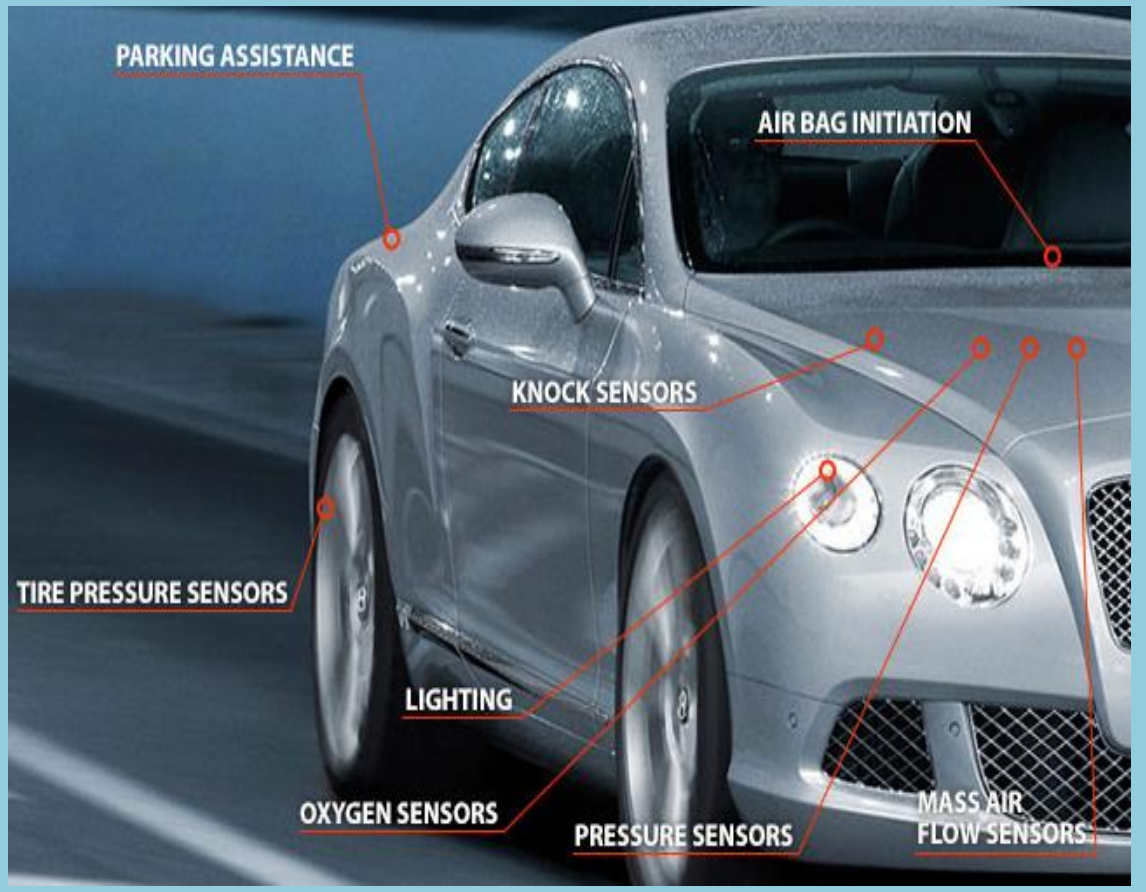
LECTURE-05: GLASS AND CERAMIC PRODUCTS



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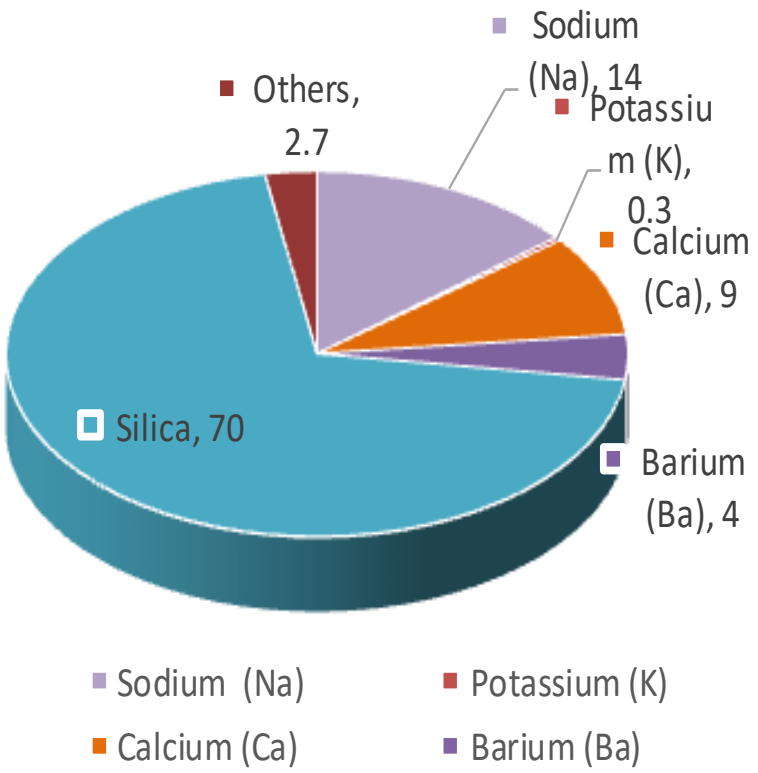
Glass

- Glass is a manufactured material formed when a mixture of sand, soda, and lime is heated to a high temperature and assumes a molten, or liquid, state.
General Properties of Glass
  - Amorphous Solid
  - No definite melting point
  - Very brittle
  - Softens on heating
  - Can absorb, reflect and transmit light
  - Good electrical insulator
  - Affected by alkalis
  - Not affected by air, water, acid or chemical reagents.
  - Possesses high compressive strength and since it doesn't have any crystalline structure , no slippage between planes can occur
  - Light in weight because it has homogeneous internal structure similar to liquids

Raw Materials of Glass



Sl.No	Name of the element	Source of the element	Name of the glass produced
1	Sodium (Na)	Na_2CO_3,Na_2SO_4	Soft glass
2	Potassium (K)	Potash, K_2CO_3,KNO_3	Hard glass
3	Calcium (Ca)	Lime, limestone	Glass with high RI
4	Barium (Ba)	$BaCO_3$	Glass with high RI
5	Lead	Litharge, red lead	Flint glass
6	Zinc	Zinc Oxide	Heat & Shock proof glass
7	Borate	Borax, boric acid	Heat & shock proof glass
8	Silica	Sand, quartz	
	Colors Yellow	Ferric Salt	
	Green	Ferrous and chromium	
	Blue	Cobalt salt	

How to Manufacture Glass?

- In glass manufacturing process there are five stages are involved they are-
  - Raw Material Preparation
  - Batch Mixing
  - Melting and Refining
  - Glass Forming
  - Annealing
- Raw Materials Preparation: The first stage of the glass manufacturing process is raw material preparation, first select the suitable raw material depending upon the types of glass that will be manufactured. Silica (SiO_2) is natural quartz in the sand and is used as the primary source for preparing glasses. The sand is must be washed properly to remove impurities which may cause undesirable coloring of the glass. The sand is classified according to grain sizes. The most desirable particle size for glassmaking is in the range of 0.1 to 0.5 mm.

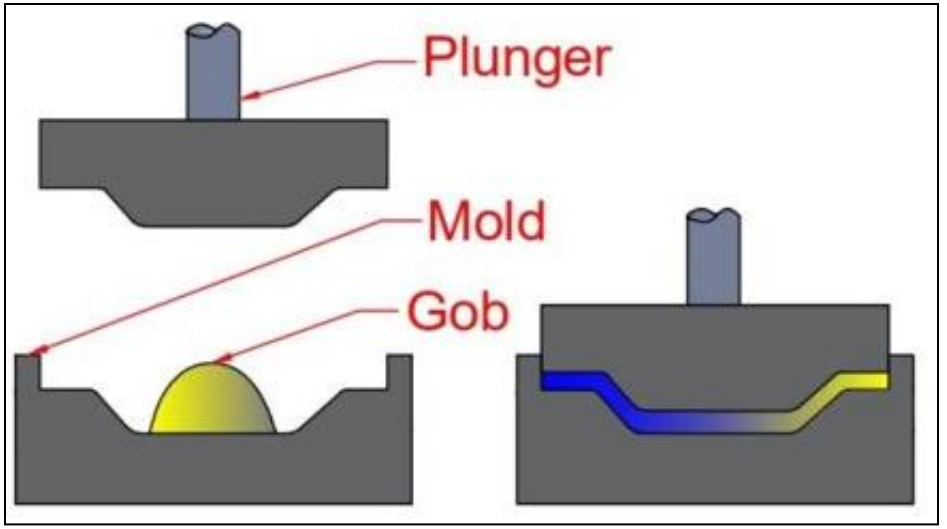
- Batch Mixing Processes: The second stage of glass manufacturing process is batch mixing, in this process, the raw material is finely powdered by the help of a grinding machine. And this process includes formers, fluxes, stabilizers and sometimes colorants according to the color required for the final product of the glasses. The materials are accurately weighed in correct proportions before they are mixed together. The fine raw materials are subsequently mixed with each other to achieve a homogenous composition after the mixing process is completed they are transferred into the melting furnace.
- Melting and Refining: The third stage of the glass manufacturing process is melting the mixed raw material in a furnace with the desired temperature. Glass is produced by heating the raw materials to an elevated temperature above which melting occurs (around 1500°C to 1600°C). The processing time took around 30 to 40 hours per charge. Homogeneity can be achieved by complete the melting and mixing of the raw ingredients. There are two types of furnace is generally used (i) Pot furnace and (ii) Tank furnace.

- Pot Furnace: A pot is a vessel made of fire-clay. This process resembles the crucible steel process. These pots are placed in specially prepared holes in the furnace. The charging and collecting doors are kept projecting outside so that raw materials may be added and molten glass may be taken out conveniently. The pots are filled with raw materials.
- Tank Furnace: It is constructed with reinforced masonry. The roof is given special shape to deflect the flames of heated gas. The ports are provided for the entry of preheated producer gas. The doors are provided for charging and for taking out the molten glass. A bridge separates the tank into two unequal compartments.

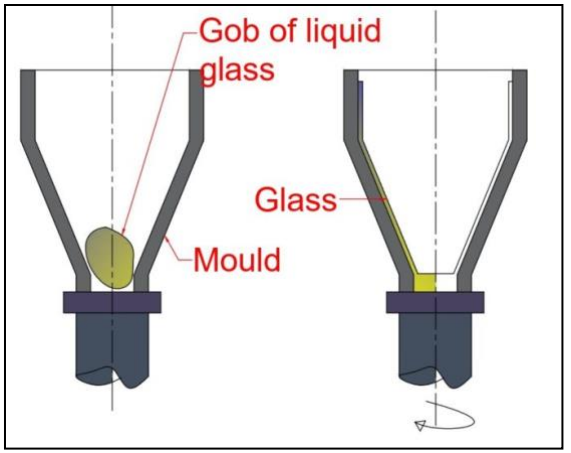
Glass Forming Processes

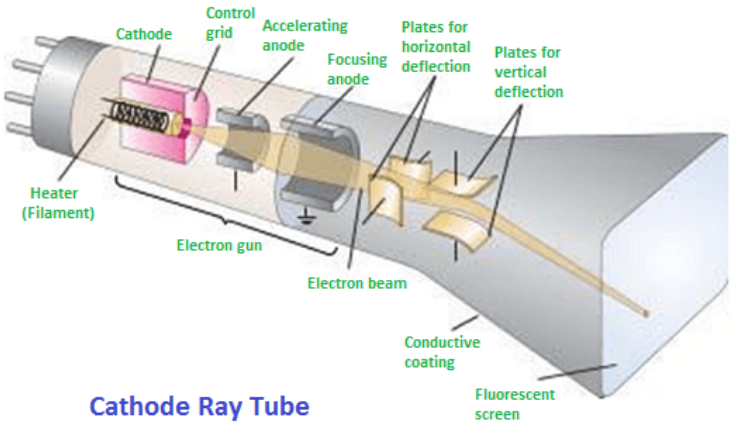
- There are six different forming shaping methods are used to fabricate glass products-
  - Pressing
  - Spinning
  - Blowing
  - Casting
  - Drawing
  - Fiber forming

- **Pressing:** Pressing is used in the fabrication of relatively thick-walled pieces like that plates and dishes. The glass piece is generally formed by pressure application in a graphite-coated cast iron mold having the desired shape; the mold is ordinarily heated to ensure an even surface.
- **Uses**: Mass production of glass pieces such as kitchen wares, headlight lenses, TV tube faceplates, and similar items are generally manufactured by pressing.

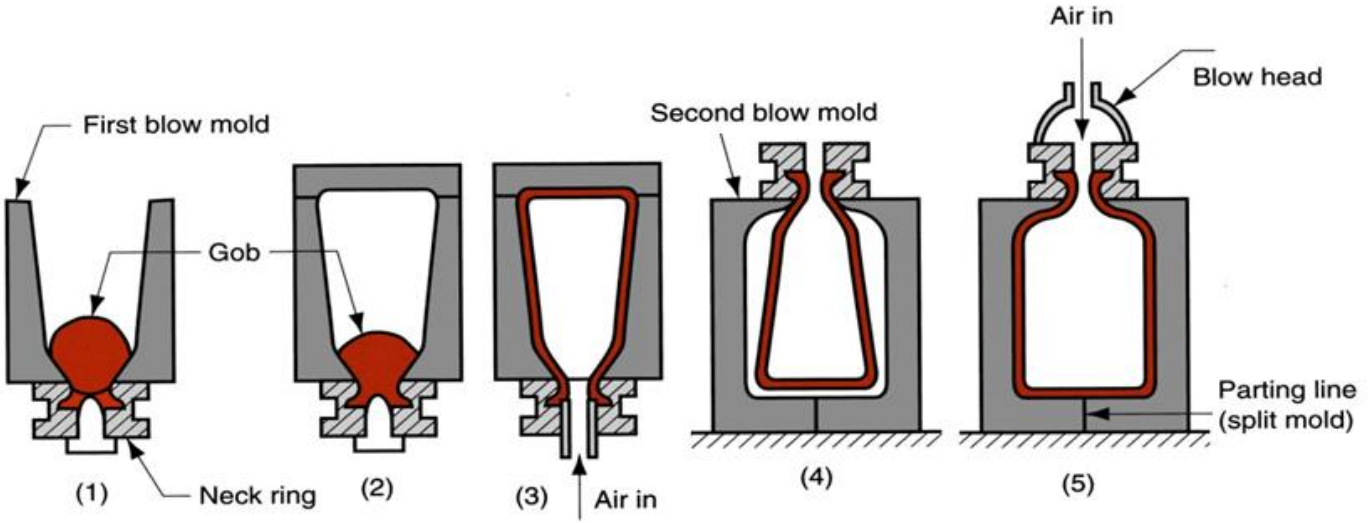


- **Spinning**: Spinning is similar to the centrifugal casting of metals. In glass-working, the term spinning replaces the conventional term of centrifugal casting. A gob of molten glass in a specified quantity is dropped in a conical mould. The mould is rotated at high speed casting centrifugal force forcing the molten glass to spread upward on the mold surface.
- **Uses**: The method is used to produce a funnel-shaped component such as the back sections of cathode-ray tubes for televisions and computer monitors, solidification progresses from the outer surface.





- **Blowing**: Glass blowing is a process to shape glass. Altho originally glass blowing used to be performed by hand, especially for art objects. Blow forming sequence: (1) gob is fed into inverted mold cavity; (2) mold is covered; (3) first blowing step; (4) partially formed piece is reoriented and transferred to second blow mold, and (5) blown to final shape
- **Uses**: The process has now been completely automated for the production of glass jars, bottles, and light bulbs which are produced in huge quantities.



- **Casting**: Casting is the method in which the molten glass when sufficiently fluid, is poured into a mold. These pieces must be cooled very slowly to avoid internal stresses and possible cracking due to temperature gradients that would otherwise be set up in the glass. After cooling and solidifying, the pieces must be finished by lapping and polishing. Casting is generally not much uses in glass working except for these kinds of special jobs.

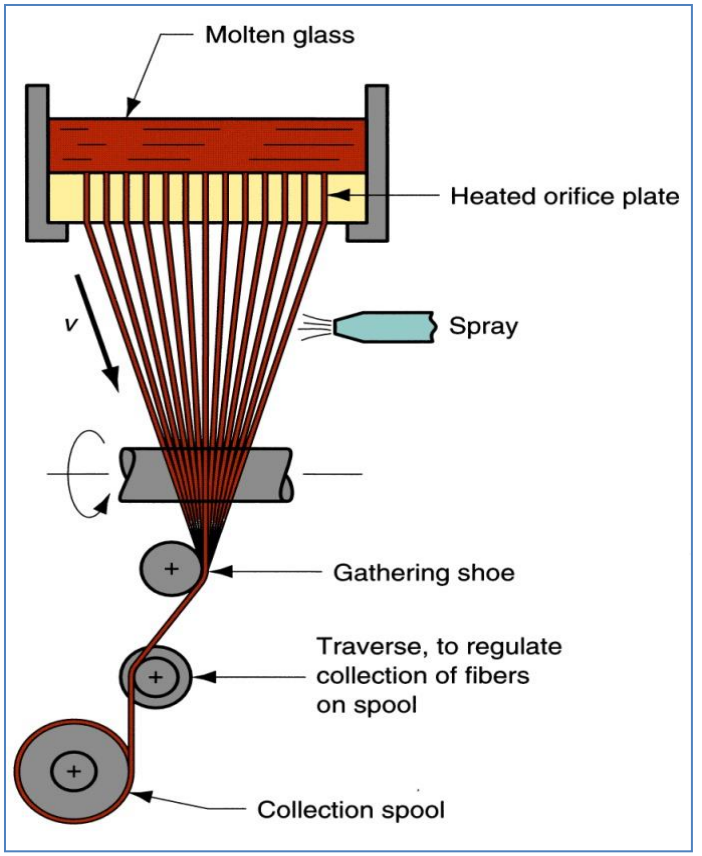
  Uses: This process is relatively massive objects, such as astronomical lenses and mirrors, are made by this method.

- **Drawing**: Drawing is an automatic process is the most practical system for the production of glass tubes with diameters from 5 to 50 mm having thin walls. On such process by which a glass tube is formed is known as the Danner process.

  Uses: Drawing is used to form long glass pieces in the form of sheet, rod, tubing, and fiber, having a constant cross-section.

- **Fiber Forming**: Fibers or filaments of glasses can be formed by drawing strands of molten glass through small apertures. Fibers of glass consist of numerous extremely fine fibers.

Uses: Glass fiber is used to make fiberglass cloth for use in reinforcing composite materials, such as e-glass fiberglass cloth. Heavier, stronger s-glass grade fiberglass cloth is used when higher tensile strength is required. Fiberglass cloth is commonly used with epoxies and resins to make stiff, high strength composites.



- **Annealing**: The last stage of the glass manufacturing process is annealing. In the time of glass forming, some air are mixed up with glass gob in the form of an air bubble. So annealing is employed to remove them.
- In this process, heating the glass to a particular temperature, keeping it there for a certain amount of time and cooling it slowly in order to remove residual internal stresses introduced during manufacture.
- The annealing of glass is a very important process because If glass particles are allowed to cool down rapidly, the superficial layer of the glass cools down first as glass is a bad conductor of heat. The interior portion remains comparatively hot and it is therefore in a state of strain. Hence, such glass particles break to pieces under very slight shocks or disturbances.
- After the glass manufacturing is completed it is inspected by the help of an automatically processes using the electronic sensors.

Types of Glass

- There are many different types of glasses with varied chemical and physical properties. A suitable adjustment of chemical compositions brings specific characteristics of the glass.
  - Commercial Glass: Commercial glass, also known as soda-lime glass is utilized in daily lives. The use is seen in the form of bottles and jars, flat glass for windows or for drinking glasses. Lime glasses are made by fusing together sand, lime or limestone, and soda-ash. Sand by itself is fused to produce glass but the temperature at which this can be achieved is about 1700°C. The melting temperature can suitably be reduced by adding other minerals and chemicals to sand.
  - High Silica Glasses: High silica glasses(containing 96% silica) are mainly used where high-temperature resistance is required, and they can be used regularly at temperatures up to about 900°C. High silica glasses have a very low thermal expansion coefficient that accounts for their high resistance to thermal shock.

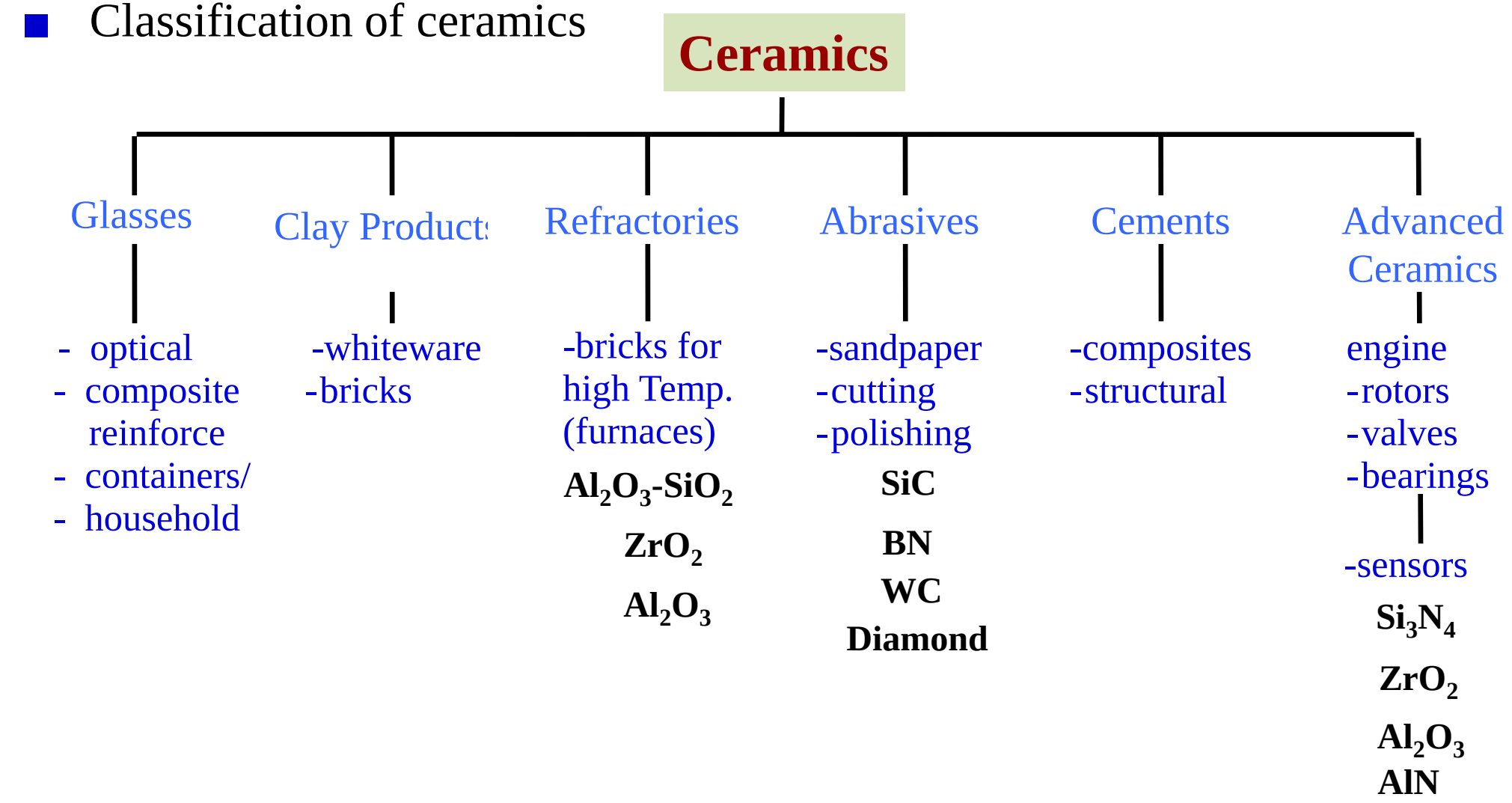
- Lead Glass: Lead glass, commonly known as the lead crystal is used to make a variety of decorative glass objects like tableware, optical purposes, neon sign tubing, and art objects because of their high luster. For windows and shields to protest personnel from X-ray radiation. It contains lead oxide instead of calcium oxide and potassium oxide instead of sodium oxide. Lead glasses have a low melting point, but they exhibit good hot workability, high electrical resistivity and high refractory indices.
- Borosilicate Glass: In borosilicate glasses, a part of silica is replaced by boric oxide which confers certain desirable properties to glasses such as thermal shock, electrical shock, and chemical stability, and it does not crack in temperature variation like other types of glasses. It is widely accepted in chemical industries, for making laboratory apparatus, ampoules, and pharmaceutical containers.

- Colored Glasses: Sometimes various substances are added to the glass fusion to obtain colored glasses. Thus, for instance, chromic oxide(Cr_2O_3) gives the glass a green color; manganese dioxide, a reddish-purple color; cobaltous oxide, a blue color, etc. In most cases, the color of the glass depends on the formation of colored silicates of iron, manganese, cobalt, etc.
- Recrystallized Glasses: Recrystallized Glass, also known as polycrystalline glass, is commonly produced by adding nucleating agents such as sodium fluoride, phosphorous pentoxide, titanium oxide or vanadium oxide into the molten glass. The glass is then formed by any of the conventional glass-forming processes and is then heat-treated to promote crystallization. Such glasses possess high hardness and impact strength and better thermal stability compared to ordinary glasses. The application of these glasses is in the manufacture of the so-called refrigerator-to oven cooking dishes.

- Fiber Glasses: Fiber glass, commonly known as glass fiber, is glass in fiber form. molten glass can be drawn through dies into fibers 2 to 10 micrometer in diameter, and is then known as fiber glass. This is not brittle as compare to ordinary glass and possesses high tensile strength. Unlike normal glass, glass fibers are almost free from surface defects and thus crack propagation under tensile loads is kept to a minimum.
- Glass Wools: Glass wools are produced by a process totally different from that of glass fiber. The molten glass is forced through some vents in the process called as a crown process by centrifugal force, forming relatively short fibers of about 0.007 mm in diameter. These are suitable for insulation.
- Foam Glasses: The foam glasses can make by introducing innumerable air cells or pores into molten glass. This on cooling becomes quite light. In fact, it floats in water as it is lighter than even cork. It is cut into required sizes and then used as heat insulating material.

Ceramics

- Classification of ceramics



- General properties of ceramics
  - Hard and high wear resistance
  - Brittle and high compressive strength
  - High elastic modulus
  - High temperature resistance
  - Good creep resistance
  - Low conductivity and low thermal expansion
  - Good chemical inertness
- Common ceramics
  - Oxides : Al_2O_3, ZrO_2
  - Nitrides : AlN, Si_3N_4, BN, TiN
  - Carbides : WC, SiC, TiC, TaC
  - Glasses : SiO_2 + others
  - Carbon : Graphite, Diamond

Whiteware Ceramics

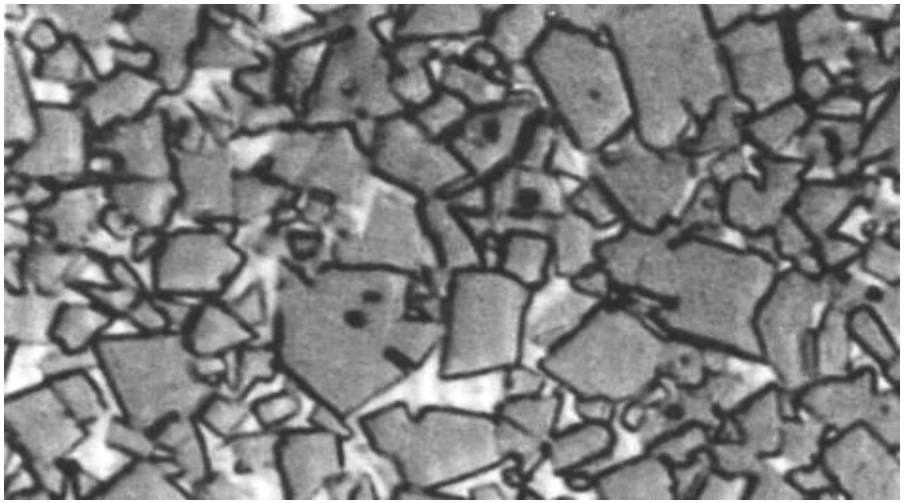
- Clay: Quartz and Feldspar
- Processing
  - Water addition, mixing
  - Air removal
  - Shaping
  - Drying
  - Coating
  - Firing
- Products
  - Brick and structural tile
  - Drain and sewer pipe
  - Decorative applications
  - Bath and kitchen structures

Glass Ceramics

- Crystalline solid
  - 0.1 to 1.0 micron grains
  - Use of nucleating agents
- Glass ceramic
  - Efficient processing in glassy state
  - Net shape process
  - Good mechanical properties versus glass
  - Low porosity
  - Low thermal expansion
  - Higher resistance to thermal shock
- Products
  - Cookware
  - Heat exchangers
  - Missile radomes

Cermets

- Combination of metals and ceramics
  - Cemented carbides
  - Bound with high temperature metal
- Properties
  - High hardness and temperature resistance
  - Improved toughness and strength
  - Improved shock resistance
- Applications
  - Crucibles and Jet nozzles
  - High temperature brakes
- Production
  - Press powder in metal mold
  - Sintering in controlled atmosphere



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