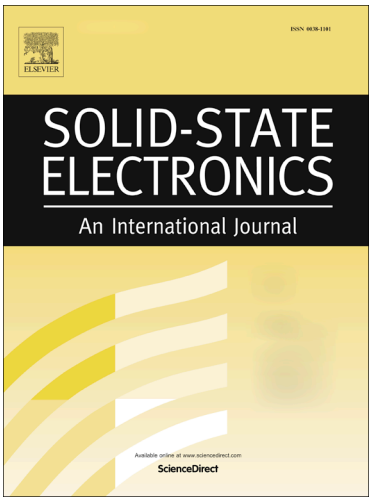

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The electron trap parameter extraction-based investigation of the relationship between charge trapping and activation energy in IGZO TFTs under positive bias temperature stress

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Highlights

- The use of ΔV_T de-embedded from the measured PBTS ΔV_T which is associated only with the charge trapping into gate insulator.
- Detailed and clear procedure of extracting the gate insulator electron trap parameters in IGZO thin-film transistors.
- Analysis of the relationship between activation energy and electron trap parameters.
- Useful in the joint-optimization of gate insulator and active films in highly stable IGZO thin-film transistors.

Abstract

Experimental extraction of the electron trap parameters which are associated with charge trapping into gate insulators under the positive bias temperature stress (PBTS) is proposed and demonstrated for the first time in amorphous indium-gallium-zinc-oxide thin-film transistors. This was done by combining the PBTS/recovery time-evolution of the experimentally decomposed threshold voltage shift (ΔV_T) and the technology computer-aided design (TCAD)-based charge trapping simulation. The extracted parameters were the trap density (N_{OT}) = 2.6×10^{18} cm^{-3}, the trap energy level (ΔE_T) = 0.6 eV, and the capture cross section (σ_0) = 3×10^{-19} cm^2.

Furthermore, based on the established TCAD framework, the relationship between the electron trap parameters and the activation energy (E_a) is comprehensively investigated. It is found that E_a increases with an increase in σ_0, whereas E_a is independent of N_{OT}. In addition, as ΔE_T increases, E_a decreases in the electron trapping-dominant regime (low ΔE_T) and increases again in the Poole–Frenkel (PF) emission/hopping-dominant regime (high ΔE_T). Moreover, our results suggest that the cross-over ΔE_T point originates from the complicated temperature-dependent competition between the capture rate and the emission rate. The PBTS bias dependence of the relationship between E_a and ΔE_T suggests that the electric field dependence of the PF emission-based electron hopping is stronger than that of the thermionic field emission-based electron trapping.

Keywords: electron trap in gate insulator, parameter extraction, IGZO TFT, PBTS instability, charge trapping, activation energy.