International Journal of Academic and Applied Research (IJAAR)
ISSN: 2643-9603
Vol. 5 Issue 6, June - 2021, Pages: 39-42

Optical and Electrical Conductivity of Fe_3O_4 and Ni_2O_3 Nano Size (Different Thicknesses) By Optical Method

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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. The optical and electrical conductivity were found by using UV spectral technique. For all samples optical conductivity increase upon decreasing concentration while electrical conductivity for Ni_2O_3 increase upon increasing the concentration and for Fe_3O_4 electrical conductivity increase upon decreasing concentration.

***Keyword**:* Optical Conductivity, Electrical Conductivity, 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]. The conductivity of semiconducting materials depends on the number of free electrons in the conduction band and also the number of holes in the valence band. Thermal energy associated with lattice vibrations can promote electron excitations in which free electrons and/or holes are created. Additional charge carriers may be generated as a consequence of photon-induced electron transitions in which light is absorbed; the attendant increase in conductivity is called photoconductivity. Thus, when a specimen of a photoconductive material is illuminated, the conductivity increases. This phenomenon is used in photographic light meters. A photo induced current is measured, and its magnitude is a direct function of the intensity of the incident light radiation, or the rate at which the photons of light strike the photoconductive material. Of course, visible light radiation must induce electronic transitions in the photoconductive material; cadmium sulfide is commonly used in light meters. Sunlight may be directly converted into electrical energy in solar cells, which also employ semiconductors. The operation of these devices is, in a sense, the reverse of that for the light-emitting diode. A p–n junction is used in which photo excited electrons and holes are drawn away from the junction, in opposite directions, and become part of an external current. Electrical conductivity in most substances and over wide range of electric field strengths we find that the current density is proportional to the strength of electric field that causes it. The linear relation between current density J and field strength E is expressed by the equation

$$J = \sigma E \qquad (1)$$

The factor σ is called the conductivity of the material; its value depends on the material; it is very large for metallic conductors, extremely small for good insulator. It may depend too on the physical state of the material [3].
Many researches were done to study the effect of Nano structure on the electric properties. One of these attempts were made in the work of M.Dirar et.al [4] where show that doping polymer with Zno causes Fermi level to change with Zno concentration. Khadija also shows that doping polymer with Cuo also changes Fermi level due to the change of Cuo concentration [5]. Thowra shows that changing the Zno and Cuo layer in FTO/Cuo/Zno/Al and FTO/Zno/Cuo/Al solar cell changes the electric power included [6]. The optical properties can be changed [7, 8, 9] by changing Nano structure as well as the electric properties.

Material and Method

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

After prepared Thin film of (Fe_3O_4 and Ni_2O_3) Nano-material deposited on ITO glass substrate with different thicknesses (55.25, 78.7, 90.9 144.9 and 263.15) nm for each. The optical and electrical conductivity were found by using UV spectral technique, by using the equation $\boldsymbol{\delta_{opt}} = \frac{\alpha nc}{4\pi}$ Where(c) is the light velocity for optical conductivity , and $\boldsymbol{\delta_{ele}} = \frac{2\lambda\delta_{opt}}{\alpha}$ for the electrical conductivity **.**The results of electrical and optical conductivity as showing blow

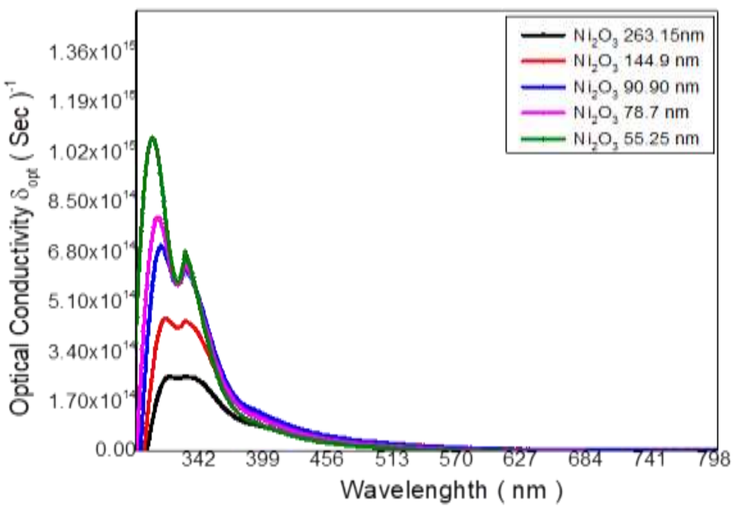

Fig (1) The relation between optical conductivity and wavelengths of five sample that made by Ni_2O_3 in different thickness

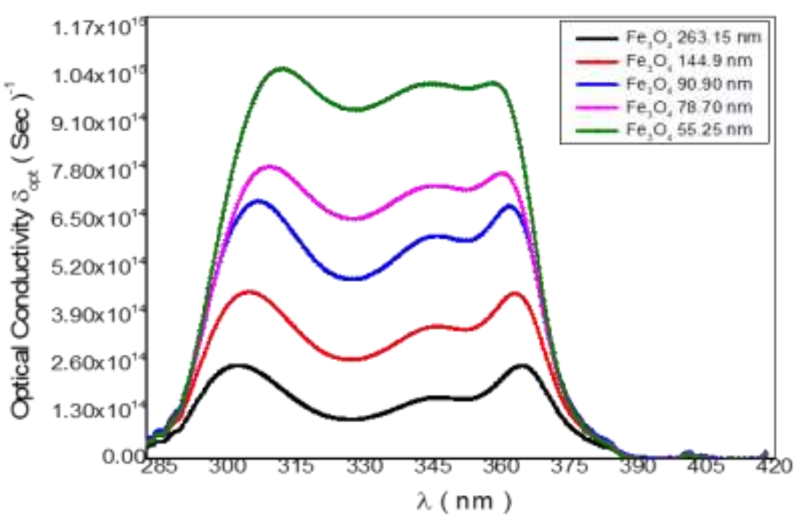

Fig (2) The relation between optical conductivity and wavelengths of five sample that made by Fe_3O_4 in different thickness

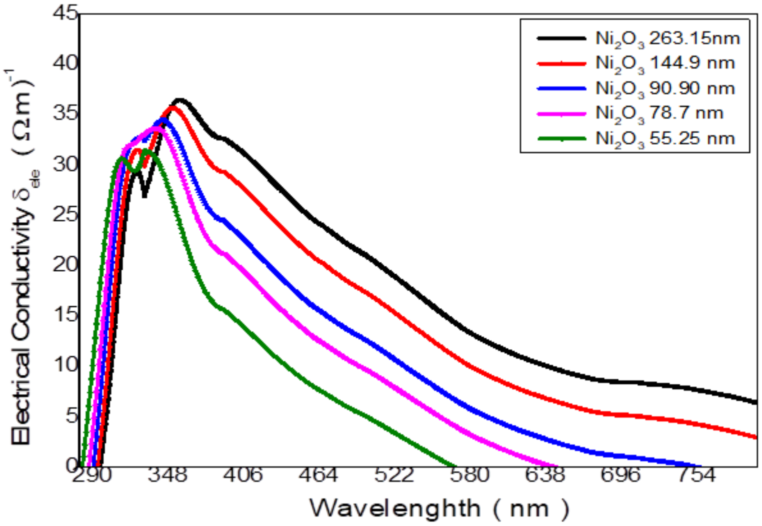

Fig (3) The relation between electrical conductivity and wavelengths of five sample that made by Ni_2O_3 in different thickness

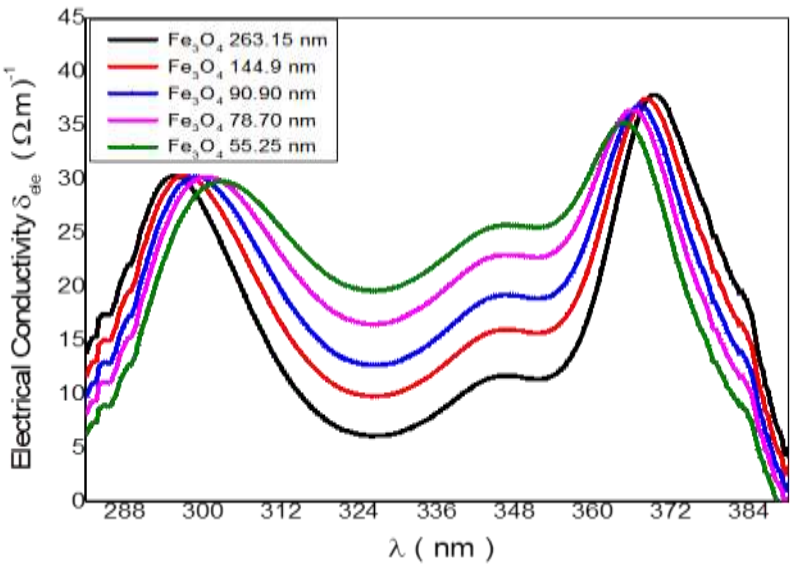

Fig (4) The relation between electrical conductivity and wavelengths of five sample that made by Fe_3O_4 in different thickness

Discussion

The optical conductivity is a measure of frequency response of material when irradiated with light which is determined using the following relation, $\boldsymbol{\delta_{opt}} = \frac{\alpha n c}{4\pi}$ Where(c) is the light velocity. The electrical conductivity can be estimated using the following relation. $\boldsymbol{\delta_{ele}} = \frac{2\lambda\delta_{opt}}{\alpha}$ The high magnitude of optical conductivity (1.07x10^{15} sec^{-1}) confirms the presence of very high photo-response of the five samples prepared by Ni_2O_3 in different thickness form , and the high magnitude of optical conductivity (1.05x10^{15} sec^{-1}) confirms the presence of very high photo-response of the five samples prepared by Fe_3O_4 in different thickness form. The increased of optical conductivity at high photonenergies is due to the high absorbance of five samples prepared by Ni_2O_3 in different thickness formand may be due to electron excitation by photon energy as it is shown in Figs (1) and (3) for Ni_2O_3 samples and fig(2) and fig(4) for Fe_3O_4 samples .In fig(3) showing the relation between electrical conductivity and wavelengths of five sample that made by Ni_2O_3 in different thickness, the value of electrical conductivity at 400 nm wavelength equal 37 $(\Omega.m)^{-1}$ for NiO 263.1 nm sample , 35 $(\Omega.m)^{-1}$ for NiO 144.9 nm sample , 33 $(\Omega.m)^{-1}$ for NiO 90.9 nm sample , 31 $(\Omega.m)^{-1}$ for NiO 78.7 1 nm sample and 29 $(\Omega.m)^{-1}$ for NiO 55.25 nm sample. But for Fe_3O_4 electrical condutivity showing in fig (4) , and the value of all sample conductivity at 377 nm equal 35 $(\Omega.m)^{-1}$ for Fe_3O_4 263.1 nm sample , 34 $(\Omega.m)^{-1}$ for Fe_3O_4 144.9 nm sample , 33 $(\Omega.m)^{-1}$ for Fe_3O_4 90.9 nm sample , 32 $(\Omega.m)^{-1}$ for Fe_3O_4 78.7 1 nm sample and 31 $(\Omega.m)^{-1}$ for Fe_3O_4 55.25 nm sample.

Conclusion

The change of Fe_3O_4 and Ni_2O_3concentrations effect on optical and electrical conductivity. For all samples optical conductivity increase upon decreasing concentration while electrical conductivity for Ni_2O_3 increase upon increasing the concentration and for Fe_3O_4 electrical conductivity increase upon decreasing concentration.

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