

Ceramic Materials

Ceramic materials are inorganic, non-metallic materials made from compounds of a metal and a non-metal. Ceramic materials may be crystalline or partly crystalline. They are formed by the action of heat and subsequent cooling. The word ceramic, derives its name from the Greek "keramos". Clay was one of the earliest materials used to produce ceramics, as pottery, but many different ceramic materials are now used in domestic, industrial and building products. Ceramic materials tend to be strong, stiff, brittle, chemically inert, and non-conductors of heat and electricity but their properties vary widely. For example, porcelain is widely used to make electrical insulators, but some ceramic compounds are superconductors. They are also more resistant to high temperatures and harsh environments than metals and polymers. Due to ceramic materials wide range of properties, they are used for a multitude of applications.

The atoms in ceramic materials are held together by a chemical bond, the two most common chemical bonds for ceramic materials are covalent and ionic. Covalent and ionic bonds are much stronger than in metallic bonds and, generally speaking, this is why ceramics are brittle and metals are ductile.

Are also referred to as "special," "technical," or "engineering" ceramics. They exhibit superior mechanical properties, corrosion/oxidation resistance, or electrical, optical, and/or magnetic properties. While traditional clay-based ceramics have been used

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for over 25,000 years, advanced ceramics have generally been developed within the last 100 year.

Advantages of Ceramics materials:

- 1- The ceramic are hard, strong and dense.
- 2- They have high resistance to the action of chemical and to the weathering.
- 3- Possess a high compression strength compared to the tension.
- 4- They have high fusion points.
- 5- They offer excellent dielectric properties.
- 6- They are good thermal insulators.
- 7- They are resistant high temperature creep.
- 8- Availability is good.
- 9- Good sanitation.
- 10- Better economy.

Classification of Ceramics

A- Classification of Ceramics materials

i- Functional Classification

- 1- Abrasives.
- 2- Pure oxide ceramics.
- 3- Fire –clay products.
- 4- Inorganic glasses.
- 5- Cementing materials.
- 6- Rocks.
- 7- Minerals.
- 8- Refractories.

ii-structural classification

- 1-*crystalline ceramic*: single-phase like MgO or multi-phase form the Al_2O_3 binary bond.
- 2-*Non- crystalline ceramic*: Natural or synthetic inorganic glasses.
- 3-*"Glass-bonded" ceramic*: Fire clay products- Crystalline phase are held in glassy matrix.
- 4-*Cements*: Crystalline or Crystalline and non- Crystalline phases.

B- Classification of Ceramics products

1. Whitewares.
2. Bricks and tiles.
3. Chemical stonewares.
4. Cement and concretes.
5. Abrasives.
6. Glass.
7. Insulators.
8. Refractories.
10. Porcelain enamel.
11. Minerals ores.
12. Slags and fluxes

- **Based On their engineering applications, ceramics are classified in to two groups as:**

1- Traditional ceramics

which are usually based on clay and silica. There is some times a tendency to equate traditional ceramics with low technology, however, advanced, manufacturing techniques are often used. Competition among producers has caused processing to become more efficient and cost effective. Complex tooling and machinery is often used may be coupled with computer-assisted process control.

2- Advanced ceramics consist of carbides (SiC), pure oxides (Al_2O_3), nitrides (Si_3N_4) non-silicate glasses and many others. It is also referred to as "special," "technical," or "engineering" ceramics. They exhibit superior mechanical properties, corrosion/oxidation resistance, or electrical, optical, and/or

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magnetic properties. While traditional clay-based ceramics have been used for over 25,000 years, advanced ceramics have generally been developed within the last 100 years.

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 makes 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". etc.), injection moulding, dry pressing, and other variations. A few methods use a hybrid between the two approaches of buttoning and puckering.

Non-crystalline Ceramics

Non-crystalline 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.