國立成功大學 106 學年度碩士班招生考試試題

系　　所：電機資訊學院-微電、奈米聯招

考試科目：固態電子元件　　　　　　　　　　　　　　　　考試日期：0213，節次：2

※ 考生請注意：本試題可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. A silicon (Si) *pn* junction diode has been doped with 10^{18} boron atoms-cm^{-3} on the *p*-side and 10^{16} phosphorus atoms-cm^{-3} on the *n*-side. What is the resultant depletion width? What is the junction capacitance in unit of F/cm^2, assuming the relative permittivity of silicon is approximately 11.68 (12.5%) ?

2. What is the resistance of a 1 cm^3 germanium (Ge) crystal that has been doped with arsenic in a ratio of 1 in 10^9 (1 part per billion) (12.5%)? [Atomic concentration in Ge is 4.42×10^{22} cm^{-3}, $n_i = 2.4\times10^{13}$ cm^{-3}, $\mu_e = 3900$ cm^2-V^{-1}-s^{-1}, and $\mu_h = 1900$ cm^2-V^{-1}-s^{-1}]

3. An AlGaAs LED emitter has a peak emission at 820 nm at 25°C. The bandgap E_g of the ternary alloys $Al_xGa_{1-x}As$ follows the empirical expression $E_g(\text{eV}) = 1.424+1.266x+0.266x^2$. What is the bandgap of this AlGaAs LED? What is the resultant composition of the AlGaAs in this LED (12.5%)?

4. Given the bandgap energy of germanium (Ge) is 0.66 eV, the density of states related effective masses of electrons and holes are respectively $1.59m_e$ and $0.33m_e$, where m_e is the free electron mass (9.11×10^{-31} kg) and the respective electron and hole drift mobilities at room temperature are 3900 and 1900 cm^2-V^{-1}-s^{-1}, determine the intrinsic concentration and intrinsic resistivity of Ge (12.5%).

5. Consider a planar N-channel MOSFET with a TiN-gate (work-function Φ_{gate} =4.61) fabricated on a P-type silicon wafer with uniform doping concentration $N_A=10^{17}$cm^{-3}. The transistor width W=1.0 μm, length L=100 nm, and the gate dielectric is HfSiON (ε = 16) with physical thickness T_{ox}=3nm.
   (a) Determine the flat-band voltage (V_{fb}) at room temperature (5%).
   (b) What is the threshold voltage (V_{th}) at room temperature (5%).
   (c) In the following table, the first column lists changes/alterations to the MOSFET design. The other columns list the responses of various measurable quantities. Fill in the blanks ("↑" for increase; "↓" for decrease; "–" for no change). (20 %)

	V_{th}	W_{dep}	V_{fb}	I_{on}	μ
Increase N_A			■		
Increase T_{ox}		■	■		■
Increase Φ_{gate}		–			■
Increase μ	■	■	■		↑

- W_{dep} : depletion region width; I_{on}: on-state drive current when $V_{ds}=V_{gs}=V_{dd}$. μ: channel mobility.
- Blanks that are already filled in can be ignored.
- The electron affinity of silicon is χ=4.05

6. Which of the following best describes the transport of enhancement mode MOSFET in the on-state (5%)?
    (a) Mainly due to diffusion of carriers in the channel
    (b) Mainly due to drift of carriers in the channel
    (c) Has equal contribution from drift and diffusion
    (d) None of the above

7. Which of the following best describes the transport of bipolar junction transistor in the forward active mode (5%)?
    (a) Mainly due to diffusion of carriers in the channel
    (b) Mainly due to drift of carriers in the channel
    (c) Has equal contribution from drift and diffusion
    (d) None of the above

8. The FinFET transistor is introduced recently to solve the problem of short channel effects in conventional planar MOSFET. Which one is **NOT** an unwanted result of short channel effect (5%)?
    (a) Gate tunneling current
    (b) Drain induced barrier lowering (DIBL)
    (c) Threshold voltage roll-off
    (d) Sub-threshold swing (SS) degradation

9. Velocity saturation reduces the MOSFET saturation current when horizontal (source-to-drain) electric field is sufficiently large. Approximately what is the value of saturation velocity for N-channel silicon MOSFET (5%)?
    (a) 2.5×10^2 cm/s
    (b) 3×10^4 cm/s
    (c) 8×10^6 cm/s
    (d) 2×10^8 cm/s