Metalurgies for wire bonding
Ultrasonic, Thermosonic and Thermocompression

- Plating processes
- Gold based metalurgies
- Aluminium based metalurgies
- Other metals
- Other interconnection techniques
- Long term reliability
- Examples

Rui De Oliveira 12/06/03
**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

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

The bath can be re-used  
by replenishing with salts or changing the anodes
Chemical plating bath

You can deposit around 6 to 10 times the metal present in one bath. The bath starts to be unstable 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 2/2

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

Firing: belt oven
Layouts/PATTERNS

Seed layer
Electro plating
« Nourrice »

Seed layer
Electro plating
« Nourrice »

Chemical plating
Thick film

Direct plate or print

Chemical plating
Thick film

Vacuum plating

Lift-off or etching
### Gold based platings 1/2

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

- **Ni/Au**: Nickel/Au plating with thicknesses ranging from 0.05 to 0.1 micrometers.
- **Ni/Pd/Au**: Nickel/Palladium/Au plating with thicknesses ranging from 0.3 to 0.05 to 0.1 micrometers.
- **Ni/ Thick Au**: Nickel/Thick Au plating with a thickness of 5 micrometers and 1 micrometer.
- **Au Cobalt**: Gold Cobalt plating with a thickness of 3 micrometers.
- **Chemical Au**: Chemical Au plating with thicknesses ranging from 0.05 to 0.1 micrometers.
- **Electro Au**: Electro Au plating with thicknesses ranging from 1.5 to 2 micrometers.
- **Ni/Au Vacuum**: Nickel/Au Vacuum plating with thicknesses ranging from 2 to 1 micrometers.
- **Au thick film**: Gold thick film plating with thicknesses ranging from 8 to 15 micrometers.

These plating types are commonly used in various applications requiring gold-based coatings.
<table>
<thead>
<tr>
<th>Plating</th>
<th>Al bonding</th>
<th>Au bonding</th>
<th>contact</th>
<th>Press fit</th>
<th>Solder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ni/Au</td>
<td>OK</td>
<td>NO</td>
<td>NO</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>Ni/Pd/Au</td>
<td>OK</td>
<td>OK</td>
<td>NO</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>Ni/Thick Au</td>
<td>OK</td>
<td>OK</td>
<td>NO</td>
<td>OK</td>
<td>OK*</td>
</tr>
<tr>
<td>Au cobalt</td>
<td>NO</td>
<td>NO</td>
<td>OK</td>
<td>OK</td>
<td>NO</td>
</tr>
<tr>
<td>Chemical Au</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>OK</td>
</tr>
<tr>
<td>Electro Au</td>
<td>OK/NO</td>
<td>OK/NO</td>
<td>NO</td>
<td>NO</td>
<td>OK*</td>
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<tr>
<td>Ni/Au vacuum</td>
<td>OK</td>
<td>OK</td>
<td>NO</td>
<td>NO</td>
<td>OK*</td>
</tr>
<tr>
<td>Au thick film</td>
<td>OK</td>
<td>OK</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
</tbody>
</table>

* Ok but not recomanded
### Aluminium based platings

<table>
<thead>
<tr>
<th>Aluminium type</th>
<th>Thicknesses (um)</th>
<th>Wedge Al</th>
<th>Ball Au</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheet 99.9 %</td>
<td>15-50</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>Vacuum evaporation</td>
<td>1.5-2 mini</td>
<td>OK/NO</td>
<td>OK/NO</td>
</tr>
<tr>
<td>Vacuum sputtering</td>
<td>1.5-2mini</td>
<td>OK*</td>
<td>OK*</td>
</tr>
<tr>
<td>Al/Si sputtering (1-2%)</td>
<td>1.5-2mini</td>
<td>OK*</td>
<td>OK*</td>
</tr>
<tr>
<td>Al/Cu sputtering(1-3%)</td>
<td></td>
<td>OK*</td>
<td>OK*</td>
</tr>
</tbody>
</table>

* 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

\[ x = \sqrt{t \cdot k_0 \cdot e^{\frac{-E}{kT}}} \]

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

Kierkendall 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
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