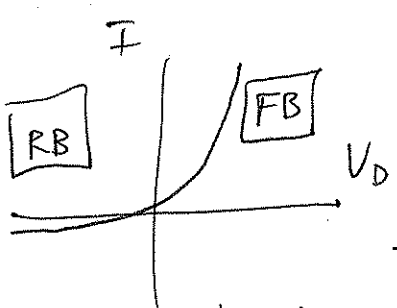
Ph 412 Lecture: (2/13/2012)

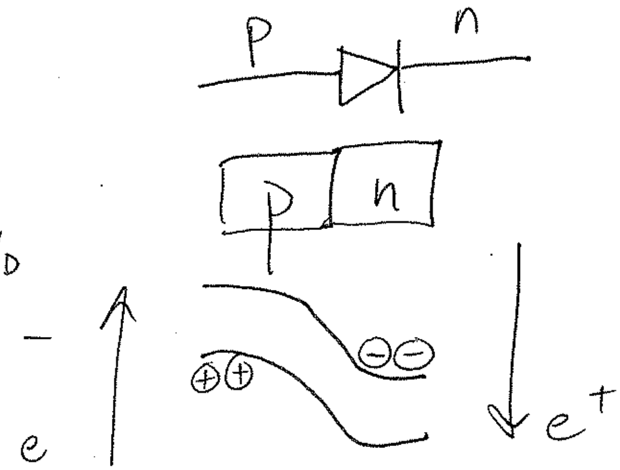
The main topic is bipolar junction transistors, but starts w/ diode review.

Diodes: "pn-junction"

p-type = mobile holes → Replace Si w/ group III.
n-type = mobile electrons → Replace Si w/ group V.



$I = I_0 (e^{qV/kT} - 1)$



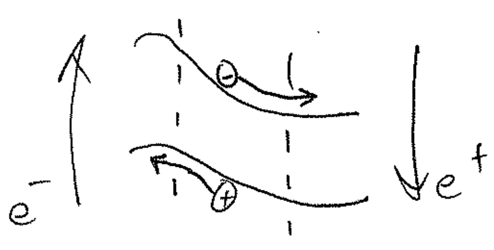
$$V_D = V_p - V_n$$

$V_D > 0 \Rightarrow$ F.B.
$V_D < 0 \Rightarrow$ R.B.

Adding (+V) to the p-type region lowers the bands making it easier for current to flow.

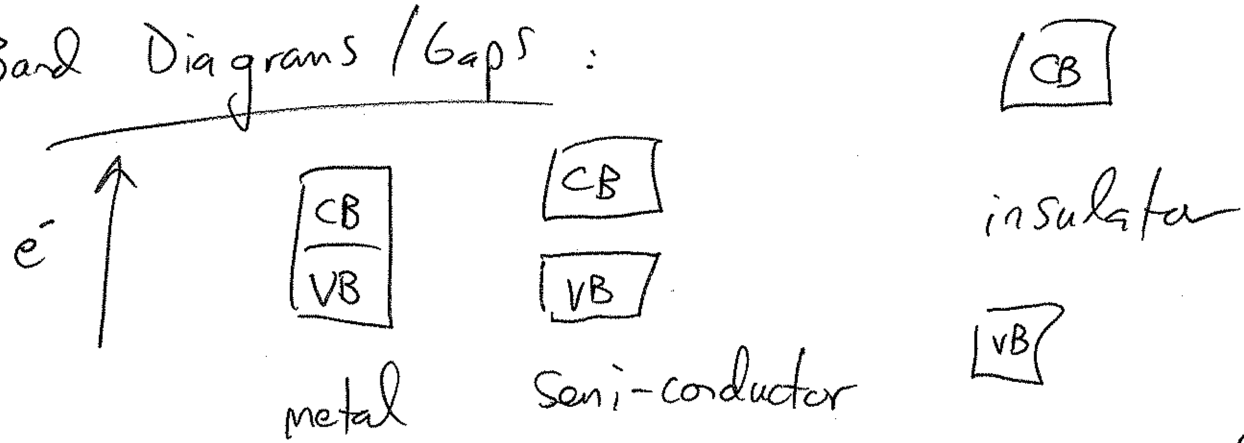
Photodiodes: Send light into the depletion region to create ⊕⊖ pairs.

LED
⊕⊖ recombination

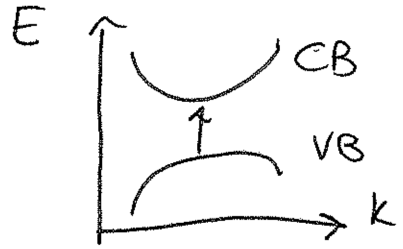


Photovoltaics
Resulting potential builds up from ⊕⊖ separation.

Band Diagrams / Gaps:



LCAO = Linear combination of atomic orbitals.

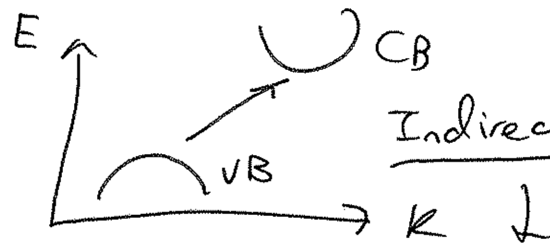


Direct → optical

$E = \hbar\omega$

$p = \hbar k$

$p = \frac{h}{\lambda}$ = small



optical = phonon-assisted

DFT.... briefly: $|\psi_i\rangle$ electrons

$$H\psi = E\psi \Rightarrow \left(\frac{-\hbar^2}{2m}\nabla^2 + V_{eff}\right)\psi_i = E_i\psi_i$$

"Kohn-Sham Equations" (1965)

$$\rho(r) = \sum_i^N |\psi_i(r)|^2$$

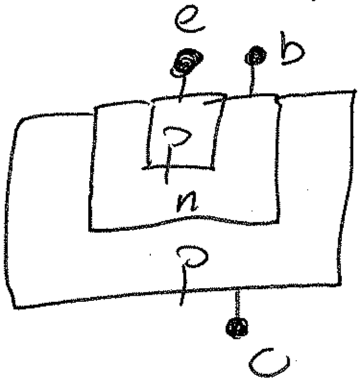
$$V_{eff} = V_{eff}(\rho(r))$$

- iterate to find lowest E_i

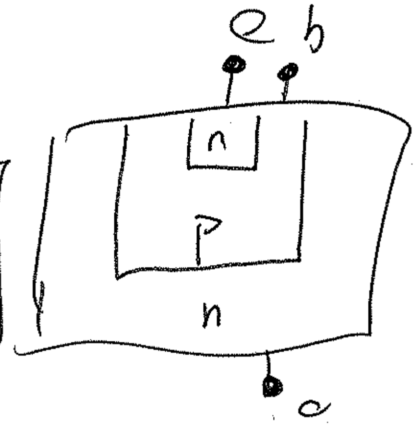
BJT's : Bipolar Junction Transistor

"pnp" or "npn"

pnp 3906

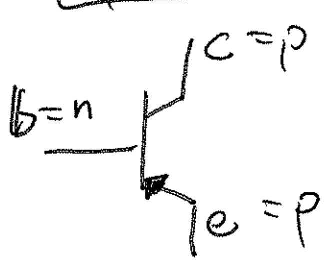


npn 3904

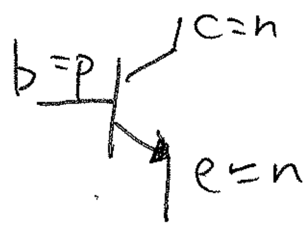


e = emitter
b = base
c = collector

pnp



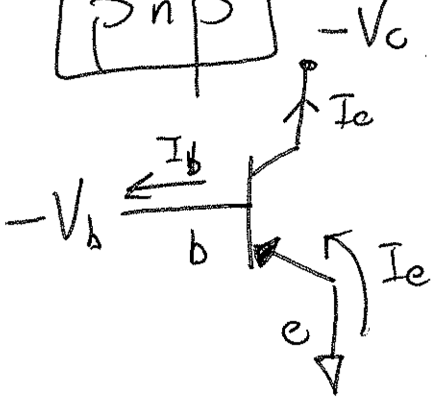
npn



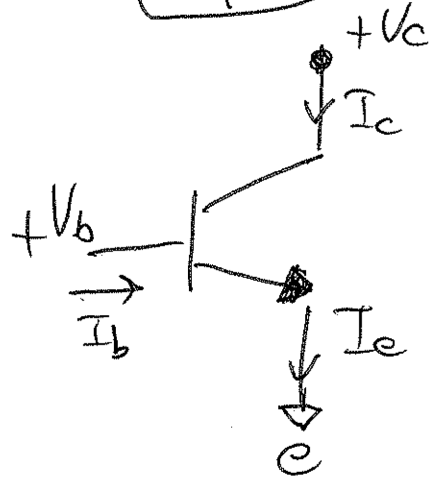
"On" Conditions

Forward bias b-e junction then repel collector current...

pnp



npn

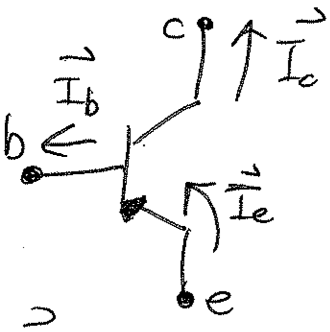


Use −V for pnp

Use +V for npn

Current Gain :

Using pnp BJT



① Conservation of $\vec{I}$

$$I_e = I_B + I_c \,, \quad \text{let } \alpha = \frac{I_c}{I_e}$$

$$\text{or } I_e = \frac{I_c}{\alpha}$$

$$I_B = I_e\left(1 - \frac{I_c}{I_e}\right) = \frac{I_c}{\alpha}(1-\alpha)$$

$$\boxed{\frac{I_c}{I_B} = \frac{\alpha}{1-\alpha} = \beta}$$

Amount of current gain...

Data :