SEMICONDUCTOR PHYSICS **ECE 1336**

Problem Set #11: Excess Carriers & Recombination-Generation Processes

1. Excess electrons and holes are generated at the end of a silicon bar (x=0). The silicon is doped with phosphorus atoms to a concentration of $N_d = 10^{17}$ cm^{-3}. The minority carrier lifetime is 1 μs, the electron diffusion coefficient is $D_n = 25$cm^2/s, and the hole diffusion coefficient is $D_p = 10$cm^2/s. If $\delta n(0) = \delta p(0) = 10^{15}$ cm^{-3}.

(a) State which carrier is the minority carrier and which is the majority carrier.

(b) Determine the steady-state electron and hole concentrations in the bar for x>0. Note your answer should be a function of x.

(c) Calculate the electron and hole diffusion current densities at x = 5μm.

2. An n-type silicon sample contains a donor concentration of $N_d = 10^{16}$ cm^{-3}. The minority carrier hole lifetime is found to be $\tau_{po} = 20$ μs. (a) What is the lifetime of the majority carrier electrons?

(b) Determine the thermal equilibrium generation rate for electrons and holes in this material.

(c) Determine the thermal equilibrium recombination rate for electrons and holes in this material.

3. Explain qualitatively why the excess carrier lifetime reduces to the minority carrier lifetime under low injection.

Note: For silicon at T=300K, the intrinsic carrier concentration, n_i, is 1.5 X 10^{10} cm^{-3}.