科目：固態電子元件(500H)

校系所組：交通大學電子研究所（甲組）
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1. (a) What's the difference between (100), {100}, [100], and <100> in describing a crystal ? (4 pts)
   (b) Please calculate the concentration of As atom (atoms/cm^3) in the $GaAs_yP_{1-y}$ fcc crystal. Assume the lattice constant of the fcc lattice is C nm [answer in term of C]. (6 pts)

2. A semiconductor crystal is doped by donor to a concentration of $1x10^{15}$ cm^{-3} and by acceptor to a concentration of $2x10^{15}$ cm^{-3}. Assuming that the bandgap, E_g, is independent of temperature, calculate (a) the hole concentrations at 0K, (5pts) (b) the electron concentration at 300K, (5pts) and (c) the hole concentration at 600K. (5pts)

   $n_i \propto e^{-E_g/2kT}$, $n_i(@300K) = 1.5\times10^{10} cm^{-3}$, $kT/q(@300K) = 25mV$, $e^{2.3} = 10$ and $E_g = 1.15eV$.

3. Consider a P-type semiconductor bar with length L under thermal equilibrium. The doping is nonuniform along the bar and the valence band edge can be expressed as $E_V = E_{V0} + (\Delta/L)\cdot x$, $0 \le x \le L$ with $\Delta > 0$.
   (a) Draw the energy band diagram for the semiconductor bar clearly showing the relative position of the conduction band edge (E_C), Fermi level (E_F), and E_V. (3 pts)
   (b) What is the electric field inside the semiconductor bar? (3 pts)
   (c) Using the Boltzmann approximation, express the electron concentration n in terms of the position of the Fermi level. (3 pts)
   (d) Continued from (c) and given that the electron concentration at $x = 0$ is C, find an expression for the electron concentration $n(x)$ along the bar. Express your answer in terms of Δ and L. (6 pts)

4. Consider an N-type Si bar doped at 2×10^{16} cm^{-3}. It is exposed to light such that electron-hole pairs are generated throughout the volume of the bar at the rate of 5×10^{19} sec^{-1}cm^{-3}. The recombination lifetime is 10^{-5} sec.
   (a) Find the np product (n: electron concentration. p: hole concentration). (5 pts)
   (b) If the light is suddenly turned off at t = 0, find the excess hole concentration $\Delta p(t)$ for t > 0. (5 pts)

5. For a silicon P/N junction with uniform doping concentration at 25 °C, answer the problems below,
   (a) Write the current equation of P/N junction (reverse current and external voltage are I_0 and V_A). (10pts)
   (b) Follow (a), what is the operation temperature (°C) when the forward current swing is 75mV/decade? (10pts)
   (c) Follow (a), further consider the recombination-generation current, what is the operation temperature (°C) if the current swing is 90mV/decade at small forward voltage? (5pts)

注意：背面有試題

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6. Consider the C-V curve of a MOS capacitor is shown in Figure 1. The oxide capacitance is Cox with p^+ poly Si gate. Answer the problems below,

(a) What is the substrate type(n or p)? (3pts)

(b) Which region (a, b, c, or d) is at accumulation state? (3pts)

(c) Explain why the capacitance of region "d" is near the same level of region "a" for curve A. (3pts)

(d) Draw and compare the C-V curves when increases the substrate doping. (3pts)

(e) Draw and compare the C-V curves if adds some fixed negative charges, -Q, in the gate oxide. (3pts)

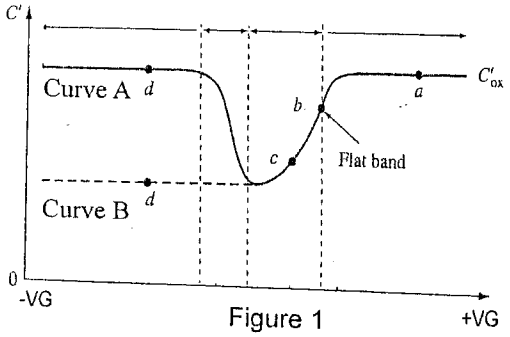

Figure 1

7. Consider the three kinds of modifications in MOSFET output current (1) Channel Length Modulation (2) Field Dependent Channel Mobility (3) Velocity Saturation, answer the problems below,

(a) When the temperature decreases, which modifications will become severe? Why? (5pts)

(b) When the channel length decreases, which modifications will become severe? Why? (5pts)