International Journal of Academic and Applied Research (IJAAR)
ISSN: 2643-9603
Vol. 5 Issue 4, April - 2021, Pages: 139-144

Refractive Index, (Real, Imaginary) dielectric constant of Fe_3O_4 and Ni_2O_3 Nano Size

***[1] Emtithal Ahmed Jadallah, Al desogi Omer Hamed[2], Kh M. Haroun3, Abdalsakhi. S. Mohammed[4], Adam Mohammed Adam Bakheet[5]**

[*1] Sudan University of Science & Technology-College of Science-Department of Material Science- Department of Physics – Khartoum – Sudan
[2]Kordfan University -Faculty of Education- Department of physics
[3]Al-Zaiem Al-Azhari University, Khartoum, Sudan
[4]Alneenlen University - and Technology Collage- Khartoum – Sudan
[5] University of Gezira, Madani Sudan

Abstract: *Thin film of (Fe_3O_4 and Ni_2O_3) Nano-material deposited on ITO glass substrate, have been prepared by spin coating method with different thicknesses (55.25, 78.7, 90.9 144.9 and 263.15) nm for each. Refractive index, real and imaginary dielectric constants were found by using UV spectral technique. For Fe_3O_4 in the range of wavelength (324-360) nm the refractive index, real and imaginary dielectric constant were shown to increase upon decreasing the concentration while for Ni_2O_3 in the range of wavelength (268-402) nm the refractive index, real dielectric constant were shown to increase upon increasing the concentration while the imaginary dielectric constant increase upon decreasing the concentration.*

Keyword*:* Refractive Index, Dielectric Constant, Concentration

Introduction

Nickel Oxide (NiO) is an important transition metal oxide with cubic lattice structure. Among the magnetic nanoparticles, fabrication of nickel nanoparticles is often more difficult than that of the other particles. This is because they are easily oxidized. To achieve pure nickel nano-crystals, numerous methods have been conducted in organic environments in order to prevent formation of hydroxide or oxidation [1]. Iron oxide nanoparticles (NPs) have attracted much consideration due to their unique properties, such as super paramagnetic, surface-to-volume ratio, greater surface area, and easy separation methodology. Various physical, chemical, and biological methods have been adopted to synthesize magnetic NPs with suitable surface chemistry [2]. Refraction: Light that is transmitted into the interior of transparent materials experiences a decrease in velocity, and, as a result, is bent at the interface; this phenomenon is termed refraction.

The index of refraction n of a material is defined as the ratio of the velocity in a vacuum c to the velocity in the medium v or

$$n = \frac{c}{v} \quad (1)$$

An equivalent expression gives the velocity of light v in a medium as

$$v = \frac{1}{\sqrt{\varepsilon\,\mu}} \quad (2)$$

Where ε *and* μ are, respectively, the permittivity and permeability of the particular substance.

From the equation (2-6), we have

$$n = \frac{c}{v} = \frac{\sqrt{\varepsilon\,\mu}}{\sqrt{\varepsilon_0\mu_0}} = \sqrt{\varepsilon_r\mu_r} \quad (3)$$

Where ε_r *and* μ_r are the dielectric constant and the relative magnetic permeability, respectively. Because most substances are only slightly magnetic, $\mu_r \cong 1$

$$n \cong \sqrt{\varepsilon_r} \quad (4)$$

Thus, for transparent materials, there is a relation between the index of refraction and the dielectric constant. The phenomenon of refraction is related to electronic polarization at the relatively high frequencies for visible light; thus, the electronic component of the dielectric constant may be determined from index of refraction measurements using Equation (4). Because the retardation of electromagnetic radiation in a medium results from electronic polarization, the size of the constituent atoms or ions has a considerable influence on the magnitude of this effect generally, the larger an atom or ion, the greater the electronic polarization ,the slower the velocity, and the greater the index of refraction [3].

Dielectric constant or relative permittivity is define by the relation

$$\varepsilon_r = \frac{\varepsilon}{\varepsilon_0} \quad (5)$$

Which is greater than unity and represents the increase in charge storing capacity by insertion of the dielectric medium between the plates. The dielectric constant is one material property that is of prime consideration for capacitor design.

Imaginary part is always positive and represents loss factor or energy absorbed. The measurement of the real part of relative permittivity ε_r is generally done by measuring the charge in capacitance of a capacitor by the introduction of the dielectric between its electrodes [4].

The electric field E, displacement X, velocity V and acceleration a takes the

$$E = E_0\, e^{-iwt} = E_m\, e^{i(kx-wt)}$$

$$x = x_0 e^{-iwt} \qquad v = \dot{x} = -iwx = v_0 e^{-iwt} \qquad a = \dot{v} = -iwv = -w^2 x \quad (6)$$

The equation of motion of electrons or any charged particle is given by

$$m\ddot{x} = eE - \gamma_0 n_0 v \quad (7)$$

Where n_0 is the medium number density hence

$$(\gamma_0 n_0 - iwm)v = eE$$

With γ_0 standing for the friction per particle. Therefore the velocity v is given

$$v = \frac{eE}{\gamma_0 n_0 - iwm} = \frac{e\,(\gamma_0 n_0 + iwm)E}{[\gamma_0^2\, n_0^2 + w^2\, m^2]} \quad (8)$$

For very small mass m and high concentration n_0, such that

$$\gamma_0 n_0 > wm \quad (9)$$

Equation (3) becomes

$$v = \left[\frac{e}{\gamma_0 n_0} + \frac{iwme}{\gamma_0^2\, n_0^2}\right] E \quad (10)$$

But the current density is given by

$$J = n\, e\, v = n\, e\, \frac{dx}{dt} = \frac{dnex}{dt} = \frac{dp}{dt} = x\, \frac{dE}{dt} = -iwxE = -iw\,(x_1 + ix_2)E$$

Where x represents electric susceptibility

Using (5) gives

$$ne^2 = \left[\frac{1}{\gamma_0 n_0} + \frac{iwm}{\gamma_0^2\, n_0^2}\right] E = [wx_2 - iwx_1]E \quad (11)$$

Equating real and imaginary parts gives

$$x_1 = \frac{-m}{\gamma_0^2\, n_0^2} \qquad x_2 = \frac{ne^2}{w\gamma_0 n_0} \quad (12)$$

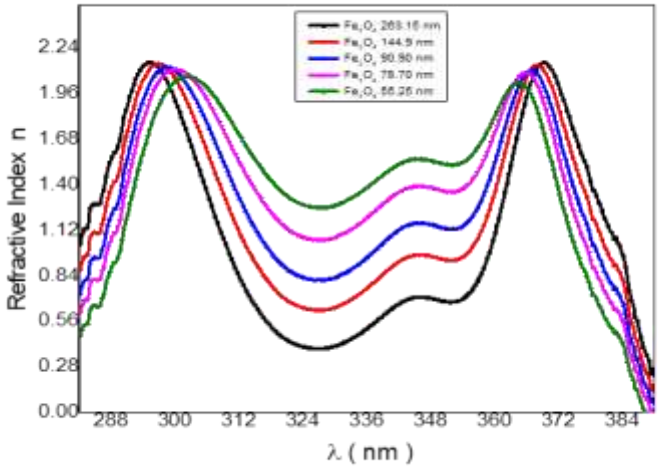
[5].

Material and Method

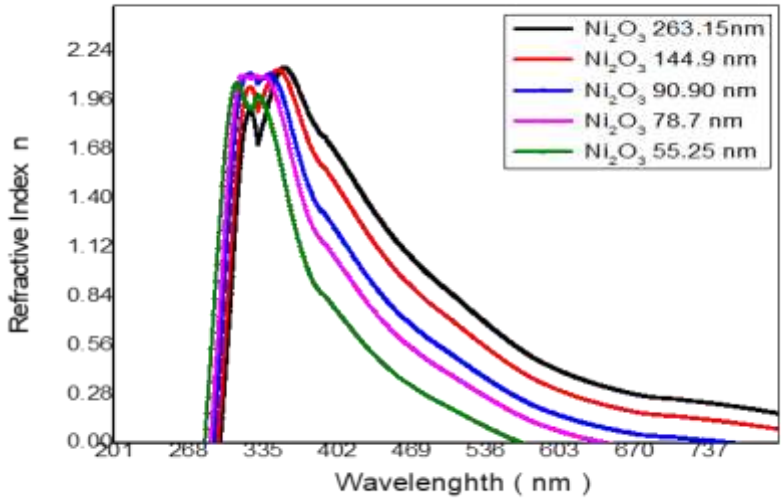
Samples Preparation

Nickel oxide thin films were prepared by spraying a 0.1 M solution of nickel nitrate of doubly distilled water onto the pre-heated amorphous glass substrates kept at (390˚C ± 10˚) C. Iron oxide thin films were prepared by spraying a 0.1 M solution of ferric nitrate of doubly distilled water onto the pre-heated amorphous glass substrates kept at (390˚C±10˚C). Film concentration or thickness was measured by using the weight difference method considering the substrate surface area and the density of the bulk nickel oxide. As the density of thin films was certainly lower than the bulk density, the actual film thickness would be larger than the estimated values the thickness of the thin film thus reflects the concentration. The structural, optical characterization of the films deposited at optimized preoperative parameters was carried out.

Results



Fig(1) relation refractive index and wavelengths of five sample that made by Fe_3O_4 in different thickness



Fig(2) relation refractive index and wavelengths of five sample that made by Ni_2O_3 in different thickness

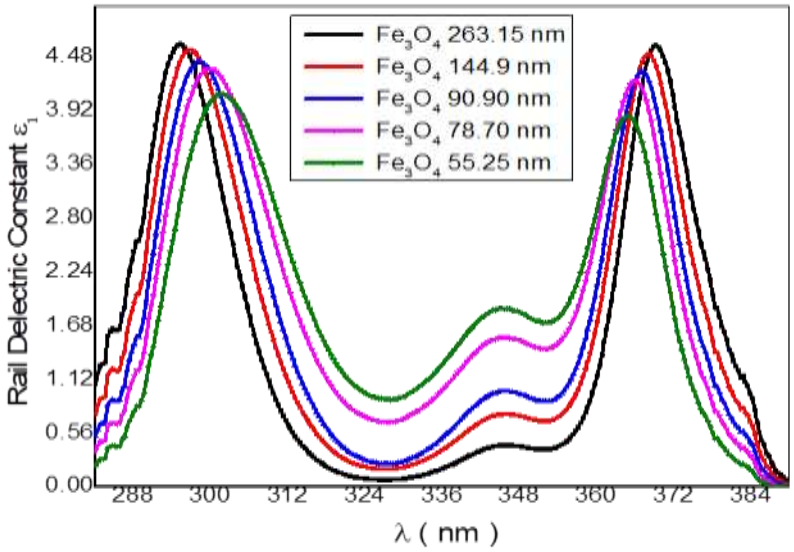


Fig (3)The relation between real dielectric constant and wavelengths of five sample that made by Fe_3O_4 in different thickness

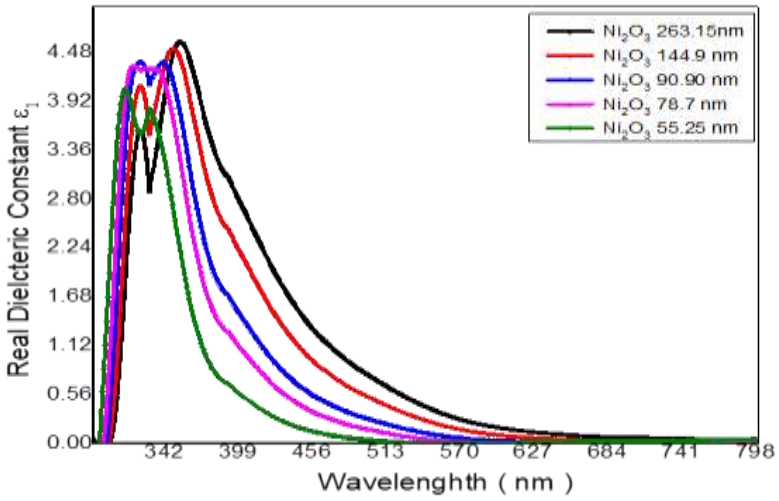


Fig (4) The relation between real dielectric constant and wavelengths of five sample that made by Ni_2O_3 in different thickness

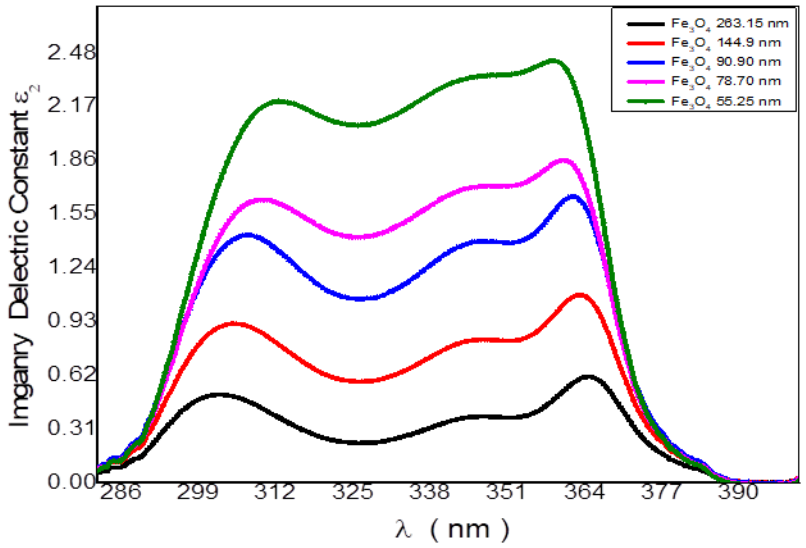
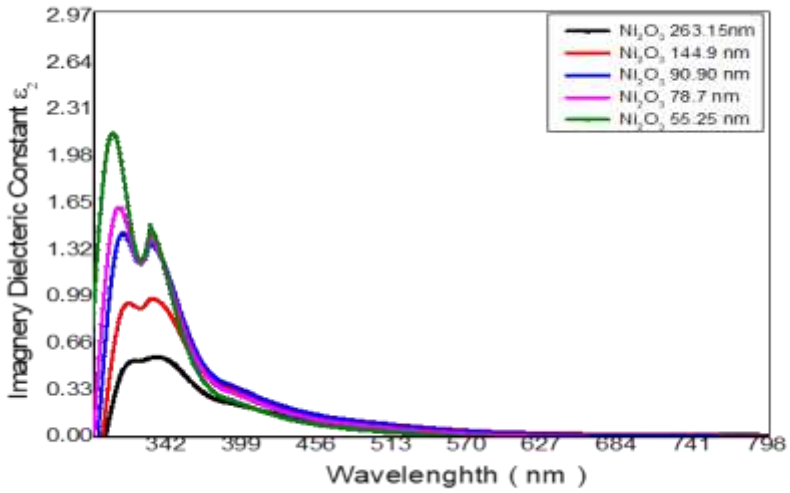


Fig (5)The relation between imagniary dielectric constant and wavelengths of five sample that made by Fe_3O_4 in different thickness



Fig(6) The relation between imaginary dielectric constant and wavelengths of five sample that made by Ni_2O_3 in different thickness

Discussion

The refractive index (n) is the relative between speed of light in vacuum to its speed in material which does not absorb this light. The value of n was calculated from the equation (3). The variation of (n) vs (λ) for all samples was treetetment by (Fe_3O_4 and Ni_2O_3) in different thickness is shown in fig.(1) and fig(2) . Fig (1) and fig(2) Show that relationsheep of all prepared sample by (Fe_3O_4 and Ni_2O_3) in different thickness refractive index (n) spectra,which shows that the maximum value of (n) is (2.14) for all(Fe_3O_4) samples and (2.16) for (Ni_2O_3) samples .Fig(3) and fig(4) shows the variation of the realdielectric constant (ε_1) with wavelengthof (Fe_3O_4 and Ni_2O_3) samples prepared in different thickness. From fig (3) and fig(4) the variation of (ε_1) is follow the

refractive index, where increased in the region (294 – 369) nm for (Fe_3O_4) samples and(306 – 352) nm for (Ni_2O_3) that tretednent in different thickness, where the absorption of the samples for these wavelength is small, but the polarizationwas increase. The value of (ε_1) equal to (0.203) at wavelengthnear (295) nm for sample Fe_3O_4 in 263.15 nm thickness and equal (0.202) for Fe_3O_4 55.25 nm thickness sample at (303 nm wavelength), but for (Ni_2O_3 in 263.15 nm thickness) sample the value of (ε_1) equal to (4.58) at wavelength near (352) nm and equal (4.04) for Ni_2O_3 55.25 nm thickness sample at (309 nm wavelength). The effect of thickness of samples increased in (ε_1) by increased the thickness . The imaginary dielectric constant (ε_2) vs (λ) was shown in fig(5) and fig(6) for (Fe_3O_4 and Ni_2O_3) samples in different thickness. Also shown in fig(5) and fig(6) the shape of (ε_2) was thesame as (ε_1), this means that therefractive index was dominated in these behavior . The maximum values of (ε_2) were different according to the tratmentoperation , so the value of (ε_1) equal to (0.203) for at wavelengthnear (295) nm for sample Fe_3O_4 in 263.15 nm thickness and while the value of (ε_2) equal to (0.6) for Fe_3O_4 in 263.15 nm thickness at wavelength (364) and equal (0.202) for Fe_3O_4 55.25 nm thickness sample at (303 nm wavelength) while the value of (ε_2) equal(2.43) for Fe_3O_4 55.25 nm thickness sample at (359 nm wavelength)these behavior may by related tothe different absorption mechanism forfree carriers. But for(Ni_2O_3) samples in different thickness the value of (ε2) equal to (0.444) for Ni2O3 in 263.15 nm thickness at wavelength (352) and equal (4.04) for Ni2O3 55.25 nm thickness sample at (309 nm wavelength) while the value of (ε2) equal(0.537) for Ni2O3 55.25 nm thickness sample at (309 nm wavelength)these behavior may by related to the different absorption mechanism for free carrier

Conclusion

The change of Fe_3O_4 and Ni_2O_3concentrations effect on refractive index and dielectric constants. For Fe_3O_4 in the range of wavelength (324-360) nm the refractive index, real and imaginary dielectric constant were shown to increase upon decreasing the concentration while for Ni_2O_3 in the range of wavelength (268-402) nm the refractive index, real dielectric constant were shown to increase upon increasing the concentration while the imaginary dielectric constant increase upon decreasing the concentration.

Reference

[1] Taghizadeh, F. (2016), the Study of Structural and Magnetic Properties of NiO Nanoparticles. Optics and Photonics Journal, Volume (6), pages (164-169). [2] Attarad Ali, HiraZafar, Muhammad Zia, IhsanulHaq, Abdul RehmanPhull, JohamSarfraz Ali, AltafHussain (2016), Synthesis, characterization, applications, and challenges of iron oxide nanoparticles, Nanotechnology, Science and Applications , Volume (9), pages (49–67).
[3] Rogers, A., (2008), Essentials of Photonics, 2nd edition, CRC Press, Boca Raton, FL.
[4] Braslavsky, S.E., (2007), Glossary of terms used in photochemistry (IUPAC recommendations 2006), Pure and Applied Chemistry, Volume (79), Pages (293–465).
[5] Emtithal Ahmed Jadallah etal, (2019), Absorption Coefficient and Energy Gap of Fe_3O_4 and Ni_2O_3 Nano-materials for Different Concentration, International Journal of Innovative Science, Engineering & Technology,
Volume(6).