**Ceramics:** Ceramics form an important part of materials group. Ceramics are compounds between metallic and nonmetallic elements for which the inter-atomic bonds are either ionic or predominantly ionic. The term ceramics comes from the Greek word *keramikos* which means ‘burnt stuff’. Characteristic properties of ceramics are, in fact, optimized through thermal treatments. They exhibit physical properties those are different from that of metallic materials.

**Properties of Ceramics Materials**

1. **Mechanical Properties:**
2. Ceramics are brittle in nature.
3. The compressive strength of ceramics are several times more than tensile strength.
4. High temperature stability
5. High hardness
6. High mechanical strength
7. Low elongation under application of stress
8. **Electrical properties:**
9. Low electrical conductivities.
10. Volume and surface resistivity decreases with increase in temperature.
11. Ceramic materials possess high frequency solution
12. Excellent insulators.
13. **Thermal Properties:**
14. Ceramic materials possess very low thermal conductivity.
15. Ceramic materials are having good thermal resistance.

**Classification of Ceramics:** Ceramics greatly differ in their basic composition. The properties of ceramic materials also vary greatly due to differences in bonding, and thus found a wide range of engineering applications. Thus ceramics are classified as follows:

1. **Based on their composition, ceramics are classified as:**
* Oxides,
* Carbides,
* Nitrides,
* Sulfides,
* Fluorides, etc.
1. **Functional classification:**
* Abrasives (Alumina, Carborundum).
* Fire clay products (Bricks, glass, etc).
* Inorganic glasses (window glass, lead glass).
* Cementing materials (Portland cement, lime, etc)
* Rocks (Granite, sandstone, etc).
* Minerals (quartz, calcite).
* Refractories (Silica bricks, magnesite)
1. **Structural classifications:**
* *Crystalline ceramics:* Single-phase like MgO or multi-phase from the MgO to $Al\_{2}O\_{3}$ binary system.
* *Non- crystalline ceramics:* Natural and synthetic inorganic glasses
* *Glass-bonded ceramics:* Fire clay products-crystalline phases are held in glassy matrix.
* *Cements:* Crystalline or non-crystalline phases.

In general, ceramic materials used for engineering applications can be divided into two groups: traditional ceramics, and the engineering ceramics. Typically, traditional ceramics are made from three basic components: clay, silica (flint) and feldspar. For example bricks, tiles and porcelain articles. However, engineering ceramics consist of highly pure compounds of aluminium oxide (Al2O3), silicon carbide (SiC) and silicon nitride (Si3N4).

***Glasses*:** glasses are a familiar group of ceramics – containers, windows, mirrors, lenses, etc. They are non-crystalline silicates containing other oxides, usually CaO, Na2O, K2O and Al2O3 which influence the glass properties and its color. Typical property of glasses that is important in engineering applications is its response to heating. There is no definite temperature at which the liquid transforms to a solid as with crystalline materials. A specific temperature, known as glass transition temperature or fictive temperature is defined based on viscosity above which material is named as super cooled liquid or liquid, and below it is termed as glass.

*Clay products*: clay is the one of most widely used ceramic raw material. It is found in great abundance and popular because of ease with which products are made. Clay products are mainly two kinds – structural products (bricks, tiles, sewer pipes) and white-wares (porcelain, chinaware, pottery, etc.).

*Refractories*: these are described by their capacity to withstand high temperatures without melting or decomposing; and their inertness in severe environments. Thermal insulation is also an important functionality of refractories.

*Abrasive ceramics*: these are used to grind, wear, or cut away other material. Thus the prime requisite for this group of materials is hardness or wear resistance in addition to high toughness. As they may also exposed to high temperatures, they need to exhibit some refractoriness. Diamond, silicon carbide, tungsten carbide, silica sand, aluminium oxide / corundum are some typical examples of abrasive ceramic materials.

*Cements*: cement, plaster of paris and lime come under this group of ceramics. The characteristic property of these materials is that when they are mixed with water, they form slurry which sets subsequently and hardens finally. Thus it is possible to form virtually any shape. They are also used as bonding phase, for example between construction bricks.

*Advanced ceramics*: these are newly developed and manufactured in limited range for specific applications. Usually their electrical, magnetic and optical properties and combination of properties are exploited. Typical applications: heat engines, ceramic armors, electronic packaging, etc.

**Some typical ceramics and respective applications are as follows:**

*Aluminium oxide / Alumina* (Al2O3): it is one of most commonly used ceramic material. It is used in many applications such as to contain molten metal, where material is operated at very high temperatures under heavy loads, as insulators in spark plugs, and in some unique applications such as dental and medical use. Chromium doped alumina is used for making lasers.

*Aluminium nitride* (AlN): because of its typical properties such as good electrical insulation but high thermal conductivity, it is used in many electronic applications such as in electrical circuits operating at a high frequency. It is also suitable for integrated circuits. Other electronic ceramics include – barium titanate (BaTiO3) and Cordierite (2MgO-2Al2O3-5SiO2).

*Diamond* (C): it is the hardest material known to available in nature. It has many applications such as industrial abrasives, cutting tools, abrasion resistant coatings, etc. it is, of course, also used in jewelry.

*Lead zirconium titanate* (PZT): it is the most widely used piezoelectric material, and is used as gas igniters, ultrasound imaging, in underwater detectors.

*Silica* (SiO2): is an essential ingredient in many engineering ceramics, thus is the most widely used ceramic material. Silica-based materials are used in thermal insulation, abrasives, laboratory glassware, etc. it also found application in communications media as integral part of optical fibers. Fine particles of silica are used in tires, paints, etc.

*Silicon carbide* (SiC): it is known as one of best ceramic material for very high temperature applications. It is used as coatings on other material for protection from extreme temperatures. It is also used as abrasive material. It is used as reinforcement in many metallic and ceramic based composites. It is a semiconductor and often used in high temperature electronics. Silicon nitride (Si3N4) has properties similar to those of SiC but is somewhat lower, and found applications in such as automotive and gas turbine engines.

*Titanium oxide* (TiO2): it is mostly found as pigment in paints. It also forms part of certain glass ceramics. It is used to making other ceramics like BaTiO3.

*Titanium boride* (TiB2): it exhibits great toughness properties and hence found applications in armor production. It is also a good conductor of both electricity and heat.

*Uranium oxide* (UO2): it is mainly used as nuclear reactor fuel. It has exceptional dimensional stability because its crystal structure can accommodate the products of fission process.

*Yttrium aluminium garnet* (YAG, Y3Al5O12): it has main application in lasers (Nd-YAG lasers).

*Zirconia* (ZrO2): it is also used in producing many other ceramic materials. It is also used in making oxygen gas sensors, as additive in many electronic ceramics. Its single crystals are part of jewelry.