Decapsulation of Cu and Ag Wire-Bonded Devices

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ESREF, EUFANET workshop
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• Introduction
• Laser pre-opening
• Decapsulation of copper-wired device:
  – Low temperature
  – Electrolysis
  – Plasma decapsulation
• Silver-wired device
• Summary
**The Challenge:** To be able to open a *variety* of IC packages made of EMC, and containing Cu or Ag wires, without damage to the wires or any bond pad coating materials (i.e. aluminum, palladium).

**Recent Approaches:**
- nitric or nitric/sulfuric acid mixes from near ambient (27°C) to medium temperatures (80°C) [1, 2]
- Sulfuric acid at medium high temperatures (attacks Al pads) [3]
- Plasma etch (long etch times)

[1] Klein, et. al., 2010 ISTFA Conference Proceedings
Laser Pre-decapsulation

- 1\textsuperscript{st} removed EMC above die and stitch bonds until tops of wire loops exposed
- 2\textsuperscript{nd} ablation step performed with exclusion zone above die
- Cannot expose die by laser, stitch bonds no problem
- Laser pre-cavity can reduce acid etch time by half [1]
- All samples in temperature study pre-decapsulated using same auto program

Cu #1 – acid at low temp

- 44°C for 40s
- 10°C for 270s

Al coating removed from lead fingers, acid attack visible on Cu wires with measured diameters of 14-19µm.

No observable attack or corrosion on the lead finger coating or die pads, wires very uniform with a measured diameter of ~19.5µm and no evidence of thinning or pitting.
• Gold-wired package allows multi-step opening
• For copper wires: better to do a one-shot decapsulation

2:1, 10°C

• Device opened in two 600 s-step process: broken wires
• Due to oxygen or air humidity exposure between the two steps.

• Phenomenon not seen by using one-step process: sample kept in equipment under pressurized nitrogen
Cu #2 – acid low temp

One-shot acid decapsulation:

- Etch time: 1000 s
- Die is fully exposed
- Several rinse baths: acetone, hot water, and alcohol
- Wires preserved, though wire surface is slightly attacked

2:1, 10°C
Cu #2 - Electrolysis

- Electrolysis
  - 10V
  - 35°C, 2:1
  - 3x180s
  - multi-step possible

• Dry chemistry parameters

<table>
<thead>
<tr>
<th>Process</th>
<th>T (°C)</th>
<th>%CF₄</th>
<th>%O₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast</td>
<td>25</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>Slow</td>
<td>25</td>
<td>10</td>
<td>90</td>
</tr>
</tbody>
</table>

• Total etch time: 3 to 4 hours.
• Final acetone rinse in ultrasonic bath was needed to remove residues on die surface.

Ball-bond and wire surface are much more preserved with plasma than with acid etching.

Furthermore, the electrical functionality of the opened devices was also checked before photoemission microscopy analysis, which could be successfully performed.
Ag wire decapsulation

- Total etch time of 200 minutes to completely expose the die
- Very long duration for a single sample
- Step by step procedure with a precise control over the etching.

<table>
<thead>
<tr>
<th></th>
<th>Results</th>
<th>Etch time</th>
<th>Electrical influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu acid low T°</td>
<td>Good</td>
<td>Slow</td>
<td>None</td>
</tr>
<tr>
<td>Cu electrolysis</td>
<td>Good</td>
<td>Fast</td>
<td>Possible</td>
</tr>
<tr>
<td>Cu plasma</td>
<td>Good</td>
<td>Very slow</td>
<td>possible</td>
</tr>
<tr>
<td>Ag acid low T°</td>
<td>Broken wires</td>
<td>Slow</td>
<td>None</td>
</tr>
<tr>
<td>Ag electrolysis</td>
<td>Not tested</td>
<td>Fast</td>
<td>Possible</td>
</tr>
<tr>
<td>Ag plasma</td>
<td>Good</td>
<td>Very slow</td>
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