Some Optical Properties of the Sputtered SnO_2 Thin Film Affected by Gamma Radiation

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الخلاصة

في هذا البحث تم دراسة بعض الخصائص البصرية كالنفاذية ، معامل الامتصاص ، معامل الخمود ، فجوة الطاقة والعمق السطحي لغشاء اوكسيد القصدير المحضر بطريقة الترذيذ قبل وبعد التشعيع ناشعاع كاما المنبعث من مصدر السيزيوم (Cs^{137}) ولمدة خمسون يوما .

النتائج بينت بان تاثير التشعيع هو زيادة في النفاذية والعمق السطحي وكذلك نقصان في معامل الامتصاص ومعامل الخمود خصوصا في المنطقة المرئية وايضا نقصان في فجوة الطاقة البصرية .

ABSTRACT

In the present work , some of optical properties of the sputtered SnO_2 thin film before and after irradiated by γ-radiation like transmission , absorption coefficient , extinction coefficient , energy gap and skin depth were studied . The results indicated that the influence of the γ-radiation from Cs^{137} gamma ray source exposed the sample film for (50 days) caused to increase the transmission and the skin depth , while decreased the absorption coefficient , extinction coefficient especially in the visible region and lowering the optical energy gap

Keywords: SnO2 films , Sputtered Thin Films , TCO film , Matter-Radiation Interaction

INTRODUCTION

Last ten years the energy-dispersive spectroscopy of high-energy radiation such as X-rays, γ-rays, and other uncharged and charged particles has improved dramatically (1). This is of great importance in a wide range of applications including medical imaging, industrial process monitoring, national security and treaty verification, environmental safety and remediation, and basic science. The influence of γ-radiation onto different types of thin films has been discussed (2,3).

Crystal structure and optical properties of metal oxide thin films were the subjects of numerous theoretical and experimental studies (4, 5).

High-energy radiations, such as γ-rays, change the physical properties of the materials they penetrate. The changes are strongly dependent on the internal structure of the absorbed substances. It is believed that ionising radiation causes structural defects (called color centers or oxygen vacancies in oxides) leading to their density change on the exposure to γ-rays (6). The influence of radiation depends on both the dose and the parameters of the films including their thickness: the degradation is more severe for the higher dose and the thinner films (7)

The absorption of γ-radiation in the thin films depends strongly upon their electronic structure which in turn changes by the interaction with photons. Ion-irradiation induced defect states near the Fermi level play a dominant role in the

variable range hopping conduction (8). Bipolar on hopping conduction appears to be affected less by ion-irradiation and is quite effective to modify the electrical transport behavior of the glass (9). The work on amorphous selenium (a-Se) showed that the disorder in the material increases upon light irradiation(10).

MATERIALS AND METHODS

SnO_2 films were prepared by dc magnetron sputtering . Argon gas 99.9998 % is used as sputter gas in pressure 6 x 10^{-2} Torr. Substrate temperature equals to 200^{o}C, and deposition time 30 minute . Target-anode distance (30 mm) .The film was deposited on (glass) with thickness (~1μm). The data of the experiment and the specifications for X-ray test were as follows: Tube anode: Cu, Wavelength [Å]: 1.54060, Divergence slit : 1^{o}. The optical constants were determined from transmittance (T), which were carried out at normal incidence using a double beam Spectrophotometer (Shimadzu UV 210A) operating in the UV/VIS over the wavelength range 350 nm - 900nm .

Irradiation for thin film sample with dose (3.7MBq) was performed using a Cs ^{137} gamma ray source exposed the sample film for (50 days) .

The transmission , absorption coefficient , extinction coefficient , energy gap and skin depth for unirradiated and irradiated sample were carried out .

RESULTS AND DISCUSSION

Transmittance is explained in figure (1) as a function of the incident wavelength for radiated and unradiated SnO_2 thin film sample. The optical properties of the sputtered SnO_2 film similar to those produced by using other methods. It is clear that there are two effects caused by irradiation , the first is the blue shift , the other is the increasing in the transmittance up to 800 nm and then decreased in the NIR region .

Consequently, the absorption coefficient (α) is determined by the following relation(11) :

α□□□-(LnT) / t …… (1)

where t is the film thickness , figure (2) shows the calculated absorption coefficient rapidly decreasing with the increasing incident wavelength (λ) and the sample has close value for α at NIR wavelengths.

It is worth to mention that the absorption coefficient is necessarily determined by overall preparation conditions . The extinction coefficient (kex) is determined by the following relation (11):

$$k_{ex} = \frac{\alpha\lambda}{4\pi} \qquad \text{……..(2)}$$

So, its behavior with wavelength shown in figure (3) is the same as for the absorption coefficient (α). The effect of the extinction coefficient on the

refractive index, and hence reflectance, is relatively higher than that of the real refractive index.

In order to determine the type of energy gap in the prepared SnO_2 sample, $(\alpha h\nu)^n$ was plotted versus the incident photon energy, and the linear behavior was obtained from the relation between $(\alpha h\nu)^2$ and (hν) as shown in Fig. (4). It is explained that the prepared SnO_2 sample has a direct bandgap and the allowed absorption processes are the dominant . Extrapolation of the linear portion of the plot to the energy axis yielded the bandgap value of about (3.3)eV, the radiation caused to lowering the energy gap to (3.25 eV) . In the photonic processes, light incident on a sample is absorbed in a length characterized by the optical skin depth (ξ), which is given by:

$$\zeta = \frac{\lambda}{2\pi k_{ex}} \quad \text{……………………………………………………………(3)}$$

In this optical skin depth, electrons can be excited to ionization states and are eventually emitted. The behavior of the skin depth with the incident wavelength is just a reciprocal to that of the absorption coefficient multiplied by 2. Fig. (5) shows the variation of skin depth (ξ) with the incident wavelength , it was increased in the visible region up to maximum value around 700nm then decreased in the IR region

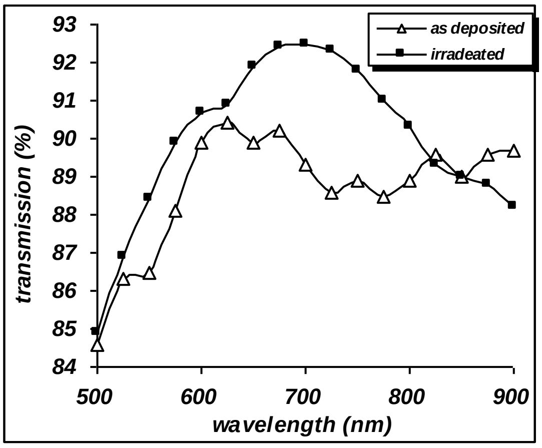

Fig.-1:The transmission of the sample

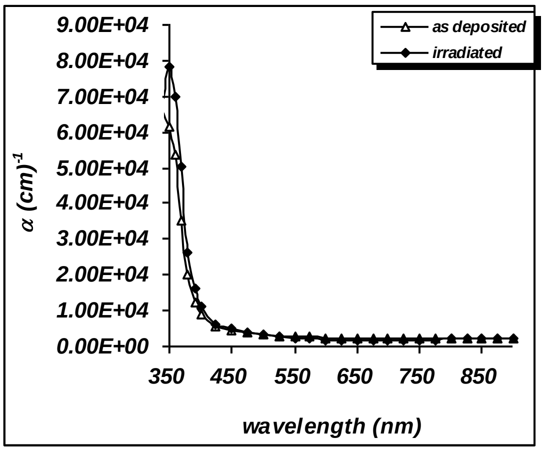

Fig.-2: The absorption coefficient

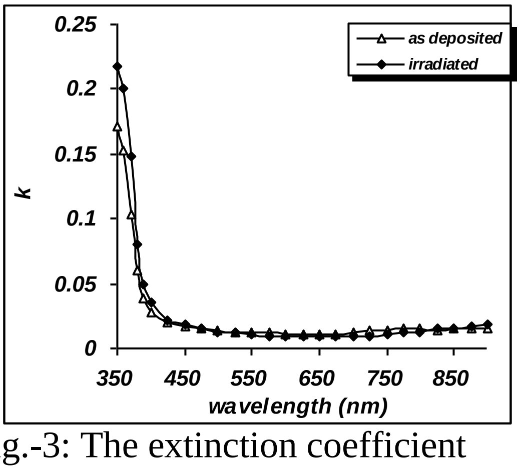

Fig.-3: The extinction coefficient

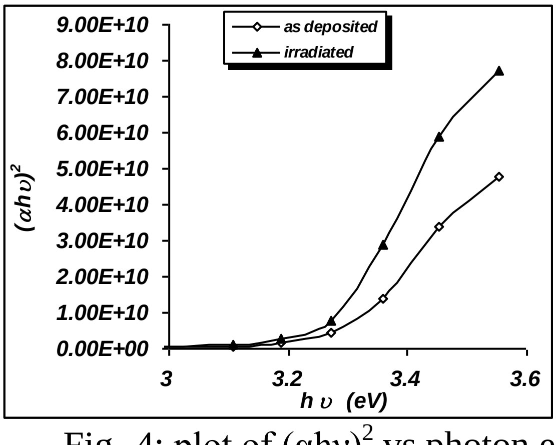

Fig.-4: plot of $(\alpha h\nu)^2$ vs photon energy .

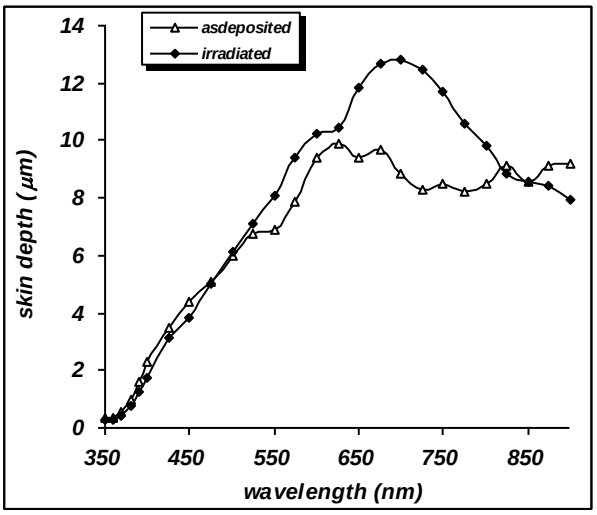

Fig.-5: The skin depth before and after irradiation .

We can conclude:

The small sensitivity in the optical properties of material to radiation or fluence in the saturation region has been attributed to the generation of high structural disorder , this damage may create a large enough concentration of localized levels , which reduces the sensitivity of parameters to further irradiation . High concentration of dangling bonds makes disordered semiconductors insensitive to doping or irradiation (11, 12).

The effects on the optical properties may be due to the increase of the disorder of the samples by irradiation . The disordered energy decreases at about 3 MBq dose and increases as the radiation doses increase for all compositions showing the increase of disorder and compaction.

The optical properties are influenced by irradiation . The blue shift and transmittance increased with the wavelength increasing , the absorption coefficient decreases, the same behavior for the optical energy gap Eopt shifted to lower energy . Also the skin depth increased with the increasing wavelength due to the absorption decreasing . So we can conclude that - doses cause the breaking of bonds leading to the increase of dangling bonds and of defects, as well as the trapping of the generated carriers "

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