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Optical Properties of Glass and Plastic Doped By Fe

[1]Mubarak Dirar Abdallah, [2]Elharam Ali Eltahir Mohammed
[3]Sawsan Ahmed Elhouri Ahmed & [4]Rawia A.Elgani

[1]International University of Africa- College of Science-Department of Physics & Sudan University of Science& Technology-College of Science-Department of Physics-Khartoum-Sudan
[2, 4] Sudan University of Science& Technology-College of Science-Department of Physics-Khartoum-Sudan
[3]University of Bahri-College of Applied & Industrial Sciences-Department of Physics
Khartoum - Sudan

Abstract:
Fe material with different concentrations was used to dope glass and plastic samples. The absorption coefficient, refractive index, real and imaginary electric constants decreases as Fe concentration increases. These results agree with theoretical relations.

Keywords: Glass, plastic, Fe, doping, absorption coefficient, refractive index, energy gap.

Introduction:
Semiconductors (SC) play an important role in modern technology. Semiconductors are formed from materials having narrow energy gap. This enables them to allow few electrons to transfer from conduction to valence band [1]. In the p- type SC the SC is doped with elements having three valance electrons. This increases positive hole concentration in the n-type SC, the doping is made with valance elements this increases free electrons concentration [2].The glass and plastic materials are widely used materials that act as a SC. Recently these materials were doped with different elements to change their physical properties one of the most important physical property is the optical properties which are useful in solar cell light sensors [3,4].The work done in superconductor's shows that doping of some substances with Fe convert them to superconductors
These materials such as glass and plastic of this work, the substances used in this work are glass and plastic as mentioned above. Section two presents the change of optical properties, section three, four, and five are devoted to results, discussion and conclusion.

2. Theoretical interpretation

The real and imaging permeability can be found from equation of Particle viscous medium of viscosity η which is given by

$\eta = \frac{1}{2} m n_0 L \nu$ (2.1)

m = particle mass

n_0 = number density

L = free path length

ν = velocity

The equation of motion under the effect of electric field of strength E is giving by

$$m\ddot{x} = e\,E - 6\pi\, a\, \eta\, \nu = e\,E - \gamma\,\nu \qquad (2.2)$$

Where

$$\gamma = 6\pi\, a\, \eta\, \nu = 3\pi\, a\, m\, L\, \nu n_0$$
$$= \gamma_0 n_0 \qquad (2.3)$$

a = Radius of the particle

$\gamma_0 = 3\pi\, a\, m\, L\, \nu$

Consider now the solution

$$x = x_0 e^{wt}$$
$$\dot{x} = iwx = \nu$$
$$\ddot{x} = -w^2 x \qquad (2.4)$$

Substituting (2.3) in (2.1) given

$$(i\gamma - mw^2)x = -\,e\,E \qquad (2.5)$$

Thus

$$x = \frac{-e}{[i\gamma - mw^2]} E = \frac{[mw^2 + i\gamma]eE}{[m^2w^4 + \gamma^2]} \qquad (2.6)$$

$$p = e\,n\,x = e^2 n \frac{[mw^2 + i\gamma]\,E}{[m^2w^2 + \gamma^2]}$$
$$= [x_1 + ix_2]\,E \qquad (2.7)$$

$$x_1 = \frac{mw^2ne^2}{[m^2w^2+\gamma^2]} \quad x_2 = \frac{\gamma ne^2}{[m^2w^2+\gamma^2]} \qquad (2.8)$$

For very large friction coefficient

$$\gamma \gg mw \qquad (2.9)$$

Hence

$$x_1 = \frac{mw^2ne^2}{\gamma^2} = \frac{ne^2mw^2}{\gamma_0{}^2 n_0{}^2} \qquad (2.10)$$

$$x_2 = \frac{ne^2}{\gamma} = \frac{ne^2}{\gamma_0 n_0} \qquad (2.11)$$

$$\sigma_1 = wx_2 = w\varepsilon_0 x_2 \qquad (2.12)$$

$$\alpha = \frac{\sigma_1}{c n_1} \qquad (2.13)$$

3. Materials & Methods:

Five samples plastics and glasses were doped by Fewith different concentration ranging from 29.3 ***μ***g/cm^2 to2623***μ***g/cm^2.

The optical properties of samples were studied by using the following devices with the following specification.

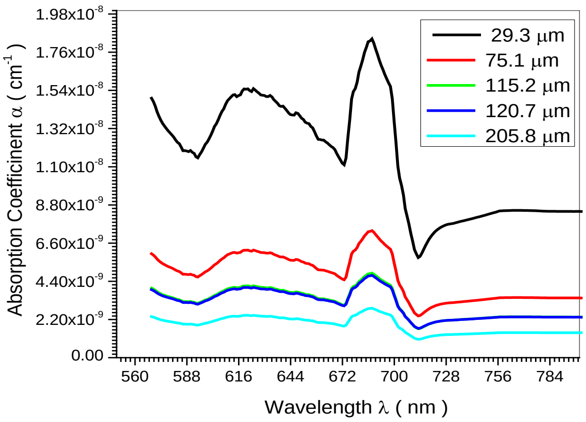
a. Spin coater

A thin film is made by the spin coating method, the number of round proportional increases with the voltage, then the thickness decreases with an increase in the number of round

b. Ultra violet (UV) spectrometer

The visible spectra obtained in shimadzo mini 1240 spectrophotometer scanning between 200 -1200 nm.The spectrophotometer measures how much of the light is absorbed by the sample.

4. Results:



Fig(1)The relation between absorption coefficient and wavelength for glass doping by Fe with different concentration

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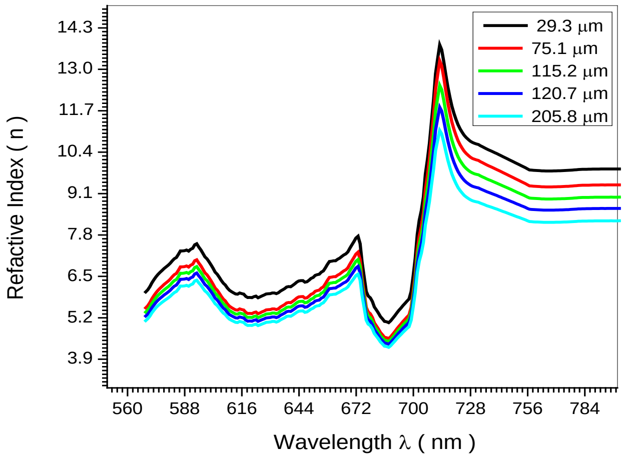


Fig(2)The relation between refractive index and wavelength for glass doping by Fe with different concentration

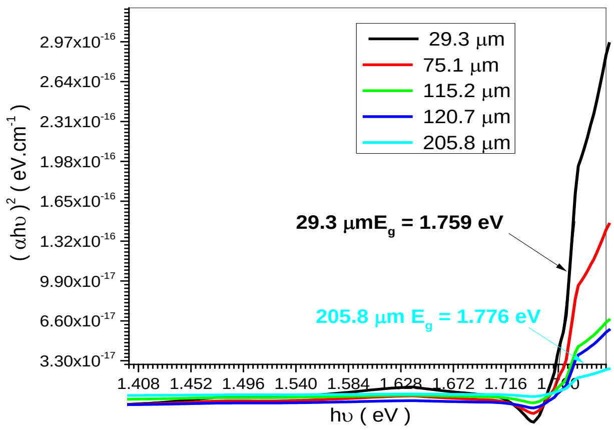


Fig (3) The optical energy gap for glass doping by Fe with different concentration

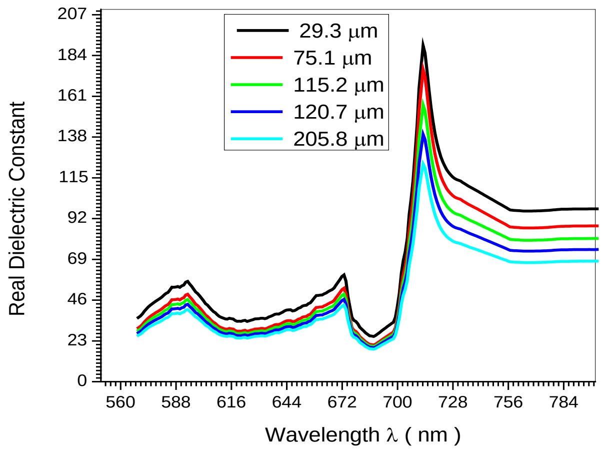


Fig (4) The relation between real dielectric constant and wavelength for glass doping by Fe with different concentration

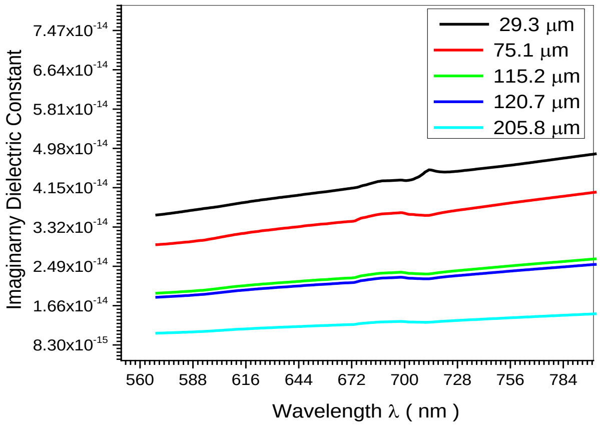


Fig (5) The relation between imaginary dielectric constant and wavelength for glass doping by Fe with different concentration

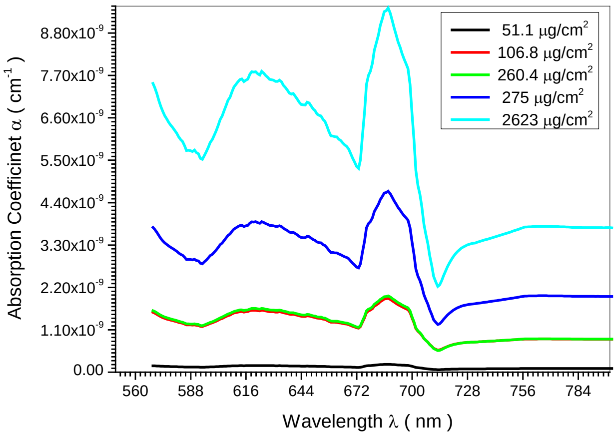


Fig (6) The relation between absorption coefficient and wavelength forplastic doping by Fe with different concentration

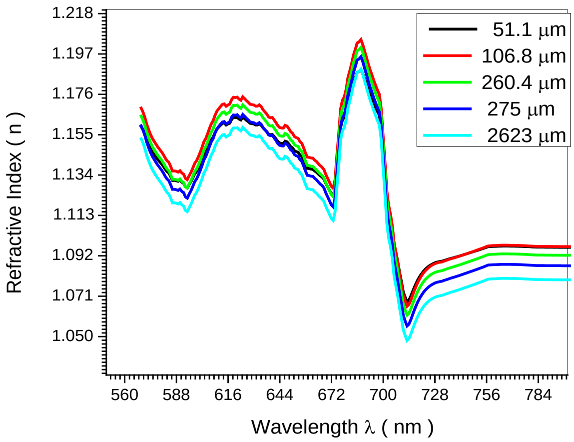


Fig (7) The relation between refractive index and wavelength forplastic doping by Fe with different concentration

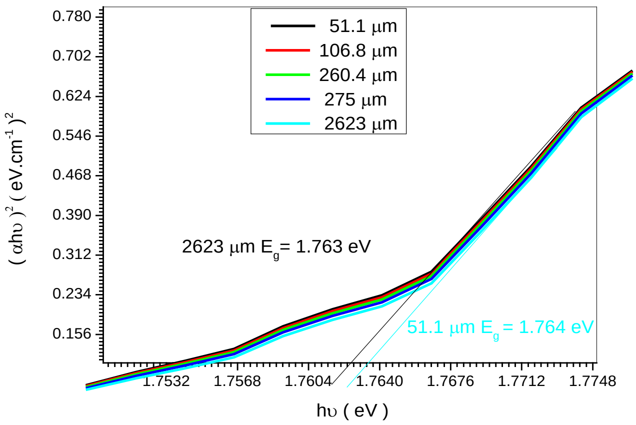


Fig (8) The optical energy gap forplastic doping by Fe with different concentration

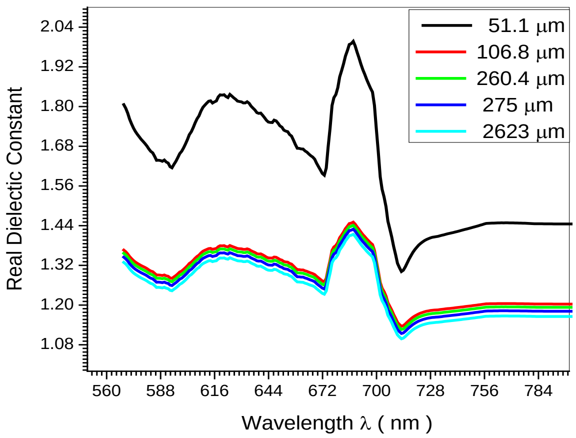


Fig (9) The relation between real dielectric constant and wavelength forplastic doping by Fe with different concentration

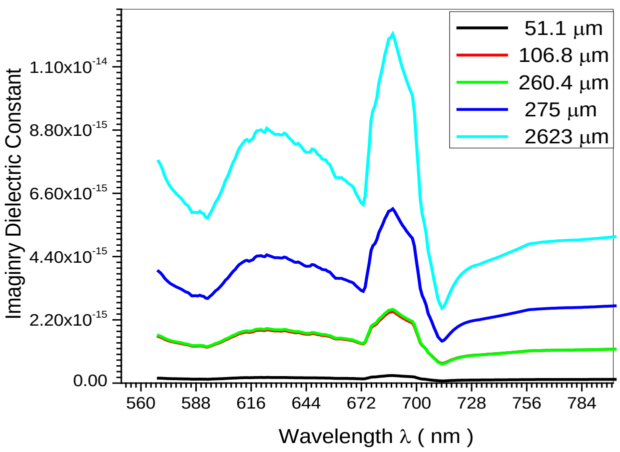


Fig (10) The relation between imaginary dielectric constant and wavelength forplastic doping by Fe with different concentration

5. Discussion

The behaviour of glass and plastic doped with Fe for some optical properties like absorption coefficient α , refractive index n_1, energy gap E_g , real and imaginary permitavity inrelationto concentration of Fe is shown in figures (1,2,3,4,5) for glass and figurers (6,7,8,9,10) for plastic respectively . The effect of increasing doping concentration of Fe on α, n_1,ε_1,ε_2,shows inverse relation except forE_g which shown that E_g is directly proportional to concentration , i.e.

$E_g \propto n_0$

$$\alpha \propto \frac{1}{n_0}$$

$n_1 \propto \frac{1}{n_0}$

$$\varepsilon_1 \propto \frac{1}{n_0}$$

$\varepsilon_2 \propto \frac{1}{n_0}$ (1)

Where n_0 represent the number density of Fe atoms. This can forms with equations (2.9, 2.10, 2.11, and 2.12)

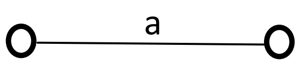
$$\alpha \sim \sigma_1 \sim \frac{1}{n_0}$$

$$\varepsilon_1 \sim 1 + x_1 \sim \frac{1}{n_0}$$

$$\varepsilon_2 \sim x_2 \sim \frac{1}{n_0} \quad (2)$$

This means that increasing Fe concentration increase into density. This increase frictional force too. This increase of friction increases absorption which is straight forward by physical intuition.

The refractive index n_1 is related to the relaxation time τ throught the relation between speed of light in a medium$v$, and in vacuumc, beside the distance a between two atoms. According to this relation



$$ct = v(t+\tau) = a$$

$$v\left(\frac{a}{c} + \tau\right) = a$$

$$\frac{v}{c}(a + c\tau) = a$$

$$\left(1 + \frac{c}{a}\tau\right) = \frac{c}{v} = n_1 \quad (3)$$

Butτ decreases as particlesdensity n_o increase

$\tau = \frac{c_0}{n_0}$

$n_1 = \left(1 + \frac{cc_0}{an_0}\right) \sim \frac{1}{n_0}$ (4)

This derivation agrees with the empirical relation between n_1 and n_0 shown in equation (5.1).

For plastic doped with Fe the empirical relation between ε_1 , n_1 is similar to that of Fe with glass. However the relations of α, αl, ε_2 shows that

$\alpha\ ,\alpha l\ ,\varepsilon_2 \sim n$ (5)

Where n is the concentration of free charge carriers which also increases when n_0 increase.

These empirical relations agrees also with the theoretical relations (2.8, 2.12, 2, 13) where

$\alpha, \alpha l \sim \sigma_1 \sim n$

$\varepsilon_2 \sim x_2 \sim n$ (6)

This indicates that the effect of free carriers becomes important than the effect of friction in the absorption process.

It is very interesting to note that the energy gap E_g, in all cases increases with n_0 i.e

$E_g \propto n_0$ (7)

This empirical relation agrees with the theoretical one, where

$n_i = N_v N_c e^{-\beta E_g}$

$E_g = \frac{1}{\beta} Ln(\frac{N_c N_V}{ni^2})$ (8)

Where

N_c , N_v are the average concentrations of carriers in the conduction and valence band respectively. The term n_i stands for free charges generated thermally. This means that increasing concentrations of Fe and Fe, increases concentration of holes N_v and concentration of free conduction electrons N_C without increasing thermally generated carriers n_i , i.e

$N_c, N_v \sim n_0$ (8)

Thus from (5)

$Eg \sim n_0$ (9)

In agreement with the empirical relation

6. Conclusion

The absorption of light by glass can be changed by changing the concentration of Fe. The increase of Fe concentration decrease absorption coefficient. For Fe absorption coefficient and the imaginary electric permittivity are preoperational to free carriers' concentration. This means that in the design of windows in homes one can enable more light to pass into the room, by decreasing concentration of Fe. It can be also be used in designing sensor and solar cells to improve their performance.

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