Optical Properties of NiO:PVA Thin Films

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Abstract: The article comprises the systematic study of the optical parameters of NiO:PVA composites. Composites contains different concentrations of NiO (0.25 and 0.5 wt%) were successfully fabricated by using solution cast technique. Effect of NiO nanoparticles on various optical properties of PVA such as absorbance, reflectance, extinction coefficient, refractive index, real and imaginary parts of dielectric constant have been studied. The results shows that how a small amount of filler concentration is right enough to produce a drastic change in the polymer matrix

INTRODUCTION

Nanocomposites of organic/inorganic materials with different compositions are of great interest now days. As a result the combination of organic/inorganic materials allow the composites to have the properties of both organic polymers (e.g. flexibility, ductility, dielectric) and inorganic polymers (e.g. rigidity, high thermal stability, strength, hardness, high refractive index) and hence could be used in various areas[1]. Therefore incorporation of nanoparticle could affect the polymer matrix effectively and makes it use in various important applications [2]Structural flexibility of the polymers both at bulk and molecular levels makes polymer advantageous for use in various applications especially in coatings. For the effectiveness of the coatings it is important to have the knowledge of the optical constant with high accuracy [3-6].Being eco-friendly, nontoxic, water soluble, degradable nature and the easiness of making thin films with metal oxide, PVA is taken into consideration in the present work [7]. The samples with different concentration of NiO were prepared by solution cast technique and characterized for optical properties in order to study the effect of doping especially on optical constants

EXPERIMENTAL

Nickel chloride hexahydrate($Nicl_2.6H_2O$), Sodium Hydroxide (NaOH), Polyvinyl alcohol(PVA) were used a raw material to get mother solution by using solution cast technique. Sol-gel technique was used to fabricate nickel oxide nanoparticles. For this sodium hydroxide solution was added drop wise to the nickel chloride solution to get precipitation. The desired solution was stirred continuously for 2 hours to get gel. After drying the powder was subjected to calcination at 290^0c in a muffle furnace to get black powder. In the second part the different concentrations of the nanoparticles were added in the polymer solution and stirred continuously by maintaining temperature up to 90^0C until the nanoparticle dispersed completely in the PVA solution to get the polymer composite. Then known volume of viscous NiO-PVAsolution was poured onto a leveled clean glass plate and left to dry at room temperature for about 48 h [8].

THEORETICAL

As it is evident that the different parameter has great effect on the optical constants. In order to justify this argument absorption coefficient (α), refractive index (n), extinction coefficient (k), real (Ɛr) and imaginary part (Ɛi) of the dielectric constant were also determined from the reflectance and transmission spectra by using the relations [9-13]

$$\alpha = \frac{1}{t}.\ln\frac{1}{T} \tag{1}$$

$$n = \frac{1+R}{1-R} + \sqrt{\frac{4R}{(1-R)^2} - k^2} \tag{2}$$

$$k = \frac{\alpha\lambda}{4\pi} \tag{3}$$

$$\varepsilon_r = n^2 - k^2 \tag{4}$$

$$\varepsilon_i = 2nk \tag{5}$$

The Tauc's relation which is used to calculate bandgap is as follows

$$(\alpha h\upsilon)^{\frac{1}{p}} = A(h\upsilon - E_g) \tag{6}$$

RESULTS AND DISCUSSION

Absorption spectra shown in Fig. 1 revel that absorption increases with increase in dopant concentrations. This might be because of the availability of large number of states due to increased filler concentrations, hence photon energy gets absorbed. Further a slight shift in the absorption edge towards high wavelength region indicates the decrease in optical band gap [14-15]. Added to this absence of absorption band in the visible region is the clear evidence that samples are transparent.

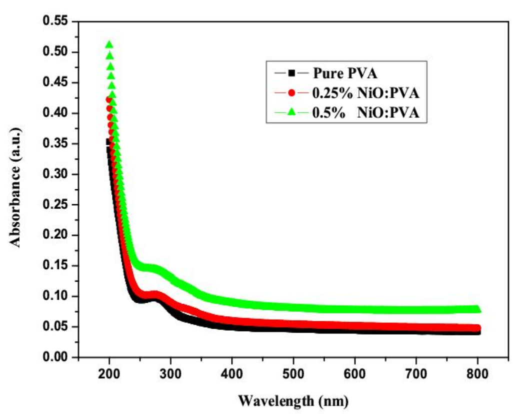

FIGURE 1. Absorption spectra of NiO:PVA films

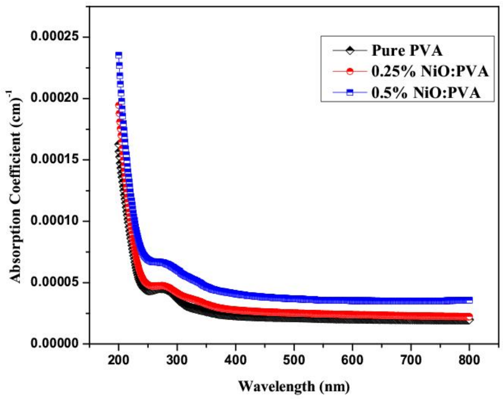

FIGURE 2: Absorption coefficient spectra of NiO:PVA films

The variation of absorption coefficients with wavelength as shown in Fig. 2 are in good agreement with the absorption results. The increase in absorption coefficients with increase in filler concentrations might be attributed to increase in absorption [16]. The small value of the extinction coefficients (Fig. 3) supports the homogeneity of the prepared composite. However the increase in k value with filler concentrations might be attributed to the increase in surface roughness [17].As it is evidentthat the refractive index of semiconductor is inversely proportional to the energy band gap [18]. This is in good agreement in our case where we get increase in refractive index (Fig. 4) with filler concentration. This suggests the densification of the films due to increase in packing density.Figure 5 shows the variation of real and imaginary part of composite with wavelength. A systematic increasing trend is observed in both the cases. The results shows that real part trend resembles the trend of refractive index because of the smaller values of k while imaginary part mainly depends on the (k) values which are related to the variation of absorption coefficients.

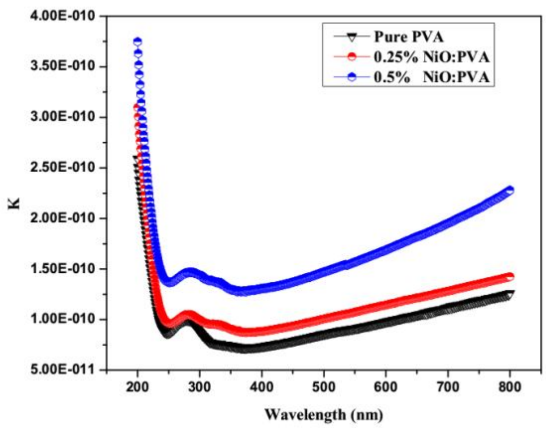

FIGURE 3. Spectral variation of extinction coefficient for NiO:PVA films corresponding to different concentration of NiO

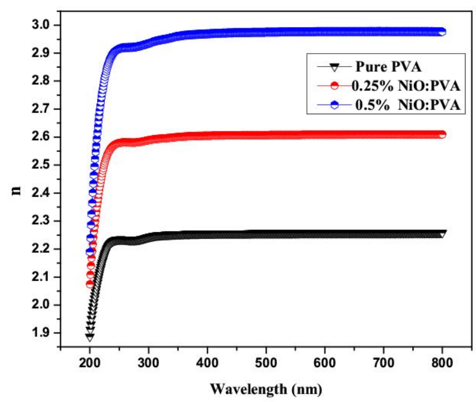

FIGURE 4. The refractive index of NiO doped PVA thin films as a function of wavelength corresponding to different concentrations of NiO

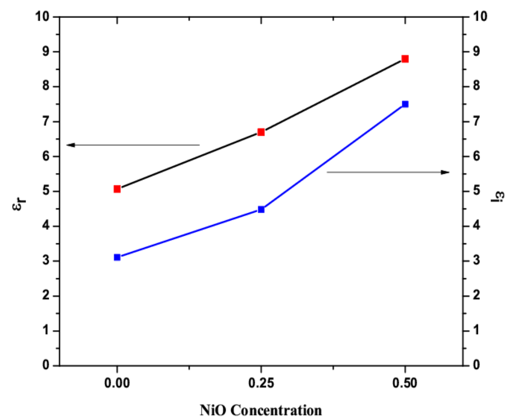

FIGURE 5. The variation of (ε_r) and (ε_i) with NiO concentration

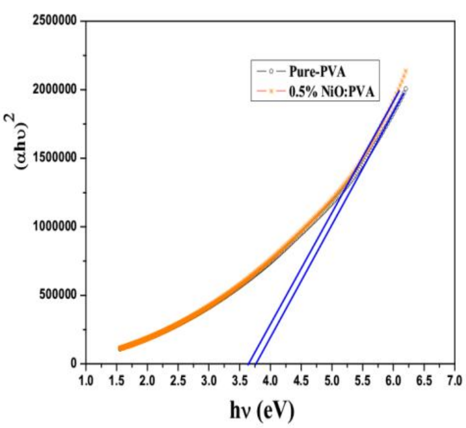

FIGURE 6: Plot of $(\alpha h\upsilon)^2$ versus incident photon energy (hv)

The plotted results show (See Fig. 6) that band gap is decreased with increase in doping concentrations. It can be noted that for pure PVA band gap comes out to about 3.82 eV and after doping 0.5 wt% the band gap value decreases to 3.6 eV. This suggests that the involvement of the Ni in the polymer matrix results in the formation of localized levels within the band gap, which construct new paths for electrons and hence facilitates the electronic transitions from valance band to the conduction band.

CONCLUSION

Composites of NiO:PVA containing 0.25 and 0.5 wt% of NiO have been obtained by solution cast technique; the effect of different filler concentrations on optical properties was studied. It is observed that absorbance, absorption coefficient, extinction coefficient and refractive index increased with filler concentrations. The optical band gap is found to be decreased with increased filler concentration suggests the availability of the deep localized states in the band gap.

REFERENCES

1. 1 Suruchi and Ramvinode, Inter. Journal of Scien. & Engg.Research**3**(1), 258-256 (2012).
2. 2 Shanghua Li, Licentiate Thesis, (2006).
3. 3 W. M. Prest, J. Appl. Phys. **50**, 6067 (1979).
4. 4 W. M. Prest, J. Appl. Phys.**51**, 5170 (1980).
5. 5 G. J. Beaucage, J. Polym. Sci. B. **31**, 319 (1993).
6. 6 T. P. Russell, Mater. Sci. Rep. **5**, 171 (1990).
7. 7 N. B. Rithin Kumar, Vincent Crasta, Rajashekar F. Bhajantri, and B.M. Praveen, J. of Poly.**7**, 846140 (2014).
8. 8 Aman Deep Acharya, BhawnaSarwan, R Sharma, S Moghe, S B Shrivastava and V Ganesan J. of Phys: Conf. Series, **836**, 012048 (2017).
9. 9 H.C. Casey Jr., D.D. Sell, K.W. Wecht. J. Appl. Phys.**46**, 250–257 (1975).
10. 10 N. Benramdane, W.A. Murad, R.H. Misho, M. Ziane, Z. Kebbab, Mater. Chem. Phys. **48**, 119–123 (1997).
11. 11 J. Tian, H. Deng, L. Sun, H. Kong, P. Yang, J.H. Chu, Thin Solid Films **520**, 5179–5183 (2012).
12. 12 J.I. Pankove, *Optical Processes in Semiconductors, Dover Publications,*(NewYork1971).
13. 13 A. Abu EL-Fadl, G.A. Mohamad, A.B. Abd El-Moiz, M. Rashad, Physica B: Condens.Matt. **366**, 44–54 (2005).
14. 14 El-Dahshan M.E. *Introduction to Material Science and Engineering. King Saud University Press*, (Saudi Arabia 2002).
15. 15 A Munaim, AHashim. *From 6th Science Conference of College of Science, University of Mustansiriah, Baghdad*, Iraq (2010).
16. 16 A. Ahmad, A. Awatif, and N. Zeid Abdul-Majied, J. of Eng. & Technology **25**(4) (2007).
17. 17 N. Tigau, V. Ciupina, G.I. Rusu, G. Prodan, E. Vasile, Rom. J. Phys. **50**, 859 (2005).
18. 18 K.S. Usha, R. Sivakomar, C. Sajeeviraja, J. Appl. Phys.**114**, 123501 (2013).