The impact of ALD ZrO_2 gate insulators on Indium Tin Zinc Oxide (ITZO) thin film transistor applications

Wan-ho Choi, hyun-jun jung, Jiazhen sheng, jung-hun lee, and Jin-Seong Park*

Division of Materials Science and Engineering, Hanyang University, Seoul, Korea
(*Corresponding authors: jsparklime@hanyang.ac.kr)

High-k dielectric materials have been extensively studied in the memory semiconductor and display industries. Especially in the field of displays, high-k materials should be studied for low-voltage operation. Especially, due to the leakage current of the high-k materials, it is necessary to study the high-k dielectric layer using atomic layer deposition (ALD) to obtain excellent insulating layer characteristics. In this study, ZrO_2 films were deposited at various temperatures by ALD.

The MIM and MIS structures were fabricated using the deposited ZrO_2 thin films to investigate the dielectric properties of the films. In order to measure the performance of the device, a thin film transistor(TFT) of back-channel-etching (BCE) structure using In-Sn-Zn-O (ITZO) was fabricated. Leakage current density of 200,250 and 300°C is 7.5×10^{-8}, 2.9×10^{-8} and 3.6×10^{-8} and k value is 17.4, 21,4 and 23.0, respectively . TFT with ZrO2 showed mobility of 23.4, 7.0, and 4.16 at 200, 250, and 300 °C and hysteresis of 0.13, 0.02, and 0.04 with subthreshold swing of 0.19, 0.15, and 0.16, respectively. And the constant current stress (CCS) test was conducted to confirm the suitability as a driving transistor. The higher the deposition temperature of ZrO_2, the better the reliability.

To figure out the differance of TFT performance, XRD and XPS were conducted. Comparing the surface composition through XPS, the ZrO_2 thin film deposited at 200 ° C showed more than two times higher composition of C than the other temperature set. Due to this impurity, defect-assist leakage mode is dominent and that increase the leakage current density. The XPS O1s spectra show that the O-deficient peak associated with Vo is the highest in the thin film deposited at 200 ° C, indicating that the mobility of the device is high and the reliability is poor.

Table 1. Surface composition analysis of ZrO_2 thin films by XPS analysis

Element	200	250	300
Zr	33.9 %	36.4 %	36.9 %
O	57.8 %	59.8 %	60.1 %
C	8.3 %	3.8 %	3.0 %

Figure 1. transfer curve of ITZO TFTs with ALD ZrO_2 deposited at (a) 200, (b)250 and (c)300°C