**2.5 ELECTRONIC MATERIALS:**

Electronic materials are the materials used in electrical industries, electronics and microelectronics, and the substances for the building up of integrated circuits, circuit boards, packaging materials, communication cables, optical fibres, displays, and various controlling and monitoring devices.

**2.5.1 Types**

These materials can be conveniently classified into three categories, namely, conductors, semiconductors, and insulators.

**2.5.2 Insulators**

An insulator is a material that does not conduct electrical current under normal conditions. Most good insulators are compounds rather than® single-element materials and have very high resistivity. Valence electrons are tightly bound to the atoms. Therefore, there are very few free electrons in an insulator. Examples of insulators are rubber, plastics, glass, and quartz.

**2.5.3 Conductors**

A conductor is a material that easily conducts electrical current. Most metals are good conductors. The best conductors are single-element materials, such as copper (Cu), silver (Ag), gold (Au), and aluminum (Al), which are characterized by atoms with only one valence electron very loosely bound to the atom. These loosely bound valence electrons become free electrons. Therefore, in a conductive material the free electrons are valence electrons.

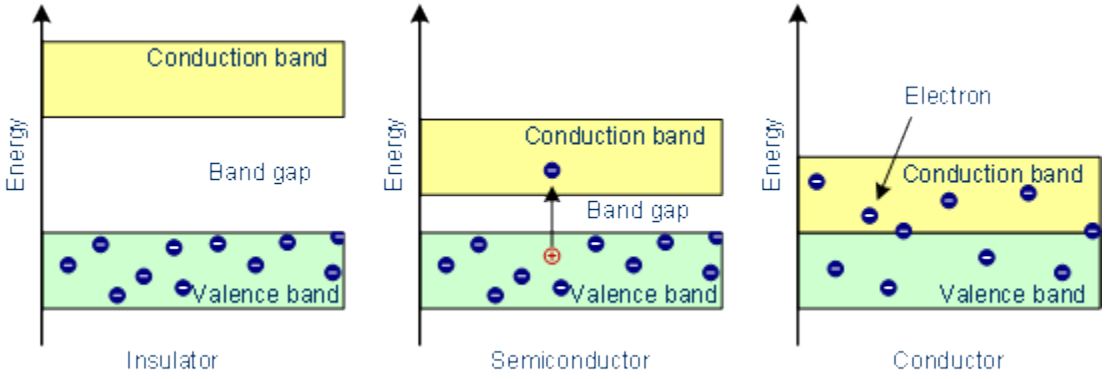
**2.5.4 Semiconductors**

A semiconductor is a material that is between conductors and insulators in its ability to conduct electrical current. A semiconductor in its pure (intrinsic) state is neither a good conductor nor a good insulator. Single element semiconductors are antimony (Sb), arsenic (As), boron (B), silicon (Si), and germanium (Ge). Compound semiconductors such as gallium arsenide, are also commonly used. The single-element semiconductors are characterized by atoms with four valence electrons. Silicon is the most commonly used semiconductor.

**2.5.5 Energy Bands:**

Recall that the valence shell of an atom represents a band of energy levels and that the valence electrons are confined to that band. When an electron acquires enough additional energy, it can leave the valence shell, become a free electron, and exist in what is known as the conduction band. The difference in energy between the valence band and the conduction band is called an energy gap or band gap. This is the amount of energy that a valence electron must have in order to jump from the valence band to the conduction band. Once in the

conduction band, the electron is free to move throughout the material and is not tied to any given atom. Figure shows energy diagrams for insulators, semiconductors, and conductors.




### 2.5.6 Applications of Semiconductors

Semiconductors are used in almost all electronic devices. Without them, our life would be much different. Their reliability, compactness, low cost and controlled conduction of electricity make them ideal to be used for various purposes in a wide range of components and devices. Transistors, diodes, photosensors, microcontrollers, integrated chips and much more are made up of semiconductors.

#### 2.5.6.1 Uses of Semiconductors in Everyday Life

- Temperature sensors are made with semiconductor devices.
- They are used in 3D printing machines
- Used in microchips and self-driving cars
- Used in calculators, solar plates, computers and other electronic devices.
- Transistors and MOSFET used as a switch in electrical circuits are manufactured using semiconductors.

#### 2.5.6.2 Industrial Uses of Semiconductors

The physical and chemical properties of semiconductors make them capable of designing technological wonders like microchips, transistors, LEDs, solar cells, etc.

The microprocessor used for controlling the operation of space vehicles, trains, robots, etc., is made up of transistors and other controlling devices, which are manufactured by semiconductor materials.

**Applications of Transistors**

Transistors are essential components across many industries due to their ability to amplify signals and switch currents.

**Consumer Electronics**

They power devices like smartphones, computers, and TVs, enhancing processing and signal clarity.

**Telecommunications**

- Transistors amplify and switch signals in routers and modems, ensuring

efficient data transmission.

### 2.5.7 Materials used in ICs

Most ICs are made of silicon, which is abundant in ordinary beach sand. Pure crystalline silicon, as with other semiconducting materials, has a very high resistance to electrical current at normal room temperature.

#### 2.5.7.1 Electronic material used in fibers

Fiber optic cables are made of materials that allow light to travel through them. They carry a lot of data very quickly on fiber strands which are the width of a human hair!

Optical fibre is a type of cable for transmitting data using pulses of light – this is significantly faster than using traditional copper cabling systems. In fact, fibre optics have revolutionized the way we communicate, with data travelling as fast as the speed of light! Fibre optic cables are used in a variety of applications, including:

- Internet and computer networking
- Telecommunications
- Cable TV
- Military and space applications

There are two main types of optical fiber: single-mode and multimode fiber. They each offer their benefits and drawbacks.

- **Single-mode fiber** is made from a super-thin fiber core of glass or plastic, through which only one ray of light can travel at a time. This makes it ideal for long-distance data transmission, as there is very little signal loss over distance. However, single-mode fiber requires specialized equipment to install, which must be considered at the start of your installation project.
- **Multimode fiber** has a larger core than single-mode fiber, meaning multiple rays of light can travel down the cable simultaneously. This makes it easier to install; however, it's not the best choice for long-distance data transmission as there is more signal loss and attenuation.

**Difference between using glass or plastic**

**Glass fiber optic cables** are made from a material called silica, which is very pure and has a very low index of refraction. This means it can carry data over longer distances with less signal loss. However, glass is more fragile than plastic and can be difficult to work with.

**Plastic fiber optic cables** are made from materials such as acrylate and polyimide. These plastics have a higher index of refraction than glass, meaning they're not suitable for long-distance data transmission. However, they are much more flexible than glass and easier to work with.

### 2.5.8 Electronic material used in cables

Cable materials are substances and components used to construct electrical cables. These materials are carefully chosen to ensure the cables' performance, durability, and safety in various applications. Common materials used in cable manufacturing include:

1. **Conductors**: Conductors are the core elements of wires and cables that carry electrical current. Common conductor wire and cable materials include:
    - **Copper**: Copper is one of the most widely used conductor materials due to its high electrical conductivity and excellent performance. It is used in most electrical and electronic applications.
    - **Aluminum**: Aluminum conductors are often used in high-voltage overhead power transmission lines due to their lightweight nature.
    - **Alloy Conductors**: Various conductor alloys, such as aluminum or copper-clad aluminum, combine the benefits of different materials.
2. **Insulation**: Insulation materials are used to cover and protect the conductor, preventing electrical leakage and ensuring safety. Common insulation materials include:
    - **Polyethylene (PE)**: PE is a common choice for insulating cables in telecommunications and low-voltage applications.
    - **Polyvinyl Chloride (PVC)**: PVC is widely used for insulation in electrical cables and wires.
    - **Cross-Linked Polyethylene (XLPE)**: XLPE is used for high-voltage and high-temperature applications, such as underground power cables.
    - **Rubber**: Rubber insulation is flexible and often used in portable or industrial cables.
3. **Jacketing**: Jacketing materials are used to provide additional protection to the cable. They can be made from materials like PVC, polyurethane, or thermoplastic elastomers (TPE). The choice of jacketing material depends on the cable's intended use and environmental conditions.
4. **Shielding**: In some cables, especially those used in high-frequency applications or areas with electromagnetic interference, shielding materials are added to protect against external interference. Common shielding materials include aluminum foil, copper tape, and conductive polymers.
5. **Filling and Filler Materials**: These materials are used to fill gaps within the cable to maintain its shape and structural integrity. Common fillers include petroleum jelly, water-blocking compounds, or powder fillers.
6. **Armor**: In cables used in harsh environments or where physical protection is necessary, metallic or non-metallic armor may be added. Examples include steel armor for armored cables used in construction or steel tape armor for subsea cables.

7. **Braid**: Braided materials, often made of copper or aluminum, shield against electromagnetic interference (EMI) and radio frequency interference (RFI).
8. **Dielectric Materials**: These materials are used in specific cables to provide electrical insulation. Examples include paper insulation in some power cables.
9. **Sheathing**: Sheathing materials are used as an outer protective layer for cables. They can be made of polyethylene, PVC, or thermoplastic compounds.

**Properties of Cables**

- **Strength and flexibility :** The cables which are used for any purpose must have a large insulation and should be easily installed.
- **Fire Resistant :** The cables which are installed should be resistant to fire accidents.
- **Long life and Heat Resistance :** As the cables are installed every sector show they should require very less maintenance as it is not feasible to maintain them in public or private facilities. The installed wiring should be heat resistant.
- **Simple Usage :** The cables should be easily installed without requirement of complex circuits
- **Cost Effective :** Cables are used every where and backbone of electrical circuits. This makes it important to ensure that they are available at fair price.

**General Applications of Cables**

Electrical cables find application in almost every aspect of our day-to-day life. Some of the places where Electrical Cables are used Include:

- ✓ Homes
- ✓ Buildings
- ✓ Malls
- ✓ Tunnels
- ✓ Mines
- ✓ Metros Projects
- ✓ Airports
- ✓ Power Plants and Factories
- ✓ Ships
- ✓ Railways
- ✓ Construction Sites

### 2.5.9 Organic solar cells types and Applications

Organic solar cells are the third generation of solar cell technology and are also known as organic photovoltaic cells (OPV). These organic solar cells are incredibly powerful when it comes to absorbing light from the sun. They are able to harness larger amounts of sunlight than other solar cells which is one of the reasons why organic power is often considered to be the future of solar technology.

OPV is a **solar cell technology** that is rapidly increasing in terms of technological advancements and popularity. Organic photovoltaic (OPV) cells are a type of solar cell that uses organic semiconductor materials to generate electricity from the sun. These organic cells, also known as plastic solar cells, aretypicallymadeup of carbon-based polymers.

These polymer cells are flexible and semi-transparent solar cells that are used to create **thin-film solar panels** or even transparent solar panels. Most organic photovoltaic cells are polymer cells. This type of polymer solar cell uses a branch of organic electronics that deals with conductive organic polymers or small organic molecules, for light absorption and charge transport to produce electricity from sunlight by the photovoltaic effect.

**Organic solar cells and Applications**

Though organic solar cells are not yet commercially available there are a few manufacturers who are producing them and using them in pilot projects.

Heliatek, Nanoflex, and Sunew are three companies that manufacture organic solar cell film, which can be applied to building facades or glass. These companies are marketing their products for use in commercial or public buildings.

Epishine and Dracula Technologies are producing small printed organic solar cells that have been designed to power small home devices such as remote controls.

However, most of these companies aren't selling their products to the wider public as of yet. It's probably going to be a few years before organic solar cells become widely available.