Chapter five

5.0 Results and discussions

5.1 Introduction:

The aim of this chapter is to discuss the results of the experimental work. Some of these results were measured and the others were calculated to determine the parameters which characterize the thin films optically.

The film is single layer deposition on substrate; it can be used in the ultraviolet, visible, or infrared regions of the spectrum. Generally each layer characterized by its refractive index (n), absorption coefficient (α), and its thickness(x).

In this chapter not presents all the data in order not to repeat the presentation of all the numbers gained during the experiment.

5.2: Results and analysis

Transmission, Reflection and Absorption measurement:

Manganese Sulfide thin films were deposited on glass substrates that have refractive index equal to (1.5) and thickness (1mm).

The transmissions, reflection and absorption coefficient for these samples were measured and found by using the procedures and equations in section (1.7.15 and 4.5). The data of the optical properties of these samples were recorded and listed in tables 5.1 to table 5.9 and figure5.1 to figure 5.6.

The measured values of incident and transmitted intensity of Different wavelengths are listed in table 5.2 below:

Table5.1 the incident and transmitted intensity of different beam wavelengths of MnS-2:

λ(nm)	(I (Volt	(I_o(Volt
577	0.272	0.295
564	0.260	0.284
494	0.240	0.351
307	0.233	0.263
237	0.212	0.253

According to the transmittance relationship $T = \frac{I}{I_o}$, the transmission percentage of the sample was calculated and listed in table below.

Table 5.2 the transmission percentage of Sample No.2 MnS-2

λ(nm)	T %
577	92.2
564	91.5
494	68.29
307	88.62
237	83.7
224	89.11

The transmissions of sample MnS-2 recorded from Ultraviolet-visible spectrometer device directly and listed in table 5.3 below:

Table 5.3 the transmission of MnS-2

λ(nm)	T
577	0.922
564	0.915

494	0.683
307	0.886
237	0.837
224	0.891

And from the results in table 5.4, and depending on the Relationship R+T+A =1. The reflectance were calculated and listed below:

Table 5.4 the reflection of Sample No.2 MnS-2

λ(nm)	R
577	0.070
564	0.080
494	0.310
307	0.110
237	0.160
224	0.100

And from the results in table 5.4, and depending on the Relationship R+T+A =1. The absorption were calculated and listed. See appendixes table.

By using beer Lambert law in section (1.7.15) and equation (1.15) and knowing the film thickness and from the results in table5.4, the absorption coefficient were Calculated as below:

Table 5.5 the absorption coefficient of Sample No.2 MnS-2

λ(nm)	α (cm^{-1})$\times 10^2$
577	8.12
564	8.88
494	3.81
307	17.79
237	12.10
224	11.54

Using following relationship from section (1.17.15) $n = \frac{\lambda}{4x}$ [53].

Where (λ) is the wavelength and (x) is the thickness of the film.

So the refractive index calculated easily and listed in table5.6 below:

Table 5.6 the refractive index of Sample No. MnS-2

λ(nm)	Refractive index (n)
577	1.69
564	1.41
494	1.23
307	1.33

Table 5.7 the absorption of Sample No.2 MnS-2

λ(nm)	A(cm^{-1})
577	0.008
564	0.005
494	0.006
307	0.004
237	0.003
224	0.009

5.3 Discussion:

The results of differential thermal analysis (DTA) for manganese sulfide MnS powder are depicted in figure5.1 below.

The melting point of MnS is 700 C°, the first exothermic peak at 112.14 C° it's a result of crystallite grain growth.

The last endothermic peaks 356.31 C° it is a result of MnS polychromic transformation.

Figure 5.1 DTA diagram of as synthesized MnS in powder form.

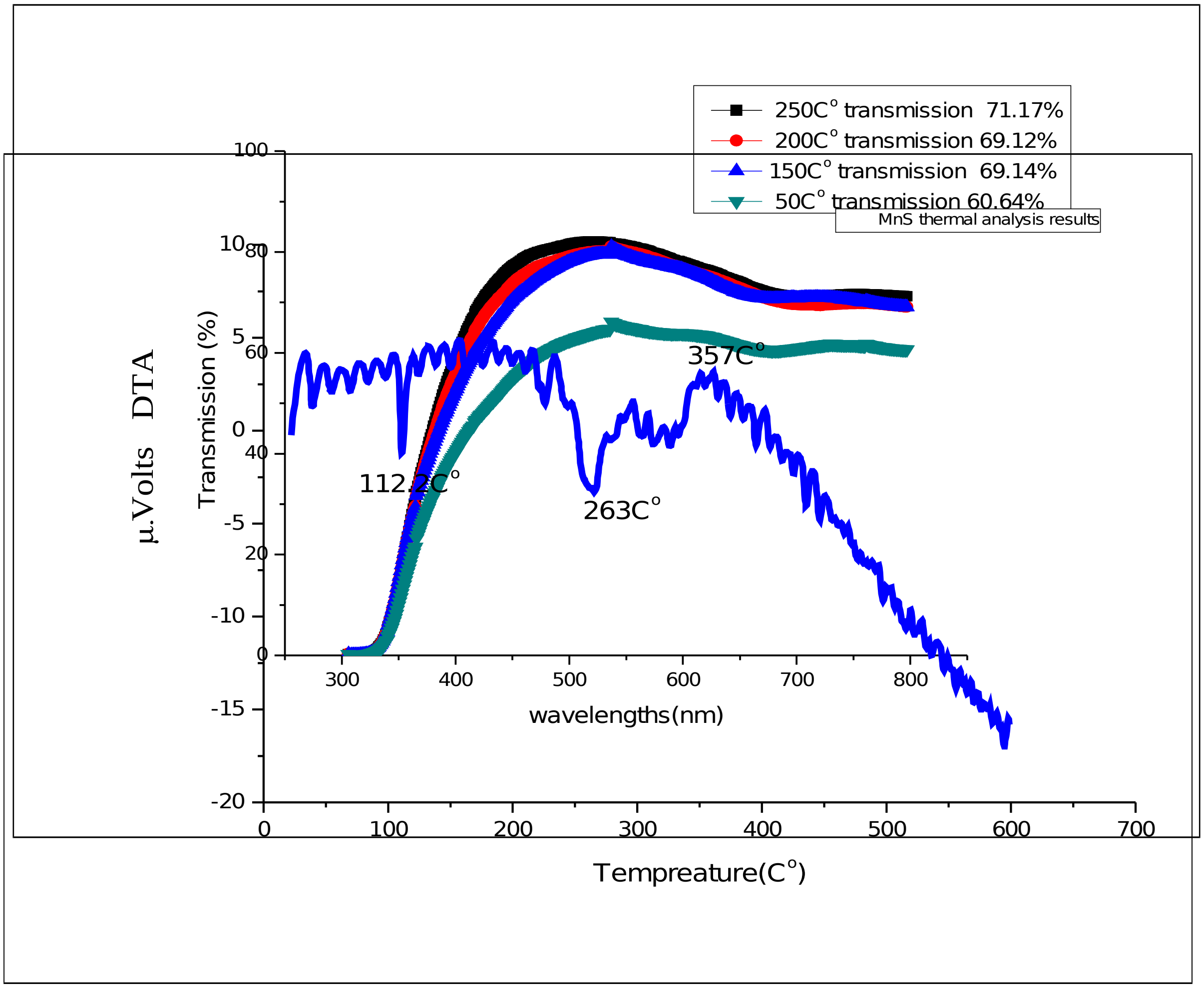

Figure 5.2 the transmission spectrum of MnS-1 versus wave lengths.

Figure 5.2 show that the transmission spectrum of sample (MnS-2) in the region between 307 to 577nm, it's clear that the transmission (%) for sample MnS-2 at 577nm is very high compared with others wavelengths.

This is a good indicator to use this material property to produce an optical filter and band transmitter at this wavelength.

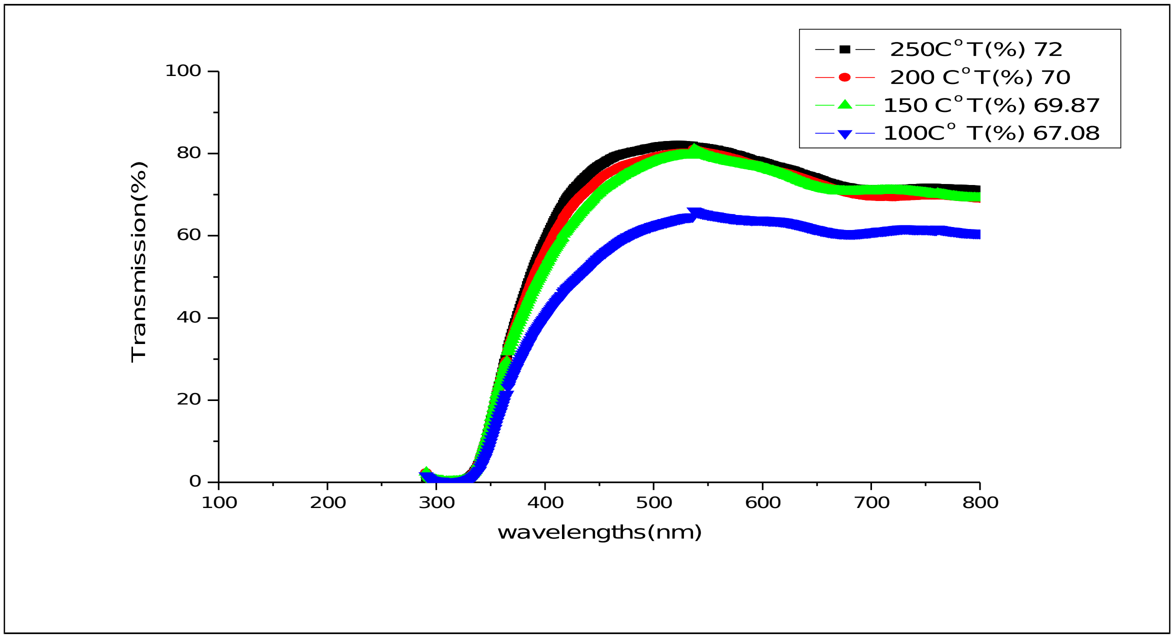

Figure 5.3 the transmission spectrum of MnS-3 versus wave lengths.

Figure 5.3 shows also that the transmission vanished for the wave lengths in the range 300 to 500 nm, thus one can use such sample as filter which suppresses these wave length only.

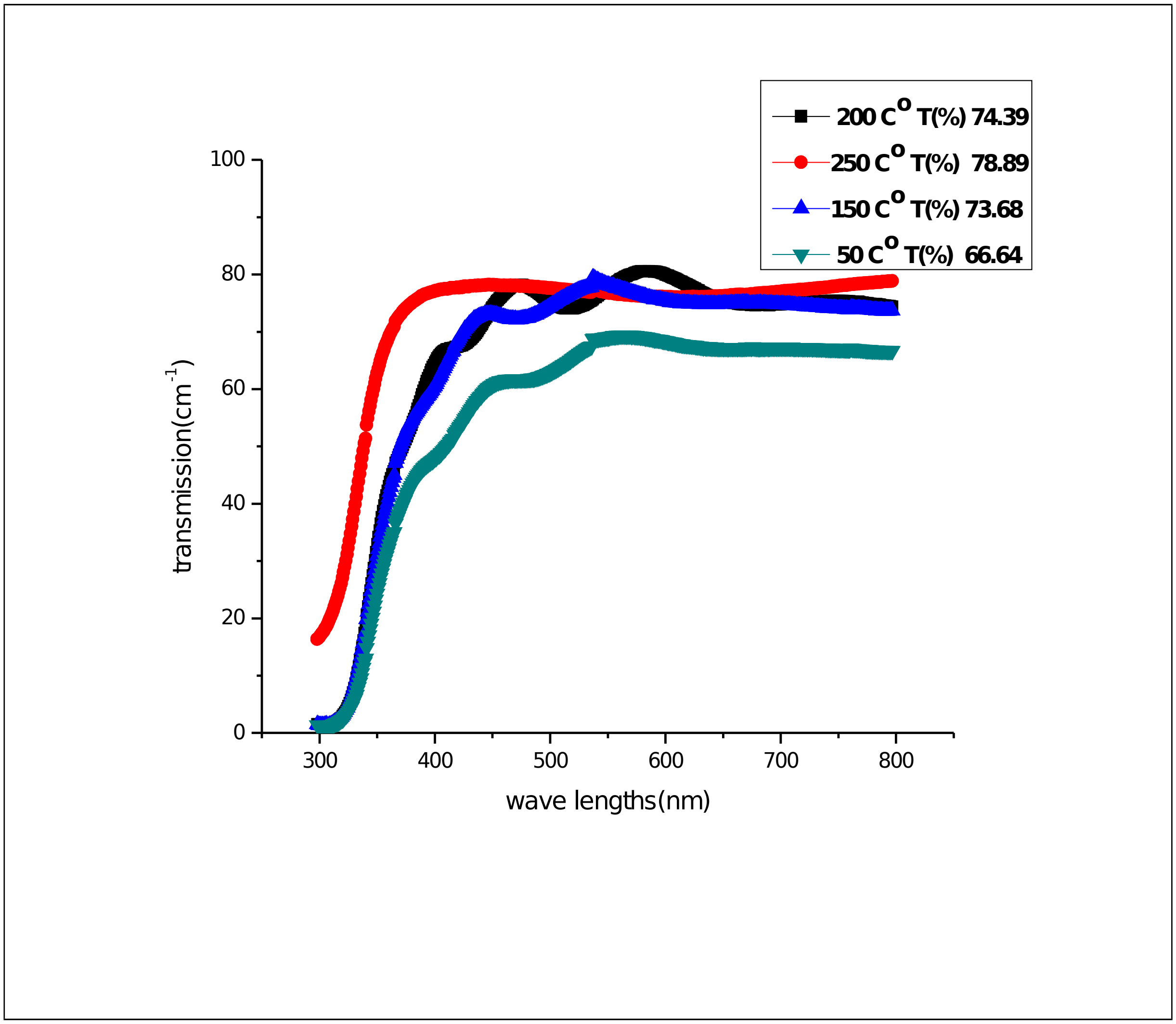

Figure 5.4 the transmission spectrum of MnS-3 versus wave lengths.

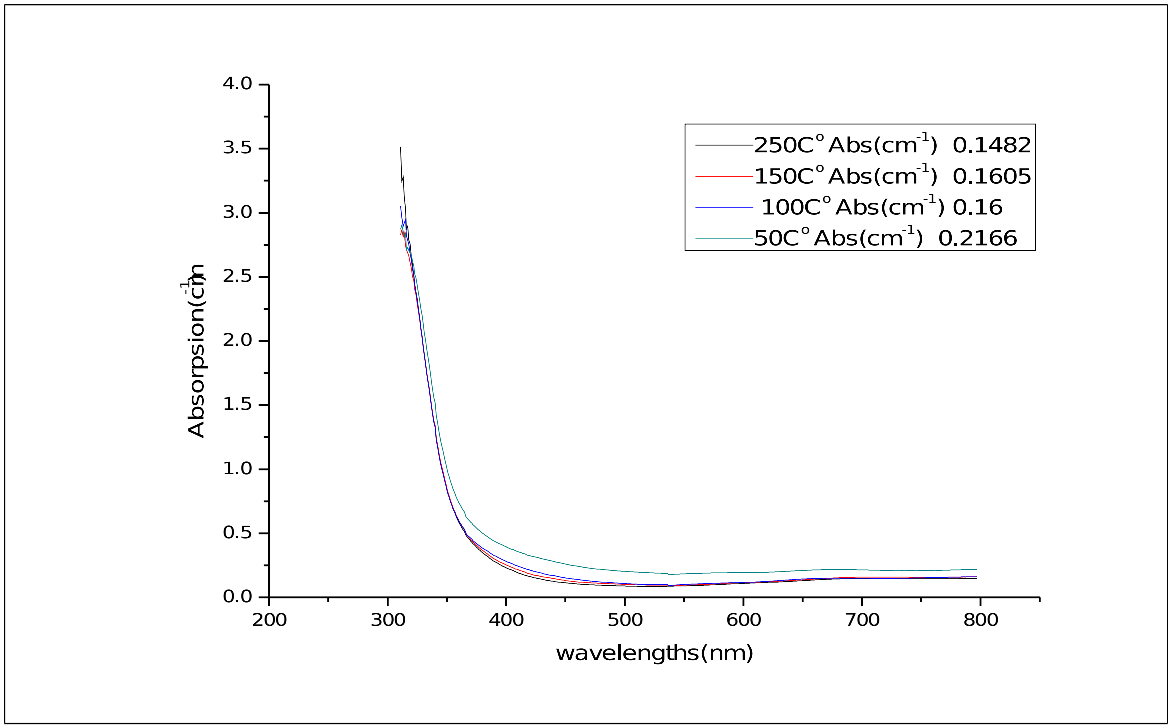

Figure 5.5 Absorption spectrum sample No.2 of MnS-2

Figure 5.4 can deduce that the absorption is maximums for the wavelengths in the wavelength 400 to 800 nm. Thus such sample can be utilized as solar heater or solar cell.

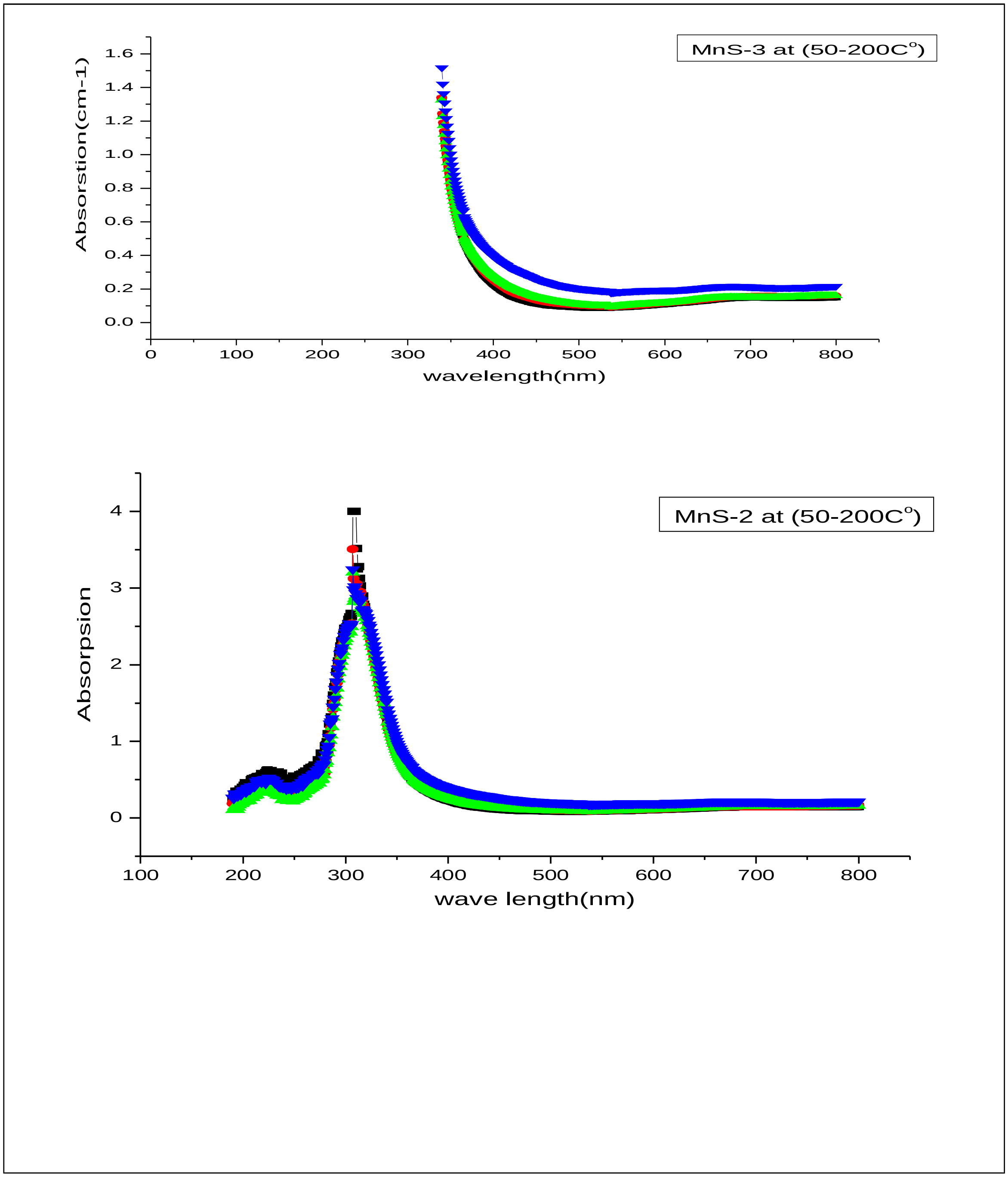

Figure 5.6 a Absorption spectrum sample No.2 of MnS-2(before treatment)

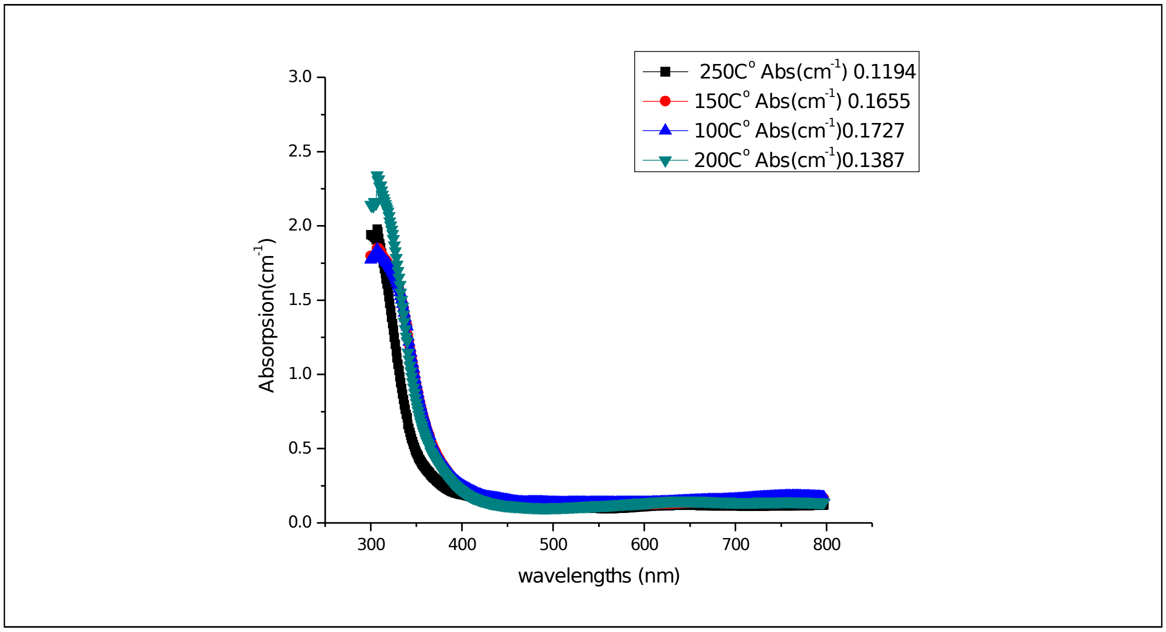

Figure 5.7 Transmission spectrum of MnS-3

Figure 5.5 shows also that the absorption vanished for the wave lengths in the range 277 to 500 nm, thus one can use such sample as filter which suppresses these wave lengths, the sample can be utilized as a monochromatic transmitter.

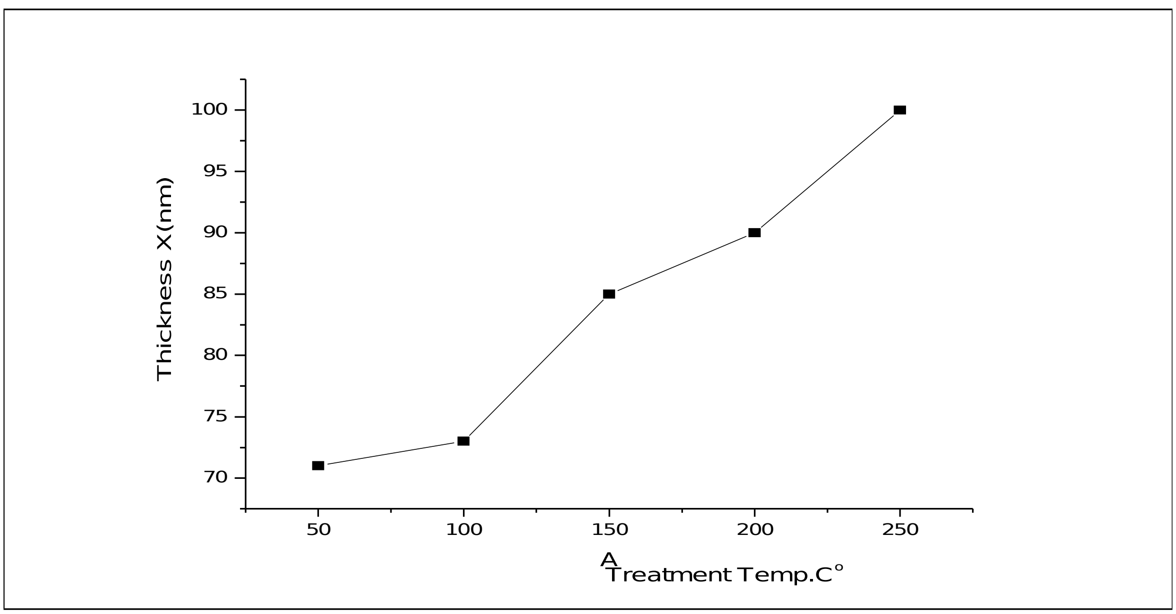

Figure 5.8 Thickness of MnS-2 versus treatment temperature.

5.5: Calculation of thickness and analysis:

From the interference fringes, D and ΔD where:

D ≡ width of fringes, ΔD ≡ the shift of fringes path.

The ratio between Δd of d called Δm

And we know that:

$$2n\Delta x = \Delta m\lambda$$

The thickness Δm ≡ Thickness of thin film

Where λ for (He-Ne) laser equal to 632 nm

And: $$\Delta m = \frac{\Delta D}{D}$$ [53]. (5.2)

Table 5.8 MnS-2 layer thickness

Sample .No	Order of (fringes(N	Width of (fringes(D	Shift of fringes path ((ΔD
MnS-1	3	0.642	0.614
MnS-2	4	0.624	0.712
MnS-3	4	0.608	0.680
MnS-4	5	0.450	0.525
MnS-5	5	0.590	0.672

The thickness of the sample were calculated from relations in equation (5.1) in section 5.3 and listed below

Table 5.9 the thickness of MnS-2.

.No	Sample	(X (μm
1.	MnS-1	0.101
2.	MnS-2	0.090
3.	MnS-3	0.088
4.	MnS-4	0.074
5.	MnS-5	0.072

Thus the average thickness of MnS is given by:

$$\bar{x} = (84.99)\ 10 \times^{-9}\ \text{m} = 0.085\mu\text{m}$$

Then the thickness of thin film (approximately) $\cong$ 0.085μm

The observation of thermal Treatment of MnS-2 layer:

Table 5.10 heat temperature and thickness.

Treatment Temperature C^{o}	Thickness X (nm)
C^{o} 50	100.74
C^{o} 100	90.14
C^{o} 150	88.36
C^{o} 200	73.73
C^{o} 250	71.98

These parameters (thickness, absorption coefficient, and refractive index) represent the optical properties of sample which are the most important parameters for any thin films.

5.5: Conclusion

From the obtained optical properties, of MnS thin films in the spectrum (190-800) nm one can conclude that:

The light transmission is temperature dependent in the visible and ultraviolet-visible region. At high temperatures the layer showed thermal instability.

The optical properties like transmission indicate that, the films can be utilized as band pass or filters, to some wave lengths.

5.6: Future work:

1. Analysis of the quality of the prepared films by using X-ray diffraction (XRD) and Scanning Electron Microscopy (SEM) and DTA techniques.
2. To grow more material doped MnS samples and try to increase the concentration in MnS.
3. To further improve the quality of the MnS thin films.

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