Serie 10

Given constants

$\epsilon_0 = 8.85 \cdot 10^{-14}\,[F/cm]$
$\epsilon_{ox} = 3.9 \cdot \epsilon_0$

Exercise 01

Consider a MOS transistor polarized as in Figure 1. We know: $V_{th} = 0.7\ [V]$, $W = 10\ [\mu m]$, $L = 0.5\ [\mu m]$, $t_{ox} = 20\ [nm]$. When the circuit is polarized with $V_{DD} = 3.3\ [V]$, the current flowing through the channel of the transistor is $I_D = 0.5\ [mA]$.
The value of electron mobility, μ_n, in the inversion channel of the MOS transistor is:

a) $\sim 200\ \left[cm^2\ V^{-1}\ s^{-1}\right]$

b) $\sim 400\ \left[cm^2\ V^{-1}\ s^{-1}\right]$

c) $\sim 600\ \left[cm^2\ V^{-1}\ s^{-1}\right]$

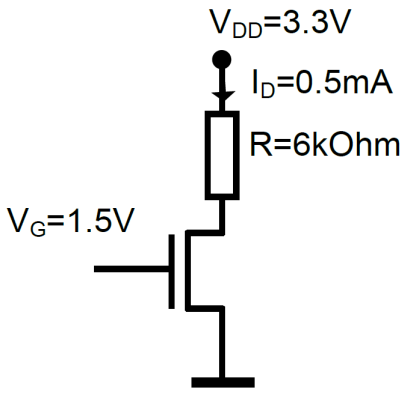

Figure 1: MOS transistor circuit.

Exercise 02

Consider a n-MOSFET on a p-type Si substrate. We know: $W = 10\ [\mu m]$, $L = 1\ [\mu m]$, $t_{ox} = 5\ [nm]$. The measured transistor characteristics are shown

in Figure 2. For Fig. 2a, $g_m = 1.4 \cdot 10^{-4}$ $[A/V]$; for Fig. 2b, we don't know the scale of the axes.

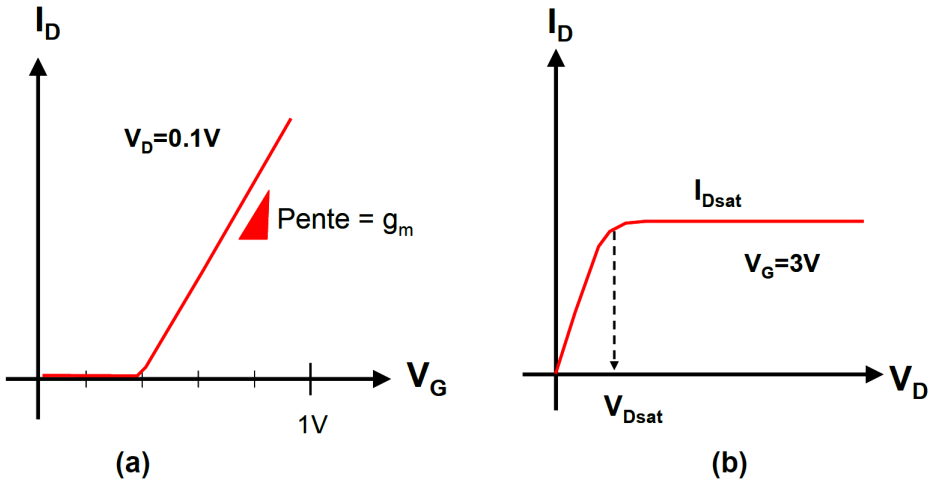

Figure 2: MOSFET characteristics.

Q1. By looking at the $I_D - V_G$ characteristics, we can conclude that at $V_G = 0.8$ $[V]$ the MOSFET is in:

- **a)** Saturation region.
- **b)** Linear region.
- **c)** Cut-off region.

Q2. The threshold voltage V_{th} of the MOSFET is:

- **a)** $V_{th} = 0.1$ $[V]$
- **b)** $V_{th} = 0.2$ $[V]$
- **c)** $V_{th} = 0.4$ $[V]$
- **d)** $V_{th} = 1$ $[V]$

Q3. The mobility μ_n of the electrons in the n-channel is:

- **a)** ~ 200 $\left[cm^2\ V^{-1}\ s^{-1}\right]$
- **b)** ~ 300 $\left[cm^2\ V^{-1}\ s^{-1}\right]$
- **c)** ~ 400 $\left[cm^2\ V^{-1}\ s^{-1}\right]$
- **d)** ~ 500 $\left[cm^2\ V^{-1}\ s^{-1}\right]$
- **e)** ~ 600 $\left[cm^2\ V^{-1}\ s^{-1}\right]$

Q4. For $V_G = 3\ [V]$, the saturation voltage V_{Dsat} is:

- **a)** $V_{Dsat} = 2.9\ [V]$
- **b)** $V_{Dsat} = 2.8\ [V]$
- **c)** $V_{Dsat} = 2.6\ [V]$
- **d)** $V_{Dsat} = 2\ [V]$

Q5. The saturation current I_{Dsat} is:

- **a)** $I_{Dsat} = 2.1\ [mA]$
- **b)** $I_{Dsat} = 4.7\ [mA]$
- **c)** $I_{Dsat} = 6.8\ [mA]$

Q6. The trend of the $I_D - V_D$ characteristics allows us to conclude that:

- **a)** This n-MOSFET has a long channel.
- **b)** This n-MOSFET shows short channel effects.
- **c)** We need the $I_D - V_G$ characteristics below threshold, in *log* scale, to determine if there are short channel effects.

Exercise 03

Choose the correct statements regarding MOS transistors on fully-depleted silicon-on-insulator (FD-SOI) substrates:

A) The depth of the depletion region controlled by the gate is thinner than the thickness of the Si film of the SOI.

B) The junction leakage currents in FD-SOI are smaller than for MOS transistor on bulk Si, for the same technological node (channel length).

C) A kink effect in the $I_D - V_D$ characteristics exists, where the drain current shows an unusual increase before the breakdown.

D) The FD-SOI shows a better resistance to ionizing radiations, with respect to partially-depleted SOI.

E) FD-SOI transistors show stronger short-channel effects than their counterparts in bulk Si.

F) The FD-SOI has inherent self-heating effects, because of the buried oxide, which increases the thermal resistance.

G) For the same channel length, transistors on FD-SOI can operate at higher frequency with respect to those on bulk Si.