Influence of growth time on crystalline structure, morphologic and optical properties of In2O3 thin films

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Citation: AIP Conference Proceedings **1653**, 020016 (2015); doi: 10.1063/1.4914207
View online: http://dx.doi.org/10.1063/1.4914207
View Table of Contents: http://scitation.aip.org/content/aip/proceeding/aipcp/1653?ver=pdfcov
Published by the AIP Publishing

Influence of Growth Time on Crystalline Structure, Morphologic and Optical Properties of In_2O_3 Thin Films

A. Attaf [a)], A. Bouhdjar, H. Saidi, Y. Benkhetta, H. Bendjedidi, M. Nouadji and N. Lehraki

Physics of thin films and applications laboratory, University of biskra, BP 145 RP, 07000 Biskra, Algeria

[a)] ab_attaf@yahoo.fr

Abstract. Indium oxide (In_2O_3) thin films are successfully deposited on glass substrate at different deposition timings by ultrasonic spray technique using Indium chloride ($InCl_3$) material source witch is prepared with dissolvent Ethanol (C_2H_5-OH), the physical properties of these films are characterized by XRD, MEB,UV-visible. XRD analysis revealed that the films are polycrystalline in nature having centered cubic crystal structure and symmetry space group $I2_13$ with a preferred grain orientation along to (222) plane when the deposition time changes from 4 to 10 min but after t = 10 min, especially when t = 13 min we found that the majority of grains preferred the plane (400). The maximum value of grain size D = 61,51 nm is attained for In_2O_3 films grown at t =10 min. the average transmittance is about 72%, The optical gap energy is found to decrease from 3.8 to 3.66 eV with growth time Increased from 4 to 10 min but after t = 10 min the value of E_g will increase to 3.72 eV. A systematic study on the influence of growth time on the properties of In_2O_3 thin films deposited by ultrasonic spray at 400 ^oC has been reported.

Keywords: Indium oxide, Ultrasonic Spray, optical and structural properties.
PACS: 68.35.-p

INTRODUCTION

Indium oxide (In_2O_3) is an important and a well-known transparent conducting oxide of n-type semiconductor exhibiting a wide band gap, chemical stability, high electrical conductivity and transparency to visible light. It is frequently used for photovoltaic devices, transparent windows; liquid crystal displays (LCD), light emitting diode (LED), solar cell, gas sensors and anti- reflecting coatings [1]. In_2O_3 thin films were prepared by variety of physical and chemical methods such as spray pyrolysis [2], vacuum evaporation [3], magnetron sputtering [4], dc- sputtering [5], sol gel [6], electron beam evaporation [7], reactive thermal evaporation [8] and pulsed laser deposition [9]. Among these deposition methods, spray pyrolysis is a versatile, most inexpensive, reproducible, commercially viable, simple to manipulate and applicable to large scale area. So far, in many researches works [10].

In the present work, In_2O_3 thin films were prepared at different substrate temperatures using indium chloride as precursor by spray pyrolysis method. The

4th International Congress in Advances in Applied Physics and Materials Science (APMAS 2014)
AIP Conf. Proc. 1653, 020016-1–020016-6; doi: 10.1063/1.4914207

structural and optical properties of the prepared thin films were characterized by XRD, UV-VISIBLE and SEM.

EXPERIMENTAL PROCEDURE

Indium oxide was deposited by spraying an alcoholic solution containing a 0.1 M of indium chloride $InCl_3$ (Merk, 99.9), on glass substrates heated at 400 ^{0}C. The films washed with distilled water. They were also kept in a detergent solution and cleaned with distilled water. Afterwards, the glass plates were kept in a solution of methanol and cleaned for approximately 15 min. Finally, the glass plates were taken out from the ultrasonic bath and once again cleaned with distilled water. In all deposition the distance spray nozzle – substrate equals 4.5 cm. All the parameters were kept constant and only the film thickness was changed through the change of deposition time.

The structure and morphology of the films were analyzed by X-ray spectroscopy on a D8 ADVANCE Diffractometer using a Cu Kα radiation (λ=1.5405 A), JOEL model JSM6301F a scanning electron microscopy, respectively, the optical transmittance spectra were obtained using UV– VIS-Nir spectrophotometer, these measurements were performed using glass as reference in a wavelength range of 200 – 800 nm.

RESULTS and DISCUSSION

Structural Properties

The X-ray diffraction tracing of the thin films at four deposition time 4 min, 7 min, 10 min and 13 min are presented in Fig.1.

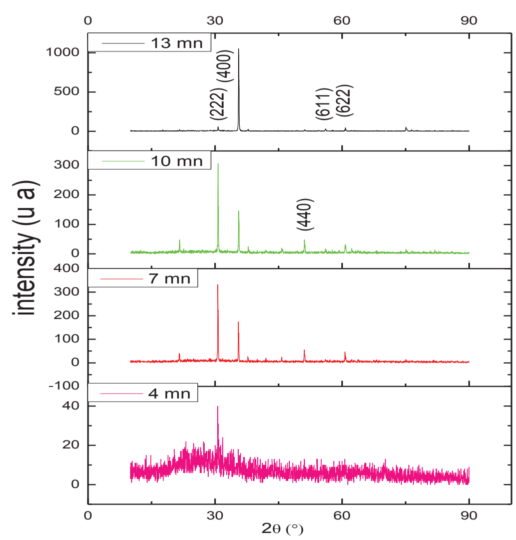

FIGURE 1. Evolution of the spectra of X-rays diffraction of In_2O_3 thin films for all deposition time.

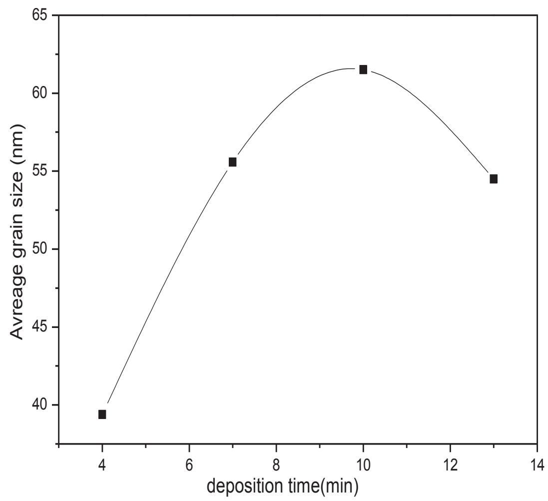

FIGURE 2. Deposition time effect on the grains size.

The deposited films are identified as polycrystalline indium oxide with a centered cubic structure, for the film witch deposited in 4 min we notice a single peak (222), but with the increase of deposition time an others peak emergent such as (400), (622), and (411), besides when the deposition time equals 13 the plan (400) has intensive important peak in this film. Figure. 2 shows that the mean crystallite size D increases with increasing deposition time, whereas the value of D for the films deposited at 13 min was 54.49 nm, which mean that the crystallite size changes with the change of peak.

Surface Morphology

Figure 3 shows the SEM surface images of the In_2O_3 thin films deposited at different times, we notice a rough surface formed with linked crystallites. The thicknesses of the films are found to be 360 and 740 nm at deposition time of 4 min and 13 min, respectively, as shown in Figure 2.(a and d).

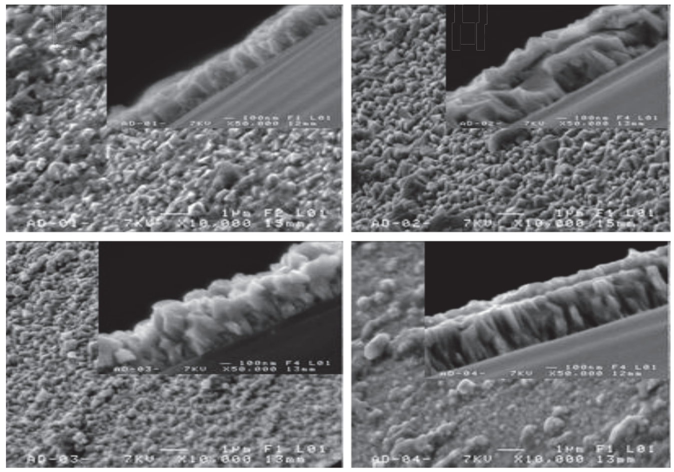

FIGURE 3. SEM surface images of the In_2O_3 thin films deposited at various deposition time of: (a) 4 min, (b) 7 min, (c) 10 min and (d) 13min.

Optical Properties

Figure. 4 shows the optical transmittance curves as a function of the wavelength for the In_2O_3 films deposited at deferent deposition times. The films deposited by 4 min exhibit a high optical transmittance (greater than 72%) in the visible region. Whereas the film witch deposited for 13 min exhibit a smallest optical transmittance equals 52 %, also we can be seen in the Figure. 4 region of 380–400 nm is the region of the absorption edge in the layers due to the transition between the valence band and the conduction band. From Fig.5 we have found that the optical band gap (E_g) decreased from 3.8 to 3.62 ev with growth time Increased from 4 to 10 min but after t =10 min the value of E_g will increase to 3.84 eV. We find also that E_U decreases with the increment of deposition time from 4 to 10 min and its values between 0.4 and 0.28 eV, but when deposition time equals 13 min The values increase to 0.38 eV as shown in Fig. 6.

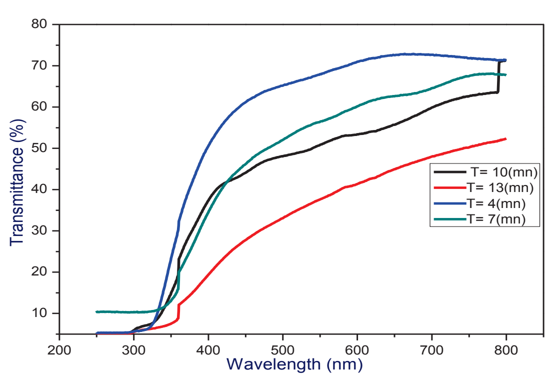

FIGURE 4. Deposition time effect in the transmittance of In_2O_3 thin films.

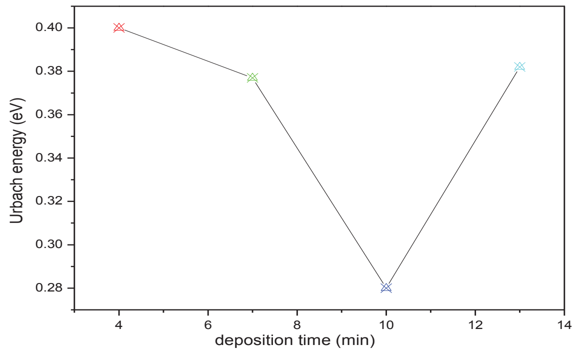

FIGURE 5. Deposition time effect on E_g values.

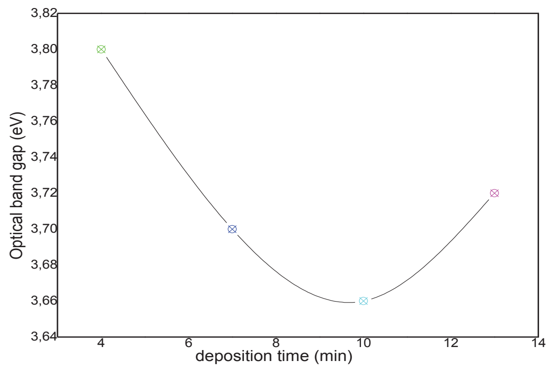

FIGURE 6. Deposition time effect on E_U values.

CONCLUSION

The effect of the deposition time on the crystalline state, surface morphology, and optical properties of In_2O_3 films was investigated. SEM images show that the films are rough with different grains sizes. X-ray diffraction reveals a polycrystalline nature for all the films and symmetry space group $I2_13$.

The optical characterization showed that our films are transparent with a value about 52 % to72%. We have found also that the optical gap is varied between 3.66 eV and 3.80 eV, and the values found of disorder are between 0.28 eV and 0.40 eV. Finally, we conclude that the deposition time is the interesting factor for control the quality of the thin films deposited by ultrasonic spray.

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