STRUCTURAL STUDIES OF SB DOPED SNO_2 THIN FILMS DEVICES

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Abstract

A series of Sb-doped samples, SnO_2 with doping levels 2mo 4 mol%, 4 mol%, 6 mol%, 8 mol% have been prepared by sol-gel and spiin coating methods. The structural properties of samples were characterized by X-ray Diffraction (XRD) analysis. The microstructural and morphology properties were examined by Scanning Electro microscopy (SEM).The optical properties of the samples were investigated by UV-Vis spectroscopy. According to UV-Vis spectroscopy, the band gap of SnO_2 :Sb varied from 3.2 eV to 3.7 eV with variation of Sb dopant concentration .According to the result, it was observed that the structural studies of Sb doped thin films devices were successfully fabricated.

Keywords: sol-gel process, spin coating, X-ray, SEM, SnO_2, Sb

Introduction

Tin Oxide (SnO2),an important n-type semiconductor with a wide band gap (Eg=3.6eV),exhibits excellent optical, electrical and chemical properties and high thermal stability. Research has shown that the semiconductor SnO2 material has potential applicability in gas sensors, glass electrodes, secondary lithium batteries, solar cells, transistors and catalysts. In recent years, doped SnO2 and SnO2- based materials, such as Sb-doped SnO2, Mn-doped SnO2 so on, have been extensively studied due to their special optical and electrical properties of these materials also depend on the sizes and shapes of particles. During the past few years, these materials have been prepared by many techniques such as sol-gel, simple thermal evaporation, hydrothermal method, and other method.

In this paper, we present our success in the synthesis of SnO2 and SnO2-Sb nanoparticles by sol-gel method with Sb dopant concentration changed from 2 to 8 mol % and some characteristics of the material.

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Experimental procedure

Sb (2 mol %, 4 mol %, 6 mol %, 8 mol %) doped SnO_2 thin films are synthesized by solid state method, using high purity (99.9% reagent grade) SnO_2 and Sb powders. These powders were weight on the basis of stoichiometric composition. The resultant stoichiometric composition of the SnO_2 (1-x) Sb(x) (x=0.01, 0.02, 0.04, 0.06 and 0.08) powders were ground by agate motor to obtain the homogeneity. The mixed powder were annealed at 500ºC for 1 hr. each mixture of Sn(1-x) Sb(x) mixed with 2-mothoxyethanol ($CH_3OCH_2CH_2OH$) solution and then heated up to 100ºC with indirect heat treatment for 1hr. Finally, homogeneous pre cursor solutions or coating solutions are obtained. The glass substrate are cleaned by standard cleaning method. The resulting pre cursor solution are deposited on glass substrates by spin coating, deposited thin films are heat treated at 600ºC for 1hr. X ray diffraction analysis was used as the major tool for identification of phase of prepared thin films. The morphology of the films was observed with scanning electron microscopy. The optical properties of the samples were investigated by UV-Vis spectroscopy.

Results and Discussion

X-ray diffraction patterns of Sb(2 mol%, 4mol%, 6mol%, 8mol%) doped SnO_2 films are shown in Fig.1 (a~d) showing the polycrystalline of the samples. Matching of the observed and standard (h k l) planes confirms that the deposited films have a primitive tetragonal structure. On the other hand, the preferred orientation was found to be along the (110) plan for all the films. However, the doped films showed lattice constants a and c for the tetragonal phase structure are determined by the relation.

$$\frac{1}{d^2} = \left(\frac{h^2}{a^2} + \frac{k^2}{a^2}\right) + \left(\frac{l^2}{c^2}\right) \quad (1)$$

where d and (hkl) are the interplanar distance and Miller indices, respectively. The lattice constant a and c were calculated and are given in table 1. The calculated lattice constants and unit cell volume matched well with the standard JCPDS data card.

In order to determine the variation of crystallite size with doping, the size of the crystallites oriented along the (110) plane was calculated using Scherrer's formula.

$$D = \frac{0.9\lambda}{B\cos\theta} \quad (2)$$

Where B,θ, and λ are the broadening of the diffraction line measured at half its maximum intensity in radians, the diffraction angle, and the x-ray wavelength, respectively. The calculated values of crystallite size are given in Table 1. It can be seen that the crystallite size decreases with increasing doping.

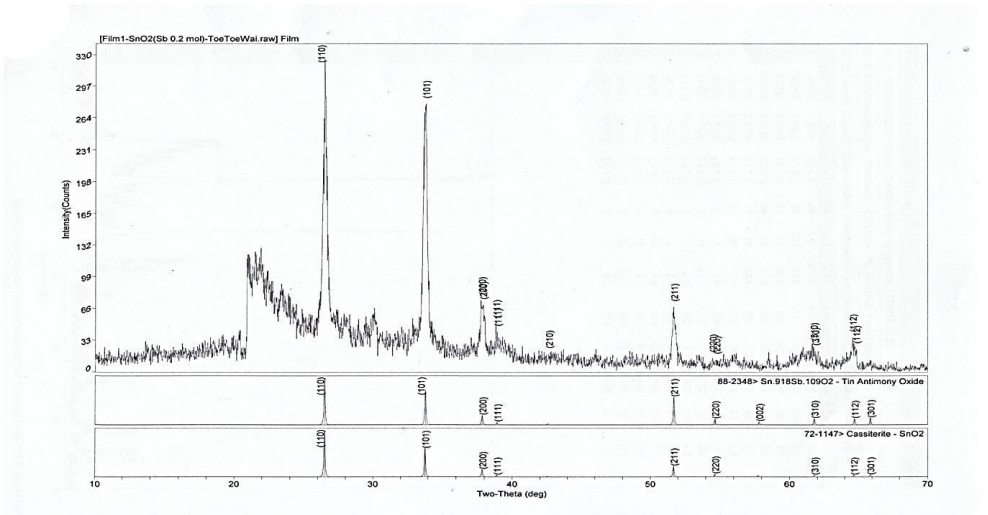

Figure 1: (a) XRD patterns obtained for Sb(2 mol% SnO_2) doped

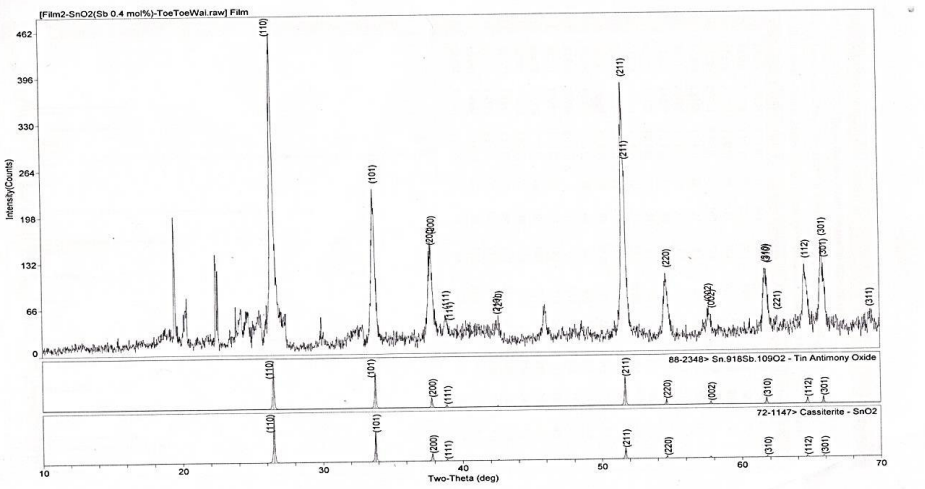

Figure 1: (b) XRD patterns obtained for Sb(4 mol% SnO_2)

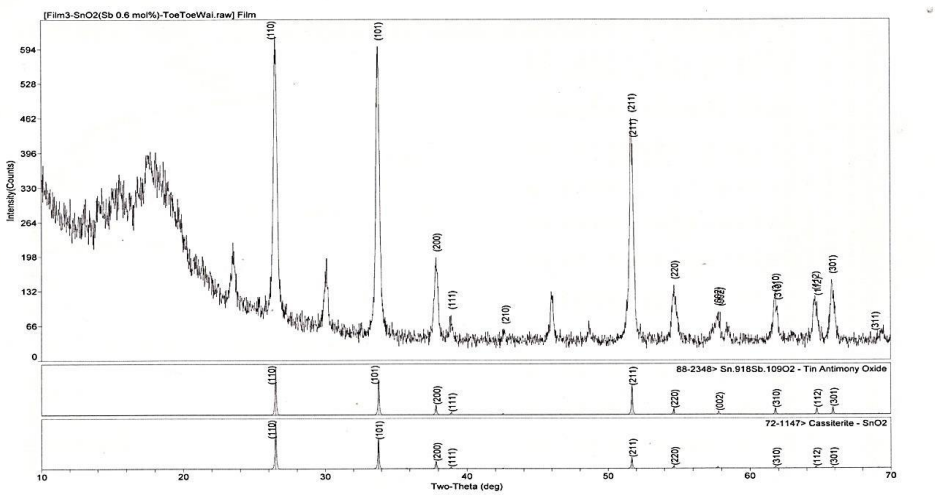

Figure 1: (c) XRD patterns obtained for Sb(6 mol% SnO_2)

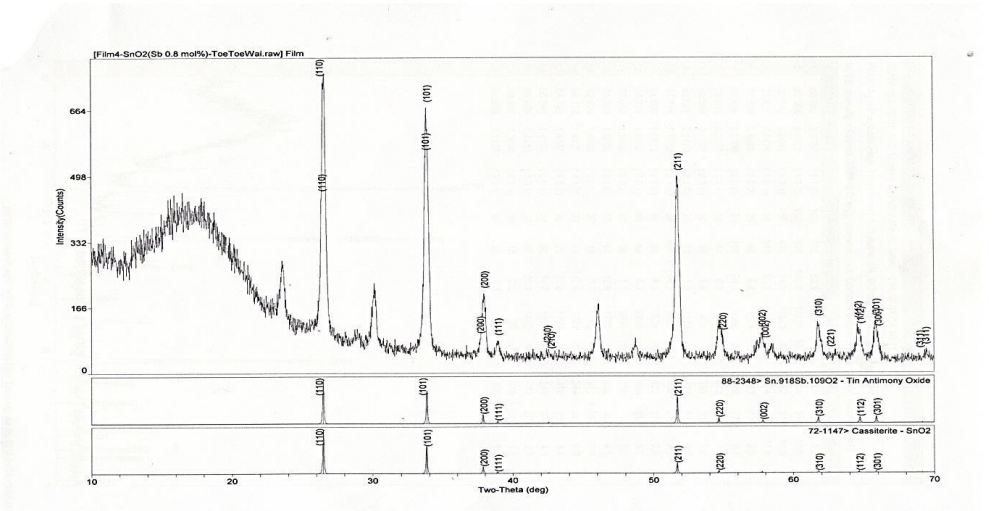

Figure 1: (d) XRD patterns obtained for Sb (8 mol% SnO_2)

Table 1: Structure parameters of SnO_2: Sb thin films

Samples	a (nm)	c (nm)	c/a	D (nm)	V $(nm)^3$
SnO2: 2% Sb	4.7512×10^{-1}	3.1929×10^{-1}	0.672	28.5403	0.0720
SnO2: 4% Sb	4.7512×10^{-1}	3.1806×10^{-1}	0.669	24.9108	0.0717
SnO2: 6% Sb	4.7489×10^{-1}	3.1880×10^{-1}	0.671	24.7980	0.0718
SnO2: 8% Sb	4.7636×10^{-1}	3.1876×10^{-1}	0.669	24.6090	0.0723

The surface morphology of the Sb-doped SnO_2 films is shown in fig.2 (a~d). In this SEM image, the spherical size SnO_2 nanoparticles with nearly uniform size from the SEM image we observed that the particles were agglomerated. The agglomeration affects dopants on the size of the particles. The size of the particles was estimated to the around 0.3-0.4 um using SEM.

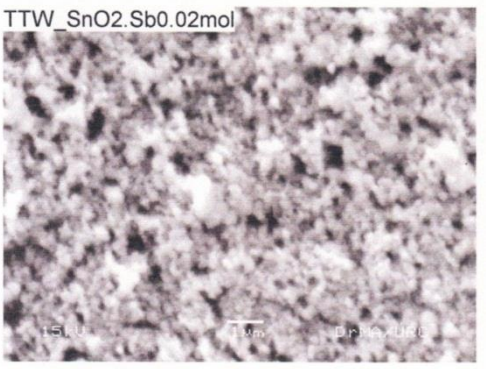

Figure 2: (a). SEM photo graph of Sb (2 mol% SnO_2)

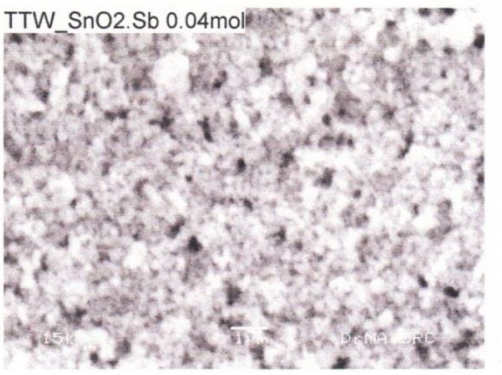

Figure 2: (b). SEM photo graph of Sb (4 mol% SnO_2)

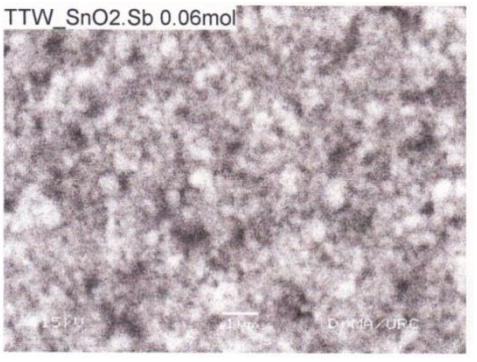

Figure 2: (c). SEM photo graph of Sb (6 mol% SnO_2)

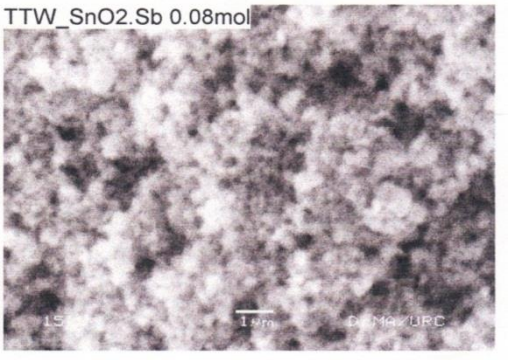

Figure 2:(d) SEM photo graph of Sb (8 mol% SnO_2)

Table 2: The particle size of SnO_2: Sb powders

Sample	Size of particles (μm)
SnO_2 : 2% Sb	0.398
SnO_2 : 4% Sb	0.327
SnO_2 : 6% Sb	0.320
SnO_2 : 8% Sb	0.285

UV-Vis violet radiation (UV) is the part of the electromagnetic radiation spectrum below visible light. The measurement of the band gap of

material is important in the semiconductor, nanomaterial and solar industries. This note demonstrated how the bandgap of a material can be demonstrated from its UV absorption spectrum. Figure3(a-d)illustrated the absorption spectra for Sb: SnO_2films. The energy bandgap of the thin films were calculated by the equation $E = hc/\lambda$.

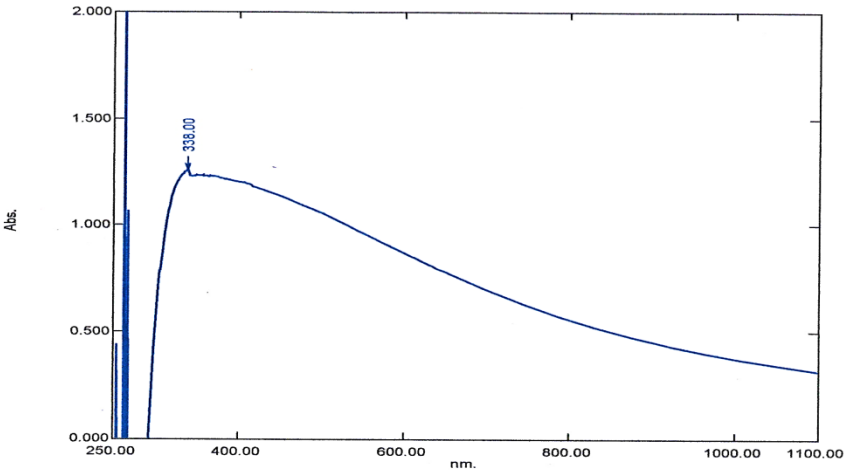

Figure 3: (a) Sb:SnO_2 2 mol% (Absorbance)

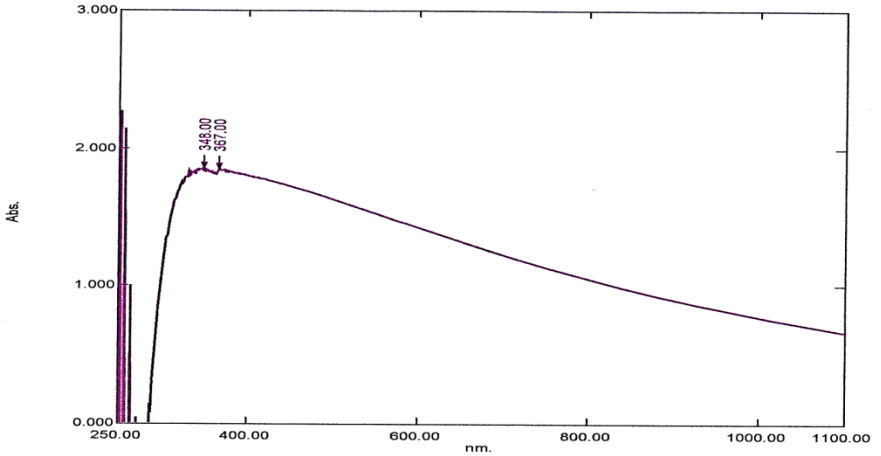

Figure 3: (b) Sb:SnO_2 4 mol% (Absorbance)

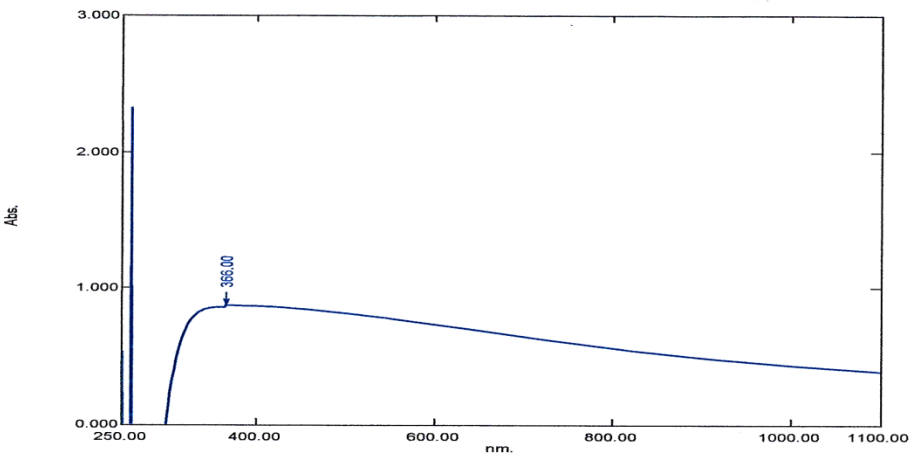

Figure 3: (c) Sb:SnO_2 6 mol% (Absorbance)

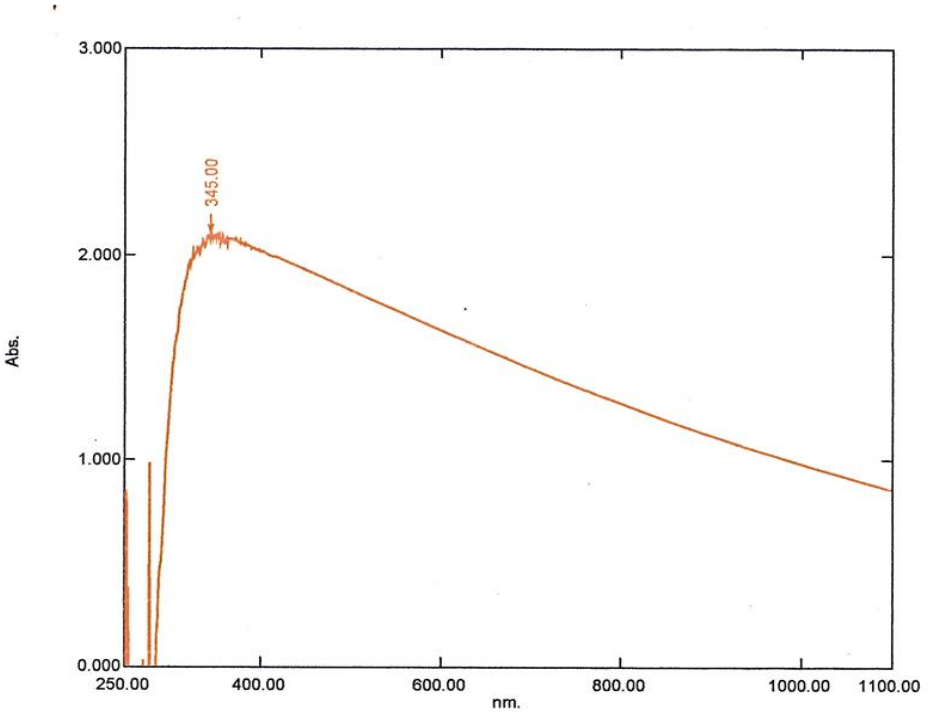

Figure 3: (d) Sb:SnO_2 8 mol% (Absorbance)

Table 3: The optical Bandgap of SnO_2 :Sb Thin Flims

Specimen	Optical Band Gap (eV)
SnO_2 : 2% Sb	3.67
SnO_2 : 4% Sb	3.37
SnO_2 : 6% Sb	3.34
SnO_2 : 8% Sb	3.23

Conclusions

SnO2:Sb transparent films deposited on g;lass substrates by sol-gel and spin coating techniques were successfully obtained.SnO2:Sb dopant films with different molar ratios were synthesized using sol-gel technique. The XRD result was indicated the tetragonal structure formation with (110) preferred orientation. The crystallite size of SnO2:Sb samples with molar ratios are 28.540nm, 24.9108nm, 24.7980nm, and 24.6090nm. According to SEM micrographs, the grains distributions were found to be highly dense. Some grains were agglomerated on some region, some grains were separated by pores. According to the UV-Vis measurements, the energy band gaps of SnO2:Sb films were found to be 3.67eV, 3.37eV, 3.34eV and 3.23eV respectively. The results showed that SnO2:Sb films exhibited a promising application for solar cell fabrication with all tested species.

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