Influence of gamma radiation on Optical properties of $(Mn_2O_3)_{1-x}(CuO)_x$ films

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Abstract

We have studied the effect of gamma irradiation by three doses (17.64, 35.28 and 52.92 Rad) on optical transmittance, reflectance, absorption coefficient, energy gap , refractive index and the extinction coefficient for $(Mn_2O_3)_{1-x}(CuO)_x$ with (x=0.5) thin films which were prepared on glass substrates by chemical pyrolysis technique. From the analysis of the absorption and transmission spectra in the wavelength range (300-900 nm) we found that the irradiation changes the optical properties under investigation in this study. The results show that the energy gap (E_g) increase with increasing of radiation dose .

Keywords : Optical properties, Gamma Radiation, Thin films

تأثير أشعة كاما على الخصائص البصرية لأغشية $(Mn_2O_3)_{1-x}(CuO)_x$

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الخلاصة

تم دراسة تأثير التشعيع بثلاث جرع (17.64 Rad) و (35.28 Rad) و (52.92 Rad) على النفاذية البصرية ,الانعكاسية, معامل الامتصاص,فجوة الطاقة, معامل الانكسار ومعامل الخمود لأغشية $(Mn_2O_3)_{1-x}(CuO)_x$ وبنسبة (X=0.5) المحضرة على قواعد زجاجية بطريقة التحلل الكيميائي الحراري. ومن تحليل طيف الامتصاصية والنفاذية في

مدى الأطوال الموجية (300 - 900 nm) وجد أن التشعيع غير الخواص البصرية قيد الدراسة. بينت النتائج أن فجوة الطاقة هي (2.19 eV) قبل التشعيع و تزداد بزيادة الجرعة الإشعاعية.

الكلمات المفتاحية : الخصائص البصرية، أشعة كاما، الأغشية الرقيقة.

Introduction

Semiconductor thin films have been produced and studied in polycrystalline form for many decades. Indeed, most new semiconducting materials have been produced in polycrystalline form before techniques developed for producing single crystals [1].

(Mn_2O_3) transparent conducting oxide is on n-type semiconductor with direct band gap around 3.2 eV that is used in Gas Sensors Devices, optical memory, and as solar energy converters [2]. Manganese Oxides have been prepared by various methods such as chemical vapor deposition [3] , sol- gel method [4] , vacuum thermal evaporation [5], and chemical spray pyrolysis [2].

Spray pyrolysis is a useful alternative to the traditional methods for obtaining manganese oxide thin films, because of its simplicity, low cost and minimal waste production, the spray pyrolysis process allows the coating of large surface and it is easy to include in an-industrial production line. This technique is also compatible with mass production systems[6]

Irradiation with X-rays, alpha, beta and gamma radiation have a significant effect on material properties and some physical properties are usually modified [7].
High energy radiations, such as γ-rays , change the physical properties of the materials and the internal structure of the absorbed substances. Studies on the changes in optical properties of thin film irradiated with ionizing radiations yield valuable information regarding the electronic processes in these materials [8].

Experimental details

Thin films of $(Mn_2O_3)_{1-x}$ $(CuO)_x$ have been prepared by chemical pyrolysis technique. The spray pyrolysis was done with a laboratory designed glass atomizer, which has an output nozzle of about 1 mm. The films were deposited on preheated glass substrates at temperature of 250°C. The chemical solution was achieved by adding 1.979 of $(MnCl_2.4H_2O)$ to 100 ml of deionized water , and adding of 1.704 of $(CuCl_2.2H_2O)$ to 100 ml of distilled water by using magnetic stirrer. The preparation achieved by taking 0.1 M of dissolve in distilled water as equations[8]:

$$M = \frac{Wt}{Mwt} \times \frac{1000}{V} \qquad \text{------ 1}$$

Where:

M : mol Concentration.

M_{wt} : Molecular weight from$(MnCl_2.4H_2O)$ and $(CuCl_2.2H_2O)$.

W_t : desired weight dissolved in distilled water.

V : Volume of distilled water.

Deposition rate (10 cm^3/min), distance between nozzle and substrate (30 $\pm$1 cm) and the carrier gas (filtered compressed air) was maintained at a pressure of 10^5 Nm^{-2} . Thicknesses of the samples were measured using the gravimetric method ,

The accuracy of thickness measurements was 200 nm, with x takes the values 0.05 .

The prepared samples were irradiated by gamma ray dose from (Cs^{137}) with activity (0.5 μ Ci), for three dose (17.64, 35.28 and 52.92 Rad).

The irradiation facility is at the Physics department, College of Science, University of Diyala . Irradiation was carried out in air and at room temperature .

Optical transmittance and absorbance were recorded in the wavelength range (300-900nm) using UV-visible spectrophotometer (Shimadzu Company Japan).

Results and discussion

Figure (1) shows the variation of Transmittance (T%) with wavelength for the samples before and after irradiation. The transmittance for unirradiated $(Mn_2O_3)_{1-x}$ $(CuO)_x$ films is lower than that for irradiated one, this might be attributed to the decrease in roughness of the irradiated thin films contributed to the drastic increased of optical transmittance [9,10].

The main radiation effect traps charges into the film which induce transmittance degradation (also called the Radiation- Induced- Attenuation (RIA))[11]. The irradiated thin film shows a softer absorption edge, possibly indicating the presence of sub-band gap levels associated with defects.

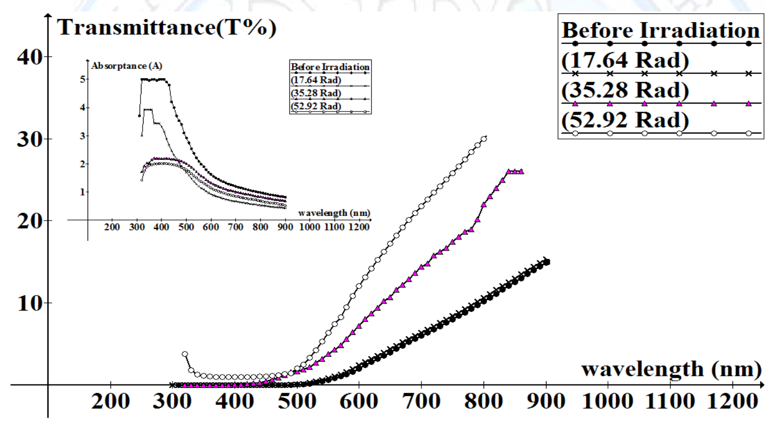

Figure (1) Optical transmittance as a function of wavelength.
The inset shows Absorbance versus Wavelength.

Figure (2) shows the reflectance of unirradiated & irradiated $(Mn_2O_3)_{1-x}$ $(CuO)_x$ films versus wavelength. From this figure the reflectance decreased with increasing radiation dose .

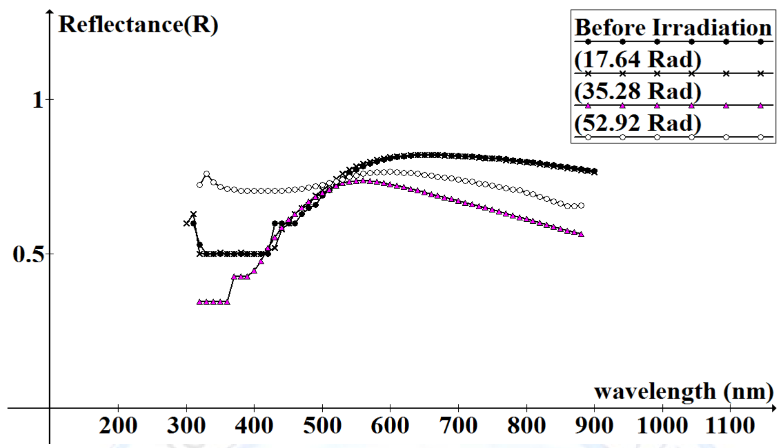

Figure (2) Reflectance as a function of wavelength.

Figure (3) shows the absorption coefficient (α) of unirradiated & irradiated $(Mn_2O_3)_{1-x}$ $(CuO)_x$ films versus photon energy.

The irradiated thin film shows a softer absorption edge, possibly indicating the presence of sub-band gap levels associated with defects. from this figure α (irradiated) < α (unirradiated). This is attributed to the decrease in the defect states which leads to the decrease in absorption coefficient.

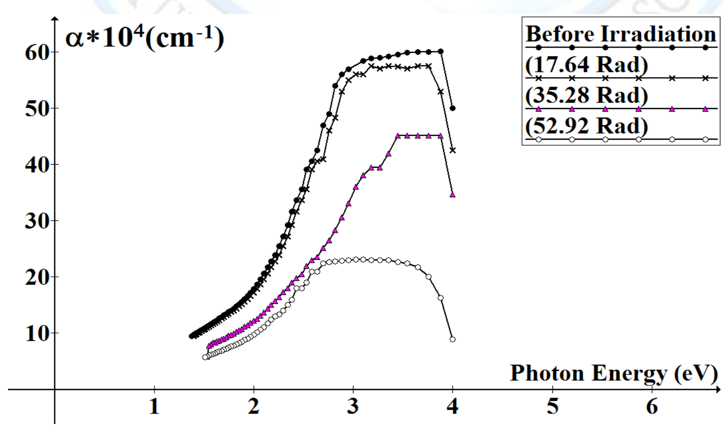

Figure (3) Absorption coefficient as a function of Photon energy.

The optical band gap of the as deposited thin films was estimated by extrapolation the linear portion of $(\alpha h\nu)^2$ versus (hν) plots using the relation [12]:

$$(\alpha h\upsilon)^2 = A(h\upsilon - E_g)^{n/2} \qquad \text{------ 2}$$

Where α represents the absorption coefficient, hυ the photon energy, A is constant and E_g is the optical band gap. For different n values, a good linearity was observed at n=1 (direct allowed transition) which was found to give the best fit for these films.

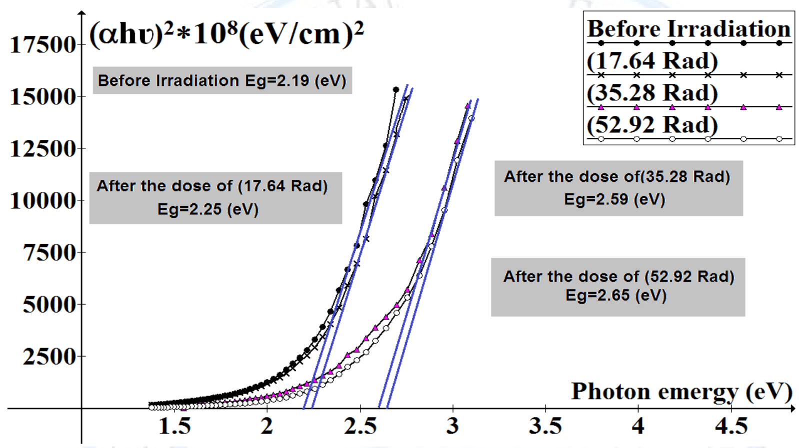

Figure. (4): Optical band gap Eg estimation for $(Mn_2O_3)_{1-x}$ $(CuO)_x$ films before and after irradiation

table(1) Show the increase in energy gap as the dose of radiation increases as in the

Table(1): The energy gap of the unirradiated and irradiated samples.

Radiation Dose (Rad)	Energy Gap (eV)
before irradiation	2.19
17.64	2.25
35.28	2.59
52.92	2.65

Refractive index is one of the fundamental properties for an optical material, because it is closely related to the electronic polarizability of ions and the local field inside materials. The refractive index ($n_\circ$) of $(Mn_2O_3)_{1-x}$ $(CuO)_x$ before and after irradiation were determined using the relation [13]:

$$n_o = [\frac{4R}{(R-1)^2} - K_\circ]^{1/2} - \frac{R+1}{R-1} \quad \text{------ 3}$$

We can observe from Figure (5) that the behavior of refractive index is nearly similar to the reflectance , the refractive index increases with increase in radiation dose .

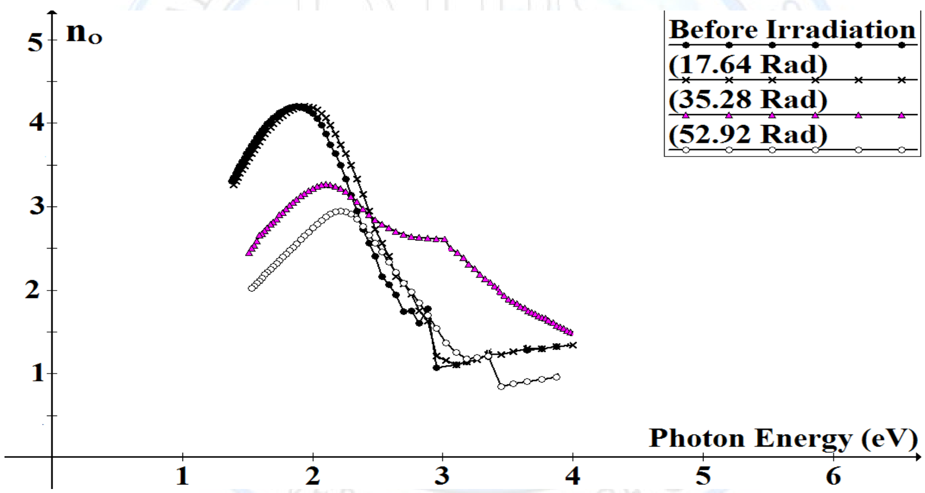

Figure (5) Refractive index as a function of Photon energy.

The extinction coefficient ($k_\circ$) is directly proportional to the absorption coefficient (α) according to the relation [14]:

$$k_\circ = \frac{\alpha \ \lambda}{4 \ \pi} \quad \text{------ 4}$$

Where (λ) is the wavelength of the incident photon.

Figure (6) shows the variation in extinction coefficient ($k_◦$) as a function of the photon energy. It can be noticed that the extinction coefficient increases with the increase in the dose of radiation.

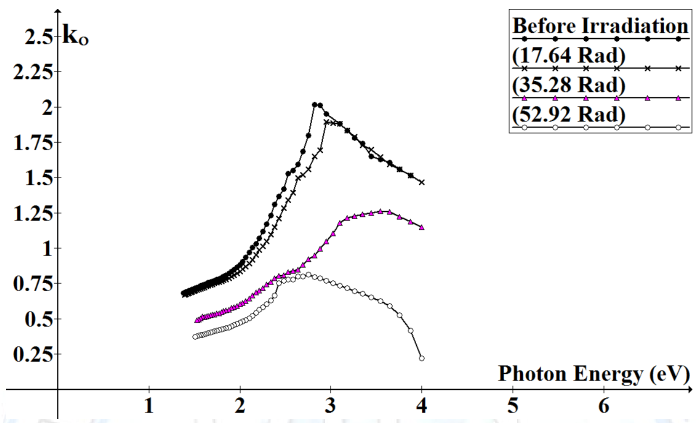

Figure (6) Extinction coefficient as a function of photon energy.

Conclusions

$(Mn_2O_3)_{1-x}$ $(CuO)_x$ thin films have been prepared successfully by chemical pyrolysis technique. It was found that the radiation dose is an important role in the evolution of $(Mn_2O_3)_{1-x}$ $(CuO)_x$ properties.

The irradiation changes the optical properties under investigation in this study. The results show that the (E_g) is (2.19 eV) before irradiation and (2.25 eV) after radiation dose (17.64 Rad) , (2.59 eV) after radiation dose (35.28 Rad) and (2.65) after radiation dose (52.92 Rad) .

References

1. L.L Kazmerski , "Polycrystalline and Amorphous Thin Films and Devices" , Academic Press,(1980).
2. K .Rajendrana "Influence of (Mn) doping on the microstructure and optical property of (ZnO)" Department of Electronics, Science College, Coimbatore, India a PhD thesis ,(2007).

3. Vijay Kumar Sharma, Venkata Srinu Bhadram, and Ghanshyam Das Varma_Japanese "Structural and Magnetic Studies of NanocrystallineMn doping ZnO Samples Synthesized by Chemical Vapor Deposition" Journal of Applied Physics,47, (2008) , 7831.
4. Yuhua Xiao, "Structure, optical, and magnetic properties of rutile $Sn_{1-x}Mn_xO_2$ thin films" Applied Surface Science, 255 (2009) 7981–7984.
5. Volodymyr Khranovskyy "Effect of oxygen exposure on the electrical conductivity and gas sensitivity of nanostructured ZnO films" Thin Solid Films, 517 (2009) ,2073.
6. Rodrigo Martins "Properties presented by ZnO thin films deposited by magnetron sputtering and spray pyrolysis", University of Lisbon, (2000).
7. M.A. Khaled, F. Sharaf, M.S. Risk and M.M. El-Ocker, Polymer Degradation and stability, (1993),40, 385
8. R.Y. Zhu "Radiation damage in scintillating crystals . Nuclear Instruments and Methods in Physics Research Section A: accelerators, Spectrometers , Ditectors and Associated Equipment" (1998),413,297-311.
9. N. Tigau, V. Ciupina, G. Prodan, G. I. Rusu, C. Gheorghies, E. Vasile, J. Optoelectron. Adv. Mater., 5, (2003),907.
10. Ali Jasim AL-Jabiry , PhD thesis , University of Technology,Baghdad,2007.
11. R.Chen et al, Solution of a kinetic equations governing trap filling. Consequences concerning dose dependence and dose-rate effects, Physical review B, (1981),Vol : 24, No. 9, November.
12. A. Y. Oral, Z. B. Bahsi and M. H. Aslant, Applied Surface Science, Vol. 253, pp. 4593, (2007).
13. Ezekoye, B. A. ; Okkek ,C. E., ,The Pacific Journal of Science and Technology, 7, (2006) , 108.
14. Pal U. , Gonzalez R. S. , Montes G. M. , Jimenez M. G. , Vidal M. A. and Torres S. "Optical Characterization of Vacuum Evaporated Cadmium Sulfide Films" , Thin Solid Films , (1997) ,305 , (1-2) , 345-350