ECE113A Fall 2003 **first Midterm Exam** Name:_______________

10-20-2003 ID no.:_______________

Sec.A: Peter Burke 10:00 to 10:50 am

PROBLEM ONE: (60 points)

NO UNITS FOR FINAL ANSWER, NO CREDIT THAT PART.

For Si at 300 K, with $N_D=10^{16}$ cm^{-3}, $N_A \ll N_D$:

A) (20 points)
Find the equilibrium electron concentration (n) in units of cm^{-3}.

If you say $n \approx N_D$ 10 points

If you say $n = 10^{16}$ cm^{-3} 10 pts

If you don't say $n \approx N_D$ but still say $n = 10^{16}$ cm^{-3}, still get full credit [20 pts.]

B) (20 points)
Find the equilibrium hole concentration (p) in units of cm^{-3}.

$$p = \frac{n_i^2}{n} \text{ or } \frac{n_i^2}{N_D} \quad \text{10 pts.}$$

$$= \frac{[10^{10}\ \text{cm}^{-3}]^2}{10^{16}\ \text{cm}^{-3}} \quad \text{5 pts}$$

$$= 10^4\ \text{cm}^{-3} \quad \text{5 pts.}$$

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PROBLEM ONE: *(continued)*

C) (20 points)
Find $E_C - E_F$ in units of eV. Use whatever method you want.

Sol. #1 5pts $E_c - E_F = -kT \ln\left[\frac{n}{N_c}\right]$ or equivalent

* 5pts. $N_c = 3.2017 \times 10^{19}\ cm^{-3}$ or equivalent

(meaning put in #s for N_c formula correctly)

$E_c - E_F =$ 0.2 eV to 0.21 eV 10pts

[[redacted]]

~~Sol. #2~~

Sol. #2

$E_F - E_i = kT \ln\left[\frac{n}{n_i}\right]$ 5 pts.

$E_F - E_i = 0.35 - 0.36$ eV 5 pts.

$E_C - E_i = \frac{E_G}{2}$ 2 pts

$E_C - E_i = \frac{E_G}{2} \pm \frac{3}{4} kT \ln\left[\frac{m_p^*}{m_n^*}\right]$ 5 pts

(either or for credit)

$E_C - E_i = 0.567$ eV ±1meV 2 pts

$E_C - E_i = 0.56$ eV ±1meV 1 pt

(either/or for credit)

$E_C - E_F = 0.208$ to 0.210 eV 3 pts

$= 0.201$ eV to 0.203 eV 1 pt.

(either or for credit)

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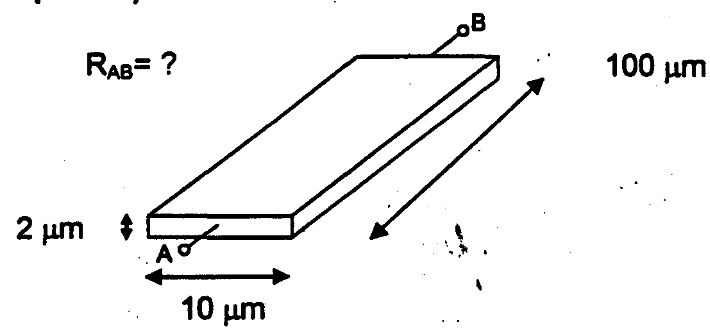
PROBLEM TWO: (40 points)



For the silicon sample at T= 300 K shown above, given $N_D=10^{16}$ cm^{-3}, $N_A \ll N_D$,

A) (20 points)
Find the resistivity ρ of the Si to within 30% in units of Ω-cm.
(You may use figure 3.8 from the text.)

Sol #1: graph 0.4 – 0.6 Ω-cm 20 pts.

else, 0 pts.

Sol #2: (Back)

If you use both methods, we grade on only method 1. (The easier method.)

B) (20 points)
Calculate the resistance R_{AB} in units of Ω, for the geometry shown above.

$$R_{AB} = \rho \frac{L}{A} \quad \text{10 pts.}$$

$$= 0.5\ \Omega\text{-cm} \frac{100\ \mu m}{2\ \mu m \times 10\ \mu m} \quad \text{5 pts.}$$

(±0.1 Ω-cm)

$$= 25{,}000\ \Omega \quad \text{5 pts.}$$

(20,000 – 30,000 Ω gets 5 pts.)

Sol # 2: Calculate

$$\rho = \frac{1}{n\mu q}$$ 5 pts

$$\mu = 1000 - 1500 \ \frac{cm^2}{V\text{-}s}$$ (Fig 3.5) 5 pts.

$$\rho = 0.41 - 0.63 \ \Omega\text{-cm}$$ 10 pts

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