

MATERIALS

electrical

Introduction

Electricity is described as the movement of electrons, which is referred to as current; the force required to move the electrons is called the voltage or potential difference. Measurements used in electrical applications include current (amp), voltage (volt), charge (coulomb), resistance (ohm), power (watt) and magnetic inductance (henry).

Materials that are relevant for electrical applications either insulate against, conduct or resist electricity flow.

Conductors

Silver

The highest performance electrically conductive element, but the high cost of silver limits its use to high requirement contact components. Alloys of silver are available to improve its hardness, for example refractory silver is alloyed with tungsten to give higher hardness and higher current performance. This material is formed using powder metallurgy.

Copper

Low electrical resistance and low cost promotes its widespread use for the majority of electrical equipment and power supply wiring. It has the added advantages of being easy to manufacture and bend into complex shapes. It is available in strip, solid core and wire forms.

Gold

Extreme resistance to oxidation, but low hardness does not provide sufficient resistance to abrasion. Low melting point restricts its use to low current applications. Alloys available to provide improved resistance to wear and strength. Used for contact applications that are sound sensitive.

Aluminium

Electrical grade aluminium has approximately half the electrical conductance of silver, but alloys with low density and high strength properties are used in high strength specification electrical cables.

Tungsten

Tungsten is used to conduct electricity in light bulbs. The diameter of wire that is used in the light bulb is tightly controlled so that on conducting electricity, heat and light energy are produced. Tungsten is used because of its excellent capability for maintaining its properties and dimensions at high temperatures. These properties are utilised in tungsten-based thermocouples, along with its high melting temperature, approximately 3,400°C.

Another electrical use of tungsten is the electrode in Tungsten Inert Gas (TIG) welding, where its high temperature performance and high hardness provide excellent resistance to wear.

Superconductors

A superconductor is a material that provides no resistance to the flow of electricity when maintained below a specific temperature. The maximum temperature at which a material is capable of being a superconductor is called the Critical Transition Temperature (T). This temperature ranges from near absolute zero to 134K for currently known superconducting materials. To provide the low temperatures necessary for a superconducting state to be achieved, the conducting elements are surrounded by liquid nitrogen or liquid helium.

A limited number of materials have been found to be capable of performing as superconductors. There are two classes of superconductor, Type 1 (mainly pure metals) and Type 2 (metallic compounds and alloys, and metal oxide ceramics).

Superconductors are used to generate magnetic fields for levitating super-trains, for detecting weak magnetic fields in Magnetic Resonance Imaging (MRI) and in high specification electric generators with superconducting wire providing in the region of 99% efficiency.

Resistors

Many different alloys of metals are available to provide electrical resistance. These are commonly grouped as follows: nickel chromium alloys, iron chromium aluminium alloys, copper nickel alloys and other metals (stainless steel, manganese-nickel, pure copper). The first two alloy groups exhibit high operating temperatures (above 1,000°C) and high resistivity (above 100 $\mu\Omega$.cm, compared with 1.7 for pure copper).

Insulators

Insulators of electricity are sometimes called dielectric materials. The aim of insulators is to prevent electricity flow outside the conducting elements.

Ceramics

Ceramics used for insulation are electrical porcelain, steatite, fosterite and alumina. They provide high dielectric strengths and constants for a wide variety of applications, especially where a superior resistance to heat is required.

Polymers

Many different polymers provide insulation in a wide range of different forms, from flexible electrical cable sheathing to moulded component housings. Thermoplastics are limited to low temperature applications, whilst thermosets can be used in applications that experience moderate heat levels.

Internet Resources

[Department of Electrical Engineering and Electronics](#) at UMIST conducts teaching and research activities in the majority of aspects of electrical and electronic engineering.

The [Superconductors.org](#) website provides background and basic technical information regarding superconductors and their applications. The link page on the website provides routes to obtain more information about superconductors from industry and academia.