CHAPTER THREE

RESULTS AND DISCUSSION

3-1 Introduction:

The results and discussion of the deposition results and the optical properties of $CuSO_4$ thin films deposited on glass substrate are presented in this chapter. Some of the results were obtained experimentally such interference fringes, some of these results were measured such as the incident and transmitted intensities, and other were calculated after the deposition such as the, Transmission percentages, reflectivity, refractive index, and absorption coefficients .

This work was limited to the case of a single layer deposited on a substrate. Practically this kind of thin films could be used in the ultraviolet, visible, or infrared regions of the spectrum. As filters, some of the wavelengths were transmitted and the other were reflected according to the characteristics of the layer that constitute this optical filter (Elhadi, 2007).

In general, each layer is characterized by its refractive index (n), its absorption coefficient (α), and its thickness (d).

3-2 Samples Results and Analysis:

In this work samples used were $CuSO_4$ solution dissolved in distilled water. According to the interference fringes that were monitored during the deposition process, different thicknesses of the sample were deposited and used to study the optical properties of the deposited films on glass substrate whose refractive index equal to (1.5) and thickness of (0.12 cm).

Part of the intensity measurement was shown in figure (3.1) which shows the sodium light source, optical lens of focal length of +20 cm used to focus the sodium emitted wavelength, and the vacuum chamber and the photo detector.

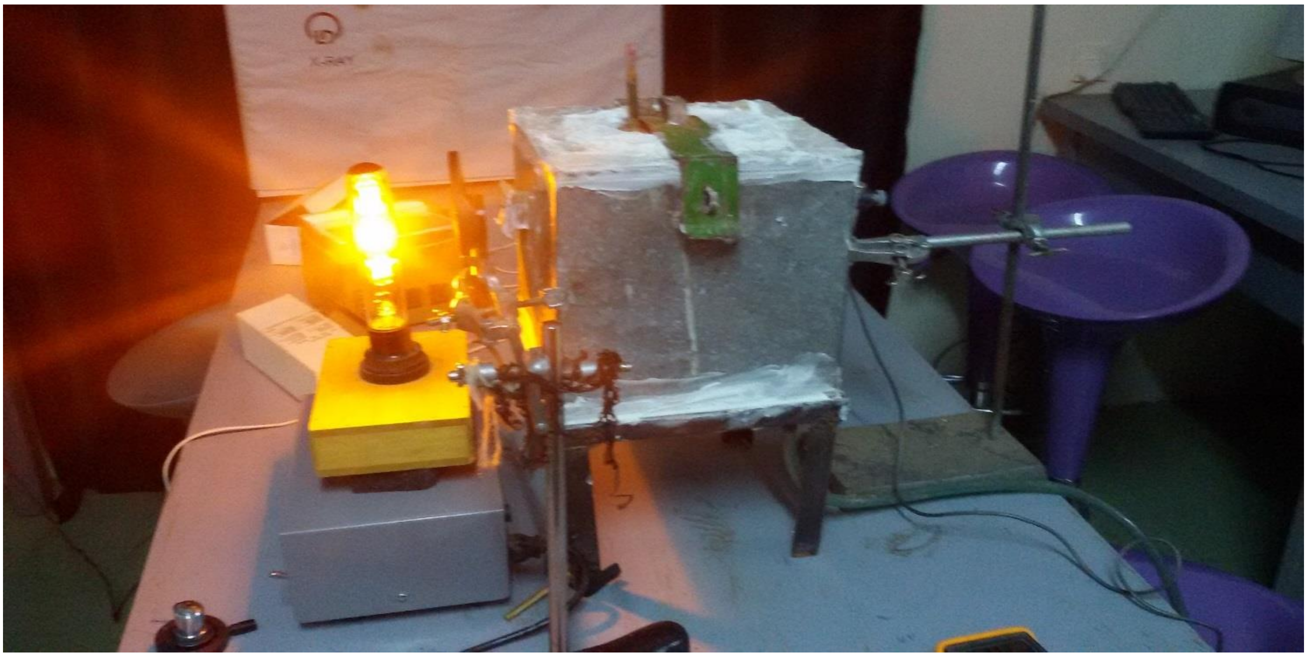

Fig.3.1: part of measurement of the transmitted intensity through the thin film using sodium light source

The results are classified as follows:

3-2-1 Results of Diode laser (532 nm) assisted deposition:

First of all the intensity of Diode laser 532 nm was monitored by CRO before deposition, the obtained intensity pattern is shown in figure (3.2). During deposition when an interference fringes reach maximum intensity, this indicate a thin film of thickness equal half- of the wavelength of the laser source. At this point the deposition was quickly stopped and the fringe was photographed as indicated in figure (3.3).

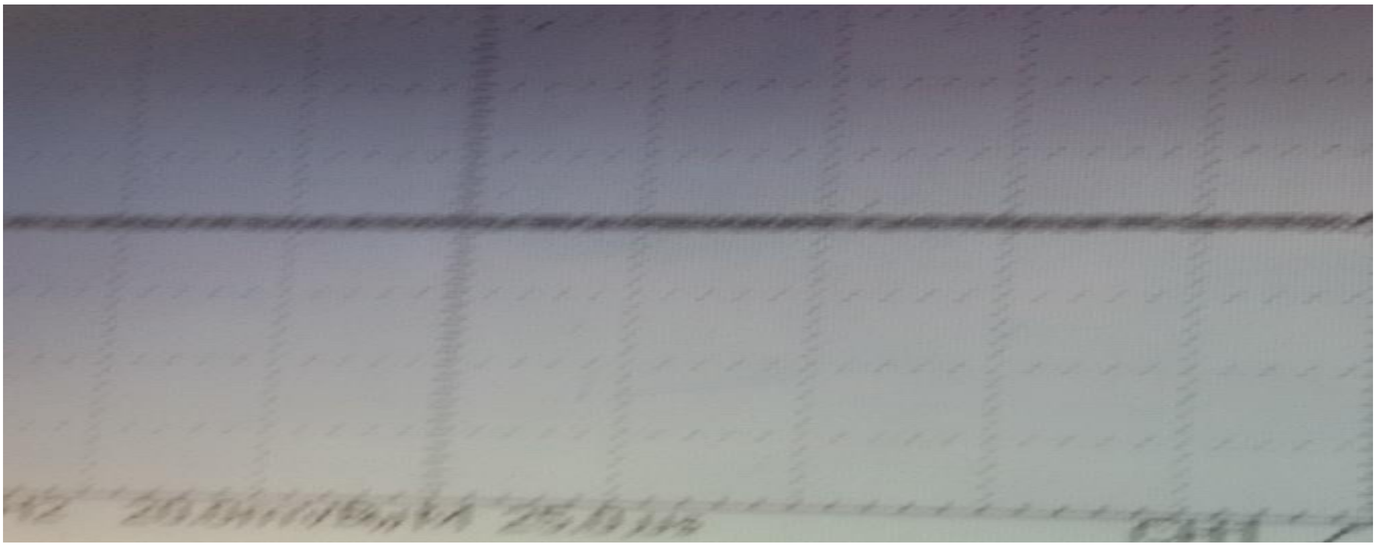

Fig.3.2 The detected Diode laser 532 nm signal before deposition

This means that the thickness of the fabricated thin film = 266 nm.

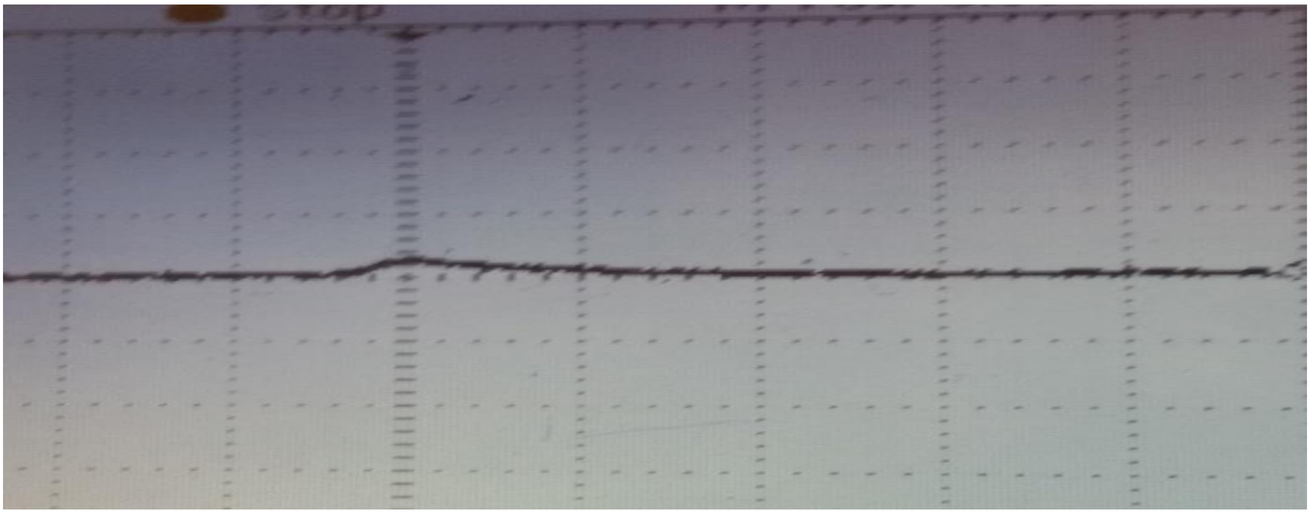

Figure 3.3: Interference fringe indicates the deposition of thin film with thickness = $\lambda/2$ of the green laser (532 nm)

Then the transmission intensities of different monochromatic light sources were detected after deposition and the results are tabulated in table (3.1) below:

Table 3.1: intensities with and without the deposited thin films with thickness = 266 nm:

Wavelength (nm)	Intensity before deposition	Intensity after deposition

± 0.1 nm	I_o± 0.001 (V)	I ± 0.001 (V)
532	0.295	0.293
589.2	0.144	0.138
632.8	0.275	0.268
660	0.347	0.327
675	0.380	0.371
820	0.388	0.371
915	0.420	0.414

The data in table (3.1) above was used to calculate the T% of the thin film. It is given in table (3.2) and plotted in figure (3-4) as a function of wavelength.

Table 3.2: wavelengths and their Transmission percentage, Reflectance calculated values:

Wavelength ± 0.1 (nm)	T	R
532	0.993	0.007
589.2	0.958	0.042
632.8	0.974	0.037
660	0.942	0.058
675	0.977	0.023
820	0.956	0.044
915	0.986	0.014

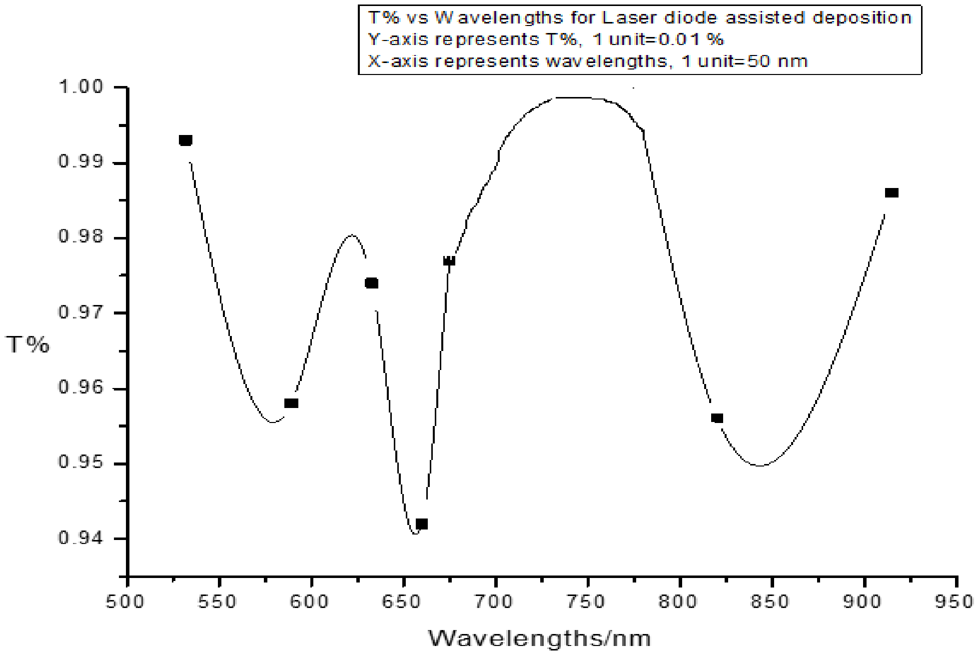

Fig.3.4: transmission percentages versus wavelengths for 266 nm thickness of CuSO4 thin film

From this figure it is clear that the fabricated $CuSO_4$ thin film has a high transmission in (532 nm) compared with other wavelengths. It is a good indicator to use this property to use it as an optical filter in this wavelength, good reflector by this material could be achieved by deposit multilayers or controlling the thickness.

The transmission percentage of the thin film at 660 nm is the lowest value for the set of wavelengths used in this study. These value indicates that this thin film can be used as a partial reflector at this wavelength.

The results of refractive indices for the given wavelengths using the relation given in (2-1) which relates the refractive index of the thin film to the index of refraction of the substrate and the value of reflectivity at a given wavelength are listed in table (3.3).

Table 3.3: Wavelengths, Reflectivities, and the calculated refractive indices:

Wavelength (nm)	R	n

± 0.1 nm		
532	0.007	1.33
589.2	0.009	1.35
632.8	0.076	1.625
660	0.057	1.562
675	0.023	1.426
820	0.044	1.515
915	0.014	1.22

The relation between the calculated refractive indices and the wavelengths is plotted in figure (3.5)

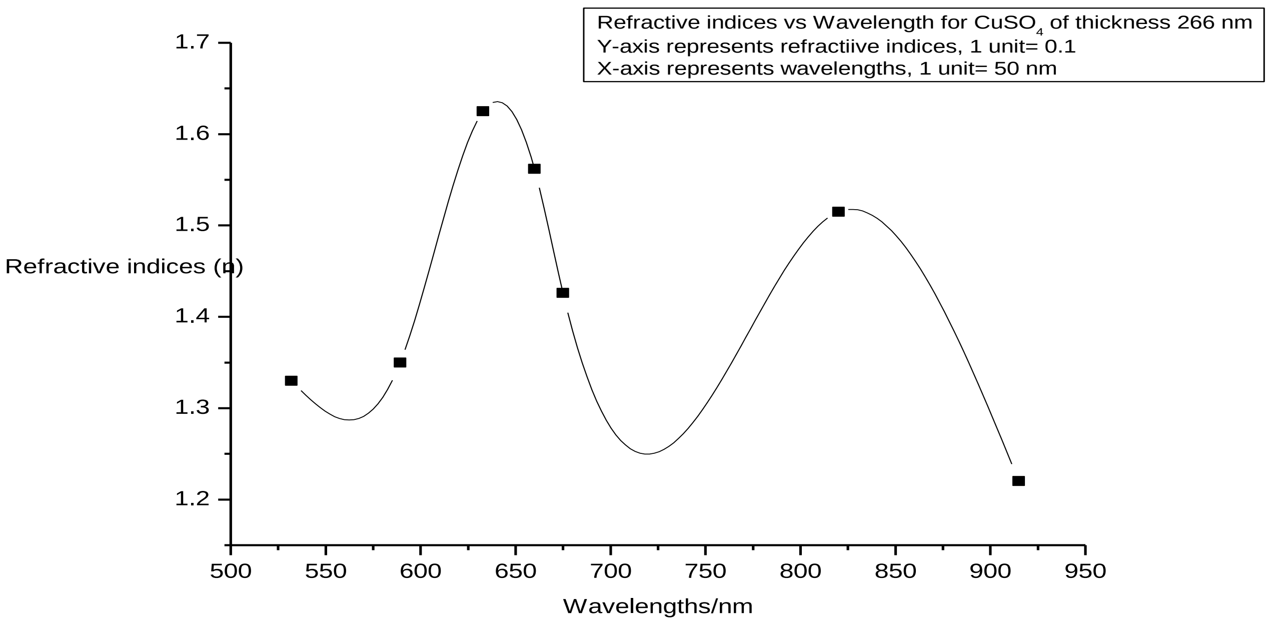

Fig.3.5: The refractive indices of $CuSO_4$ thin film 266 nm versus wavelengths

The refractive index of any material in thin film profile is usually deviates from that of the bulk of the same material (Geunther, 1984). This is due to the void fraction typical of the thin film microstructure.

The absorption coefficients were calculated using equation (2-2).The calculated values for the absorption coefficients were given in table (3. 4).

Table 3.4: wavelengths and the calculated values for the absorption coefficients:

Wavelength ± 0.1 (nm)	Absorption coefficients ($X\ 10^3\ cm^{-1}$)
532	49.65
589.2	48.62
632.8	59.50
660	55.31
675	52.37
820	54.44
915	45.22

The calculated absorption coefficients versus wavelengths is plotted in figure (3.6) below:

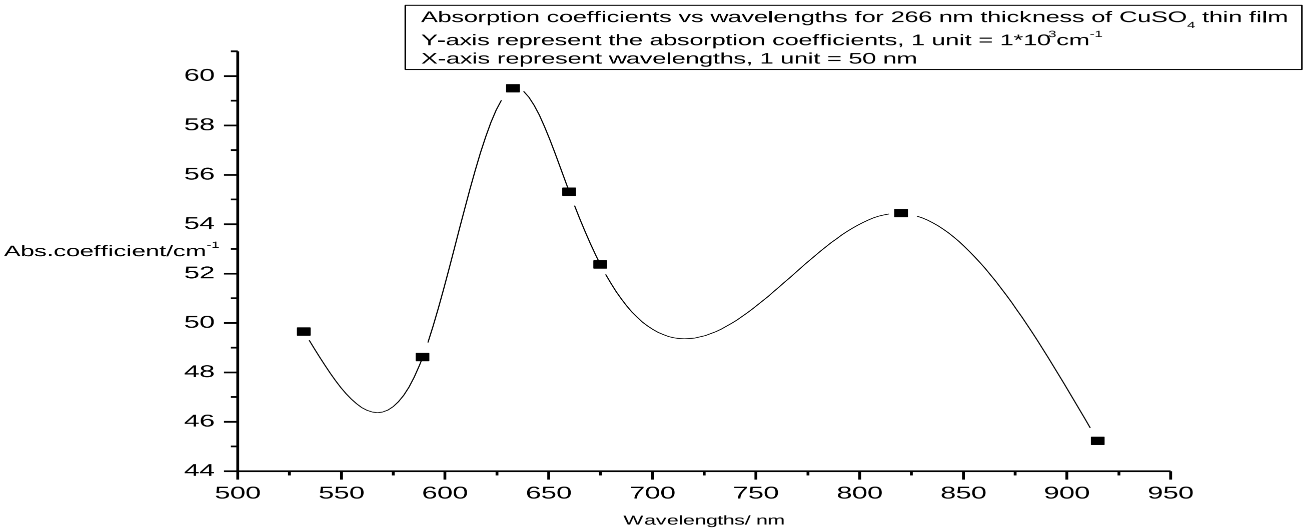

Fig.3.6: Absorption coefficients versus wavelengths for the 266 nm thin film CuSO4

This figure together with figure (3.5) support the idea of using such film as an optical filter or as a reflector in specific wavelengths.

3-2-2 Results of He-Ne laser assisted deposition:

To fabricate another thin film from the same material but with different thickness, a He-Ne laser was used to assist the liquid phase deposition. The interference fringes that indicates the deposition of half-wavelength of the He-Ne laser is shown in figure (3.7).

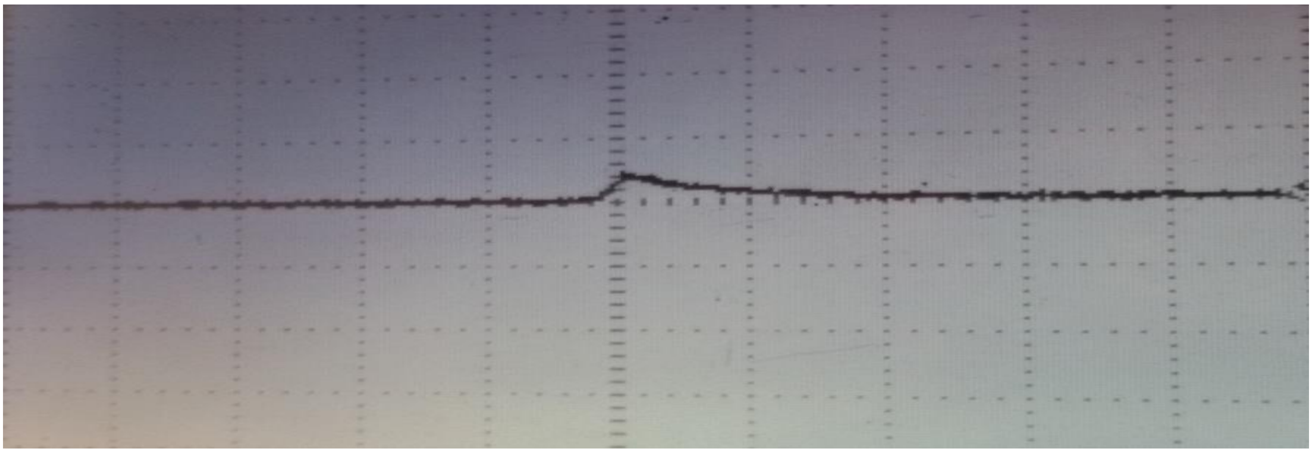

Figure 3.7: Interference fringe indicates deposition of λ/2 of He-Ne laser thickness of the thin film of $CuSO_4$.

Then the transmission intensities of different monochromatic light sources were detected after deposition and the results are tabulated in table (3.5).

Table 3.5: intensities with and without deposition of thin film with 316.4 nm thickness:

Wavelength ± 0.1 (nm)	Intensity before deposition I_o± 0.001 (V)	Intensity after deposition I ± 0.001 (V)
532	0.288	0.281
589.2	0.147	0.139
632.8	0.280	0.268
660	0.360	0.337
675	0.374	0.361
820	0.383	0.367
915	0.417	0.396

Table (3.6) lists the calculated transmission percentages for different wavelengths and the reflectivity at each wavelength.

Table 3.6: wavelengths and their Transmission and Reflectance:

Wavelength ± 0.1 (nm)	T	R
532	0.975	0.025
589.2	0.945	0.055
632.8	0.957	0.043
660	0.936	0.067
675	0.965	0.035
820	0.958	0.042
915	0.949	0.051

The transmission percentages (T %) versus wavelengths is plotted in figure (3.8) below:

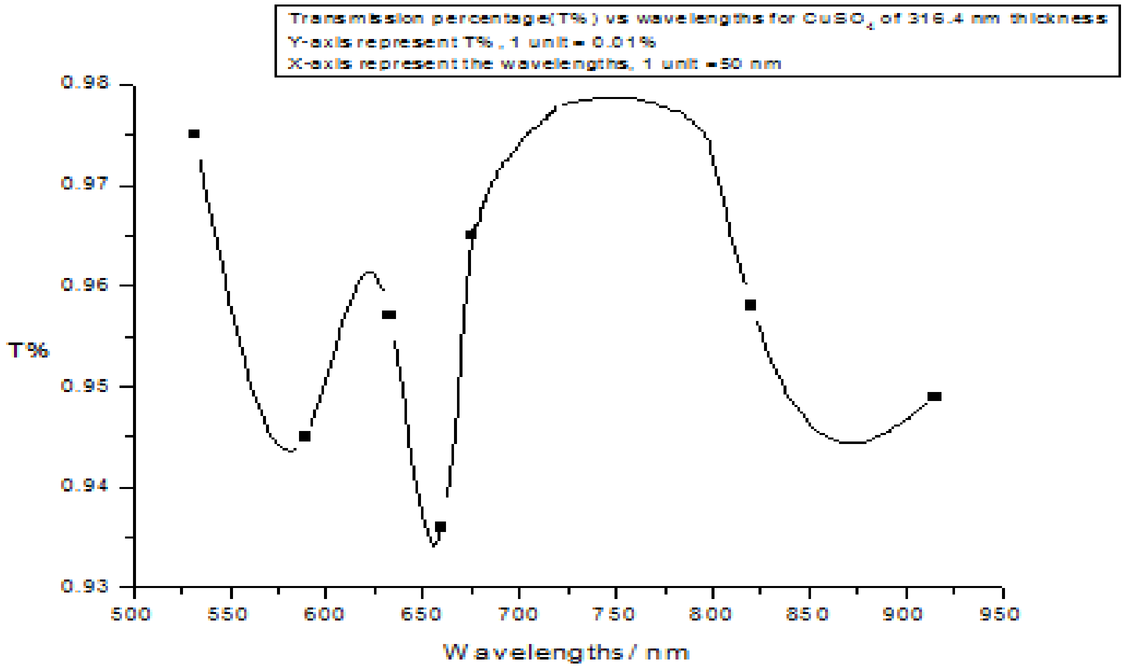

Fig.3.8: transmission % versus wavelengths for He-Ne laser assisted deposition of $CuSO_4$ thin film

From this figure it is clear that the fabricated $CuSO_4$ thin films has a high transmission at (532 nm) compared with other wavelengths. This figure support the idea in figure (3.4) to use it as an optical filter in this wavelength. It is clear that the increase of the thickness of the film decreases it is transmission this is clear in the (532) nm wavelength, hence the transmission was decreased from (99%) to about (97%). The transmission of the thin film at (660) nm is the lowest value for the set of wavelengths used in this study. This value indicates that this thin film can be used as a partial reflector at this wavelength, and also support the discussion for that thin film of (266 nm) thickness.

The results of refractive indices for the given wavelengths using (2-1) which relates the refractive index of the thin film to the index of refraction of the substrate and the values of reflectivity at a given wavelength are listed in table (3.7).

Table 3.7: wavelengths and the calculated refractive indices for 316.4 nm thickness:

Wavelength ± 0.1 nm	R	n
532	0.025	1.44
589.2	0.055	1.55
632.8	0.043	1.51
660	0.067	1.6
675	0.035	1.48
820	0.042	1.5
915	0.051	1.54

The calculated refractive indices as a function of wavelengths is plotted in figure (3.9).

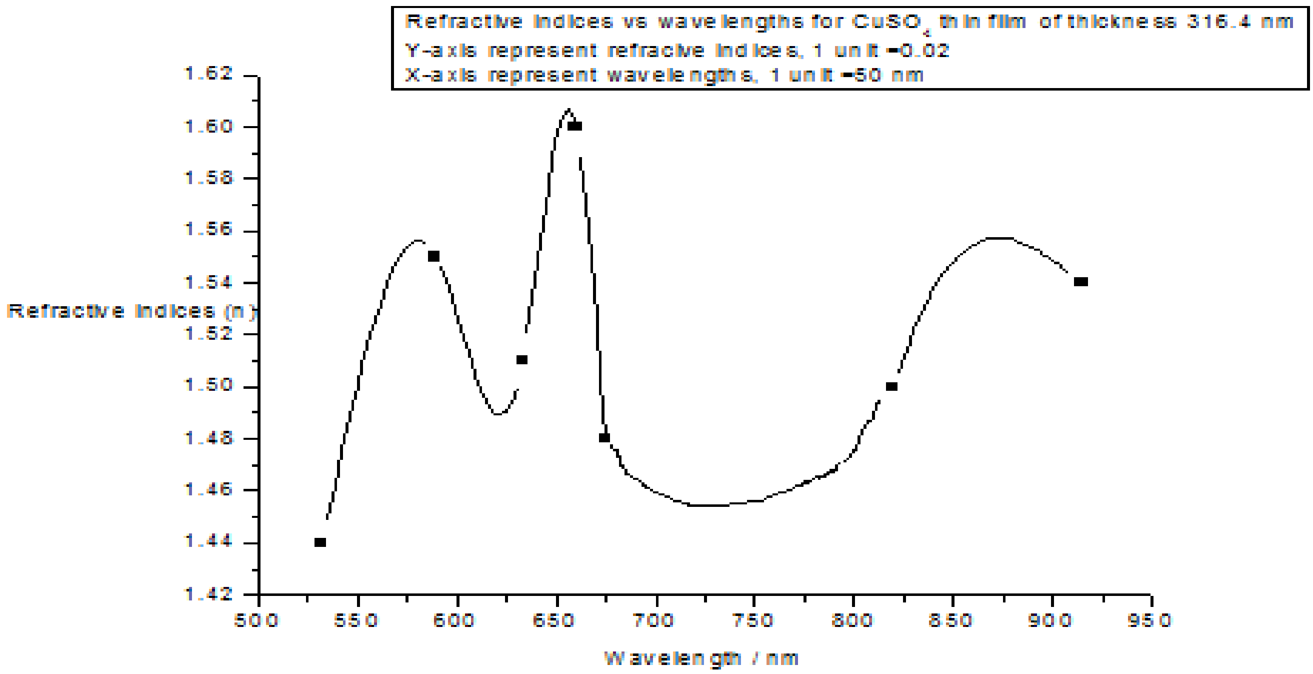

Fig.3.9: The refractive indices of 316.4 nm $CuSO_4$ thin film versus wavelengths

The absorption coefficients were calculated using equation (2-2), the calculated values for the absorption coefficients for 316.4 nm thickness of the film of $CuSO_4$ deposit in glass substrate are listed in table (3. 8).

Table 3.8: wavelengths and the absorption coefficients for 316.4 nm thickness:

Wavelength ± 0.1 (nm)	Absorption coefficients (X 10^3 cm^{-1})
532	44.374
589.2	46.294
632.8	45.672
660	47.332
675	45.139
820	46.735
915	46.190

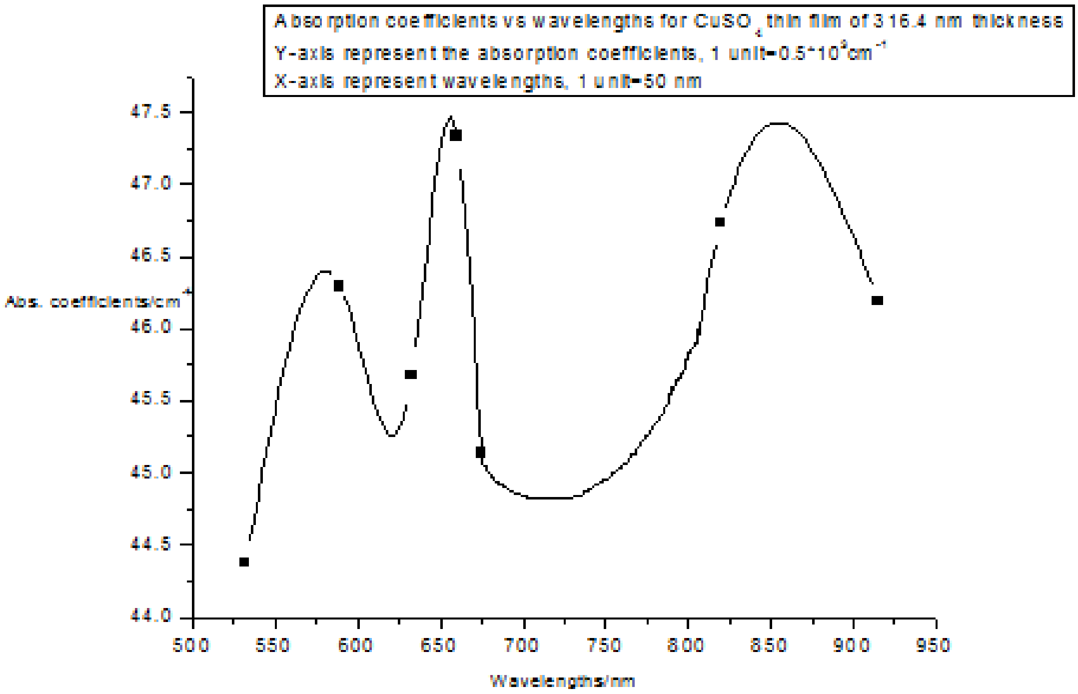

Fig.3.10: Absorption coefficients of 316.4 nm $CuSO_4$ thin film versus wavelengths

Increasing the thickness of the thin film ($CuSO_4$) reduced the absorption coefficients and this was evident from the results in tables (3.7 and 3.8) except (915) nm where the opposite situation was occur. The absorption coefficient was found to be increased in this wavelength.

3-3 Conclusions:

From the obtained results of the $CuSO_4$ thin films, one can conclude that:

1- Thin films of $CuSO_4$ of different thickness can be obtained by evacuation method.
2- The thickness of the deposited liquid sample can be controlled and measured via interference fringes of the transmitted laser light.
3- The evacuation method is a good solution for cheap study manufacturing of optical components.
4- The CuSO4 can be used to produce optical components in the range from visible to IR regions.

3-4: Recommendations:

It is recommended that:

1- Usage of other laser sources as assistance in the deposition process.

2- Investigation the ability of using evacuation method to form thin PN junction, as a suggestion, using multilayer deposition technique.

3- Investigation of the stability of the fabricated thin film, i.e., its mechanical properties.

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