# Non prescious alloys

# Noble metals and alloys

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## Alloys used in dentistry :

pure metal : one metallic element

alloy : two or more metallic elements
used for strong structures
conduct heat, electricity
lustrous

binary alloy: mixture of two metals

ternary alloy: mixture of three metals

In molten state metals usually show solubility one within another. When the molten mixture is cooled to below the melting point, 4 things might occure:

1. The component metals remain soluble in each other forming a solid solution: -random, –ordered, -interstitial
2. The two metals can be completely insoluble in the solid state
3. The two metals can be partially soluble in the solid state.
4. The two metals can form intermetallic compounds with precise chemical formulation.

Base metal alloy: an alloy composed of metals that are not precious

Precious alloy: primarily composed of elements, that are precious

Semiprecious alloys: an alloy composed of precious and base metals.

**I.Non prescious alloys:** NiCr : bridge and crown casting
CoCr: partial denture framework casting

**CoCr alloys (stellites):** 35-65% Co
20-35% Cr
0-30% Ni + Mo, Si, Be, Bo, C

Cr : - harden the alloy
- corrosion resistance

Si : - good casting properties, and ductility

Be : - refine the grain structure

C : - hardness, strength, ductility
- too much results brittleness, becouse of carbide phase
- high melting temperature is good for discontinous carbid phase

**NiCr alloys:** 70-80% Ni
10-20% Cr + Mo, Be, Si, Bo, C

# Manipulation of base metal casting alloys :

T fusion of NiCr and CoCr : 1200-1500 C
gold : 950 C

melting: gold : gas-air mixture
base metal alloy : acetylen-oxygen flame
electrical induction furnace

too much oxigen : can cause oxidation of the alloy

excess of acetylen: increase metal carbide – embrittlement

investment moulds : can be silica-bonded or phosphate bonded, gypsum-bonded investments might decompose above 1200 C

density values : are half as casting gold alloys, extra thrust is necessary during casting

trimming and polishing : is a great expense, becouse of hardness, sandblasing, electrolytic polishing

## Properties:

-CoCr are hard-----------polishing is difficult

-final surface is : durable, and resistant to scratching

-both has very good corrosion resistance by the layer of chromic oxide

-CoCr has low ductility ( planning clasp) and is further reduced if the concentration of carbide is increased during melting.

-NiCr is ductile, -------- restoration can be burnished, high P value indicate, that high stress is needed for effective burnishing

-Pcocr>Pnicr able to withstand high stress,without permanent deformation.

-E(modulus of elasticity) are high in both metal.---- rigidity.

## Comparison with casting gold alloy:

-CoCr and NiCr are alternatives to casting gold alloy type III. and IV.

-CoCr is rigid ( E ) is high advantage for connector, disadvantage for clasp.

-Density is lower-------more difficult to produce defect free castings.

-Gypsum bonded investment can't be used.

-Resist stresses without deformation ( same like gold)

## Cast partial Denture alloy:

-connectors: - rigid ( E ) is high

- not deform permanently (high P)
- lighter base ( lower density of base metal alloys).

-clasp: - should not deform permanently ( high P )

-should have increased flexibility ( E ) is lower engage deep undercuts

-ductile (to adjust)

-stress developed in CoCr clasp is more than double than in an equivalent gold alloy clasp.

-type IV gold is the best for clasp.

For reasons of cost CoCr alloys are almost universally used, despite their limitations.

## Crown and Bridge alloy:

- should be hard and rigid and durable
- should have adequate mechanical properties
- success of crown and bridge alloys depends on the accuracy of casting
- gold is the best with greater density ( better castability), less casting shrinkage ( 1,4%).
- NiCr is widely used in ceramo metallic restorations

## Biocompatibility:

- Be: animal carcinogen
- Ni: allergic contact dermatitis
- Ti+Va: excellent biocompatibility

# II.Wrought Alloys

Casting is not the only way how metal can be shaped. An alternative is to use cold working. A wrought structure by cold working at room temperature:

- bent
- hammer
- drawn

**Examples for wrought alloys – burs-wires-denture bases**
**Steel and stainless steel are the most widely used wrought alloys**

# I. Steel:

-iron+carbon(2%) – if carbon is greater it produce a very brittle alloy, which is unsuitable for cold working.

-corrosion resistant by passive oxid layer on the surface.
-in the solid state steel is able to adopt a variety of structures depending on the carbon content and temperature.

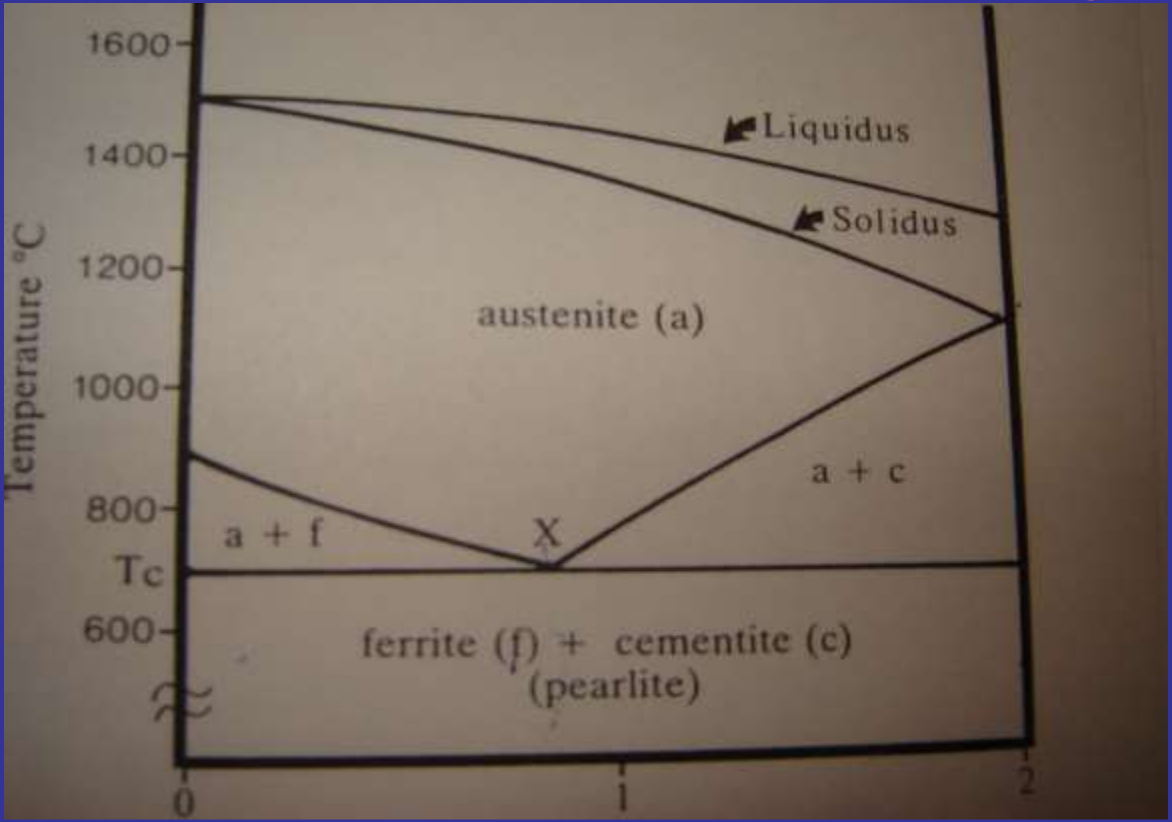
- above 723 C solid solution of carbon in iron with a face centered cubic structure is formed= a u s t e n i t e.

-below 723 C austenite breaks down into two phase:

1. f e r r i t e ( carbon cc. is up to 0,02%), softer,more ductile
2. c e m e n t i t e ( $Fe_3C_2$) hard and brittle

1.+2.= p e a r l i t e

These transitions are illustrated in the iron-carbon phase diagram.




The critical temperature: $T_c$= eutectic temperature, at this point, the alloy undergo phase separation

In case of iron-carbon system, the transition occure within the solid state.

Eutectoid alloy =containing 0,8% carbon

Hypereutectoid alloy=contain more carbon (cementite),cutting instruments

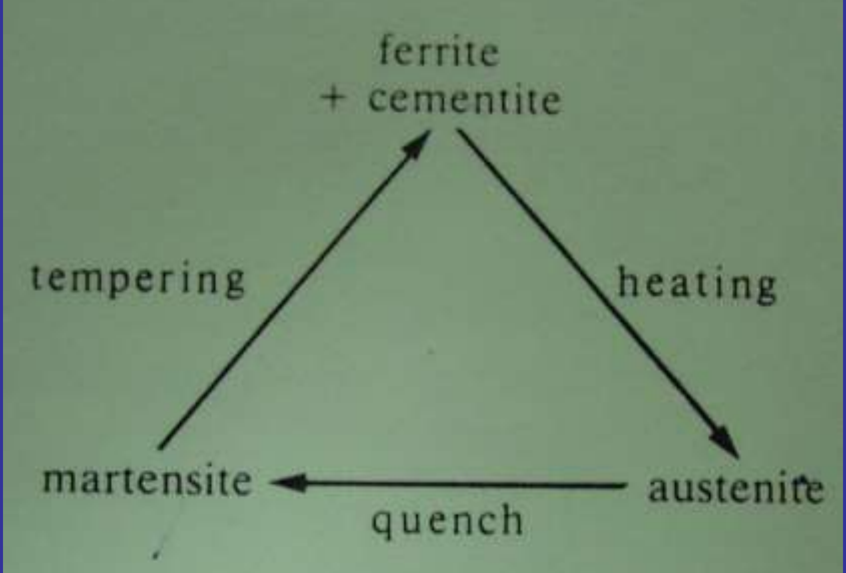
Hypoeutectoid alloy=contain less carbon (more ferrit),non cutting instr., forceps

# Steel can be further hardened by heat treatment:

1.Stainless steel is heated to a temperature 1000 C and cooled slowly: the f.c.c.structure is transformed to b.c.c.=ferrite+cementite with reasonable physical properties

2.Steel is heated 1000C and cool rapidly: there is no time to form cementite. Distorted cubic structure is formed= martensite( hard and brittle)

3.Martensite is heated to above 200-500 C diffusion of carbon atoms occures with the production of a less distorted cubic structure= tempering or softening the alloy. Low temperature heat treatment is carried out for a long time , the structure become cubic.




.2 Fig. 10.2 Diagram illustrating the hardeni
ing cycle of heat treatments which can be us

**Stainless steel:** -iron + carbon + Cr ( to improve corrosion resistance)+ Ni ( corrosion resistance +strengthen the alloy)

1.austenitic stainless steel: - 18%Cr, 8% Ni (18/8)

-not possible to harden by heat, only by cold working

- a thin sheet of stainless steel(0,2mm) is pressed by a hydraulic press, or by a sudden pressure vawe. It is very light, thin, conduct heat rapidly, no surface detail, acrylic difficult to apply.

-non cutting instruments, wires, denture bases

-the wrought structures ( after bending, swaging, drawing): has higher P(comparing to not cold worked alloys) has higher E----suitable for orthodontics.

2.martensitic stainless steel: -smaller Cr+Ni (12%+0%)

-good corrosion resistance

-can be hardened by heat treatment.

-cutting instruments and probe

**Wires: -** used for the construction of orthodontic appliances, wrought clasps, and rests on partial dentures.

-produced by **drawing** ( grain structure is highly fibrous)

- requirements: - bent without fracturing
  - -corrosion resistance
  - -joined by soldering or welding
  - -spring back ability, becouse it underwent large deflections without permanent deformation

$$\text{spring back potencial} = \frac{\text{Yield stress}}{E}$$

-should have a **value of stiffness**: increasing thickness of a wire from 0,6mm to 0,7mm increases stiffness by a factor of 1,86.

## Commonly used wires:

1.stainless steel wire: -18/8 austenitic type

-high E

-high value of yield stress and spring back

-sufficient ductility, to allow bending without fracture: soft, half hard, hard

-after bending, a stress relief anneal is carried out to relieve internal stresses= heating the wire to 450 C for 10 min.

-annealing procedure can be carried out only with stabilized stainless steel wires, which contain small Ti.

-joining of stainless steel wire can be accomplished by soldering or welding( silver and copper) to lower the fusion temperature.

-welding: pressing 2 pieces of wire together between 2 elektrodes, than passing an electric current, that melts wire at the contact points.

$$\Delta T \text{ x } \alpha \text{ x } J^2 \text{ x } R \text{ x } t$$

**2. Gold wire :** - similar to type IV. casting gold
-contains : 60% gold, 15% silver, 15% copper, 10% platinum
- E is lower than stainless steel wires.
-easily soldered

**3. CoCr wire:** - Co : Cr : Ni : Fe : Mo
40 : 20 : 15 : 16 : 7 portions
- excellent ductility
- wire can be hardened by heat treating at 480 C
- E is similar to stainless steel
- difficult to solder

**4. Ni Ti wire:** -nitinol : equal amount of Ni+ Ti
- flexible: E is low-------low forces can be applied
-excellent spring back properties: high yield stress
- limited ductility
-useful for large tooth movement over long period of time with low forces.

**5. B titanium wire:** - Ti+ Mo; ductile; good formability; spring back ability is same as stainless steel; E is lower than stainless steel.

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**II.Precious Metals:** - Noble metals + silver

-Noble metals: Platinum group+ gold

-Platinum group : Platinum, Palladium, Iridium, Rhodium, Osmium, Rhuthenium

**Properties:** - good metallic surface

-react easily with sulfur-------form sulfides

-resistance to oxidation, corrosion: -during heating, casting, soldering

Platinum group of metals: -light group: Ru, Ro,Pa at.weight:100

-heavy group: Osm, Ir, Pl at. weight:190

## Gold:

**1.Pure gold :-** too soft, malleable, ductile metal

- doesn't oxidize under atmospheric conditions
- is attacked by only a few of the most powerful oxidizing agents
- yellow colour with strong metallic luster
- melting point of the pure metal :1063C
- the presence of less than 0,2% lead causes gold to be extremely brittle.

-gold is soft and lead, it must be alloyed with copper, silver, platinum

2.Gold foil : -for pure gold fillings

- when 2 pieces of pure gold are pressed together, metallic bonds are formed at their contact point, and the gold is welded together.

-we use cold welding when building up a pure gold filling

-cohesive gold is used, 0,001 mm thin gold sheet.

-condensation of gold can be carried out : by hand or by mechanical vibrator .

advantages: - perfectly corrosion resistant

- does not rely on a relatively soluble cement lute for retention.

In high load bearing areas has sufficient rigidity and elastic limit to resist distortion. Today becouse of high costs and long procedure , we rarely use this method.

3.Mat gold: - gold also serves as filling material, and hand condensation.

4.Casting gold alloy:-casting gold is essentially an alloy of gold, silver and copper modified with platinum and palladium.

-gold, platinum and palladium confer corrosion resistance , while silver and copper produce superior mechanical proper ties.

# Classification of gold alloys:

1. carat number: number of parts by weight of gold in 24 parts of an alloy.
2. fineness value: number of parts by weight of gold in 1000 parts of the alloy
3. nobility ( gold content ):% of gold in the alloy.

TypeI.:85% gold, heat treatment is not possible, not high stress can be.

II.: 75% gold, good for inlays, harder, 18c.

III.: 70% gold, hard,good for bridges

IV.:65% gold, extra hard for partial denture and clasp.

low gold content alloy :2- 10% gold, normally 45-50% is used.- palladium content is high.

-similar to typeIII. and typeIV. gold alloys

-ductility is significantly lower than conventional

-extension is as little as2%

-good properties and good clinical performance

-lower costs-----widespread use

**Hardening heat treatments of T.III and IV.Gold alloys:**
**Phase diagram for Silver-Copper system: precipitation hardening**

-the component metals are only partially soluble in the solid state

-the solidified alloy consists of a mixture of two solid solutions

1.one in which small quantities of copper are dissolved in silver (called the α solid solution)

2.one in which small quantities of silver are dissolved in copper ( called βsolid solution)

αBF and CG = solvus lines---indicate the decreasing solubility of copper in silver and silver in copper as the temperature decreases. Eg: solubility of copper in silver is 9% at 780 C ( eutectic temperature) but only 2% at 400C

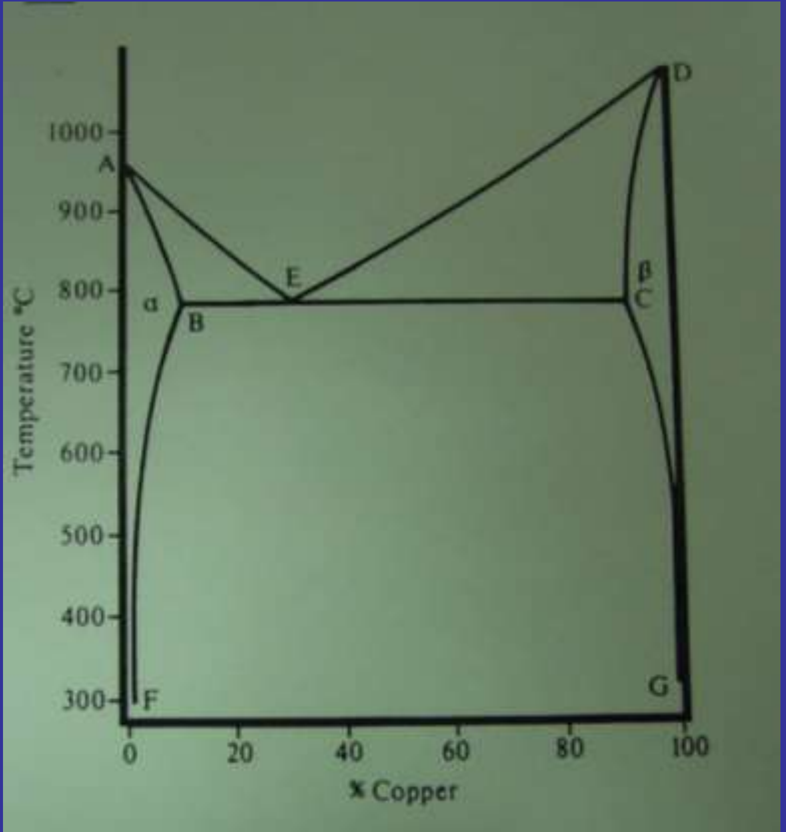


Fig. 7.1 Phase diagram of the silver–copper system.

ABECD= solidus line

AED= liquidus line

E= eutectic composition: 28%Cu 72%Ag

α has composition:B

β has composition:C

# Gold-Copper system:

-they form a continuous series of solid solutions over the whole range of compositions

-the solid solutions are random substitutional solid solutions with face centered cubic lattice

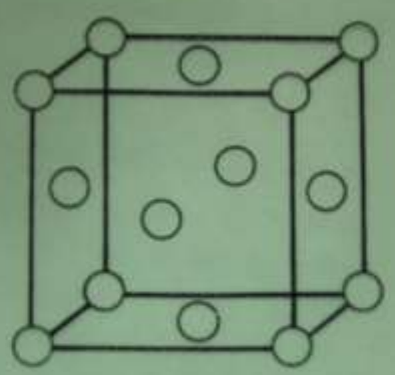


Fig. 7.2 Disordered, face centred cubic, gold–copper alloy. Circles represent either gold or copper.

# Phase diagram for the gold copper system: order hardening

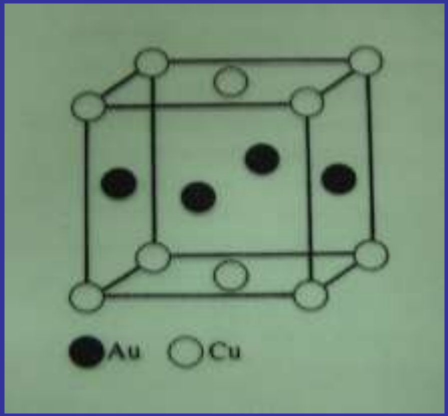
-the solidus and liquidus are close together, and coincide at point M

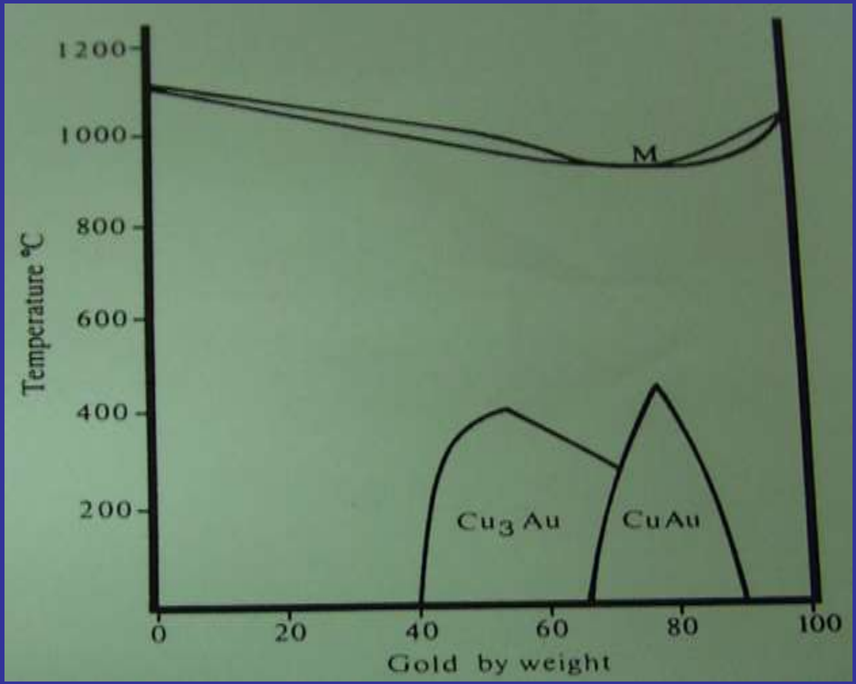
-between 40% gold, and 90% gold, the alloys are capable of undergoing a solid solid transition to an ordered lattice.

-the ordered lattice, in which gold and copper take up specific lattice sites called a superlattice

$Cu_3Au$ result of heat treatment: change in size and shape, increase in hardness and strenght, reduction of ductility -order hardening.

Precipitation: Ordered tetragonal structure CuAu of a heat treated gold copper alloy, containing 75% gold



## Other Noble Metals:

I.Platinum:-pure platinum: -high fusing point

-resistant to oral conditions, and elevated temp.

-platinum foil: used for fused porcelain restorations (it doesn't oxidize at high temperature, higher melting point than porcelain, expansion coefficient is same as porcelain

- used for pins, posts in crown and bridge restauration

Properties:- bluish white colour

-as hard as copper

-gravity:21,37

-melting point: 1755 C

-ductile and malleable---can be produced as foil, or fine drawn wire

-lighten the colour of yellow gold alloys

**II.Palladium:**

- **not used in pure state**
- **used in many alloys combined with gold or silver**
- **cheaper than pl.**
- **white**
- **gravity is 11,4**
- **malleable, ductile**
- **melting point1555 C**
- **prevent corrosion of silver in the oral environment.**

**III.Iridium:**

- **small amounts are present in dental alloys**
- **white, hard, brittle metall**
- **specific gravity 22.42**
- **high melting point 2440 C**

IV.Silver:-in the mouth it forms black sulfides

- malleable, ductile
- white colour
- conduct heat and electricity
- stronger and harder than gold, softer than copper
- melting point is 960,5 C
- adding of small amount of palladium to silver containing alloys, prevent the rapid corrosion in the oral environment
- is a component of most dental gold alloys

## Silver –palladium alloys:

- contain little gold
- contain primarily silver and palladium
- around 25% palladium with small quantities of copper, zinc, iridium, and gold
- lower density than gold alloys---influence castability
- similar properties to the typeIII. And IV.gold alloys


Thank You for Your
attention!