New characterization techniques for SOI and related devices

S.Okhonin[1, 2], M.Nagoga[1, 2], P.Fazan[1, 2]

[1] STI, IMM, LEG, EPFL (Swiss Federal Institute of Technology), CH-1015 Lausanne, Switzerland

[2] Innovative Silicon S.A., PSE-C, EPFL, CH -1015 Lausanne, Switzerland

As deep submicron CMOS is evolving to Partially Depleted (PD) and Fully Depleted (FD) SOI technologies [1], it is mandatory that characterization techniques introduced on bulk devices be extended to SOI. The choice of a Floating Body (FB) device introduces also a few parasitic and generally undesirable circuit behaviours such as “kink-effect”, “history dependence” and “self-heating”. To insure the future of SOI devices for Ultra Large Scale Integrated (ULSI) circuits, these effects need to be measured and modelled accurately. This paper describes the measurement techniques used to characterize SOI FB devices. They include transient measurements, self-heating measurements, and the Transient Charge Pumping (TCP) method.

1. Transient measurements

A specially designed measurement set-up allows to change the pulse period *T* and the pulse edge time *ΔT* in a wide range to avoid a “history” effect.

Figure 1 compares the experimental results and the simulations performed with the LETISOI compact analytical model. We observe that the model correctly predicts the beginning of the kink-effect.

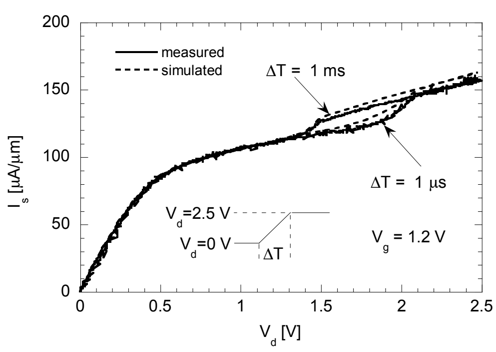

Fig. 1: Measured and simulated I_s-V_d curves for a 0.25 μm N-MOSFET with L/W=0.25/25 μm. The shift of the kink-effect threshold for different ΔT is correctly simulated.

2. Self-heating study

The transient characteristics can be also affected by the self-heating effect. To study the influence of self-heating on the transients we applied the pulsed measuring technique described in [2]. A setup for measurement of output *I-V* curves, using short (few nanosecond) gate pulses, has been realized.

Figure 2 shows pulsed and DC curves measured in a 0.1μm PD SOI transistor. We explain the differences between DC and pulsed measurements by the fact that the kink-effect is appearing on DC characteristics at lower drain voltages than in the case of transient I-V_d curves.

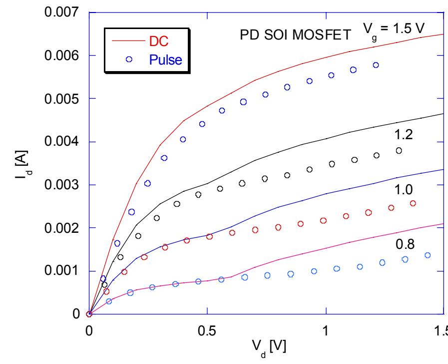

Fig. 2 *I-V* curves for PD SOI MOSFET.

3. Transient Charge Pumping (TCP)

The widely accepted Charge Pumping (CP) technique [3] has been extensively applied to measure the interface trap density in bulk MOSFETs. However up to now this method could not be used for the characterization of Floating Body (FB) SOI MOSFETs having a layout and structure as used in real circuits. Recently we introduced a new method, which allows using the CP principle to measure the interface trap density directly in FB PD and FD SOI MOSFETs having a standard layout [4, 5]. Our method, namely Transient Charge Pumping (TCP), is based on the removal of majority carriers from the floating body through recombination at interface traps, as in the “normal” CP method. The decrease in the quantity of majority carriers in the FB causes a considerable MOSFET’s current reduction that is used to calculate the interface trap density.

By changing the base level of the gate pulses the dependence of the current decrease on the gate pulse base level can be measured (Fig. 3). These curves are very similar to the “classical” CP dependencies measured on the bulk devices.

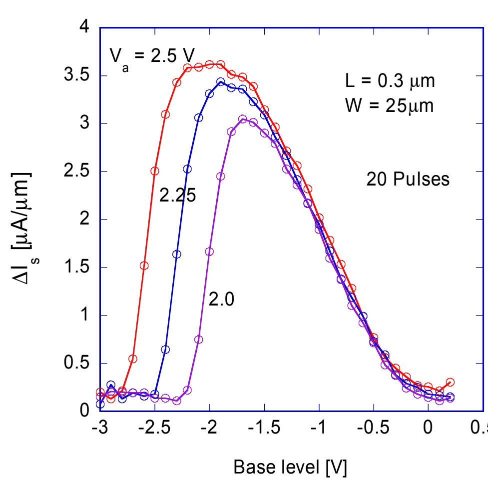

Fig. 3 TCP dependencies measured on a FB NMOSFET.

References:

[1] M.M. Pelella et al., *Proc. of IEEE Int. SOI conf*, p.1, 2001.
[2] K. Jenkins et al, *IEEE Trans. on Electron Devices*, vol. 44, p. 1923, 1997.
[3] G. Groeseneken et al., *IEEE Trans. on Electron Devices*, vol. 31, p. 42, 1984.
[4] S. Okhonin et al., *IEEE Electron Device Letters,*vol. 23, p. 279, 2002.
[5] S. Okhonin et al., *Proc. of IEEE Int. SOI conf*, p.171, 2002.