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Microelectronics HW1

1. A Si sample is doped such that it has 10^{17} cm^{-3} electrons in it's conduction band (i.e. $n = 10^{17}$ cm^{-3}) at both 300K and 200K. Calculate the hole concentrations at 300K and 200K. Figure 2.20 has the n values for various temperatures.

$n=10^{17}$

$n_{i\ |300K} =10^{10}$

$p=n_i^2/n=(10^{10})^2/10^{17}=10^3=1000$

$n_{i\ |200K} =5.246x10^4$

$p=n_i^2/n=(5.246x10^4)^2/10^{17}=2.752x10^{-8}$

2. (Problem 2.17 in text) Determine the equilibrium electron and hole concentrations inside a uniformly doped sample of Si under the following conditions:
    a. $T=300K$, $N_A << N_D$, $N_D = 10^{15}$ cm^{-3}.

$n_i=10^{10}$
$n=N_D$
$p=n_i^2/N_D$
$n=10^{15}$
$p=10^5$

    b. $T=300K$, $N_D << N_A$, $N_A = 10^{16}$ cm^{-3}.

$n_i=10^{10}$
$p=N_A$
$n=n_i^2/N_A$
$n=10^4$
$p=10^{16}$

    c. $T=300K$, $N_A = 9x10^{15}$ cm^{-3}, $N_D = 10^{16}$ cm^{-3}.

$n_i=10^{10}$
$n=(N_D-N_A)/2 + [((N_D-N_A)/2)^2 + n_i^2]^{½}$
$p=n_i^2/n$
$n=10^{15}$
$p=10^5$

    d. $T = 450$ K, $N_A=0$, $N_D = 10^{14}$ cm^{-3}.

$n_i=4.7x10^{13}$
$N_D>>N_A$
$n=N_D$
$p=n_i^2/N_D$
$n=10^{14}$
$p=2.209x10^{13}$

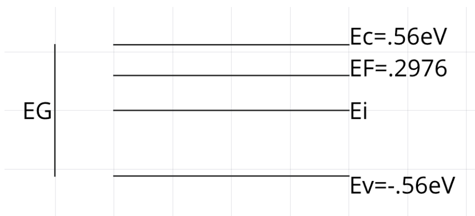
    e. $T = 650$ K, $N_A=0$, $N_D = 10^{14}$ cm^{-3}.

$n_i=1.2x10^{16}$
$N_D>>N_A$
$n=N_D$
$p=n_i^2/N_D$
$n=10^{14}$
$p=1.44x10^{18}$

Note: d and e could not be solved with the information given. $N_A=0$ was not given in d or e, it had to be found in the textbook.

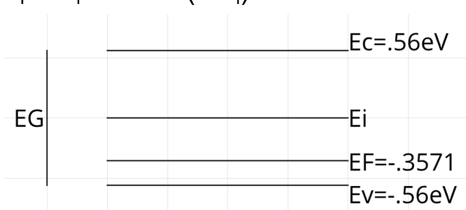
3. (Problem 2.18 in text) For each of the conditions specified in Problem 2, determine the position of E_i, Compute $E_F - E_i$, and draw a carefully dimensioned energy band diagram for the Si sample. Note: E_G (Si) = 1.08 eV at 450 K and 1.015 eV at 650 K. Also, read exercise 2.4 in text (page 55).
    a. A

$E_F - E_i = k\,T\ln(n/n_i) = 0.2976$ eV



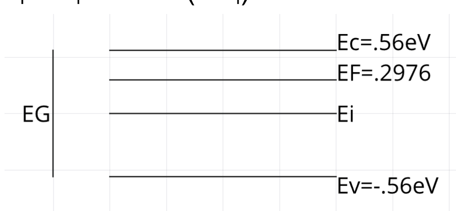
    b. B

$E_F - E_i = k\,T\ln(n/n_i) = -0.3571$ eV



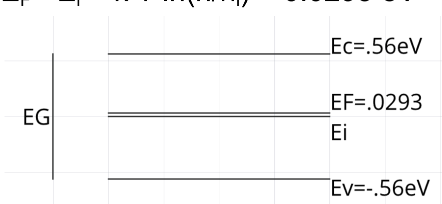
    c. C

$E_F - E_i = k\,T\ln(n/n_i) = 0.2976$ eV



    d. D

$E_F - E_i = k\,T\ln(n/n_i) = 0.0293$ eV



    e. E

$E_F - E_i = k\,T\ln(n/n_i) = -0.2681$ eV