ELECTRICAL ENGINEERING MATERIALS

Unit II : Conducting and Semi-Conducting Materials

Topic: Low Resistivity Materials

Important Questions with Answers (3rd Semester, Electrical Engg.)

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Short Answer Questions

Q.1 Write the properties and applications of copper.

Ans. Copper is the most widely used conducting material. Its conductivity is next only to silver, and it is much cheaper.

Properties:

1. Low resistivity (about 1.7×10^{-8} Ω·m), so power loss is small.
2. High ductility and malleability, so it can be drawn into thin wires and rolled into sheets.
3. Good tensile strength.
4. Good resistance to corrosion, because a thin protective oxide layer forms on it.
5. Easy to solder and weld.
6. High melting point (about 1085 °C).

Applications:

1. House wiring and power cables.
2. Windings of motors, generators and transformers.
3. Bus bars and switchgear parts.
4. Commutator segments of DC machines.
5. Earthing strips and contacts.

Q.2 Make a comparison between hard drawn copper and annealed copper.

Ans. Hard drawn copper is drawn through dies at normal temperature, so it becomes hard and strong. Annealed copper is heated to a high temperature and cooled slowly (annealing), so it becomes soft and flexible.

Basis	**Hard drawn copper**	**Annealed copper**
Treatment	Drawn cold, no annealing	Heated and cooled slowly
Hardness	Hard	Soft
Tensile strength	High	Lower
Flexibility	Less flexible	More flexible and ductile
Conductivity	Slightly lower	Slightly higher
Uses	Overhead lines, bus bars, commutator segments, trolley wires	Cables, house wiring, windings, flexible leads

Q.3 Write the applications of silver, gold and platinum in the electrical engineering field.

Ans. The applications are as follows.

Silver (best conductor, very costly):

1. Contacts of switches, relays and circuit breakers.
2. Silver plating on conductors and connectors.
3. Fuse elements in some special fuses.
4. Contacts in solar cells and electronic circuits.

Gold (does not corrode, very costly):

1. Contacts of sensitive relays and low-voltage, low-current switches.
2. Gold plating of connector pins in electronic equipment.
3. Thin bonding wires inside integrated circuits.

Platinum (does not oxidise, very costly):

1. Contacts of sensitive relays.
2. Resistance thermometers and thermocouples (with rhodium).
3. Electrodes.

Note: Platinum is a high resistivity material. It is covered in detail in the note on High Resistivity Materials.

Q.4 Write short notes on aluminium and steel as conducting materials.

Ans. Aluminium is the second most used conducting material after copper.

Aluminium properties:

1. Resistivity about 2.8×10^{-8} Ω·m; conductivity is about 60% of copper.
2. Very light (density about one-third of copper) and cheaper than copper.
3. Lower tensile strength than copper.
4. A strong oxide layer protects it from corrosion but makes soldering difficult.

Aluminium uses:

Overhead transmission and distribution lines, power cables, bus bars, windings of small machines and transformers.

Remember: For the same resistance, aluminium needs about 1.6 times the area of copper, but is still about half the weight.

Steel:

Steel is an alloy of iron and carbon. It has very high tensile strength and is cheap, but its resistivity is much higher than copper and it rusts (so it is galvanised). Uses: core of ACSR, earth wires, earthing pipes and strips, guy wires and tower parts.

Q.5 What is ACSR? Write its full form, construction and uses.

Ans. ACSR stands for Aluminium Conductor Steel Reinforced. It is a stranded conductor in which aluminium wires are wound around a core of galvanised steel wires.

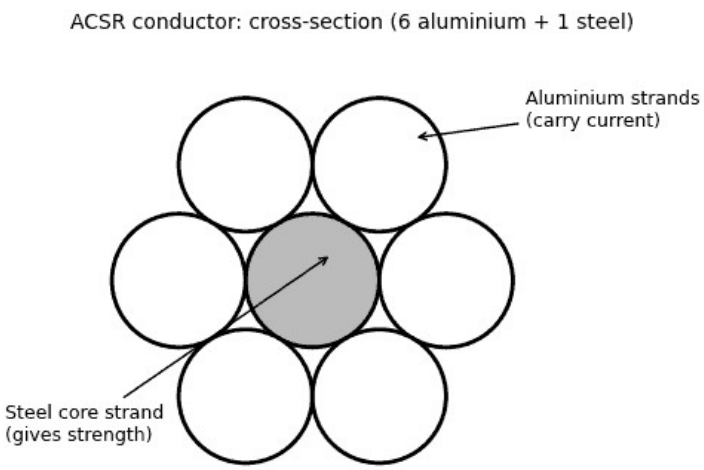


Fig. 1 Cross-section of an ACSR conductor (6 aluminium strands over 1 steel strand)

Why this combination:

Aluminium is light but weak. Steel is strong but a poor conductor. In ACSR, the steel core gives strength and the outer aluminium carries the current.

Properties:

1. High tensile strength and light weight.
2. Good conductivity, as most of the current flows through aluminium.
3. Lower cost than copper conductors.
4. Suitable for long spans between towers.

Uses:

Overhead transmission lines and overhead distribution lines.

Q.6 Write short notes on brass and bronze (composition, properties and uses).

Ans. Brass and bronze are copper alloys. Adding another metal makes copper harder and stronger but lowers its conductivity.

Basis	Brass	Bronze
Composition	Copper and zinc (generally about 60–70% copper)	Copper and tin (generally about 90% copper)
Properties	Harder than copper, easy to cast and machine, good corrosion resistance	Harder and stronger than brass, good wear and corrosion resistance
Uses	Plugs, sockets, terminals, lamp holders, switch parts, nuts and bolts	Springs, clamps, contacts, bearings and parts that wear

Remember: Brass = copper + zinc. Bronze = copper + tin. Brushes of DC machines are generally made of carbon, not bronze.

Long Answer Question

Q.7 Discuss low resistivity conducting materials with their properties and applications.

Ans. Low resistivity materials are conducting materials which offer very little opposition to current and have high conductivity. They are used to carry current with minimum power loss and heating. The main materials are silver, gold, copper, aluminium, steel, ACSR, brass and bronze.

1. Silver:

Best conductor, soft and ductile, tarnishes slowly, very costly. Used for contacts of switches and relays, silver plating and special fuse elements.

2. Gold:

Very good conductor, does not corrode, soft, very costly. Used for sensitive relay contacts, plating of connectors and bonding wires in ICs.

3. Copper:

Resistivity about 1.7×10^{-8} Ω·m, ductile, strong, corrosion resistant, easy to solder. Hard drawn copper is strong (bus bars, overhead lines, commutator segments). Annealed copper is soft and flexible (cables, wiring, windings).

4. Aluminium:

About 60% of the conductivity of copper, light and cheap, lower strength, hard to solder. Used for overhead lines, cables, bus bars and windings of small machines.

5. Steel:

Very strong but higher resistivity and rusts. Used for earth wires, earthing, guy wires and as the core of ACSR.

6. ACSR:

Aluminium Conductor Steel Reinforced: aluminium wires over a steel core. Strong, light and cheap. Used in overhead transmission lines.

7. Brass and bronze:

Copper alloys. Brass (copper + zinc) is used for plugs, sockets, terminals and switch parts. Bronze (copper + tin) is used for springs, clamps and contacts.

Comparison:

Material	Main advantage	Main limitation	Typical use
Silver	Best conductivity	Very costly	Contacts
Gold	Does not corrode	Very costly, soft	Contacts in electronics
Copper	High conductivity and strength	Costlier than aluminium	Wires, windings
Aluminium	Light and cheap	Lower strength	Overhead lines
Steel	Very strong	High resistivity, rusts	Earth wire, ACSR core
ACSR	Strong and light	Not for indoor wiring	Transmission lines

Brass, bronze	Hard, corrosion resistant	Lower conductivity	Terminals, springs

Note: Resistivity values are approximate textbook values and are not given in the syllabus.

Points to Remember (for MCQ and True/False)

1. Copper is the most used conducting material. Aluminium is the second.
2. Silver is the best conductor but is too costly for general use.
3. ACSR means Aluminium Conductor Steel Reinforced.
4. Brass is an alloy of copper and zinc. Bronze is an alloy of copper and tin.
5. The commutator of a DC motor is made of copper (hard drawn copper).
6. Brushes of DC machines and slip-ring motors are made of carbon, not bronze.
7. Hard drawn copper is strong. Annealed copper is soft and flexible.
8. Ductility is the property of being drawn into wires.