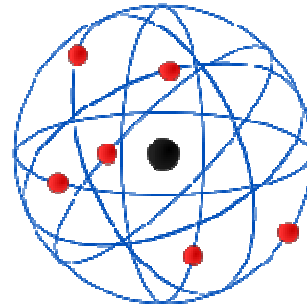


# Materials

Materials are composed of atoms which are formed by a central nucleus surrounded by a cloud of negatively charged electrons.

Atomic nucleus consists of two types of particles – protons and neutrons. Proton or atomic number ( $Z$ ) denotes number of protons in a nucleus and uniquely identifies a chemical element. Elements in a periodic table are ordered by their atomic number. Elements occurring naturally range from atomic number  $Z = 1$  (Hydrogen – H) to  $Z = 92$  (Uranium – U). Elements with an atomic number higher than 92, for example  $Z = 94$  (Plutonium – Pu) are created artificially.



Protons are positively charged particles. The cloud surrounding the protons consists of negatively charged particles called electrons. The number of electrons in a regular atom is equal to the number of protons in its nucleus. Therefore, the atom is electrically neutral.

Materials have varying internal structures and therefore a varying ability to conduct electric current. Based on their ability to conduct electricity, we categorize materials as follows:

- Conductors
- Insulators
- Semiconductors

## Conductors

Conductors are produced from metals that have the ability to carry electrical charge and thus are good electric conductors. Conductivity is denoted by the symbol  $\gamma$ . In addition to conductivity, conductors should also be affordable, have good physical properties and resist corrosion. Conductors are most frequently manufactured from copper, aluminium, silver, gold or platinum. Alloys of these metals are also used, as they may exhibit better physical properties than pure metals themselves.

### Copper (Cu)

High degree of copper purity (99,98 %) is achieved by electrolysis. In a humid environment, a green coating is created on the surface of copper materials, which protects it from further corrosion. After silver, copper is the second best conductor of electric current.

Copper is mostly used in wire conductors (in power grids, electric motors and transformers), circuit boards and thermal dissipaters used in semiconductors.

### Aluminum (Al)

Aluminum is the most abundant element in Earth's crust. It is produced by refining aluminum rich ore using electrolysis with a purity of 99,5 to 99,9 %. It is a good heat and electric current conductor. When exposed to air, the surface oxidizes. Compared to copper, aluminum is lighter and softer.

It is used as a conductor (in power grids), in production of capacitors, heat dissipaters and semiconductors.

### **Silver (Ag)**

Silver resists oxidation well and is used to coat brass contacts in High-Fidelity and high-frequency electronic equipment.

### **Gold (Au)**

Gold's conductive properties make it an ideal metal to achieve low resistance in High-Fidelity electronics, integrated circuits and other computer equipment.

### **Carbon (C)**

It has lower conductivity than metals, but carbon is very stable and resistant. Carbon's melting point is very high (around 3847 °C) and therefore is used high-temperature applications, for example in welding.

### **Alloys**

The properties of pure metals can be changed by alloying. Alloying produces better strength and lower melting point in materials. The conductivity is also lowered by alloying.

Alloy of copper and 5-45 % of zinc is called brass.

Alloy of copper and 2-13 % of tin is called bronze. It is used in the production of conductive springs and contact in electrical sockets.

Alloy of copper and 5-10 % of aluminum is called Duralumin. It is used in the production of screws, bearings, etc.

Aluminum alloys are used as construction materials such as Dural. For power distribution grids, special aluminium alloy called Aldrey is used.

Alloys of copper and nickel are most often used as resistive materials.

### **Insulators**

Materials that do not conduct electric current are called insulators. The negatively charged cloud surrounding the atom's nucleus in insulators contains electrons which are not released easily, therefore insulators are bad conductors. Examples of insulators are plastic materials, glass, rubber, ceramic, paper, etc. The use of insulators depends on their electric, physical and mechanical properties.

Insulators are used to protect humans from electric shock by separating conductive materials, such as wires, from other conductive materials, such as water, other wires, etc. They are also used as dielectric material in electronic components such as capacitors.

### **Semiconductors**

Materials that have an electric conductivity between that of a conductor and an insulator are called semiconductors. Conductivity of semiconductors can be influenced by adding various mixtures or by physical changes, such as light intensity, temperature change, or changing magnetic field.

High purity elements such as germanium (Ge) and silicon (Si) or alloys (for example Gallium-Arsenide) combined with very small amount of another element are almost exclusively utilized in the production of semiconductors. The ratio of purity/impurity is  $10^{10}$  atoms of Si to one atom of another element (for example aluminium, phosphorus, etc.).

## Magnetic materials

There are two types of magnetic materials

- magnetically hard materials
- magnetically soft materials



Permanent magnets are made from magnetically hard materials. Most widely used permanent magnets are ferrites and AlNiCo magnets.

Ferrites are produced by heating an intimate mixture of powdered hematite ( $\text{Fe}_2\text{O}_3$ ) and barium peroxide ( $\text{BaO}_2$ ). They are known for their hardness but also for their fragility.

AlNiCo alloys make strong permanent magnets. They are composed of aluminum, nickel and cobalt with a small quantity of iron, copper and titanium.

Permanent magnets are used in DC motors, small dynamos, loudspeakers, microphones, sensors and also in measuring equipment.

Temporary magnets are made from soft magnetic materials (steel), which take on magnetic properties only when they are within a strong magnetic field, but lose their magnetism when the magnetic field disappears. They are utilized in electromagnets, relays, etc.

## VOCABULARY

artificial – umelý  
conductor – vodič  
semiconductor – polovodič  
insulator – izolátor  
affordable – cenovo dostupný  
Earth's crust – zemská kôra  
achieve – dosiahnuť  
heat dissipater – rozptylovač tepla, chladič  
melting point – bod topenia  
power grid – elektrická sieť, rozvod elektrickej energie  
ratio of purity – pomer čistoty  
welding – zváranie  
tin – cín  
alloy – zliatina  
silicon – kremík

insulate – izolovať  
insulate a wire – izolovať drôt  
insulation – izolácia  
faulty insulation – zlá izolácia  
isolate – izolovať, separovať, oddeliť  
isolate a patient – izolovať chorého  
isolated – ojedinelý, sporadický  
isolation – izolácia, osamelosť  
live in isolation – žiť v izolácii  
brass – mosadz  
copper – meď  
surrounding – okolitý  
influence – vplyv, ovplyvniť  
magnetic field – magnetické pole  
residue – zvyšok  
tungsten – volfrám

Note:

*Both power and Ethernet cables must be **insulated** so that wires carrying electricity or digital signal don't touch each other. In addition these two cables have to be **isolated** from each other to prevent possible interference.*

*Napájacie i ethernetové káble musia byť **izolované**, aby vodiče, po ktorých sa šíri elektrický prúd alebo digitálny signál, sa nedotýkali. Káble musia byť taktiež fyzicky **oddelené** od seba, aby sa predišlo rušeniu.*