PhD Preliminary Written Exam
Spring 2014

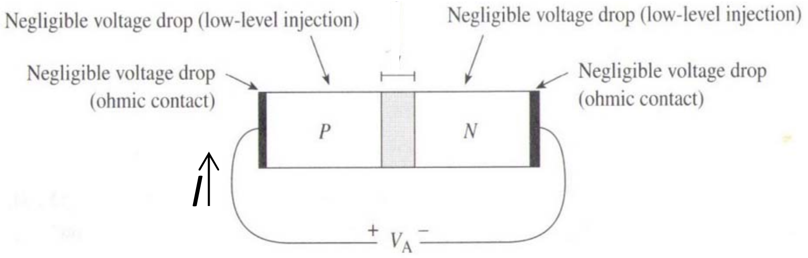
Problem 6
Semiconductor Devices

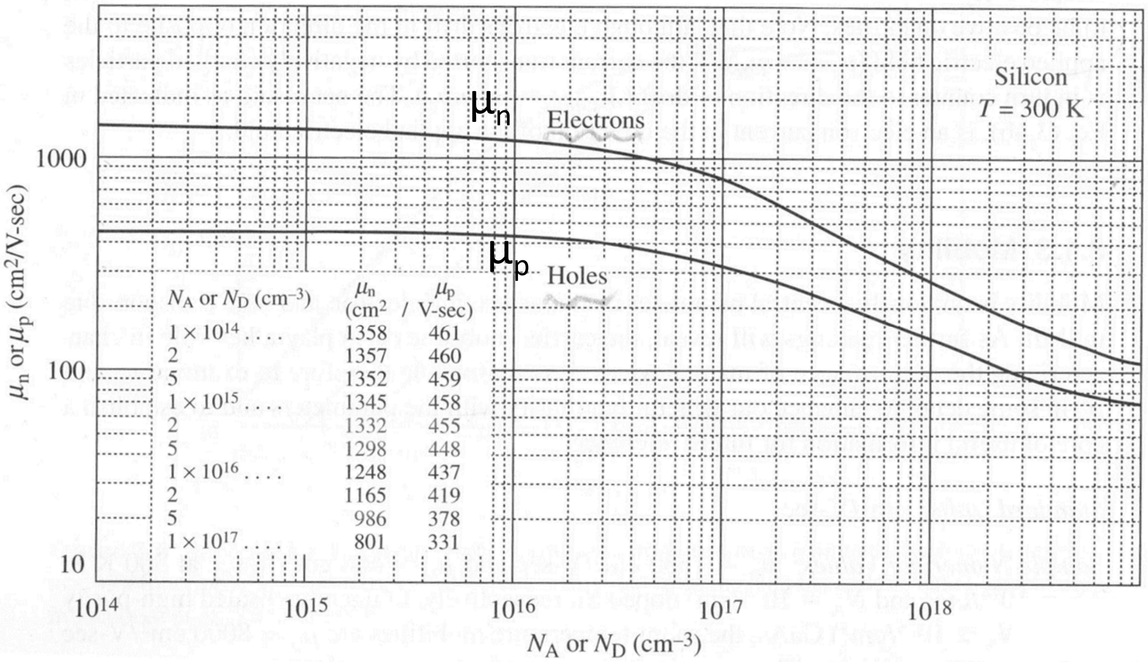
An ideal Si p-n junction diode with cross-sectional area A=0.001 cm^2 had been fabricated in your lab, and the voltage drop (V_{bi} = 0.6946V) across the depletion region under equilibrium conditions (zero bias) was measured with the tools you developed. You also developed a system that visualizes the depletion width (W=9.6 x 10^{-5}cm) of the diode under the equilibrium conditions. In order to test the diode you applied a forward bias (V_A) of 0.65V.

Find current (I) with a forward bias (V_A=0.65 V) at room temperature (300 K).

Assume that the current is diffusion dominated, and total number of acceptor atoms (N_A) is less than that of donor atoms (N_D). The electron (τ_n) and hole (τ_p) minority-carrier lifetime is 2.5ms, respectively.

Physical constants: Electronic charge q= 1.60 x 10^{-19} C,
Intrinsic carrier concentration at 300 K n_i =1.5x10^{10} /cm^3
Boltzmann's constant k=1.38x10^{-23} J/K
Permittivity of free space ε_o=8.85 x 10^{-14} F/cm
Relative dielectric constant of Si K_s= 11.8





N_A or N_D (cm^{-3})	μ_n (cm^2 / V-sec)	μ_p
1 × 10^{14}	1358	461
2	1357	460
5	1352	459
1 × 10^{15}	1345	458
2	1332	455
5	1298	448
1 × 10^{16}	1248	437
2	1165	419
5	986	378
1 × 10^{17}	801	331

Figure 1. Room temperature carrier mobilities as a function of the dopant concentration in Si. μ_n is the electron mobility; μ_p is the hole mobility.