Prevention of Sn whisker formation by surface treatment of Sn plating Part II

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Surface treatment on Sn plating

“Thin (0.05µm)” Ni plating forms discontinuous Ni nano particles islands on Sn surface
“Thick (0.2 µm)” Ni plating covers Sn surface
Changes in whisker maximum length

No whisker is formed on thick Ni/Sn plating

Wetting behavior of various surface treatment samples

Wetting of thin Ni plating is equivalent to Sn plating while that of thick Ni is worse.
**Experimental details**

- **Materials**: 1) pure Sn plating  
  (t:6μm, current density: 5A/dm² - 5.5min)  
  2) thin (0.05μm) Au or Pd/Sn plating  
  3) thick (0.2μm) Au or Pd/Sn plating

- **Electrode**: Cu, 42alloy
- **Exposure at room temperature over 8000 hrs**
- **Microstructure observation**: TEM, SEM, XRD
- **Static indentation loading test** (load:300g)
- **Wetting test**

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GD - Specimens with pure Sn plating were the controls. Purpose was to see if a thin or thick coating of Au or Pd/Sn, presumably electrodeposited, would inhibit whisker growth yet preserve solderability.

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**As-plated Microstructure**
Surface microstructure (Au-Sn/Cu)

Cross sectional microstructure
**Thick Au-Sn/Cu**

- By the time of microstructure analysis, a substantial fraction of the thick Au has already reacted with the Sn to form IMC.

**Thick Pd-Sn/Cu**

- By the time of microstructure analysis, only a small fraction of the thick Pd has reacted with the Sn to form IMC.
Room temperature exposure test

Surface microstructures after RT exposure for 8400 hrs

Thin Au

Thin Pd

Thick Au

Thick Pd
XRD analysis before/after RT exposure (thick Au)

- Au layer gradually changed to AuSn2 phase during R.T. exposure result in the surface morphology was changed after long-term exposure.

Changes in whisker maximum length as function of time

- No whisker is formed on thin and thick Au or Pd/Sn plating

GD - 200 nm Ni suppressed whisker growth for as long as data were reported (~3 yrs).

GD - Au and Pd/Sn (thin or thick) suppressed whisker growth for as long as data were reported (~8000 hrs).
Summarizing the Sn whisker formation behavior during R.T. exposure

Metal layers are very uniform and stable during R.T exposure, thus, it acts as protective layer of Sn whisker nucleation on Sn plating surface.

◆ Growth of IMCs between Sn and Cu during RT exposure

GD - Even though Pd-Sn IMC has formed after 3 mo. at RT a continuous layer of Pd remains.

Static indentation loading test
Experimental details

- Plating: pure Sn(t:6μm), thin and thick Ni, Au, Pd-Sn plating
- Electrode: Cu, 42 alloy
- Loading time: 24~240 hours

Surface Observation (168 hrs)

- Thin Au/Cu
- Thick Au/Cu
- Thin Pd/Cu
- Thick Pd/Cu
Cross sectional microstructure (168 hrs)

✓ Sn whiskers are formed at surface where the Pd layer is broken.

Changes in Sn whisker length (Thin layer)

<table>
<thead>
<tr>
<th>Plating</th>
<th>Electrode</th>
<th>24hrs</th>
<th>72hrs</th>
<th>120hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sn</td>
<td>Cu</td>
<td>≤10 μm</td>
<td>≤10 μm</td>
<td>≤20 μm</td>
</tr>
<tr>
<td></td>
<td>42alloy</td>
<td>≤20 μm</td>
<td>≤20 μm</td>
<td>≤20 μm</td>
</tr>
<tr>
<td>0.05 Ni/Sn</td>
<td>Cu</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>42alloy</td>
<td>X</td>
<td>≤10 μm</td>
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<td>X</td>
</tr>
<tr>
<td></td>
<td>42alloy</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

✓ Metal-Sn plating is much stable against Sn whisker formation under external applied stress condition.
Wetting test

**Wetting behavior of various surface treatment samples**

- **Wetting balance method**
- **Solder:** Sn-3Ag-0.5Cu
- **Flux:** RMA, **Temp.: 245 °C**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Composition</th>
<th>Surface</th>
<th>Solder</th>
<th>Flux</th>
<th>Temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>0.05 Au/Sn</td>
<td>Ni/Cu</td>
<td>Sn</td>
<td>RMA</td>
<td>245 °C</td>
</tr>
<tr>
<td>A2</td>
<td>0.05 Au/Sn</td>
<td>Ni/Cu</td>
<td>Sn</td>
<td>RMA</td>
<td>245 °C</td>
</tr>
<tr>
<td>A11</td>
<td>0.2 Au/Sn</td>
<td>Cu</td>
<td>Sn</td>
<td>RMA</td>
<td>245 °C</td>
</tr>
<tr>
<td>A21</td>
<td>0.2 Au/Sn</td>
<td>Ni/Cu</td>
<td>Sn</td>
<td>RMA</td>
<td>245 °C</td>
</tr>
<tr>
<td>P1</td>
<td>0.05 Pd/Sn</td>
<td>Ni/Cu</td>
<td>Sn</td>
<td>RMA</td>
<td>245 °C</td>
</tr>
<tr>
<td>P2</td>
<td>0.05 Pd/Sn</td>
<td>Ni/Cu</td>
<td>Sn</td>
<td>RMA</td>
<td>245 °C</td>
</tr>
<tr>
<td>P11</td>
<td>0.2 Pd/Sn</td>
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</table>
Summary

✔ Au or Pd layer on Sn plating surface stop whisker formation during room temperature exposure.

✔ Thin and Thick Au or Pd plating form the continuous and uniform layer.

✔ Both Au and Pd platings form IMCs with Sn plating.

✔ Both Au and Pd platings has a great effect in suppressing Sn whisker formation under external indentation pressure.

✔ Wettings of Au or Pd plating are equivalent to Sn.