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Subgap DOS-based analysis on the electrical/mechanical stress-induced degradation of flexible IGZO TFTs

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Indium-gallium-zinc-oxide (IGZO) thin-film-transistors (TFTs) have advantages, such as high mobility (>10 cm^2/Vs), large-area uniformity, and optical transparency (E_g > 3.0 eV), and are also suitable for wearable/IoT applications due to their compatibility wtih a low-temperature process on flexible/stretchable substrates. For the instability-aware design, the electrical stress-induced instability of IGZO TFTs needs to be separately investigated from the mechanical stress-induced one. However, the experimental study discriminating the electrical stress from the mechanical stress has been rarely reported. In this work, the positive bias stress (PBS)-induced thershold voltage shift (ΔV_T) of IGZO TFT with Al_2O_3 gate insulator (GI) is investigated based on experimentally extracted subgap density-of-states (DOS) with the comparison between the flat and tensile stress conditions (bending radius = 20 mm), as shown Fig. 1(a).

Measured transfer curves and ΔV_T are shown in Fig. 1(a) and (b). The PBS-induced ΔV_T increases and saturates or decreases again while it is larger in tensile stress condition than in a flat condition. In order to analyze the mechanical stress-dependence of the PBS ΔV_T, the subgap DOS is extracted before and after PBS (Fig. 1(c)) by using the photoresponse of C-V characteristic [1]. Typically, in the case of SiO_2 GI, a positive PBS ΔV_T is observed due to the charge trapping. However, when the Al_2O_3 is used as GI, the hydrogen migration becomes dominant after a lapse of PBS time [2] while the ΔV_T in the early PBS time is dominated by charge trapping. Especially in the tensile stress, the interface charge trapping is more dominant than the broken bond of Al_2O_3 (AlO-H➔AlO+H) at the beginning of PBS and the ΔV_T decreases again after 700 seconds because more hydrogen bonds of Al_2O_3 are broken and the resulting hydrogens migrate into IGZO film and subsequently are combined with oxygens, which results in donor creation ($H+O^{2-}$➔$-OH+e^-$). Therefore, the PBS-induced donor creation becomes more activated in tensile stress rather than in the flat condition (Fig. 1(c)). Our approach shows the feasibility of systematic anaysis on the electrical/mechanical stress-induced degradation of IGZO TFTs.

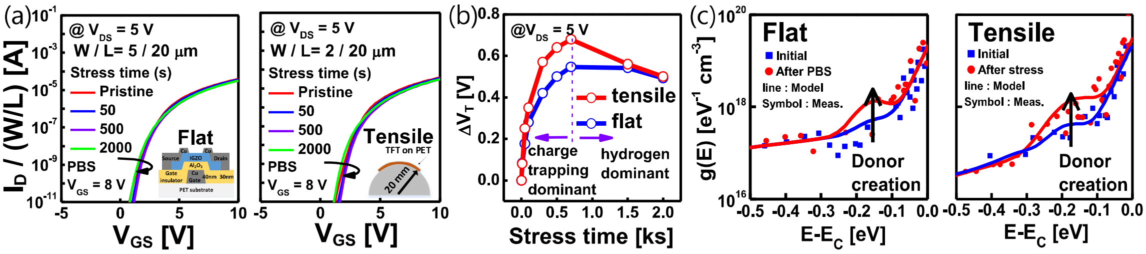

Fig. 1. (a) Transfer curves. Inset shows flat and tensile stress conditions, (b) ΔV_T, and (c) Extracted subgap DOS of IGZO TFTs under PBS

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