

ECSE-2210 Microelectronics Technology
Class Activity 8 – Solution

1. Name three generation and three recombination processes. Which one is more common in Si and Ge? Which one is more common in GaAs?

Carrier generation by Band-to-band transitions, carrier generation through R-G centers, and carrier generation via impact ionization.

Recombination process from Band-to-band, recombination process through R-G center and Auger recombination.

In Si and Ge, R-G center recombination-generation is more common or dominant.

In GaAs, band-to-band generation and recombination is the dominant mechanism

2. Explain what “direct band-gap” and “indirect band-gap” semiconductor mean. (One sentence each)

In direct band-gap semiconductors, the electron-hole (EH) pairs recombine via band-to-band recombination emitting the energy as radiation. The momentum of electrons and holes are the same.

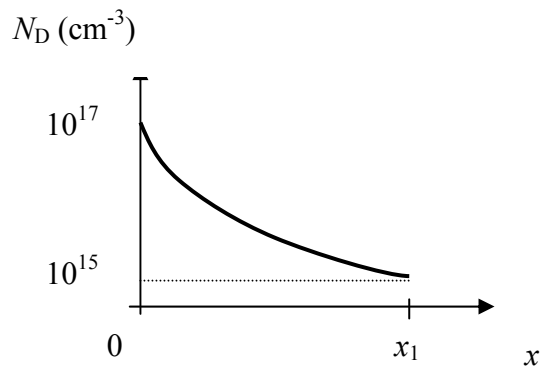
In indirect semiconductors, the EH pairs recombine via an R-G center, and the energy is given out as heat to the lattice. Both a change in momentum and change in energy are involved in these transitions.

3. An n-type silicon sample is doped such that the doping concentration decreases exponentially from 10^{17} cm^{-3} to 10^{15} cm^{-3} as x increases from zero to x_1 (see the figure below). The sample is in thermal equilibrium. The magnitude of the electric field inside Si between $x = 0$ to $x = x_1$ is: (Choose one). Explain your choice.

- (a) Linearly decreasing
- (b) Linearly increasing
- (c) Constant
- (e) Exponentially decreasing
- (f) Zero

And

The direction of \mathcal{E} -field is in the **(positive x , negative x : choose one)** direction.



The magnitude of the electric field is constant since $\mathcal{E} = (1/q) dE_i/dx$. Since n varies exponentially, the band diagram should vary in a linear fashion, so the slope dE_i/dx is constant. The direction is in the positive x direction.

