**Amalgam alloy:** is an alloy made of liquid mercury and other solid metal particulate alloys made of silver, tin, copper, etc, and sometimes Zn, Pd, and In, etc. The solid alloy is mixed with (liquid) mercury in a mechanical vibrating mixer and the resulting material is packed into the prepared cavity. One of the solid alloys is composed of at least 65% silver and not more than 29% tin, 6% copper, 2% zinc, and 3% mercury. The reaction during setting is thought to be

$$\gamma + Hg \rightarrow \gamma + \gamma_1 + \gamma_2$$

in which the $\gamma$ phase is $Ag_3Sn$ (mechanically the strongest) , the $\gamma_1$ phase is $Ag_2Hg_3$ ( major matrix phase in set amalgam), and the $\gamma_2$ phase is $Sn_7Hg$ (weakest phase, corrodes easily).

Figure: picture of amalgam filler.

## Constituents in Amalgam

Basic:

- Silver (Ag) : increase strength, expansion, and corrosion resistance.
- Copper (Cu) : increase strength, reduces corrosion, and creep.
- Tin (Sn) : decease expansion and lengthens the setting time.
- Mercury (Hg) : activate reaction only pure metal that is liquid at room temp.

Other:

- Zinc (Zn) : decrease oxidation of other elements, provides better clinical performance.
- Indium (In): decrease surface tension, reduce creep and Marginal breakdown, increase strength and improvement of corrosion resistance.
- Palladium (Pd) : reduce corrosion rate.

## Classification of Amalgam Alloys:

Dental alloys can be classified into four groups :

1. Copper content:
   - Low copper alloys :(2-6 wt% Cu)
   - High copper alloys (13-30 wt% Cu)
2. Presence or absence of zinc
   - Alloys containing more than 0.01% wt Zn
   - Free alloy zinc less than 0.01% wt Zn
3. The shape of alloy particles :
   Spherical , spherical irregular , and lathe- cut irregular ( miro-cut , fine-cut, and coarse-cut ).
4. Number of metals in alloy :
   - Binary alloys ( Ag, Sn)
   - Ternary alloys ( Ag, Sn, Cu )
   - Quarternary ( Ag, Sn, Cu, Pb or In )

## Properties of Dental Amalgam

Dental amalgam must have several properties to withstand the stress and corrosive environment where it is used :

1. **Strength :** the strength of an amalgam restoration must be high enough to resist the biting forces of occlusion. The strength of the amalgam depends that are present. Having more of the stronger phases results in a stronger material. There are two types of strength are compressive and tensile strength. However, the tensile and shear strengths are comparatively low. Therefore, amalgam should be supported by tooth structures for clinical success in the long term. There are many factors affecting strength of dental amalgam , which are :
   1. Particle size
   2. Particle shape
   3. Microstructure of amalgam
   4. Porosities and voids in amalgam
   5. Hg/Alloy ratio
   6. Trituration time
   7. Condensation pressure
   8. Corrosion activity

2. **Creep:** is a slow change in shape caused by compression due to dynamic intra-oral stress. Creep causes amalgam to flow, such that unsupported amalgam protrudes from the margin of the cavity. These unsupported edges are weak and may be further weakened by corrosion. Creep also creates overhangs on fillings leading to food trapping and secondary decay. Creep occurs because of grain boundary sliding. There are several factors affecting the creep resistance which are :
   1. Microstructure of amalgam.
   2. Hg/Alloy ratio
   3. Trituration
   4. Condensation pressure
   5. Delay between trituration and condensation.

3. **Dimensional Change :** the net contraction or expansion of an amalgam is called its dimensional change. dimensional change is negative if the amalgam contracts and positive if it expands during setting. dimensional change is affected by many factors, such as:
   A. Components
   B. Moisture contamination: in case of alloys containing Zn, if contaminated with moisture before amalgam is set, may evince delayed or secondary expansion. The gas is formed as follows:

$$Zn+H_2O \rightarrow ZnO + H_2$$

4. **Corrosion resistance:** corrosion resistance of dental amalgam is very important property, because the applied environment (human body) is very aggressive, and during the reaction between the amalgam and its environment, different corrosion products will be released (especially mercury) and enter the human body which may affect negatively the health after certain time. Two types of corrosion accurse :
   1. Chemical corrosion (Tarnish).
   2. Electrochemical corrosion.

## Advantage of Dental amalgam:

1. It is durable.
2. Least technique sensitive of all restorative materials.
3. Applicable to a broad range of clinical situations.
4. Newer formulations have grater long term resistance to surface corrosion.
5. It has good long term clinical performance.
6. Ease of manipulation by dentist.
7. Minimal placement time compared to other materials.
8. Corrosion products time compared to other materials.
9. Long lasting if placed under ideal conditions.
10. Very economical.
11. Self sealing.
12. Biocompatible.

## Disadvantage of Dental amalgam:

1. Some destruction of sound tooth tissue.
2. Poor esthetic qualities.
3. Long term corrosion at tooth restoration interface may result in ditching leading to replacement.
4. Galvanic response potential exists.
5. Local allergic potential.
6. Concern about possible mercury toxicity that affects the CNS, kidneys and stomach.
7. Marginal breakdown.
8. Bulk fracture.
9. Secondary caries.

## Other Metals:

1. Gold and gold alloy: are useful metals in dentistry as a result of their durability, stability, and corrosion resistance.

2. Tantalum: corrosion-resistant, lower stiffness, high ductility and toughness.
3. Niobium : lower density than Ta but the same properties.
4. Magnesium alloys : low elasticity module.
5. Zirconium and zirconium alloy : characteristics corresponding to Ti, but it is twice as expensive.
6. Ni-Cr : (crowns and bridges, dental applications).