Detection of Charge Traps in Silicon Nanowire MOSFETs Using Transient Current Measurements

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1. Introduction: RTN due to charge traps has attracted more and more attention, since it has been regarded as a major issue in scaled transistors [1]. With MOS device scaling, the amplitude of RTN increase rapidly [2]. For better predict RTN impacts on devices and circuits, RTN amplitude distribution should be investigated in detail. However, traditional measurement methods require long measurement times. To detect more RTNs in a limited number of samples with shorter time, transient current measurement methods have been proposed [3]. In this study, the transient method is applied to the charge trap detection in nanowire MOSFETs.

2. Measurement method: Inspired by (Time Dependent Defect Spectroscopy) TDDS method [3], the difference between the transient method and the traditional method is that in the transient method, a "High Vg phase" is added before the measurement phase. Fig.1 shows how Vg changes during the measurement. In the "High Vg phase", traps in the device have a higher probability of capturing carriers. These captured carriers have a high probability of being released during the measurement phase. With this method, we can observe more RTN during the measurement phase.

3. Result and Discussion: Table 1 gives the sample parameters (FDSOI FETs and nanowire FETs [4]) and measurement conditions. Fig.2 shows RTN measurement results of FDSOI FETs measured with the traditional and transient methods. The definition of ΔI_d is also given in Fig.2(a), where ΔI_d is extracted with the GMM method [5]. Obviously, for the same set of FDSOI samples, more RTN can be observed with the transient method, especially large RTN. It is confirmed that ΔV_{th} shows the exponential distribution (Fig.3), where ΔV_{th} is defined by $\Delta V_{th} = \Delta I_d / g_m$ [4]. Fig.4 shows the measured data of nanowire FETs. We can observe a large amount of RTN in nanowire when proper ΔVg is applied.

4. Conclusion: With the transient method, we observed more RTN with larger amplitude. We also applied the method to nanowire MOSFETs. This method helps us to obtain the statistical characteristics of RTN, especially the statistical characteristics of complex RTN.

References [1] N. Tega et al., IEDM, p.771, 2009. [2] K. Takeuchi et al., VLSI Tech, p.54, 2009. [3] T. Grasser et al., IRPS, p.16, 2010. [4] H. Qui et al., VLSI Tech, p.T50, 2017. [5] Z. Zhang et al., INEC, p.1, 2016.

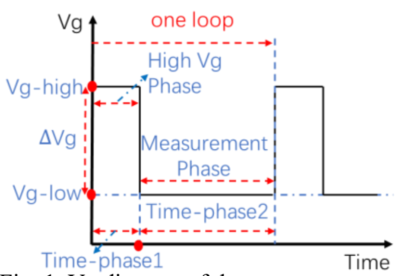
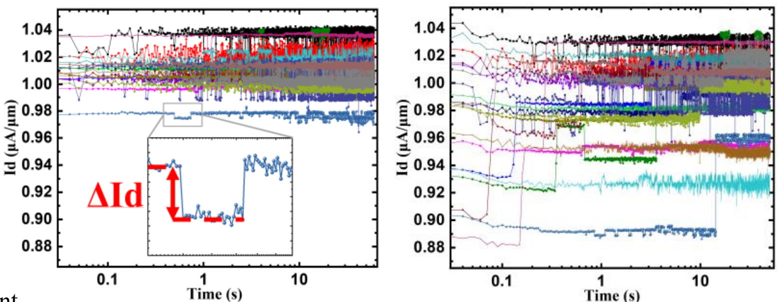


Fig. 1. Vg diagram of the new measurement method.



(a) Traditional methods. (b) Transient methods.

Fig. 2. RTN of FDSOI FETs measured with (a) traditional and (b) transient methods. I_d has been normalized by W.

Table 1. Sample parameters and measurement conditions. V_{th} is defined at 1×10^{-7}A *W/L for FDSOI FET and at 1×10^{-9}A for nanowire FET.

	FDSOI	Nanowire
W (nm)	140	2
L (nm)	100	100
Tox (nm)	2	10
Vg-high	Vth+1.5V	Vth+4V
Vg-low	Vth	Vth
Time-phase1	10s	10s
Time-phase2	50s	250s

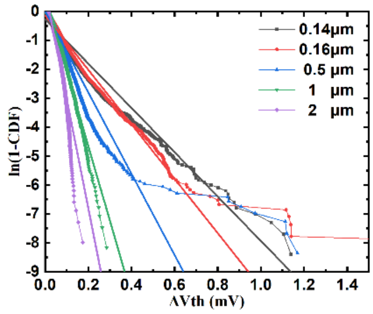


Fig. 3. ΔV_{th} distribution of FDSOI FETs.

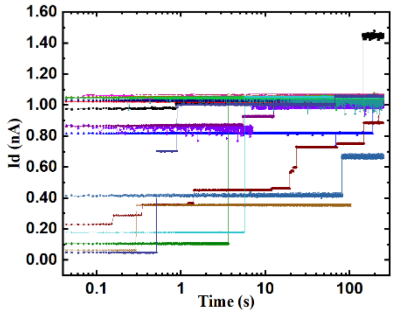


Fig. 4. RTN measurement data of nanowire FETs by the transient method.