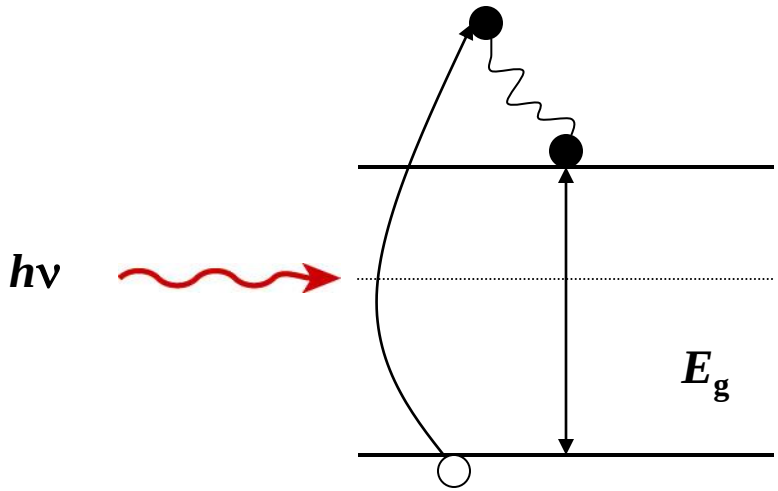
Lecture-3

Photo-Diodes

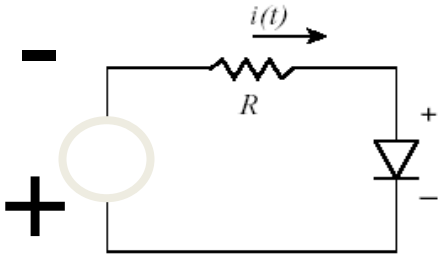
Photo-generation:

- An important generation process in device operation is ***photo-generation***

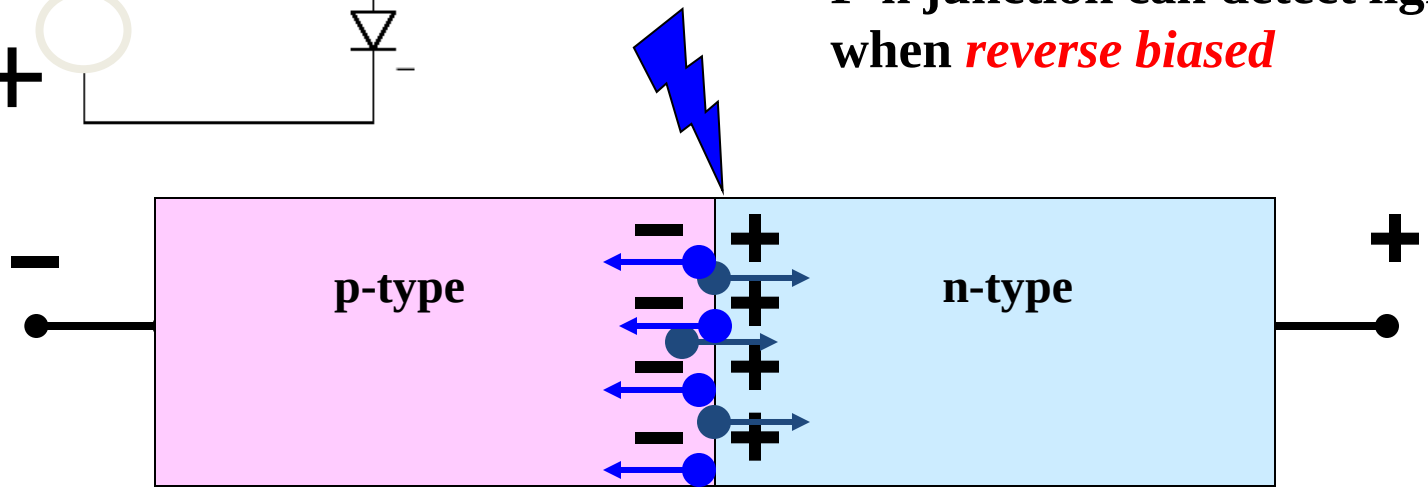
- If the photon energy ($h\nu$) is greater than the band gap energy, then the light will be absorbed and electron-hole pairs will be generated.



Photodetectors:



P-n junction can detect light when *reverse biased*



When light shines on a p-n junction, the photon energy RELEASES free electrons and holes i.e. electron-hole-pairs are generated optically.

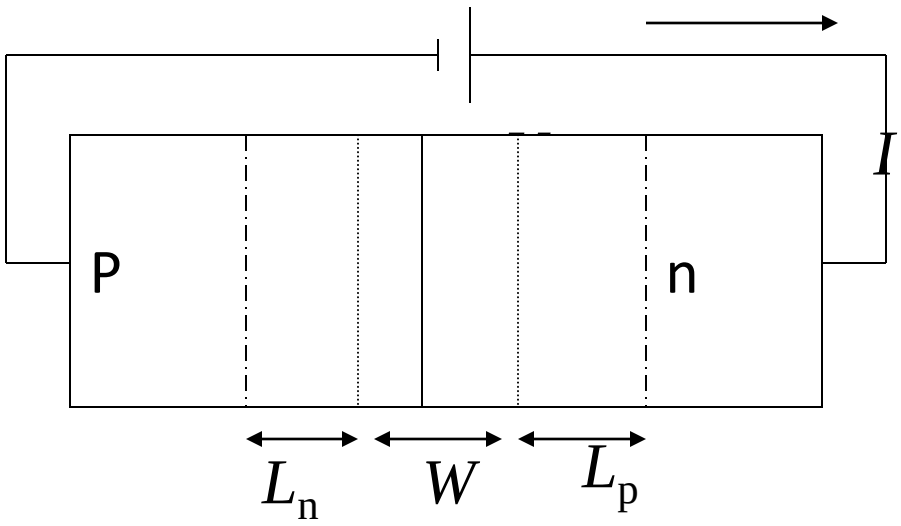
They are referred to as PHOTO-ELECTRONS and PHOTO-HOLES

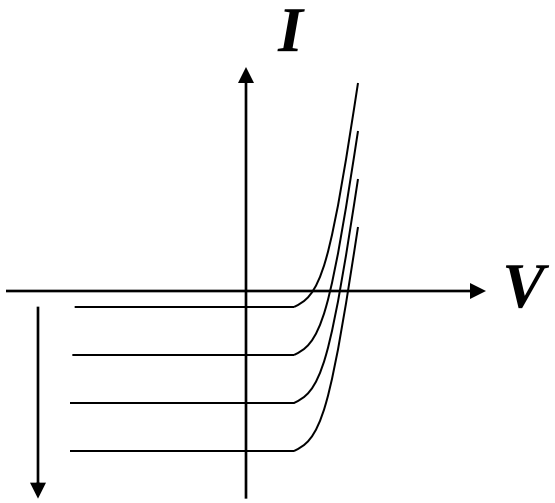
The applied voltage separates the photo-carriers attracting electrons toward "plus" and holes toward "minus"

As long as the light is ON, there is a current flowing through the p-n junction.

Photodiodes

Specifically designed for detector application and light penetration





Increasing
light intensity

Photodiodes

- ***Spectral response*** - an important characteristic of any photo-detector. ***Measures how the photocurrent, I_L varies with the wavelength of incident light.***

- ***Frequency response - measures how rapidly the detector can respond to a time varying optical signal.*** The generated minority carriers have to diffuse to the depletion region before an electrical current can be observed externally. Since diffusion is a slow process, the maximum frequency response is a few tens of MHz for p n junctions.

- ***Higher frequency response (a few GHz) can be achieved using p-i-n diodes.***

TUNNEL DIODE (Esaki Diode)

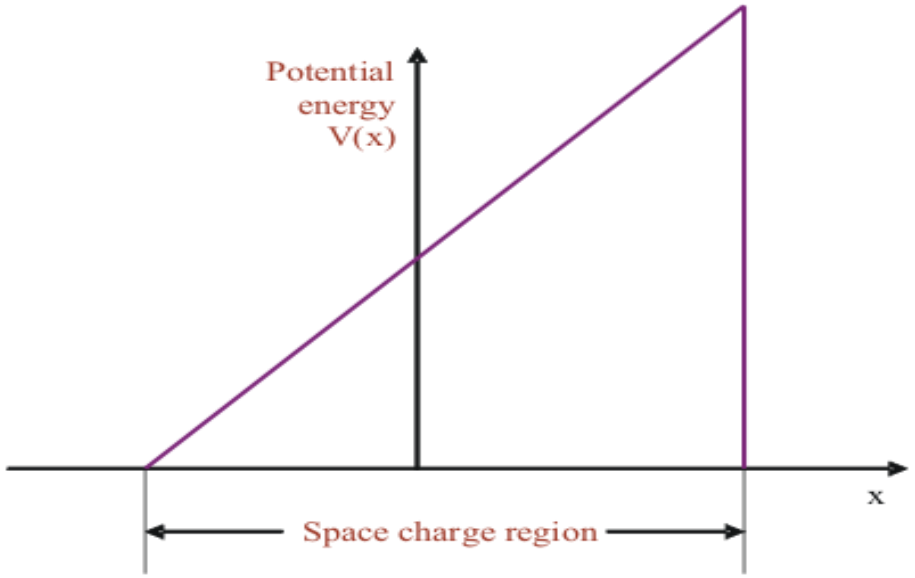
- It was introduced by Leo Esaki in 1958.
- Heavily-doped p-n junction
  - Impurity concentration is 1 part in 10^3 as compared to 1 part in 10^8 in p-n junction diode
- Width of the depletion layer is very small (about 100 A).
- It is generally made up of Ge and GaAs.
- It shows tunneling phenomenon.
- Circuit symbol of tunnel diode is :

What is Tunneling?

- **Classically**, carrier must have energy at least equal to potential-barrier height to cross the junction .

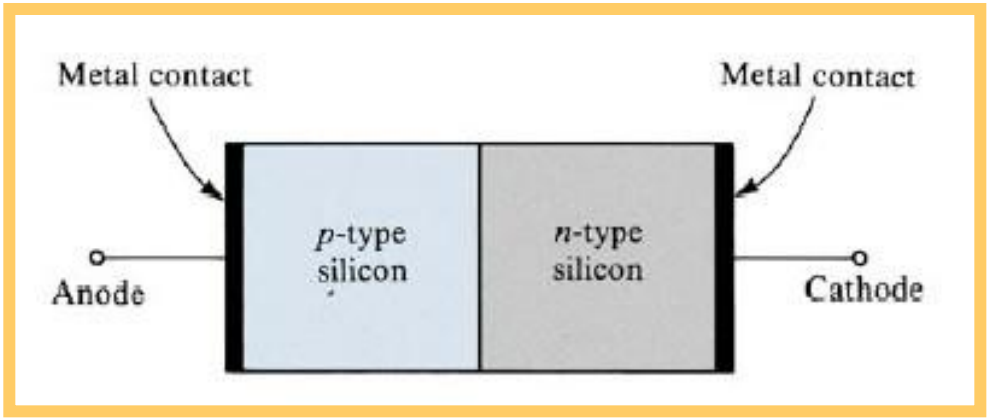
- But according to **Quantum mechanics** there is finite probability that it can penetrate through the barrier for a thin width.

- This phenomenon is called **tunneling** and hence the Esaki Diode is know as **Tunnel Diode**.



Triangular potential barrier approximation of the potential barrier in the tunnel diode.

Metal Contacts



<Ohmic contact>

- No rectifying action.
- The current can flow in both direction

<Schottky contact>

- The difference of carrier concentrations of the two materials at the contact.
- A barrier potential exists.
- rectifying action occurs.
- Mostly used in switching circuits. (turn on/off switches)

Metal Contacts I-V Characteristics