Influence of $Al_2O_3/In_{0.76}Si_{0.24}O_{0.99}C_{0.01}$ interface on reliability for oxide thin film transistor

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Recently, influence of dipole and fixed charge of SiO_2/Al_2O_3 interface on threshold voltage (V_{th}) control has been reported in back-gate-type Indium oxide (InO_x)-based thin film transistors (TFTs) with SiO_2/Al_2O_3 dielectric [1]. Previously, effect of In-Si-O film as a new InO_x-based channel material on stability of transistor properties was demonstrated [2]. Here, we pay attention to characteristics at interface between the Al_2O_3 dielectric and $In_{0.76}Si_{0.24}O_{0.99}C_{0.01}$ (ISOC) channel of ISOC TFT with Al_2O_3 dielectric. In this paper, we focus on the reliability of bottom-gate-type ISOC TFT with Al_2O_3 dielectric.

The bottom-gate-type ISOC TFTs were fabricated as follows. At first, Pt gate electrode was patterned on Si/SiO_2 substrate using photolithographic process. Next, a 30-nm-thick Al_2O_3 film was deposited on Pt gate electrode by ALD at 300 °C using TMA precursor and H_2O gas and was annealed at 300 °C in O_2. A 10-nm-thick ISOC film was subsequently deposited on Al_2O_3 film by sputtering using SiC and In_2O_3 targets and was annealed at 300 °C in air. The Au (100 nm)/Ti (10 nm) source/drain electrodes were patterned on ISOC film and was finally annealed at 250 °C in O_3.

Fig. 1 shows typical I_d-V_g properties of the TFT with Al_2O_3 dielectric. The V_{th}, on/off current ration and filed-effect-mobility value of Al_2O_3/ISOC TFT were -0.3 V, 6.4×10^8 and 15.2 cm^2/Vs, respectively. The lower subthreshold swing (SS) of 88.5 mV/decade was obtained. Negative gate bias stress was applied to examine stability of transistor properties of Al_2O_3/ISOC TFT. The change of V_{th} (ΔV_{th}) increased with increasing the V_g-V_{th} (Fig. 2 (a)). The ΔV_{th} in Al_2O_3/ISOC TFT was -4.6 V at a stress time of 3 h when V_g-V_{th} was applied -10 V. This suggested that the ISOC channel body was depleted, and the holes near the Al_2O_3/ISOC interface were trapped by deep donor-like trap states, which were oxygen-vacancy-related defect states, as shown in Fig. 2(b) [3].

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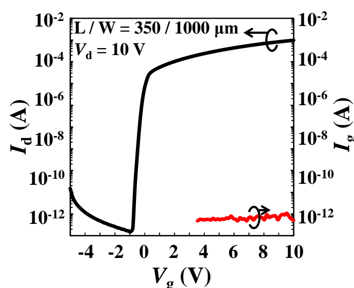

Figure 1 I_d-V_g and I_g-V_g characteristics of the Al_2O_3/ISOC TFT. The SS was 88.5 mV/decade.

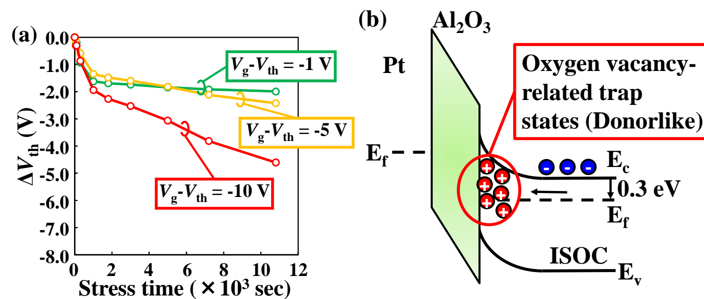

Figure 2 (a)The ΔV_{on} as a function of stress time under NBS and (b) a band diagram of Al_2O_3/ISOC TFT.