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
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

Gold bath (electroplating)
Ni, Au, Cu, Pd, Ag

The bath can be re-used by replenishing with salts or changing the anodes.
You can deposit around 6 to 10 times the metal present in one bath. The bath starts to become 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 1/2

Screen printing machine

Screen : stainless steel mesh
Screen printing plating 2/2

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

Firing: belt oven
Layouts/Pattems

Seed layer

Electro plating

«Nourrice»

Direct plate or print

Chemical plating
Thick film

Lift-off or etching

Vacuum plating
<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>
<tr>
<td>Plating</td>
<td>Al bonding</td>
<td>Au bonding</td>
</tr>
<tr>
<td>--------------------</td>
<td>------------</td>
<td>------------</td>
</tr>
<tr>
<td>Ni/Au</td>
<td>OK</td>
<td>NO</td>
</tr>
<tr>
<td>Ni/Pd/Au</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>Ni/Thick Au</td>
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<td>OK</td>
</tr>
<tr>
<td>Au cobalt</td>
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<tr>
<td>Chemical Au</td>
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<td>NO</td>
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<tr>
<td>Electro Au</td>
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<tr>
<td>Ni/Au vacuum</td>
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<td>OK</td>
</tr>
<tr>
<td>Au thick film</td>
<td>OK</td>
<td>OK</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>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

Kirkendall effect (Al to Au bond)

Curve $X=\text{cte}$

$X = \text{thickness of AuAl}_2$
$t = \text{Time}$
$T = \text{Temperature}$
$K = \text{Boltzmann constant}$
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