TGV and Integrated Electronics

Shin Takahashi
ASAHI GLASS CO., LTD.
Glass and Electronics

- Designing /Decorative material
- Opening material
- Laboratory glass
- Display devices
- Optical component
- Human interface devices

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www.edokiriko.or.jp

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Jan. 21st, 2015

European 3D TSV Summit
GLASS FOR SEMICONDUCTOR PACKAGING
Glass for Semiconductor Packaging

- Image Sensor
- MEMS
- Integrated Passive Devices
- Photonic Devices
- 2.5D/3D Integrated Packaging
  - Interposer

Glass for “Diverse Packaging”
### Comparison – Substrate Core

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Ideal Properties</th>
<th>Organic</th>
<th>Si</th>
<th>Glass</th>
</tr>
</thead>
</table>
| **Electrical** | - High resistivity  
- Low loss, Low K | green | red | green |
| **Physical**   | - Smooth surface  
- Thin and Large size availability | yellow | green | green |
| **Thermal**    | - High Conductivity | yellow | green | red |
| **Mechanical** | - High Strength, High modulus  
- Low warpage | red | yellow | yellow |
| **Chemical**   | - Resistance to process chemicals | yellow | yellow | yellow |
| **Reliability**| - CTE matched Si and PCB | yellow | yellow | yellow |
| **Cost**       | - At 25um pitch I/O | red | red | grey |

Today’s technologies are too expensive. .. Looking for “Third Option”.

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Motivation for Glass Interposer

- Large glass core
- Low warpage
- Good electrical properties with low loss, low dielectric constant and high resistivity
Many Challenges for Glass Interposer

Technical Challenges (driven by Industrial Consortia)
- Productive TGV formation
- Fine wiring
- Micro bumping & Interconnection
- Assembly
- Inspection
- Demonstration
- Characterization and Reliability
- Low cost technical concept

Industrial Challenges
- Process Integration
- Supply chain
- Standardization
- Low cost and higher yield
- Volume

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Key Challenges

**Gen. 0**
Early Stage
2010 - 2013
- TGV formation
- TGV Metallization
- Performance & Reliability

**Gen. 1**
TGV Wafer
2014 - 2016
- Supply Chain (Wafer Process)
- Inspection & Assembly
- Low Cost

**Gen. 2**
TGV Panel
2016 ~
- Supply Chain (Panel Process)
- Entire Process Design with Industry Partners
- Performance & Reliability
- Lower Cost
RECENT RESEARCH ACTIVITIES FOR GLASS INTERPOSER
Glass is only the beginning...

Pitch: 120µm, Diameter: 60µm(TOP) (Thickness: 300µm)

Pitch: 150µm, Diameter: 65µm(TOP) (Thickness: 500µm)

for Thick Glass...

Pitch: 100µm, Diameter: 60µm(TOP) (Thickness: 180µm)

Pitch: 50µm, Diameter: 25-30µm(TOP) (Thickness: 100µm)

for Thin Glass...
Glass Interposer Manufacturing

Process Flow

1. Glass hole formation

2. Cu plating & CMP

3-1. Dielectric forming

3-2. Seed deposition & Photo litho

3-3. Cu/Au/Ni plating & Seed etching

4.
Cu Metallized Via and Fine Cu Wiring

300um thick

60um Φ TGV

Fine Cu wiring fabricated by SAP (semi-additive process)
Highly bulk resistance of TGV resulted in insertion loss less than -0.12dB at 20GHz.
Reliability Test

- Fully filled Cu vias
- -40°C to 85°C with a dwell-time of 30 min. at each temperature (MIL standard 833)

No significant resistance changes after 1000 cycles
Double side thick polymer worked as buffer to relax stress created by CTE mismatch
Conformal Cu Plating – Electrical Test

354nmTiW; 1950nmCu (both sides) + thin Cu layer plated

Daisy-chain via test:
- 5000 vias = 45 Ohm
- 2500 vias = 23 Ohm
- Single via resistance of 15-18mOhm

Metallized glass vias
Conformal Cu Plating – Thermal Cycle Test

- Conformal vias
- 3 step cycling (-55°C; RT; 125°C)
- Measurement of daisy-chain based on 100 vias
- Only 4 of 250 measured lines (each consist of 100 vias) show an open circuit
- 3 daisy-chains are measured without significant changes, which consist of 5000 vias
Conductive Paste Filling

**Benefit:**
Using CTE matched Cu for higher reliability and hermetic seal of TGV

- Capability for 50um diameter via filling with 130um via pitch
- CTE matched Cu

<table>
<thead>
<tr>
<th>Demonstration result</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass thickness</td>
<td>300um</td>
</tr>
<tr>
<td>Via pitch</td>
<td>200um</td>
</tr>
<tr>
<td>Via diameter</td>
<td>70um (top)</td>
</tr>
<tr>
<td></td>
<td>40um (bottom)</td>
</tr>
<tr>
<td>Metal via</td>
<td>Cu type</td>
</tr>
</tbody>
</table>

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TOWARD TGV PANEL
(FUTURE CHALLENGES)
Future Challenges

Panel Level
- How to use?
- Who can use?

Large size TGV substrate for “Wide range of application”
*Interposer, ...

Wafer Level
- Further Test Data as a “Package”
- Production Technology
*RF, MEMS, Sensor
Roadmap for TGV Commercialization

**TGV Panel**
- Panel base process: >500mm
- 30~100um thin glass
- Pre/Post process harmonization is under development

**Interposer, other electronic devices**

**Technology Today**
- 6 – 8 (12) inch glass wafer with through holes
- 300 ~ 500um thick glass wafer
- Metallization by partner (optional)
- Compatible with Wafer Level Process

**TGV Wafer**
- Better yield & productivity
- 6 – 8 (12) inch glass wafer with through holes
- Metallization (optional)
- Compatible with Wafer Level Process

**RF, MEMS, Sensor and others**
Message

- **TGV Wafer:**
  - Stepping into Individual Development from Basic Research
  - Needs further reliability test results.

- **TGV Panel:**
  - It can be the low cost solution for future interposer (needs infrastructure)

- TGV will create the Diverse Packaging not only for the interposer.
Nano/Micro Fabrication Technology Platform

- Dry Etching
- Wet Etching
- Glass Forming
- Ultra thin glass (50um thick glass)
- Super-polishing Ra $\leq 0.2$ nm
- Nano Imprint
- Glass Drilling

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“Look Beyond”

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