I. The different classes of materials

I. Main families of materials

- polymers,
- ceramics and glass,
- metals and alloys,
- composites.

I.1. Polymers

Polymers are formed from simple molecules, called monomers, which can join together by covalent bonds (strong energetic bonds) during a chemical polymerisation reaction.

The result is macromolecules, which can themselves be linked by energetically weak bonds (van der Waals or hydrogen).

Macromolecular chains are mainly made up of carbon, hydrogen, oxygen and chlorine atoms.

I.2. Ceramics and glass

I.2.1. Ceramics

Ceramics are among the materials first shaped by man: pottery, vases, etc. They are inorganic, non-metallic materials. There are two main families:

- Technical: they are derived from synthetic chemistry and their composition is rigorously defined. They are usually oxides, carbides or nitrides (Al_2O_3, SiC, etc.).

- Traditional: derived from common minerals, their composition is variable. Cements and concretes belong to this family.

I.2.2. The glass

Derived of common minerals, they are characterized by their high silica content and their totally amorphous (vitreous) structure.

The main characteristic of ceramics and glass is that they are brittle, so they have little resistance to tensile stress.

On the other hand, they are highly resistant to compressive stress, corrosion, wear and high temperatures (especially ceramics); they are refractory materials. They are good electrical and thermal insulators.

I.3. Metals and metal alloys

Metals are distinguished by the increase in their electrical resistivity with temperature, which are the most specific characteristics of metallic elements.

The metallic bond can be described as follows: the electrons in the outer electronic layer of each atom are free, which explains the good thermal and electrical conductivity of metals.

Metals are generally polycrystalline, i.e. made up of a large number of small grains or crystals, varying in size from 2 to 100 μm and bounded by surfaces known as grain boundaries.

Each grain is in fact a small single crystal.

A grain consists of a regular stack of atoms, generated by a lattice.

When a material is polycrystalline, the orientation of the crystal lattice in each grain is random; the material can be considered isotropic, meaning that its properties are identical regardless of the direction in space in which they are measured.

If the material consists of only one grain, it is monocrystalline.

I.4. A composite material

A composite material can be defined as a combination of at least two immiscible materials. This combination makes it possible to achieve mechanical and/or physico-chemical performance that the basic constituents cannot achieve on their own.

The most common combination is made from fibrous reinforcements embedded in a matrix:

- **The reinforcement acts as a skeleton, providing mechanical strength and rigidity.**

- **The matrix acts as a binder, fixing the final shape of the part. It also transfers stresses to the fibers.**

The transfer of forces between fiber and matrix is only effective if the fiber/matrix adhesion is of good quality.

Depending on the nature of the constituents, composite materials can be classified into several families

The family, by far the most representative, brings together composite materials made up of fibers of mineral or organic origin (glass fibers, carbon), associated with organic matrices.

The other families occupy very specialized industrial sectors (space, etc.), they are used in very specific applications (resistance to high temperatures, very strong abrasions, etc.).

In these families, we can cite composites with ceramic or metallic fibers associated with matrices also ceramic or metallic or even carbon/carbon composites.

Table 1: The different classes of materials

Metals and allays	**Iron and steels Aluminium and alloys Copper and alloys Nickel and alloys Titanium**
Polymers	**Polyethylene (PE), Polymethyl methacrylate (PMMA), Nylon or Polyamide (PA), Polystyrene (PS), Polyvinyl chloride (PVC), Polyethylene Terephthalate (PET), Polyether ether Cetone (PEEK), Epoxides (EP), Elastomers, including natural rubber (CN)**

Glass and ceramics	**Alumina (Al2O3), sapphire, Silica glass (SiO2) and silicates, Silicon carbide (SiC), Silicon nitride (Si3N4),**
Composites	**Glass fiber reinforced polymers (GFRP), Carbon fiber reinforced polymers (CFRP),**
Natural materials	**Wood, Leather, Cotton/wool/silk, Rock/chalk, sand**