編號： 198

國立成功大學九十九學年度碩士班招生考試試題

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系所組別： 電機工程學系在職專班甲組

考試科目： 半導體概論（專班）

考試日期：0306，節次：3

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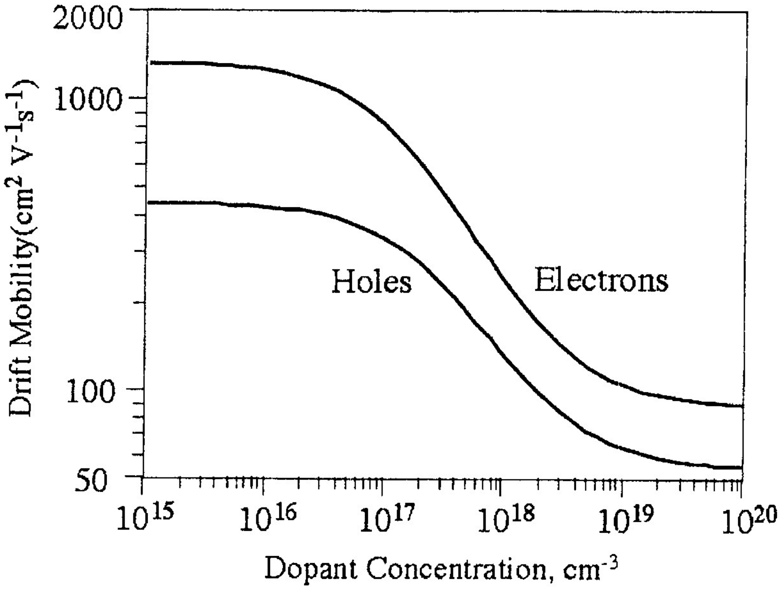
Some physical constants, diagrams and formula for your reference:

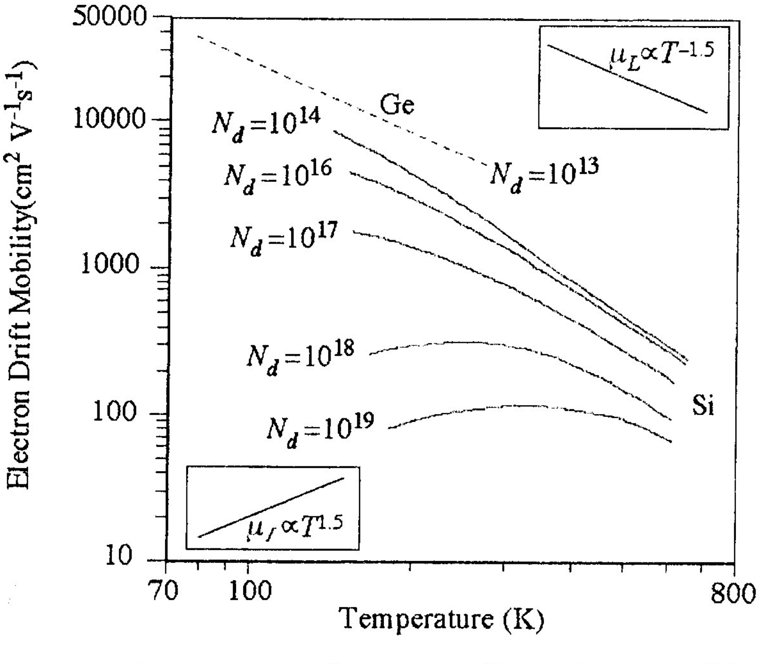
$e = 1.602\times10^{-19}$ C, electron concentration $n = N_c \exp\left[-\left(E_c - E_F\right)/kT\right]$

Boltzmann constant $k = 1.3806\times10^{-23}\,\mathrm{J\,K^{-1}} = 8.6174\times10^{-5}\,\mathrm{eV\,K^{-1}}$

Intrinsic electron concentration in Si at 300 K = $1.45\times10^{10}\ \mathrm{cm^{-3}}$



The variation of the drift mobility with dopant concentration in Si at 300 K



Drift mobility versus temperature for *n*-type Ge and *n*-type Si samples.

（背面仍有題目,請繼續作答）

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1. Explain the following concepts: (a) intrinsic semiconductor, (b) extrinsic semiconductor, (c) formation of energy band, (d) effective mass, (e) degenerate and nondegenerate semiconductors, (f) Schottky junction and (g) ohmic contacts. (15%)

2. a. A Si wafer has been doped *n*-type with 10^{17} As atoms cm^{-3}.

   1. Calculate the conductivity of the sample at 27°C.
   2. Where is the Fermi level in this sample at 27°C with respect to the Fermi level (E_{Fi}) in intrinsic Si?
   3. Calculate the conductivity of the sample at 127°C.

   b. The above *n*-type Si sample is further doped with 9×10^{16} boron atoms (*p*-type dopant) per centimeter cubed.

   1. Calculate the conductivity of the sample at 27°C.
   2. Where is the Fermi level in this sample with respect to the Fermi level in the sample in (a) at 27°C? Is this an *n*-type or *p*-type Si? (20%)

3. Consider an *n*-type semiconductor and weak injection conditions. Assume that the minority carrier recombination time, τ_h, is constant (independent of injection – hence the weak injection assumption). The rate of change of the instantaneous hole concentration, $\partial p_n / \partial t$, due to recombination is given by

$$\frac{\partial p_n}{\partial t} = -\frac{p_n}{\tau_h} \qquad [1]$$

The net of increase (change) in p_n is the sum of the total generation rate G and the rate of change due to recombination, that is,

$$\frac{dp_n}{dt} = G - \frac{p_n}{\tau_h} \qquad [2]$$

By separating the generation term G into thermal generation G_0 and photogeneration G_{ph} and considering the dark condition as one possible solution, show that the relationship for the excess carriers under photogeneration and recombination is given by

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$$\frac{d\Delta p_n}{dt} = G_{ph} - \frac{\Delta p_n}{\tau_h} \qquad [3]$$

What are the assumptions inherent in Equation 3? (15%)

4. Sketch an ideal energy band diagram for nP straddling heterojunction. The capital letter N means the material has larger bandgap (i.e. material bandgap P > n). Indicate the conduction band, valence band, Fermi level, ΔEc, ΔEv and build potentials $V_{bi\,n}$ and $V_{bi\,P}$. (20%)
5. Calculate the flat band voltage for an MOS capacitor with following conditions:
   silicon substrate doping $N_a = 10^{16}$ cm^{-3}, silicon dioxide thickness 500 Å, and n+ ploysilicon gate (Φ_{ms}= -1.1 eV) with an equivalent trap charge of Q_{ss}= 10^{11} electronic charges per cm^2 at the oxide-silicon interface. (permittivity of silicon dioxide is $3.45\text{x}10^{-13}$ F/ cm) (15%)
6. Describe how (a) phonon absorption (b) phonon emission in photon absorption process in an indirect bandgap semiconductor. (15%)