

DENTAL PORCELAIN

By

Dr. Tayseer Mohamed











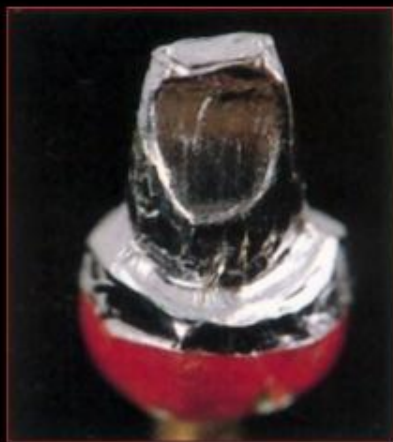




Master model with dies



Platinum foil adapted to die



Finished Cores

- **Ceramic** is defined as product made from non-metallic material by firing at a high temperature.
- **Application**
 1. Ceramo-metal restoration.
 2. ceramic for fixed partial dentures.
 3. Ceramic crowns, inlays, veneers and onlays.
 4. Ceramic denture teeth.

Inlay



Onlay





- The more restrictive term **porcelain** refers to a specific compositional range of ceramic material composed of kaolin, silica and feldspar and fired at high temperature.
- Dental ceramics for *metal-ceramic* restorations belong to this compositional range and are commonly referred to as **dental porcelains**.

Advantages of dental porcelain

- Biocompatible as it is chemically inert.
- Excellent esthetic.
- Thermal properties are similar to those of enamel and dentine.

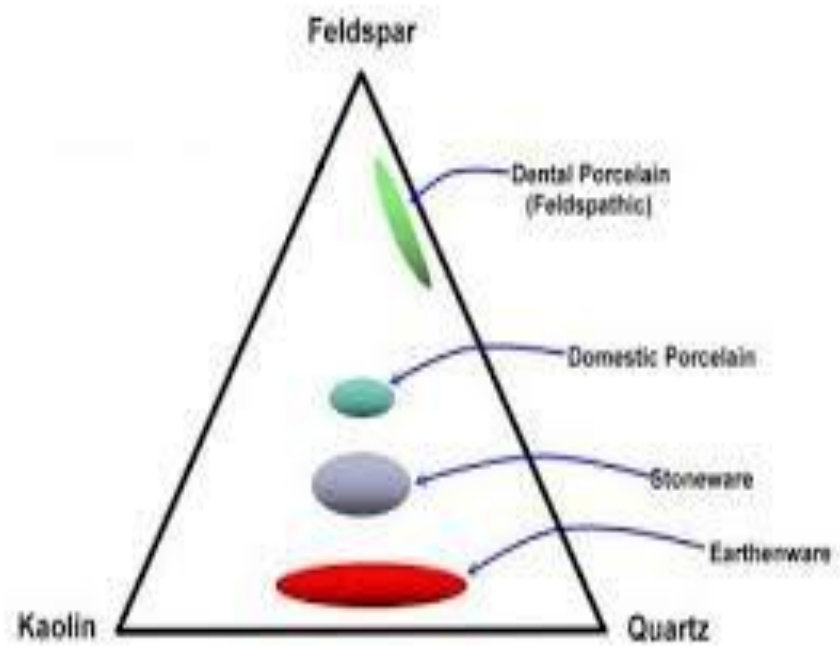
Disadvantages

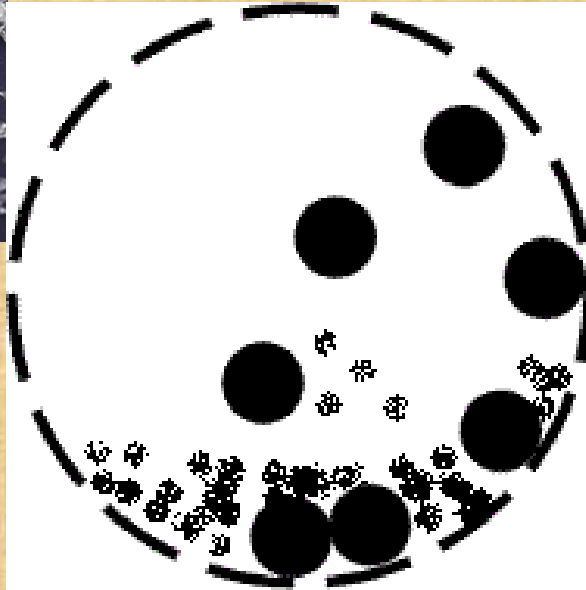
- High hardness so make abrasion to antagonist natural dentitions and difficult to adjust and polish.
- Low tensile strength so it is brittle material.

COMPOSITION

1. **Feldspars** are mixtures of ($K_2O \cdot Al_2O_3 \cdot 6SiO_2$) and ($Na_2O \cdot Al_2O_3 \cdot 6SiO_2$), fuses when melts forming a glass matrix.
2. **Quartz** (SiO_2), remains unchanged during firing, present as a fine crystalline dispersion through the glassy phase.
3. **Fluxes** used to decrease sintering temperature.
4. **Kaolin** act as a binder.
5. **Metal oxides**, provide wide variety of colors.

MANUFACTURE





- Different components of dental porcelain are melted on a refractory crucible with high temperature reaction (1200°).
- The material is then quenched in water while it is red hot to break it up in small fragments.
- Frits are ball-milled to achieve powdered material supplied to the dental lab.

After the manufacturing process is completed feldspathic dental porcelain consists of:

a) Glassy phase with amorphous structure.

- lower resistance to crack propagation so brittle.
- Translucency.

b) Crystalline phase or mineral phase:

Is leucite, potassium alumino-silicate (10- 20 %):

- Controls the thermal expansion coefficient of porcelain.
- Contribute to the strength of porcelain.

PROCESSING

MANIPULATION

1. Placement of the platinum foil.
2. Condensation.
3. Building.
4. Firing or sintering.
5. Glazing.
6. Cooling.

1. Placement of the platinum foil

- ☐ Die is covered with a platinum foil.
- ☐ The platinum foil withstands the fusion temperature of the porcelain.

.

2. Condensation

☐ The plastic mass of powder and water is applied to the die which is coated with platinum foil.

Function of condensation

- a. Adapt the porcelain to the required shape.
- b. Remove as much water from the material as possible to decrease firing shrinkage.

Methods of condensation

- a. Vibration
- b. Spatulation
- c. Brush

3. Building

There are three types of porcelain used in this stage:

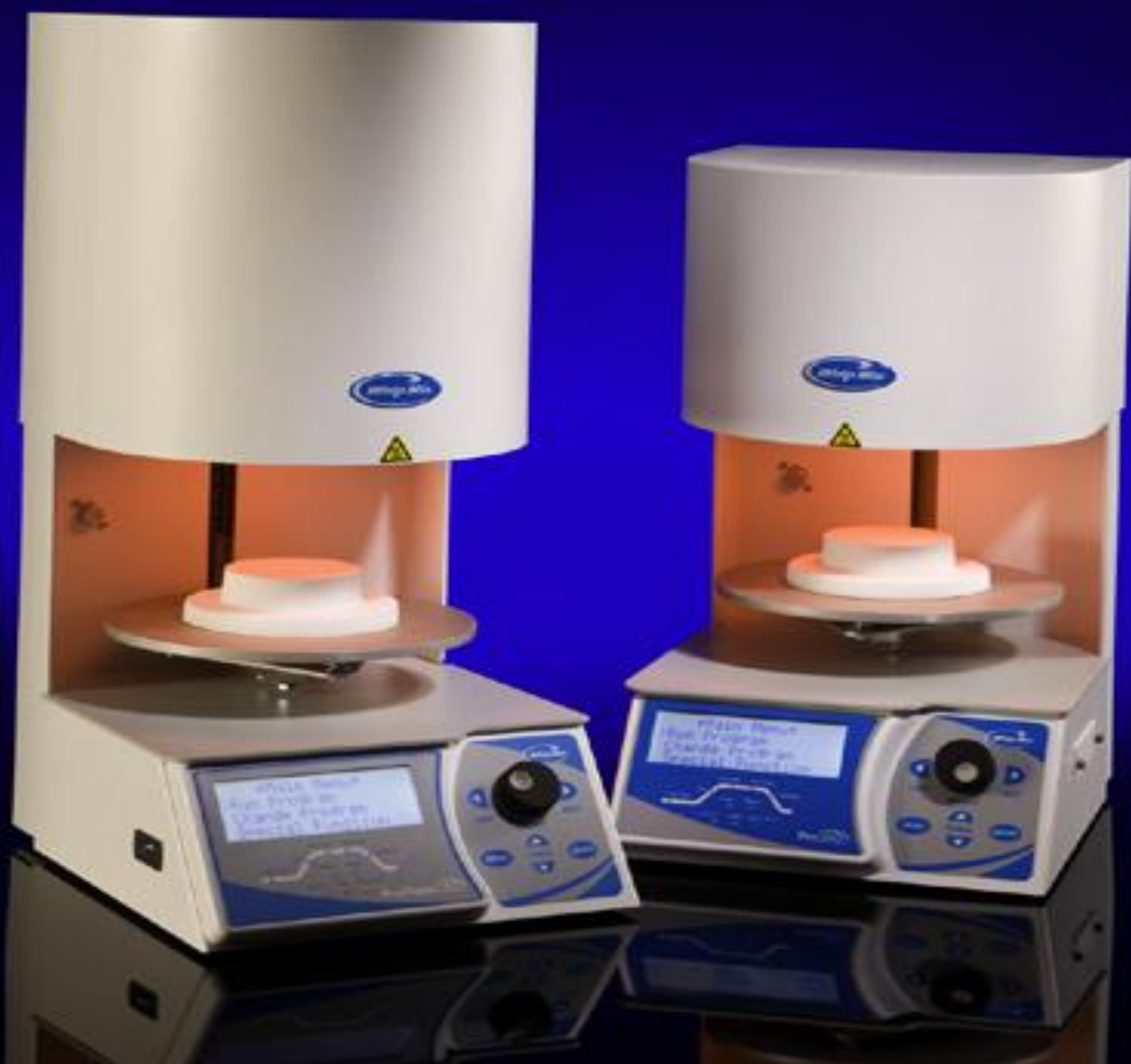
- a. Opaque porcelain:** Mask the color of the cement used for adhesion of the restoration.
- b. Body or dentin porcelain:** Makes up the bulk of the restoration by providing most of the color or shade.
- c. Enamel porcelain:** It provides the translucent layer of porcelain in the incisal portion of the tooth.

4. Firing or sintering

It is to fuse the particles of porcelain powder producing hard mass.

❑ Stages of firing:

- a. **Low bisque stage:** Particles lack complete adhesion, low amount of shrinkage occur, and very porous.
- b. **Medium bisque stage:** water evaporates with better cohesion to the powder particles and some porosity .
- c. **High bisque stage:** fusion of particles to form a continuous mass, complete cohesion and no more shrinkage.



5. Glazing

The glazing is to obtain a smooth surface that simulates a natural tooth surface.

It is done either by:

- i. **Auto glazing:** rapid heating up to the fusion temperature for 1-2 minutes to melt the surface particles.
- ii. **Add on glazing:** applying a glaze to the surface and re-firing.

☐ Auto glazing is preferred to an applied glaze .

6. Cooling

- ❑ Slowly and uniformly otherwise rapid cooling leads to ununiform shrinkage which causes stresses that causes cracks and loss of strength.

STRENGTHENING

Two principles deficiencies are in dental porcelain

A. Brittleness.

B. Low tensile strength.

Methods used to overcome:

I. Methods of strengthening brittle materials.

II. Methods of designing components to minimize stress concentration and tensile stresses.

METHOD TO OVERCOME

**Methods of
strengthening
brittle materials**

**Designing
components to
decrease stress
concentration**

**Development of
residual compressive
stresses**

**Interruption of crack
propagation**

1. Ion exchange
2. Thermal tempering
3. Thermal compatibility

1. Dispersion of crystalline phase
2. Transformation toughening

I. Methods of strengthening brittle materials.

1. Development of residual compressive stresses within the surface of the material (because the material is weak in tension)

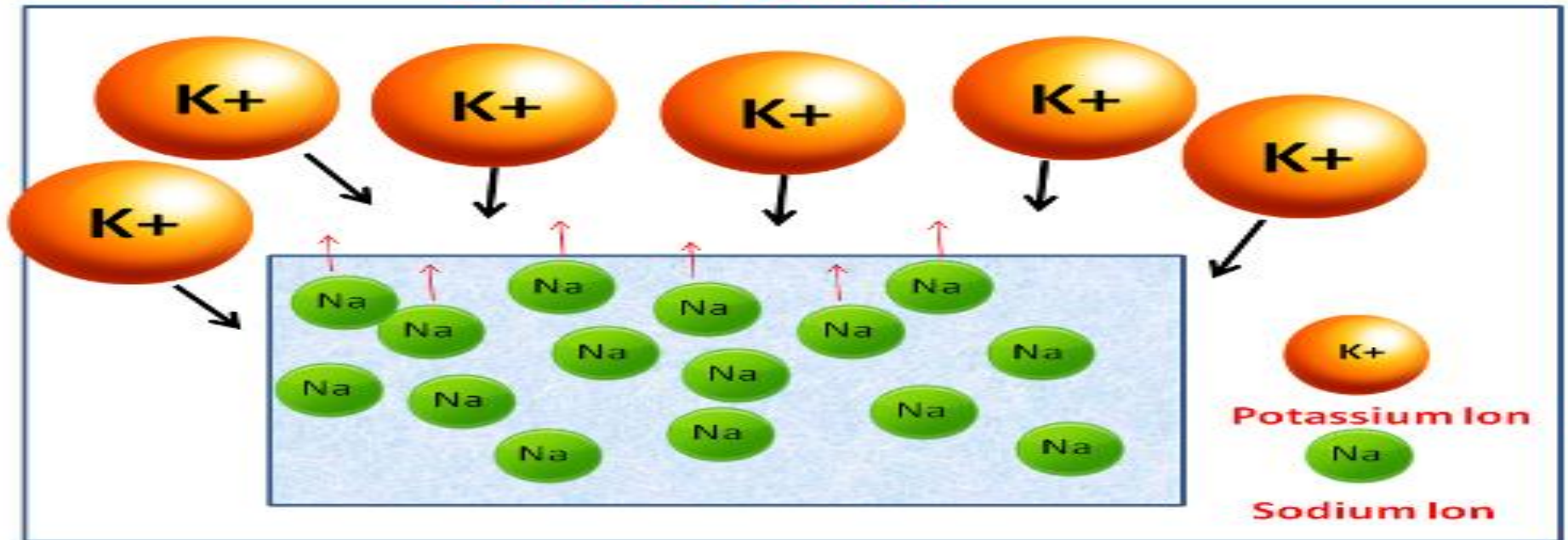
- A. Ion exchange.
- B. Thermal tempering.
- C. Thermal compatibility.

2. Interruption of crack propagation

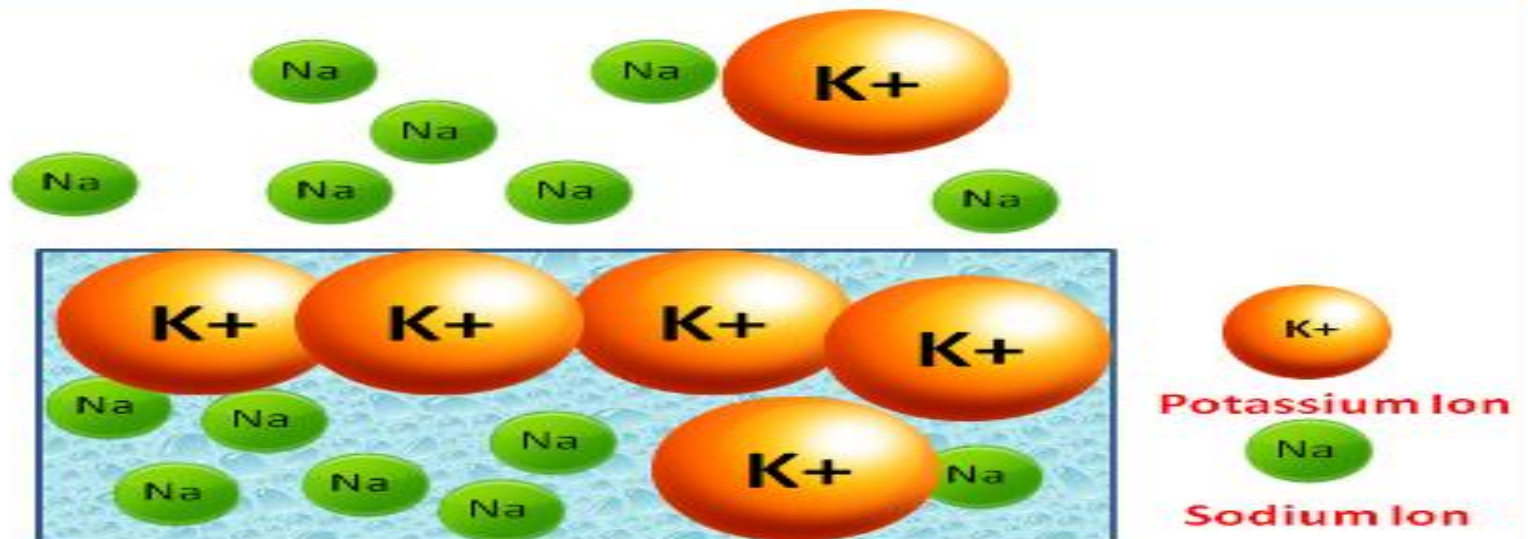
A. Ion exchange

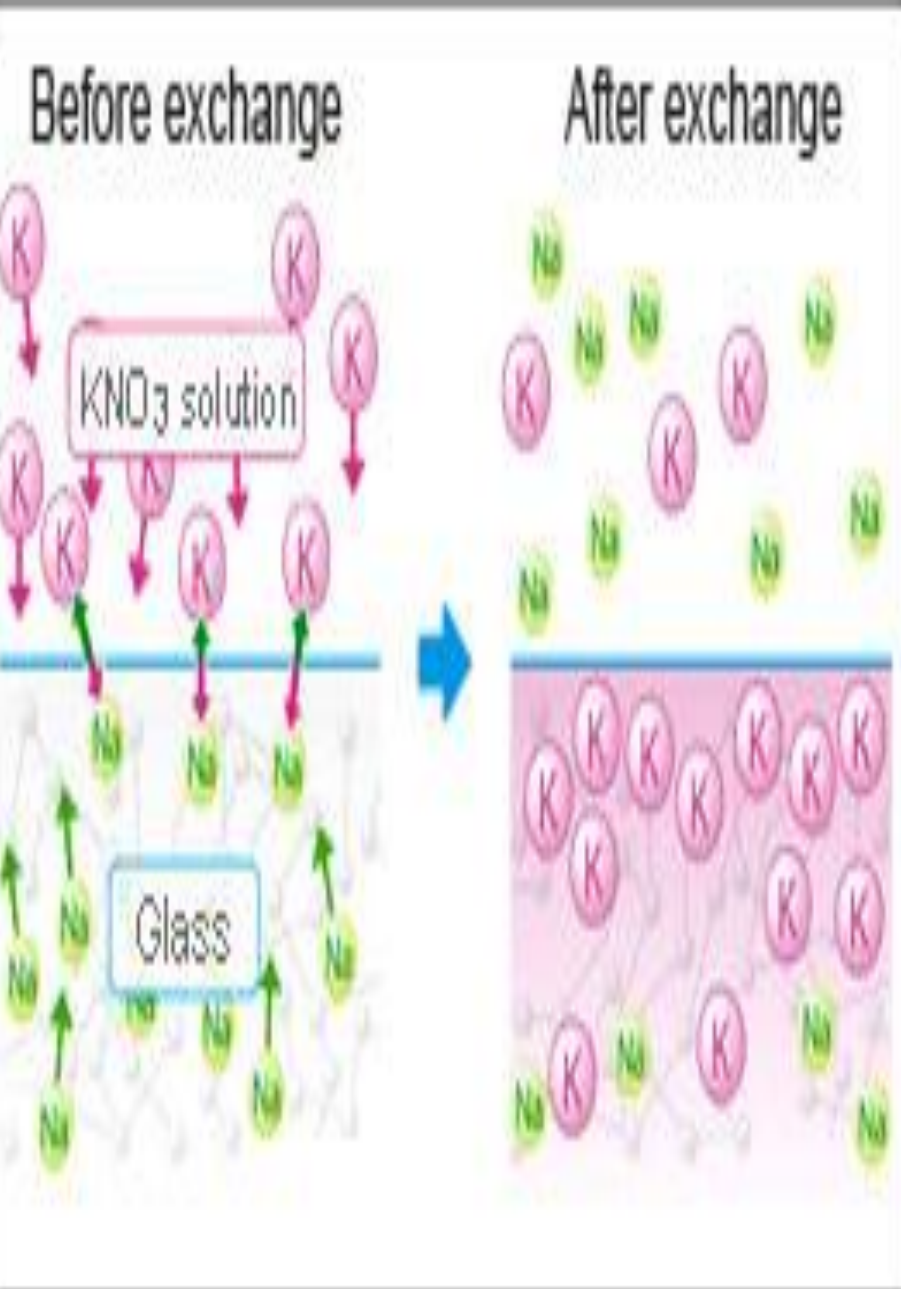
- Exchange larger potassium ions for the smaller sodium ions.
- The forcing of the potassium ion into the place formerly occupied by the sodium ion creates large residual compressive stresses in the surface subjected to this chemical treatment.

BEFORE ION EXCHANGE

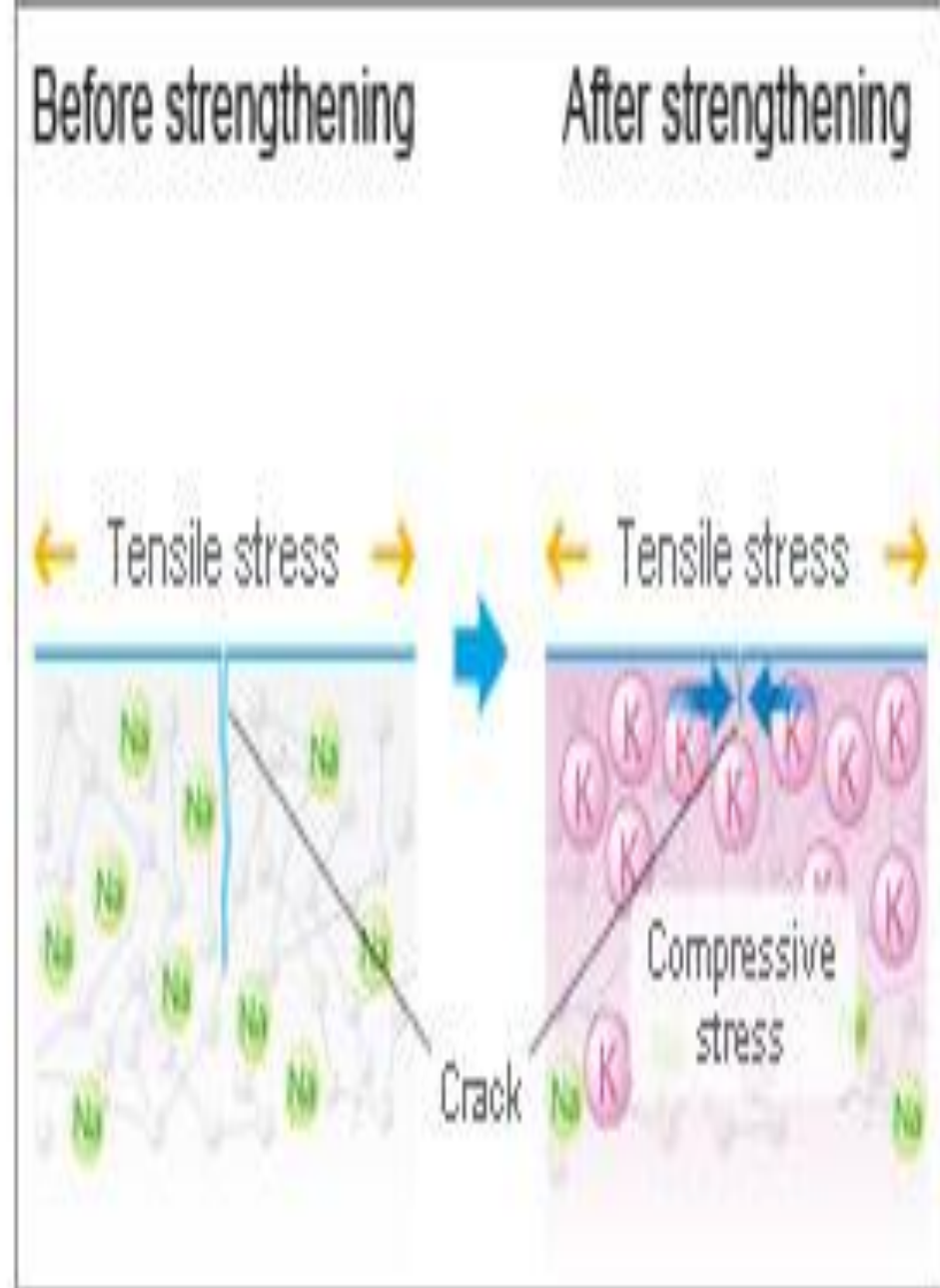


AFTER ION EXCHANGE





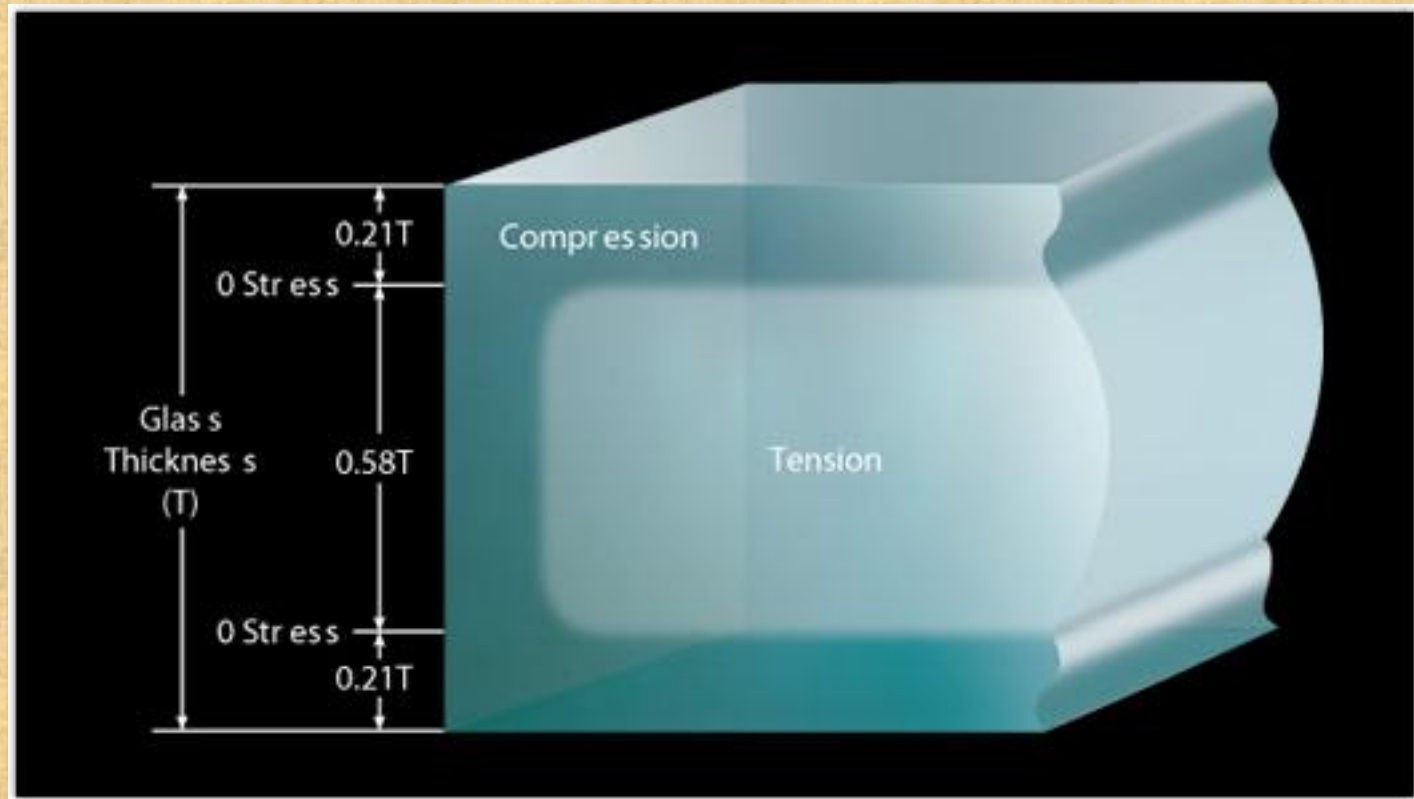
Ion exchange mechanism



Mechanism showing how cracks are developed

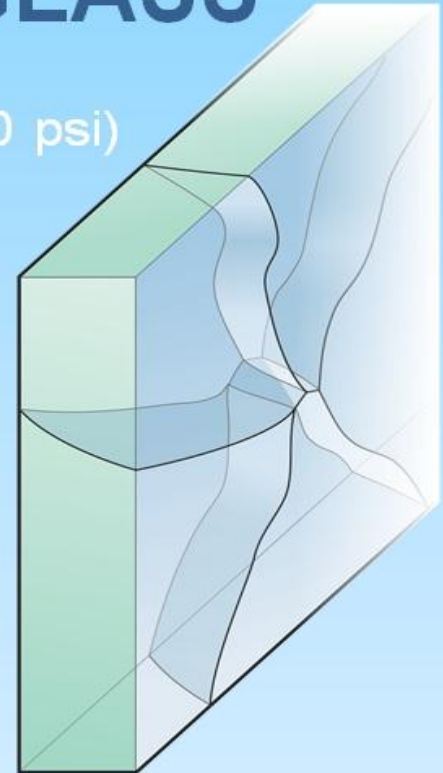
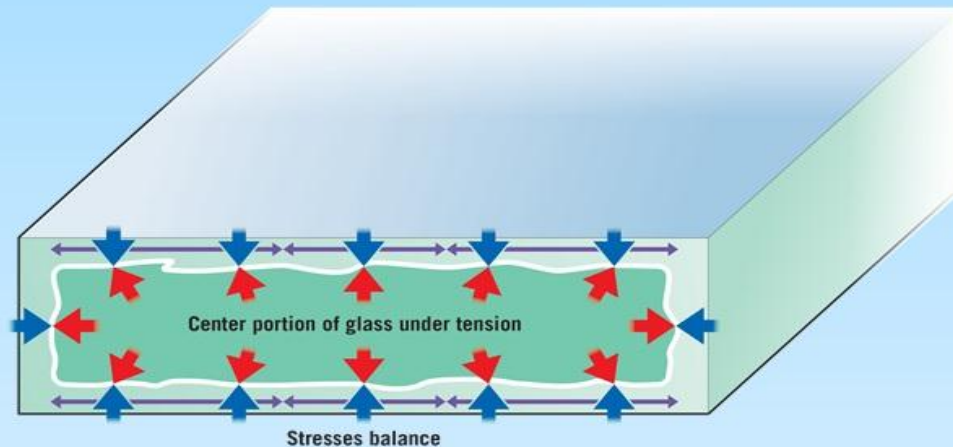
B. Thermal tempering

- When the ceramic is suddenly cooled, the outer surface solidifies and surrounds the softer molten core.
- This rapid cooling produces a skin of rigid glass surrounding a soft core. As the molten core solidifies, it tends to shrink and pulling the outer layer.
- This creates residual tensile stresses in the core and residual compressive stresses within the outer surface.



HEAT-STRENGTHENED GLASS

Surface of glass in compression (3,500-7,500 psi)



A Tensile Stress | Compressive Stress

Glass
Thickness



Heat Strengthened Glass

B Tensile Stress | Compressive Stress

Glass
Thickness



Tempered Glass

C. Thermal compatibility

1. Metals and porcelain are designed with a slight mismatch in their thermal expansion coefficient.
2. Metal contracts slightly more than the porcelain.
3. This mismatch leaves the porcelain in residual compression and provides additional strength for the restoration.

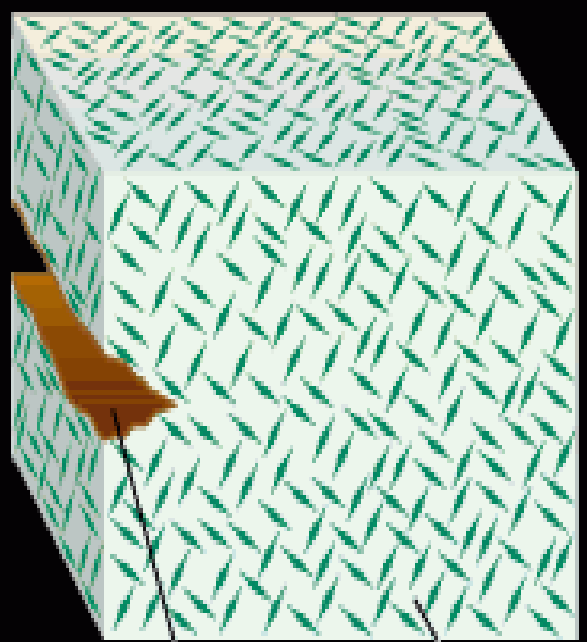
2. Interruption of crack propagation

a. Dispersion strengthening: This done by incorporating a different phase of a different material, very hard crystalline phases (alumina or leucite) that is capable of hindering a crack from propagation “crack stoppers”.

b. transformation toughening:

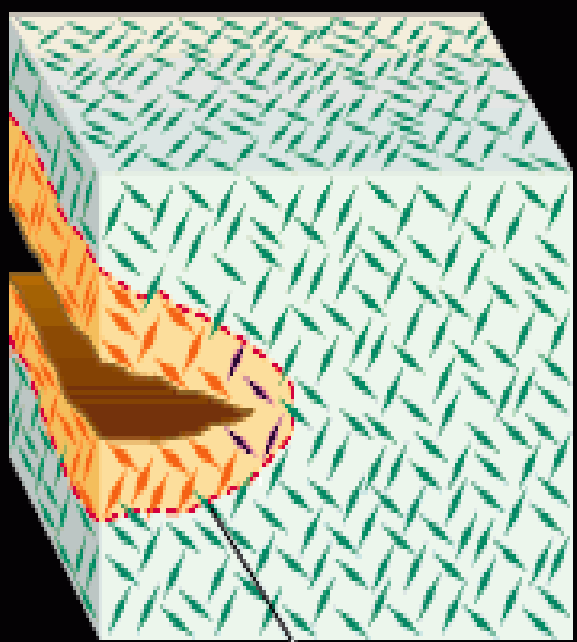
- Relies on the crystal structure changes under stress.
- Zirconia transformed into different crystal phase with increase in volume so produce compression on the crack and arrest its propagation.

crack initiation



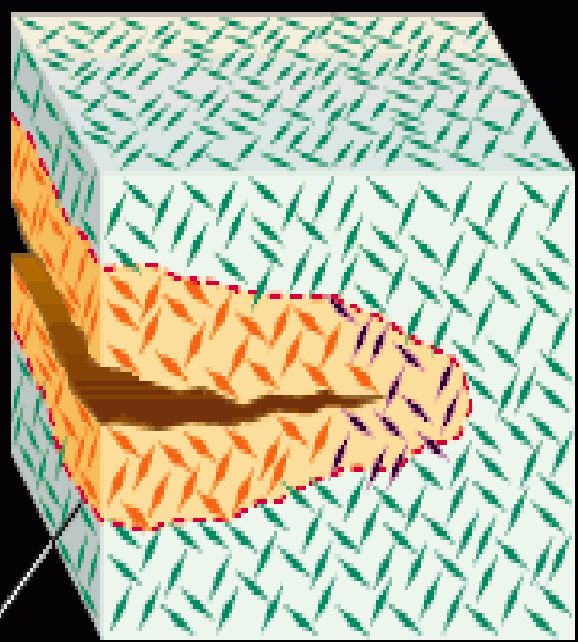
crack zirconia matrix

early stage
of crack propagation



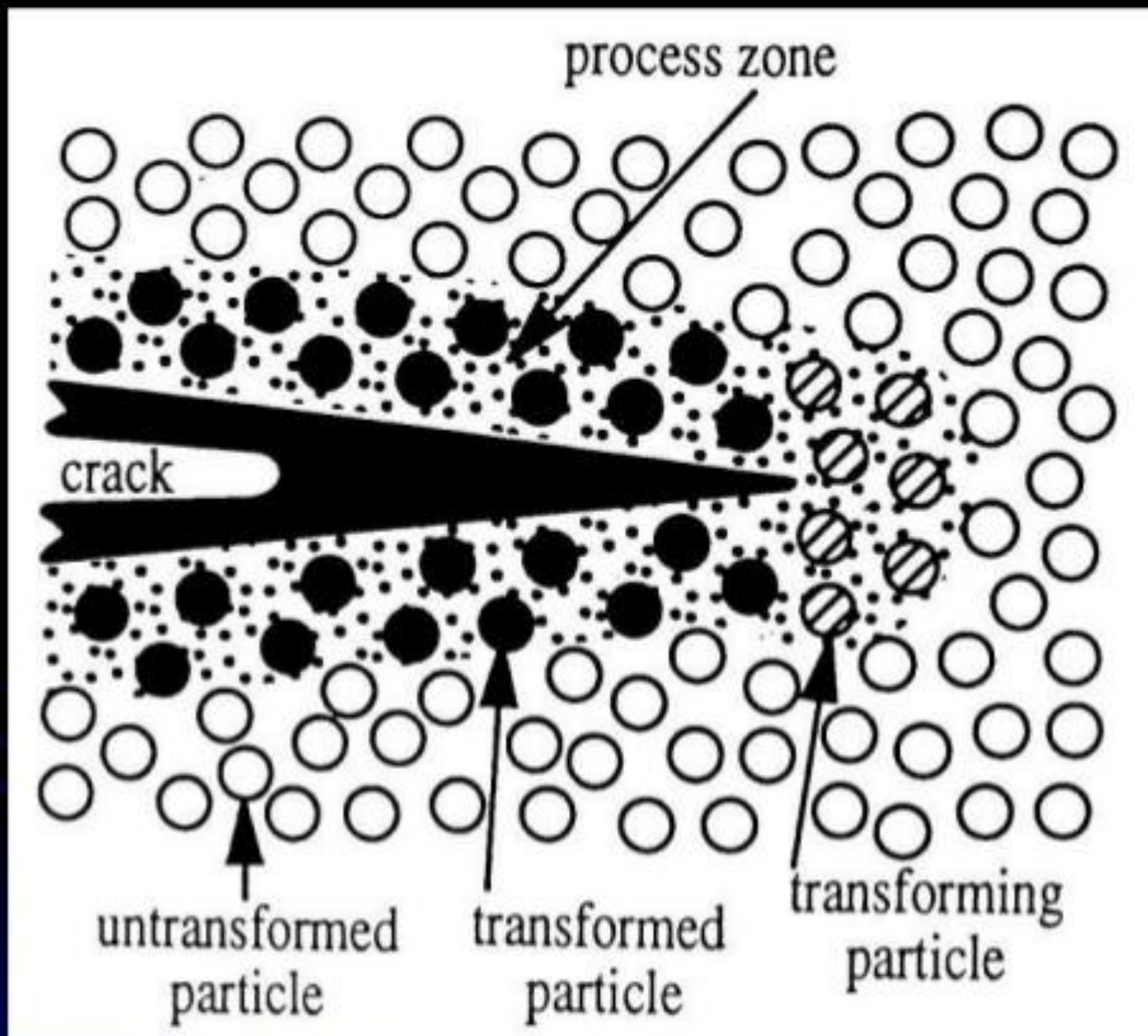
process zone crack-closing stress field

later stage
of crack propagation



process zone

-  tetragonal particles
-  tetragonal particles transforming into monoclinic particles
-  already transformed monoclinic particles



II. Design of ceramics restorations

Avoiding stress concentration.

- a. Removal of folds of the platinum foil.
- b. Removal of sharp line angles.
- c. Removal sudden changes in porcelain thickness.

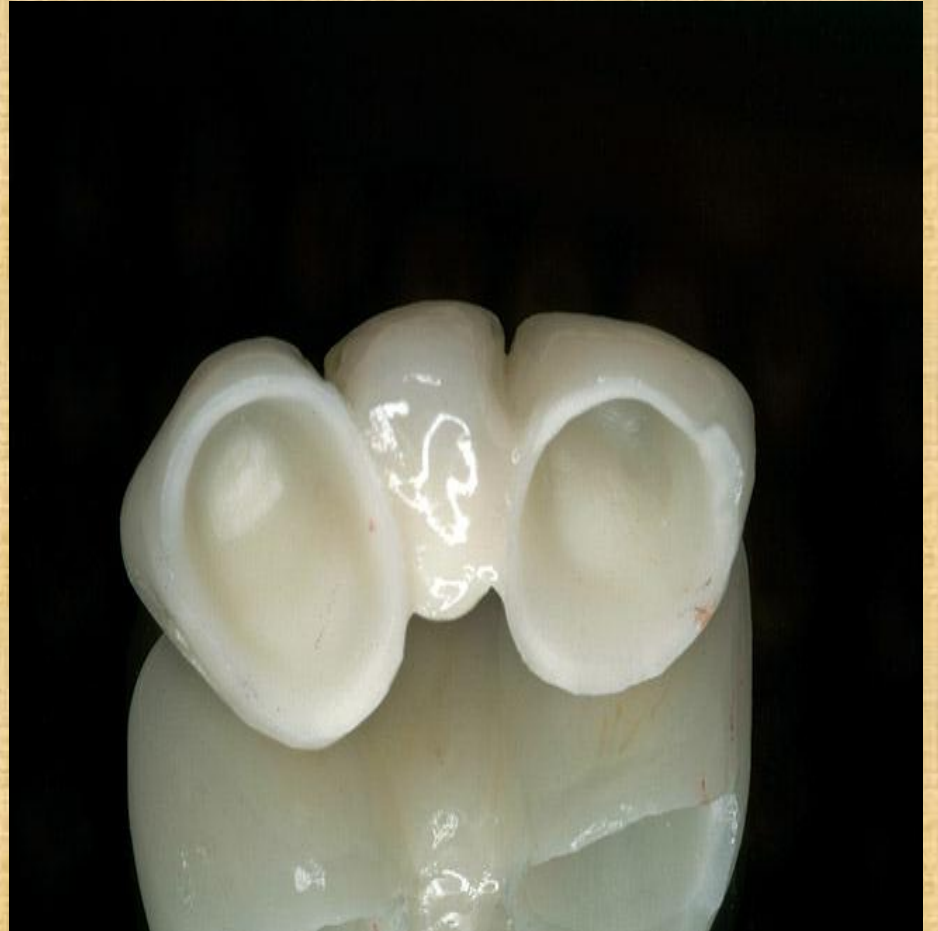
CERAMO-METAL RESTORATION

- Ceramo-metal restoration combines the advantages of both metal (high mechanical properties) and the porcelain (good esthetic).
- Metal-ceramic restorations consist of a cast metallic framework (or core) on which at least two layers of ceramic are baked.

Processing of ceramo-metal restoration

- Wax framework is fabricated on the die.
- The framework is cast by lost wax technique.
- It is important that all sharp angles rounded to avoid stress concentration.
- Sandblasting of the cast metal copy.
- Degassing is done to form oxide layer to improve bonding to ceramic.

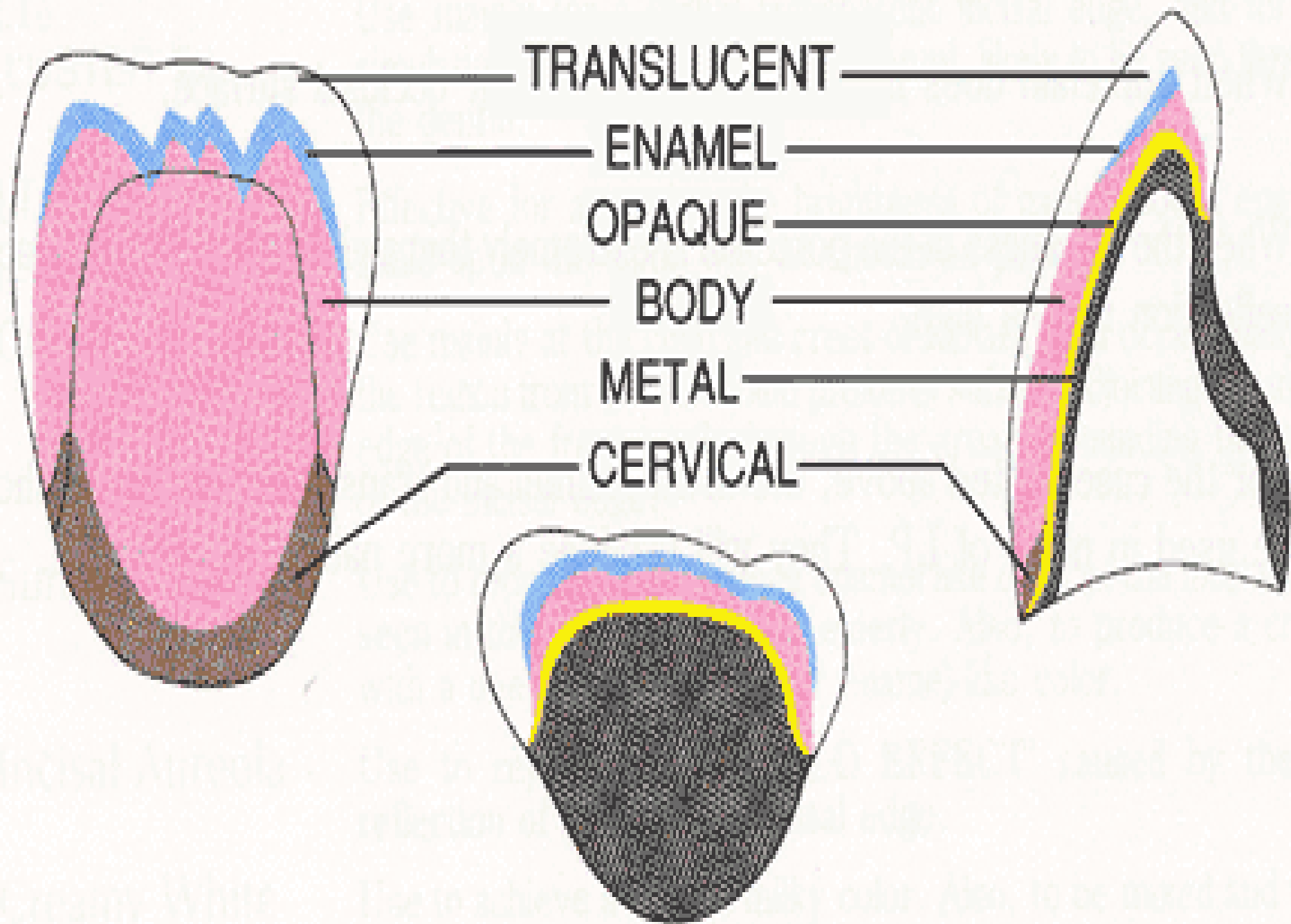
- The first layer applied is the opaque layer to mask the darkness of the oxidized metal framework. This thin opaque layer also contributes to the metal-ceramic bond.
- The next step is the buildup of dentin and enamel (most translucent) porcelains to obtain an esthetic appearance similar to that of a natural tooth





Copyright (C) Wada Precision Dental Laboratories Co. Ltd. ALL Rights Reserved.





Requirements for a Metal-Ceramic System

METAL

- The alloy must have a high melting temperature to withstand high firing temp of porcelain.
- Adequate stiffness and strength of the metal framework.
- High resistance to deformation at high temperature is essential.
- Adequate thickness of metal.

Porcelain

1. Porcelain must have a low fusing temp to avoid creep of the metal framework.
2. Porcelain must wet the alloy to avoid voids forming at ceramo-metal interface.

Porcelain and metal

1. A good bond between the ceramic and metal.
2. Coefficients of thermal expansion (CTE) of the porcelain and metal must be compatible

3. Adequate design of the restoration is critical.
- The preparation should provide for adequate thickness of the metal coping, as well as enough space for an adequate thickness of the porcelain to yield an esthetic restoration.
 - During preparation of the metal framework, prior to porcelain application, it is important that all sharp angles be eliminated and rounded to later avoid stress concentration in the porcelain

MECHANISM OF BONDING

1. Chemical bond:

- Chemisorption by diffusion between the surface oxides on the alloy and in the ceramic. These oxides are formed during wetting of the alloy by the ceramic and firing of the ceramic.

2. Mechanical bonding

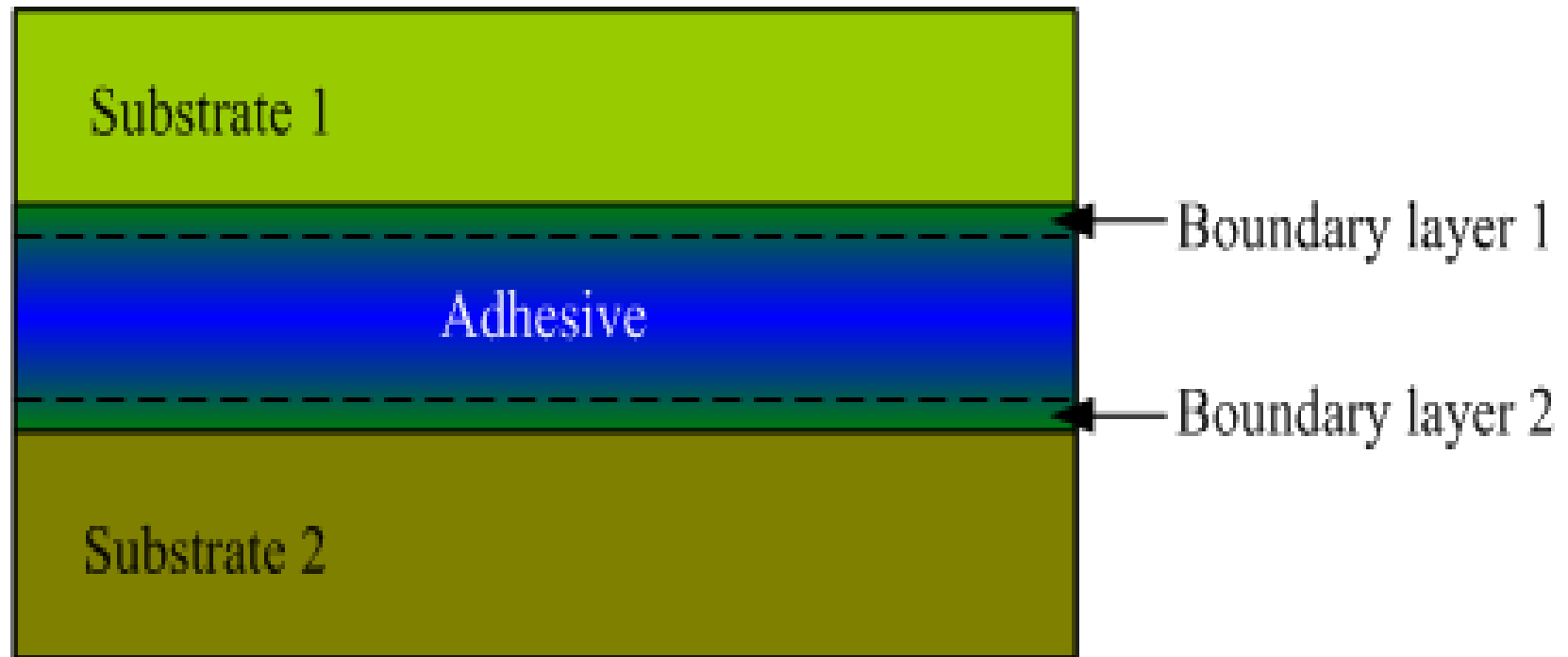
Mechanical interlocking between the two materials: through surface roughness and irregularities.

- **Base-metal alloys** contain elements, such as nickel, chromium and beryllium, which form oxides easily during degassing, and care must be taken to avoid too thick an oxide layer.
- **Noble metals**, resistant to oxidizing so it must have indium and tin to form surface oxides.

Failure of metal-ceramic bonding

1. **Cohesive failure:** Porcelain-porcelain, metal-metal, oxide-oxide.
2. **Adhesive failure:** Porcelain-oxide, metal-oxide, metal-porcelain.
3. **Mixed failure:** Any combination of the previous failures.

Structure of adhesive joint



ALL CERAMIC RESTORATION