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THE STRUCTURAL, MORPHOLOGICAL AND OPTICAL PROPERTIES OF TIN OXIDE THIN FILMS PREPARED BY SPIN COATING METHOD

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Abstract

Structural, Morphological and Optical properties of tin oxide thin films were deposited by spin coating technique on glass substrates. Three different types of solvents are used in this spin technique ethanol, isopropanol and n-propanol. The variation in the Structural, Morphological and Optical properties of tin oxide thin films deposited using different solvents were characterized by X-ray diffraction, Scanning electron microscope, Fourier transform infrared spectroscopy and UV-vis spectroscopy. The result indicates that the material could be used for optoelectronic devices and laser application.

Keyword: Spin Coating, Sol-gel, Structural and Optical Properties

Introduction

Thin films play an important role on microelectronics, optical coating, integrated optics & super conductor etc. Transparent conducting oxide (TCO) thin films such as zinc oxide, tin oxide & cadmium oxide have been studied and used in a semiconductor & optoelectronic devices (1). Tin (II) oxide has attracted significant attention due to its native P-type conductivity & stability in maintaining both structure and electronic properties for recent years (2). Commonly tin oxides is available in two oxidation states divalent (tin (II) oxide SnO) is P-type semiconductor & tetravalent (tin (IV) oxide- SnO_2) is N- type semiconductor respectively (3). Tin oxide thin films can be prepared by variety of technique such as pulsed laser deposition, ultrasound assisted and microwave assisted methods, thermal evaporation, sputtering, vapour-liquid-solid synthesis, hydrothermal deposition, spray pyrolysis sol-gel dip

coating and spin coating. Sol gel techniques have many advantages such as low reaction temperature easy process and low cost method for preparation of thin films with a high sensing characteristic.

SnO_2 is a special oxide material because it has a low electrical resistance with high optical transparency in the visible range. Due to these properties, apart from gas sensors, SnO_2 is being used in many other applications, such as electrode materials in solar cells, light-emitting diodes, flat-panel displays, and other optoelectronic devices where an electric contact needs to be made without obstructing photons from either entering or escaping the optical active area and in transparent electronics, such as transparent field effect transistors [4,5].

Experimental details

Sol-gel Spin coating method:

Sol-gel spin coating has been used decades long to decades long to deposit thin films. A spin process involves depositing a small material put on the centre of a substrate and then to be spin the substrate. Centripetal acceleration causes the material to spread onto the surface of substrate. The Properties regarding material (Viscosity drying rate, percent solids, surface tension etc) and spin parameters (spin speed, acceleration and time etc). Impact film properties, Spin parameters vary and substrates. So there is no fixed rule. Spin coating system is a cheap and easy method. But specific problems can sometimes be formed such as too thin or too thick formation s air bubbles on water surfaces, comets and centre circle like chuck etc (6).

Deposition of SnO_2 thin films:

Spin coating technique was adopted for the preparation of tin oxide (SnO_2) thin films. The material used in this investigation was $SnCl_2.2H_2O$ (Purified from Merck), n-Propanol (99.5 % Nice chemicals, India) and Isopropanol (Merck). The tin oxide films were prepared using $SnCl_2.2H_2O$ and alcohol as the Sn & O precursors, respectively. Initially sol, was prepared by dissolving 0.5 mole of $SnCl_2.2H_2O$ in one of the three solvents ethanol, Isopropanol and n-propanol. The prepared solution was magnetically stirred for five hours in a closed container and aged for 30 hours at a room temperature to increase the viscosity. Before spin coating the glass substrate were pre cleaned with acetone, Isopropanol and distilled water. The as prepared sol was spin coated on a glass substrate maintained 1500 rpm for 40 sec. After spin coating, glass substrates were annealing with 423 K for 15 min to

remove the residual organic solvents. The films were deposited with ethanol, isopropanol and n-propanol solvents.

RESULT AND DISCUSSION

CRYSTAL STRUCTURAL AND SURFACE MORPHOLOGY

X-Ray powder diffraction **(**XRD) spectrum is used to identify the crystalline phase resent in materials and to measure the structural properties of these phases. The structural characterization of spin coated tin oxide thin film was carried out by using Simens Diffractometer Model wave length range λ=0.1540 nm. The X-ray diffraction pattern of the SnO_2 thin films prepared, by using three different types of solvents fig 1. The tin oxide thin films having sharp peaks which are due to the degrading of crystallinity. The film is polycrystalline in nature having all peaks corresponding to the specific planes with maximum intensity peak from (110) planes. The result is in agreement with the reported JCPDS data SnO_2. The strongest peak observed at $2\theta = 26.43^o$ can be attributed to the (101) plane. The (211), (101), (110) and (022) peaks also observed at 2θ= 17.64°, 26.43°, 33.48° and 33.3^o respectively. It is speculated that both the preparation condition & oxidation performance of different solvents were responsible for the degree of stabilization of Sn-O and O-SnO_2 phases oxygen concentration has been stabilized as an important parameters for controlling SnO_x film formation (7).

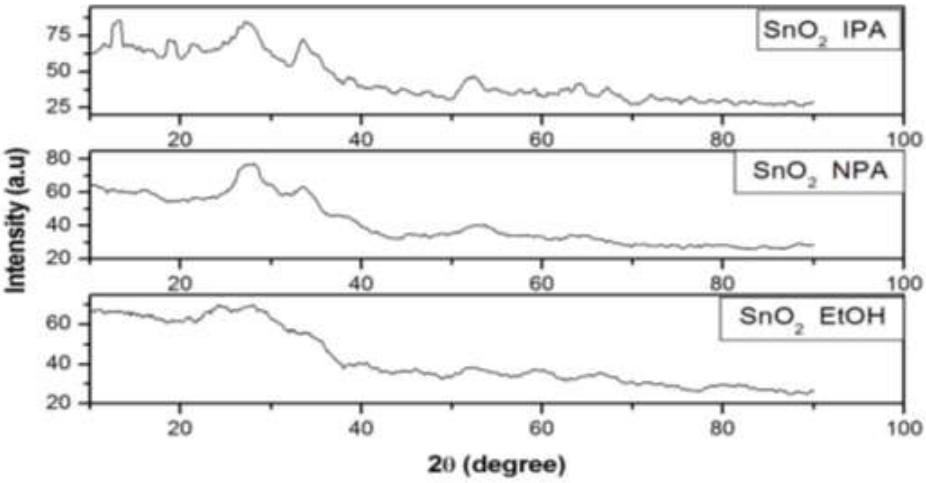

Fig 1: X-ray diffraction pattern for tin oxide thin films

Scanning electron micrographs of the deposited films with 1500 and 10000 magnifications are shown in Fig 2.The nanostructure of the prepared films was analysed

using a field emission scanning electron microscope. The morphology of the particles was uniform distribution and the high magnification image, indicating the spherical shape grains shown in above Fig 2. The SEM provides the investigator with a highly magnified image of the surface of a material that is very similar to what one could expect if one could actually see the surface visually. The SnO_2 thin films have a spherical shape and agglomerations shape with good surface coverage and good crystallinity [8]. This is in good agreement with literature survey [9].

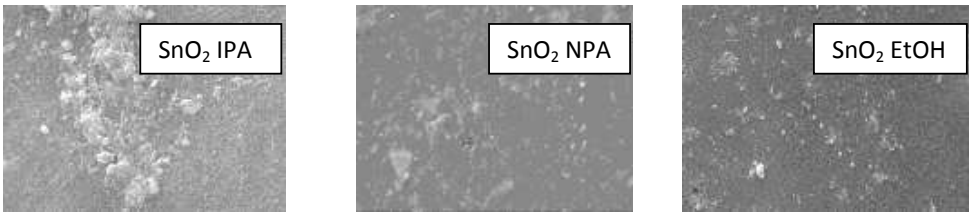

Fig.2. Scanning electron microscopy images of SnO_2 thin films:

OPTICAL CHARACTERIZATION

The FT-IR analysis of Tin oxide thin films is recorded between 250 and 4000 cm^{-1} by using Brukker IFS 66V FT-IR spectrophotometer as shown in fig 3. From the fig 4 it is clear that as the changing solvents to change transmittance value, and also increases, all bands have been assigned to the absorption peaks of Sn-O, Sn-O-Sn, Sn-OH and O-H bond vibration. The absorption peaks between 400 cm^{-1} to 700 cm^{-1} are assigned to Sn-O &Sn-O-Sn vibration of SnO_2 small peaks 1400 cm^{-1}– 1900 $cm^{-1}$is attributed to Sn-OH vibrational mode. Since the precursor solution contains water Sn-OH vibrational appears in the spectrum.

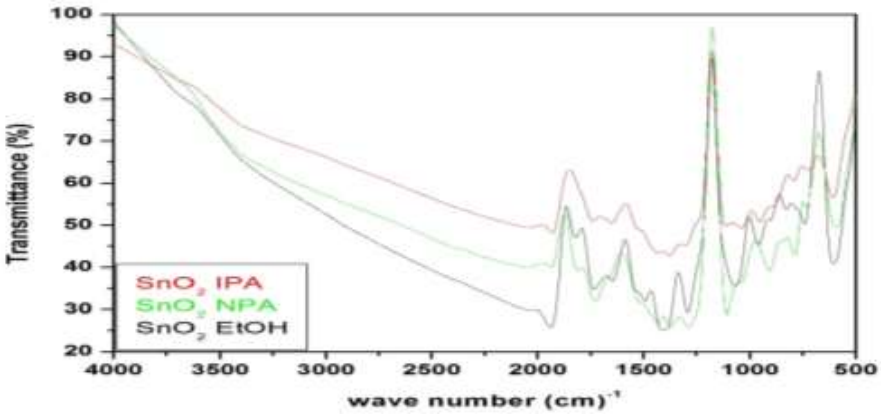

Fig 3 FT-IR of SnO_2 thin films

Fig (4) shows the transmittance and bandgap energy spectra of SnO_2 thin films. It shows the films are transparent (50%) in the visible region and the obtained band gap energy is 2.60 – 3.10 eV. The value of absorbance in UV region is found to be increased sharply with increasing wavelength and becomes almost constant towards the visible region. Therefore, the optical absorption spectra for the SnO_2 thin films annealed at different temperature. The fundamental absorption refers to band to band transitions, i.e to the excitation of an electron from the valence band to the conduction band.

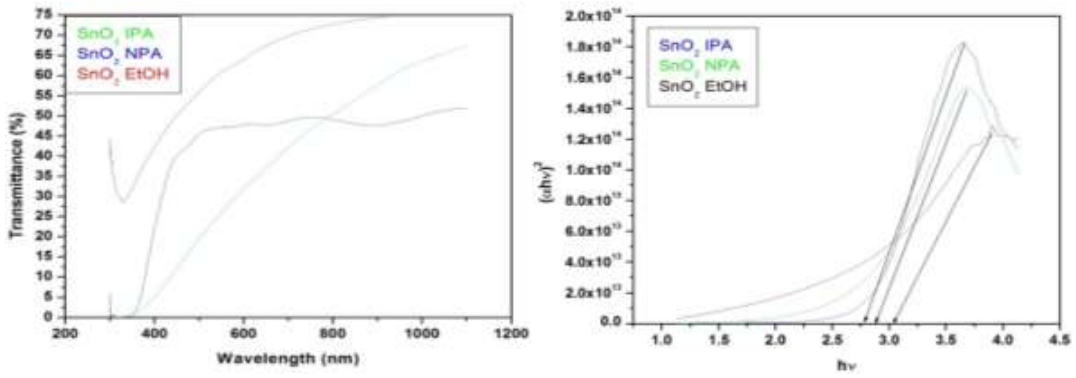

Fig. 4 Tramittance and bandgap energy spectra of Tin oxide thin film.

The fundamental absorptions, which manifest itself by rapid rise in absorption, can be used to determine the band gap of material (10). The lower cutoff wavelength was found to be at 306 - 326nm and its shows transparency in the entire visible region. The energy of incident photon is greater than the forbidden energy gap. The absorption coefficient is calculated using the following equation (1),

$$\alpha = \frac{\ln(1/T)}{t} \qquad -----(1)$$

where, α is the absorption coefficient, T is the transmittance and t is the thickness. The dependence of absorption coefficient of films on wavelength is shown in fig. It indicates that the absorption coefficient increases upto certain values of wavelength in UV region then exponentially decreases and finally becomes constant in the visible and NIR region.

The optical bandgap is calculated by equation (2),

$$(\alpha h\nu)^n = B(h\nu - E_g) \qquad -----(2)$$

where, α is the absorption coefficient, hν is the photon energy, B is a constant and E_g is the optical bandgap.

CONCLUSION

The XRD analysis showed that films are polycrystalline nature. The surface morphology of the film was measured using SEM, which indicates the spherical shape and agglomeration of the samples. Functional group of SnO_2 presented in FT-IR studies. Optical characteristics of the thin film were determined from the transmittance spectra in the UV-VIS region using the envelop method. The lower cutoff wavelength was found to be at 306 - 326nm and its shows transparency in the entire visible region. It shows the films are transparent (50%) in the visible region and the obtained band gap energy is 2.60 – 3.10 eV.

Reference

1. P. umadevi, M. vivekanand& N. prithivikumaran, "Influence of annealing time on the electrical properties of CdO thin films coated by sol-gel coating method", Journal of chemical and pharmaceutical science, 9, 1013-1016, 2016.
2. W. guo, Fu.L.zhang, Y. zhang, L.Y.Liang, Z. M. Liu, H.T. Cao &X.Q.Pan, Appl. Phys. Lett 96, 042113, 2010.
3. M. Marikkannan, V. Vishnukanthan, A. Vijayshankar, J. Mayandi and J. M. Pearce, "A Novel synthesis of tin oxide thin films by sol-gel process for optoelectronic applications", AIP advances, 5, 027122, 2015.

4. J. F. Wager, "Transparent electronics," *Science*, vol. 300, no. 5623, 1245–1246, 2003.
5. R. L. Hoffman, B. J. Norris, and J. F. Wager, "ZnO-based transparent thin-film transistors," Applied Physics Letters, vol.82, no. 5, article 733, 2000.
6. Spin coating Process theory, www.brewerscience.com (accessed in 27.07.2018).
7. X. Liu, D. Zhang, Y. Zhang & X. Dai J. Appl. Phys 107, 064309, 2010.
8. C. Matei ghimbeu, R. C. Van landschoot and J. schoonman J.Eur. cer. Soc. 2, 207, 2007.
9. Vikas Kalas, Vijay Kumar Anand and S.C.Sood, IJITKM 35, 973-978, 2014.
10. J. I. Pankove, optical processes in semiconductor, prentice hall, New Jersey, 1984.