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Effect of Schottky Barrier and Amorphous Structure of Sno_2 Thin Film

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ABSTRACT:

To research the properties of SnO_2 thin films with various annealing conditions, SnO_2 was prepared by RF magnetron sputtering system and annealed in an atmosphere and in a vacuum for 10 minutes. All films were analyzed by the XRD, PL and I-V measurement systems. The crystalline of annealedSnO_2 films decreased with increase the annealing temperature, and the SnO_2 annealed at 200 ℃showed the amorphous structure. SnO_2 with amorphous structure improved the electrical properties owing the high potential barrier at a Schottky contact. The binding energy of Schottky contact was 530.4 eV.

Keywords: *XRD, Electrical Properties, SnO_2, Depletion region. Amorphous structure*

INTRODUCTION:

The transparent thin film must have high transmittance and high electron density, and wide band gap of 3.1 eV to be used for a transparent electrode. [1-4]It is known that there are various transparent electrode such as ITO (Indium Tin Oxide), zinc based oxide semiconductor, IGZO (Indium Gallium Zinc Oxide) SnO_2, and ZTO. [5-8]Generally, oxide semiconductor increases the conductivity owing the oxygen vacancy, and the characteristics of these oxide semiconductors were changed by the content of this oxygen vacancy. However, it was not clear to the correlation between charge carriers and a formation of oxygen vacancy to enhance the electrical properties. The electrical characteristics of device were closely related to the Schottky and Ohmic contacts.[9-11]

In this study, the annealing effect of SnO_2 was researched to Schottky contact and potential barriers. The annealing changed the structure and then chemical and electrical properties were changed. Therefore, the relationship between the amorphous structure and electrical properties of SnO_2 was also observed.

MATERIALS AND METHODS

SnO_2 thin films were prepared on p-type Si substrate by RF magnetron sputter with 70 W for 10 minute. As-deposited SnO_2films were annealed in an atmosphere condition and a vacuum for 10 minute. The annealing temperature was 100℃ and 200℃. Most specimens were analyzed by XRD, PL, XPS and I-V measurement system. Al electrode was deposited by the evaporating system. It was studied on the correlation between the electrical properties and the chemical shift. The effect of a Schottky contact and amorphous structure of SnO_2film was researched.

RESULTS

Figure1 is the XRD pattern of SnO_2annealed in an air. As-deposited film showed the high crystallinity, and the crystallinity decreased with increasing the annealing temperature. The depletion layer increased at the interface and finally, the SnO_2became an amorphous structure through the annealing process.

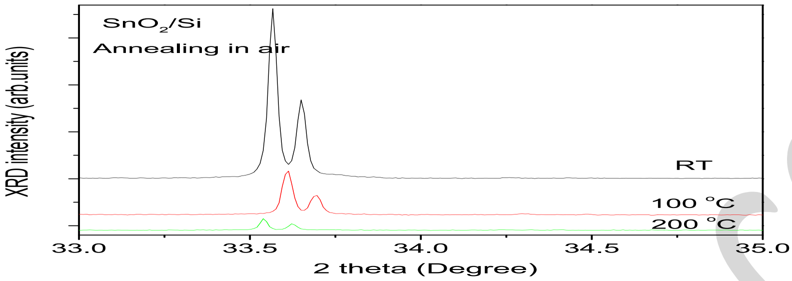

Fig. 1 XRD patterns of SnO_2 thin films after annealing process in an atmosphere pressure

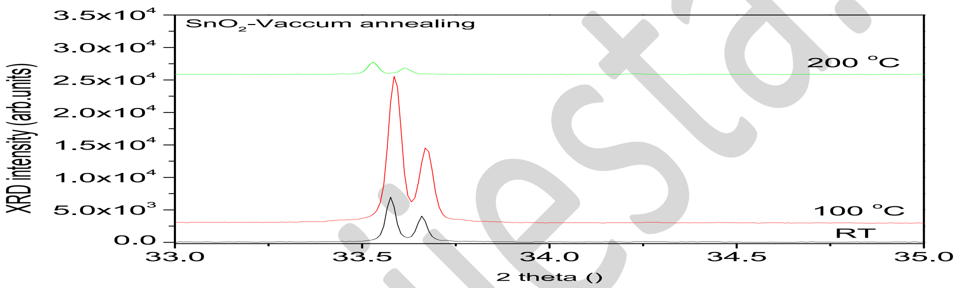

Fig. 2XRD patterns of SnO_2 thin films after annealing process in a vacuum

Figure 2 is the XRD pattern of SnO_2annealed in a vacuum. As-deposited film was a crystal structure, and the crystallinity of SnO_2annealed at 100 °C was the highest.

However, the SnO_2annealed at 200 °C was decreased because of the reduction of carriers and the formation of depletion region owing to the annealing process in a vacuum.

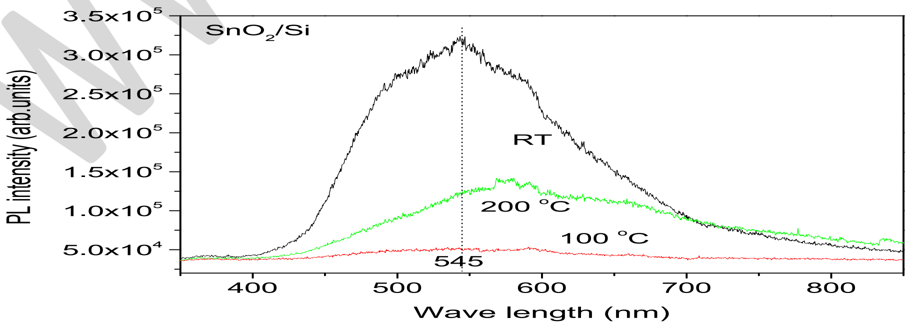

Fig. 3PL spectra of SnO_2 thin films after annealing process in an atmosphere pressure

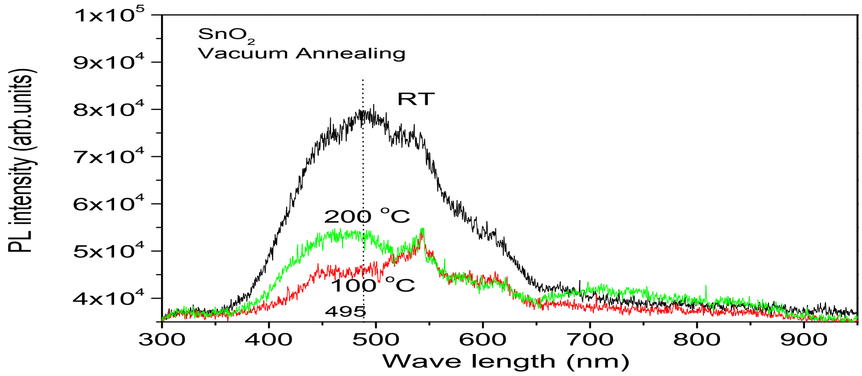

Fig. 4PL spectra of SnO_2 thin films after annealing process in a vacuum

Figure 3PL spectra of SnO_2 thin films after annealing process in an atmosphere pressure. The intensity of PL decreased with increasing the annealing temperature.

Figure4 is the PL spectra of SnO_2 thin films after annealing process in a vacuum. The intensity of PL spectra was also decreased with increasing the temperature as similar to figure 3. However, the chemical shift was different. The main peak of SnO_2 annealed in an air was 545 nm and that in a vacuum was 495 nm to shift lower wave length. Therefore, it could be prospected that the electrical properties of SnO_2 annealed in a vacuum become more performance.

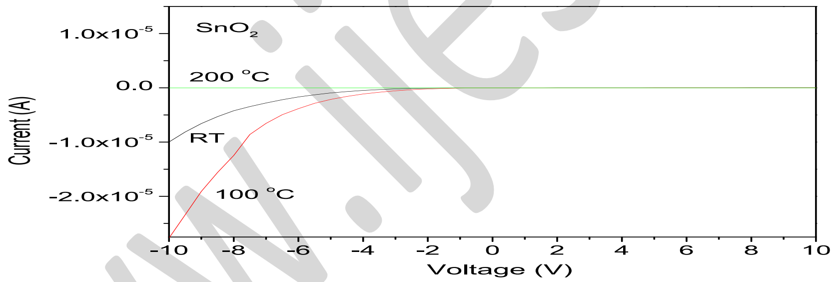

Fig. 5I-V characteristic of SnO_2 thin films after annealing in an air condition

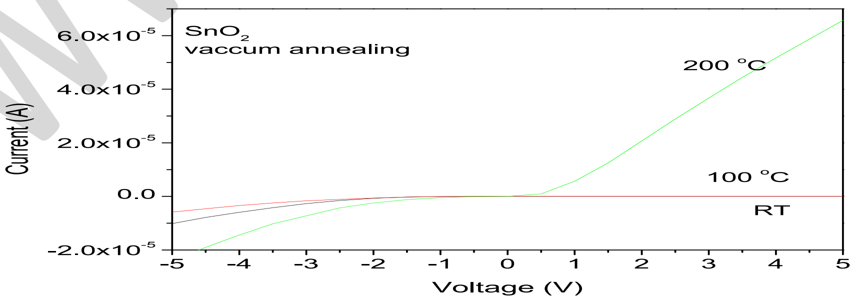

Fig. 6I-V characteristic of SnO_2 thin films after annealing in a vacuum

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Figure 5 explains the I-V characteristic of SnO_2 thin films after annealing in an air condition. The I-V curves are shown the non-linear Schottky contact. The reduction of gradient of I-V causes the depletion layer, which was increased with increasing the annealing temperature. That is, the depletion layer also means the Schottky barrier. So we could know that the Schottky barrier increased with annealing temperature.

Figure 6 is the I-V characteristic of SnO_2 thin films after annealing in a vacuum. Most showed the Schottky contact and the I-V curve of SnO_2 annealed in a vacuum was especially the bidirectional ambipoalr characteristics.

Figure 7 is the comparison between the current-voltage characteristics SnO_2annealed in an air and vacuum in accordance with the annealing temperatures.

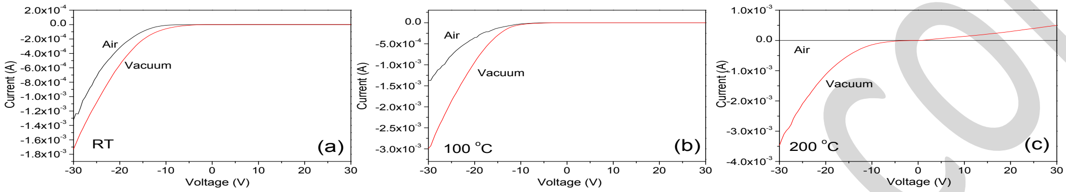

Fig. 7 Comparison between the current-voltage characteristics SnO_2annealed in an air and vacuum in accordance with the annealing temperatures.

Most samples demonstrated that the gradient of I-V curves of annealed in a vacuum was higher than that annealed in an air. Therefore, it was confirmed that the amorphous structure enhanced the electrical properties of SnO_2films.

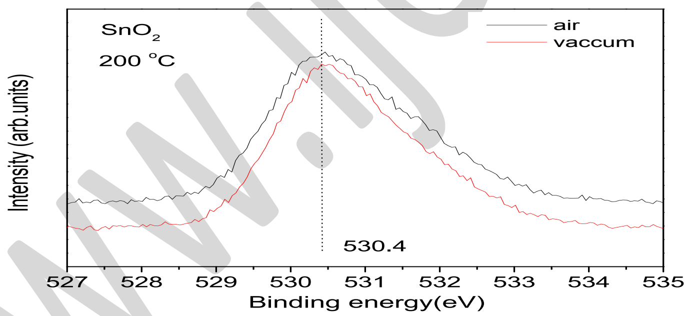

Fig. 8.O 1s spectra of SnO_2 thin films depending on various annealing process at 200 ^oC

Figure8 is the O 1s spectra of SnO_2 thin films depending on various annealing process at 200 ^oC. The binding energy indicated 530.4 eV, and this result was the same of XRD pattern of amorphous structure SnO_2films. Besides, the 530.4 eV elucidates a Schottky contact as a potential barrier.

DISCUSSION

To research the characteristics of SnO_2 thin film, the $SnO_2$was deposited by RF magnetron sputtering system and annealed by various conditions such as air and vacuum. The SnO_2films became an amorphous structure with annealing process, and the electrical properties of annealed films improved owing to the Schottky barrier. The ideal ambipolar properties were obtained at high degree of amorphous structure.

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