Metalurgies for wire bonding Ulrasonic ,Thermosonic and Thermocompression

-Plating processes

-Gold based metalurgies

-Aluminium based metalurgies

-Other metals

-Other interconnection techniques

-Long term reliability

-Examples

Plating processes

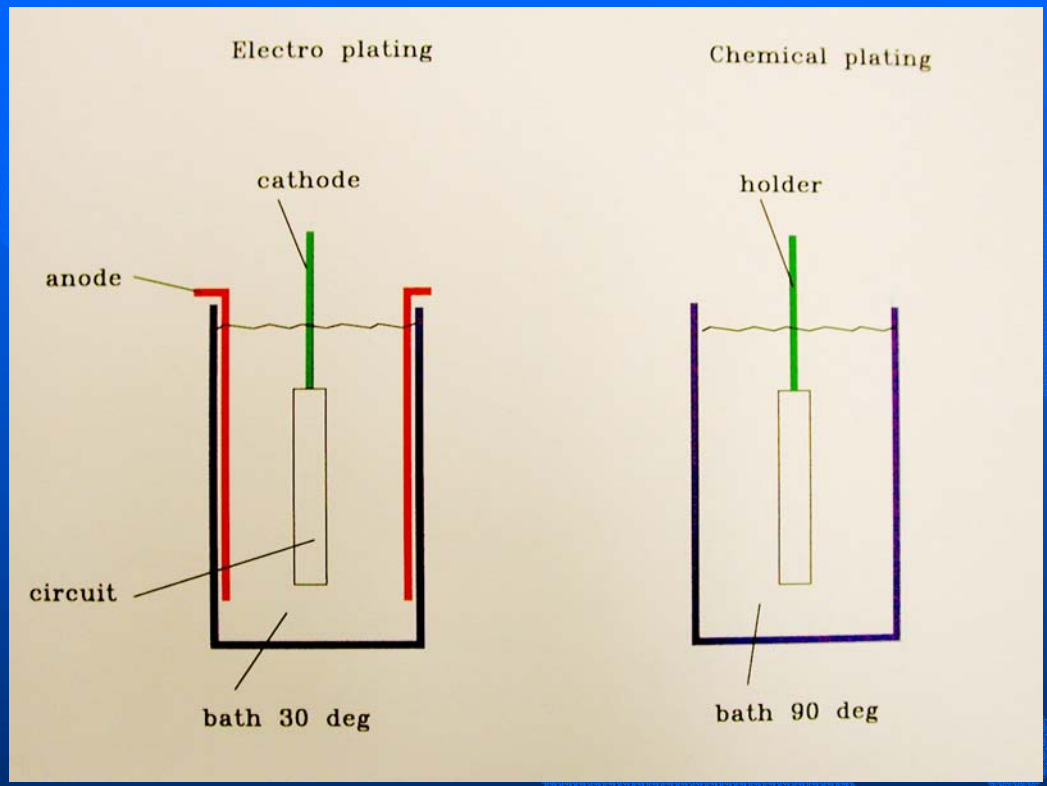
Electro & Chemical plating

Vacuum plating

Thick film plating

Layout/patterns

Electro-plating/Chemical -plating



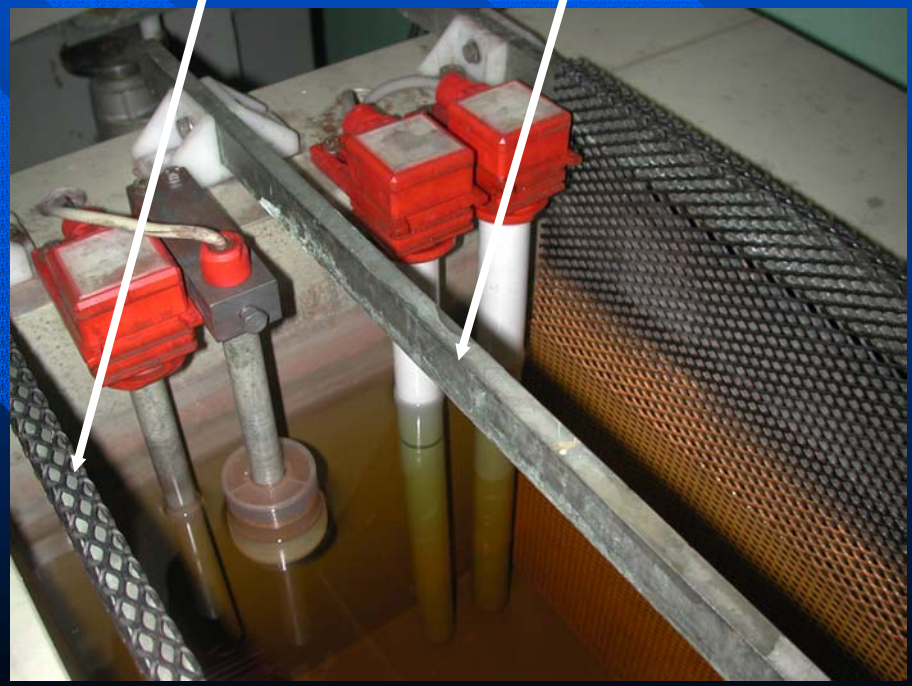
Electro plating
-Plate only on metals
-Metal in salts or directly the electrodes
-Metals thickness depends on time/temp/current

Chemical plating
-Plate only catalysed metals
-Metal in salts
-Deposition by immersion or autocatalytic
-thickness is not fully temperature and time dependent

Electroplating bath

Anode

Cathode



Gold bath (electro plating)
Ni, Au, Cu, Pd ,Ag

The bath can be re-used
by replenisching with salts or
changing the anodes

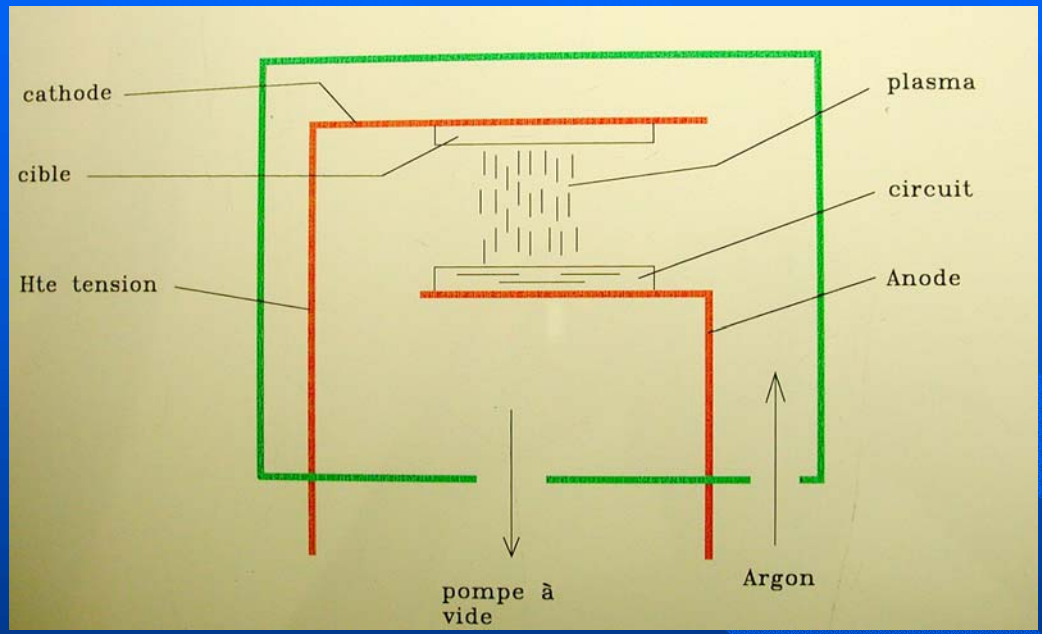
Chemical plating bath

Gold bath (chemical plating)

Ni , Au , Pd, Cu

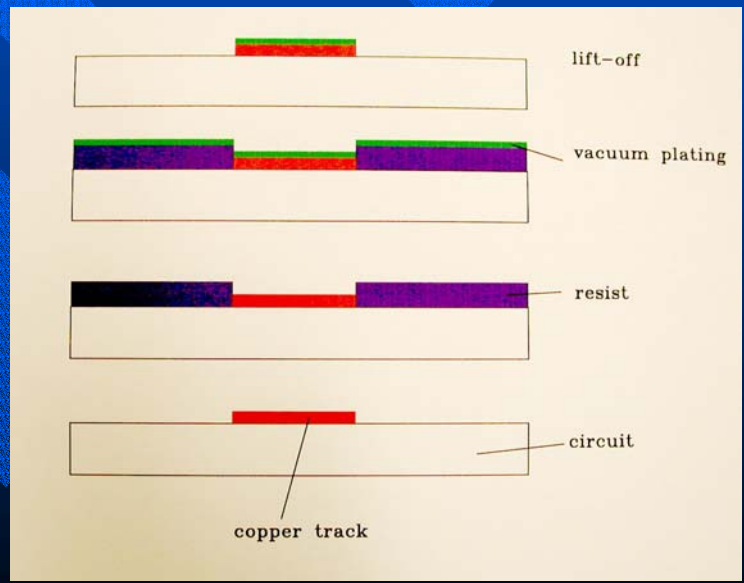
You can deposit around 6 to 10 times the metal present in one bath
The bath start to be instable after that.

Vacuum plating



-Amorphous deposition
-Metals deposited :Ni,Cu,Al,Au,TI,Pd etc
-Ductility depends on Argon pressure

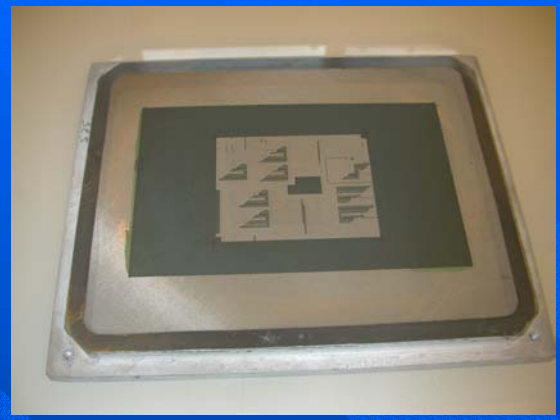
Lift-off

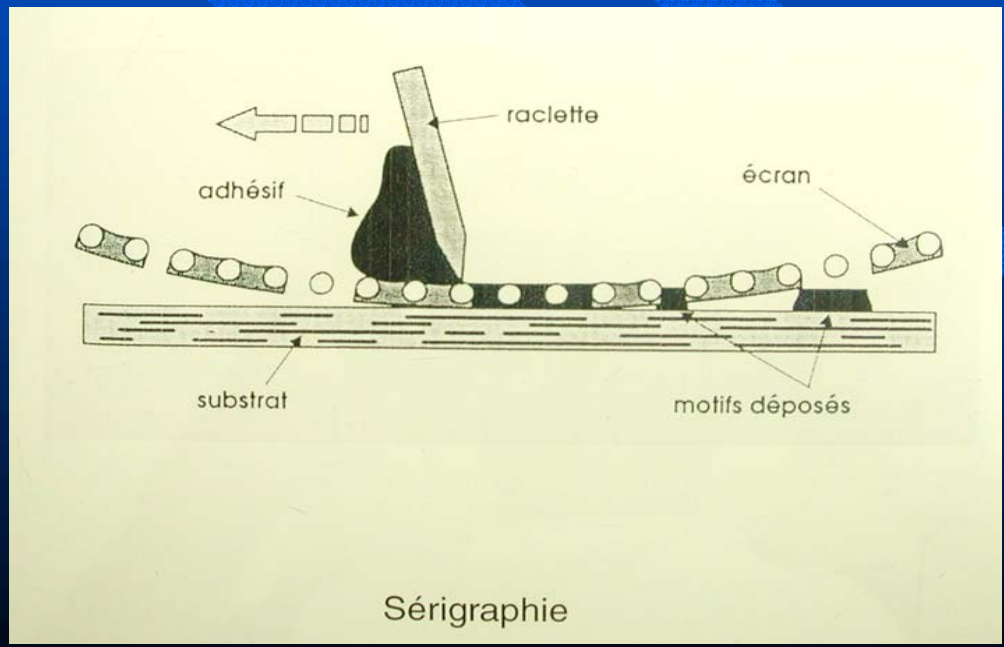


Screen printing plating 1/2

Screen printing machine

Screen : stainless steel mesch



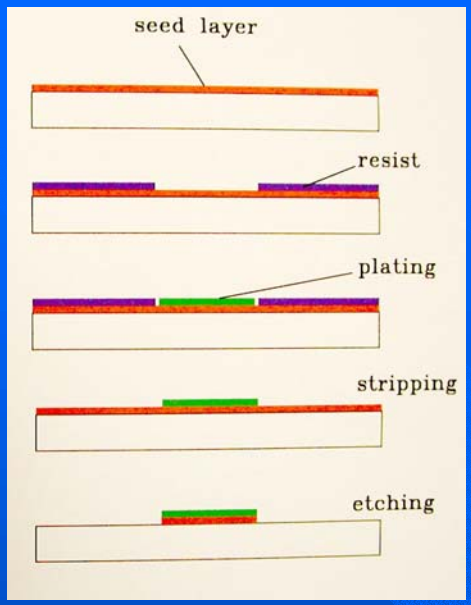


Screen printing plating 2/2

Firing :belt oven

Metals: Thick Au , Ag, PtAu, PdAu
Special Gold alloys for reduced Kirkendall effects

Layouts/Patterns



Seed layer

Electro plating

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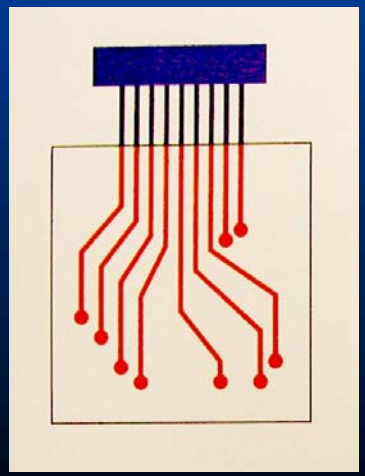
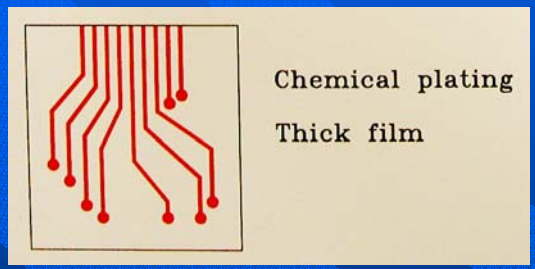
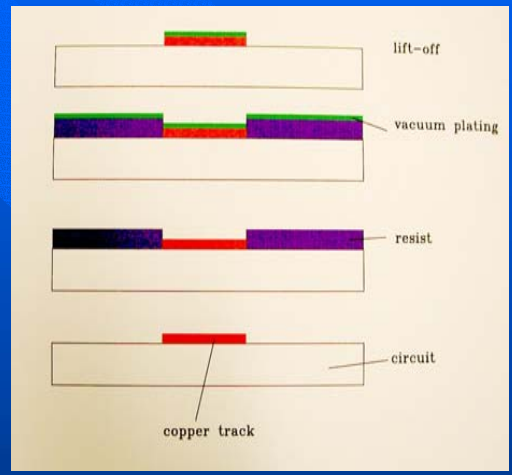




Direct plate or print

Chemical plating
Thick film



Lift-off or etching

Vacuum plating

Gold based platings 1/2

Type	Thicknesses (um)	Plating type
Ni/Au	5/0.05-0.1	chemical
Ni/Pd/Au	5/0.3/0.05-0.1	chemical
Ni/ Thick Au	5/1	chemical/electro
Au Cobalt	3	electro
Chemical Au	0.05-0.1	chemical
Electro Au	1.5-2	electro
Ni/Au Vacuum	2/1	sputtering
Au thick film	8-15	Screen printing

Gold based platings 2/2

Plating	Al bonding	Au bonding	contact	Press fit	Solder
Ni/Au	OK	NO	NO	OK	OK
Ni/Pd/Au	OK	OK	NO	OK	OK
Ni/Thick Au	OK	OK	NO	OK	OK*
Au cobalt	NO	NO	OK	OK	NO
Chemical Au	NO	NO	NO	NO	OK
Electro Au	OK/NO	OK/NO	NO	NO	OK*
Ni/Au vacuum	OK	OK	NO	NO	OK*
Au thick film	OK	OK	NO	NO	NO

* Ok but not recomanded

Aluminium based platings

Aluminium type	Thicknesses (um)	Wedge Al	Ball Au
Sheet 99.9 %	15-50	OK	OK
Vacuum evaporation	1.5-2 mini	OK/NO	OK/NO
Vacuum sputtering	1.5-2mini	OK*	OK*
Al/Si sputtering (1-2%)	1.5-2mini	OK*	OK*
Al/Cu sputtering(1-3%)		OK*	OK*

* Depend on the parameters during the process

Other metals

-Cu → bondable but not reliable

-Ag → bondable but not reliable

-Cr → difficult to bond due to passivation

-Ni → difficult to bond due to passivation

-Pt Au → bondable but not as good as Gold

-Pd or Ni/Pd → Seem to be as good as Gold but not very used (chemical & electro)

Other interconnections techniques with similar processes as wire bonding

-TAB (tape automated bonding)

Thermocompression Au/Au or Au/Sn

-Bump bonding

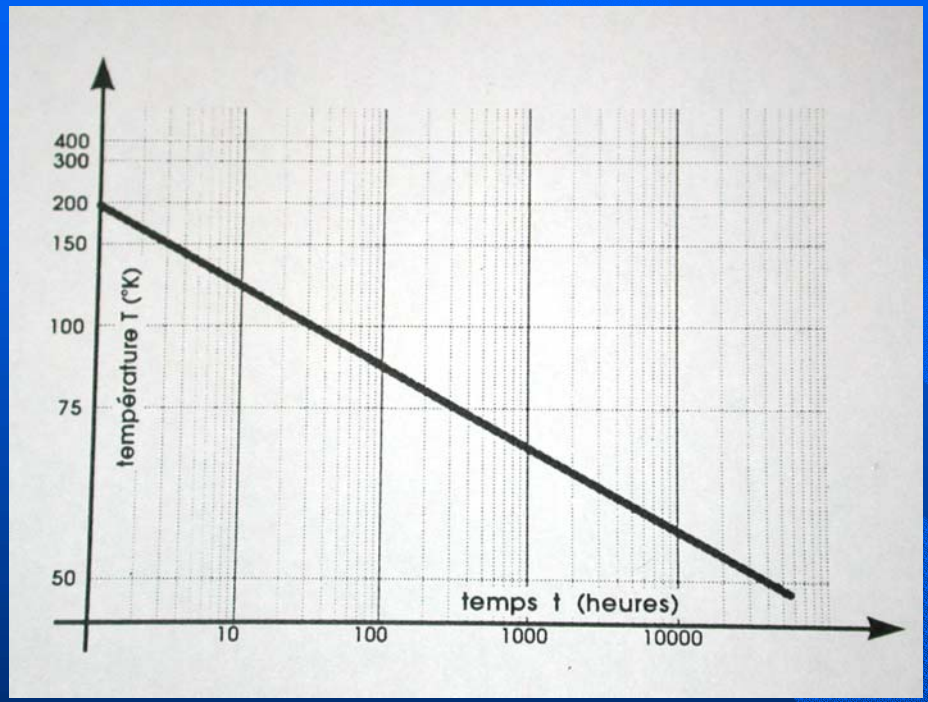
Thermocompression Au/Au (C4 or ball bumps)

-SMD component bonding

Ultrasonic SnPb/SnPb

Long term reliability 1/3

Kierkendall effect (Al to Au bond)

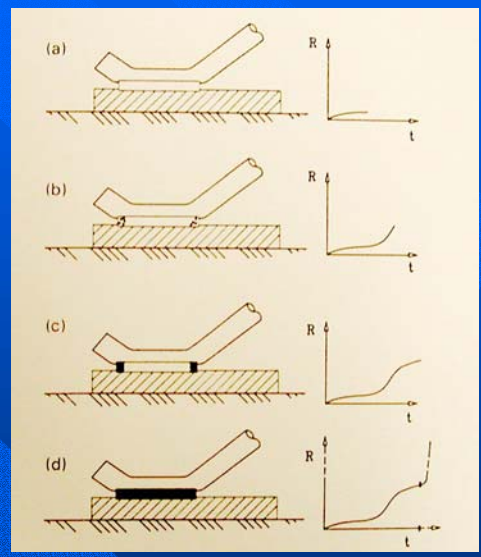


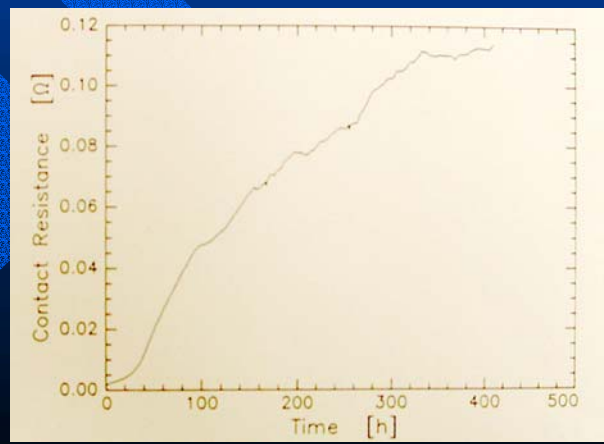
Curve X=cte

$$x = \sqrt{t \cdot k_0 \cdot e^{\frac{-E}{K \cdot T}}}$$

X=thickness of AuAl2
t= Time
T=Temperature
K=Boltzmann constant

Kirkendall voids evolution





Long term reliability 2/3

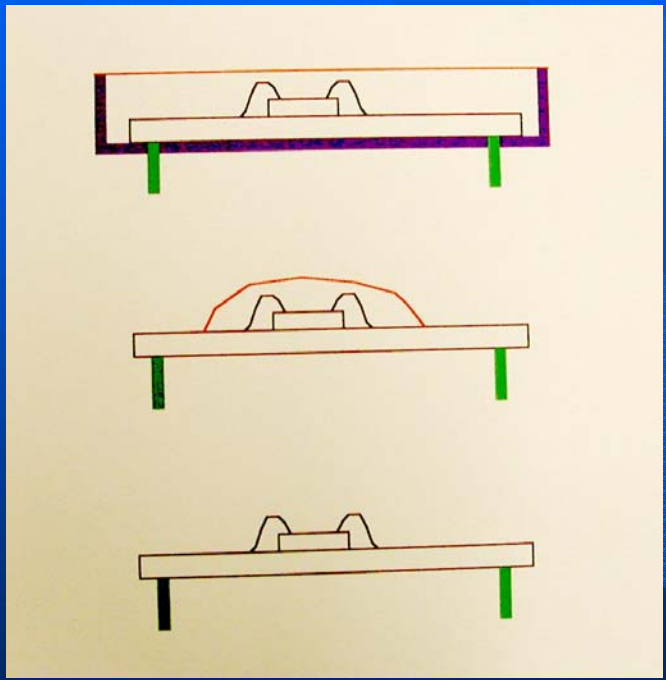
Kirkendall voids observed in 2 cases:

-Aluminium bonding on thick gold pads (1 to 15um)
Not on immersion gold (0.05um)

-Gold bonding on Aluminium pads

No information on intermetallics with Pt/Au or Pd

Long term reliability 3/3



- Sealed package with Nitrogen without humidity
- Glass epoxy Glob-top , silicon gel, Polyimide glob-top. Sensitive to CTE mismatch
- No protection , need a controlled atmosphere and no humidity

Examples