CONDUCTORS, INSULATORS, SEMICONDUCTORS

In electrical engineering materials may be classified into three groups, i.e. conducting materials, insulating materials and semi conducting materials depending on their ability to conduct electricity.

The first category includes conductors, i.e. materials which provide an easy path for an electric current. Conductors are materials that obey Ohm’s law and have very low resistance. We have already mentioned the electron theory which states that all matter is composed of atoms. Atoms consist of a small positive nucleus surrounded by a cloud of electrons. Conductors are materials where some of these electrons are free to move. These free electrons, considered identical to the outermost, or valence electrons, are not constrained to remain in a particular atom. They are able to move freely in matter or a vacuum when an external electric field acts on them. The electric conductivity of the material is dependent upon the atomic structure of the material of which the conductors are made. Normally, conductors have three or less valence electrons, insulators have five or more and semiconductors usually have four valence electrons. To end up with, the materials in which it is easy to get electrons to move and provide a flow of electric current, are conductors. They are mostly metals, such as copper, aluminium, silver, gold, etc.

Copper and copper-based alloys are unique in their desirable combination of physical and mechanical properties. Due to their high electrical and thermal conductivity, they are very important in electrical industry. Copper is widely used for cables, transformer windings etc. Although silver is a slightly better conductor than copper, it is too expensive for common use. Aluminium is not as good conductor as copper, but it is cheaper and lighter. It is resistant to atmospheric weathering and today it is the dominant metal for the transmission lines of electrical energy.

Materials which offer high resistance to current flow are called insulators. Even the best insulators do release an occasional free electron to serve as a current carrier. However, for most practical purposes we consider an insulator to be a material that allows no current flow through it. Common insulator materials used in electrical devices are paper, wood, plastics, rubber, glass etc. Notice that common insulators are not pure elements. They are materials in which two or more elements are joined together to form a new substance. In the process of joining together, elements share their valence electrons. This sharing of valence electrons is called covalent bonding. It takes a lot of added energy to break an electron free of a covalent bond.

Between the extremes of conductors and insulators is a group of materials known as semiconductors. The basic property of a semiconductor is given by its name - it “conducts a little bit”. A semiconductor will carry electric current, but not easily as a normal conductor. Semiconductors are midway between conductors and insulators. They are neither good conductors nor good insulators. Under certain conditions they allow a current to flow easily but under others they behave as insulators. Germanium and silicon are semiconductors. The total conductivity in semi conducting materials is the sum of electron current and hole current. Semiconductors are extremely important industrial materials, they are materials from which electronic devices such as transistors, diodes, integrated circuits, and solar cells are manufactured. Without them modern electronic technology would not be possible, it would be even inconceivable.

TERMS AND DEFINITIONS

electrical conductivity - the ability of a material to conduct an electric current, as measured by the current per unit of applied voltage; it is the reciprocal of resistivity

electrical resistance - the measure of the difficulty of the electric current to pass through a given material; its unit is the ohm (Ω)

conduction band - the unfilled energy levels into which electrons can be excited to become conductive electrons; a band that when occupied by mobile electrons, permits their net movement in a particular direction, producing the flow of electricity through the solid

dopant or doping agent - an impurity element added to a semiconductor material under precisely controlled conditions to create PN junctions required for transistors and semiconductor diodes

integrated circuit (IC) - a single semiconductor chip or wafer which contains thousands or millions of circuit elements per square centimetre

transistor (Transfer resistor) - an active semiconductor device that has three or more electrodes, i.e. emitter, base and collector; it can perform practically all the functions of tubes, including amplification and rectification

DISCUSSION QUESTIONS

1. What materials are there in electrical engineering?

2. According to what has this classification been made?

3. What are conductors?

4. How many valence electrons do conductors have?

5. What metals are considered good conductors?

6. What are the most important properties of copper?

7. What is copper used for?

8. Say something about silver and aluminium.

9. Why is aluminium used for open wire lines?

10. What is an insulator?

11. Name some insulators.

12. What are semiconductors?

13. What is the difference between conductors and semiconductors regarding total conductivity?

14. What are semiconductors used for?

FILL IN THE MISSING WORDS (some words may be used more than once)

Aluminum atomic bars conductivity conductor copper electricity gold insulators made metals power lines resistance sheets silver spans supports tubes weight wire

1. The electrical \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of matter is dependent upon the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ structure of the material from which the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ have an extremely high \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ to the flow of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

3. Some \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ are better conductors of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ than others.

4. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is the best conductor, followed by \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

5. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is used where \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is a major consideration, such as high-tension \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, with long \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ between \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

6. Conductors are usually found in the form of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, but may be in the forms of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ or \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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