PROBLEM SET – 4

Thursday, December 6th, 2007

Problem 1.

In a sample of Si, the electron and hole mobilities are 0.15 and 0.05 $m^2V^{-1}s^{-1}$, respectively. Calculate the room-temperature diffusion co-efficients for electrons and holes, and calculate the diffusion lengths if the lifetime for both types of carriers is 10^{-4} s.

Problem 2.

We form a p-n junction of GaP (E_g = 2.25 eV) using $N_A = 10^{18}$ cm^{-3} and $N_D = 10^{16}$ cm^{-3}. The dielectric constant is 9, and the effective masses of electrons and holes are 0.35 and 0.5 times the free electron mass, respectively. (a) Calculate the equilibrium junction voltage. (b) Calculate the wavelength at which a transition from opacity to transparency will occur, and the wavelength at which the reverse transition will occur. Sketch the reflectivity vs. wavelength, with these two wavelengths indicated.

Problem 3.

At t = 0, a voltage V is applied across a resistance R and a capacitance C connected in series. Derive the time dependence of (a) the current, (b) the voltage across the capacitance, and (c) the voltage across the resistance. (Hint: current $I = dQ/dt$)

Problem 4.

Diamond has a dielectric constant of 5.68. Calculate the polarization, electric displacement, and dielectric susceptibility when diamond is exposed to an electric field of 1 V/mm.

Problem 5.

The dielectric constant of quartz is 3.85 at low frequencies, and its index of refraction for visible light is 1.46. What fraction of its polarization is ionic (a) at low frequencies (b) at frequencies of visible light?

Problem 6.

Cobalt has a saturation magnetization of 1.4×10^6 A/m, and an atomic volume of 6.7 cm^3/mole. (a) What is the magnetic dipole moment of each cobalt atom in Bohr magnetons? (b) You apply a magnetic field in the easy direction with a coil of 10 turns per meter carrying a current of 0.3 mA, and determine that the total field $\boldsymbol{B}$ within the sample is one tesla. Calculate $\boldsymbol{M}$ and determine what percentage of the volume now consists of domains with magnetization parallel to the field.