Working Principle of a Semiconductor Based Solar Cell

Excitation of Charge Carriers II

Week 2.3.2

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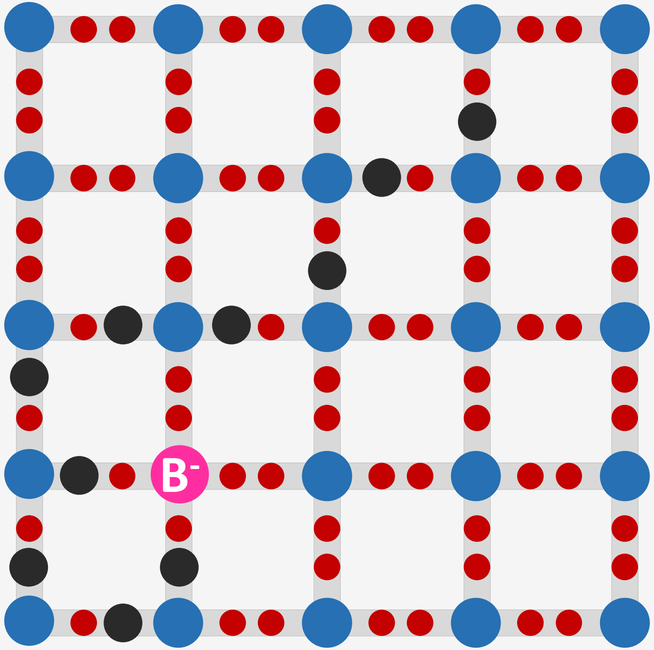
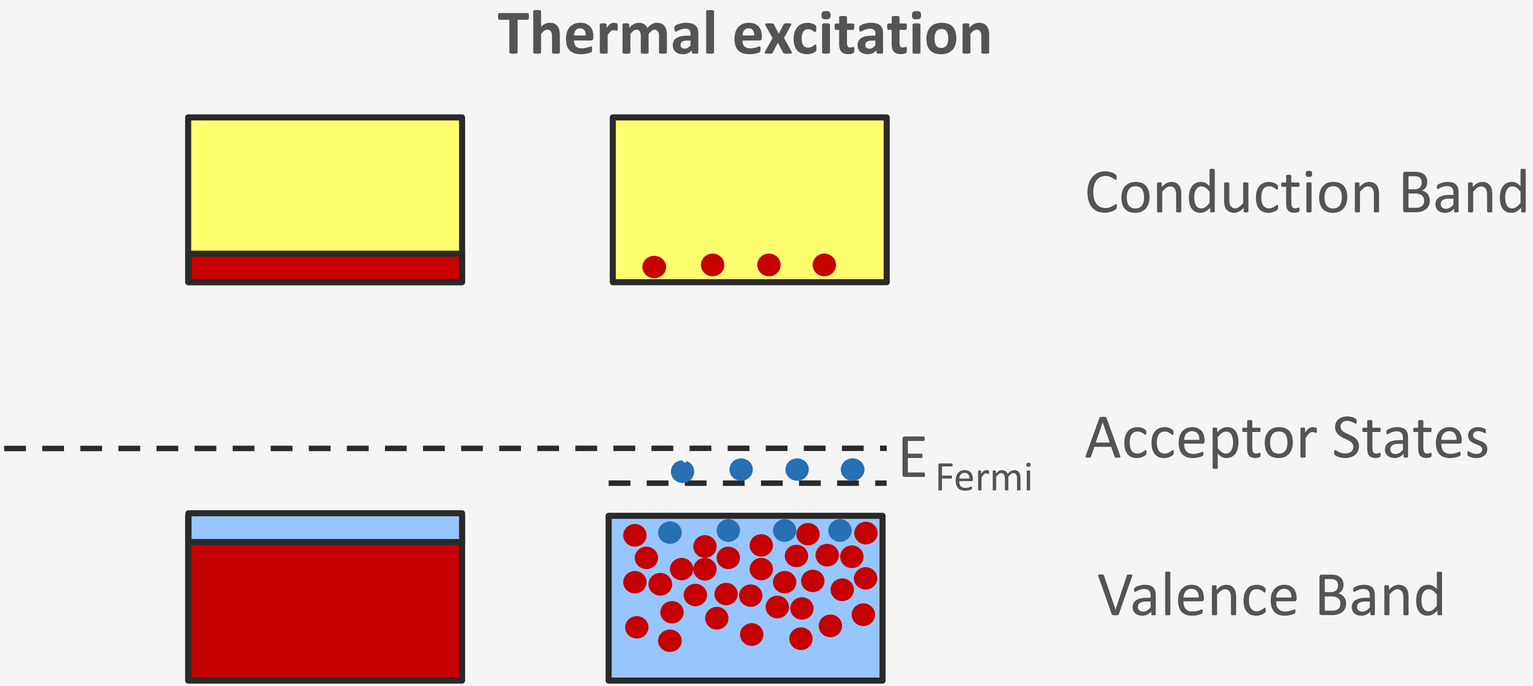
p-Doping



Energy band diagram of p-doped Silicon



Typical Concentrations:

$$\frac{\text{Majority Carriers}}{\text{Minority Carriers}} = \frac{10^{16}\ \text{cm}^{-3}}{10^{4}\ \text{cm}^{-3}}$$

Si density in c-Si is 5×10^{22} cm^{-3}

Law of Mass Action

$n =$ electron carrier concentration
$p =$ hole carrier concentration

} $n \cdot p = 1{,}21 X 10^{20}\ cm^{-6}$

Intrinsic material $n = p = n_{intrinsic} = 1{,}1X10^{10} cm^{-3}$

Doping: *At Room Temperature:*

$$n_0\, p_0 = (n_{intrinsic})^2$$

n-type doping

$$n_0 = N_D$$

$$p_0 = \frac{(n_{intrinsic})^2}{n_0}$$

p-type doping

$$p_0 = N_A$$

$$n_0 = \frac{(n_{intrinsic})^2}{p_0}$$

Example

n-type doping

$$n_0 = N_D$$

$$p_0 = \frac{(n_{intrinsic})^2}{n_0}$$

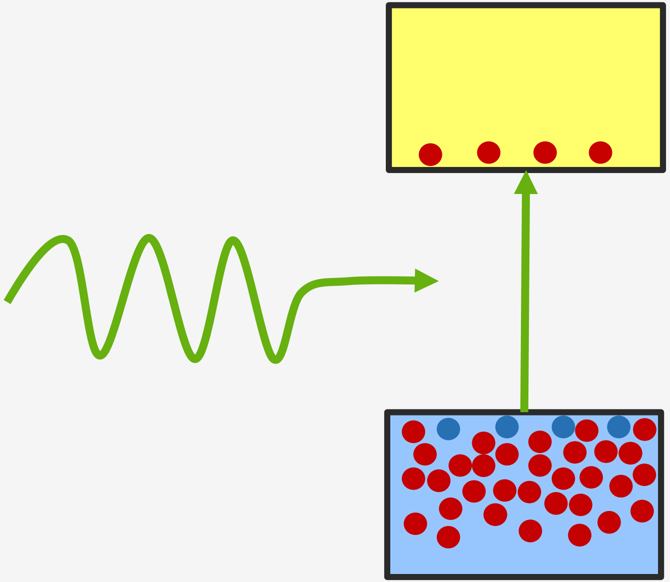
n-type doping example

$$n_0 = N_D = 10^{16}\ cm^{-3}$$

$$p_0 = \frac{1{,}21X10^{20}}{10^{16}} = 1{,}21X10^{4}\ cm^{-3}$$

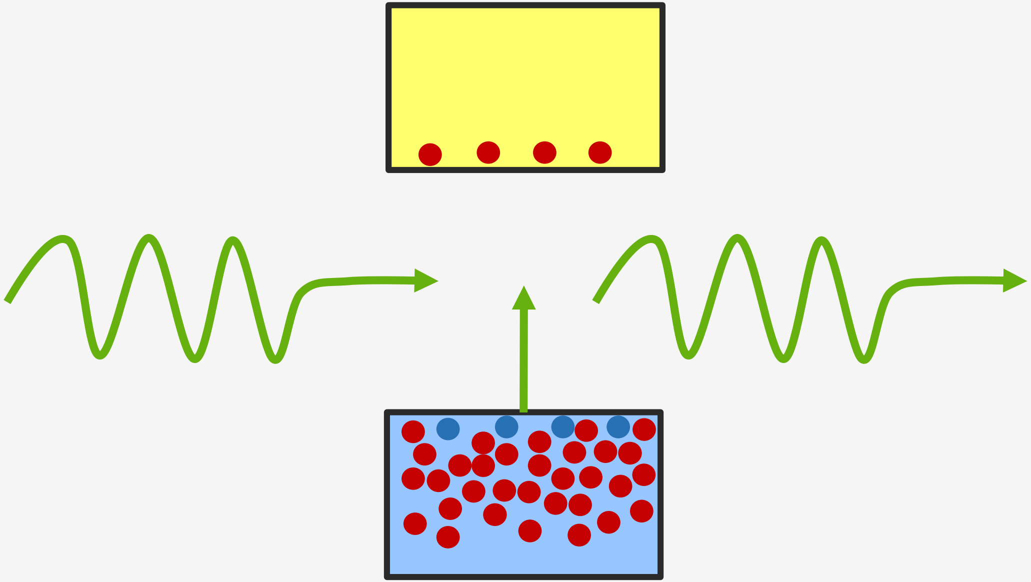
Light Absorption *scenario 1*

$E_{ph} = E_G$:



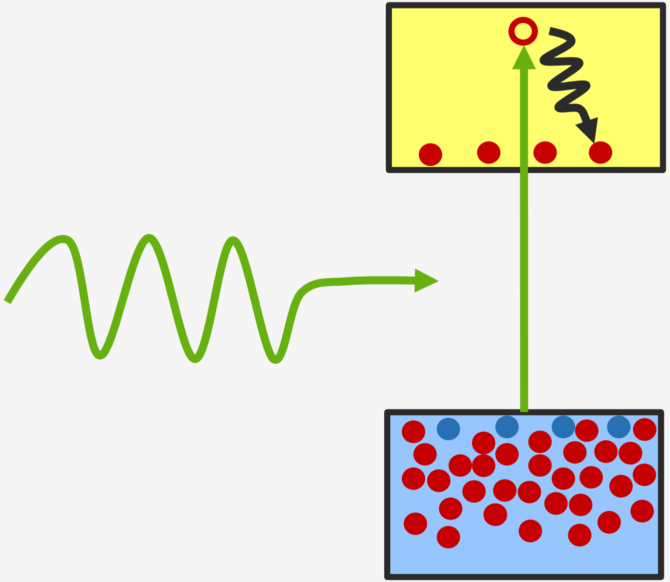
Light Absorption *scenario 2*

$E_{ph} < E_G$:



Light Absorption *scenario 3*

$E_{ph} > E_G$:



Light Absorbtion in doped material

before light absorption:

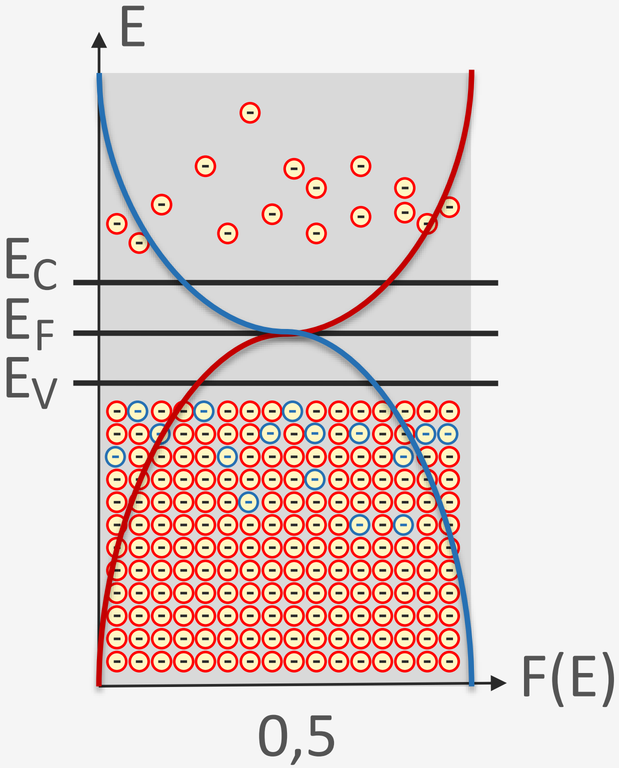
$$\frac{\text{Majority Carriers}}{\text{Minority Carriers}} = \frac{10^{16}\ \text{cm}^{-3}}{10^{4}\ \text{cm}^{-3}}$$

Light Absorbtion in doped material

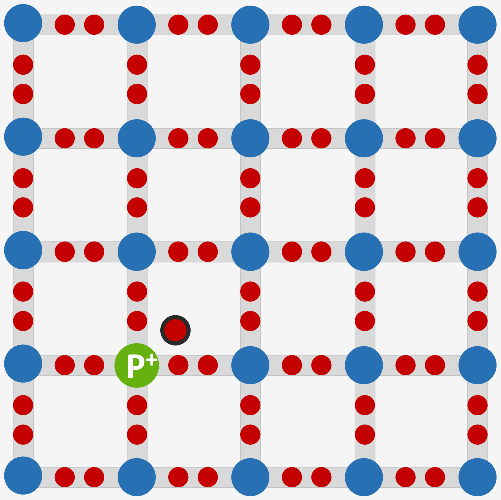
10^{11} now electron-hole pairs:

$$\frac{\text{Majority Carriers}}{\text{Minority Carriers}} = \frac{10^{16} + \cancel{10^{11}}\ cm^{-3}}{\cancel{10^{4}} + 10^{11}\ cm^{-3}}$$

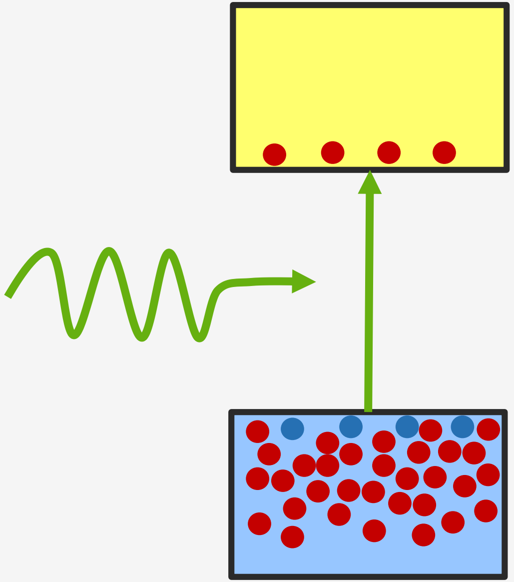
Temperature



Doping



Light



Thank you for your attention!