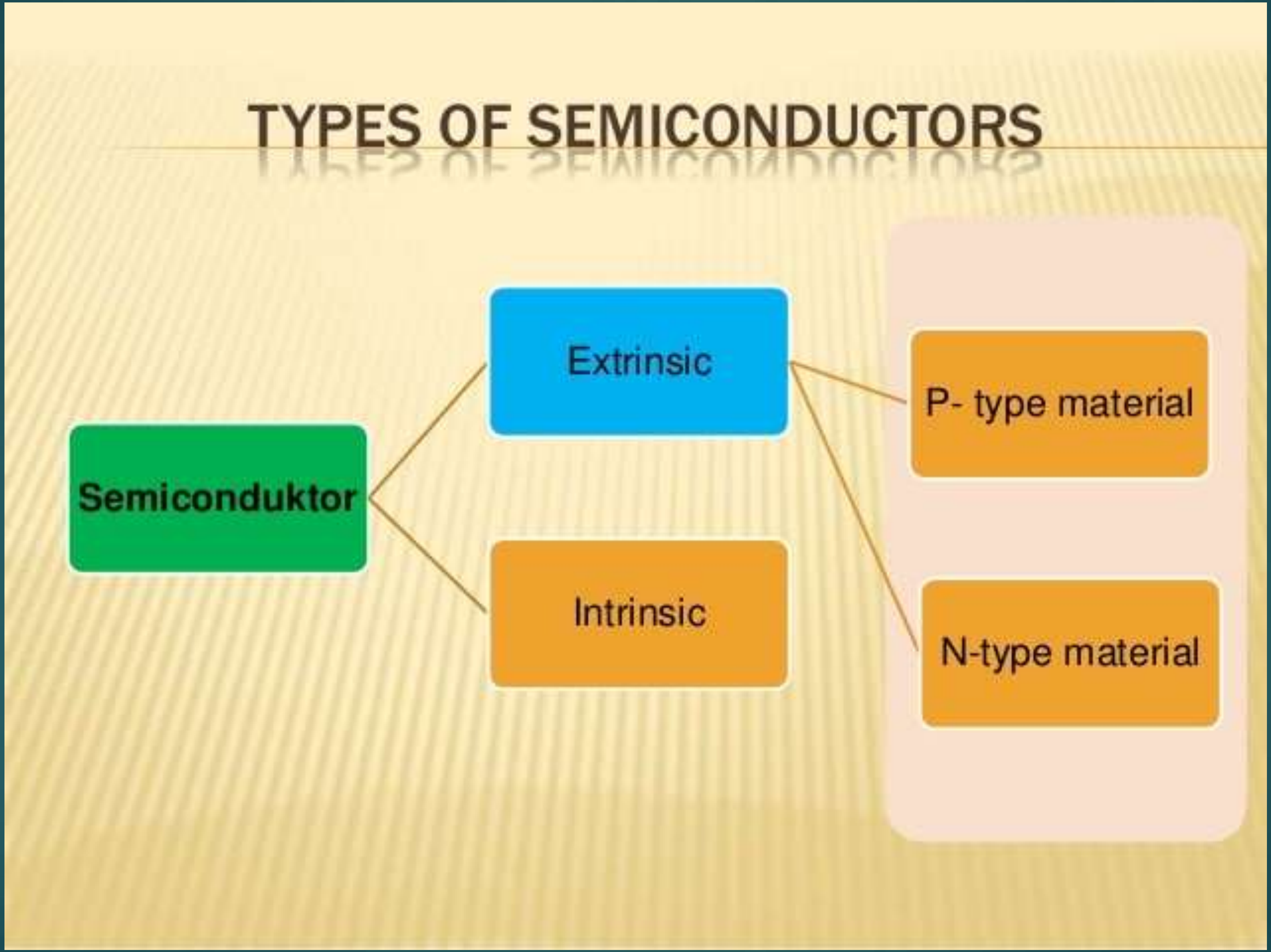
Diodes

Semiconductors are materials whose electrical properties lie between Conductors and Insulators.

Ex : Silicon and Germanium


TYPES OF SEMICONDUCTORS
Semiconduktor
Extrinsic
Intrinsic
P- type material
N-type material

Intrinsic Semiconductor

- *A Semiconductor which does not have any kind of impurities, behaves as an Insulator at 0k and behaves as a Conductor at higher temperature is known as Intrinsic Semiconductor or Pure Semiconductors.*

- *Germanium and Silicon (4^{th} group elements) are the best examples of intrinsic semiconductors and they possess diamond cubic crystalline structure.*

Extrinsic semiconductor

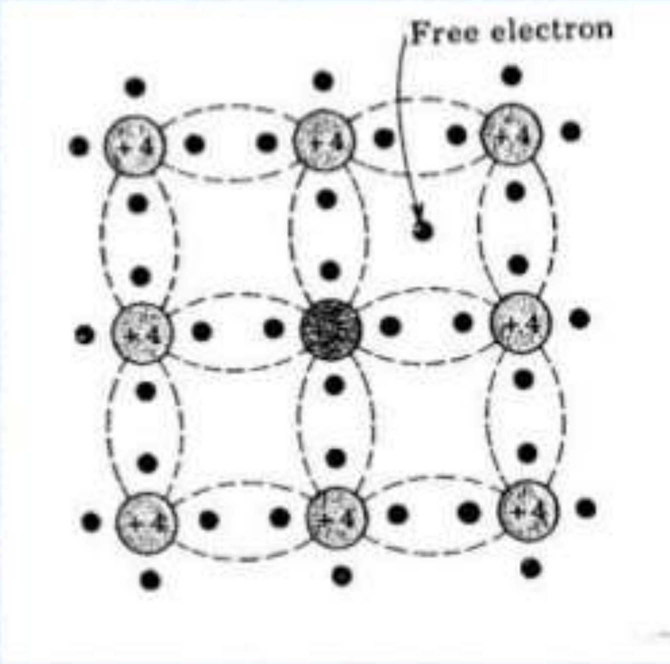
- Pure semiconductor have small conductivity at room temp. therefore they are not of much use.
- By adding some amount of impurity atoms to a pure semiconductor, we can change its conductivity or characteristics.
- The process of adding impurity to a pure semiconductor is called "doping".
- Doping is done at a rate such that only one atom of impurity is added per 10^6 to 10^{10} semiconductor atoms.
- On adding impurities, either the no. of electrons or holes increases.
- A doped semiconductor is called "extrinsic semiconductor".
- Types of extrinsic semiconductors,

✓ N – type semiconductor

✓ P – type semiconductor

N-type semiconductor

- The Pentavalent impurity atoms are added to a pure semiconductor, "N-type semiconductor" is obtained.
- The pentavalent impurity atom has five outer (valence) electrons, rather than the four of silicon.
- The size of the pentavalent atoms is roughly same as that of Si or Ge. For eg. P, Sb, As, etc....
- The amount of impurity is very small, it is assumed that each impurity atom is surrounded by Si atoms.
- The phosphorus atom has five valence electron. Only four of the valence electrons are required for covalent bonding.
- The fifth electron has no chance of forming a covalent bond.
- The fifth is much more easily detached from the parent atom.



- The fifth is much more easily detached from the parent atom .
- A very little amount of energy is required to deattach this electron from the nucleus of its parent atom.
- The energy needed to free the fifth electron is smaller than the thermal energy at room temperature virtually all are freed.
- The energy for Si and Ge are 0.05eV and 0.01 eV .
- Each impurity atom donates one electron to the conduction band, therefore pentavalent impurity is called "Donor type impurity".
- Large number of donated electrons , there are also some thermally generated electron-hole pairs.
- Large number of electrons increases the rate of recombination of electrons with holes.
- The net concentration of holes is much less than intrinsic value.
- N – type semiconductor is also called " donor ion"
- The donor ion is held and is called positively charged " immobile ion".
- Electrons are in majority carriers.

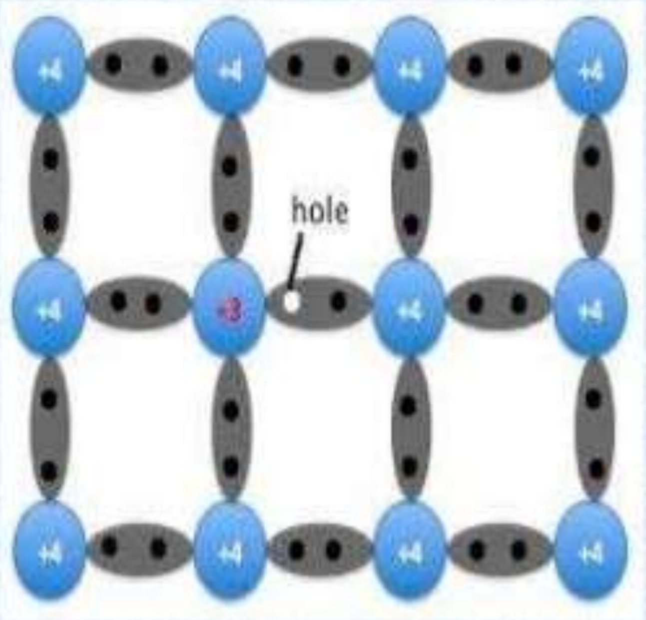
N – type semiconductor

- Holes are in minority carriers
- It has large number of immobile positive ions.
- N – type semiconductor is not negatively charged but they are electrically neutral.
- The total number of electrons is equal to the total number of holes and immobile ions.

The negative charge is exactly balanced by the positive charge.

P- type semiconductor

- The trivalent impurity atoms are added to the pure semiconductor , p-type semiconductor.
- The trivalent impurity atoms have three electrons in the valence shell.
- The size of the trivalent atoms is roughly same as that of Si or Ge. eg. B , Al , Ga , In etc.....
- The amount of impurity is very small, it is assumed that each impurity atom is surrounded by Si atoms.
- the doping atom has only three electrons in its outer shell i.e, In
- The impurity atom (In) is surrounded by silicon atoms.
- These three electrons form covalent bonds with the three neighbouring silicon atoms.



P-type semiconductor

- The fourth silicon atom can not make a covalent bond with the Indium atom because the indium atom does not have fourth valence electron.
- The fourth covalent bond is incomplete.
- A vacancy that exists in the incomplete covalent bond constitutes a hole.
- The hole has a tendency to complete the covalent bond from the neighbouring atoms to complete the covalent bond.
- An electron from neighbouring atoms require some energy to jump into the vacancy.
- At room temperature , this small amount of energy is provided by thermal energy. For eg, the energy for Si and Ge is 0.05 eV and 0.01 eV respectively .
- When an electron from the neighbouring atoms jump into the vacancy around the Indium atom to complete the covalent bonds, the effect is two fold.

- The large no. of holes are created due to acceptor type impurities .
- The large no. of holes increases the rate of recombination of holes with electrons so that no. of electrons is further reduced then intrinsic level .
- In P-type semiconductors , holes are the majority carriers and electrons are the minority carriers .
- The P-type materials has holes as majority carriers electrons as minority carriers and

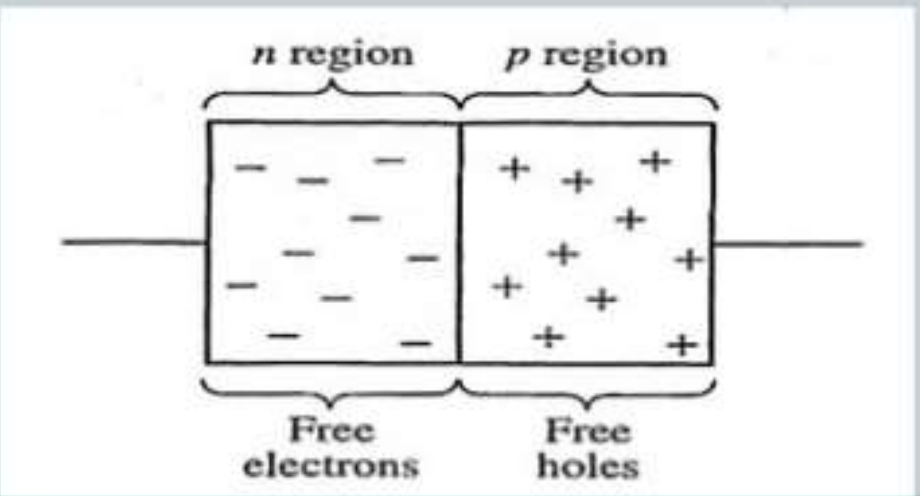
  negative mobile ions .
- They have two type of charge carriers and immobile negative ions .

- Semiconductors are classified in to P-type and N-type semiconductor
- P-type: A P-type material is one in which holes are majority carriers i.e. they are positively charged materials (++++)
- N-type: A N-type material is one in which electrons are majority charge carriers i.e. they are negatively charged materials (-----)

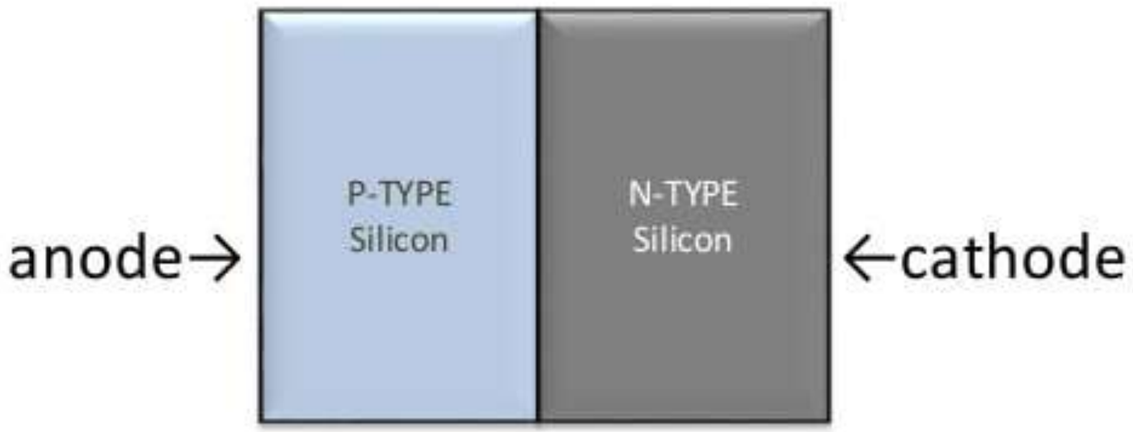

DIODE
signal diode
light emitting diodes
IR LEDs
photodiodes
transient voltage supression diodes
zener diodes
constant current diode
shottkey diode
shockley diode
step recovery diodes
super barrier diode
tunnel diodes
varactor diodes
PIN diodes
point contact diode
vaccum diode
LASER diodes
silicon controlled rectifier
peltier diodes
gunn diode
crystal diode
avalanche diode
Types of Diode

Diodes

Electronic devices created by bringing together a *p*-type and *n*-type region within the same semiconductor lattice. Used for rectifiers, LED etc



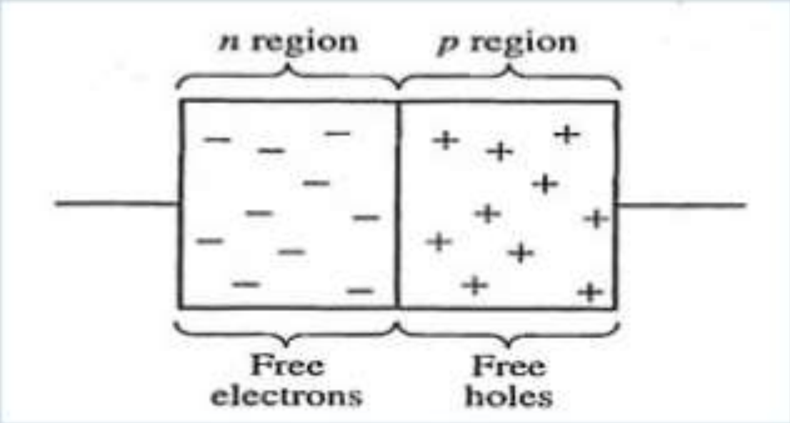
Physical structure of diode

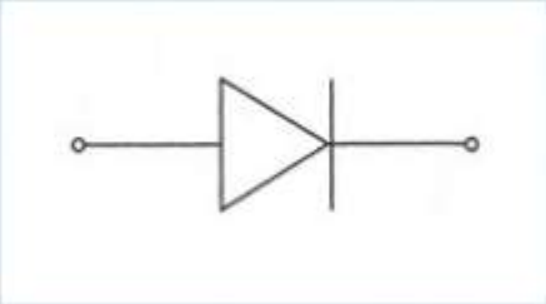


- Diodes are formed by joining P-Type and N-Type Semi Conductor.

Diodes

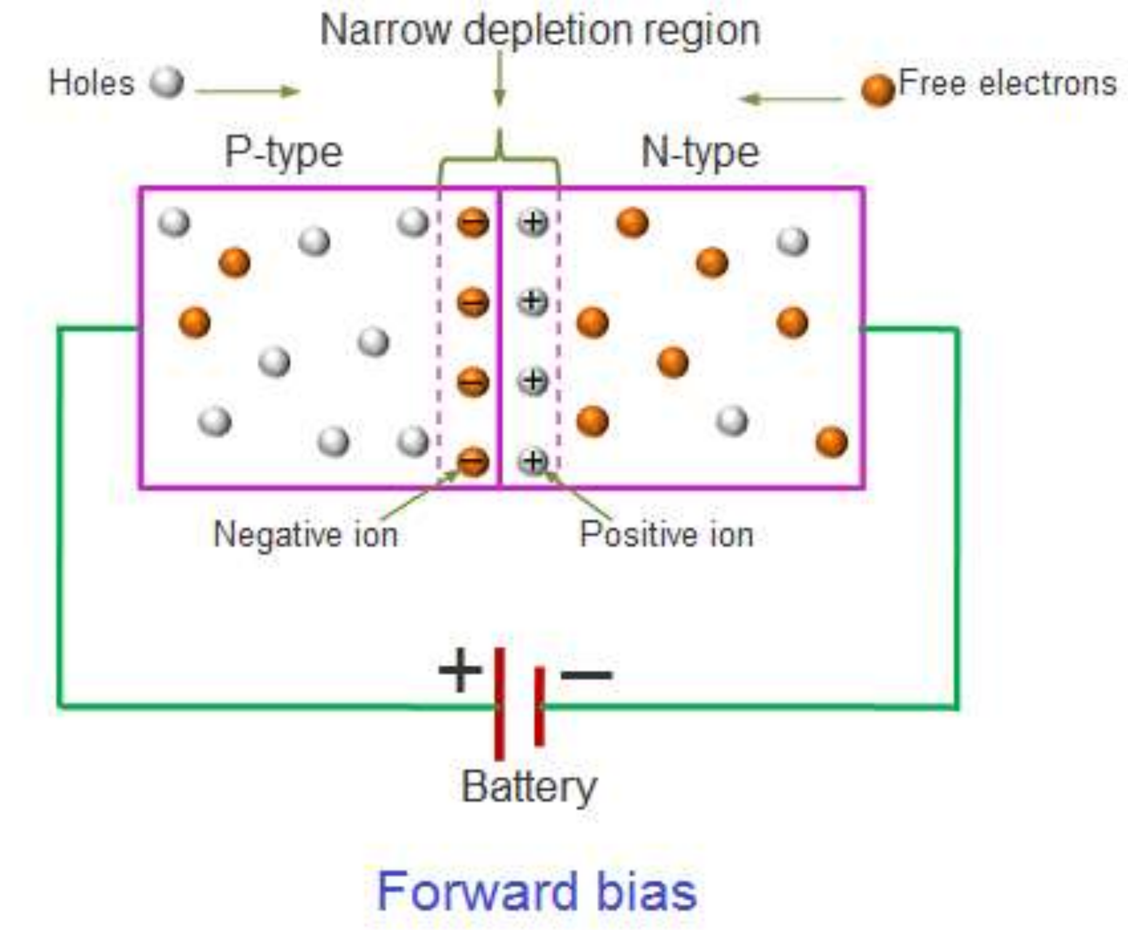
It is represented by the following symbol, where the arrow indicates the direction of positive current flow.

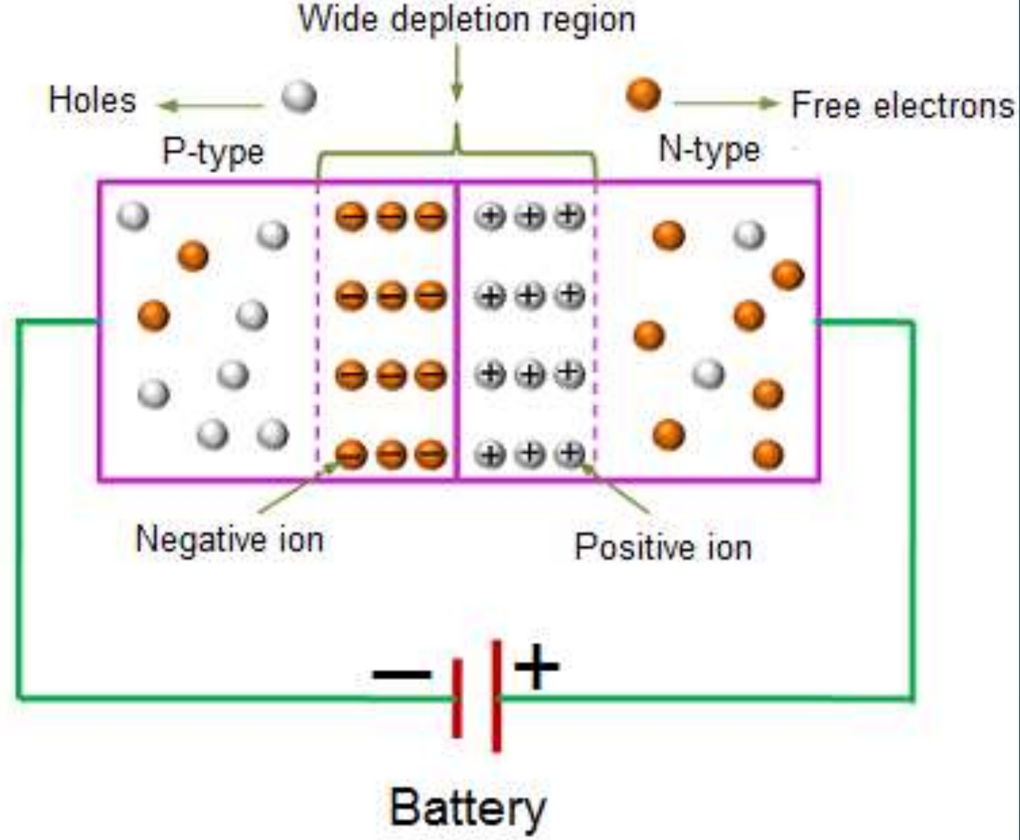




Characteristics of Diode

- Diode always conducts in one direction.
- Diodes always conduct current when “Forward Biased” (Zero resistance)
- Diodes do not conduct when Reverse Biased (Infinite resistance)


Narrow depletion region
Holes
Free electrons
P-type
N-type
Negative ion
Positive ion
+
−
Battery
Forward bias



Reverse bias