Ceramics

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CERAMICS

"A ceramic is an inorganic non-metallic solid made up of either metal or non-metal compounds that have been shaped and then hardened by heating to high temperatures and subsequent cooling".

Although different types of ceramics can have very different properties, in general ceramics are corrosion resistant and hard, but brittle. Most ceramics are also good insulators and can withstand high temperatures. These properties have led to their use in virtually every aspect of modern life.

Some elements, such as carbon or silicon, may be considered ceramics.

Ceramic materials are brittle, hard, strong in compression, weak in shearing and tension. They withstand chemical erosion that occurs in other materials subjected to acidic or caustic environments.

Ceramics generally can withstand very high temperatures, such as temperatures that range from 1,000°C to 1,600°C (1,800°F to 3,000°F). A glass is often not understood as a ceramic because of its amorphous (non crystalline) character.

RAW MATERIALS

Traditional ceramic raw materials include

- **clay** minerals such as **kaolin.**
- **Alumina** is a more recent materials which is **aluminium oxide**.
- **Silicon carbide** and **tungsten carbide** is the modern ceramic materials, which are classified as advanced ceramics. Both are valued for their abrasion resistance, and hence find use in applications such as the wear plates of crushing equipment in mining operations.

Crystalline ceramics

Crystalline ceramic materials are not amenable to a great range of processing. Methods for dealing with them tend to fall into one of two categories – either make the ceramic in the desired shape, by reaction *in situ*, or by "forming" powders into the desired shape, and then sintering to form a solid body. Ceramic forming techniques include shaping by hand (sometimes including a rotation process called "throwing"), slip casting, tape casting (used for making very thin ceramic capacitors, e.g.), injection molding, dry pressing, and other variations.

Noncrystalline ceramics

Noncrystalline ceramics, being glasses, tend to be formed from melts. The glass is shaped when either fully molten, by casting, or when in a state of toffee-like viscosity, by methods such as blowing to a mold. If later heat treatments cause this glass to become partly crystalline, the resulting material is known as a glass-ceramic, widely used as cook top and also as a glass composite material for nuclear waste disposal.

TYPES OF CERAMICS PRODUCTS

For convenience, ceramic products are usually divided into four sectors;

- Structural, including bricks, pipes, floor and roof tiles.
- Refractory's, such as kiln linings, gas fire radiant, steel and glass making crucibles
- White wares, including tableware, cookware, wall tiles, pottery products and sanitary ware

Technical, (engineering, advanced, special, and in Japan, fine ceramics) can also be classified into three distinct material categories:

Classification of technical ceramics

- Oxides: alumina, beryllia, ceria, zirconia
- Nonoxides: carbide, boride, nitride, silicide
- Composite materials: particulate reinforced, fiber reinforced, combinations of oxides and nonoxides.

Each one of these classes can develop unique material properties because ceramics tend to be crystalline.

Examples of whiteware ceramics

Earthenware, which is often made from clay, quartz and feldspar.
Stoneware
Porcelain, which is often made from kaolin
Bone china

PROPERTIES OF CERAMICS

- Extreme hardness
  - High wear resistance
  - Extreme hardness can reduce wear caused by friction
- Corrosion resistance
- Heat resistance
  - Low electrical conductivity
  - Low thermal conductivity
  - Low thermal expansion
  - Poor thermal shock resistance

APPLICATIONS OF CERAMICS

- **Knife blades:** the blade of a ceramic knife will stay sharp for much longer than that of a steel knife, although it is more brittle and can snap from a fall onto a hard surface.
- **Ceramic brake disks** for vehicles are resistant to abrasion at high temperatures.
- **Advanced composite ceramic** and metal matrices have been designed for most modern armoured fighting vehicles because they offer superior penetrating resistance against shaped charges(such as HEAT rounds) and kinetic energy penetrators.

- **Small arms protective inserts;** Ceramics such as alumina and boron carbide have been used in ballistic armored vests to repel large-caliber rifle fire. Such plates are known commonly as small arms protective inserts, or SAPIs. It is also used to protect the cockpits of some military airplanes, because of the low weight of the material.
- **Ball bearings;** Ceramics can be used in place of steel for ball bearings. They are much less susceptible to wear due to their high hardness and last for triple the lifetime of a steel part. They also deform less under load, meaning they have less contact with the bearing retainer walls and can roll faster.

CERAMICS & ITS VARIOUS USES

- Aerospace: space shuttle tiles, thermal barriers, high temperature glass windows, fuel cells
- Consumer Uses: glassware, windows, pottery, Corning¨ ware, magnets, dinnerware, ceramic tiles, lenses, home electronics, microwave transducers
- Automotive: catalytic converters, ceramic filters, airbag sensors, ceramic rotors, valves, spark plugs, pressure sensors, thermistors, vibration sensors, oxygen sensors, safety glass windshields, piston rings

- Medical (Bioceramics): orthopedic joint replacement, prosthesis, dental restoration, bone implants
- Military: structural components for ground, air and naval vehicles, missiles, sensors
- Computers: insulators, resistors, superconductors, capacitors, ferroelectric components, microelectronic packaging
- Other Industries: bricks, cement, membranes and filters, lab equipment
- Communications: fiber optic/laser communications, TV and radio components, microphones

Whiteware:

- Crockery
- Floor and wall tiles
- Sanitary-ware
- Electrical porcelain
- Decorative ceramics

ABRASIVES

•Because of their hardness, high wear resistance, high toughness

- Tools:
  --for grinding and polishing
  --for cutting
  --for oil drilling

oil drill bits

Abrasive blades

- Solutions:
  – coated single crystals or polycrystalline diamonds or SiC or corundum (aluminum oxide) in a metal or resin matrix. (blades)
  – coated single or polycrystalline crystals on paper or cloth. (sand paper)
  – loose abrasive grains. (for polishing)

coated single crystal diamonds

polycrystalline diamonds in a resin matrix.

CLAY PRODUCTS

-***earthenware*** e.g. plant pot
(dirty red brown, very cheap, opaque)

-***stoneware*** e.g. coffee mug, plate, bowl
(cheap, heavy, opaque)

-***porcelain*** e.g. table wares plate, souvenirs
(clean, light, translucency)

-***bone china*** e.g. table wares, souvenirs
(very clean, very expensive, very good translucency, light, mostly ivory colour)

earthenware

stoneware

porcelain

bone china

GLASS

- Glasses are non-crystalline silicates containing with other oxides , e.g., CaO, Na_2O, K_2O and Al_2O_3.
- Mostly glasses are transparent and easy to fabricate or form.

- Glass-ceramics are glasses which are transformed to crystalline state with fine polycrystalline grains.
- High strength, high thermal conductivity, high thermal shock resistance ,e.g., Pyrex

REFRACTORY

- A material to use in high temperature furnaces.
- Consider Silica (SiO_2) - Alumina (Al_2O_3) system.

mullite, alumina, and crystobalite (made up of SiO_2) tetrahedra as candidate refractories.

Refractory

GENERAL COMPARISON OF MATERIALS

Property	*Ceramic*	*Metal*	*Polymer*
Hardness	Very High	Low	Very Low
Elastic modulus	Very High	High	Low
Thermal expansion	High	Low	Very Low
Wear resistance	High	Low	Low
Corrosion resistance	High	Low	Low


Thank You!