Lecture after quiz-3

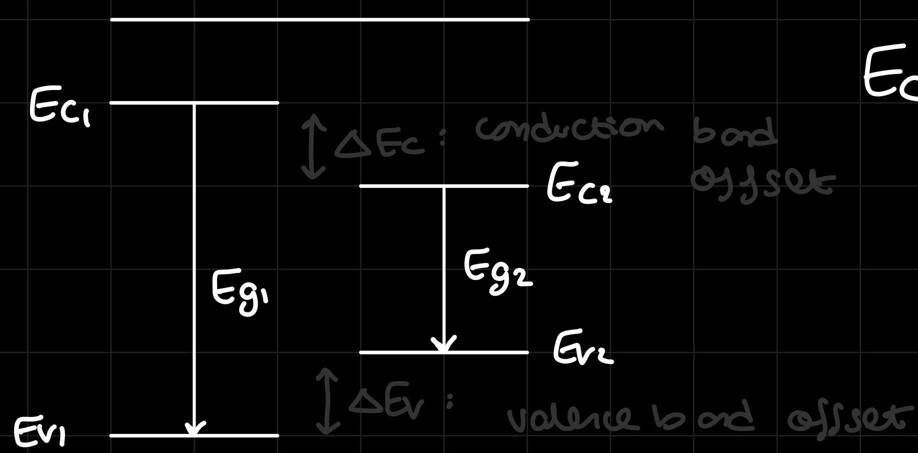
→ HETERO Junctions

Hetero structure devices : devices with a position dependent alloy composition

→ Type of hetero junctions

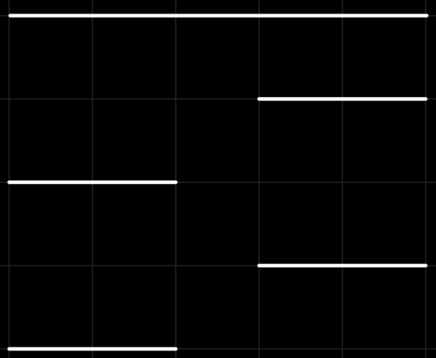
- Straddling Gap
- Staggered gap
- Broken gap

① Staggered gap



$E_{c1} > E_{c2}$, $E_{v1} < E_{v2}$

(2) Staggered Gap



$E_{C1} < E_{C2}$

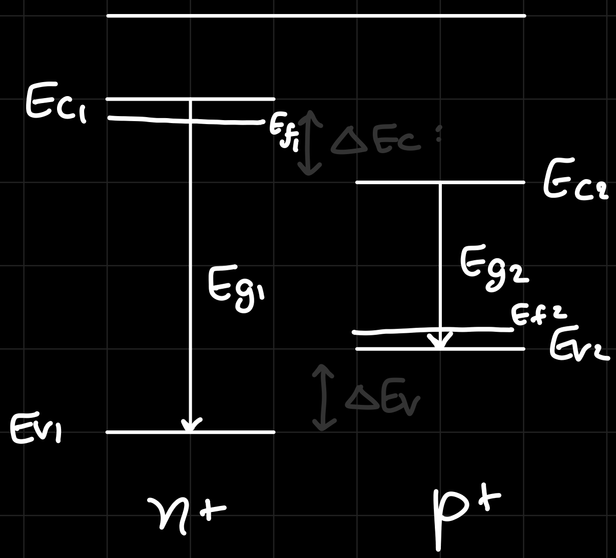
$E_{V1} < E_{V2}$

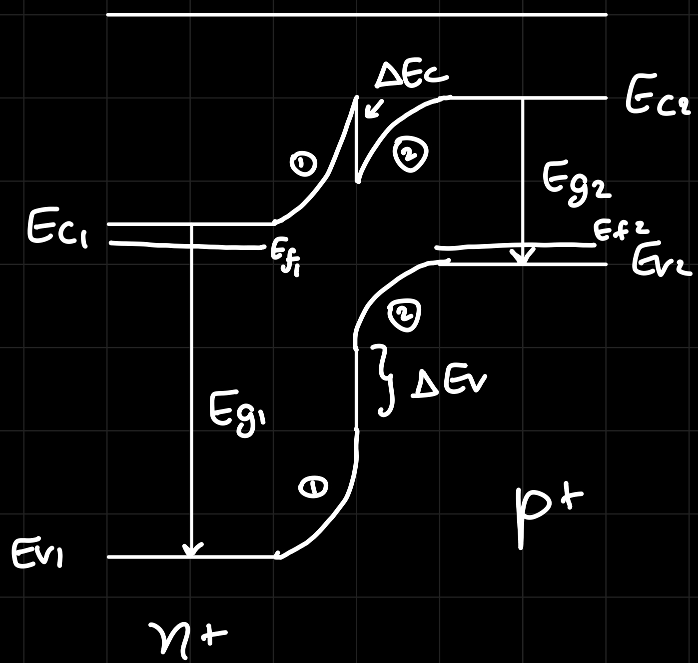
(3) Broken Gap

$E_{C2} > E_{V2} > E_{C1} > E_{V1}$

eg: $Al_{0.3}Ga_{0.7}As$

before contact



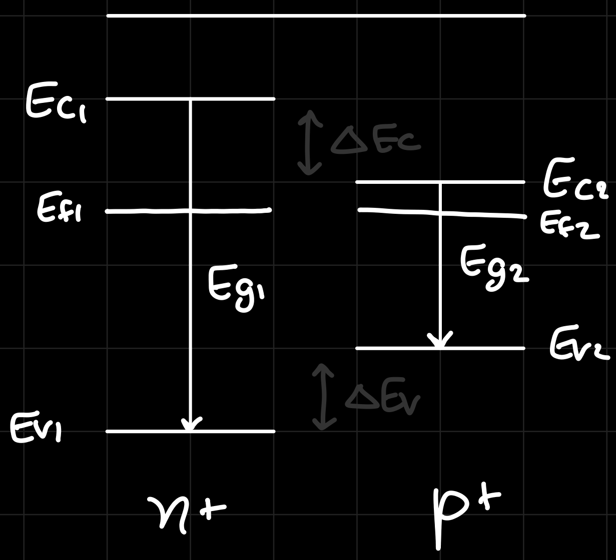


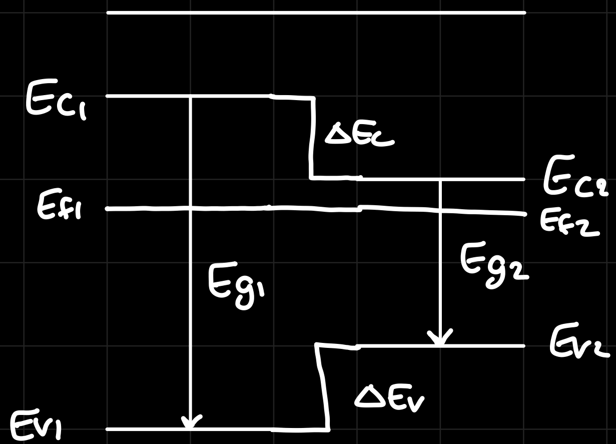
① : e⁻ depleted

② : e⁻ accumulated

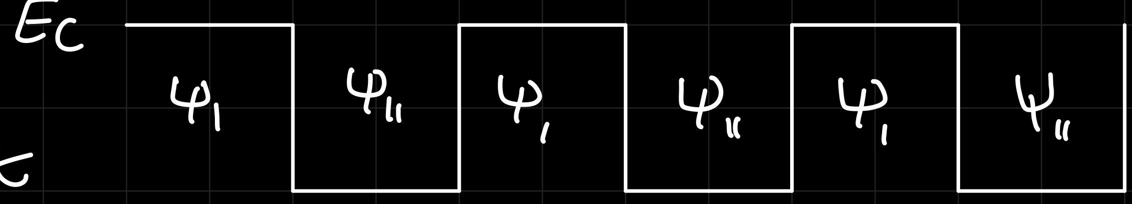
how to determine $\overline{E}$ for the sudden jump due to the offsets?

How about we choose doping so that no band bending required (E_f const)





What if we add more such SC pairs?



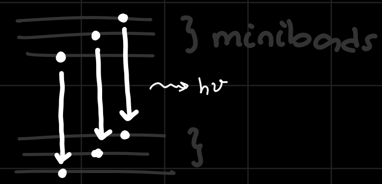
we get quantum well

Kronig Penny Model
quantized periodicity

This conduction band will form mini bands. We can also think about valence band similarly.

miniband (super lattice design)

quantum cascade laser

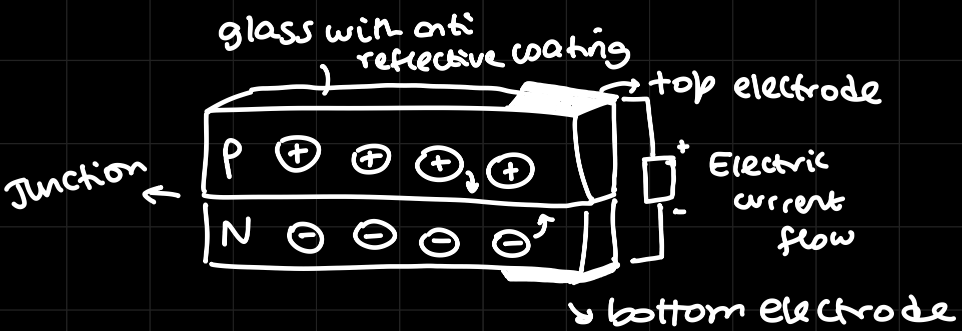


if the distance of traversal is kept constant, we can achieve a radiation of same freq with very high intensity (LASER)

SOLAR CELL

$h\nu$ absorbed : free e^- → electron hole pair generated
↓
This charge is held in a solar cell

Utilizes a PN Junction



works in unbiased mode

The charges in the depletion region must be immediately separated ($h\nu$) and stored

$$\boxed{I = I_{ph} - I_d}$$

I_{ph} → photogenerated current

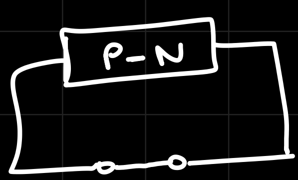
I_d → like leakage current
→ diode/dark current
due to thermal excitation inside the device

need to minimize I_D and maximize I_{ph}

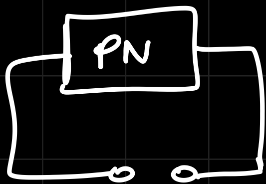
$$I = I_{ph} - I_0\left(e^{\frac{qV}{k_BT}} - 1\right)$$

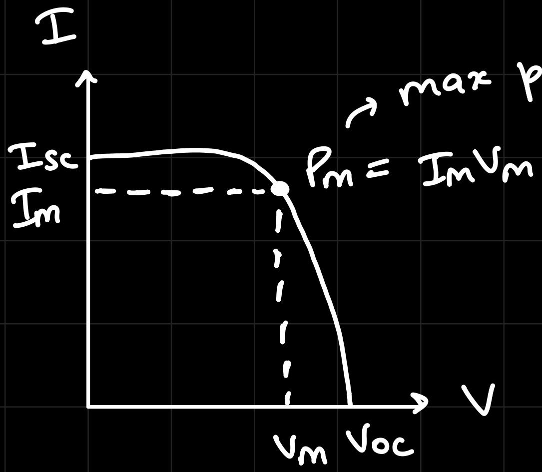
* short circuit current : max I generated with no bias/resistance

I_{sc}



* Open ckt voltage : max V generated in open ckt condition
(V_{oc})





→ max power point of a solar cell

SOLAR Efficiency (Schockley - Queisser Limit)

The max efficiency for a single pn junction solar cell is 33.7%
at E_g = 1.4eV

but Si → E_g = 1.1 eV
resulting in η_{max} = 32% only

visible range : 1.6eV → 3.4eV
but $\eta_{33.7}$ → E_g = 1.4eV < 1.6eV

we get better η efficiency by stacking layers of diff materials (with varying band gaps) to capture wider range of frequency spectrum.

≡ Tandem Solar Cell

Theoretically, we got 50% − 52% η

Still we use Si because practical use case wise, it offers mix of η and complexity.