HITACHI

Hitachi Chemical
Working On Wonders

Material technology enhances the density and the productivity of the package

May 31, 2018

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Packaging Solution Center
Advanced Performance Materials Business Headquarter

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Outline

1. Materials for high density packaging
2. Bonding Force Leveling (BFL) Film
3. Molded reflow process with NCF & EMC
4. Bump Stabbing process
5. RDL-first FO-PLP TV and “JOINT”
6. Summary

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Packaging material product line up of Hitachi Chemical

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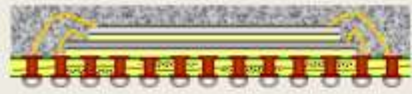
Flip Chip BGA

Stacked CSP

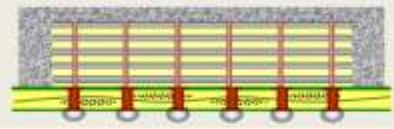


Wafer Level CSP

FOWLP

2.5D PKG

3D PKG



- Buffer Coatings/Redistribution Materials
- CMP Slurry
- Die Attach Film
- Dielectric Material/Build UP, SAP Prepreg
- Dry Film Resist
- Release Film
- Substrate
- Solder Resist
- Temporary Bonding Film
- Solid/Liquid EMC, Embedded Sheet
- Thermally Conductive Film
- Temporary Bonding Film
- Underfill

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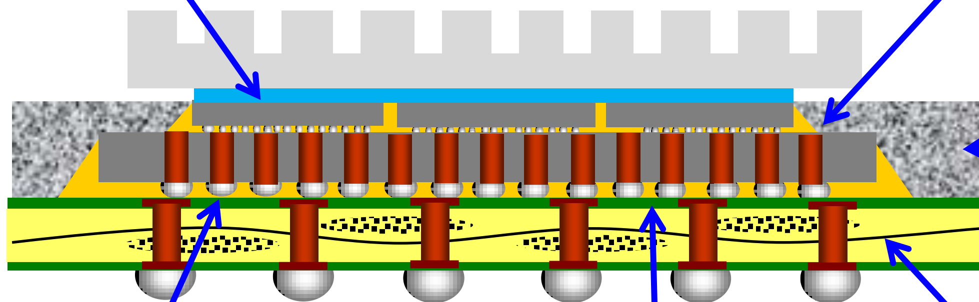
Material can contribute to the performance of the high density package

Thermal Interface material
- High thermal conductive : 40 W/mK

Underfill material
-CUF : Small gap filling: 25 μm
-NCF : Thin die: <50 μm

EMC
- Thermal conductive: 6 W/mK
- Low loss: Df=0.005@60GHz



Organic laminate
- Low CTE: 0.8 ppm/°C
- Low Loss: Df=0.0035@10GHz

Solder resist
- High Tg: >200°C
- Low CTE: <20 ppm/°C

Dry film resist
-Resolution: L/S=2/2 μm

Can material do other contributions?

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Issues of high density interconnecting

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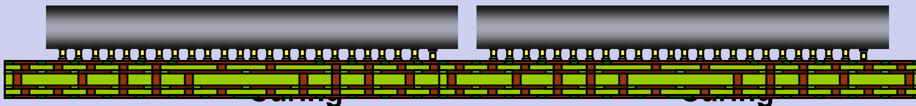
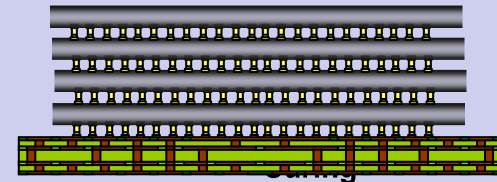
Typical die configurations of high density packages

Side by side (2.5D)



Die stack with TSV (3D)



- Fine pitch
- Many bumps

Precise alignment and small bump interconnection.
Thermal compression bonding (TCB) is usually used.

Low productivity!

Can material enhance the productivity?

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Function of Packaging Solution Center (PSC) of HC

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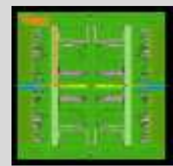
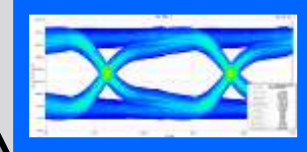
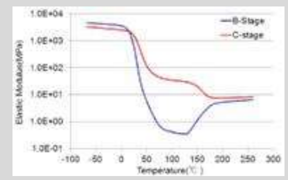
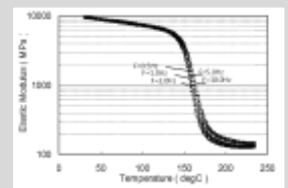



Package TV design

Package (RDL) wiring

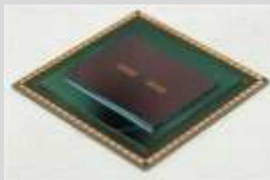
Evaluation of material property

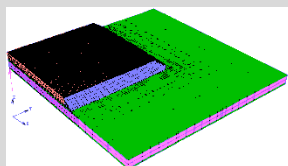
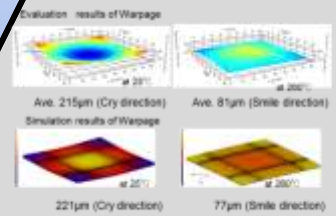
PSC for assembly

Assembly of Advanced package

Evaluation of package reliability

Modeling



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Improvement of productivity in TCB process

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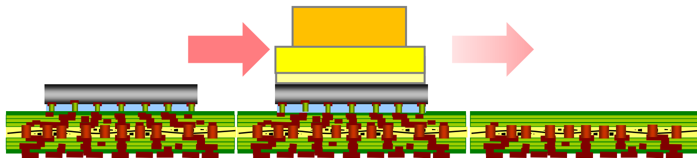
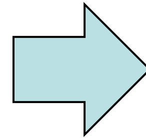
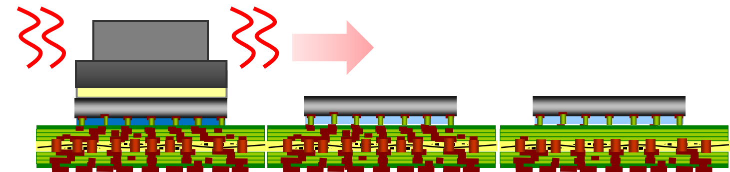
◆ Conventional TCB process

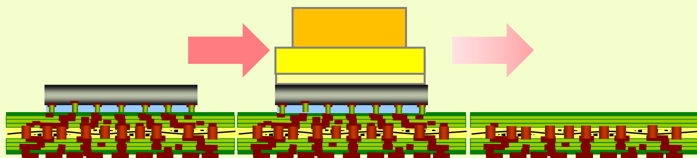
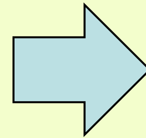
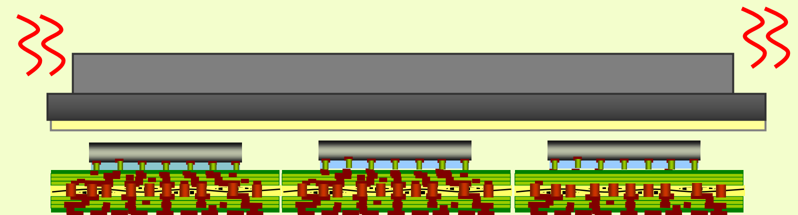
Pre-bonding **Main bonding (die by die)**

- The die by die sequential process step

◆ Gang-bonding process

Pre-bonding **Main bonding (gang-bonding)**

- Multi die soldering on the substrate with single large head

Gang-bonding process can significantly enhance the productivity

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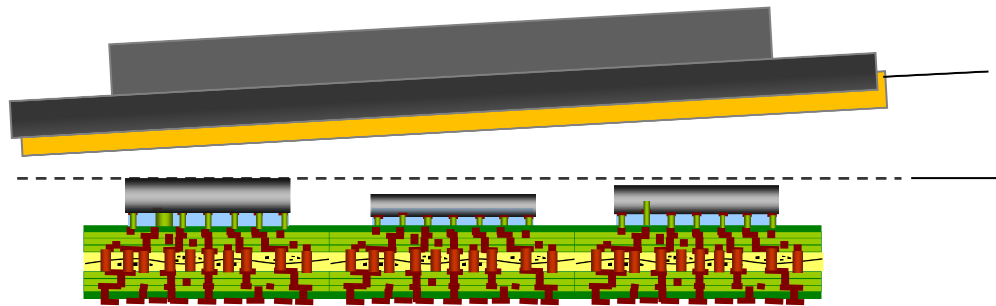
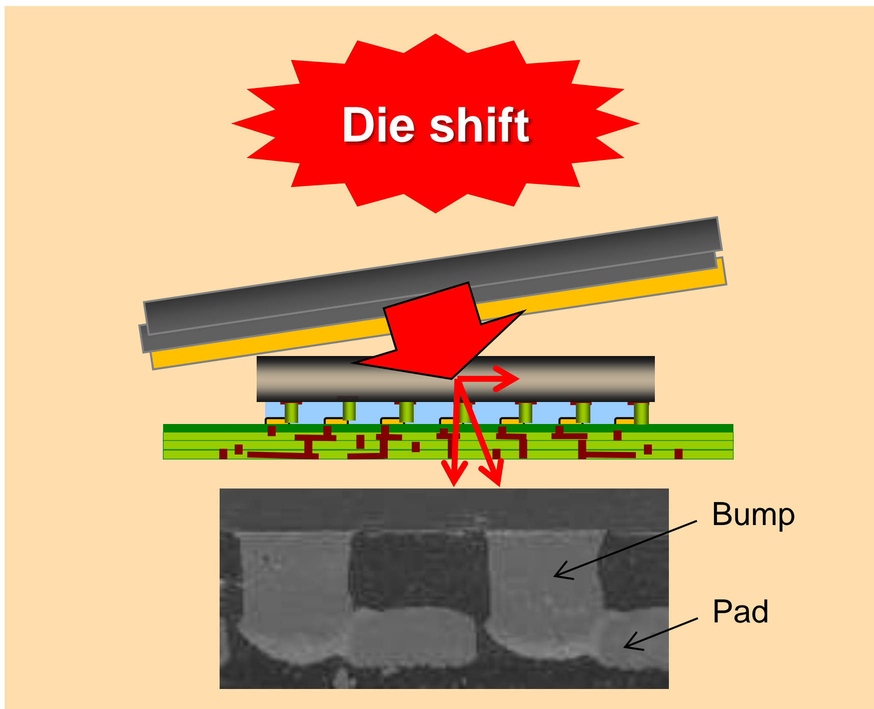
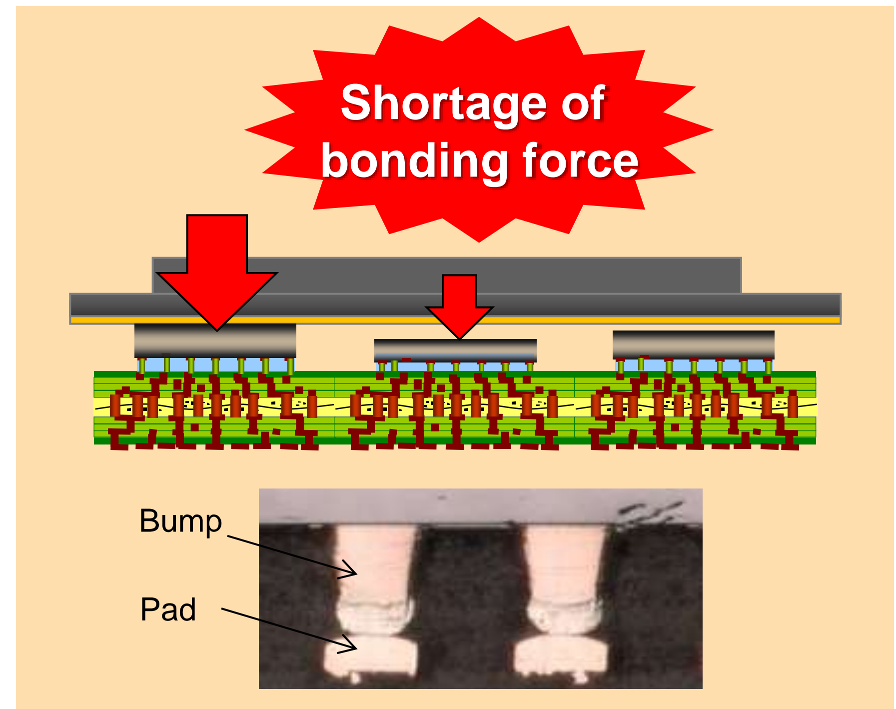
Issues of gang bonding on TCB



- Unparalleled head
- Unevenness of the die height (due to bump height, pad thickness, and thickness unevenness of substrate surface)





Die shift and the shortage of bonding force may happen at the gang-bonding

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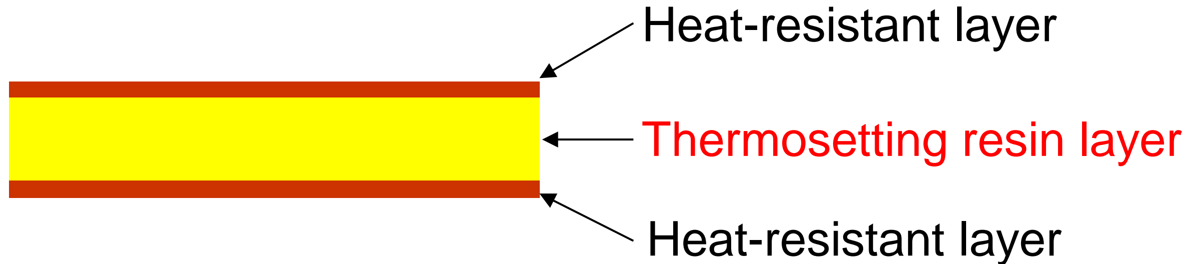
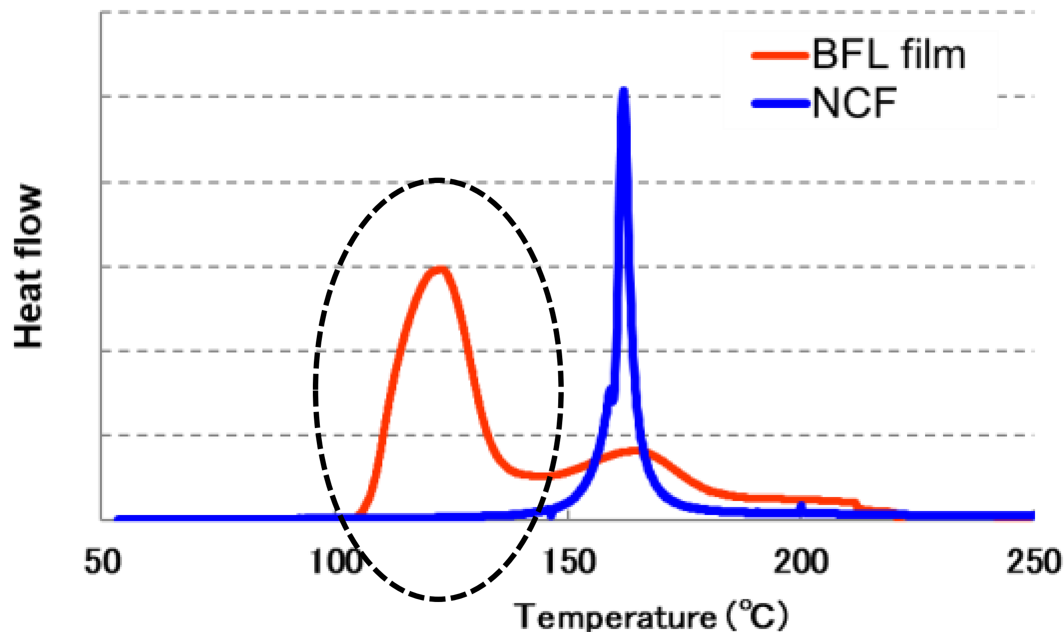
Characteristics of the BFL film

BFL: Bonding Force Leveling

◆ Structure of the BFL film



◆ DSC chart of the BFL film



✓ Thermosetting resin layer of BFL film cures faster than the resin of NCF to compensate the height difference among the dies before multi dies gang bonding.

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BFL film compensates the deviation

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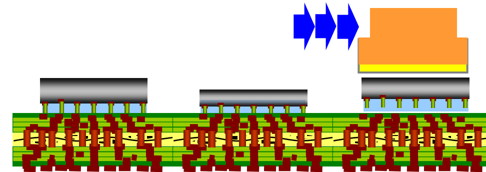
BFL can enhance the productivity of TCB process

Die placement

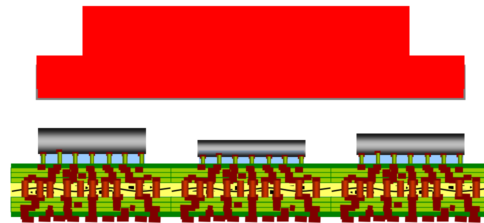


BFL film

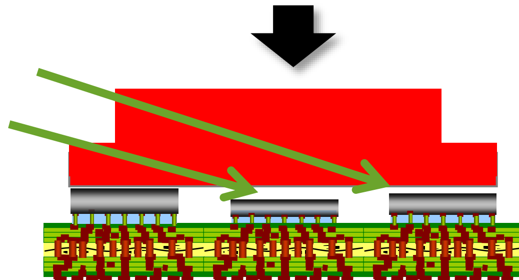
Without BFL film

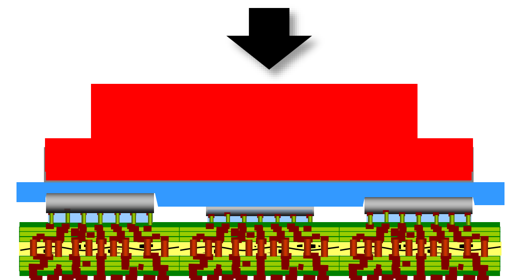
With BFL film

Gang bonding



Interconnection error due to gap deviation





BFL can compensate the gap deviation
High productivity gang bonding !

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Set up of the test of CoS gang-bonding with BFL

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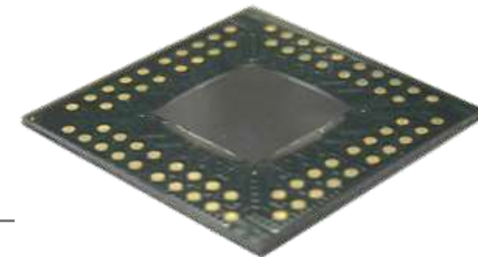
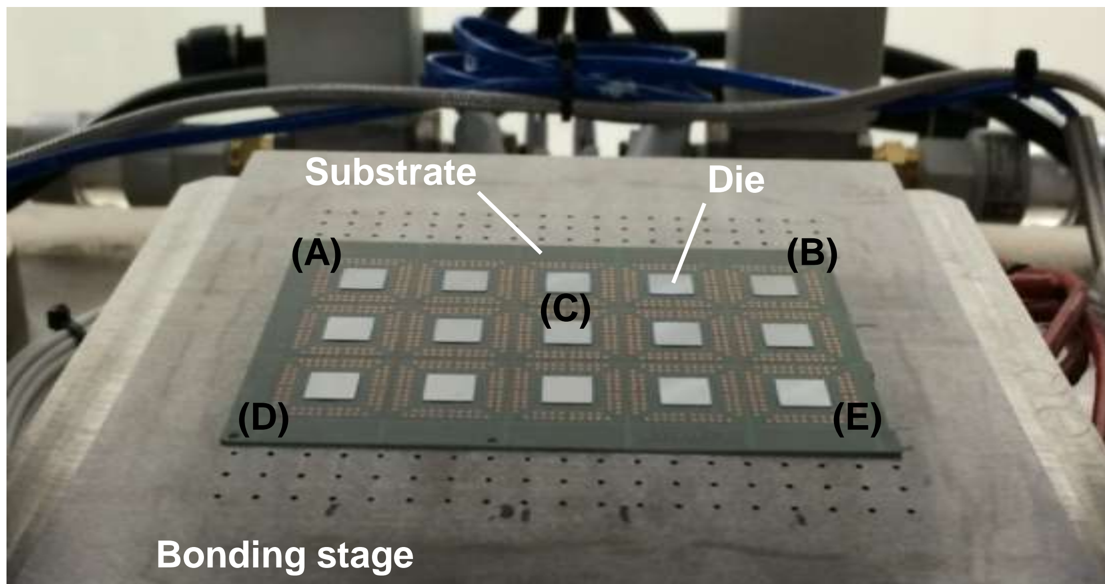
◆ Test vehicle specification

Die	7.3 mm×7.3 mm, 100 μm^t Peripheral bump : 80μm pitch Full array bump : 300μm pitch Bump height : Cu Pillar (30 μm^t) +SnAg Solder (15 μm^t)
Substrate	Top layer Cu thickness: 15 μm Total thickness: 0.36 mm
NCF	Thickness: 40 μm



TV appearance



- Condition: 80 °C/50 N/3 s
- Gang bonding by HTB-MM (Alpha Design Co., Ltd.)
  Condition: 300 °C/750 N/15 s

◆ Evaluation

- Daisy chain (all dies)
- Die shift (A-E dies)
- Void in NCF

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The results of gang-bonding with BFL

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Item	No film	Teflon	BFL film
Daisy chain test (Pass /Total)	8/15	14/15	15/15
Die shift after pre-bonding	Die shift of Y axis (μm); Die shift of X axis (μm); (A) (B) (C) (D) (E)	Die shift of Y axis (μm); Die Shift of Y axis (μm); (A) (B) (C) (D) (E)	Die Shift of Y axis (μm); Die shift of X axis (μm); (A) (B) (C) (E) (F)
Ave. die shift	30 μm	27 μm	5 μm
Void in NCF by C-SAM observation	Void		
	NG	OK	OK

The BFL film performed worked well at 15-die gang bonding

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"Molded reflow " process

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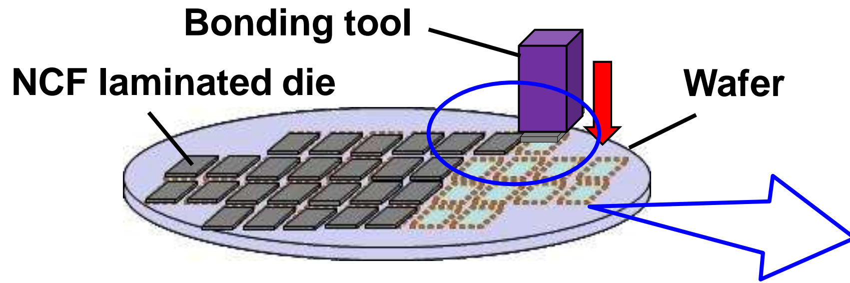
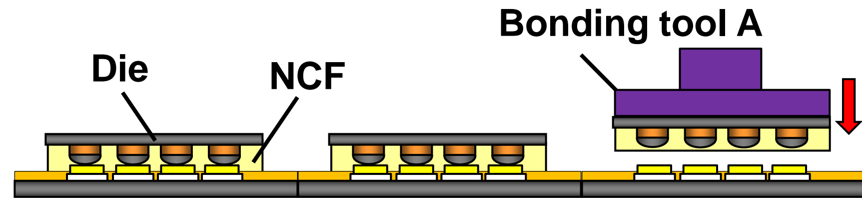
Pre-bonding



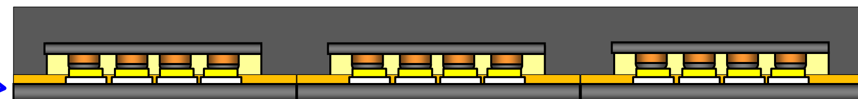
Only placement!
No TCB!



Molding

Reflow

Solder joint formation



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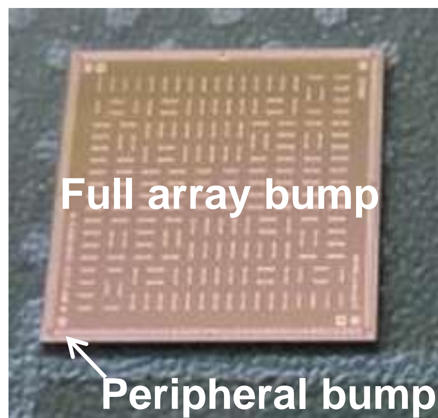
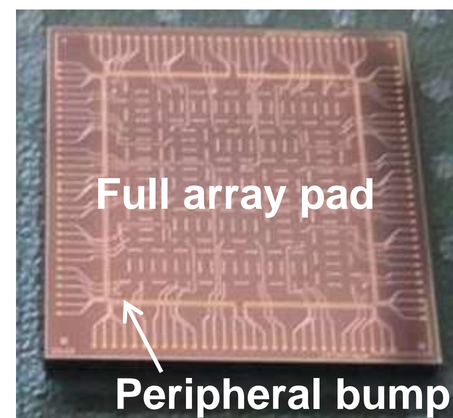
Die specification of TV

Top die	7.3 mm x 7.3 mm, 100 μm^t Passivation : SiN Peripheral bump : 80 μm pitch, 648 pin Full array bump : 300 μm pitch, 400 pin Bump height : Cu Pillar (30 μm^t) + Sn/Ag Solder (15 μm^t)
Bottom die	10 mm×10 mm, 100 μm^t Passivation : SiN Pad : Ni/Au plating





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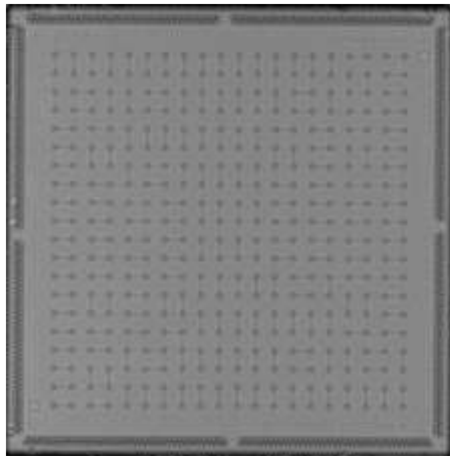
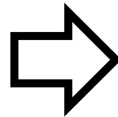
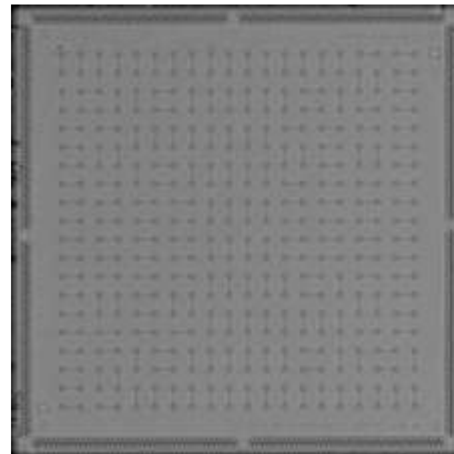
CoC assembly by molded reflow

NCF: Specially designed for reflow process (Lower viscosity NCF).
Pre-bonding condition: 130 ˚C / 2 s
Reflow condition: 170 ˚C / 2 min + 190 ˚C / 2 min + 260 ˚C / 2 min + 190 ˚C / 2 min by convection ovens.

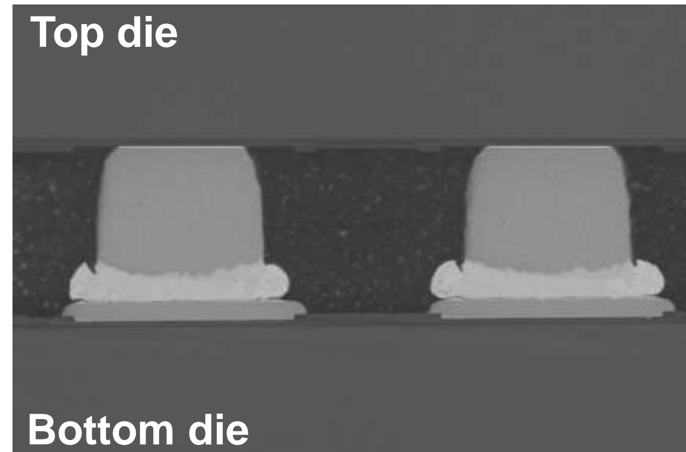


SAM image
After pre-bonding





SAM image



SEM image of cross section
After reflow

Void Suppression and making solder joint were successfully archived with the NCF by molded reflow process.

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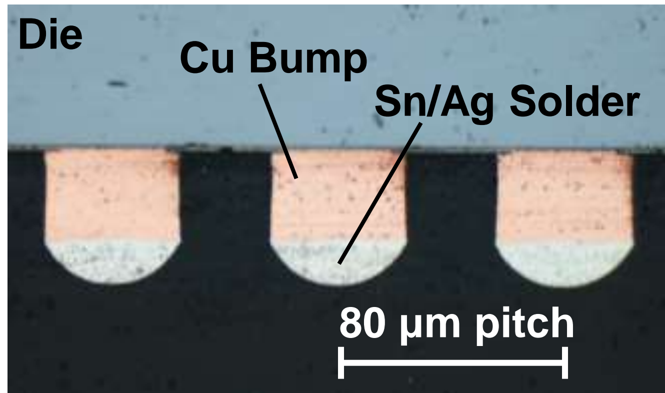
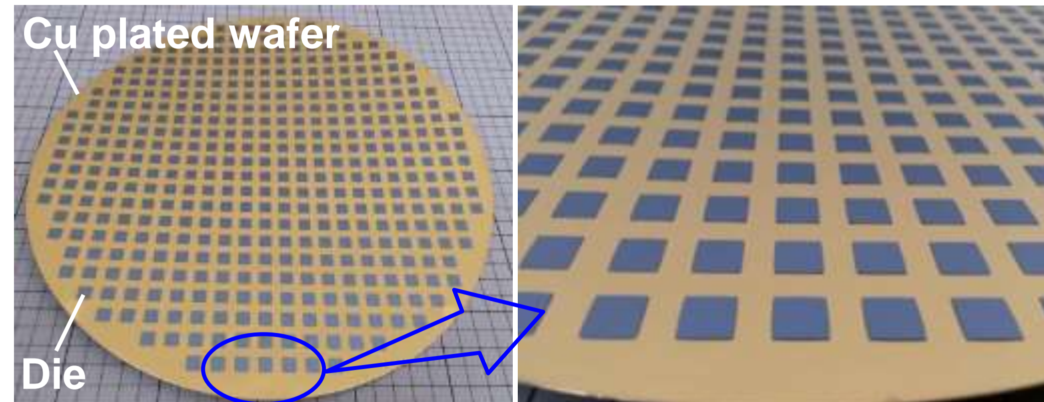
CoW assembly by molded reflow

Top die	Size : 7.3 mm × 7.3 mm , Thickness 100 μm Peripheral bump : 80 μm pitch, 328 pin Bump height : Cu Pillar (30 μm) + Sn/Ag Solder (15 μm)
Plated wafer	12 inch wafer , Thickness 250 μm Plating thickness : Cu 4 μm/ Ni 4 μm /Au 0.1 μm



Bump structure of top die



Photos of CoW

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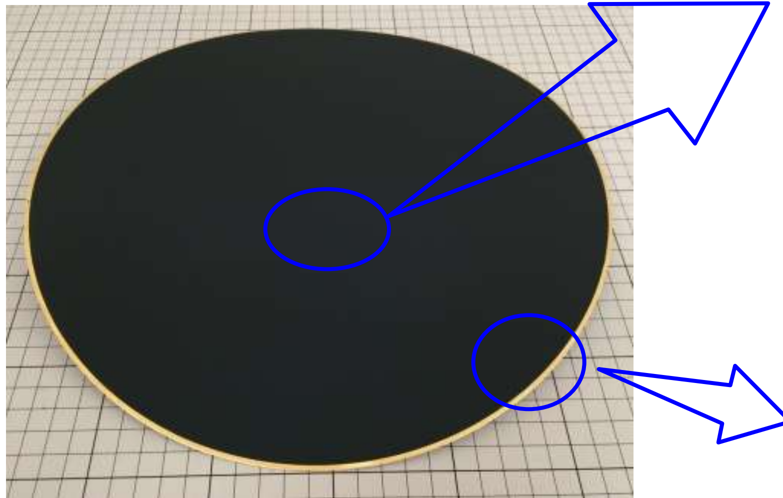
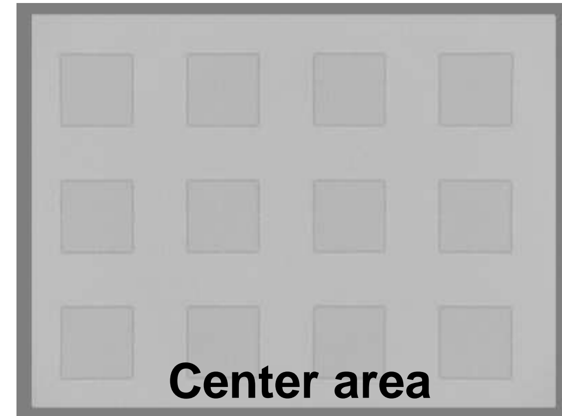
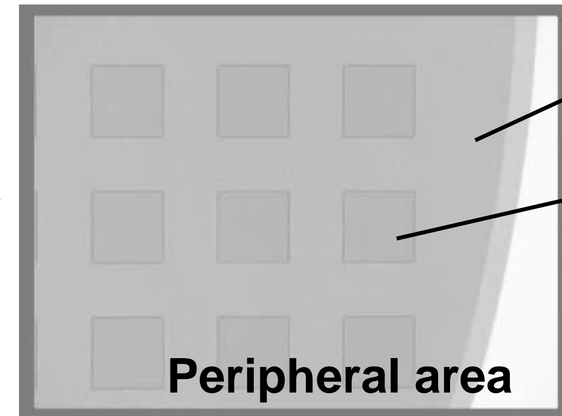
X-ray image of molded reflow CoW

Chip on wafer: 421 dies
Gap between dies: 5 mm
Molding cap thickness: 300 μm



After molding
(Before reflow treatment)





X-ray image after molding

No die shift was observed.

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3D die stacking TSV-PKG assembly by Molded reflow process

Bumped wafer (Wafer for top & TSV die)

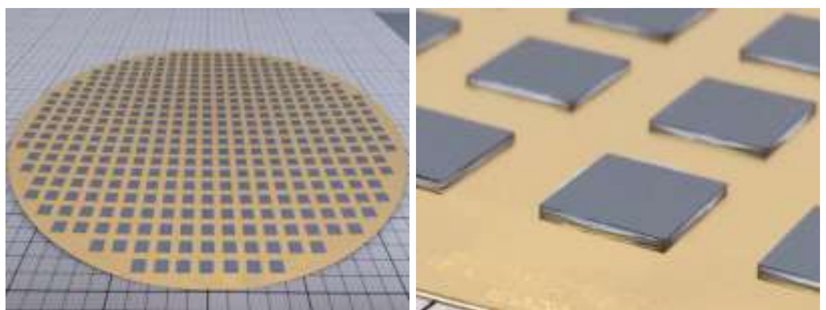
NCF

Dicing blade

Bonding tool

Plated wafer

Lamination → **Dicing** → **Pre-bonding** → **3 die stacking (Under pre-bonding condition)** → **Over-molding** → **Reflow treatment**



3 dies stacking CoW

Chip on wafer: 421×3 = 1263 dies
Gap between dies: 5 mm

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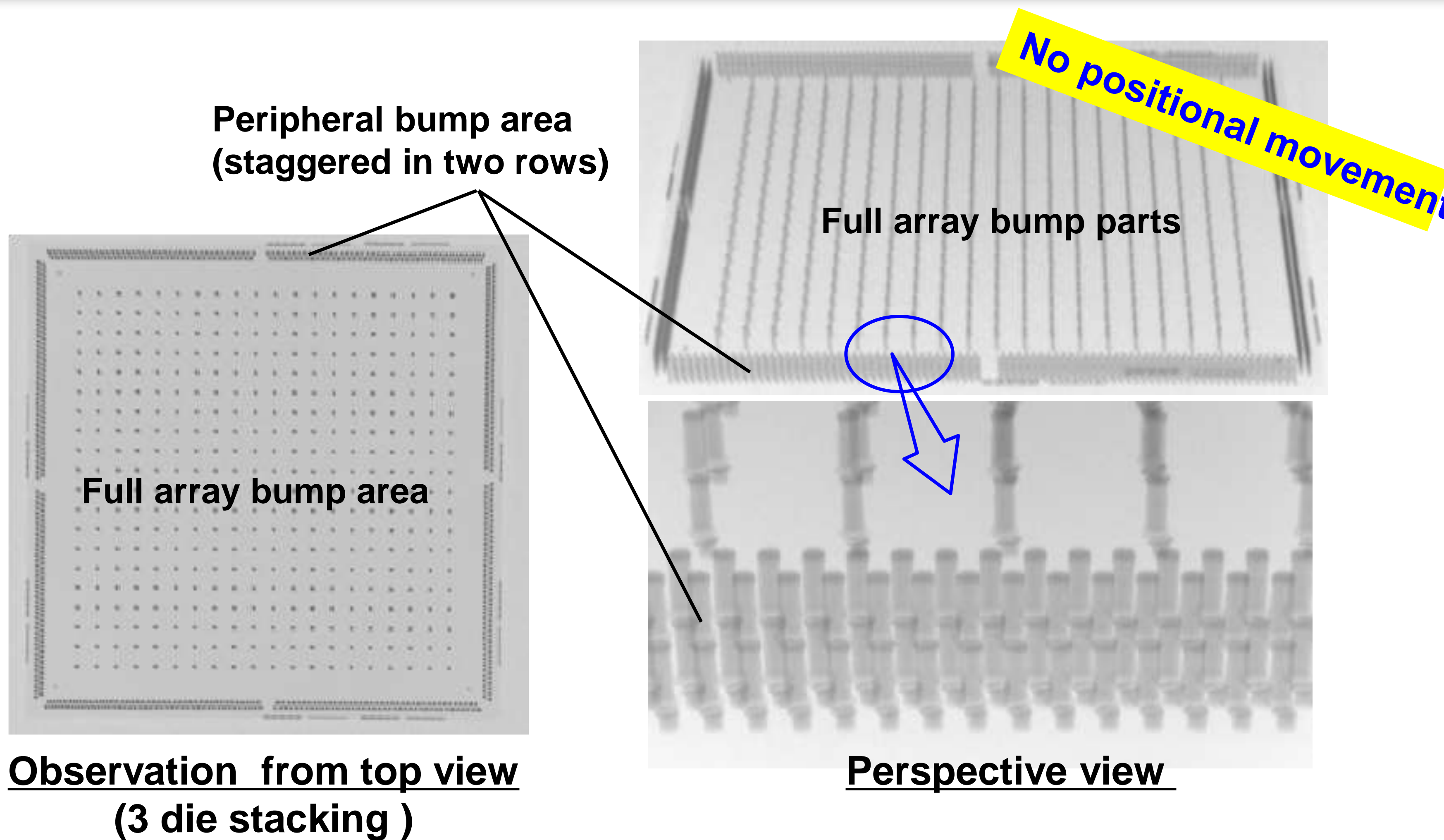
X-ray image after over-molding



No die shift was observed by over-molding.

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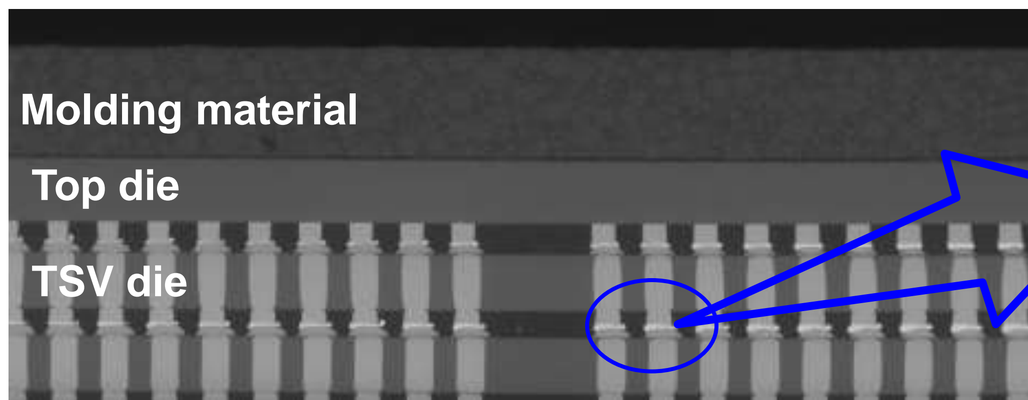
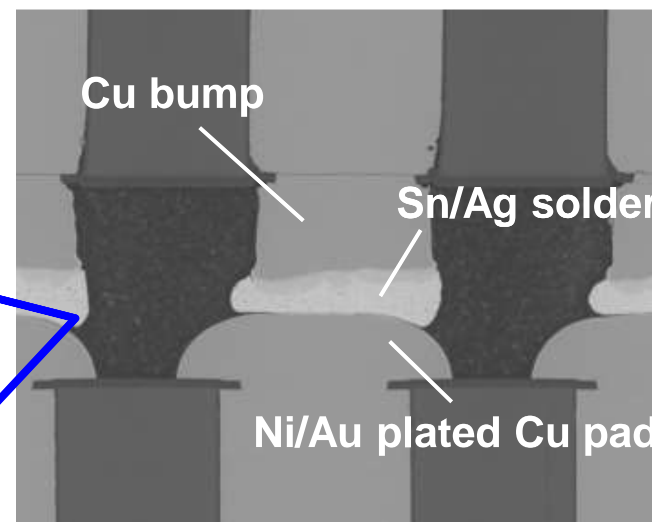
Cross section of TSV-3D die stacking

Molding cap thickness: 500 μm





Cross section after reflow

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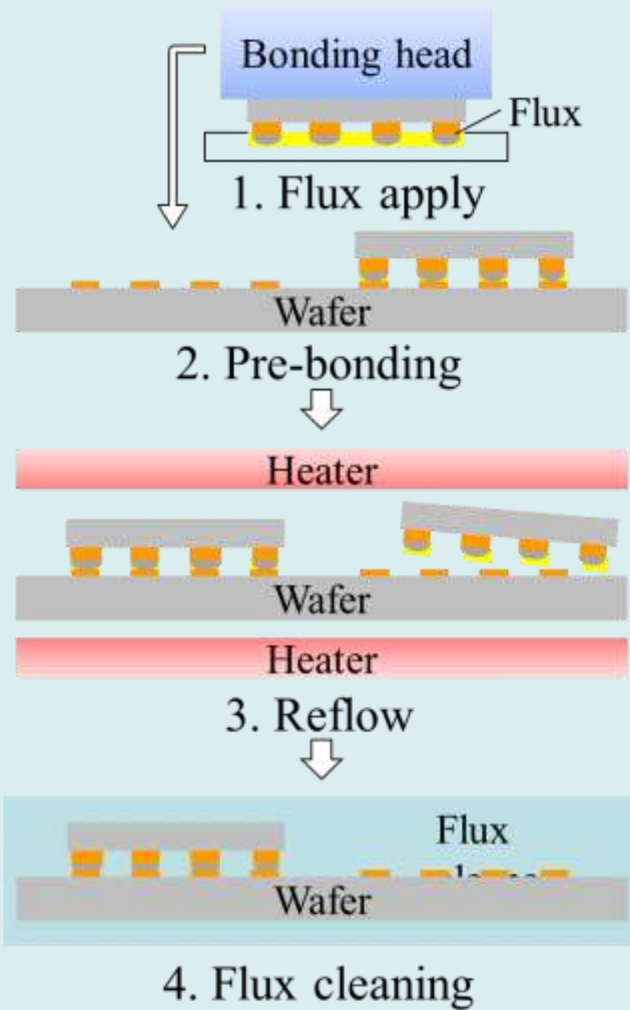
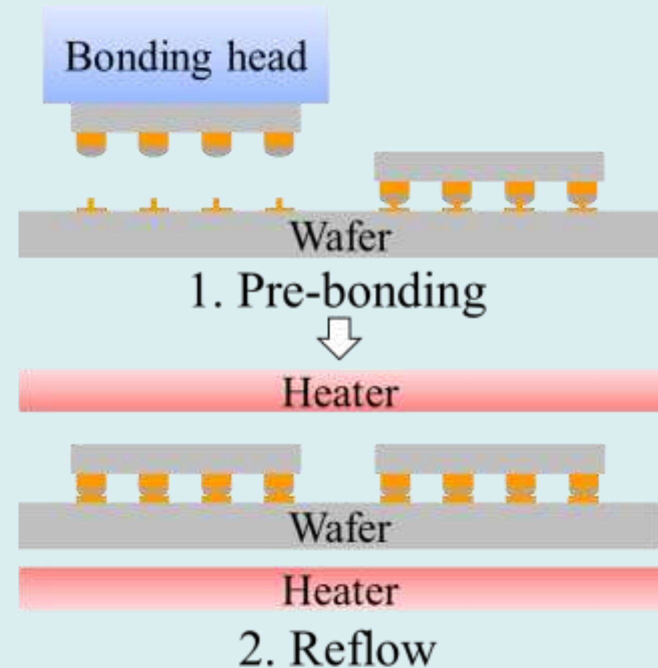
Bump stabbing assembly

Conventional mass reflow process



Bump stabbing mass reflow process



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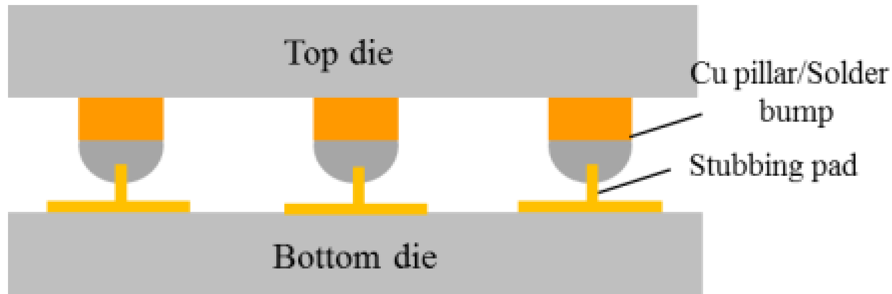
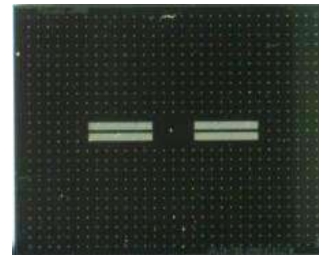
Test vehicle specification

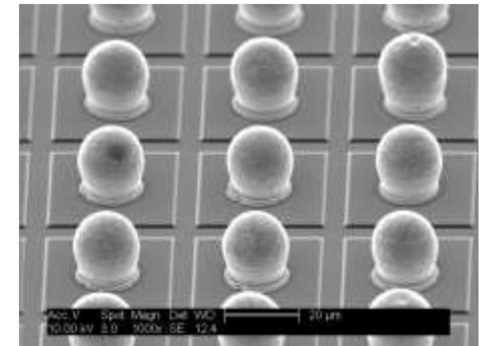
Bump stabbing



Top die



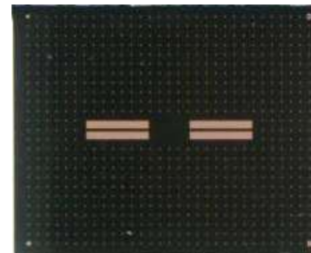
Bumps of the top die



TV die specifications

Top die	Size	10 x 8 mm
	Thickness	0.725 mm
	Bump pitch	I/O : 40 µm Dummy : 300 µm
	Bump size	Φ20 µm
	Bump height	Cu/Sn-Ag : 10 µm/8 µm
Bottom die	Size	10 x 8 mm
	Thickness	0.725 mm
	Pad pitch	I/O : 40 µm Dummy : 300 µm
	Pad size	Φ26 µm
	Pad height	Bottom/Stubbing : 2 µm/3 µm

Bottom die



Pads of the bottom die

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Solder joint by bump stabbing

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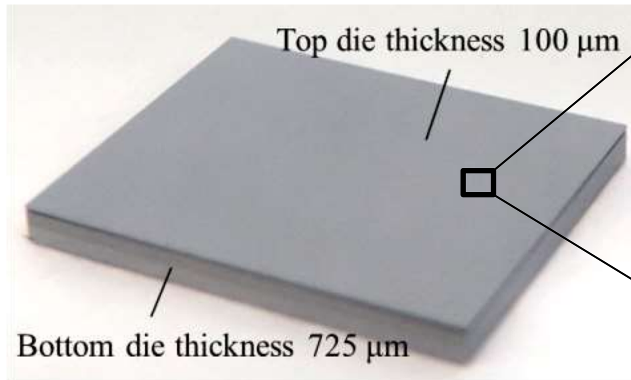
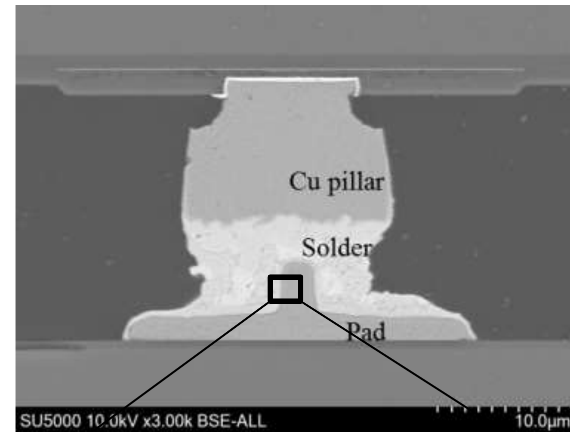
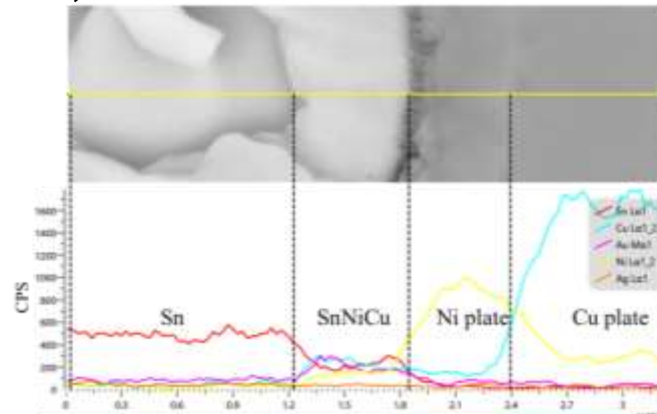
Stacked dies



Cross section of joint





Sn-Ni-Cu alloy was formed.

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3D die stacking

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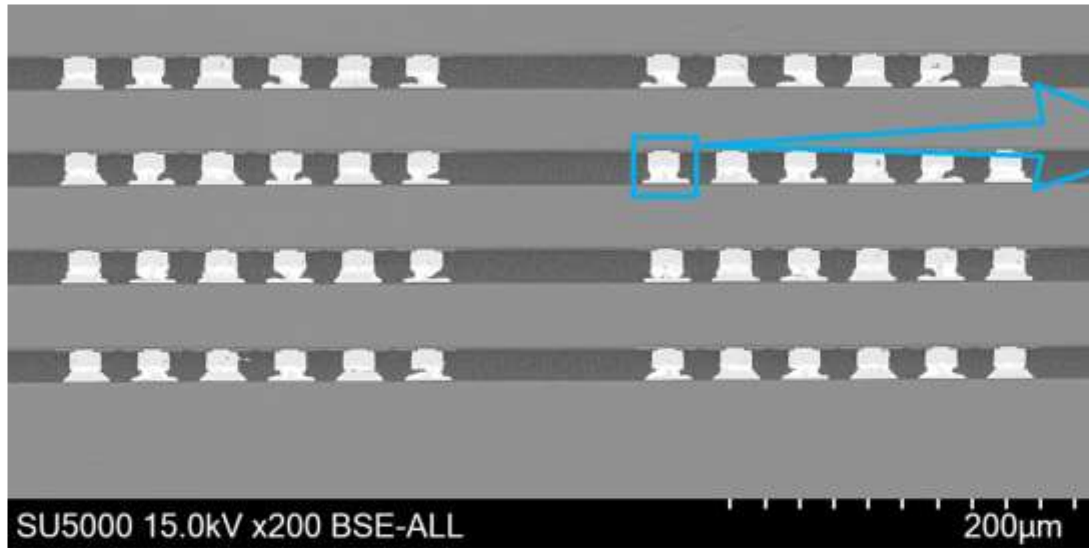
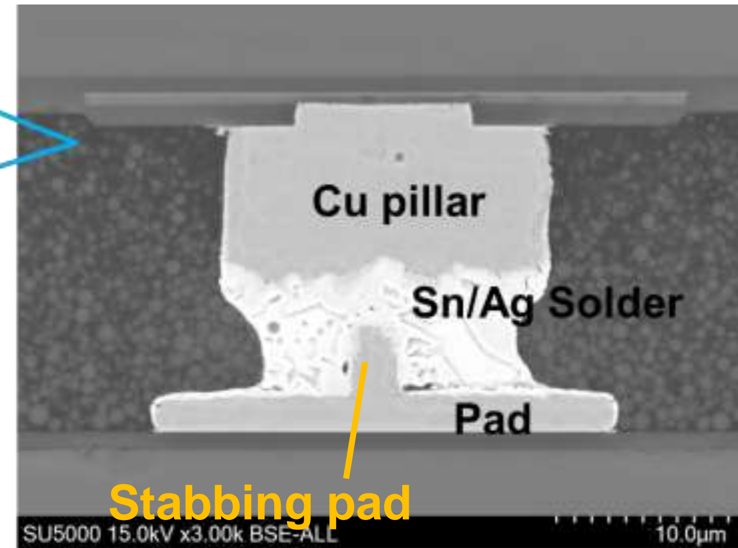
Die thickness : 40 µm
Stack layer : 4





Cross section after reflow treatment

Solder joints were formed with good alignment

***Details will be presented at session 33-4 (3:30 pm on June 1)**

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Contents

1. Materials for high density packaging
2. Bonding Force Leveling (BFL) Film
3. Molded reflow process with NCF & EMC
4. Bump Stabbing process
5. RDL-first FO-PLP TV and “JOINT”
6. Summary

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Consortium "JOINT" has been founded!

State of the art jisso technologies of material and equipment get together, which can provide the solution.

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Summary

Enhancement of the productivity of high density interconnection was studied and demonstrated, which were related 2.5D and 3D packages.

- **BFL film : Side by side multiple die TCB gang bonding**
- **Molded reflow: CoW multiple die bonding including 3D die stacking**
- **Bump stabbing process: 3D die stacking**
- **Expanding film**
- **RDL first FO**
- **Consortium "JOINT"**

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Thank you!

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