Semi-Conductor Physics and Information Storage

Lecture 1

Unit: 4

Engineering Physics
AAS0201A

B.Tech (2nd Sem.)

Anurag Tyagi
Assistant Professor
Applied Sciences

Content

Name of Topic	Duration (Hrs.)	% of Coverage in Exams
Electrical conductivity , conductivity of conductors and semiconductors	02	2%
Formation of bands in solids, classification of solids on the basis of band theory	01	2%
Fermi-Dirac distribution function, Fermi energy	01	2%
Position of fermi level in intrinsic and extrinsic semiconductor	02	4%
Variation of fermi level with temperature	01	4%
Photovoltaic effect, construction and working of solar cell	02	4%
Basics of magnetic and semiconductor memories	01	2%

Content

- Introduction to the Concept of electrical conductivity
- Conductivity of conductors and semiconductors
- Classification of solids on band theory
- Fermi- Dirac distribution function
- Position of Fermi level in intrinsic and in extrinsic semiconductors
- Variation of Fermi level with temperature
- Photovoltic effect
- Solar cell
- Basics of magnetic, and semiconductor memories

Unit Objective

- To provide the basic knowledge of semiconductor devices
- To provide basic physics knowledge of energy band gap.
- To Provide the knowledge of storage memories in computer system.

Course Objective

CO1: To provide the knowledge of Relativistic Mechanics and their uses to engineering applications.

CO2: To provide the knowledge of Quantum Mechanics and to explore possible engineering utilization

CO3: To provide the knowledge of interference, diffraction.

CO4: To provide the knowledge of the phenomenon of semiconductors and its uses to engineering applications.

CO5: To provide the basic knowledge of Optical Fiber and Laser which is necessary to understand the working of modern engineering tools and techniques.

Course Outcome

After completion of course students are;

CO1 Able to solve the relativistic mechanics problems

CO2 Able to apply the concept of quantum mechanics

CO3 Able to apply the laws of optics and their application in various processes

CO4 Able to define the laws of semiconductors.

CO5 Able to explain the working of modern engineering tools and techniques of optical fiber and laser.

CO-PO and PSO Mapping

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12
CO1	3	2	1	-	2	2	2	-	-	-	-	2
CO2	3	2	1	-	1	2	2	-	-	-	-	2
CO3	3	3	1	-	2	2	2	-	-	-	-	2
CO4	3	2	2	-	2	3	2	-	-	-	-	2
CO5	3	2	2	-	2	2	2	-	-	-	-	2
Mean	3.0	2.2	1.4	-	1.8	2.2	2.0	-	-	-	-	2.0

Topic Objective

- To provide the knowledge of electrical conductivity.

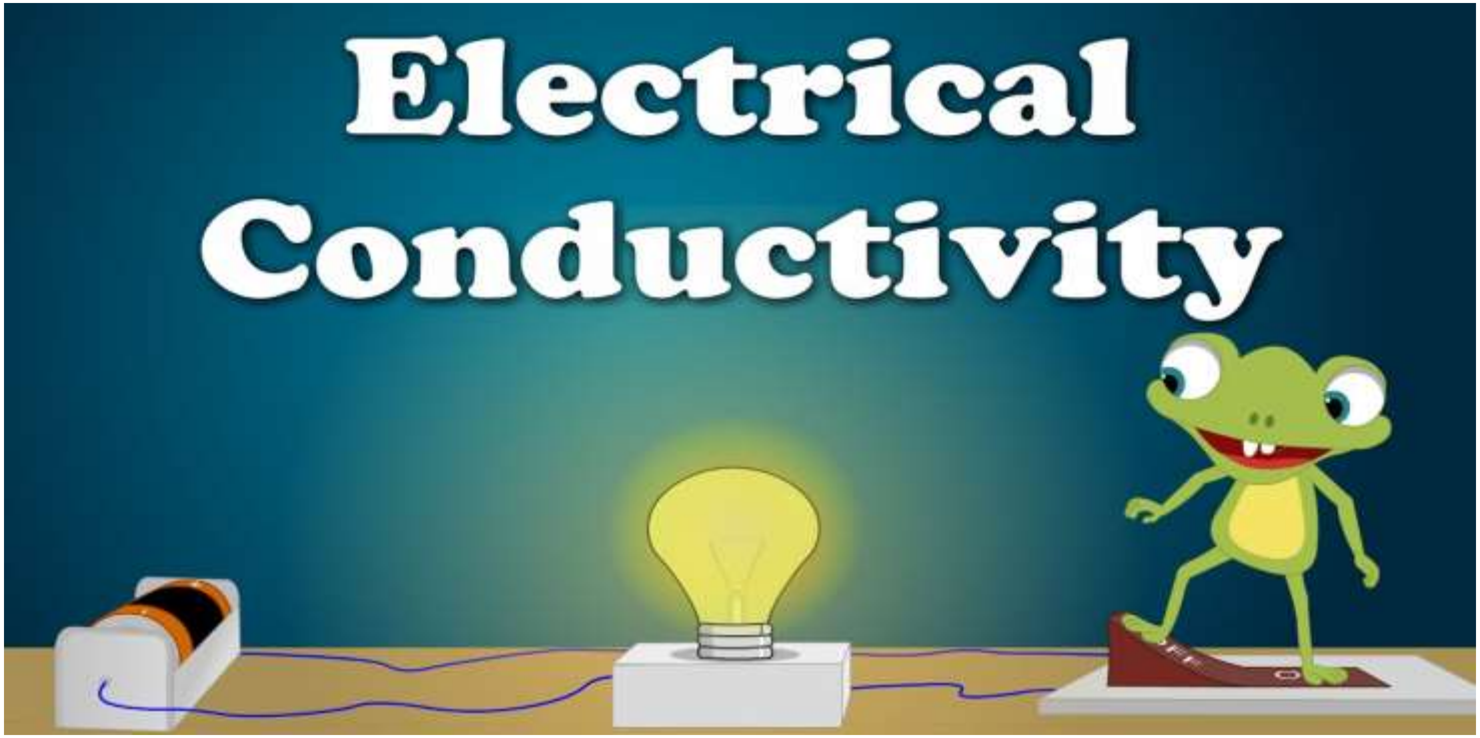
Topic Outcome

After completion of the topic students are;

- Able to formulate the electrical conductivity.

Today's Lecture

- Introduction
- Electrical conductivity
- Electrical conductivity formulae



- **Conductivity** is the phenomenon of transmitting something like heat, electricity or sound.
- **Electrical conductivity** is a result of the movement of electrically charged particles inside the material.

Electrical conductivity

- Most important properties of **metals** are high thermal and electrical conductivity.
- Electrical conductivity is that **property which measures** the ability of material to allow the electric current to flow
- **Silver** has highest electrical conductivity
- Ideal metal has higher conductivity
- Insulators has lower conductivity
- Metals having complex structure such as As, Sb, Bi, Sn , Hg have lower conductivity compare to ideal metals and large conductivity compare to insulators

Electrical conductivity formulae

- Atoms of metal elements are characterised by the presence of valence electrons. Electrons in the outer shell which are free to move . These free electrons are allow metals to conduct an electric field.

- Conductivity equation in the case of metals is given as

$$\boxed{\sigma = n\, q\, \mu_e}$$

σ = conductivity	$(\text{ohm-m})^{-1}$
n = carrier density	(# of carriers/m^3)
q = electric charge	1.6×10^{-19} (C)
μ_e = electron mobility	$(m^2/(V\text{-}s))$

Electrical conductivity formulae

- For some materials, current density is directly proportional to electric field

$$J = \sigma E$$

Where σ is constant of proportionality and is refers as the conductivity of conductor

- Conductance is inverse of resistance, similarly conductivity is inverse of resistivity.

$$\sigma = \frac{1}{\rho}$$

Where ρ depends upon length and area of conduction

- Units of Conductivity is $\Omega^{-1}\ m^{-1}$ or S (Siemens)

Daily Quiz

1. Conductivity is high

    (a) insulator (b) conductor

    (c) both (a) and (b) (d) semi-conductor

2. Conductivity of semi-conductor

    (a) More than insulator (b) Lower than Conductor

    (c) Between conductor and insulator (d) None of these

3. Define Mobility.

4. Define conductivity.

Semi-Conductor Physics and Information Storage

Lecture 2

Unit: 4

Engineering Physics
AAS0201A

B.Tech (2^{nd} Sem.)

Anurag Tyagi
Assistant Professor
Applied Sciences

Topic Objective

- To provide the knowledge of conductivity of conductors and semiconductors.

Topic Outcome

After completion of the topic students are;

- Able to define the conductivity in conductors and semiconductors.

Prerequisite and Recap

- Electrical conductivity is that **property which measures** the ability of material to allow the electric current to flow
- Units of Conductivity is $\Omega^{-1}\ m^{-1}$ or S (Siemens)

Today's Lecture

- Conductivity in conductors
- Conductivity in semiconductors
- Examples

Conductivity of Conductors and semiconductors

- **Conductors:** Mostly are metals (that allow current to flow)
  higher electrical conductivity
- **Insulators** : Non-metals (don't allow current to flow)
  lower electrical conductivity
- **Semiconductor** : Metalloids
  Electrical conductivity lies between above two

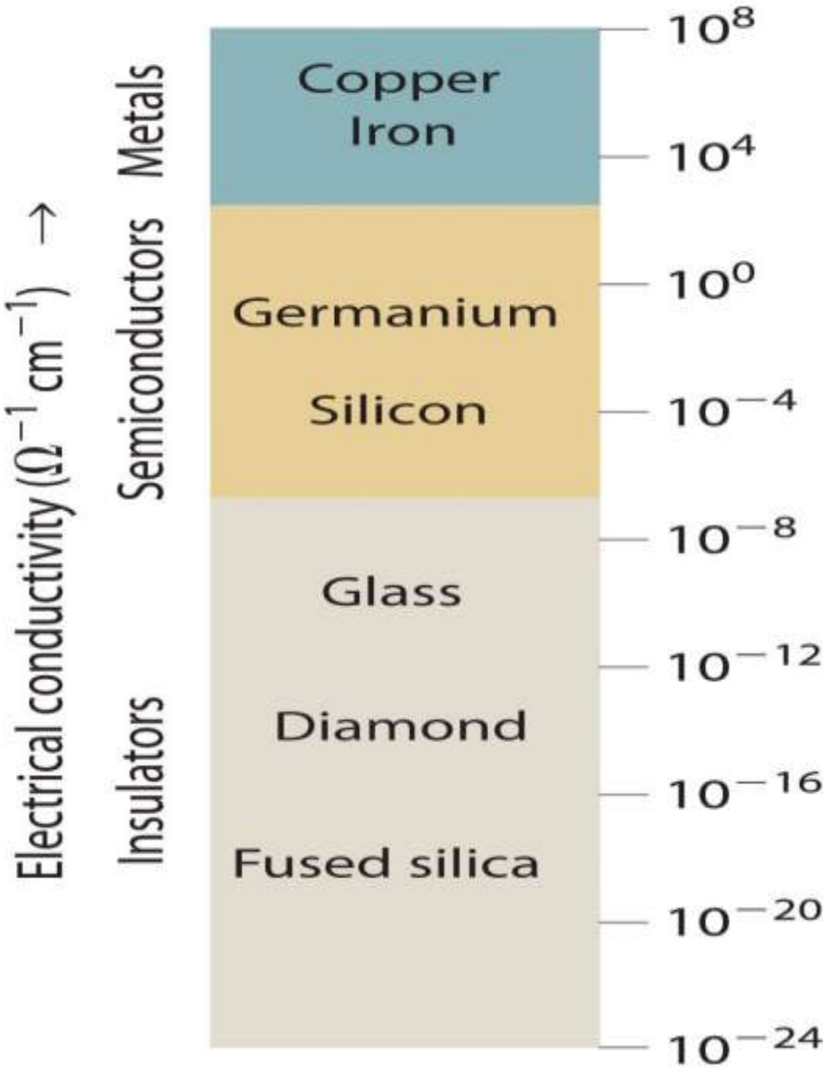
Metals: $\sigma > 10^5 \ (\Omega m)^{-1}$

Semiconductors: $10^{-6} < \sigma < 10^5 \ (\Omega m)^{-1}$

Insulators: $\sigma < 10^{-6} \ (\Omega m)^{-1}$

Few examples

Material	Resitivity, ρ(Ω-m)
Conductors	
Silver	1.59×10^{-8}
Copper	1.68×10^{-8}
Gold	2.44×10^{-8}
Aluminium	2.65×10^{-8}
Tungsten	5.6×10^{-8}
Iron	9.71×10^{-8}
Platinum	10.6×10^{-8}
Mercuy	98×10^{-8}
Nichrome(Ni,Fe,Cr alloy)	100×10^{-8}
Semiconductors	
Carbon(Graphite)	$(3\text{-}60)\times10^{-5}$
Germanium	$(1\text{-}500)\times10^{-3}$
Silicon	0.1 - 60
Insulators	
Glass	$10^{9}\text{-}10^{12}$
Hard rubber	$10^{13}\text{-}10^{15}$



Daily Quiz

1. *A pure semiconductor behaves like an insulator at 0^0 K because*

a) There is no recombination of electrons with holes

b) Drift velocity of free electrons is very small

c) Free electrons are not available for current conduction

d) Energy possessed by electrons at that low temperature is almost zero

2. Conductivity of metals are of the order of……
3. Conductivity of semi-conductor lies between…….
4. Write the conductivity of Silver and Gold.
5. write the conductivity of silicon and germanium.

Semi-Conductor Physics and Information Storage

Lecture 3

Unit: 4

Engineering Physics
AAS0201A

B.Tech (2nd Sem.)

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Topic Objective

- To provide the knowledge of band theory of solids .
- To provide the knowledge of classification of solids on the basis of band theory.

Topic Outcome

After completion of the topic students are;

- Able to define the band theory of solids.
- Able to classify the solids on the basis of band theory.

Prerequisite and Recap

- **Conductors-** higher electrical conductivity
- **Insulators-** lower electrical conductivity
- Electrical conductivity of **Semi-Conductor** lies between conductor and insulators

Today’s Lecture

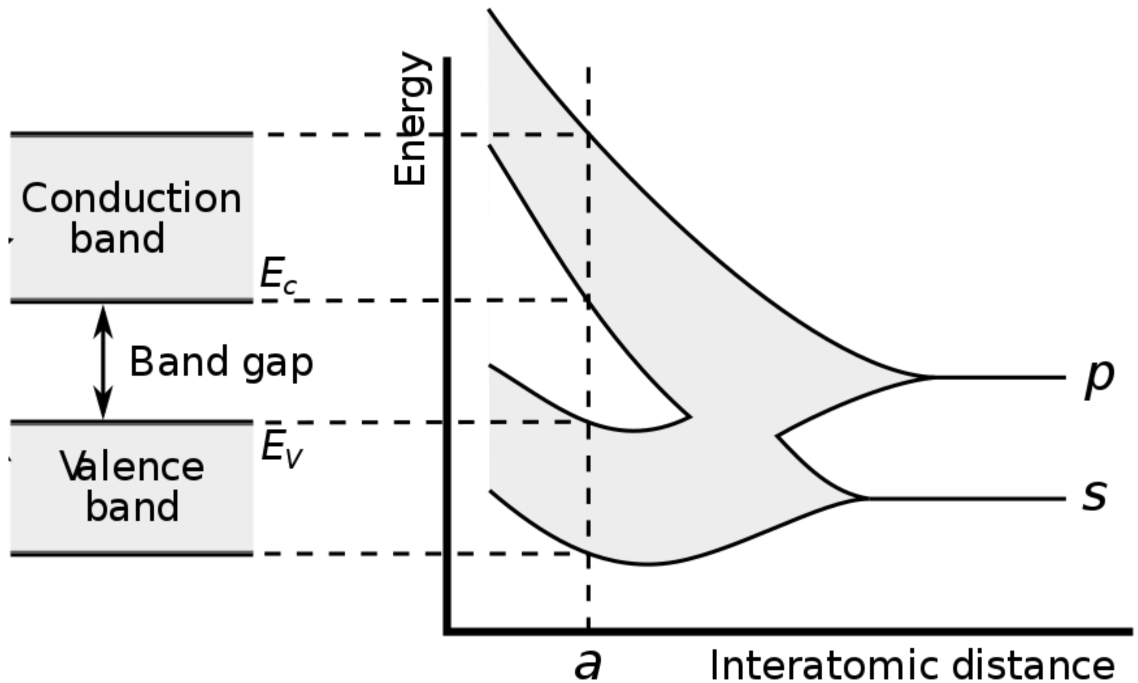
- Formation of band in solids
- Classification of solids on the basis of band theory
- Introduction of bands in extrinsic semiconductor on the basis of band theory

Band Theory

Calculations of allowed energy state in solid state refers as band theory. To obtain full band structure we need to solve Schrodinger equation for full lattice potential.

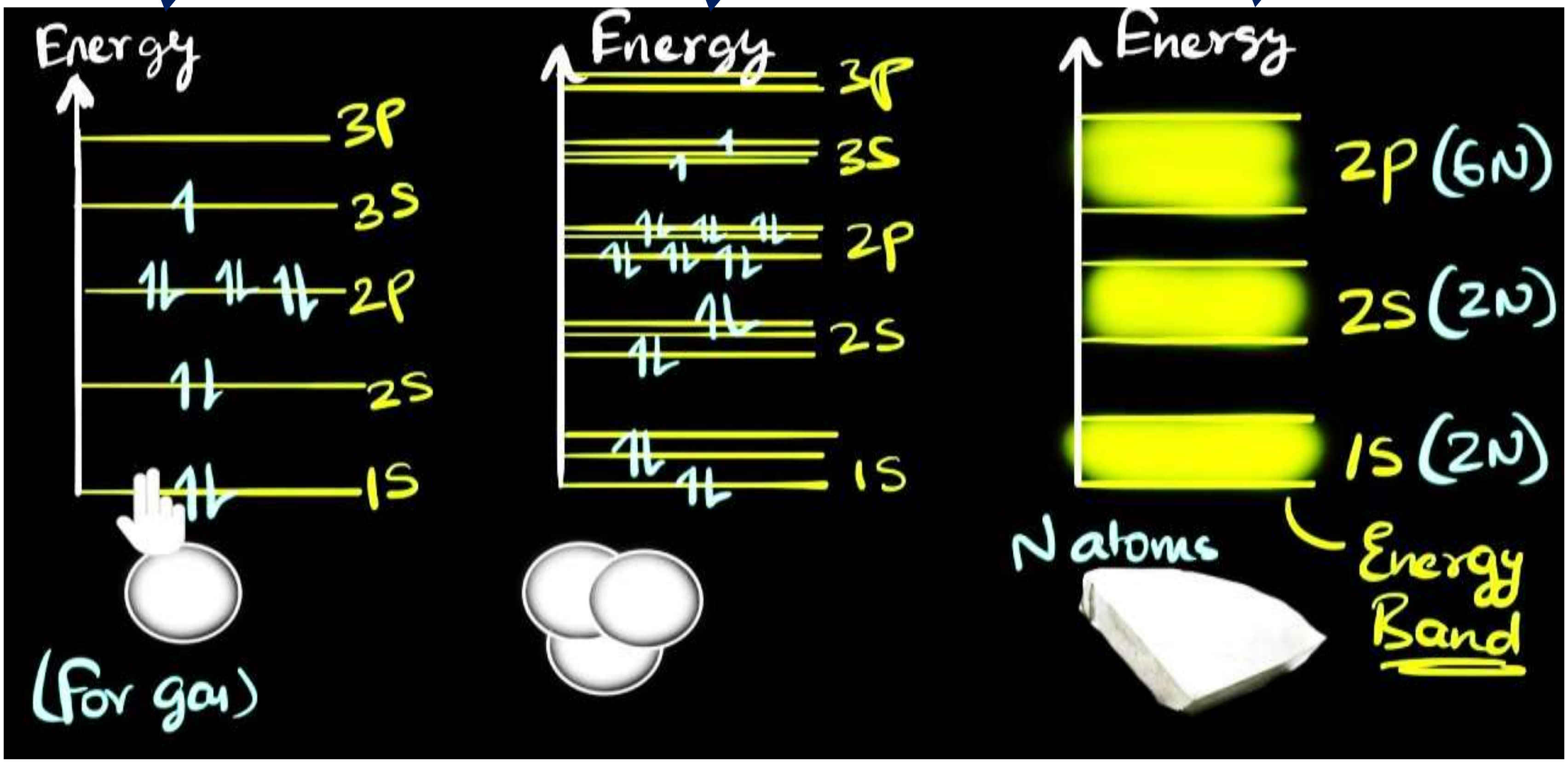
Two model can use to describe bands in Solids

- Nearly Free electrons model
- Tightly bindings model



Formation of band in solids

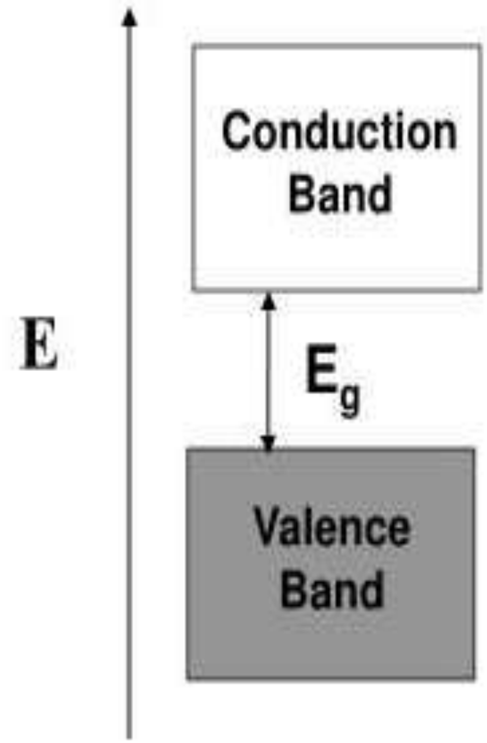
1 atom | Having 3 atoms | Crystal of having N atoms



Classification of solids on the basis of band theory

There are three bands in solids

- **Valence band:** Band of energy occupied by valence/outer electrons is known as valence band. It is either complete or partially filled.
- **Conduction band:** It is the permitted energy band which has higher energy. It may be unfilled or partially filled.
- **Forbidden energy gap/band:** In between these two bands, there is a gap that is refers as forbidden gap. Electrons cannot exist in this gap.

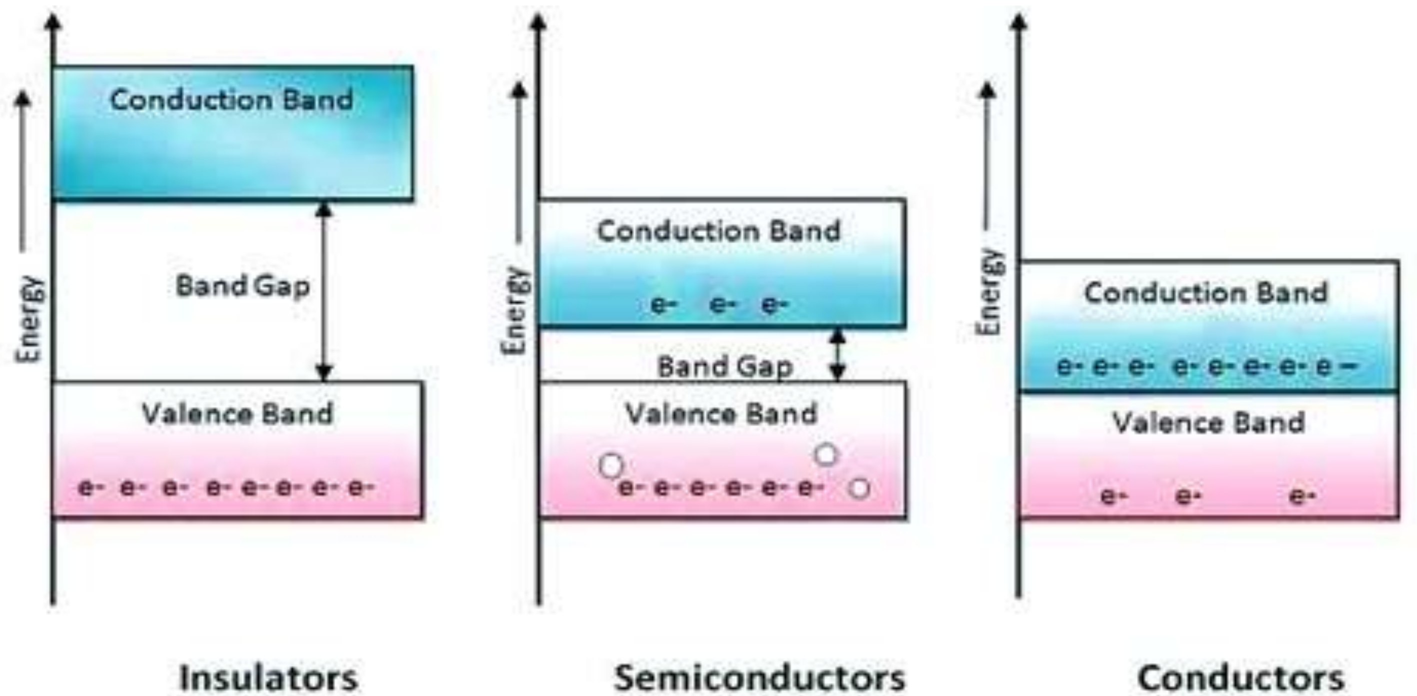


Classification of solids on the basis of band theory

Insulator – large band gap b/w valence and conduction band

Conductor – overlapping bands

Semiconductor- forbidden gap lies near about 1ev



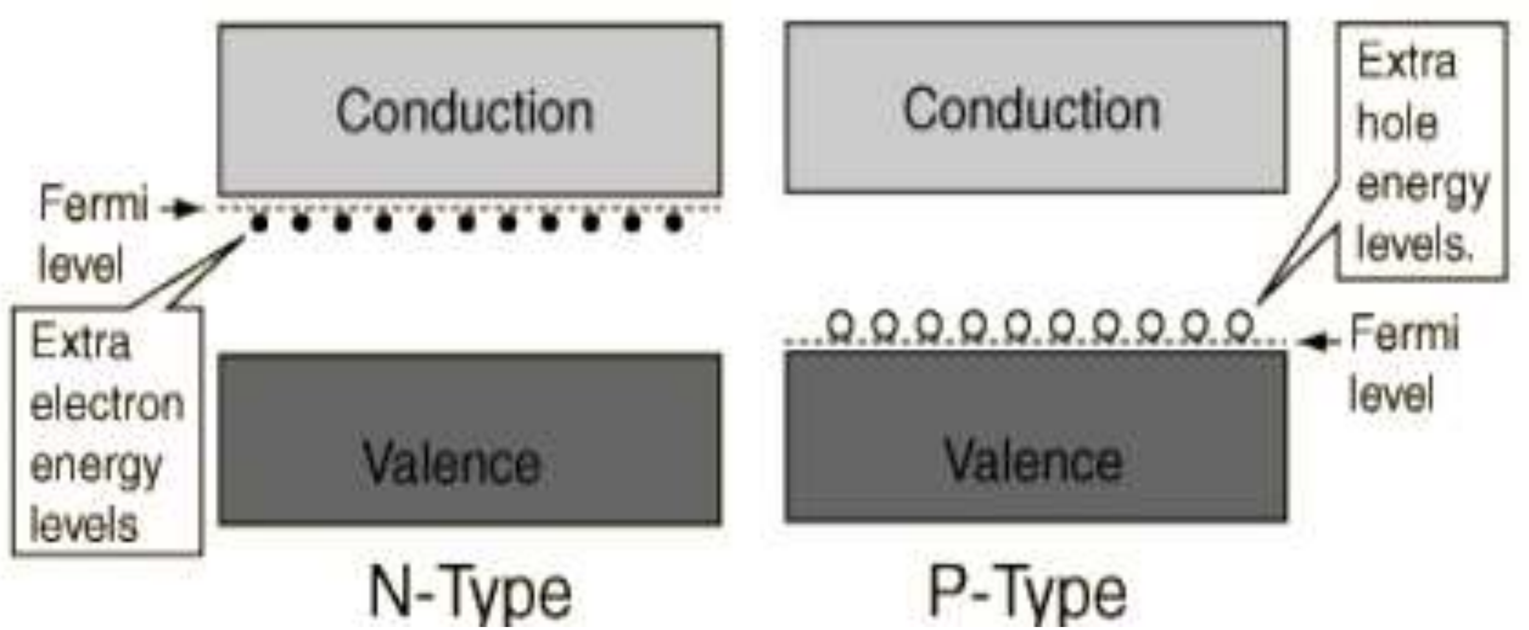
Types of Semi-Conductor

- **Intrinsic semiconductor**
  - Pure form of
  - Ge, Si
  - ($n_e = n_h = n_i$)
- **Extrinsic semiconductor**
  - **N - Type**
    - Pentavalent impurity
    - P, As, Sb etc.
    - Donar impurity - N_D
    - ($n_e >> n_h$)
  - **P - Type**
    - Trivalent impurity
    - Ga, B, In, Al
    - Donar impurity - N_D
    - ($n_h >> n_e$)

Band theory on Extrinsic semi-conductor

N-Type – For each impurity atoms one energy state (donar state) is introduced in the band gap just **below the conduction band**

P-Type – For each impurity atoms one energy state (acceptor state) is introduced in the band gap **just above the valence band**



Daily Quiz

1. Define valance band and conduction band.
2. What is forbidden gap.
3. *Valence band and conduction band overlap each other in*

   (a) Conductors (b) Insulators

   (c) Semiconductors (d) None of these

4. *Which of the following statements is not correct about n-type semiconductors?*

a) They are obtained by adding pentavalent impurity to intrinsic semiconductors

b) There is a large no. of free electrons

c) There are some holes as minority charge carriers

d) Doping gives negatively charged acceptors and negatively charged free electrons

Semi-Conductor Physics and Information Storage
Lecture 4

Unit: 4

Engineering Physics
AAS0201A

B.Tech (2nd Sem.)

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Topic Objective

- To provide the knowledge of Fermi-Dirac distribution function.
- To provide the knowledge of Fermi energy and Fermi level.

Topic Outcome

After completion of the topic students are;

- Able to calculate the probability of the state occupied by an electron.
- Able to define Fermi energy and Fermi level.

Prerequisite and Recap

- There are three bands in solids: valence, conduction and forbidden band gap
- Insulator – large band gap b/w valence and conduction band
- Conductor – overlapping bands
- Semiconductor- forbidden gap lies near about 1ev
- In N-Type semiconductor – Donar state is introduced in the band gap just below the conduction band
- P-Type semiconductor – Acceptor state is introduced in the band gap just above the valence band.

Today's Lecture

- Fermi –Dirac distribution function
- Fermi –Dirac distribution function graph at 0K
- Fermi-Energy
- Fermi level

Fermi-Dirac Distribution function

Fermi Function express Probability that the state of given energy E is occupied by electrons under the condition of thermal equilibrium (how many of existing state at energy E are filled with electrons)
Electrons in solids follow Fermi-Dirac statistics.

Fermi –Dirac probability distribution function is

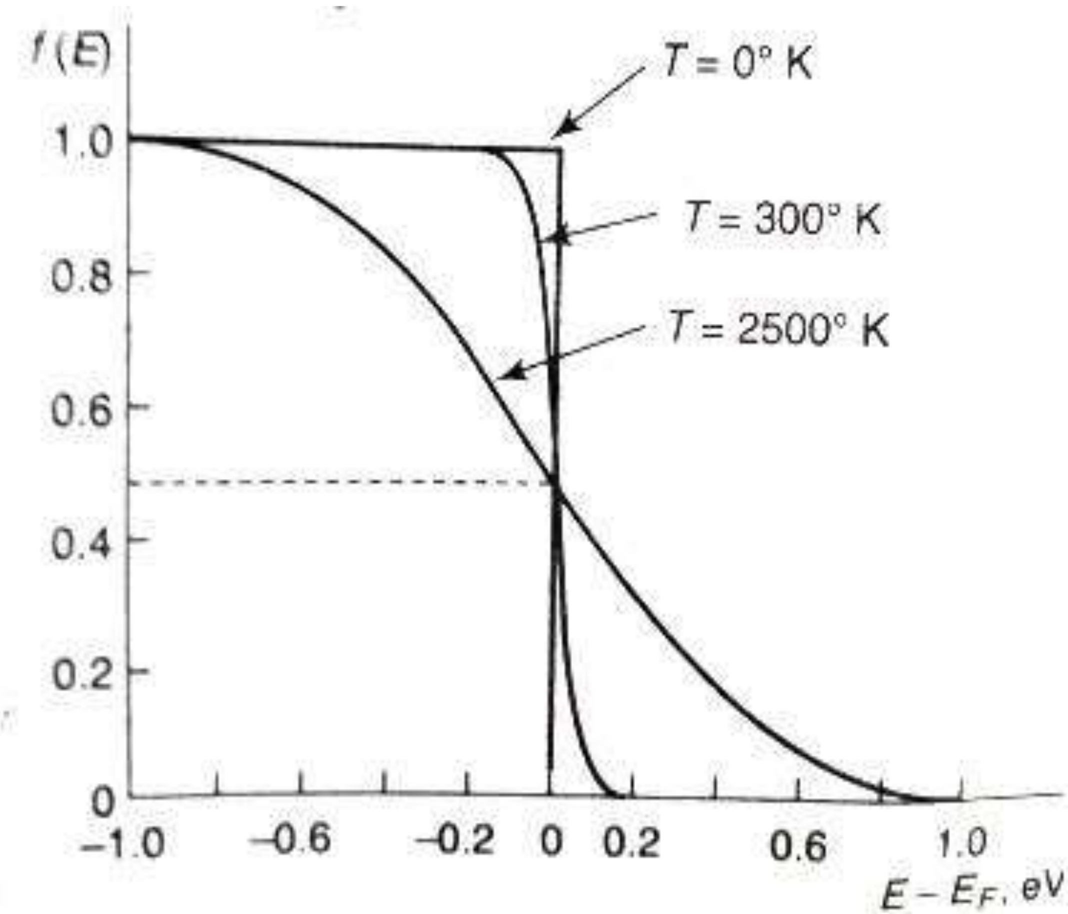
$$\mathbf{f(E)} = \frac{1}{1 + e^{\frac{(E - E_f)}{kT}}}$$

Where E_f =Fermi-Energy
k=Boltzmann's constant
T= temp.

Fermi-Dirac Distribution function at temp 0K

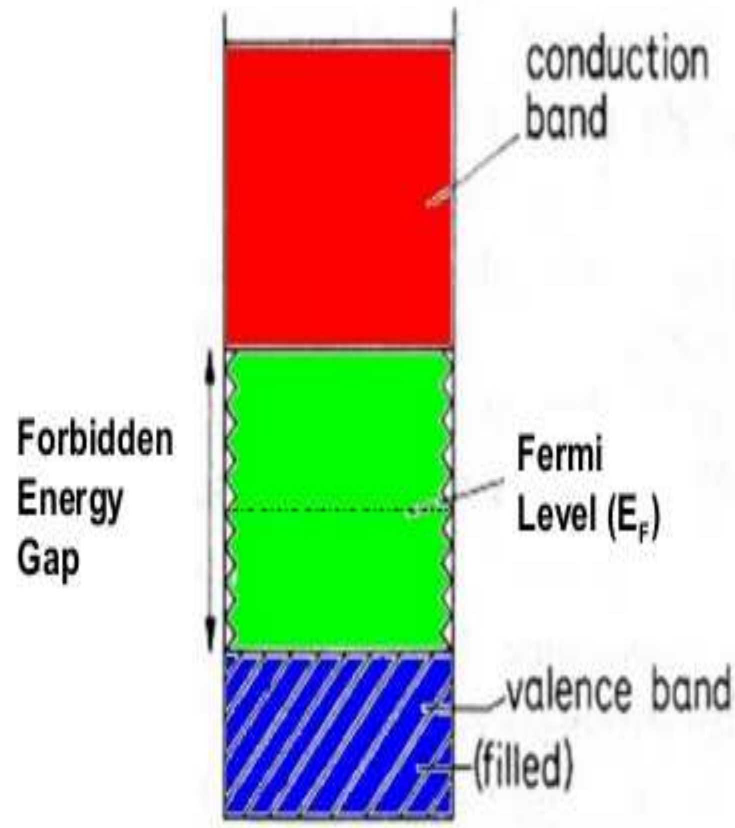
- When T=0K and E> E_f then F(E) =0
- When T=0K and E< E_f then F(E) =1
- When T=0K and E= E_f then F(E) = 1/2

Means 0< f(E) <1



Fermi Energy & Fermi Level

- Fermi level energy is the quantum mechanical concept.
- It is the energy level above which probability for finding electrons is zero at absolute 0K in the case of semiconductor.
- No electrons exist above fermi energy level at 0K



Daily Quiz

1. write Fermi drac distribution function.
2. Define Fermi energy.
3. What is Fermi level?
4. *Fermi level lies exactly in the centre of the forbidden energy gap E_g between the conduction band and valence band*

   (a) N – type semiconductor (b) P – type semiconductor

   (c) Intrinsic semiconductor (d) None of these

5. *The forbidden energy gap of carbon in diamond structure is*

   (a) 0.7 eV (b) 1.1 eV

   (c) 6 eV (d) None of these

Daily Quiz

6. *Fermi level lies slightly below the bottom conduction band in*
   (a) N – type semiconductor (b) P – type semiconductor
   (c) Intrinsic semiconductor (d) None of these
7. *Fermi level lies slightly above the top of valence band in*
   (a) N – type semiconductor (b) **P – type semiconductor**
   (c) Intrinsic semiconductor (d) None of these

Semi-Conductor Physics and Information Storage

Lecture 5

Unit: 4

Engineering Physics
AAS0201A

B.Tech (2nd Sem.)

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Topic Objective

- To provide the knowledge of Fermi level in intrinsic semiconductors.

Topic Outcome

After completion of the topic students are;

- Able to examine the position of Fermi level in intrinsic semiconductors.

Prerequisite and Recap

- Fermi –Dirac probability distribution function is

$$f(E) = \frac{1}{1 + e^{\frac{(E - E_f)}{kT}}}$$

- Fermi-Energy level above which probability for finding electrons is zero at absolute 0K

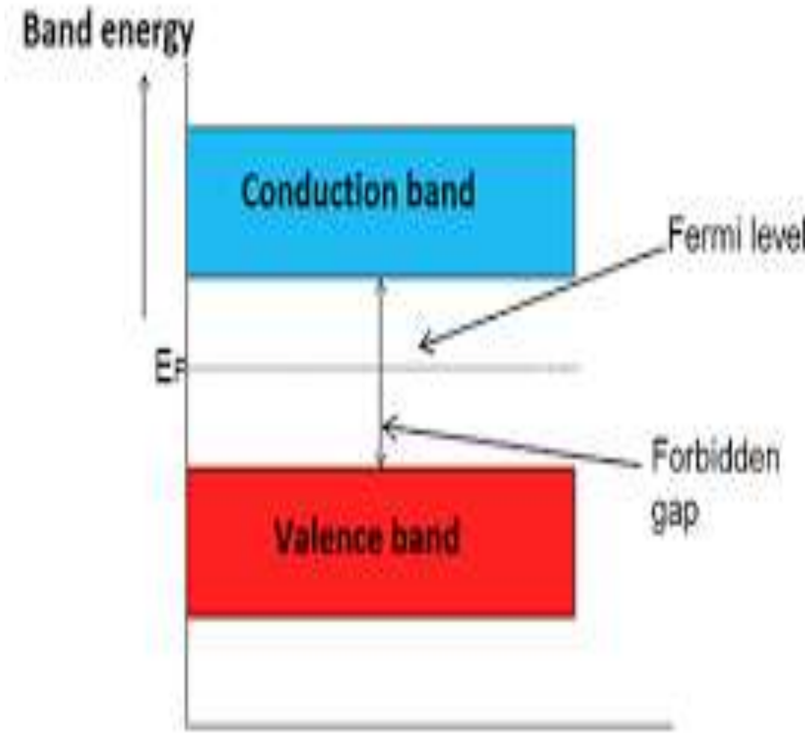
Today's Lecture

- Position of Fermi-level in Intrinsic Semiconductor

Position of Fermi-level in Intrinsic Semiconductor

- No. of electron and holes are equal in the case of intrinsic semi-conductor. Thus fermi level lies exactly between conduction and valence band.

- At absolute 0K, all energy state above fermi level are empty and below of it are occupied

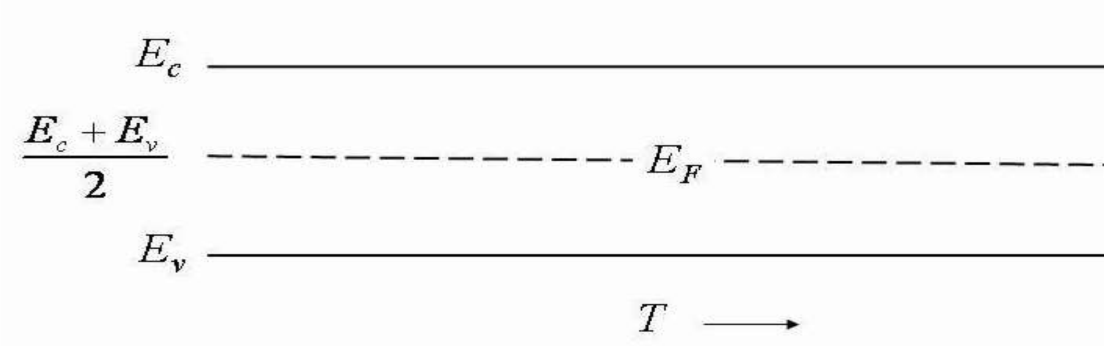


Fermi-level in Intrinsic Semiconductor

Fermi level E_f is given as

$$E_f = \frac{E_c + E_v}{2} + \frac{kt}{2} \log \frac{N_v}{N_c}$$

Where $\mathbf{E_c}$ = Energy level of conduction band , $\mathbf{E_v}$ = Energy level of valence band
N_v = No. of electrons in valence band ,N_c = no. electrons in conduction band
T= Temp. in K



Semi-Conductor Physics and Information Storage

Lecture 6

Unit: 4

Engineering Physics

AAS0201A

B.Tech (2nd Sem.)

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Topic Objective

- To provide the knowledge of Fermi level in extrinsic semiconductors.

Topic Outcome

After completion of the topic students are;

- Able to examine the position of Fermi level in extrinsic semiconductors.

Prerequisite and Recap

- Fermi level in case of intrinsic semiconductor lies exactly between conduction and valence band.

Today's Lecture

- Position of Fermi-level in N-type Semiconductor
- Position of Fermi-level in P-type Semiconductor

Position of Fermi-level in N-Type Semiconductor

No. of electron are large in the conduction band because of donar impurities.

Due to this fermi level lies close to the conduction band in the case of N-Type Semiconductor

For N-type Semiconductor, Fermi level E_f is given as

$$\mathbf{E_f = E_c - kT \log \frac{n_c}{N_D}}$$

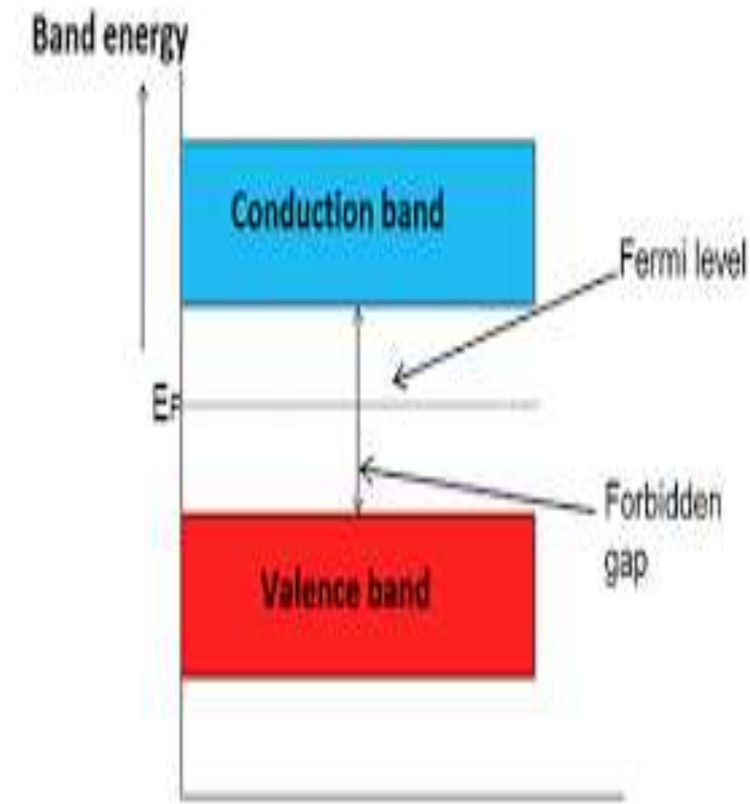
Where,

$\mathbf{E_c}$ = Energy level of conduction band

N_D = Concentration of donar impurity

N_c = no. electrons in conduction band

T= Temp. in K



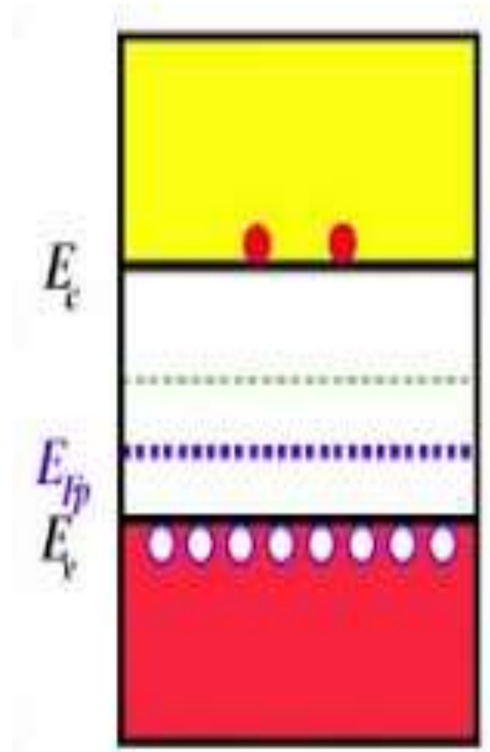
Position of Fermi-level in P-Type Semiconductor

No. of holes are large in the valence band because of accepter impurities.

Due to this fermi level lies close to the valence band in the case of P-Type Semiconductor

For P-type Semiconductor, Fermi level E_f is given as

$$E_f = E_c + kT \log \frac{n_v}{N_A}$$



Where,

E_c = Energy level of conduction band

N_A = Concentration of acceptor impurity

n_v = no. holes in valence band

T= Temp. in K

Weekly Assignment

Q.1) What do you mean by Fermi level and derive Fermi level in intrinsic semiconductor?

Q.2) Explain the variation of Fermi level with temperature in extrinsic semiconductor.

Q.3) Show that at 0K fermi level lies exactly mid of the valence and conduction band

Semi-Conductor Physics and Information Storage

Lecture 7

Unit: 4

Engineering Physics
AAS0201A

B.Tech (2nd Sem.)

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Topic Objective

- To provide the knowledge of Fermi level with temperature.

Topic Outcome

After completion of the topic students are;

- Able to explain the position of Fermi level with temperature.

Prerequisite and Recap

- Fermi level lies close to the conduction band in the case of N-Type Semiconductors
- Fermi level lies close to the valence band in the case of P-Type Semiconductors

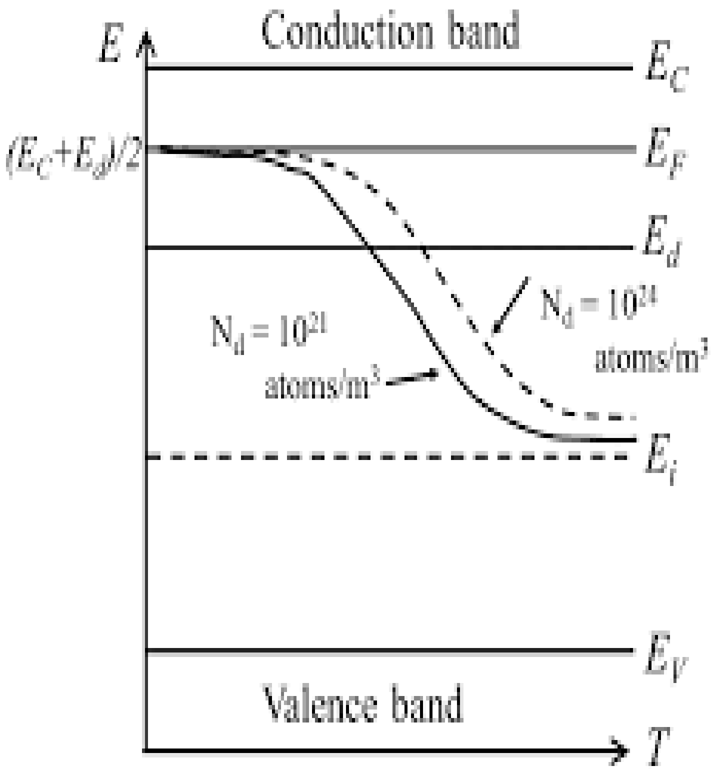
Today's Lecture

- Variation of Fermi level with temperature

Position of Fermi level in N-Type Semiconductor

Position of Fermi level in P-Type Semiconductor

Position of Fermi-level in N-Type semi-conductor with temperature

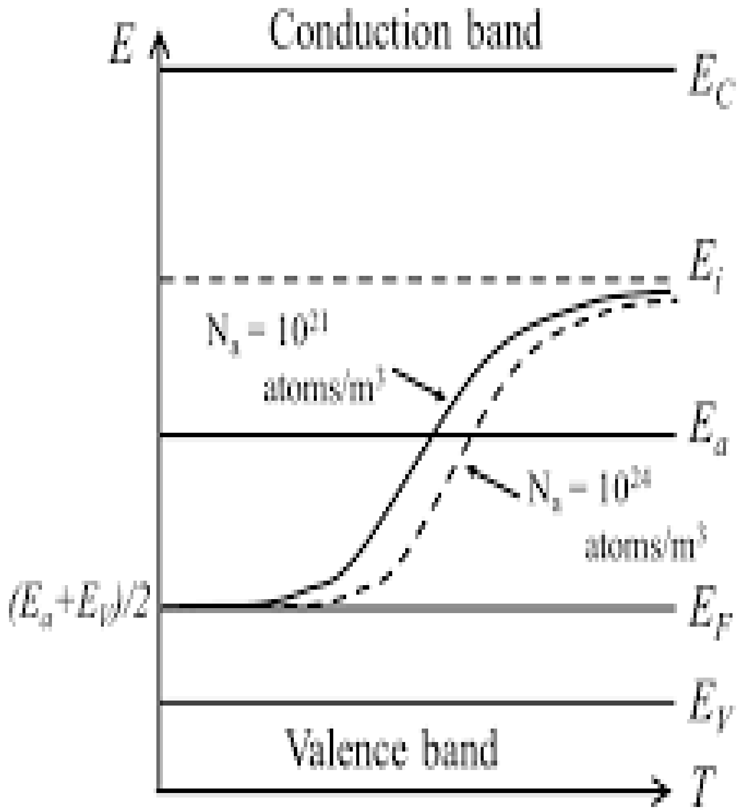


Increase in temp. generate electron hole pair due to the breaking of covalent bond. Thus material tends to behave more like intrinsic semi-conductor.

E_f tends to **move downwards** as no. of holes increases with increase in temp.

E_f is the fermi level of intrinsic semiconductor

Position of Fermi-level in P-Type semi-conductor with temperature



Increase in temp. generate electron hole pair due to the breaking of covalent bond. Thus material tends to behave more like intrinsic semi-conductor.

E_f tends to **move upwards** as no. of electrons increases with increase in temp.

E_f is the fermi level of intrinsic semiconductor

Daily Quiz

1. Energy band is high

   (a) insulator (b) conductor

   (c) both (a) and (b) (d) semi-conductor

2. Fermi level in case of intrinsic semi-conductor lies

   (a) above of donar level (b) none of these

   (c) below of donar level (d) exact mid of valence and conduction band

3. Fermi level in case of P-type semiconductor lies

   (a) above of donar level (b) above of Acceptor level

   (c) below of donar level (d) below of Acceptor level

Daily Quiz

4. Fermi level in case of P-type semiconductor lies

(a) above of donar level (b) above of Acceptor level

(c) below of donar level (d) below of Acceptor level

Weekly Assignment

Q.1) Comment on variation of E_f with doping concentration and temperature.

Q.2) Distinguish between N-type and P-Type semiconductor

Semi-Conductor Physics and Information Storage

Lecture 8

Unit: 4

Engineering Physics
AAS0201A

B.Tech (2nd Sem.)

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Applied Sciences

Topic Objective

- To provide the knowledge of photovoltaic effect.
- To provide the knowledge of solar cell.

Topic Outcome

After completion of the topic students are;

- Able to explain the photovoltaic effect.
- Able to explain the principle and construction of solar cell

Prerequisite and Recap

- With temperature, Extrinsic semi-Conductor tends to behave more like intrinsic semi-conductor
- E_f tends to **move upwards in case of P-Type Semi-conductor**
- E_f tends to **move downwards in case of N-Type Semi-conductor**

Today's Lecture

- Photo-voltaic effect
- Solar cell
- Construction of solar cell

Photo-voltaic effect

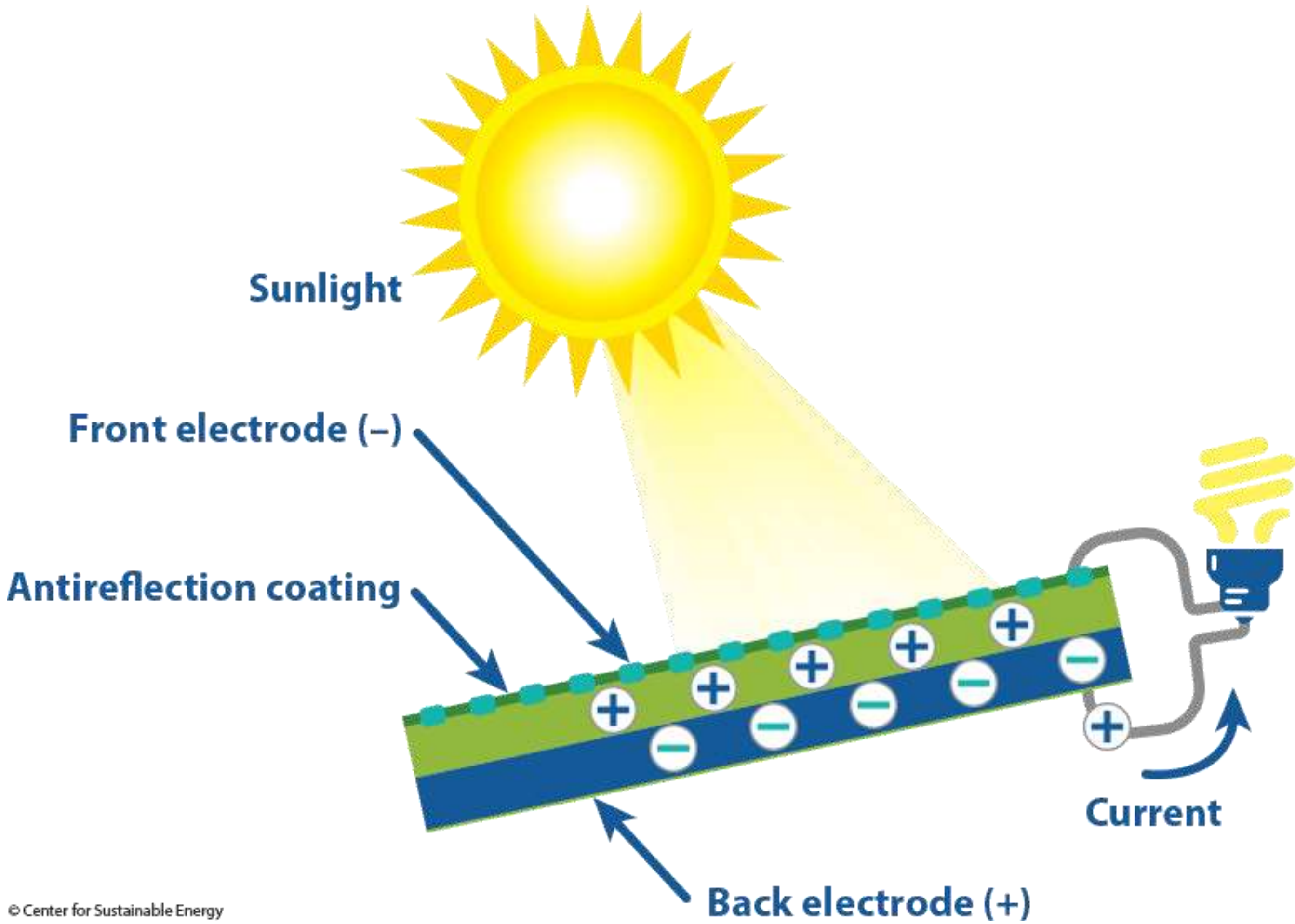
- Photo-voltaic effect was first discovered in 1839 by Edmond Becquerel.

- Creation of a voltage in a material upon exposure to EM radiation is known as **photo-voltaic effect**

- Certain semiconductor materials absorb certain wavelength.

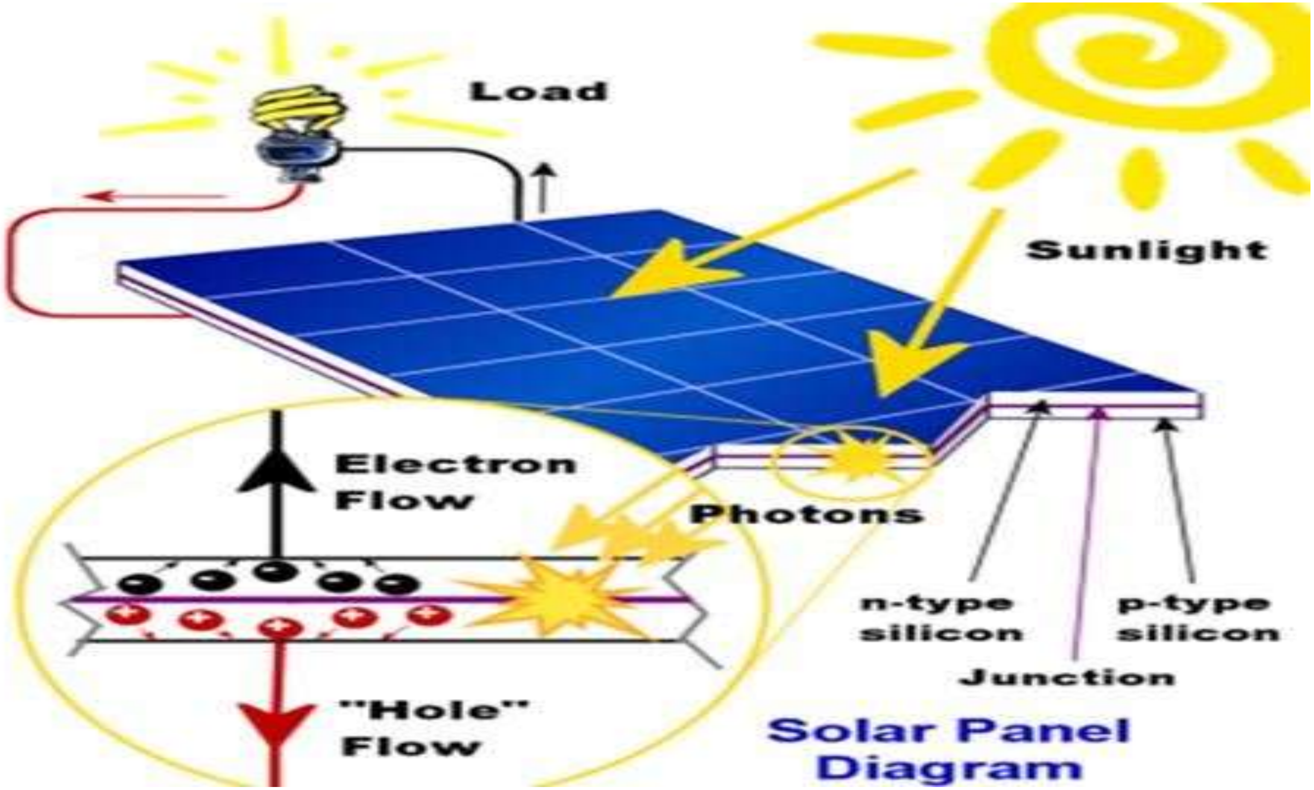
  E.g: crystalline silicon

Photo-voltatic effect

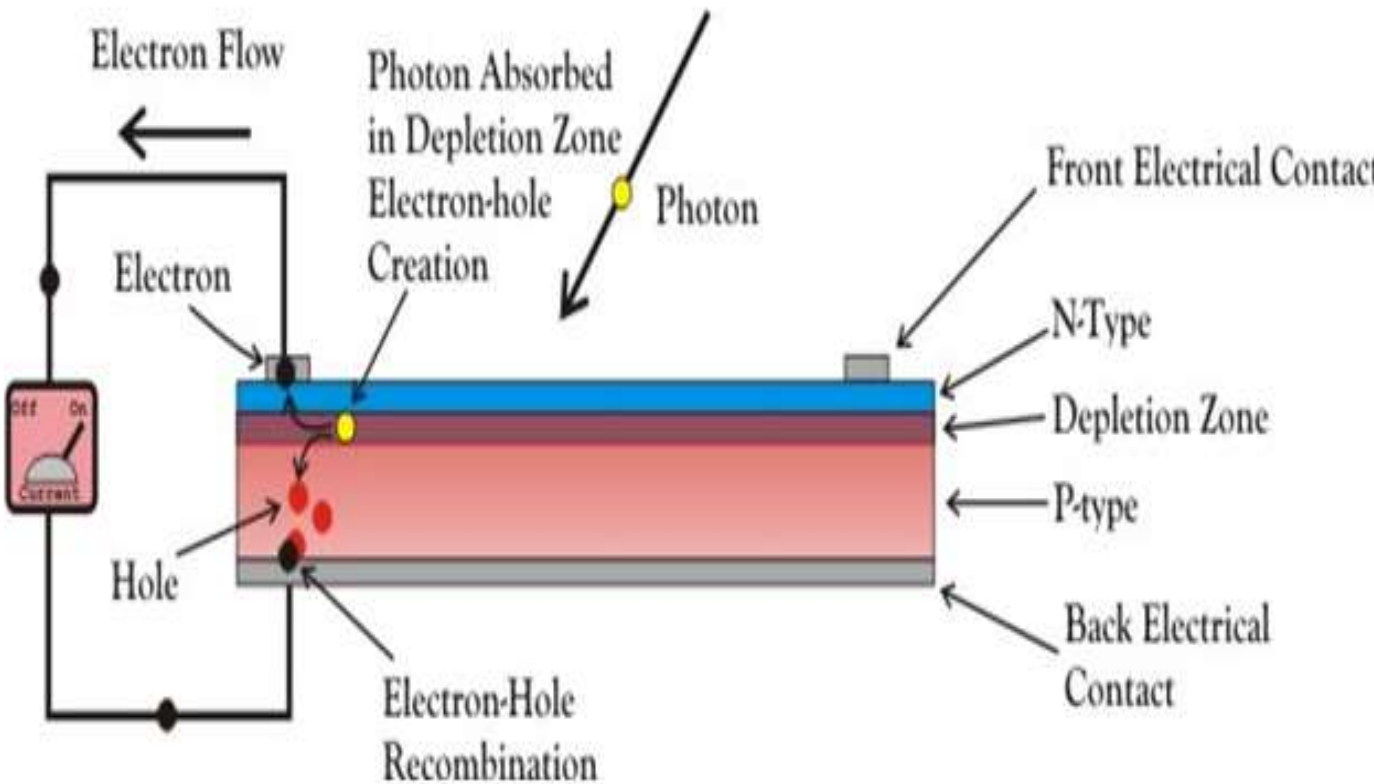


Solar Cell

- A solar cell (also known as a photovoltaic cell) is defined as an electrical device that converts light energy into electrical energy through the photovoltaic effect.



Construction of Solar Cell



Semi-Conductor Physics and Information Storage

Lecture 9

Unit: 4

Engineering Physics
AAS0201A

B.Tech (2^{nd} Sem.)

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Topic Objective

- To provide the knowledge of working and applicatons of solar cell.
- To provide the knowledge of advantages and disadvantages of solar cell

Topic Outcome

After completion of the topic students are;

- Able to define the working and applications of solar cell.
- Able to distinguish between advantages and disadvantages of solar cell

Prerequisite and Recap

- Creation of a voltage in a material upon exposure to EM radiation is known as **photo-voltaic effect**
- A solar cell is an electrical device that converts light energy into electrical energy through the photovoltaic effect

Today's Lecture

- Working of Solar Cell
- Applications of Solar cell
- Advantages and disadvantages of Solar cell

Working of Solar Cell

- When light falls on the p-n junction, it can easily enter in the junction to create a number of electron-hole pairs. The free electrons in the depletion region can quickly come to the n-type side of the junction. Similarly, the holes in the depletion can quickly come to the p-type side of the junction.
- Once, the newly created free electrons come to the n-type side, it cannot further cross the junction because of barrier potential of the junction. Similarly holes which come to p-type side can't cross the junction.
- As the concentration of electrons becomes higher in one side, i.e. n-type side of the junction and concentration of holes becomes more in another side, i.e. the p-type side of the junction, the p-n junction will behave like a small battery cell.
- A voltage is set up which is known as photo voltage. If we connect a small load across the junction, there will be a tiny current flowing through it.

Advantage and disadvantages of Solar Cell

Advantages:

- No pollution associated with it.
- It must last for a long time.
- No maintenance cost.

Disadvantages:

- It has high cost of installation.
- It has low efficiency.
- During cloudy day, the energy cannot be produced and also at night we will not get solar energy.

Applications of Solar Cell

Daily Quiz

1. Solar cell function is based upon

   (a) photoelectric effect (b) None of these

   (c) Photovoltaic effect (d) photosynthesis effect

2. RAM stands for

   (a) Random access memory (b) None of these

   (c) Read access memory (d) Read only memory

3. Semiconductor memory are

   (a) RAM (b) ROM

   (c) both (a) and (b) (d) None of these

Weekly Assignment

Q.1) Explain photovoltaic effect

Q.2) Explain the construction and working of Solar cell.

Semi-Conductor Physics and Information Storage

Lecture 10

Unit: 4

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Engineering Physics
AAS0201A

B.Tech (2nd Sem.)

Topic Objective

- To provide the basic knowledge of different types memories.

Topic Outcome

After completion of the topic students are;

- Able to define the basics of semiconductor memories and magnetic memories.

Prerequisite and Recap

- Working of Solar Cell
- Applications of Solar cell
- Advantages of Solar cell

Today's Lecture

- Memory
- Semi-conductor Memory
- Magnetic Memories

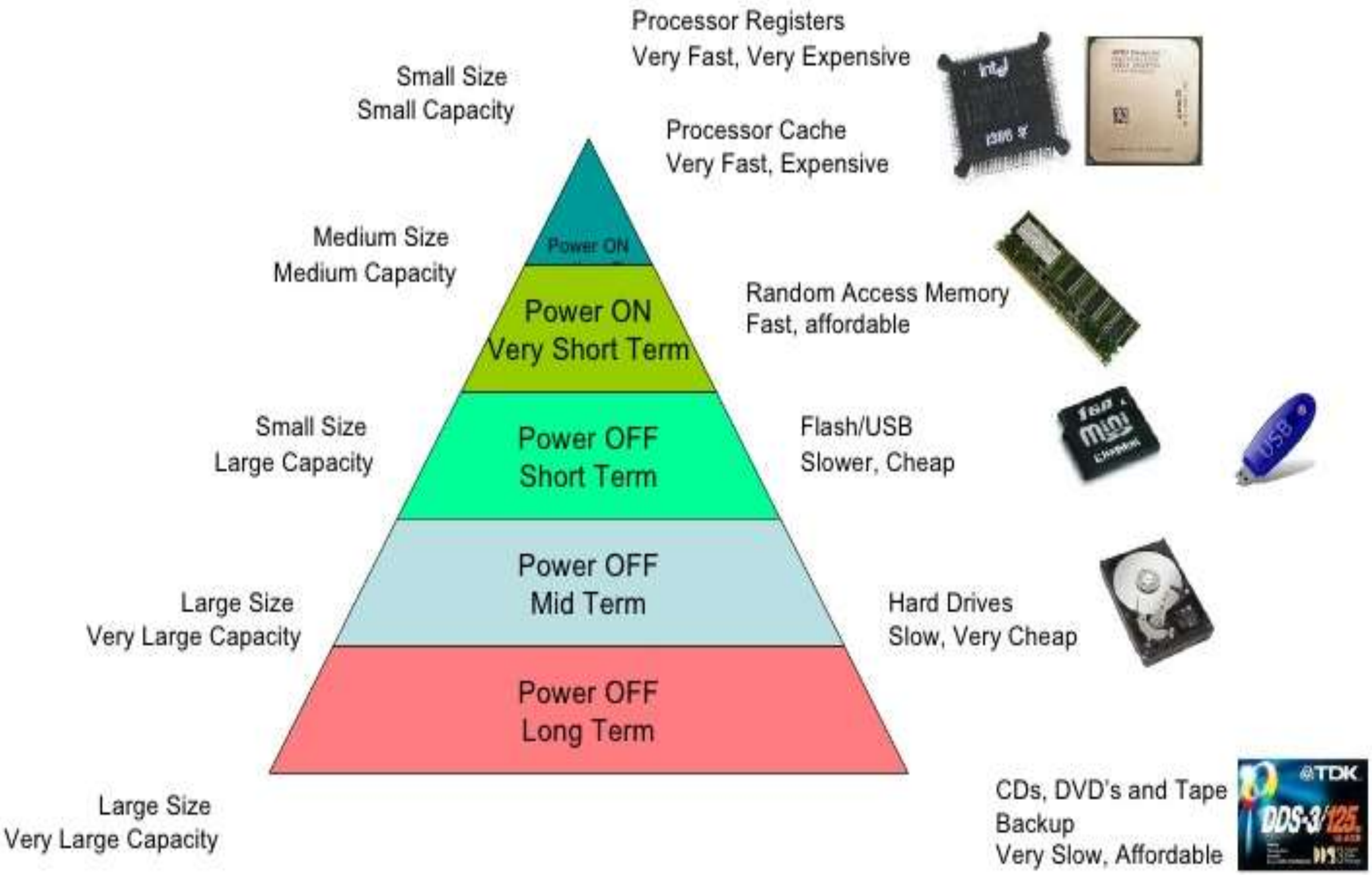
Memories

Memory is the device that is used to store data on a temporary or permanent basis for use in a electronic digital computer.

3 different categories of computer memory

- **Main memory (Primary memory) :** That stores small amount of data and information that will be immediately used by the CPU
- **Secondary memory (Back up):** That stores much large amount of data and information (an entire software program) for external periods of time
- **Internal Processor memory:** That stores temporary storage of instruction and data.

Computer Memory hierarchy



Types of Main Memory

- **Semiconductor Memory :**

Semiconductor memories uses semiconductor-based integrated circuits to store information. Both volatile and non-volatile forms of semiconductor memory exist.

RAM and ROM are Semiconductor memory

- **Magnetic Memory:**

Magnetic memory uses different patterns of magnetization on a magnetically coated surface to store information. Magnetic storage is non-volatile.

Magnetic tape and floppy are magnetic memory

Daily Quiz

1. *The temporary memory of computer is*
   (a) ROM (b) secondary memory
   (c) primary memory (d) RAM
2. *Cassettes are based on*
   (a) Electricity (b) Magnetism
   (c) Electromagnetism (d) Semiconductors
3. *The smallest Unit in digit system is*
   (a) Bit (b) Byte
   (c) Kilobyte (d) Megabyte
4. *Permanent memory is*
   (a) ROM (b) RAM
   (c) Program Tape (d) Plain Disc

You-tube Video Links

1. https://www.youtube.com/watch?v=64nr4hDtVTg
2. https://www.youtube.com/watch?v=0u3MTNeOtg0
3. https://www.youtube.com/watch?v=1DHCV3LgITY&t=408s
4. https://www.youtube.com/watch?v=kCN-7wA8HUE
5. https://www.youtube.com/watch?v=lc8R-wqEnk0
6. https://www.youtube.com/watch?v=Afwx9bxvT3s
7. https://www.youtube.com/watch?v=zh5HS1sUYhw
8. https://www.youtube.com/watch?v=7m17eYAtNZo
9. https://www.youtube.com/watch?v=sXcsKzJylrA
10. https://www.youtube.com/watch?v=V0yzDRDU_BU

NPTEL video Links

1. https://nptel.ac.in/courses/108108122/
2. https://nptel.ac.in/courses/115104109/

Daily Quiz

Q.1 Give the Band theory of soilds.

Q.2 Define Fermi-Dirac distribution function.

Q.3 Define Fermi energy level.

Q.4 Define conductivity of a semiconductor.

Weekly Assignment

***Short answer type:*.**

Q-1) What do you mean by conductivity ?

Q.2) What is Energy band gap in semiconductor?

***Long answer type:*.**

Q-1) Explain the variation of Fermi level with temperature in extrinsic semiconductor.

Q.2) Show that at 0K fermi level lies exactly mid of the valence and conduction band

Q.3) Distinguish between N-type and P-Type semiconductor

Q.4) Explain photovoltaic effect

Q.5) Explain the construction and working of Solar cell.

Previous Year Questions paper

Printed Pages : 4

AS-202(C)

(Following Paper ID and Roll No. to be filled in your Answer Book)

PAPER ID : 199240

Roll No.

B. Tech.

(SEM. II) THEORY EXAMINATION, 2014-15

ENGINEERING PHYSICS-II (C)

(FOR CS/IT etc.)

Time : 3 Hours] [Total Marks : 80

Note: Attempt questions from each Section as per instructions.

SECTION - A

1 Attempt all parts of this question. Each part carries 2 marks. 2×8=16

(a) What do you mean by phase velocity and group velocity?

(b) Explain Heisenberg's uncertainty principle?

(c) Distinguish between Type-I and Type-II superconductors.

(d) What are buckyballs?

(e) What are the properties of diamagnetic materials?

199240] 1 [Contd...

Previous Year Questions paper

SECTION - B

2 Attempt any three parts of this question. $8\times3=24$
Each part carries 8 marks.

(a) Find the de-Broglie wavelength of a neutron of energy 12.8MeV. Mass of neutron is 1.675×10^{-27}kg.

(b) An electron has a speed of 1.05×10^{4}m/s within the accuracy of 0.01%. Calculate uncertainty in the position of the electron.

(c) The critical field for niobium is 1×10^{5} A/m at 8K and 2×10^{5} A/m at 0K. Calculate the transition temperature of the element.

(d) An iron rod of volume 10^{-3} m^{3} and relative permeability 1200 is placed inside a long solenoid wound with 5 turns per cm. If a current of 0.5 amp is passed through the solenoid, find the magnetic moment of the rod.

(e) At what temperature can we expect a 10% probability that electrons in a metal will have an energy which is 1% above E_F . The Fermi energy of the metal is 5.5 eV.

199240] 2 [Contd...

Previous Year Questions paper

SECTION - C

Attempt any one part of all the questions of this section. Each question carries 8 marks. $8 \times 5 = 40$

3 (a) What are matter waves? Describe Davisson and Germer experiment for the study of electron diffraction and prove that electrons possess wave nature.

(b) Find an expression for the energy states of a particle in a one –dimensional box. Also calculate the normalized wave function.

4 (a) How are Cooper pairs formed? Explain the BCS theory of superconductor.

(b) What are carbon nanotubes? Describe a method for synthesis of carbon nanotubes.

5 (a) What do you mean by polarization in dielectrics? Explain different types of polarization and their mechanism.

(b) What is meant by Hysteresis? Explain hysteresis loss. Prove that the area of the B-H curve is equal to the hysteresis loss per unit volume of the specimen in one cycle.

199240] 3 [Contd...

Previous Year Questions paper

6 (a) What is a solar cell? Describe its working with suitable diagram.

(b) What do you mean by Fermi level? Show that the Fermi level of an intrinsic semiconductor lies half way between conduction and valance bands.

7 (a) What is a spatial light modulator? Explain the working of liquid spatial light modulator.

(b) What do you understand by memories in computer? Describe various types of memories in detail.

Physical Constants:

Mass of electron	$m_e = 9.1\times10^{-31}$ kg
Speed of Light	$c = 3\times10^{8}$ m/s
Plank's constant	$h = 6.63\times10^{-34}$ J-s
Mass of Proton	$m_p = 1.67\times10^{-27}$ kg
Permeability of free space	$\mu_0 = 4\pi\times10^{-7}$ H/m
Permittivity of free space	$\varepsilon_0 = 8.854\times10^{-12}$ F/m
Avogadro's number	$N = 6.023\times10^{23}$ per mole

199240] 4 [ ]

Previous Year Questions paper

Printed page:03 Subject Code: AAS0101A

Roll No:

NOIDA INSTITUTE OF ENGINEERING AND TECHNOLOGY, GREATER NOIDA

(An Autonomous Institute Affiliated to AKTU, Lucknow)

BACHELOR OF TECHNOLOGY (B.Tech)

(SEM: First Theory Examination (2020-2021)

SUBJECT NAME: ENGINEERING PHYSICS

Time: 3 Hours Max. Marks:100

General Instructions:

- All questions are compulsory. Answers should be brief and to the point.
- This Question paper consists of 03 pages & 8 questions.
- It comprises of three Sections, A, B, and C. You are to attempt all the sections.
- Section A -Question No- 1 is very short answer type questions carrying 1 mark each, Question No- 2 is short answer type carrying 2 mark each. You are expected to answer them as directed.
- Section B - Question No-3 is Long answer type -I question with external choice carrying 6 marks each. You need to attempt any five out of seven questions given.
- Section C - Question No. 4-8 are Long answer type -II (within unit choice) questions carrying 10 marks each. You need to attempt any one-part a or b.
- Students are instructed to cross the blank sheets before handing over the answer sheet to the invigilator.
- No sheet should be left blank. Any written material after a blank sheet will not be evaluated/checked.

SECTION – A

1.	Answer all the parts-	[10×1=10]	CO
a.	What is massless particle?	(1)	CO1
b.	Write Lorentz transformation equations of space and time.	(1)	CO1
c.	What is Higgs Boson?	(1)	CO2
d.	Write any one application of uncertainty principle.	(1)	CO2
e.	What do you understand by coherent sources?	(1)	CO3
f.	Name any two optical filters.	(1)	CO3
g.	Define skin depth. OR Define Photovoltaic effect.	(1)	CO4
h.	Write Maxwell's equation of Ampere's law. OR Define Fermi Dirac distribution function.	(1)	CO4
i.	Name any two dielectric materials. OR Write different types of magnetic and semiconductor memories.	(1)	CO5
j.	Define Ferro-electricity. OR Define dispersion in optical fibres.	(1)	CO5

Previous Year Questions paper

Subject Code: AAS0101A

2. Answer **all** the parts. [5×2=10] CO

a. Write down the postulates of special theory of relativity. (2) CO1

b. Calculate the de-Broglie wavelength of an electron which has been accelerated from rest through a potential difference of 100 volt. (2) CO2

c. What do you mean by resolving power of a grating? (2) CO3

d. Explain the concept of displacement current. (2) CO4

OR

Define drift velocity.

e. Explain the concept of polarization of dielectric materials. (2) CO5

OR

Explain the construction of optical fibre.

SECTION – B

3. Answer any five of the following- [5×6=30] CO

a. Derive the relativistic energy-momentum relationship in special theory of relativity. (6) CO1

b. Derive the Schrodinger time independent and time dependent wave equations. (6) CO2

c. Discuss the phenomenon of Fraunhofer diffraction at single slit and show that the relative intensities of successive maxima are nearly : (6) CO3

$$1 : \frac{4}{9\pi^2} : \frac{4}{25\pi^2} : \frac{4}{49\pi^2} \ldots\ldots\ldots\ldots$$

d. Write down the Maxwell's equations in differential and integral form and give physical significance of each (no derivation required). (6) CO4

OR

Explain the construction and working of solar cell.

e. Derive an expression for Claussius -Mossotti equation. (6) CO5

OR

Stablish the relation between Einstein's coefficients of radiation transitions.

f. A soap film of refractive index 1.43 is illuminated by white light incident at an angle of 30°. The reflected light is examined by a spectroscope in which dark band corresponding to the wavelength 6000 Å is observed. Calculate the thickness of the film. (6) CO3

g. Consider a rod of length 2 cm inclined at an angle 60° along the direction of motion in a frame moving at speed 0.9c. What will be the length of rod as measured by an observer from rest frame? (6) CO1

SECTION – C

4 Answer any one of the following- [5×10=50] CO

a. Derive an expression for Einstein's mass energy relation. What does it signify physically? (10) CO1

b. An observer on a railway platform finds that a train moving with velocity 0.6c passes him in half a second. What is the length of the train measured by him and the proper length? (10) CO1

Previous Year Questions paper

Subject Code: AAS0101A

5.	**Answer any one of the following-**		
a.	Show that $\psi(x, y, z, t) = \psi(x, y, z)\, e^{-i\omega t}$ is a wave function of a stationary state.	(10)	CO2
b.	A particle is in motion along a line $x = 0$ and $x = L$ with zero potential energy. At point for which $x < 0$ and $x > L$, the potential energy is infinite. Solving Schrodinger equation, obtain energy eigen values & normalized wave function for the particle.	(10)	CO2
6.	**Answer any one of the following-**		
a.	Newton's rings are observed in reflected light of wavelength 5890 Å. The radius of the convex surface of the lens is 100 cm. A liquid is put between curved surface of lens and plate. The diameter of 10th ring is 4.2 mm. Calculate the refractive index of liquid when ring is dark.	(10)	CO3
b.	Describe how Newton's rings experiment can be used to determine the refractive index of a liquid.	(10)	CO3
7.	**Answer any one of the following-**		
a.	Deduce Coulomb's law of electro-statistics from Maxwell's first equation. Or Explain the concept of electrical conductivity in metals and derive the expression for electrical conductivity for n-type and p-type semiconductors.	(10)	CO4
b.	What is Poynting vector? Derive and explain Poynting theorem. **OR** Derive an expression for the position of Fermi level in intrinsic and extrinsic semiconductors.	(10)	CO4
8.	**Answer any one of the following-**		
a.	A metal sphere of radius a carries charge Q. It is surrounded by a linear dielectric material of permittivity ϵ and radius b. Find bounded surface and volume charge densities. **OR** Discuss the construction and operation of He-Ne laser. Why the discharge tube is made narrower in He-Ne laser?	(10)	CO5
b.	What are different types of polarization? Explain **OR** Differentiate between step index and graded index optical fiber. Derive the relation for acceptance angle in optical fiber.	(10)	CO5

Expected Questions for University Exam

Q.1) What do you mean by Fermi level and derive Fermi level in intrinsic semiconductor? [2012]

Q.2) Explain the variation of Fermi level with temperature in extrinsic semiconductor. [2012, 2014]

Q.3) Show that at 0K fermi level lies exactly mid of the valence and conduction band [2013]

Q.4) Comment on variation of E_f with doping concentration and temperature. [2011, 2010]

Q.5) Distinguish between N-type and P-Type semiconductor [2013]

Q.6) Explain photovoltaic effect [2011]

Q.7) Explain the construction and working of Solar cell. [2010]

Summary

- Electrical conductivity is that **property which measures** the ability of material to allow the electric current to flow
- Electrical conductivity of **Semi-Conductor** lies between conductor and insulators
- **Semiconductor-** forbidden gap lies near about 1ev
- In N-Type semiconductor – Donar state is introduced in the band gap just below the conduction band
- P-Type semiconductor – Acceptor state is introduced in the band gap just above the valence band

Summary

- Fermi level lies close to the conduction band in the case of N-Type Semiconductors
- Fermi level lies close to the valence band in the case of P-Type Semiconductors
- With temperature, Extrinsic semi-Conductor tends to behave more like intrinsic semi-conductor
- Creation of a voltage in a material upon exposure to EM radiation is known as **photo-voltaic effect**
- A solar cell is an electrical device that converts light energy into electrical energy through the photovoltaic effect

References

1. Introduction to Solid State Physics by Charles Kittel
2. Solid State physics by Ashcroft and Mermin.
3. Basic Electrical And Electronics Engineering By R. K. Rajput
4. Numerical Problems in Physics, Volume 1 by Devraj singh
5. http://homepages.wmich.edu/~leehs/ME695/Chapter%2011.pdf

Thank You