

## Study Of Electrical and Optical Properties Of Thin Films

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### Abstract

The planning and properties of phosphorus-doped SnO<sub>2</sub> films, deposited on a warmed borosilicate glass utilizing the concoction vapor testimony, are accounted for in this paper. It is watched that the resistivity of the film reductions and its carrier focus increments as the doping grouping of phosphorus increments up to 3.7 wt.%. Sputtering powers of 0.375– 0.750 W/cm<sup>2</sup> and of 0.750 W/cm<sup>2</sup> were connected, individually, to the tin and tungsten targets so as to obtain films with diverse Sn/W proportions. The deposited amorphous films were annealed for four hours at 400 °C keeping in mind the end goal to solidify the films.

The films sputtered with 0.750 W/cm<sup>2</sup> power for the two modes were found to have  $\alpha$ -SnWO<sub>4</sub> structure crystalline after annealing. Electrical resistivity of the films was measured at different temperatures between room temperature and 400 °C in engineered air and in nitrogen. The resistivity changes of the films at presentation to carbon monoxide were also measured at different temperatures between room temperature and 400 °C. Optical reflectance and transmittance spectra of the films were recorded in the

0.3< $\lambda$ <2.5  $\mu$ m range, and the genuine and nonexistent parts of the mind bogging refraction file were registered in the visible range.

**Keywords:-** Reflectance spectra, structure crystalline, thin film, transmission contrasted, Optical properties

### INTRODUCTION:

The SnO<sub>2</sub> thin film has a transparent electrode and has a transparent electrode for a display, a solar cell, a transparent warm element, and an electric element. The SnO<sub>2</sub> thin film is fabricated by shower, synthetic vapor testimony, and sputtering. It can be fabricated in huge sums by sputtering, making the items more affordable. Notwithstanding, those produced by sputtering have defects caused by variety in temperature, affidavit time, measure of oxygen in the chamber, measure of plasma created (attributable to the adjustment in the supply control power), and vacuum in the chamber. The underlying condition of the substrate when a thin film develops can influence the electrical and optical properties of the thin film. Along these lines, so as to enhance the electrical and optical properties of the SnO<sub>2</sub> thin film, it is important to anchor the unwavering quality

of the thin film and to control the defects in the thin film.

Economic and stable transparent conductive SnO<sub>2</sub> films are of significant enthusiasm, because of their application in sun based cells, optoelectronic gadgets, thin film resistors, antireflection coatings, photochemical devices and electrically conductive glass. An undertaking has been made in the present detailed study to prepare SnO<sub>2</sub> films by using financial shower pyrolysis strategy. It has been accounted for as of now that the splash pyrolysis procedure is most appropriate for acquiring tin oxide films in vast territory substrate applications. Tin oxide films doped with antimony have intriguing electrochemical properties in various electrode forms, for example, low temperature electrochemical ignition of natural contaminations, ozone creation, and natural electro-union. Thus in the present examination, the antimony doped SnO<sub>2</sub> films were set up by splash pyrolysis strategy and their electrical and optical properties are investigated.

There are different film statement methods, however one which is advantageous and of minimal effort is compound vapor affidavit (CVD). In the CVD technique SnCl<sub>4</sub>, SnCl<sub>2</sub> or organometallic mixes of tin, for example, tetramethyl tin or dibutyl tin diacetate, have been utilized as tin hotspots for the statement of SnO<sub>2</sub> films. The vapors of an appropriate tin-bearing compound are conveyed into the reactor and disregarded the warmed substrate together with an oxidizing specialist. In the reactor,

the vapor of the tin-bearing compound breaks down and a tin oxide film is framed on the warmed substrate. The component of film arrangement by the CVD method has been all cases it has been discovered that SnCl<sub>4</sub> or (CH<sub>3</sub>)<sub>4</sub>Sn responds at first glance with an ingested oxygen atom or water molecule.

Thermodynamic calculations of the response somewhere in the range of SnCl<sub>4</sub> and H<sub>2</sub>O. They have tentatively watched that the development rate at first increments with the temperature and levels off at higher statement temperatures. The idea of the substrate is additionally an essential parameter for film statement. Manificier and Fillard [7] have revealed the piece and optical transmission of SnO<sub>2</sub> films deposited on different glasses at various film thickness for substrates, for example, Pyrex, Corning 7301, Corning 7059 and Corning 7913. The Corning 7059 displays the best transmission of 92% in the wavelength range 0.4-2.2 μm and furthermore has a lower antacid particle content. Different laborers [4,8] have likewise detailed the resistivity of SnO<sub>2</sub> films deposited on combined quartz, pop lime glass, borosilicate glass and sapphire as 1.6×10<sup>-4</sup> Ω·m, 1.5×10<sup>-4</sup> Ω·m, 1.7×10<sup>-4</sup> Ω·m and 1.1 × 10<sup>-5</sup> Ω·m separately. Their particular transmissions are 88.3%, 83.0%, 89.57% and 90.20.

From the revealed information, the borosilicate glass has enhanced transmission contrasted and melded quartz and pop lime glass. That is the reason the borosilicate glass is utilized as the substrate for the present investigation. The electrical and the

optical properties of SnO<sub>2</sub> films can be additionally expanded by doping with aggregate V elements, for example, antimony 9, phosphorus 1° and arsenic 11. Expansion of phosphorus to SnO<sub>2</sub> films deposited by the CVD system prompts interesting outcomes and merits facilitate examination. In the present investigation, SnO<sub>2</sub>:P films of various phosphorus focuses have been manufactured by the CVD strategy. The resistivity, carrier fixation and versatility as a component of phosphorus doping focus have been estimated. The optical transmission in the visible-UV area and X-beam diffraction example of the films at two doping fixations have been additionally acquired.

**Methodology:**

To produce the SnO<sub>2</sub> thin film by radio frequency (RF) sputtering, the Sn target is introduced in the chamber, and power is provided to the chamber to make plasma, with the goal that the Sn<sup>+</sup> ions are dropped onto the metal Si substrate in the chamber and all the while, the high-immaculateness oxygen (99.99%) is infused to store the SnO<sub>2</sub> thin film. As of now, the measure of Sn + particles to be dropped is firmly identified with the measure of plasma in the chamber, which is impacted by the power

force in the chamber. In this examination, the thin film was developed by changing the testimony temperature in the chamber to 350°C; the measure of oxygen presented was 40 sccm; the affidavit time was 1 h; and the power was changed to 100, 150, and 200 W (S1, S2, and S3). Further, S4, S5, and S6 thin films were deposited on the Si substrate at a temperature of 350°C and an oxygen stream rate of 40 sccm, and after that the powers provided at an indistinguishable conditions from S1, S2, and S3 films were 100, 150, and 200 W.

The shapes and normal sizes of the thin films were estimated by electron microscopy (SEM, Hitachi, S-4700, Japan), and the structural characteristics of the thin films were dictated by concentrate their X-beam diffraction designs. The electrical properties of the SnO<sub>2</sub> thin films were estimated utilizing a Hall impact estimating gadget. The PL of the thin films was estimated at room temperature.

Sample	Power W	O flow sccm	Deposition temp. °C	Deposition time hr	Preoxygen time hr	Thickne ss (nm)	Grain size (nm)
S1	100	40	350	1		10	23
S2	150	40	350	1		25	22
S3	200	40	350	1		40	27

S4	100	40	350	1	1	12	26
S5	150	40	350	1	1	30	27
S6	200	40	350	1	1	50	29

Hitachi U-3400 twofold pillar spectrophotometer.

For Fluorine-Doping Ammonium Fluoride (NH<sub>4</sub>F) disintegrated in doubly refined water was added to the starting arrangement. Though for Antimony-Doping Antimony-Trichloride (SbCl<sub>3</sub>) broke up in isopropyl liquor was included. The general measure of arrangement for each situation was set up to 50 ml and a similar measure of arrangement was showered on pre-warmed substrates. The rehashed analyses of every affidavit demonstrated that the films could be repeated effortlessly. A broad care was taken in giving adequate splash interim between progressive showers for the substrates return to statement temperature in the wake of experiencing warm deterioration. This has brought about the best possible decay of the films that thus delivered the most minimal ever sheet opposition esteems revealed for the doped SnO<sub>2</sub> films from SnCl<sub>2</sub> antecedent. The electrical examinations were done by Hall estimations in van der Pauw setup. The surface morphology was considered utilizing JSM 840 filtering electron microscopy. A Philips X' Pro X-beam diffractometer has been utilized for getting XRD designs. The transmittance and reflectance spectra are gotten utilizing

The as-deposited films were portrayed for their physical properties and the electrical and optical properties are thought about in this paper. The electrical examinations were made by the blend of Hall coefficient and van der Pauw resistivity estimations. The negative indication of the Hall voltage affirmed that the films are n-type conducting. The temperature reliance of resistivity estimations demonstrated that the films are worsen. Promote the film decadence was affirmed by evaluating Fermi vitality. The optical examinations were made with the utilization of Hitachi U-3400 UV-VIS-NIR spectrophotometer by recording transmittance and reflectance spectra.

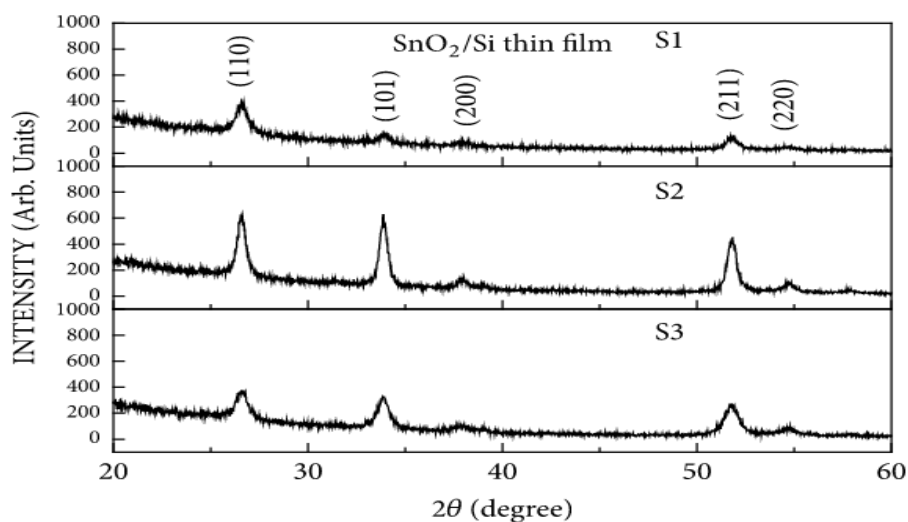
### Results and Discussion

The XRD consequences of the films developed at a consistent intensity of 100, 150, and 200 W at a statement temperature of 350°C, an affidavit time of 1 h, and an oxygen stream rate of 40 sccm. At the point when the force of the provided control was expanded (110), both the (101) plane and the (211) plane had an inclination for tendency for crystal growth. The XRD results acquired after thin film development under conditions like those for S1, S2, and of plasma provided changes. The force of the XRD pinnacles of the thin film is expanded and diminished when the power

provided to the chamber is expanded to 100, 150, and 200 w. It is seen that the thickness of the thin film is diminished by diminishing the thickness of the thin film, which appears concur with the outcome. The development course of the thin film may change as indicated by the underlying development states of thin films. The underlying development condition can be an imperative parameter in the grain development of thin films, and changes in the development surface of the thin film will change the molecule shape, molecule measure, and electrical attributes of the thin film.

S3, after oxygen had streamed on the Si substrate for 1 h preceding the thin film was deposited. The (110), (211), and (101) planes of the thin films expanded in power as the development surface diminished. The thin film development by sputtering is

impacted by the power provided to the chamber. XRD tops are identified with the thickness of the thin film and the thickness of the thin film will change as the measure. The surface of S1, S2, and S3 thin films developed at a testimony temperature of 350°C, an affidavit time of 1 h, an oxygen flow rate of 40 sccm, and provided powers of 100, 150, and 200 W. The thin films were roundabout, and the molecule sizes expanded with the provided control. The state of the thin film and the molecule estimate are connected with the power of the precious stone face of the thin film. In the event that the molecule estimate changes, the quality and bearing of the development surface of the thin film may change.



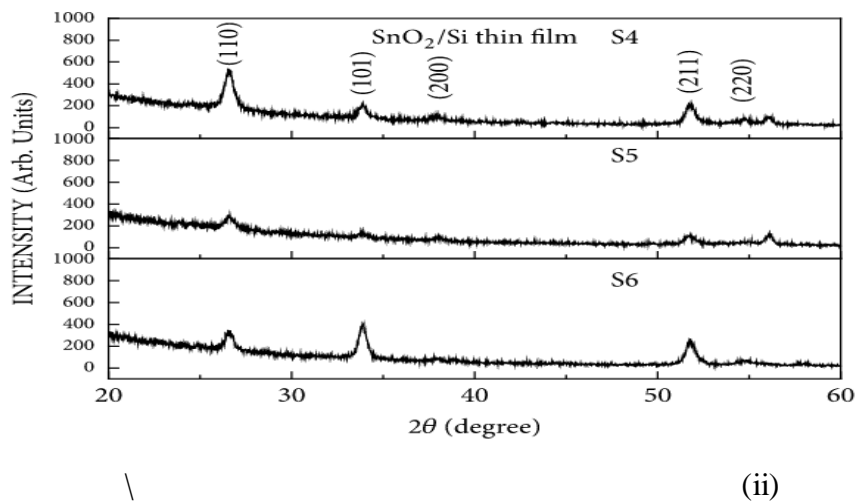


Figure 1: X-beam diffraction patterns of the SnO<sub>2</sub> thin films of S-1, S-2, and S-3 groups (an) and S-4, S-5, and S-6 groups (b).

Further, the SiO<sub>2</sub> layers deposited by providing oxygen onto the Si substrate; the thin films were then shaped under indistinguishable conditions as those for S1, S2, and S3 thin films. The thin films are round, as on account of S1, S2, and S3 thin films and the molecule estimate increments with the provided control. Additionally comprehension of microstructural development could be accomplished considering that the starting material displays auxiliary defects which, are identified with high oxygen vacancy focus.

### Optical properties

The acquired transmittance and reflectance spectra from the optical examinations. It

was discovered that the transmittance diminished with expanding Sb doping focus regardless of the affidavit temperature. Encourage it was discovered that for a given doping focus the transmittance indicates higher incentive for the films deposited at low temperature (350 °C). For instance, the transmittance estimation of 63 % watched for the film with 0.5 wt. % of Sb arranged at 350 °C was discovered diminished to an estimation of 54 % (at 800 nm) for the film arranged with the same doping fixation at 400 °C. This is in logical inconsistency to the electrical conduct where the higher testimony temperature (400 °C) prompts better electrical properties.

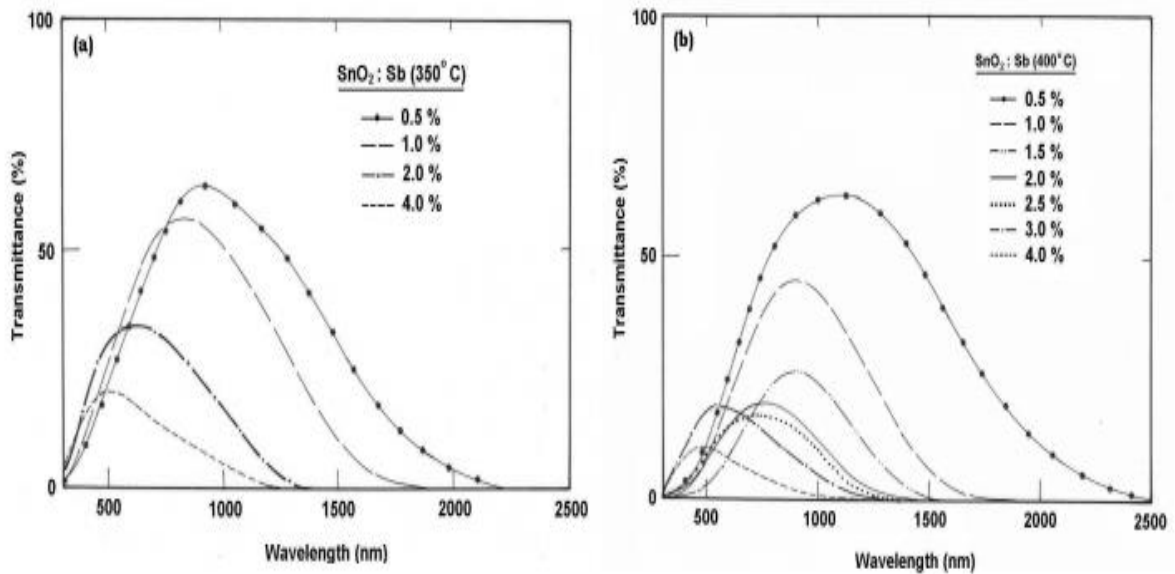


Figure 2: Transmittance spectra as a component of wavelength for SnO<sub>2</sub> :Sb thin films arranged at Ts of (a) 350 °C and (b) 400 °C separately

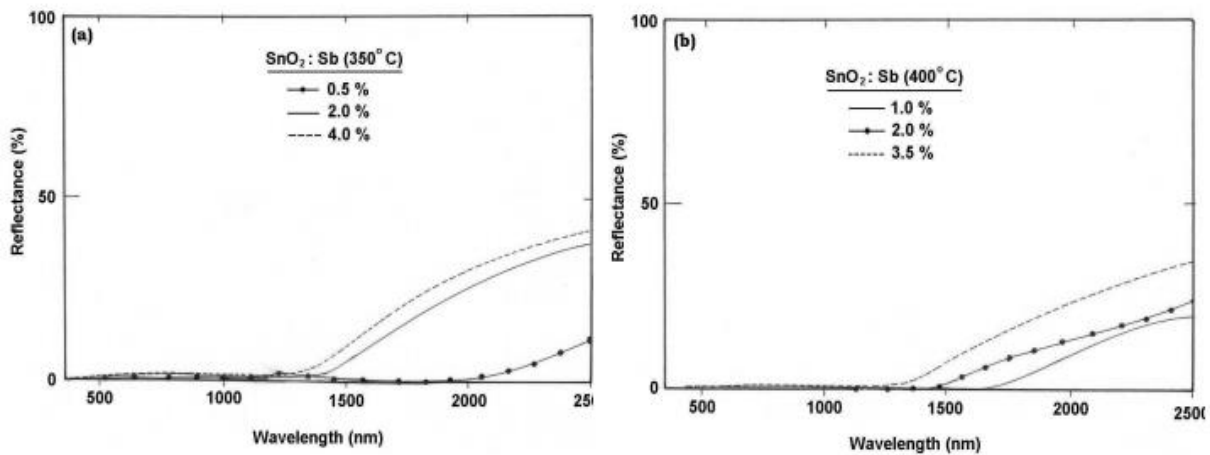


Figure 3: Reflectance spectra as an element of wavelength for SnO<sub>2</sub> :Sb thin films arranged at Ts of (a) 350 °C and (b) 400 °C separately

From the plot of reflectance spectra, it is understood that the reflectance of the considerable number of films is very nearly zero till the wavelength of around 1500 nm for both substrate temperature. For the film

arranged with 0.5 wt. % of Sb at 350 °C, the reflection begins simply after 2000 nm. For both substrate temperatures, the films demonstrate increment in reflectance (over 1500 nm) with the expansion in Sb doping.

The films arranged at bring down substrate temperature have marginally higher reflectance esteems than those arranged at higher substrate temperature over the wavelength of ~1500 nm. The transmittance for the chose wavelengths of 600, 700, 800, and 900 nm are plotted against the capacity of Sb doping in the films arranged at lower and higher substrate temperatures individually.

It is obvious from the assume that for the films arranged at bring down temperatures the transmittance esteem at each chosen wavelength diminishes with expanding Sb doping focus. It was comprehended that as the doping builds, the rate of decline of transmittance of the higher wavelengths (800 and 900 nm) is higher than that of lower wavelengths (600 and 700 nm). As a result, the transmittance that demonstrated augmentation with expanding wavelength at bring down doping levels (< 2 wt. %) found to indicate decrement in transmittance with expanding wavelength at higher doping levels (> 2 wt. %). For the films arranged with higher substrate temperature, as the doping fixation increment, the transmittance

demonstrates a reliable decrement for the higher wavelengths. Though the transmittance for the lower wavelengths demonstrates a decrement till the Sb doping of 1.5 wt. % yet then demonstrates a slight increment.

The average molecule sizes of S1– S6 films. The average molecule sizes of S1, S2, and S3 thin films are 23, 22, and 27 nm, individually. The average molecule sizes of S4, S5, and S6 thin films sintered in an oxygen climate are 26, 27, and 29 nm, individually. The average size dividing of S4, S5, and S6 films sintered in an oxygen air was not as much as that of S1– S3 films.

At the point when the SnO<sub>2</sub> thin film is developed after oxygen streams over the Si substrate, the average molecule size of the SnO<sub>2</sub> thin film is affected by the SiO<sub>2</sub> layer, and henceforth, the deviation is lessened regardless of whether the power force of the particles is expanded.



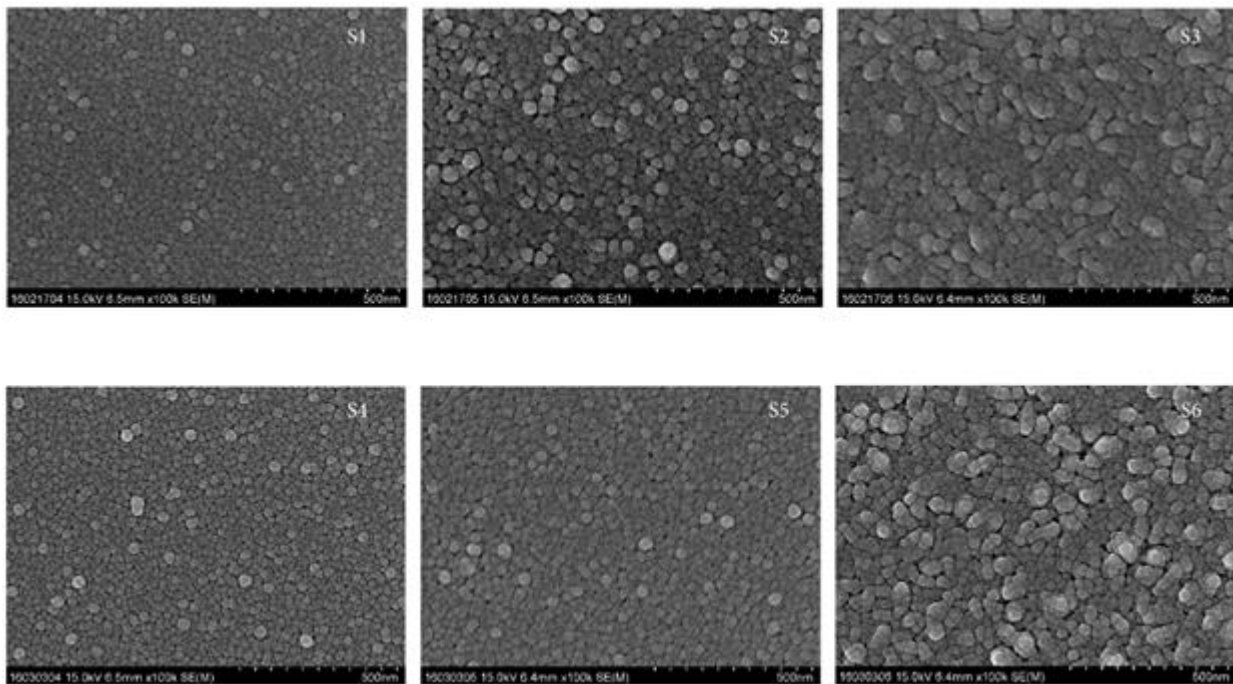


Figure 2: SEM pictures of the surface of the SnO<sub>2</sub> thin films of S-1, S-2, and S-3 groups and S-4, S-5, and S-6 groups.

The versatility and surface charge thickness of the thin film acquired through the Hall estimation of thin films S1 to S6; the portability of S1– S6 was 11.9, 7.41, 7.31, 10.2, 8.24, and 3.39, separately. The versatility of the thin film diminished as the provided control expanded, and it diminished consistently when the power provided to thin films S4, S5, and S6 was expanded in the oxygen environment.

Accordingly, the force of intensity provided to the thin film appears influence the versatility in the thin film. The surface charge densities of S1, S2, and S3 expanded to  $8.785 \times 10^{13}$ ,  $1.266 \times 10^{14}$ , and  $6.246 \times 10^{13}$ , separately. That is, the force of intensity provided when the thin film was deposited influences the vehicle charge thickness of the thin film.

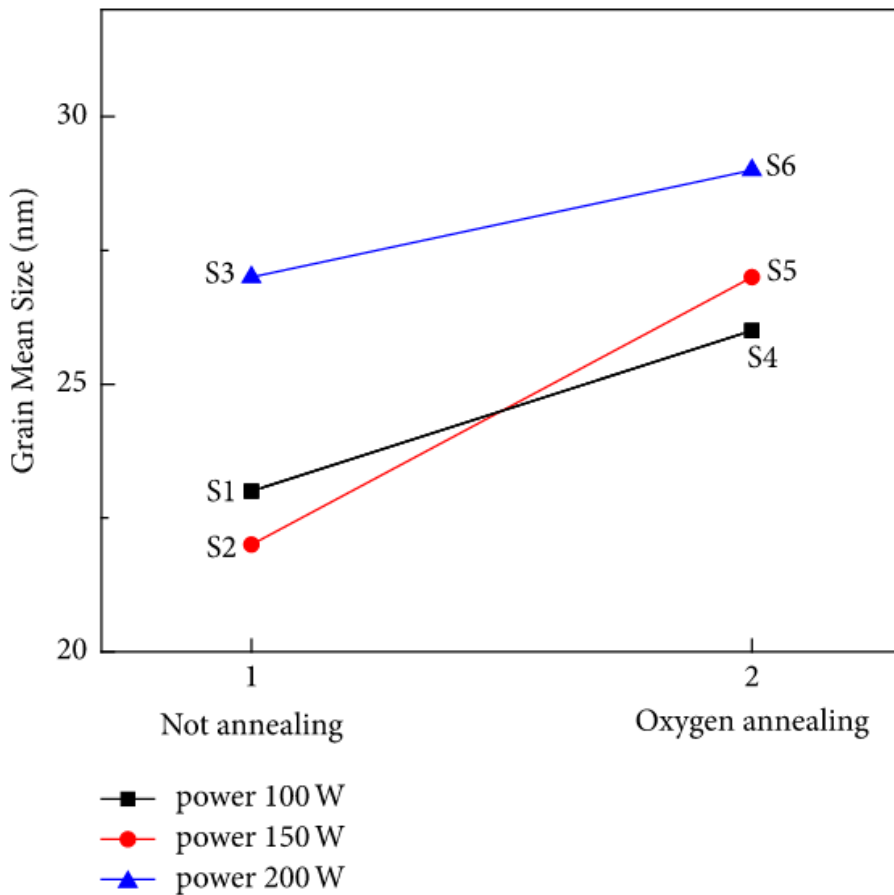


Figure 3: Mean grain size of the SnO<sub>2</sub> thin films of S-1, S-2, and S-3 groups (1) and S-4, S-5, and S-6 groups (2).

The surface charge densities of S4, S5, and S6 films sintered in the oxygen environment were  $2.646 \times 10^{14}$ ,  $3.071 \times 10^{14}$ , and  $1.747 \times 10^{15}$ , individually, and the vehicle charge thickness of S4– S6 when an indistinguishable power from that for S1– S3 was provided was marginally bigger than that of S1– S3. This is on account of the SiO<sub>2</sub> + SnO<sub>2</sub> thin film shaped on the Si substrate, and the carrier thickness expands on account of the bigger measure of oxygen than that present in the unadulterated SnO<sub>2</sub> thin film. It was affirmed that the force of provided control influences the surface

charge thickness and the portability of the thin film and therefore that the SiO<sub>2</sub> layer between the Si substrate and the SnO<sub>2</sub> thin film influences the electrical properties of the thin film. By and large, the quick development rate of the thin film causes the poor electrical and optical properties because of the expansion of harshness and stick opening. In the abatement in portability and PL force in S3 and S6, which have the biggest power amid film development, gives off an impression of being because of the poor thin film properties.

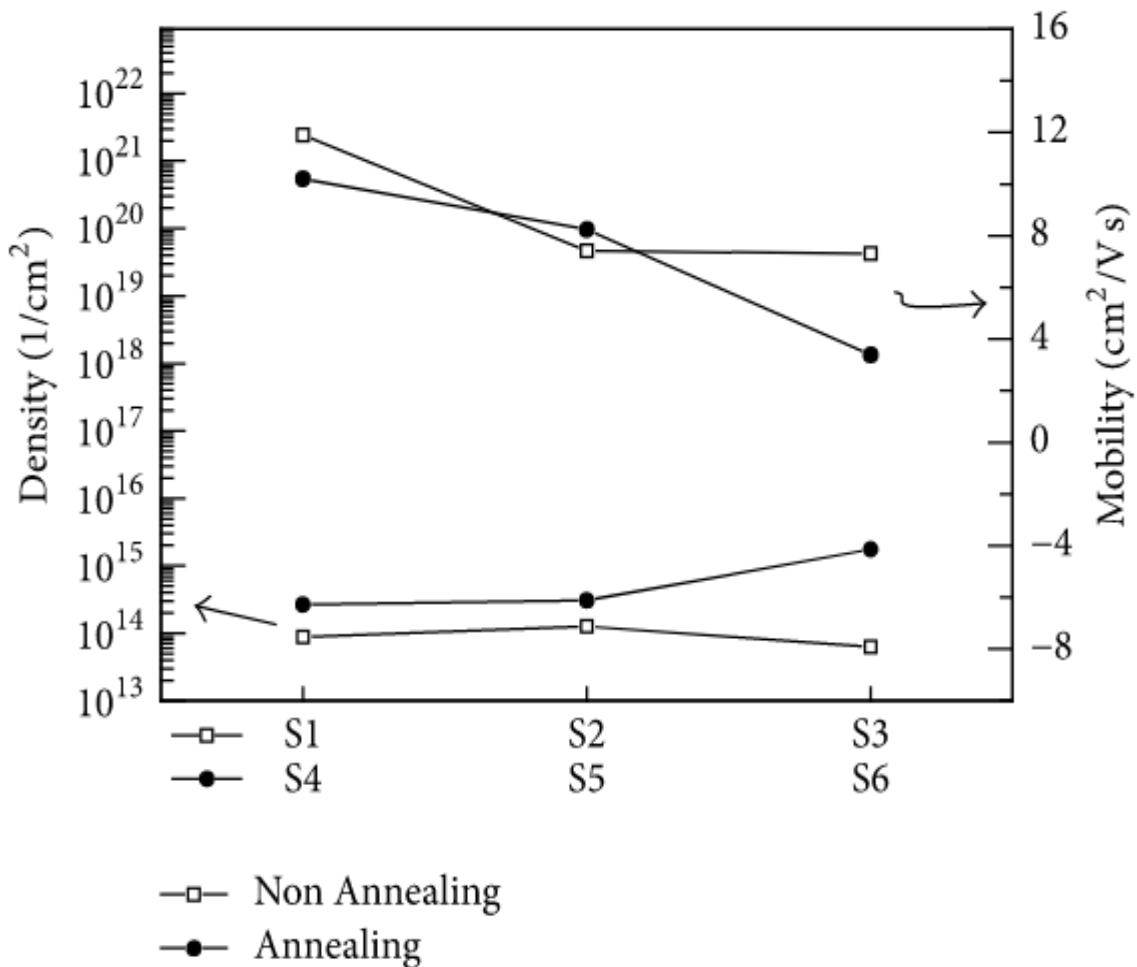


Figure 4: Hall effect data of the SnO<sub>2</sub> thin films.

The PL estimation of thin films S1– S6. The PL powers of S4, S5, and S6 films with SiO<sub>2</sub> layer were not exactly those of S1, S2, and S3 films. On account of S4, S5, and S6 films, the discharge wavelengths of 431 nm and 444 nm (relating to S1– S3 films) moved to 434 nm and 415 nm, separately. The SnO<sub>2</sub> thin film developed on the SiO<sub>2</sub> layer has distinctive oxygen defects on

the film surface, and the interface between the substrate and the thin film is unique in relation to that between the substrate and unadulterated SnO<sub>2</sub> thin film: the outflow top move of the photoluminescence. This is steady with the adjustment in the carrier thickness of the surface of the SnO<sub>2</sub> thin film.

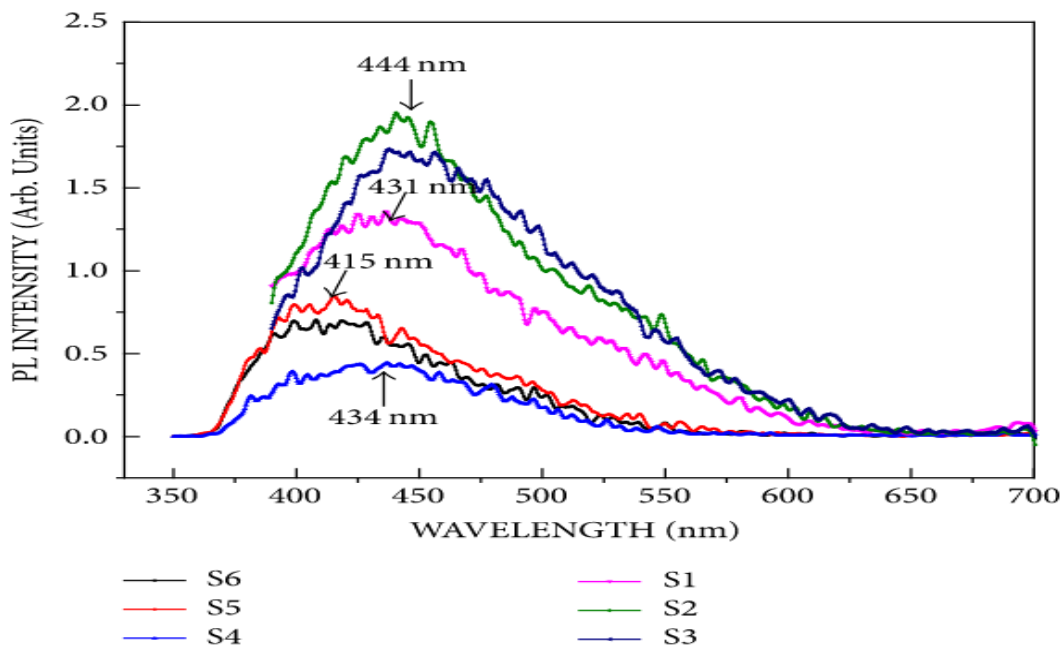


Figure 5: Photoluminescence spectra of the SnO<sub>2</sub> thin films.

Sample	Resistivity (ohm cm)	Carrier density (cm <sup>-2</sup> )	Mobility (cm <sup>2</sup> /V-s)
S1	$0.5984 \times 10^4$	$8.785 \times 10^{13}$	11.9
S2	$0.6651 \times 10^4$	$1.266 \times 10^{14}$	7.41
S3	$1.368 \times 10^4$	$6.246 \times 10^{13}$	7.31
S4	$0.2310 \times 10^4$	$2.646 \times 10^{14}$	10.2
S5	$0.2467 \times 10^4$	$3.071 \times 10^{14}$	8.24
S6	$0.1054 \times 10^4$	$1.747 \times 10^{15}$	3.39

Table 2: Hall coefficient

### Conclusion

Thin films of antimony doped tin oxide thin films were set up by shower pyrolysis strategy from SnCl<sub>2</sub> antecedent at two diverse substrate temperatures. The films arranged at higher substrate temperature indicated least sheet opposition. The base

sheet obstruction accomplished in the present investigation is the most reduced among the detailed qualities for these materials arranged from SnCl<sub>2</sub> forerunner. Regardless of the substrate temperature, the transmittance of the films diminishes continuously with increment in Sb doping

focus. The films arranged at bring down substrate temperature demonstrated the most extreme transmittance. In the SnO<sub>2</sub> thin films developed specifically on the Si substrate, the forces of (110) plane, (101) plane, and (211) plane showed a fortifying inclination to diminish. Be that as it may, in SiO<sub>2</sub>+ SnO<sub>2</sub> thin films, the (110), (101), and (211) planes displayed an inclination to diminish gradually, and the development example of SnO<sub>2</sub> thin films changed by the underlying creation condition of the thin film. The SEM pictures of the thin films demonstrate that SnO<sub>2</sub> thin films developed specifically on the Si substrate had a huge normal molecule measure with expanding power force, and the normal molecule estimate interim of the SnO<sub>2</sub> thin films developed on the SiO<sub>2</sub> layer in the oxygen climate was little. In the Hall impact estimation, the force of intensity provided to the SnO<sub>2</sub> thin film was influenced by the surface charge thickness of the thin film, yet the thin film deposited by sintering in the oxygen air demonstrated the surface charge thickness.

It was affirmed that the SiO<sub>2</sub> layer between the substrate and the thin film influences the electrical properties of the thin film inferable from the defects in the SnO<sub>2</sub> surface and thin film. The optical properties of the thin films developed straightforwardly on the substrate were additionally not quite the same as those of the SnO<sub>2</sub> thin films developed on the SiO<sub>2</sub> layer by sintering in the oxygen environment.

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