Study and Evaluation the optical Properties of binary oxide nanocomposite (Tin oxide/Iron oxide) films deposited by Chemical Spray Pyrolysis.

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Abstract:

In this research, nanocomposite Tin oxide/ Iron oxide films were effectively formed on glass plate using the (C.S.P) at a substrate temperature of (500°C), with a thickness of about (300nm) and various composite ratio (25,35,45,55%). Transmittance rises as the wavelength range widens, but falls as the Iron oxide concentration increases. Increased Iron oxide concentration causes a rise in absorbance, which declines rapidly at high energies, The band gap narrows as the Iron oxide concentration rises, with band gap value ranging from (3.4 to 2.61) eV..

Keywords: (optical properties of films, nano-dioxide, deposited by dissolution).

دراسة وتقيم الخصائص البصرية للأغشية اكسيد النانو الثنائي (اكسيد القصدير / اكسيد الحديد) المترسبة بواسطة الانحلال الحراري بالرش الكيميائي

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الملخص:

في هذه الدراسة ، تم ترسيب أغشية المركب النانوي SnO_2 / Fe_2O_3 بنجاح على قواعد زجاجية بتقنية الرش الكيميائي (CSP) عند درجة حرارة القاعدة (٥٠٠ درجة مئوية) ، وكان سمك الأغشية المحضرة حوالي (٣٠٠ نانومتر) ، وبتراكيز مختلفه للمركب ٪ (٥٠،٤٠،٣٠،٢٠). ولوحظ زيادة النفاذية لجميع الأغشية الرقيقة مع زيادة نطاق الطول الموجي ، وانخفاضها مع زيادة تركيز Fe_2O_3 ، تزيد الامتصاصية مع زيادة تركيز Fe_2O_3 وتنخفض بسرعة عند الأطوال الموجية القصيرة (الطاقات العالية) ، وقد تم حساب فجوة الطاقة البصرية للانتقال الألكتروني المباشر المسموح وتتراوح قيمتها بين eV (2.62 – 3.4) . كما تم حساب الثوابت البصرية مثل (معامل الامتصاص (α) والتوصيل البصري (σ) الانعكاس (R) ، معامل الانكسار (n)) لجميع الأغشيه كدالة لطاقة الفوتون ،وايضا تمت دراسة الأجزاء الحقيقية والخيالية من ثابت العزل (εr، εi)الذي تم قياسها كدالة لطول الموجة.

الكلمات المفتاحية : (خصائص البصرية للأغشية، اكسيد النانو الثنائي، مترسبة بواسطة الانحلال).

Introduction

Their physical, , magnetic , and chemical properties are remarkable.nanometer-sized materials have recently received a lot of attention. The behavior of these materials differs from that of bulk semiconductors. As particle size reduces, the semiconductor's band structure changes. The bands' borders divide into discrete energy levels when the band gap increases. Quantum size effects are what they're called. These quantum scale effects have attracted a lot of interest in both basic and applied research[1-5].

Tin oxide (SnO_2) thin film is a well-known n..type semiconductor with a wide band gap and good simultaneous conductivity and optical transparency in the visible wavelength. Iron oxide (Fe_2O_3) thin film, on the other hand, is an n..type semiconductorOnly a few studies on the optical characteristics of Tin oxide/Iron oxide binary thin films have been published so far [6.7].Because the electronic structure of SnO_2 and Fe_2O_3 may be affected, it can be used to control the chemical and physical properties of these composite to some extent [8]. Because of their unusual optical and electric properties, semiconductor composite materials have been intensively researched [9-12]. Both SnO2 and Fe2O3 are essential inorganic semiconductors that could be used in Li..ion batters, and gas sensors, [13-15]. Their compositealso drew a lot of interest because of their stability, excellent gas-sensitive, and prospective use on Li ion battery electrodes [16-18]. Although some researchers have developed and examined Tin oxide/ Iron oxide composite thin films and nanopowders [16,17].

The goal of this research is to use a chemical spray pyrolysis process to make Tin oxide/ Iron oxide Nanocomposite films on a glass substrate and investigate the influence of composite concentration on the optical properties of these films.

2. Experimental

To make a 0.1 mol concentration solution from 0.811 gram of (Stannic Chloride Hydrated) was melted in 55. ml of distilled water.

Secondary created Tin oxide pure from 0.1Mol concentration precursor solution of pure Stannic Chloride Hydrated, mole weight (350.58gram /mole, it was prepared by dissolving 1.753gram of Stannic Chloride Hydrated ($SnCl_45H_2O$) in 55 ml from the water. Both solutions was mixed together in a flask with a circular bottom. Spray pyrolysis was used to deposit Tin oxide/ Iron oxide nanocomposite with differing Tin oxide and Iron oxide ratios on a glass substrate. Stannic Chloride $SnCl_4$ and HematiteChloride $FeCl_3$ were chosen as Stannic and Hematite sources, respectively, from two types of aqueous solutions. Table 1 shows how to make Tin oxide/ Iron oxide nanocomposite with various compositions.

The deposition parameters for the Tin oxide/ Iron oxide films were the same. To obtain a solution with a concentration of 0.1 Mole, the pure Stannic Chloride, pure Hematite Chloride and distilled water were properly combined. During the film growth, the substrate temperature was set to 500°C.

Table.1: The consentration of SnO_2 and Fe_2O_3.

Percentage	SnO_2.	Fe_2O_3.
PureSnO_2	100	0
25%	75	25
35%	65	35
45%	55	45
55%	45	55
PureFe_2O_3	0	100

Thick the samples was calculated by the relationship

$$t' = \frac{\Delta m'}{A.\rho'} . \qquad (1)$$

t'.. the thin films thickness ,

$\Delta m'$.. change in the weight,

ρ'.. The density of the thin films material .

3. Results and discussion

UV-VIS. spectrophotometer is used to measure the optical characteristics of deposited nanocomposite Tin oxide/ Iron oxide coatings on glass plate at 500°C. The optical transmittance in the wavelength band (340-1051) nm is measured at normal incidence.

Fig.. .1 shows the transmittance spectra of Tin oxide./ Iron oxide films coated with various Iron oxide concentrations. In the near-infrared range, films coated with Tin oxide exhibit a maximum transmittance of 87 percent,. The transmission of films widens as the wavelength range grows and decreases as the Iron oxide concentration increases.. The Iron oxide pure had the lowest transmittance, which was 65 percent.

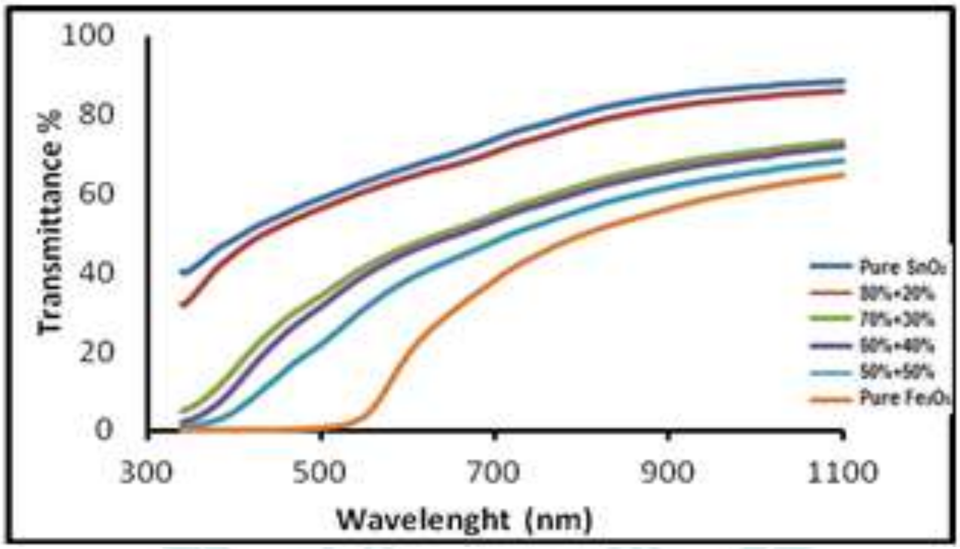


Fig 1. The optical Transmittance of SnO_2/ Fe_2O_3.

Thelogarithm of the reciprocal of the transmittances are used to get the absorbance (A.)[19]:

$$A. = \log. \frac{1}{T} \qquad (2)$$

Fig.. 2. depicts the absorbance spectra of thin films made of Tin oxide./ Iron oxide nanocomposite. Because the energies of photons falling is low, the absorption spectrum exhibits exponential decrease as wavelength increases. With increasing Fe2O3 concentration, the highest absorption peak moves to a longer wavelength. Film absorption decreases as wavelength rangeincreases, andincreases as the Fe2O3 concentration increases.

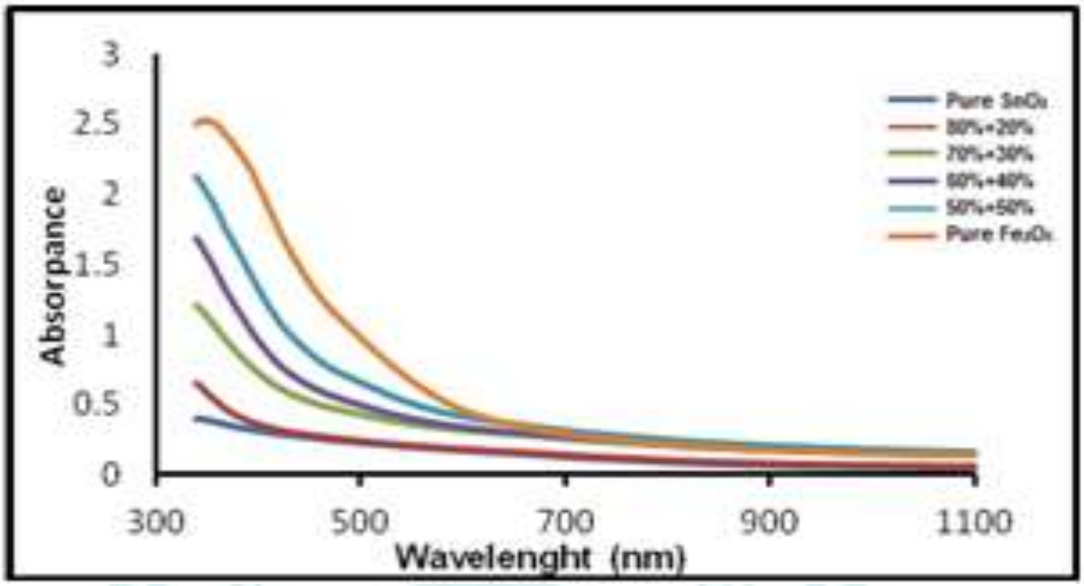


Fig. 2. The optical Absorption of of SnO_2/ Fe_2O_3 nanocomposite .

The optical absorption coefficient of Tin oxide./ Iron oxide nanocomposite as a function of photon energy calculated from absorbance data using equations [20]:

$$\alpha = 2.303\frac{A}{t} \qquad (3)$$

A..the absorptances of film

t.. is the samplesthickness.

The absorption coefficient of Tin oxide./ Iron oxide nanocomposite films increases with increasing photon energy, as seen in Fig. 3. Nanocomposite films' absorption coefficient increased at the UV./VIS. interface, then steadily increased in the visible range. as well as absorptioncoefficients greaterthan ($\alpha \geq \geq \geq 10^4 cm^{-1}$) at high photonic energies than direct occurrence of electronictransitions.

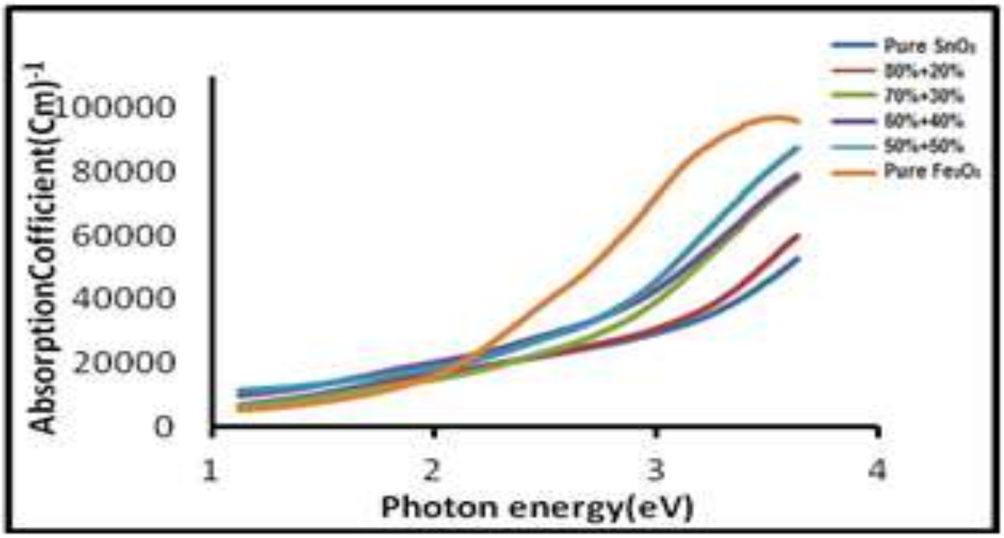


Fig.3.The absorption Coefficient of of SnO_2/ Fe_2O_3

The optical energy gap (E_{gap}) was determined by Tauc equation [21]

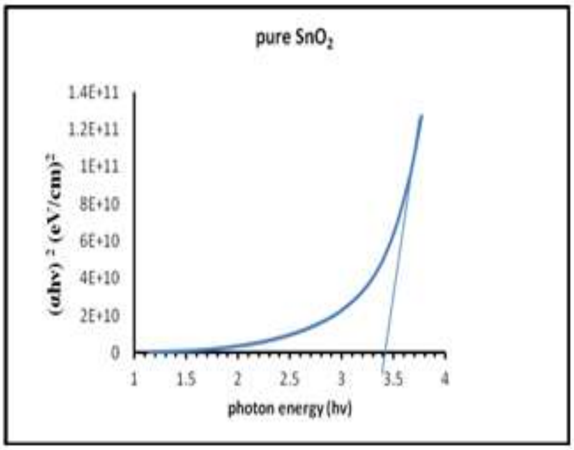
$\alpha.h\upsilon = B.[h\upsilon. - E_{gap}.]^{.r}$ (4)

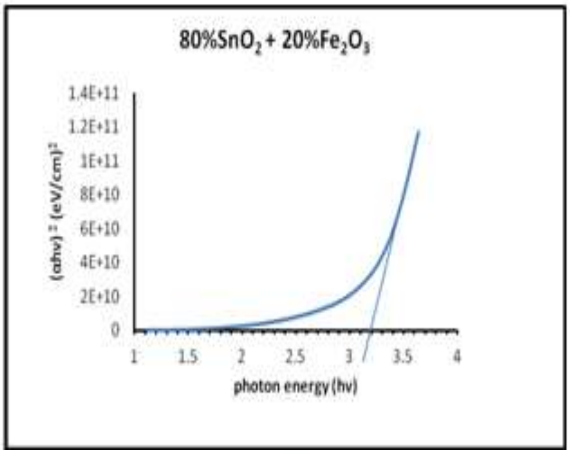
B …. constant,

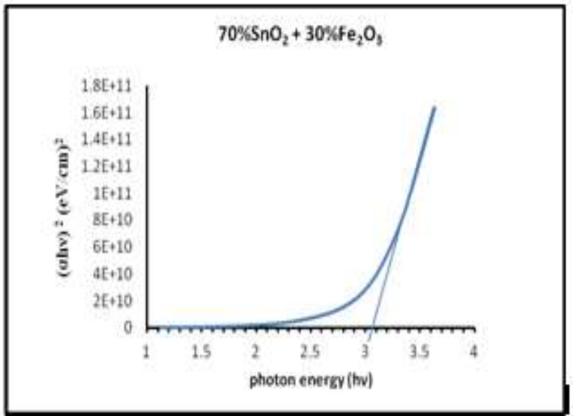
hυ …. photons energy,

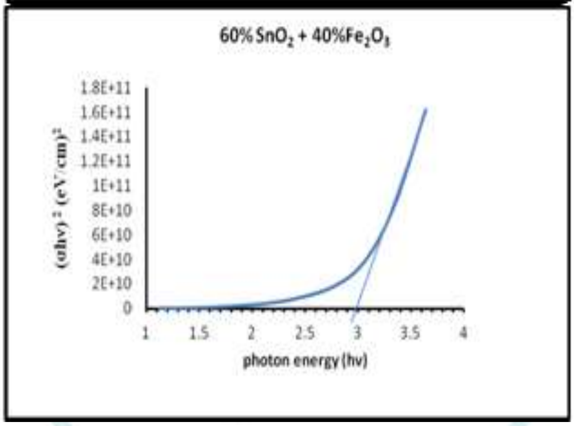
α …. absorptioncoefficient,

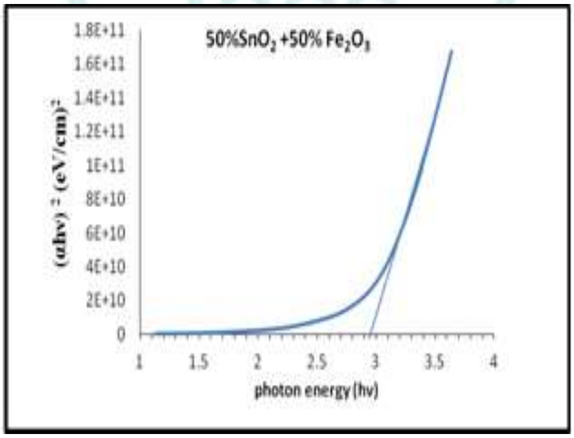
Table 1 shows that the band gap of SnO2/Fe2O3 nanocomposite thin films is in the range (3.41-2.63 eV) (2). With increasing Iron oxide content, the band gap of Tin oxide films decreases.






70%SnO2 + 30%Fe2O3
(αhν)² (eV/cm)²
photon energy (hv)


60% SnO2 + 40%Fe2O3
(αhν)² (eV/cm)²
photon energy (hv)


50%SnO2 +50% Fe2O3
(αhν)² (eV/cm)²
photon energy (hv)

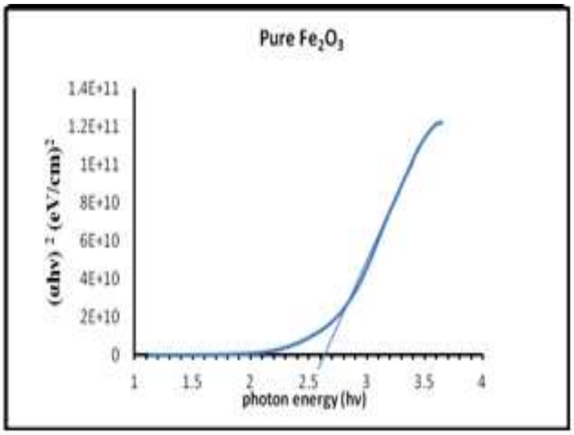


Fig.4. Band gap variation in Fe_2O_3/SnO_2 nanocomposite thin film productions at various Fe_2O_3 concentrations.

Tab..2 .the values of optical energy gap for SnO_2/Fe_2O_3 nanocomposite.

Preparation condition	Band gap energy (eV)
Pure. SnO_2	3.41
25% Fe_2O_3	3.2
35%Fe_2O_3	3.12
45%Fe_2O_3	3
55% Fe_2O_3	2.91
Pure. Fe_2O_3	2.63

The reflection of the films was found through the use of relationships. [23]:

$$R.+T.+A.=1 \qquad (5)$$

Fig.. 6. depicts the variation in reflectance of the Tin oxide./ Iron oxide nanocomposite as a function of wavelength. It's important to note that the reflectivitygradually climbed to its maximumvalues at particular wavelength, then gradually decreased as the wavelength increased. The overall reflectance of the film increased as the Fe_2O_3 concentration increased.

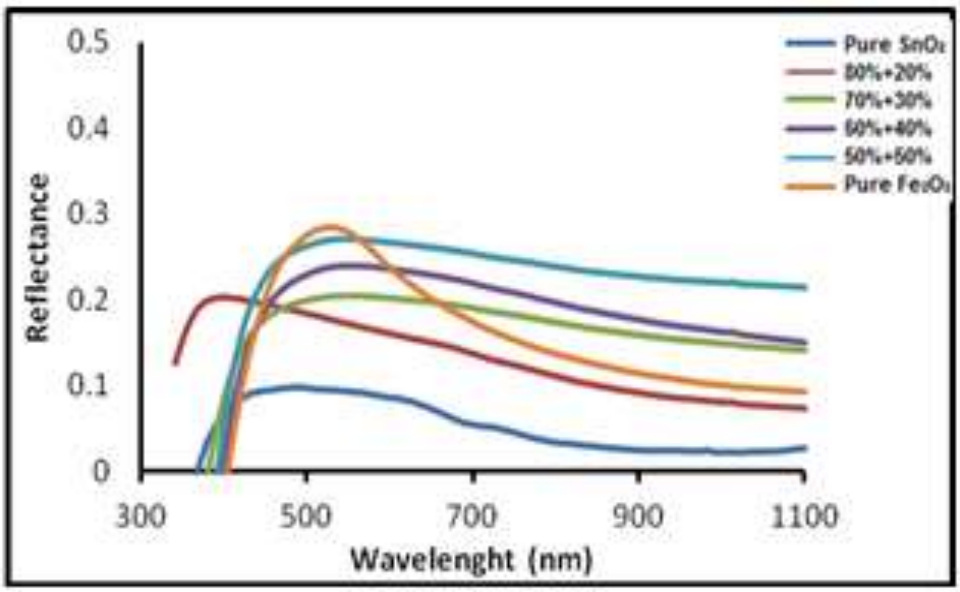


Fig.6 :The Reflectance of SnO_2 /Fe_2O_3 .

the refractionindex can be calculated from relation ship [24]:

$$.n = \frac{1+R^{.1/2}}{1-R^{.1/2}} \qquad (6)$$

The relationship between the RefractiveIndex and wavelength in the range (900-1100) is seen in Fig.7.. The increase in Iron oxide concentration causes a rise in the refractiveindex overall. This rise is dueto a general increase in reflectance as Iron oxide concentration rises.

The greatest value in the refractive index increases with Iron oxide concentration, implying that an increase in iron oxide concentration has influenced the nature of the surface, which occurs during reflection and leads to the verity of the refractive index.

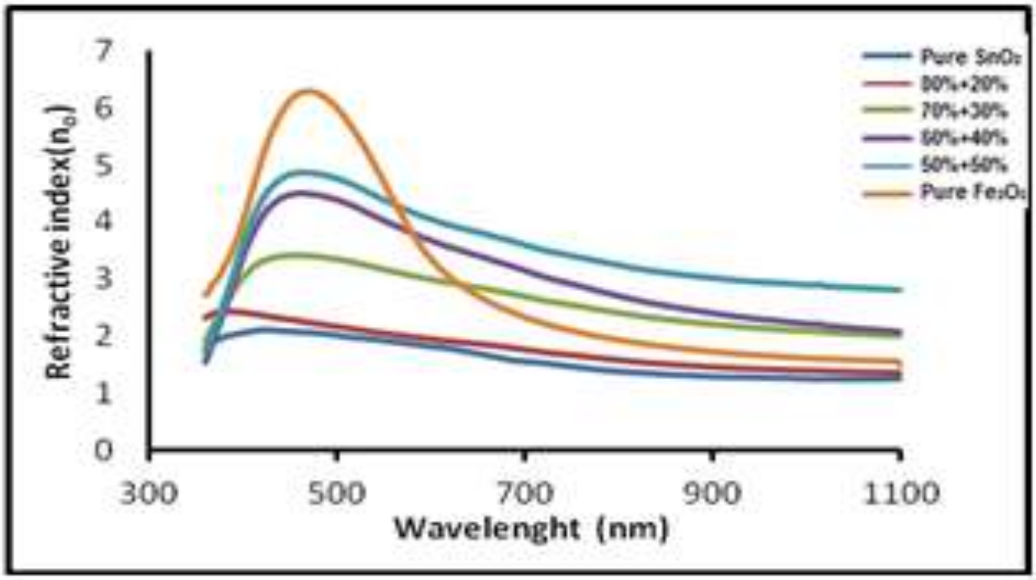


Fig.7.The Refractiveindex of SnO_2 /Fe_2O_3 .

The extinctioncoefficient was calculated by equation [25]:

$$k_o = \frac{\alpha.\lambda}{4.\pi} \qquad (7)$$

The variation of the extinction coefficient with wavelength for Tin oxide./ Iron oxide nanocomposite with various Iron oxide concentrations is shown in Fig.8. The extinction coefficient decreases with increasing wavelength and increases with increasing Iron oxide concentration. Surface optical scattering and optical loss will rise as surface roughness increases with increasing Iron oxide content in crystalline films [26].

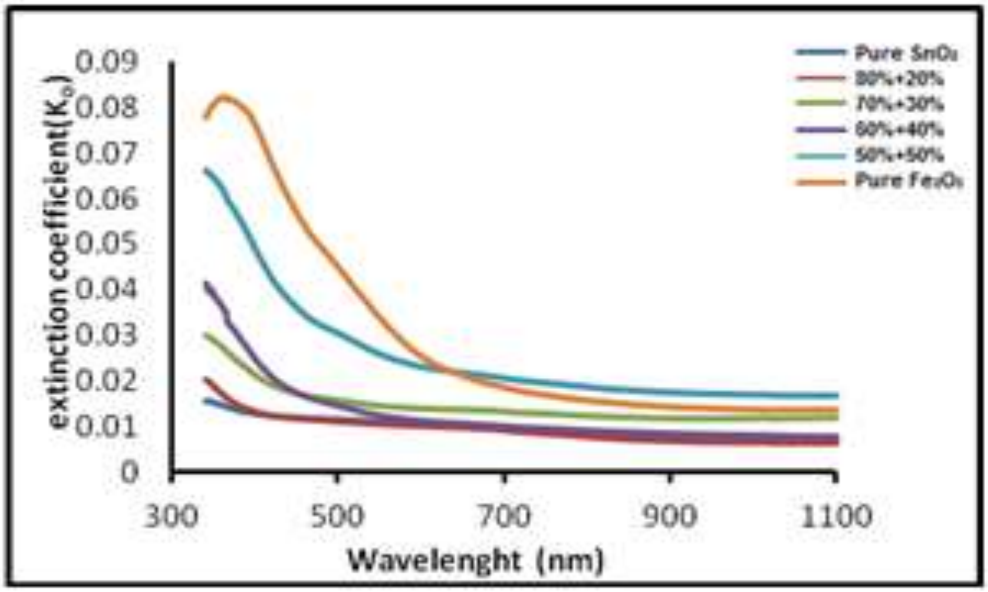


Fig.8. The Extinction Coefficient of SnO_2 /Fe_2O_3 nanocomposite.

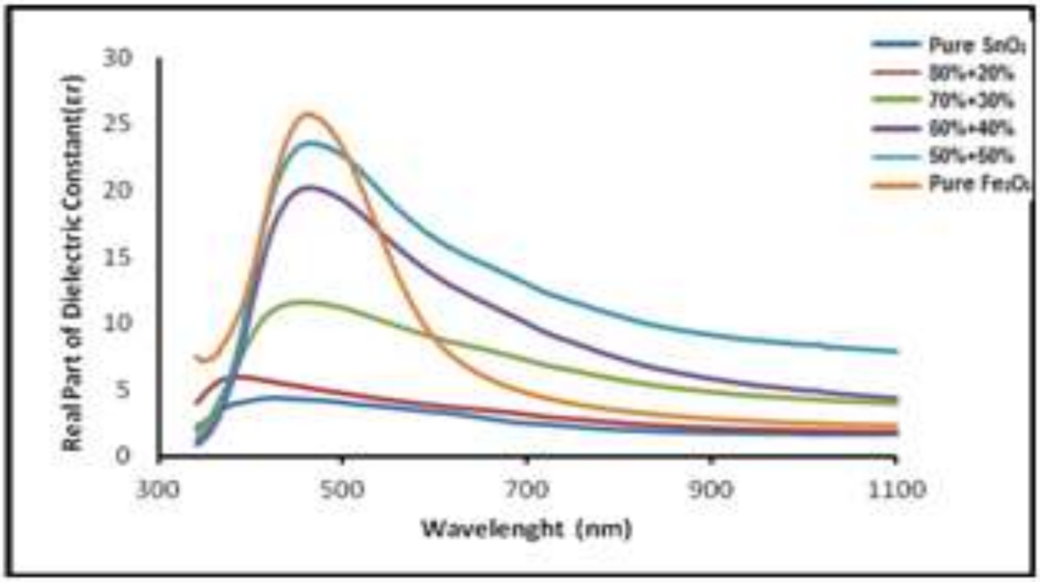
The real and imaginary components of the complex dielectricconstant are represented by relations. [27]:

$\varepsilon_r = n^2 - K^2$ (8)

$\varepsilon_i = 2\,n\,K$ (9)

The real (ε_{real}), and imaginarypart(ε_{ima}) of dielectricconstant of the SnO_2/Fe_2O_3 nanocomposite thin films have been investigated using the equation (8) and (9) as shown in fig.9.

The variation of (ε_{real}), (ε_{ima}) with wavelength for SnO_2/Fe_2O_3 nanocomposite with different Fe_2O_3 concentration. The obtained results show that the values of real part (ε_{real}) of dielectricconstant are decreased with increasing of wavelength for SnO_2/Fe_2O_3 thin films, especially, it increased with increase of Fe_2O_3 ratio .



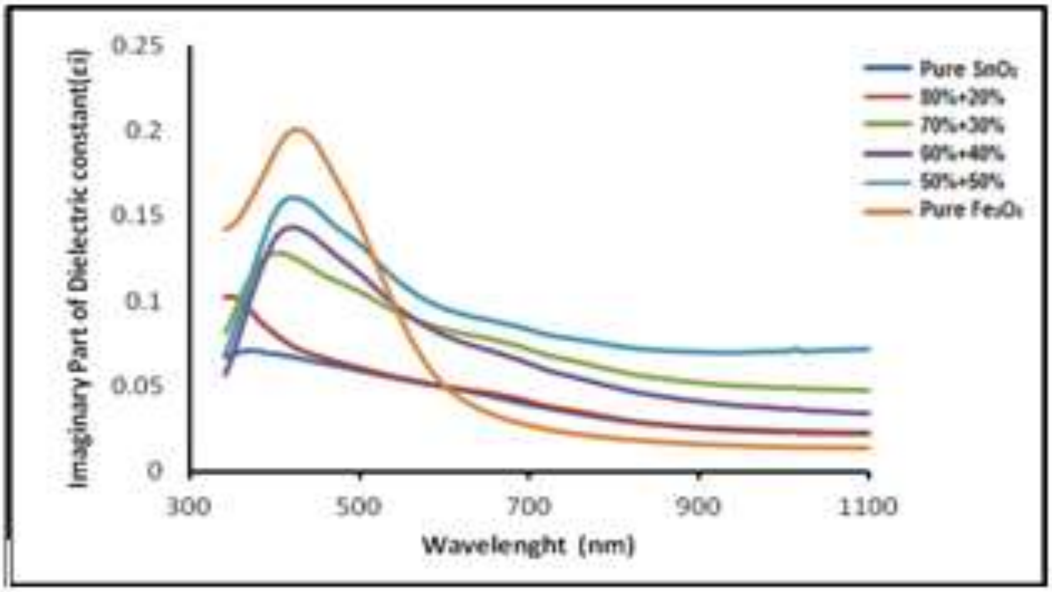


Fig.9. The Real and ImaginaryParts of DielectricConstant of Tin oxide/Iron oxide.

Fig.10, For varying Fe_2O_3 concentrations of Tin oxide./ Iron oxide nanocomposite thin films, the variation of optical conductivity as a function of photon energy is shown. The optical conductivity of the Tin oxide./ Iron oxide nanocomposite increases with increasing photon energy, as seen in the picture. This implies that the rise in optical conductivity is caused by electrons being ejected by photonenergy, and that the opticalconductivity of the films increases as the Fe_2O_3 concentration in the films increases.

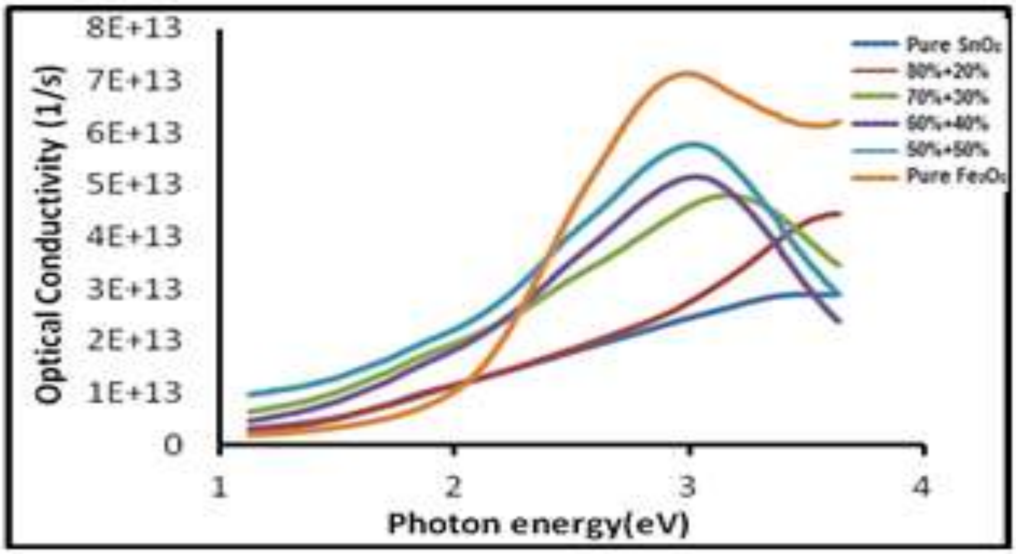


Fig.10.The Optical Conductive ofSnO_2 /Fe_2O_3 ratio.

Conclusions

Chemical spray pyrolysis was used to make Tin oxide/Iron oxide nanocomposite thin films with different Iron oxide ratio (0,25,35,45,55,100 percent) on a glass substrate at a temperature of (500 ^oC). The transmittance of all films increased with increasingwavelength range and decreased with increasing Fe2O3 ratio. The pure SnO2 thin films has a maximum transmittance of 87 percent in the nearinfrared region, and the Fe2O3 thin films has aminimum transmittance of 64 percent in visible region, according to the optical properties. When Fe2O3 concentrations rise, the band gap lowers, and band gap values vary from 3.41 to 2.63 eV.

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