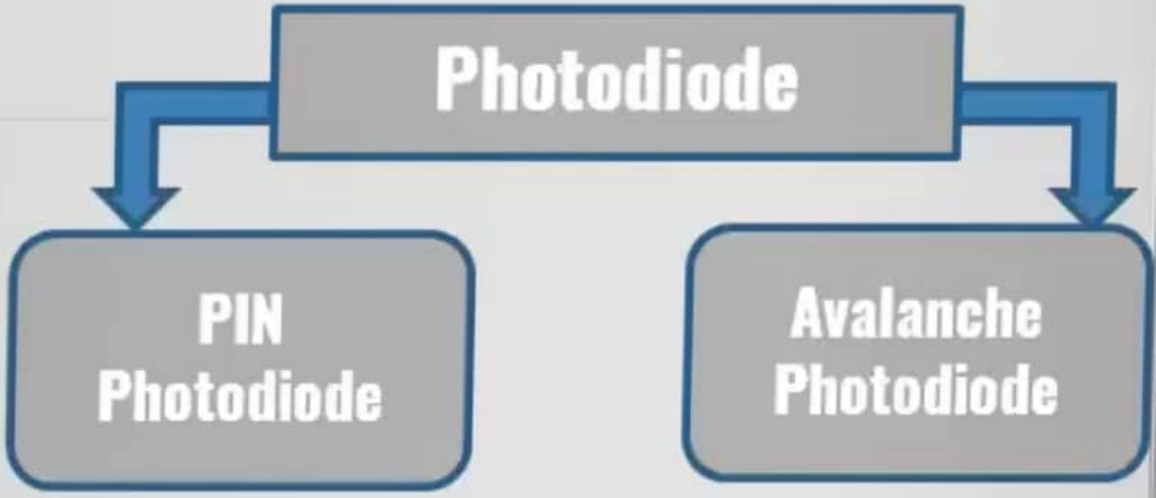
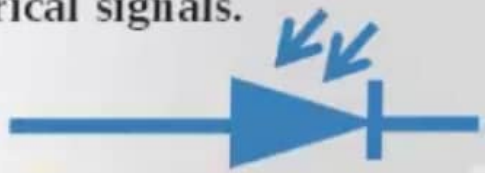
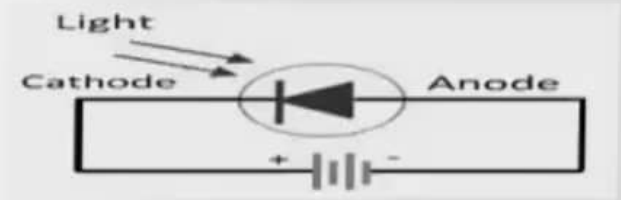
Photodiode



Photodiode is one kind of detector, that can able to convert the optical signals into electrical signals.



Photodiode is a P-N junction diode operated in Reverse Bias.



Different kinds of photodiodes are developed to reach the specific applications.

The working operation of both type of photodiodes are same.

PIN photodiodes are developed to increase the response speed.

Avalanche photodiodes are used where high level sensitivity is needed

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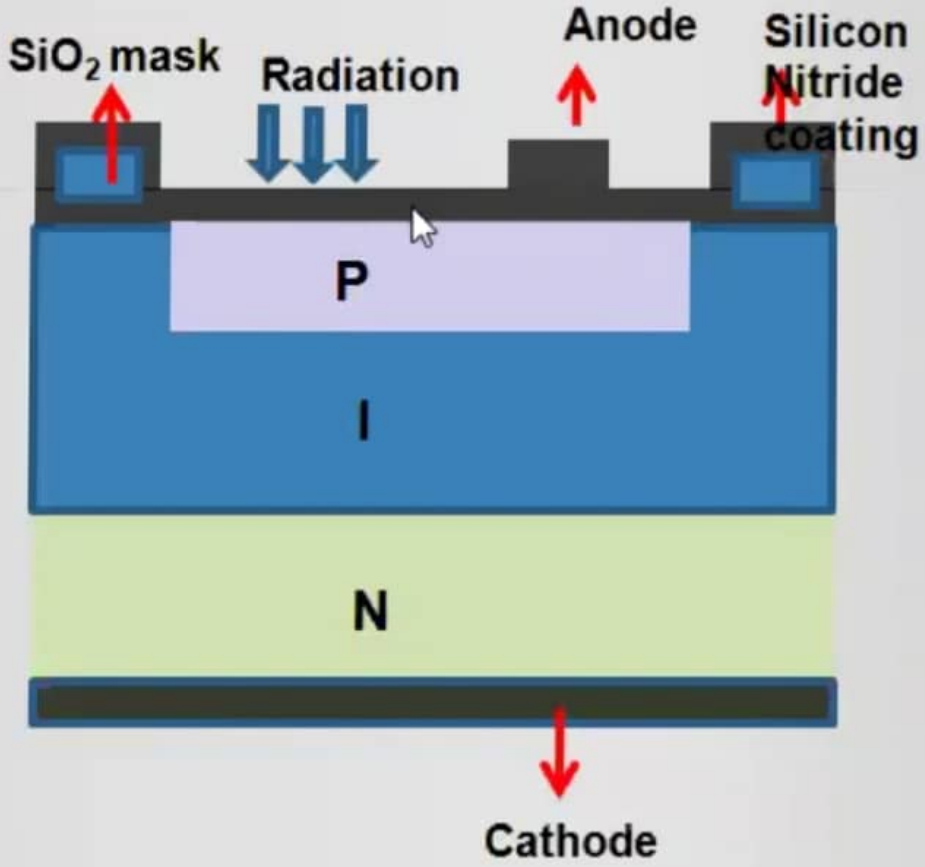
A P-N junction photodiode is made of two layers namely p-type and n-type semiconductor whereas PIN photodiode is made of three layers or regions namely are P-region, an intrinsic region and an N-region.

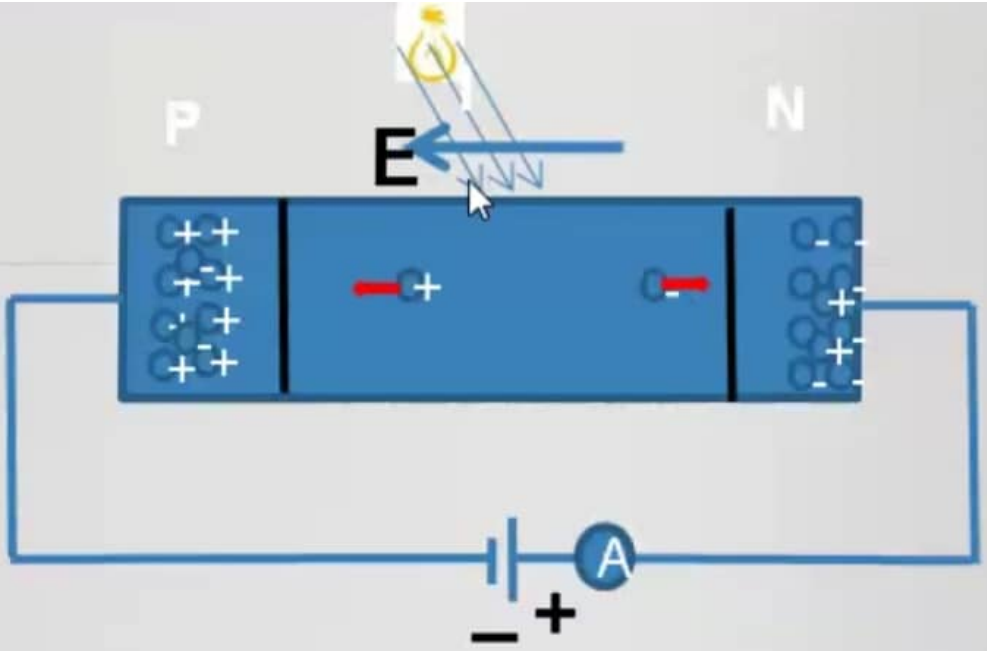
Construction

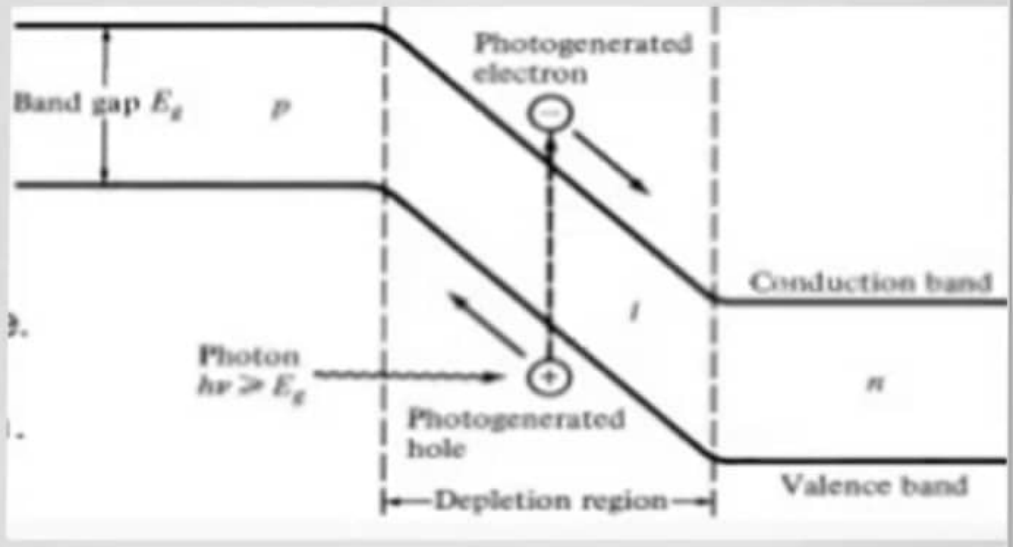
- A PIN diode is made up of three semiconductor materials. The intrinsic semiconductor separated by two heavily doped p and n type semiconductor material. Top layer (P) of PIN diode thickness is low around 1 μm.
- The top face of the diode is protected by a layer of SiO_2 in which there is a window for light to shine on the semiconductor.
- This window is coated with a thin anti-reflective layer of Silicon Nitride.



Working

- When the reverse bias is applied to PIN diode the width of depletion region starts increasing in the intrinsic region and it increases till it reach to the thickness of the intrinsic layer with increase of applied reverse voltage.
- In this point, the intrinsic layer is swept free of mobile charge carriers.
- In this condition, there is no electron-hole recombination takes place within the depletion region because it is completely free of mobile charge carriers. And each photon absorbed generates one electron-hole pair.





PIN diode uses and advantages..

Due to the unique properties of the PIN diode, it is used in a number of areas.

- ***High voltage rectifier:*** The intrinsic region provides a greater separation between the P and N regions, allowing higher reverse voltages to be tolerated.

- ***RF switch:*** The intrinsic layer between the P and N regions increases the distance between them. This also decreases the capacitance between them, thereby increasing the level of isolation when the diode is reverse biased.

- ***Photodetector:*** As the conversion of light into current takes place within the depletion region of a photodiode, increasing the depletion region by adding the intrinsic layer improves the performance by increasing the volume in which light conversion occurs.

Avalanche Photodiode

➢Avalanche Photodiodes are high sensitivity, high speed semi-conductor "light" detector.

➢Avalanche photodiode structural configuration is similar to the PIN photodiode. Avalanche diode also consists of three regions like PIN diode.

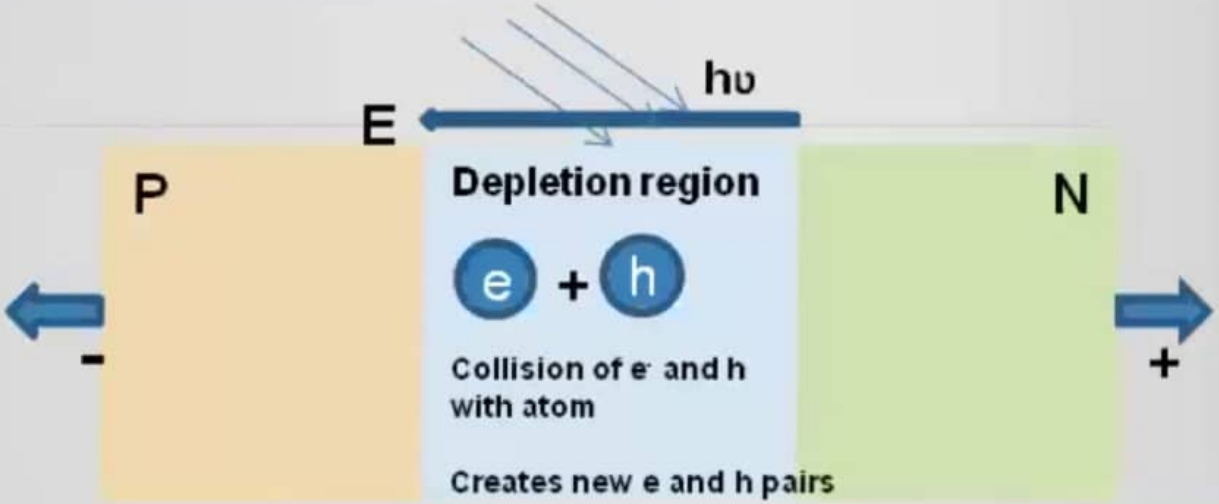
- p-region,
- intrinsic region,
- n-region

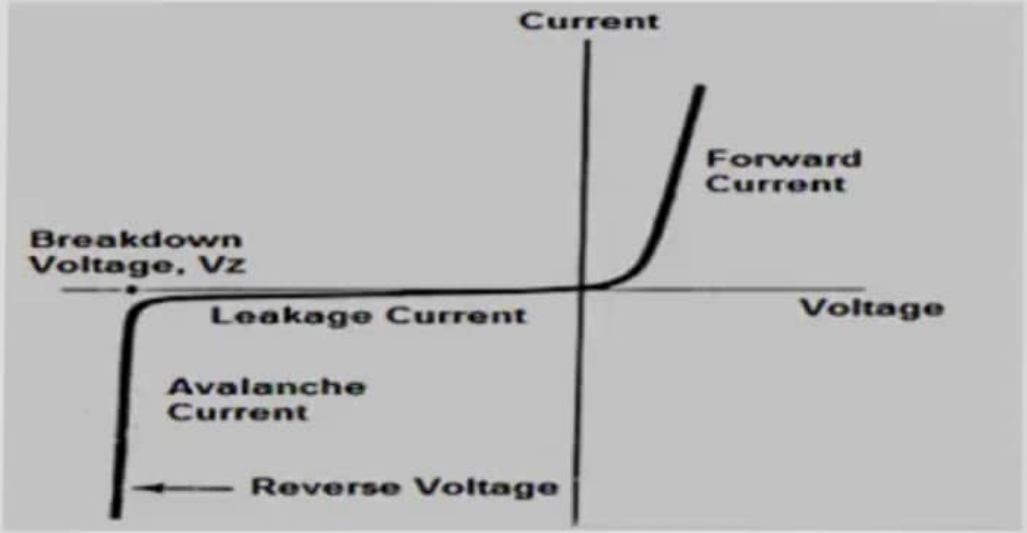
Difference compare to PIN?

- Avalanche photodiode operates under a high reverse bias condition (avalanche breakdown cond.).
- The electron- hole pairs that are generated by incident photons are accelerated by high electric field to kick new electrons from the VB to CB .
- These are swept out of the depletion region quickly due to the low transit time.
- The current sensitivity is increases from 30 to 100 times due to its avalanche operation.

Reverse breakdown/Avalanche breakdown

- Avalanche breakdown occurs when diode is connected with high reverse voltage.
- The reverse bias voltage increases the electrical field across the depletion region.
- The velocity of minority charge carrier crossing the depletion region increases due to the generated E across the depletion region.
- These carriers collide with the atoms of the crystal. Because of the violent collision, the charge carrier takes out the electrons from the atom.





Avalanche Photodiode uses and advantages..

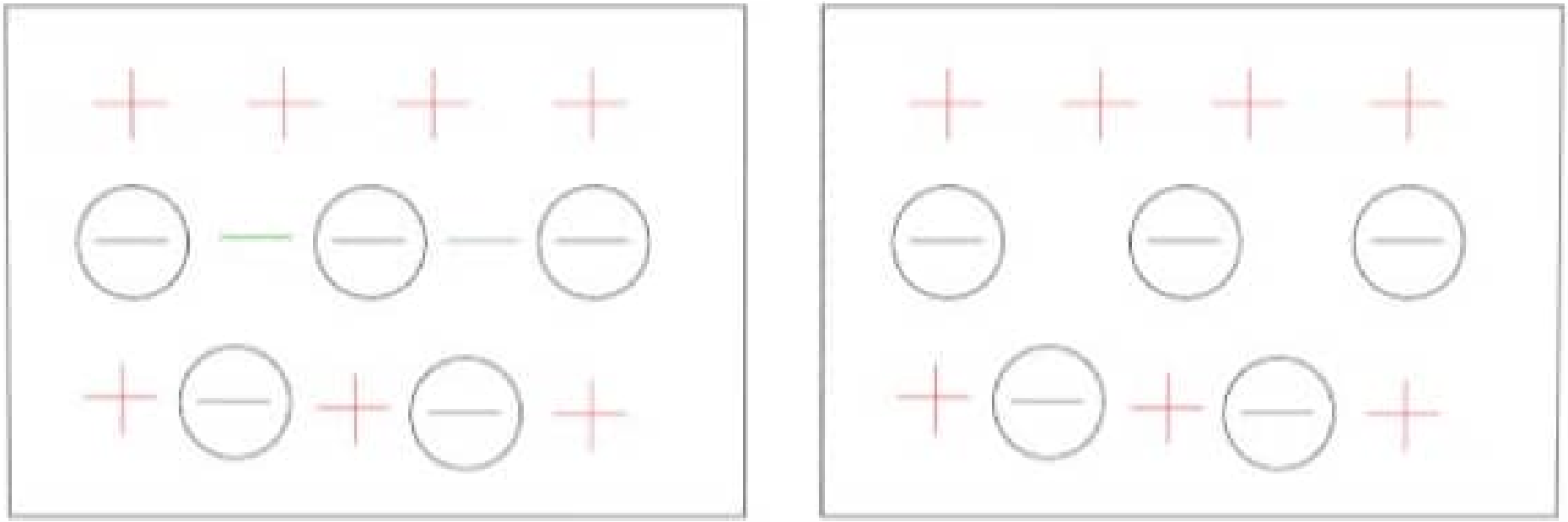
Due to their performance advantages APDs are then used widely in **applications** such as

- distance measurement,
- data transmission (over fibre or through free space),
- range finding,
- high speed industrial inspection (including colour measurement) and
- in various other medical and scientific instrumentation.

The mobile charge can move in and out of the semiconductor, while the fixed charge does not move at all. Holes and electrons are movable whereas ions are not movable hence they are immobile.

Mobile Charge Carriers and Immobile Ions in P type semiconductor

- The P type semiconductor material is formed by addition of acceptor type impurity atoms (gallium, indium, aluminum, boron) to pure silicon / germanium crystals.
- The number of holes added is equal to the number of boron atoms (acceptor impurities) because each atoms contribute one hole.
- When hole moves away from its parent atom, the remaining atoms become negative ion.
- This ion cannot take part in the conduction because it is fixed in the crystal structure of semiconductor.
- The holes and electrons are movable whereas ions are not movable therefore they are called as immobile ions.



WITH MINORITY CARRIERS

WITHOUT MINORITY CARRIERS

P TYPE MATERIAL

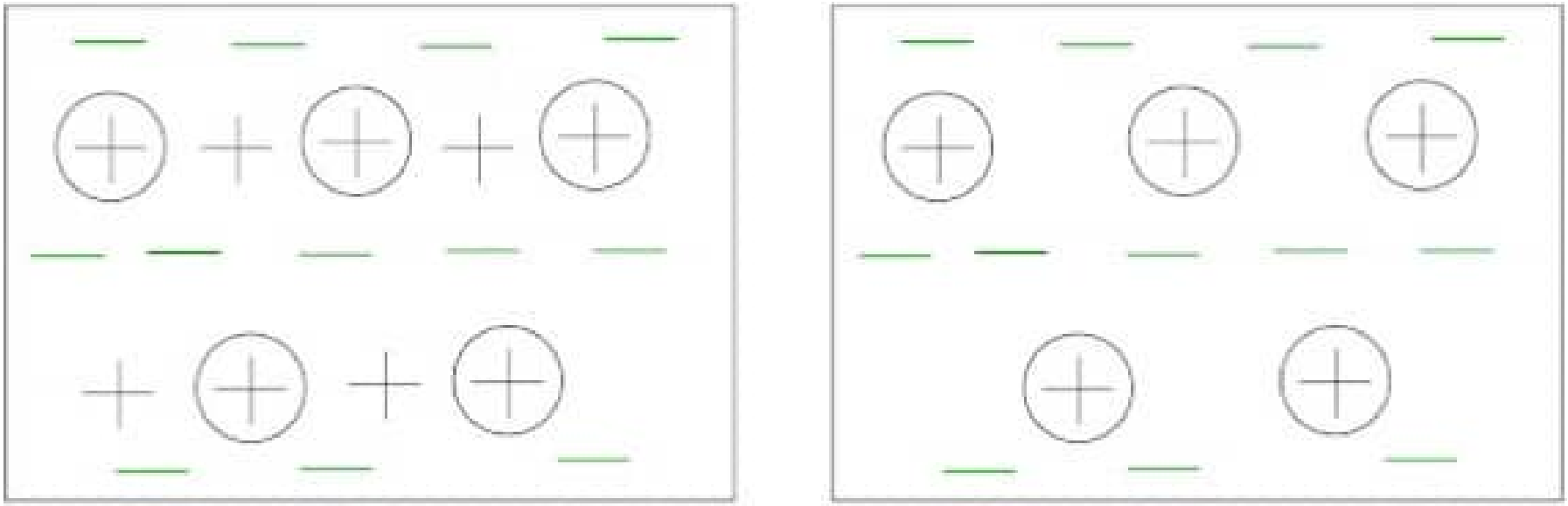
IMMOBILE IONS

FREE AND MOBILE HOLES

THERMALLY GENERATED ELECTRONS

Mobile Charge Carriers and Immobile Ions in N type semiconductor

- Similarly, the N type semiconductor is formed by addition of donor type impurity atoms (Antimony, Phosphorus, Arsenic) to pure silicon / germanium crystals.
- The number of free and mobile electrons are equal to the number of donor impurity atoms.
- When electron moves away from its parent atom, it leaves behind positive ion.



WITH MINORITY CARRIERS

WITHOUT MINORITY CARRIERS

N TYPE MATERIAL

IMMOBILE IONS

FREE AND MOBILE ELECTRONS

THERMALLY GENERATED HOLES

Cells

Cells generate electricity and also derives chemical reactions. One or more electrochemical cells are batteries. Every cell has two terminals namely:

1. ***Anode:*** Anode is the terminal from where the current flows in from out i.e. it provides an incoming channel for the current to enter the circuit or the device.
2. ***Cathode:*** Cathode is the terminal from where the current flows out i.e. it provides an outgoing current flow from the circuit or the device.

Learn more about Electric Charge here in detail

There are two simplest ways for cell connectivity are as follows:

1. ***Series Connection:*** Series connection is the connectivity of the components in a sequential array of components.
2. ***Parallel Connection:*** Parallel connection is the connectivity of the components alongside to other components.

Cells in Series Connection

In series, cells are joined end to end so that the same current flows through each cell. In case if the cells are connected in series the emf of the battery is connected to the sum of the emf of the individual cells. Suppose we have multiple cells and they are arranged in such a way that the positive terminal of one cell is connected to the negative terminal of the another and then again the negative terminal is connected to the positive terminal and so on, then we can that the cell is connected in series.

Cells in Series

- When the electron leaves the first cell it is given a boost to 1.5 volts. It then enters the second cell and given another boost of 1.5 volts for a total of 3.0 volts. Cells can be added in series indefinitely to increase the voltage of the battery.

Cells in Parallel Connection

Cells are in parallel combination if the current is divided among various cells. In a parallel combination, all the positive terminal are connected together and all the negative terminal are connected together.

Cells in Parallel

- We can add more energy (current) without adding more voltage by adding the cells in parallel. By doing this the run time of the electrical device can be increased.