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Studying the Effect of Silica Nanoparticles on Optical Properties of Polyvinyl Alcohol Thin Films for Semi-conductors Applications

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Abstract:
This search includes measurement of some optical properties of Polyvinyl alcohol thin film such as absorbance, transmittance, coefficient of absorbance, and refraction index via Spectrophotometer Spectroscopy (UV-1800. The effect of Silica nanoparticles on these properties were also studied. Imaginary and real Dielectric constant of samples were calculated.
The results showed that all these propertiesincreased linearly by adding of 5% of silica nanoparticles except the transmittance has versus behavior of absorbance.

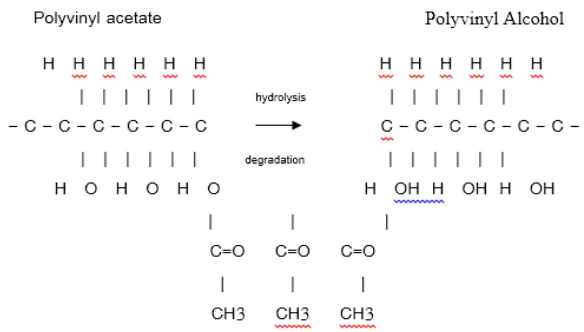
Keywords: *polyvinylalcohol, SiO2 nanoparticle , thin film, UV- spectrum , optical properties.*

1. INTRODUCTION

The science and engineering that are included in the synthesis, design, applicationand characterization of materials and devices that have the smallest functional organization in at least one dimension on the nanometer scale or a billion meters called Nanotechnology. In recent years, increasing applications of nanotechnologyin the field of materials, followed by electronics and medicine [1].

There is a growing research interest in polymeric nanocomposites due to improvements in thermal, optical, electrical, and mechanical properties and their large capacity for high functional materials[2] .When the light falls on a substance, several reactions occur, as a result of the interaction of the falling radiation with the material absorption process as a part of the falling light is absorbed by the material and turns into heat and the other part passes through the material called light and the remaining part suffers a reflection process called light reflected [3].

Polyvinyl alcohol is one of the transparently polymer, it dissolves slowly in water at low temperature but it has high water dissolubility at high temperatures. It has an resistance to solvents and oils, good insulating material,good storage capacity for charging as well as low electrical conductivity,these properties make polyvinyl alcohol (PVA) an exceptional polymer for microelectronic industry[4].



As long as the Spectrophotometer calculates the relative value of the light, this value is closely related to absorption by the Lambert-Beer law, which states that the absorptive fraction of the falling radiation is directly proportional to the

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number of absorbent particles and thickness of the model according to the following equation: [3]

$$\log\frac{I}{I_0} = A = -\alpha_{op}CL \text{ ....(1)}$$

where (α_{op}) : The absorption coefficient of light

(A) : absorption

(C) concentration, and (L) thickness of the sample.

The optical absorption coefficient α is the abilityof a material to absorb light of a given wavelength.The variation of optical absorption coefficient α with wavelength can be calculated from the optical absorptionspectrum using the Beer-Lambert's relation (eq.2) :[5]

$$\alpha_{OP} = slope/L \text{ ....(2)}$$

(I / I°) :Transmittance (T) is the ratio between photovoltaic energy from surface to photovoltaic energy falling on the surface and is associated with absorption as shown in the relationship below [6,7,8]:

$$T = e^{-2.303A} \text{ ....(3)}$$

The refractive index is the ratio between the speed of light (c) in the vacuum to its velocity (v) in any given medium and a given wavelength, and is given by the following equation: [9,10]

$$n = \frac{c}{v} \text{ ....(4)}$$

Reflectivity is the ratio of the energy of light reflected to the energy of the falling light. The reflectivity value is given by equation: [6,11]

$$R = \left[\frac{n-1}{n+1}\right]^2 \text{ ....(5)}$$

The value of the critical angle of a separating surface between two visuals is defined as the angle of fall, the angle of the refraction angle is 90 °, and the light is reflected completely (internal reflection). Meaning that no energy loss occurs when reflection is given by the relationship: [8]

$$\theta_c = \mathrm{Sin}^{-1}(1/n) \text{ ....(6)}$$

The Brewster angle is the angle of fall where the reflected light is fully polarized and the polarization mode is only vertical and perpendicular to the refractive beam (partially polarized) and depends on the refractive index of the material Brosster was the first to discover that the reflected and broken rays are perpendicular, Refractive index with the following relations: [12]

$$\frac{\mathrm{Sin}\ \theta_B}{\mathrm{Sin}\ \theta_R} = n \text{ ....(7)}$$

Since the angle of refraction) we have $90-\theta_B$)=(θ_R (

$$\mathrm{Sin}\ \theta_B = n\mathrm{Sin}\ (90-\theta_B)$$

$$\frac{\mathrm{Sin}\ \theta_B}{\mathrm{Sin}\ \theta_R} = \frac{\mathrm{Sin}\ \theta_B}{\mathrm{Cos}\ \theta_B} = n \text{ ....(8)}$$

$$n = \tan\theta_B \text{ ....(9)}$$

$$\theta_B = \tan^{-1}(n) \text{ ....(10)}$$

2. MATERIALS AND METHODS

Polyvinylalcohol (PVA) with density (1.19 g/cm3), and molecular weight is (95000g/mol) , as a matrixand silica nanoparticles with 50 nm particle size from Aldrich German company , as additive were used.

The use of casting technique for the preparation of nanocomposites, as follow: first ,dissolvedthe polyvinyl alcohol in distilled water by using magnetic stirrer and second,Silica nanoparticles are adding to a solution at concentrations of 5 wt%.The UV / 1800 / Shimadzu spectrophotometer was used in the wavelength range (200-800) nm to measure the optical properties of nanocomposites .

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3. RESULTS AND DISCUSSION

3.1 UV- Absorption Spectrum

Fig.1 show the UV spectra of nanocomposites with wavelength ofincident light for pure PVA and PVA/SiO2. The absorption of PVA increases with the addition of(5)%wt from SiO2 nanoparticle. Increased absorption attributed to nanoparticles that absorb incident light.This result agreement with Tariq J. Alwan, 2010 [13]

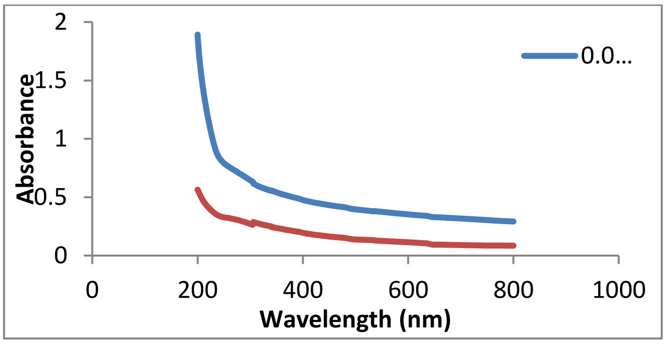

Figure 2: Optical absorbance of (PVA) polymer, PVA/ SiO2

3.2 UV- Transmittance Spectrum

Figure 2. show the transmission values of pure PVA and PVA/SiO2 nanocomposite through 200-850 nm wavelengths. The results showdecreasing the transmission through (200-300 nm) wavelength .The effect of the addition of SiO2nanoparticles leads to a decrease transmission values within the range of ultraviolet radiation, any increase in absorbance values causes a decrease in transmission values.

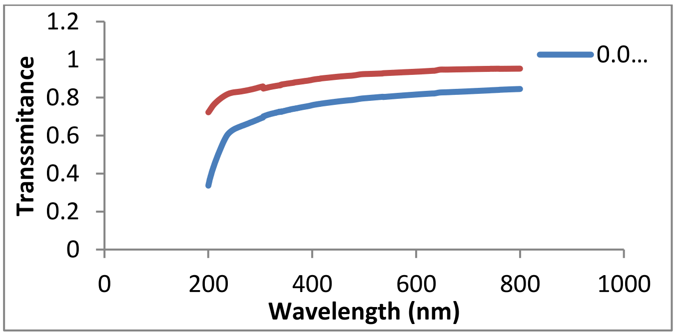

Figure 1: Optical Transmittance of (PVA) polymer, PVA/ SiO2

3.3 Reflectance

The values of reflectivity were calculated from equation (5) for PVA and PVA/SiO2. Figure 3 shows the increase of these values with additionnanoparticle. This is due to the increase in the number of polymer particles in the solution ,Thus increasing the density of the solution as the reflectivity depends entirely on the density [14].

The presence of nanoparticle lead to increase the amount of reflected radiation .Also, this characteristic depends mainly on the refractive index according to theeq.5, so the reflectivity behaves similarly to the refractive index.

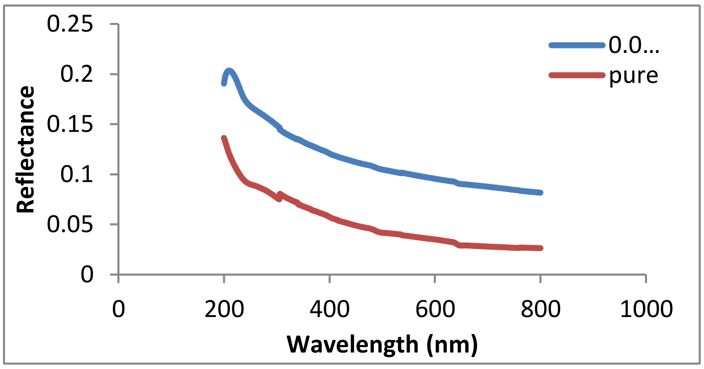

Figure 3Optical Reflectance as wavelength of (PVA) polymer, PVA/ SiO2 nanocomposite

3.4Absorption Coefficient

Fig.4 shows the increase in absorption coefficient because of the increased density of solutions due to addition nanoparticle, which leads to the increase of absorption light according to Lambert-Beer's law and thus increase the absorption coefficient [17].

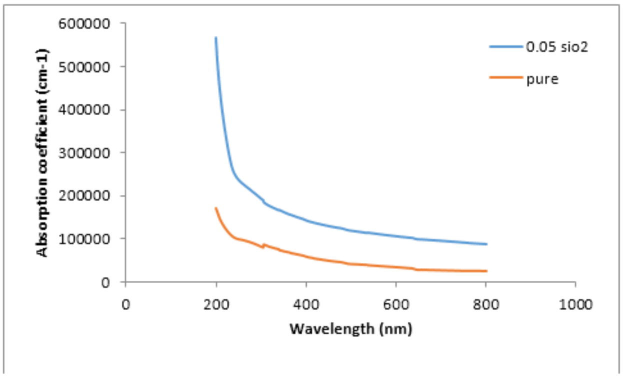

Figure 4 shows the absorption coefficient of samples

3.5 Extinction coefficient

Fig.5 show as the extinction coefficient (K) increases with adding SiO2 nanoparticle, this behavior of extinction coefficient can be ascribed tothe difference in absorption coefficient since k directly proportional to α.

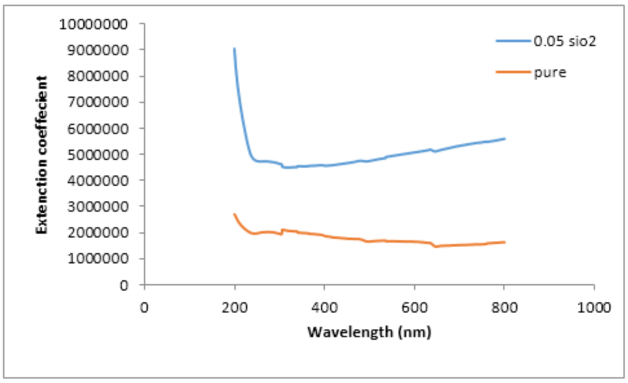

Figure 5 The extinction coefficient for PVA and PVA/SiO2 nanocomposite as a function of wavelength

3.6 Refractive index

Fig. 6 shows the variation of the refractive index ofnanocomposites as the function of photon energy. Refractive index increases due to the addition of SiO2nanoparticles, and this behavior can be attributed to the increased packing density of the nanocomposite as a result of the content of filler ,this result agreement with (Amma, et al.,2005)[15]

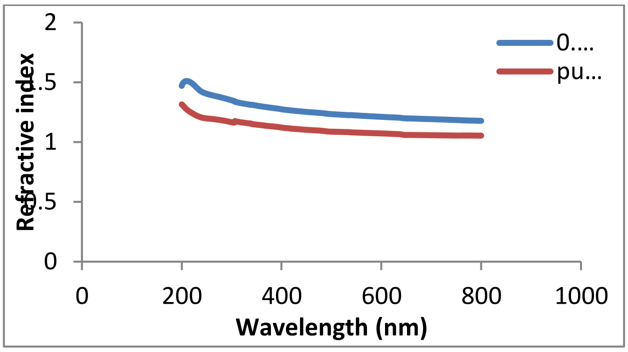

Figure 6. The refraction index of PVA/SiO2nanocomposite as a function of wavelength

3.7 Indirect energy gap

The energy band gap values were obtained by extrapolating the straight line portion of the curves to a zero absorption coefficient of the samples as shown in Figure 7.It was obtained band gap 5.3 eV for pure PVA and reduced to 5 eV with the addition of 5 wt% SiO2 nanoparticles in SiO2 / PVA nanocomposite .There is decrease in band gap with adding of SiO2 nanoparticles due to increased local levels in theforbidden energy gap [16].

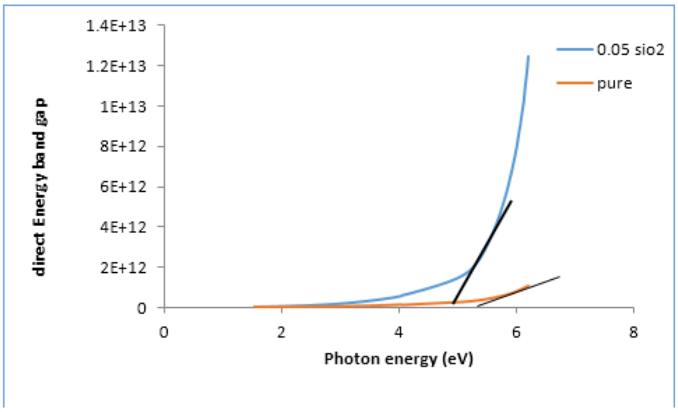

Figure 7effect of SiO2 nanoparticle on the energy band gap of nanocomposites

Table 1. shows the energy gaps of samples

No. of samples	Contents	Energy gap (Ev)
1	PVA	5.3

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2	PVA+SiO_2	5

3.8 Real and Imaginary dielectric constant

The relationship between real and imaginary of the dielectric constant as the wavelength ofpure PVA, PVA/SiO2 nanocomposite as shown in figure 8,9 . From thesefigures, we can see increasing the real and imaginary parts ofdielectric constant with the addition of the silicananoparticle , because silica nanoparticles have high dielectric constant and increase of the average mean path of electron which creates from increasing roughness of the sample surface according to AFM results.

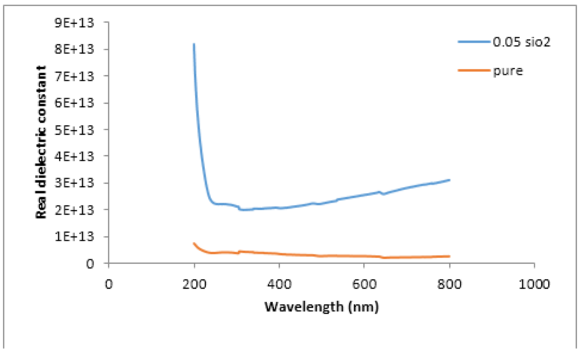

Figure 8. Shows the Real dielectric Constant

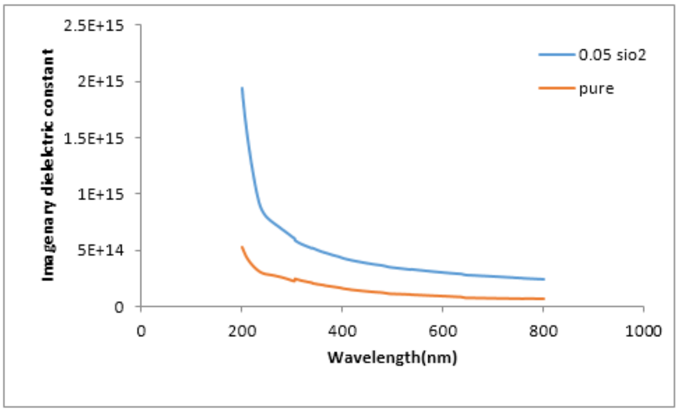

Figure 9. Shows the Imaginary dielectric Constant

3.9 AFM Morphology of Thin Film

Fig 10 a, b show the 3-D Morphology of pure PVA and PVA+SiO2nanocomposites respectively . We notice , the roughness of surface of sample increases after adding of Sio2 nanoparticles , this is because there are an agglomeration regions creates in the surface, which leads to decrease of conductivity of sample and increase the dielectric constant , because increasing average mean path of electron.

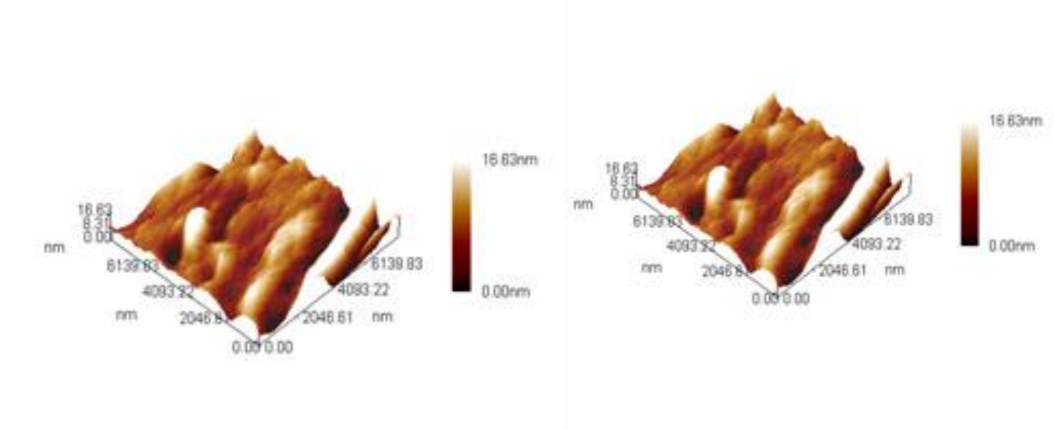

Figure 10. Show AFM of the samples (a) pure PVA,(b) PVA+ 5%wt SiO2

4. CONCLUSION

It is shown that

1. Addition of silica leads to enhance the optical properties of PVA thin film for semi-conductor application

2. Higher energy band gab of PVA/ SiO2 nanocomposite thin film was obtained than PVA thin film.

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