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Characterization of Tin Oxide Doping Antimony Thin Layer With Sol-Gel Spin Coating Method for Electronic Device

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Abstract. Antimony tin oxide coating research has been carried out using a spin sol gel coating method with different doping concentrations of 0, 5, 10, 15, 20 %. The results of the study on the morphological structure (SEM) of thin films that have been carried out showed more cracks on the surface of the morphology of thin layers without doping compared to thin layers with doping antimony. The Results of crystal structure of XRD in thin antimony doping tin oxide layer shows the grinding index of tin oxide crystals, 101, 110, 211, 220. In grain size, with increasing antimony doping percentage, the average grain size decreases. The optical properties using UV-Vis in thin films of antimony tin oxide doping show samples including semiconductor materials that can be used as electronic devices as seen from the reduction of this energy gap from 3.680 to 3.574 eV. Also seen is an increase in the percentage of antimony doping and repetition of layers, the lower the transmissions value, but the value of absorbance of the thin layer increases.

Introduction

A thin layer is a layer consisting of material inorganic, organic, metal and organic metal mixtures with thicknesses in the order of micrometers to nanometer orders which have the properties of insulators, semiconductors, conductors, or superconductor [1].

Tin oxide in its development has been widely applied for example in solar cells, gas sensors and TCO (Transparent Conductive Oxides). This is the concern of scientists in the world, one of them is by trying to improve the electrical performance of the thin film through experimental doping percentage variations The results showed that tin oxide had several advantages, namely having a band gap width of around 3.5 eV [2], so that the electrons were quite easy to move. The thin layer also has high transparency in optical properties, low electrical resistance in electrical properties, high stability in the fields of mechanics, chemical resistance and toxic gas sensitivity [3,4,5].

These advantages can also be modified as needed by providing additional doping. Tin oxide is usually doped with indium [6], lithium [7] zinc [8],copperaluminum [9], flour [10], antimony and flour [11] as well as indium and palladium [12]. Antimony is one of the dopant elements that is quite good in the thin layer of tin oxide with several advantages, namely increasing the conductivity properties [13], reducing resistivity properties [14], improving optical properties [15], improving electrical properties [16], dopant for transparent material Conductor Oxide [17] and good response to sensor applications [18]. These advantages can be known by characterizing using several test equipment such as UV-Vis spectrophotometer, X-Ray Diffraction (XRD) and Scanning Electron Microscope (SEM) coupled with Energy Dispersive X-Ray (EDX).

This research uses sol-gel spin coating technique with several considerations, namely having a short crystallization process, low temperature use, nano particles, pure results [19] are economical and simple. Some parameters involved in the sol-gel spin coating technique are concentration of

solution, concentration of doping, rotational speed, turn around time, aging time, coating repetition and heat treatment.

Materials and Methods

The basic ingredients use tin (II) chloride dihydrate or $SnCl_2.2H_2O$ with purity of 98% Merck, a molar mass of 225.63 gr / mol. The doping material uses $SbCl_3$ or antimony (III) chloride with 99% purity and a molar mass of 228.1 gr / mol. Solvents use ethanol with purity of 98%, a molar mass of 46.07 gr / mol. The material used for deposition is a substrate made of glass measuring 5 x 15 x 15 mm. Stages of research include sol-gel making, thin film making, and characterization. Sol-gel maker uses antimony III chloride with variations in doping of 0, 5, 10, 15 and 20 %, dissolved in 20 ml ethanol. Then the solution is stirred using stirring magnetic at room temperature until the solution is homogeneous. Sol solution is divided into five parts namely 0, 5, 10, 15 and 20%. Then let stand for 48 hours. Making a thin layer using spin coater for 30 seconds with a speed of 2000 rpm. After that the substrate is heated for 10 minutes in an oven at 350 °C. Characterization was carried out using Scanning Electron Microscope (SEM) coupled with Energy Dispersive X-Ray (EDX) for morphological structure, crystal structure and a UV-Vis Spectrophotometer for the optical.

Results and Discussion

The results of characterization of tin oxide doping antimony can be explained using SEM, XRD, and UV-Vis equipment as follows. The results of the analysis using the SEM test coupled with the EDX seen in Fig. 1 (a) and 1 (b). For Fig. 1 (a) is the surface morphology of tin oxide thin layer with 0% doping antimony showing the surface to be fractured and broken. While for Fig. 1 (b) is a thin layer of tin oxide with doping of 20% antimony, the surface of the coating is smooth and flat. This surface is what in theory in semiconductors will produce electricity.

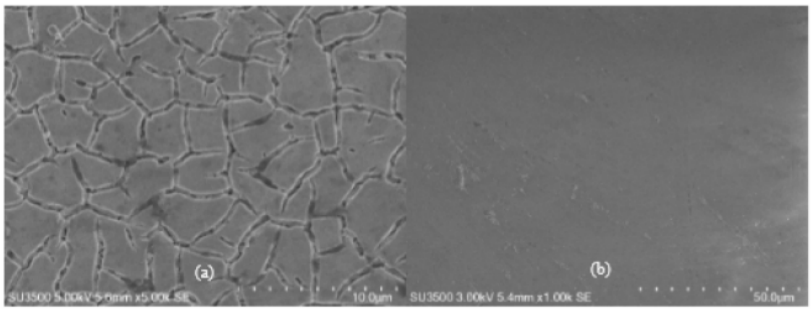


Fig. 1. Surface morphology of thin layer of tin oxide with doping (a) 0% Antimony and (b) 20% antimony.

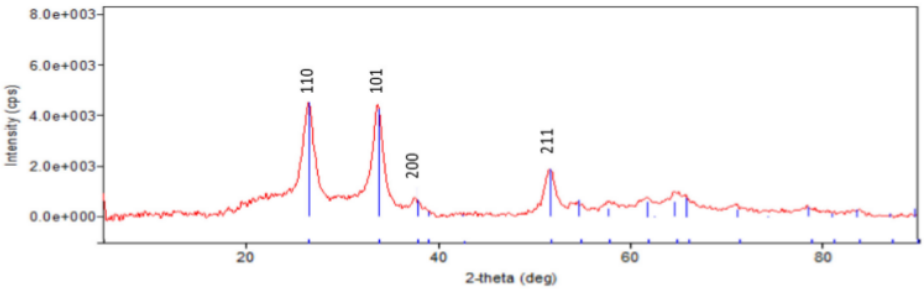
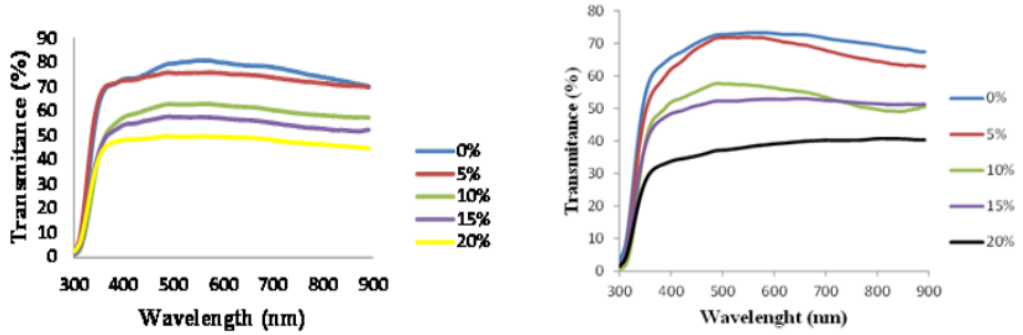


Fig. 2. Graph of the intensity of diffraction in the size of a crystal grain.

X-Ray Diffraction (XRD) to determine the orientation phase of crystals that have been formed. XRD results can be seen in Fig. 2. Fig. 2 shows a shift in peak position due to the addition of doping given to the thin oxide layer so that it affects the shape, size and structure of the crystals contained in the thin layer. The higher the percentage of doping given to the thin layer of tin oxide causes the size of the crystal grains to decrease.

The results of optical properties using UV-Visible at a wavelength of 300 - 800 nm. The highest transmittance is 80.93% at 0% doping percentage with 1 time layer repetition, while the lowest transmittance is 40.74% at 20% doping percentage with 3 times repetition of the layer (Fig. 3).



(a) (b)

Fig. 3. Graph of transmittance of thin film tin oxide variation doping antimony repetition: (a) one time and (b) three times.

The highest absorbance value is 0.65% at a percentage of 20% with three times the repetition of the layer while the lowest absorbance is at 0.10% at 0% doping percentage and one time repetition. The results showed that the increasing percentage of doping and repetition of layers, the transmittance value decreased while the value of absorbance increased as well as the repetition of layers.

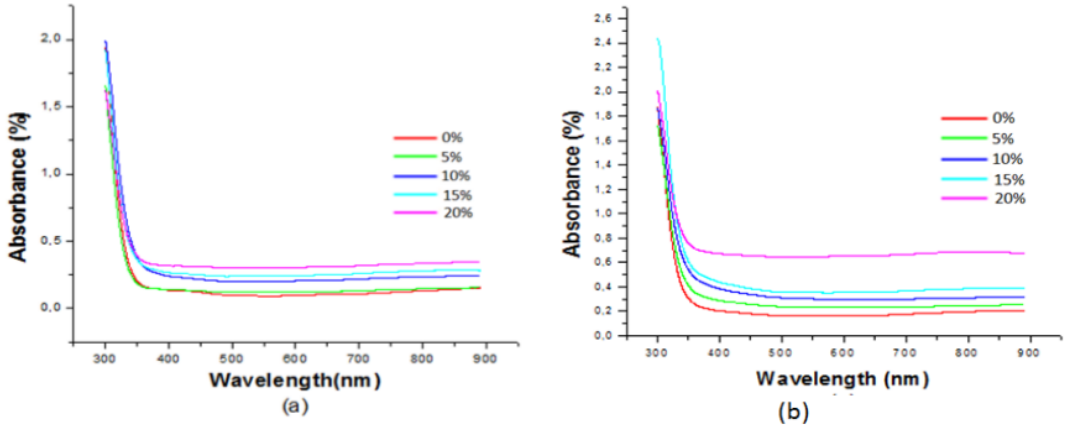
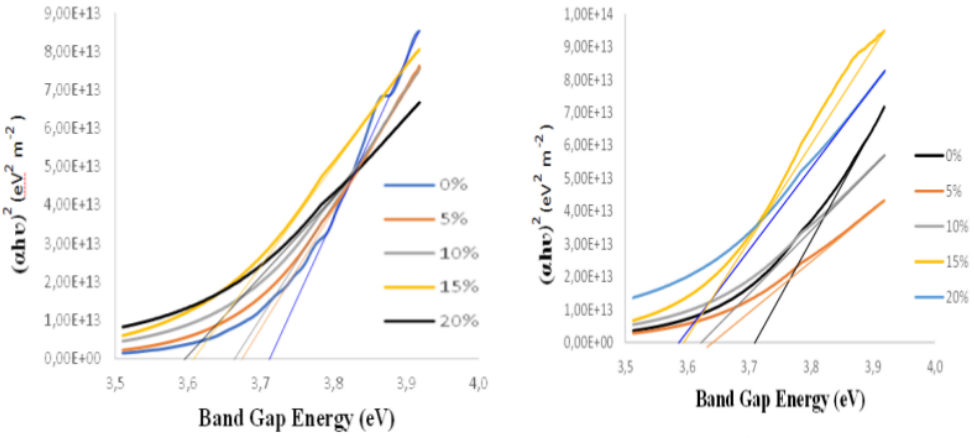


Fig. 4. Graph of absorbance of tin oxide thin film variation of antimony doping with variations in layer repetition: (a) one time and (b) three times.

The band gap energy value for the thin oxide layer with antimony doping of 0, 5, 10, 15, 20 % on the glass substrate was also obtained by looking for a linear regression relationship of $(\alpha hv)^2$ as a function of band gap energy, the following graph is obtained. Fig. 5(a) and 5(b) are showing band gap energy for all antimony doping concentration variations. In Fig. 5(a) the results of extrapolation

from the slope of linear regression obtained the band gap energy decreasing from 3.680 to 3.590 eV, with increasing antimony concentrations from 0% to 20%. While Fig. 5(b) is the result of the energy band gap which decreased from 3.680 to 3.574 eV with increasing antimony doping antimony concentrations from 0% to 20% for the repetition process three times the layer. The results of this band gap energy obtained show better than one layer. The data from the band gap energy corresponds to the results of the SEM testing coupeled with EDX where it is seen that the smooth surface of the samples shows a low band gap energy so that the conductivity is higher.



(a) (b)

Fig. 5. Band gap energy variation for doping with variations in layer repetition: (a) one time and (b) three times.

Conclusion

The morphological structure of thin layers using doping is seen to be less cracked compared to thin layers without doping. The index miller of the antimony doping SnO_2 layer has a index miller in accordance with tin oxide crystals, namely 101, 110, 220, 211. The percentage increase in antimony doping results showed the decrease in the average peak point of the grain size. The optical properties of thin films that have been successfully studied include the properties of the transmittance, absorbance, and energy gap values. The lower transmittance value indicates the absorbance value increases according to the percentage of doping and repetition of the layers. Furthermore, for the energy gap, it can be seen increasingly with the higher doping and the number of layers.

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