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LECTURE -9

FERMI - LEVELS IN SEMICONDUCTORS

* ELECTRONS BEHAVE USING FERMI-DIRAC STATISTICS

DISTRIBUTION OF ELECTRONS OVER A RANGE OF ALLOWED ENERGY LEVELS AT THERMAL EQUILIBRIUM

$$f(E) = \frac{1}{1 + e^{(E-E_F)/KT}}$$

$f(E)$ → FERMI-DIRAC DISTRIBUTION FUNCTION!

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f(E) GIVES THE PROBABILITY THAT AN AVAILABLE ENERGY STATE AT "E" WILL BE OCCUPIED BY AN ELECTRON AT TEMP. T

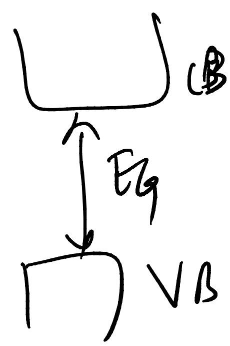
AT $E = E_F$ $$f(E) = \frac{1}{1+e^{(E_F - E_F)/kT}} = \frac{1}{2}$$

$\Rightarrow$ 50%

* NO ELECTRON CAN EXIST IN BAND GAP EVEN THOUGH A FINITE PROBABILITY EXISTS!

$\therefore$

NO STATES ARE AVAILABLE IN E_g!



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$$n_0 = n_i \, e^{(E_F - E_i)/KT}$$

$E_F - E_i \uparrow$

$E_c - E_F \downarrow$ $n_0 \uparrow$

$$E_F - E_i = KT \ln\left(\frac{n_0}{n_i}\right)$$

$$p_0 = n_i \, e^{(E_i - E_F)/KT}$$

$$E_i - E_F = KT \ln\left(\frac{p_0}{n_i}\right)$$

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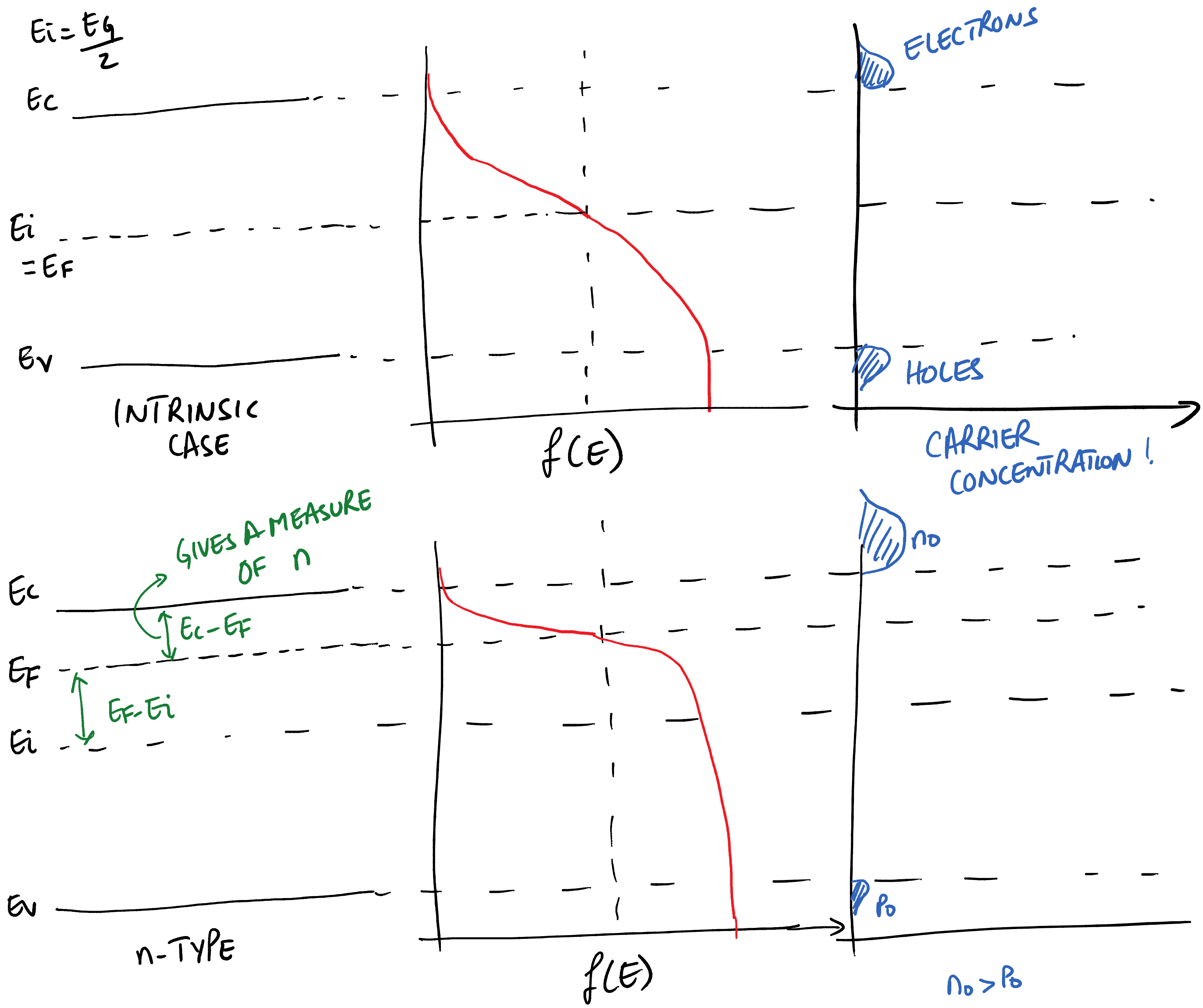

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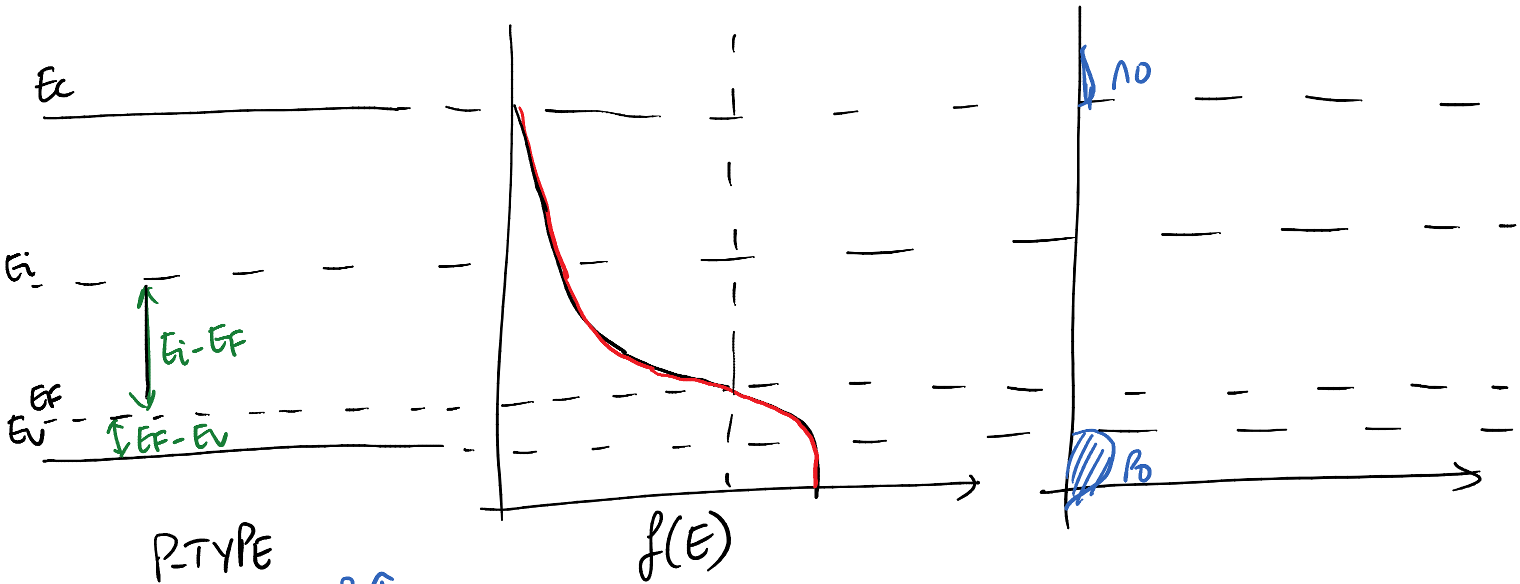

P-TYPE

$E_i - E_F \uparrow$ $p_0 \uparrow$

$E_F - E_v \downarrow$

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Ex

* CAN USE APPROX. FOR n_0 AND p_0

↳ DEPENDS ON THE PROBLEM!

Si
RT

$E_g = 1.12\,eV$

$KT = 0.0259\,eV$

$N_a^- = 1\times10^{12}\ cm^{-3}$ → P-TYPE MATERIAL

p_0 MAJORITY!

FOR SMALL PROBLEM APPROX.

$p_0 = 1\times10^{12}\ cm^{-3}$

$n_0 = 2.25\times10^{8}\ cm^{-3}$

$n_0 p_0 = n_i^2$

$$E_i - E_F = KT \ln\left(\frac{p_0}{n_i}\right)$$

$$= 0.0259 \ln\left(\frac{1\times10^{12}}{1.5\times10^{10}}\right)$$

$E_i - E_F = 0.1087\ eV$

$E_F - E_i = -0.1087\,eV$

$E_i > E_F$