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Structural properties of tin oxide thin films prepared by sol-gel technique

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Abstract
The influence of the bath temperature of tin oxide nanolayers on the surface of the glass subtract prepared by dip coating method was investigated. The bath temperature varied from 313 K to 373 K in a step of 20 K. The deposited films were annealed at 400 ºC. These films were characterized by using FT-IR, XRD, SEM and EDAX. The results indicated that the material could be used for optical and laser applications.

Keywords: Tin oxide thin films, optical and laser

Introduction
The sol-gel technique may be considered an adequate procedure for high purity and homogeneous films preparation, based on the hydrolysis and polycondensation of metal organic precursors such as metal alkoxides. In the recent years, this depositions technique created a lot of interest due to the fact that its advantage mainly related to low temperature of processing, large area coating, low equipment cost and good electrical and optical properties [1-2].

Transparent conducting tin oxide (SnO_2) semiconductors are widely used as transparent films in electronic devices such as thin film solar cells, display devices, electro-chromic displays, defogging aircraft and automobile windows, gas sensors, light-emitting diodes, flat-panel displays and other optoelectronic devices, etc. [3-5].

The simple and cheap technological equipment was used, homogeneity on the molecular level in solution allowing a stoichiometry and an excellent compositional control and ability to coat large and complex area substrates. The sol-gel technique also offers a versatile method for the preparation of optical quality films with controlled refractive indices and small thicknesses, allowing a Nano scale control of the film structure.

Nowadays the study and application of thin film technology is related to all the branches of science and technology due to the fast development of Nano Technology. The present paper which deals with thin film of Tin Oxide is very valuable in researcher due to its vast applications. Tin oxide thin films have some highly beneficial properties such as transparency for visible light, reflectivity for infrared light, and a low electrical sheet resistance, making them suitable for a wide variety of applications such as in transistors.

The semiconductors are widely used as transparent films in electronic devices such as thin film solar cells, display devices, electro-chromic displays, defogging aircraft and automobile windows, gas sensors. Recently, many papers have reported the preparation and properties of (SnO_2) film such as chemical precipitation method [6], sol-gel dip coating [7], spray pyrolysis [8], plasma oxidation [9] and ink jet printing [10], etc.

In this work the properties of amorphous (SnO_2) thin films were investigated by studying their structure, morphology, composition and transmittance at room temperature. The films were characterized by X-ray diffraction (XRD), scanning electron microscope observations, energy dispersive analysis by X-ray (EDAX), and transmittance measurements. Based on these aspects, the researchers undertook to grow these films by a cost effective dip technique which becomes very important on account of their practical applications.

Experimental Procedure
The coasting solution used for the experiment was prepared from an anhydrous $SnCl_4$ by sol gel process. Pure SnO_2 sols were prepared from anhydrous $SnCl_4$ distilled water, n-propanol

(C_3H_7OH), and isopropanol ($2\text{-}C_3H_7OH$) at a molar ratio $SnCl_4H_2O$: C_3H_7OH: $2\text{-}C_3H_7OH$ = 1:9:9:6. At first, the $SnCl_4$ was dropped into two-thirds of the total amount of propanol. Then one-third of the total distilled water dissolved in the remaining n-propanol (C_3H_7OH) was added for pre-hydrolysis of the tin precursor. It was stirred for 1 hr and after that the previously prepared sol was mixed with the solution of the remaining amount of H_2O dissolved in the prescribed amount of isopropanol ($2\text{-}C_3H_7OH$). It was again stirred for 1 hr. With this procedure, clear and homogeneous sols were prepared. The influence of bath temperature varied from 313K, 333K, 352K and 373 in a step of 20K. The prepared films were annealed at 400 ^oC.

Results and Discussion

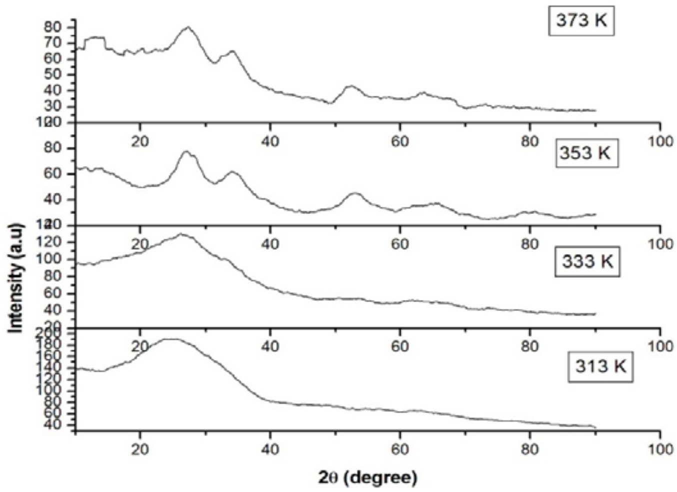

Fig 1: X-ray diffraction patterns of tin oxide thin films coated at different bath temperatures

The X-ray diffraction patterns of the SnO_2 thin films deposited at 313-373 K are shown in Fig.1. The X-ray diffraction patterns of SnO_2 thin films deposited at an optimized substrate. The tin oxide thin film having sharp peaks is indicative of the degrading of crystalline. Diffraction pattern was obtained with 2θ from 20^o to 90^o. The XRD pattern of the films shows that as the synthesized film is polycrystalline in structure and nano crystalline in nature with the tetragonal phase, it shows preferential orientation along axis. The film is polycrystalline in nature having all peaks corresponding to the specific planes with the maximum intensity peak from (110) planes. The result is in agreement with the reported JCPDS data of pureSnO_2. The strongest peak observed at 2θ =37.96^0 can be attributed to the (200) plane. The (211), (101), (110), and (311) peaks were also observed at 2θ = 17.64^o, 26.43^0, 33.48^0 and 13.55^0 respectively.

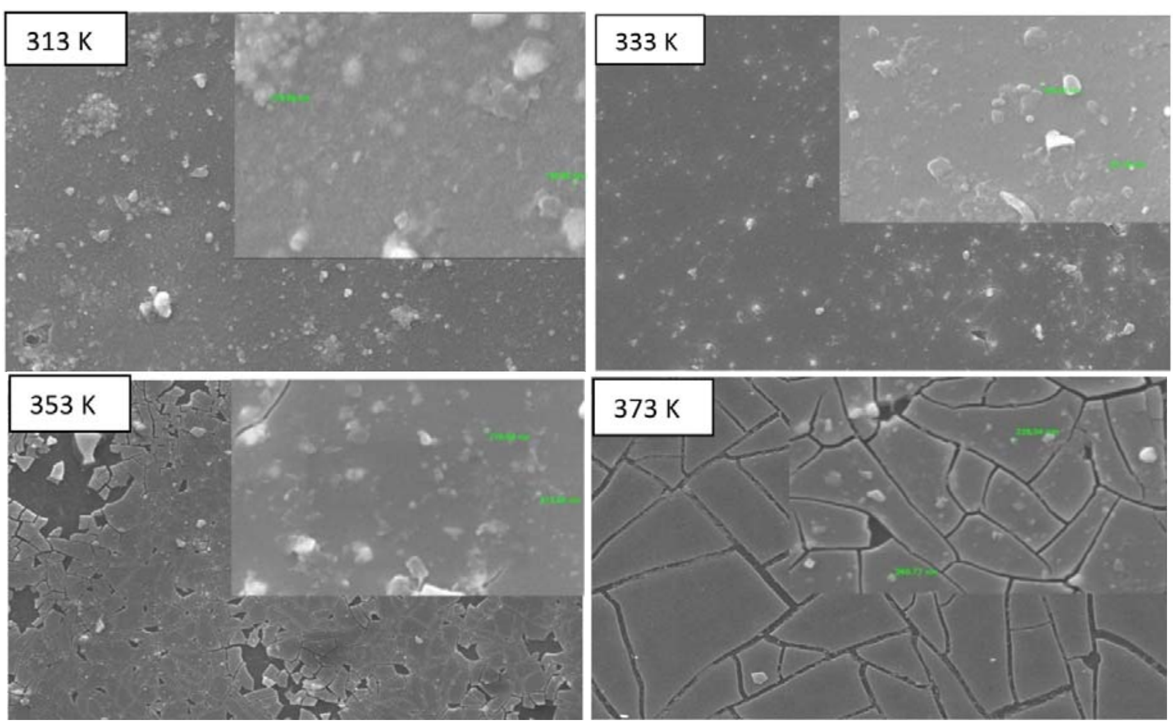

Fig 2: Scanning electron microscopy images of tin oxide thin film coated at different bath temperatures

Scanning electron microscope (SEM) images of the deposited films bath temperature at 313-373 K shown in above fig 2. Scanning electron micrographs of the deposited films with 1500 and 10000 magnifications will be taken films. The nanostructure of the prepared films was analyzed using a field emission scanning electron microphone. The morphology of the particles was uniform distribution and the high magnification image, indications the spherical shape grains shown in above Fig.2. The average grain size was about 120.74 to 288.44nm. Larger particles may be due to the agglomeration of smaller crystallites as shown in the low magnification image as presented in Fig 2. The surface morphology of the film was measured using SEM. With temperature increase, particle size changes to spherical and agglomeration as shown in Fig 2. In high magnification SEM structure, some of the agglomerated grain groups can be observed.

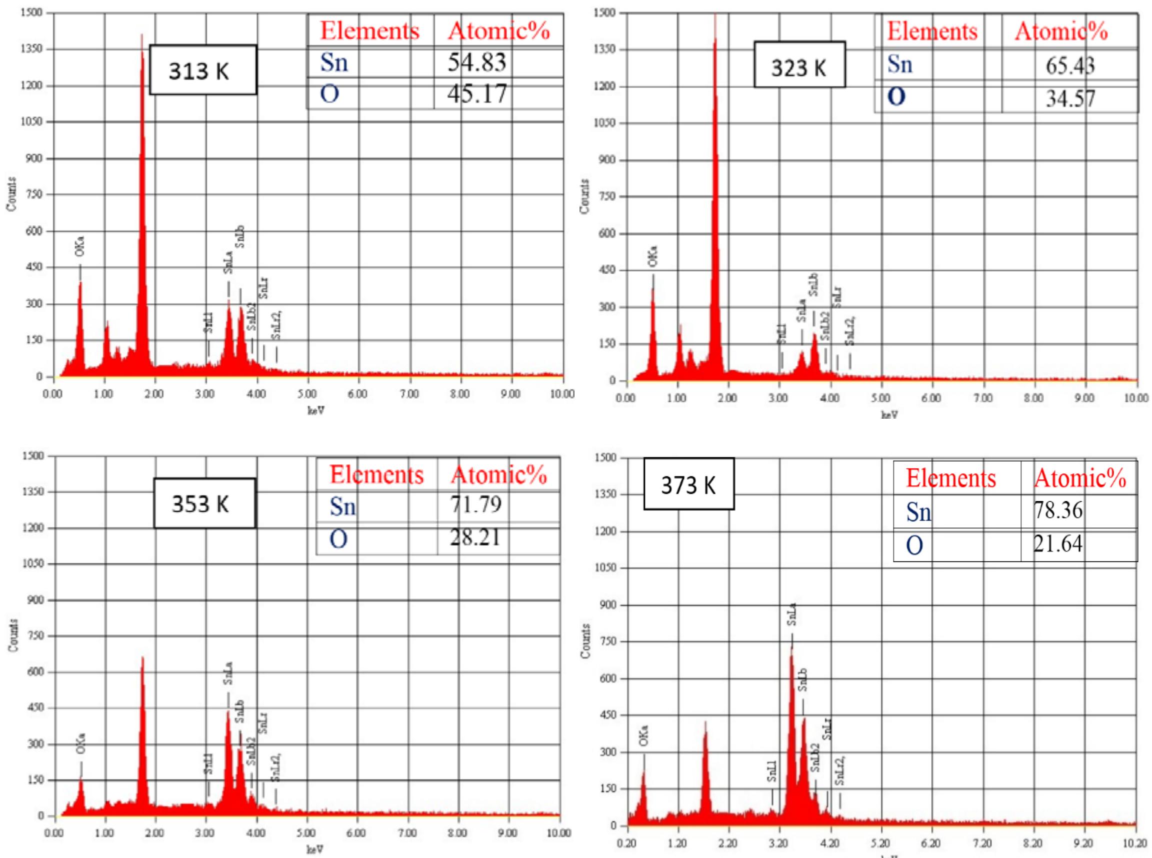

Fig 3: Energy dispersive X-ray analysis spectra of tin oxide thin film at different bath temperatures

Quantitative analysis of the film was carried out using EDAX technique for SnO_2thin films bath temperature at 313-373 K to study the composition in the film Figure 3. The peaks corresponding to Sn and O are observed in the EDAX indicating the formation of SnO_2SnO_2product and the atomic percentages so Sn and O and their values are listed in inset Table for deposited at 313 to 373 K showing that the sample was slightly tin rich, which is in good agreement with the previous reports of V.S. John *et al.* [11]. The elemental analysis confirms that the thin films so prepared were nonstoichiometric in nature.

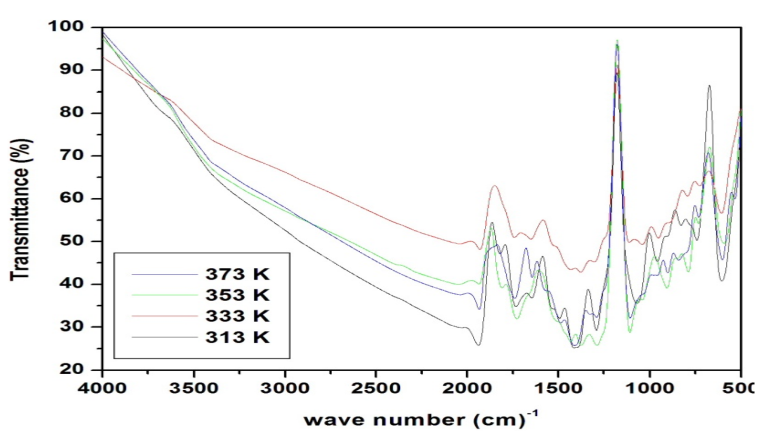

Fig 4: FT-IR Spectra of tin oxide thin film at different bath temperatures

The FT-IR analysis of Tin oxide thin film annealed at 400°C was recorded between 250 and 4000 $cm^{-1}$by using Bruker IFS 66V FT-IR spectrophotometer as shown in fig 4. From the fig 4 it is clear that as the annealing temperature increases, transmittance value also increases. All bands assigned to the absorption peaks between 400 cm^{-1}to700 $cm^{-1}$are assigned to Sn-O &Sn-O-Sn vibration of SnO_2. Small peaks 1400 cm^{-1}1900 cm^{-1} are attributed to Sn-OH vibrational mode. Since the precursor solution contains water, Sn-OH vibrational appears in the spectrum.

Conclusion

Tin Oxide films were synthesized on glass substrate by the dip coating method. These films of the compound are polycrystalline in nature which was conformed from the XRD peaks. The presence of the elements Tin and oxygen was conformed from EDAX analysis. The elemental analysis conformed that the prepared thin films are nonstoichiometric in nature the surface morphology of the film was studied using SEM which indicated spherical shape and agglomeration the sample all the functional group present in Tin oxide should absorb the FTIR studies.

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