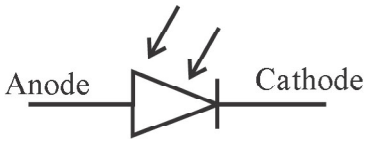
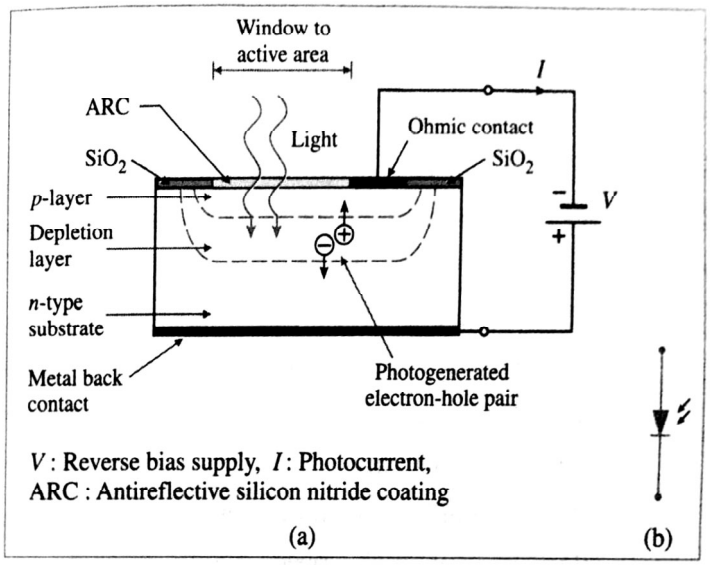
Photo Diode :

A photodiode is a special type of a p-n junction diode which converts light energy into electrical energy. It generates current when exposed to light. It is also called as *photodetector or a photosensor.* It operates in reverse biased mode. Figure (a) shows the circuit symbol of a photodiode.



(a) : Circuit symbol of photodiode.

Only mionority current flows through a photodiode. Figure shows schematic of the structure of a photodiode.

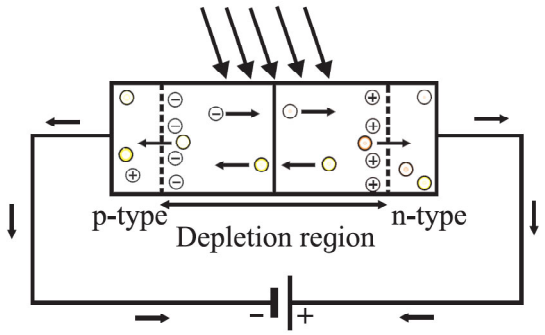


(a) Planar photodiode (b) Circuit symbol

The p-n junction of a photodiode is placed inside a glass material so that only the junction of a photodiode is exposed to light. Other part of the diode is generally painted with an opaque colour or covered. Figure (b) shows a typical photodiode.

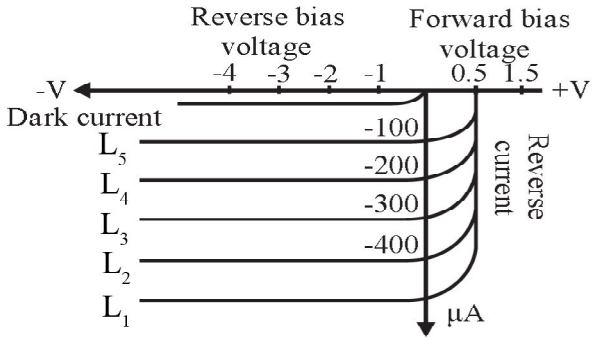
Working Principle of Photodiode:

When a p-n junction diode is reverse biased, a reverse saturation current flows through the junction. This current is due to the minority carriers on its either side.(Electrons are minority carriers in the p-region and the holes are minority carriers in the p-region of a diode). *The reverse current depends only on the concentration of the minority carriers and not on the applied voltage.* This current is called the dark currant in a photodiode because it flows even when the photodiode is not illuminated.



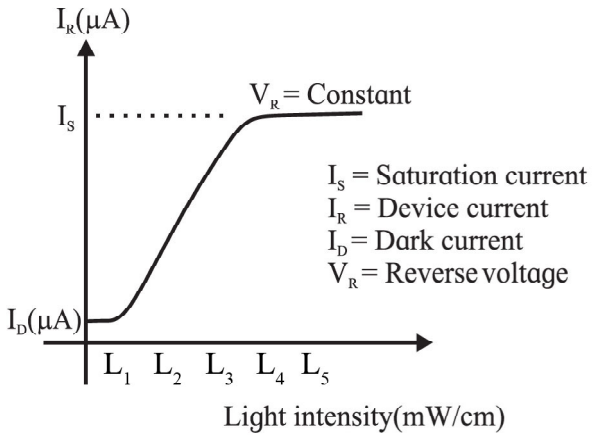
Schematically shows working of a photodiode

When a p-n junction is illuminated, electron-hole pairs are generated in the depletion region. The energy of the incident photons should be larger than the band gap of the semiconductor material used to fabricate the photodiode. The electrons and the holes are separated due to the intrinsic electric field present in the depletion region. The electrons are attracted towards the positive terminal of batttery and the holes are attracted towards the negative terminal of batttery. More carriers are available for conduction and the reverse current is increased. *The reverse current of a photodiode depends on the intensity of the incident light.* Thus, the reverse current can be controlled by controlling the concentration of the minority carriers in the junction. Figure shows the I-V characteristic of a photodiode. It clearly shows the relation between intensity of illumination and the reverse current of a photodiode.



The I-V characteristic of a photodiode.

The total current passing through a photodiode is the sum of the photocurrent and the dark current. Figure below shows the graphical relation between the reverse current of a photodiode and the intensity of illumination incident on the photodiode. The sensitivity of the device can be increased by minimizing the dark current.



Relation between the reverse current of a photodiode and the intensity of illumination

As you can see from the curve, reverse current increases initially with increase in the intensity of illumination. It reaches a constant value after certain voltage is reached. This constant value is called the saturation current of the photodiode. One more term associated with a photodiode is its dark resistance R_d. It is the resistance of a photodiode when it is not illuminated. Dark resistance of a photodiode (R_d) is defined as the ratio of the maximum reverse voltage and its dark current.

$$R_d = \frac{Maximum\ reverse\ voltage}{Dark\ current}$$

Advantages of photodiode

1) Quick response when exposed to light.
2) Linear response. The reverse current is linearly proportional to intensity of incident light.
3) High speed of operations.
4) Light weight and compact size.
5) Wide spectral response. For example, photodiodes made from Si respond to radiation of wavelengths from 190 nm (UV) to 1100 nm (IR).
6) Relatively low cost.

Disadvantages of photodiode

1) Its properties are temperature dependent, similar to many other semiconductor devices.
2) Low reverse current for low illumination levels.

Applications of photodiode

The basic concept used in almost all these devices/applications is that a photodiode conducts whenever light strikes it and it stops conducting the moment light stops. Some applications of a photodiode are:

1) Counters and switches.
2) Burglar alarm systems.
3) Detection of visible and invisible radiations.
4) Circuits in which fast switching and high-speed operations are required.
5) Fiber optic communication systems.
6) Optocouplers, used to provide an electric isolation between two electronic circuits.
7) Photo sensors/detectors, for accurate measurement of light intensity.
8) Safety electronics like fire and smoke detectors