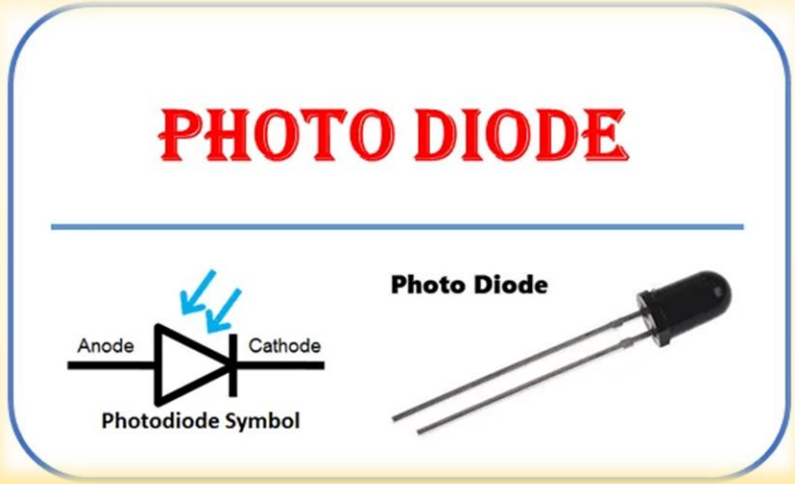
Photo diode



DEFINITION

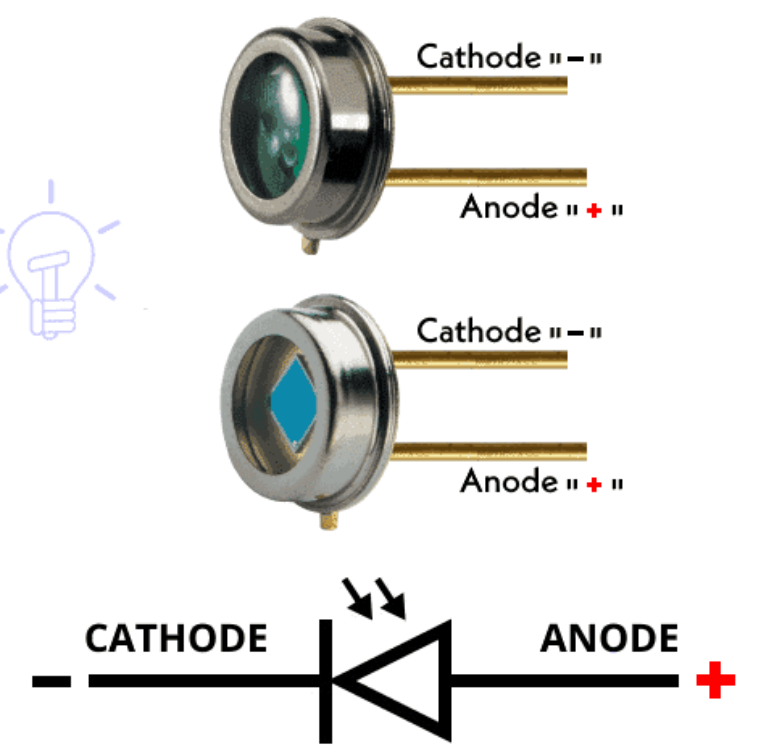
A photodiode is defined as a semiconductor device that converts light into electric current.

A photodiode is defined as a PN junction diode that generates current when exposed to light.

Photo diode

Material:

Doped semiconductors.

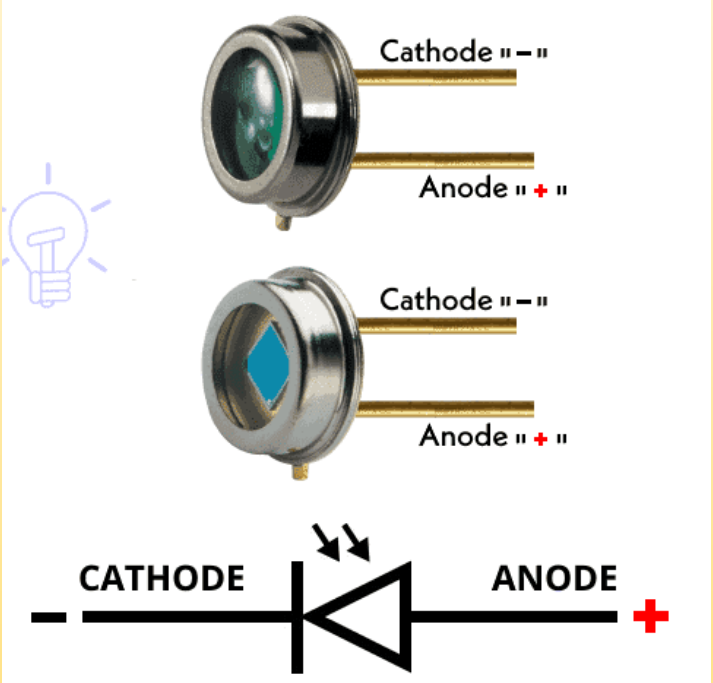


Working Principle:

Photodiodes create electron-hole pairs when exposed to light, generating a photocurrent in reverse bias conditions.

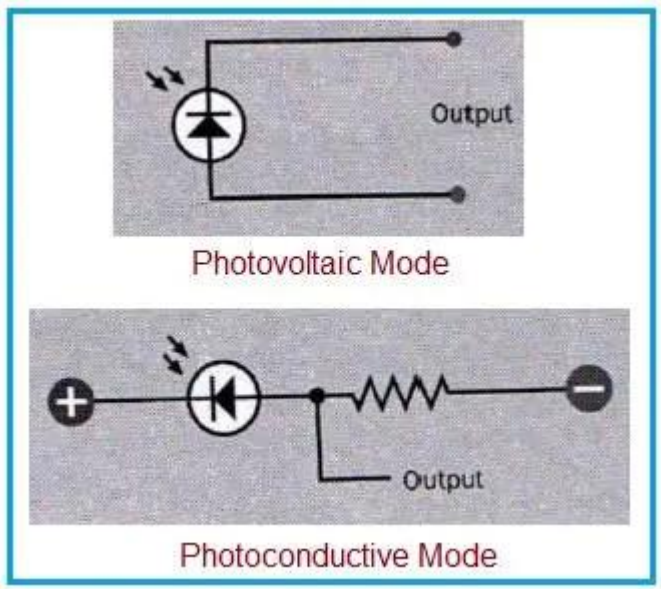
Photo diode

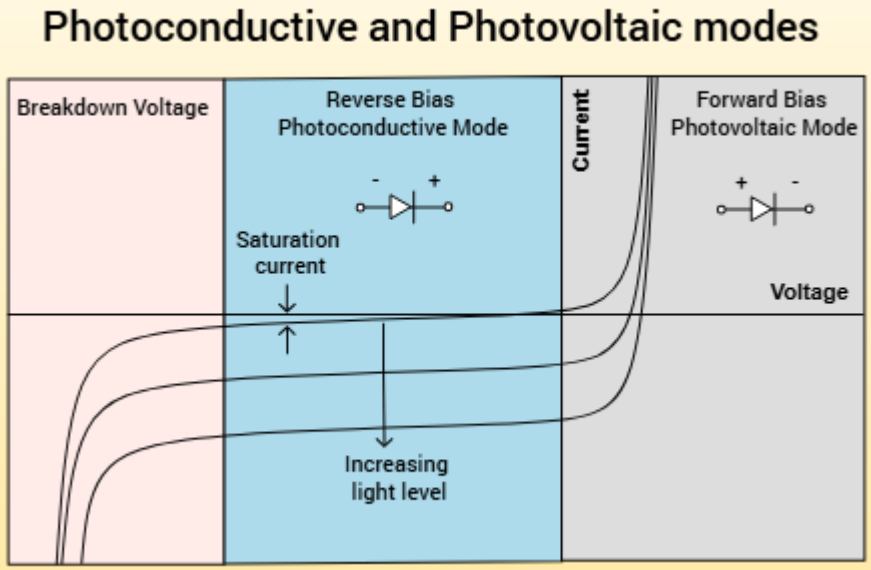
- **Photovoltaic Mode (No Bias):**
  - Generates a small voltage (~0.5V) when exposed to light (like a solar cell).
  - Used in low-power applications (e.g., light meters).



- **Photoconductive Mode (Reverse Bias):**
  - Applied reverse voltage (varying resistance with light).
  - Light creates **electron-hole pairs**, increasing reverse leakage current.

Photo diode

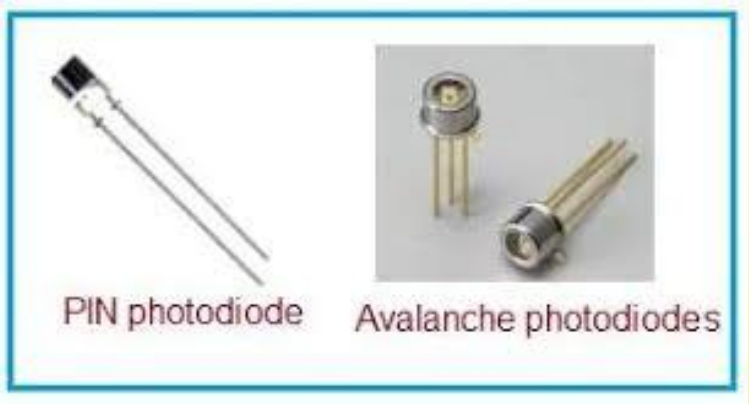




Feature	Photovoltaic Mode	Photoconductive Mode
Bias	Zero bias	Reverse bias
Dark Current	No “dark” current	Has “dark” current
Linearity	Linear	Nonlinear
Noise	Low (Johnson)	Higher (Johnson, Shot)
Typical Use Cases	Precision Applications	High-Speed Applications

Photo diode

Types of Photodiodes



1.PN Photodiode

Basic type, moderate speed.

2.PIN Photodiode

Wider depletion zone → **faster response & better efficiency**.

3.Avalanche Photodiode (APD)

Internal gain (like a photomultiplier) → **high sensitivity for weak light**.

4.Schottky Photodiode

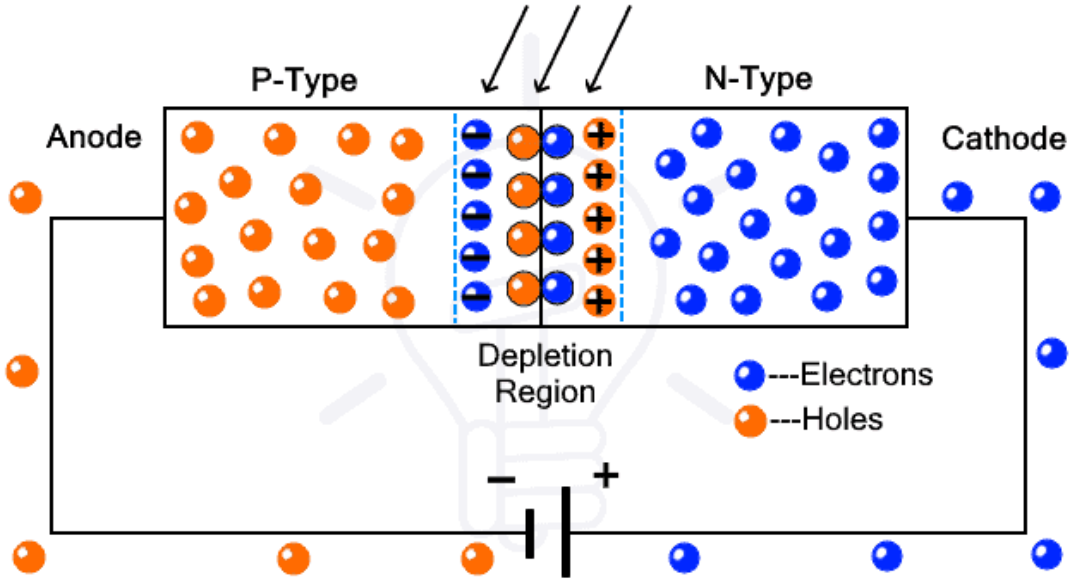
Metal-semiconductor junction → **UV/IR specialized**.

Photo diode

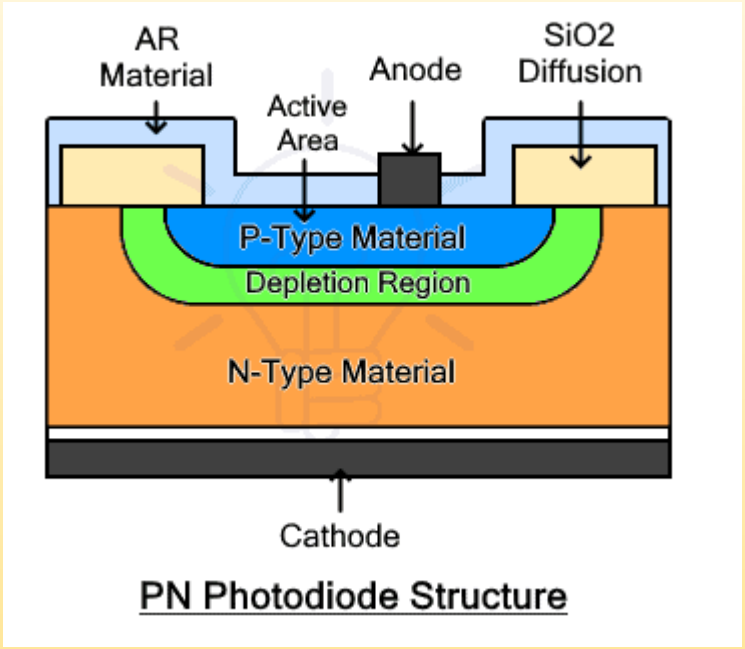
Types of Photodiodes

1.PN Photodiode

Basic type, moderate speed..



Photodiode Working



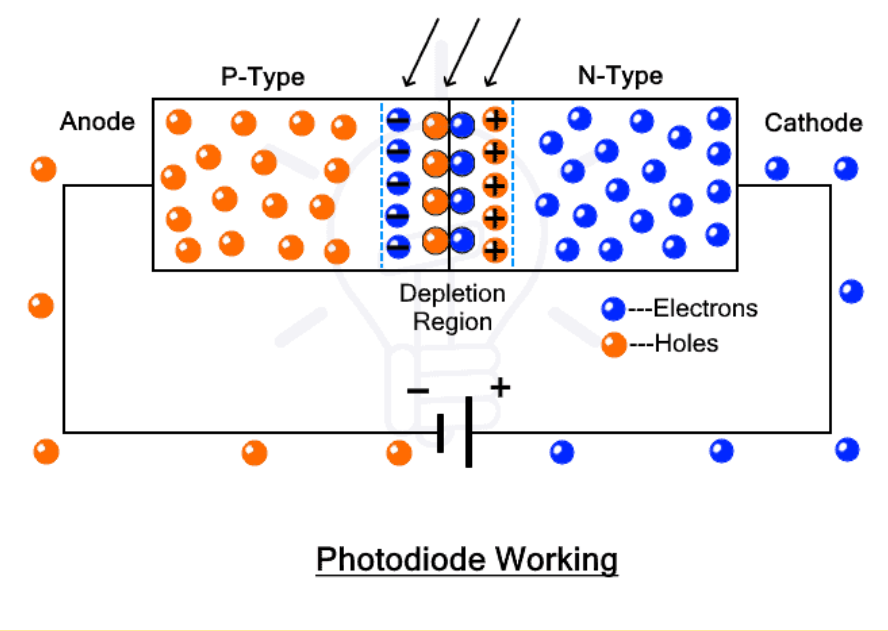
PN Photodiode Structure

Photo diode

Types of Photodiodes

1.PN Photodiode

Basic type, moderate speed..



Photodiode Working

When the light of sufficient energy strikes the photodiode, it creates electron-hole pairs in the semiconductor material. This process is also known as the **inner photoelectric effect.**

The photocurrent is proportional to the light intensity for a specific wavelength and temperature.

Photo diode

Types of Photodiodes

1.PN Photodiode

Basic type, moderate speed..

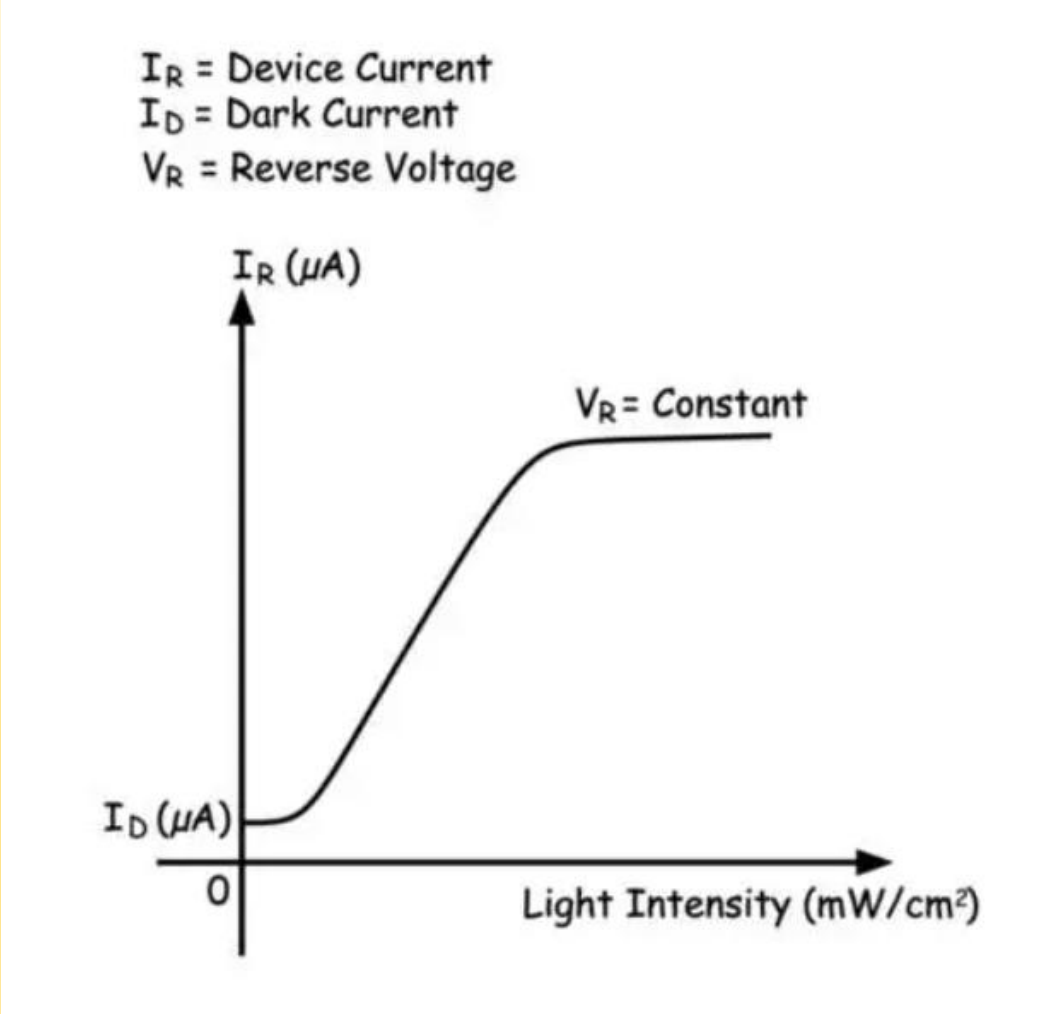


Photo detectors

The two main photo detectors used in optical fiber communication system are,

- **p-i-n – Photo diode (PIN Diode)**
- **Avalanche Photo Diode (APD)**

(i) PIN Diode:

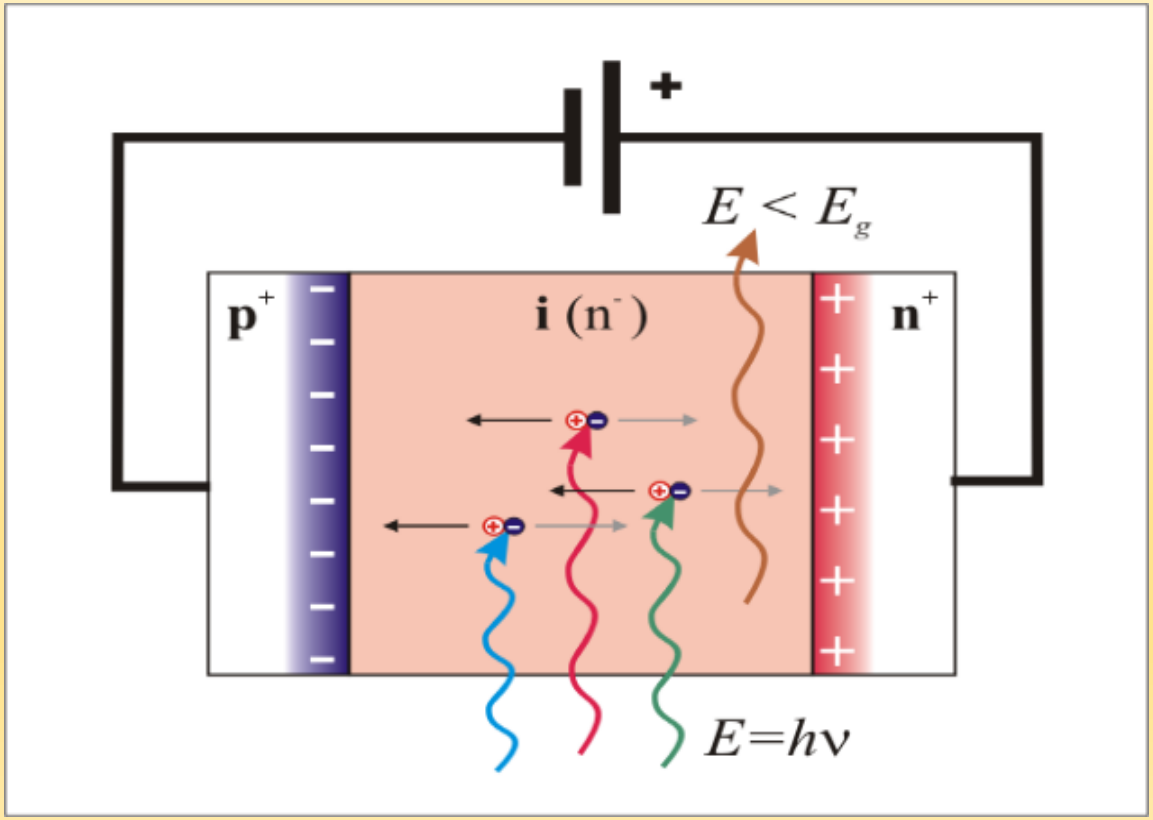
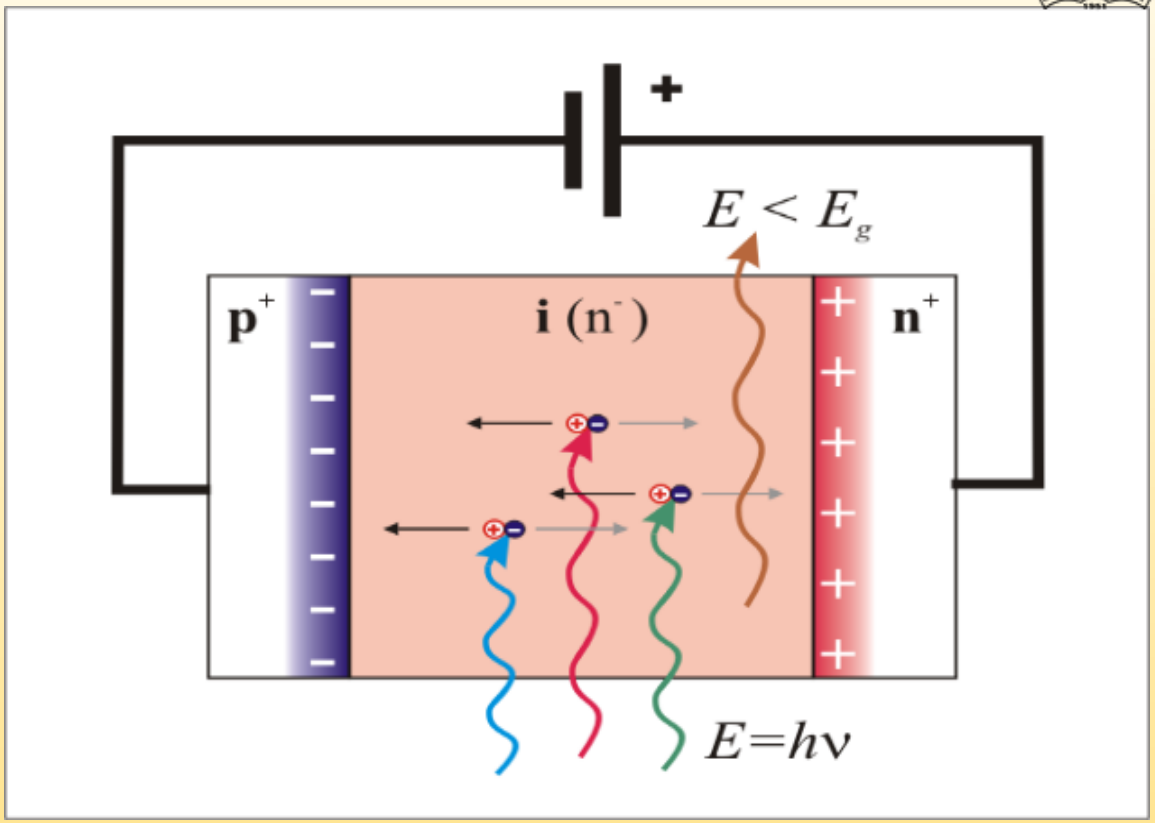


Photo detectors

(i) PIN Diode:

A diode with a wide and undoped intrinsic semiconductor region between a p-type and an n-type semiconductor region.



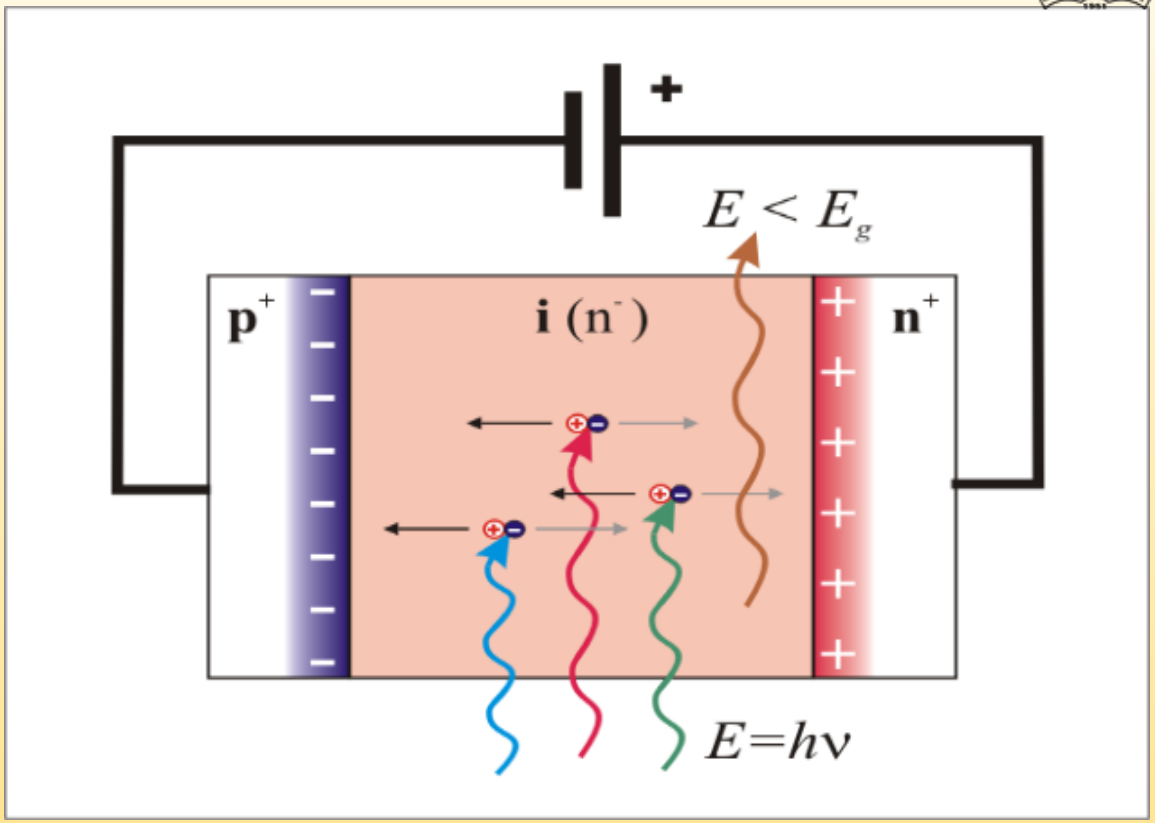
The working of the PIN diode is similar to the P-N junction diode, but the PIN diode has an intrinsic region, and this region works as a depletion layer between the layers P and N.

In an unbiased PIN diode, charge carriers will distribute, i.e., charges of the depletion region try to transmit to the basic part.

Photo detectors

(i) PIN Diode:

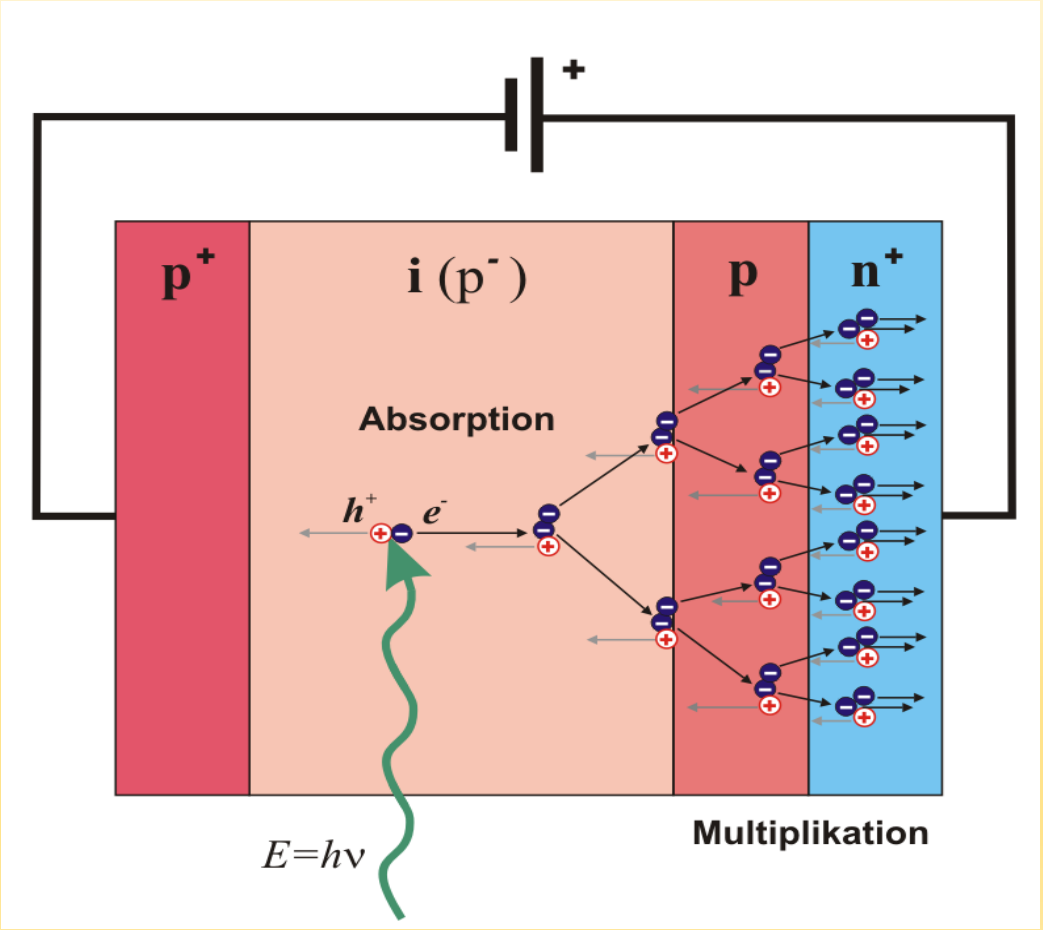
A diode with a wide and undoped intrinsic semiconductor region between a p-type and an n-type semiconductor region.



- **When forward-biased, the depletion region shrinks, and current flows through the diode.**
- **When reverse-biased, the depletion region widens, and the intrinsic region's resistance increases, impacting the response time.**

Photo detectors

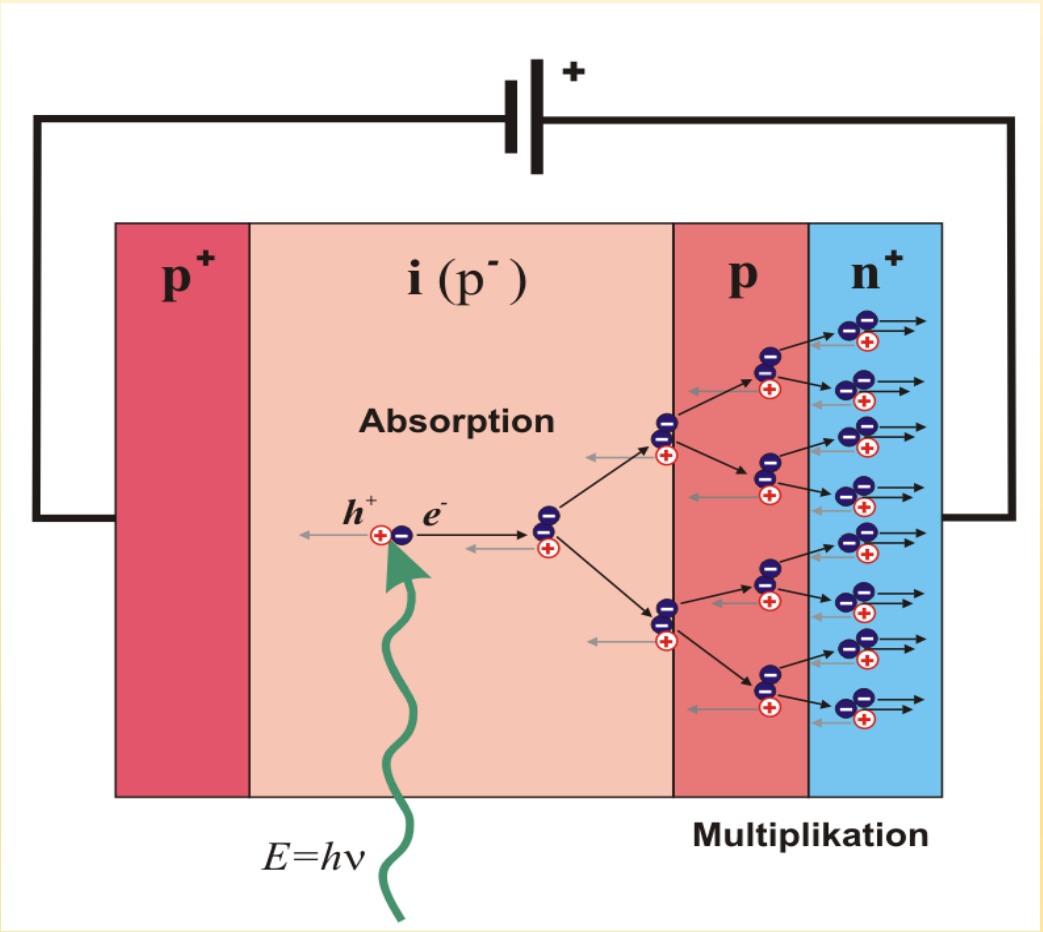
(ii) Avalanche Photo Diode (APD)



- Avalanche photo diode consists four regions viz, p^+, i, p and n^+ with necessary biasing.
- The layer-1 consists of a heavily doped n-region, denoted by n^+.
- The layer-2 is made up of p-region and
- layer-4 is heavily doped with the same p-region, denoted by p^+.
- The intrinsic (neutral) region is lightly doped with the p-material.

Photo detectors

(ii) Avalanche Photo Diode (APD)



- **Avalanche Effect:**

When a photon strikes the photodiode, it generates a free electron. This electron, under the influence of the high reverse bias, gains enough energy to ionize other atoms in the material, creating more electrons.

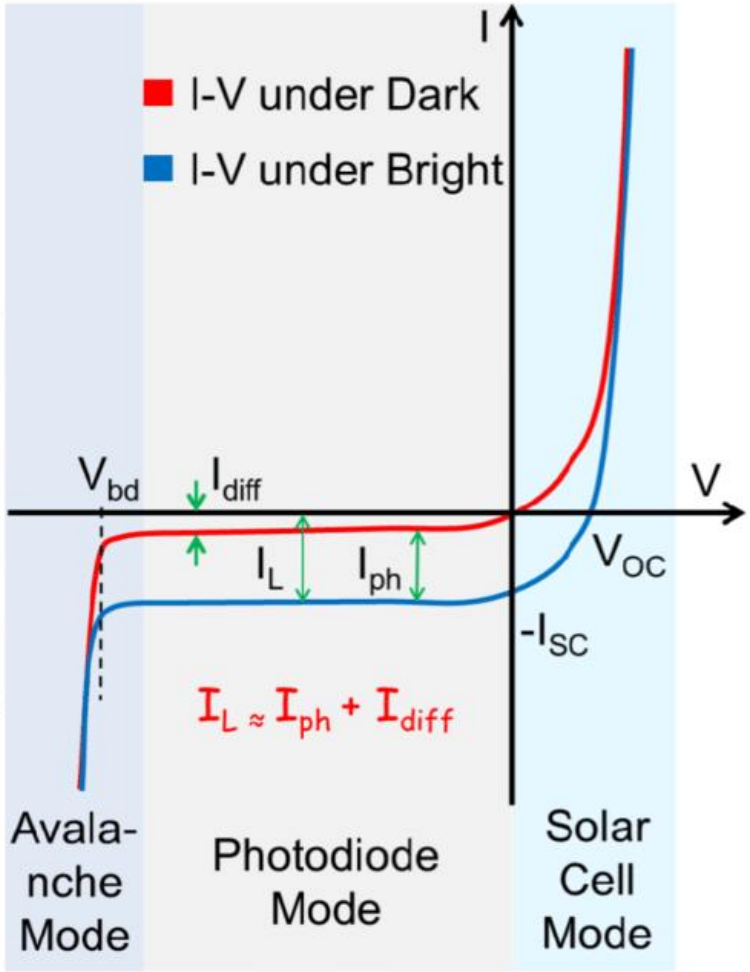
- **Amplification:**

This process of ionization and electron generation creates a cascade, or avalanche, of electrons, resulting in a significant increase in photocurrent, which is the internal gain.

Photo detectors

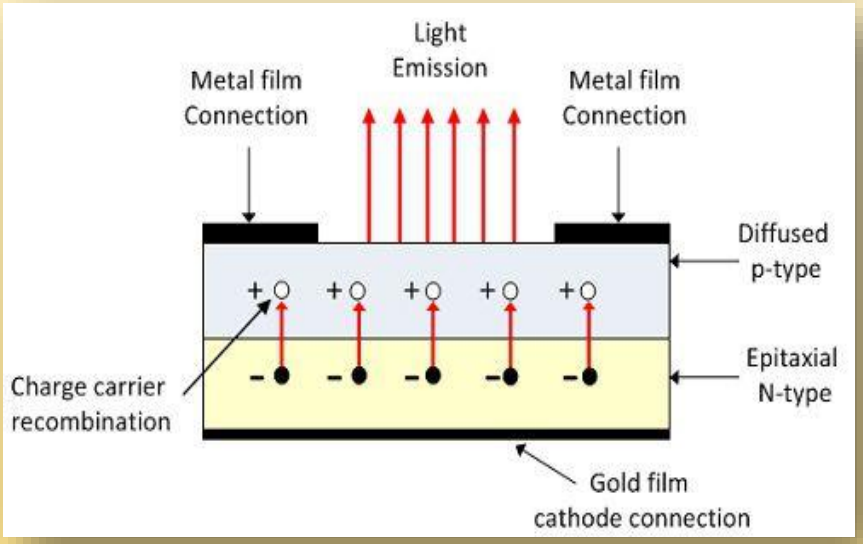
(ii) Avalanche Photo Diode (APD)

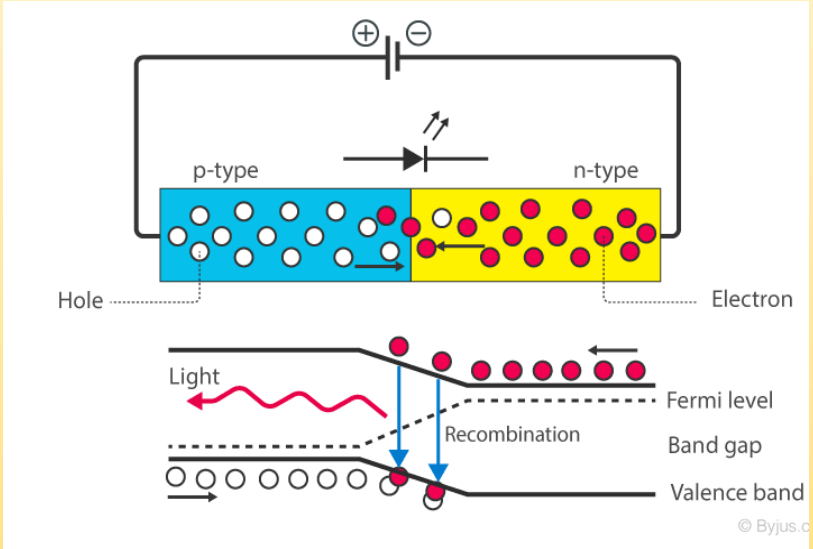
V_{OC}	Open Circuit Voltage
V_{bd}	Break Down Voltage
I_L	Total Photodiode Current
I_{ph}	Photon Current
I_{diff}	Diffusion Current



LEDs - Light emitting Diode

It is a p-n junction diode which emits light when it is forward biased.

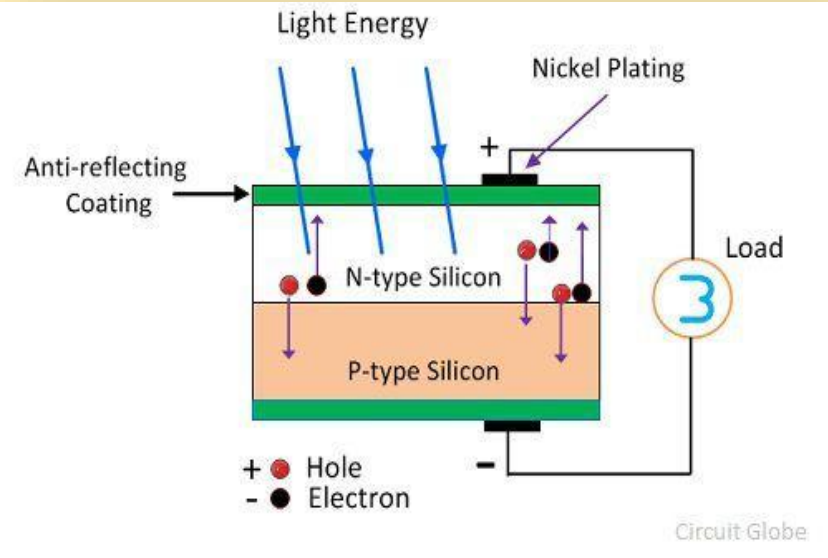


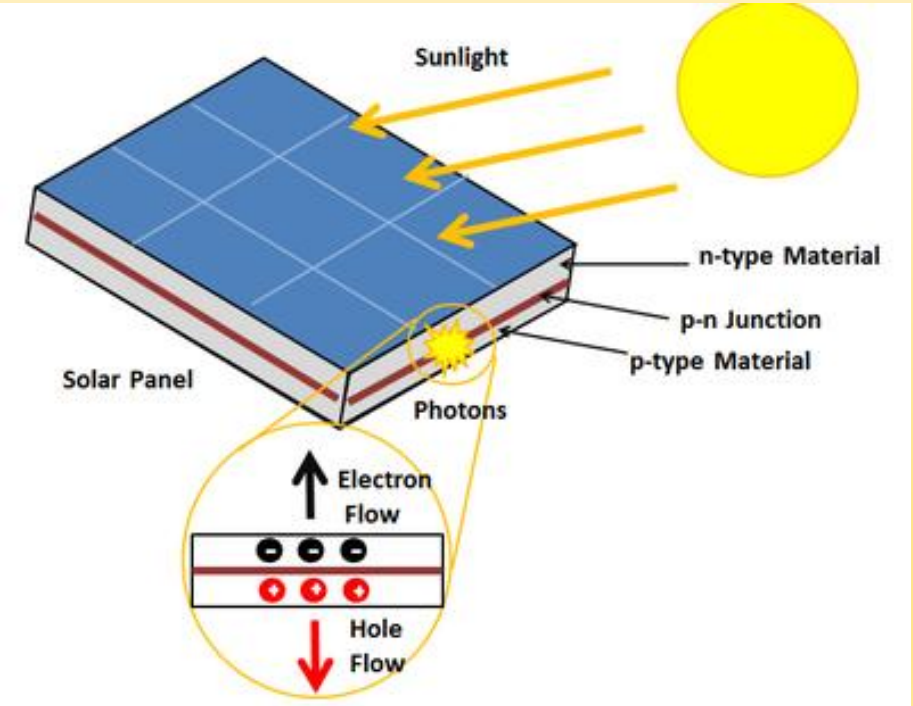


The injection of electrons into the p-region from n-region makes a direct transition from the conduction band to valence band. Then, the electrons recombine with holes and emits photons of energy

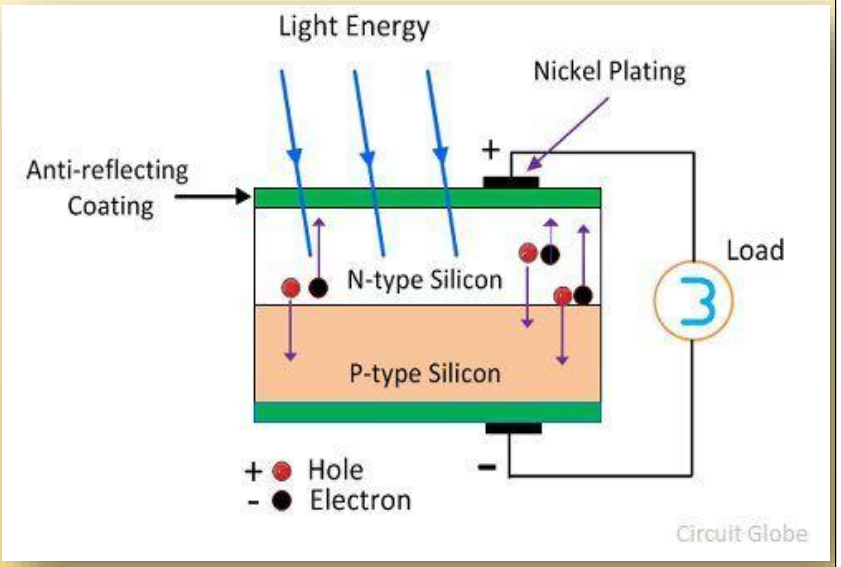
Solar Cells

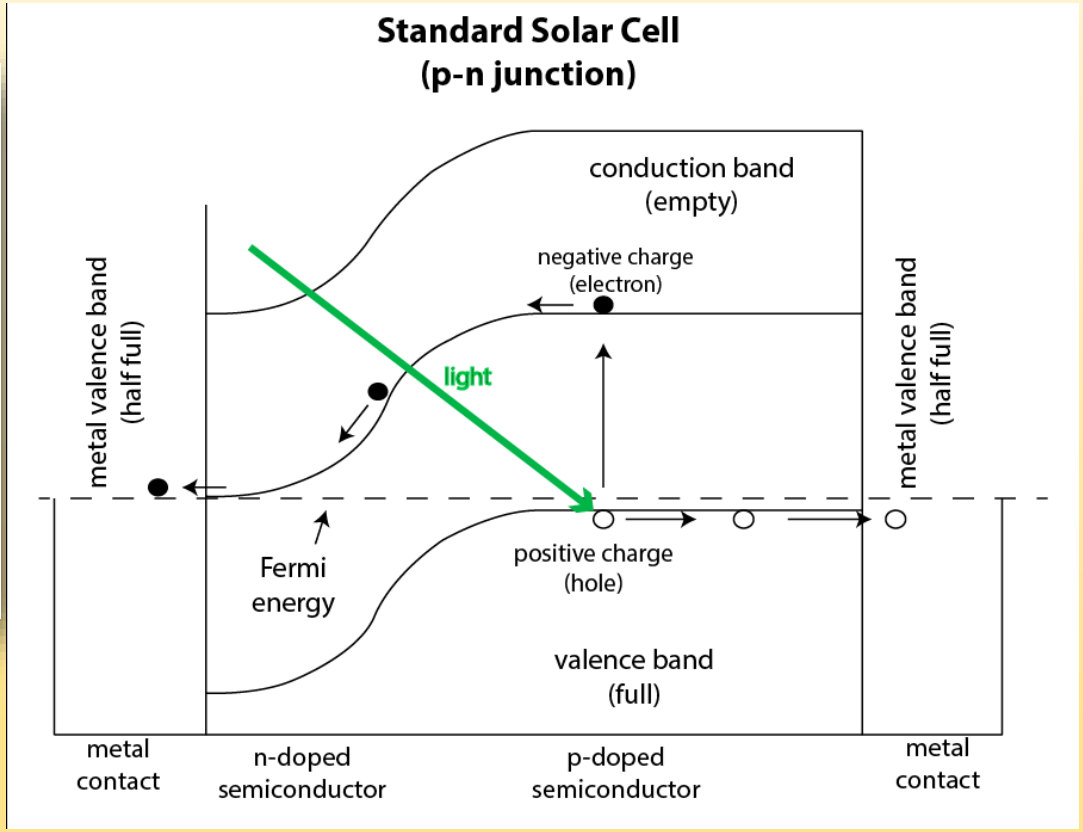
It is a P – N junction diode which converts solar energy (light energy) into electrical energy.





Solar Cells


Light Energy
Nickel Plating
Anti-reflecting Coating
+
N-type Silicon
P-type Silicon
Load
+ Hole
- Electron
Circuit Globe


Standard Solar Cell
(p-n junction)
conduction band
(empty)
negative charge
(electron)
light
metal valence band
(half full)
metal valence band
(half full)
Fermi
energy
positive charge
(hole)
valence band
(full)
metal
contact
n-doped
semiconductor
p-doped
semiconductor
metal
contact