BBMerlion

Physics

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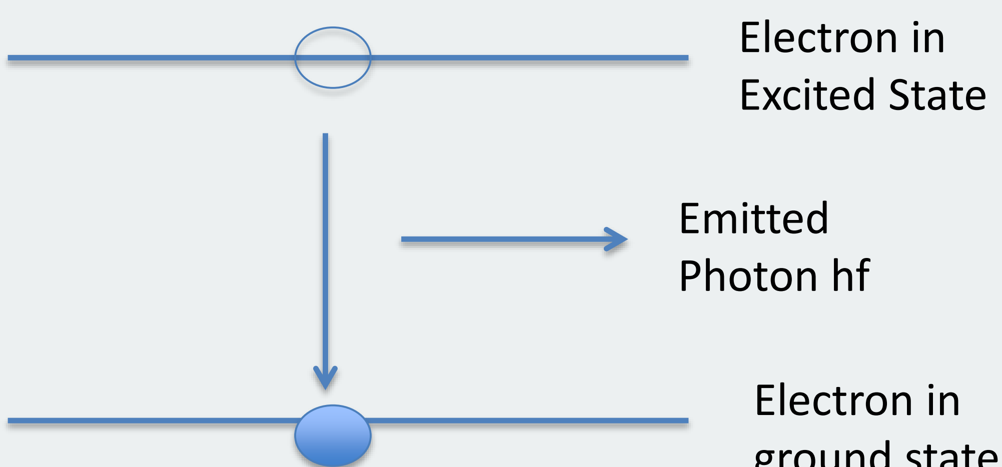
LASERS AND SEMICONDUCTORS

Objective

- Basic principles of lasers
- Energy bands, conductors and insulators
- Semiconductors
- Depletion region of a p-n junction

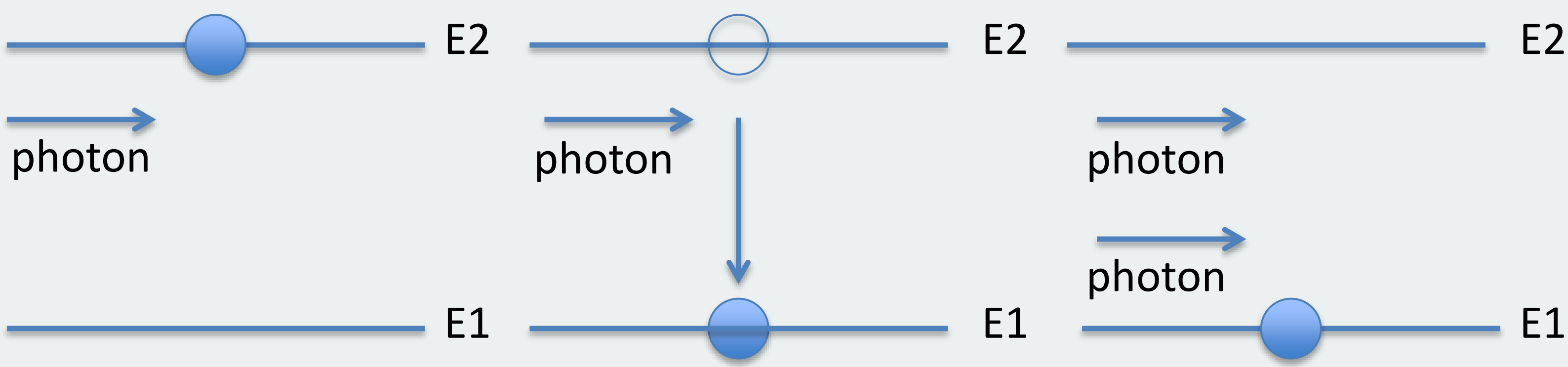
Basic Principle of Lasers

- Spontaneous emission: when an electron drop from excited state to ground state without any external event triggering it



Basic Principle of Lasers

- Stimulated emission: A process whereby an incoming photon causes another photon of the same frequency & phase (& direction) to be emitted from an excited atom.



Basic Principle of Lasers

- Population Inversion: when a population such as atoms and molecules exist with more excited state than lower energy state
- Laser: A monochromatic, coherent, parallel beam of high intensity light

Basic Principle of Lasers

Conditions to perform laser

- Atoms of the laser medium must have a meta-stable state.
- The medium must be in a state of population inversion.
- The emitted photons must be confined in the system long enough to allow them to cause a chain reaction of stimulated emissions from other excited atoms.

Energy bands, Conductors and Isolators

- In isolated solid atom, the atom is close to each other and make an interaction
- the interaction resulting each discrete energy level is split into many sub-levels
- These sub-levels are extremely close to one another such that they form an **energy band**

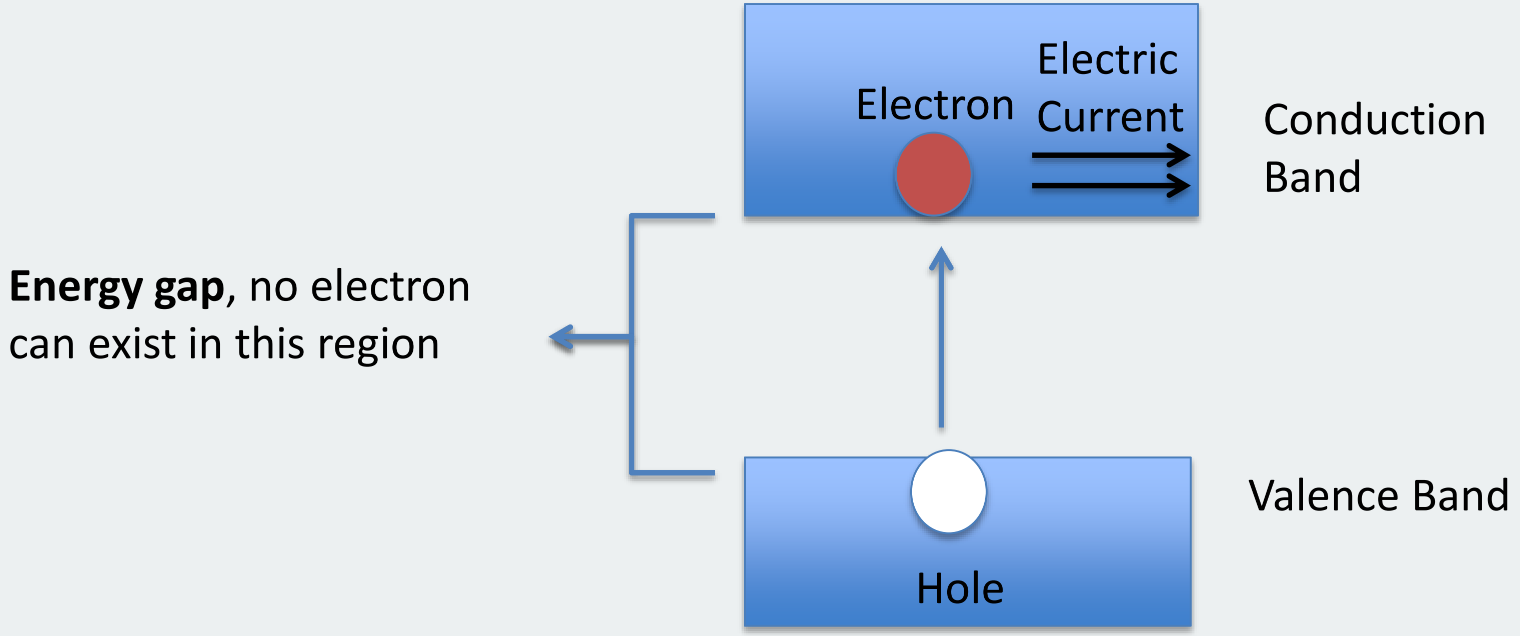
Energy bands, Conductors and Isolators

Conduction band: the range of electron energy where the electron has high enough energy to accelerate under the influence of electric field so that the electic current occur

Valence Band: In solids, the valence band is the highest range of electron energies in which electrons are present at absolute zero temperature

Energy bands, Conductors and Isolators

To achieve electric current, the electron need to be in conduction band, before that, the electron need to jump from valence band to conduction band leaving **hole** in valence band.



Energy bands, Conductors and Isolators

Conductor:

- The conduction band is partially filled with electrons
- Valence band is fully occupied
- No distinction between conduction band and valence band (no energy gap)
- With no energy gap, only small amount of energy needed to bring the electron jump from valence band to conduction band
- In conduction band the electron easy to flow and make electrical current, this make it as a good conductor

Energy bands, Conductors and Isolators

Conductors

Conduction Band

//////////////////////////

Valence Band

No Energy Gap

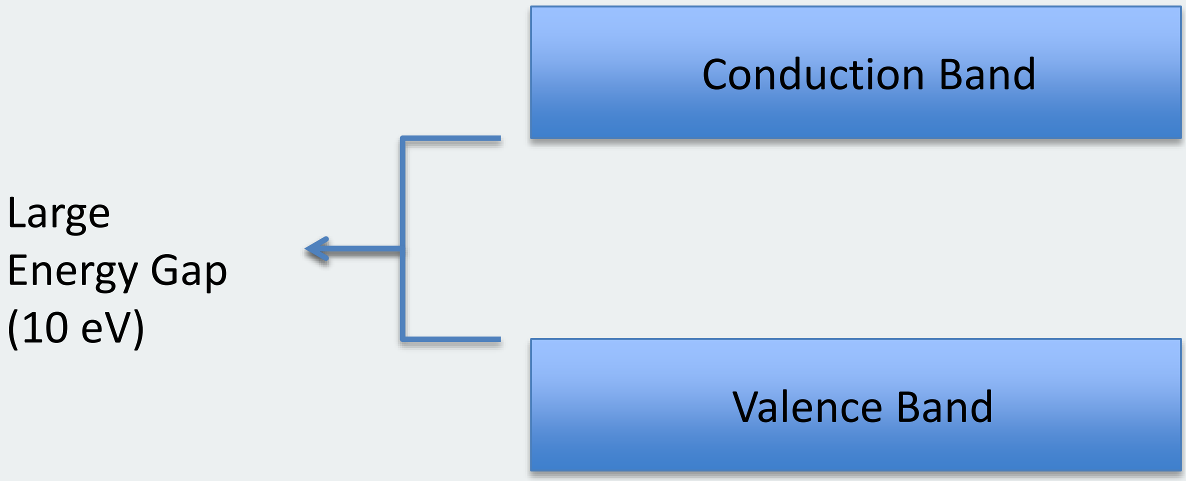
Energy bands, Conductors and Isolators

Isolators:

- Initially the conduction band is completely empty
- Valence band is fully occupied
- Large energy gap (around 10 eV) make electron need high energy to jump from valence band to conduction band, hence electron is not easy to flow (low conductivity)

Energy bands, Conductors and Isolators

Isolators



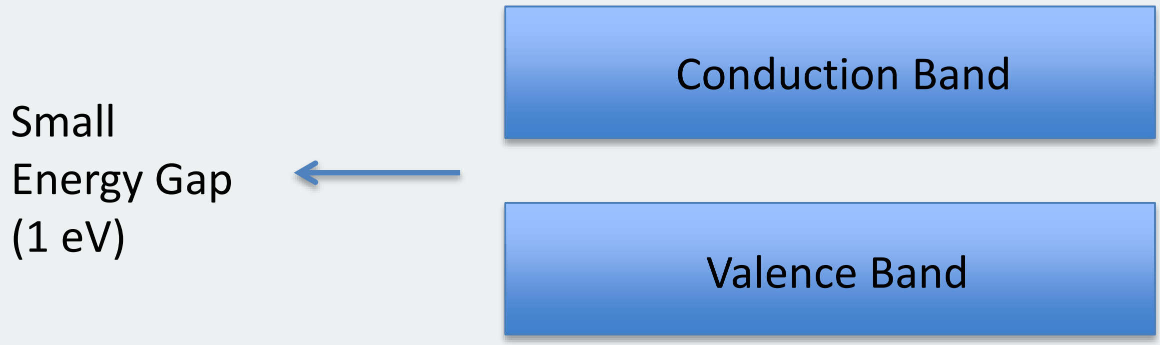
Energy bands, Conductors and Isolators

Semiconductor

- Initially the conduction band is completely empty
- Valence band is fully occupied
- Small energy gap (around 1 eV) make electron need only a relatively small energy to jump from valence band to conduction band

Energy bands, Conductors and Isolators

semiconductors



Semiconductors

- Doping: adding impurity to semiconductor to control its electronic properties
- n-type doping increases the no. of free {NOT: valence } electrons; p-type doping increases the no. of holes
- Not valence (conduction) electron can be called negative carrier
- Hole can be called positive carrier

Semiconductors

Based on the band theory, a semiconductor has a completely filled valence band and an empty conduction band with a small energy gap in between. Hence there are no charge carriers and the electrical resistance is high.

- When temperature is low, electrons in the valence band do not have sufficient energy to jump across the energy gap to get into the conduction band.
- When temperature rises, electrons in the valence band receive thermal energy to enter into the conduction band leaving holes in the valence band.
- Electrons in the conduction band & holes in the valence band are mobile charge carriers and can contribute to current.
- Increasing the number of charge carriers means lower resistance.

2 Type of Doping

- N-type Doping

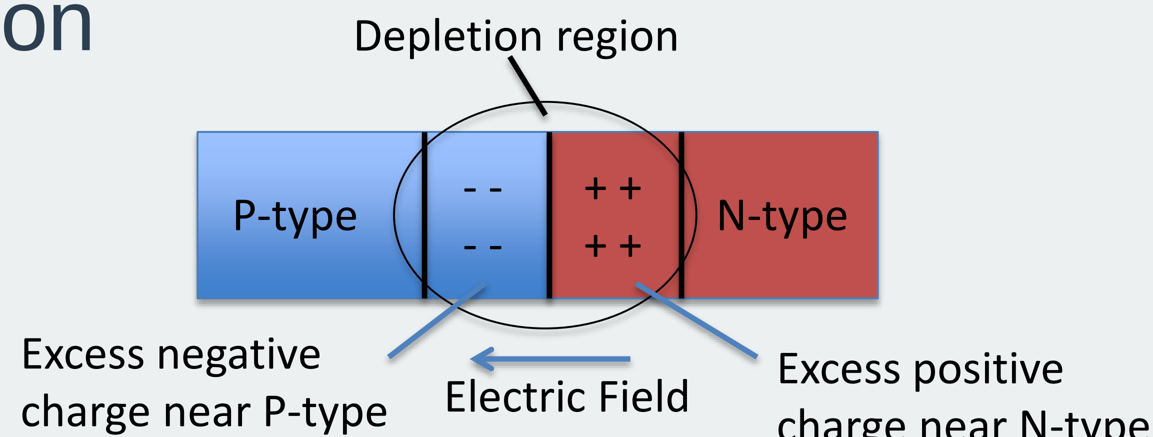
the **majority charge carrier** is the electron, its **minority charge carrier** is the hole

- P-type Doping

the **majority charge carrier** is the hole, its **minority charge carrier** is the electron

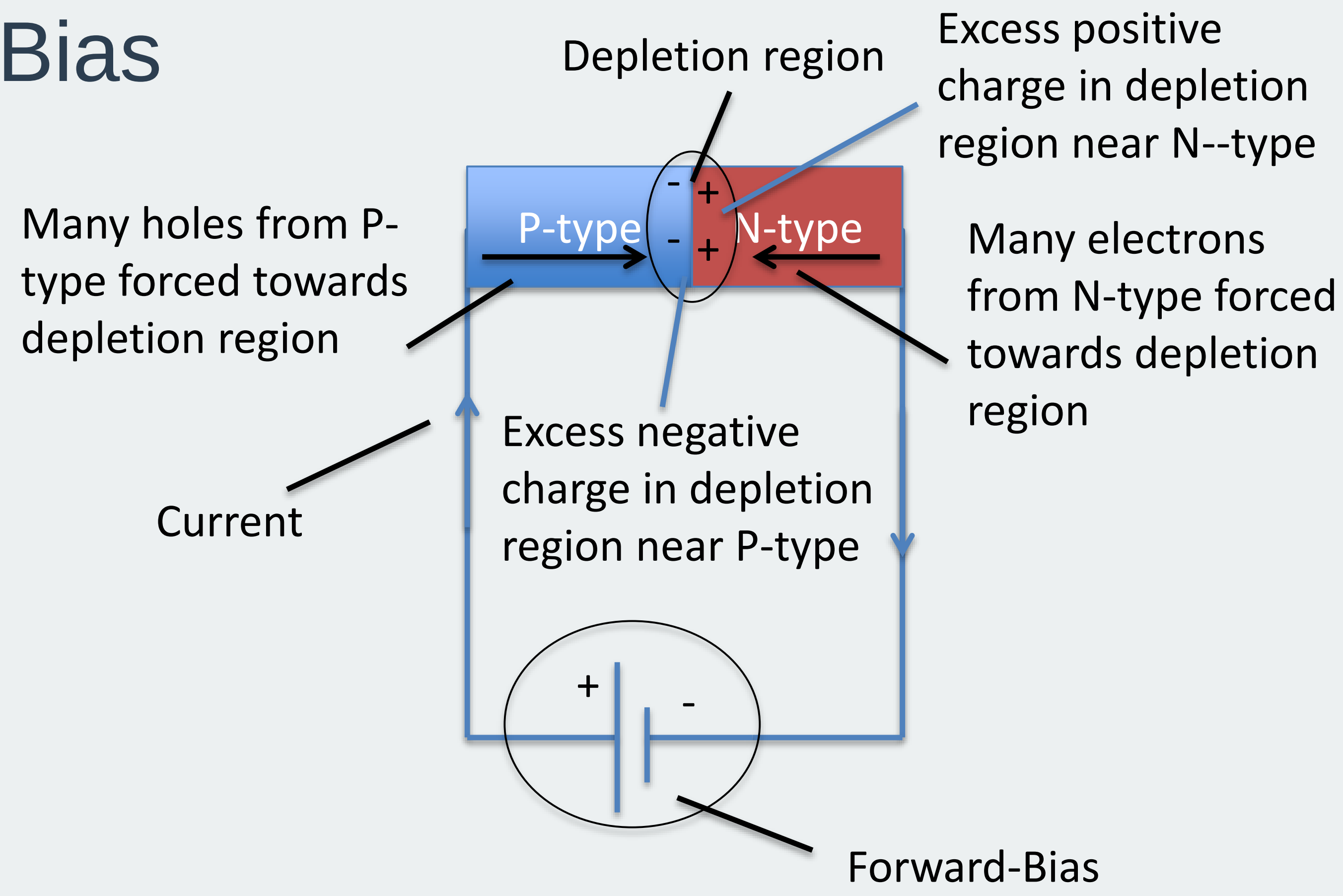
Depletion Region of a P-N Junction

P-N junction made by doping the adjacent regions of semiconductor by p-type and n-type dopants. The **minor** carrier of each region will be attracted into the junction, creating a region with electric field called depletion region



Depletion Region of a P-N Junction

Forward-Bias



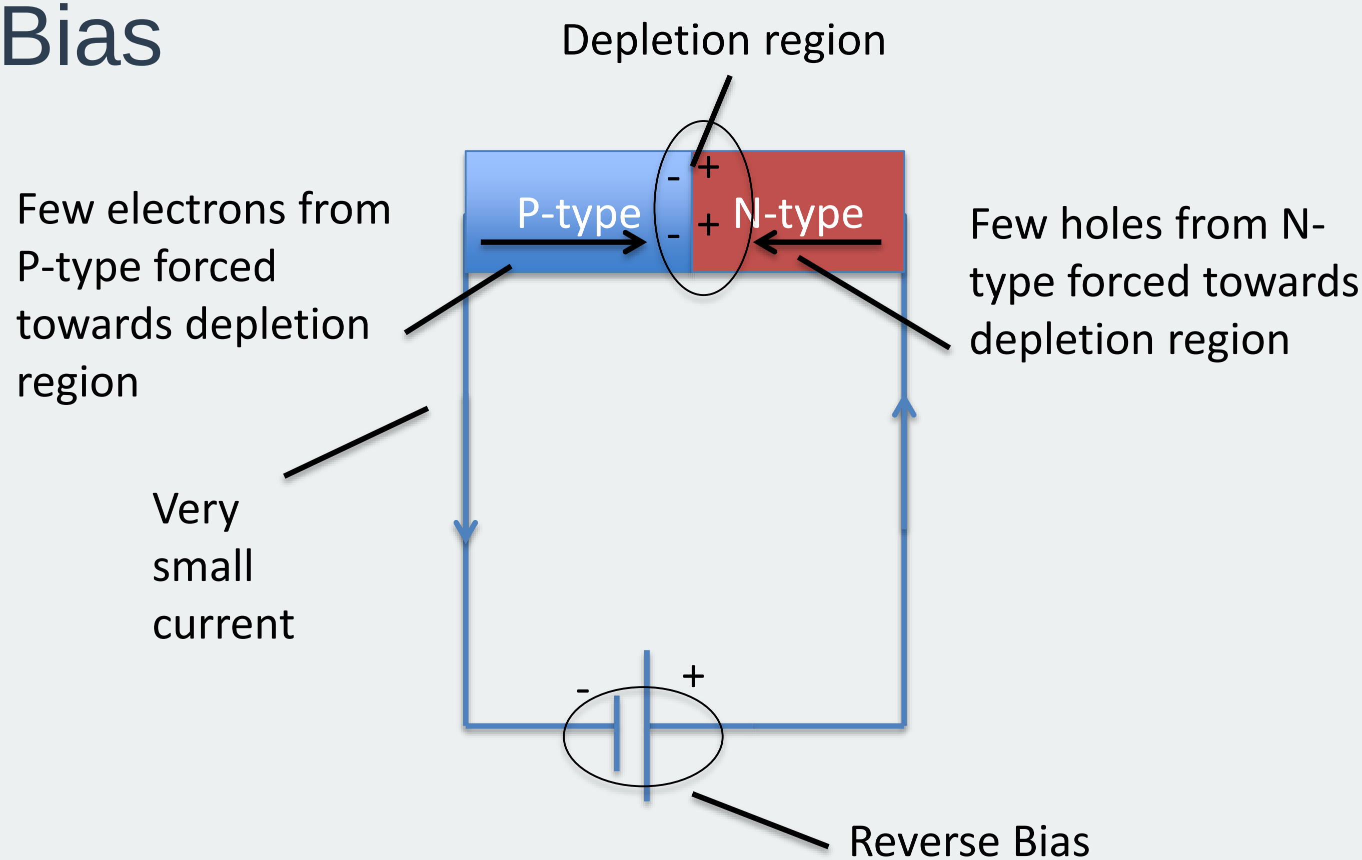
Depletion Region of a P-N Junction

Forward Bias

- The dominant positive carrier (holes) from P-type forced towards depletion region
- The dominant negative carrier (electrons) from N-type forced towards depletion region
- The holes from P-type will collide with the abundance amount of electrons in depletion region, and electrons from N-type will collide with holes in depletion region (become neutral), hence the forward bias produce current, narrows the depletion region and reduces the potential difference in depletion region

Depletion Region of a P-N Junction

Reverse-Bias



Depletion Region of a P-N Junction

Reverse-Bias

- The minor negative carrier (electrons) from P-type forced towards depletion region
- The minor positive carrier (holes) from N-type forced towards depletion region
- The negative terminal of the battery pulls the holes from P-type and the positive terminal of the battery pulls the electrons from N-type make the depletion region become wider, and increase the potential difference in depletion region, small current occur.

References

A level complete guide, Themis Publisher,

www.xtremepapers.com,

Physics MCQ with helps (topical).