Influence of Laser Pulse Energies on the Structure and Optical Properties of SnO$_2$ Films Prepared by Laser Induce Plasma

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Review Article

INTRODUCTION

Tin oxide films (SnO$_2$) have been studied with a focus on application to sensors, transparent electrodes in displays, heat mirrors and transparent conducting oxide (TCO) coatings for solar cells [1-5]. SnO$_2$ films have been prepared by several deposition techniques, such as pulse laser deposition (PLD), photo-MOCVD, reactive evaporation, spray paralysis, sol-gel process, and dc/rf sputtering [6-8]. PLD is the plasma produced by the interaction of high-energy laser pulses with matter in any state of aggregation [9,10]. Laser induced plasmas of metals and alloys are of great interest since they have different attractive and important applications, e.g. material processing, thin film deposition, the synthesis of nanoparticles, the elemental analysis of multi component materials, precision machining, and laser induced breakdown spectroscopy (LIBS), surgery, and laser micro-probe mass spectroscopy [11-13].

Typical Experimental Set-Ups

PLD experiment was carried out under vacuum pressure (6 x 10$^{-2}$ mbar by using Varian DS219 Rotary pump). The beam of Nd:YAG laser with second harmonic frequency (λ=532 nm, 10 ns, 6 Hz) was focused onto target. The target of the deposition was SnO$_2$ bulk with purity 99.999%, shaped liked disc with a diameter of 1 cm. the target was kept onto rotating holder (speed 4 rev/min) to prevent fast drilling. The substrate distance from the target was fixed to 2 cm,

The PLD experiment was performed at room temperature and the as-grown samples were not annealed after deposition. PLD setup scheme has been shown in Figure 1. The crystalline structure was examined using X-ray diffraction (XRD). Optical properties (UV/VIS absorption spectrum) of the SnO$_2$ films were performed using, (UV-Visible spectrometer). The laser pulse energy was varied from (400-800) mJ with increment.
RESULTS AND DISCUSSIONS

X-Ray Diffraction Spectra

The XRD patterns of the SnO$_2$ thin film is given in Figure 1. Figures 2a-2c shows the X-ray diffraction patterns for undoped SnO$_2$ films grown on glass substrates. We can be seen that the degree of crystalline and grain size variation with laser energy this can be interoperate in term the improvement the crystal stricture of these films with increasing the laser energy, it seems that all the films are polycrystalline [11]. The grain size (D) of the material; which plays an important role in the material properties, can be estimated easily from the X-ray spectrum by means of full width at half maximum (FWHM) method that is often calculated by Scherrer’s relation [9],

$$D = \frac{k\lambda}{\beta \cos \theta}$$

Where $\lambda$ is the wavelength of X-ray used (1.54 Å), $\beta$ is the full width half maximum (FWHM) of the peak and $\theta$ is the glancing angle. The calculated crystalline size (D) of Tin oxide is tabulated in Table 1. The FWHM and the grain size of the samples are shown in Table 1.

![Figure 1: Pulsed laser deposition (PLD) system.](image)

![Figure 2a: XRD of SnO$_2$ thin film with Number of shoot=400 and different energies.](image)

![Figure 2b: XRD of SnO$_2$ thin film with Number of shoot=600 and different energies.](image)
Figure 2c: XRD of SnO$_2$ thin film with Number of shoot=800 and different energies.

Table 1: Thin film and different energies.

<table>
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<th>Energies</th>
<th>2θ (Deg.)</th>
<th>FWHM (Deg.)</th>
<th>d$_{hk1}$ Exp. (Å)</th>
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**UV-Visible Spectroscopy**

The optical properties of SnO$_2$ have been determined by using spectrophotometer in the wavelength range (200-1100) nm. SnO$_2$ thin films were successfully deposited onto glass substrate and the films were very transparent. Transmittance spectra recorded for SnO$_2$ films as a function of wavelength range (200-1100 nm) at different energies 400, 600, and 800 mJ shown in **Figure 3**.

This **Figure 4** show that the transmittance decreases with increasing of energies due to increasing of thicknesses.

Figure 3: Shows the Transition of SnO$_2$ thin films as a function of wavelength.
The absorption coefficient ($\alpha$) is calculated using the equation, \[ \alpha = \frac{\ln (1/T)}{d} \] (1)

Where $T$ is transmittance and $d$ is film thickness (Figure 5). The absorption coefficient ($\alpha$) and the incident photon energy ($h\nu$) are related by the following equation \[ (\alpha h\nu)^2 = A (h\nu-E_g) \] (2)

The typical plots of $(\alpha h\nu)^2$ versus $h\nu$ for SnO$_2$ thin films with (400, 600, and 800) mJ energies deposited on glass substrate is shown in Figure 6. It is observed that increase in energies of laser lead to increase in optical band gap from 2.756 eV to 2.9 eV. This may be associated with variation the crystal structure with laser energies.

**CONCLUSIONS**

In this work we have reported the influence of energies of laser in the structural and optical characteristics of SnO$_2$ thin films.

We describe bellow summarization of our work:

1. The deposition films are having the polycrystalline structure of Tin oxide with cubic structure.
2. The intensity of x-ray diffraction was proportional with laser energies
3. The optical properties was proportional with laser energies.
4. The band gap increase with increasing of laser energies.

**REFERENCES**