Studies on Fine Pitch 2-Metal Layer Chip-on-Flex (COF) Packaging

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Introduction of Fine Pitch 2-metal Layer COF Packages

- Why fine pitch 2-metal layer COF (chip-on-film) packages?
  - Higher I/O counts and heat generation of COF packages

1. Fine pitch capability
2. Improved assembly yield
3. Enhanced heat dissipation capability
4. Higher density packages
2-metal Layer COF assembly & Characterization

2-metal layer COF assembly

<table>
<thead>
<tr>
<th>Bonding methods</th>
<th>Adhesive bonding</th>
<th>Metallurgical bonding</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>ACF bonding</td>
<td>NCF bonding</td>
</tr>
<tr>
<td>Tool temp. (°C)</td>
<td>255</td>
<td>255</td>
</tr>
<tr>
<td>Stage temp. (°C)</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>Pressure or force</td>
<td>60 MPa</td>
<td>60 MPa</td>
</tr>
<tr>
<td>Time (s)</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Underfill/ Sn diffusion</td>
<td>.</td>
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Characterization

1. Electrical properties
   - Contact resistances
   - Insulation resistances - fine pitch capability

2. Mechanical property
   - Peel adhesion strength

3. Thermal property
   - Heat dissipation capability

4. Reliability evaluation
   - High temperature/humidity test
     (85 °C/85% RH, 1000 hours)
   - Thermal cycling test
     (-40 °C, 15 min ~ 125 °C, 15 min, 1000 cycles)
Electrical Properties of Fine Pitch 2-metal Layer COF Packages

- **Joint resistance**
  - 2-metal layer COF packages showed stable joint resistances below 5 mΩ.

- **Insulation resistance** *(short criterion < 10⁸ Ω)*
  - 2-metal layer COF packages showed good insulation properties.
    - ACF bonding: > 20 µm pitch
    - NCF and AuSn metallurgical bonding: all pitches
Mechanical Properties of Fine Pitch 2-metal Layer COF Packages

- 2-metal layer COF packages had good adhesion strength.

![Graph showing peel adhesion strength](image)

- Peel adhesion strength for ACF, NCF, and AuSn were measured and compared.

- Torn electrode and FPC side are indicated in the image.
Thermal Property & Reliability Evaluation

**Heat dissipation capability**
- Measured joint temperature
- Simulated joint temperature

25 °C decrease

**Reliability evaluation**
- High temperature/ humidity test
- Thermal cycling test

- All 2-metal layer COF packages showed stable joint resistances during 85°C/85% RH and T/C reliability tests.

2-metal layer COF package enhanced heat dissipation capability.
Conclusions

- Fine pitch 2-metal layer COF packages were successfully demonstrated.
  - By ACF, NCF, and AuSn metallurgical bonding

  ![Top side](image1)
  ![Bottom side](image2)

- Fine pitch 2-metal COF packages had good electrical, adhesion, and thermal properties as well as excellent reliability.
  - Low contact resistances: < 5 mΩ
  - Stable Insulation resistances: except 20 μm pitch at ACF bonding
  - Adhesion strength: > 600 gf/cm
  - Improved heat dissipation capability: ~ 25 °C reduction
  - Good 85°C/85% RH and T/C reliability