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\cite{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$\mu$m and a channel length of 100$\mu$m.

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., $V_{gs}$>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.

$$I_D = \left( \frac{C_{ox}W}{2L} \right) (V_G - V_{th})^2 \quad \text{for} \quad V_G > V_D > V_{th} \quad (1)$$

where $W$ is the channel width, $L$ is the channel length, $C_{ox}$ 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 (1.2%, 1.8%)](image)

4. Conclusions

Effect of O$_2$ partial pressure has been clearly observed to manipulate the $V_{th}$ value of TFTs.

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References