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Irradiation of the thin films of MnS with fast neutrons and the possibility of using the new characteristics in optical detector

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Abstract

The optical detectors which had been used in medical applications, and especially in radioactive treatments, need to be modified studied for the effects of radiations on them. This study included preparation of the MnS thin films in a way that vacuum thermal evaporation process at room temperature 27˚C with thickness (400+-10nm) nm and a sedimentation rate of 0.39nm/sec on glass floors. The thin films prepared as a detector and had to be treated with neutron irradiation to examine the results gained from this process. The results decay X-ray (XRD) showed that all the prepared thin films have a multi-crystalline structure with the dominance of the direction (111), the two samples were irradiated with a neutron irradiation source (^{241}Am-^{9}Be) with activity (12 Ci) and flux (10^5 n/cm^2.s). It emits fast neutrons from the (α, n) the first sample was irradiated for one week and the second sample was irradiated for two weeks, the X-ray diffraction (XRD) and UV-Visible Spectroscopy were examined before and after irradiation, and its properties were changed and become possible to use in optical detectors which in turn can be used in many industrial applications especially in medicine.

Keywords: X-ray diffraction; UV-Visible Spectroscopy; Irradiation fast neutrons; thin film; optical detector.

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1. Introduction

The thin film is a layer with a high surface –to- volume ratio ranging from fractions of a nanometer monolayer to several micrometers in thickness, the materials crystalline and amorphous nature depends on their form of precipitation. [1].

The MnX (X = O, S, Se, Te) are recognized for their important electronic structure and magneto-optical characteristics. [2] The undependable oxidation state and less toxicity of these compounds make them important materials in many applications [3].

The MnS which belongs to this collection of material has important properties such as direct wide band gap [3.1eV], an exhibition of a mixture of magnetism and semiconductivity (dilute magnetic semiconductor). [4], which is frequent in nature and absence of poisoning. Manganese Sulphide is used in many applications like a solar cell, selective coatings, photoconductors, sensors and anti-reflection coatings. [5]

Up to now, MnS has been prepared by many various ways like, hydrothermal, radio-frequency sputtering, molecular beam epitaxial (MBE) and chemical bath deposition (CBD). [6]

MnS has a direct band gap, and it can be used as window material in photovoltaic solar cells. The semiconducting nature of MnS films is found to be p-type. [7]

Until now Investigation of MnS crystallites has been largely restricted because of some difficulties with its preparation. [8]

In neutron irradiation experiments, either thermal or fast neutrons play a role. The energy of fast neutrons is high to induce point glitch by direct collisions with nuclei. [9].

The aim of this study is to investigate the dynamics and mechanical properties in the different crystal structures of MnS in view of the first principles For this, we give systematic theoretical investigations about structural parameters, elastic, and dynamics properties of three phases of MnS in order to yield valuable information about the physical properties of MnS.

2. Experimental work

The MnS is prepared of compound from alloy of ratio (1:1) (MnS) (lineage key -live equivalent to an atomic ratio of each compound), then the mixture in the furnace at a temperature reaches up to (1200) and left the sampler inside the furnace until it is cool gradually and then flushed sample and extract the broken substance. Then the MnS powder has been deposited MnS from this alloy by thermal evaporation technique using a coating unit in a vacuum about (2×10^{-5}) mbar and put it in a special evaporation molybdenum boat. The rate of evaporation was (23.5nm/min) and the film thickness (400 nm) was measured by the interference method. The substrate glass was placed directly above the source at a distance about 18 cm after cleaning the glass and the thin film which deposited one study the structural, topography and optical properties of 2 films (as-prepared ,150, and 250) °C were analyzed separately by (XRD) x-ray diffract meter and transformation Fourier infrared spectroscopy and UV-Vis spectrophotometer and microscopic images. The neutrons beam irradiations of these two thin films samples, the first sample was irradiated for a week and the second sample was irradiated for two weeks, the irradiation source of neutrons is A(241Am-9Be) it has activity (12Ci) and flux (105n/cm2.s) was used. It emits fast neutrons from the (α,n) reaction according to the nuclear equation: 49Be + 24He → 612C + 01n + 5.76 MeV……..(1). [10] This source of a rod of (Am-Be) is surrounded by a paraffin wax. The paraffin wax is usually used for moderating the neutrons from fast to thermal neutrons; it is shown in Figure (1). After the irradiation processes of neutrons, some experimental studies like the (XRD) and UV-V is spectrophotometer and microscopic images of the thin films of the MnS before and after irradiation.

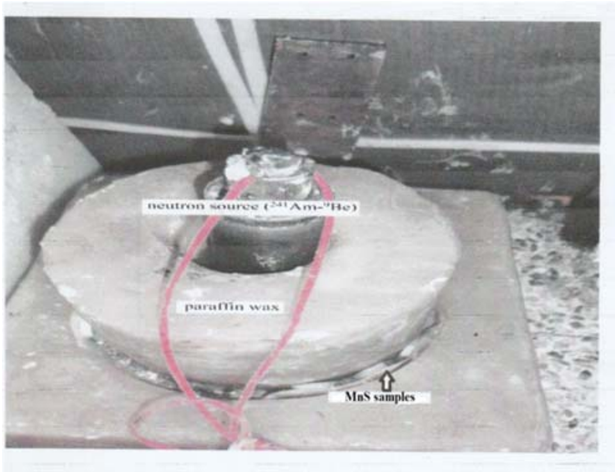

Fig. 1. Neutrons irradiation source used in the present study

3. Results and Discussion

The XRD studies are a quantitative and non-destructive technique, which is commonly used to study the crystal structure and its parameters of a compound. Figure (2) shows the XRD diffractograms of control and treated MnS samples as prepared and after the first sample irradiated for one week and also the second sample irradiated for two weeks, it appears two strongest peaks to the three samples which were [(111) and (220)].

These results are in an agreement with the standard InSb XRD [X-ray diffraction data file [00-006-0518]. It was accounted the crystallite size (D) by using the Scherer's formulation. [11],

$$D = 0.94\,\lambda / \beta\, Cos\theta \qquad (1)$$

where λ (1.54056 Å) is the X-ray wavelength, θ is the Bragg's angle and β is the full width at half maximum (FWHM) of the diffraction peak in radians. We observed zink blend structure (a=b=c) of formed InSb compound semiconductor we have calculated d-values from the equation as given by (2).

$$d = d = \sqrt[2]{h^2 + k^2 + I^2} \cdots\cdots\cdots (2)$$

Observed in the examination of the X-ray diffraction when the 2Θ was increasing the size of the crystalline size of MnS thin film oscillates but when the first began irradiation per week the crystalline size growing, and increased more in the third sample irradiated for two weeks, whenever by increasing irradiation the crystallite size increased.

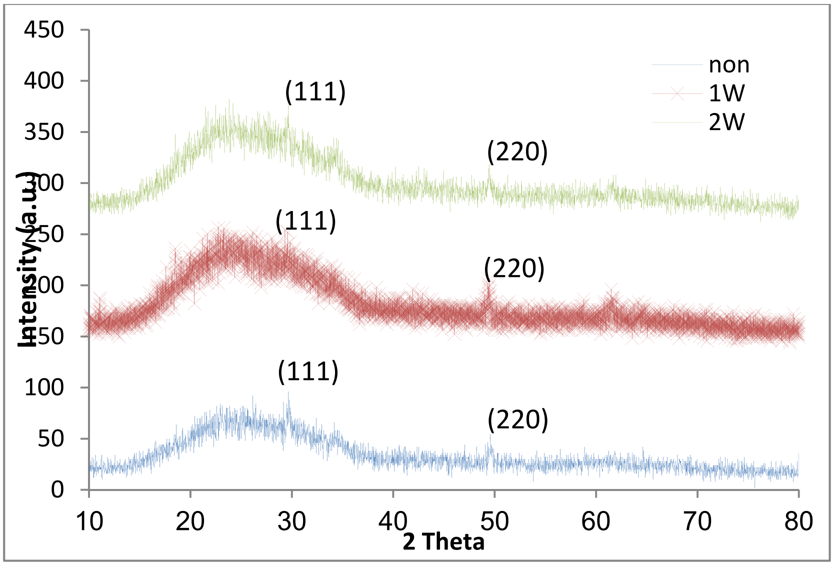

Fig. 2. XRD spectra of MnS films deposited as prepared and films irradiated for (1week) and films irradiated for (2weeks)

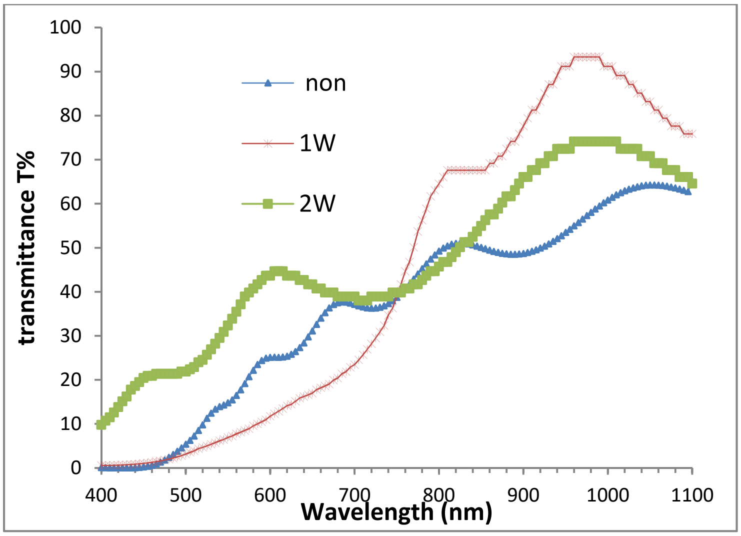

Fig.3: Optical transmittance of MnS films which as prepared and irradiation in one week and in two weeks

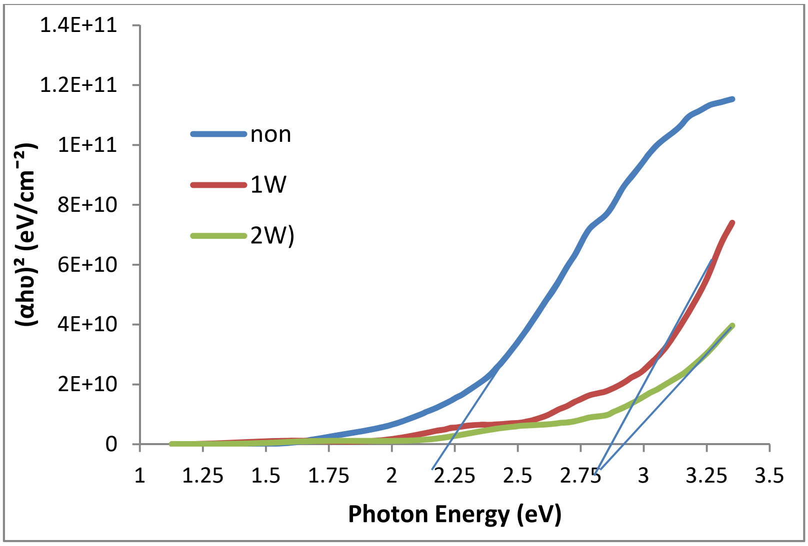

Fig.4: Plot of $(\alpha h\nu)^2$ versus hν curve of annealed and as-prepared MnS thin films And the irradiated for one week and two weeks.

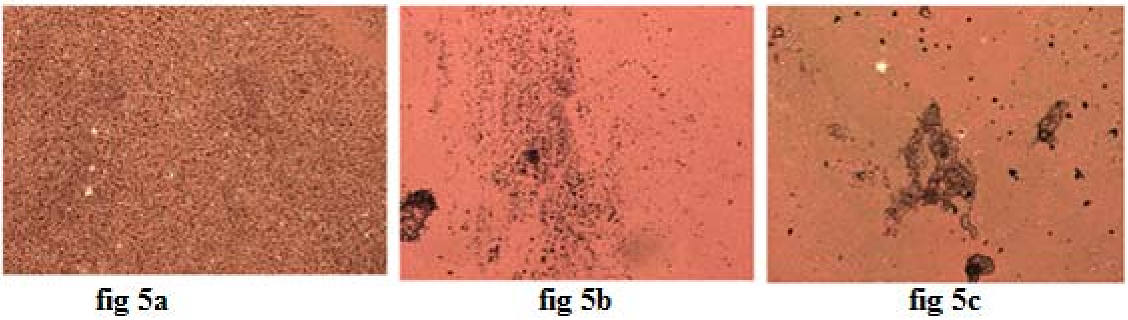

Fig. 5. a,b,c:- samples examined microscope photos

Table 1. X-ray Diffraction assignment different irradiation of neutrons of the three samples

samples	2theta (deg)	β (deg)	(hkl) planes	d-observed(Å)	d-standard(Å)	D (nm)
As prepared	29.66	0.5	(111)	3.00917	3.015000	**17.80424**
	49.33	0.8000	(220)	1.84872	1.847000	**11.84432**
Irradiation one week	29.32	0.48000	(111)	3.01513	3.015000	**18.53128**
	49.32	0.54000	(220)	1.84416	1.847000	**17.54714**
Irradiation two weeks	29.66	0.52000	(111)	3.02311	3.015000	**17.11931**
	49.4	**0.46000**	**(220)**	**1.84276**	**1.847000**	**20.6055**

The transmittance (T) characteristic can be a tool for the analysis of thin films. Figure (3) shows transmission spectra of MnS thin films which are prepared by thermal evaporation techniques and deposited on glass substrate, all the films had their highest absorption in the Uv region of the electromagnetic spectrum, in three cases when the thin film as prepared without irradiation and after the two samples irradiation, it was also noted that the drawing between the transmittance and the wavelength of the three cases were shared by one point intersection note that there is a discrepancy between the drawing for three cases, it has been observed that the permeability thin film exhibited regular behavior at a wavelength of 400 to 700 nm and in case of the first irradiated sample for one week stepped transmittance to 70 and continued decreased to 65 in the third sample that irradiated for two weeks, so that the sample was irradiated for a week to gain great energy from neutrons falling more than the second sample that irradiated for two weeks where the material began to settle down, but all cases were operating the visible light and infrared. So we observe that increasing the duration of irradiation decreases transmittance.

The optical energy gap of MnS was calculated by the relation [12].

$$\alpha h v = A(h v - E g)^{n}$$

Where A is a constant, v is the transition frequency and the exponent n characterizes the nature of band transition. (Where α is the absorption coefficient)

The curves of $(\alpha h\upsilon)^2$ versus hυ were plotted and are shown in Figure (4). The optical energy gap of the deposited MnS thin films by thermal evaporation techniques and deposited on glass substrate were found to be (2.2545,28565) eV for (as prepared) and the first sample irradiation in one week was found to be (2.8837,18990) and also the second sample of MnS irradiated in two weeks was found to be (2.9879,15341).

Through these results, it was observed that the more duration of irradiation, the higher the energy gap.

When the three samples examined microscope to examine the polarization and the microscope type is Leica DM 2500P images the thin films appeared as shown in the following formats where graphics. (5a,b, and c) where (5a) represents the thin film without irradiation and (5b) is the thin film which irradiated with neutrons for one week and (5c) is the thin film which irradiated with neutrons for two weeks.

4. Conclusion:

After this experimental, we conclude by increasing irradiation the crystallite size increased and that the sample was irradiated for a week to gain great energy from neutrons falling more than the second sample that irradiated for two weeks where the material began to settle down and also the optical energy gap of the deposited MnS thin films increase with more duration of irradiation thus, the properties of the thin films become more useful after irradiation in neutrons. In a nutshell, we have developed a simple method for the processing of MnS thin film nanomaterials. XRD and optical transmittance and energy gaps studies uncovered that the films with and without irradiation were polycrystalline in nature. There were big changes in the roofs morphology when neutrons beam irradiation. And because of the optical and morphological characteristics of the irradiated films proposed these materials, they are suitable for the optical reagents, sensors and in medicine.

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