系所組別： 微電子工程研究所
考試科目： 固態電子元件
考試日期：0307，節次：2

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1. An electron with energy of 3.5 eV impinges on a potential barrier of height 5.0 eV and thickness 1.5 Å, what would be the corresponding transmission coefficient? Please repeat the calculation for a barrier with thickness of 20 Å. (12%)

2. If the number of ionized donor can be given by $n = \dfrac{N_D}{1+e^{(E_F-E_D)/kT}}$ and for an n-type silicon with 10^{17} cm^{-3} titanium donor impurities and a donor level at E_D = 0.21 eV, find the ratio of the neutral donor density to the ionized donor density at 77 K. (Hint: N_C (Si) = 2.86×10^{19} cm^{-3}) (13%)

3. The bandgap of $Si_{1-x}Ge_x$ is given by $1.17 - 0.96x + 0.43x^2 - 0.17x^3$. If we have a $Si_{1-x}Ge_x$/Si HBT with x = 12% in the base region (x = 0% in emitter and collector regions), and assume the base current is due to emitter injection efficiency only, what would be the expected change in the common-emitter current gain between 0° and 110°C? (13%)

4. You are asked to design a Si p-n junction which would meet the specifications of $N_D = 3.5 \times 10^{18}$ cm^{-3} and $\mathscr{E}_{max} = 5 \times 10^5$ V/cm at V_R =40 V and T = 300 K. Please determine the corresponding p-type doping concentration (N_A) as needed for meeting these design criteria. (12%)

5. Assume the drain current (I_D) vs. gate voltage (V_{GS}) of an n-channel MOSFET measured at drain voltage V_D = 0.1 V is shown in Fig. 1. This device has substrate doping concentration $N_A = 10^{17}$ cm^{-3}, channel width W = 10 μm, channel length L = 1 μm, and gate oxide d = 4 nm. Find the inversion carrier mobility. (12%)

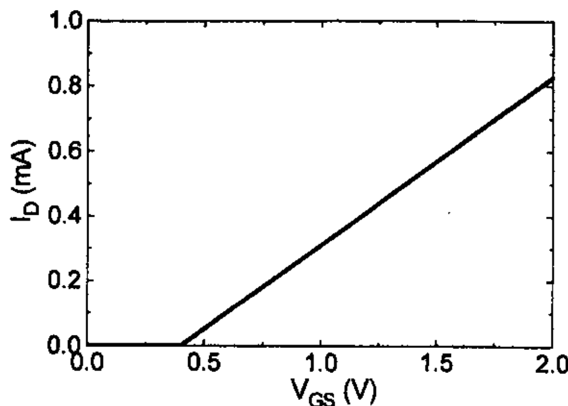

Fig. 1

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6. Assume a p-channel MOSFET has substrate doping concentration N_D = 5×10^{16} cm^{-3}, W = 10 μm, L = 1 μm, and d = 6 nm. Find the change in threshold voltage at T = 300 K when the substrate bias is varied from 0 V to 1 V. (14%)
7. For a Si p-n junction solar cell with photocurrent 50 mA, diode saturation current 1 nA, and cell area 10 cm^2, calculate the open-circuit voltage of this solar cell at 300 K. (10%)
8. For an n-channel GaAs MESFET with mobility 9000 cm^2/V-s, n-channel doping concentration 5×10^{15} cm^{-3}, channel width 10 μm, channel length 1 μm, and channel thickness 0.4 μm, calculate the cutoff frequency of this device at 300 K. (14%)

Hint: dielectric constant of SiO_2 = 3.9
dielectric constant of GaAs = 12.4
dielectric constant of Si = 11.9
intrinsic carrier concentration of Si = 10^{10} cm^{-3}
Boltzmann constant = 1.38×10^{-23} J/K
elementary charge = 1.6×10^{-19} C
permittivity in vacuum = 8.85×10^{-14} F/cm