High Density Organic Interposer for 2.5D/3D Multi-Chip Packages

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Unimicron Technology Corp.
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Agenda

- Introduction
- Challenges & Key Development Areas
- Technical Aspect Of Organic Interposer
- Organic Interposer Structure
- Summary & Conclusion
Laminate Substrate in 2.5D/3D Package

- FCBGA Substrate W/ Current Technology
  - 150um Bump Pitch
  - 14/14um Line/Space
  - 60/90um Via/Pad
  - .........................

Source: YOLE Development

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Value Proposition

- **PCB & Carrier**
  - *(Low Cost)*

- **Unimicron Organic Interposer**
  - *(Value)*

- **IC Fab Si Interposer**
  - *(Performance)*

- **Organic FC Substrate**

- **2.5D/3D Interposer**

- **World Class Quality**

- **NATIONAL QUALITY AWARD**

- **Unimicron**
Organic Interposer Offerings

Cost

<table>
<thead>
<tr>
<th></th>
<th>Silicon</th>
<th>Glass</th>
<th>Ceramic</th>
<th>Organic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel Size</td>
<td>12”</td>
<td>20”+</td>
<td>6”</td>
<td>20”</td>
</tr>
<tr>
<td>Via forming</td>
<td>RIE</td>
<td>Laser, others</td>
<td>Laser,</td>
<td>Laser,</td>
</tr>
<tr>
<td>Copper plating</td>
<td>Blind via</td>
<td>Blind/through via</td>
<td>Blind/through via</td>
<td>Blind/through via</td>
</tr>
<tr>
<td>Liner</td>
<td>CVD</td>
<td>Not needed</td>
<td>Not needed</td>
<td>Not needed</td>
</tr>
<tr>
<td>CMP</td>
<td>CMP</td>
<td>CMP</td>
<td>CMP</td>
<td>CMP</td>
</tr>
<tr>
<td>Dielectric film</td>
<td>CVD/Spin coating</td>
<td>CVD/Spin coating, Lamination</td>
<td>Lamination</td>
<td>Lamination</td>
</tr>
</tbody>
</table>

Well Established Infrastructure & Supply Chain

- Substrate manufacturing
- Package assembly
Challenges & Key Development Areas

❖ **Core Material**
  ➢ Thin Core Capability
  ➢ Low CTE
  ➢ High Modulus

❖ **Dielectric Material**
  ➢ Low CTE & High Modulus
  ➢ Electroless Copper Compatibilities
  ➢ Low Insulation & Loss Tangent Properties
  ➢ Fine Via Formation
  ➢ Thin ABF Thickness

❖ **Dry Film Material, Chemicals, etc.**
Challenges & Key Development Areas (cont.)

- **Cu Trace Fine Line/Space Capability**
  - Cu Trace Thickness/Tolerance
  - Cu Surface Roughness
  - Cu Adhesion

- **Sub-100um Bump Pitch**
  - Cu Pillar Bump On Fine Trace

- **Laser Via/PTH Capability**
  - Via Hole Cleaning
  - High Aspect Ratio Via Filling

- **Planarization**
  - Large Area CMP

- **And More………..**
Core Material Selection

- Production Core Thickness: 800/600/400/200um
- Future Development: ≤ 150um Thickness; Ultra Low CTE & High Modulus Properties
Dielectric Material/ABF Selection

- Production Dielectric Thickness: 20um
- Future Development: < 20um Thickness; Ultra Low CTE & High Modulus
Dielectric Material/ABF Selection (cont.)

- Loss Tangent & Dielectric Constant

![Graph showing Df (5.8GHz) vs. Dk (5.8GHz) for different companies and R & D. Targets are indicated by a dashed box.]
Dielectric Material/Prepreg Selection

- Production Trace L/S: Min. 15/15um
- Future Development Area: < 15/15um L/S
## Fine Line Patterning Technology Approach

<table>
<thead>
<tr>
<th></th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
</table>
| **SAP** *(Semi-Additive)* | ![Image](image1) | 1. Low cost  
2. Conventional process  
3. Liquid film process  
4. Post Cu Plated  
5. Copper plating uniformity  
6. Cleanness after laser trench |
| ![Image](image2) | ![Image](image3) | 1. Material limitation  
2. Line width & Cu thickness control  
3. Better electric performance  
4. Better reliability |
| **LE** *(Laser Embedded)* | ![Image](image4) | ![Image](image5) | ![Image](image6) | 1. Cu plating uniformity  
2. Cleanness after laser trench |

**Pros**
- Low cost
- Conventional process
- Liquid film process
- Post Cu Plated
- Copper plating uniformity
- Cleanness after laser trench

**Cons**
- Material limitation
- Line width & Cu thickness control
- Better electric performance
- Better reliability
Fine Line/Space Development

Leading Dry Film Capability

Dry Film Yield

L/S (um)

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Sub-100um Bump Pitch Capability

- Cu Pillar Bump On Cu Trace
- Production Capability: 40/80um Staggered Bump Pitch On Min. 15/15um Cu Trace L/S
- Future Development: ≤ 10/10um L/S; Large Body Size

Source: Amkor
Laser Drill Equipment Evolution

- Deep UV: 180~320 nm
- UV: 320~400 nm
- CO2: 10.6 um

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Fine Via Formation Capability

- Production Rule: 75um (PTH) & 60um (Blind Via)
- Future Development: ≤ 40um (Organic Interposer)
Copper Metal Filling

**TSV Via Filling Technology**

⇒ Aspect Ratio=1: 10

**IC Substrate PTH Filling Technology**

⇒ Aspect Ratio=1:2

➢ Future Development for Organic Interposer

- Cost Efficiency
- Improve AR to 1: 1.33 or Higher; Fine Via and Thin Core Thickness
- Tighten Pad Size/Registration ≤ +/- 30um

Source: Claudio Truzzi, Alchimer S.A., Massy, France

High Performance, but expensive

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# Target Technical Accomplishment

<table>
<thead>
<tr>
<th>Bump Pitch</th>
<th>Cu Trace L/S</th>
<th>Through Via &amp; Micro Via</th>
<th>Thickness</th>
<th>Layer Count</th>
<th>Body Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min. 40/80um Staggered</td>
<td>I. 5/5 - 10/10um</td>
<td>≤ 40um</td>
<td>I. Standalone: ≤ 250um</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>II. &lt; 5/5um</td>
<td></td>
<td>II. Integration: N/A</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Organic Interposer/Organic Interposer Like

Type I: Stand Alone

Type II: Integration

Type III ?????

Brainstorming...

- Collaboration Between End Customers, OSATs And Substrate Suppliers Is Essential And Critical
  - Electrical And Mechanical Functionality
  - 1st Level and 2nd Level Interconnect Joint Reliability

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Development Timeline

❖ Process Module Readiness

➢ Line/Space
  ◆ 10/10 um Q4/2012
  ◆ 8/8 um Q4/2013
  ◆ 5/5um Q4/2014
  ◆ < 5/5um TBD

➢ Through Via
  ◆ 40um Q4/2013
  ◆ 20um Q4/2014

❖ Material Module Readiness

◆ Core Material Q4/2013; Q4/2014
◆ Dielectric Material Q4/2013; Q4/2014
Summary and Conclusion

- **Organic Interposer Has Potential To Become High Density Interconnect Substrate**
  - Competitive Cost And Loads Of Fine Features

- **The Keys To Success Include Core And Dielectric Materials, Fine L/S And Via Drilling Technology, Etc.**
  - Fab. Process Equipment/Concept Plays An Important Role
  - Low Cost Tool/Equipment, Such As Steppers, LDI, Via Forming, Etc. Are Needed To Be Developed
Summary and Conclusion

- Low Cost Organic Interposer Can Be Materialized In The Near Future With The Effort Of Entire Industry Working Toward This Direction

- Unimicron Welcomes Business Partners’ Collaboration To Future Advance Substrate Development Programs