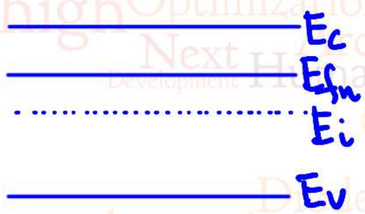
Quasi-Fermi Levels

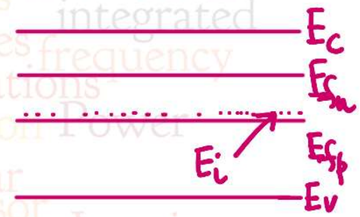
Quasi-Fermi levels are conceptual constructs, defined energy levels that can be used in conjunction with the energy band diagram to specify the carrier concentrations inside a semiconductor under nonequilibrium conditions.

- Two energies, E_{fc}, the quasi Fermi level for electrons, & E_{fv}, the quasi-Fermi level for holes
- These energies are related to the nonequilibrium carrier concentrations in the same way E_f is related to the equilibrium carrier concentrations

A uniformly donor-doped silicon wafer at room temperature is suddenly photo-illuminated at $t = 0$. Assuming $N_d = 10^{14}/cm^3$, and excess electrons and holes, $\Delta n = \Delta p = 10^{11}/cm^3$ throughout the semiconductor, find the non-equilibrium positions of the Fermi levels.



For $t < 0$



For $t \geq 0$

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Quasi-Fermi Levels

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RECALL

$$n = n_i e^{\frac{E_F - E_{f_i}}{kT}}$$

$$p = n_i e^{\frac{E_{f_i} - E_F}{kT}}$$

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$$n = n_i e^{\frac{E_{fc} - E_{fi}}{kT}} \Rightarrow E_{fc} = E_{fi} + kTln\left(\frac{n}{n_i}\right)$$

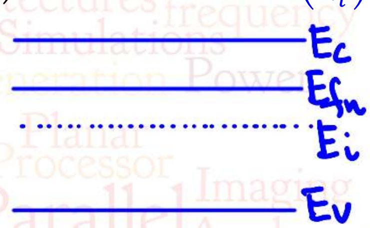
$$p = n_i e^{\frac{E_{fi} - E_{fv}}{kT}} \Rightarrow E_{fv} = E_{fi} - kTln\left(\frac{p}{n_i}\right)$$

For $t < 0$, Equilibrium State: $n_0 = 10^{14}/cm^3$

$p_0 = 10^6/cm^3$

$$E_F - E_{f_i} = kTln\left(\frac{N_d}{n_i}\right) \cong 0.25eV$$

A uniformly donor-doped silicon wafer at room temperature is suddenly photo-illuminated at $t = 0$. Assuming $N_d = 10^{14}/cm^3$, and excess electrons and holes, $\Delta n = \Delta p = 10^{11}/cm^3$ throughout the semiconductor, find the non-equilibrium positions of the Fermi levels.



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For $t \geq 0$, non- Equilibrium State:

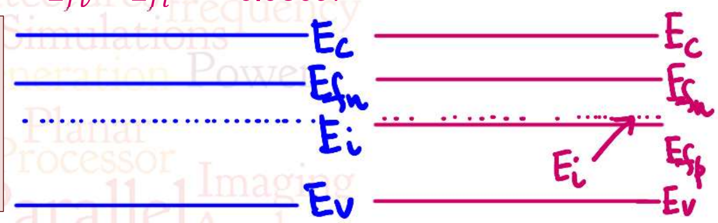
$$n = n_0 + \Delta n = 10^{14}/cm^3$$

$$p = p_0 + \Delta p = 10^{11}/cm^3$$

$$E_{fc} - E_{fi} = E_f - E_{f_i} = 0.25eV$$

$$E_{fv} - E_{fi} = -0.060eV$$

A uniformly donor-doped silicon wafer at room temperature is suddenly photo-illuminated at $t = 0$. Assuming $N_d = 10^{14}/cm^3$, and excess electrons and holes, $\Delta n = \Delta p = 10^{11}/cm^3$ throughout the semiconductor, find the non-equilibrium positions of the Fermi levels.



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