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Structural and Optical Properties of SnO_2 Thin Films for Conductive Glass $(12\ x12cm)^2$ by Thermal Spray Method

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Abstract

Tin dioxide (SnO_2) thin film is one of the important transparent conducting dioxides (TCOs) .due to its electrical and optical transparency in visible light, it is applied in various fields such as solar cells, optoelectronic devices, heat mirrors, gas sensors. SnO_2 thin film layer was grown up on a (12 x12cm^2) glass sheet by thermal spray method and a study of the structural, optical, morphological and electrical properties is introduced.

Keywords: Structural properies; Optical Properties; SnO_2; Thin Films; Conductive Glass; Thermal Spray.

1. Introduction

Tin di-oxide (SnO_2)thin films is a n-type semiconductor with wide energy band gap (3.6 ev). The un doped SnO2 [1] Stannic dioxide thin films are attractive for many opto-electronic devices due to their unique physics properties such as high electrical conductivity , high transparency in the spectral response region of the silicon solar cell, a good adhesion with the glass, economic, and stable in different weather conditions. These properties make tin oxide suitable for many applications, particularly as an electrode material in solar cell, light emitting diodes, transparent electromagnetic shielding materials, etc [2].

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Studies on effect of substrate type, deposition rate, oxygen partial pressure and temperature are widely performed by many researchers to improve the structural, electrical and optical properties of the thin film. In this study, we have grown SnO2 thin film and study the effect of SnO2 on the structure and optical properties of the growth film using X-ray diffraction (XRD), UV-Vis transmission spectroscopy and atomic force microscopy (AFM).

2. Experiment

In this study, The glass substrate is used for conductive glass preparation. In this work used commercial glass (12 x12cm^2) and thickness (1.1) mm was used, taken from local market, cleaned successfully with water, detergent, acetone and isopropyl alcohol, then dried and mounted in the furnace.

SnO_2 thin film is used as transparent, low resistance, conductive glass coating in this study. Solution was prepared by mixing $SnCl_4$with a methanol. then the glass was sprayed with the solution and heated at above 500 $^{\circ}$c to decompose the $SnCl_4$ to SnO_2. Noting that should not breathe the fumes and work in a well ventilated area.

Figure (1) shows the transparency of the prepared conductive glass.

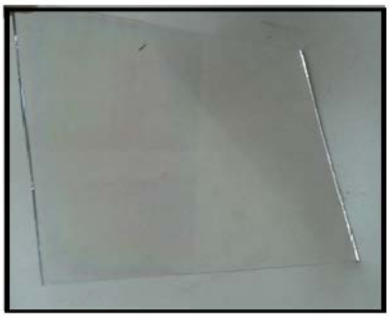


Figure 1: SnO_2 thin film on glass substrate (totally transparent)

The optical properties of films afterward were characterized using (OPTIMA SP-3000) spectrophotometer. The transmission spectrum in the visible light (200nm – 1100 nm)

The properties of the prepared conductive glass are summarized in table (1):

Table 1: The specifications of the conductive sheet.

Area of conductive glass	12x12cm^2
Film thickness	6 µm
Resistance	650 Ω

The films were characterized by means of structural, optical, morphological techniques. the x-ray diffraction studies were carried out using (XRD -6000) Labx, was supplied by SHIMADZU company to investigate the structure of deposited films, The grain size was estimated from these XRD spectra using the Scherer equation(1):[3].

$$D = \frac{0.9\ \lambda}{\beta\ COs\ \theta}$$

Where:-*D:* is the average grain size, λ: is the wavelength for X-ray source (X-ray source is CuKα with λ=1.5406Å), *β:* is the Full Width at Half Maximum (FWHM) of XRD peaks ,*θ*: is the Bragg angle .the X-ray diffractmeter use (CuK*α* radiation line of wavelength of 1.54 ˚A in 2*θ* range from 20◦ to 60◦ (Fig. 2).

The UV- Visible transmittance of the prepared SnO_2 thin film is measured using (OPTIMA SP-3000) spectrophotometer supplied by Optima Company, in the spectral range (200 - 1100) nm Fig. (3) ,For this the fundamental absorption coefficient (α) was evaluated using $\alpha = 2.303\ (\frac{A}{b})$ Where *A* is the absorbance and *b* is thickness of the film. Fig. [4] shows the variation of $(\alpha h\upsilon)^2$ versus hυ for SnO_2 thin film deposited at above 500 ˚c. The resultant value of Eg for Sno2 Slide is found to be about 3.75 eV indicating a crystal size is (16) nm. This expansion in the energy gap gives more evidence for the formation of the Sno2 Slide

The surface morphology of the films was observed using CSPM AA3000 AFM supply by Angstrom Company, root mean square (RM**S**) values of surface roughness and the crystallite size were estimated to study the effect of the deposition temperature Fig.(5).

Figure (6 a,6 b) shows a cross-section SEM image of the Sno2 Thin Films was using by SEM TESCAN VEGA ш CZECH, about (100- 200) nm.

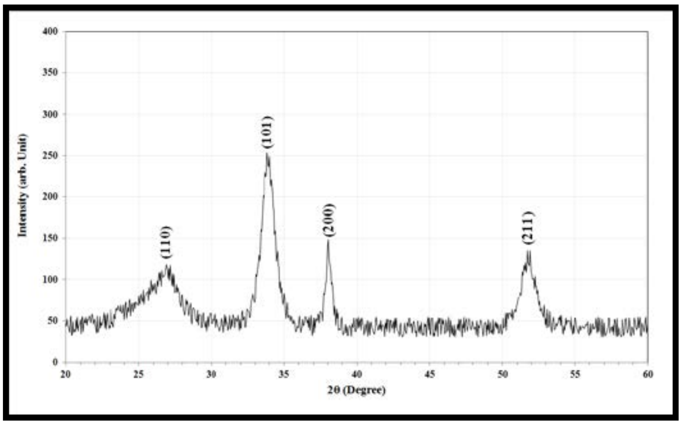
The electrical Conductivity of Sno2 Thin Films was determined by two point probe method at the temperature .The Variation Conductivity as a function of temperature were given in Fig (7).

3. Results

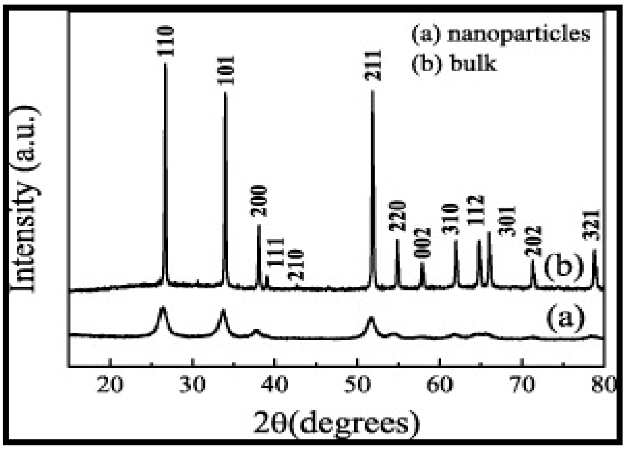
the XRD patterns of the SnO_2 thin films were studied to optimize the growth conditions. Figures 2(a) and 2(b) show the XRD spectra of the films , The peaks at 2? values of 26.6°, 33.8°, 37.9°, 51.8°.are associated with miler indices of (1 1 0), (1 0 1), (2 0 0), and (2 1 1) respectively.

The spectrum shows different diffraction peaks , but the (101) peak is the most obvious among the other crystal faces. This indicates that the SnO2 thin films have good orientation of preferred growth.

The UV- Visible transmittance of the prepared SnO_2 thin film Fig.(3). Show The instrument covers the range (200-1100 nm). The relative transmittance vary over the range (80 – 95) % in the region (400 -1100) nm.

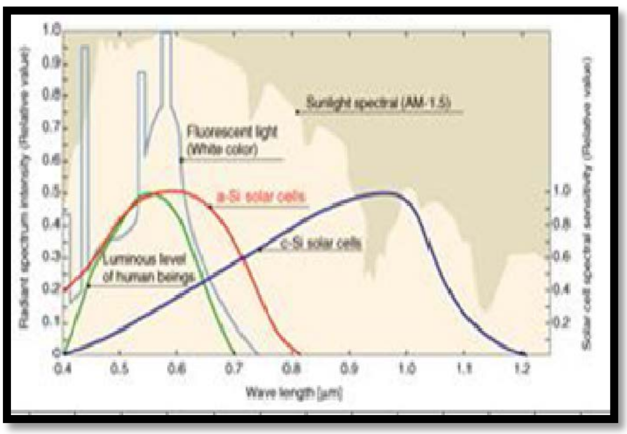


(a)

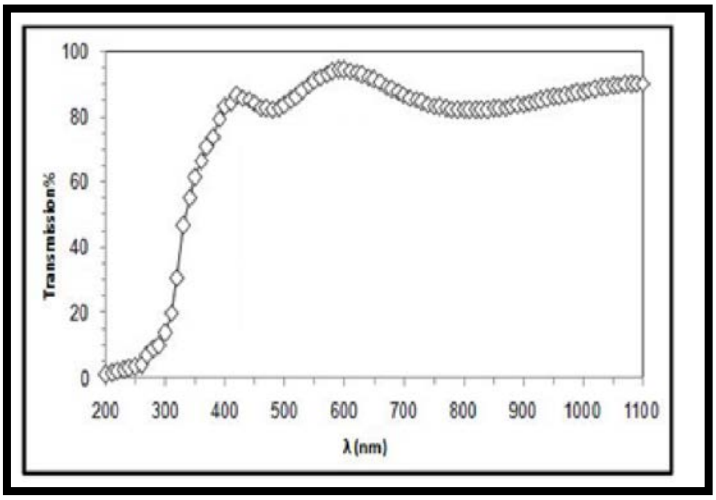


(b)

Figure 2: a comparison between: a- X-ray diffraction pattern for the prepared SnO_2 thin film and . b- A reported X-ray diffraction for nano particles and bulk SnO_2 [4].



(a)



(b)

Figure 3: (a)The normalized optical transmission spectrum of the conductive glass ,(b) The normalized optical transmission spectrum of the conductive glass compared to the solar cell spectral response [5]

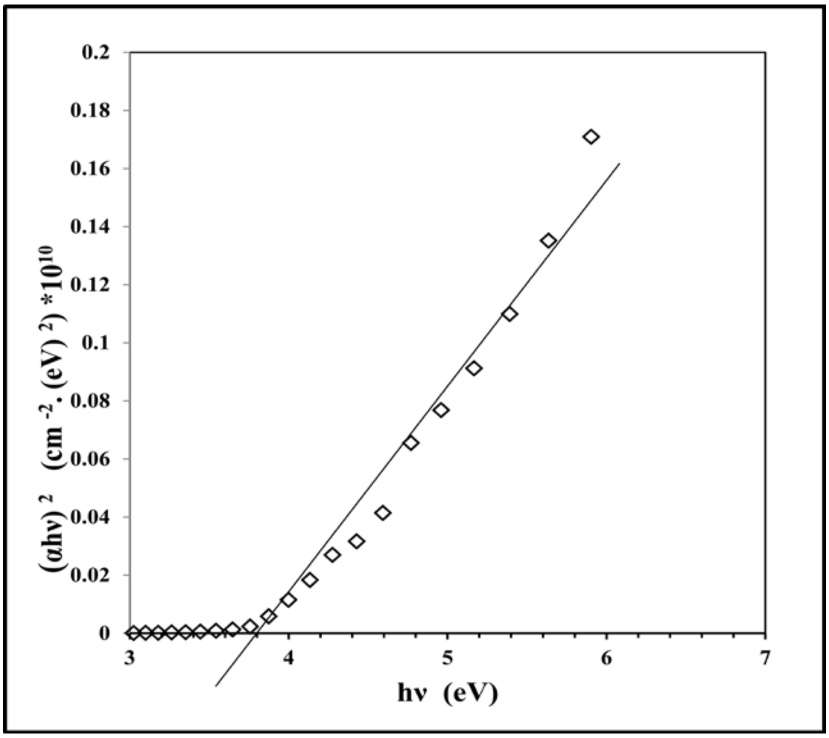


Figure 4: $(\alpha h\nu)^2$versus photon energy for Sno2 thin films

The surface morphology of the films (AFM) test showed that the average particle diameter of the prepared conductive glass surface was (183.8nm), root mean square (RMS) values of surface roughness and the crystallite size were estimated to study the effect of the deposition temperature (Fig. 5)[6].

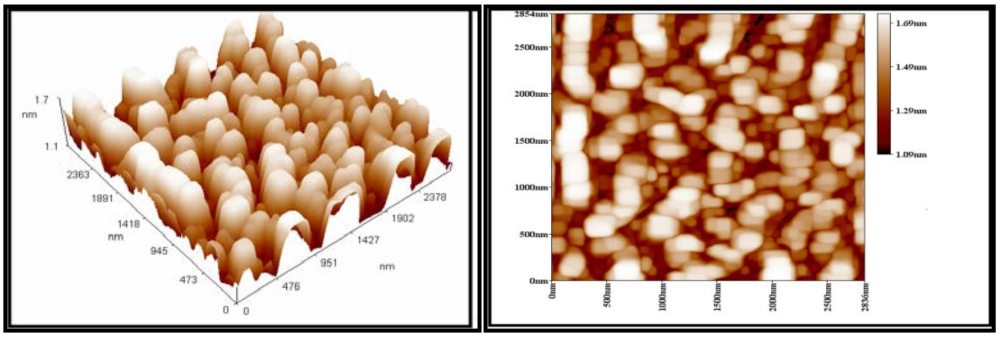


Figure 5: AFM image of SnO_2 thin film

The Figure (6 a) shows a scanning electron microscope SnO_2 thin film view of the shield before spreading the dust, the grain size is distributed over a relatively ranging from about (100- 200) nm. While figure (6 b) shows the same sample after spreading the dust particles from its top, here show the regular spreading of the dust .The grain size percentage distribution of shield after spreading the dust, the grain size is distributed over a relatively ranging from about (3-5) µm.

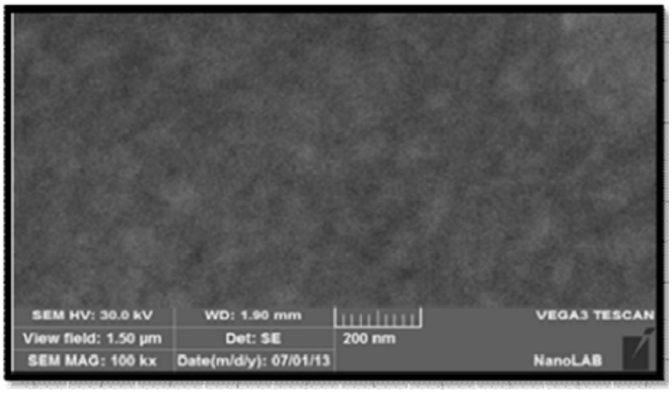


Figure 6 a: Scanning electron microscope photo of the clean shield

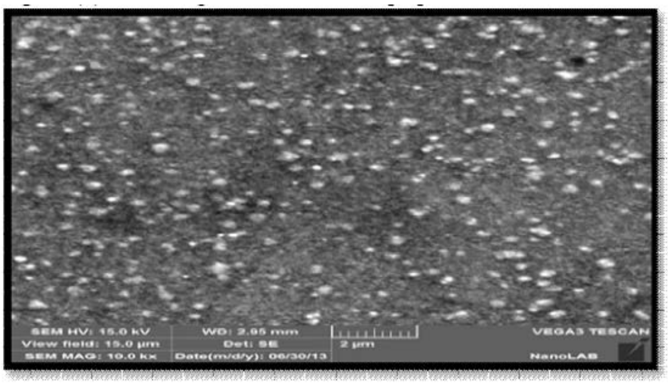


Figure 6 b: Scanning electron microscope photo of the shield after spreading the dust (white spots).

The electrical Conductivity of Sno2 Thin Films calculated from the plot of ln(σ) versus (1/T) , it can be seen that one or two activation energies , were consistent with thermally activated conduction and tunneling of the charge carriers respectively. Increased electrical conductivity continuing to thin film increasing the temperature and this semiconductor features where increasing concentration of charge carriers Increased temperature It was found that form the study of dc conductivity that there were two conduction mechanism which reveal that there is two activation energies the first had the values (0.022732 eV) and the second (0.04428 eV) and that the conductivity decrease as increase the temperature [7].

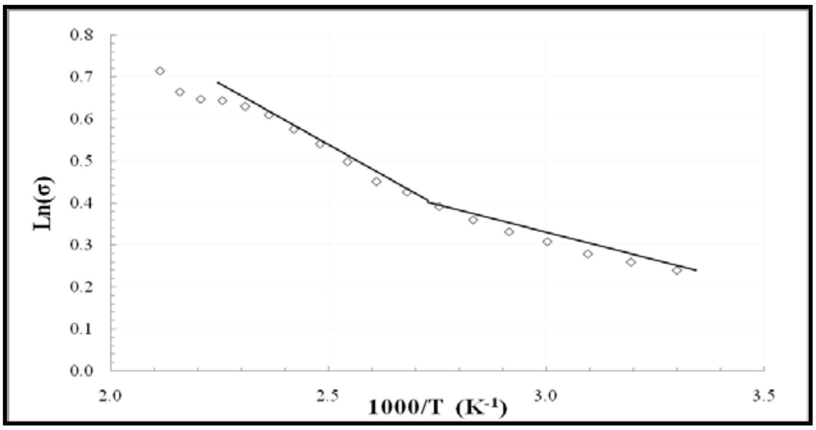


Figure 7: Variation of ln σ versus (1000/T) for SnO_2 thin films

The florescence spectra of the samples have been measured using SL174 spectrophotometer supplied by ELICO Company with the spectrum range from (200-800) nm as shown in figure (8).

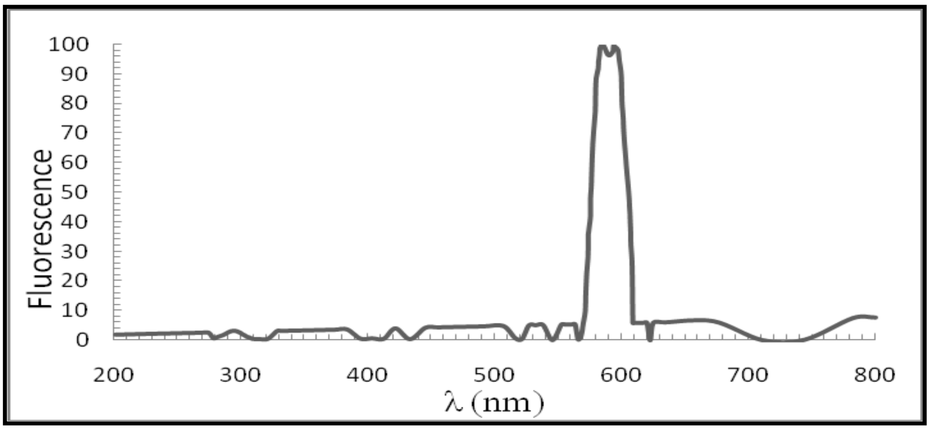


Figure 8: The fluorescence spectrum of the SnO_2 thin film

4. Conclusions

- A conductive glass for preventing the dust or the airborne particulate from depositing on the surface of the solar panels or different surface was prepared as a thin film from SnO_2 . The conductive glass was brought to contacts with the upper surface of the solar cell.
- For the first time in this field we showed that it is possible to use the direct current to energize the conductive glass.

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