Study on the change of performance of a-IGZO TFTs depending on processing parameters

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Abstract : Thin-film transistors (TFTs) were fabricated using amorphous indium gallium zinc oxide (a-IGZO) channels by rf-magnetron sputtering at room temperature. We have studied the effect of oxygen partial pressure on the threshold voltage(V_{th}) of a-IGZO TFTs. Interestingly, the V_{th} value of the oxide TFTs are slightly shifted in the positive direction due to increasing O_2 ratio from 1.2 to 1.8%. The device performance is significantly affected by varying O_2 ratio, which is closely related with oxygen vacancies provide the needed free carriers for electrical conduction.

Key Words : a-IGZO, Oxide TFT, channel, O2 partial pressure, transistor, threshold voltage

1. Introduction

Amorphous In-Ga-Zn-O (a-IGZO) has been tremendously investigated for its practical applications because it is related with the superb optical and electrical properties. It is well known that oxide semiconductor properties are highly dependent on their oxygen content, since oxygen vacancies provide the needed free carriers for electrical conduction[1]. The threshold voltage(V_{th}) parameter due to varying O_2 partial pressure described as the electrical properties of a-IGZO TFTs is the purpose of this work.

2. Experimental

In the present work, a-IGZO films were deposited on SiO_2 (100nm)/Si substrate using conventional rf-magnetron sputtering. We employed input rf power of 100W in Ar and O_2 mixing gases as fixed total pressure of 0.67Pa. The O_2 gas content was varied from 1.2% to 1.8%. All electrical characterizations were carried out using a semiconductor parameter analyzer in the dark at room temperature measured on devices with a electrode width of 50㎛ and a channel length of 100㎛.

3. Results and Discussion

The representative transfer characteristic of a-IGZO TFT with varying O_2 partial pressure and drain-to-source voltage (V_{DS})=10V are showed in Fig. 1. All of the TFTs are n-channel and operate in enhancement mode (i.e., $V_{th}>0$). The V_{th} was defined by the linearly fitting the square root of I_D vs.V_G curve of the transistor operating in the saturation region. Following is the expression for the operation of a field effect transistor in the saturation region.

$$I_D = \left(\frac{C_i \mu_{sat} W}{2L}\right)(V_G - V_{th})^2 \quad for \quad V_D > V_G - V_{th} \qquad (1)$$

where W is the channel width, L is the channel length, Ci is the capacitance per unit area of the gate-insulator. Interestingly, the V_{th} value conspicuously shifted in the positive direction from 2.0 to 9.1 V as O_2 ratio is increasing from 1.2 to 1.8%. The containing O_2 compensate for the oxygen vacancies like a p-type dopant.

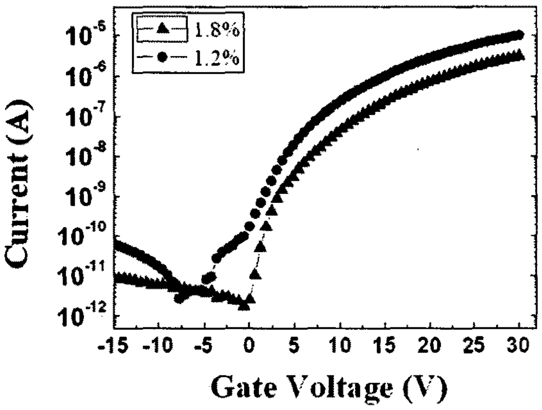

Fig. 1 Variation of V_{th} as a function of O_2 partial pressure (t_{active} 50nm)

4. Conclusions

Effect of O_2 partial pressure has been clearly observed to manipulate the V_{th} value of TFTs.

Acknowledgments

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References

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