Solutions

a) If the silicon is doped 10^{17} cm^{-2} n-type, Find the position of the Fermi energy of silicon with respect to the silicon conduction band edge.

E_C-E_F = -kT*ln(n/Nc) = 0.0257eV*ln(10^{17}/3.2x10^{19}) = 0.15eV

b) Find the probability of occupancy for a conduction band state with exactly enough to overcome the barrier and go into the oxide.

f(E) = 1/(1+exp[-(E-E_F)/kT]) = 1/(1+ exp[1.15eV/0.0257eV]) = 3.7x10^{-20}

c) Assuming the parabolic band approximation (not a very good approximation for such a large distance from the band edge, but use it anyway), find the density of states at the same energy as described in part b.

$g_c(E) = 8\pi\, m_n^* \,(2\, m_n^*(E-Ec))^{1/2} / h^3$ = 4.9x10^{46} m^{-3} J^{-1} = 7.8*10^{21} cm^{-3} eV^{-1}

d) Now multiply parts b) and c) together to get the concentration of electrons per eV that have enough energy to get over the barrier. Multiply this by kT, to get an idea of the concentration of electrons with enough energy to get over the barrier.

N(KE>1eV) = 7.4 cm^{-3}

e) Finally assume that the electrons are traveling at the saturated velocity for electrons in silicon at room temperature, find the leakage current density (J).

J=qnv = 1.1x10^{-11} Amp/cm^2 = 11 pA/cm^2