# FLOATING BODY EFFECTS IN 0.15 μm PARTIALLY DEPLETED SOI MOSFETs BELOW 1 V

T. Saraya, M. Takamiya, T. N. Duyet, T. Tanaka*, H. Ishikuro, T. Hiramoto, and T. Ikoma*

Institute of Industrial Science, University of Tokyo, 7-22-1 Roppongi, Minato, Tokyo 106, Japan
*Texas Instruments Tsukuba R&D Center, Tsukuba 305, Japan

The SOI MOSFET has attracted much attention as a very low power, low voltage device. The supply voltage is reduced to less than 1 V for extreme low power applications. The floating body effects, which is one of the most serious problems in partially depleted (PD) SOI MOSFETs, would be very different when the supply voltage is reduced below 1 V, because the bipolar effect and the impact ionization would be suppressed. However, most of the previous studies on the floating body effects have been reported in the regime of 1.5 - 3 V. In this paper, we have investigated the floating body effects in 0.15 μm PD MOSFETs below 1 V.

Thin film SOI MOSFETs with single drain are fabricated on SIMOX substrates. The thicknesses of the gate oxide, SOI layer, and buried oxide are 5.0 nm, 100 nm, and 100 nm, respectively. The poly-Si gate is defined by the electron beam lithography. The gate length is 0.15 μm. (The effective gate length is 0.1 μm.) Two types of devices, with and without body contact, are fabricated. The devices operate in the PD mode when a high negative voltage is applied to the substrate, although they operate in a fully depleted (FD) mode when Vsub = 0 V. The I-V characteristics, transient current, and impact ionization current are measured at Vsub = -12 V, where the device is in the PD mode and the threshold voltage is 0.5 V.

Figure 1 shows Ids-Vds characteristics of the 0.15 μm MOSFET with a body contact. The kink is observed when the body is floating. Figure 2 shows the transient drain current in the 0.15 μm device without body contact resulting from turn-on pulse on (a) gate and (b) drain. Large transient variation is observed at Vds less than 1 V. At the gate pulse, the current undershoot is usually observed at Vds above 1.5 V due to the impact ionization [1]. In our experiments, however, the current overshoot is observed at Vds below 1 V, as shown in Fig. 2 (a). This overshoot is well explained by the redistribution of holes after the depletion region expansion due to the gate pulse and suppressed impact ionization below 1 V. At the drain voltage pulse, on the other hand, the current undershoot is clearly observed at Vds above 0.9 V, while the overshoot due to the hole redistribution is observed below 0.7 V, as shown in Fig. 2 (b).

To investigate the drain voltage dependence of the transient effects more clearly, the static and transient Ids-Vds characteristics are measured as shown in Fig. 3. The static and transient current intersect each other at a certain Vds. The current undershoots above the cross point. The drain voltage at the cross point reaches the minimum value of 0.73 V at Vg-Vth = 0.25 V, indicating that the current undershoot takes place even at Vds below 0.75 V. The observed current undershoot is due to the impact ionization. Figure 4 shows the body current of the body-contacted device. The body current due to the impact ionization is clearly observed even when the drain potential is less than the bandgap energy (1.1 eV) [2]. Although the impact ionization current becomes less than the noise level below 0.8 V, it is found from Fig. 3 that the impact ionization takes place and causes the transient effects even below 0.75 V. The transient above 1.5 V is usually very fast (nanosecond order) [1] due to large impact ionization current. In our case, however, the transient is slow as shown in Fig. 2 because the impact ionization current is small below 1 V. The minimum drain voltage at which the impact ionization is observed becomes lower as the device is scaled [2]. These results indicate that the floating body effects have a significant influence on the device characteristics in scaled MOSFETs even when the supply voltage is reduced below 1 V.

In summary, the floating body effects in 0.15 μm PD MOSFETs below 1 V are studied. It is confirmed that the impact ionization takes place at the drain potential below the bandgap energy and causes the large transient drain current even when the supply voltage is less than 1 V as the device is scaled. It is concluded that the floating body effects remain a serious problem even when the supply voltage is reduced below 1 V.

**References:** [1] J. Gautier, K.A. Jenkins, and Y.-C. Sun, IEDM Tech. Dig. pp.623, 1995.
[2] A. Hori, A. Hiroki, K.M. Akamatsu, and S. Odanaka, Jpn. J. Appl. Phys. 35, pp.882, 1996.

0-7803-3315-2 96CH35937

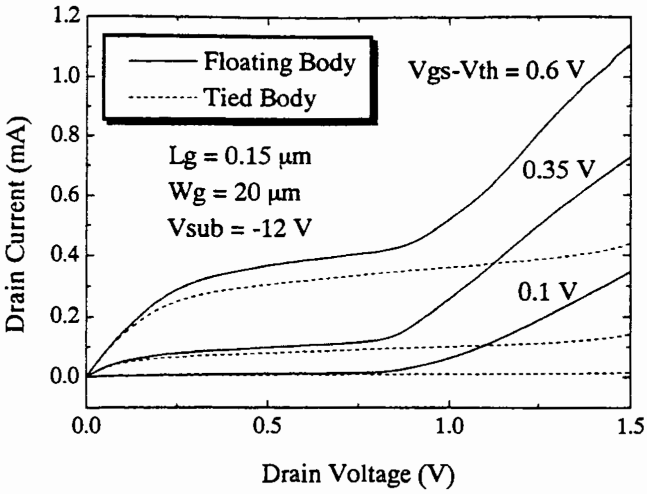


Fig.1. Ids - Vds characteristics of the 0.15μm PD SOI nMOSFET with a body contact. The solid lines and dashed lines show the floating body and tied body characteristics, respectively.

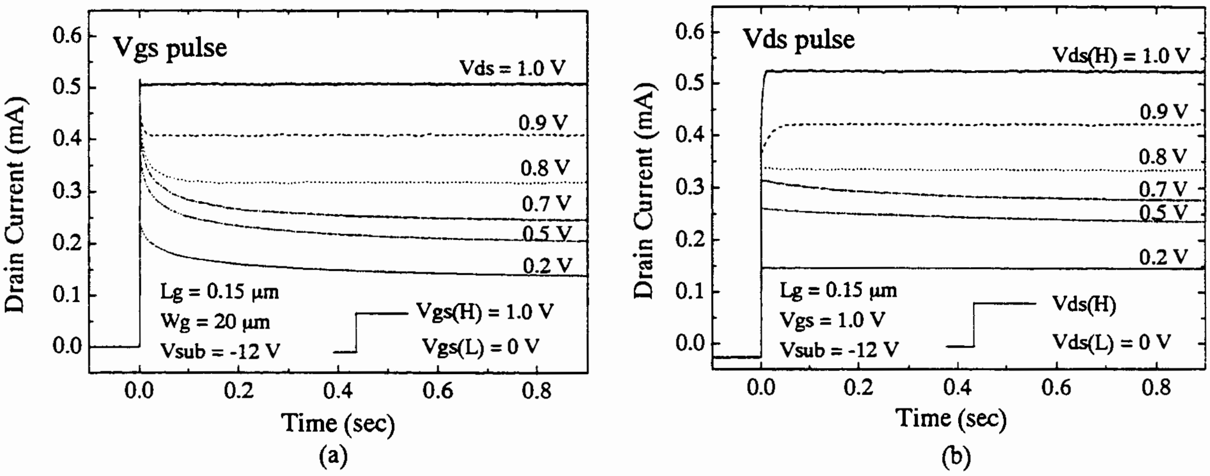


Fig.2. Transient drain current characteristics in the PD SOI nMOSFET without a body contact. (a)Turn-on pulse on gate voltage. (b)Turn-on pulse on drain voltage.

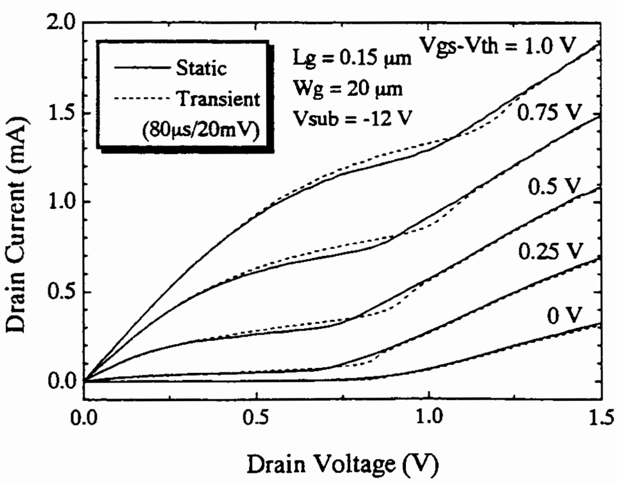


Fig.3. The scanning speed dependence of the Ids - Vds characteristics in the PD SOI nMOSFET without body contact. The scanning rate of the drain voltage is 3sec / 20mV for static and 80μsec / 20mV for transient measurements.

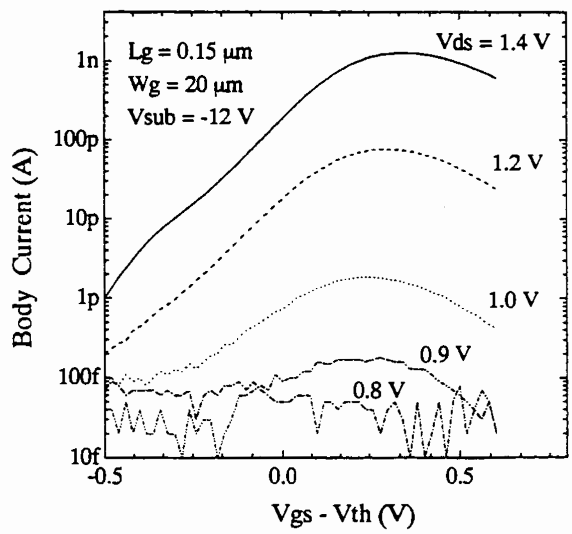


Fig.4. The body current as a function of gate voltage at different drain voltages in the PD SOI nMOSFET with a body contact.



0-7803-3315-2