Overpad Metallizations and Probe Challenges

June 6 to 9, 2010
San Diego, CA  USA
Why Packaging “stuff” at Probe Conference

- More and more wafers with ENIG finish
- Reliability data applicable to contactor finishes for probes and sockets
- Metal to metal interactions extrapolate to probe and test
Alternate Finishes for Bond Pads
Probing and Wirebond of Al

- If its wirebondable..................its probable!
- Root cause of both wire bond and probe issues lies at the corrosion layer at the surface of the aluminum pads.
- Eliminate the aluminum or corrosion layer and probe “should” improve.
ENIG or ENIPIG Instead of Al Pads

- ENEPIG has the following advantages compared to standard Al pads in standard and high temp applications:
- Gold wire bondable at all stages in the process
- No corrosion of the electroless nickel
- Excellent heat resistance
- **ENIG can also be applied to Copper and Steel**

- At probe:
  - Probing on Au versus Al
  - Optimized probe conditions and reduced cycle time
Cleaning Improvements

As Recvd

BPS100
5min
Electroless Processing of Aluminum Pads
Process for Plating Electroless NiAu NiPdAu

Pre treatment

EL-Ni

Flash Au

EL-Pd

Flash Au

Direct heavy gold

Auto catalytic gold

Auto catalytic gold

ENIG  
ENAG  
ENEPIG  
ENEPA  
ENEPA

Target Gold thickness

0.03~0.06 um  
0.2~0.5 um  
0.03~0.06 um  
0.2~0.5 um  
0.1~0.3 um
Wire Bonding Reliability Test Condition

Wire bonding condition

- Equipment: TPT HB16 (semi-auto wire bonder)
- Capillary: B1014-51-18-12 (PECO)
- Wire: 1mil-gold
- Stage temperature: 150 deg.C
- Ultra Sonic: 250mW (1st), 250mW (2nd)
- Bonding Time: 200msec (1st), 50msec (2nd)
- Loading force: 25g (1st), 50g (2nd)
- Step: 0.700mm (1st to 2nd wire length)

Pull point A B C D E
### Results of Wire Bond Pull Test

**Heating treatment:** 175 deg. C - 16 hr.

<table>
<thead>
<tr>
<th>Pd thickness (um)</th>
<th>Au thickness (um)</th>
<th>AVG. strength (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.03</td>
<td>0.05</td>
</tr>
<tr>
<td>0</td>
<td>*</td>
<td>4.3</td>
</tr>
<tr>
<td>0.01</td>
<td>6.8</td>
<td>7.9</td>
</tr>
<tr>
<td>0.02</td>
<td>6.7</td>
<td>7.9</td>
</tr>
<tr>
<td>0.03</td>
<td>6.0</td>
<td>7.7</td>
</tr>
<tr>
<td>0.05</td>
<td>6.8</td>
<td>7.6</td>
</tr>
<tr>
<td>0.07</td>
<td>7.0</td>
<td>7.8</td>
</tr>
<tr>
<td>0.10</td>
<td>6.0</td>
<td>6.7</td>
</tr>
<tr>
<td>0.12</td>
<td>7.2</td>
<td>8.4</td>
</tr>
<tr>
<td>0.15</td>
<td>6.5</td>
<td>8.5</td>
</tr>
<tr>
<td>0.20</td>
<td>6.0</td>
<td>8.8</td>
</tr>
<tr>
<td>0.30</td>
<td>6.6</td>
<td>8.8</td>
</tr>
</tbody>
</table>

- Pd provides an excellent barrier to Ni migration through the Au.
- 15 minutes in the Pd bath typically provides 0.2um of Pd.
- Wire bonding strength for ENEPIG is higher than ENIG even with thin Pd thickness range.
- Au thickness increase shows improvement in wire bond strength while Pd thickness increase does not.
- Thin layer of Pd or thick gold layer. Economics or cycle time decision.
Study of Wire Bonding Reliability
AES Analysis of ENAG and ENEPIG After Heat Treatment

Even with a thin layer of Pd the analysis shows that Ni does not diffuse to the wirebond surface when using ENIPIG.
Effects of HTS on Ball Shear Strength

- Al-Au stable up to 500 hour then degradation begins
- Au-Au stable at all hours up to 4khrs
- Au-Au improves at higher temp likely due to solid state diffusion at the interface

Image courtesy IEEE 2006
Illustration of Wire Neck Shape by Different Gold Thickness

The thickness of wire neck are different according to the cushioning properties of gold.

Ni

Au 0.05um

Au 0.4um

Ni

Au : 50-80Hv, Pd : 200-300Hv, Pd-P : 450-550Hv, Ni-P : 550-600Hv
The length of failure line are different compared with strong or weak strength point. The thickness of the wire just above the bonding area is markedly different.
Cross Section Au-Al at 500Hrs @150C

- No cleaning prior to wirebonding.
- Die were sawn in DI water with no chemistry
- Failures begin as early at 150 hours
- Failure at IMC

Image courtesy IEEE 2006
Analysis of packaged units reliability

- No failures seen at 4khrs up to 200C
- No fracturing at interface.
- Reduced wirebond temp
- Less force on wire bond settings

Image courtesy IEEE 2006
Imaging of Bond Pads
Aluminum Oxide and OF

Clockwise from upper left aluminum plus oxide, aluminum in air and aluminum after 2 min CF4+O2 plasma. Same lighting conditions and magnification.

Note darkening of surface and oxide deltas between the surfaces.
Aluminum Oxide and OF-II

Clockwise from upper left aluminum plus oxide, aluminum in air and aluminum after 2 min CF4+O2 plasma. Same lighting conditions and magnification.

Note the refractive layer diminishes with processing and is replaced by the CRES layer.
Pad Conditions Pre and Post ENIPIG

- Top pad cleaned in BPS100 then allowed to sit in DI for 90 min
- Complete missing metal in probe mark

- Bottom pad has ENIPIG
- Probe mark is filled with new metal
- Smooth finish on plating
Cleaning with w/ and w/o BPS100

• Pads on the top were not cleaned prior to ENIG process
• Incomplete coverage and rougher surface

• Bottom die has been cleaned with BPS100 prior to processing.
• Complete coverage
### Wirebondability

<table>
<thead>
<tr>
<th></th>
<th>Wire bondable t=0</th>
<th>Wire bondable t=24hrs</th>
<th>Wire bondable t=72</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare aluminum</td>
<td>Marginal</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Cleaned aluminum</td>
<td>Good</td>
<td>Marginal</td>
<td>No</td>
</tr>
<tr>
<td>Cleaned aluminum +DI water soak</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>ENIG</td>
<td>Yes</td>
<td>Slightly marginal</td>
<td>No</td>
</tr>
<tr>
<td>ENIPIG</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Ni/PdCo/Au</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

In many cases the NiPd and NiPdCo remains wirebondable without gold.
Summary

- Conditions at probe and wirebond show a similar root cause for poor process control.
- Wire bonding on plated parts compared to bare aluminum shows marked improvement.
- Cleaning with BPS100 improves the ENIG process.
- Wire bonding strength for ENEPIG is higher even with low Pd thickness range.
- Nickel does not diffuse to the top surface with heat treatment even if Pd and Au are thin.
- Increasing Au thickness shows improvement in wire bond strength while increased Pd thickness does not.
- The thickness of wire neck are different according to cushioning properties of the gold deposit.
Thank You!

Thank you for taking time to listing to this presentation.

Special thanks to:
Uyemura International Corporation
Don Gudeczauskas for assisting with ENIG/ENIPIG support.

Questions?