FINE CLAD is a solution for high density, low cost PWB.
Principle of bonding technique
**Principle of bonding technique**

1. **Step 1**: Material A, B
   - In vacuum
   - Oxide and absorbate

2. **Step 2**: Surface activated treatment
   - Activated surface

3. **Step 3**: Roll bonding
   - Activated surface
Manufacturing process
Manufacturing process

Ion etching device

Material A

Uncoiling device

Vacuum chamber

Rolling mill

Material B

Coiling device

Uncoiling device
Features of FINE CLAD
Feature 1: Flat and clean bonding interface

Feature 2: A variety of possible metal combinations

Feature 3: Pattern roll bonding
Feature 1  Bonding interface
Cross section of FINE CLAD

Cu/Ni FINE CLAD

Conventional Cu/Ni clad

Interface = Flat

Is there alloy layer in the interface?

No! Suitable for selective etching
Outline of selective etching

(Selective etching: Etching only one side metal of clad material)

Example: Cu/Al FINE CLAD

Patterning photoresist

Selective etching Cu

Cross section of Cu/Al after Cu selective etching
### Metal combinations for selective etching

<table>
<thead>
<tr>
<th>Etching metals</th>
<th>Metals for etching stopper</th>
<th>Etchant for selective etching</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu</td>
<td>Al</td>
<td>Acid etchant (sulfuric acid etc.)</td>
</tr>
<tr>
<td>Al</td>
<td>Cu</td>
<td>Sodium hydroxide etchant etc.</td>
</tr>
</tbody>
</table>
| Cu             | Ni                          | Sulfuric acid + hydrogen peroxide etchant  
|                |                             | Ammonium persulfate etchant  
|                |                             | Commercial Alkaline etchant |
| Ni             | Cu                          | Commercial Ni etchant |
| Cu, SUS        | Pd, Ag                      | Ferric chloride etchant |
| Ag, Cu         | SUS                         | Ferric nitrate etchant |

**What is the best use of FINE CLAD by using these merit?**
FINE CLAD for Printed Wiring Board

Etching bump provides high density, low cost PWB
Structure and etching process

Cu/Ni/Cu FINE CLAD

- Cu for circuit: 10 ~ 35 μm thickness
- Ni layer: 0.5 ~ 3 μm (electrolytic plating)
- Cu for bump: 50 ~ 150 μm
Role of etched Cu bump
Features of etched Cu bump

① Simultaneous bump formation enables to reduce cost of PWB.
② Small diameter bumps enable high density.
③ Cu bumps are suitable for conductive via.
④ Direct interconnection of bump with circuit enables to simplify the manufacturing process.
Process of multi layer PWB

Cu/Ni/Cu clad

Bump forming and Ni removing

Laminating resin

Hot press

Patter forming

Repeat
ML-PWB (for mobile phone)

Produced by NORTH corp., Japan (layer : 1+2+1)
Flexibility of products design

- Stacked via
- Landless design
- Pad on via
- All IVH
Application to the package substrate
Etched Cu bump

Cross section
Package substrate

IC chip

Solder ball

Packaging

Cu/Ni/Cu/Ni/Cu clad

Bump forming

Laminating

Insulating resin

Bump forming

Circuit forming
Substrate sample
(resin : polyimide)

IC chip

Solder ball

Cross section

Bump

Circuit

Bump

1mm

100μm
Material for power module substrate

Structure: Cu/Al
Merit: Possible to form Al pad for Al wiring and Cu circuit.

Base material

Al (for Al wire bonding pad)
Cu (circuit)

Selective etching

Al pad

Al wire

Cu circuit
**Bump formation for QFN**

**Structure:** Cu alloy / Cu alloy

**Merit:** Possible to improve the reliability of QFN mounting.

- Clad material:
  - Cu alloy A
  - Cu alloy B

- Half etching

- Selective etching:
  - Cu alloy B

- IC chip setting and molding
- Resin
- Wire
- Au plating

- Removing clad material

- Mounting

- PWB
Bump formation for QFN

Reverse mushroom shape bumps improve the mounting reliability.

Cross section after etch

50μm
Copper Laminated Resin sheet

FINE CLAD changes the RF PWB design.
Rolled Cu foil (10 ~ 35μm thickness)

Flat interface

Low dielectric constant resin sheet
(25 ~ 100μm thickness)
(Liquid crystal polymer : LCP)
Cross section of Cu laminated resin sheet

Advantages of developed material

<table>
<thead>
<tr>
<th></th>
<th>Developed material</th>
<th>Conventional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface</td>
<td>Flat</td>
<td>Rough</td>
</tr>
<tr>
<td>Skin resistance</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Accuracy of pattern</td>
<td>Excellent</td>
<td>good</td>
</tr>
</tbody>
</table>
High frequency characteristics

<table>
<thead>
<tr>
<th>Attenuation / dB/m</th>
<th>Frequency / GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>-5</td>
</tr>
<tr>
<td></td>
<td>-10</td>
</tr>
<tr>
<td></td>
<td>-15</td>
</tr>
<tr>
<td></td>
<td>-20</td>
</tr>
<tr>
<td>Rolled Cu foil 35μm</td>
<td></td>
</tr>
<tr>
<td>Conventional electrodeposited Cu foil 35μm</td>
<td></td>
</tr>
</tbody>
</table>

Cu foil : 7μm thickness
LCP film: 50μm thickness
L/S : 50μm / 50μm
Peeling strength: over 600g/cm at 180° peeling test

Cu side
(LCP is remained on Cu)

LCP side
(LCP is fractured at inside)
Application to multi-layer PWB

Manufacturing process of all LCP PWB

Pattern formation

Core board

Ltype LCP

Rolled Cu foil

Laminating and drilling

Via filling and pattern forming

lltype LCP
Features

① Flat interface reduces skin resistance.

② Flat interface enables to form fine pitch pattern.

③ Combination with low dielectric constant resin sheet enables the application to RF PWB.

④ A variety of resin sheets are available.
Multi-layer sheet for embedded resistor

FINE CLAD provides the embedded passive devices.
Rolled Cu foil (flat interface)
(10 ~ 35μm thickness)

Resistant layer
(Ni-Cr etc.)

Low dielectric constant resin sheet
(25 ~ 100μm thickness)
(Liquid crystal polymer: LCP)
Process for resistor element

- Base material
- Cu selective etching
- Resistant layer etching
- Cu selective etching

Cross section:
- Resistor element
- Circuit

Upper side view:
- Resistor element
- Circuit
Specifications

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistive material</td>
<td>Ni-Cr</td>
</tr>
<tr>
<td>Thickness of layer</td>
<td>10 ~ 200nm</td>
</tr>
<tr>
<td>Sheet resistance</td>
<td>25, 50, 100Ω/□</td>
</tr>
</tbody>
</table>

Resistor

Circuit
Features

① Low TCR material is used.
② Resistor can be formed only by etching process.
③ Flat thin film enables to improve the accuracy of etching.
Feature 2  Materials combinations
### Manufacturing range

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Material thickness</td>
<td>10μm ~ 1mm</td>
</tr>
<tr>
<td>Product thickness</td>
<td>30μm ~ 1mm</td>
</tr>
<tr>
<td>Product width</td>
<td>2.5 ~ 600mm×Coil</td>
</tr>
</tbody>
</table>
### Materials combinations

<table>
<thead>
<tr>
<th></th>
<th>Al</th>
<th>Cu</th>
<th>Ni</th>
<th>Ag</th>
<th>Au</th>
<th>Pd</th>
<th>Pb</th>
<th>Sn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
<td>●●●</td>
<td>●●●</td>
<td>●●●</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>●●●</td>
<td>●●●</td>
</tr>
<tr>
<td>Cu</td>
<td>●●●</td>
<td>●●●</td>
<td>●●●</td>
<td>●●●</td>
<td>●●●</td>
<td>—</td>
<td>—</td>
<td>●●●</td>
</tr>
<tr>
<td>Ni</td>
<td>●●●</td>
<td>●●●</td>
<td>●●●</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>●●●</td>
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<tr>
<td>Ag</td>
<td>—</td>
<td>●●●</td>
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<td>●●●</td>
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<tr>
<td>Au</td>
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<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Pd</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>●●●</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Pb</td>
<td>●●●</td>
<td>—</td>
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<td>—</td>
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<td>Steel</td>
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<td>●●●</td>
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<tr>
<td>Ti</td>
<td>●●●</td>
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<td>●●●</td>
<td>—</td>
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<td>—</td>
<td>●●●</td>
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</tr>
<tr>
<td>Mo</td>
<td>●●●</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

- **Al**: Including 1000, 2000, 3000, 4000, 5000 alloy
- **Cu**: Including 1020, 1100, 1201, 5210 alloy
- **Steel**: Including SUS304, SUS316, SUS430, Invar, 42 alloy etc.
- **—**: Bonding has not been verified.
### Mechanical properties of clad before and after cladding

<table>
<thead>
<tr>
<th></th>
<th>Material</th>
<th>Thickness (mm)</th>
<th>Hardness (Hv)</th>
<th>Tensile strength(N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before cladding</strong></td>
<td>SUS304</td>
<td>0.201</td>
<td>170</td>
<td>703</td>
</tr>
<tr>
<td></td>
<td>Al</td>
<td>0.056</td>
<td>24</td>
<td>59</td>
</tr>
<tr>
<td><strong>After cladding</strong></td>
<td>SUS304</td>
<td>0.200</td>
<td>173</td>
<td>572*</td>
</tr>
<tr>
<td></td>
<td>Al</td>
<td>0.055</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td><strong>Before cladding</strong></td>
<td>steel</td>
<td>0.271</td>
<td>137</td>
<td>343</td>
</tr>
<tr>
<td></td>
<td>Al</td>
<td>0.030</td>
<td>25</td>
<td>59</td>
</tr>
<tr>
<td><strong>After cladding</strong></td>
<td>steel</td>
<td>0.270</td>
<td>139</td>
<td>316*</td>
</tr>
<tr>
<td></td>
<td>Al</td>
<td>0.029</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td><strong>Conventional clad</strong></td>
<td>SUS304</td>
<td>0.243</td>
<td>287</td>
<td>744*</td>
</tr>
<tr>
<td></td>
<td>Al</td>
<td>0.051</td>
<td>24</td>
<td></td>
</tr>
</tbody>
</table>

* Strength of clad material

Mechanical properties of raw material have hardly changes before and after cladding.
Drawing and ironing of FINE CLAD

Al clad steel

Cu clad steel

Ti/Al/SUS304 clad
Feature 3  Pattern roll bonding
Pattern roll bonding 1
~ safety vent ~
Manufacturing process of safety vent for Li ion secondary battery
Parts for Li ion secondary batteries
Pattern roll bonding 2

~ Plate type tube ~
Trial sample of plate type tube

① Pattern bonding by paint patterning (BN paint)

② Pattern bonding by cladding sheet with stamped substrate
Example of pattern bonding after expansion treatment
FINE CLAD is a solution for high density, low cost PWB.