[TC3-G-3]

TCAD-based analysis on the relationship between the physical parameters in charge trapping and the stretched exponential model parameters in amorphous InGaZnO TFTs under the positive gate bias temperature stress

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Amorphous indium-gallium-zinc oxide (a-IGZO) thin-film transistors (TFTs) have been empolyed in next generation display applications and successfully demonstrated in AMOLED manufacturing [1]. However, bias temperature stress (BTS) instability still remains as challenging issue for successful commercialization of oxide semiconductor TFTs. Physical mechanism on BTS instability, for example the charge trapping into gate insulator (GI) under the positive BTS, is frequently modeled as the stretched exponential (SE) function which follows , where ΔV_T is the threshold voltage shift under BTS [2]. However, the distinct relation between the physical parameters and the SE mode parameters has been rarely clarified in spite of its importance in perspective of quantitative modeling of BTS instability.

In this paper, the activation energy E_a for electron trapping into GI is quantitatively investigated by using the well-calibrated TCAD [3] in terms of the critical parameters, such as the location (region A, B, and C), energy level ($E_{T,GI}$) [Fig. 1(a)], spatial density (N_{OT}), and capture cross section (σ) of electron traps in GI. Our TCAD platform was already validated by comparing the simulation results with many kinds of experimental data. It is found that the simulated ΔV_T is well fitted with the SE function and increases either as the location of electron traps becomes further from the interface between a-IGZO active and GI or as the $E_{T,GI}$ exists closer to the conduction band minimum of IGZO ($E_{C,IGZO}$) [Fig. 1(b)-(d)]. It is because the tunneling probability is higher in the case of $E_{T,GI}$ closer to $E_{C,IGZO}$ and the de-trapping out of GI is easier in the case of A rather than C. The linear relationship between E_a and $E_{T,GI}$, which is extracted from the Arrehenius equation ([Fig. 1(e)], is clearly observed while the E_a is independent of the location of GI charge traps [Fig. 1(f)]. On the other hand, the E_a is more strongly dependent on σ rather than on N_{OT} [Fig. 1(g) and (h)]. Our result is potentially useful for the experimental SE modeling of the charge trapping-related BTS instability mechanism in a-IGZO TFTs.

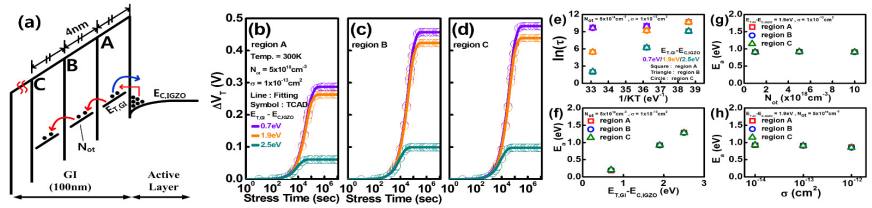

Fig. 1. (a) Schematic illustration of electron trapping into GI. Bias stress time-evolution of ΔV_T in the case of electron trap region (b) A, (c) B, and (d) C. (e) ln(τ)-1/kT curve. The effects of (f) $E_{T,GI}$-$E_{C,IGZO}$, (g) N_{OT}, and (h) σ on the activation energy E_a by using various temperatures of 300,320, and 350K. Bias stress condition: V_{GS}=+30 V and V_{DS}=0 V.

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