HAFNIUM OXIDE-BASED FERROELECTRIC THIN-FILM TRANSISTOR WITH a-InGaZnO CHANNEL FABRICATED AT TEMPERATURES ≤ 350°C

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HfO_2-based ferroelectric materials integrated with oxide-based thin-film transistors have been considered as potential candidates for back-end-of-line compatible ferroelectric field-effect transistors, which can be vertically stacked on silicon CMOS circuits to realize high-density neural network applications. However, the formation of ferroelectric orthorhombic phase in HfO_2-based materials usually requires an annealing temperature of 400°C or higher. In this work, ferroelectric thin-film transistors (Fe-TFTs) were developed by monolithically integrating HfZrO2 (HZO) ferroelectric capacitors with amorphous indium-gallium-zinc oxide (a-IGZO) TFTs at a maximum processing temperature of 350°C on a glass substrate. A butterfly-shaped C-V curve was clearly observed in the low-temperature annealed metal-HZO-metal capacitor, indicating the formation of ferroelectricity in the HZO layer, as shown in Fig. 1. The positive and negative coercive voltages were 3 V and -2.4 V, respectively. The dielectric constant was 20.65. The field-effect mobility, threshold voltage, subthreshold swing and on/off current ratio of the a-IGZO TFT extracted from the transfer characteristics shown in Fig. 2 were 6.15 $cm^2V^{-1}s^{-1}$, 1.5 V, 0.1 V/dec and 4.3×10^7, respectively. Fig. 3 shows the transfer hysteresis curves of the low-temperature Fe-TFTs in a metal-ferroelectric-metal-insulator-semiconductor configuration. The Fe-TFTs exhibited large hysteresis memory windows of 2.8 V and 3.8 V when the area ratios between ferroelectric capacitors and gate insulators (A_{FE} / A_{DE}) were 1/8 and 1/12, respectively. The result shows a great potential for back-end-of-line compatible memory applications.

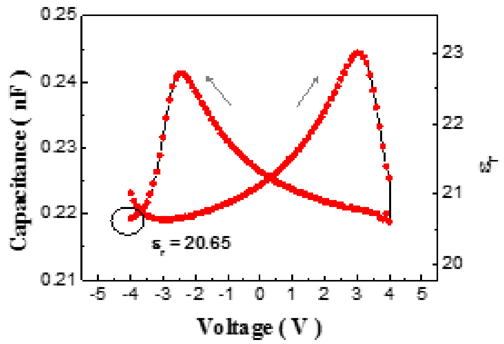

Figure 1 – Capacitance-voltage curve & dielectric constant of low-temperature annealed HZO ferroelectric capacitor.

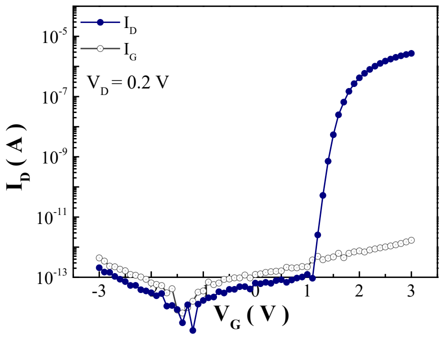

Figure 2 –Transfer characteristics of the inverted-staggered IGZO TFT measured at VDS = 0.2 V.

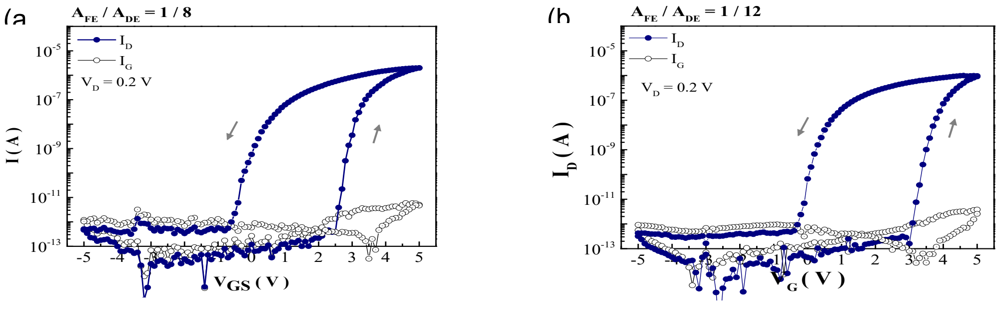

Figure 3 – Transfer hysteresis curves of on-glass HZO FeTFTs with (a) A_{FE} / A_{DE} = 1 / 8 and (b) A_{FE} / A_{DE} = 1 / 12. The Fe-TFTs are operated at VDS = 0.2 V.