Advanced Insulating Film for Next-Generation Smartphone Performance Requirements

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Presentation Contents


2. Insulation Build-up Materials; Ajinomoto Build-up Film (ABF)
   Low Dielectric Loss ABF for high frequency package
   Next Generation ABF for Thinner Application

3. Molding Film (ABF-LE)
Over View of the Ajinomoto Group (as of March 31, 2017)

<table>
<thead>
<tr>
<th>Foundation</th>
<th>May 20, 1909</th>
<th>Paid-in Capital</th>
<th>JPY 79,863million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of employee</td>
<td>34,452</td>
<td>Net sales FY2017</td>
<td>JPY 1,150.2 billion</td>
</tr>
</tbody>
</table>

(as of March 31, 2017)

Lower resource fermentation technology
Nutrition for animals, plants, and marine creatures

Foods

Amino Science

Pharmaceuticals and Health

Eat Well, Live Well.

Proprietary and Confidential of AJICO
Insulation Build-up Materials; Ajinomoto Build-up Film (ABF)
ABF Application

**Electric Product**

**Print Circuit Board (PCB)**

**CPU Package**

- **IC Chip**
- **Underfill**
- **C4 solder bump**
- **Solder resist**
- **Dielectric Material**
  - Core material (FR-4 or 5)
  - PTH plugging resin
  - Solder ball (2nd level interconnect)

**Packaging Substrate**

**X-sectional view**
Outline of Manufacturing Substrates using ABF

1; Preparation of core-boards

2 ; ABF vacuum lamination

3; Pre-curing

4 ; Laser Via formation & Desmear

5 ; Thin Cu plating

6 ; Photo Dry Film Resist lamination

7 ; Patterning

8 ; Electro Cu plating

9; Dry Film removal

10; Thin Cu etching & Full-curing (180-200degC)

Repeat for multilayered Build-up

[Packaging substrates]
Manufacturing Process of ABF

1. Mixing
2. Varnish manufacturing
3. Coating
4. Drying
5. Cover film

Materials:
- Resin, filler
- PET
- ABF (10-100um)
- Cover Film
Smartphone PKG trend & ABF development trend

Patch antenna + (Yagi antenna)

Feed layers
Substrate (wiring)
FPC socket
FPC

EMI shield
RF Front End IC
Transceiver IC

Antenna Substrate

High speed transmission
Low Dielectric Loss ABF

FO-PLP for Wide bus memory

Top RDL 2L
TSV
Die partitioning
Logic nets by Cu Pillar

Application Processor

AP function side (2 signal & power)
Silicon capacitor x n
RDL

High density & Thin structure

Thinner ABF
**Next Build-up Material for High Speed Application**

- **Requirement for Low Transmission Loss**

  Transmission loss ($\alpha$)  
  \[= \text{Dielectric loss} (\alpha_d) + \text{Conductor loss} (\alpha_c)\]

  \[\alpha_d \propto \sqrt{\varepsilon} \times \tan\delta\]

  $\varepsilon$: Dielectric constant  
  $\tan\delta$: Dielectric loss tangent

  To reduce the transmission loss...  
  **$\Rightarrow$ Low dielectric loss tangent ($Df$)**

- **ABF for High Speed Transmission**

  **GX series (Epoxy and Phenol Hardener)**

  **GZ series (Epoxy and Cyanate Ester)**

  **GL series (Epoxy and Phenolic Ester Hardener)**

  Reduction of polar group
## Outline of New ABF GL series

<table>
<thead>
<tr>
<th>ABF</th>
<th>GX92</th>
<th>GX-T31</th>
<th>GZ41</th>
<th>NEW GL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CTE (ppm: 25-150degC)</strong></td>
<td>39</td>
<td>23</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td><strong>Tg (degC, tensile TMA)</strong></td>
<td>153</td>
<td>154</td>
<td>176</td>
<td>153</td>
</tr>
<tr>
<td><strong>Dielectric constant</strong></td>
<td>3.2</td>
<td>3.4</td>
<td>3.3</td>
<td>3.3</td>
</tr>
<tr>
<td><strong>(5.8GHz)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Loss tangent</strong></td>
<td>0.018</td>
<td>0.014</td>
<td>0.0074</td>
<td>0.0044</td>
</tr>
<tr>
<td><strong>ABF Surface</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>after desmear</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>(SEM, x3500)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Evaluation of Transmission Loss

*Formula of strip line impedance

\[
Z_s = \frac{30\pi}{\sqrt{\varepsilon_r}} \left(\frac{(2H + t)}{(W + 0.441(2H + t))}\right)
\]

W : 45-50um
2H : 80um
t : 13-23um
\(Z_s\) : 50Ω

Transmission Loss:
GX92 >> GX-T31 > GZ41 > GL

Cross sectional view image of PKG

Low Df material shows lower transmission loss.
Next Generation ABF for Thinner Application

■ Redistribution layer of 2.1D / Fan-out package

✓ Thinner LtL, Smaller via, Finer Line & Space ➔ Using Smaller Silica

■ Development of New ABF with smaller Silica

New ABF with smaller silica showed smooth surface after E-less Cu plating
**Fine Line & Fine Via Formation**

**After Wet desmear**

**After Cu plating**

_Smooth surface ➔ L/S = 2/2 by SAP_

_Ø5um via by UV Laser_
Insulation reliability (Line to Line)

- HAST condition
  130degC, 85%RH, 3.3V

<table>
<thead>
<tr>
<th>ABF</th>
<th>L/S=2/2um</th>
<th>L/S=3/3um</th>
<th>L/S=5/5um</th>
</tr>
</thead>
<tbody>
<tr>
<td>GX92</td>
<td>NG</td>
<td>150hrs pass</td>
<td>200hrs pass</td>
</tr>
<tr>
<td>GX-T31</td>
<td>NG</td>
<td>200hrs pass</td>
<td>200hrs pass</td>
</tr>
<tr>
<td>New ABF with smaller Silica</td>
<td>200hrs pass</td>
<td>200hrs pass</td>
<td>200hrs pass</td>
</tr>
</tbody>
</table>

New ABF with smaller silica keeps good insulation even L/S = 2um /2um.
Molding Film
**Background**

- **Market expectation for Fan-out WLCSP**

  - Fan-in WLCSP
  - Fan-out WLCSP
  - FC-BGA

  - Advantages over fan-in WLCSP
  - ✓ No pad pitch restriction due to fan-out area
  - ✓ Only KGD is packaged!
  - ✓ Potential SiP integration
  - ✓ Lower thermal resistance

  - Advantages over FC-BGA
  - ✓ Thinner
  - ✓ Shorter inter connection due to substrate-less
  - ✓ Future potential for SiP / 3D integration
  - ✓ Lower thermal resistance

- **Wafer form to Panel form**

  - 8 inch: 300mm x 300mm
  - 12 inch: 500mm x 500mm

- **Integrated antenna in FO-WLP**

  - Antenna array
  - RFIC
  - Heat sink

  (IME Industry Forum: High Density FOWLP Platform for Next Generation Mobile/2.5D/5G Systems, March 2016)
### Characteristics of Sheet Molding Compound

<table>
<thead>
<tr>
<th>Material Name</th>
<th>LE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTE (30-150degC)(ppm/K)</td>
<td>TMA</td>
</tr>
<tr>
<td>CTE (50-150degC)(ppm/K)</td>
<td>&lt;15</td>
</tr>
<tr>
<td>CTE (150-240degC)(ppm/K)</td>
<td>&lt;25</td>
</tr>
<tr>
<td>Young’s modulus (GPa)</td>
<td>&lt;15</td>
</tr>
<tr>
<td>Breaking strength (MPa)</td>
<td>50</td>
</tr>
<tr>
<td>Elongation (%)</td>
<td>&gt;1.0</td>
</tr>
<tr>
<td>Dielectric constant (Dk)</td>
<td>3.2~3.3</td>
</tr>
<tr>
<td>Dissipation factor (Df)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Peel strength (kgf/cm)</td>
<td>Cu Plating</td>
</tr>
<tr>
<td>x-y HAST L/S=15/15um</td>
<td>130degC, 85%, 3.3V</td>
</tr>
</tbody>
</table>

#### Low CTE & Low Young’s Modulus
- No warpage after the one-side resin curing

**LE: No warpage!**

**GX13: Big warpage!**

(Laminated on 4 inches φ Si wafer)

- Low Df value
- Good insulation reliability

### Suitable for Molding Material!
Summary

1. **Advanced Build-up Materials; Next Generation ABF**
   - **Low Dielectric Loss ABF**
     Lower Df ABF showed lower transmission loss
     >> Applicable to high frequency packages
   - **Next Generation Material for Thinner Application**
     Good Processability & Insulation Reliability
     >> Applicable to WLP/PLP redistribution layer and thinner packages

2. **Molding Film (ABF-LE)**
   Low Warpage, Good HAST Reliability, and Low Loss Tangent
   >> Suitable for FO-WLP/PLP
Eat Well, Live Well.

Thank you very much for your attention!