INTRODUCTION TO CERAMICS, GLASS AND REFRACTORIES

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5) Ceramic Powders

Ceramic Powder Preparation

Preparation methods

Mechanical Method

Natural Minerals

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Crushing (to 5 mm)

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Grinding (to 1 mm)

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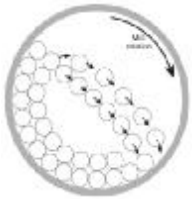

Ball Milling (to 0.5 – 10 µm)

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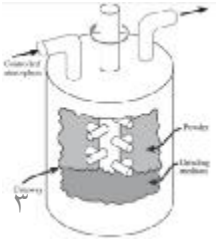

Attrition Milling (to 0.1 – 5µ)

Chemical Method

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Sol-gel Processing

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1)Control on Particle Morphology
2)Purity
3) ≤ 0.1µ

Vapour Phase

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Materials Evaporation-Condensation

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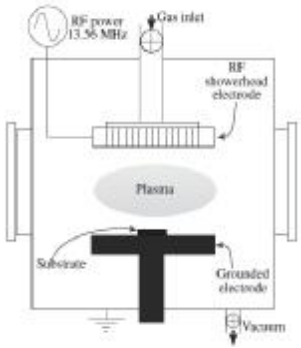
1)Very Expensive
2)High Purity
3)Nano-Particle (10^{-9}m)



Types of Particles: It is important to be able to distinguish between different types of particles.

•**Primary Particle:** discrete low porosity unit (0.1 – 1.0 μ) it may be a single crystal, a multi-phase polycrystalline, a multi phase polycrystalline, amorphous or a glass. The pores are isolated from each other.

•**Agglomerate:** small mass of bonded primary particles having a network of interconnected pores.

- *Hard agglomerate:* solid bridges between particles due to sintering, fusion or chemical reaction.
- *Soft Agglomerate:* Particles are connected by surface force such as electrostatic.

•**Particle:** Measured by particle size measuring techniques, can be primary, agglomerate or a mixture.

•**Granule:** Large soft agglomerate for example the product from a spray drier.

•**Colloid:** Small particle less than 1μ dispersed in a fluid and maintained in suspension by Brownian motion.

•**Floc:** Clumped of colloidal particles in liquid suspension.

Powder requirements for high quality ceramic microstructure:

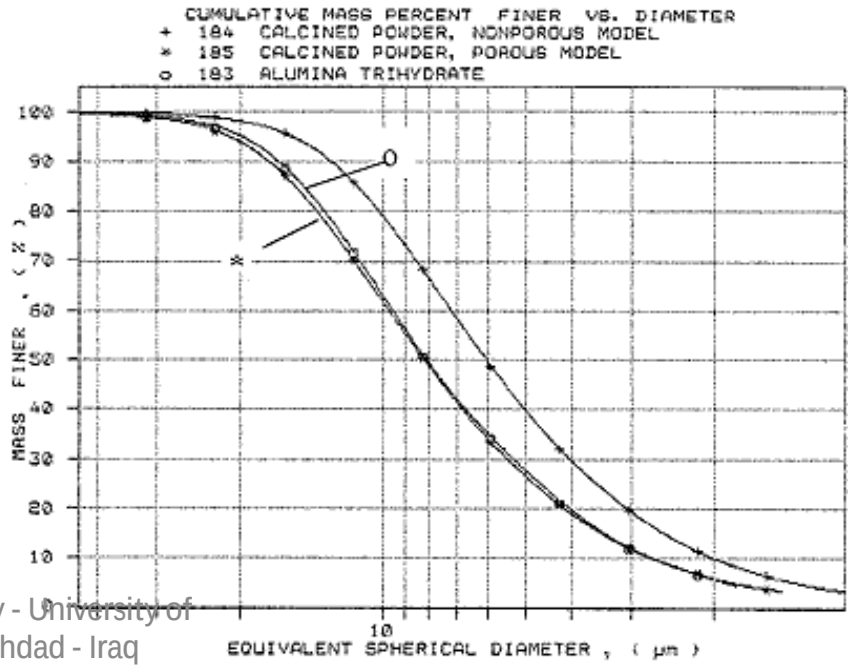
•**Mean size:** Less than 10μ; less than 0.5μ better to control sintering rate since; **ΔL/L** proportional to $\mathbf{d^{-n}}$ where **ΔL/L** is the linear shrinkage (sintering)**, d** grain size and **n** is a factor

•**Particle size distribution**: Determine packing density and sintering behaviour. Mostly large particles and sufficiently small particles to fill in the interspaces will result in compact of high green density.

. Shape: Shape of particles such as elongated or spherical influence packing density & powder flowability

•**Homogeneity:** agglomerates may result in non homogenised microstructure

•**Purity:** impurities may cause a precipitation of another phase at grain boundaries which reduce strength and decrease creep resistance. Inclusions act as a flaw and for different thermal expansion cause microcracking.



Preconsolidation and Additives

The desired powder is compacted into final shape by various forming techniques such as pressing, slip casting, injection moulding, extrusion and then strongly bonded and densified. A uniform compact having uniform properties and no distortion is required. Depending on specific forming method the powder requires special treatments or processing and various additives prior to compaction and densification.

Binders: are added to provide enough strength in the "green" body to permit handling and machining.

Dispersing agents: To control **pH** of slurries and provide particle surface charge and particle-particle repulsion.

Plasticizers: Rheological aid, improve flexibility of binder film, allow plastic deformation of granules.

Wetting agents: reducing of surface tension

Lubricants: To decrease particle-particle and particle-tool friction during compaction

Sintering aids: To aid densification

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