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[Mohammed, 4(6): June 2017] ISSN 2348 – 8034
DOI- 10.5281/zenodo.808172 Impact Factor- 4.022

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

OPTICAL PROPERTIES OF GLASS AND PLASTIC DOPED BY CU

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ABSTRACT

Glass and plastic samples are doped with Cu at different concentrations. The results obtained show that increasing Cu concentration decreases absorption coefficient, refractive index, real and imaginary electric permittivity, where as energy gap increases. These results surprisingly agree with the theoretical model that treats Cu as an electric dipole.

Keywords: *Glass, plastic, Cu, doping, absorption coefficient, Refractive index, energy gap.*

I. INTRODUCTION

Optical properties of materials play an important role in technology.

They are important for solar cells and light sensor [1]. The optical properties include absorption, refractive index, reflection and transmission. The optical properties can be changed by doping or by physical techniques [2].The emergence of nano science raises a hope in changing optical properties of materials by controlling the nano size and concentration or geometry [3].Nano science shows that nano particles behavior is descended by the laws of quantum mechanics [4].One of the importance materials used in doping is Cu .It was shown in literature that doping some materials with Cu can change them to superconductivity this is encourages to try to see how Cu can change the optical properties of glass and plastic this done in section 2,3,4,and 5 are devoted for results , discussion and conclusion .

II. 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

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

Where

$\gamma = 6\pi\,a\,\eta\,\nu = 3\pi\,a\,m\,L\,\nu n_0$

$= \gamma_0 n_0$ (2.3)

a = Radius of the particle

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

Consider now the solution

$x = x_0 e^{wt}$

$\dot{x} = iwx = v$

$\ddot{x} = -w^2 x$ (2.4)

Substituting (2.3) in (2.1) given

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

Thus

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

$$p = e\,n\,x = e^2 n\,\frac{[mw^2 + i\gamma]\,E}{[m^2w^2 + \gamma^2]}$$

$$= [x_1 + ix_2]\,E \quad (2.7)$$

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

For very large friction coefficient

$\gamma \gg mw$ (2.9)

Hence

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

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

$$\sigma_1 = w\,\varepsilon_2 = w\varepsilon_0 x_2 \quad (2.12)$$

$$\alpha = \frac{\sigma_1}{cn_1} \quad (2.13)$$

III. MATERIALS& METHODS

Five samples plastics and glasses were doped by Cu with different concentration ranging from 28.9 μg/cm^2 to 1965.8μg/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.

ISSN 2348 – 8034
Impact Factor- 4.022

IV. RESULTS

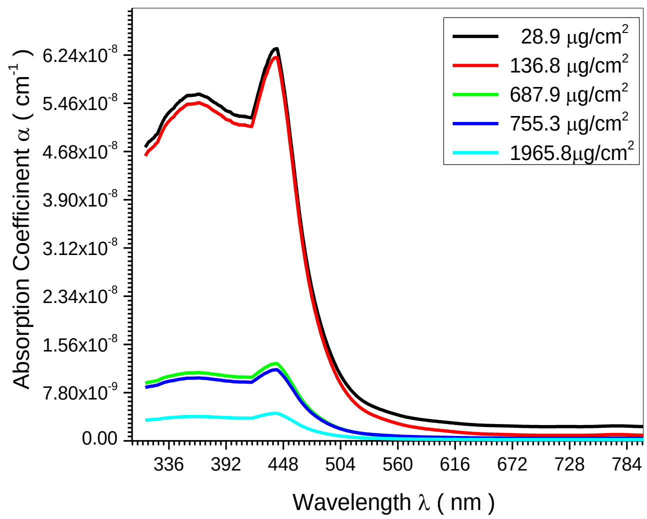

Fig (1) The relation between absorption coefficient and wavelength for glass doping by Cu with different concentration

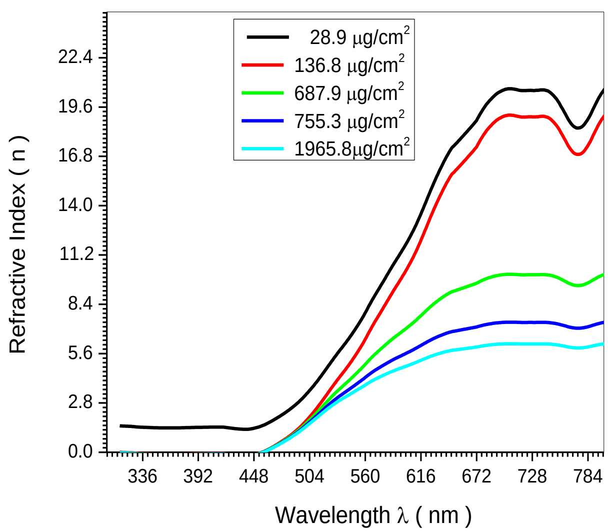

Fig (2) The relation between refractive index and wavelength for glass doping by Cu with different concentration

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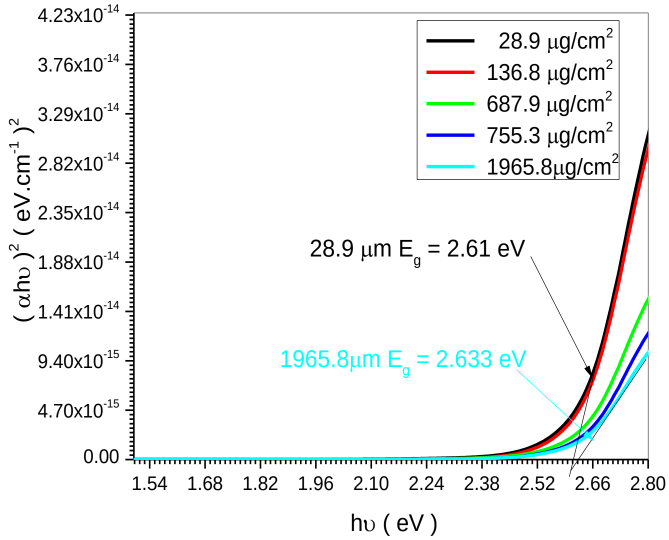

Fig (3) The optical energy gap for glass doping by Cu with different concentration

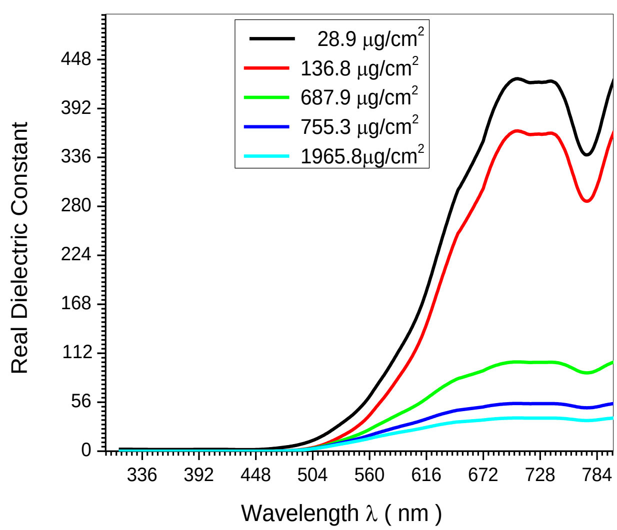

Fig (4) The relation between real dielectric constant and wavelength for glass doping by Cu with different concentration

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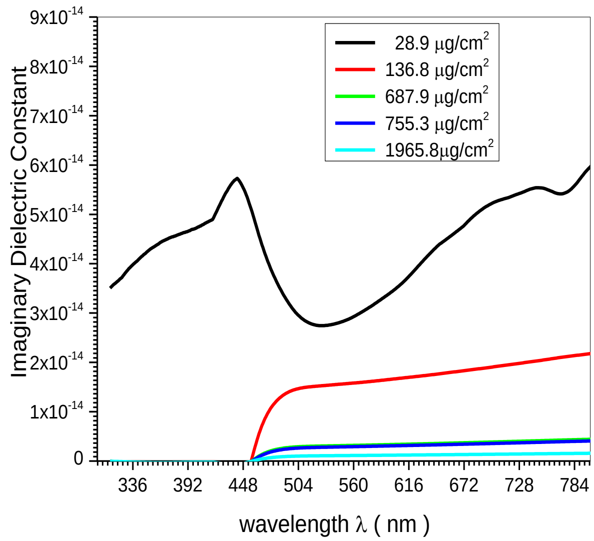

Fig (5) The relation between imaginary dielectric constant and wavelength for glass doping by Cu with different concentration

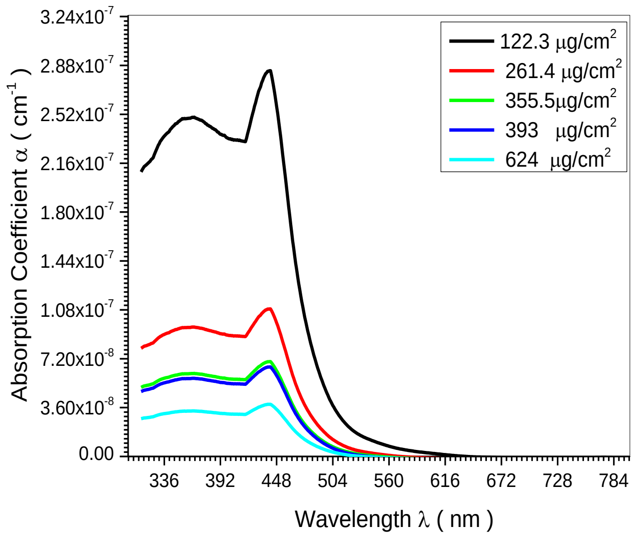

Fig (6) The relation between absorption coefficient and wavelength forplastic doping by Cu with different concentration

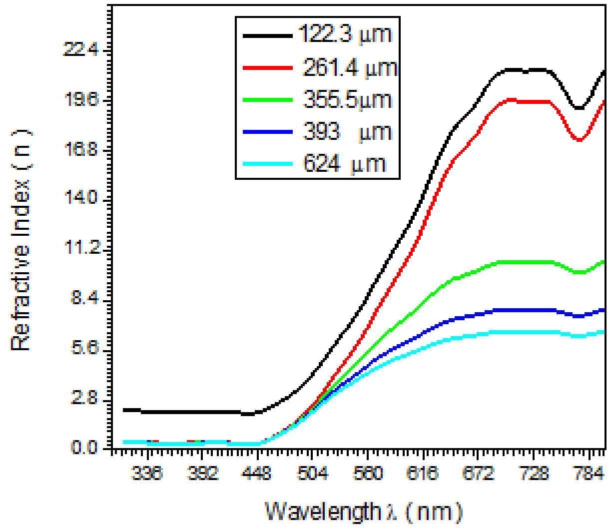

Fig (7) The relation between refractive index and wavelength forplastic doping by Cu with different concentration

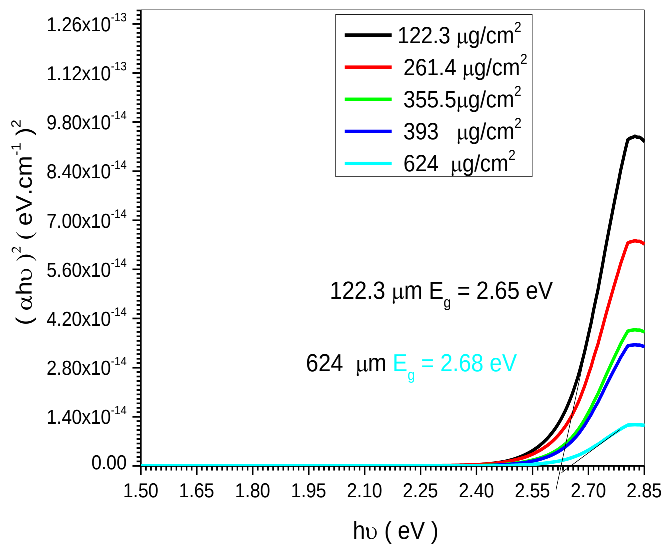

Fig (8) The optical energy gap forplastic doping by Cu with different concentration

ISSN 2348 – 8034
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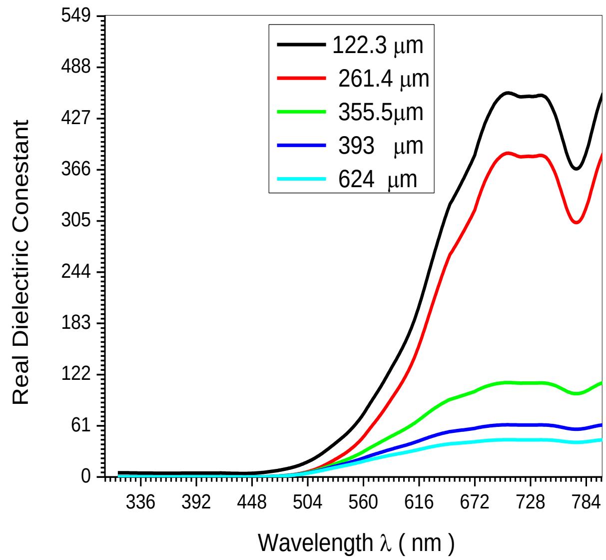

Fig (9) The relation between real dielectric constant and wavelength forplastic doping by Cu with different concentration

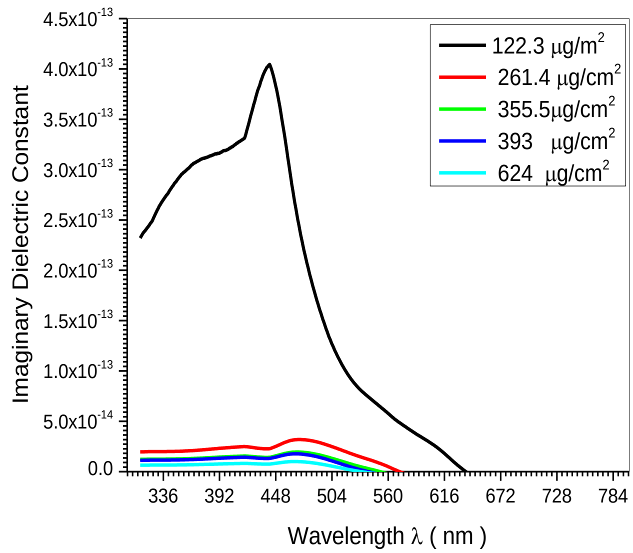

Fig (10) The relation between imaginary dielectric constant and wavelength forplastic doping by Cu with different concentration

V. DISCUSSION

The behaviour of glass and plastic doped with Cu for some optical properties like absorption coefficient α , refractive index n_1, energy gap E_g , real and imaginary permitavity inrelationto concentration of Cu 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

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concentration of Cu 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.

$E_g \propto n_0$

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

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

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

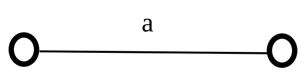
$\varepsilon_2 \propto \frac{1}{n_0}$ (5.1)

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

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

$\varepsilon_1 \sim 1 + x_1 \sim \frac{1}{n_0}$ (5.2)

This means that increasing Cu concentration increase into density. This increase frictional forcetoo. 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 ina medium v,and in vacuum c,beside the distance a between two atoms . According to this relation



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

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

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

$\left(1 + \frac{c}{a}\tau\right) = \frac{c}{v} = n_1$(5.3)

Butτ decreases as particlesdensity n_o increase

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

$n_1 = \left(1 + \frac{cc_0}{an_0}\right) \sim \frac{1}{n_0}$ (5.4)

This derivation agrees with the empirical relation between n_1 and n_0 shown in equation (1).

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

$E_g \propto n_0$ (5.5)

This empirical relation agrees with the theoretical one, where

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

$E_g = \frac{1}{\beta} Ln\left(\frac{N_c N_v}{ni^2}\right)$ (5.6)

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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 Cu 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

$$N_c, N_v \sim n_0 \qquad (5.7)$$

Thus from (5.5)

$$Eg \sim n_0 \qquad (5.8)$$

In agreement with the empirical relation

VI. CONCLUSION

The absorption of light by glass can be changed by changing the concentration of Cu. The increase of Cu concentration decrease absorption coefficient. This means that in the design of windows in homes one can enable more light to pass into the room, by decreasing concentration of Cu. It can be also be used in designing sensor and solar cells to improve their performance.

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