Improvement the Electrical Characteristics of Thin Film Transistors Utilizing an Ultra-thin High Conductivity Layer at the Active/Insulator Interface

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Amorphous oxide semiconductor based thin film transistors (AOS TFTs) are promising candidates to replace silicon-based TFTs [1]. Since the first time reported in 1995 [2], indium tin zinc oxide (ITZO) is a potential use as a transparent AOS for optoelectronic devices. In spite of the ITZO TFT optimization processes, further investigation is needed to improve both of the mobility and stability of the devices. This study examines the performance and the bias stability of double-channel ITO/ ITZO TFTs. A flat ITO films with 5 nm-thick is inserted in an ITZO active channel using DC sputtering system to exploit the high mobility properties of ITO films. The electrical properties of the double-channel device are improved in compared with the single – ITZO or ITO – channel device. The transfer characteristics of TFT using single ITO or ITZO, and double ITO/ITZO active layer have shown in Fig. 1(a). The insert of ultra-thin ITO layer on ITZO TFTs exhibit superior field effect mobility (approximately ~75.5 cm^2/Vs) to that of the ITZO only TFTs (~33.4 cm^2/Vs). The improvement of electrical properties are shown not only in field effect mobility but also in other parameters such as subthreshold slope (SS = 0.39 V/dec), ON/OFF current ratio (I_{ON}/I_{OFF} = ~10^8), and interface trap density ($N_{it} = 7.88\times10^{11}$ cm^{-2}) in comparison with the single ITZO active layer (SS = 0.56 V/dec, I_{ON}/I_{OFF} = ~10^7, and $N_{it} = 1.82 \times 10^{12}$ cm^{-2}). Furthermore, the threshold voltage shifts for the ITO/ ITZO double layer device decrease from 6.63 and -6.79 V (for ITZO only device) to 1.35 and -2.69V under positive and negative bias stress, respectively (Fig. 1(b) and (c)). The number of electron in the ITZO layer has been increased due to the electrons injection from the high conductivity ITO layer. As a result, the mobility increases in the double active layers TFT. Besides, the better reliability of the double channels device suggests that the interfacial trap density can be decreased by the insert ion of a very thin ITO film into the ITZO/SiO_2 reference device. Therefore, the double-stacked active layer is a promising approach for achieving highly stable as well as high performance TFT devices.

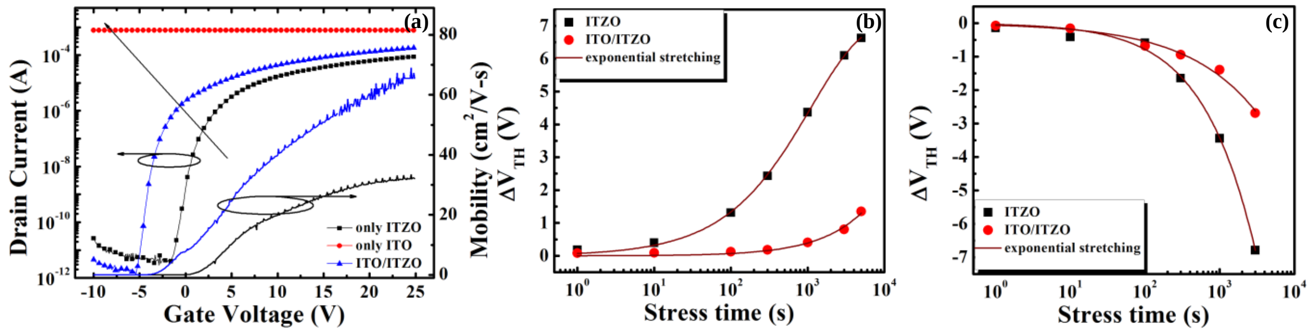

Fig. 1. (a) Transfer characteristics and field effect mobility of single and double active layers. Threshold voltage shift with time under (b) positive and (c) negative bias stress for ITZO TFTs.

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