Problems for Carrier Transport Phenomena

3-2: Assume that the mobility of electrons in silicon at T=300K is μ_n=1300cm^2/Vs. Also assume that the mobility is mainly limited by lattice scattering. Determine the electron mobility at (a) T=200K and (b) T=400K.

3-5: Consider a compensated n-type silicon at T=300K, with a conductivity of σ=16 (Ω-cm)$^{-1}$ and an acceptor doping concentration of 10^{17} cm^{-3}. Determine the donor concentration and the electron mobility. (A compensated semiconductor is one that contains both donor and acceptor impurity atoms in the same region).

3-7: A four-point probe (with probe spacing of 0.5mm) is used to measure the resistance of a p-type silicon sample. Find the resistivity of the sample if its diameter is 200mm and its thickness is 50μm. The contact current is 1mA, and the measured voltage between the inner two probes is 10mV.

3-10: Consider a semiconductor that is non-uniformly doped with donor impurity atoms ND(x), show that the induced electric field in the semiconductor in thermal equilibrium is given by

$$E(x) = -\left(\frac{kT}{q}\right)\frac{1}{N_D(x)}\frac{dN_D(x)}{dx}$$

3-11: An intrinsic Si sample is doped with donors from one side such that $N_D=N_o\exp(-\alpha x)$. (a) Find an expression for the built-in field E(x) at equilibrium over the range for which $N_D>>n_i$. (b) Evaluate E(x) when α=1 μm^{-1}.

3-16: The total current in a semiconductor is constant and is composed of electron drift current and hole diffusion current. The electron concentration is constant and equal to 10^{16} cm^{-3}. The hole concentration is given by

$$p(x) = 10^{15}\exp\left(\frac{-x}{L}\right)\ \text{cm}^{-3}$$

where L=12μm. The hole diffusion coefficient is D_p=12cm^2/s and the electron mobility is μ_n=1000cm^2/Vs. The total current density is J=4.8A/cm^2. Calculate (a) the hole diffusion current density versus x, (b) the electron current density versus x, and (c) the electric field versus x.