

Dental Ceramics



-Dr Naveen D.N

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Introduction

- Ceramic was probably the first material to be artificially made by humans, and has held the attention of dental profession for more than 200 yrs.
- Ceramics, metals, polymers, and composites are used in dentistry to restore teeth.
- Ceramics are characterized by their esthetics, hardness, thermal and electrical insulation and biocompatibility.

- Ceramics have been used from the medieval period.
- Down the ages, they have undergone tremendous transformations.
- These transformations have improved their application in various areas of restorative dentistry.
- To this day, **Ceramics** in their various forms remain the workhorse of restorative dental practice.

Definition

- "Ceramic" is derived from Greek words

  "Keramikos" = Earthen

  "Keramos" = Burnt stuff.

- Ceramics are defined as compounds of one or more metals with a non metallic element (usually silicon, boron, oxygen) that may be used as a single structural component or as one of the several layers that are used in the fabrication of a ceramic based prosthesis.

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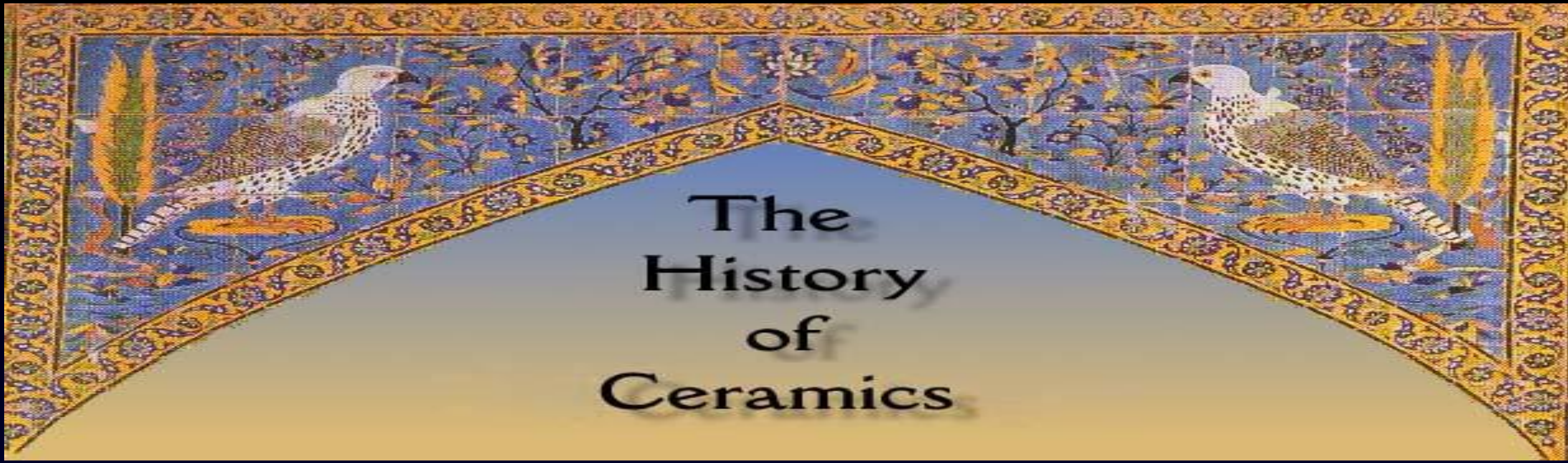
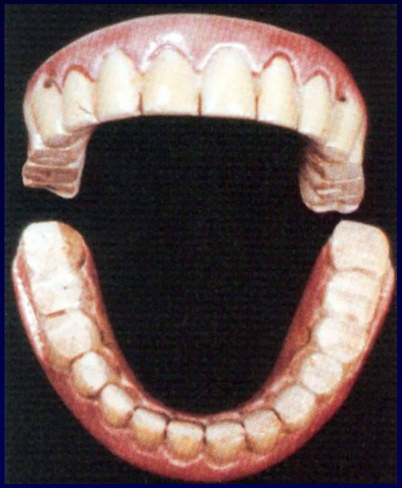


Ceramic paintings and Vases



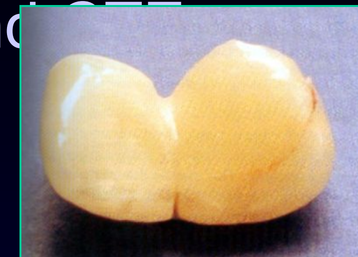
Denture teeth
&
Dentures -Duchateau 1789

History

- 700 BC – **Etruscans** – teeth of ivory & bone held in gold framework
- 1728 - **Pierre Fauchard**, French Dentist first proposed the use of porcelain in dentistry
- 1789 - **First porcelain tooth** material patented by a French dentist – **De Chemant** in collaboration with a French Pharmacist – **Duchateau** .

- 1817 - Introduction of porcelain teeth to the United States by a French Dentist, **Planteau**
- 1822 - Development of baking process in Philadelphia by Peale
- 1825 - Commercial production of these teeth began by **Stockton**
- 1839 - Invention of Vulcanized rubber allowed porcelain denture teeth to be used effectively in a denture base
- 1903 - **Dr. Charles Land** developed the first ceramic crown

- 1962– **Weinstein & Weinstein** – Feldspathic porcelains that allowed control of sintering temperature and CTE



- 1963 - Development of 1st commercial porcelain by Vita Zahnfabric
- 1965 - Significant improvement in the fracture resistance of porcelain by McLean and Hughes
- 1980 - **Pressable glass ceramic (IPS empress)** containing 34 vo1% leucite, and Zr ceramics introduced
- 1983 - **First dental CAD/CAM**

- 1984 - **Dicor** developed by Adair and Grossman
- 1986 -1st generation **CEREC 1** (Siemens CAD CAM)
- 1989 - Concept of **all ceramic post and core** introduced
- Late 1990's - **IPS empress 2** a second generation pressable ceramic made from Lithium – disilicate framework with a apatite layered ceramic
- Early 1992's - **Celay copy milling** system commercially available.
- 1994 - 2nd generation **CEREC 2 CAD/CAM**

CLASSIFICATION

- According to **Indications** (PHILLIPS)
- Ceramics for Artificial teeth
- For crowns & inlays
- Anterior Bridge porcelain
    - Posterior bridges
- Posts & cores
- Stain ceramic
- Glaze ceramic

- Based on **Translucency**
  - Opaque
  - Translucent
  - Transparent

- **According to the firing temperatures**
  - High fusing – more than 1300°C
  - Medium fusing - 1101 – 1300°C
  - Low fusing - 850 – 1100°C
  - Ultra low fusing – less than 850°C

High fusing:

- Minimizing the additives such as sodium or potassium,
- Maximizing the silicate cross links.
- Low solubility, high strength and high stability.
- Hardness exceeds enamel by 30%.

Medium fusing & Low fusing:

- Increasing the amount of additives in porcelain, reducing no.of   crosslinks within the silicate network
- Slightly weaker and less stable than high fusing
- Fired under vacuum.

- **Based on Application**
- Opaque porcelain
- Body porcelain
- Enamel porcelain
- **According to Firing Technique**
- Air fired (at atmospheric pressure)
- Vacuum fired (at reduced pressure)
- Diffusible gas firing

- **According to method of fabrication**

1. **Conventional Powder and slurry ceramics**
    - Alumina reinforced porcelain : Hi-ceram
    - Magnesia reinforced porcelain : Magnesia cores.
    - Leucite reinforced (high strength) : Optec HSP.
    - Zirconia reinforced : Mirage II.

2. **Castable ceramics - Dicor**

3) **Machinable ceramics** - Digital systems (CAD/CAM)

4. Pressable ceramics

- By pressure molding and sintering

    1. Shrink free alumina reinforced ceramic

        Cerestore/Alceram

    2. Leucite reinforced ceramic

        IPS empress, IPS empress 2 , Optec OPC

5.Infiltrated ceramics

- Alumina based - Inceram alumina
- Spinel based - Inceram spinel
- Zirconia based - Inceram zirconia

- **<u>According to substructure or core material as</u>**

A. Metal ceramic systems

Cast metal ceramics –Vita Metal Keranuk

Non-cast metal systems (foil crown system)

B. All ceramic systems

General properties of ceramics

1. **Biological properties :**

- Relatively inert, chemically stable & corrosion resistant which renders it highly biocompatible .
- Its ability to attain highly smooth & polished surfaces doesn't allow plaque accumulation.

2. **Chemical properties** :

  - It resist attack by chemicals.

- The solubility is extremely low and is probably the most resistant material to attack by oral fluids.

3.Mechanical properties :

Property	Value
Flexure Strength	Ground-75.8 Mpa(11,000psi) Glazed141.1Mpa(20,465psi)
Compressive Strength	331Mpa(48,000psi)
Tensile Strength(low)	34 Mpa(5000psi)
Shear strength(low)	110 Mpa(16,000psi)
Modulus of elasticity(high)	60-70 Mpa(10x106 psi)
Surface hardness	460KHN

Property	Value
Coefficient of thermal expansion	$12 \times 10^{-6} /^0C$
Thermal conductivity	$0.0050^0C/cm$
Specific gravity Refractive index	2.2-2.3(true value 2.4) 1.52 to 1.54

4. **Thermal properties :**

-They have insulating capacity.

5. **Optical properties** :

-They have good optical properties

-life like translucency

- Opaque porcelain - very low translucency to mask color of underlying metal
- Body – 20-35%
- Incisal- 45-50%.
- Inorder to match the fluorescence of porcelain to that of enamel – Uranium oxide/cerium oxide are added.

ADVANTAGES

- ✔ Good esthetic qualities
- ✔ High hardness
- ✔ High compressive strength - 50,000 psi
- ✔ Excellent biocompatibility
- ✔ Relatively inert.
- ✔ Chemically stable & Corrosion resistant.
- ✔ Conducive to gingival health – as it prevents plaque accumulation.

DISADVANTAGES

- Porcelain is extremely hard material and causes excessive wear of the opposing natural tooth structure or the restorative material.
- Very brittle – ceramic is inherently fragile in tension.
- Tensile strength is low
- The shear strength is low because of lack of ductility in the material.

- Voids and blebs greatly reduce the strength and specific gravity
- More tooth reduction.
- Technique sensitive.
- Specialized training required & Expensive equipment required.
- Difficult to repair if fails.

Indications for ceramics:

•Veneers - Esthetic alternative to discolored teeth..

Congenital anomalies

- Inlays
- Onlays
- Abutment retainers
- Denture tooth materials.
- Orthodontics as ceramic brackets.

Composition

1. Feldspar – Basic glass former
2. Kaolin (China clay) – Binder
3. Silica (Quartz) – Filler
4. Water – Important glass modifier
5. Fluxes – Glass modifiers
6. Colour pigments
7. Opacifying agents
8. Stains and colour modifiers
9. Fluorescent agents
10. Glazes and Add-on porcelain

- Dental porcelains are to a large extent, glassy materials.
- Glasses are supercooled liquids – vitrification
- Principal anion present in glass is oxygen anion – which form stable bonds with small multivalent cations such as Si,B,P.
- These ions are called glass formers.
- Dental ceramics - Silicon & Boron oxide - Principal network

Composition of Dental Porcelain

Component		Function
Feldspar	60-80%	• Basic glass former
Kaolin(China clay)	3-5%	Binder
Silica(Quartz)	15-25%	•Filler Unchanged at the usual firing temperatures : stability to the mass during heating. Provides strength and hardness
Alumina	8-20%	Glass former
Boric oxide	2-7%	Glass former and fluxes
Oxides of Na, K and Ca Metallic pigments	9-15% Less than 1%	Fluxes or glass modifiers Color matching

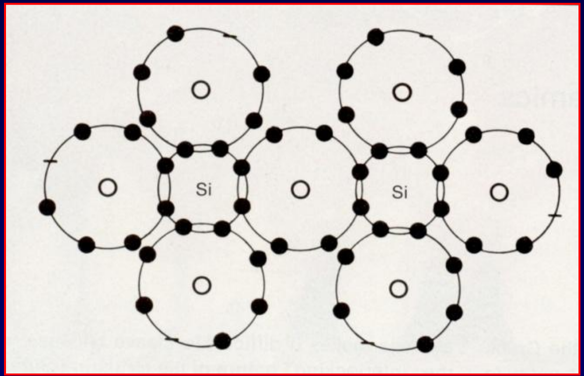
Feldspar:

- It is the basic glass former
- During firing, feldspar fuses and acts as a matrix and binds silica and kaolin.
- When it is mixed with metal oxides and fired at high temperatures, it can form a glass phase that is able to soften and flow slightly. Because of this, the porcelain powder particles coalesce together.
- The process by which the particles coalesce is called liquid phase sintering

- Dental purposes –K based feldspar
- 1.Increased resistance to pyroplastic flow
- 2. Increased viscosity

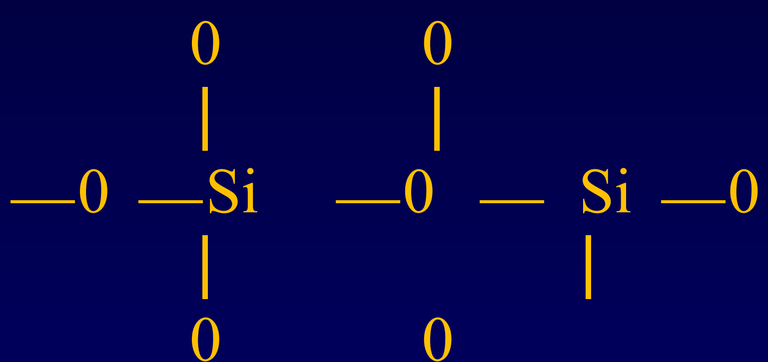
Silica: Strengthener

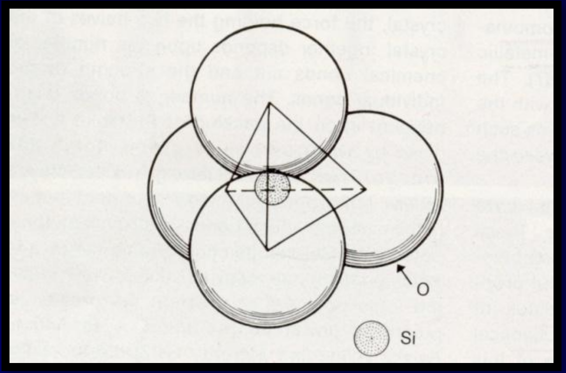
- **Strength, firmness and greater translucency**
- Pure quartz crystals (SiO_2) are used in dental porcelains.
- Silica remains unchanged at temperature normally used in firing porcelain and this contributes stability to the mass during heating by providing a framework for other ingredients.



It can exist in four different forms.

- Crystalline quartz
- Crystalline cristobalite
- Crystalline tridymite
- Non-crystalline fused silica





Kaolin (White China Clay) : Binder

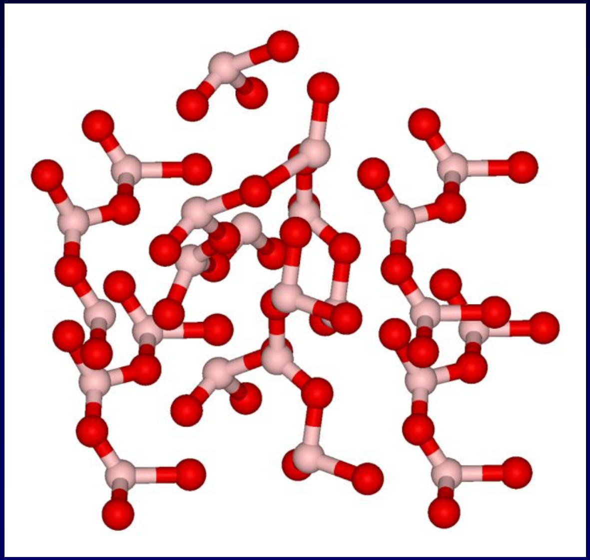
- When mixed with water, it forms a sticky mass, which allows the unfired porcelain to be easily worked and molded.
- On heating, it reacts limitedly with feldspar & the limited reaction provides rigidity
- And also adheres to quartz framework, shrinks during firing.
- Drawback :-white in color – decreases translucency of porcelain. Hence used in small conc: 4-5%

Glass formers

- Silicone & boron oxides are used to form the principle glass network.

Boron oxide fluxes

- Powerful flux (Glass modifier)
- Can also act as a glass former & forms its own glass network- Boron glasses



Glass Modifiers (Flux): *Oxides of Na, K & Ca*

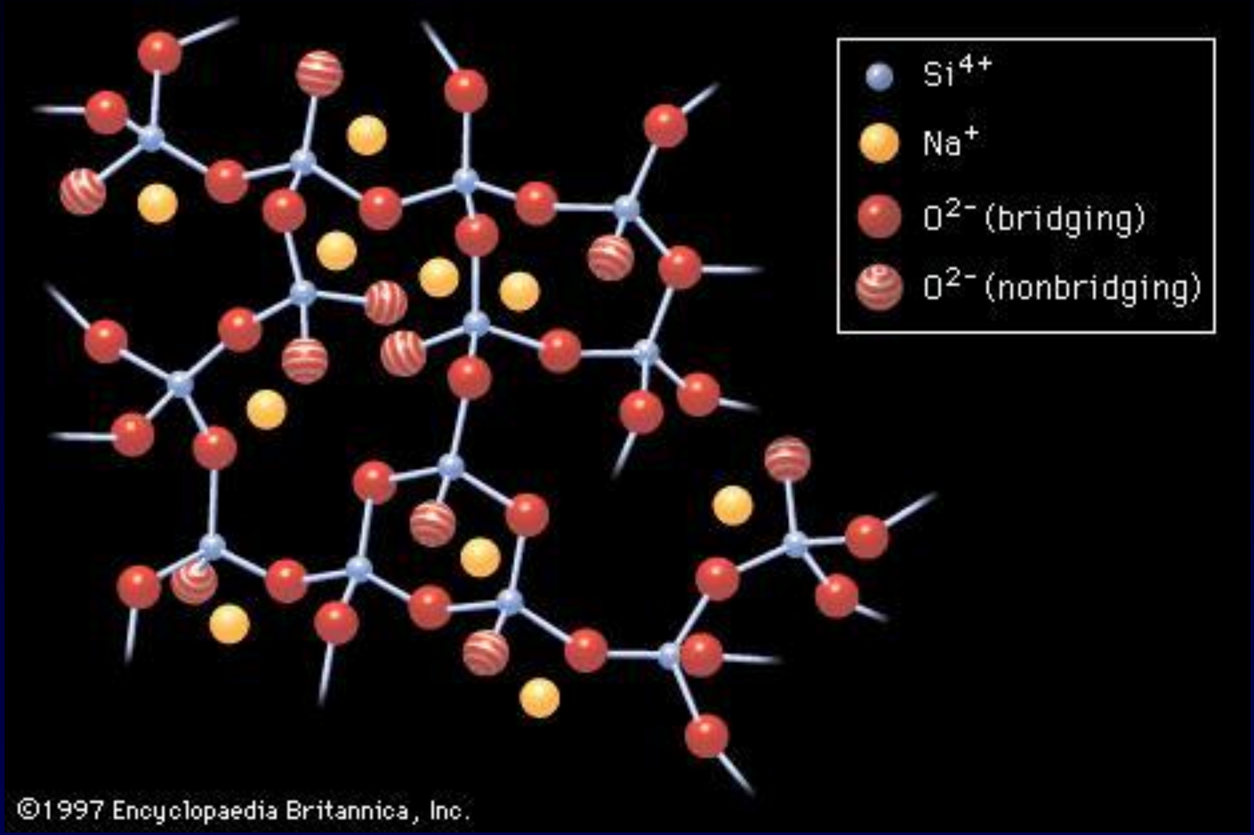
Elements that interfere with the integrity of the SiO_2 (glass) network and alter their 3 dimensional state.

Functions:

- To decrease the softening point.
- To decrease viscosity

Higher concentration of glass modifiers

- Devitrification due to disruption of too many tetrahedral networks



Si4+
Na+
O2- (bridging)
O2- (nonbridging)
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Alumina:

- The α form is used in ceramics and generally ball milled as powder below 10-20μ in size.
- It replaces some silica in glass matrix.
- It gives strength and opacity to the porcelain.
- It alters the softening point and increases the viscosity of porcelain during firing.

Coloring agents

- Pigmenting or coloring oxides are added to obtain various shades that are needed to create a natural teeth appearance.
- These pigments, generally metal oxides, are added to the glass used for porcelain manufacture and are then subjected to the fritting process. The frit so obtained is highly color concentrated.
- These colored glasses are then finely ground and blended with the unpigmented porcelain powder to obtain the proper hue and chroma.

Different coloring pigments used in dental porcelain.

* Ferric oxides -Grey
* Chromium oxide, Ca oxide -Green
* Cobalt salts -Blue.
* Ferric oxides, Ni Oxide -Brown
* Titanium oxide -Yellowish brown.
* Mn oxide -Lavender
* Indium - Yellow/Ivory

Opacifying agents :

Consists of metal oxide ground to a very fine particle size to prevent speckled appearance of porcelain.

- Ceresin oxide
- Ti oxide.
- Sn oxide
- ZrO_2 –most popularly used opacifying agent

Stains:

- Stains are generally low fusing colored porcelains used to imitate markings like enamel crack lines, calcification spots, fluoresced areas etc.
- These are also called as surface colorants or characterization porcelain.
- Stains in finely powdered form are mixed with H_2O or glycerin
- Wet mix is applied, with brush either on to the surface of porcelain before glazing.

Glazes

Glazes are low fusing uncolored glass powders that are applied on the surface of a porcelain restoration & fired at a maturing temperature lower than that of the restoration to produce a transparent glossy layer on the surface

Purpose of glazing :

- To seal the open pores on the surface of a porcelain
- To impart an impervious smooth surface and develop greater translucency in the porcelain restorations

Self glaze

After all the constituents of the porcelain have completely melted to form a single phase glass, the porcelain is further heated to reach glazing point at which the surface becomes plastic & flows to form a shiny continuous surface.

Add-on glazes

- Are uncolored glasses whose fusing temperature have been lowered by the addition of glass modifiers.
- Disadvantages of add-on glazes are its low chemical durability & difficult to apply evenly.

METHODS

TO

STRENGTHEN PORCELAIN

Methods of strengthening porcelain

Introduction of residual compressive stresses into the surface of the material

- Ion exchange
- Thermal tempering
- Thermal expansion coefficient mismatch
- Polishing

Interruption of crack propagation

- Dispersion of a crystalline phase
- Transformational toughening
- Hydrothermal porcelain

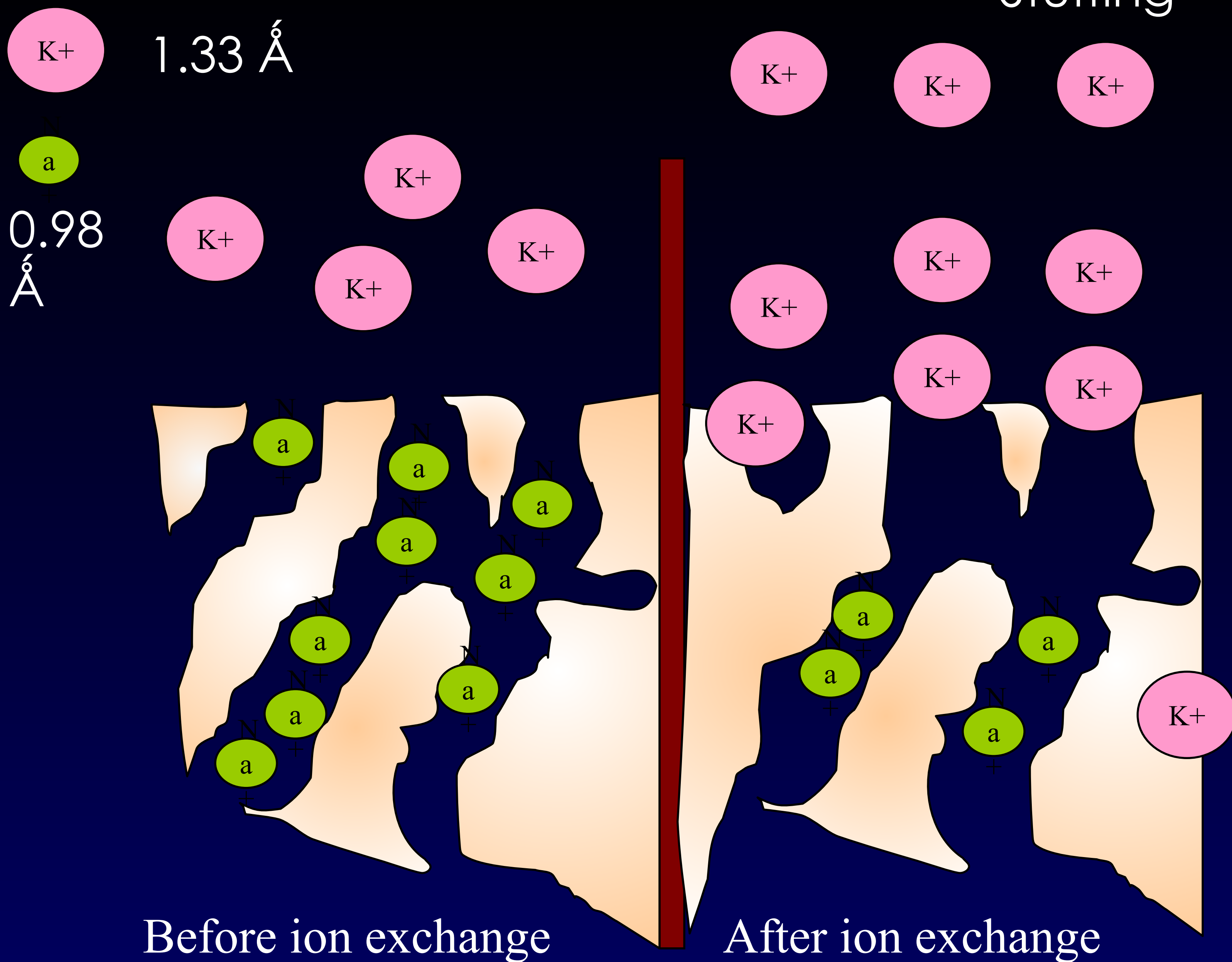
Ion exchange mechanism :

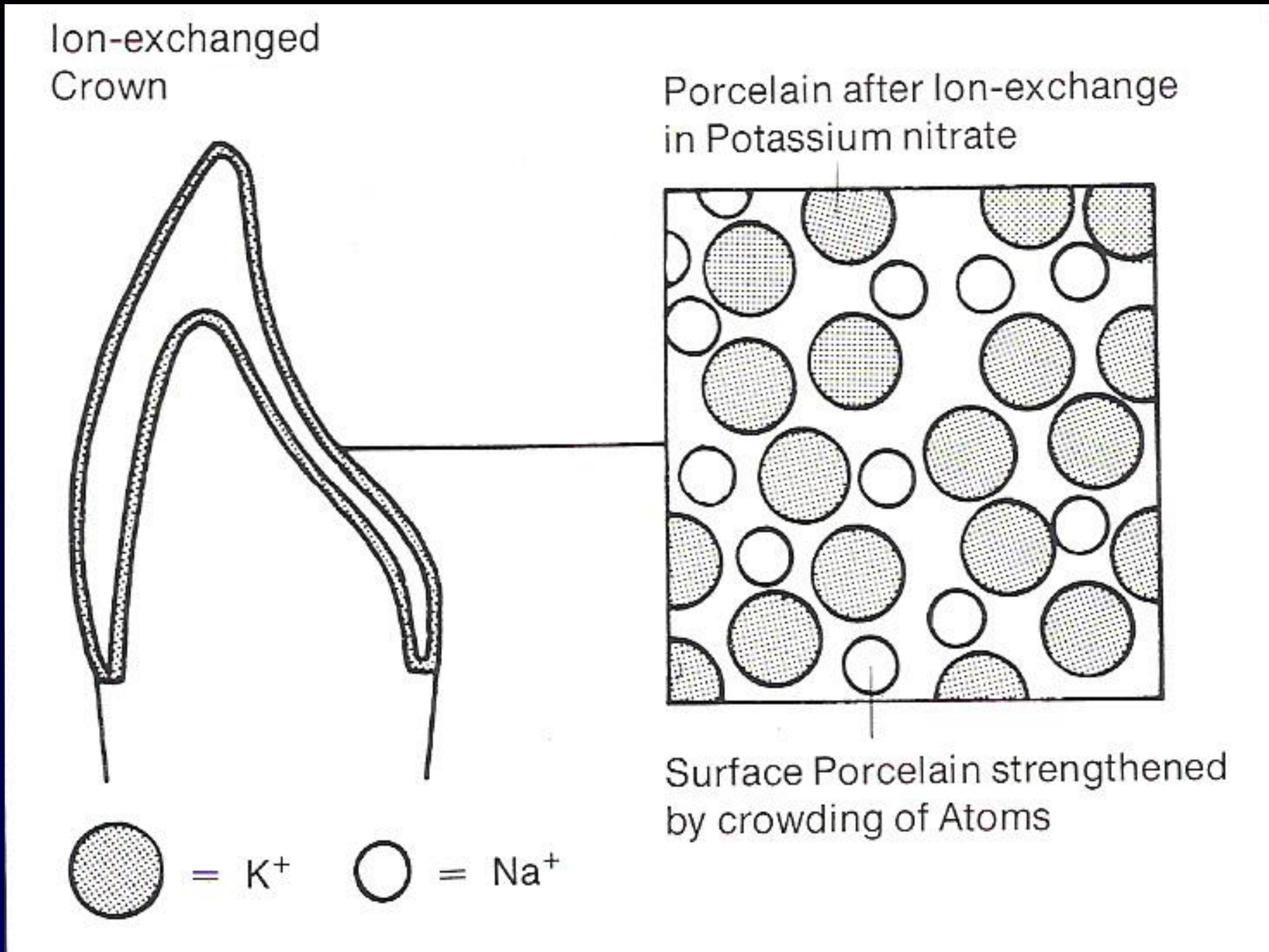
- This technique is called as ***chemical tempering*** and is the most sophisticated and effective way of introducing residual compressive stresses.

- In this procedure a sodium containing glass is placed in a bath of molten potassium nitrate, potassium ions in the bath exchange places with some of the sodium ions in the surface of the glass particle.

- The potassium ion is about 35% larger than the sodium ion.

Stuffing

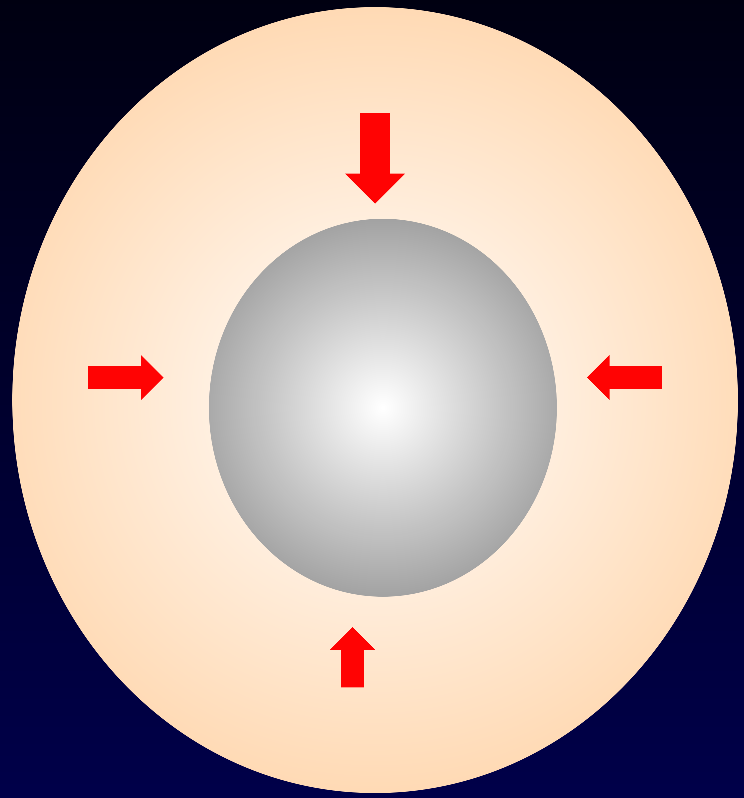



Ion-exchanged Crown
Porcelain after Ion-exchange in Potassium nitrate
Surface Porcelain strengthened by crowding of Atoms
= K+
= Na+

Thermal Tempering:

- This is the most common method of strengthening glass.
- This creates residual surface compressive stresses by rapidly cooling (quenching) the surface of the object while it is hot and in the softened state.
- This rapid cooling produces a skin of rigid glass surrounding a soft molten core.
- As the molten core solidifies, it tends to shrink, but the outer skin remains rigid.
- The pull of the solidifying molten core, as it shrinks, creates residual tensile stresses in the core and residual compressive stresses within the outer surface

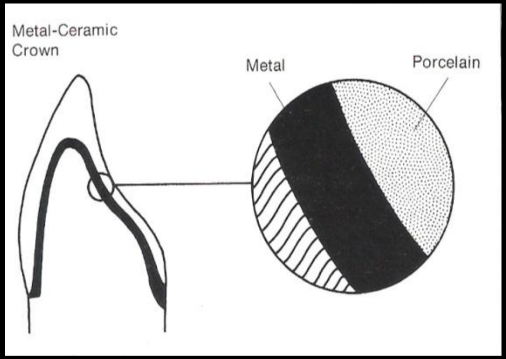
Thermal Tempering:



Quench hot molten glass in silicone oils or other liquids so as to

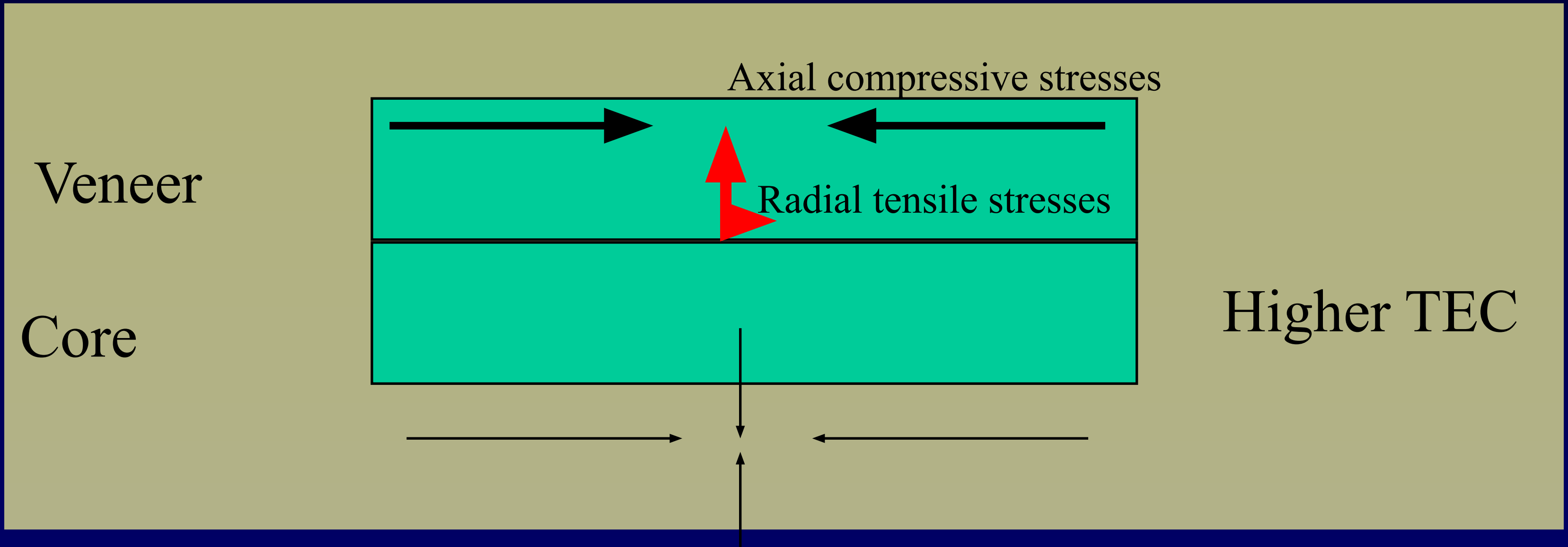
uniformly cool the surface

Thermal Coefficient Mismatch



- TEC alloy > TEC porcelain
- Core shrinks more putting veneer in compression
- Difference not > 0.5-1 ppm/˚C

• This mismatch leaves the porcelain in residual compression.



Polishing

Advantage:

- Reduces the surface flaws.
- Dramatically increases the strength by 50-100%

Shofu or Soflex finishing disks-Reglazing .

Disruption of crack propagation

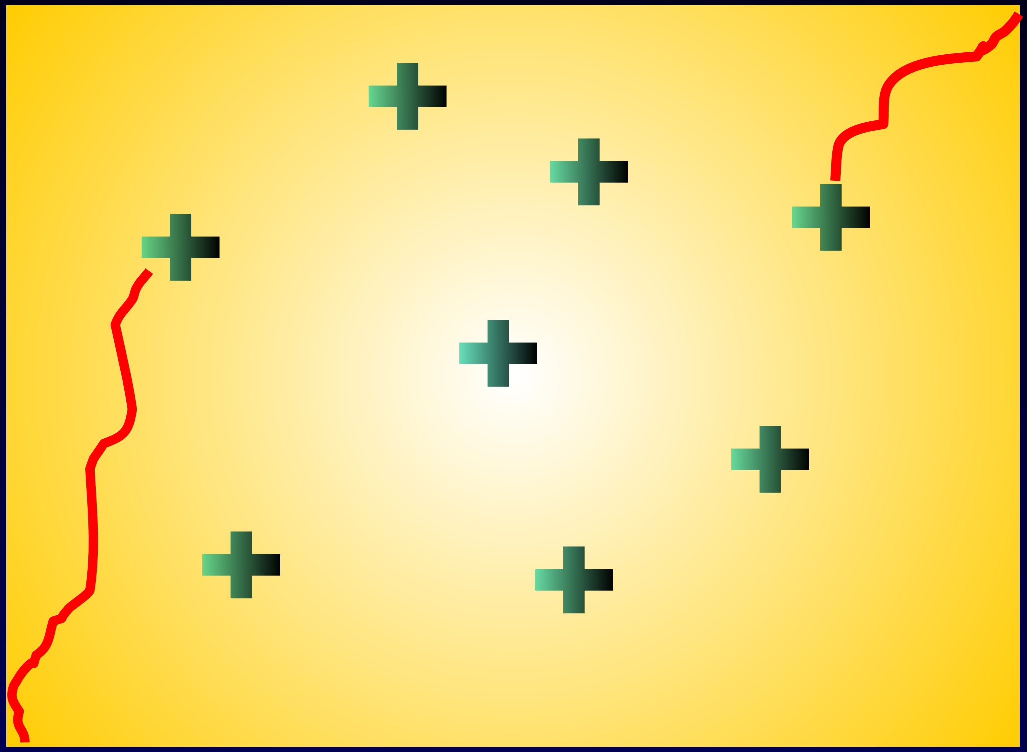
This can be categorized into 3 types:

1. Crack tip interactions

2. Crack tip shielding

3. Crack bridging

Interruption of crack propogation



Crack tip interactions:

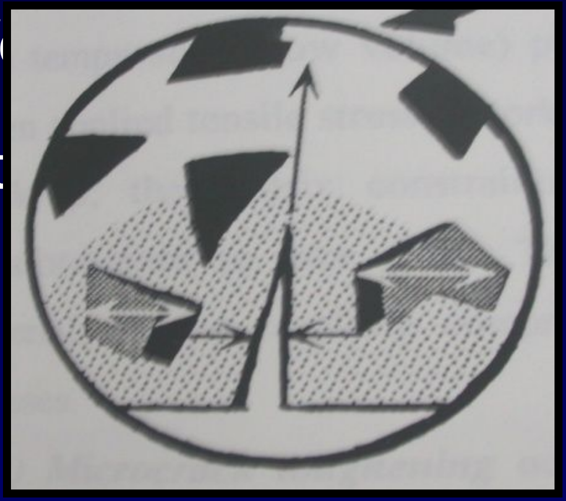
- These occur when obstacles in the microstructure act to deflect crack motion.

- These obstacles are generally second phase particles and act to deflect the crack out of the crack plane.
- It has been theorized that the reorientation of the crack plane leads to the reduction of the force being exerted on the crack in the area of deflection.

Crack tip shielding:

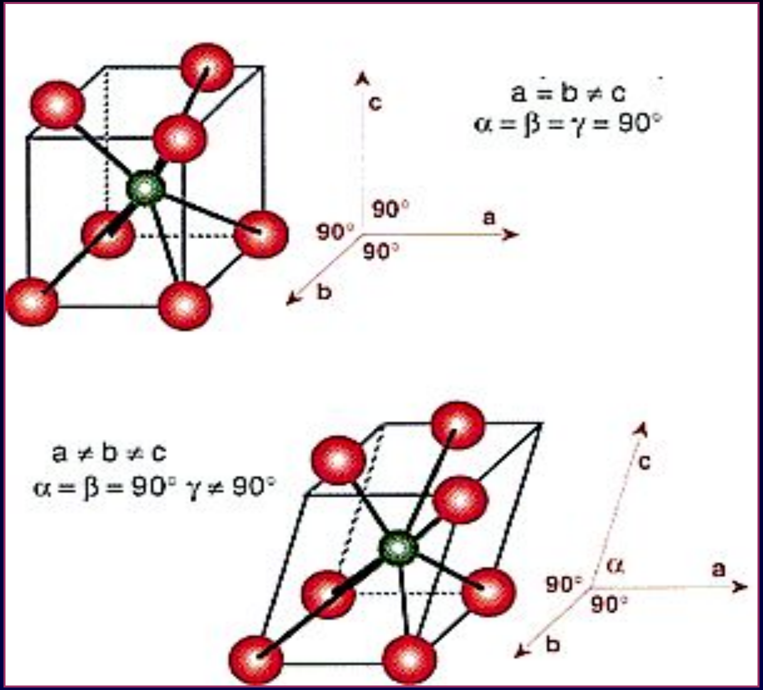
Transformation Toughening

- This is most often associated with the presence of zirconia. Under stressed conditions, zirconia undergoes a high to low temperature phase transformation which involves a 3% to 5% volume increase.
- The transformed phase occupies a greater volume in the bulk material resulting in compressive f
counteract / shield any advancing crack t



Phases of Zirconia

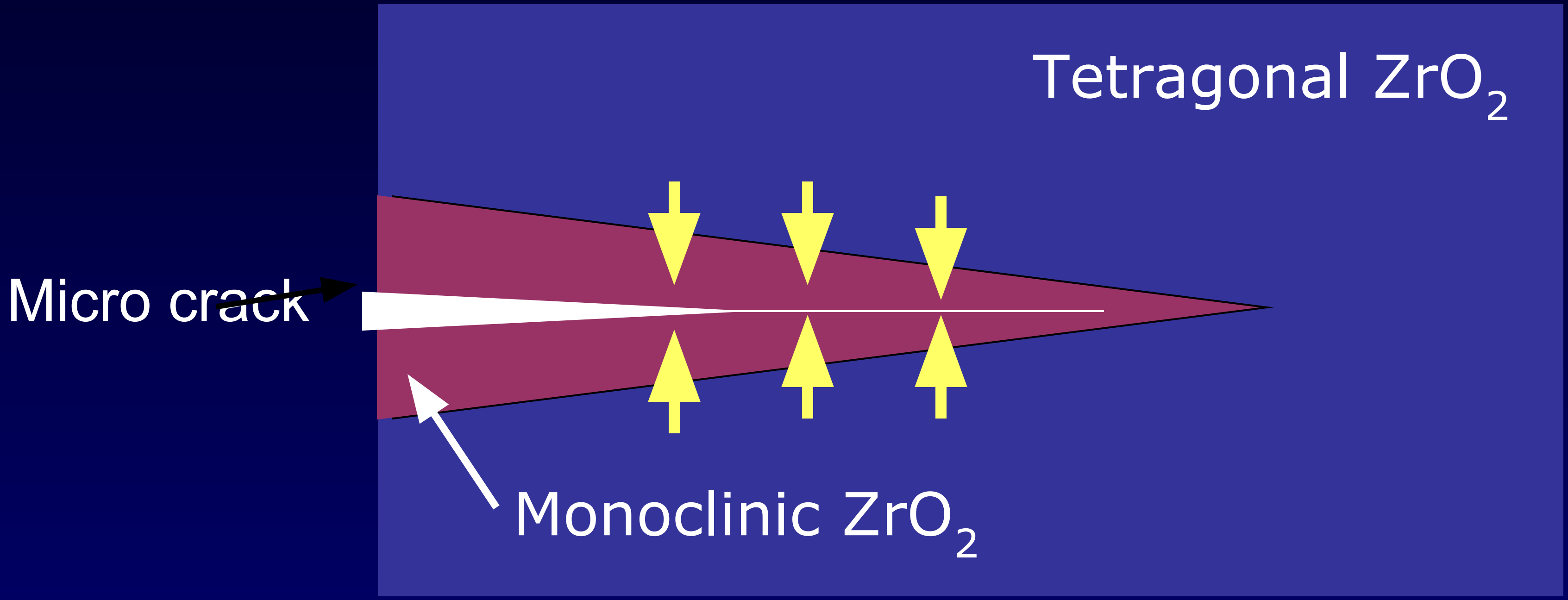
Tetragonal (T)



Monoclinic (M)

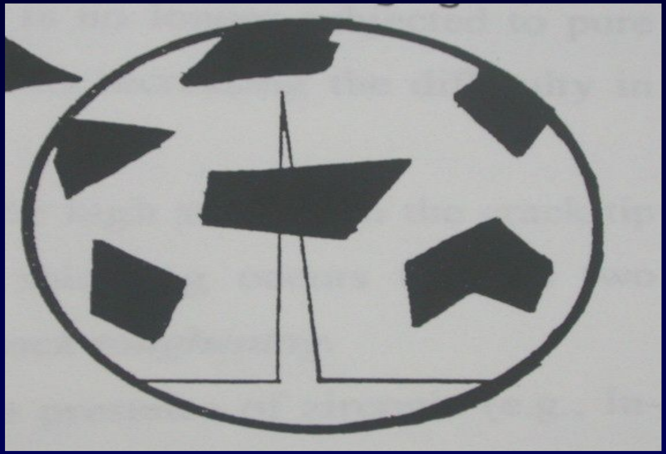
Phase transformation from tetragonal (T) to monoclinic (M) has associated volume increase (4%)

Transformation Toughening



Crack Tip Bridging:

- This is the third strengthening mechanism that has been proposed.
- It occurs when a second phase acts as a ligament to make it more difficult for the crack faces to open.



DISPERSION STRENGTHENING

Definition

Method of strengthening glasses and ceramics by reinforcing them with a dispersed phase of a different material that is capable of hindering a crack from propagating through the material. This process is referred to as ***dispersion strengthening***

- Since the glass is the weak component, dispersion of a crystalline phase helps to manage crack growth.
- During firing, the glass melts and flows around the crystals, forming an ionic bond between the matrix and the crystals.
- Fracture lines will then pass through both phases; the high rigidity of the crystals results in the crystalline phase bearing a higher portion of the load.
- Thus resulting in restricted flaw size and an increase in the toughness of the system.

•

- Alumina - Procera all ceram

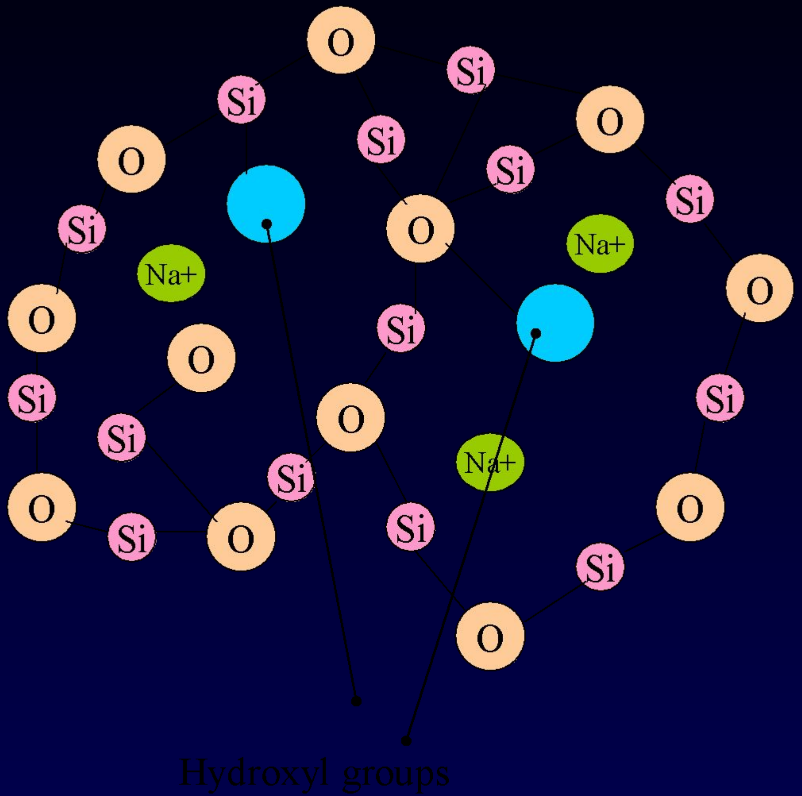
  In-ceram alumina

- Leucite - Optec HSP, IPS Empress, OPC).
- Tetrasilicic fluoramica - Dicor, Dicor MGC
- Lithium disilicate - OPC 3G, IPS Empress 2
- Magnesia alumina spinel - In Ceram spinel

Hydrothermal Porcelain

- **Ducera LFC.**
- Specialized nonfeldspathic composition
- Forms a plasticized surface layer when hydrated.
- Surface hardness is reduced.
- Flexural strength is increased
- The increase in strength is due to the plastic nature of the hydrated surface, which allows for deformation of surface flaws and prevents them from propagating through the bulk.

Hydrothermal Porcelain



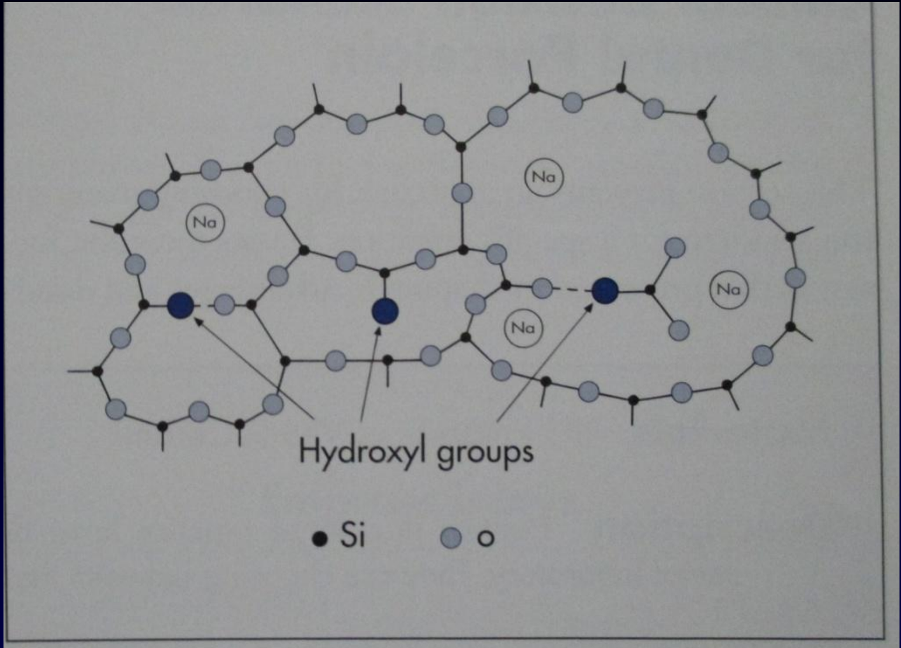


Fig 15-24 Structure of hydrated glass. (From O'Brien, 2000. Adapted with permission from *The Compendium of Continuing Education in Dentistry*.)

Reducing stress raisers:

- Stress raisers are discontinuities in brittle materials that cause stress concentration.
- The design of ceramic dental restoration should avoid the stress raisers.
- Abrupt changes in shape/ thickness in the ceramic contour can act as stress raisers and make the restoration more prone to failure.

- Notches caused in the porcelain due to the folds of the underlying platinum foil substrate, sharp line angle in the preparation, large changes in the thickness of porcelain are factors creating areas of stress.

- Usually contact points should be avoided and contact areas should be preferred to avoid localized stress areas.

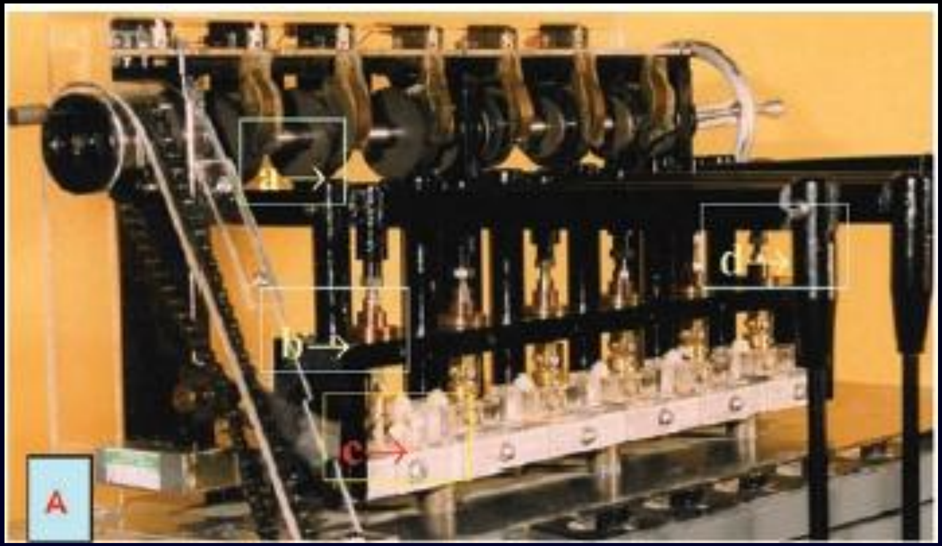
Maged K. Etman. Confocal Examination of Subsurface Cracking in Ceramic Materials. J Prosthodont 2009 ;18: 550–9.

- To investigate the relation between crack propagation and ceramic microstructure following cyclic fatigue loading, and to qualitatively evaluate and quantitatively measure the surface and subsurface crack depths of three types of ceramic restorations with different microstructures using a Confocal Laser Scanning Microscope (CLSM) and SEM.

Table 1 Ceramic materials used

Trade name	Composition	Manufacturer
AllCeram	AllCeram (feldspathic low-fusing porcelain)	Ducera Dental GmbH & Co. KG, Rosbach, Germany
Sensation SL	Glass-ceramic, Leucite-reinforced glass-ceramic	Leach & Dillon Products, Cranston, RI
IPS e.max Press Experimental glass ceramic	Glass-ceramic, densely packed rod-like lithium disilicate crystals	Ivoclar, Schaan, Liechtenstein

- Twenty (8×4×2mm3) blocks of AllCeram (AC), experimental ceramic (EC, IPS e.max Press), and Sensation SL (SSL) were prepared, ten glazed and ten polished of each material.
- Sixty antagonist enamel specimens



- Wear was induced for 80K cycles at 60 cycles/min with a load of 40 N and 2-mm horizontal deflection.
- The specimens were examined for cracks at baseline, 5K, 10K, 20K, 40K, and 80K cycles.

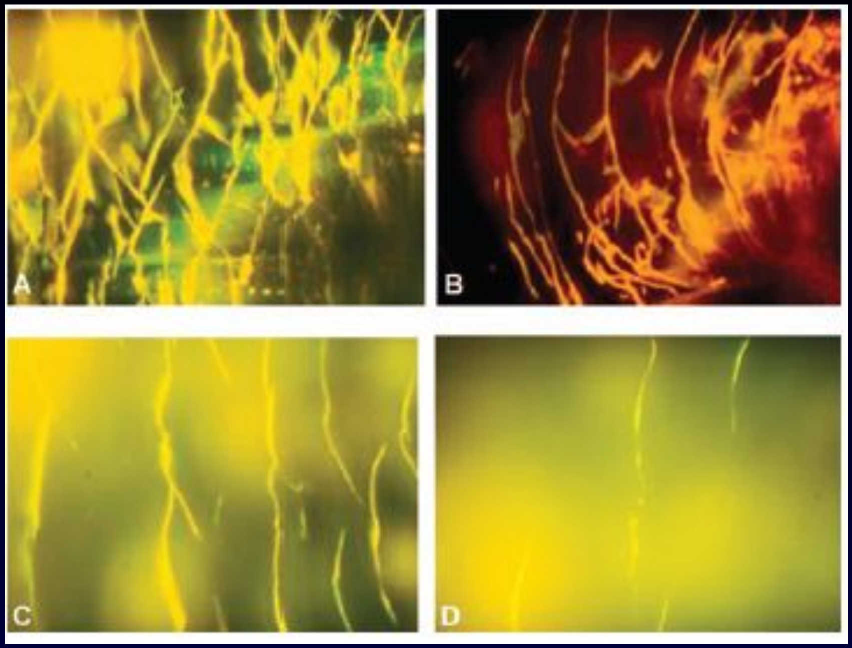


Table 2 Means and standard deviations (SD) of crack depth

	Crack depth (micron)				
	Wear cycles				
Ceramic material	5000	10,000	20,000	40,000	80,000
AllCeram polished					
Mean	8.55	10.07	15.40	23.88	32.15
SD	1.961	2.654	4.290	3.031	7.850
AllCeram glazed					
Mean	8.45	13.40	18.05	24.45	33.98
SD	1.739	2.479	3.782	6.441	10.060
Sensation SL polished					
Mean	12.43	18.88	24.65	30.13	39.40
SD	4.057	4.863	4.995	8.582	10.507
Sensation SL glazed					
Mean	11.70	14.70	25.55	32.53	42.88
SD	2.738	4.109	5.104	6.887	8.386
Experimental polished					
Mean	0.25	0.00	0.00	0.00	0.00
SD	0.954	0.000	0.000	0.000	0.000
Experimental glazed					
Mean	3.73	0.72	0.58	0.70	0.10
SD	4.076	1.783	1.647	1.636	0.632

- The microstructure and the technique of build-up of ceramic restorations may have an effect on crack initiation and propagation.
- An overall view of the data from this investigation suggests that Sensation SL is not much more resistant to crack initiation and propagation than AllCeram.
- The higher subsurface crack depth of Sensation SL and AllCeram demonstrates the potential unreliability of these materials in stress-bearing areas.
- The experimental ceramic showed higher resistance to crack formation, and this may make it more reliable for stress-bearing areas.

Fabrication of metal fused to ceramic restoration:

Requirements for alloys for porcelain bonding.

- **Coefficient of thermal expansion of alloy** close or nearly the same as that of porcelain.

- **Fusion temperature** of the alloy higher than that of the porcelain so that it resists melt or sag at the firing temperature of porcelain.

- **The modulus of elasticity:** should be high to prevent flexing of metal framework and hence avoid fracture of porcelain.
- Capable of forming **bond** with porcelain.
  - Oxide formation which provide a chemical bond.
  - Capable of wetting porcelain :Mechanical

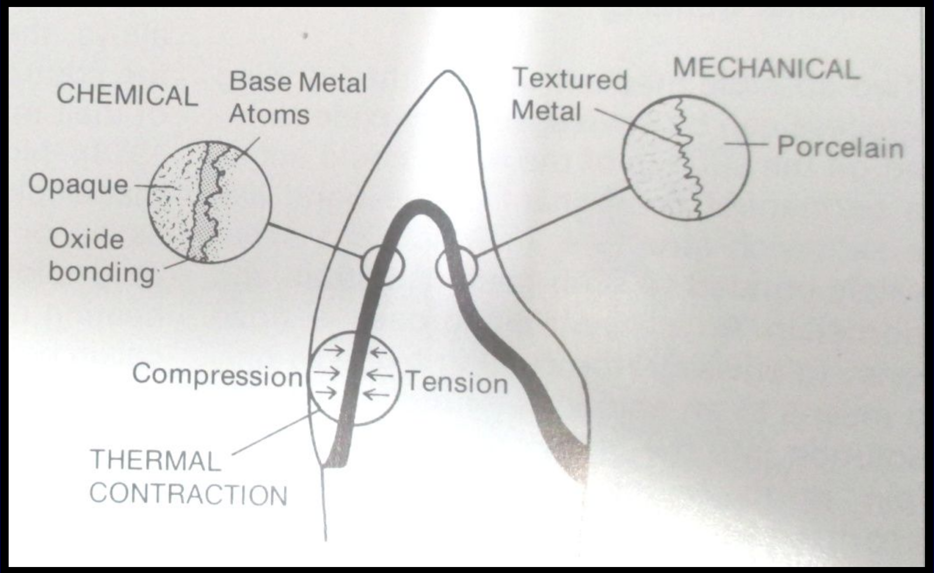
Cast metal ceramic alloys:

- **Noble metal alloy systems:**
  - High gold: Gold platinum palladium
  - Low gold: Gold palladium silver
  - Gold free: Palladium silver
  - Palladium Copper.
- **Base metal alloys:**
  - Nickel Chromium alloys without beryllium.
  - Nickel Chromium alloys with beryllium.
  - Co- Cr based alloys
- **Foil copings**
  - Bonded platinum foil coping.
  - Swaged gold alloy foil coping.

Typical composition for alloys for PFM restorations						
%	Au	Pt	Pd	Cu	Ag	Others
High gold	86	9	5	-	-	-
Low gold	52	38	-	-	-	9% In
Pd Ag	-	-	65	-	35	-
Pd Cu	-	-	80	15	-	5% others
Ni Cr	-	-	-	-	-	65%Ni,17%Cr

Metal ceramic bond - 3 factors

- Chemical
- Mechanical
- Vanderwaals forces



Nature of the metal ceramic bond:

Chemical bonding:

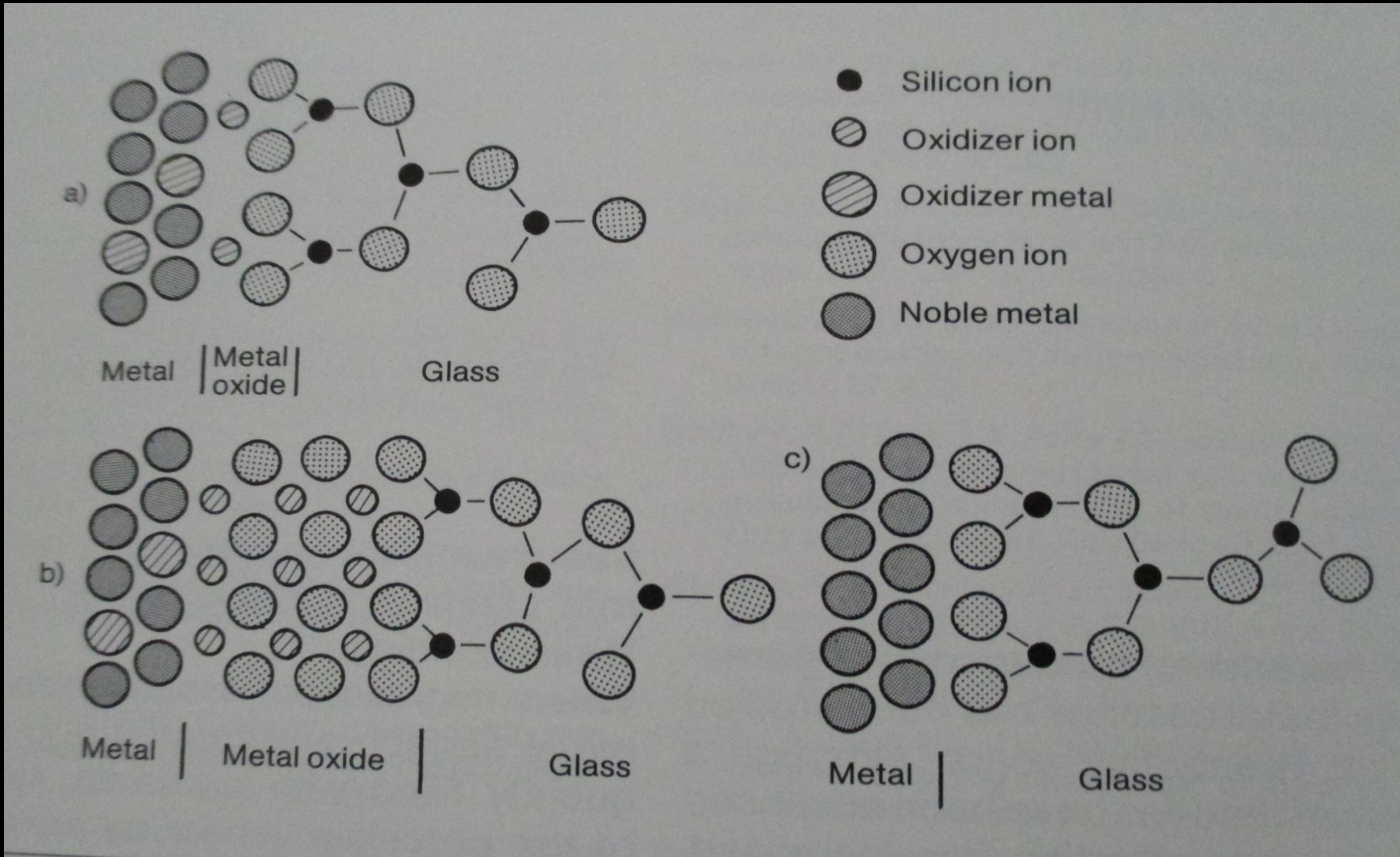
Electron transfer between oxygen of glassy phase of porcelain and oxidized metal surface.

- Primary bonding mechanism for most dental ceramics.
- Adherent oxide layer is essential for good bond formation.
- Precious metal alloy: tin and indium oxide
- Base metal alloys :chromium oxide – oxidation can be easily achieved.
- But thick oxide layer is subject to spalling and fracture.

Oxidation or degassing:

- Procedure recommended to clean the metal of organic debris
  and remove entrapped surface gases such as hydrogen.

- **Advantage:**
- Removes volatile contaminants not eliminated by Steam or air
  abrasion.
- Allows specific oxides to form on the surface which help in
  bonding.



A) Monomolecular oxide layer

B) Discrete oxide layer

C)Vanderwaals forces,

Rathi S, Parkash H, Chittaranjan B, Bhargava A. Oxidation heat treatment affecting metal-ceramic bonding. Indian Journal of Dental Research 2011;22(6).

- Forty-five bar specimens of each two commercially available base metal alloys Mealloy and Wirorn-99 were fabricated.
- Dimensions of each specimen were 15.0 × 2.0 × 0.5 mm (according to the ISO 6872-1984).

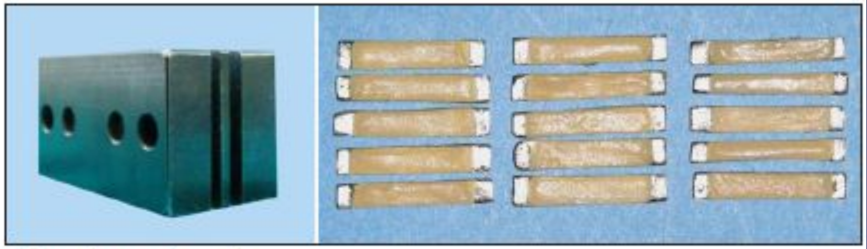


Figure 1: Customized jig and prepared samples

- According to the surface pretreatments the samples of the two groups were categorized into three subgroups:
- With OHT only,
- with sandblasting only (with Al2O3 of 110 µm) and

- Application of commercially available Duceram porcelain in thickness of 2.00mm was applied over the surface of metal with the pretreatments. Samples were then placed under SEM for EDX examination to evaluate ionic changes that occurred at the metal-ceramic interface.
- Flexural bond strength of each sample was calculated under Universal Testing Machine.

- **Results:**
- **The one-way ANOVA indicated no significant influence of either metal type (P=0.811)** or any surface pretreatment (P=0.757) on the metal-ceramic bond strength.
- **Conclusion:**
- **OHT resulted in the increase in amount of oxides at the metal-ceramic interface.**
- However, neither metal type nor surface pretreatments affected bond strength.

Mechanical interlocking:

- Presence of surface roughness
- Wettability is important for bonding.
- Smaller the contact angle: better is the wetting

efficiency.

Vanderwaals Forces:

Bonding results from forces of attraction between polarized

ions in close proximity to each other but without the

exchange of electrons as seen in true chemical

Fabrication

- Various methods of fabricating ceramic restorations
- Condensing and sintering
- Pressure molding and sintering
- Casting
- Slip casting, sintering and glass infiltration
- Milling by mechanical and digital systems

Condensing and sintering

- The feldspathic porcelain of traditional PFM, some alluminous porcelains (Vitadur-N, Hi-Ceram), and pure alumina ceramic (Procera AllCeram) are condensed and sintered at high temperatures.

Slip casting

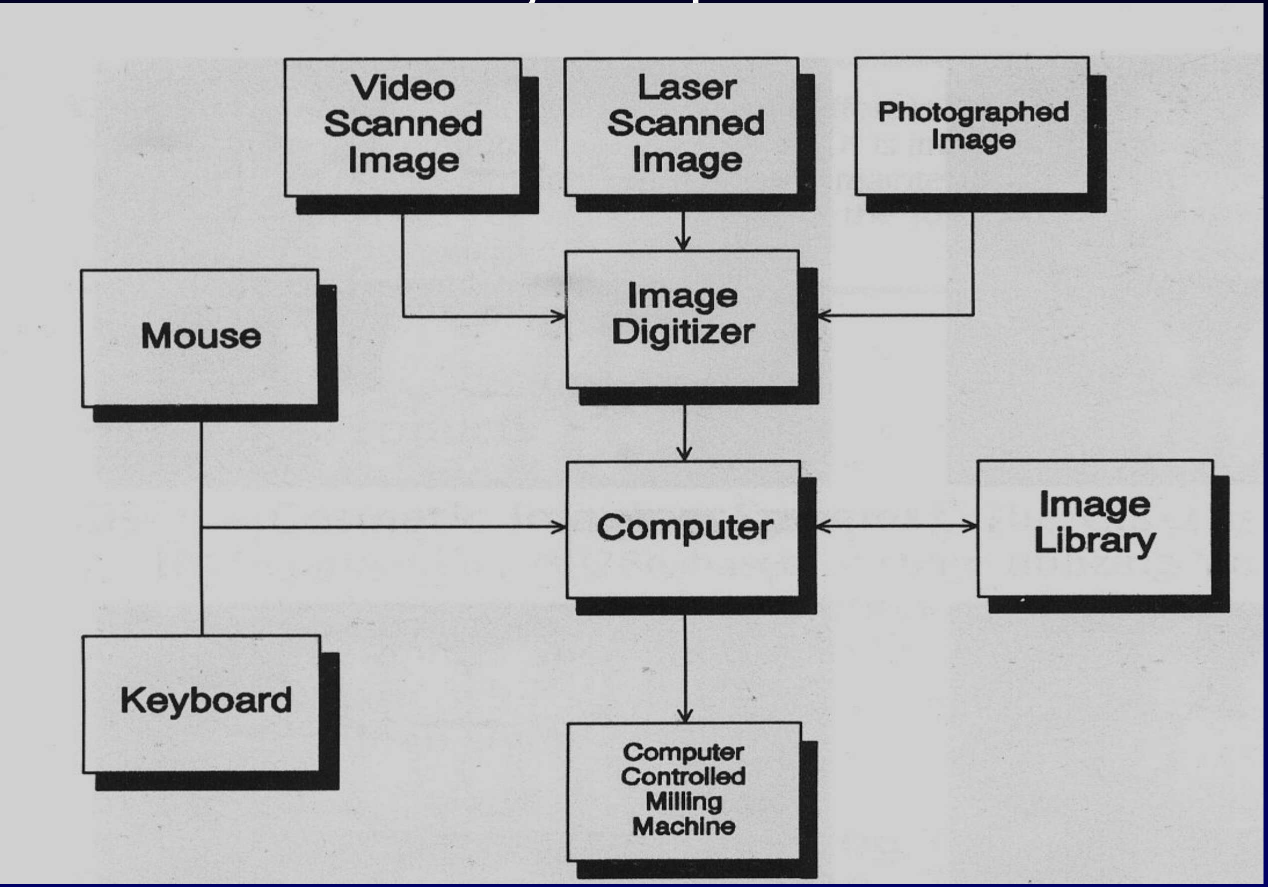
- The slip-casting fabrication method involves the creation of a porous core by slip casting, which is sintered and then infiltrated with a lanthanum-based glass, producing two interpenetrating continuous networks: a glassy phase and a crystalline infrastructure.
- The crystalline infrastructure could be alumina, spinel, or zirconia-alumina

Pressure molding and sintering

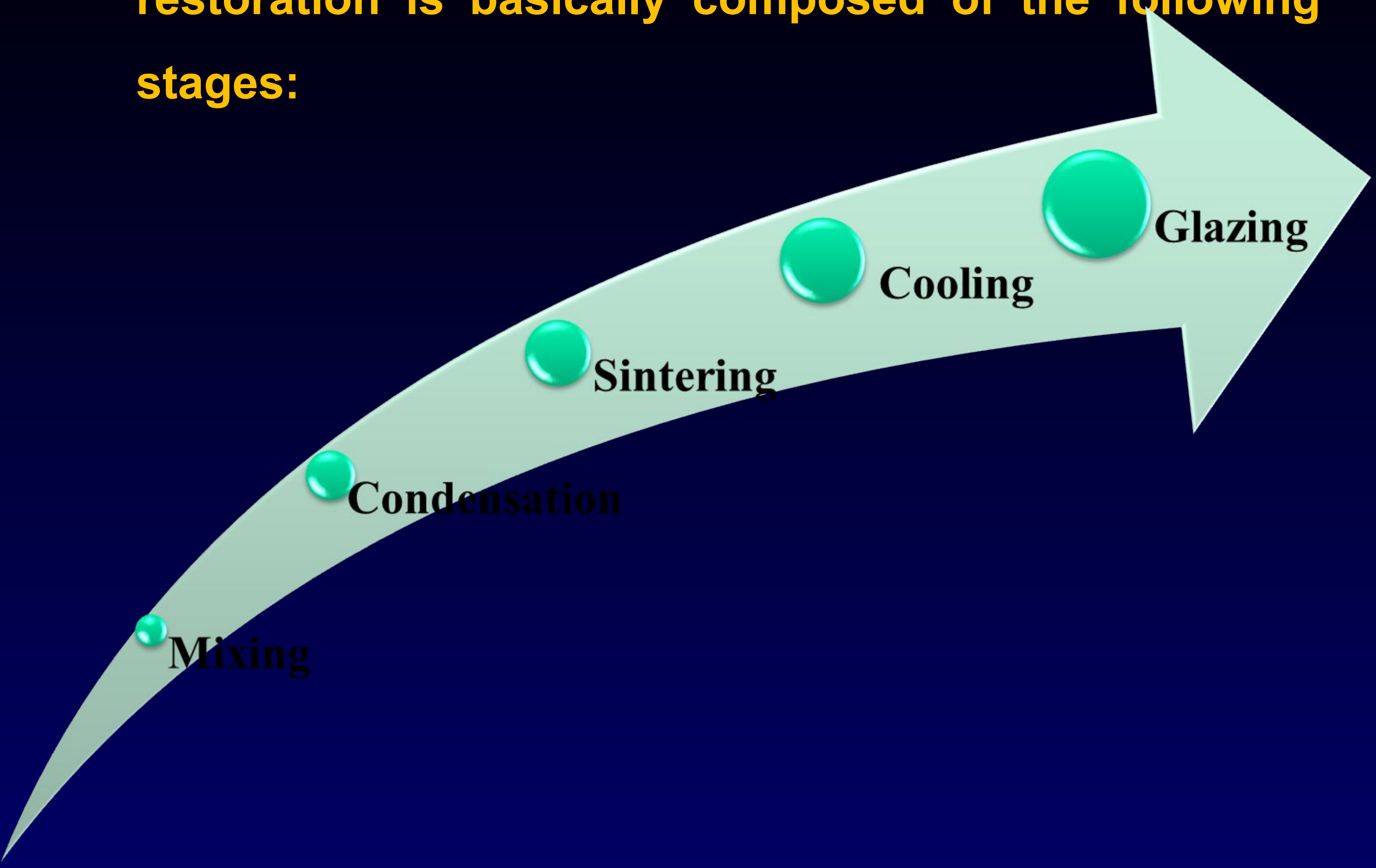
- This method uses a piston to force a heated ceramic ingot through a heated tube into a mold, where the ceramic forms cools and hardens to the shape of the mold.
- When the object has solidified, the mold is broken apart and the ceramic is removed.
- Eg :- IPS Empress, IPS Empress 2, OPC, OPC-3G and Finesse All-Ceramic.

Computer-aided design/computer-aided manufacturing

- Available as prefabricated ingots
- Ingots are milled or cut by computer controlled tools

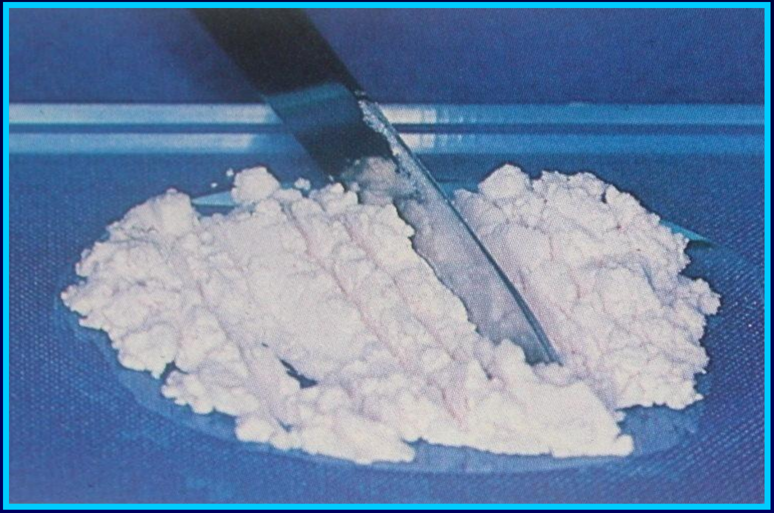


However, fabrication of a conventional porcelain restoration is basically composed of the following stages:



•Mixing

Dry porcelain powder is mixed with the binder on a glass slab using spatula (or glass mixing rod) into a thick creamy consistency which can be carried in small increments with an instrument or brush



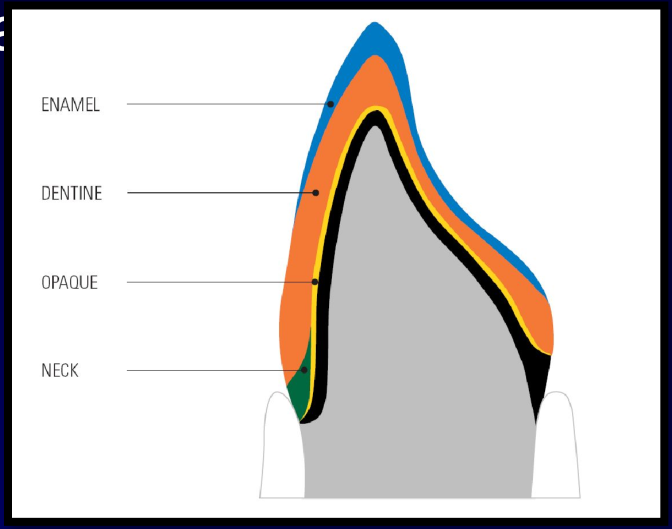
Building up of porcelain:

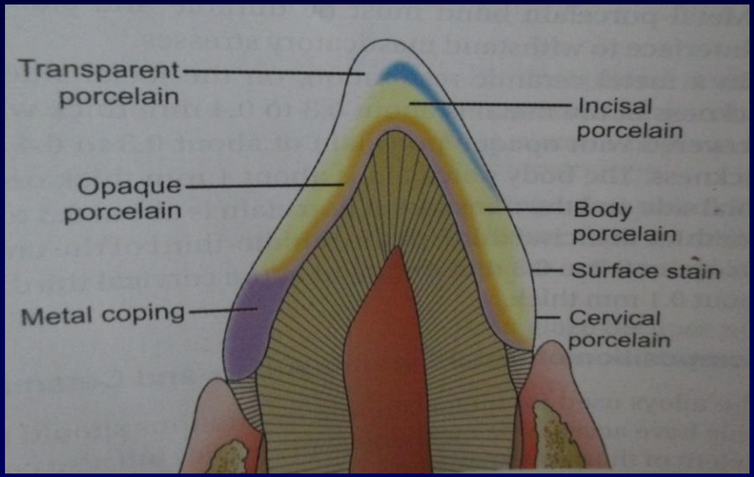
A plastic mass : Powder and liquid.

With a brush, the plastic mass is applied over the matrix.

It is built to the shape of a crown in layers of core, dentin and

ena



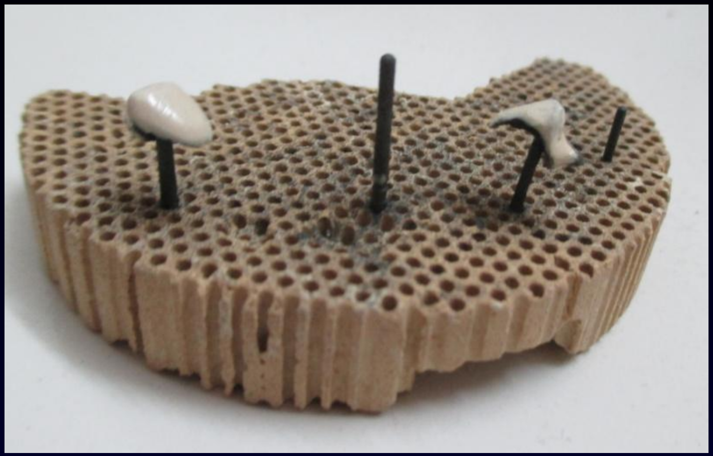


Powder opaque

Paste opaque

Spray on method

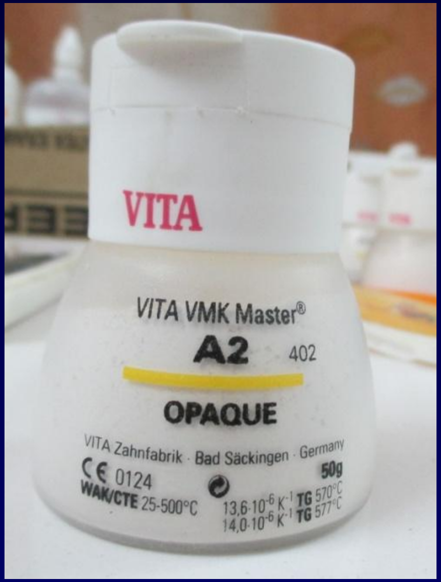
Application of Wash Opaque



Application of opaque: Hides color and forms bond.

Dentin Layering: Body porcelain

Enamel: Incisal porcelain.


VITA
VITA VMK Master®
A2 402
OPAQUE
VITA Zahnfabrik · Bad Säckingen · Germany
CE 0124
50g
WAK/CTE 25-500°C
13,6·10^-6 K^-1 TG 570°C
14,0·10^-6 K^-1 TG 577°C

Condensation

- The process of bringing the particles closer and of removing the liquid binder is known as condensation.

- **Liquid binder :**
- Distilled water.
- Propylene glycol :alumina core build up.
- Alcohol or formaldehyde based liquids :opaque or core build up.

- **Aim :** To pack the particles as close as possible in order to reduce

  the amount of porosity and shrinkage during firing.
- **Factors determining the effectiveness of condensation:**
- **Size of the particles:**
    - One size: void space of 45%
    - Two sizes : 25%
    - Three or more sizes:22%. **Gap Grading System.**
- **Shape of the particles:** Round particles :better packing compared to angular particles.

Methods of Condensation

- Vibration
- Spatulation
- Brush technique
- Whipping.

Wet brush technique/
Brush additive technique:

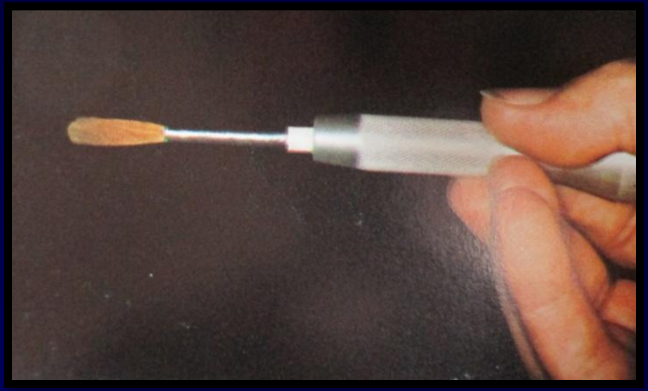
- Creamy
- Capable of being transferred in small increments.
- High quality sable hair brushes

Advantages of wet brush technique:

- Maintains the moisture content in the porcelain.
- Metal spatulas causes more rapid drying out.
- The brush can be used to introduce enamel colors, effect masses or stains without changing instruments.
- Greater control over small increments.

Vibration:

- Mild vibration to densely pack the wet powder upon the underlying matrix.
- The excess water :blotted with a tissue.



Spatulation:

Spatula used to apply and smoothen the porcelain

Disadvantages:

- Danger of dislodging the porcelain particles ,may cause invisible cracks.

- **Dry Brush technique:**

  Dry powder sprinkled over the wet porcelain

  Disadvantage:

- It enhances the risk of porcelain drying out
- Control of powder : difficult ,time consuming

Whipping

- A large soft brush moved in light dusting action over the wet porcelain
- Brings excess water to the surface,
- Same brush can be used to remove any coarse surface particles

  along with excess water.
- Combination of vibration and the whipping.

- Pre firing procedures:
- If directly placed in a hot furnace, it will evolve steam rapidly ,crumble or explode.
- Dry the wet structure in a warm atmosphere before placing into the hot furnace.

Sintering or firing

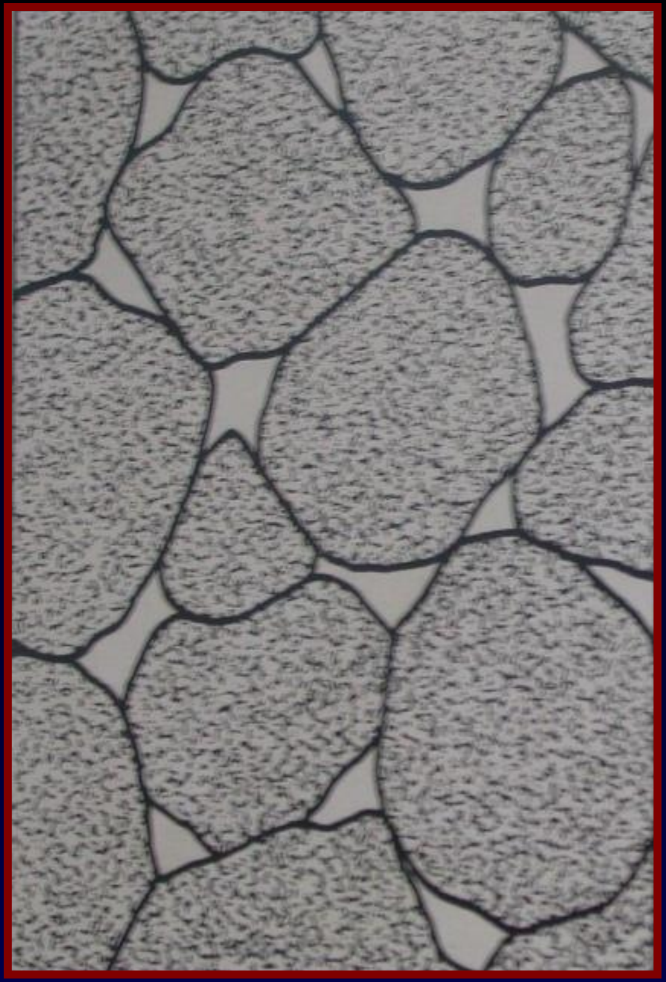
Is defined as a process of heating closely packed particles to achieve inter-particle bonding and sufficient diffusion to decrease the surface area or increase density of the structure.

- The particle fusion or compaction of glass is often referred to as ***sintering***

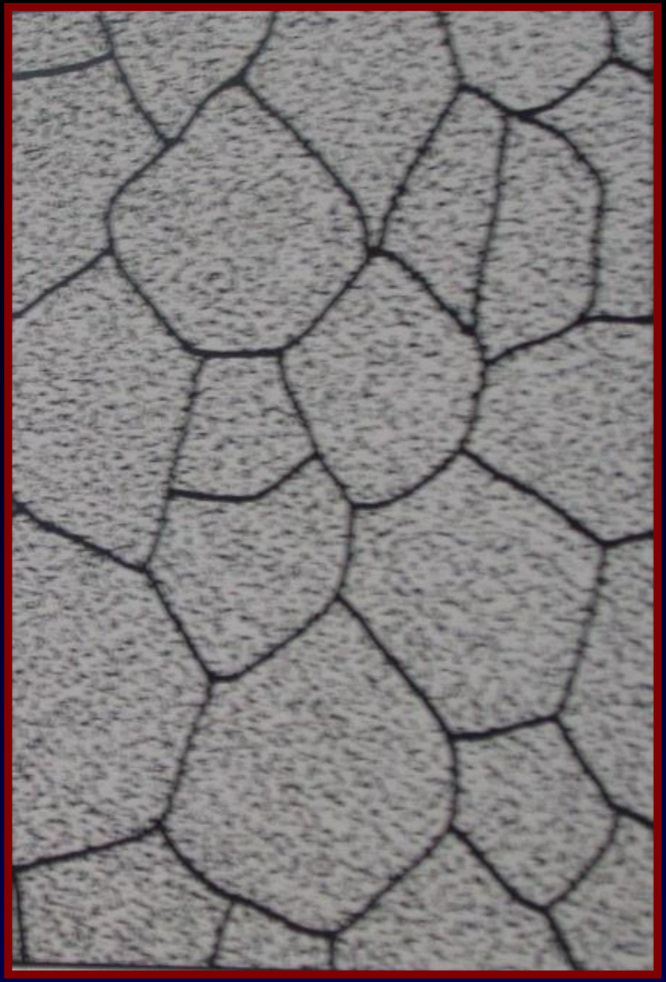
During firing, the following changes are seen in the porcelain

- Loss of water
- Firing shrinkage - 32 –37% for low fusing
  28 – 34% for high fusing
- Glazing - 955 – 1065°C

- After the mass has been fired, it is cooled very slowly because rapid cooling might results in surface cracking and crazing



BEFORE FIRING



AFTER FIRING

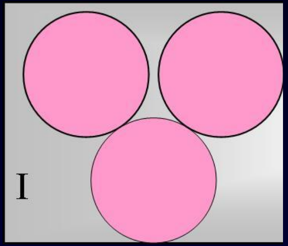
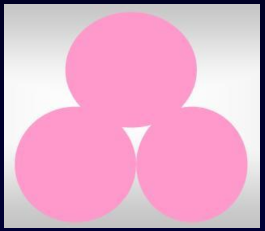
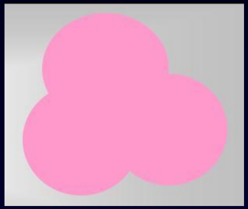
After firing, grain boundaries fuse to form prismatic structure

Different media can be employed for firing like

1. Air
2. Vacuum
3. Diffusible gas - He, H_2 or steam


VITA
VACUMAT 40 T


+ Press
Multimat2 Touch
DENTSPLY

STAGES OF MATURITY	Low bisque	Medium bisque	High bisque
Characteristic feature	Grains start to soften & coalesce at contact points 	Flow of glass grains increase & residual entrapped air becomes sphere shaped 	Firing shrinkage complete 
Particle cohesion	Incomplete	Considerable	Complete
Porosity	Highly porous	Decreased but porous	Slight/absent
Shrinkage	Minimal	Majority/definite	High
Surface texture	Porous	Still porous &matte surface	Smooth surface

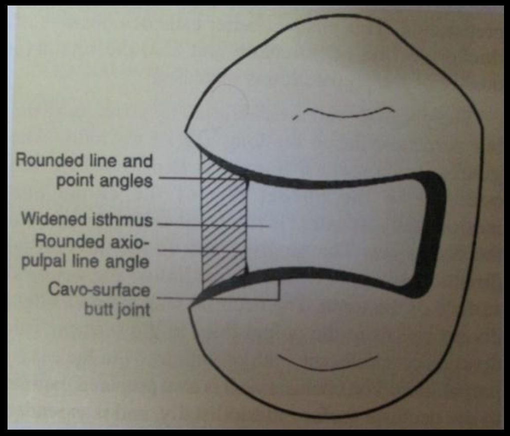
Cooling

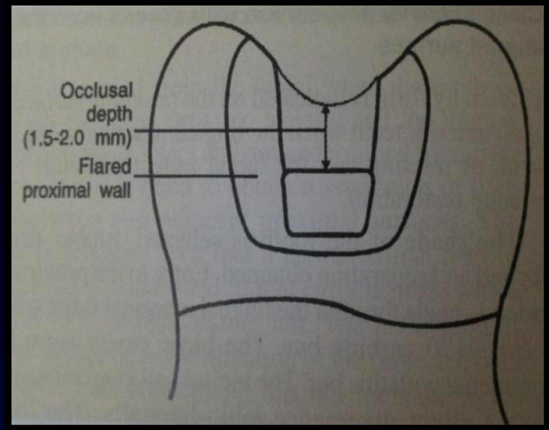
- Being poor conductors of heat and brittle in nature, whenever, porcelain restorations are heated or cooled the process must be carried out slowly.
- Rapid cooling or sudden changes in temperature after firing of porcelain would result in cracking or fracture of glass and loss of strength because of development of tensile stresses.

Glazing

- Produces a smooth, shiny and impervious outer layer
- Decrease crack propagation

Ceramic inlays





- Similar to metal inlays except that bevels & flares are not given here.
- Depth - 1.5 to 2 mm; width – 1.5mm
- 6-8 º divergence
- O.6mm clearance
- Gingival floor width – 1mm
- All internal angles rounded
- Cavosurface margins – butt angled

METAL CERAMIC RESTORATIONS

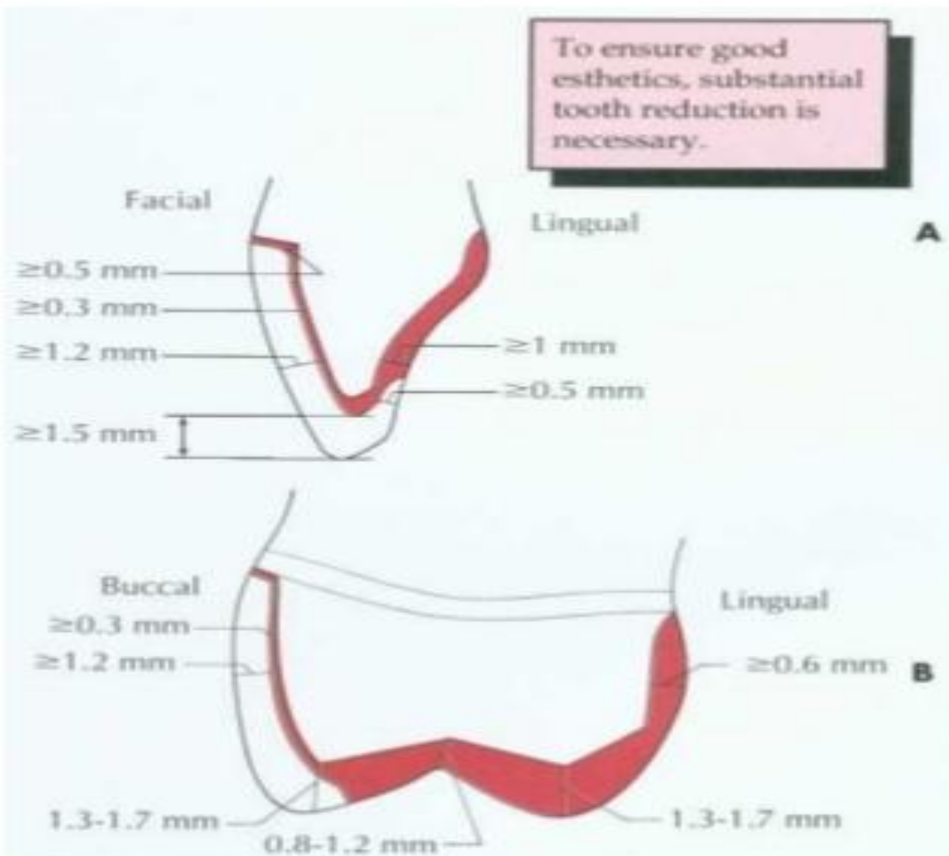
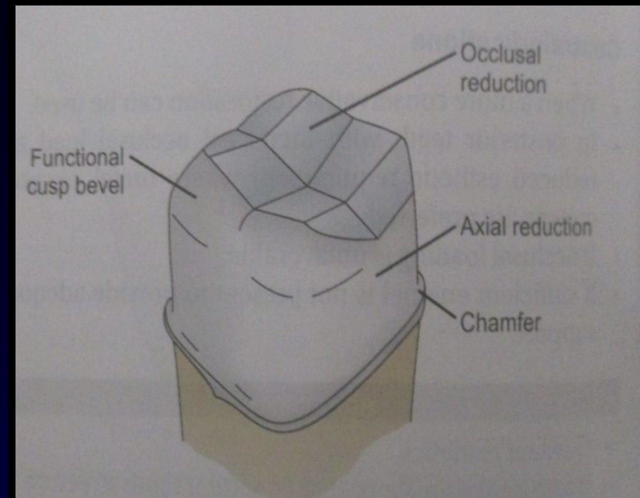


Fig. 9-1. Recommended minimum dimensions for a metal-ceramic restoration on an anterior tooth (A) and a posterior tooth (B). Note the significant reduction needed compared to that for a complete cast or partial veneer crown.



ALL CERAMIC CROWNS

CONCLUSION

- Dental ceramic technology is one of the fastest growing areas of dental material research and development.
- The past decades have seen the development of several new groups of ceramics.
- The diversity of dental ceramics continuous to stimulate laboratory and clinical research.

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THANK YOU….