Ionic Liquid Gating effects on a-IGZO Thin Film Transistors: A Novel Method for Amorphous Metal Oxide Activation

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Ionic liquid (IL) gating is a powerful technique for accumulating large carrier densities at the liquid-solid interface. The reason for this effect lies in the fact that ILs form a thin electric double layer at the IL-solid interface; consequently they can generate extremely high electric fields by introducing exceptionally large charge densities at the interface. However, the gating efficiency of any IL gated device depends on various factors including but not limited to, gating voltage, temperature, IL capacitance, gate electrode geometries, etc.. We report IL gated thin film transistors (TFTs) based on amorphous Indium Gallium Zinc Oxide (a-IGZO) active layers with excellent a field effect mobility of 14.20 $cm^2V^{-1}s^{-1}$, and a threshold voltage of 0.5 V. The effect of IL gate electrode size in the co-planar side gate geometry on gating efficiency of the device has also been studied. As the ratio of IL gate electrode size to channel area increased from 1:1 to 10: 1, the TFT current was increased up to one order in magnitude. Furthermore, we report controllable activation of a-IGZO channel using IL gating at room temperature. Activation is controlled by electric field-induced oxygen migration across the ionic liquid-semiconductor interface. Finally, we demonstrate a transparent flexible thin film metal oxide transistor on a polyamide substrate created using this simple technique (see Figure 1). This study demonstrates the potential of field-induced activation as a promising alternative to traditional post-deposition thermal annealing which opens the door to wide scale implementation into flexible electronic applications.

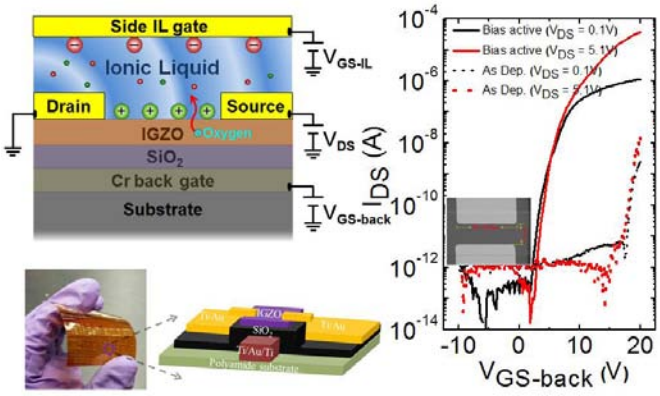

Figure 1: Field induced activation of amorphous indium gallium zinc oxide for flexible transparent TFT application: Schematic cross-section of the dual-side gated a-IGZO TFT on a silicon substrate used for field induced activation testing (upper left). Optical micrograph and schematic of the fabricated flexible a-IGZO TFT on polyamide substrate (lower left) via IL field induced activation method. Electrical characteristics (Transfer curves) for the field induced activated TFT (right). The corresponding curves for the as deposited device are also plotted for comparison.