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Thorough Investigationof Kink-Related Excess Noise in Deep Submicron SOI N-MOSFETs on Unibond Substrate

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1. Introduction

High performance low-power RF integrated circuits are key components for the booming market of communication equipments. Previous works have already demonstrated the excellent capability of RF-dedicated SOI-MOSFET's [1-3]. Therefore, low-frequency noise in CMOS/SOI, which can either directly impact homodyne receivers or enhance phase noise in oscillators [4], needs to be characterized. Recently, it has been found that the current-voltage (I-V) kink can be suppressed by higher frequency operation [5]. As a result, low-frequency noise is the only remaining floating body related obstacle for the integration on a single chip of floating body SOI MOSFET's in RF front-end circuits. Some papers have already been dedicated to study this phenomenon, especially in PD-SIMOX [6-8]. But, no detailed investigation has been done for Moderately-Fully-Depleted SOI, Body-tied devices or UNIBOND MOSFETs.

The aim of this paper is to present a thorough investigation of low-frequency noise behavior in different types of SOI devices. The dependence with the drain bias will be discussed and the impact of the body contact on the noise will also be shown.

2. Results and discussion

N-channel Unibond MOSFETs fabricated at LETI-Grenoble with four different types of layout were used in this study: Partially-Depleted floating body (PD), Moderately-fully-depleted (MFD), Source/Body-tied (SB-tied) and Body-tied (B-tied) devices. The relevant technological details are: front gate oxide thickness t_{ox} of 4.5nm, buried oxide thickness t_{box} of 380nm and final film thickness t_{Si} of 40nm for MFD and of 100nm for the other architectures.

In Fig. 1, are shown, for the various structures, the output drain current (Fig. 1.a) and the corresponding output conductance (Fig. 1.b). A substantial kink effect is clearly observed in the case of PD device, and for a drain bias corresponding to the kink effect in static measurements a low-frequency excess noise occurs (Fig. 2). In the case of MFD structures, the excess noise is almost suppressed at f=10Hz and L=0.25 μm (Fig. 2). This behavior can be attributed to 2D effect. Indeed, when the gate length is reduced, the "effective" doping is smaller due to short channel effects. As a consequence, the full depletion behavior is improved compared to long channel devices. This explains why floating body effect, in MFD devices, is higher on long channel (inset of Figs. 1-2).

The floating body effect induces a kink-related noise overshoot, which superimposes a Lorentzian spectrum on the flicker noise [6]. Different mechanisms have been proposed to explain this excess noise, such as trap-assisted generation-recombination noise [6] or electronic tunneling noise between the gate oxide and the channel resulting from the ac kink effect [7]. This behavior is clearly shown in Fig. 3 (the same variations are obtained for 1μm MFD device). It is important to note that the corner frequency f_0 and the plateau noise level of the Lorentzian spectrum depend both on the drain bias (Fig. 4). For PD devices, f_0 increases and the noise level of the plateau of Lorentzian spectrum decreases continuously as the drain bias is enhanced. However, in the case of MFD-SOI, it is found that the plateau level increases in the pre-kink region and reaches a maximum at V_d corresponding to dc-kink before decreasing for higher V_d. In addition, in the pre-kink region, f_0 is almost constant before increasing at higher V_d.(Fig. 4).

On the other hand, no kink-related excess noise is observed in source/body tied or body-tied SOI NMOS (Fig. 2). The kink effect disappears when the SOI film is contacted to ground. The low peak, observed at high V_d for the SB-tied (Fig. 2), may be due to RTS mechanisms which yield low-frequency noise overshoot. Furthermore, a pure 1/f noise is obtained for these devices (Fig. 5) and this demonstrates the body contact efficiency.

3. Summary

The low frequency noise in various SOI NMOSFETs architectures is experimentally investigated. It is found that the excess noise due to the floating body effect has been suppressed in the case of body-tied devices. This demonstrates the suitability of such structures, but, a trade-off between body contact efficiency and penalty of parasitic effects has to be considered. For moderately FD devices, the excess noise can only be suppressed in the short channel length range.

References

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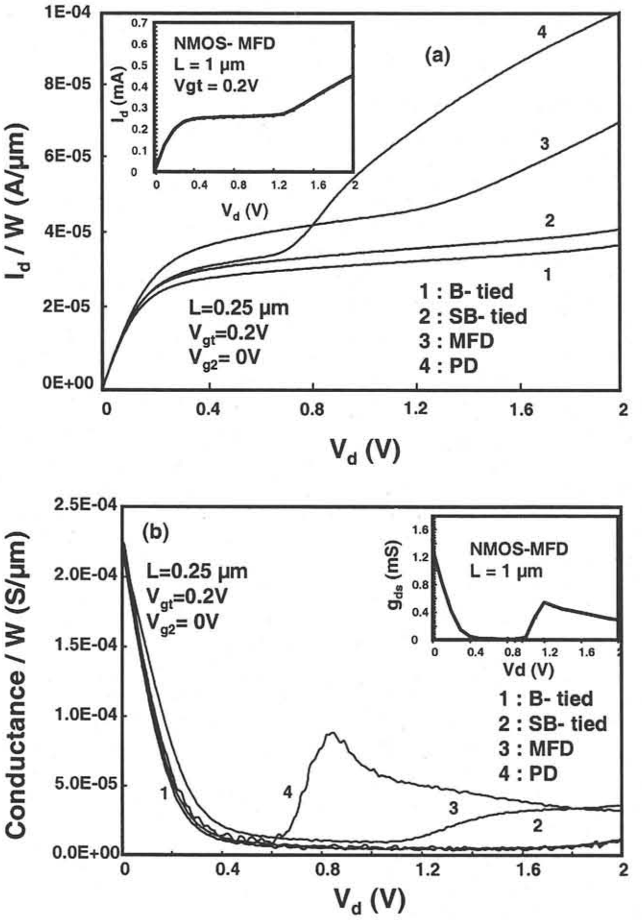

Figure 1. Output drain current (a) and conductance (b), normalized by the width W, versus drain bias for different layouts. The gate voltage is V_{gt} = 0.2 V. The insets show the drain current and the output conductance for 1µm MFD SOI device.

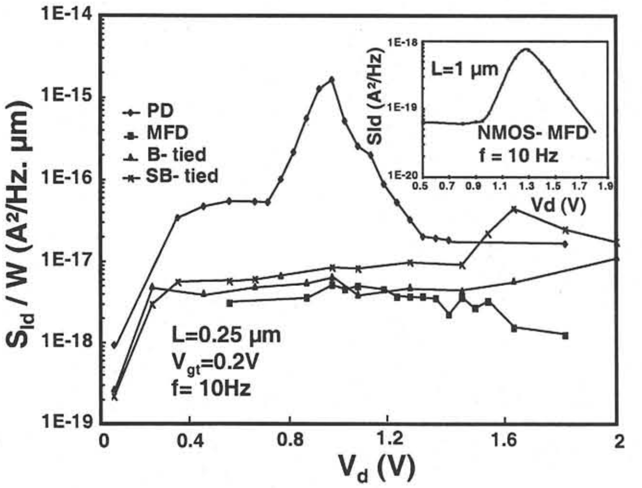

Figure 2. Drain current noise spectral density, normalized by the width W, at the frequency f=10 Hz, for the four different architectures, versus drain bias. The inset shows the drain current spectral density versus V_d for the MFD device at L=1µm.

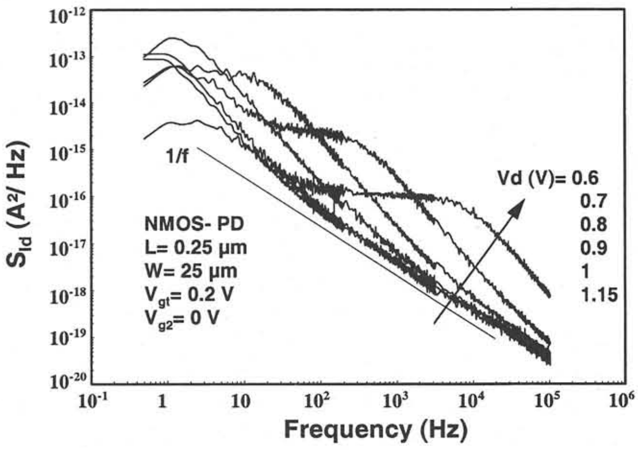

Figure 3. Drain current spectral density versus frequency for the 0.25 µm PD device (floating body), at different drain voltages.

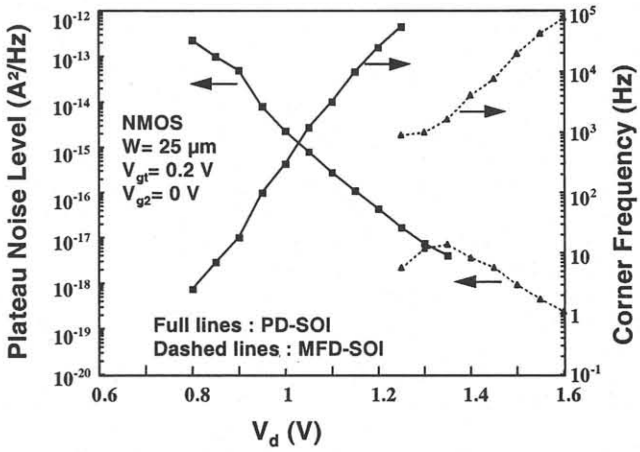

Figure 4. Drain bias dependence of the plateau noise level and the corner frequency for 0.25µm PD device with floating body (full lines) and 1µm MFD device (dashed lines).

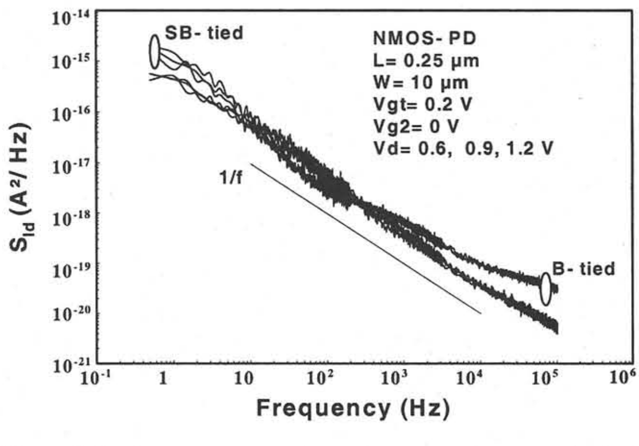

Figure 5. Drain current spectral density versus frequency for body tied and source- body tied devices, at different drain voltages. W/L= 10/0.25 µm, and V_{gt}= 0.2 V