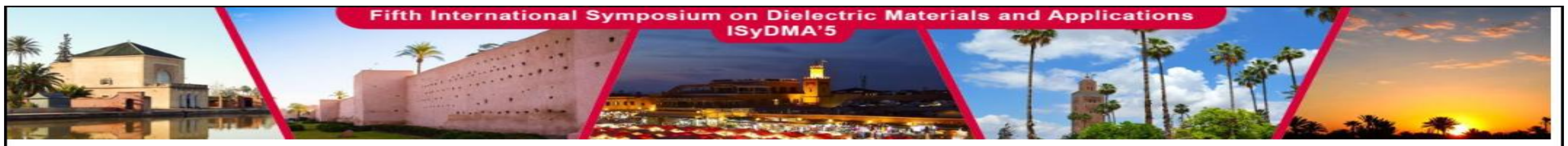

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Effect of incorporating two gate insulators (SiO2 and Al2O3) on the performance of the a-IGZO-based TFT transistor

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Abstract: In this work we presented the simulation of the effect of the deep defects created by hydrogen on the performances of the thin film transistor of amorphous indium gallium zinc oxide (a-IGZO TFT) by incorporating two gate insulators Al2O3 and SiO2. The results obtained are compared with those obtained by a-IGZO TFT - SiO2.

INTRODUCTION

Metal oxides talc indium gallium oxide Amorphous zinc (a-IGZO) is a new promising for the development of thin film transistor because of their high electronic mobility, their low threshold voltage (Vth), high surface stability and low temperature manufacturing process [1,2]. In this study, we studied the effect of defects near-valence band (Ev) [3] on the output parameters of the a-IGZO TFT using the TCAD. a detailed numerical simulation is performed to understand the effect of defects near MBV on the performance of a-IGZO TFT with two gate insulators (Al2O3 and SiO2).

Physical model by SILVACO-ATLAS

A 2D inverted-staggered a-IGZO TFT structure has been defined in this work which is illustrated in Figure 1. It consists of an active layer a-IGZO (20 nm thick), two insulators layers, the first is alumina (Al2O3) with a thickness of 50 nm and the second is silicon dioxide (SiO2) have the same thickness as alumina (50 nm) and a silicon wafer substrate (n ++) as gate. The length (L) and width (W) of the channel are 30 and 180 µm respectively. The source and the drain have a thickness of 5 nm made up of titanium (Ti).

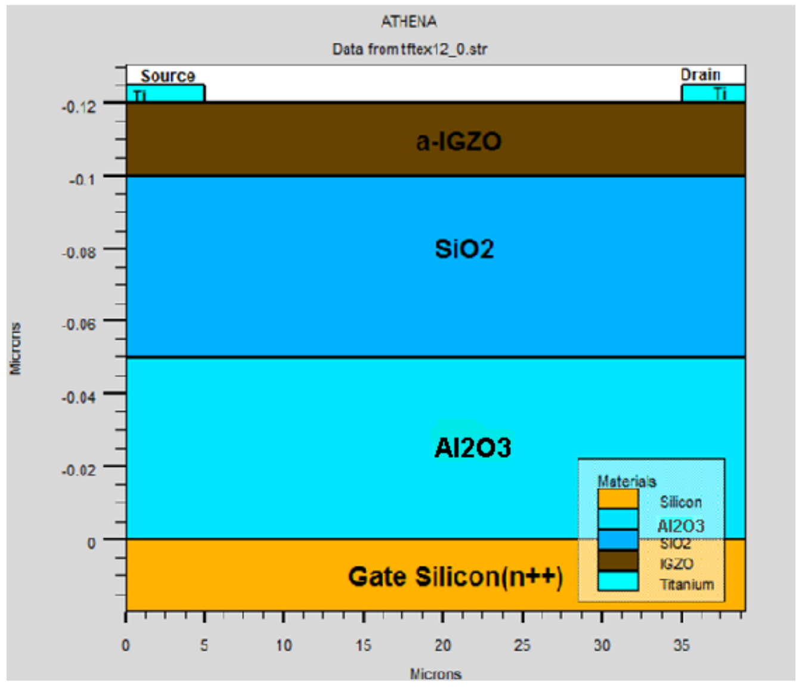

Figure 1: 2D inverted-staggered a-IGZO TFT structure with two gate insulators Al2O3 and SiO2.

Result and discussion

we have 4 types of DOS for donor and acceptor type defects[4].

$$g_{vt}^{D}(E) = N_{td}\exp\left(\frac{E_v - E}{W_{td}}\right), g_{ct}^{A}(E) = N_{ta}\exp\left(\frac{E - E_c}{W_{ta}}\right), g_{G}^{D}(E) = N_{gd}\exp\left(\frac{-(E - E_{gd})^2}{W_{gd}}\right),$$

$$g_{G}^{A}(E) = N_{ga}\exp\left(\frac{-(E - E_{ga})^2}{W_{ga}}\right)$$

Effect of the tail donor density (Ntd)

Effect of the decay energy (Wtd)

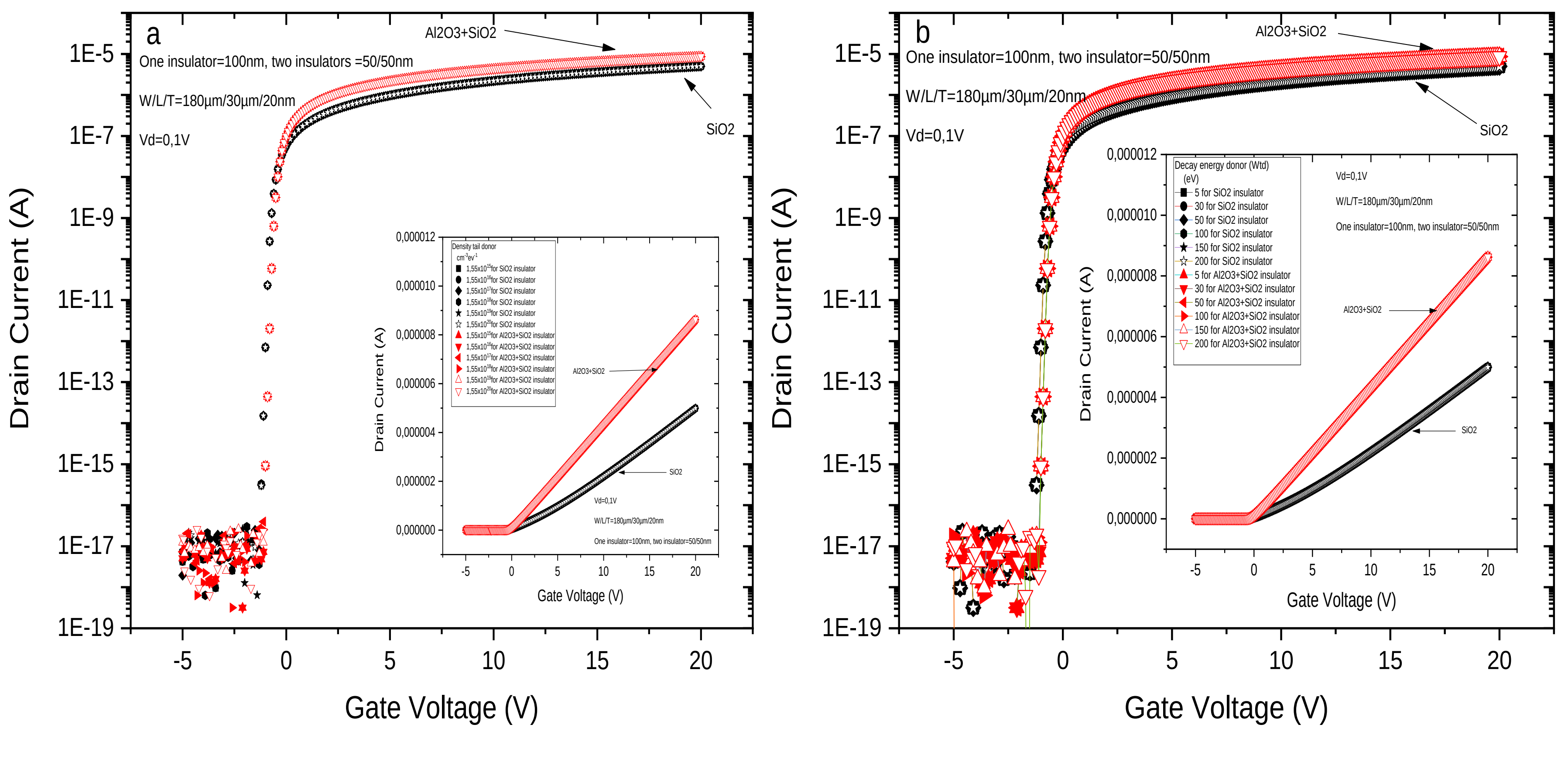

Figure 2: The effect of a) the donor tail densities, b) decay energy on the TFT transfer characteristics with two gate insulators (Al2O3+SiO2).

Effect of the Gaussian acceptor density (Nga)

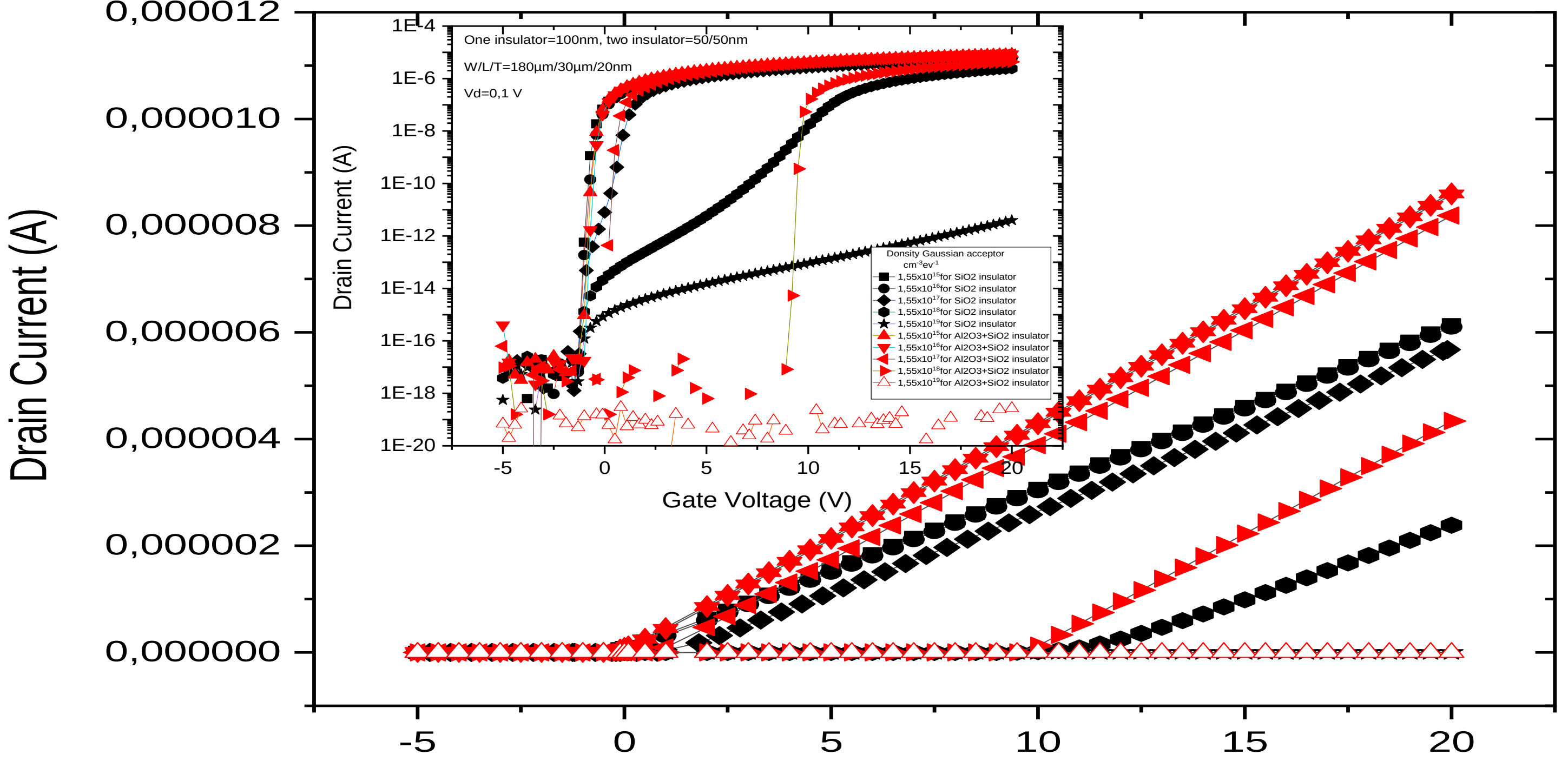

Figure 3: The effect of Gaussian acceptor density on the TFT transfer characteristics

Effect of the Gaussian acceptor energy width (Wga)

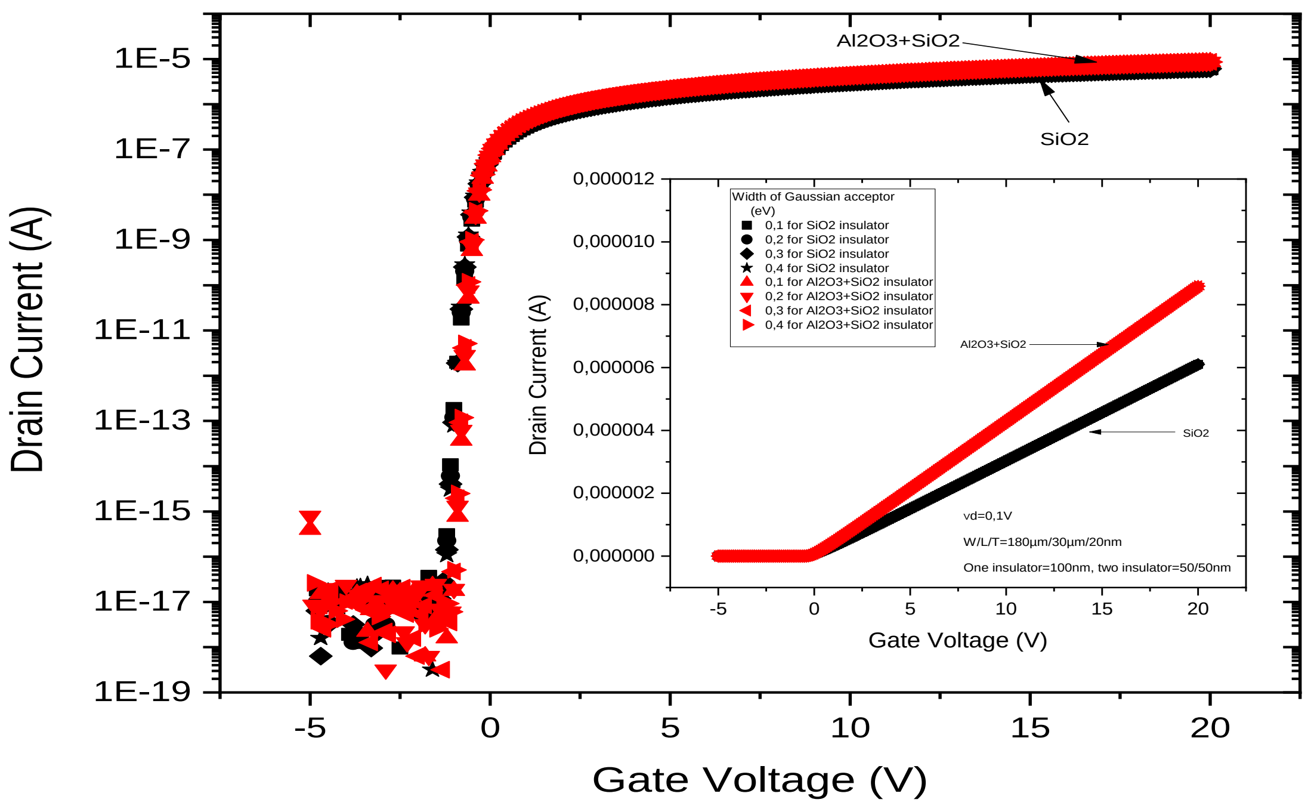

Figure 4: The effect of Gaussian acceptor width on the TFT transfer characteristics

Output parameters	**Two gate insulators Al2O3 and SiO2**				**One gate insulator SiO2**			
	Ntd= 1.55x10^{15} ($cm^{-3}eV^{-1}$)	Wtd=5 (meV)	Nga= 1.55x10^{18} ($cm^{-3}eV^{-1}$)	Wga=0.1 (eV)	Ntd= 1.55x10^{15} ($cm^{-3}eV^{-1}$)	Wtd=5 (meV)	Nga= 1.55x10^{18} ($cm^{-3}eV^{-1}$)	Wga=0.1 (eV)
Ioff (A)	3.23 x10^{-19}	3.23x10^{-19}	1.58 x10^{-19}	2.22x10^{-18}	9.54x10^{-19}	3.23x10^{-18}	2.23 x10^{-18}	9.54x10^{-19}
Ion (A)	8.7x10^{-6}	8.7 x10^{-6}	4.33 x10^{-6}	8.57 x10^{-6}	5.01x10^{-6}	5.01 x10^{-6}	2.39x10^{-6}	6.16x10^{-6}
Ion/Ioff	2.69 x10^{13}	2.69 x10^{13}	2.74 x10^{12}	3.86 x10^{12}	5.24x10^{12}	1.55 x10^{12}	1.07 x10^{12}	6.46x10^{12}
Vth (V)	-0.01	-0.01	9.73	0.08	2.38	2.39	11.50	0.10
µeff ($cm^2V^{-1}s^{-1}$)	14.9	14.9	14.7	14.9	13.8	13.7	13.5	13.7
SS (V/dec)	0.113	0.10	0.992	0.104	0.15	0.14	1.61	0.130

Table 1: Comparison of the TFT a-IGZO output parameters to two Al2O3+ SiO2 gate insulators compared to a single reference gate insulator SiO2.

Conclusion

We concluded that defects close to the valence band are not donor defects but acceptor defects with a Gaussian distribution which can also degrade mobility. On the other hand we can improve the output values of a-IGZO TFT by stacked insulator gate structure of Al2O3 and SiO2 based on this mechanism, an optimized stacked GI structure that exhibited a low subthreshold swing and high µeff was found and used to achieve low-voltage operation in a TFT device. The new improve values of the output parameters: µeff, Vth, the Ion / Ioff and SS are given respectively: 14.9 cm2/ Vs, -0.01 V, 2.69x10^{13} and 0.11 V/dec.

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