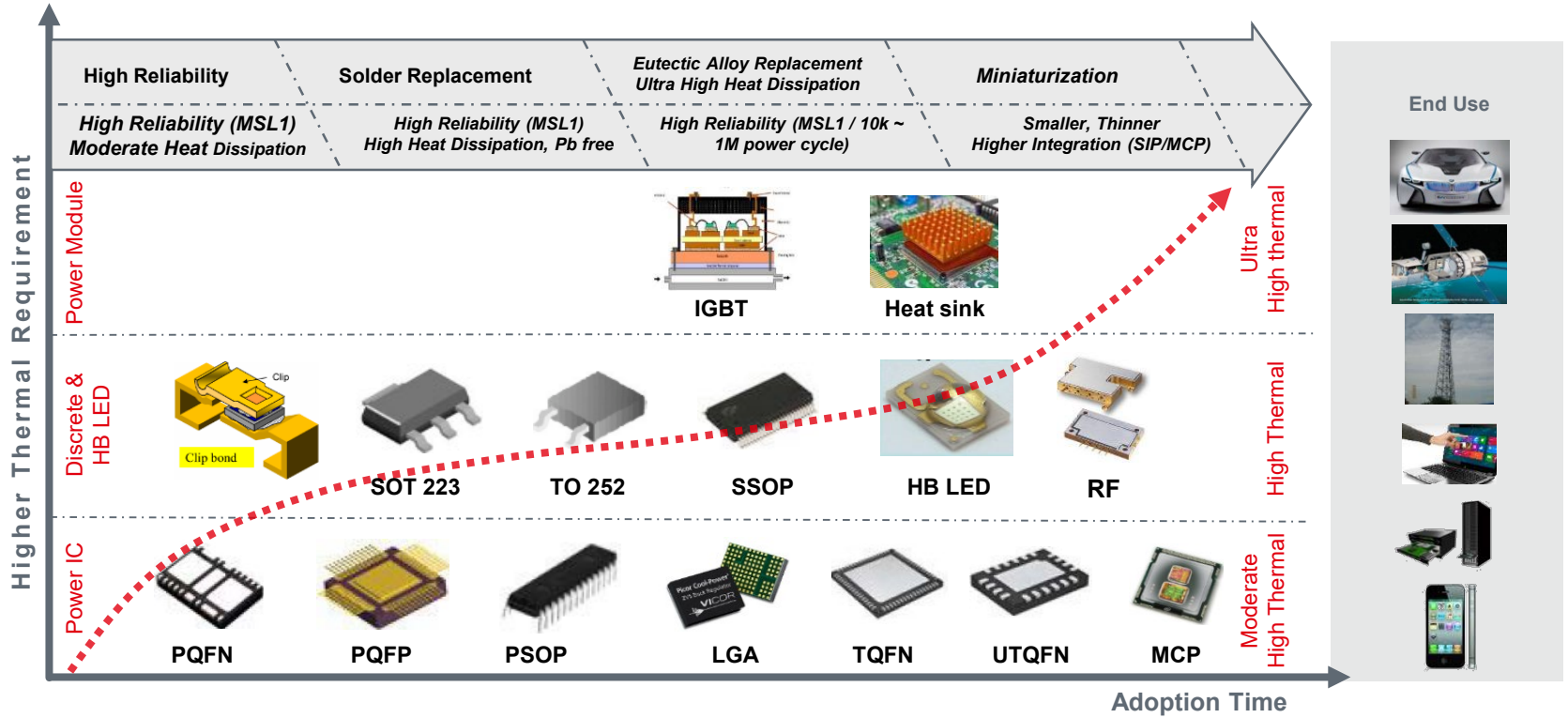
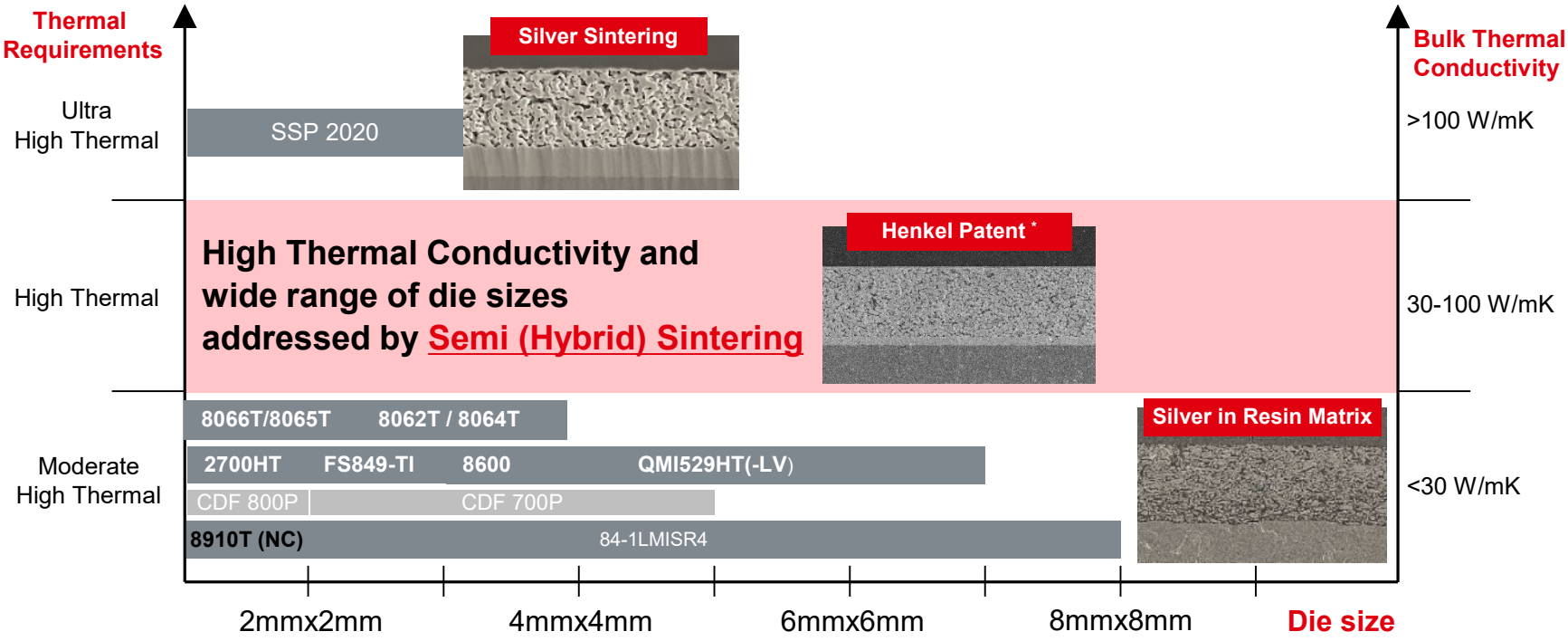
LOCTITE ABLESTIK ABP 8068TA Data Package

Henkel Electronic Materials

Applications for High Thermal Die Attach Pastes



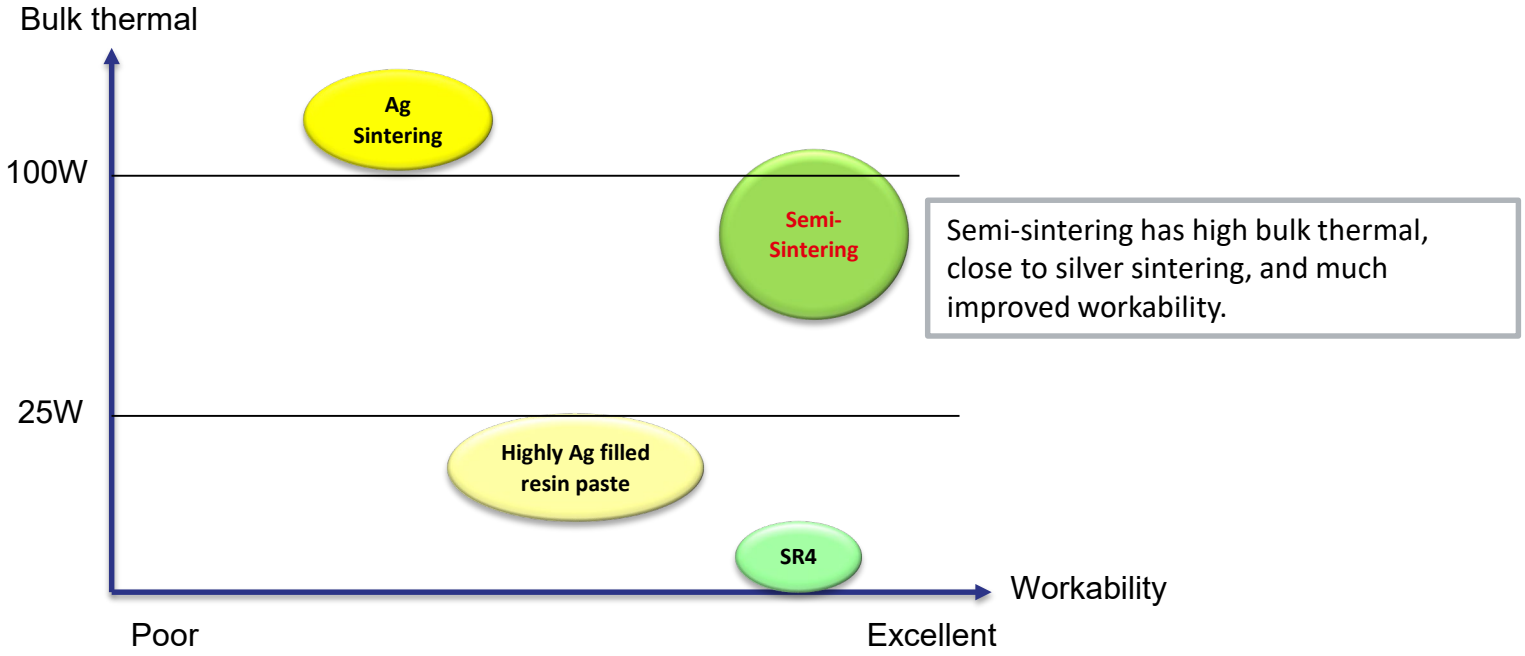
Henkel High Thermal Die Attach Paste Solutions



Henkel Hybrid Sintering System

- Sintering + Resin system
- Paste-like workability and dispensability
- Solder replacement

High thermal technology



Semi-sintering has high bulk thermal, close to silver sintering, and much improved workability.

Workability includes work life, phase separation, dispensability, open time etc.

LOCTITE ABLESTIK ABP 8068TA

1. Key Material Properties
2. Work Life
3. Dispensing Performance
4. Open Time and Stage Time
5. Resin Bleed Out
6. Adhesion Performance
7. In-Package Thermal Resistance
8. Reliability Performance
9. Appendix

Key material properties

Property	ABP 8068TA	Property	ABP 8068TA
Technology	Semi-Sintering	Recommended Cure profile	20min ramp to 130ºC,hold 30min; +15min ramp to 200ºC, hold 1h.
		Alternatively	1h ramp + 1h@200ºC
Chemistry	Epoxy	Weight Loss on Cure, by TGA	4.0%
Filler type	Silver	Bulk Thermal Conductivity (W/mK)	110
Density, g/ml	5.4	Volume R (ohm·cm)	7E-06
Viscosity @ 25ºC (cps)	9,500	Tg by TMA	No obvious Tg point
Thixotropic Index	6.0	CTE (ppm/ºC)	54
Open time	2 hrs	Modulus @25ºC (GPa)	11.8
Stage time	> = 4 hrs	Modulus @150ºC (GPa)	2.1
Work Life @ 25ºC	24hrs	Modulus @250ºC (GPa)	1.5
Recommended Storage Temperature	-40 ºC	Tg by DMA	51ºC
Storage Life (@ -40ºC)	1 year		

Target application

	Dispense type	Chip BSM	Curing temperature	Curing time	Curing gas	Substrate finish	Target application
8068TA	Needle/Pin transfer*	**Au/Ag**	>=175	>1hr	Air/N2	Cu/Ag/PPF/Au	-
PA LGA	Needle	Au	~200	1hr	N2	Au	Yes
HBLED	Pin transfer	Au	~200	1hr	Air	Ag	Yes
Power QFN/SOP	Needle	Ag	~200	1hr	N2	Cu/Ag/PPF	Yes
Power QFN/SOP	Needle	Si	~200	1hr	N2	Cu/Ag/PPF	No

- *No actual testing data, it is highly possible that 8068TA can be pin transfer based on its open time, viscosity and TI, technical team will evaluate pin transfer afterwards;
- ABP8068TA can be used on, but not limited to, above target application.

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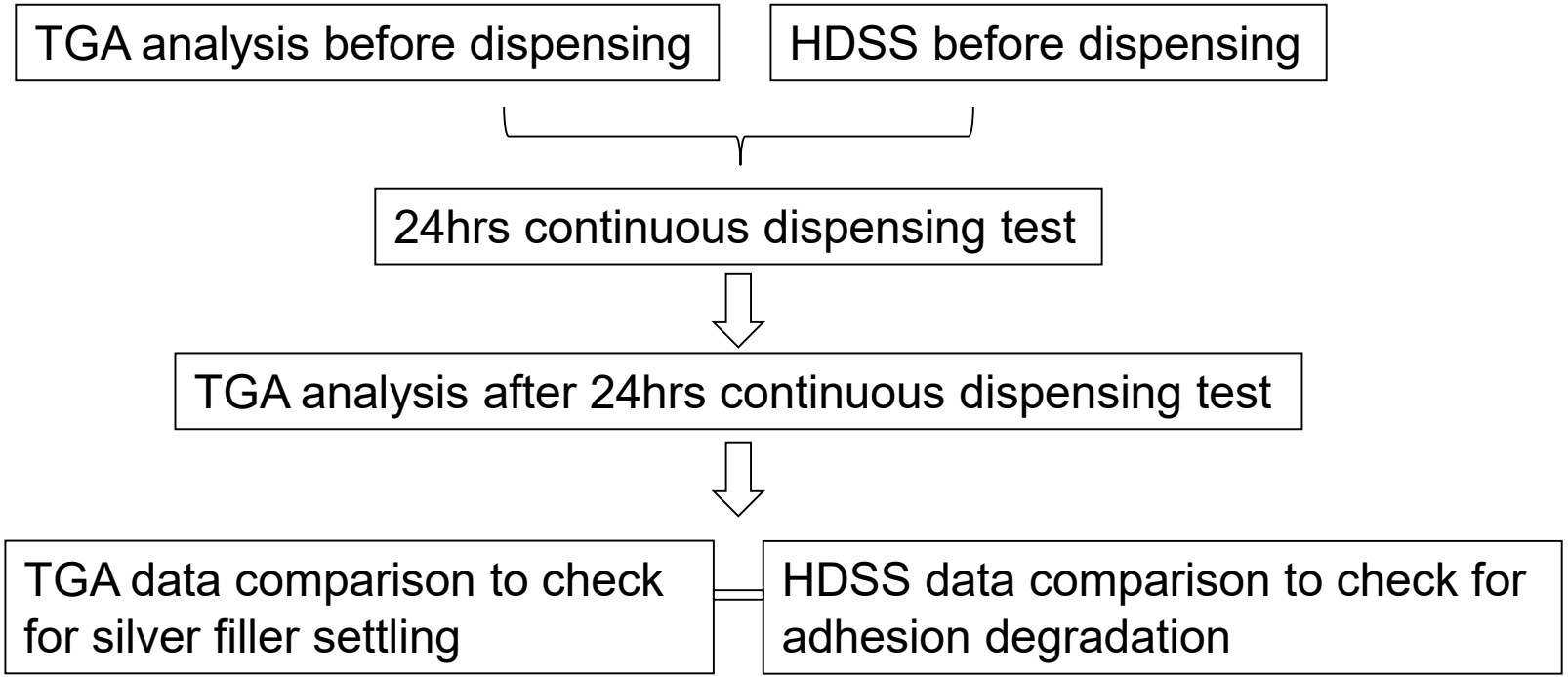
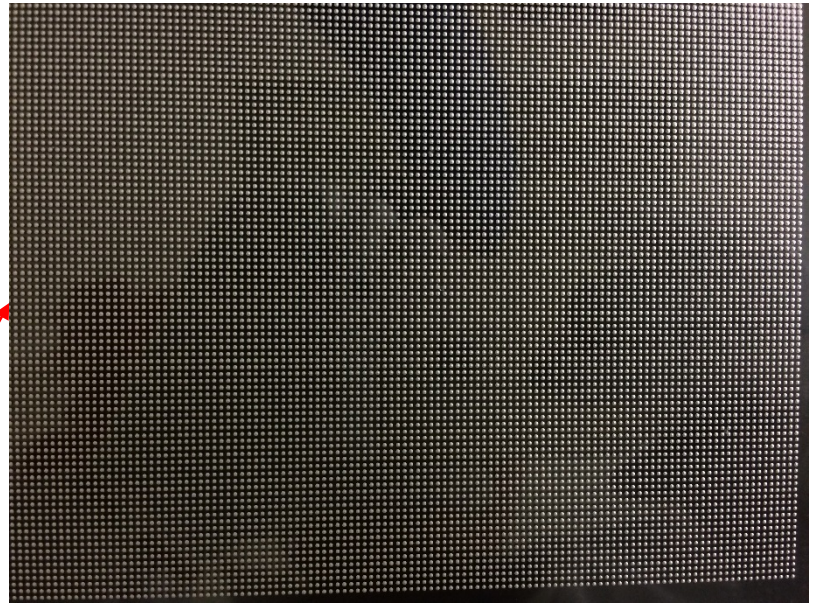
Work Life Test procedure



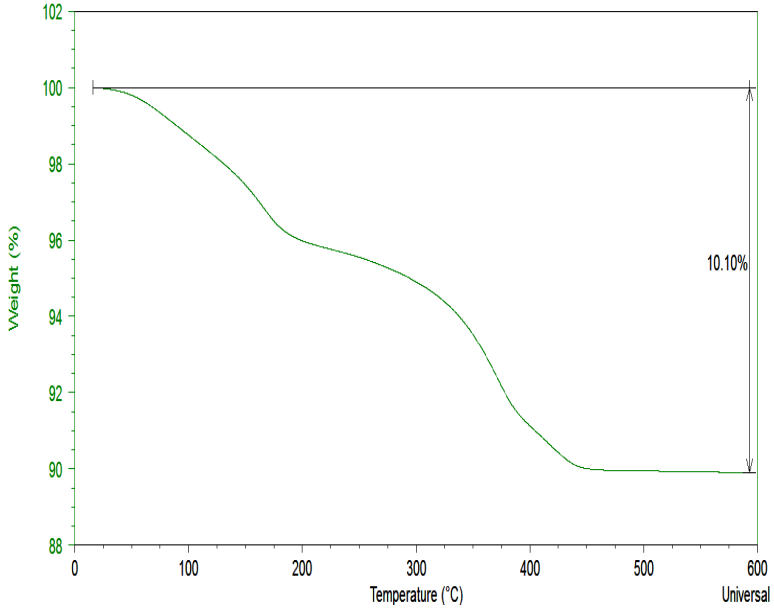
Continuous Dispensing Test

No missing dots, no separation

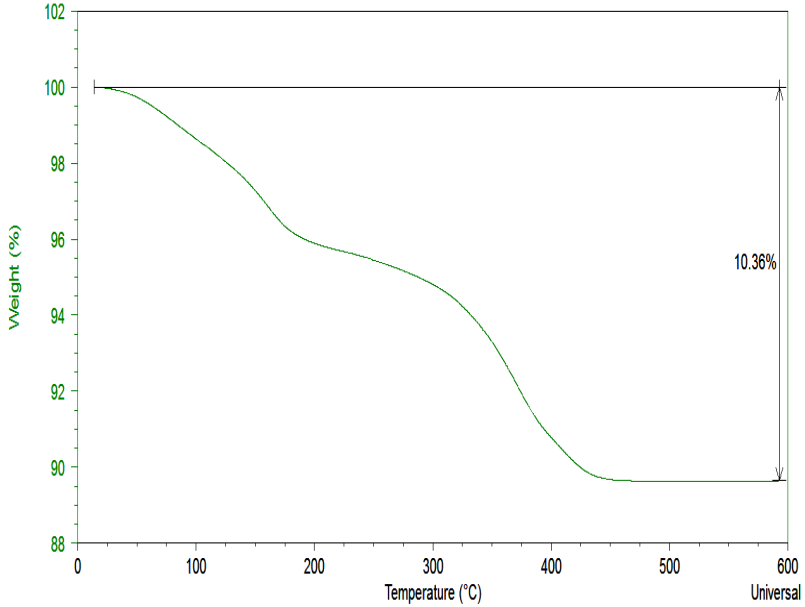


TGA Weight Loss at 600C comparison

Before 24hrs continuous dispensing



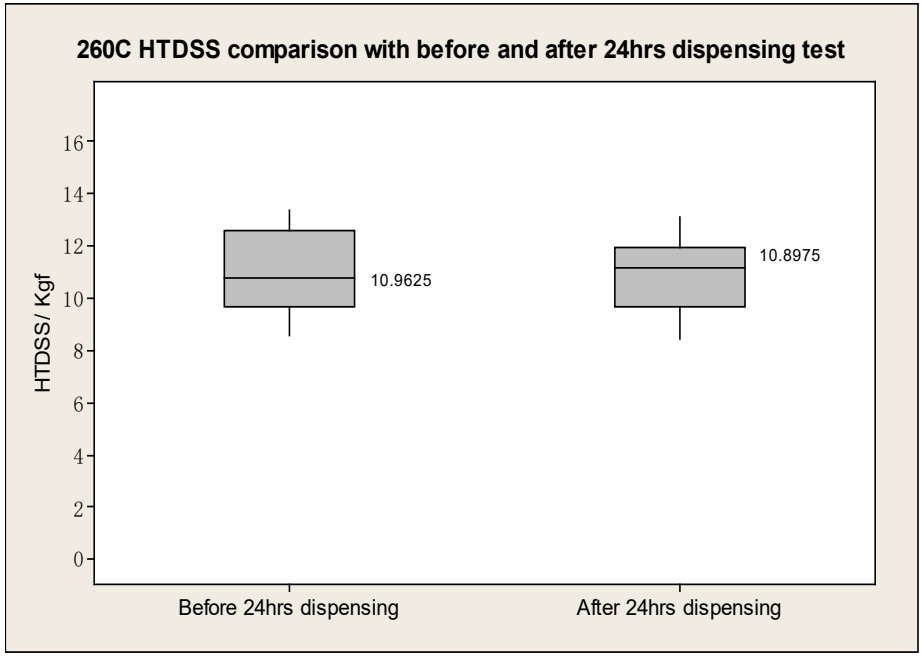
After 24hrs continuous dispensing



- Insignificant Change in Weight Loss Indicates No Silver Settling

HDSS@260C Before and After 24 hours of dispensing

3x3mm Ag BSM die, Cu Leadframe, 30min ramp to 200C + 1hour at 200C cure



No statistical difference

One-way ANOVA: Before 24hrs dispensing, After 24hrs dispensing

Source	DF	SS	MS	F	P
Factor	1	0.02	0.02	0.01	0.936
Error	14	35.77	2.55		
Total	15	35.78			

S = 1.598 R-Sq = 0.05% R-Sq(adj) = 0.00%

Level	N	Mean	StDev
Before 24hrs dispensing	8	10.963	1.693
After 24hrs dispensing	8	10.897	1.498

Individual 95% CIs For Mean Based on Pooled StDev

```
Level
Before 24hrs dispensing  (----------------*----------------)
After 24hrs dispensing   (----------------*----------------)
                         --+---------+---------+---------+-------
                          9.80      10.50     11.20     11.90
```

Pooled StDev = 1.598

- No compositional difference in paste before and after 24 hours of dispensing

Summary

- ABP 8068TA has work life up to 24 hours.
  - During 24 hours of continuous dispensing, no missing dots or paste separation was observed.
  - As measured by TGA analysis, no silver settling occurred during the continuous dispensing period, since no difference in resin/filler was observed
  - HDSS testing showed no adhesion degradation after 24hours of continuous dispensing.

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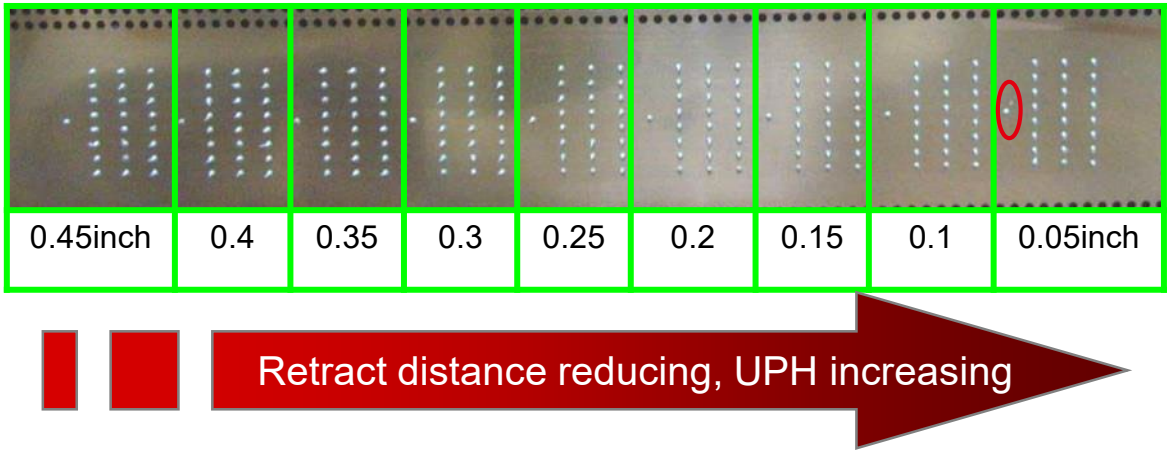
Dispensing

Dot Dispensing Test Methodology

- Henkel has standard dot dispensing method: totally dispense 9 groups with the same parameters except different retract distance. This testing simulates different UPH from low to high, output is total defective dot quantity.

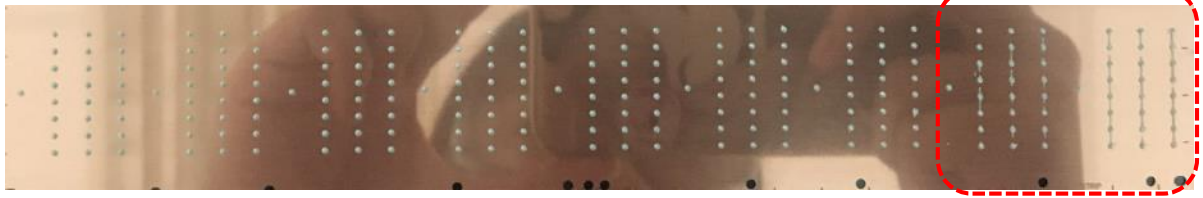


ABP 8068TA Dispensability

Standard Dot Dispensing

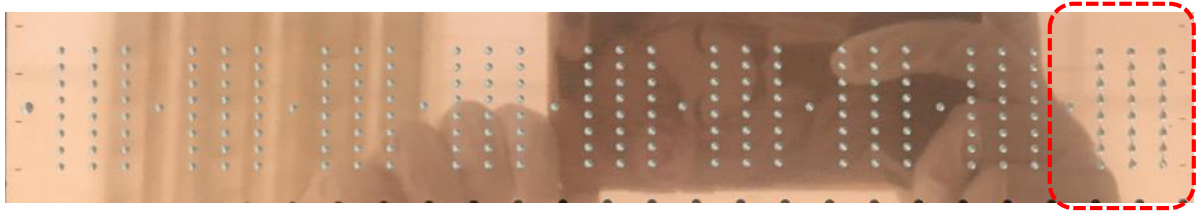
- 9 groups of dots dispensed at increasing UPH from left to right (22G, ID 400um needle).
- Result showed ABP8068TA is better than QMI 529HT, comparable to 84-1LMISR4.

QMI529HT



Tailing
in last 2 groups

ABP8068TA



Slight Tailing
in last group

84-1LMISR4

Tailing
in last group

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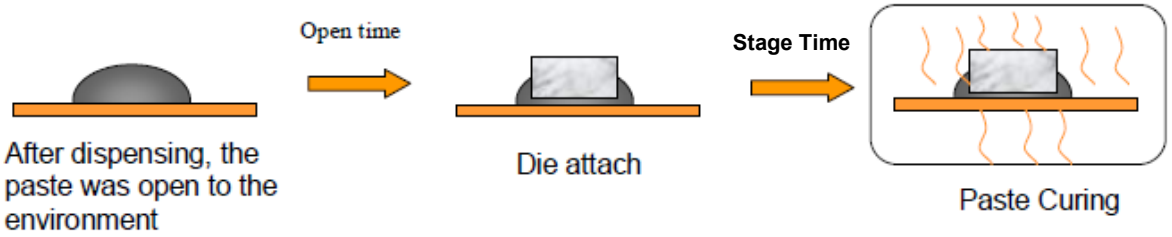
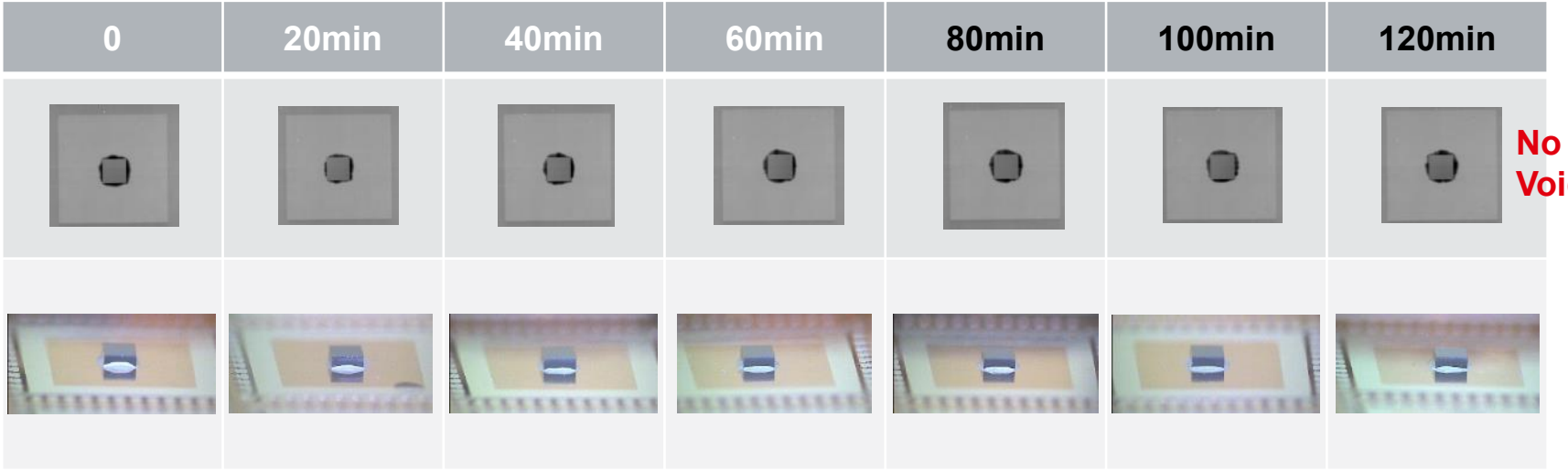
Open (Tack Free) Time
Introduction

- Very often, high power applications feature small package sizes with many packages on a single strip
- Hence, pastes used in these applications must withstand long time periods after paste is dispensed and before die is placed, and also between die placement and adhesive curing.
- Definition
  - **<u>Open time</u>:** the time after dispensing and before die attach, during which the paste is open to the environment
  - **<u>Stage time</u>**: the time after die attach and before curing



Open Time _ Coverage and Fillet Height

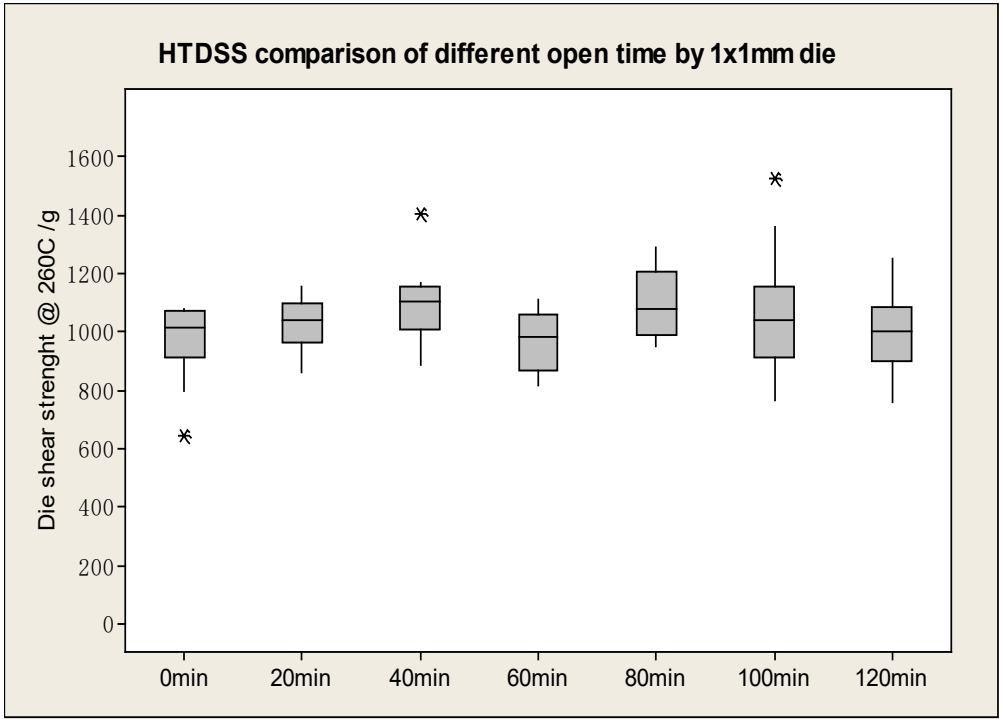
Small Die (1x1mm)



- No significant change in coverage on dies bonded with same bond force and bond time, even after open time of up to 2 hours.

Open time check by HDSS@260C (1X1mm die)

Cure: 200C 1hr with N2, Cu LF



No statistical difference

One-way ANOVA: 0min, 20min, 40min, 60min, 80min, 100min, 120min

Source	DF	SS	MS	F	P
Factor	6	194364	32394	1.60	0.163
Error	63	1277097	20271		
Total	69	1471461			

S = 142.4 R-Sq = 13.21% R-Sq(adj) = 4.94%

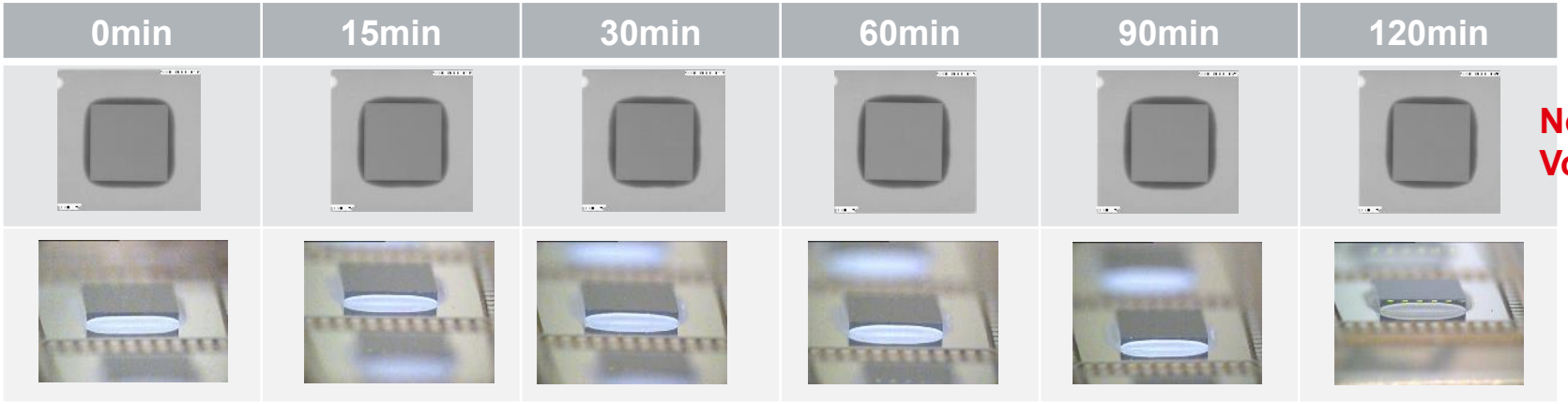
Individual 95% CIs For Mean Based on Pooled StDev

Level	N	Mean	StDev
0min	10	968.4	141.1
20min	10	1026.3	94.8
40min	10	1102.1	139.2
60min	10	972.6	101.8
80min	10	1100.2	117.9
100min	10	1067.8	224.4
120min	10	1000.2	137.8

880 960 1040 1120

Open Time _ Coverage and Fillet Height

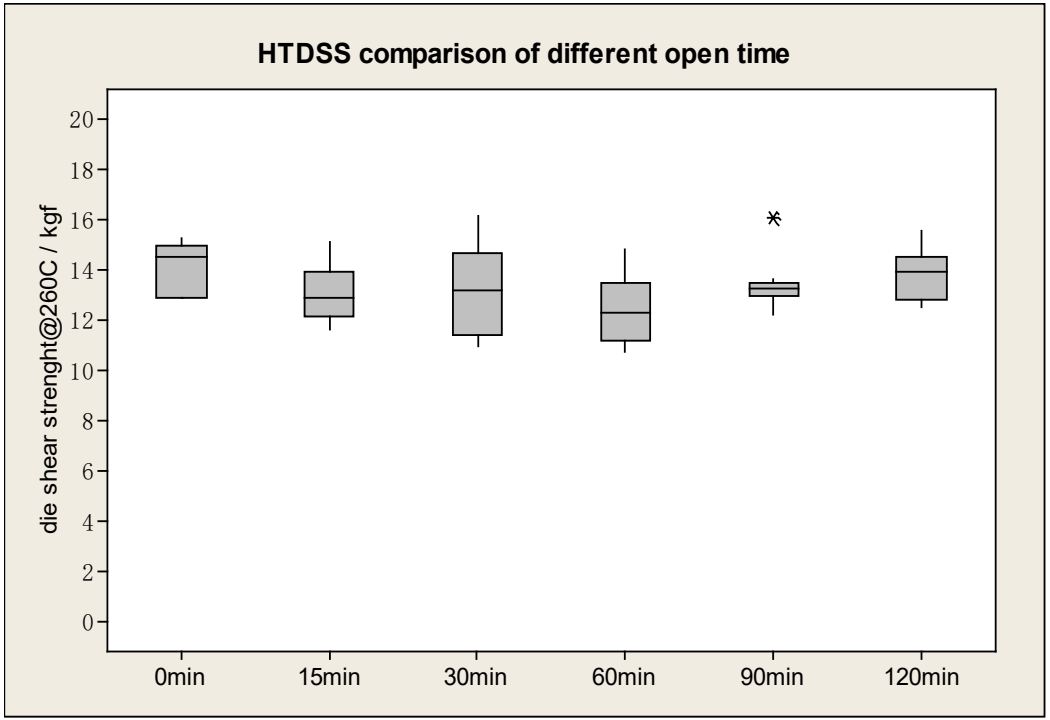
Medium Die (3x3mm)



- No significant change in coverage & fillet height on dies bonded with same bond force and bond time, even after open time of up to 2 hours.

Open time check by HDSS@260C (3X3mm die)

Ag plated LF



No statistical difference

One-way ANOVA: 0min, 15min, 30min, 60min, 90min, 120min

Source	DF	SS	MS	F	P
Factor	5	16.57	3.31	2.05	0.086
Error	54	87.35	1.62		
Total	59	103.92			

S = 1.272 R-Sq = 15.94% R-Sq(adj) = 8.16%

Level	N	Mean	StDev
0min	10	14.086	1.043
15min	10	13.131	1.205
30min	10	13.153	1.843
60min	10	12.465	1.289
90min	10	13.413	1.022
120min	10	13.841	1.031

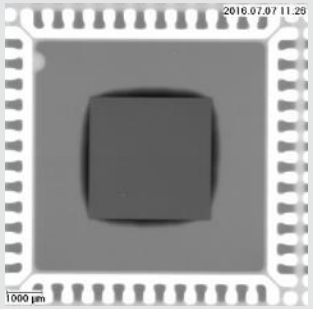
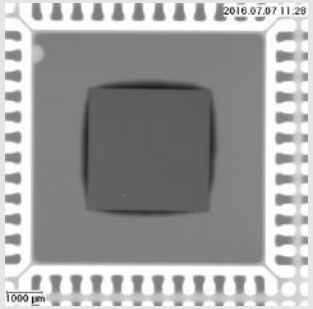
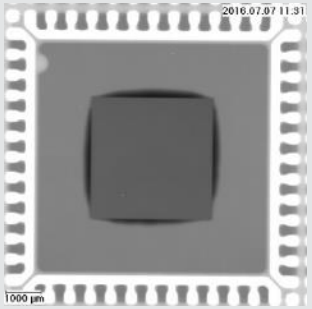
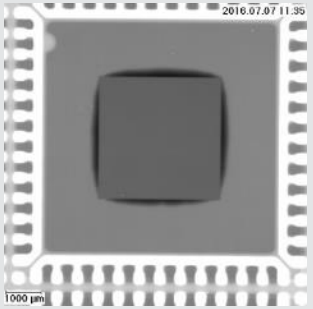
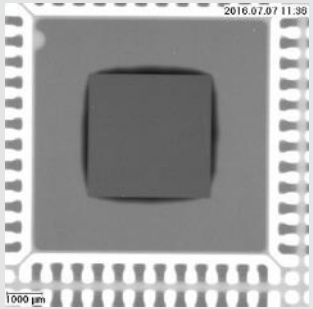
Individual 95% CIs For Mean Based on Pooled StDev

12.0 13.0 14.0 15.0

Pooled StDev = 1.272

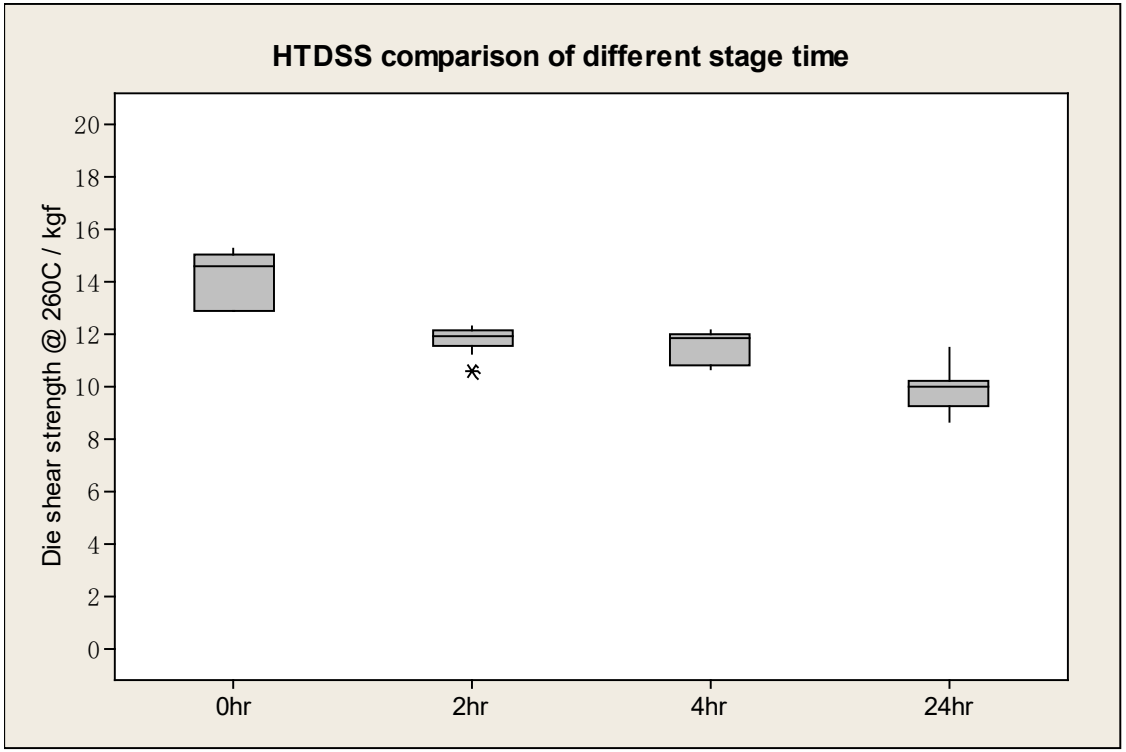
Stage time test

Void inspection after cure for Ag/Cu LF

0	2hr	4hr	6hr	24hr
				
0/60	0/60	0/60	0/60	0/60

- No void. No change in coverage.

Stage time check by HDSS@260C (3X3mm die)



Summary

- Coverage, fillet height and DSS demonstrated long open time, up to 2 hours, for ABP 8068TA with small and medium die sizes (more data to be collected)
- Stable stage time- recommend 4 hrs with no significant change in bond line and adhesion.
- No void found in cured bond line for various die sizes along considerably long open time and stage time.

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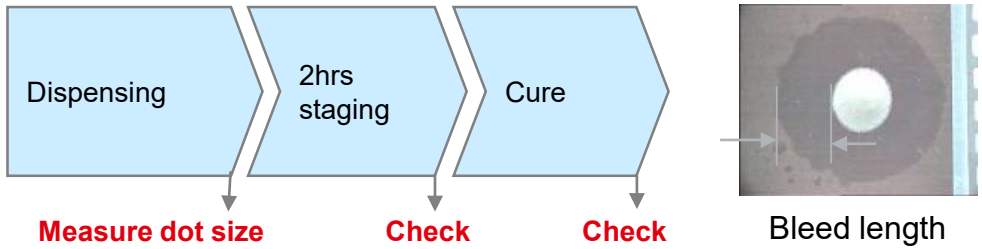
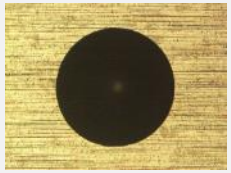
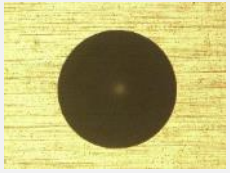
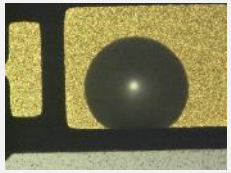
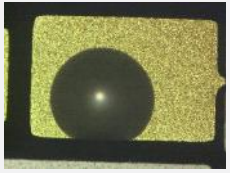
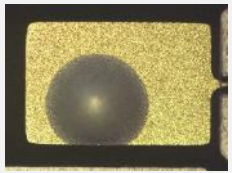
Resin Bleed Out
Introduction

- Resin Bleed Out (RBO)Testing:
  - The adhesive is dot dispensed onto the test leadframes surfaces, Cu and Ag plated Cu
  - The diameter of the dots is observed. Subsequently the adhesive dot size, including any bleed, is re-measured after defined time intervals (T = 0, 2hrs) at ambient conditions.
  - The adhesive dots were cured using the recommended cure profile and the adhesive dot size again re-measured.



RBO check with in-house QFN LF and substrate

	0hr	2hrs	After cured	
Ag				**Slight RBO on Ag LF**
Cu				**No RBO on Cu LF**
PPF				**No RBO on PPF LF**
Au				**No RBO on Au LF**

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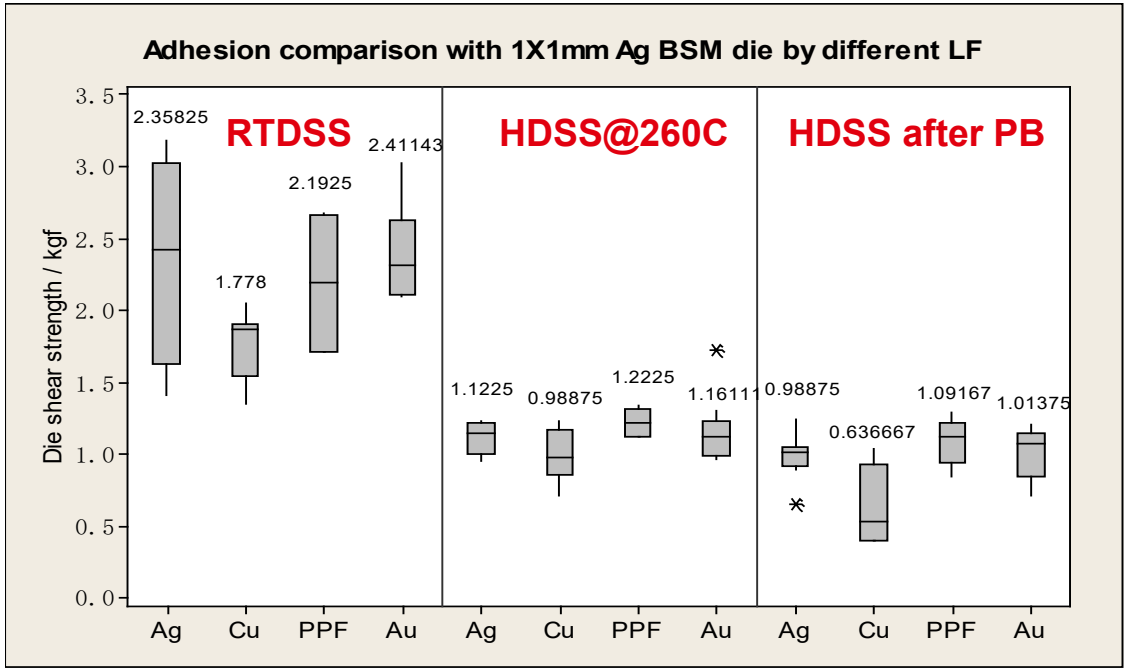
Adhesion Performance as Measured by Die Shear Strength (DSS)

Test Condition

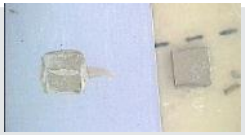
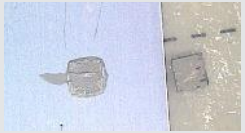
- Substrate: AgCu, Cu, PPF (NiPdAu), Au plated L/Fs
- Die: Ag BSM, 1x1mm, 2x2mm, 3x3mm, 5x5mm
- Curing condition: 20min ramp to 130C dwell for 30min, then 10min ramp to 200C dwell 1hr
- Die Shear Strength measured at various temperatures and conditions:
  - ✓ RTDSS
  - ✓ HDSS @ 260C
  - ✓ HDSS @ 260C after ParrBomb (2 atm for 16h @ 121C)

Adhesion data for 1x1mm Ag BSM die

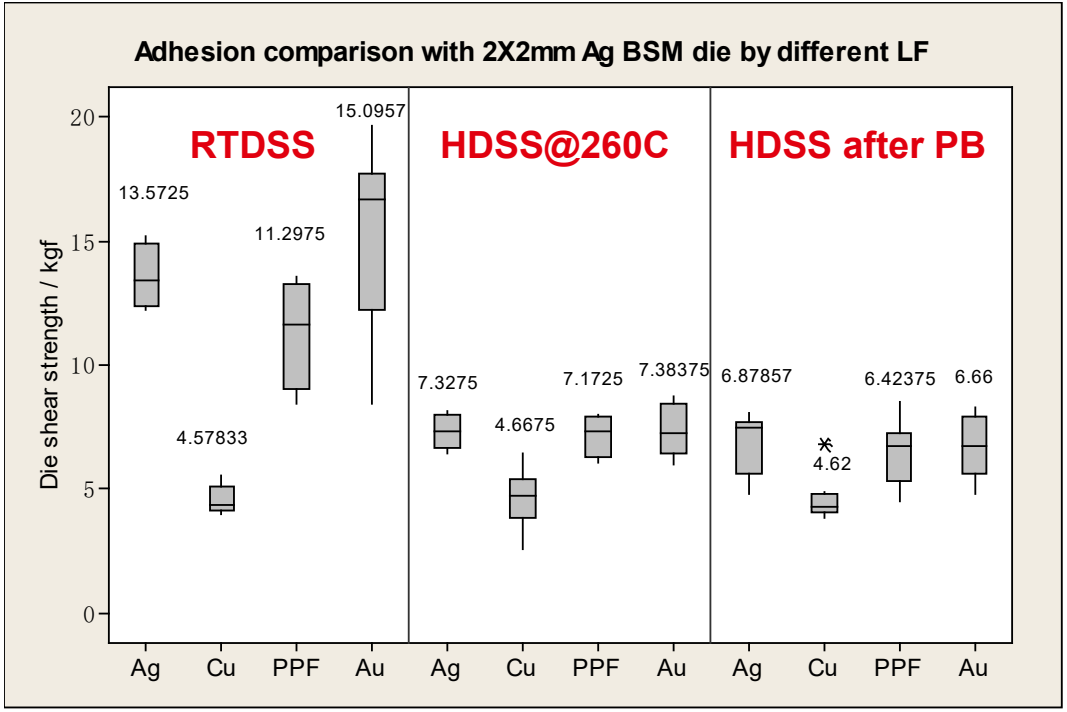


- Consistent and Excellent Performance on All Leadframes

Failure modes observed with 1x1mm die

	RT	HTDSS @ 260C	PB @ 260C
Ag	 Cohesive	 Cohesive	 Cohesive
Cu	 Cohesive	 Cohesive	 Partial Cohesive
PPF	 Cohesive	 Cohesive	 Cohesive
Au	 Cohesive	 Cohesive	 Cohesive

Adhesion data for 2x2mm Ag BSM die



- Excellent adhesion values on all leadframe surfaces

Failure modes observed with 2x2mm die

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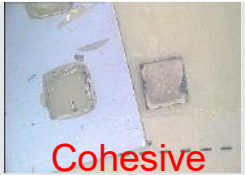
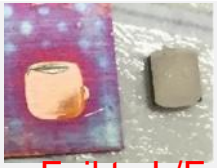
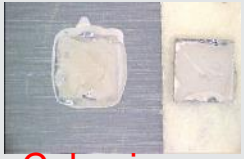
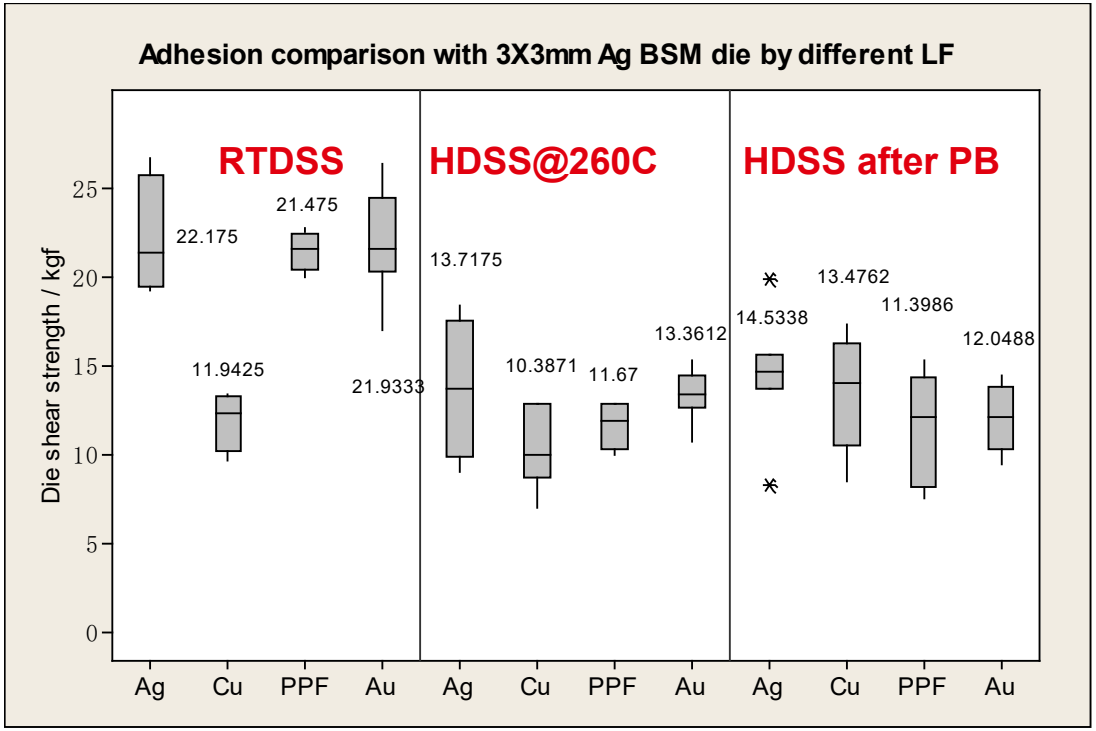
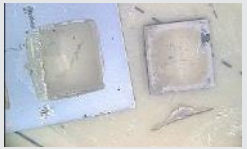
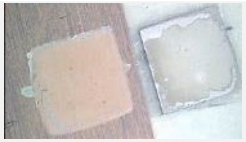
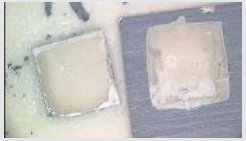
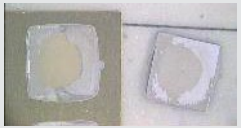
Ag	 Cohesive	 Cohesive	 Cohesive
Cu	 Fail to L/F	 Fail to L/F	 Fail to L/F
PPF	 Cohesive	 Cohesive	 Cohesive
Au	 Cohesive	 Cohesive	 Cohesive

Adhesion data for 3x3mm Ag BSM die

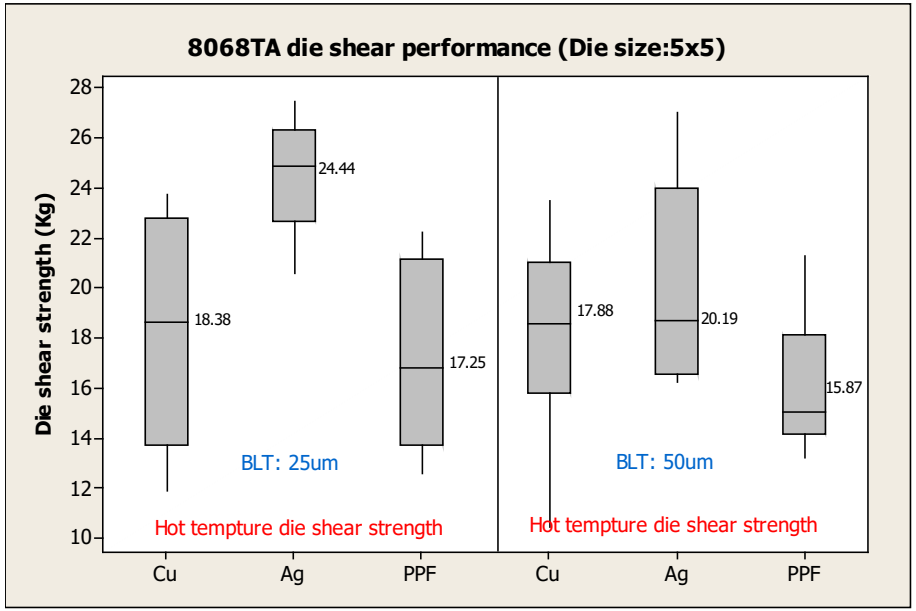


- Excellent adhesion values on all leadframe surfaces

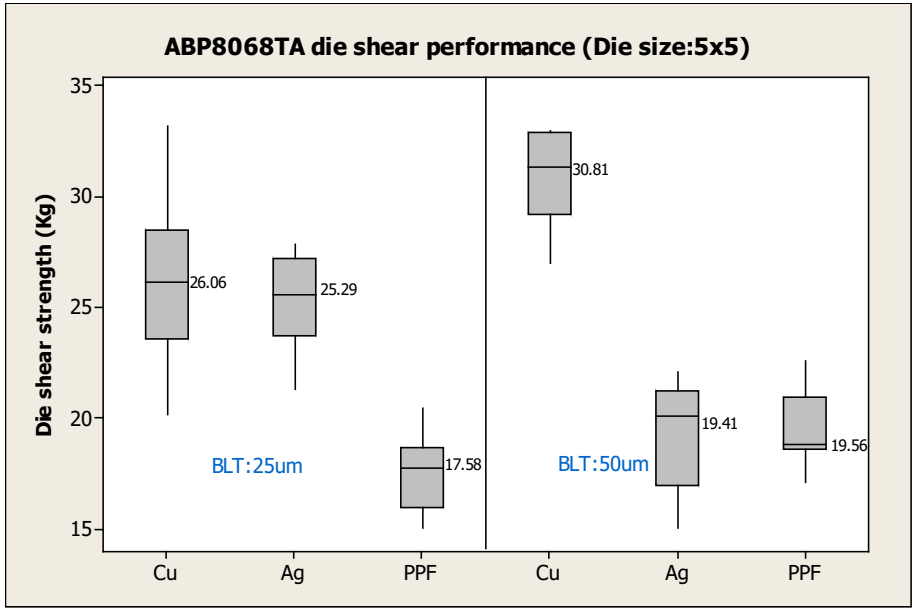
Failure mode with 3x3mm die

	RT	HTDSS @ 260C	PB @ 260C
Ag	 Cohesive	 Cohesive	 Cohesive
Cu	 Partial Cohesive	 Fail to L/F	 Partial Cohesive
PPF	 Cohesive	 Cohesive	 Cohesive
Au	 Cohesive	 Cohesive	 Cohesive

Adhesion for 5x5mm die size

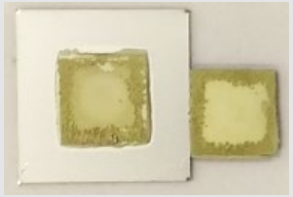
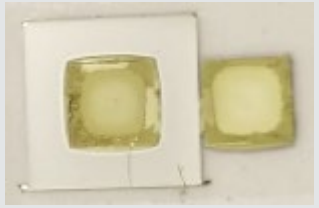
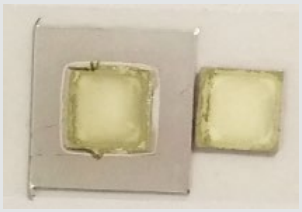
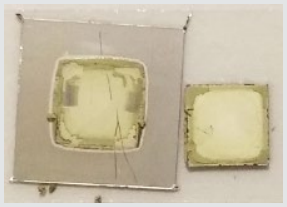
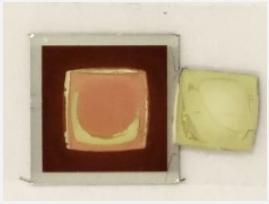
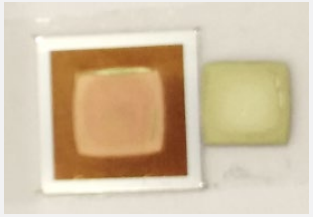
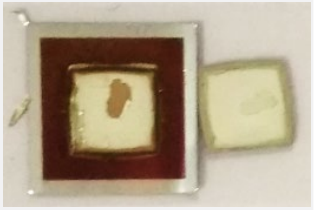
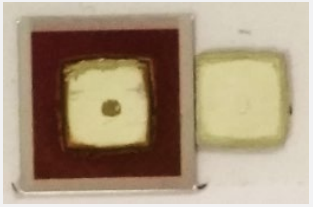
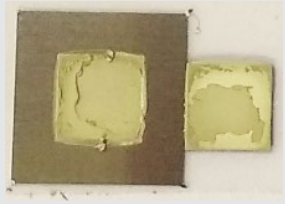
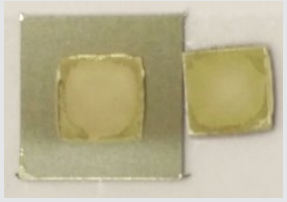
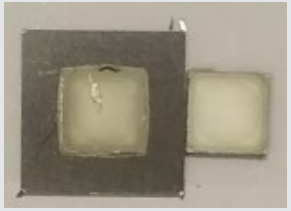
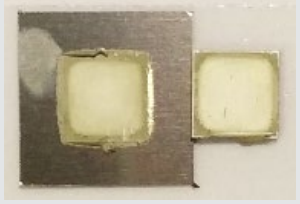


Hot adhesion @260C



Hot adhesion @260C after parr bomb

Failure mode with 5x5mm die

	HTDSS @ 260C(1mil)	HTDSS @ 260C(1mil)	PB @ 260C (2mil)	PB @ 260C (2mil)
Ag				
Cu				
PPF				

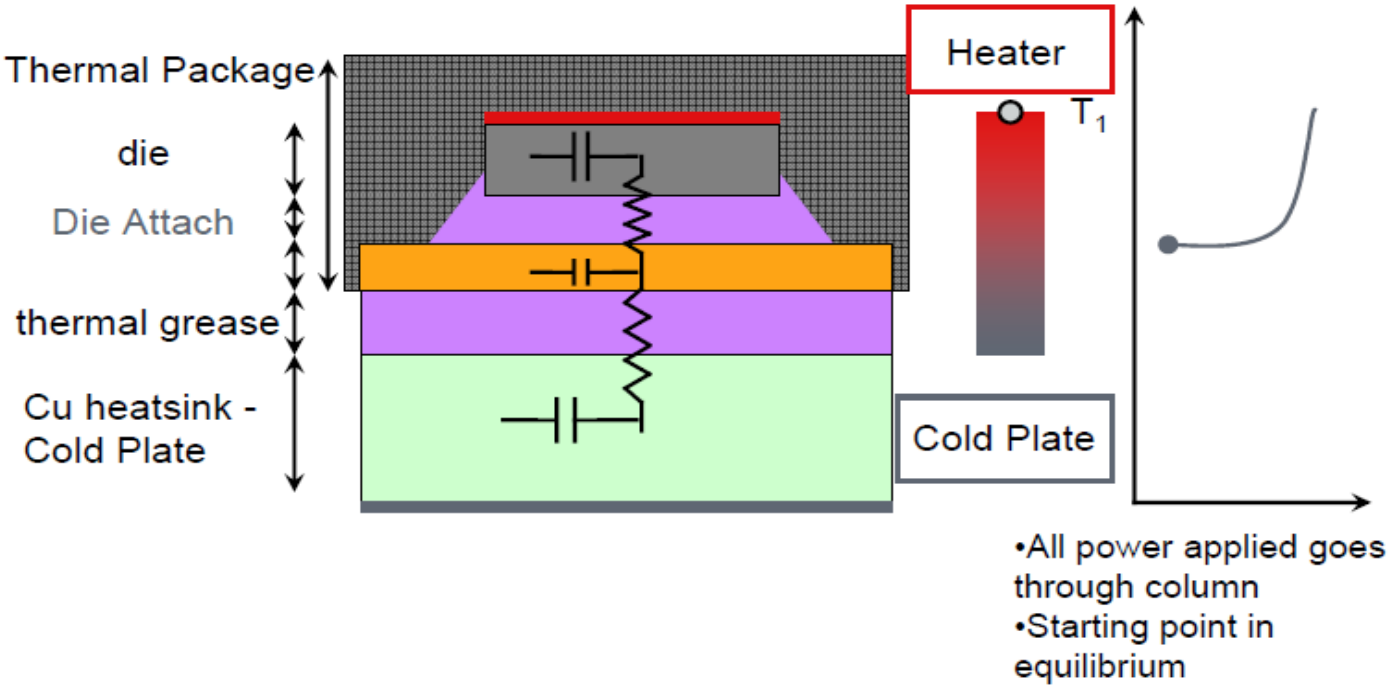
Summary

- ABP 8068TA shows robust adhesion performance on various leadframe surface finishes, including Ag, Cu, PPF and Au.
    - On Ag, Cu, PPF and Au, robust adhesion from small die size all the way up to die size as big as 5x5mm (the recommended curing profile is suitable for die size <=5*5mm).
    - When die size >5*5mm, longer step curing is highly recommended to get a dense, void free bond line(data are under collection).

LOCTITE ABLESTIK ABP 8068TA

1. Key Material Properties
2. Work Life
3. Dispensing Performance
4. Open Time and Stage Time
5. Resin Bleed Out
6. Adhesion Performance
7. In-Package Thermal Resistance
8. Reliability Performance
9. Appendix

Transient Thermal Resistance Testing System

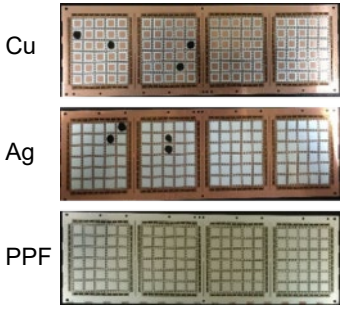


Test Condition - Equipment

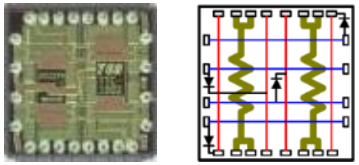
- Equipment :
  - Datacon 2200evo for die bonding
  - Optical Microscope for BLT/coverage/fillet verification
  - Phoenix X-Ray machine for void inspection
  - Box oven for cure
  - EUROPLASMA for plasma cleaning
  - ASM GOCU wire bond machine
  - TOWA Y-1E for die bonded lead frame molding
  - A-WD-300 for package singulation
  - Ultrasonic clean machine for singulated package cleaning
  - Sonix Fusion for Ultrasonic Scan analysis
  - In-package thermal resistance tester

Test Condition - Material

- Material:
  - Die: 2.54mmx2.54mm, 15mil thickness, thermal resistance test function die,
  - Lead frame: Henkel standard 7X7 Cu,Ag and PPF QFN lead frames
  - 1 mil gold wire
  - Molding compound: Sumitomo EME-G770HCD (Cure + PMC)



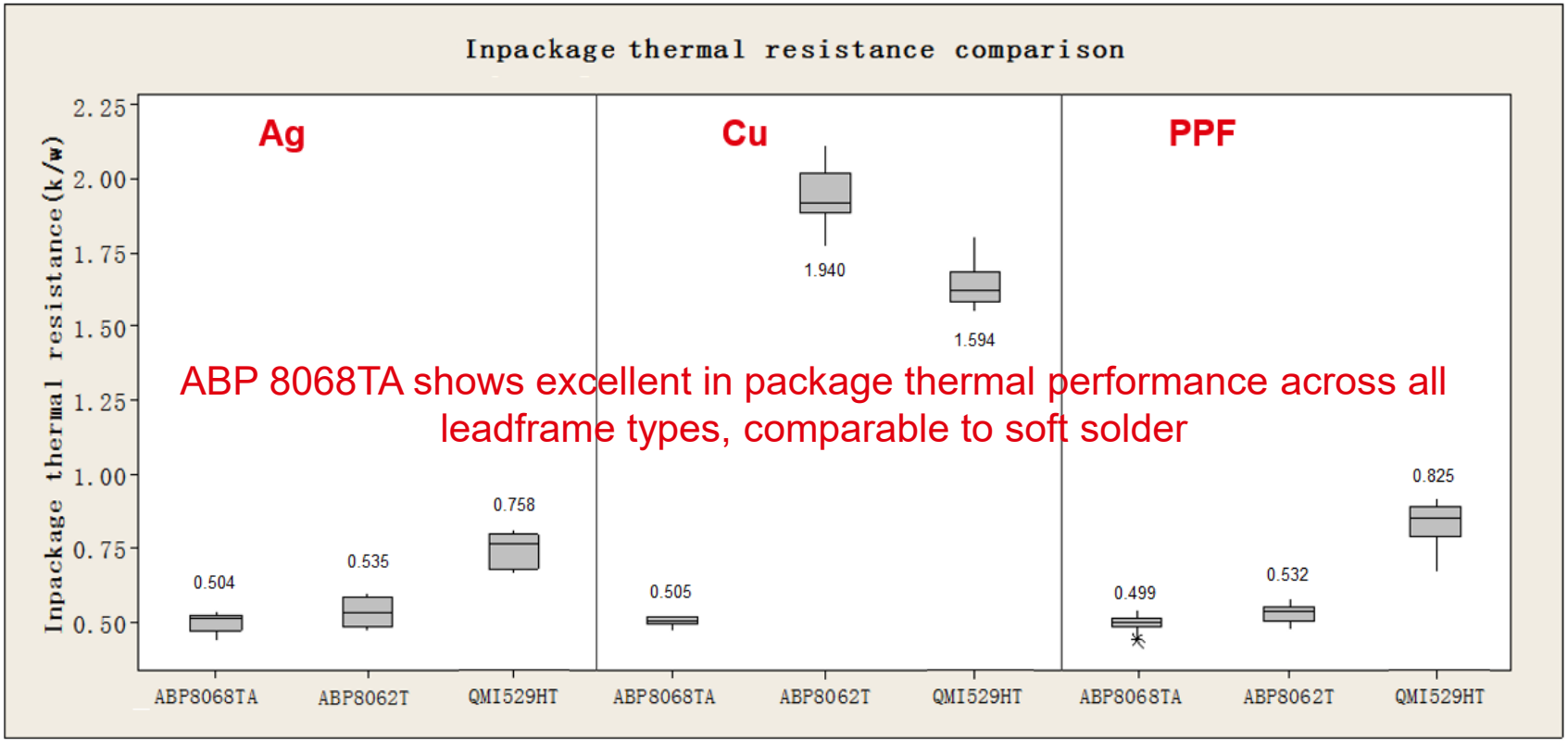
QFN 7X7 LF



Functional die

Electrical – Heating : TTC-1002 # of Resistors : 2
Resistance Value : 7.6 Ω ±10 % (each resistor)
Resistance Variation : ±5 % (for die from a specific wafer)
Max Resistor Power : 6 W (6V @ 1A) each
Backside metallization : Ti Ni Ag

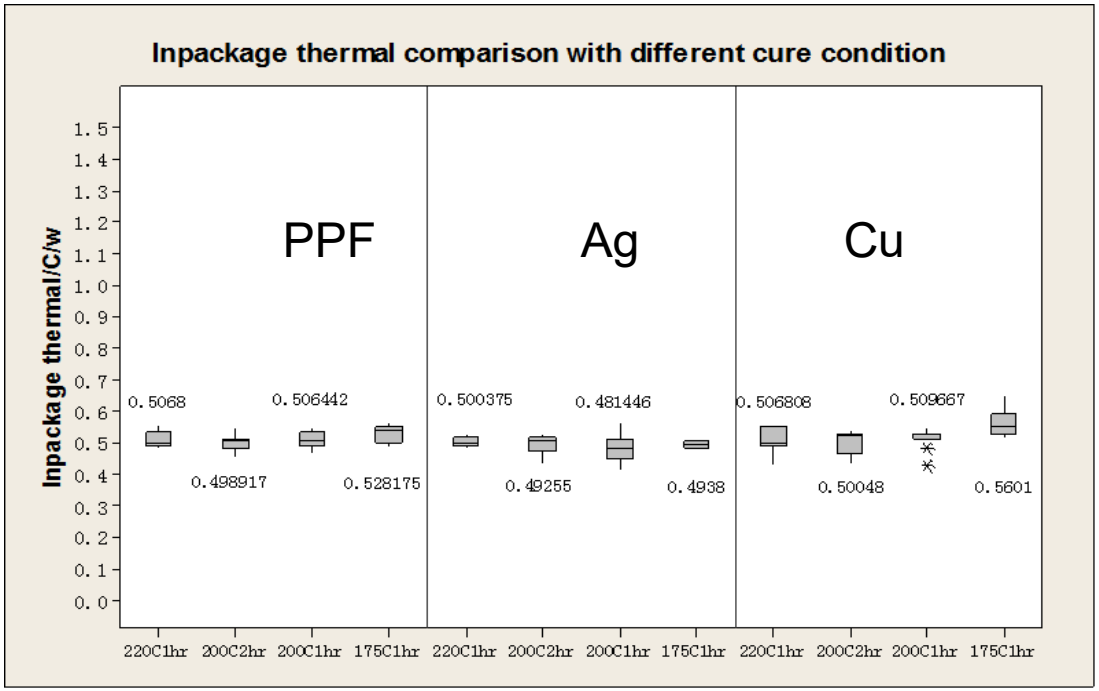
In-package thermal comparison with ABP 8062T & QMI 529HT



ABP 8068TA shows excellent in package thermal performance across all leadframe types, comparable to soft solder

* **8068TA**: 30min ramp to 200C + 1h@200C
* **8062T**: 45min ramp to 200C + 30min@200C
* **529HT**: 30min@200C

In-package thermal with different cure temperature and time



- ABP 8068TA can achieve low inpackage thermal resistance even cured at 175C@1hr.
- For Cu LF application, suggest curing at 200C or above which can achieve equal inpackage thermal with Ag and PPF LF.

Summary

- ABP 8068TA has best-in-class thermal performance among Henkel high thermal pastes, much better than widely adopted high thermal pastes like QMI 529HT and ABP 8062T, and even full silver sintering pastes such as SSP 2020.
- ABP 8068TA can achieve low inpackage thermal resistance even cured at 175C@1hr.
- For Cu LF application, suggest curing at 200C or above which can achieve equal inpackage thermal with Ag and PPF LF.
- ABP 8068TA shows in-package thermal resistance similar to that of soft solder, which means it could be a viable replacement for solder, given its excellent workability.

LOCTITE ABLESTIK ABP 8068TA

1. Key Material Properties
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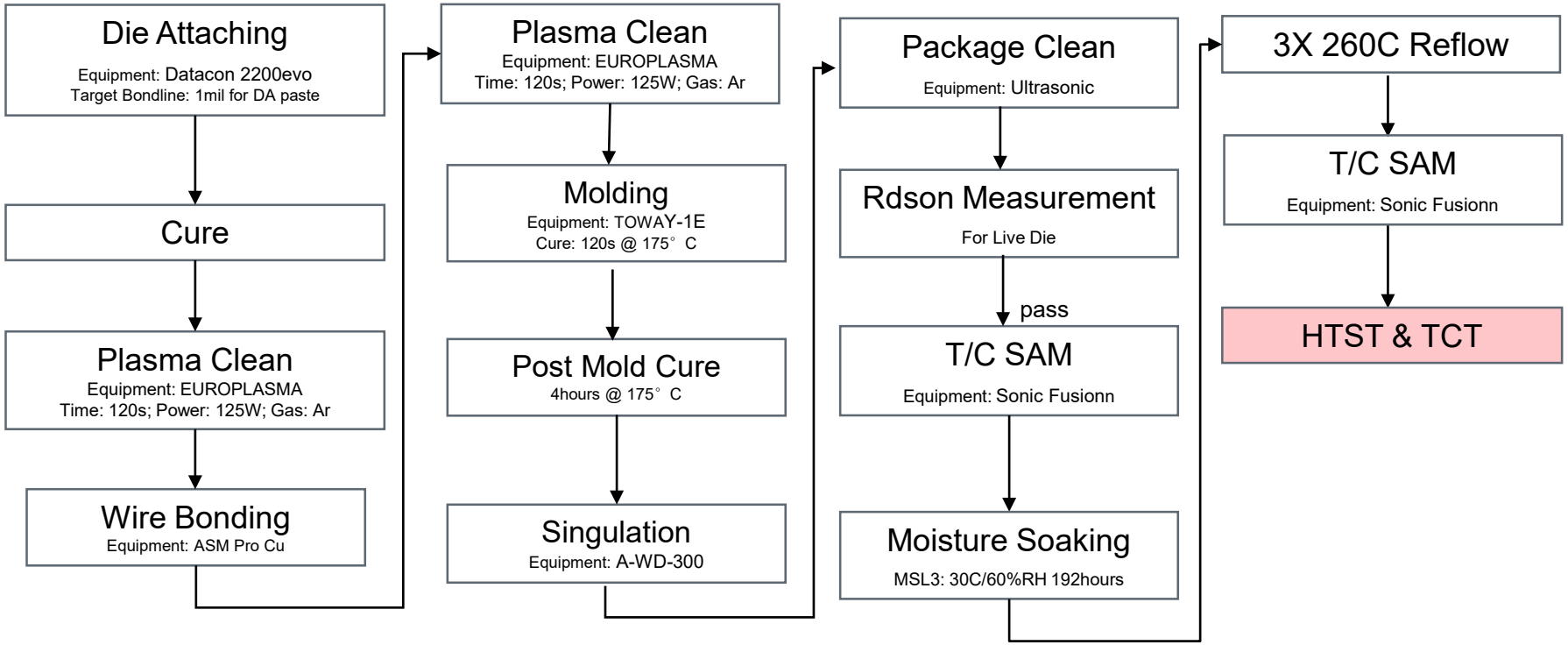
Test Item

- MRT with different die size(1x1,3x3,5x5mm Ag BM die with Cu Ag PPF lead frame)
- MRT with different cure temperature and cure time (Ag PPF lead frame)
- High temperature Storage test @175C
- Temperature cycle test (-65C~150C)

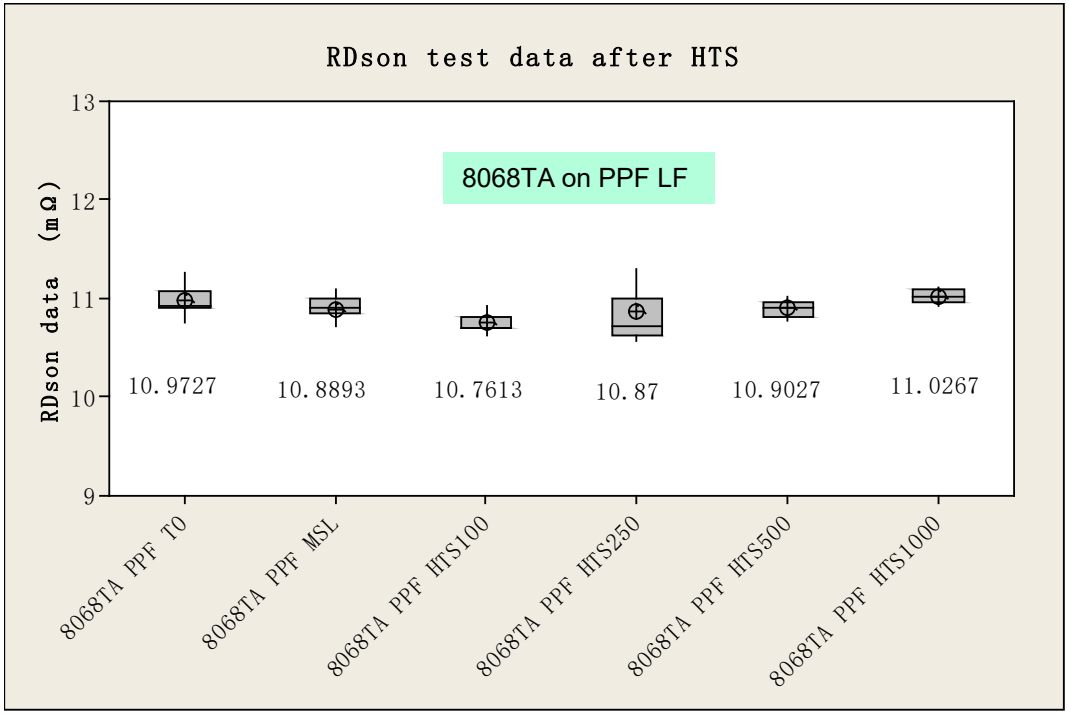
Process Flow



MRT Result summary

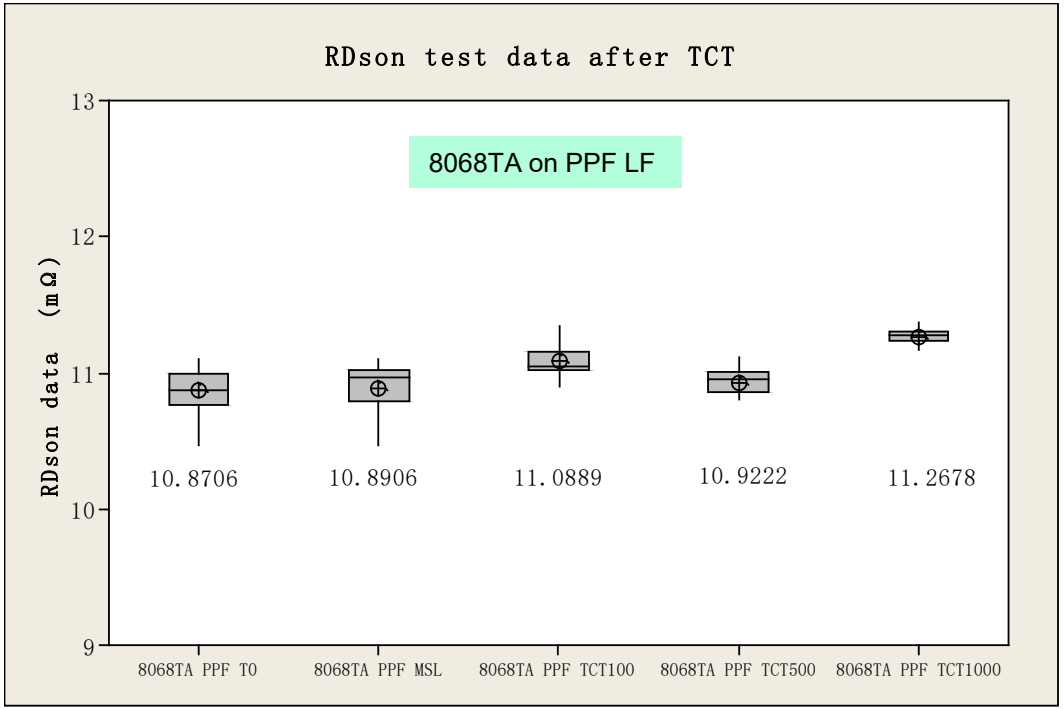
Package	Die size	Die BSM	Leadframe finish	MSL 1 260	MSL 3 260
QFN4x4	1x1	TiNiAg	Cu	Pass	Pass
QFN7x7	2.16x1.76	TiNiAg	Cu	NA	Pass
QFN4x4	1x1	TiNiAg	Ag/Cu	Pass	Pass
QFN7x7	2.5x2.5	TiNiAg	Ag/Cu	Pass	Pass
QFN7x7	3x3	TiNiAg	Ag/Cu	Pass	Pass
QFN4x4	1x1	TiNiAg	PPF	Pass	Pass
QFN7x7	2.16x1.76	TiNiAg	PPF	NA	Pass
QFN7x7	2.5x2.5	TiNiAg	PPF	Pass	Pass
QFN7x7	3x3	TiNiAg	PPF	Pass	Pass
QFN12x12	5x5	TiNiAg	PPF	Pass	Pass

HTST summary



Rdson quite stable within 1000 hours.

TCT summary



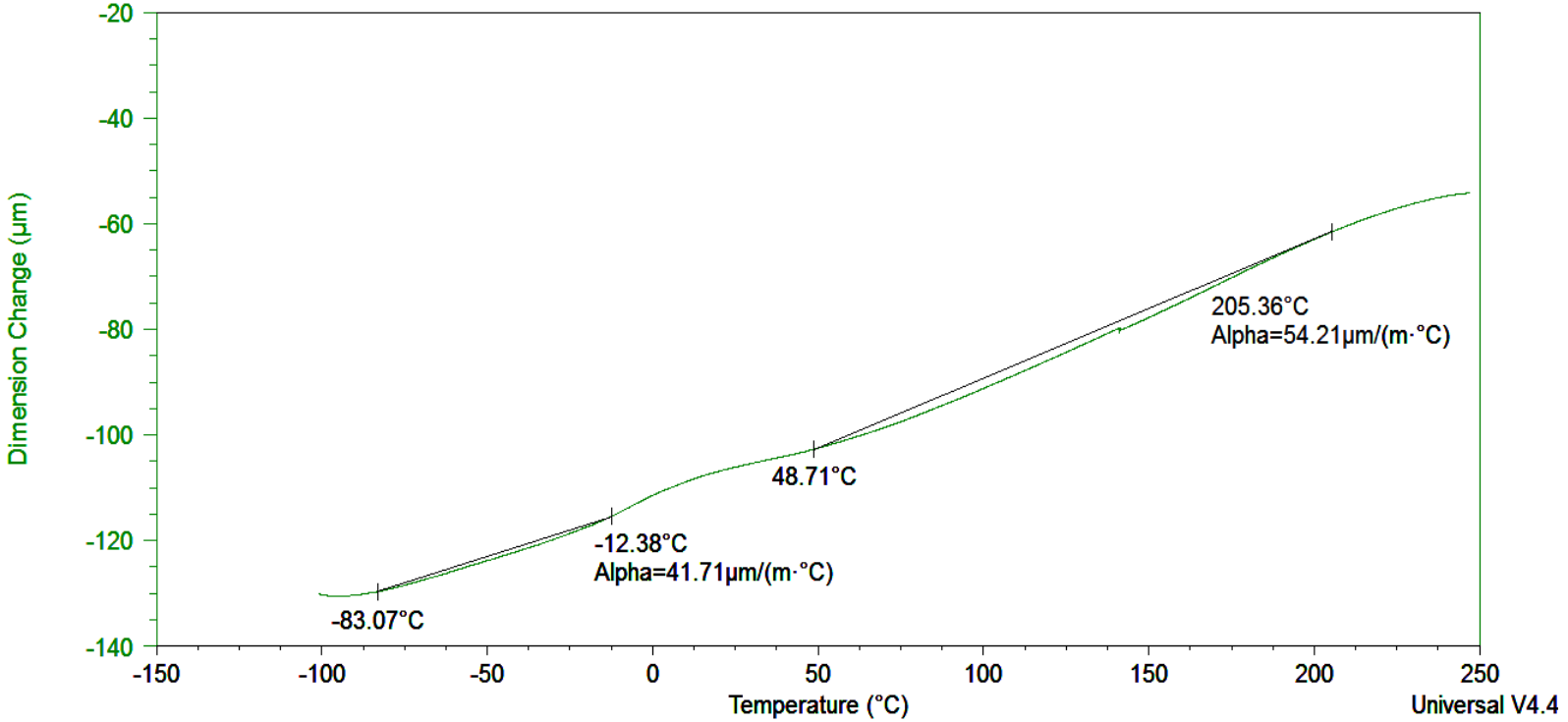
Rdson quite stable within 1000 temperature cycle.

High Thermal Die Attach Pastes

Appendix

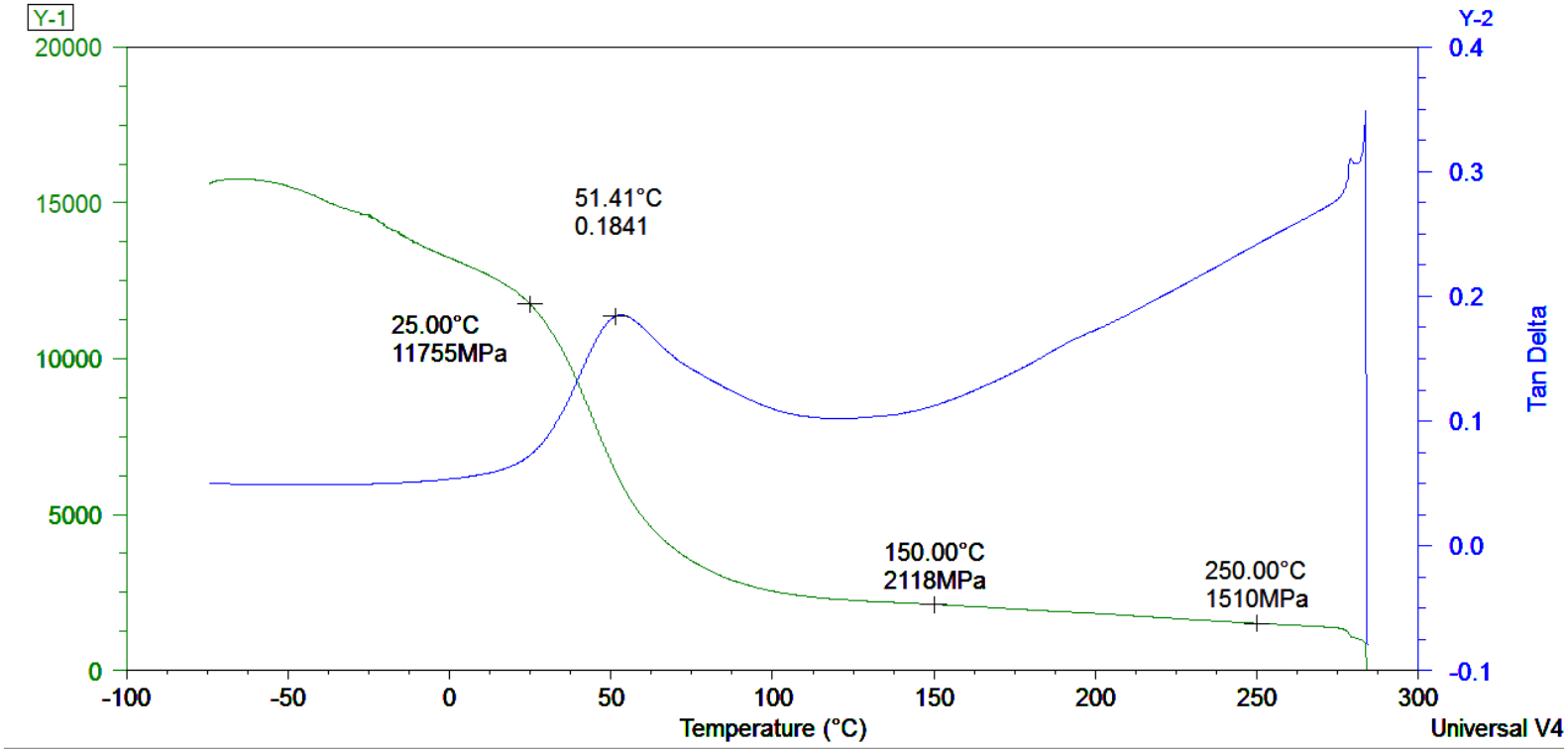
Thermal Analytical Data

CTE-TMA Method



Thermal Analytical Data

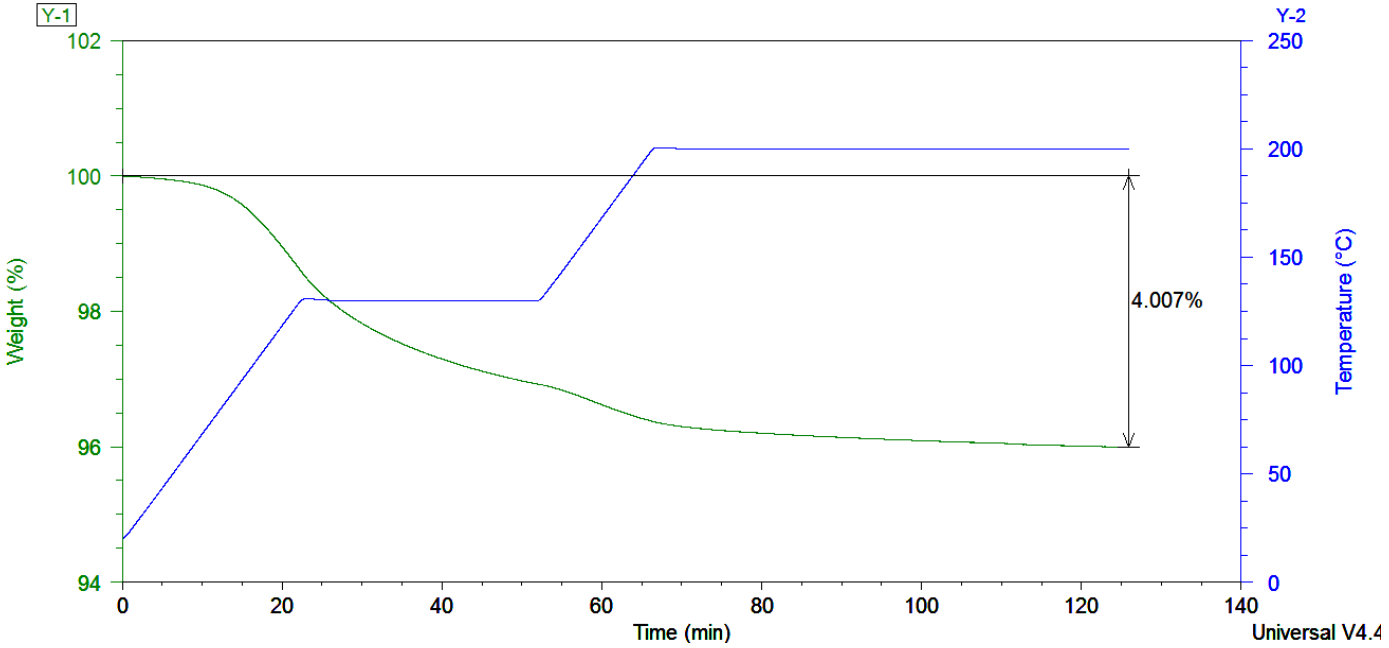
DMA



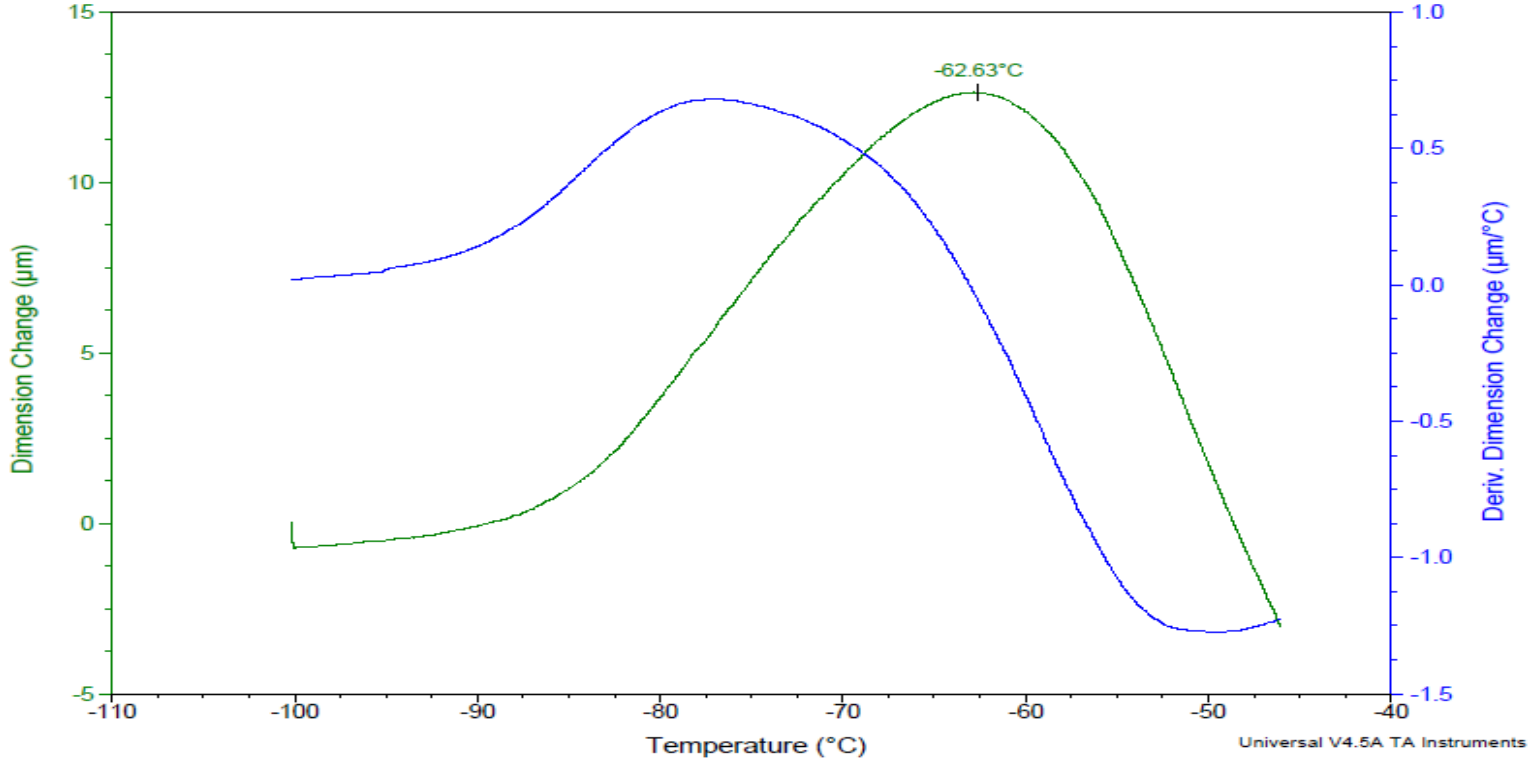
Thermal Analytical Data

TGA During Cure

- The weight loss with standard cure condition (20min ramp from RT to 130° C and dwell for 30min, 15min ramp from 130° C to 200° C and dwell for 1h)

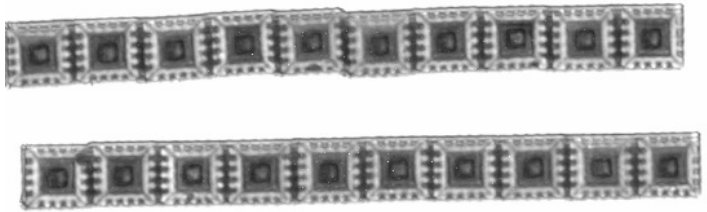
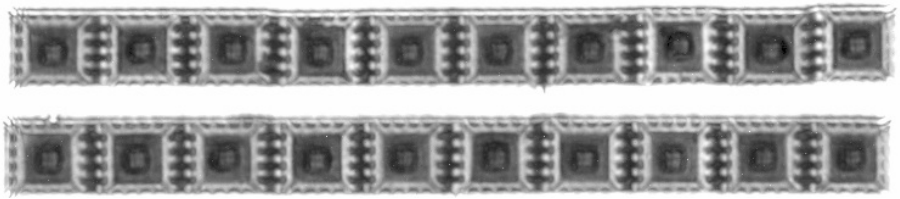
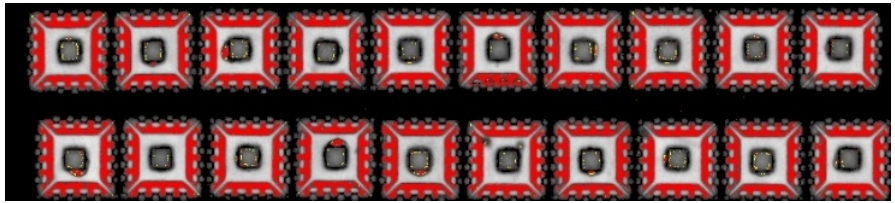


Freezing point



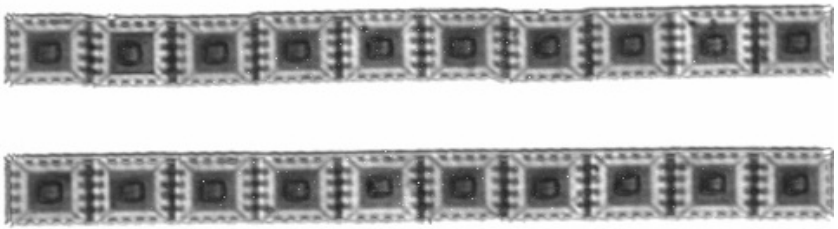
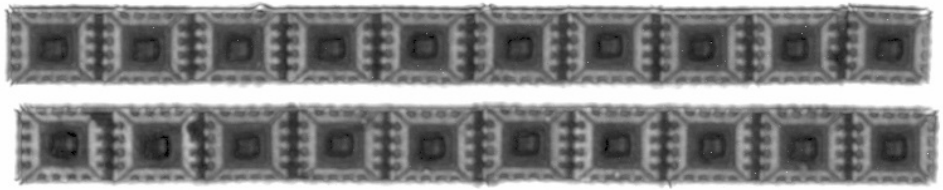
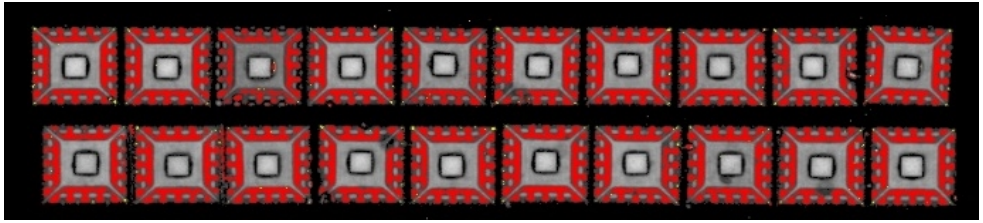
1X1mm Ag BM die with Ag LF MSL1

DA	DP	DT	DA&DP
0/20	0/20	0/20	0/20

T-SCAN Before MSL1	
T-SCAN After MSL1	
C-SCAN After MSL1	

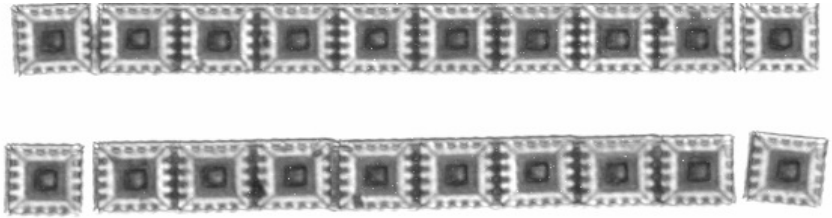
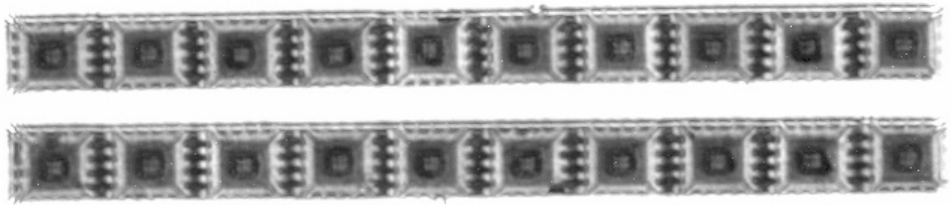
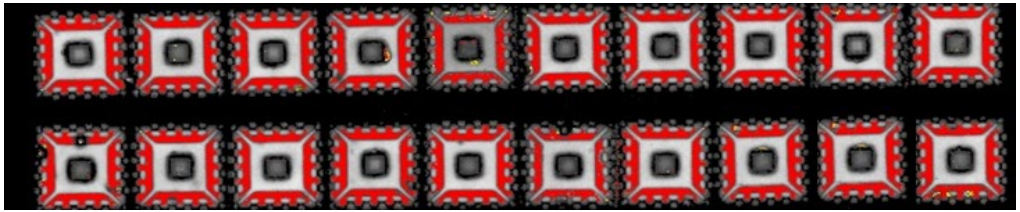
1X1mm Ag BM die with Cu LF MSL1

DA	DP	DT	DA&DP
0/20	0/20	0/20	0/20

T-SCAN Before MSL1	
T-SCAN After MSL1	
C-SCAN After MSL1	

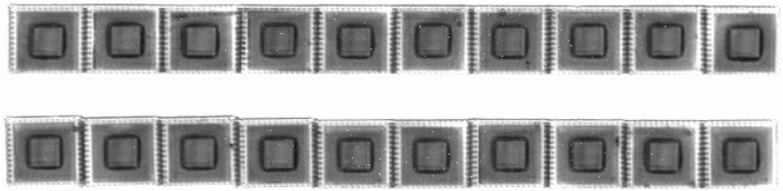
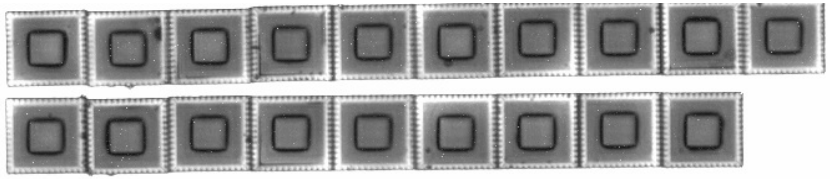
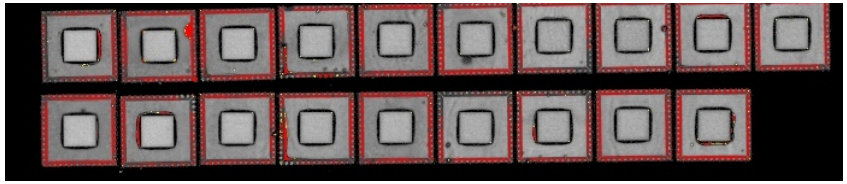
1X1mm Ag BM die with PPF LF MSL1

DA	DP	DT	DA&DP
0/20	0/20	0/20	0/20

T-SCAN Before MSL1	
T-SCAN After MSL1	
C-SCAN After MSL1	

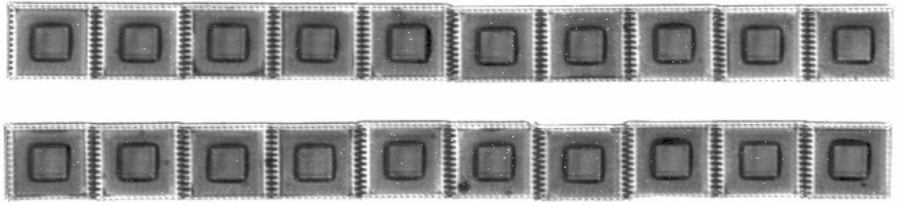
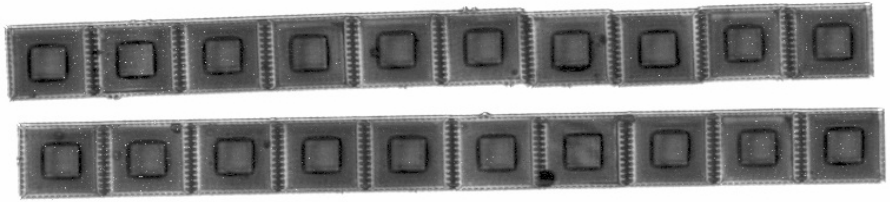
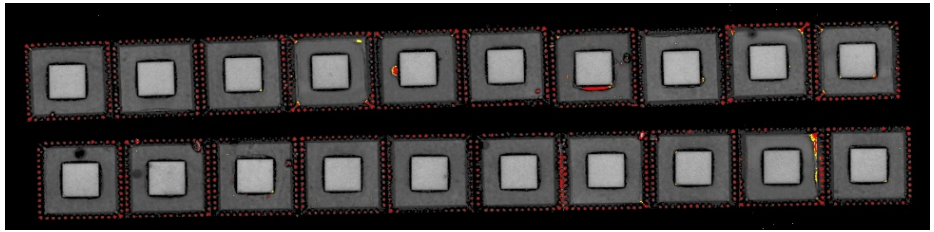
3X3mm Ag BM die with Ag LF MSL1

DA	DP	DT	DA&DP
0/19	0/19	0/19	0/19

T-SCAN Before MSL1	
T-SCAN After MSL1	
C-SCAN After MSL1	

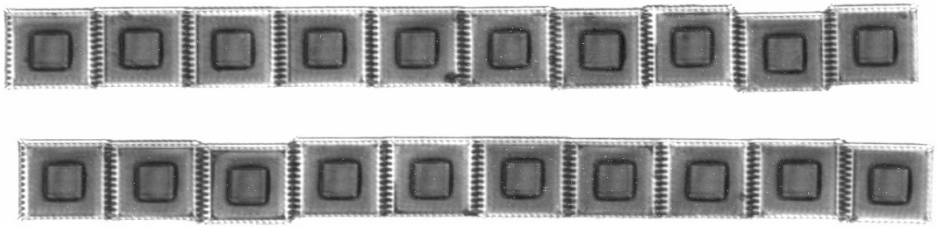
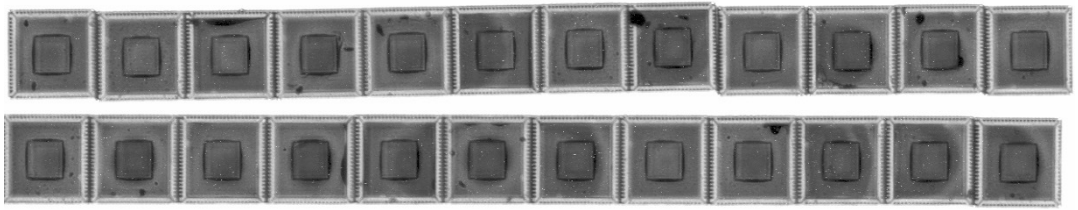
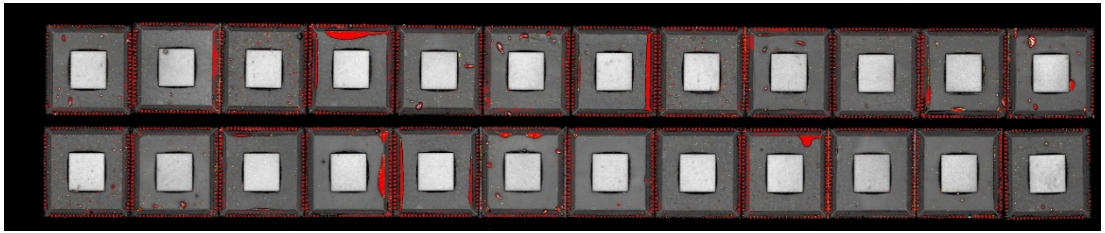
3X3mm Ag BM die with PPF LF MSL1

DA	DP	DT	DA&DP
0/20	0/20	0/20	0/20

T-SCAN Before MSL1	
T-SCAN After MSL1	
C-SCAN After MSL1	

5X5mm Ag BM die with PPF LF MSL1

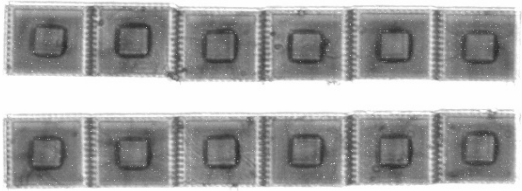
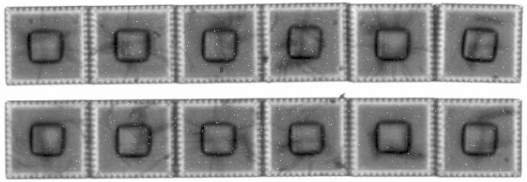
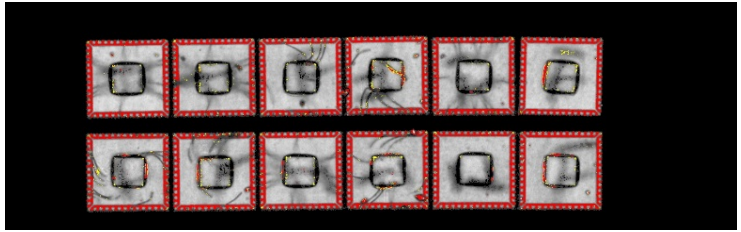
DA	DP	DT	DA&DP
0/24	0/24	0/24	0/24

T-SCAN Before MSL1	
T-SCAN After MSL1	
C-SCAN After MSL1	

2.54X2.54mm Ag BM die with Ag LF MSL1

Cured with 175C 1hr

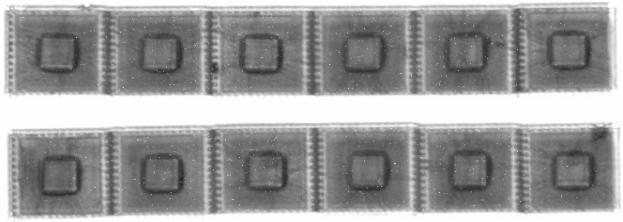
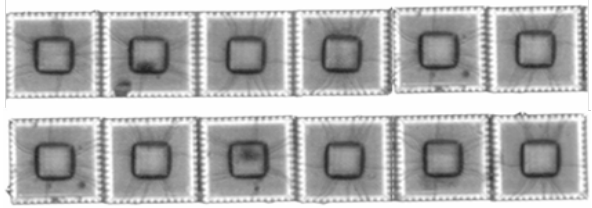
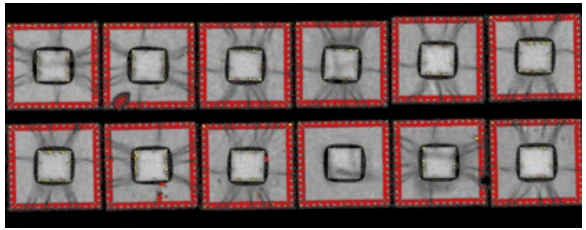
DA	DP	DT	DA&DP
0/12	0/12	0/12	0/12

T-SCAN Before MSL1	
T-SCAN After MSL1	
C-SCAN After MSL1	

2.54X2.54mm Ag BM die with PPF LF MSL1

Cured with 175C 1hr

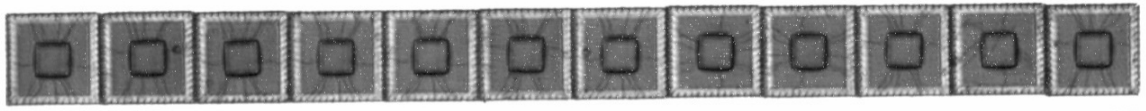
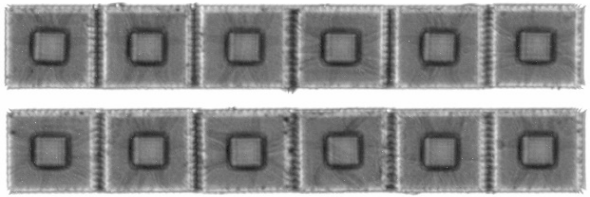
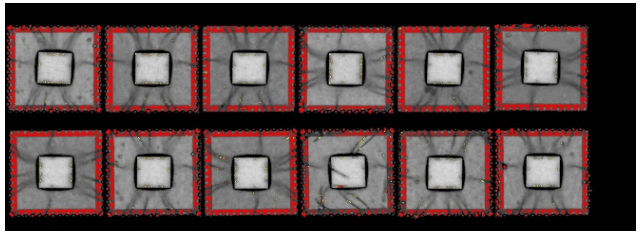
DA	DP	DT	DA&DP
0/12	0/12	0/12	0/12

T-SCAN Before MSL1	
T-SCAN After MSL1	
C-SCAN After MSL1	

2.54X2.54mm Ag BM die with Ag LF MSL1

Cured with 200C 1hr

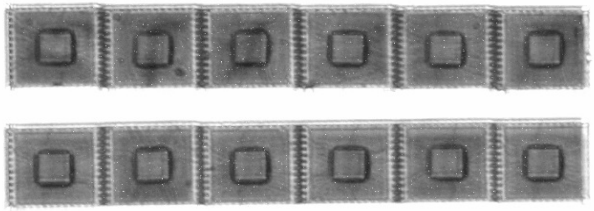
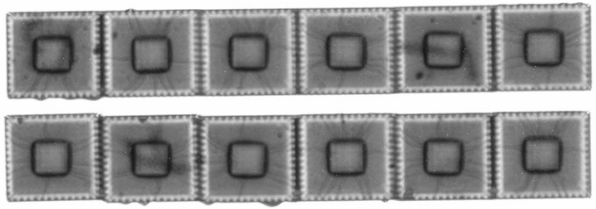
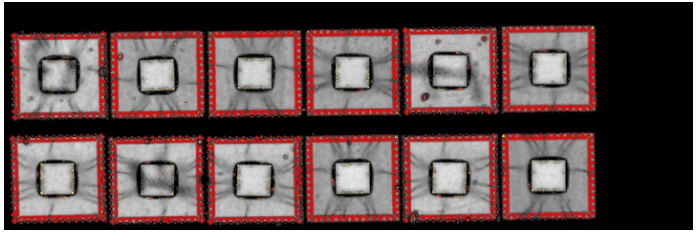
DA	DP	DT	DA&DP
0/12	0/12	0/12	0/12

T-SCAN Before MSL1	
T-SCAN After MSL1	
C-SCAN After MSL1	

2.54X2.54mm Ag BM die with PPF LF MSL1

Cured with 200C 1hr

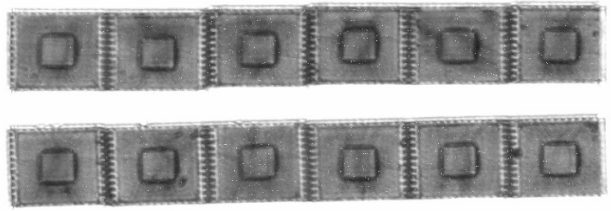
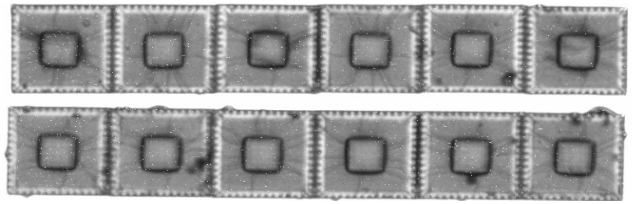
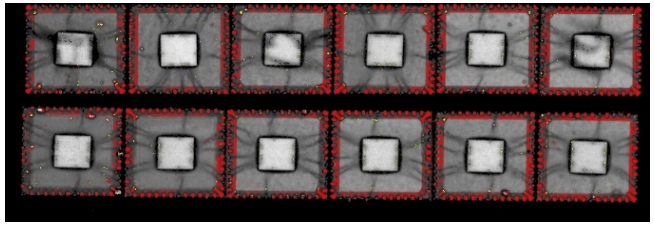
DA	DP	DT	DA&DP
0/12	0/12	0/12	0/12

T-SCAN Before MSL1	
T-SCAN After MSL1	
C-SCAN After MSL1	

2.54X2.54mm Ag BM die with Ag LF MSL1

Cured with 200C 2hr

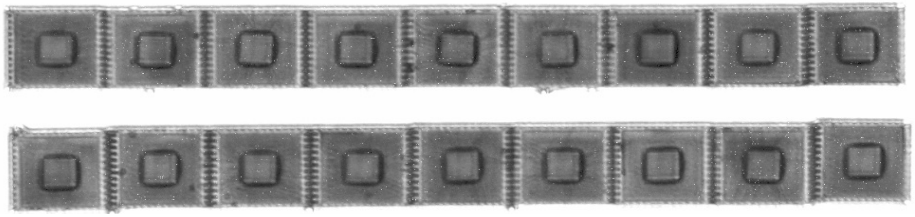
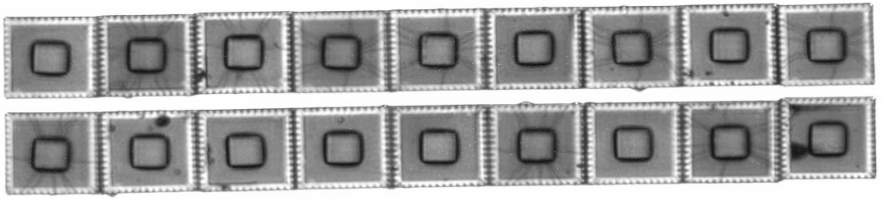
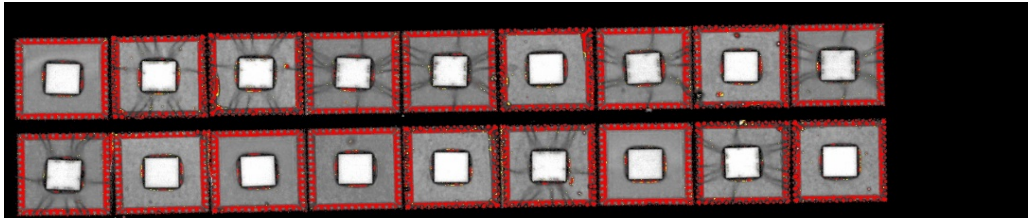
DA	DP	DT	DA&DP
0/12	0/12	0/12	0/12

T-SCAN Before MSL1	
T-SCAN After MSL1	
C-SCAN After MSL1	

2.54X2.54mm Ag BM die with PPF LF MSL1

Cured with 200C 2hr

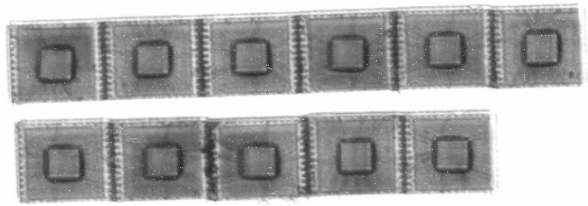
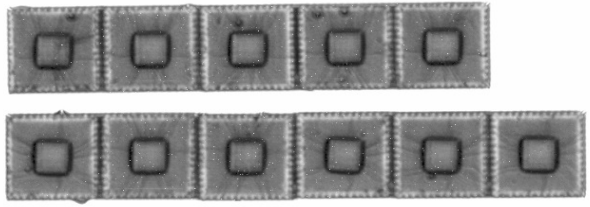
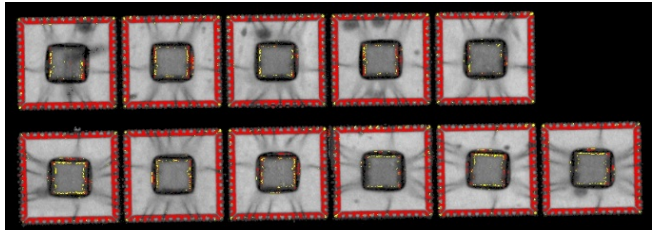
DA	DP	DT	DA&DP
0/18	0/18	0/18	0/18

T-SCAN Before MSL1	
T-SCAN After MSL1	
C-SCAN After MSL1	

2.54X2.54mm Ag BM die with Ag LF MSL1

Cured with 220C 1hr

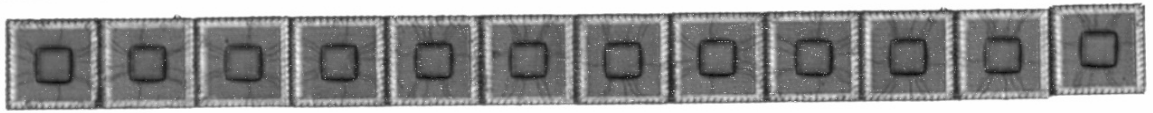
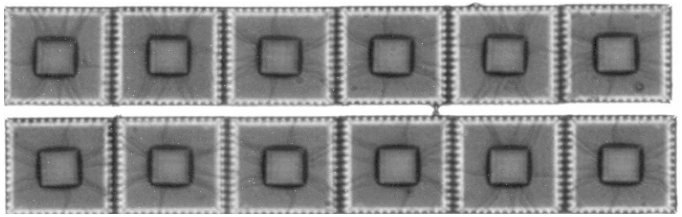
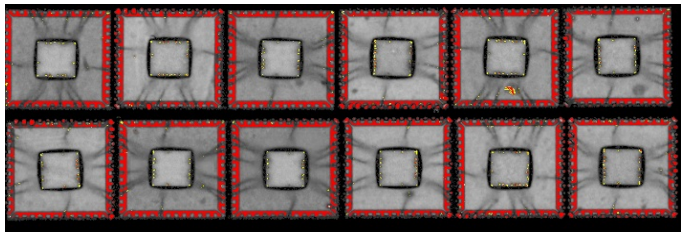
DA	DP	DT	DA&DP
0/11	0/11	0/11	0/11

T-SCAN Before MSL1	
T-SCAN After MSL1	
C-SCAN After MSL1	

2.54X2.54mm Ag BM die with PPF LF MSL1

Cured with 220C 1hr

DA	DP	DT	DA&DP
0/12	0/12	0/12	0/12

T-SCAN Before MSL1	
T-SCAN After MSL1	
C-SCAN After MSL1	

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