EXAMPREP

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Preparation for Electronic Device & Circ

CT-1:

NB: (All answers are collected from YT + Articles)

1) **Define extrinsic Semiconductor ?**

Extrinsic semiconductors are semiconductors that are doped with specific impurities. The impurity modifies the electrical properties of the semiconductor and makes it more suitable for electronic devices such as diodes and transistors.

While adding impurities, a small amount of suitable impurity is added to pure material, increasing its conductivity by many times. Extrinsic semiconductors are also called *impurity semiconductors* or *doped semiconductors*
.

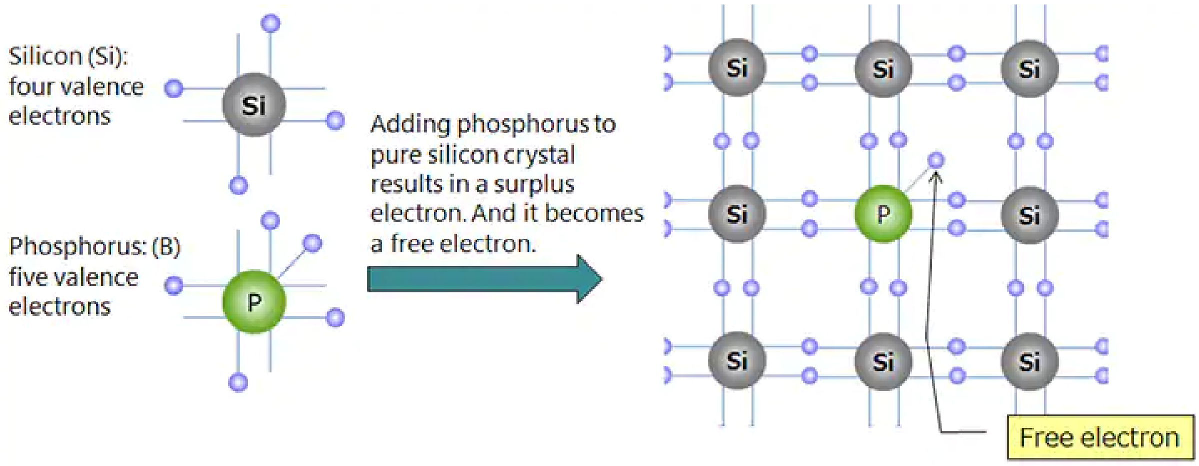
2) **How n-type material is formed ?**

When a **tetravalent** atom such as Si or Ge is doped with a **pentavalent** atom (*Atoms with valency 5; such as Arsenic (As), Phosphorous (Pi), Antimony (Sb), etc*.), it occupies the position of an atom in the crystal lattice of the Si atom. The four of the electrons of the pentavalent atom bond with the four neighboring silicon atoms, and the fifth one remains weakly bound to the parent atom. As a result, the ionization energy required to set the fifth electron free is very low, and the electrons become free to move in the lattice of the semiconductor. Such semiconductors are termed as n-type semiconductors.

Keywords:

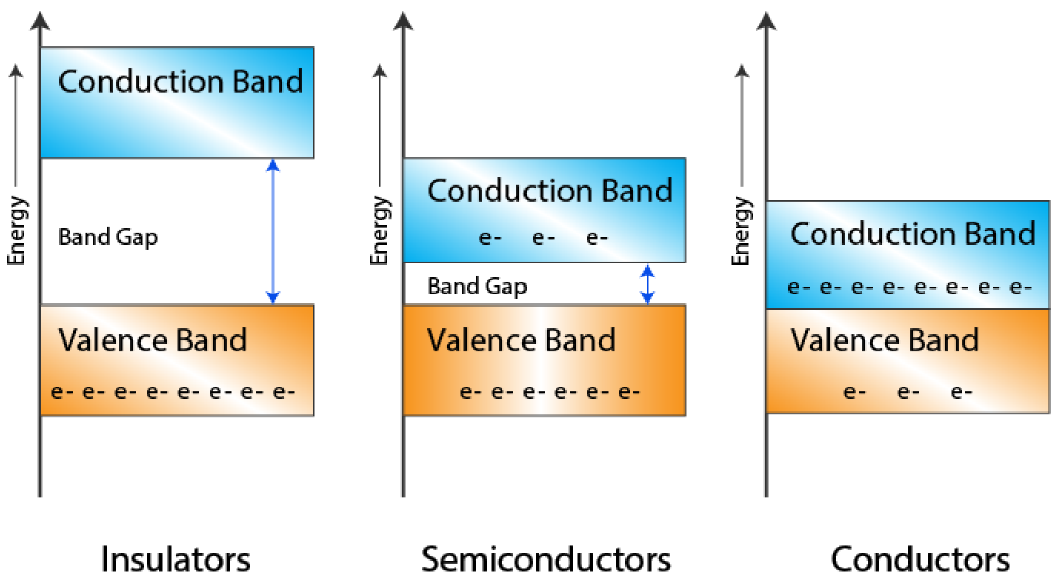
- N type is formed due to doping of **pentavalent atoms**
- 4 electron creates bond with dopant 4 electrons, and rest-1-electron moves freely

- **N** type is **N**egative
- Majority carriers are electrons and minorities are holes
- electrons > holes



3) **Sketch and explain energy levels for insulators, semiconductors and conductors.**

Energy Level : Energy level is quantized energy value of an atom.



Insulators :

Forbidden Band Gap = Conduction band - valance band ≥ **5.0 eV**

Can't conduct current

Due to high forbidden band gap, the electron couldn't go to conduction band. So, it **can't conduct** current. Example: Wood, Glass

Semiconductors:

Forbidden Band Gap ≤ **1.1 eV (approx.)**

Semiconductor requires **small conductivity**. Example : Si, Ge..

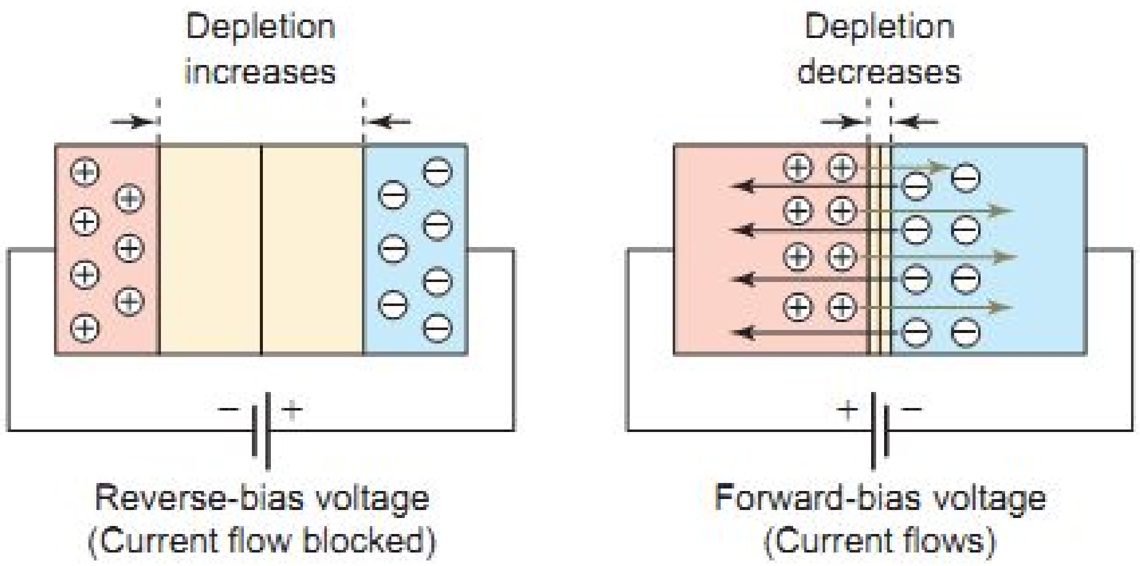
Conductors:

Forbidden Band Gap ≈ **0 eV**

There is no forbidden gap between the valence band and conduction band which results in the overlapping of both the bands. **High Conductivity**. The number of free electrons available at room temperature is large. Example : Au, Al, Cu..

4) **Explain PN Junction in Forward Bias and Reverse Bias condition.**

PN junction is a semiconductor diode which can conduct current in the one-direction.

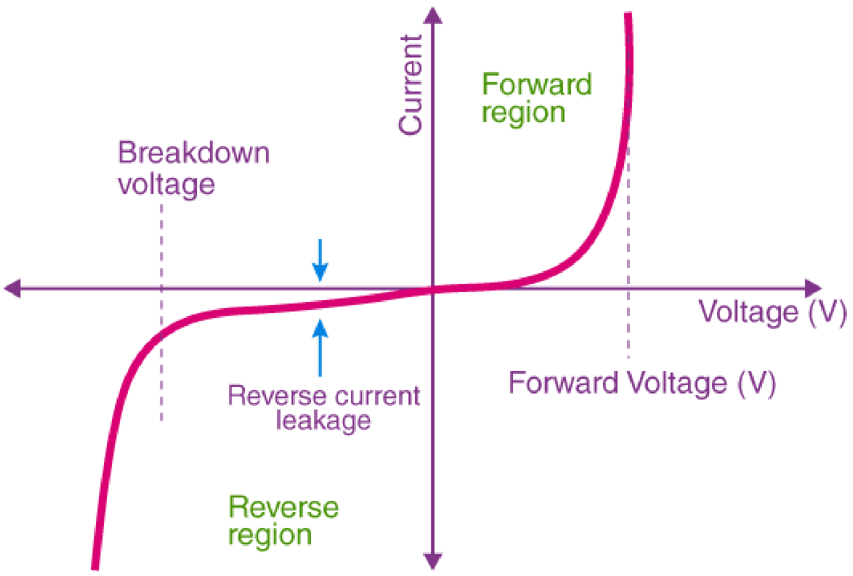


Forward Bias:

- P-side connected to the positive terminal of the battery and N-side connected to the negative terminal of the battery
- By increasing the voltage of the battery, the depletion layer decreases and the barrier potential gets reduced, the current-carriers is proportional to the potential/voltage
- If the potential increases to a significant value (also known as Knee voltage), the carriers increases more and the circuit conducts current
- Resistance low
- depletion layer thin/narrow
- voltage in anode $>$ cathode
- voltage across diode $>$ 0

Reverse Bias:

- P-side connected to the negative terminal and N-side connected to the positive terminal of the battery
- Applying external voltage, barrier voltage, so the depletion layer increases and the motion of the carriers also decreases. Circuit conducts no current butt
- There's a current named **Leakage Current (due to thermally generated minority carrier, which is created by minority carrier).** *For all basic purposes, leakage current is very small, and, thus, is normally negligible.*
- After a significant value of external voltage, the diode breaks (looks like kind of short circuit) and so much current flow to the circuit, which is known as **Breakdown voltage**
- Resistance high
- depletion layer wide
- voltage in cathode $>$ anode
- voltage across diode < 0



4) Show the Comparison between valance band and conduction band.

Basis for Comparison	**Valence Band**	**Conduction Band**
Abbreviated as	VB	CB
Existence wrt fermi-level (forbidden energy gap at 0 degree temperature)	It is present below fermi-level.	Its existence is above fermi-level.
Effect of external excitation	Electrons move out of valence band	Electrons reaches the conduction band/ move into the conduction level
Energy state	Lower	Comparatively higher
Electron density	High	Low
Force by nucleus	Strong	Weak
Presence of electrons causes band to be	Partially or completely filled.	Empty or partially filled.
Definition	The lower energy level of semiconductor is called Valance band	A conduction band is defined as that energy band that consists of free electrons that are responsible for conduction.

5) What is Forbidden Energy Gap ?s

The gap between the valence band and the conduction band is referred to as the forbidden gap. As the name suggests, the forbidden gap doesn't have any energy and no electrons stay in this band. If the forbidden energy gap is greater, then the valence band electrons are tightly bound or firmly attached to the nucleus. We require some amount of external energy that is equal to the forbidden energy gap.

Keywords :

- lies between valance and conduction band
- doesn't have energy and electron
- forbidden band $\propto$ valance-electron and nucleus bonding
- conductivity $\propto \frac{1}{value\ of\ forbidden\ band}$

6) Differences Between Conductors, Semiconductors & Insulators:

Characteristics	Conductor	Semiconductor	Insulator
Definition	A conductor is a material that allows the flow of charge when applied with a voltage.	A semiconductor is a material whose conductivity lies between conductor & insulator	An insulator is a material that does not allow the flow of current.
Temperature Dependence	The resistance of a conductor increases with an increase in temperature.	The resistance of a semiconductor decrease with increases in temperature. Thus it acts as an insulator at absolute zero.	Insulator has very high resistance but it still decreases with temperature.
Conductivity	The conductors have very **high conductivity** (**10-7 ℧ /m**), thus they can conduct electrical current easily.	They have **intermediate conductivity** (**(10-7 ℧ /m** to **10-13 ℧ /m**), thus they can acts as insulator & conductor at different conditions.	They have very **low conductivity** (**10-13 ℧ /m),** thus they do not allow current flow.

Characteristics	Conductor	Semiconductor	Insulator
Conduction	The conduction in conductors is due to the **free electrons** in metal bonding.	The conduction in semiconductor is due to the **movement of electron & holes**.	Th*ere are no free electrons or holes thus, there is no conductio*n.
Band gap	There is **no or low energy gap** between the conduction & valance band of a conductor. It does not need extra energy for the conduction state.	The band gap of semiconductor is greater than the conductor but smaller than an insulator i.e. **1 eV**. Their electrons need a little energy for conduction state.	The band gap in insulator is huge (**+5 eV**), which need an enormous amount of energy like lightning to push electrons into the conduction band.
Resistivity	**Low** (10-5 Ω/m)	**Normal** (10-5Ω/m to 105 Ω/m)	**Very High** (105 Ω/m)
Coefficient of Resistivity	It has **positive coefficient** of resistivity i.e. its resistance increase with temperature	It has **negative coefficient** of resistivity.	The coefficient of resistivity of an insulator is also **negative** but it has very huge resistance.
Absolute Zero	Some special conductors turn into **superconductors** when supercooled down to absolute zero while other have finite resistance.	The semiconductors turn into **insulator** at absolute zero.	The insulator's **resistance increase** when cooled down to absolute zero.
Valence Electron in Outer Shell	**1 Valence electron** in outer shell.	**4 Valence electron** in outer shell.	**8 Valence electron** in outer shell.
Examples	Gold, Copper, Silver, Aluminum etc.	Silicon, Germanium, Selenium, Antimony**,** Gallium Arsenide (known as semi insulator),Boron etc.	Rubber, Glass, Wood, Air, Mica, Plastic, Paper etc.

Characteristics	Conductor	Semiconductor	Insulator
Application	The metals like iron & copper etc. that can conduct electricity are made into wires and cable for carrying electric current.	Semiconductors are used every day electronic devices such as cellphone, computer, solar panel etc as switches, energy converter, amplifiers, etc.	The insulators are used for protection against high voltages & prevention of electrical short between cables in circuits.

7) Comparison between Zener and Avalanche

Avalanche Breakdown	Zener Breakdown
Occurs from collision of carriers (due to high voltage applied in reverse bias)	occurs because of direct rapture of covalent bond due to high electric field
occurs in lightly doped diode	heavily doped diode
depletion layer is wide	depletion layer is narrow
it occurs higher than 6 Volt	below 6 Volt
The increase in temperature increases the breakdown voltage.	The increase in temperature decreases the breakdown voltage.

Formula:

1) Current Voltage Relation:

$$I_D = I_S(e^{\frac{V_d}{\eta\, v_T}} - 1)$$

For Room temperature : $V_T = 0.026$ Volt

$V_T = \frac{T(kelvin)}{11600}$

2) Dynamic Resistance (AC):

$$R_D = \frac{\eta V_T}{I_D}$$

3) AC Average Resistance :

$$R_D = \frac{\triangle V}{\triangle I}$$

4) Static Resistance (DC) :

$$R_S = \frac{V}{I}$$