Temperature-dependency of the Donor Creation under Positive Gate and Drain Bias Stress in Self-Aligned Top-Gate a-InZnO TFTs

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Positive gate and drain bias stress (PGDBS)-induced instability is one of the most important issues in the oxide thin-film transistor (TFT)-driven active-matrix organic light-emitting diode (AMOLED) display backplanes. Moreover, the self-aligned top-gate oxide TFT has attracted much attention as a promising device structure for high-definition high frame rate displays due to a high current drivability and low RC delay [1-2]. However, the temperature-dependence of PGDBS-induced instability of high-mobility oxide TFTs has been rarely investigated.

In this work, the temperature-dependency of PGDBS-induced threshold voltage shift (ΔV_T) in the high-mobility amorphous indium-zinc-oxide (a-IZO) TFTs is investigated. The negative ΔV_T is observed under PGDBS (V_{GS}=V_{DS}=13 V) [Fig. 1(a)~(f)]. By using the extracted subgap density-of-states, we show that the negative ΔV_T results from the donor creation which originates from the oxygen vacancy ionization ($V_o \rightarrow V_o^{2+} + 2e^-$) [Fig. 1(g)]. The magnitude of ΔV_T increases either with the increase of temperature or with wider TFT channel width [Fig. 1(a)~(d)]. In addition, the magnitude of ΔV_{TR} (ΔV_T readout condition interchanging the source and drain in comparison with those during PGDBS) is prominently larger than that of ΔV_{TF} (ΔV_T readout condition maintaining the positions of source and drain in comparison with those during PGDBS) [Fig. 1(e)~(f)].

It is found that the temperature-dependenc of ΔV_T is attributed to more activated impact ionization followed by the donor creation (V_o^{2+} creation) [3]. It suggests the electron mean free path (l_c) during PGDBS becomes longer with the increase of temperature [Fig. 1(h)]. It is consistent with the thermal release of trap-limited conduction and percolation mobility model [4]. It is also shown that the TFT width-dependence and the difference between ΔV_{TR} and ΔV_{TF} are due to the more activated donor-creation by self-heating and the local donor-creation, respectively.

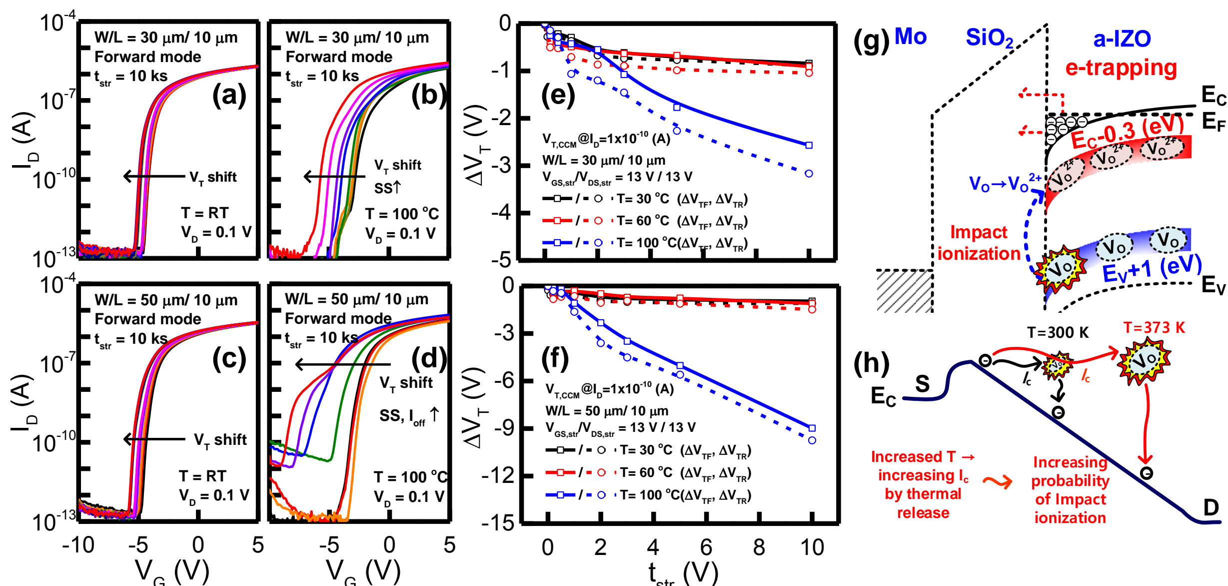

Fig. 1(a)-(f) I_D-V_G and ΔV_T under PBS with various temperature and width as stress time (g) vertical (h) lateral energy band diagram

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