Oxygen vacancy-dependent density-of-states and its effect on the negative bias illumination stress-induced degradation in amorphous oxide semiconductor thin-film transistors

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Negative bias illumination stress (NBIS)-induced instability have emerged as a challenging issue for mass production of the display backplanes using amorphous oxide semiconductor (AOS) thin-film transistors (TFTs) [1]. On the other hand, oxygen vacancy (V_O) has been well known as critical material/process-controlled parameter for AOS technology [2]. However, details for the effect of the amount of V_Os on the density of subgap states (DOS) experimentally extracted from TFT characteristics have been rarely addressed. Here we report the V_O-dependent DOS and its effect on NBIS degradation in amorphous InGaZnO (a-IGZO) TFTs [Fig.1 (a)]. The amount of V_Os was controlled by changing the oxygen flow rate (OFR) of the dc sputtering with a gas mixture of Ar/O_2 (35/OFR sccm) from 21, 42 to 63. DOS was extracted by the monochromatic photonic capacitance-voltage technique [3]. It was found that the OFR-controlled amount of V_Os changed the DOS near valence band edge as well as that the DOS near conduction band edge [Fig. 1(c)], which explained well the OFR-dependent I-V/mobility curve [Fig. 1(b)] and NBIS degradation [Fig. 1(d)]. Noticeably, the OFR-sensitive DOS peak was found to be located around in 1 eV above valence band edge, which was consistent with [4]. Physical mechanism and details on methods will be presented. Our results are expected as great promise in not only the physical insight on the V_O-effect on the trade-off between the performance and instability but also the method for optimizing the amount of V_Os in AOS TFT technology.

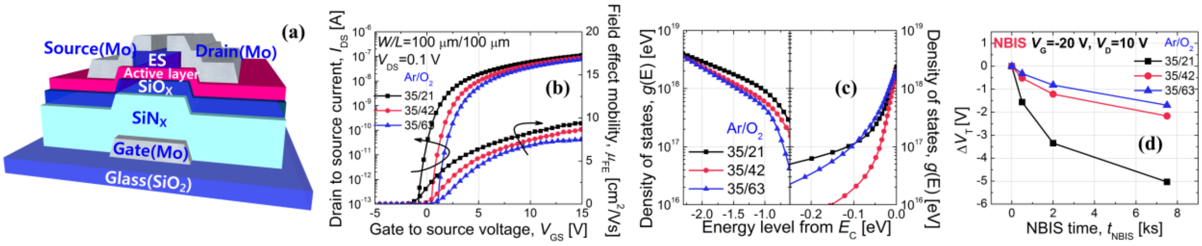

Fig. 4. (a) a-IGZO TFTs device structure, (b) the I_{DS}-V_{GS} transfer curve and field-effect mobility, (c) extracted the subgap DOS, (d) and the NBIS-induced ΔV_T as a function of stress time.

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[3] H. Bae et al., SID Symposium Digest of Technical Papers, 44, pp. 1033-1036 (2013).
[4] S, Lee et al., IEEE IEDM Technical Digest, pp. 24.3.1-24.3.4 (2012).