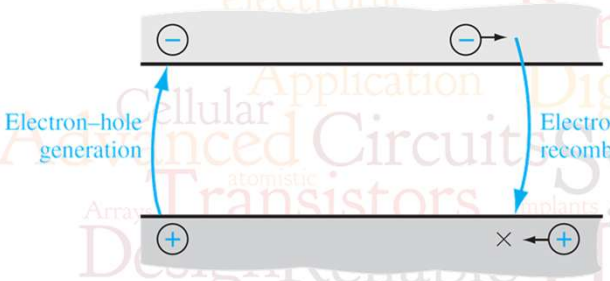
Carriers in Semiconductors under equilibrium



- *Generation* is the process whereby electrons and holes are created
- *Recombination* is the process whereby electrons and holes are annihilated
- In thermal equilibrium, carrier concentrations are independent of time, and therefore, the generation and recombination rates are equal

$$G_{n_0} = G_{p_0} = R_{n_0} = R_{p_0}$$

Thermal Generation rate of electrons | Thermal Generation rate of holes | Recombination rate of electrons | Recombination rate of holes

Unit of #/cm^3-s

90

Excess Carriers in Semiconductors

Symbol	Definition
n_0, p_0	Thermal-equilibrium electron and hole concentrations (independent of time and also usually position)
n, p	Total electron and hole concentrations (may be functions of time and/or position)
$\delta n = n - n_0$ $\delta p = p - p_0$	Excess electron and hole concentrations (may be functions of time and/or position)
g'_n, g'_p	Excess electron and hole generation rates
R'_n, R'_p	Excess electron and hole recombination rates
τ_{n0}, τ_{p0}	Excess minority carrier electron and hole lifetimes

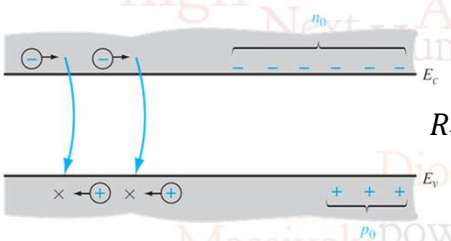
For the direct band-to band generation, the excess electrons and holes are also created in pairs:

$$g'_n = g'_p$$

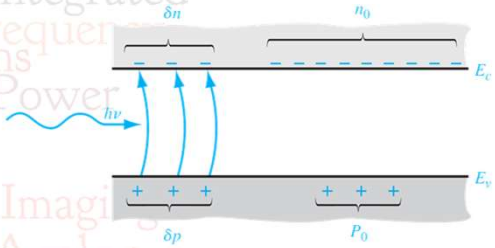
On external influence, excess electrons and holes are generated:

$$n = n_0 + \delta n$$
$$p = p_0 + \delta p$$

$$np \neq n_0 p_0 \neq n_i^2$$

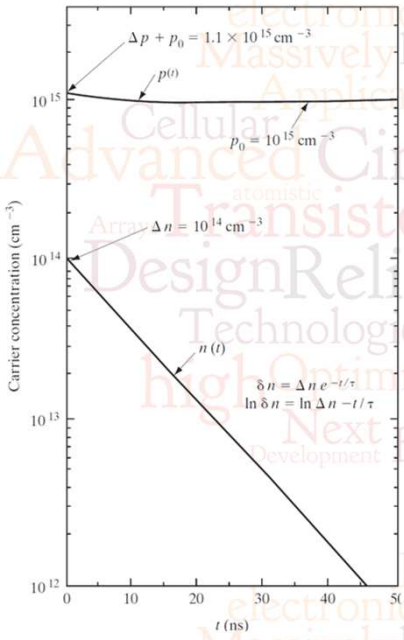


$$R'_n = R'_p$$

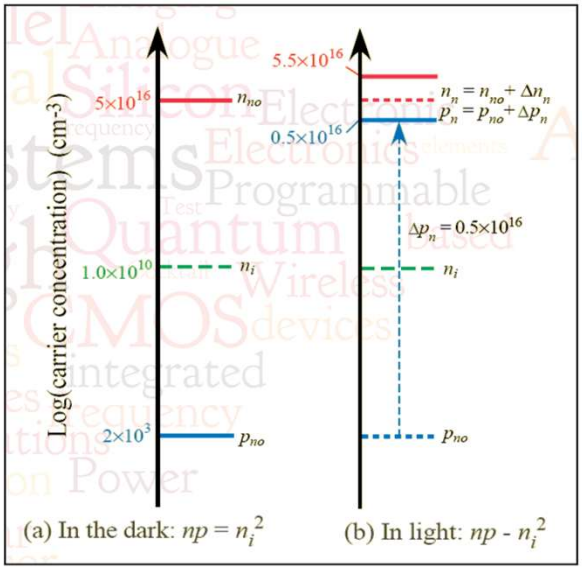


91

Practice Example



GaAs is doped with 10^{15} acceptors/cm^3. The intrinsic carrier concentration is approximately 10^6 cm^{-3}, carrier recombination lifetime of 10 ns.



96