Proposal for Adopting Thermoset Resin to Enable『Joint Protection Flux & Paste』Overcome Fine Pitch, Low Temperature Assembly Issues Plus Reliability Reinforcement

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Vice President
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- Packaging Roadmap vs. SMIC R&D Direction
- Application of Epoxy Flux & Paste
- Summary
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Development Background

Automotive TCT Reliability Requirement
- AEC Q100 (IC), Q200 Require

Fine Pitch Trend
- Move to pitch 120um, 90um. Gap 50, 30 um

Package Warpage by Heat Effect
- NOW, HIP, Shorting, Stretched joint

Weak Heat-Resistance Parts
- Smart phone, imaging sensors

Energy and Cost Saving
- CO₂ reduction

Source: Internet
Packaging Roadmap vs. R&D Direction

Fine Pitch

Demand for the Development of "Micro Soldering Technology"

Source: SBR technology

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Application of Epoxy Flux & Thermoset Paste

Epoxy Flux For Chip Attach

Thermoset Paste For Embedded & SMT

Epoxy Flux For Ball Attach

Each material can be selected by application.
Epoxy Flux
JOINT PROTECT FLUX
SMIC JPF

Key Features:

# Fine Pitch
# Reliability Reinforcement
# Epoxy Flux
# Thermoset Resin
# Joint Protection
# No Clean
# Cost Reduction

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Concept of Epoxy Flux (Chip Attach)

**Normal flux Process**

1. Flux dipping & Mounting
2. Reflow
3. Cleaning
4. Baking
5. Underfill flow
6. Cure
7. Finish

**Joint protect flux (No clean)**

1. Flux dipping & Mounting
2. Reflow
3. Baking
4. Underfill flow
5. Cure
6. Finish

**Joint protect flux (No Underfill)**

1. Flux printing or dispensing & Mounting
2. Reflow
3. Cure or No cure
4. Finish

Finish

- Without Cleaning & Baking !
- Underfill ! ! (Under development)

**Notes**

- 150μm pitch
- Flux Residue
- UF

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Chip Attach Epoxy Flux (Present and Future)

~At Present Market~

<table>
<thead>
<tr>
<th>Die size</th>
<th>□ 1~3mm</th>
<th>□ 5~8mm</th>
<th>□ 10~12mm</th>
<th>□ 15mm over</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flux type</td>
<td>Epoxy flux</td>
<td>Epoxy flux</td>
<td>No clean flux</td>
<td>No clean flux</td>
</tr>
<tr>
<td></td>
<td>No clean flux</td>
<td>Water-soluble flux</td>
<td>Water-soluble flux</td>
<td>Water-soluble flux</td>
</tr>
</tbody>
</table>

Epoxy flux is considered for **small die & low cost model** application.

Flux residue of SMIC JPF becomes “**Thermosetting Resin**”. Therefore, it **reinforces solder joint** and has good performance for **strength and reliability**!

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**SMIC JPF**

Junction reinforced

150um pitch

Next Generation Epoxy Flux (Under development)

**Half filling**

**Full filling**
Next Generation Epoxy Flux (Reflow & TCB)

**Reinforced shape**
- Junction reinforced
- Half filling
- Full filling

**Flux property**
- High wettability
- High heat-resistance
- Trade Off Relationship

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- **Reflowable**
- **Reflowable & TCB**
- **TCB**

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**Advantage**
- Reflowable Epoxy flux
  - High mass productivity
  - Low cost

**Disadvantages**
- TCB Epoxy flux
  - No chip shift
  - No warpage

- Chip shift
- Warpage

- Low mass productivity
- High cost

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When die size become bigger, or bump pitch become finer, **out gas** is difficult to escape. And **chip shift** become easy to occur. Therefore, TCB mounting is indispensable.

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Concept Epoxy Flux (WLP Ball Attach)

**Normal flux Process**

- Flux supply
- Ball mounting
- Reflow
- Cleaning & Baking

**Joint protect flux**

- Flux supply
- Ball mounting
- Reflow

You can reduce a cleaning process by using SMIC JPF. And the residue of SMIC JPF can reinforce solder junction.

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Mechanical Strength

**Ball Shear Strength**

◇ Test Condition

<table>
<thead>
<tr>
<th>Flux type</th>
<th>SMIC JPF Water-soluble flux</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solder alloy</td>
<td>SAC305</td>
</tr>
<tr>
<td>Ball diameter</td>
<td>0.3mm</td>
</tr>
<tr>
<td>Substrate</td>
<td>Cu-OSP coupon</td>
</tr>
<tr>
<td>SRO</td>
<td>0.24mm</td>
</tr>
<tr>
<td>Stencil thickness/aperture</td>
<td>0.1mm/0.24mm</td>
</tr>
<tr>
<td>Test speed</td>
<td>300μm/sec</td>
</tr>
<tr>
<td>Test height</td>
<td>15μm</td>
</tr>
<tr>
<td>Reflow times</td>
<td>1, 3, 6</td>
</tr>
<tr>
<td>Reflow profile</td>
<td>25-250C 0.5C/sec, 250C peak</td>
</tr>
<tr>
<td>Fracture mode</td>
<td>Mode 2 : solder</td>
</tr>
</tbody>
</table>

Even if increased reflow times, shear strength of SMIC JPF is higher than Water-soluble flux.

WF-6317 is general water soluble flux. WF-6317 coupons clean for water after reflow.
**Drop Test**

- **SMIC JPF**
  - Mean: 196.10
  - Std Dev: 87.96
  - Number: 10

- **Only Solder Joint**
  - Mean: 9.90
  - Std Dev: 5.74
  - Number: 10

**Improved solder joint strength.**

- **Only Solder Joint**
  - After 16 times: Crack
  - After 135 times: Crack
  - After 305 times: Crack

- **SMIC JPF**
  - After 135 times: Crack
  - After 305 times: Crack

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Solder Wettability

Test condition

1. Flux: EF-100, Conventional JPF, Water-soluble flux
2. Solder sphere: M705(Sn96.5/Ag3.0/Cu0.5) [size: 0.60mm]
3. Substrate: Cu-OSP coupon
4. O2 conc.: 100ppm
5. Mask for printing: Thickness 0.2mm, Opening 0.5mm

Test method

- Flux print → Sphere mount → Reflow
- Spread dia. measurement (Micro scope)

Wettability of SMIC JPF is better than conventional and almost the same as water-soluble flux!
Insulation Reliability

Since the ion migration does not occur and keep stable. The insulation reliability is good.

**Condition**
- Environment: 85°C/85%RH
- Measured voltage: 100V
- Applied voltage: 50V
- Time: 1000h
Since weight loss is about 8% after reflow. (Almost no change.) SMIC JPF can reinforce the solder joint with enough flux quantity.
Thermoset Paste

JOINT PROTECT PASTE

SMIC JPP

Key Features:

# Low Temperature
# Reliability Reinforcement
# Thermoset Resin
# Joint Protection
Low Temp. Process Issues

The hardness and brittleness of Sn-Bi solder has poor 「Impact resistance characteristic」

Have to develop a product doesn’t crack when fall and even if the stress happened won’t be damaged during assembly.
Flux Compose from JPP

The Approach From Flux Materials

Conventional Solder Paste

- Alloy Function
  - Electronic & Mechanical Joint
- Flux Function
  - Metal Deoxidize Effect
  - Spread Effect
  - Self-Alignment

Joint Protect Paste

- Alloy Function
  - Electronic & Mechanical Joint
- Flux Function
  - Metal Deoxidize Effect
  - Spread Effect
  - Self-Alignment

Reinforcement on Solder Joint

Reinforced the solder joint strength by “Flux Residue”. 

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Reinforcement from Flux Residue

Protect Joint by Flux Residue

**Joint Protect Paste (JPP)**

- **BGA**
  - Solder
  - PCB
  - FLUX

- **Chip**
  - Solder
  - PCB
  - FLUX

Due to flux residue became “Thermoset Resin”, reinforces solder joint.

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Due to “Thermoset Resin Protection”, JPP has significant increased on drop reliability, compares to other rosin type paste.
Joint Strength after TCT

TCT Condition: -40°C ⇔ 130°C / 30mins

Shear Strength (3216 Chip)

Shear Strength (2012 Chip)

Due to “Thermoset Resin Protection”, JPP has significant increased on TCT reliability, compares to other rosin type paste.

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Drop Test Results (Board Level)

### Table 1: Alloy composition

<table>
<thead>
<tr>
<th>Senju name</th>
<th>Alloy composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>L20</td>
<td>Sn-58Bi</td>
</tr>
<tr>
<td>L27</td>
<td>Sn-40Bi-Cu-Ni</td>
</tr>
<tr>
<td>M705</td>
<td>Sn-3Ag-0.5Cu</td>
</tr>
</tbody>
</table>

**Figure 1:** Alloy combination of ball and paste

- Paste1: L20-JPP-J10(W)-T7M
- Paste2: L27-LT142ZH Type4
- Paste3: M705-S101ZH-S4(W2)

### Result
- Disconnection occurred only in Combination ②.
- Disconnection of Combination ② was 60%.

### Table 2: Shock test

<table>
<thead>
<tr>
<th>Combination ①</th>
<th>Combination ②</th>
<th>Combination ③</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ball composition</td>
<td>M705</td>
<td>M705</td>
</tr>
<tr>
<td>Paste composition</td>
<td>L20JPP</td>
<td>L27</td>
</tr>
<tr>
<td>Failure</td>
<td>0/10</td>
<td>6/10</td>
</tr>
</tbody>
</table>

※ Drop number: 40times

**Figure 2:** Shock test specification

- Resistance of daisy-chain is measured. If resistance exceeds 1.5 times of initial one, cracking is assumed.
Joint Protect Paste Issues and Solutions

1. Storage Instability
2. Big Void
1) Storage Instability

- Competitors’ hardener in epoxy paste activates SnBi Solder Activator Hardener.

  - Epoxy
  - SnBi Solder
  - Activator
  - Hardener

- Senju developed a non-reactive hardener.

  - Epoxy
  - SnBi Solder
  - Activator
  - Hardener

SMIC JPP could be kept in refrigerator condition.
### 2) Void Occur Mechanism

<table>
<thead>
<tr>
<th></th>
<th>Start melting</th>
<th>During melting</th>
<th>After cooling</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conventional</strong></td>
<td><img src="image" alt="" /></td>
<td><img src="image" alt="" /></td>
<td><img src="image" alt="" /></td>
</tr>
<tr>
<td></td>
<td>Expand</td>
<td></td>
<td>Shrink</td>
</tr>
<tr>
<td><strong>JPP</strong></td>
<td><img src="image" alt="" /></td>
<td><img src="image" alt="" /></td>
<td><img src="image" alt="" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Expand</td>
<td>Harden</td>
</tr>
</tbody>
</table>

The big void occurred in JPP due to harden, didn't shrink.
Void Solution

SMIC Total Solution

Leading-in market Performance
- Related to smart phone
- Image sensor
- Inside component assembly
- Related to Communication

Assembly Technologies

Paste develop

Powder develop

Analysis, evaluation Technologies

Equipment develop

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### Void Solution

<table>
<thead>
<tr>
<th></th>
<th>During heating</th>
<th>During cooling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional JPP</td>
<td>[Image of conventional process]</td>
<td>[Image of conventional process]</td>
</tr>
<tr>
<td>Improved JPP</td>
<td>[Image of improved process]</td>
<td>[Image of improved process]</td>
</tr>
</tbody>
</table>

**Point:** During solder melting, resin could not get harden.

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<th>After cooling</th>
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<tr>
<td>Conventional JPP</td>
<td>[Image of conventional process start melting]</td>
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</tr>
<tr>
<td>Improved JPP</td>
<td>[Image of improved process start melting]</td>
<td>[Image of improved process during melting]</td>
<td>[Image of improved process after cooling]</td>
</tr>
</tbody>
</table>

**Point:** Develop the new flux which could shrink the void.

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Summary

Key features of SMIC JPF ~

# Fine Pitch
# Reliability Reinforcement
# Epoxy Flux
# Thermoset Resin
# Joint Protection
# No Clean
# Cost Reduction

Key features SMIC JPP ~

# Low Temperature
# Reliability Reinforcement
# Thermoset Resin
# Joint Protection

A Soldering Partner You Can Rely On ~ SMIC.

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Thanks For Your Attention!!!