Novel Materials and Activities for Next Generation Package

Hitachi Chemical., Co.Ltd.
Packaging Solution Center
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1. Activities of Packaging Solution Center

2. Novel Materials for Next Gen. PKG
   - RDL (Redistribute dielectric material)
   - EMC related materials
   - Temporary bonding sheet
   - Ultra-Low CTE substrate & Solder resist
HC Production Lineup

- Materials for Buffer Coating
- Interlayer Dielectric Materials
- CMP Slurry for Cu/Barrier Metal
- CMP Slurry for STI
- Photo Sensitive Dry Film
- High Density Interposer
- Printed wiring boards
- Dicing Tape
- Underfill Material
- Epoxy Molding Compounds
- Die Bonding Film
- QFN Support tape
- Die Bonding Paste
- Liquid Encapsulant
- Solder Resist
- Build-up Materials
- Package Substrate
R&D Structure for Technology Integration

~3 years Products

Material development division
- CMP slurry
- Epoxy mold compound
- Underfill materials
- Die bonding materials
- Buffer coating materials
- Redistributed materials

3~10 years Products

Tsukuba Research Laboratory
- Next generation materials
- Open innovation

Packaging Solution Center
R&D Center (Selangor)

PKG assembly / Process evaluation / Simulation
- Assembly & PKG evaluation
- New evaluation methods
- Simulation technology
Activities of Packaging Solution Center

**Customers**

- Customer demands
- Propose the total solution

**Hitachi Chemical**

Packaging Solution Center

- **Material Properties**
- **Reliability Evaluation**
- **Structure Analysis**
- **Package Assembly**

**Material Properties**
- Adhesion
- Elastic modulus
- CTE etc.

**Reliability Evaluation**
- Reflow resistance
- TCT resistance
- Warpage etc.

**Structure Analysis**
- Stress Simulation
- Warpage
  - FEM: Finite Element Method

**Package Assembly**
- Wafer dicing
- D/B, TCB bonding
- Mold (Transfer / Compression)
New Materials for Next Generation

a) FC-BGA (Chip size: ~ 23mm)
b) FC-CSP (Exposed-Die w/laser via)
c) FO-WLP (12inch, Panel)
d) Stacked-CSP (Silicon interposer w/TSV)

Die attach film
Molding compound
Capillary underfill
Core material
Build-up material
Solder resist

RDL
Fine patterning material
Pre-applied underfill
Ultra low CTE core
Temporary bonding film
High thermally conductive

Available

Next Generation

Pre-applied underfill
Fine patterning material
RDL
Ultra low CTE core
Temporary bonding film
High thermally conductive

New Materials for Next Generation

a) FC-BGA (Chip size: ~ 23mm)
b) FC-CSP (Bare Die, Std. Laser via)
c) Stacked-CSP

Ultra low CTE core
Temporary bonding film
High thermally conductive
Pre-applied underfill
Fine patterning material
RDL

Available

Next Generation

Pre-applied underfill
Fine patterning material
RDL
Ultra low CTE core
Temporary bonding film
High thermally conductive

New Materials for Next Generation

a) FC-BGA (Chip size: ~ 23mm)
b) FC-CSP (Exposed-Die w/laser via)
c) FO-WLP (12inch, Panel)
d) 2.5D,3D-PKG (Silicon interposer w/TSV)
Concept of Open Laboratory

【Concept】
◆ Reduce the evaluation time for customer test PKG (Device/PCB etc.)
◆ High accuracy analysis with advanced equipment
◆ Propose the solution with combination of HC materials
◆ Evaluate of new materials for next generation customer PKG
◆ Suggest new solution with Equipment maker & consortium

Packaging Solution Center
/ Materials combination
/ Assembly test
/ Reliability test
/ Simulation

Open Lab.
Customer
Fabless/OSAT/
Foundry/PCB

Device, Equipment
New process/Evaluation

Tsukuba labo.

Consortium
Advanced device/PKG

Promote of new materials evaluation/qualification
Evaluate next generation PKG with customer
**Activity of Open Laboratory**

Supports a materials & process in cooperation with customers

### Conventional Process

- Material Presentation
- Submission of Sample
- Customer's Evaluation
- Customer's approval

### New Process (Open Lab.)

- Material Presentation
- Our Sample
- Offered customer’s Device
- Assemble test in Open Lab.
  - Fix the process condition & Propose the new materials combination / process with customer
- Customer's approval

(Interaction)
1. Activities of Packaging Solution Center

2. Novel Materials for Next Gen. PKG
   - RDL (Redistribute dielectric material)
   - EMC related materials
   - Temporary bonding sheet
   - Ultra-Low CTE substrate & Solder resist
WLP Related Materials

**Wafer Level PKG**

- **WLP**
  - Buffer Coat
    - PI, PBO, AH series
  - 2nd Under Fill
    - CEL-C series
  - Substrate
    - E-679/700 series
  - Solder Resist
    - SR/FZ series
  - Back side protection

- **FO-WLP**
  - Solid / Liquid EMC
  - Release sheet
  - Temporary bonding film
  - Material for Fine Patterning
    - Dry film, Solder resist
  - Redistribution material
    - (Liquid / Film)
  - Ultra-low CTE / High Modulus Substrate
    - (Ex. Substitution of silicon interposer)

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**Back side protection**

**Substrate**

- E-679/700 series

**Solder Resist**

- SR/FZ series

**WLP**

**FO-WLP**
Low Temperature Curable Photosensitive Dielectric ; AH series

Features
- Positive-Tone Photo Definable
- Alkaline (2.38% TMAH) Developable
- Low Temperature Curable (180~250°C)
- Low Residual Stress
- Low Cure Shrinkage
- High Resolution

Cross Section (5µm Mask)
μ-Trench/Via Formation Film ; Trevia

- High resolution: Via < 10 µm
- Developable by 2.38 % TMAH or 1.0%KOH aqueous
- Excellent heat-resistant properties
- Suitable for trench and photovia process
- Available for Semi-additive process

Structure of “Trevia DF series”

Feature

Base Film
Photosensitve layer
Cover Film

- Lamination (100 °C)
- UV exposure
- PEB (75 °C/8 min)
- Development
- Curing (180 °C/1 h)
Liquid Encapsulant for WLP

◆ Low warpage WLP resin for Printing type
CEL-C-7700, C-7732

◆ Low warpage WLP resin for Compression type
CEL-C-1980 series

High filler loading (86~88wt%) by close packing.
Average silica size is approx. 5um

- Low thermal expansion coefficient
- Low modulus
- Shrinkage reduction
Approach from Solid EMC

- Low warpage
- Low die shift
- Low stand-off
- Low temp. cure

High Tg
Tg : 160°C

Low modulus
E’ : 2-3GPa

Low CTE
CTE 1 : 7ppm/K

Low Mold shrinkage
Mold shrinkage : -0.05

High activity at low temp.
Molding time
- 120°C: 350s
- 125°C: 300s
- 130°C: 250s
- 150°C: 100s
Features of TM-X series

- Film type (1 Layer Type & 2 Layer Type)
  - Easy handling
  - Good thickness uniformity
  - Thickness is controlled at HC (not at customer)

- Mechanical debonding at room temperature
  - Equipment cost is lower.
  - Both Si wafer and glass wafer can be used.

- 2 Layers film: thermosetting film (hard) + thermoplastic film (soft)
  - Compatibility of good BG with de-bonding performance
TSV Related Materials

2.5D PKG
- Thermally conductive film: ✓ High thermal, ✓ Good adhesion
- Dry film resist for Cu pillar: ✓ High resolution

3D PKG
- Pre-applied under Fill: ✓ Good connection, ✓ Short cure bonding
- Capillary flow underfill: ✓ Good gap filling
- Low CTE Substrate; MCL series
  ✓ Low warpage
  ✓ High insulation
- High Tg Solder resist; SR/FZ series
  ✓ High insulation
- Materials for Fine Patterning
  ✓ Fine patterning
- Solid / Liquid EMC Embedded sheet: ✓ Good molding
- CMP; HS series
  ✓ High removal rate
  ✓ Good planarity
- Temporary bonding film
  ✓ Easy debonding
  ✓ Heat resistance
- Redistribution material
  ✓ High resolution
  ✓ Trench/Photo-via

Materials for Fine Pattering
- High resolution

Thermally conductive film
- High thermal
- Good adhesion

Dry film resist for Cu pillar
- High resolution

Capillary flow underfill
- Good gap filling

Low CTE Substrate; MCL series
- Low warpage
- High insulation

High Tg Solder resist; SR/FZ series
- High insulation

Materials for Fine Patterning
- Fine patterning

Solid / Liquid EMC Embedded sheet
- Good molding

CMP; HS series
- High removal rate
- Good planarity

Temporary bonding film
- Easy debonding
- Heat resistance

Redistribution material
- High resolution
- Trench/Photo-via
New low CTE Core Materials

Positioning of materials for PKG application

New material (E777G) have super low CTE
# Hitachi Solder Resist Line-up

## Film Type

<table>
<thead>
<tr>
<th>Product</th>
<th>Current Status</th>
<th>Planned HVM Year</th>
<th>Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>FZ-2700G</td>
<td>Final stage of sample work with several customers</td>
<td>2013</td>
<td>High TCT &amp; HAST Durability</td>
</tr>
<tr>
<td>SR-F</td>
<td>Final stage</td>
<td>2013</td>
<td>Film Ver. of SR7300G</td>
</tr>
<tr>
<td>SR-FA</td>
<td>R&amp;D → Sample Working</td>
<td>2014</td>
<td>Film Ver. of SR7400G</td>
</tr>
</tbody>
</table>

## Liquid Type

<table>
<thead>
<tr>
<th>Product</th>
<th>Current Status</th>
<th>Planned HVM Year</th>
<th>Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR7200G</td>
<td>Current main product</td>
<td>-</td>
<td>Halogen Free</td>
</tr>
<tr>
<td>SR7210G</td>
<td>HVM</td>
<td>-</td>
<td>HAST Durability, Fewer Air Voids</td>
</tr>
<tr>
<td>SR7300G</td>
<td>HVM</td>
<td>-</td>
<td>High TCT &amp; HAST Durability</td>
</tr>
<tr>
<td>SR7400G</td>
<td>Sample working with several customers</td>
<td>2014</td>
<td>Ultra Low CTE</td>
</tr>
<tr>
<td>SR-M</td>
<td>Sample working</td>
<td>2013</td>
<td>Better Usability for Wider Applications</td>
</tr>
</tbody>
</table>
Integrated Technologies for Fine Patterning

Ultra fine pitch primer
- AirFoil, Cobra
  (flat surface)

Ultra Low CTE Laminate
- E-700G series

Low Dk/Df HDI material
- GIGALLA series

High resolution Photosensitive Film
- RY/RD series

L/S=3/3μm Ultra fine line

Primer

[High adhesive energy material]
(Chemical bonding)

X : functional group of interaction with Cu

Free volume = 0.256 cm$^3$/cm$^3$

MCL-E-705G; CTE=2.8ppm

MCL-E-770G; CTE=1.8ppm

Rz=0.04-0.06um

Cu

Activation

Precious metal

Oxidation

Dissolution of CuO

Microscopic indentation is formed

Dry treatment

Thin CuO film is formed
The entry contents of these data based on the results of our experiment done until May. 2015 do not guarantee their characteristic values. The contents may be revised according to new findings if necessary. Please examine the process and the condition carefully and confirm before mass production.