Anomalous Increase of Field-Effect Mobility in In-Ga-Zn-O Thin-Film Transistors Caused by Dry-Etching Damage Through Etching-Stopper

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In-Ga-Zn-O (IGZO) thin-film transistors (TFTs) have been received great attention for use in next-generation active-matrix displays because it exhibits higher electron mobility (μ>10 cm^{2}V^{-1}s^{-1}) as compared with conventional amorphous Si TFTs [1]. Bottom-gate structure with an etching-stopper (ES) is widely utilized for the IGZO TFTs. In this research, we report the influence of plasma induced damage during dry-etching (D/E) of source/drain (S/D) electrodes on field effect mobility (μ) of the IGZO TFTs.

The detail fabrication process of the IGZO TFTs was reported elsewhere [2]. The thickness of SiO_x-ES layer, which was deposited by plasma-enhanced chemical vapor deposition (PE-CVD), was varied from 100 to 200 nm to change the channel protection ability against the S/D-D/E process. The indium-tin-oxide (ITO) as S/D electrodes were patterned by D/E or wet etching (W/E). For the D/E, an inductively coupled plasma etching was used in a mixed gas of CH_4/Ar with substrate bias of 60 W. Finally, the TFTs were post-annealed in N_2 at 250 °C for 1 hour.

Fig. 1 shows the transfer characteristics of the IGZO TFTs with (a) ES:100nm+S/D-W/E, (b) ES:100nm+S/D-D/E and (c) ES:200nm+S/D-D/E. The channel width and length (W/L) of Fig. 1 were 50/20 (μm). When the ES thickness was 200 nm, the μ of S/D-D/E TFT was almost same as the TFT with S/D-W/E. However, μ of the S/D-D/E TFT increased to around 30 cm^{2}V^{-1}s^{-1} when the ES thickness reduced to be 100 nm. This result suggests that the S/D-D/E induced damage caused an anomalous increase of the μ of the TFT when the ES thickness reduced. Fig. 2 shows the results of transfer length method (TLM) obtain from those TFTs. For the TFTs with ES:200nm+S/D-D/E and ES:100nm+S/D-W/E as shown in Fig. 2-(a) and (c), L dependence and intersection of the resistances are clearly obtained from the slopes at different gate voltages. However, the TFT with ES:100nm+S/D-D/E, which observed an anomalous increase of μ, was not able to identify the channel length dependence as shown in Fig. 2(b). These results suggest that plasma induced damage into the IGZO channel through thinner ES-layer, and it influenced on the channel resistance, result in an overestimation of μ.

The detailed mechanisms for the anomalous increase of μ will be presented at the conference.

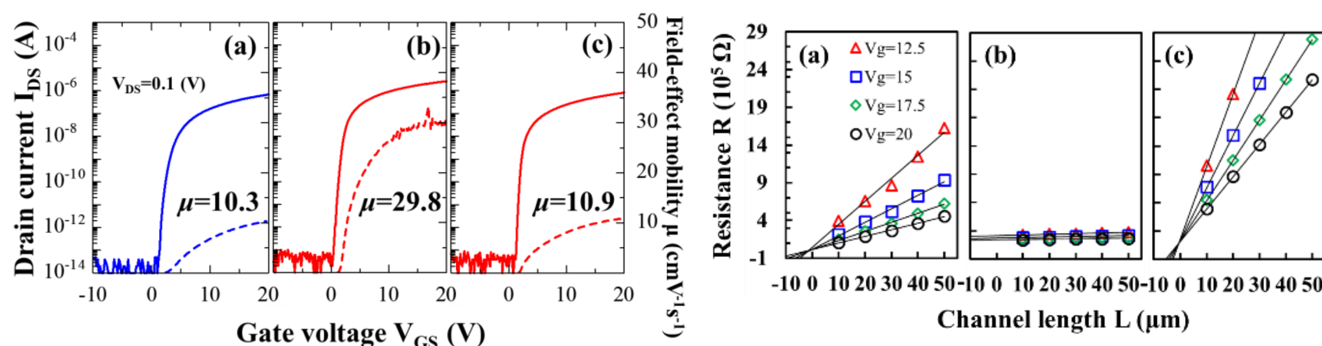

Fig. 1. Transfer characteristics of the IGZO TFTs with (a) ES:100nm+S/D-W/E, (b) ES:100nm+S/D-D/E, and (c) ES:200nm+S/D-D/E

Fig. 2. TLM results of the TFT with (a) ES:100nm+S/D-W/E, (b) ES:100nm+S/D-D/E, and (c) ES:200nm+S/D-D/E

References

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