國立中山大學101學年度碩士暨碩士專班招生考試試題

科目：半導體概論【電機系碩士班甲組】

題號：4068

1. Formulate the ideal diode current-voltage characteristics, $I_D = I_S \cdot \exp(V_D/\eta V_T - 1)$, with respect to the Diode cross-sectional area A, the carrier diffusion lengths: L_n and L_p, the carrier diffusion coefficients: D_n and D_p, the equilibrium minority-carrier densities: n_{po} and p_{no}, and the diode voltage bias: V_D. Where η is ideal factor of the diode. (20%)

2. Show the fabrication process and draw its corresponding I_D - V_D and $I_D - V_G$ current characteristics of an Enhancement mode N-channel MOSFET (*ENH nMOS*) and a Depletion mode N-channel MOSFET (*DEP nMOS*) respectively. (Note: You need point out the main differences between them) (20%)

3. A MOSFET has a threshold voltage of $V_T = 0.5$ V, a subthreshold swing (*SS*) of 100 mV/decade, and a drain current of 0.1 μA at V_T. What is the subthreshold leakage current at $V_G = 0$ V? (20%)

4. Nowadays for CMOS IC industry we normally need a buffered layer placed between a high-k Ta_2O_3 and the silicon substrate. Please calculate the effective oxide thickness (*EOT*) when the stacked gate dielectric is Ta_2O_3 ($k = 25$) with a thickness of 7.5 nm on a buffered nitride layer ($k = 7$) and a thickness of 1 nm). Also calculate *EOT* for a buffered oxide layer ($k = 3.9$) and a thickness of 0.5 nm). (20%)

5. Consider an n-channel MOSFET with source and drain doping concentrations of $N_D = 10^{19}$ cm^{-3} and a channel region doping of $N_A = 3 \times 10^{16}$ cm^{-3}. Assume a channel length of $L = 0.6$ μm, $\varepsilon_s = 11.9 \times 8.85 \times 10^{-14}$ F/cm, $n_i = 1.5 \times 10^{10}$ cm^{-3} and assume the source and the body are at ground potential. Assuming the abrupt junction approximation please calculate the theoretical punch-through voltage. (20%)