

Laser irradiation effect on the optical properties of $Se_{82.05}S_{5.15}Te_{12.8}$ and $Se_{87.41}S_{4.03}In_{8.56}$

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ABSTRACT

The amorphous nature of the green thin film samples $Se_{82.05}S_{5.15}Te_{12.8}$ and $Se_{87.41}S_{4.03}In_{8.56}$ was confirmed by X-ray and SEM. The glass transition range and the melting transition range were characterized by onset temperature and offset temperature for each sample. The crystallization temperature for each sample was fixed specified temperature. The two thin film samples were suffer from photo-darkening and photo-bleaching under the effect of laser beam irradiation. This may lead to some type of phase transformation under the effect of laser beam irradiation.

INTRODUCTION

The optical properties, absorbance (A), transmittance (T), reflectance (R), refractive index (n), extinction coefficient (K), and absorption coefficient (α) are an important characteristics for chalcogenide materials (1, 2, 3). The photo induced phenomena exhibited in chalcogenide can be grouped in three categories (4). The photon mode, in which the photo – electronic excitation directly induces atomic structural changes. The photo-thermal mode, in which the photo-electronic excitation induces some structural changes with aid of thermal activation, and the heat mode, in which the temperature rise induced by optical absorption. These three kinds of phenomena are likely to appear in sulfides, selenides and tellurides (4, 5, 6). The interesting properties of the chalcogenide materials are their sensitivity to the light action (6). The photo induced effects are photo-darkening, photo-bleaching, photo-induced fluidity and ductility, photo-induced expansion and compression and photo-induced phase transformation. Many types of photo sensitive processes have been detected in chalcogenide materials were accompanied by changes in their optical properties. This light induced changes in chalcogenide due to their structural flexibility and also due to their high-laying lone-pair p states in their valence bands (7, 10). The aim of this work is to study the effect of the laser beam irradiation on the optical properties of the thin film samples $Se_{82.05}S_{5.15}Te_{12.8}$ and $Se_{87.41}S_{4.03}In_{8.56}$.

MATERIALS AND METHODS

Experimental technique:-

The samples $Se_{82.05}S_{5.15}Te_{12.8}$ and $Se_{87.41}S_{4.03}In_{8.56}$ were prepared by using melt quenching technique. The proper ratio of the pure element (purity 5N) were adjusted and melted in silica tube under vacuum (10^{-4} torr). The melted samples were kept 15 hours at 700 °c to insure good melting

and best homogeneity. The melted samples were quenched in ice- water. The X-ray diffraction confirms the amorphous nature of the ingot samples. The thin films of these two samples were prepared using femto-pulsed laser deposition technique on quartz substrate. The obtained thickness were determined using ZYG-omaxim-G-p and found to be in range 55-65 μm . The optical transmittance and optical reflectance of these thin film samples were recorded in the wavelength range 200-2500 nm using JACOVS00 UV/VIS/NIR computerized spectrophotometer. The irradiation laser wavelength source was green 532nm, power 100 mw and fixed at 0.4m from the irradiated thin films.

RESULTS AND DISCUSSION

- **Structure of the green samples $\text{Se}_{82.05}\text{S}_{5.15}\text{Te}_{12.8}$ and $\text{Se}_{87.41}\text{S}_{4.03}\text{In}_{8.56}$:-**

X-Ray diffraction pattern was recorded in fig [1]. This figure confirms the amorphous nature of these two samples. The energy dispersive x-ray analysis (EDX) confirms the atomic percentage ratio of the two samples under test.

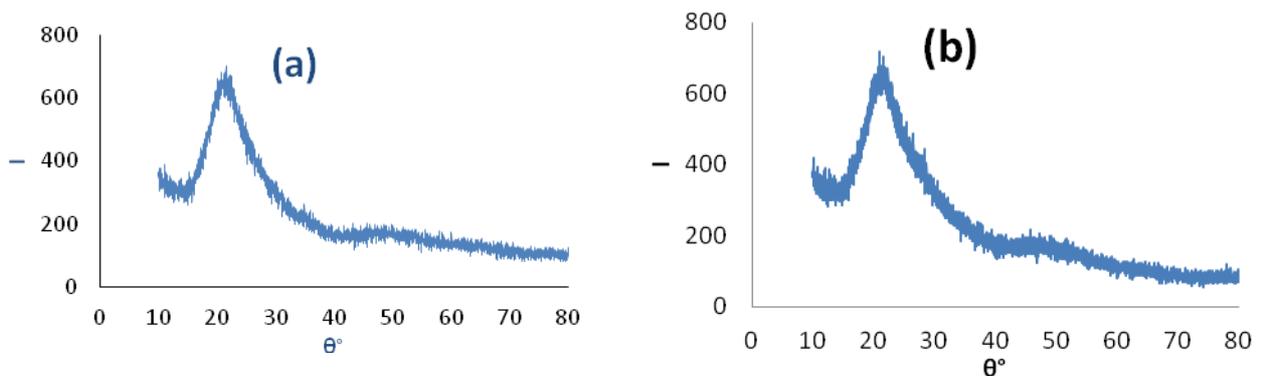


Fig [1]:- X-ray diffraction pattern of prepared thin film (a) $\text{Se}_{82.05}\text{S}_{5.15}\text{Te}_{12.8}$ & (b) $\text{Se}_{87.41}\text{S}_{4.03}\text{In}_{8.56}$

Figure [2] illustrate that the SEM micrographs of these two samples have no uniform size of particles with wide size distribution confirming the amorphous state as obtained by x-ray

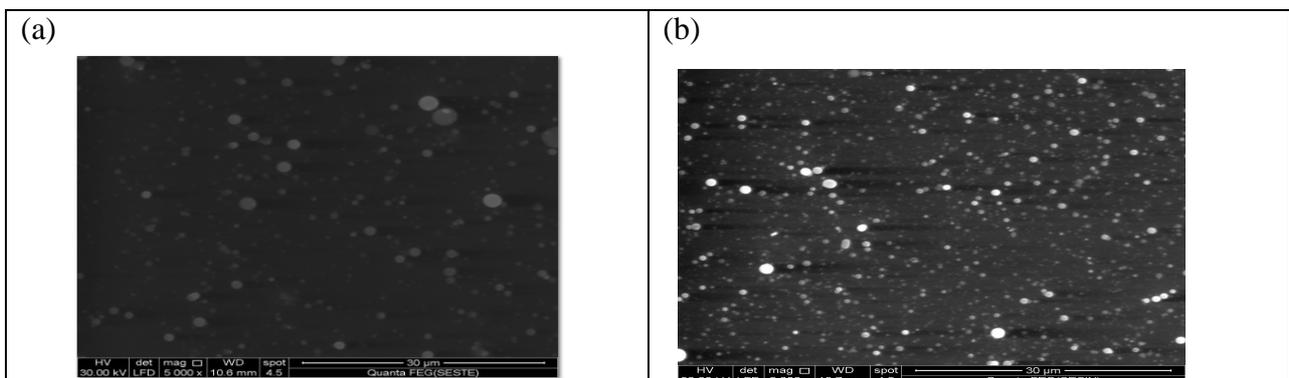


Fig [2]:- SEM of prepared thin film (a) $\text{Se}_{82.05}\text{S}_{5.15}\text{Te}_{12.8}$ & (b) $\text{Se}_{87.41}\text{S}_{4.03}\text{In}_{8.56}$

Figure [3] show the DTA thermograms recorded at heating rate 10 degree / min. the extract transition points, glass transition (T_g), the crystallization temperature (T_c) and melting temperature were recorded in table (1)

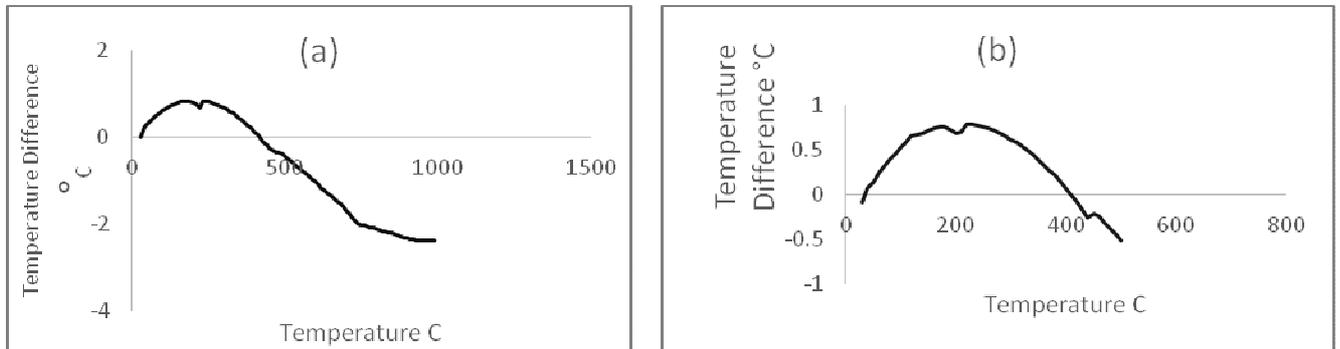


Fig [3] DTA of green samples (a) $Se_{82.05}S_{5.15}Te_{12.8}$ & (b) $Se_{87.41}S_{4.03}In_{8.56}$

Table (1)

Alloy	T_g C°		T_c C°	T_m C°	
	Onset	offset		Onset	offset
$Se_{82.05}S_{5.15}Te_{12.8}$	200	220	270	400	1000
$Se_{87.41}S_{4.03}In_{8.56}$	175	200	230	410	450

It's clear that both of the T_g and T_m were presented as endothermic peaks and each of them cover a range of temperatures characterized by onset and offset temperatures. This may be due to the difference in bonds length and bonds strength of the formed network for each sample. The exothermic peak (T_c) for each sample was specified at fixed temperature.

• **Optical properties of green samples:**

Figure [4] shows the recorded nonlinear transmittance (T) and reflectance (R) of the two amorphous samples $Se_{82.05}S_{5.15}Te_{12.8}$ and $Se_{87.41}S_{4.03}In_{8.56}$ in the spectral wavelength range 200 – 2500 nm. These results reveal that the two samples characterized by zero (T) and about 10 - 15 % (R), which mean maximum absorbance during the ultraviolet region of light spectra. During the visible and infrared region there are detect three peaks of each T and R. The values of T were in range 60 – 80 %, while the values of R were in range 20 – 30 %. This means that these two samples are a good light absorber within the UV region, and can be used as a transparent window during the visible and infrared regions.

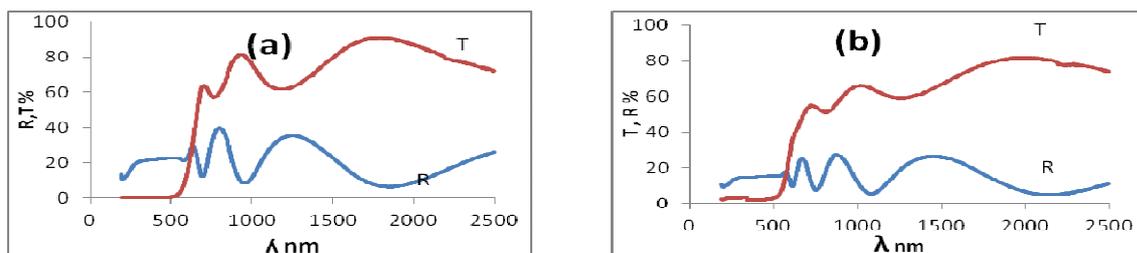


Fig [4] Transmittance (T) and reflectance (R) of thin film green samples (a) $Se_{82.05}S_{5.15}Te_{12.8}$ & (b) $Se_{87.41}S_{4.03}In_{8.56}$

Figure [4] was used to calculate the optical parameters, refractive index (n), extinction coefficient (K), absorption coefficient (α) and optical energy gap of these two samples (11 – 14). Figures [5 – 6] show the nonlinear relations of each of n, K and α as a function of wavelength in spectral wavelength range 200 -2500 nm for the two green samples under the test.

Figure [5] n – λ curves show three peaks covering the visible and near infrared region, while during the ultraviolet region the n values were independent on wavelength.

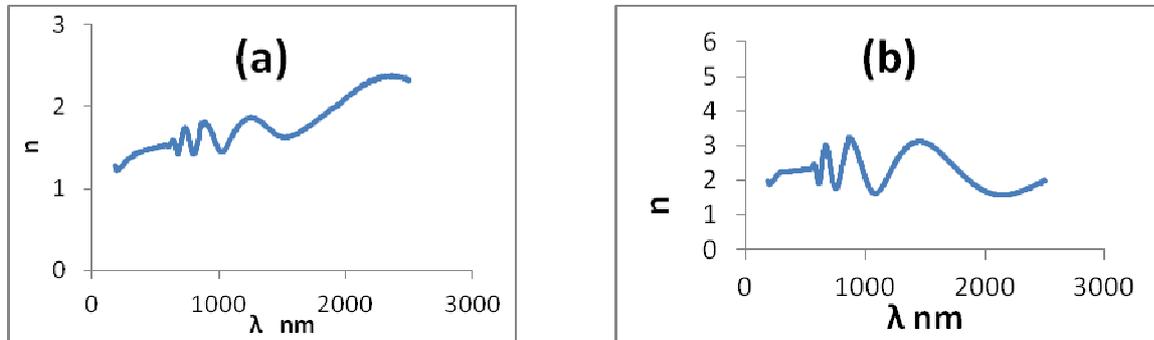


Fig [5] Refractive index of thin film green samples (a) $\text{Se}_{82.05}\text{S}_{5.15}\text{Te}_{12.8}$ & (b) $\text{Se}_{87.41}\text{S}_{4.03}\text{In}_{8.56}$

Figure [6] shows k – λ relation, which reveals that the maximum value of K has been detected during UV and visible regions. This value decrease to be minimum value during the infrared region for a both samples.

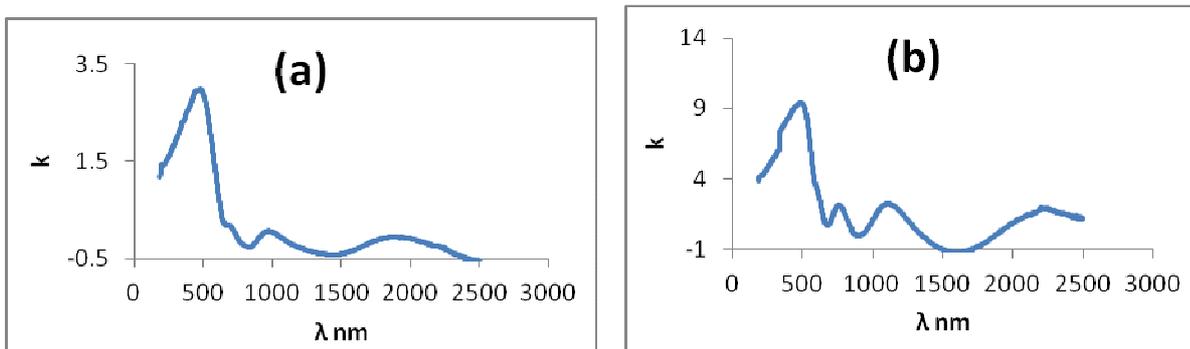
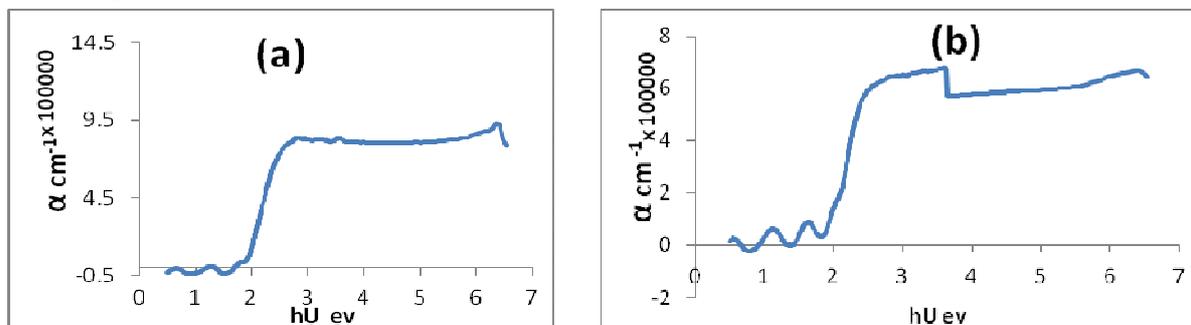


Fig [6] Extinction coefficient (k) for prepared thin film green samples (a) $\text{Se}_{82.05}\text{S}_{5.15}\text{Te}_{12.8}$ & (b) $\text{Se}_{87.41}\text{S}_{4.03}\text{In}_{8.56}$

Figure [7] shows α – λ relation, which confirm that these two samples are good absorber during the ultraviolet region.



Fig[7] Absorption coefficient for prepared thin film green samples (a) $\text{Se}_{82.05}\text{S}_{5.15}\text{Te}_{12.8}$ & (b) $\text{Se}_{87.41}\text{S}_{4.03}\text{In}_{8.56}$

The optical energy gap (E_g^0) of these two green thin films samples were calculated from the relation $(\alpha h\nu)^{1/2}$ as a function of $h\nu$ and found to be 1.7 e.V, 1.8 e.V for the samples $\text{Se}_{82.05}\text{S}_{5.15}\text{Te}_{12.8}$ and $\text{Se}_{87.41}\text{S}_{4.03}\text{In}_{8.56}$ respectively.

Laser induced processes in the alloys $\text{Se}_{82.05}\text{S}_{5.15}\text{Te}_{12.8}$ and $\text{Se}_{87.41}\text{S}_{4.03}\text{In}_{8.56}$

- **Laser induced photo – current:**

The laser induced photo-current was recorded as a function of time, figure [8], for the sample $\text{Se}_{82.05}\text{S}_{5.15}\text{Te}_{12.8}$ at 30 °c, 50 °c, 100 °c. These isotherms were selected to be below the glass transition temperature as detect from DTA thermograms to insure that the induced current is due to laser beam irradiation only.

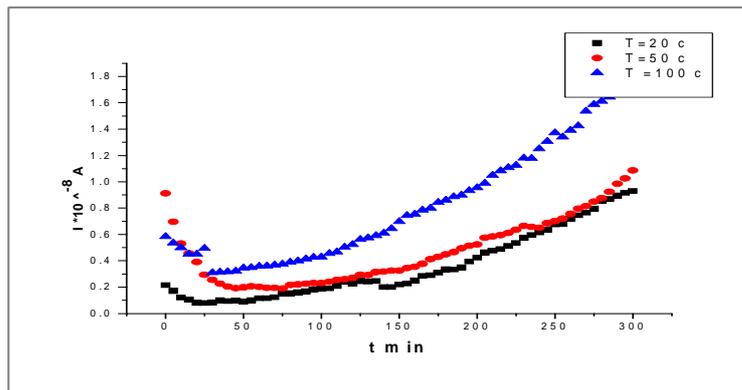


Fig [8] laser photocurrent of $\text{Se}_{82.05}\text{S}_{5.15}\text{Te}_{12.8}$ at different temperature

Figure [8] show that the photo-current increases monotonically as the laser exposure time increases. In the same time, the value of the photo-current found to be media temperature dependence. This result means that the sample under test is sensitive to a both laser radiation and the media temperature.

- **Laser induced photo-darkening:**

The green thin film samples $\text{Se}_{82.05}\text{S}_{5.15}\text{Te}_{12.8}$ and $\text{Se}_{87.41}\text{S}_{4.03}\text{In}_{8.56}$ have been exposed to laser beam 532 nm for 5 min. The values of each of T and R were recorded with wavelength in the spectral range 200 – 2500 nm. This experiment was repeated step –wisely at laser exposure time 15, 35, 70, 100, 240 and 300 min ,for $\text{Se}_{82.05}\text{S}_{5.15}\text{Te}_{12.8}$ separately. The results were illustrated on the same graph of, figure [9]. This graph shows that the three peaks of the green samples of both T and R has been shifts towards longer wavelength as the thin film samples were irradiated by the laser beam. In the same time the peaks intensities were decreased. The detected peak shift and the detected peaks intensities decreases were increases as the laser exposure time increases. These results means that the thin film samples under test suffer from photo-darkening. This detected photo-darkening increases as laser beam exposure time increases.

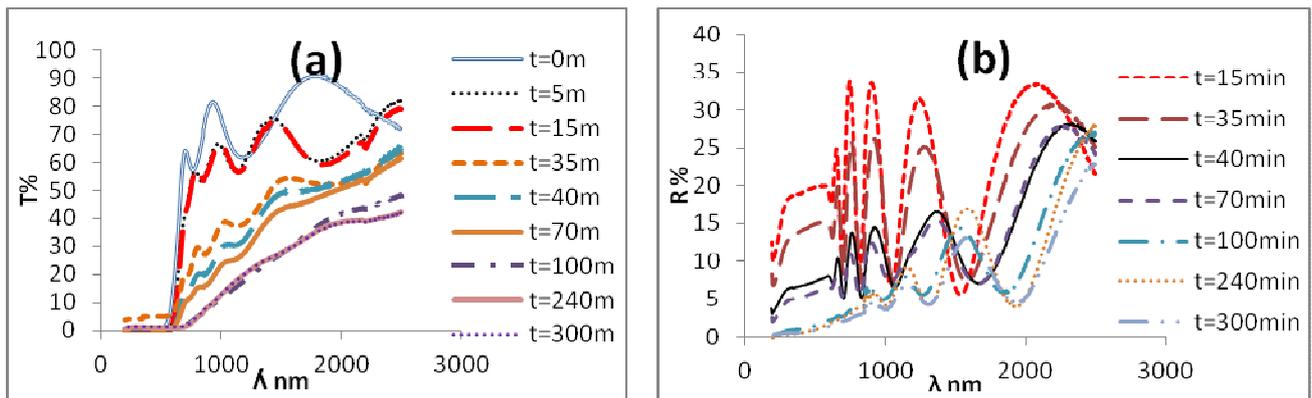


Fig [9] photo-darkening of $Se_{82.05}S_{5.15}Te_{12.8}$ thin film (a) transmittance (b) reflectance.

The same results were obtained for the sample $Se_{87.41}S_{4.03}In_{8.56}$ for both (T) and (R) and represented in figure [10].

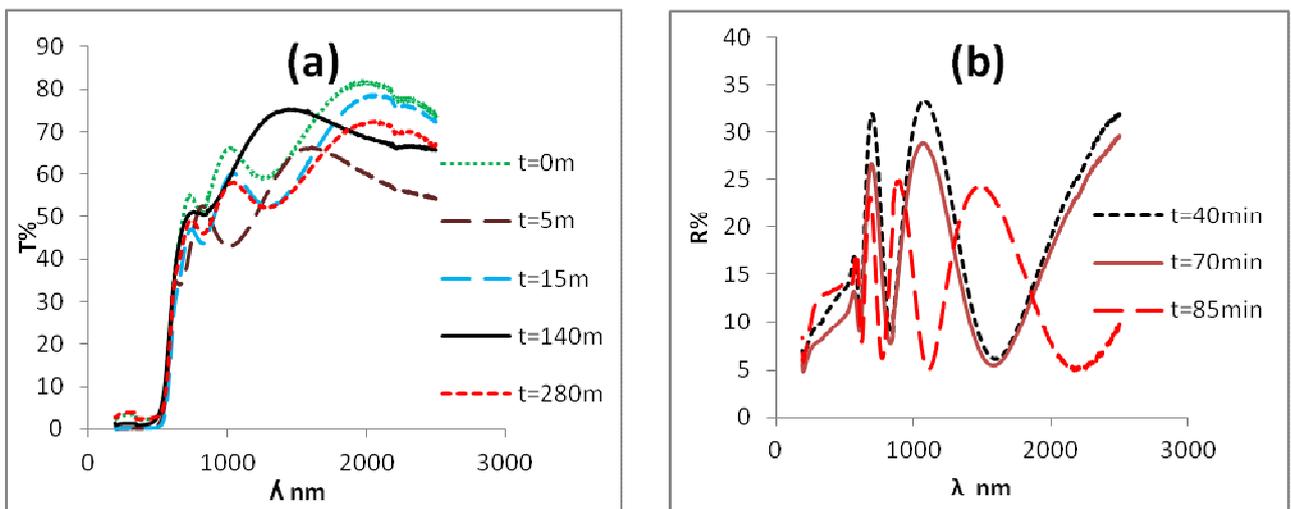


Fig [10] photo-darkening of $Se_{87.41}S_{4.03}In_{8.56}$ thin film (a) Transmittance (b) Reflectance

• **Laser induced photo-bleaching of $Se_{82.05}S_{5.15}Te_{12.8}$ and $Se_{87.41}S_{4.03}In_{8.56}$:-**

The exposure of thin film samples to laser beam irradiation induce under a certain time of exposure photo-darkening. Under another exposure time the peaks of T and R have been suffer from blue shift. This was detected for the sample $Se_{82.05}S_{5.15}Te_{12.8}$ from the T and R spectra at laser exposure time 20, 55, 120, 160 min figure [11] .

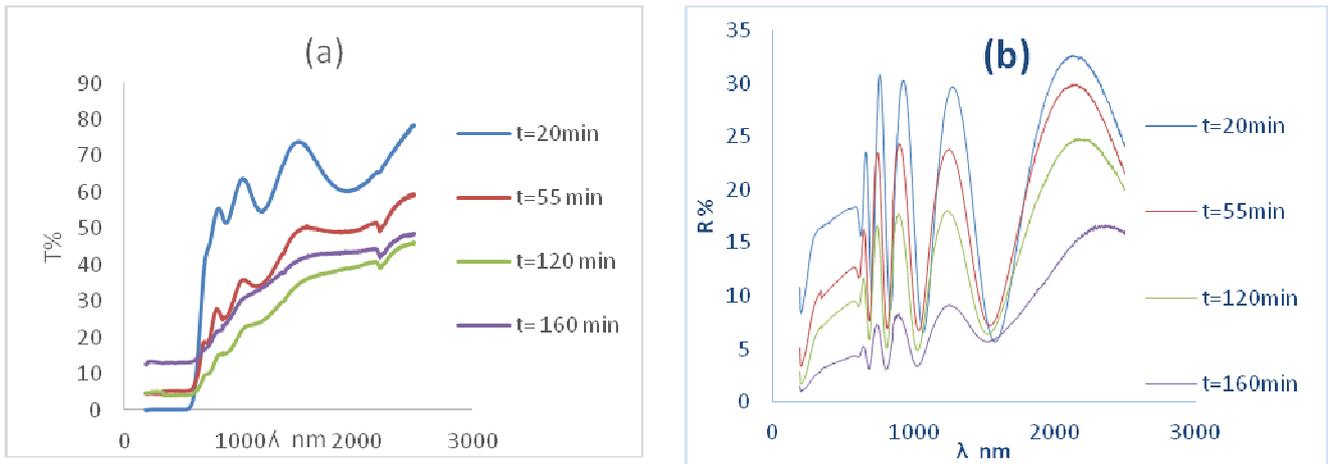


Fig [11] The photo-bleaching of $Se_{82.05}S_{5.15}Te_{12.8}$ thin film (a) transmittance (b) reflectance

This blue shift means that the thin film samples suffer from photo-bleaching. This mean that the absorption of light increases. This may confirm that these materials are good absorber in the high photo energy regions. Also, the thin film samples $Se_{87.41}S_{4.03}In_{8.56}$ shows the same phenomena as photo-bleaching as it exposed to laser irradiation at the exposure time periods 10, 20, 30, 40, 70 and 100 min. These results were illustrated in figure [12].

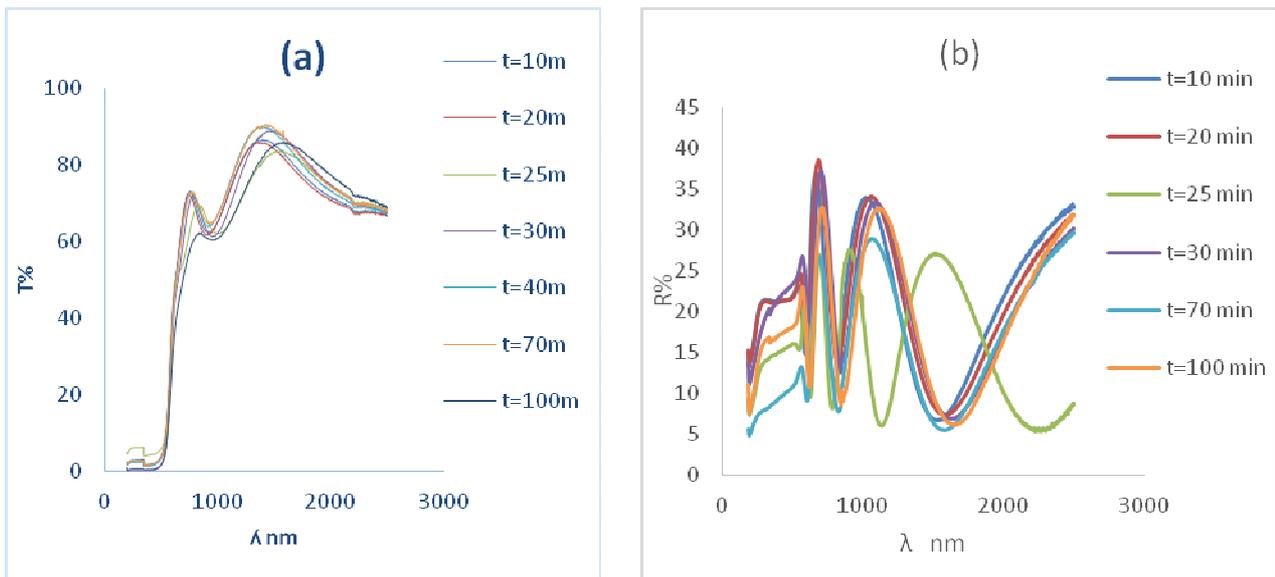


Fig [12] The photo-bleaching of $Se_{87.41}S_{4.03}In_{8.56}$ thin film (a) Transmittance (b) reflectance

- **Laser induced changes in the optical parameters of the alloys $Se_{82.05}S_{5.15}Te_{12.8}$ and $Se_{87.41}S_{4.03}In_{8.56}$**

The values of T and R for the given two thin film samples and their changes under the effect of laser beam irradiation were employed to study the changes of their optical parameters (n), K , α and E_g° at each step.

The nonlinearity of each of n , k and α as a function of wavelength in spectral range 200 – 2500 nm show a hesitation between blue and red shifts.

Also, the values of n , k and α peaks intensities have been changed, the hesitation between blue and red shift means that these two samples vibrate between photo-darkening and photo-bleaching.

Finally, the detected vibration between photo-darkening and photo-bleaching for the recorded values T, R, K, n and α may be consider as an indicator about some type of expected phase changes for the two samples under test (15).

CONCLUSION

The green thin film samples $Se_{82.05} S_{5.15} Te_{12.8}$ and $Se_{87.41} S_{4.03} In_{8.56}$ structure has been confirmed by x-ray and SEM to be amorphous in nature.

The changes of T, R, n , K, and α are non-linear behavior as a function of wavelength in the spectral range 200 – 2500 nm. These two thin film samples are good light absorber during the ultraviolet region and can be used as a transparent window during the visible and infrared region. The results of T, R, n , K and α under the effects of laser beam irradiation indicate that these two thin film samples suffer for red shift under a certain laser exposed time. In the same time it suffer from blue shift under another time of laser exposure. This vibration between photo-darkening and photo-bleaching may be an indicator about some expected type of phase transformation of these two samples.

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