Device Packaging 2012

Hitachi Chemical
Working On Wonders

NCP (Non Conductive Paste) for Narrow Gap Flip Chip Package and TSV Package

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Hitachi Chemical materials lineup

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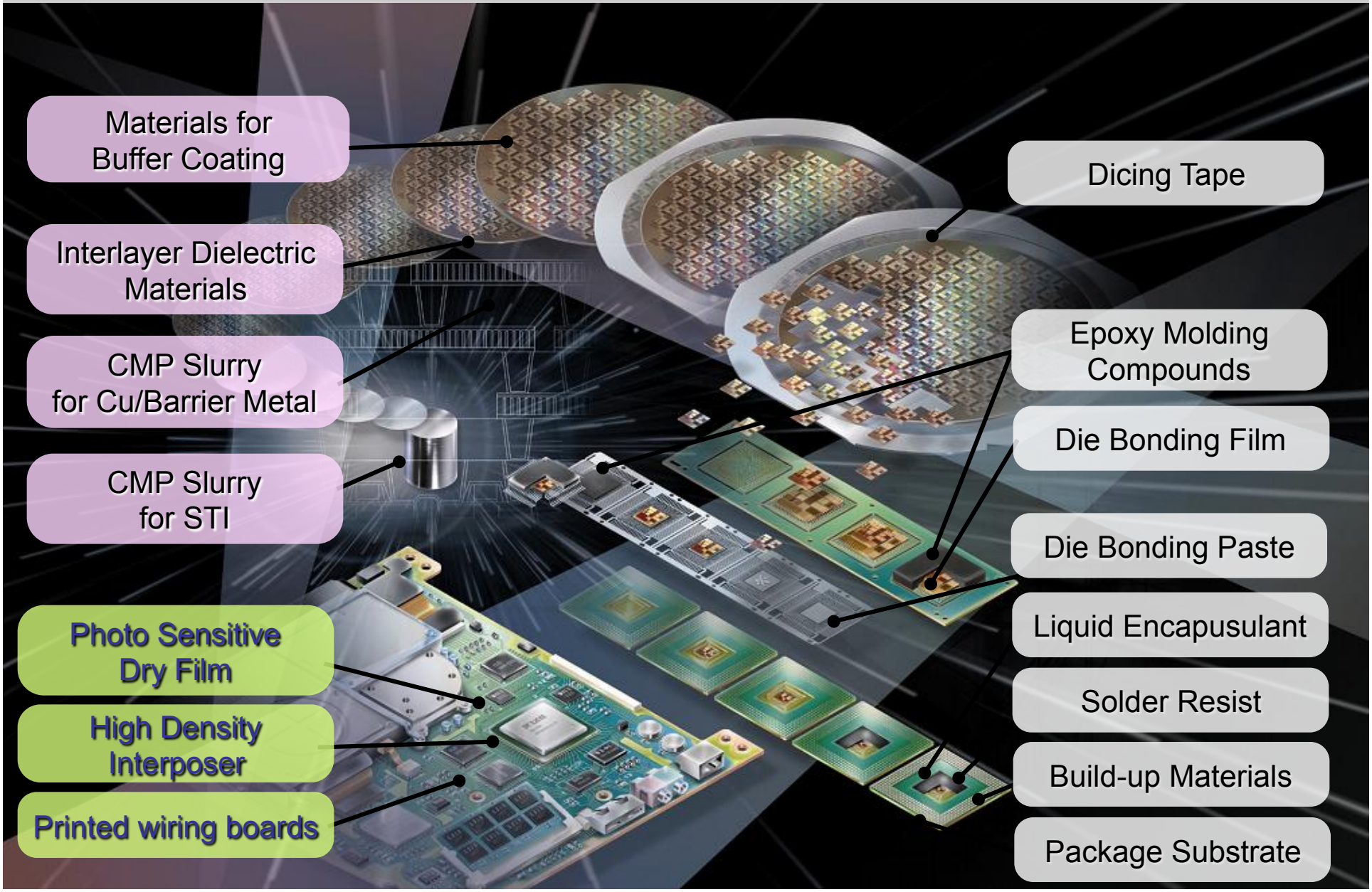

Material system solution (MSS)

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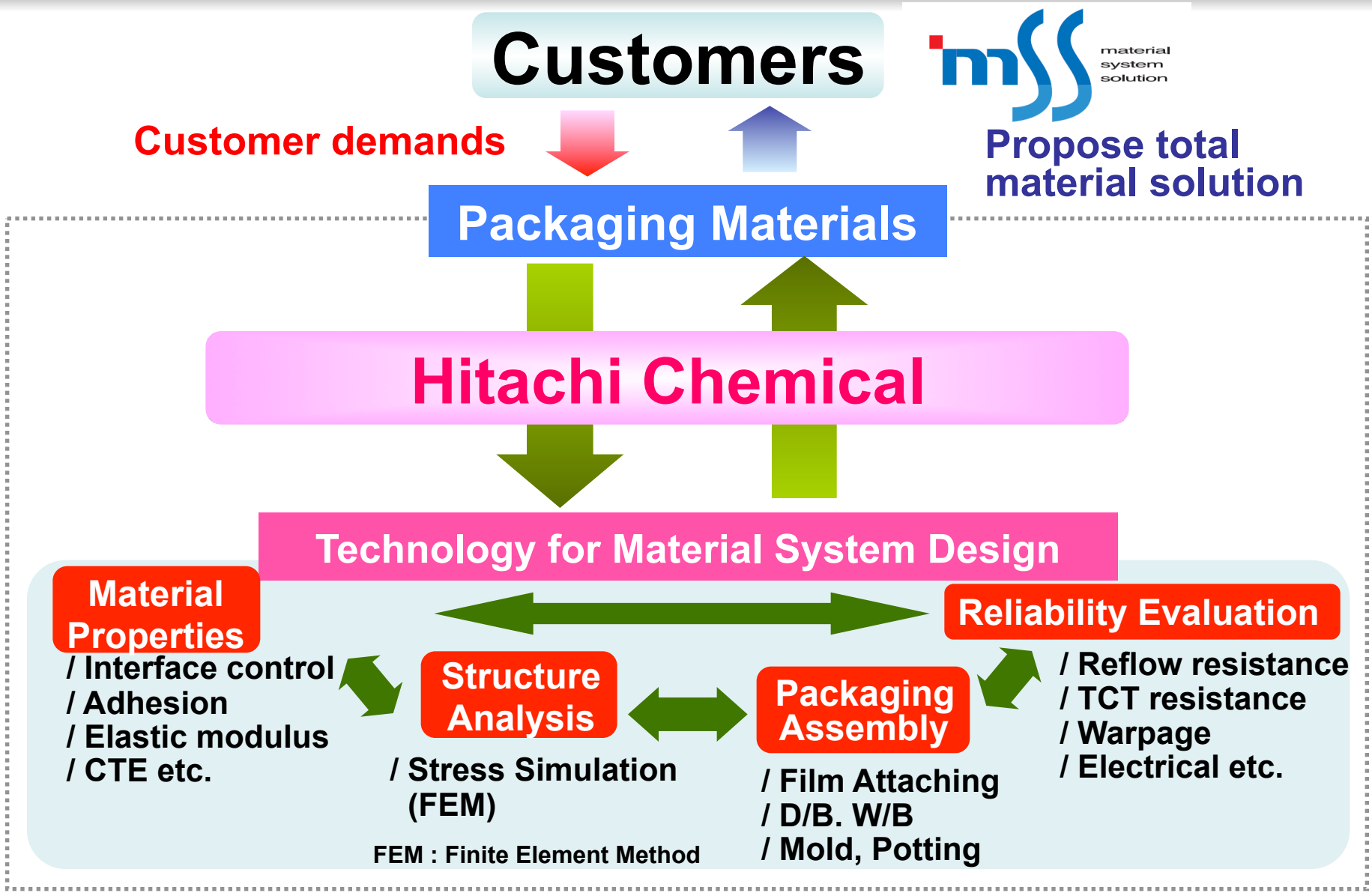

Material system solution (MSS)

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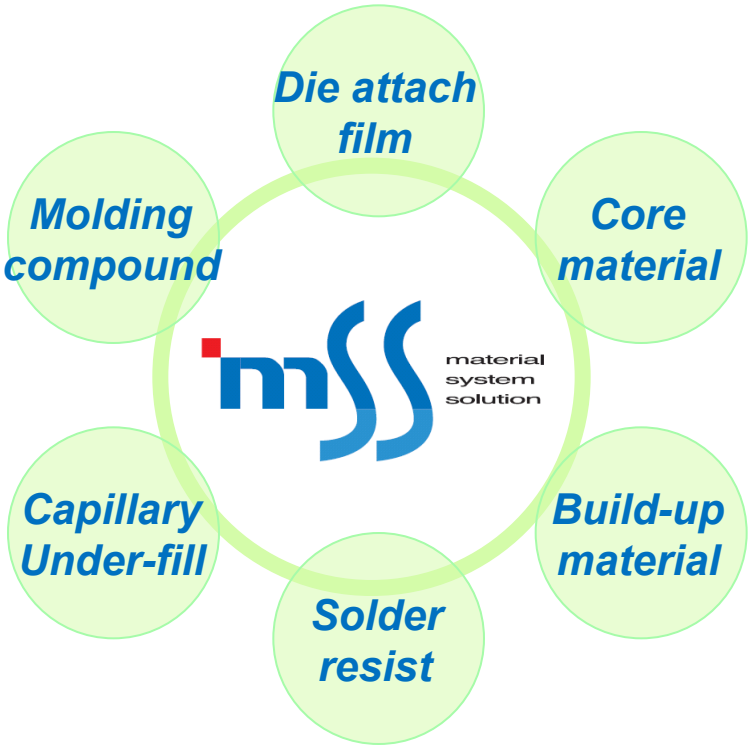
2011 (available)



a) FC-BGA (Chip size : ~ 20mm)
b) FC-CSP (Bare Die, Std. TMV)
c) Stacked-CSP

Next generation

a) FC-BGA (Chip size : 20 ~ 25mm)
b) FC-CSP (Exposed-Die TMV)
c) WLFO
d) 2.5D-PKG (Silicon interposer)

Contents

FC package roadmap

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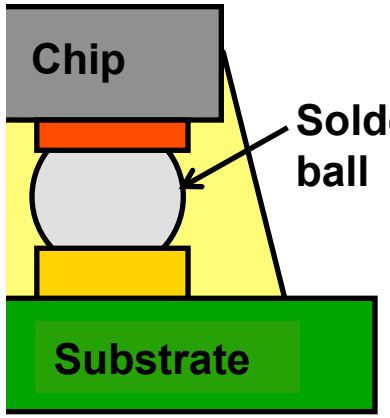
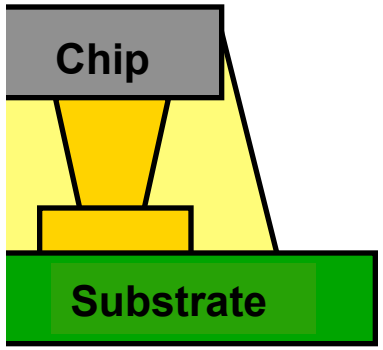
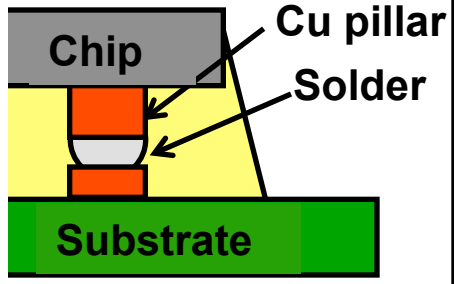
Item		unit	2010	2012	2014	2016	2018	2020
Chip - Substrate	Pad pitch	um	40 * (150-200)	40 (135-200)	40 (120-180)	35 (110-150)	30 (110-150)	30 (90-150)
	Chip thickness		70 (200)	50 (100)	50 (100)	50 (90)	50 (90)	35 (80)
	Bump diameter		20 (90)	17 (80)	17 (80)	17 (80)	15 (70)	15 (70)
	Bump height		10 (75)	9 (65)	9 (65)	9 (55)	8 (55)	8 (45)
	Gap		15 (50)	12 (40)	12 (40)	12 (35)	10 (35)	10 (30)
Chip – Chip	Pad pitch		40	40	40	20	20	20

*Top:Peripheral, (Bottom):Area array

Source ; Japan Jisso Gijyutu Roadmap 2011

➢Finer pad pitch and narrow gap is expected

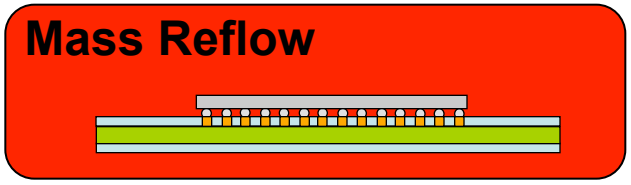
Pros and Cons for FC structures

Item	Solder balls	Au stud / plated	Cu pillar with solder cap
Structure			
UF	CUF / MUF	CUF / NCP / NCF	CUF / MUF / NCP / NCF
Pros	High reliability Existing platform	Less oxidation	Finer pitch Lower cost
Cons	Challenging finer pitch	Challenging fine pitch Higher cost	Difficult filling

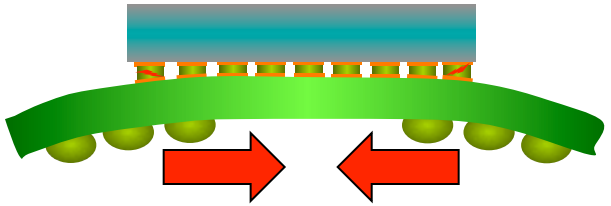
➢To meet higher pin count requirement, more Cu pillar is expected with finer pitch.

MR vs TCB

•Mas Reflow then CUF

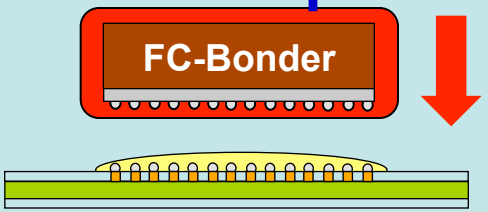


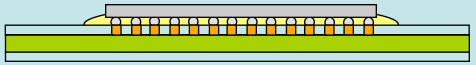
✓Substrate is heated to reflow temp



✓Flux residue to cause voids and delamination
✓Stress on low-k
✓Warpage
✓Stress relaxation is after CUF

•Thermal Compression Bonding with NCP or NCF





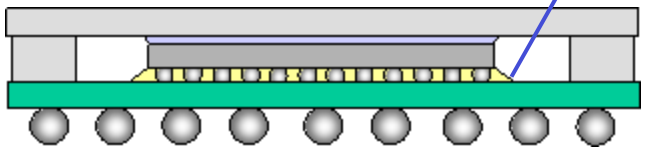
✓Substrate could be less heated.
✓No additional flux is needed.

✓Instant stress relazation with underfill
✓Low stresss on low-k
✓Low warpage

➢Thermal compression bonding with NCP/F would reduce stress on low-k less than Mass Reflow.

FC, 2.5D and 3D TSV

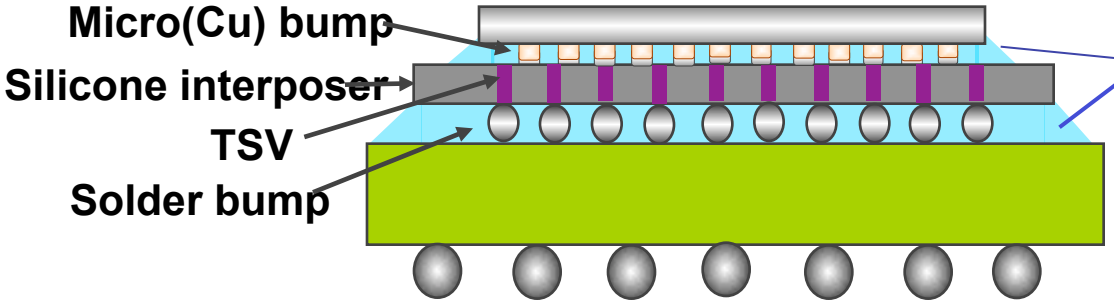
•FCBGA/CSP



CUF, MUF, NCP, NCF

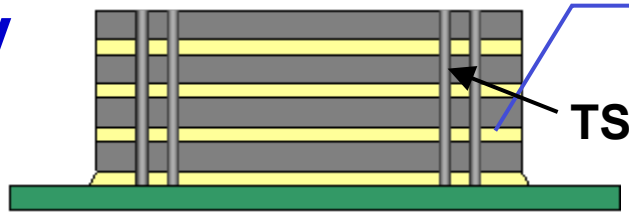
MUF : Mold Underfill
NCP : Non Conductive Paste
NCF : Non Conductive Film

•2.5D TSV



CUF, NCP, NCF

•3D TSV

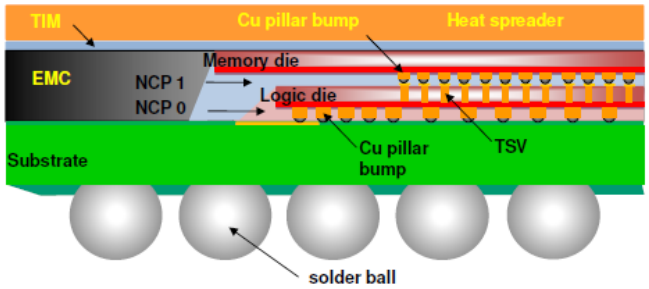


CUF, NCP, NCF

Examples of NCP for TSV

•Mobile applications

Mobile Applications

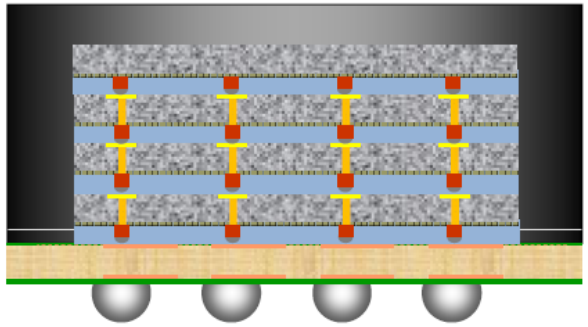


Wide I/O memory die (~1200ubumps, no TSV)
28nm (Cu pillar, 10um dia. TSV)
Substrate (14 x 14 /12 x 12 mm)
Die 2 Substrate interconnection : TCNCP
Die 2 Die interconnection : TCNCP
Heat spreader attach (exposed die molding) :optional

➢NCP x 2 + Mold

•Memory stacking

Process Flow – Memory Stacking



NCP dispensing and TC bonding 1
TC bonding 2, 3 and 4

Mold
Solder ball attach

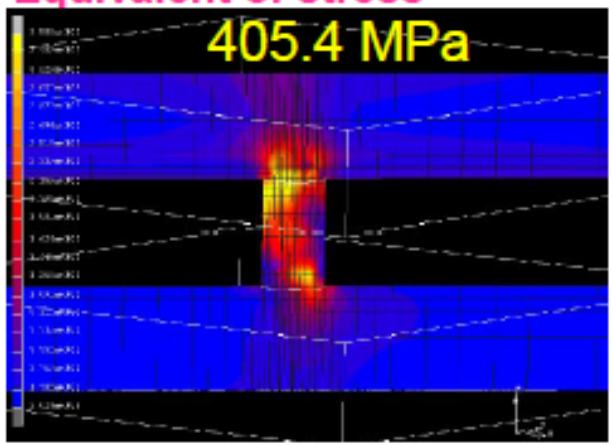
Source : CH Lee, Amkor at MEPTEC 2.5D, 3D and Beyond, 2011

➢NCP x 4 + Mold

CUF (Capillary underfill)

◆Stress distribution before underfill

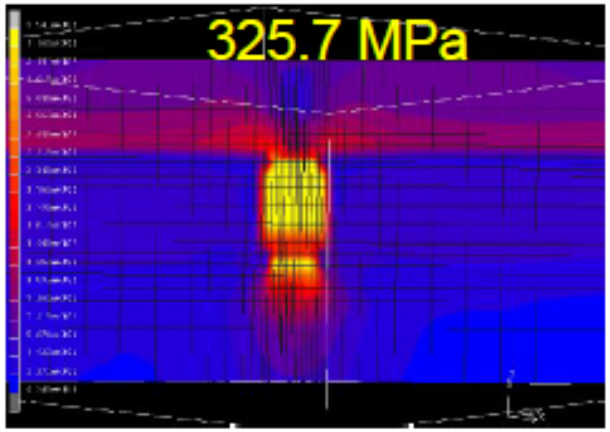
Equivalent of stress



Underfill can reduce stress

◆Stress distribution after underfill

Equivalent of stress



For micro bump & 2.5D

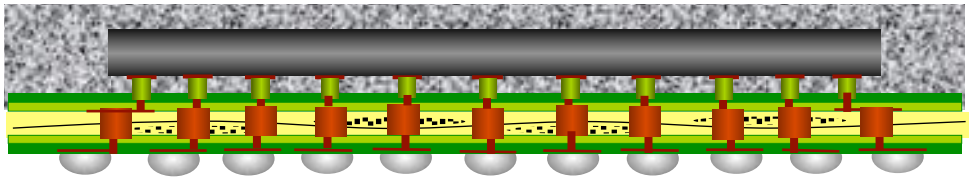
CEL-C-3730S Narrow gap filling type

For large die 28nm

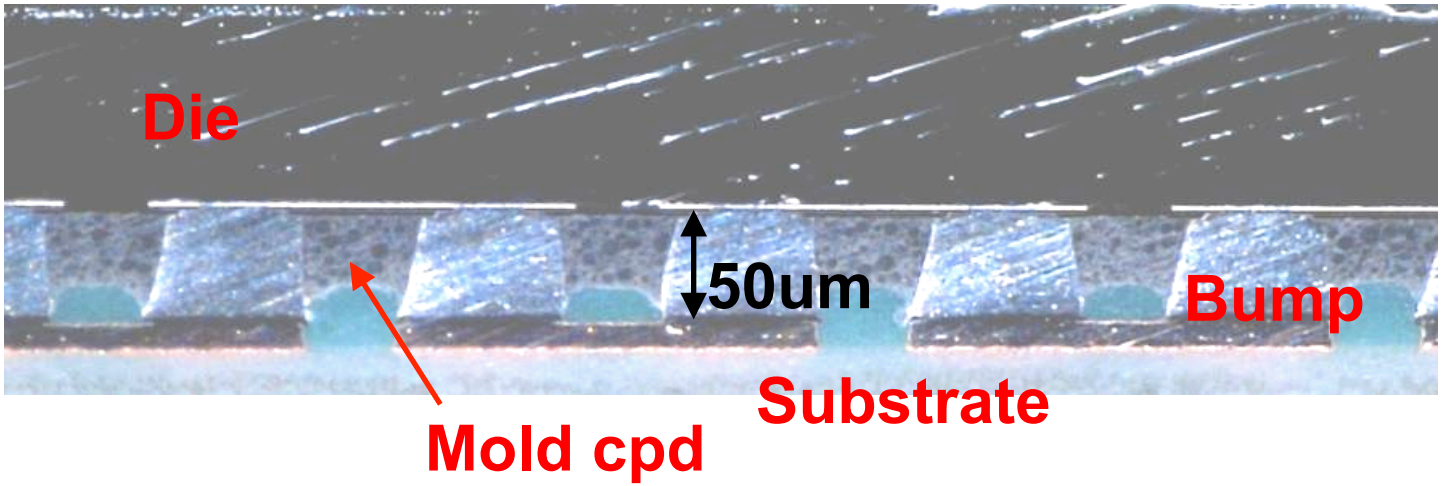
CEL-C-3730S Lower stress type

- **Lower warpage**
- **Better bump protection**

MUF (Mold underfill)



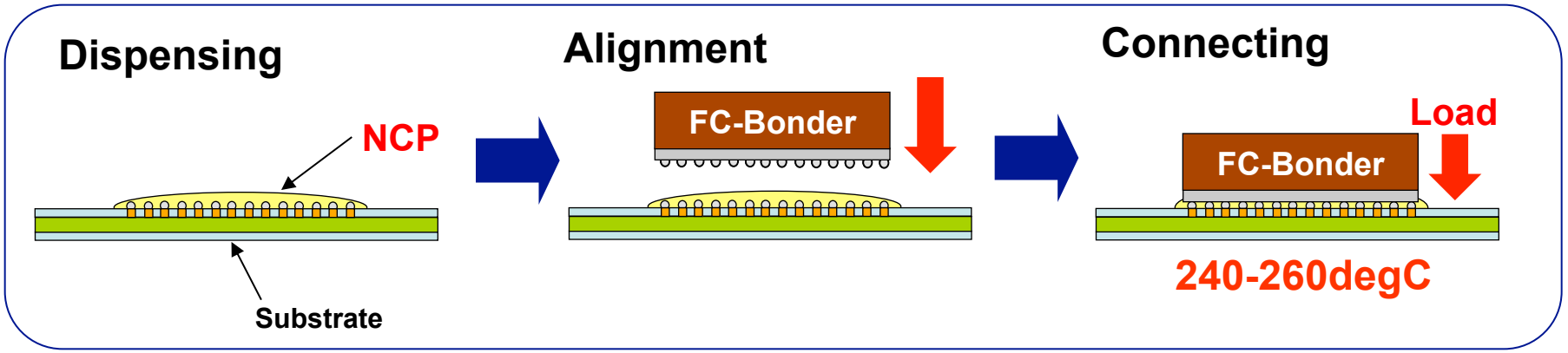
Overmold and underfill at the same time with transfer mold (exposed die is optional)

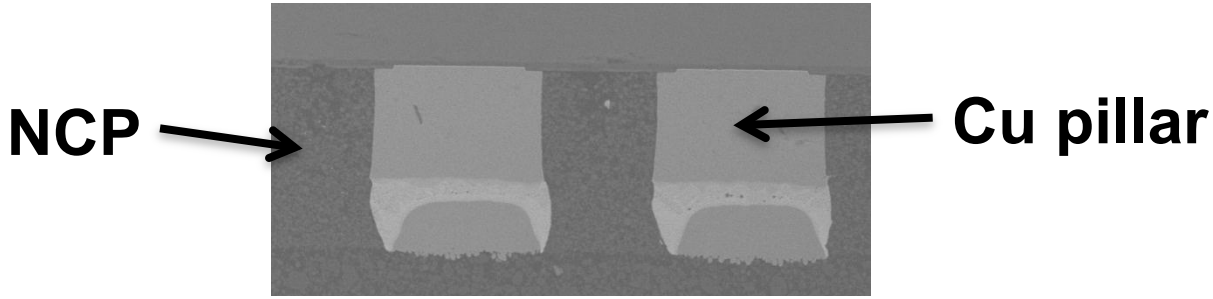


CEL-9700HF&ZHF/9740HF/1800HF series

- Good gap filling by filler top cut and average control
- Warpage control
- Lower material cost than CUF

NCP (Non Conductive Paste)

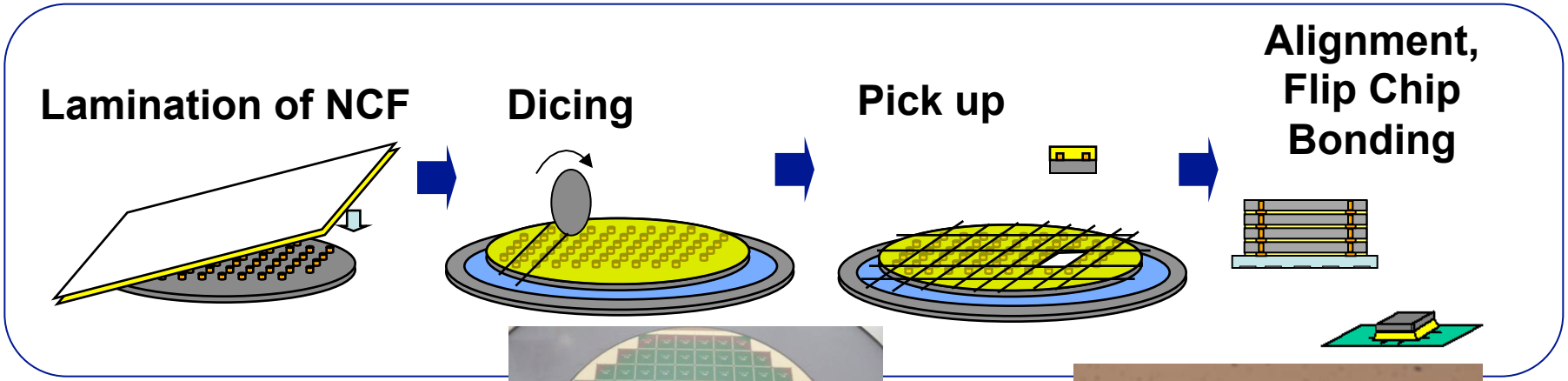


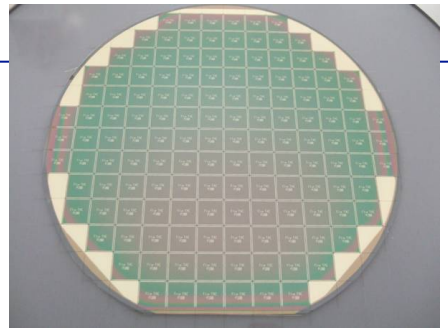


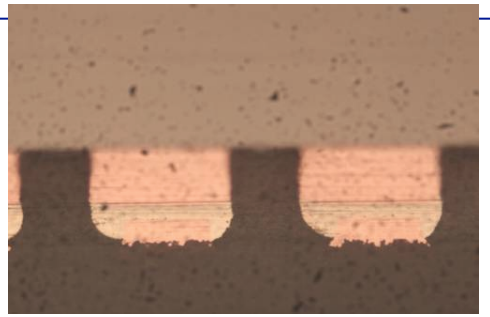
CEL-C-8200 series

- Applicable for finer pitch and narrower gap
- Lower stress caused by connection
- Applicable for Cu pillar and TSV

NCF (Non Conductive Film)



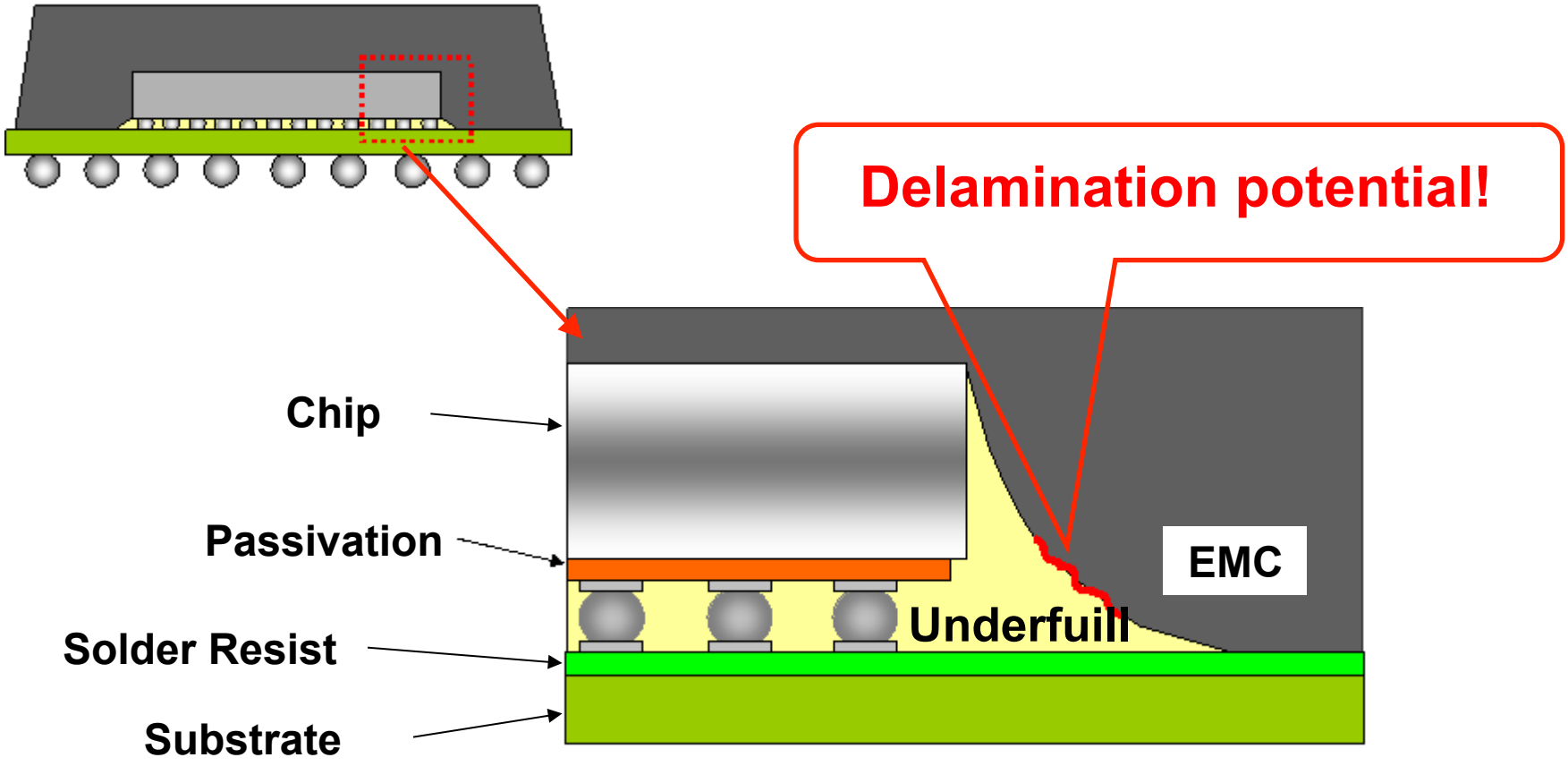




CEL-S-2000 series

- Applicable for finer pitch and narrower gap
- Lower stress caused by connection
- Applicable for Cu pillar and TSV
- Applicable for wafer base process
- Back grinding compatibility (optional)

Over molding



- Over molding is optional.
- Appropriate combination of underfill and over molding materials needs to be selected.

Contents

NCP process and requirements

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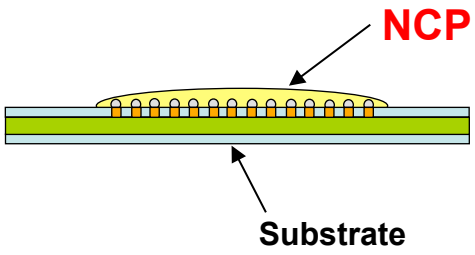
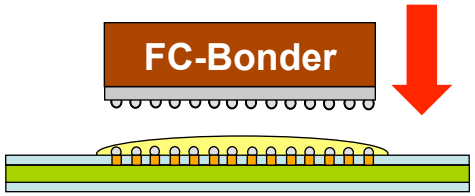
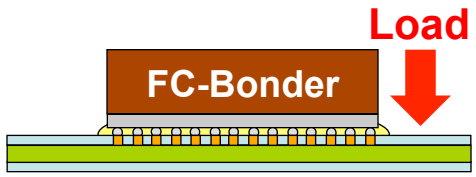
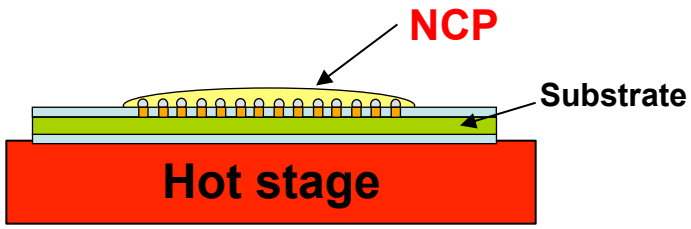
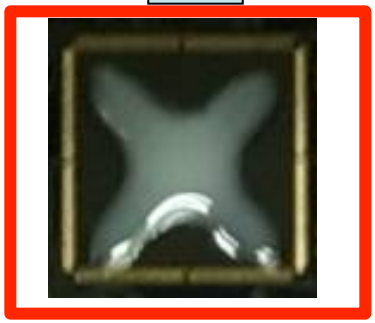
Process	Requirement	NCP Properties
Dispensing 	・Dispensability	・Viscosity ・Thixotropic index
Alignment 	・Wettability ・Voidless	・Viscosity ・Thixotropic index
Connecting  240-260degC	・Voidless ・Connectivity ・Curability	・Few volatile ・No trapping ・Gel Time

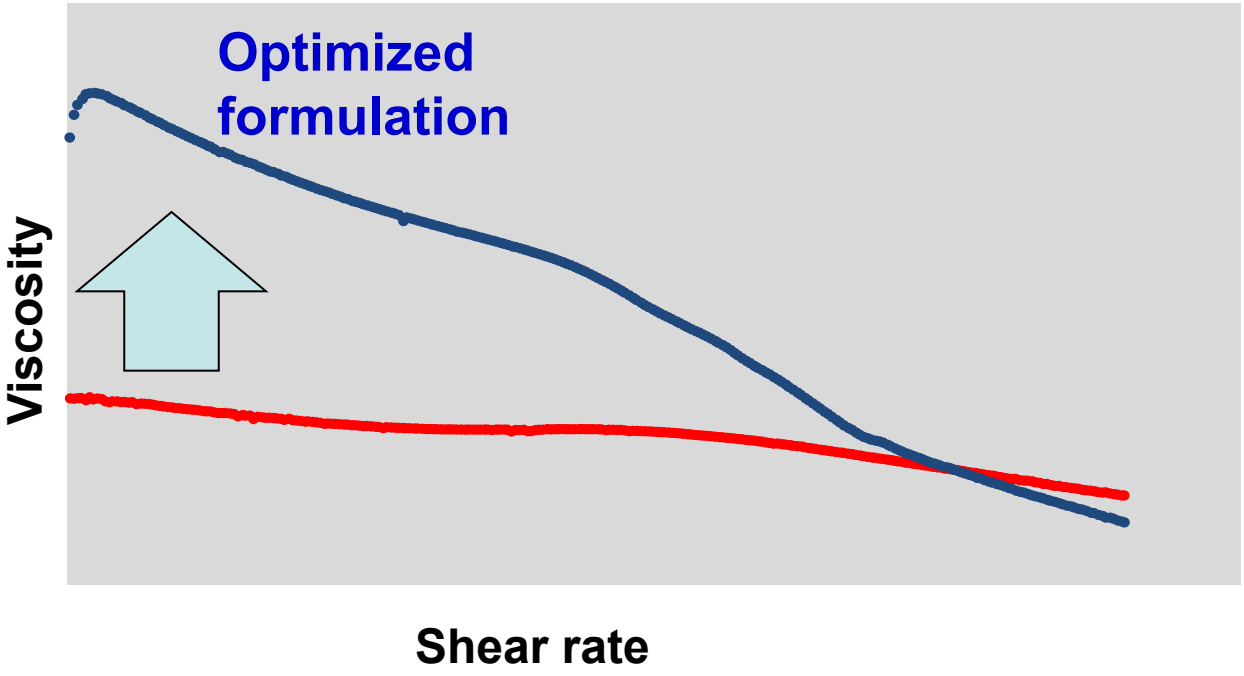
Shape retention



✓Good shape retention

✓Poor shape retention



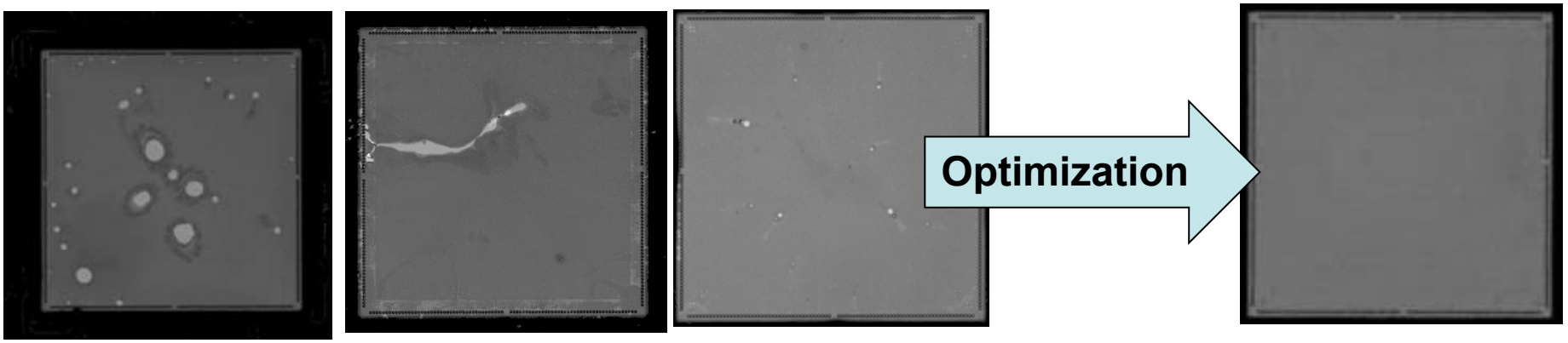


➢High thixotropy at hot stage temp is needed to have good shape retention

Voids

Source of voids

1.Outgas
2.Moisture
3.Trapped air



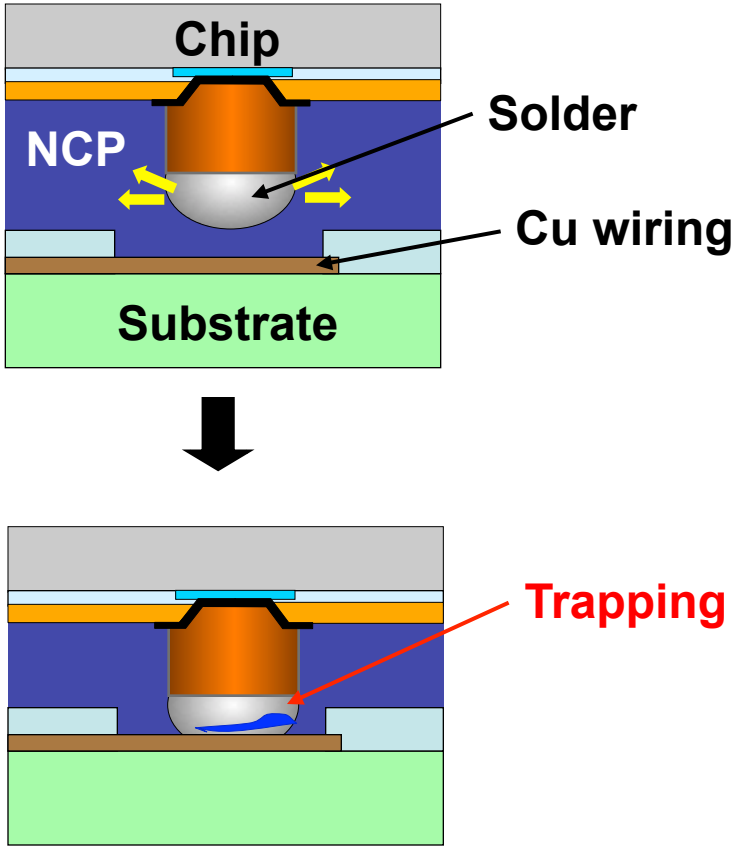
✓Different types of voids

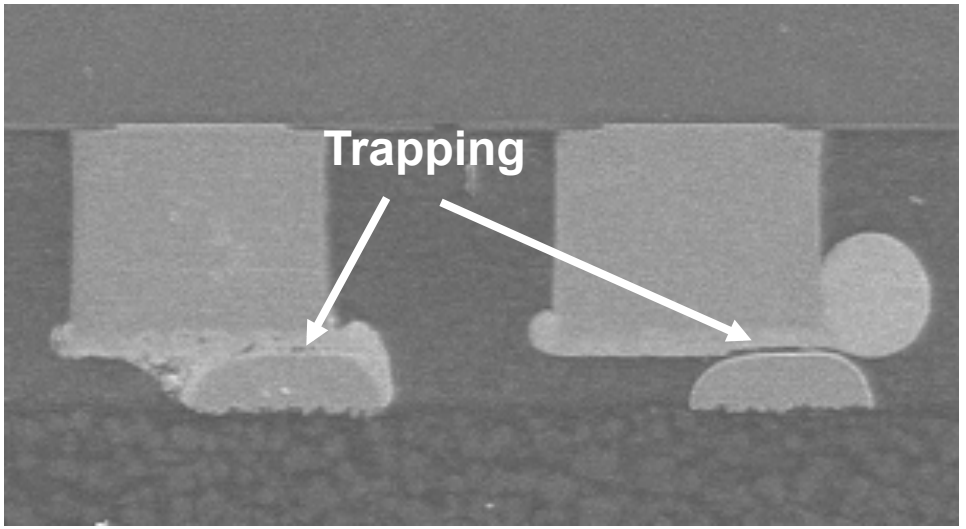
✓No voids

➢Formulation and process needs to be optimized to eliminate voids.

Connectivity and Trapping

Trapping mechanism

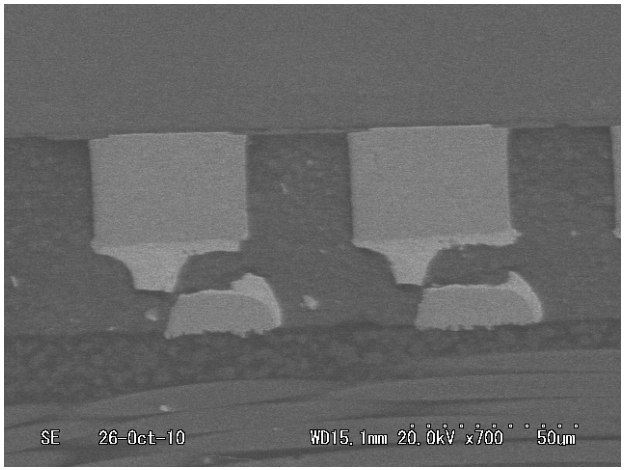




Trapping consists of silica mainly.

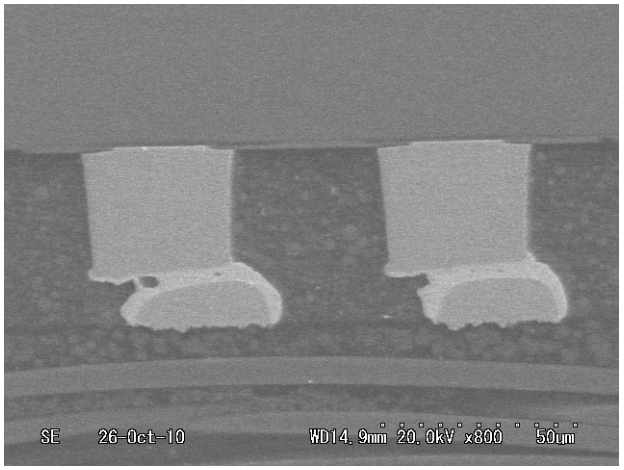
Connectivity and Trapping

➢Standard CUF



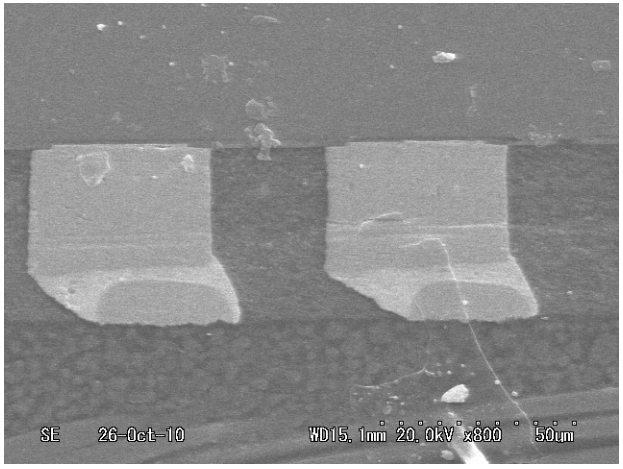
✓No connectivity due to poor fluxing capability

➢Old NCP Formulation



✓Poor connectivity and trapping

➢Optimized NCP Formulation

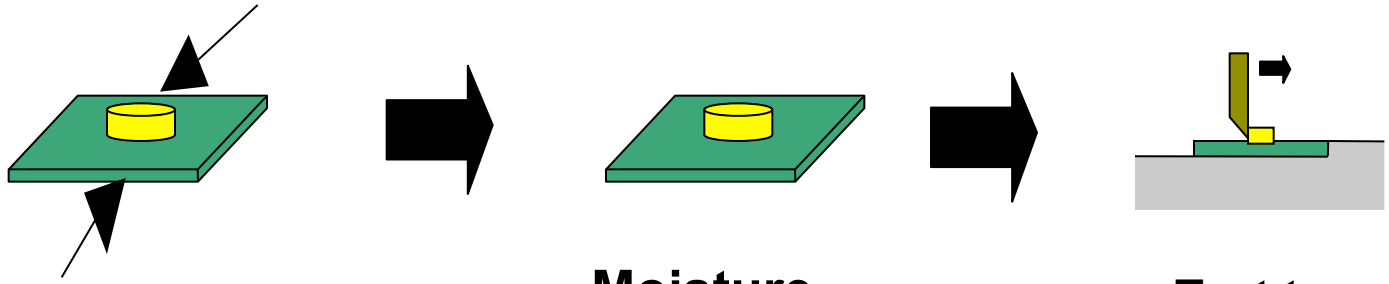


✓Good connectivity and no trapping

➢Formulation selection improved connectivity without trapping thanks to good fluxing capability.

Shear strength test method

- CEL-C-8200-L15(NCP)
- CEL-C-3730S(CUF)



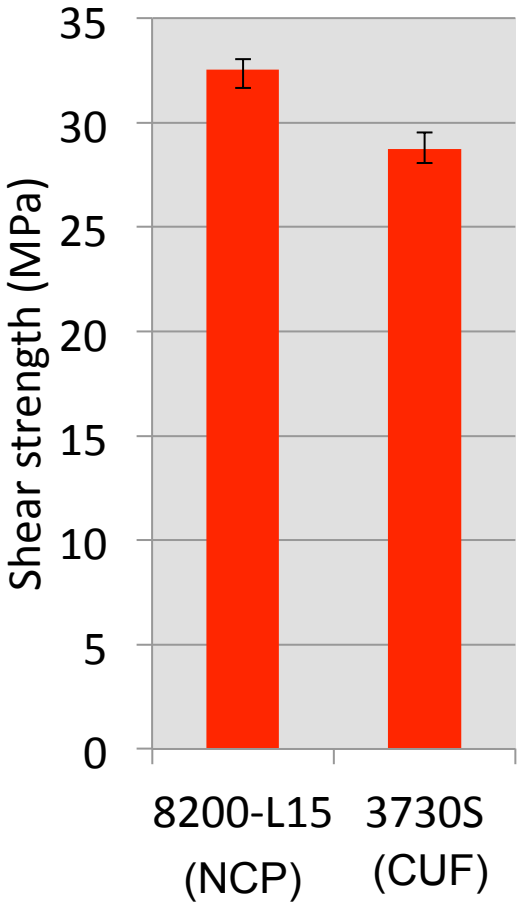
Adherend
: Polyimide (HD-4104)
or SiO2
or SiN

Moisture absorption
: Precond L3

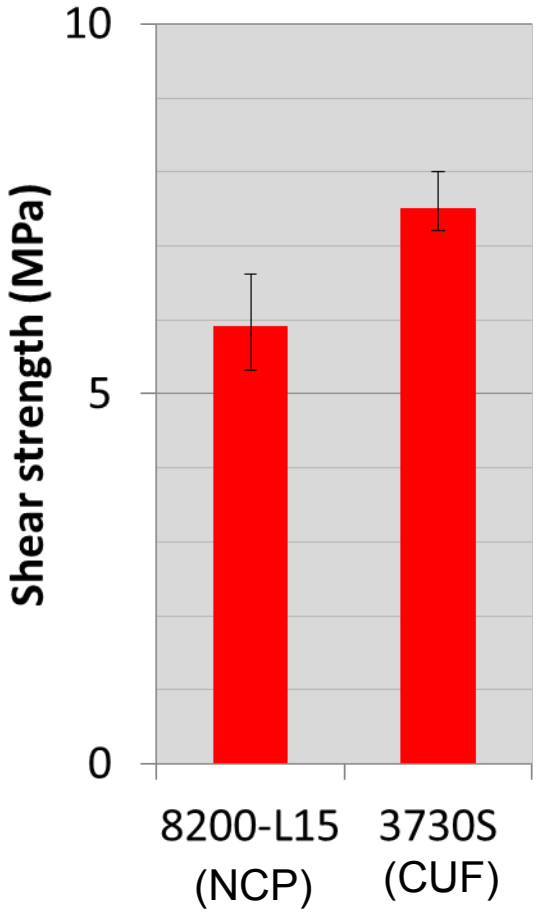
Test temp.
: 25degC

Shear strength

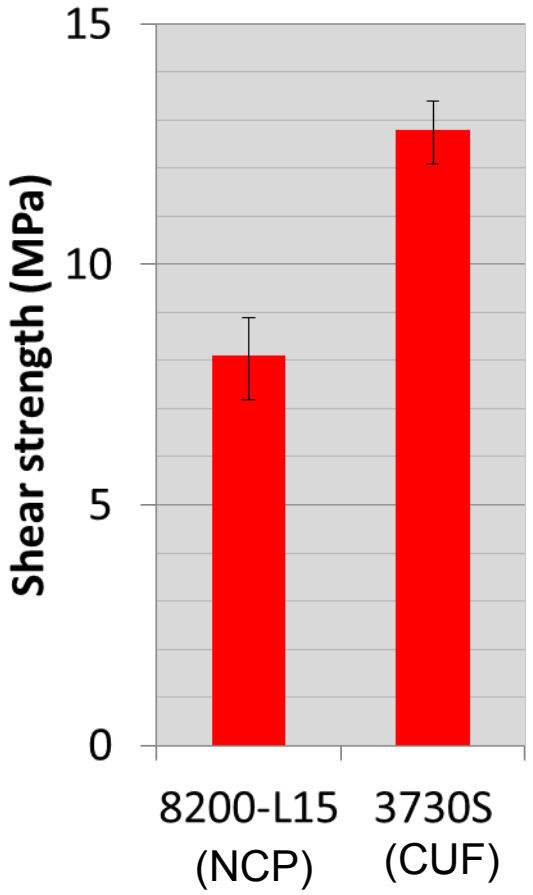
Adherend=PI



Adherend=SiO2



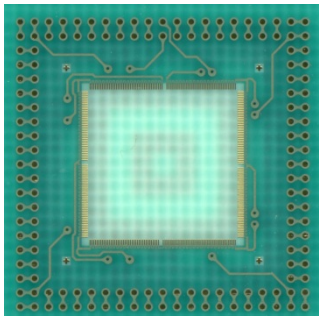
Adherend=SiN



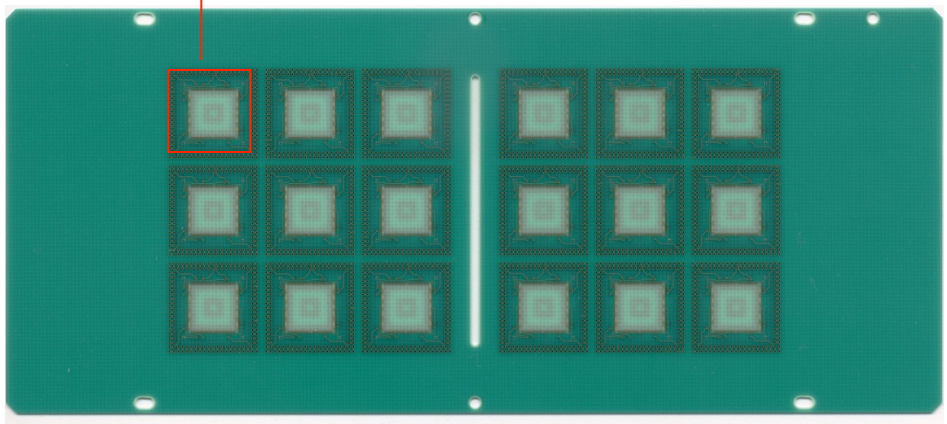
➢**CEL-C-8200-L15 showed good adhesion to PI, SiO2 and SiN.**

Specification Substrate & Die

Specification of Substrate

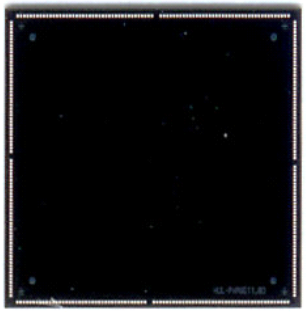


- Size : 14 x 14mm
- Thickness : 300um
- Core material
  : E-679FG
- Solder resist
  : SR7200G(10-15um)
- Bump materials
  : Cu + Ni(5.0um)
  +Pd(0.3um) +Au(0.35um)

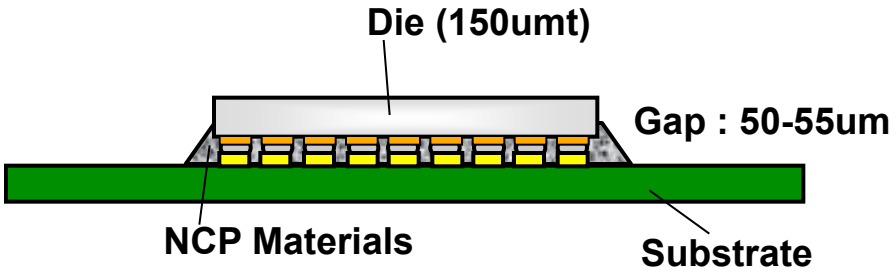


- Substrate Size : 60mmx140mm
- 9pcs(3X3pcs)x 2blocks

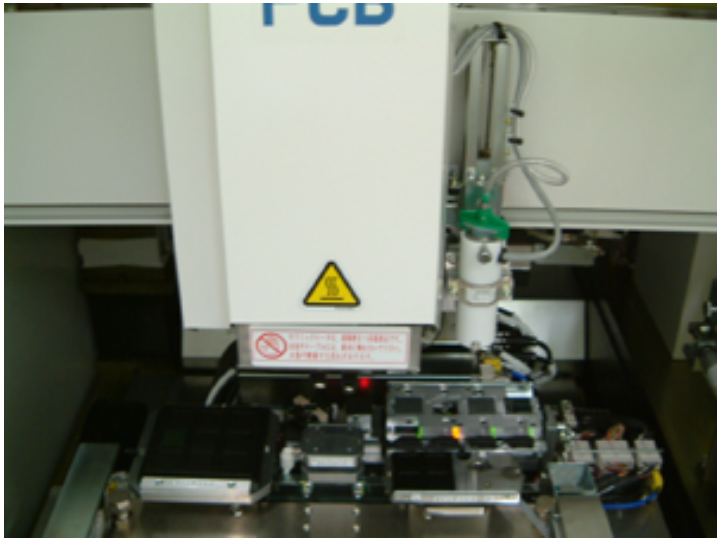
Specification of Die



- Size : 7.3mm x 7.3mm
- Thickness : 150um
- Bump materials
  : Cu Pillar(30um)
  + SnAg(15um)
- Bump pitch : 80um
- Number of pad
  : 328 (82 x 4 lines)
- Passivation layer : Si3N4



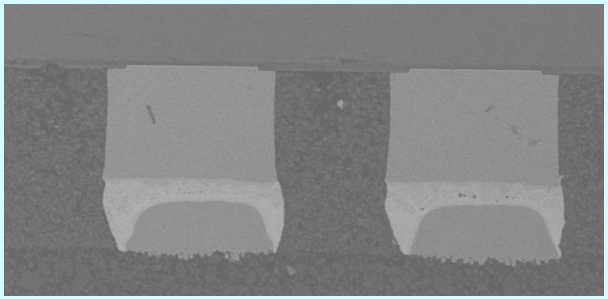
Flip Chip Bonder

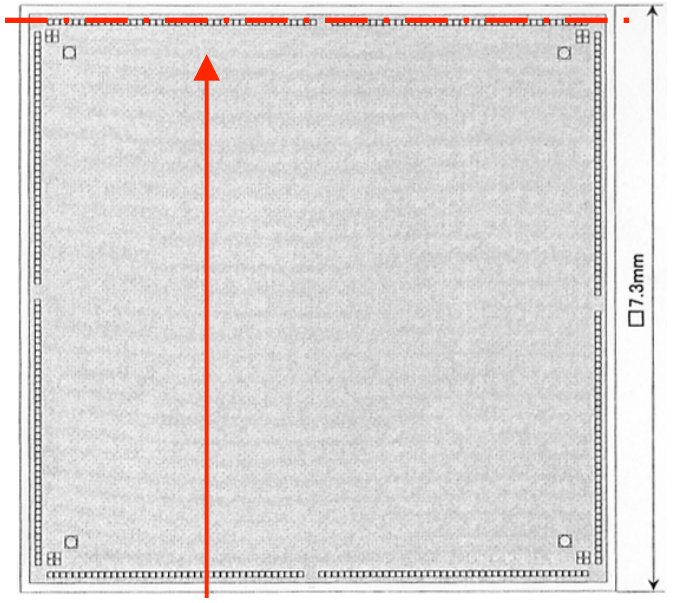


Flip Chip Bonder Specification

Item	Specification
Substrate Size (mm)	100mm×100mm max
Die Size (mm)	3mm～20mm
Accuracy	±3um/3σ
Load	5N～490N
Temperature	Max 500degC
Die supply	□2“、☐4” Tray

Bonding results

Items	CEL-C-8200-L15
C-SAM	
	No void
Connectivity	Good
Trapping	



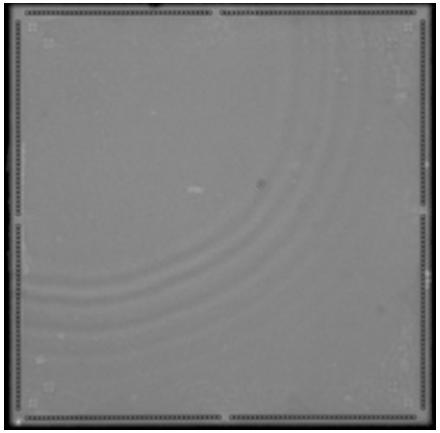
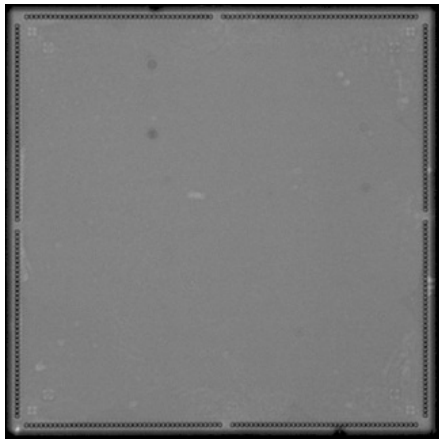
Observation Point
82 bump / Polishing Line

No trapping and Good interconnection!

Reliability evaluation results

Items	Test condition	CEL-C-8200-L15
MSL	Level 3 (30degC / 60%RH / 192h) IRR 260degC x 5 times	Pass
TCT	Condition B (-55degC ⇔ 125degC) (air to air each 15min)	1000cyc
HAST (unbiased)	135degC / 85%RH	200h
HAST (with bias)	135degC / 85%RH / 1.3V	200h

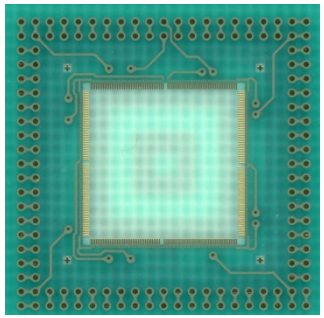
Reliability evaluation results

Item	SAM
Time 0	
After MSL	

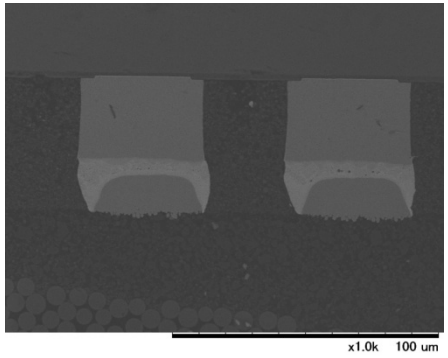
➢C-8200-L15 showed good performance of MSL.

Influence of pad finish

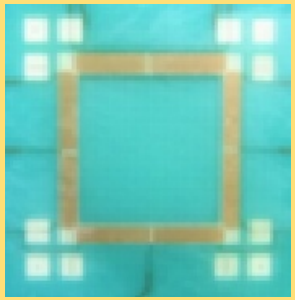
➢Cu/Ni/Pd/Au



✓Good connection



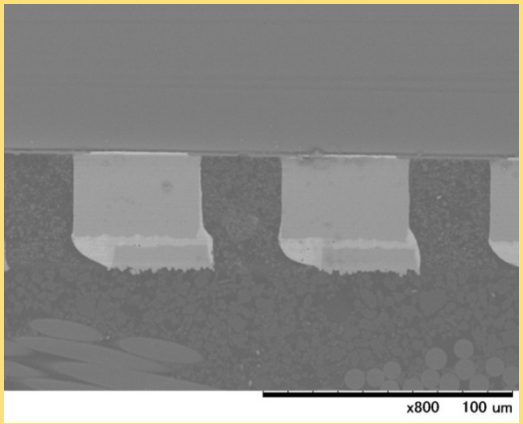
➢Cu-OSP (Cu-Organic Solderability Preservative)



✓Worse connection

Optimization

✓Good connection



➢Cu-OSP is more difficult to have good connection

➢CEL-C- 8200-L15 showed good connection even with Cu-OSP

Contents

Summary

1. MSS (Material System Solution) would be needed to meet requirements of challenging advanced packages.
2. NCP (Non Conductive Paste) could be potential solution for fine pitch and 28nm device at Flip chip and TSV packages.
3. Hitachi Chemical developed NCP material, CEL-C-8200-L15 with good shape retention, good underfilling and good connectivity.
4. Cu-OSP is more difficult to have better connection.