Synthesis and Characterization of Thermally Annealed Sno2 Thin Film Using Thermal Evaporation Technique

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Abstract- Tin oxide (SnO2) shows high infrared reflectance in addition to high visible light transmittance because of the wide band gap. This material has been widely studied for its applications as heat mirrors, transparent electrodes for solar collectors, optoelectronic devices, gas sensors, catalyst supports, and solar cells. In the present work, SnO2 thin films were deposited on the glass substrate using thermal evaporation method. This novel process is fast and can be completed at lower temperature. We have carried out the thermal evaporation of SnO2 powder in a pellet form. The deposited thin films of SnO2 were annealed at 400 0C temperature and the change in structural properties and optical properties was studied as a function of annealing temperature using XRD and UV spectrophotometer.

**Keywords: Thin Films, Annealing, Thermal evaporation, Tin oxide**

# **I. Introduction**

Thin film of SnO2 have wide band gap, transparency to visible light and *n*-type conduction behavior which gives many potential applications in gas sensors, smart window, phototransistor, flat panel display, solar cells, light emitting diodes, transparent electromagnetic shielding materials and infrared heat mirror. SnO2 films can be prepared by different methods such as sol-gel method [1-2], chemical vapor deposition [3], chemical spray pyrolysis [4] sputtering [5], pulsed laser deposition [6].

The structure, appearance and performance of different preparation techniques of thin films, such as the film thickness uniformity, and the glass substrate binding firmness, surface topography, has a evaporation method as reported by Jahnavi et al [7]. They observe that band gap energy increases with an increasing annealing temperature for SnO2 films. Thermally evaporated SnO2 films of thickness in the range 100-600 nm were successfully deposited onto glass substrate at ambient temperatures by Shadia [8].

In this work the properties of amorphous SnO2 thin films are investigated by studying their structure, morphology, composition and transmittance at room temperature and after annealing at 400 0C temperature. The films were characterized by X-ray diffraction (XRD), scanning electron microscope observations, energy dispersive analysis by X-ray (EDAX), and transmittance measurements. The indirect band gap of the films were estimated and discussed [9]

# **II. Materials and Methods**

In the present work, transparent conducting thin film of tin oxide was deposited by thermal vacuum evaporation method [thermal evaporation unit model 12A4D] at ambient temperature on glass substrates of dimensions (6×2.6×0.1cm3) with a high vacuum (~10-5 mbar).[10]The substrates are cleaned in methanol, followed by distilled water. The films showed light brown colour that becomes darker with film thickness. The deposited substrate was annealed in air at a temperature of 400 0C for three hours to improve the crystalline size, optical transparency and electrical conductivity [11].

Optical characterization was studied from absorption % Vs. wavelength curve which was plotted from the data obtained from absorption spectrum analysis of the film by using a double beam Shimadzu UV 1601 (PC) spectrophotometer with respect to a piece of glass similar to the substrates in the wavelength range 300-1100 nm.

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# **Screenshot_2017-03-15-22-31-10_com.miui.gallery_1489597283505.jpg**

Fig.1 (b): Deposited SnO2 films

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Fig.1 (a): Hind High Vacuum coating unit model 12A4D

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# **III. EXPERIMENTAL RESULT**

1. **Structural properties:**

The X- ray diffraction (XRD) pattern of SnO2 thin films are shown in below fig.2. (a) & (b). The peaks at 2Ө values of 29.2 ˚, 31.24 ˚, and 34.6 ˚ can be associated with (111), (020), and (002) respectively. The SnO2 product shows orthorhombic structure which is in good agreement with JCPDS 00-029-1484 .Data average particle size (D) was determined using the Scherer’s equation



(1)

Where D is the Crystallite size, 0.9 is the shape factor, λ is the X-ray wavelength, β is the full width at half maximum of the diffraction peak, and Ө is the Bragg diffraction angle in degree. The average particle size was found to be in the range of 82 nm.



Figure 2(b): XRD Pattern of SnO2 (WA)

Figure 2(a): XRD Pattern of SnO2 (Annealing)

b) **Optical Properties:**

Fig.3 shows the optical absorption spectra in the visible light region (300 nm- 800nm) for sample annealed at 400 0 C. It shows the film annealed at 400 0 C exhibits lowest absorption (i.e. highest transmittance) in the range of 500 nm – 700 nm with maximum transmittance is 80%.



Figure 3: Optical absorption spectra of SnO2

It has been observed that the band gap for SnO2 was 3.09 eV at 400˚C temperatures and 3.4 eV at ambient temperature (fig.3.). This less band gap of thin films deposited by thermal evaporation technique may be due to improvement of the degree of crystallization and growth of grain



Figure 4(a) Energy band gap for SnO2 (annealed)

Figure 4(a) Energy band gap for SnO2 (without annealed)

**IV. CONCLUSION**

In a present work, we have carried out tin oxide thin film deposition using thermal evaporation method. The structural and optical properties of a SnO2 sample were investigated. The XRD pattern of the prepared sample is indexed to the orthorhombic structure of SnO2. The average particle size is 82 nm of the SnO2 Nanoparticles. The optical band gap of the SnO2 was found to be 3.09 eV at 400˚C temperature and 3.4 eV at ambient temperature. The band gap decreases due to increase in grain size and improvement of the degree of crystallization. The deposited SnO2 films can be used for gas sensing [12]

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