The Future is Precious. TANAKA

Hybrid sintering dieattach material with printing process for power semiconductor

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Ag Adhesive Material R&D sec.

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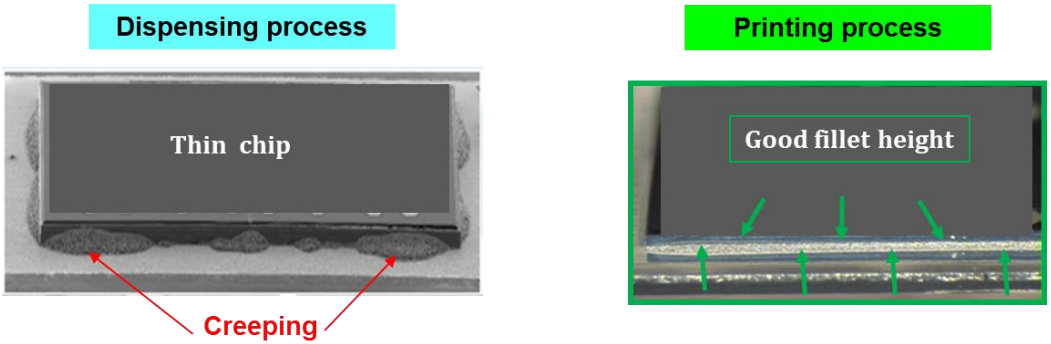
Motivation for hybrid sintering with robust process

■Motivation



Recently power package size is getting smaller and large capacity. Required dieattach characteristic material is higher thermal conductivity, reliability and suitable assemble process.

Tanaka has been developing hybrid sintering material for solder alternative, RF device and so on. For instance, it is facing issue fillet height for thinner die using conventional die attach process .Tanaka is working out to resolve glue creeping issue using improved version of TS9854 and new material formulation. However, chip thickness with hybrid sintering paste is a big challenge for the workability. Tanaka introduce dispensable and printable hybrid sintering paste.

■Objective

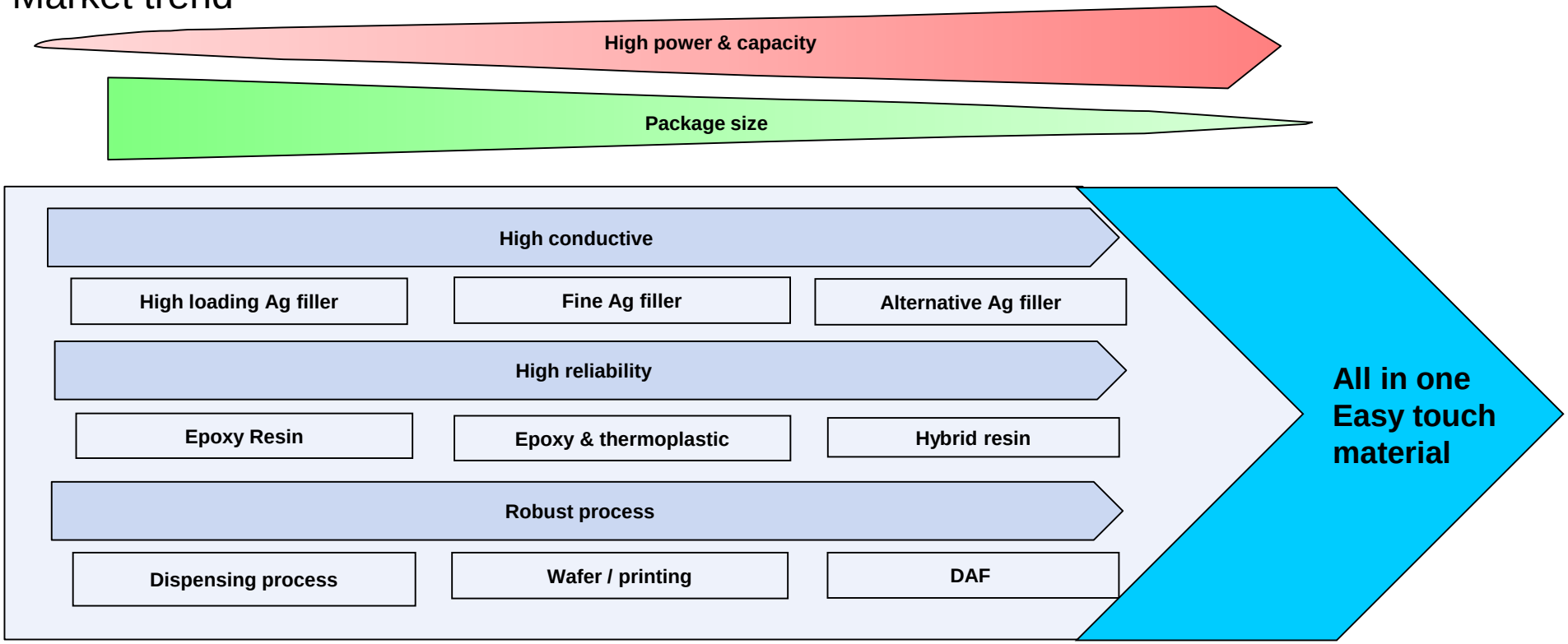
-To assess TS9854 hybrid sintering process characteristic and high reliability.
-To judge whether TS9854 workable dispensing process and printing in house criteria.
-To propose hybrid sintering dieattach material with good performance and robust process.

■Approach

-To design and formulate silver fine filler, resin system and solvent for hybrid sinter material.
-To evaluate die shear value, thermal conductivity, volume resistivity and physical reliability.
-To check dispensability and printability with DA process for our device in house data.

High thermal conductive die attach material

Market trend

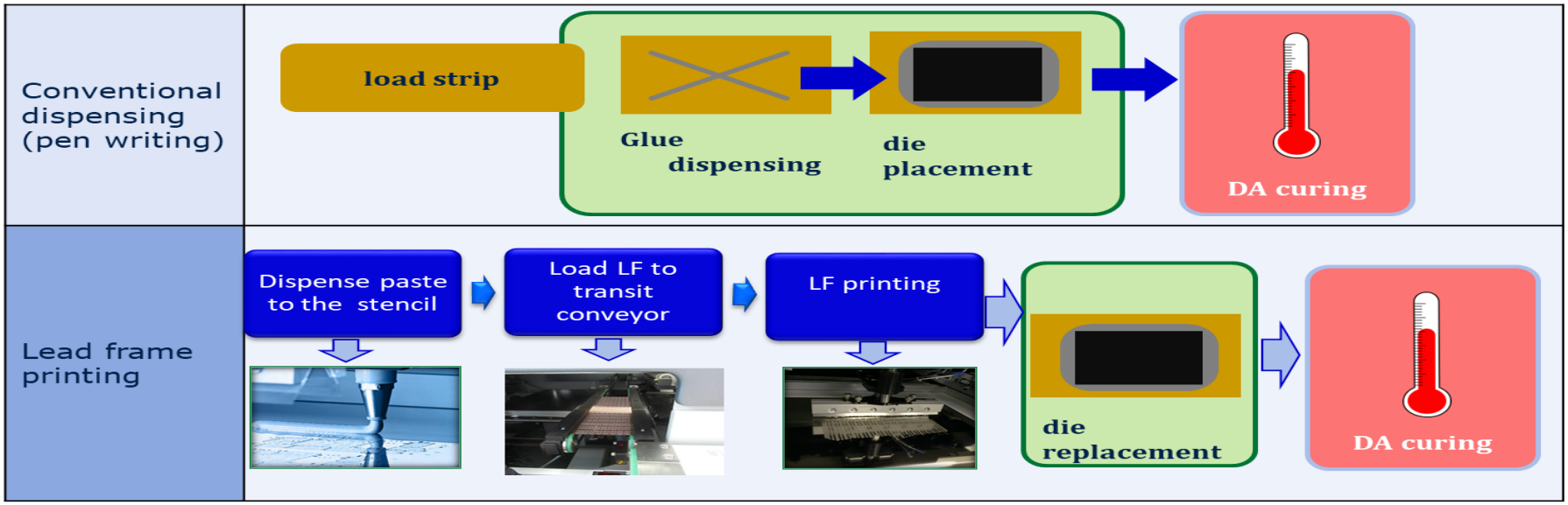


-Thermal conductivity control Ag powder loading, size and shape.

-High reliability is contributed by resin system and metal bonding.

-Customized all process by resin system, suitable Ag filler and solvent.

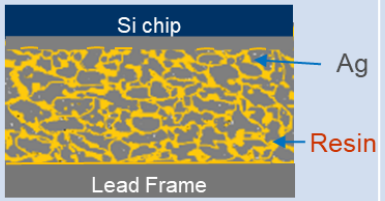
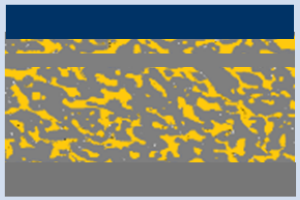
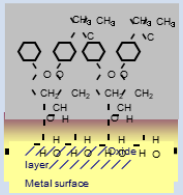
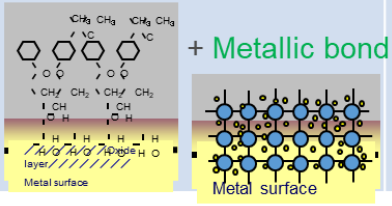
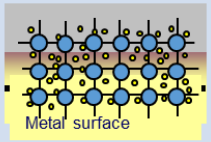
Die attach process technology



■Die attach process for thin wafer

	Glue Dispensing	Wafer Printing	LF Printing	DAF
Process	▪ Dispensing⇒DA⇒Cure	▪ Printing⇒Cure⇒laminate⇒ Dicing⇒DA⇒Cure	▪ Printing⇒DA⇒Cure	▪ Laminate⇒Dicing⇒DA ⇒Cure
Advantage	▪ Accessible for all type of chip size ▪ Easy to convert /set-up for different package. ▪ transfer multiple die size substrate ▪ Easy process	▪ Uniformly of fillet height ▪ Consistency in BLT/TILT Better thermal and electrical properties than dispensing ▪ No creeping ▪ Controlled BLT & fillet ▪ No bleed	▪ Can run for <60um wafer thickness ▪ Better processability than dispensing for thinner die. ▪ No fillet height ▪ Controlled BLT & fillet ▪ Easy process	▪ No filler height ▪ Controlled BLT & fillet ▪ No bleed
thickness	▪ Above 100um	▪ >60um	▪ >60um	▪ >60um
Challenge	▪ Filler height ▪ Bleed out ▪ Tack time ▪ Die tilt ▪ Insufficient coverage	▪ Less wetting to LF back side ▪ Compatible dicing tape ▪ Flying die ▪ Process interaction	▪ Special tool per die size ▪ Bleed ▪ Tack time ▪ Not B-staged ▪ chip to pad clearance	▪ Supply roll material ▪ Process interaction

Concept hybrid sintering dieattach material

	Ag-adhesive	Hybrid Ag-adhesive	Pure sinter -Ag
Feature	・Low modulus ・Good adhesion to bare Si chip	・**High thermal conductivity** ・**High Hot-DSS**	・High thermal conductivity ・High Hot-DSS
Image			
Resin type	Epoxy, etc.	Epoxy	
Conductive path	Contact of Ag powder	Sintering of Ag powder	Sintering of Ag powder
Thermal conductivity	＜50W/mK	50~170W/mk	＞150W/mK
Adhesion mechanism	Resin adhesion 	Resin adhesion 	Metallic bond 

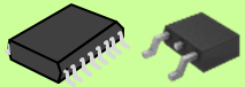
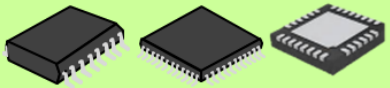
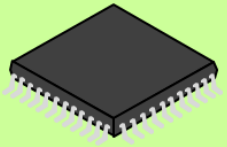
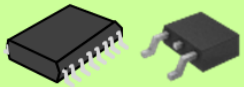
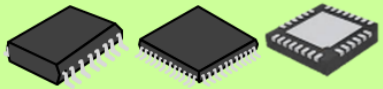
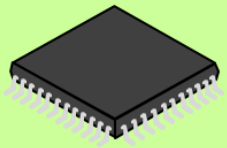
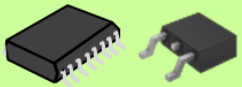
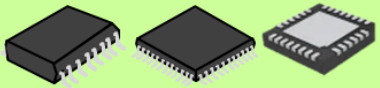
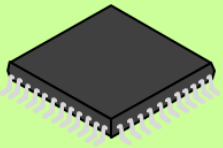
■Characteristic

-Good adhesion on Ag, Au and Cu.
-Good reliability TC2000 no delami 1mmx1mm to10mmx10mm
-High thermal conductivity > 100W / m.k
-Lower resistivity

■Process

-Dispensable and Printable
-Pressure less
-No bleed out
-void less
-N2 and Air curable < 250 degC

Targeting package & application

Chip	LF	< □ 3x3mm For Small Chip	3x3mm~5x5mm For Middle Chip	< 10x10mm For Large Chip
Chip BSM Ni/Ag or Ni/Au	Ag	 SOP/HSOP/TO/TSSOP	 SOP/QFP/QFN	 LQFP
	PPF	 SOP/HSOP/TO/TSSOP	 SOP/QFP/QFN	 LQFP
	Cu	 SOP/HSOP/TO/TSSOP	 SOP/QFP/QFN	 LQFP

■Application

-Automotive
-LED
-RF device

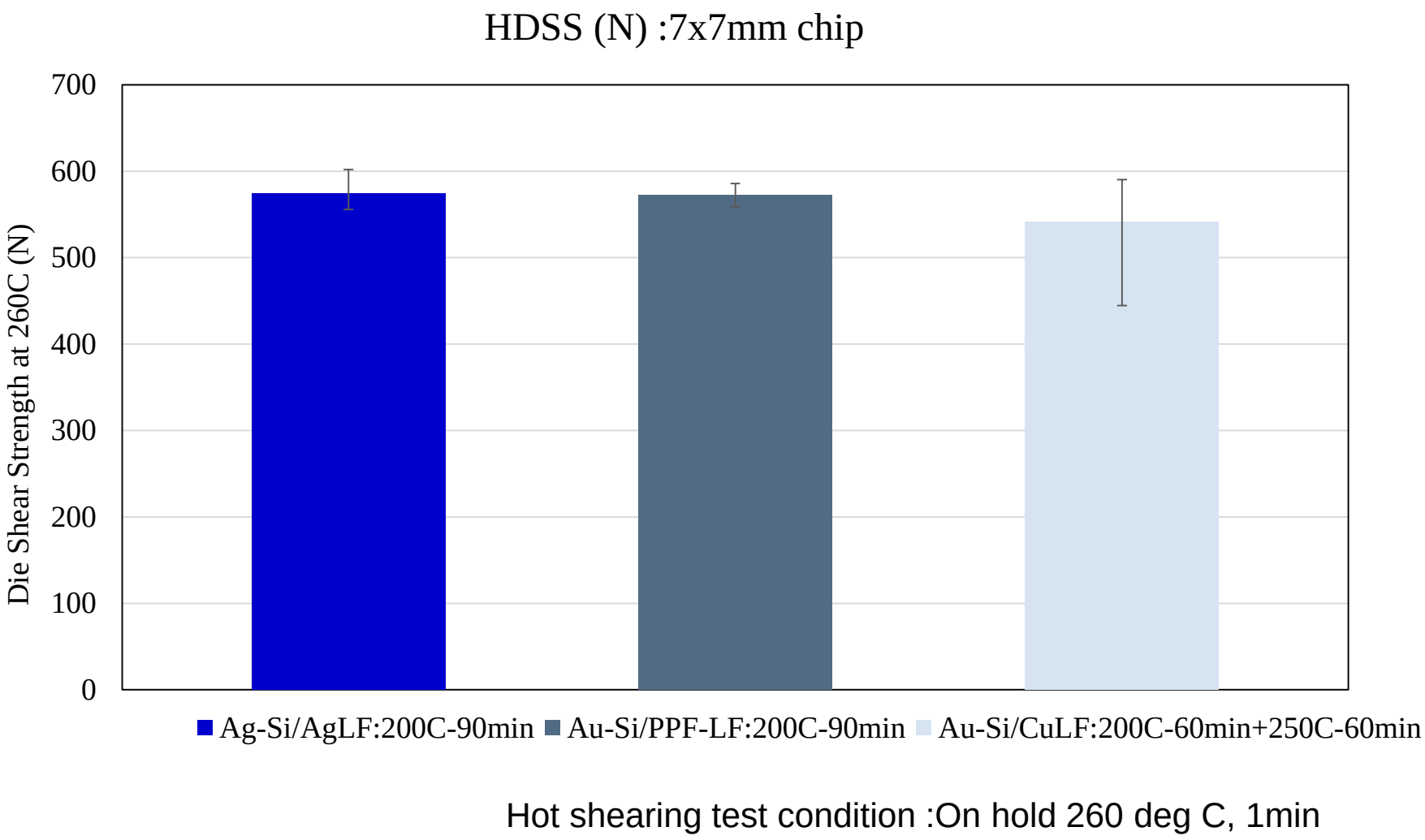
Properties of printable hybrid sintering TS9854

Confidential

		TS-9854	*
Feature		➢ High Thermal Conductivity ➢ Good Adhesion to bare Cu LF ➢ Printable/ Dispensable	
Storage Condition		below -40℃ in freezer	
Ag Content		88 wt%	Calculated after 850 ℃ firing
Viscosity		25 Pa.s	E-type 3° corn, 5rpm @ RT
Thixotropic Index		8	0.5rpm/5rpm
Volume Resistivity		10.0 x 10^{-6} Ω·cm	Resistivity meter
Die Shear Strength	at RT	40 N/mm^2	2x2mm Si-die (BSM:Ag) / Ag plated LF
	at 260℃	15 N/mm^2	
Elastic Modulus	at RT	15,000 MPa	Measured by DMS
	at 260℃	5,400 MPa	
Coefficient of Thermal Expansion	α1	28 ppm/℃	Measured by TMA
	α2	28 ppm/℃	
Tg		-	
Thermal Conductivity		120 W/m·K	Measured by Laser flush

*Representative value

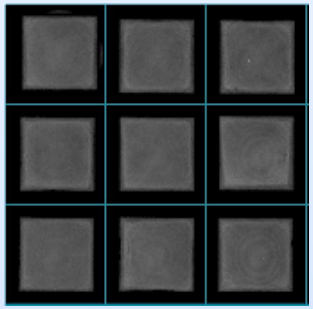
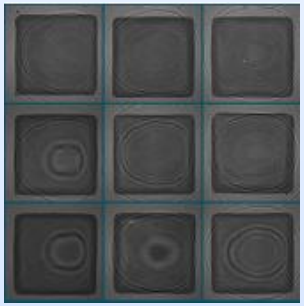
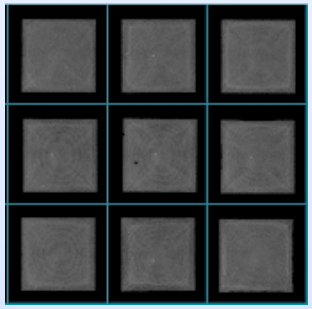
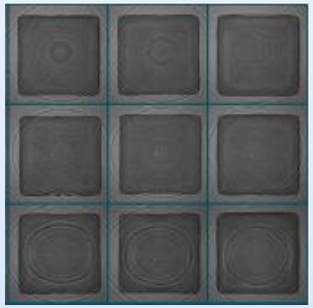
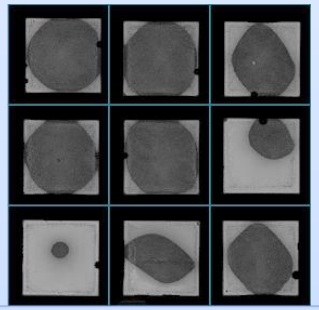
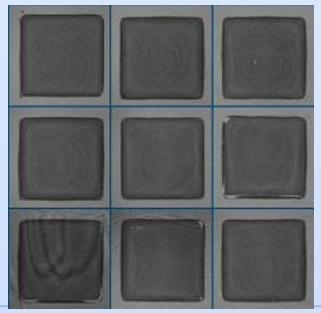
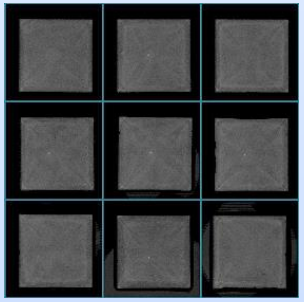
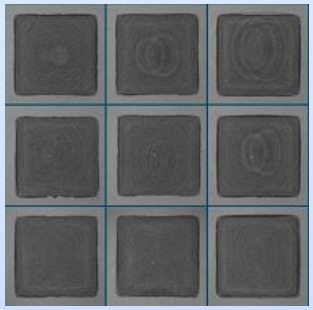
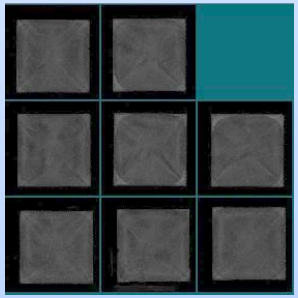
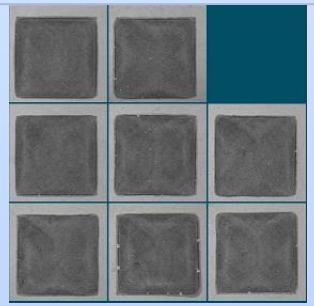
Hot shearing value results with BSM



Hot shearing test condition :On hold 260 deg C, 1min

Physical reliability test by SAT

■7x7mm Au sputtered chip/Cu LF

TC	Before improvement		TS-9854	
	Chip side	LF side	Chip side	LF side
0x				
1000x				
2000x	No data (Delamination)	No data (Delamination)		

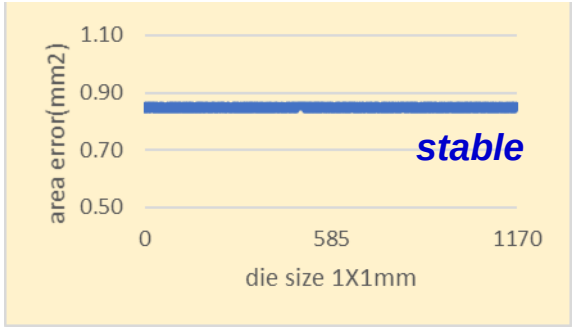
Cure profile: 200C-60min +250C-90min in N_2 (O_2: 80ppm)
TCT condition: -50⇔150℃ each 30min
SAT: Probe 140MHz (C-Scan)

Dispensability procedure for hybrid sintering

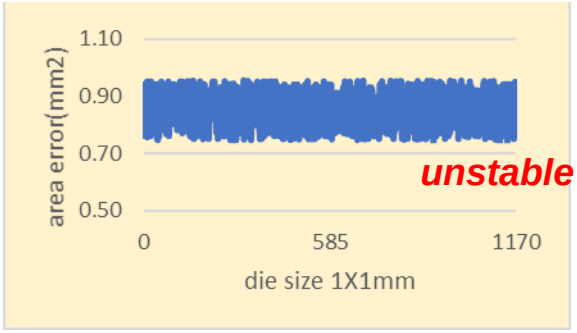
30g/10cc syringe

Pattern shape

Good dispensability



Bad dispensability



Standard deviation σ

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

n = The number of data points

$\bar{x}$ = The mean of the x_i

x_i = Each of the values of the data

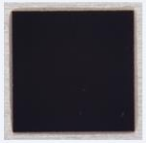
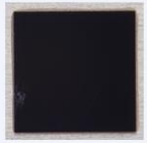
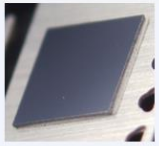
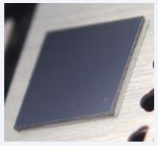
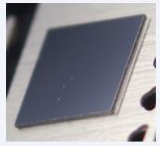
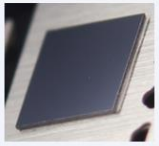
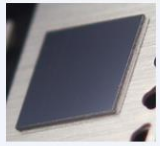
Coefficient of variation C.V.

C.V.= σ/average

Comparing the standard deviation of the shape area to.get the variation of the two LF data.

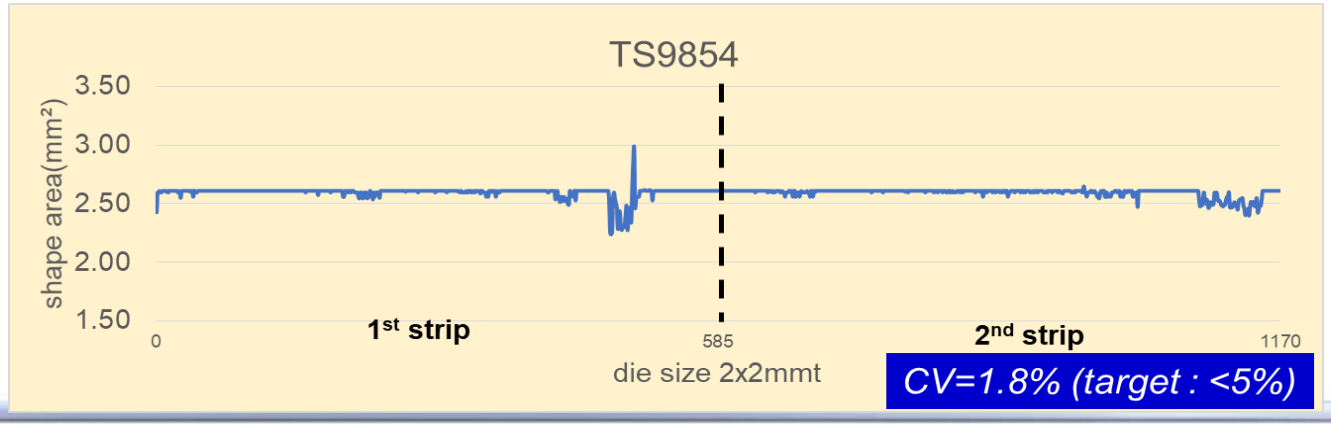
Target of Dispensability:
CV=<5%

DA output response with dispensing process

location	A45	A36	A27	A18	A9	M1
paste						
Top view						
coverage	100%	100%	100%	100%	100%	100%
						
Fillet height	30%	30%	50%	30%	30%	40%
BLT(um)	31.3	30.7	31.0	31.3	30.8	30.6
TILT(um)	3.8	4.0	5.0	4.7	4.7	3.7
Die placement(um)	4	4	4	5	3	4

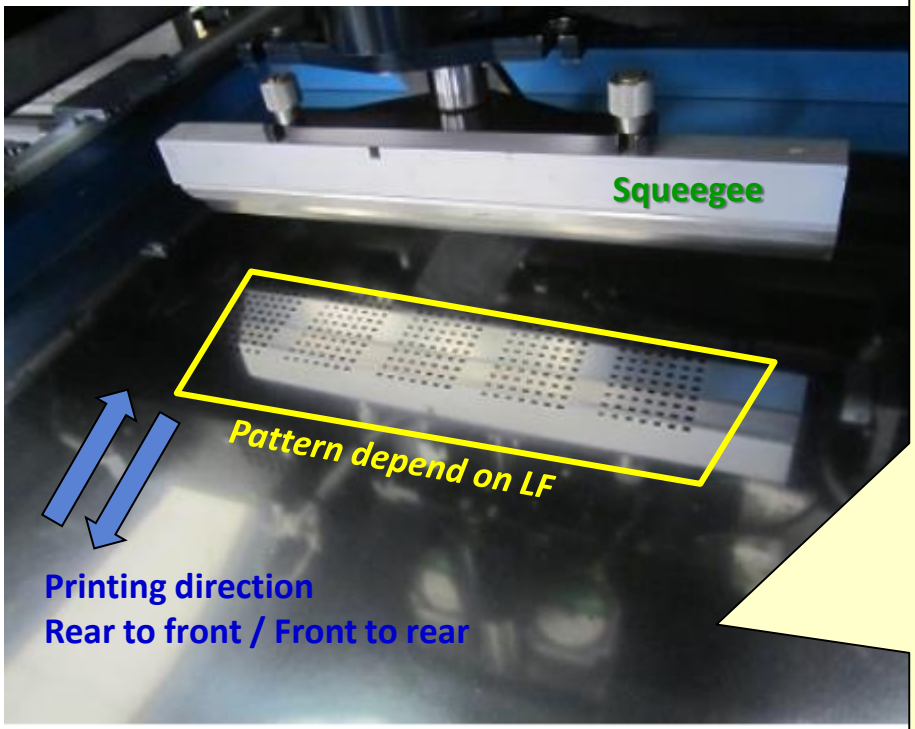
(die size: 2x2mm 75um thickness)

Target : BLT **15-35**um, Tilt <20um, FH <75%, Coverage 100%

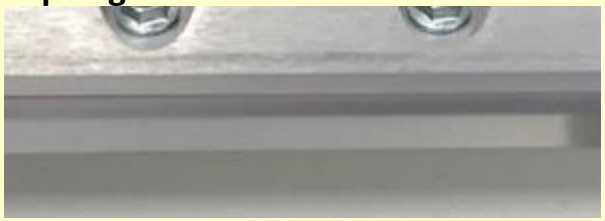


Printing tooling & parameter for thinner die

Printing process	2D printing
Sample	TS-9854
Stencil mask	thickness 50μm, designed by TANAKA
Printing force	5kg
Printing speed	15mm/sec



Squeegee

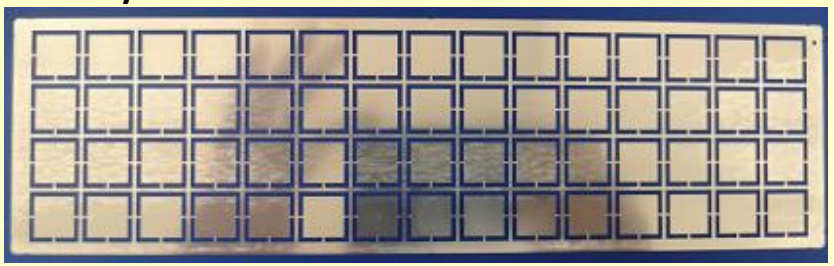


Stencil mask designed by TANAKA

Si dummy die

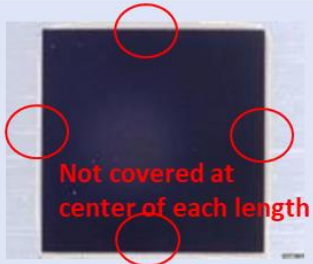
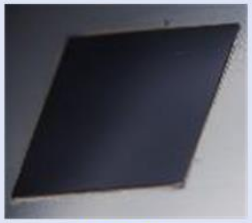
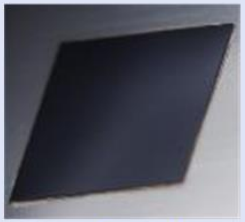
4x4mm
60um thickness

Dummy Leadframe



DA output response with printing process

Chip size 4x4mm 60um thickness

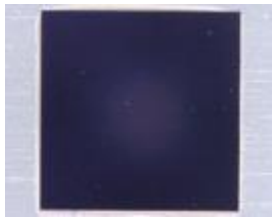
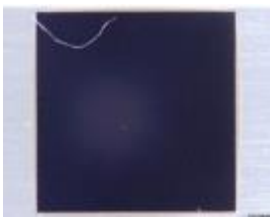
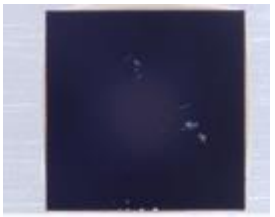
sample	TS-9854			
Design	SH05	SH06	SH07	SQ08
After printing				
DA top view **(Coverage%)**	 (100%)	 (100%)	 (95%)	 (100%)
DA corner view **(Fillet height%)**	 (50%)	 (50%)	 (60%)	 (70%)
BLT (dry)	31.5	30.6	30.8	35.6
Tilt (dry)	4.3	4	9.3	6.3

Design of SH05,06 & SQ08 (X, Y=102%) shows coverage 100% and fillet height <70% .

Tack time evaluation result with printing process

Chip size 4x4mm 60um thickness

Same DA parameters were used during 0-6hr tack time evaluation

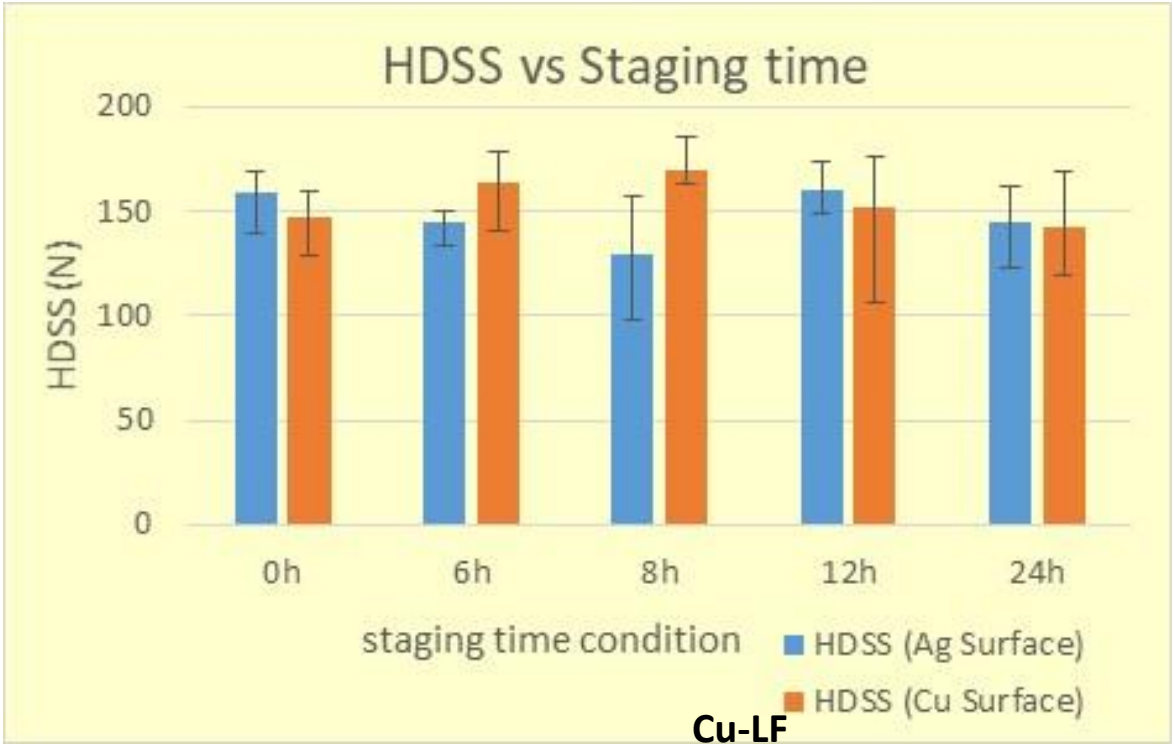
Design: SH05		TS-9854			
Tack-time		0hr	2hr	4hr	6hr
Upper view					
Coverage		100%	100%	100%	100%
BLT (wet)		35.3um	34.8um	34.7um	36.6um
Tilt (wet)		6.0um	4.3um	4.0um	5.8um
BLT (dry)		27.3um	28.9um	28.1um	31.3um
Tilt (dry)		8.9um	6.5um	7.2um	10.9um
Fillet height	A	<50%	<50%	<50%	<50%
	B	<50%	<50%	<50%	<50%
	C	<50%	<50%	<50%	<50%
	D	<50%	<50%	<50%	<50%

Between 0 and 6 hours BLT and TILT are stable and coverage (100%) & F/H(<75%) have also achieved their targets.

Target : BLT 20-40um, Tilt <20um, FH <75%, Coverage 100%

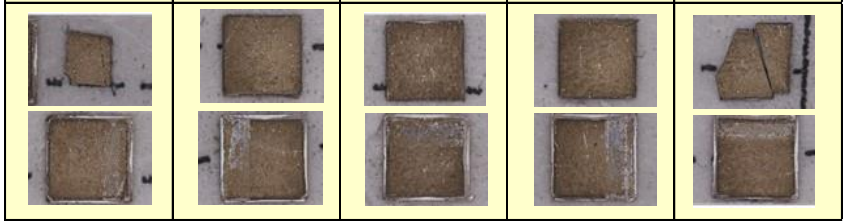
Staging time evaluation with printing process

Chip size 4x4mm 60um thickness



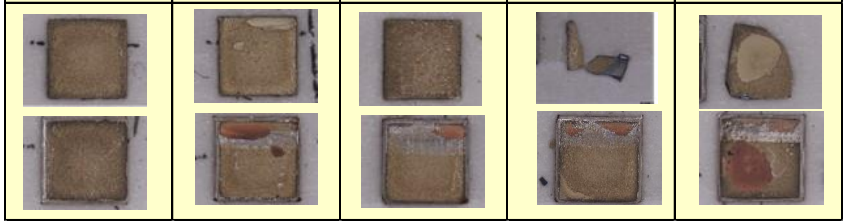
Ag-LF

0h	6h	8h	12h	24h
158	**145**	**130**	**160**	**144**



Cu-LF

0h	6h	8h	12h	24h
147	**164**	**169**	**151**	**142**



HTDSS value is stable from 0hr to 24hrs staging on both LF.
However failure mode with Cu LF at 24hr staging shows Cu interfacial failure.

Void observation with staging time

Chip size 4x4mm 60um thickness

No.	Check Items	Target	Staging time					
			0hr	6hr	8hr	12hr	(24hr)	Result
1	X-ray image	-						-
	Void ratio	<5%	<1%	<1.2%	<1%	<1.4%	<3.5%	Passed
2	Void observation (by SEM)	No variation	No variation				-	Passed
3	Delamination check (by SEM)	No delamination	No delamination				-	Passed
4	Hot-DSS (by DSS)	Within 20% change to 0hr DSS	-	<10%	<10%	<10%	(<10%)	Passed
5	Failure mode (by Microscope)	Cohesion	Cohesion				(CuLF)	Passed

Check items for staging time are all passed against our target.
TS-9854 can be achieved 12hr of staging time.

Printable hybrid sintering results

Paste type		TANAKA target	TS-9854
DSS with bare CuLF		>30MPa	45
HDSS with bare CuLF		>15MPa	20
Failure Mode with CuLF		Cohesion	Cohesion
Printability		Even	almost even
		No tailing	no tailing
		No smearing	no smearing
(wet)DA	BLT	20-40um(Dry)	30 μm (dry)
	Tilt	<20um	<10μm
	Coverage	100%	100%
	Fillet height	<75%	<75%
	Tack time	>2hr	6 hours
	Staging time	> 4hr	12hr
	Void	Single 5% Cum. 10%	Less than 1%
	Bleed out	<200 um	no bleed out

Hybrid sintering paste TS9854 is printable in printing process with leadframe and 4mmX4mm die size. Coverage 100% and <75% of F/H can be achieved with 60um thickness wafer . Tack time can be achieved >6hr with TS-9854. Staging time can be achieved 12hr.

Tanaka propose thin wafer and high reliability for power package.

Hybrid sintering die attach material TS9854

-Hybrid sintering TS9854 is applicable dispensing process and printing process.
=>Commercialized product TS9854 use for automotive power device with thin die.

-Good reliability on back metallization chip 1mm to 10mm on Ag, PPF and Cu LF.
=>It is contributed by metal bonding and resin adhesion.

-TS9854 is printable various package.
=>Original designed printing mask & tooling for customer device.
=>It is adjusting suitable viscosity by solvent quantity.

-TS9854 is good manufacturability.
=>Longer tack time, staging time and void less by solvent type with formulation.

-Tanaka hybrid sintering can customize depend on requirement.

Thank you!