Reduction of Pass-Gate Leakage by Silicon-Thickness Thinning in Double-Gate MOSFETs

W. Sakamoto, T. Endoh, H. Sakuraba, F. Masuoka
Research Institute of Electrical Communication, Tohoku University
2-1-1 Katahira, Aoba-ku, Sendai 980-8577, Japan

Abstract

This paper shows reduction of Pass-Gate Leakage (PGL) by silicon-thickness thinning in DG MOSFET. The charge transported by PGL current has been reduced to about 10.7% by silicon-thickness thinning 100nm to 10nm.

Introduction

New transistor structures like DG MOSFET and its varieties are candidates for future ULSI [1]. However, these floating body devices include DG MOSFET have various undesirable effects known as floating body effect. PGL current which has been reported in SOI MOSFETs [2][3][4] is one of the floating body effects, and may upset the logic or memory (SRAM or DRAM) function. This paper reports reduction of PGL with silicon-thickness thinning in DG MOSFETs.

Reduction of Pass-Gate Leakage

Consider enhancement-type (normally off) DG nMOSFET shown in Fig.1. Gate and Drain voltage are fixed (V_{fG}=V_{bG}=0V, V_D=1.5V) and source voltage (V_S) swings 0- 1.5V, 1.5-0V as shown in Fig.2. PGL current flows according to following process.

1) When the source is pulsed from 0 to 1.5V, reverse bias is applied to source-body junction which causes reverse bias current $I_R(t)$ as shown in Fig.3. Holes are accumulated to body with $I_R(t)$, and body potential $V_B(t)$ rises. If the hold time T_H is long enough, the junction comes to thermal equilibrium (worst case: body is fully charged and $V_B(t)$ takes maximum value).

2) When the source is pulsed from 1.5V to 0V, source-body junction is forward biased and parasitic npn bipolar junction transistor current flows. This current is Pass-Gate Leakage (PGL) current. Its magnitude and total charge transported by PGL current depends on T_H, and become maximum at worst case. PGL current affects when T_H is on the order of milliseconds in SOI MOSFET [2].

3) Then source is pulsed to 1.5V, source-body junction is reverse biased, and back to 1).

In DG MOSFET, source-body pn-junction area is proportional to silicon-thickness (t_{Si}). If the lifetime doesn't depend on t_{Si}, $I_R(t)$ can be reduced using thinner t_{Si}, which allows $V_B(t)$ to take longer time to be maximum value in phase 1).

Initial value of PGL current in phase 2) isn't proportional to t_{Si}, because smaller source-body pn-junction capacitance causes larger initial source-body potential difference $V_{BS}(t)$. However, the thinner t_{Si} is, the faster PGL current reduces. Because hole recombination current required for body discharging is large and $V_{BS}(t)$ reduces fast by t_{Si} thinning. Fig.4 shows PGL current at worst case in DG MOSFETs with 2D device simulation [5]. The charge transported by PGL current (Integral of Fig.4) is shown in Table.1. PGL can be reduced to use thinner t_{Si} in DG MOSFETs.

Conclusion

In this paper, we have shown reduction of pass-gate leakage (PGL) by silicon-thickness (t_{Si}) thinning in DG MOSFETs. Using thinner t_{Si}, longer time is needed to charge the body fully. Even if the body is fully charged, PGL current reduces faster, and total charge transported by PGL current can be reduced.

References

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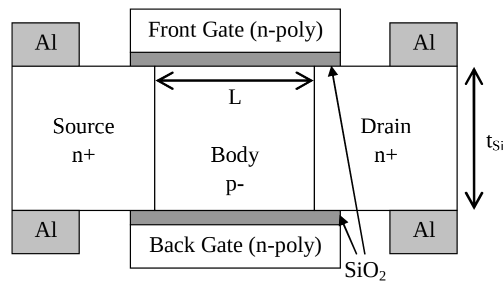

Fig.1: The structure of DG MOSFET

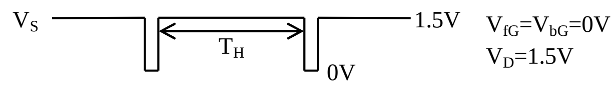

Fig.2: Bias Condition

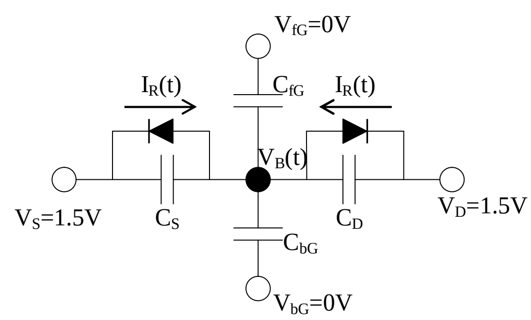

Fig.3: Equivalent circuit of DG MOSFET in phase 1)

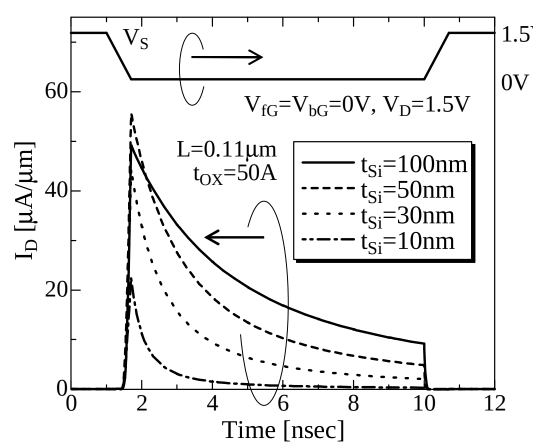

Fig.4: Pass-Gate Leakage (PGL) current at worst case in phase 2)

Table.1: The total charge transported by PGL current in phase 2) (Integral of Fig.4)

t_{Si} [nm]	100	50	30	10
Charge [fC/µm]	177	134	76	19