CHAPTER 8(15)

Ceramic Materials

Why study ceramics?

- Bricks
- Cement
- Concrete
- Roof tiles
- Windows
- Skylights
- Smart glass
- Glass fibers

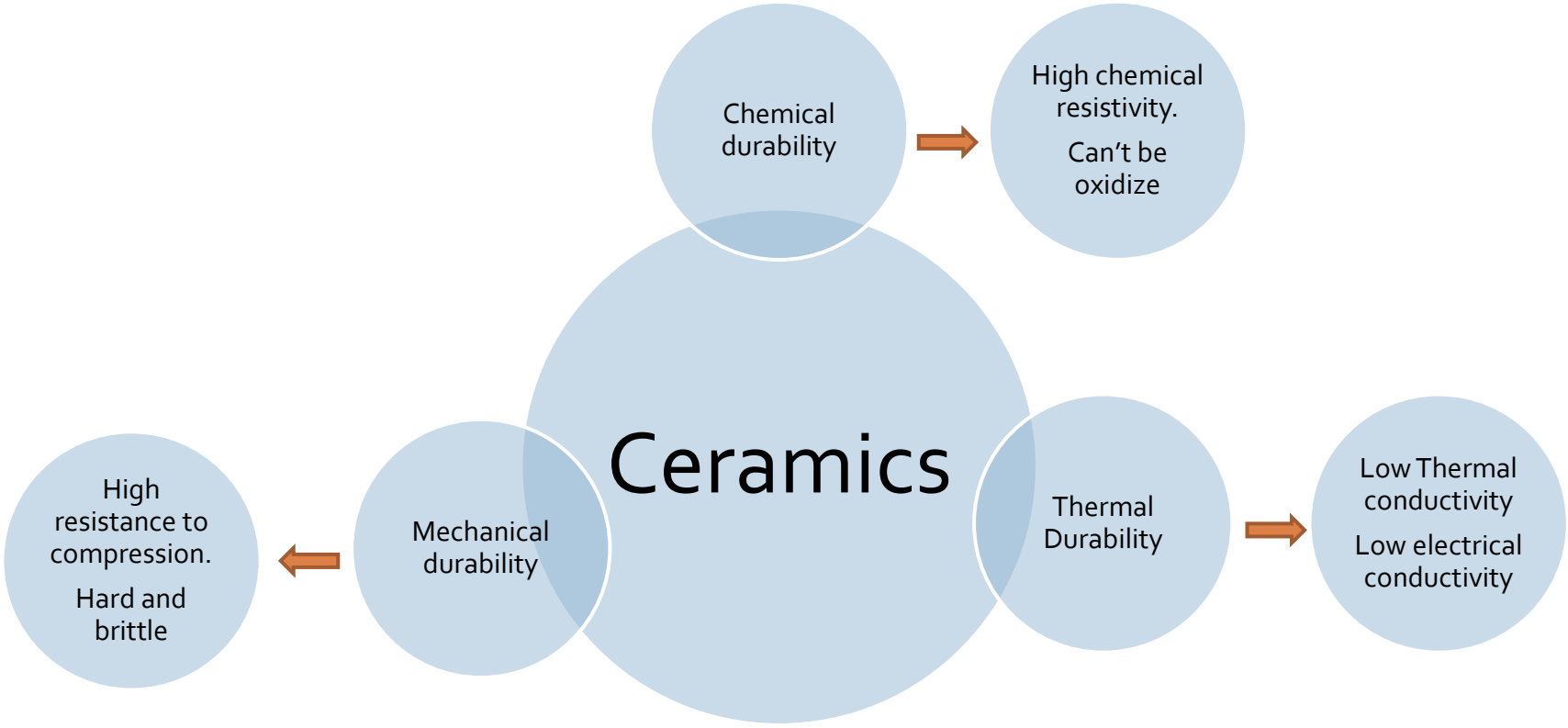
Why study ceramics?

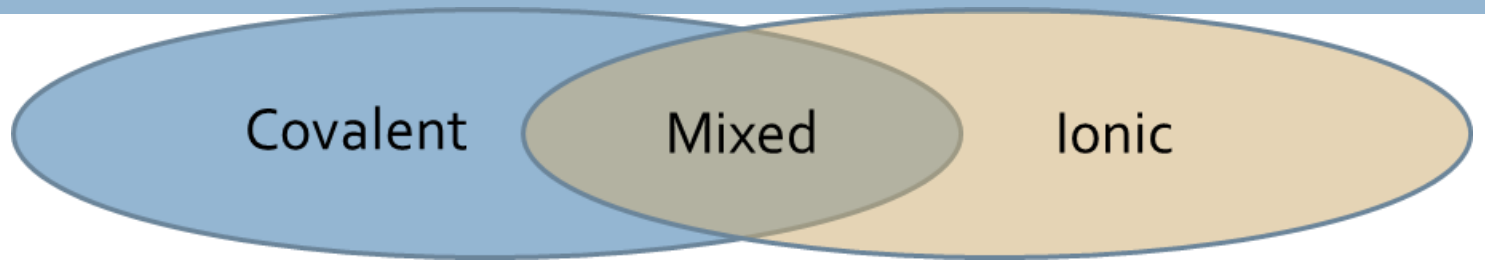
- Ceramic capacitors: Electrical charge storage, between metallic layer.
- Piezoelectric ceramics: Transform mechanical energy into electric energy or vice versa.
- Flexible glass: organic light emitting diodes (OLEDs).

What are they?

Made from inorganic materials having non-metallic properties, usually processed at a high temperature at some time during their manufacture.

Properties

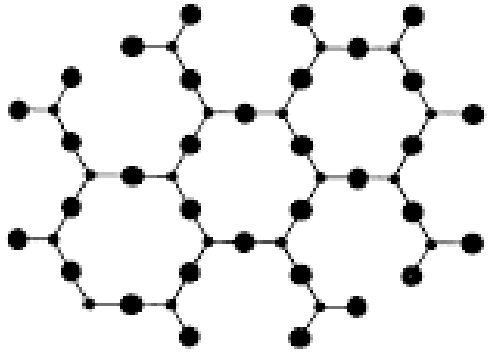

Chemical durability
High chemical resistivity.
Can't be oxidize
Ceramics
Mechanical durability
High resistance to compression.
Hard and brittle
Thermal Durability
Low Thermal conductivity
Low electrical conductivity

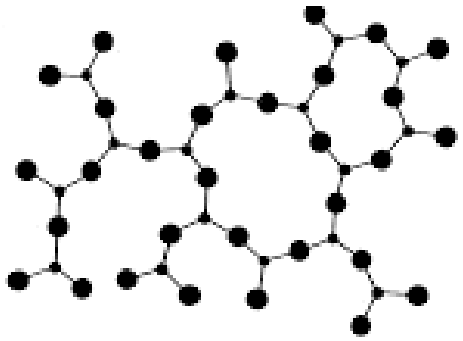


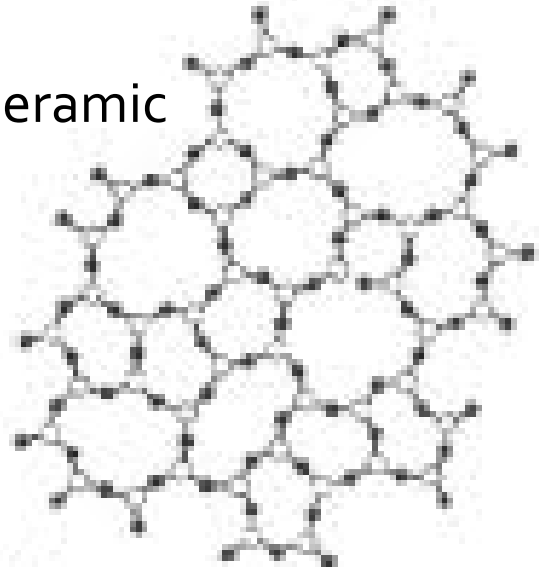
Structure

- Mostly Ionic
- Net charge of the structure should be Zero
- Few covalent ceramics

1. Crystalline: Ceramic
2. Amorphous: Glass
3. Crystalline process from amorphous: Glass Ceramic







Classification based on chemical composition

Oxides based

Silicate and non-silicate oxide ceramics (alumina,zirconia, etc)

Non-oxides

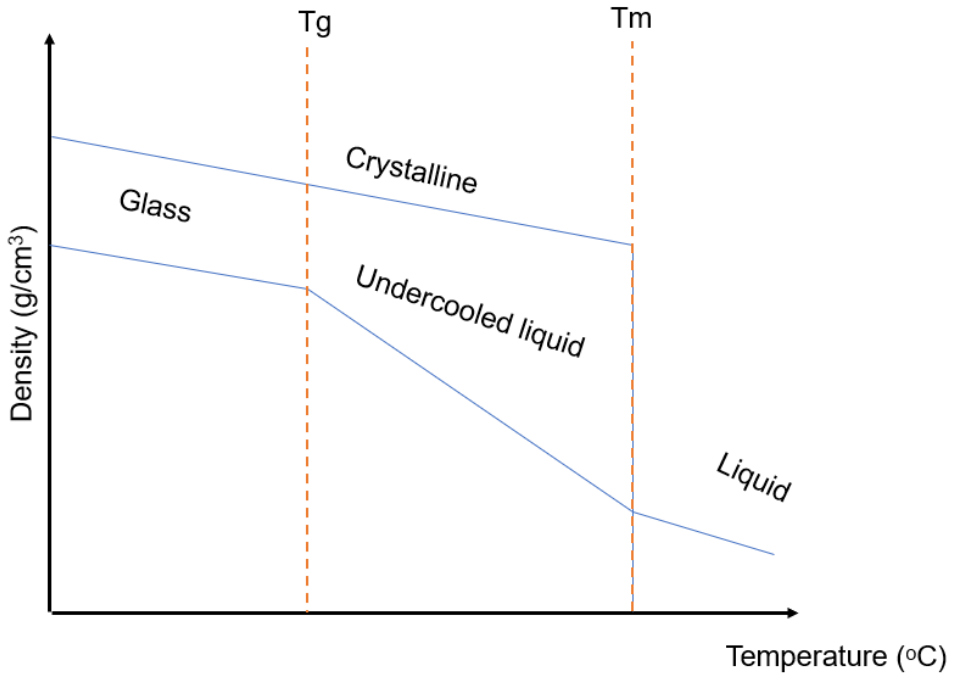
Carbides, borides, nitrides, silicides

Composites

Particulate reinforced, combinations of oxides/nonoxides.

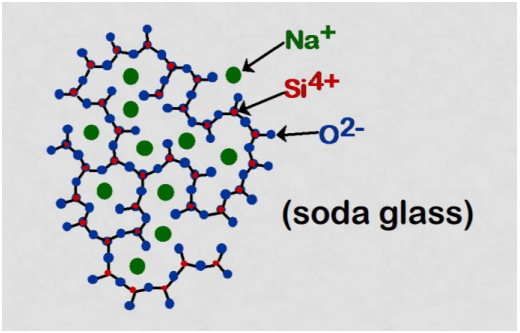
Glass

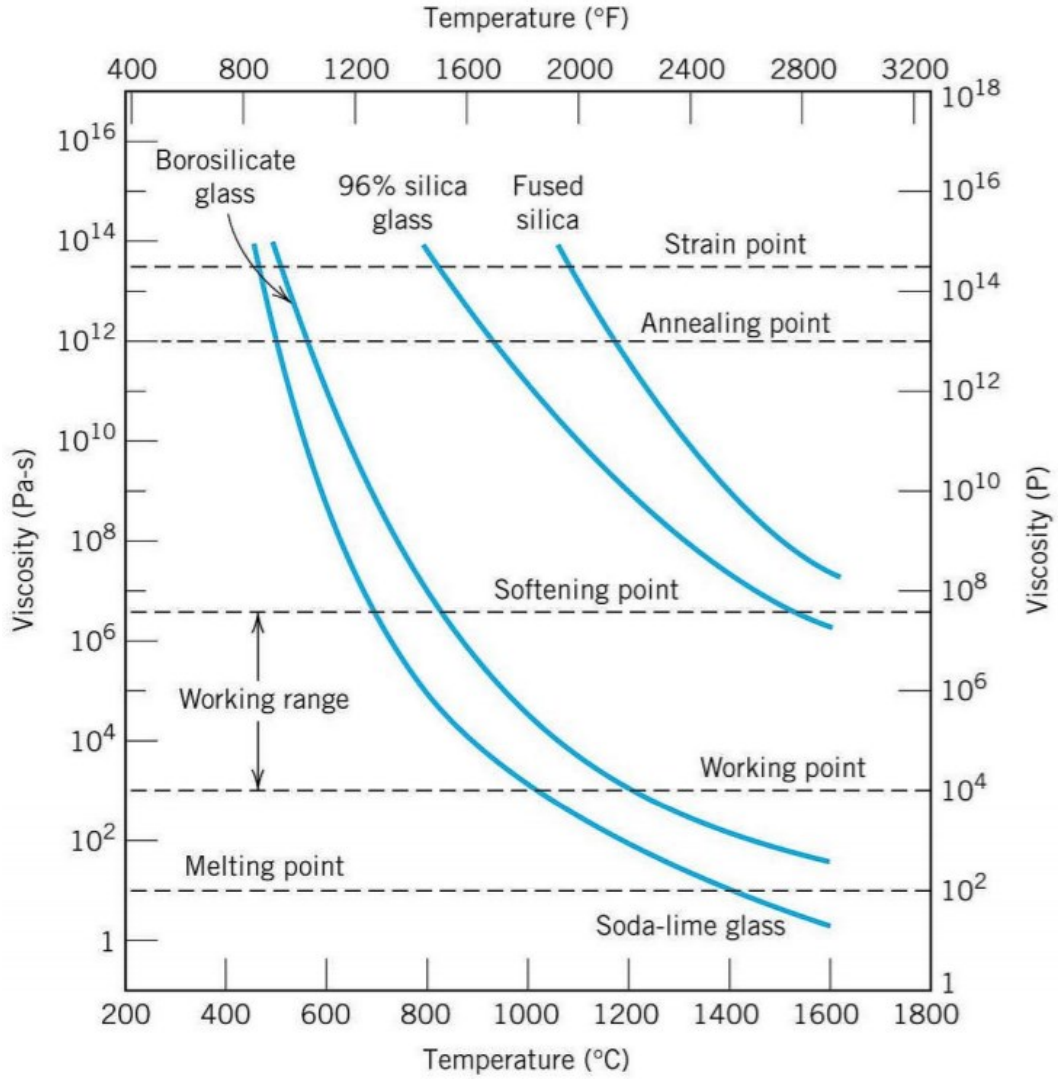
- Inorganic Glasses: Metastable material that has hardened and become rigid. However, the structure is not organized due to impurities.



Tg: Glass temperature (not fixed)
Tm: Crystalline temperature

Silica (SiO2) behaves this way





Glass properties: Viscosity

- Melting point: viscosity = 100 P, above this temperature glass is liquid
- Working point: viscosity = 10^4 P, glass is easily deformed
- Softening point: viscosity = $4x10^7$ P, maximum T at which a glass piece maintains shape for a long time
- Annealing point: viscosity = 10^{13} P, relax internal stresses (diffusion)
- Strain point: viscosity = $3x10^{14}$ P, above this viscosity, fracture occurs before plastic deformation

Glass forming operations - between softening and working points

Glass properties

Mechanical Properties

- Brittle
- Low Weibull modulus
- Low mechanical strength

Electrical properties

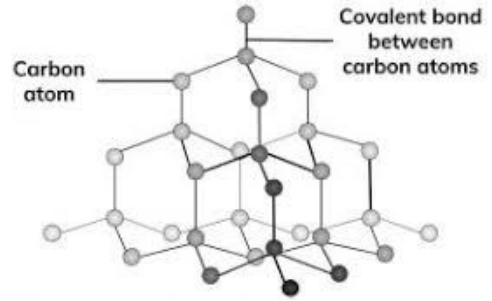
- Low conductivity.

Thermal properties

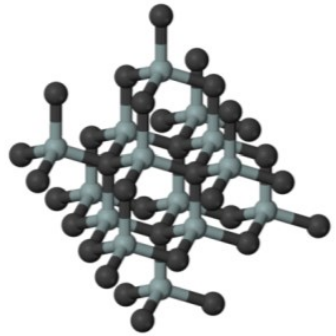
- Low Thermal conductivity
- Low Thermal shock

Covalent ceramics

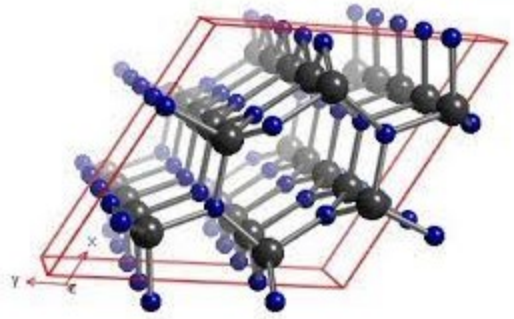
- Diamonds



Spherulite (SiC)



Silicon Nitrate



Applications

- Glass: optical, containment
- Clay products: Whiteware, bricks
- Abrasives: Cutting, polishing
- Cements: Composites, structural
- Advanced ceramics: sensors, bearings, rotors