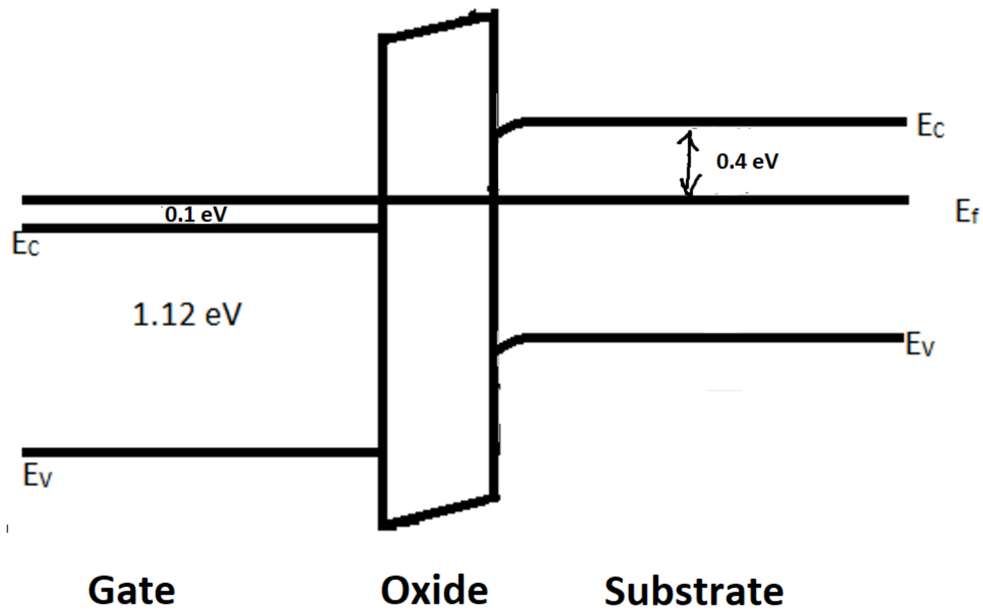
ECE 305 – Fall 2018

Homework 10 Solution

1. a.



The Fermi level is aligned throughout, since the system is in equilibrium.

b. $\Phi_{MS}=\Phi_M-\Phi_S=(\chi-0.1)-(\chi+0.4)= -0.5$ eV

This value is not small enough to be neglected, as it will induce significant band bending and thus significantly change carrier concentration at semiconductor-oxide interface compared to bulk of semiconductor as E_F-E_C is in the order of same magnitude with the value.

c. Accumulation, as it can be seen from figure in a. that the majority carrier concentration increases at the semiconductor-oxide interface at equilibrium

2. a. On current when $V_{GS}=V_{DS}=V_{DD}=1.2$ V
$I_{DS}=14$ μA/μm*W=14 μA/μm*2 μm=28 μA

Off current when $V_{DS}=V_{DD}=1.2$ V and $V_{GS}=0$ V
$I_{DS}=$ 2μA/μm*2 μm=4 μA

Alternatively,
Usually off-V_{GS} is lower than the threshold voltage which in this case is negative. So any value of subthreshold current <(1E-9 μA/μm*2 μm) should be acceptable.

b. Below subthreshold voltage the current is exponential with V_{GS}, so the log I_{DS} -V_{GS} will appear linear. Thus the subthreshold voltage marks the end of the linear region at approximately -1 V.

c. Subthreshold swings at both $V_{DS}=1.2$ V and $V_{DS}=0.05$ V are approximately 250 mV/decade (well above the theoretical minimum for MOSFETs at room temperature).

As the subthreshold swing at $V_{DS}=1$ V is expected to lie between those subthreshold swings, it is also expected to be approximately 250 mV/decade.

d. $\Delta V_{GS}=0$ at the subthreshold region for a change of V_{DS} from 1.2 V to 0.05 V. So the DIBL, which is given by the ratio of gate voltage shift to drain voltage shift, is 0.

e. $|Q|=C_{ox}(V_G-V_T)=3*(1.2-(-1))=6.6$ μC/cm^2
f. At $V_{DS}=0.25$ V and $V_{GS}=1.2$ V, $I_{DS}=4$ μA/μm*2 μm=8 μA
Total resistance=$V_{DS}/I_{DS}=31$ k Ω
Channel resistance=Total Resistance-R_S-R_D=31k-5-5=31k Ω

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