composites and on the arrangement and distribution way of atoms in the crystal lattice. From the Fig 4 the energy gab decreases with increasing the concentration of ($NiNO_3$). The optical energy gap decreased from (3. 6) ev for pure PVP films to (3. 2) for15%$NiNO_3$. This is possibly due to increase absorption coefficient as a result of introducing dopant atoms and hence E_g will be decreasing.

3.3 Refractive Index and Extinction Coefficient

The most important optical properties are the refractive index (n) and the extinction coefficient (K).

The refractive index as a function of wavelength can be calculated by using the equation where R reflection coefficient and K the extinction coefficient [9]:

$$n = \left(\frac{4R}{(1-R)^2} - K^2\right)^{1/2} - \frac{(R+1)}{(R-1)} \ldots\ldots\ldots (3)$$

Fig 5 shows the variation of refractive index (n) of the composite with photon energy. Refractive index (n) increase with increasing photon energy and concentration of dopant.

The extinction coefficient (k) was calculated using the following equation:

$$K = \alpha\lambda/4\pi \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Fig. 6 represent the variation of the extinction coefficient (k) with the incident photon energy in this figure the variation is simple in the low energy region while the variation increased in the high photon energy region this behavior may be as a result to the variation of the absorption coefficient which leads to spectral deviation in the location of the charge polarization at the attenuation coefficient due to the loses in the energy of the electron transition between the energy bands.

3.4 Dielectric Constant

The knowledge of real part (ε_1) and imaginary part (ε_2) of the dielectric constant provide information about the loss factor. The real and imaginary parts of dielectric constant ($\varepsilon_1$and ε_2) can be calculated by using equations [10, 11]:

$$\varepsilon_1 = n^2 - k^2 \ldots\ldots\ldots\ldots\ldots (5)$$
$$\varepsilon_2 = 2nk \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Fig 7 shows that the real part of the dielectric constant variation is very clear spatially in the high impurities concentration this may be due to the no resonance between the frequencies of the incident photon energy (electromagnetic and the induced dipoles in the composite) .

While in the imaginary part Fig 8 there is absorption to the energy from an electric field due to dipole motion, so the variations of imaginary part nearly constant until it reaches to the high photon energy where increased with increase the concentration of $NiNO_3$.

4. Conclusion

- PVP-NiNO3 composite films are obtained by casting method. the films are characterized by UV-VIS spectra. the transition were found to be indirect type. the energy band gap decrease with increase the concentration of $NiNO_3$.
- The refractive index and extinction coefficient have been found to increase with increase the concentration of $NiNO_3$.
- The real part (ε_1) and imaginary part (ε_2) of the dielectric constant have been found clear variation with the concentration of $NiNO_3$ and the photon energy.
- it was shown from the studies that the addition of inorganic material into the polymer results in fabrication of new composite film low cost, it will contribute to produce a new material that might potentially be used as an alternative or substitute material for many other application.

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