Basic

1. When computing SRH recombination rates, we usually focus on defects with energy levels near the middle of the bandgap. Beginning with the SRH expression, show that states near the middle of the bandgap have the largest effect on the SRH recombination rate.

2. Consider an n-type semiconductor having ND =10^17cm−3 under uniform optical excitation. Assume a SRH G-R process. Let G be 10^20EHP/cm3/s and τ = 10μs. Find electron and hole concentrations and the position of quasi fermi levels (Fn and Fp) under steady state condition. Repeat the calculation if ND = 10^13cm–3.Assume T = 300K, ni = 10^10cm−3 .

3. Consider that the semiconductor of the previous problem is in steady state till t = 0.Now at time t = 0, the intensity of the light is reduced to half for $t \geq 0$.Find $\Delta np(t)$ for $t > 0$.

4. 10^{13} EHP/cm^3 are created optically every microseconds in a Si sample with $n_o=10^{14}$ cm^{-3} and electron and hole lifetimes are both 2 μs. Find electron and hole concentrations and the position of quasi Fermi levels (F_n and F_p) under steady state condition.

5. Consider a silicon semiconductor at 300K doped with n-type having ND =10^13cm−3. Assume a blue light is generating electron hole pairs at a rate of 10^15/cm3/s.

a) Assume band to band recombination (rate constant = 10^-14). Comment whether it is high level or low level injection. Also calculate life time of minority carrier.

b) Assume a trap level is introduced 0.3eV below the conduction band minimum spatially. Comment whether it is high level or low level injection (τ = 10μs for both electrons and holes).

c) What is the overall lifetime of minority carrier if both recombination’s are present?

Advanced

1. Initially in equilibrium and not affected by room light, a uniformly doped silicon wafer sitting on your desk is struck by a mysterious ray at time t = 0. As a result all minority carriers are wiped out and majority carriers are unaffected. The wafer doping is NA = 10^16/cm3 , τn = 10^−6 s, and T = 300 K.

1.1 What is Δn at t = 0+?

1.2 Does generation or recombination dominate at t = 0+? Explain.

1.3 Does low-level injection condition exist inside the wafer at t = 0+? Explain.

1.4 Starting from the appropriate differential equation, derive Δnp(t) for t > 0.

2. A Si sample with $10^{16}/cm^3$ donors is optically excited such that $10^{19}/cm^3$ electron-hole pairs are generated per second uniformly in the sample. The laser causes the sample to heat up to 450 K. Find the quasi-Fermi levels and the change in conductivity of the sample upon shining the light. Electron and hole lifetimes are both 10 us and $n_0 = 10^{14}$ cm^{-3} at 450 K.