Marwari college Darbhanga

Subject---physics (Hons)

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Topic--- Optoelectronic (Basic Electronics)

Lecture series---33

By:- Dr. Sony Kumari,

Assistant professor

Marwari college Darbhanga.

Optoelectronics

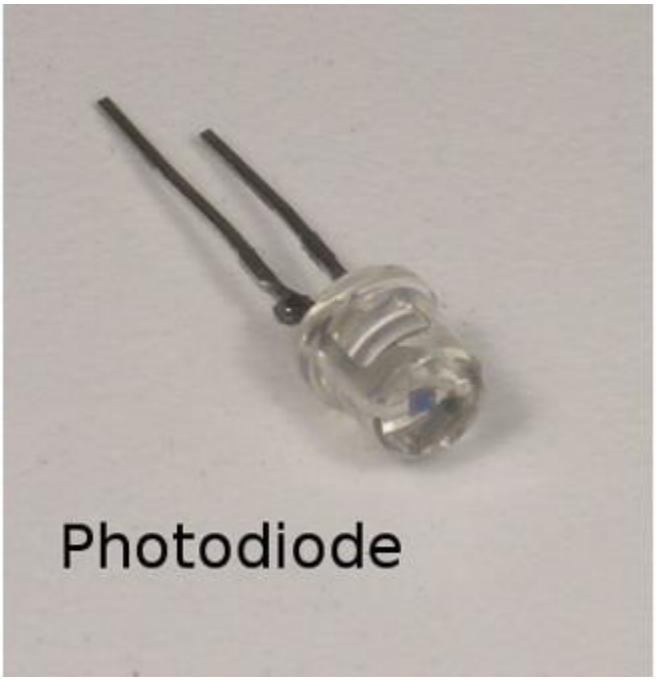
Optoelectronics (or **optronics**) is the study and application of electronic devices and systems that source, detect and control light, usually considered a sub-field of photonics. In this context, *light* often includes invisible forms of radiation such as gamma rays, X-rays, ultraviolet and infrared, in addition to visible light. Optoelectronic devices are electrical-to-optical or optical-to-electrical transducers, or instruments that use such devices in their operation. *Electro-optics* is often erroneously used as a synonym, but is a wider branch of physics that concerns all interactions between light and electric fields, whether or not they

form part of an electronic device. Optoelectronics is based on the quantum mechanical effects of light on electronic materials, especially semiconductors, sometimes in the presence of electric fields.

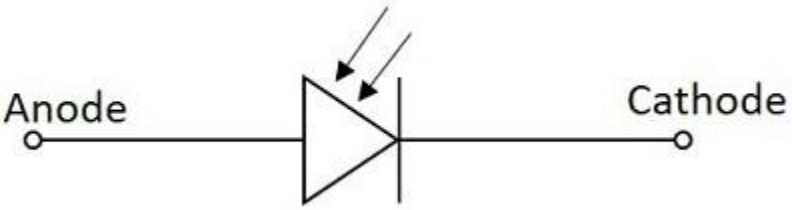
Photo Diode

Photo diode, as the name implies, is a PN junction which works on light. The intensity of light affects the level of conduction in this diode. The photo diode has a P type material and an N-type material with an intrinsic material or a depletion region in between.

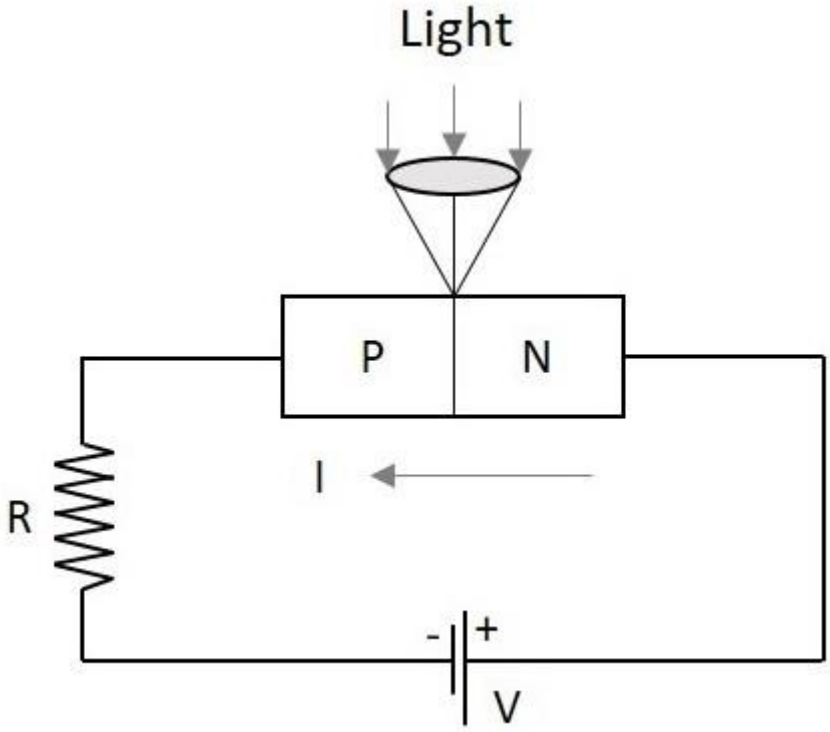
This diode is generally operated in reverse bias condition. The light when focused on the depletion region, electron-hole pairs are formed and flow of electron occurs. This conduction of electrons depends upon the intensity of light focused. The figure below shows a practical Photo diode.



The figure below indicates the symbol for a photodiode.



When the diode is connected in reverse bias, a small reverse saturation current flows due to thermally generated electron hole pairs. As the current in reverse bias flows due to minority carriers, the output voltage depends upon this reverse current. As the light intensity focused on the junction increases, the current flow due to minority carriers increase. The following figure shows the basic biasing arrangement of a photo diode.



The Photo diode is encapsulated in a glass package to allow the light to fall onto it. In order to focus the light exactly on the depletion region of the diode, a lens is placed above the junction, just as illustrated above.

Even when there is no light, a small amount of current flows which is termed as Dark Current. By changing the illumination level, reverse current can be changed.

Advantages of Photo diode

Photo diode has many advantages such as −

- Low noise
- High gain
- High speed operation
- High sensitivity to light
- Low cost
- Small size
- Long lifetime

Applications of Photo diode

There are many applications for photo diode such as −

- Character detection
- Objects can be detected .
- Used in circuits that require high stability and speed.
- Used in Demodulation
- Used in switching circuits
- Used in Encoders
- Used in optical communication equipment

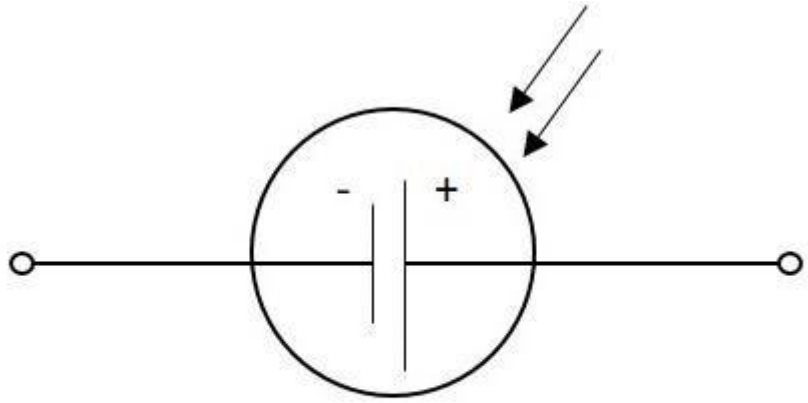
Another diode of such a kind is Solar cell. It is termed as a cell though it is a diode. Let us get into the details.

Solar Cell

The light dependent diodes include Solar cell, which is a normal PN junction diode but has its conduction by the rush of photons which are converted into the flow of electrons. This is similar to a

photo diode but it has another objective of converting maximum incident light into energy and storing it.

The figure below represents the symbol of a solar cell.



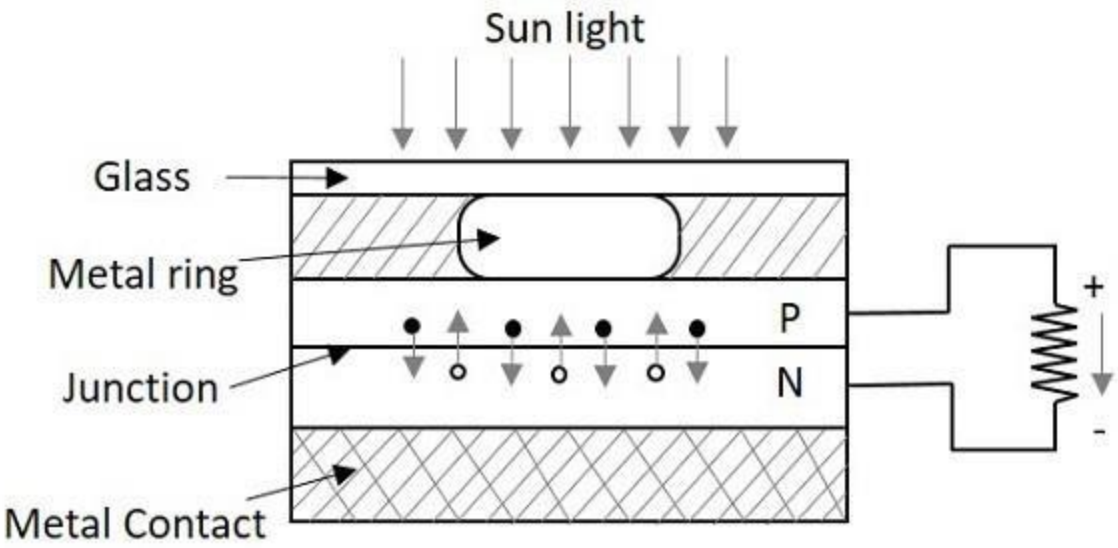
Symbol of Solar Cell

A solar cell has its name and symbol indicating storing of energy though it is a diode. The feature of extracting more energy and storing of it is concentrated in the solar cell.

Construction of a Solar cell

A PN junction diode with an intrinsic material in the deletion region is made to encapsulate in a glass. The light is made to incident on maximum area possible with thin glass on the top so as to collect maximum light with minimum resistance.

The following figure shows the construction of a Solar cell.



When the light is incident on the solar cell, the photons in the light collide with valence electrons. The electrons are energized to leave the parent atoms. Thus a flow of electrons is generated and this current is directly proportional to the light intensity focused onto the solar cell. This phenomenon is called as the **Photo-Voltaic effect**.

The following figure shows how a solar cell looks like and how a number of solar cells together are made to form a solar panel.

Solar panel

Solar cell

Difference between a Photo diode and Solar cell

Photo Diode works faster and concentrates on switching rather than providing more power at the output. It has a low capacitance value because of this. Also the area of incidence of light energy is lesser in Photo diode, according to its applications.

A Solar cell concentrates on delivering high output energy and storing the energy. This has high capacitance value. The operation is a bit slower than photo diode. According to the purpose of the solar cell, the area of incidence of light is larger than photo diode.

Applications of Solar Cell

There are many applications for Solar cell such as −

Science and Technology

- Used in Solar panels for Satellites
- Used in telemetry
- Used in Remote lighting systems etc. Commercial Use

- Used in Solar panels for storage of electricity
- Used in Portable power supplies etc.
- Used in household uses such as cooking and heating using solar energy Electronic

- Watches
- Calculators
- Electronic Toys, etc.

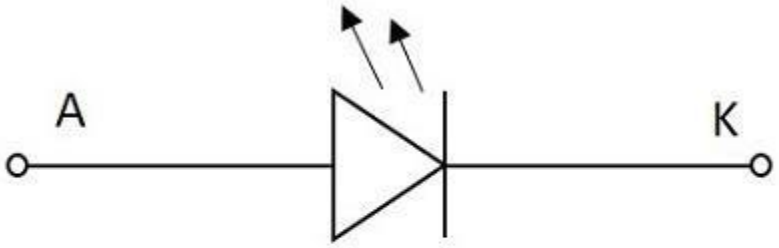
Some diodes emit light according to the voltage applied. There are two main types of diodes in this category. They are LEDs and Laser diodes.

LED Light Emitting Diodes

This one is the most popular diodes used in our daily life. This is also a normal PN junction diode except that instead of silicon and

germanium, the materials like gallium arsenide, gallium arsenide phosphide are used in its construction.

The figure below shows the symbol of a Light emitting diode.



Symbol of LED

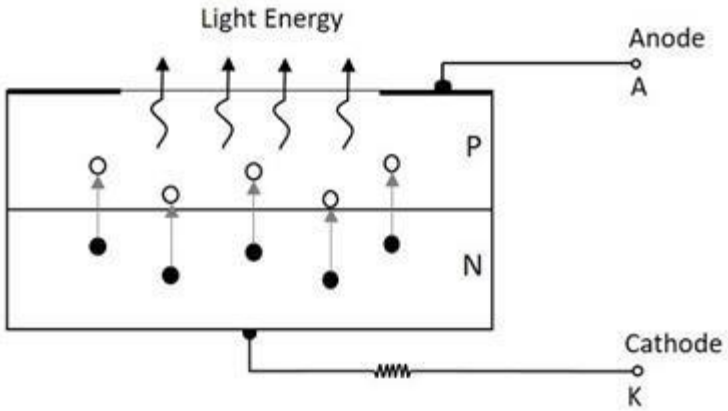
Like a normal PN junction diode, this is connected in forward bias condition so that the diode conducts. The conduction takes place in a LED when the free electrons in the conduction band combine with the holes in the valence band. This process of recombination emits light. This process is called as Electroluminescence. The color of the light emitted depends upon the gap between the energy bands.

The materials used also effect the colors like, gallium arsenide phosphide emits either red or yellow, gallium phosphide emits either red or green and gallium nitrate emits blue light. Whereas gallium arsenide emits infrared light. The LEDs for non-visible Infrared light are used mostly in remote controls.

The following figure shows a how the practical LEDs of different colors looks like.

LED in the above figure has a flat side and curved side, the lead at the flat side is made shorter than the other one, so as to indicate that the shorter one is **Cathode** or negative terminal and the other one is **Anode** or the Positive terminal.

The basic structure of LED is as shown in the figure below.



Basic Structure of LED

As shown in the above figure, as the electrons jump into the holes, the energy is dissipated spontaneously in the form of light. LED is

a current dependent device. The output light intensity depends upon the current through the diode.

Advantages of LED

There are many advantages of LED such as −

- High efficiency
- High speed
- High reliability
- Low heat dissipation
- Larger life span
- Low cost
- Easily controlled and programmable
- High levels of brightness and intensity
- Low voltage and current requirements
- Less wiring required
- Low maintenance cost
- No UV radiation
- Instant Lighting effect

Applications of LED

There are many applications for LED such as −

In Displays

- Especially used for seven segment display
- Digital clocks
- Microwave ovens
- Traffic signaling
- Display boards in railways and public places
- Toys

In Electronic Appliances

- Stereo tuners
- Calculators
- DC power supplies
- On/Off indicators in amplifiers
- Power indicators

- **Commercial Use**

- Infrared readable machines
- Barcode readers
- Solid state video displays

- **Optical Communications**

- In Optical switching applications
- For Optical coupling where manual help is unavailable
- Information transfer through FOC
- Image sensing circuits
- Burglar alarms
- In Railway signaling techniques
- Door and other security control systems

Just as LED has many advantages and applications, there is another important diode called Laser diode, which also has got many advanced features and scope of future. Let us discuss about Laser diode.