MPT(Micro Pattern Treatment) technology to protect the delamination

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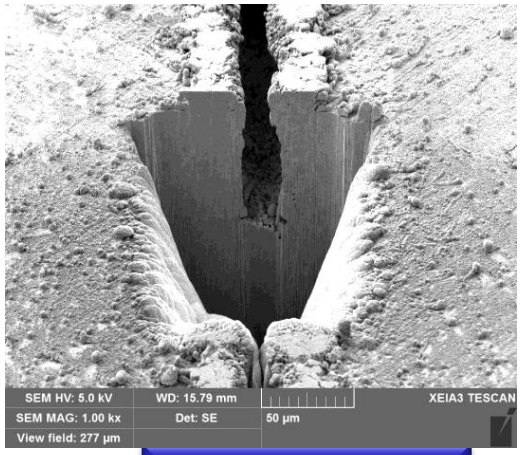
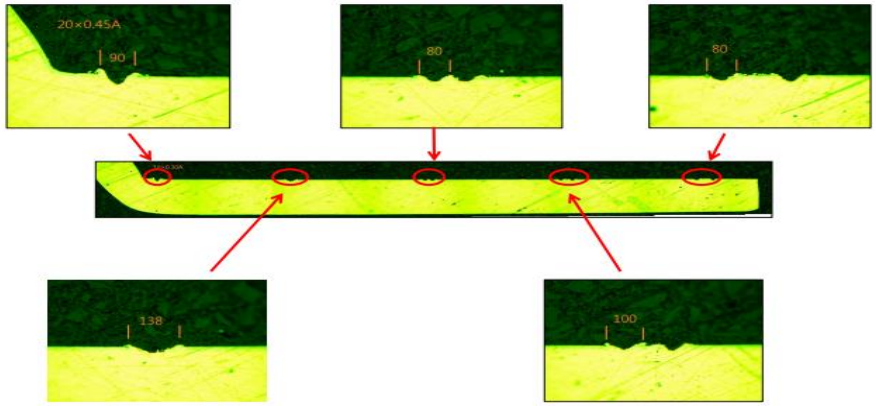
Contents

1. What the MPT(Micro Pattern Treatment) is

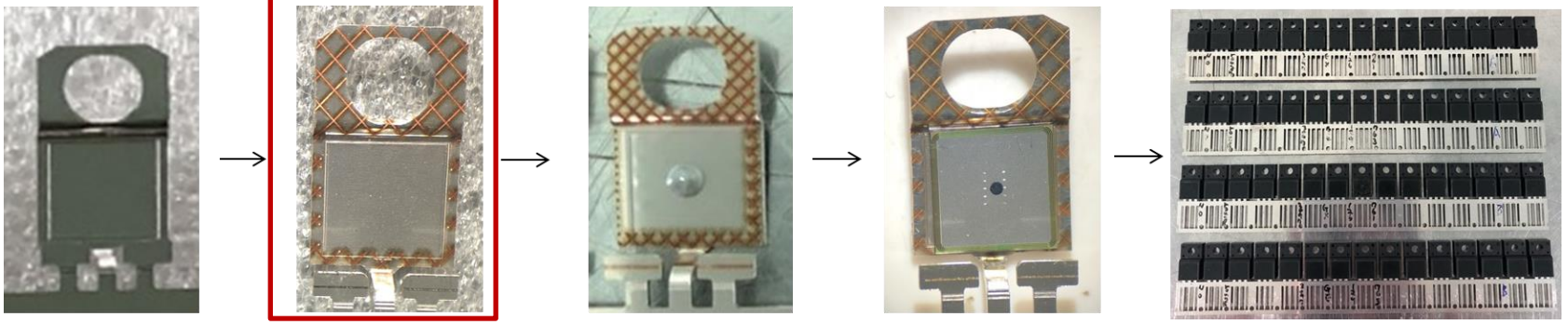
Metal surface treatment for high reliability (Micro pattern using Laser)



Cross-Section



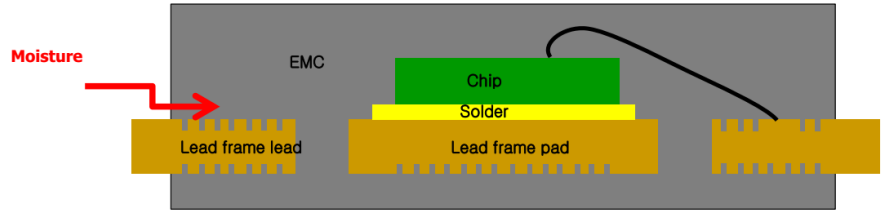
Laser pattering

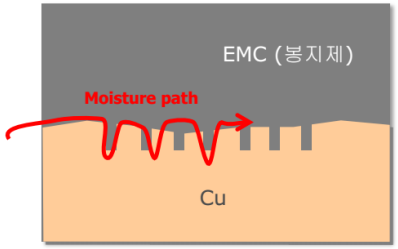


2. Background & Applications

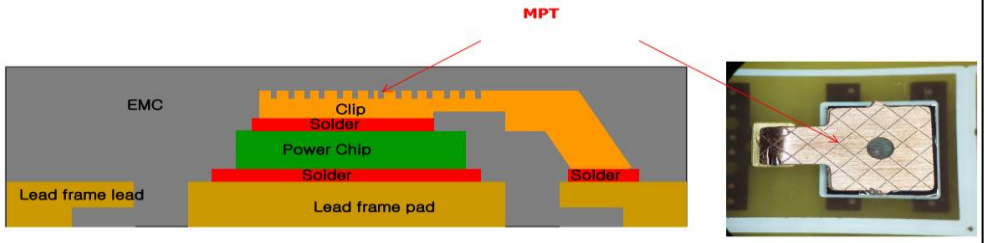
We can make the MPT on L/F, DBC and Clip surface.

Moisture ingress prevention



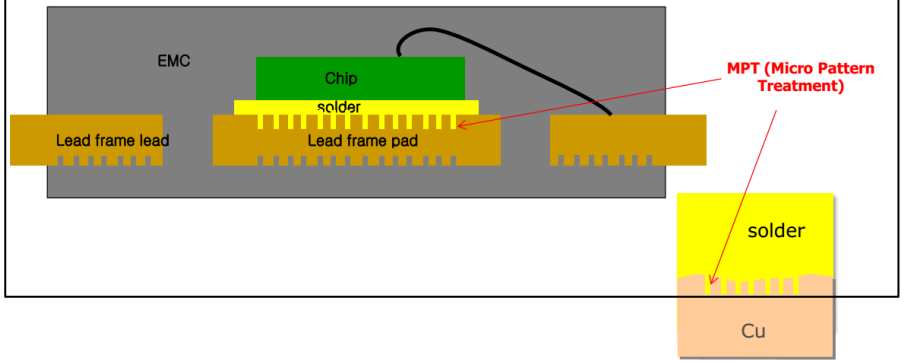


Increase clip to mold adhesion



- ✓ **Long moisture path !!**
- ✓ **High EMC, Solder adhesion !!**

Increase solder to leadframe adhesion



3. Why we need the MPT.

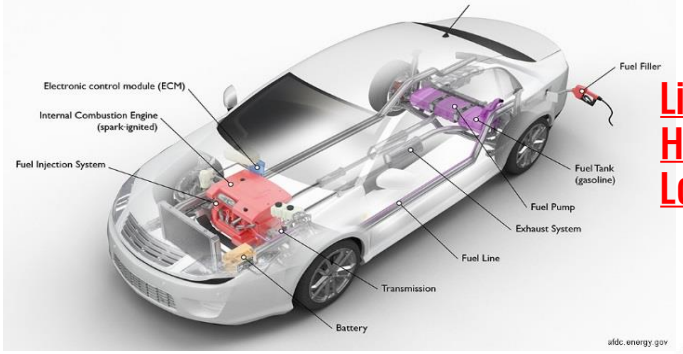
Internal stress is increased caused by small and thin package. ➔ To protect the Del., we need high adhesion EMC.

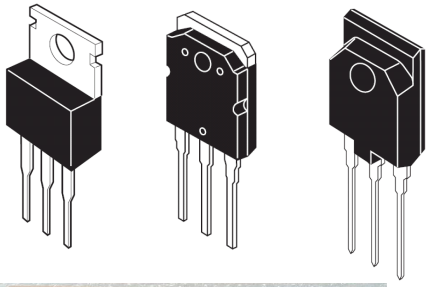
Auto motive

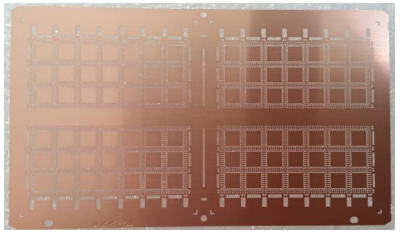
Power Package

MPT

Current



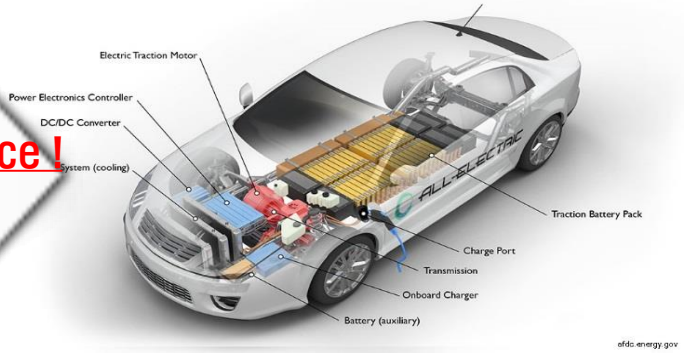


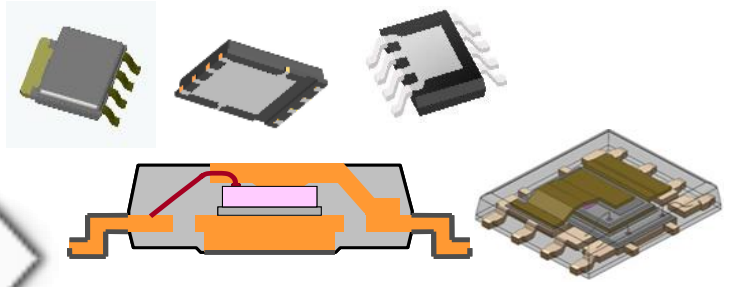


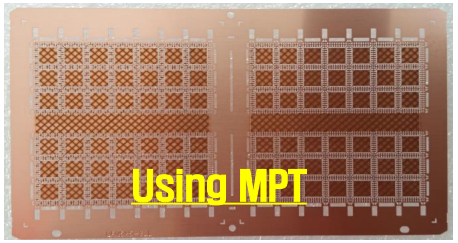
Light !
High performance !
Long life time !

Small !
Thin !
High reliability !

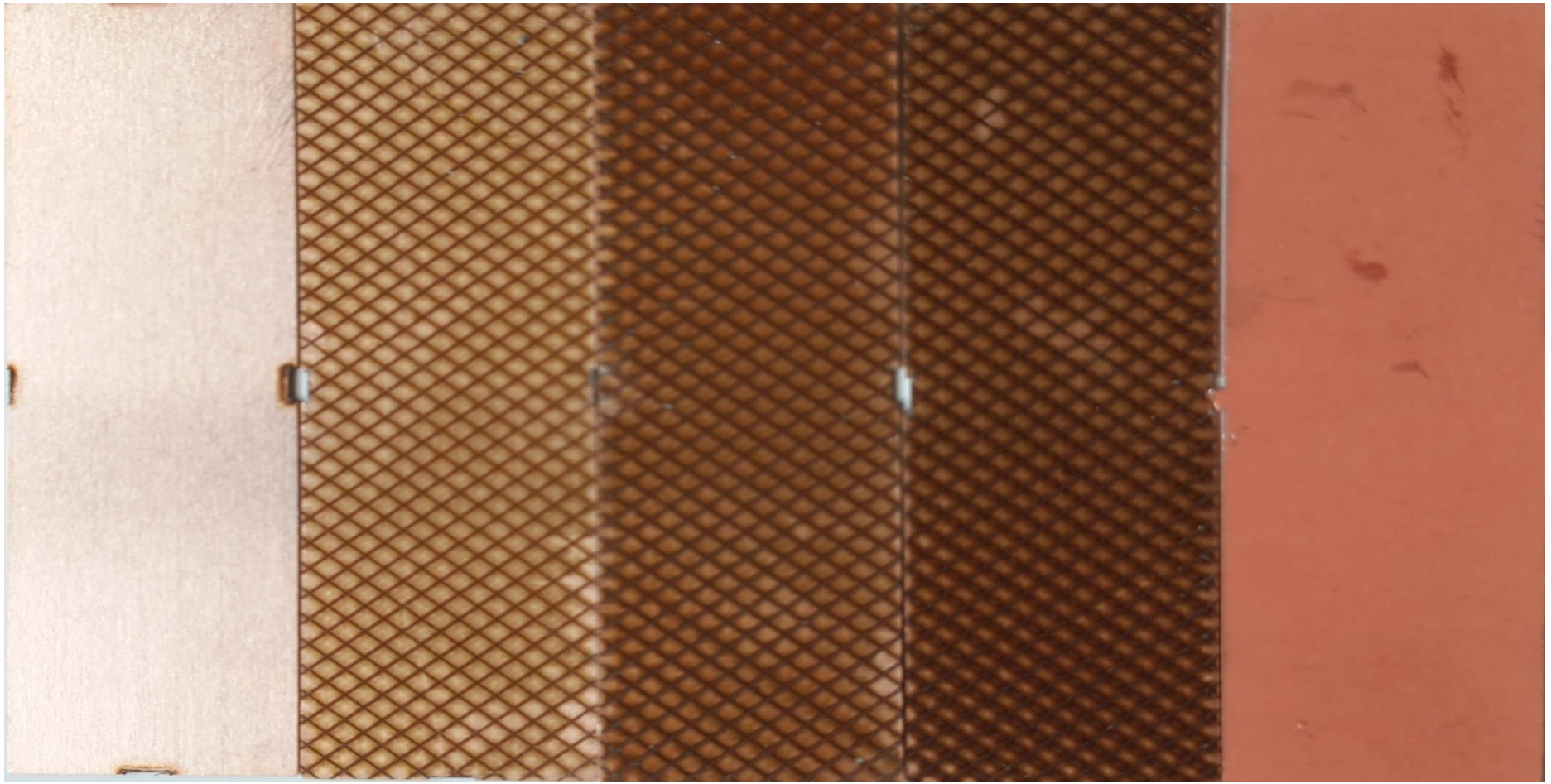
Future



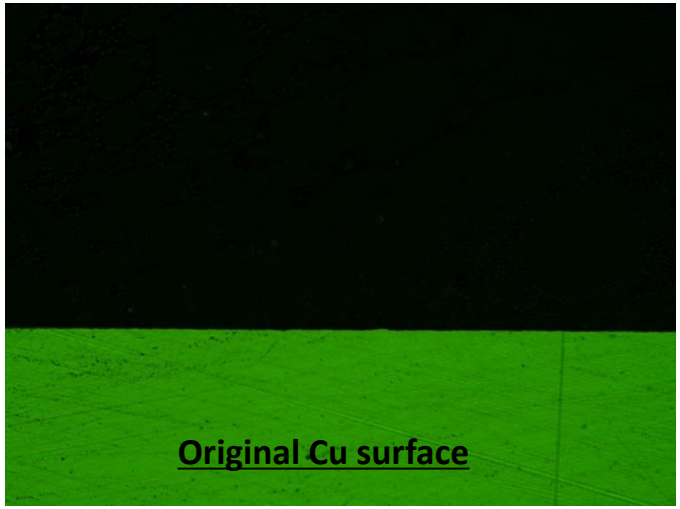


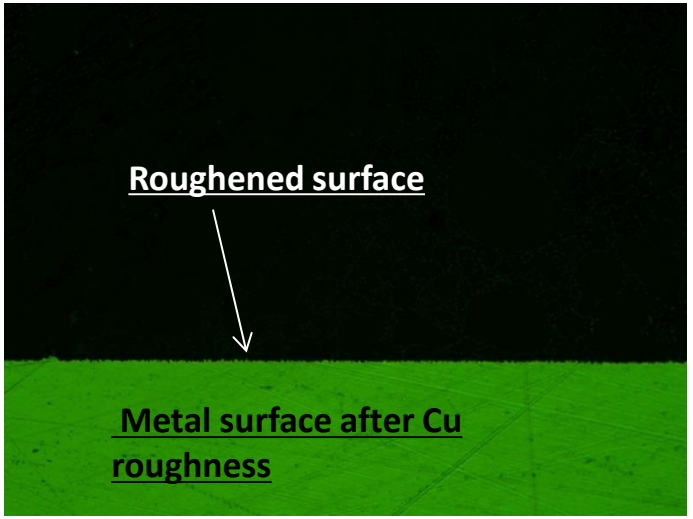


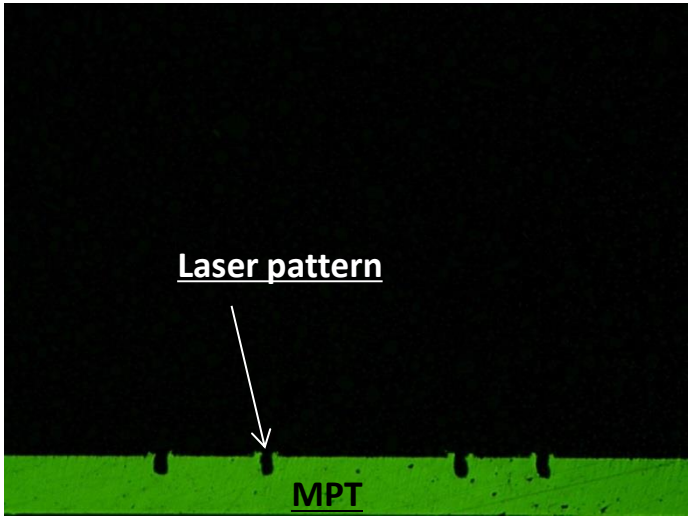
4. Test report of EMC adhesing using MPT



(Original) power 60% : case 1 power 100% : case 2 power 70%:case3 Roughened Cu

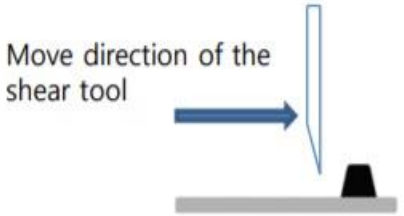


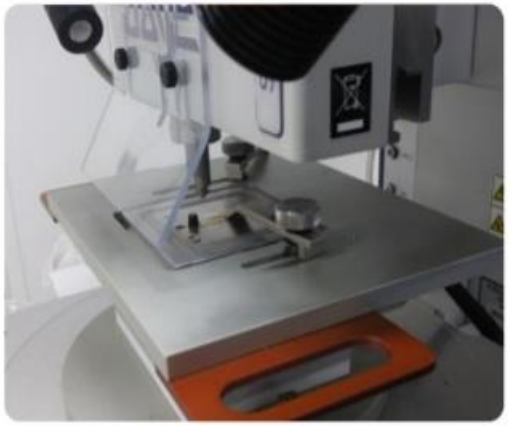




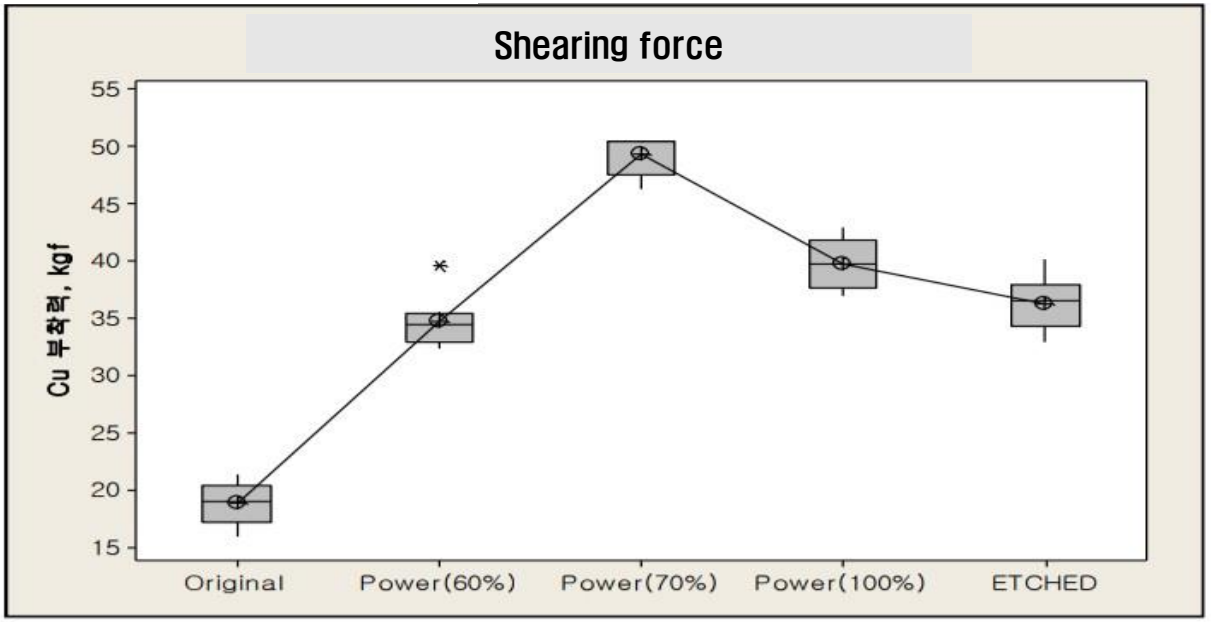
◈ Test method : Button shear

Molded EMC size : 5.5ϕ X 5mm





Adhesion test report



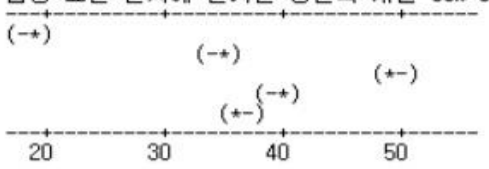
일원 분산 분석: Original, Power(60%), Power(70%), Power(100%), ETCHED

출처	DF	SS	MS	F	P
요인	4	3929.41	982.35	222.76	0.000
오차	35	154.35	4.41		
총계	39	4083.76			

S = 2.100 R-제곱 = 96.22% R-제곱(수정) = 95.79%

수준	N	평균	표준 편차
Original	8	18.887	1.815
Power(60%)	8	34.763	2.306
Power(70%)	8	49.488	1.796
Power(100%)	8	39.850	2.146
ETCHED	8	36.388	2.369

합동 표준 편차에 근거한 평균의 개별 95% CI



합동 표준 편차 = 2.100

KTMC KCC Transfer Molding Compound **KCC** Corporation

844, YONGAM-RI, BONG DONG-EUP WANJU-GUN, JEON BUK, KOREA
TEL) 82-63-260-1880 FAX) 82-63-260-1885

KTMC-5400GV

1. Characteristics

Environmentally friendly version Epoxy mold compound (Green)
It has the higher glass transition temperature (T_g)
- **Especially it can be applied for SiC chip devices.**

Good performance in high junction temperature($T_j \geq 175$degC)

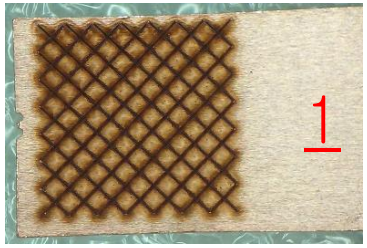
2. Formulation

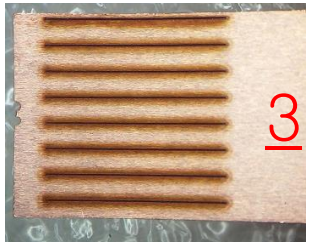
Inorganic component	85±2 wt%
Resin system	Special Epoxy Resin / Multi functional type
Filler	Type : Fused silica only Shape : Spherical mainly
Flame Retardant	Inorganic

3. Recommended Application

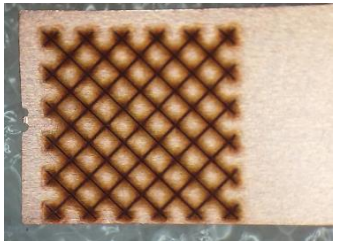
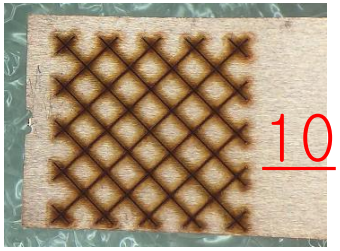
Packages	High temperature operating devices etc.

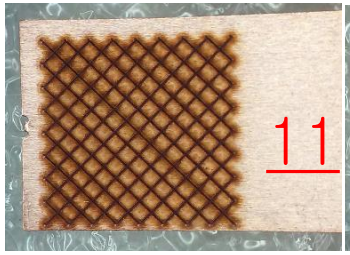
Cu	Unit	Adhesion test result															
LOT No.		Original Cu	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14	#15
1	kgf	23.39	41.74	36.18	37.98	45.02	45.71	37.36	34.84	38.88	38.02	44.91	>50.5	>50.59	>50.61	>50.61	49.58
2		19.51	45.39	36.66	33.00	45.92	38.96	40.40	36.43	41.74	35.87	45.94	47.96	>50.62	>50.58	49.05	50.32
3		20.99	43.87	44.54	33.63	44.93	45.61	35.53	33.43	39.50	41.64	43.36	47.43	>50.57	>50.61	42.90	49.05
4		23.69	42.10	36.70	38.84	40.96	45.73	36.20	34.85	42.63	45.73	42.98	43.38	>50.59	>50.64	47.22	49.58
5		21.28	42.55	40.16	33.99	47.94	44.67	43.07	35.87	39.75	40.96	48.48	>50.6	>50.57	>50.59	50.42	>50.56
6		21.37	41.33	37.98	35.99	43.90	48.66	30.63	37.65	36.75	38.96	44.61	48.49	>50.59	>50.56	40.30	>50.59
7		24.02	50.57	37.71	39.69	48.49	47.55	35.55	38.64	39.40	40.20	49.52	>50.57	>50.57	>50.58	47.19	>50.57
8		21.83	44.41	39.72	-	49.98	45.36	34.72	41.64	43.02	37.01	41.57	48.53	>50.59	>50.58	49.35	>50.59
Aver.		22.04	43.94	38.56	36.16	45.89	45.28	36.68	36.67	40.21	39.80	45.17	>50.6	>50.6	>50.6	>50.6	>50.6
Stdev		1.68	3.24	2.95	2.71	2.87	2.86	3.75	2.60	2.11	3.10	2.72	-	-	-	-	-



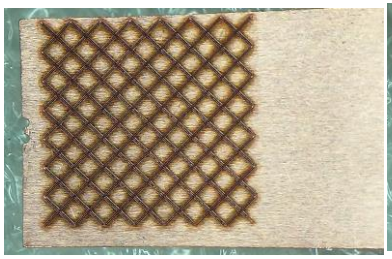
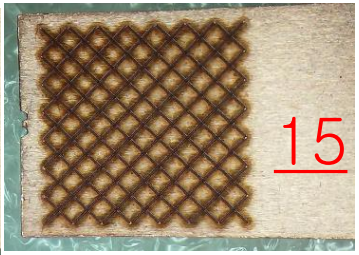




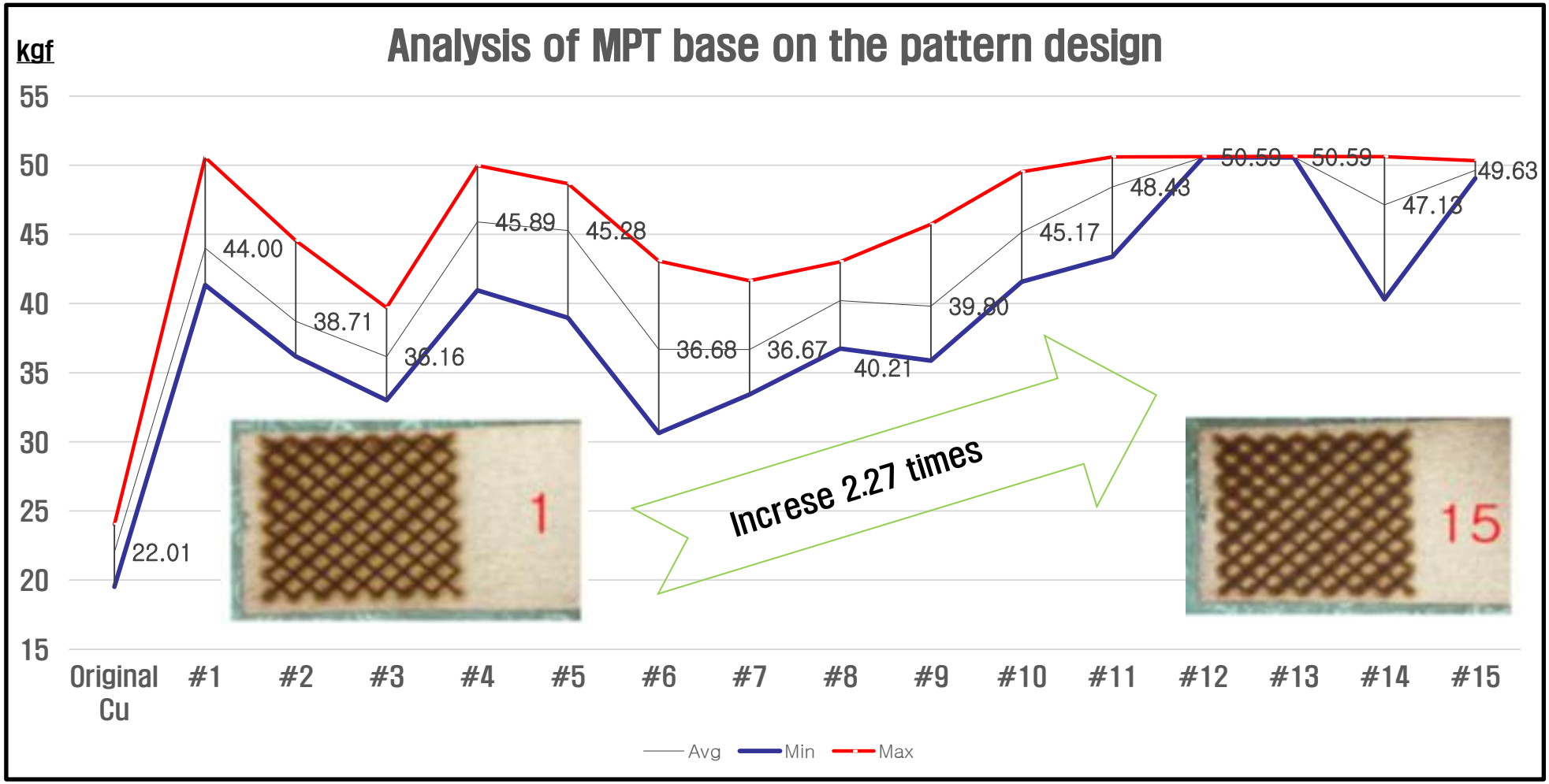







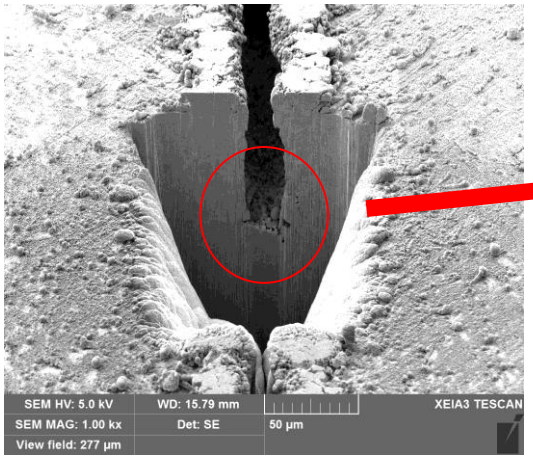



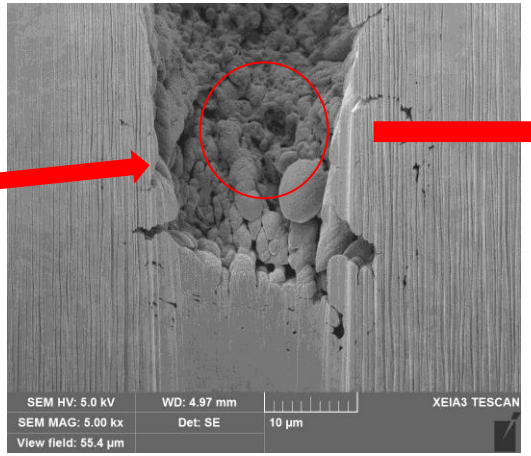
EMC adhesion strength
➔ We can control the adhesion according to the pattering.

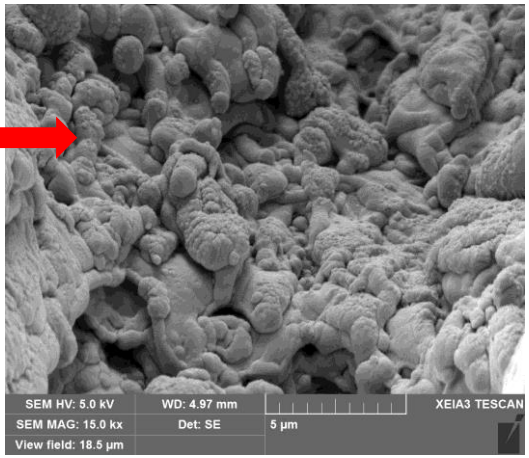


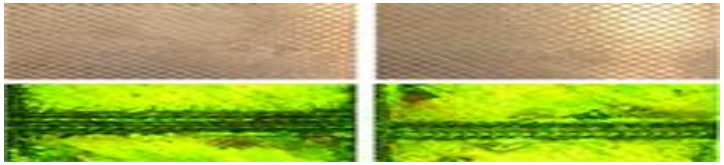
FIB analysis of MPT

* FIB photo of MPT









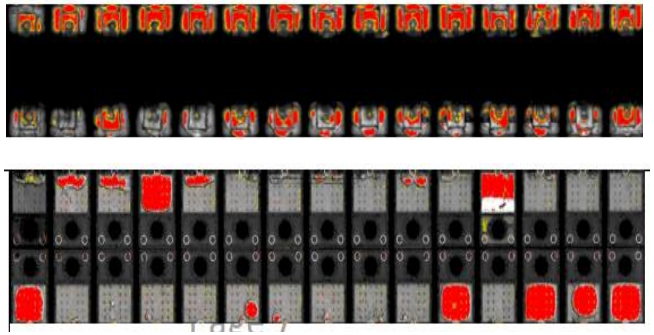
5. Rel. test when we use the MPT

MPT advantage
Rel. : protection of Del. Molding : Increasing of EMC adhesion

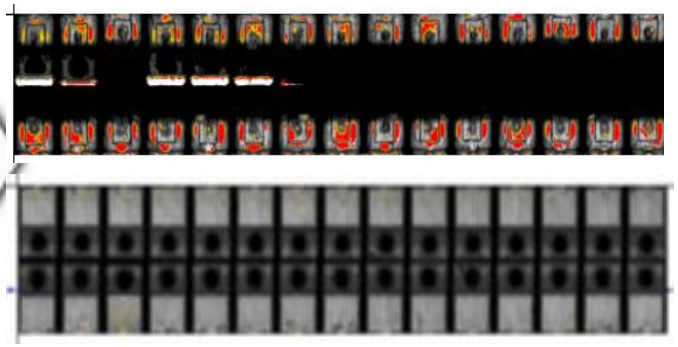
No laser patterning

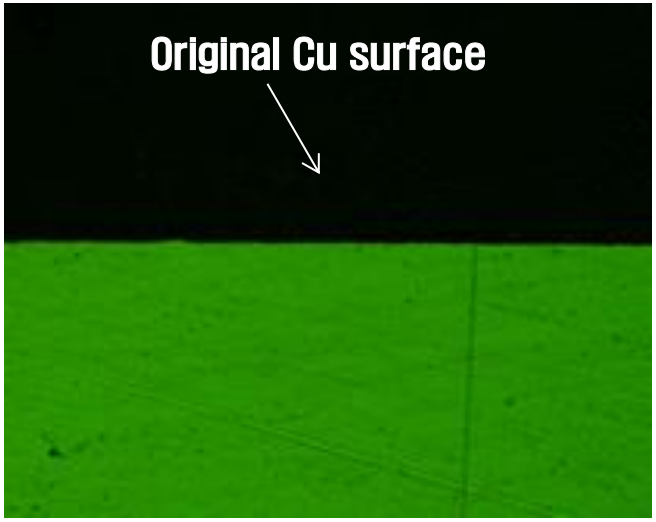
Laser patterning

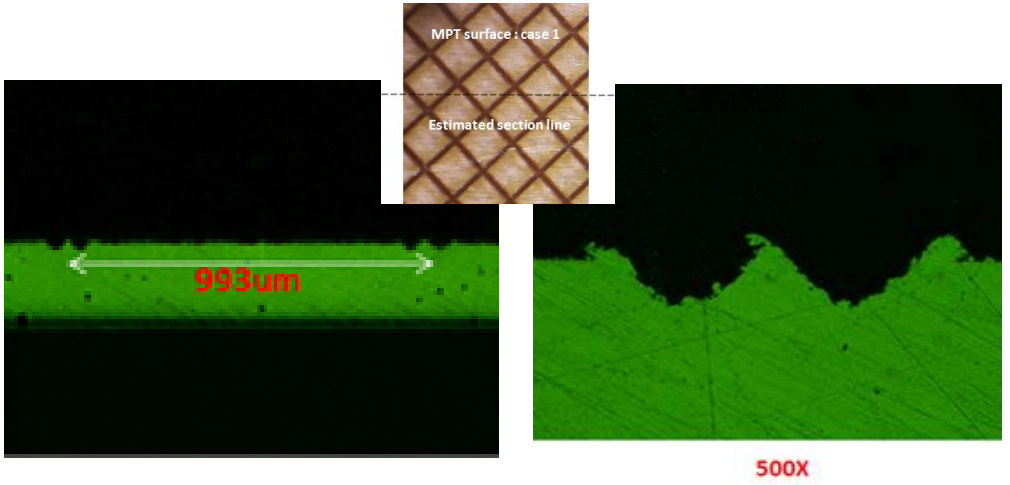
After thermal cycling



High Rel.







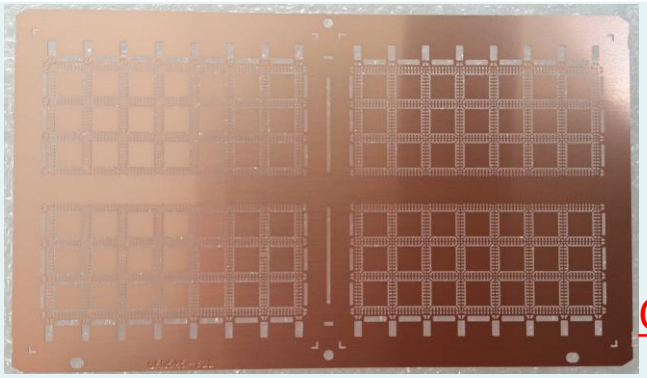
1. T/C Rel. test using QFN package.

Objective

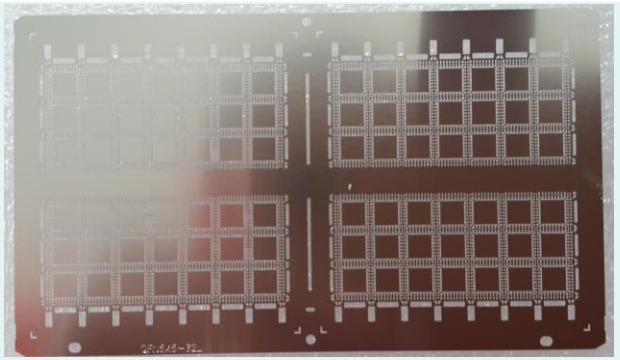
To compare the delamination performance by CSAM of different leadframe surface finish with Micro Laser Patterning Technology after thermal cycle -45~150℃ @15mins dwell time.

Delamination Evaluation Matrix

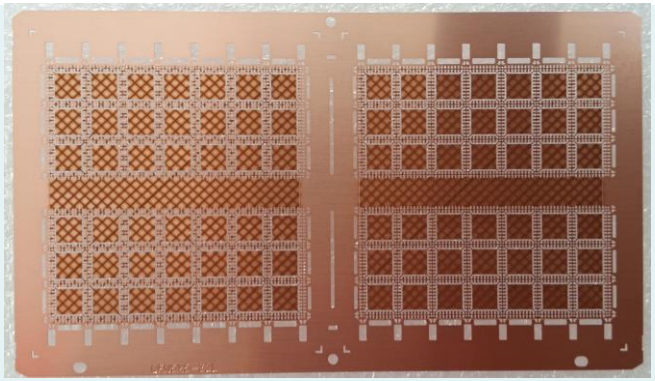
Leg	Leadframe Finish	Leadframe Adhesion Enhancer	EMC	Quantity
1	Cu bare	None	KTMC-5800GQS	1 Leadframe (84 units)
2	Cu bare	Micro patterning	KTMC-5800GQS	1 Leadframe (84 units)
3	Cu bare	Black oxide treatment	KTMC-5800GQS	1 Leadframe (84 units)
4	Ni plated	None	KTMC-5800GQS	1 Leadframe (84 units)
5	Ni plated	Micro patterning	KTMC-5800GQS	1 Leadframe (84 units)
6	Ni/Au plated	None	KTMC-5800GQS	1 Leadframe (84 units)



Copper

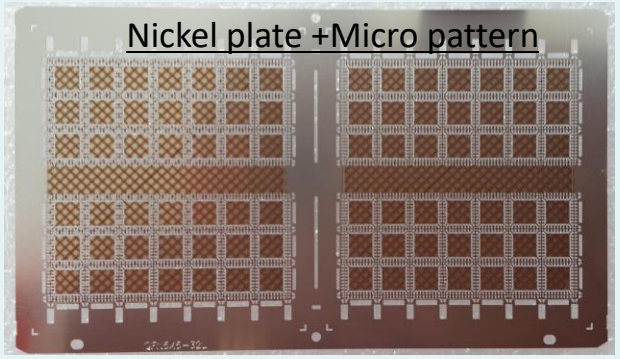


Nickel

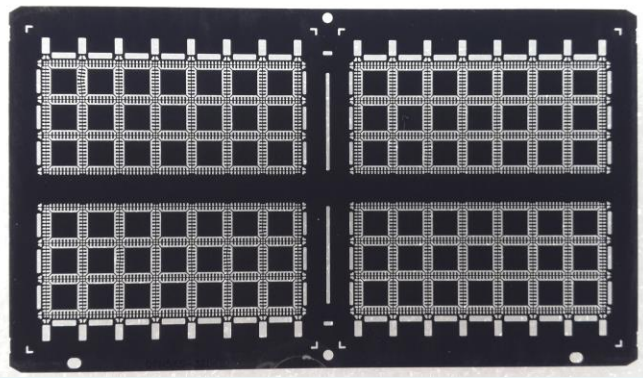


Copper
+ MPT

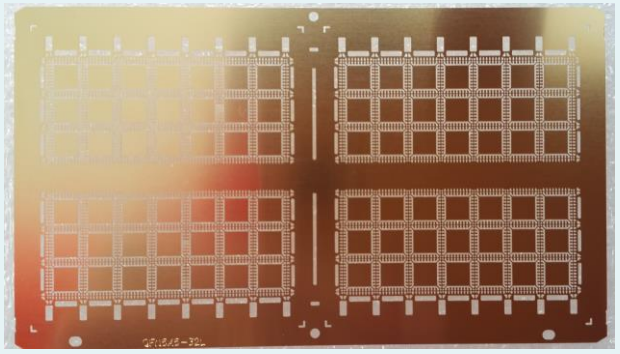
Nickel plate +Micro pattern



Nickel + MPT

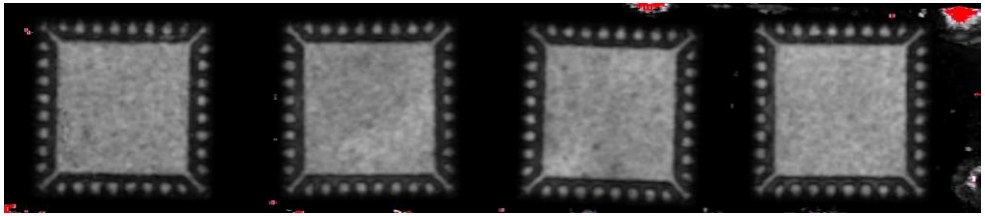


Black
oxide

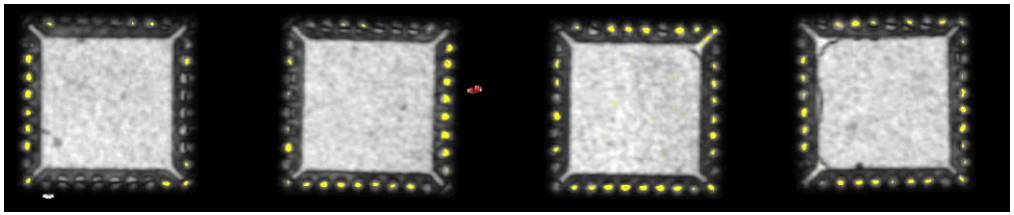


PPF

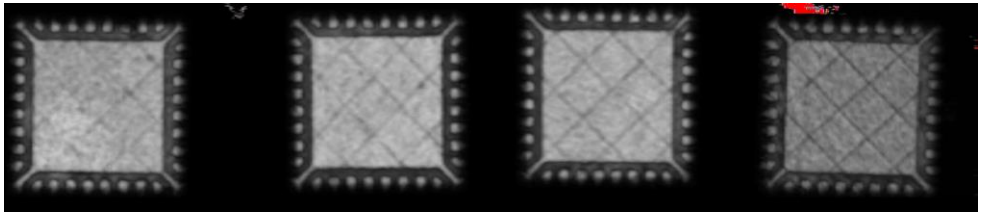
After T/C 1000 cycle



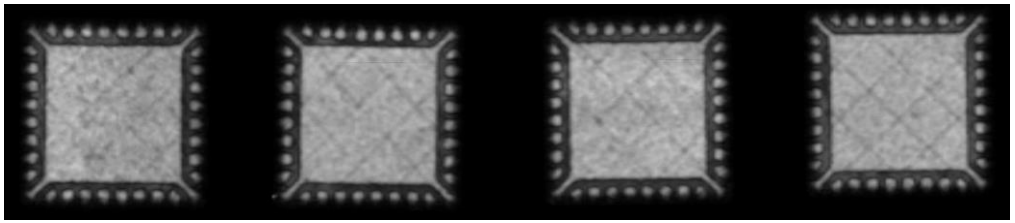
Copper



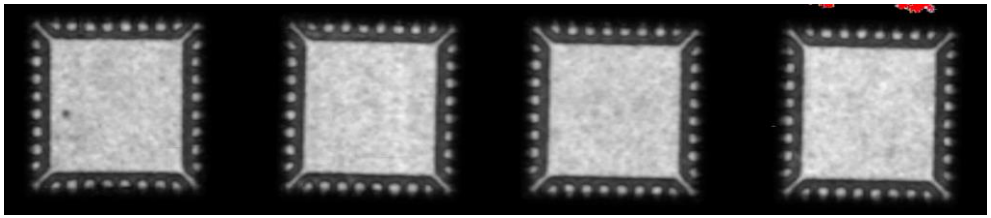
Nickel



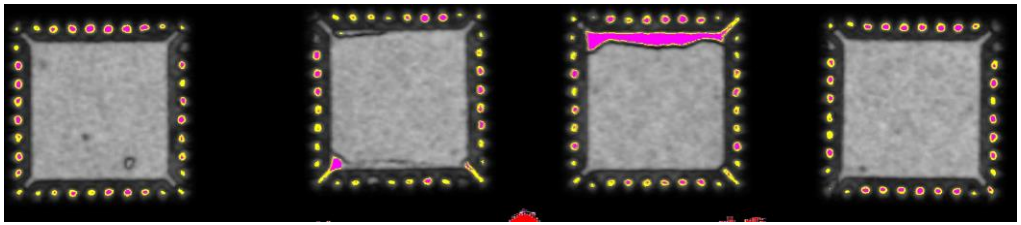
Copper + MPT



Nickel + MPT

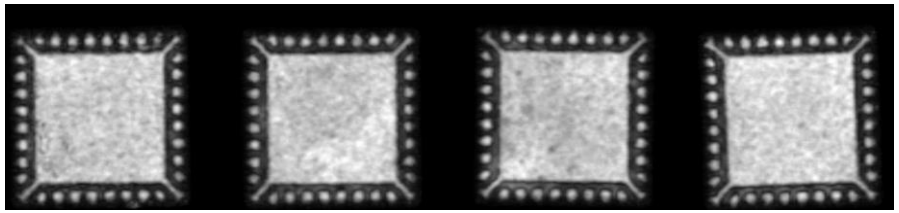


Black oxide

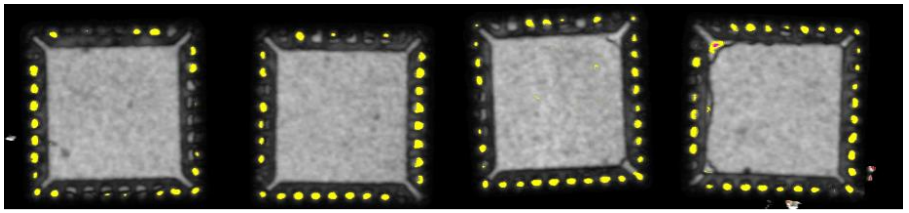


PPF

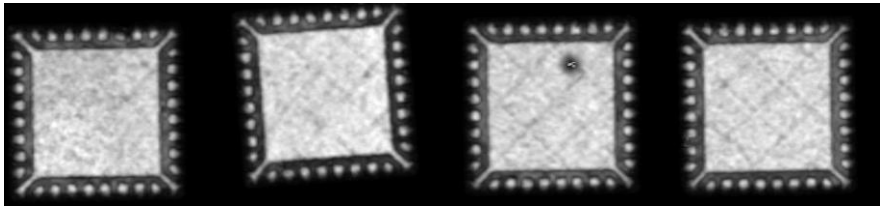
After T/C 2000 cycle



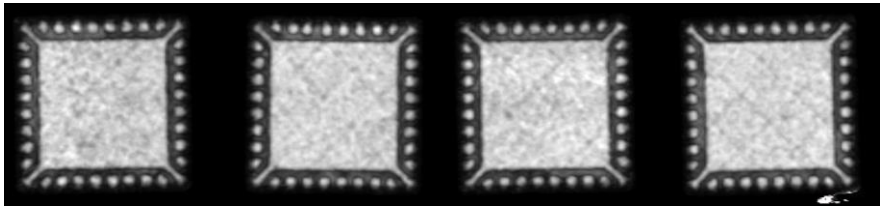
Copper



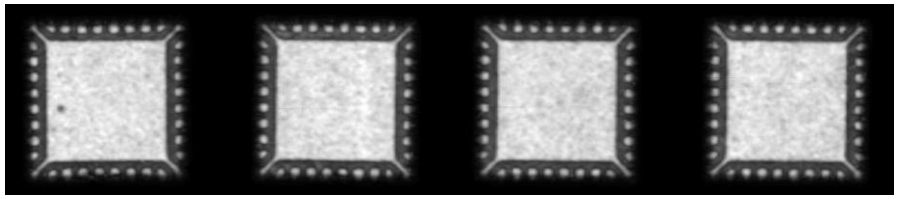
Nickel



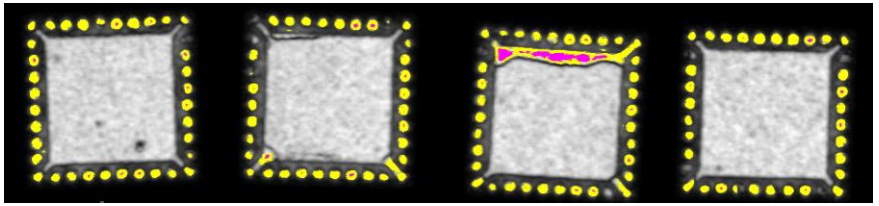
Copper + MPT



Nickel + MPT

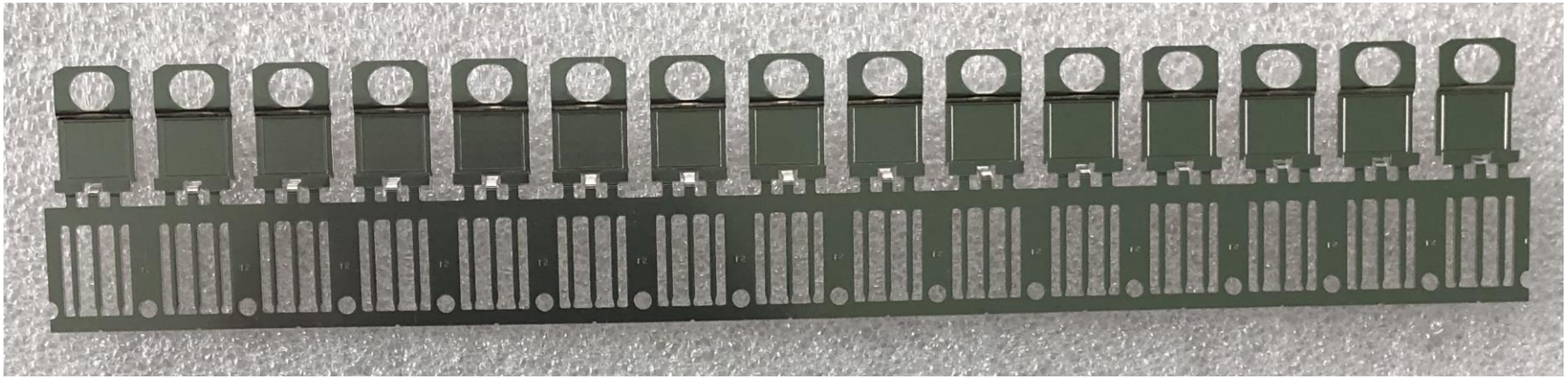


Black oxide



PPF

2. T/C Rel. test using TO-220 package



Top

Bottom

Top

Bottom

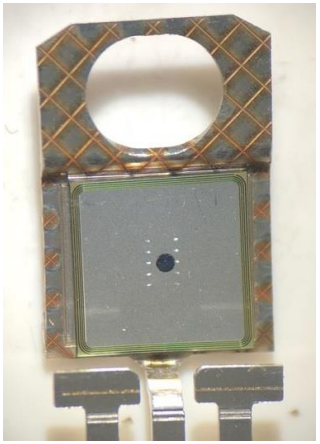
Groove Width	80 ~ 140 μm
Groove Depth	35~45 μm

TO-220 Packaging process

TO-220

Laser groove
Top & Bottom side

Solder dispense
on DAP



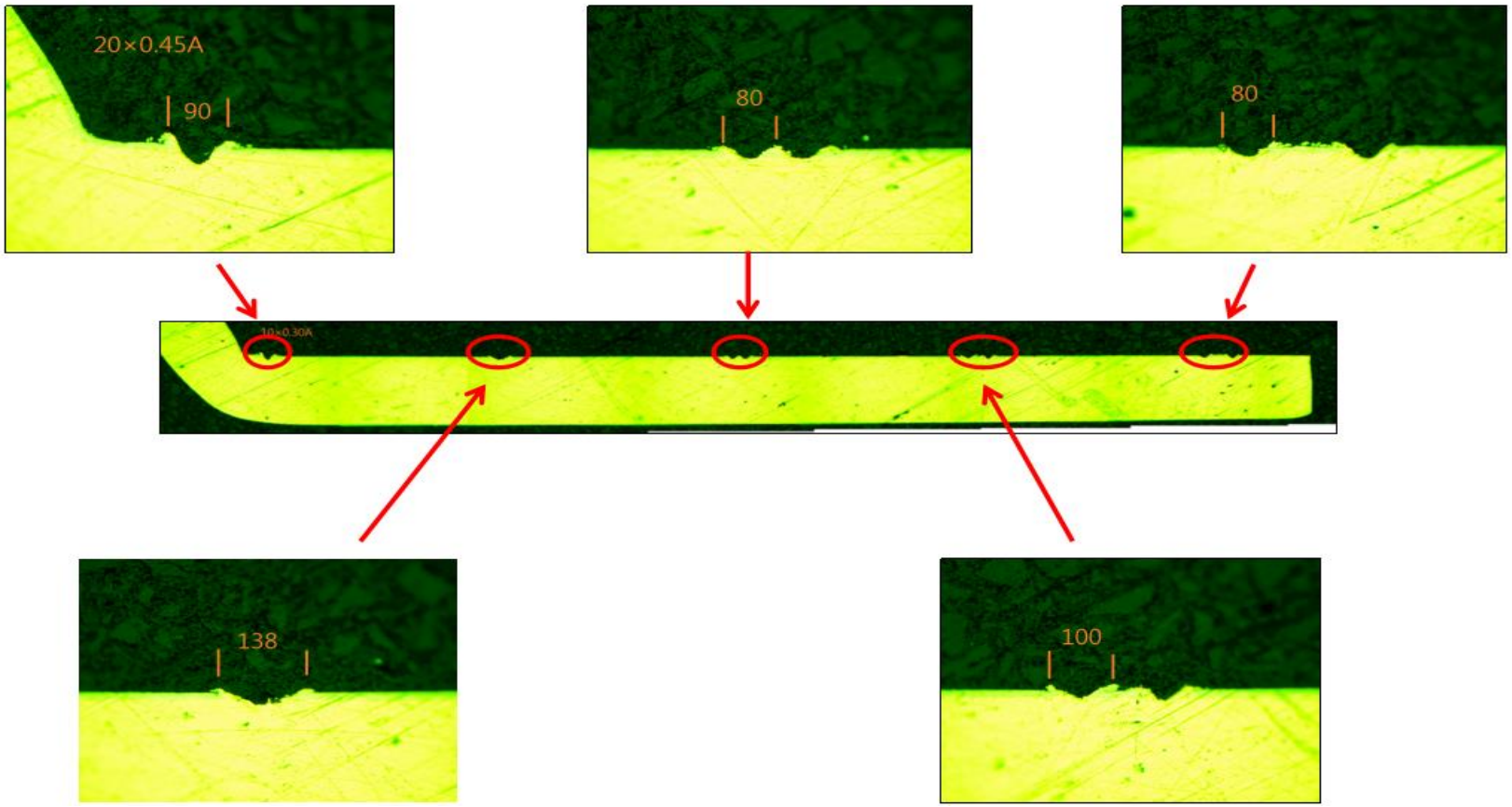
6.84 x 6.84mm
Chip attach

220 ㅇC Hot Plate Soldering
5 minute

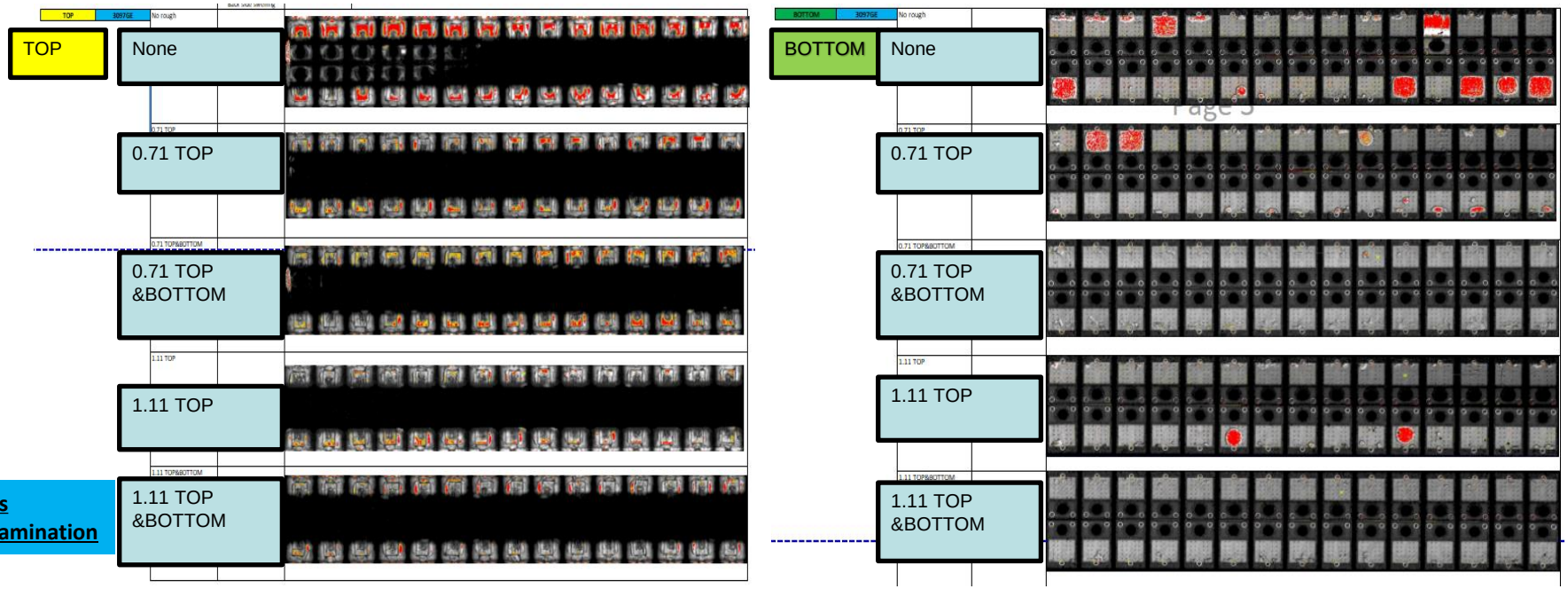
Transfer MoldingEMC by
1.) KCC 3097GX
2.) KCC 3097GE

TMCL

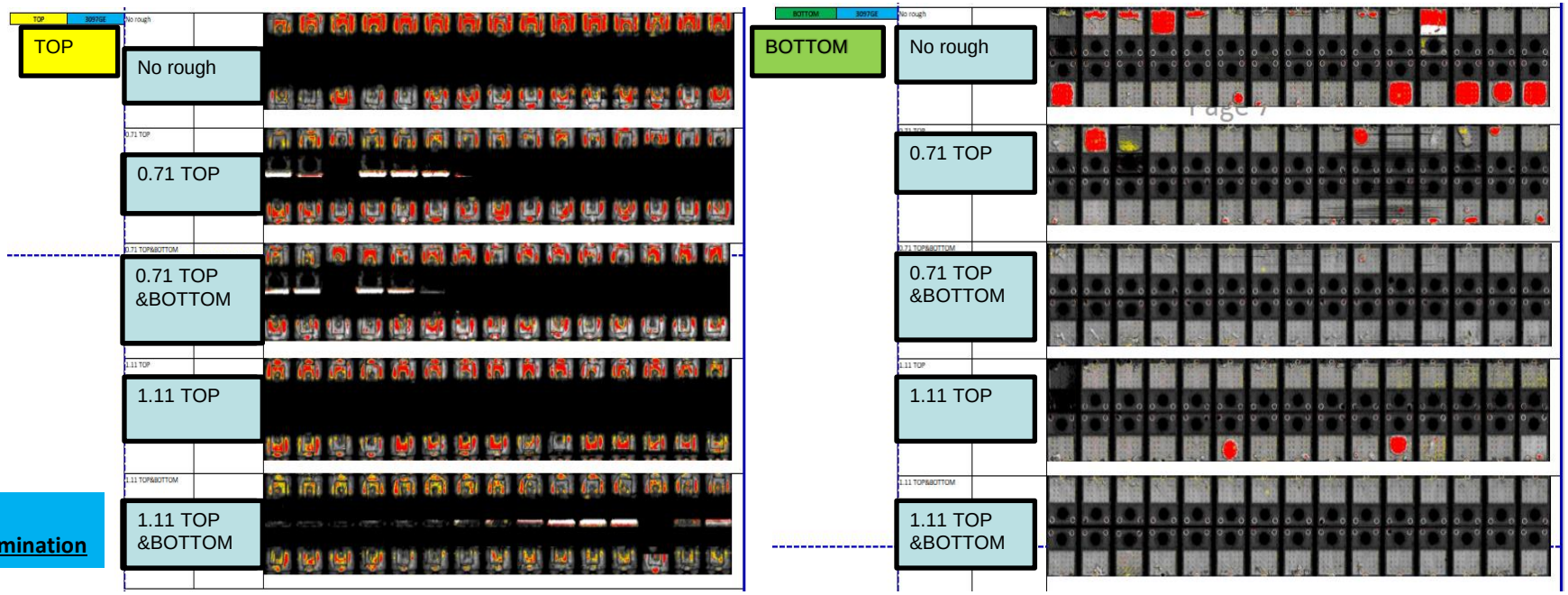
TO-220 Cross-Section



Initial CSAM

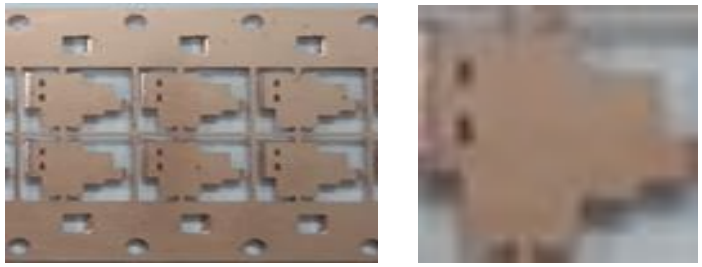


CSAM AFTER 500 CYCLES

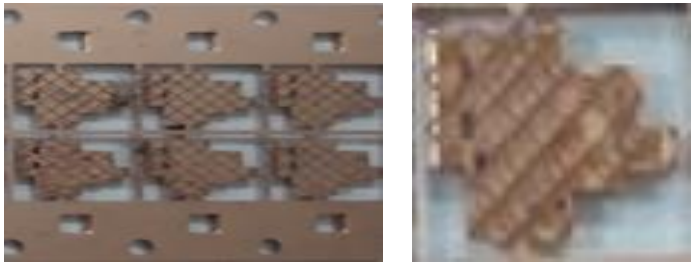


Less delamination

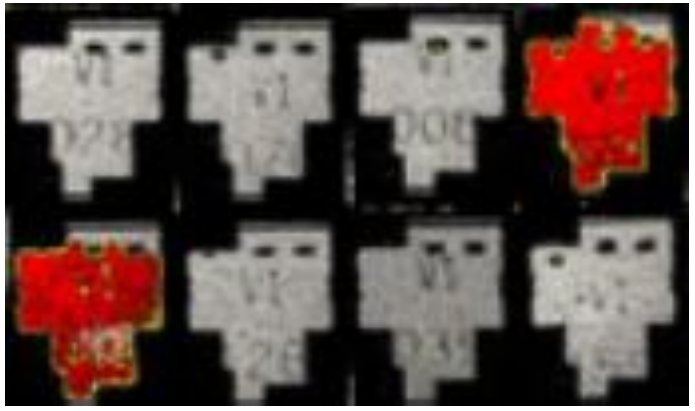
MSL1 pass for automotive application : A customer



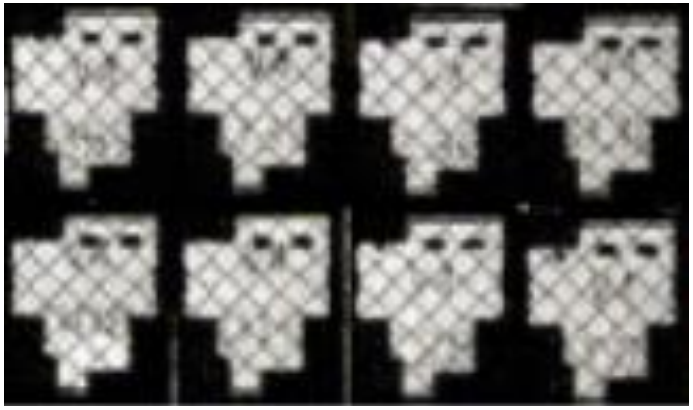
Before MPT



After MPT



We can find the Del. After MSL1

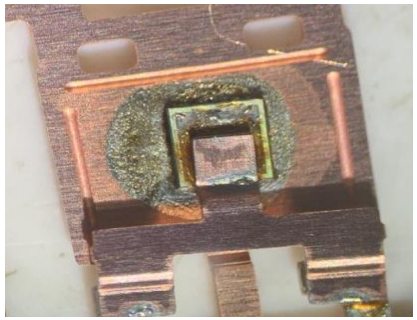


We cannot find the Del. After MSL1

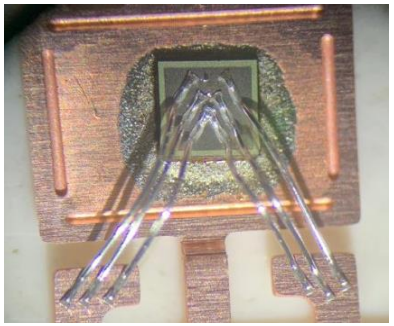
6. Electrical performance and Del. after Rel. test (TMCL, MSL1)

We found the high performance function when we use the MPT through the TO-252.

TO-252

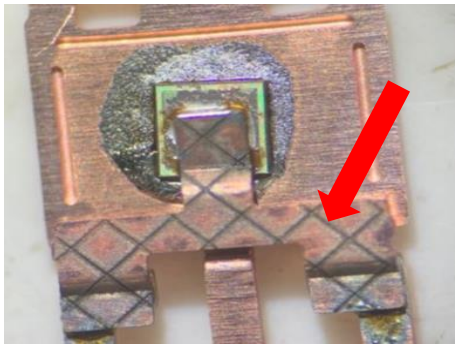


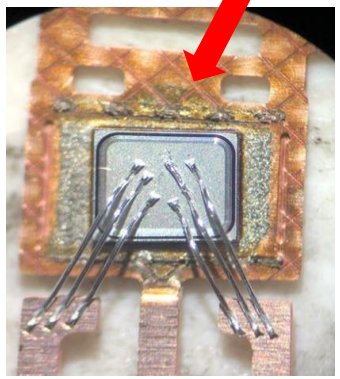
Clip (No MPT)



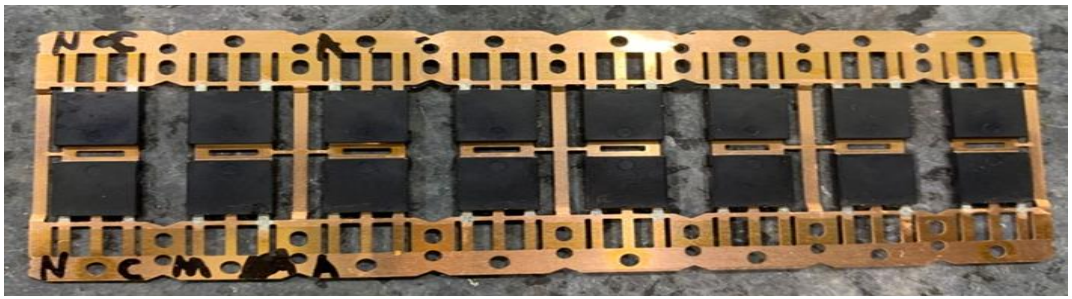
Wire bonding

VS



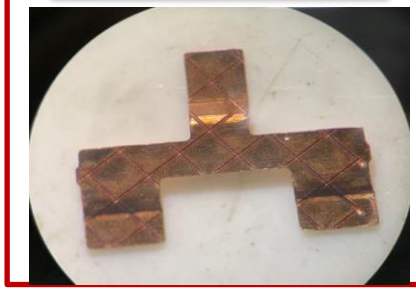


Clip and W/B with MPT



Molding

Laser pattering



TO-252 Clip with MPT

TO-252 Clip

6-1. PKG resistance result after TMCL

	NCI	NCIM	NW	NWM	NCK	NCKM
Initial	63.40	58.40	64.80	58.40	58.74	55.80
500TC MSL1	66.00	59.00	62.20	67.50	59.10	53.70
1000TC MSL1	69.50	56.80	68.60	67.10	59.90	54.40
2000TC MSL1	70.20	58.00	66.80	65.20	60.30	54.70
	N社 diode Clip I社 solder	N社 diode Clip I社 solder MPT	N社 diode Wire	N社 diode Wire MPT	N社 diode Clip CS社 solder	N社 diode Clip CS社 solder MPT

Remark : We used "I社" solder for chip attacing for all of sample

TO-252 Clip vs Clip with MPT

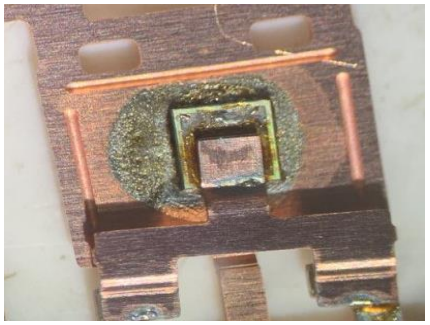
TO-252 Clip vs Clip with MPT electrical performance

N Diode Clip (No MPT)									
Sample #	1	2	3	4	5	6	7	8	Avg
6A input : (mV)	755	756	773	754	762	791	750	714	756.9
8A input : (mV)	879	877	896	893	906	928	877	825	885.1
PKG Registance(mΩ)	61.1	59.8	61.1	67.9	71.9	67.1	62.1	56.4	63.4

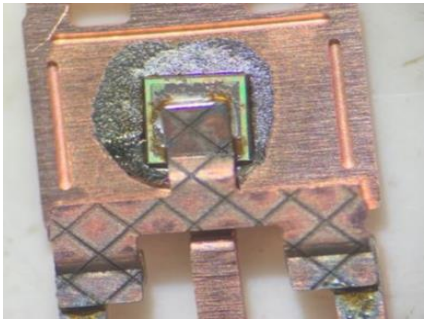
Improved registance : around – 5.0 mΩ

N Diode Clip with MPT									
Sample #	1	2	3	4	5	6	7	8	Avg
6A input : (mV)	709	707	702	693	695	710	681	695	699.0
8A input : (mV)	830	830	819	811	817	831	796	819	819.1
PKG Registance(mΩ)	58.3	59.9	58	57.8	58.9	59.7	55.4	59.4	58.4

Clip (No MPT)

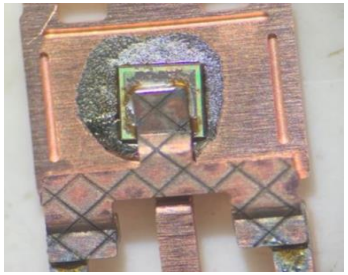


Clip with MPT

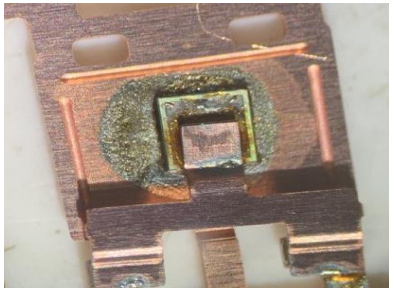


TO-252 Clip vs Clip with MPT : Comparing of Electrical Curve trace

TO-252 PKG Clip vs Clip with MPT : Diode Graph



N Diode Clip MPT



N Diode Clip (No MPT)

The Clip with MPT is better performance than just Cu Clip.

TO-252 Wire bonding vs Clip with MPT

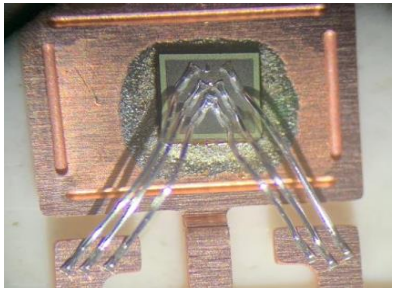
TO-252 W/B vs Clip with MPT electrical performance

N Diode Wire bonding									
Sample #	1	2	3	4	5	6	7	8	Avg
6A input : (mV)	736	754	754	756	743	751	770	737	750.1
8A input : (mV)	862	878	882	882	865	885	919	866	879.9
PKG Registance(mΩ)	63	63.2	64.2	64.6	62.9	63.9	72	64.2	64.8

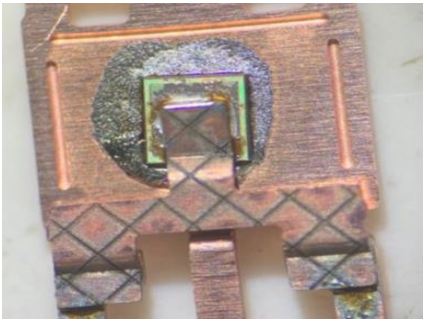
Improved registance : around – 6.4 mΩ

N Diode Clip with MPT									
Sample #	1	2	3	4	5	6	7	8	Avg
6A input : (mV)	709	707	702	693	695	710	681	695	699.0
8A input : (mV)	830	830	819	811	817	831	796	819	819.1
PKG Registance(mΩ)	58.3	59.9	58	57.8	58.9	59.7	55.4	59.4	58.4

Wire bonding

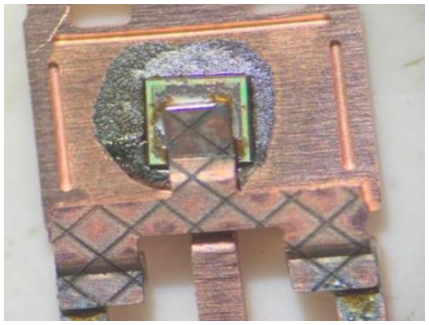


Clip with MPT

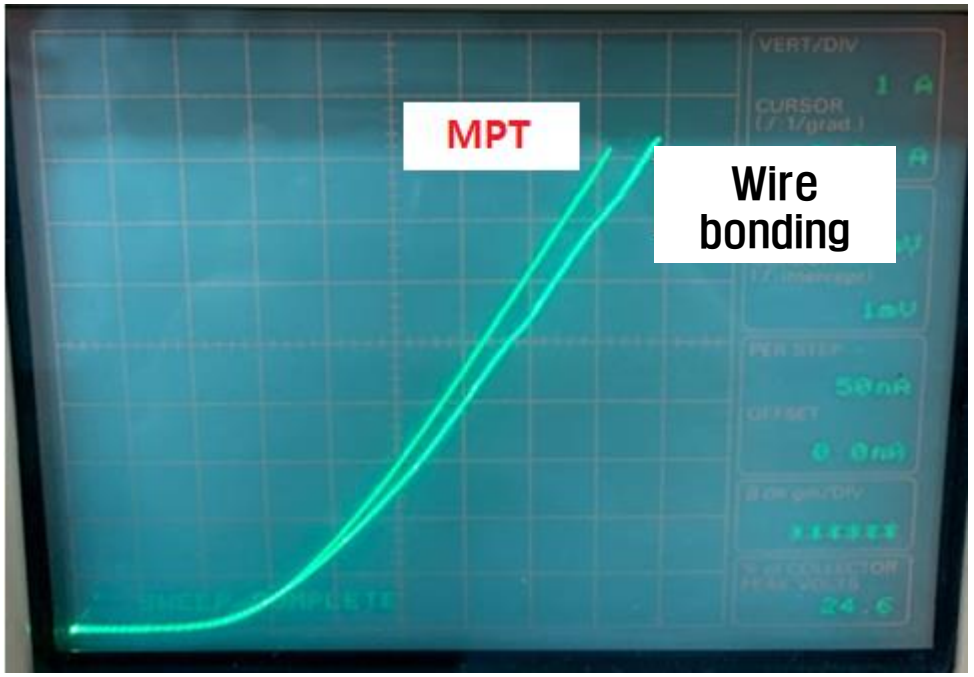


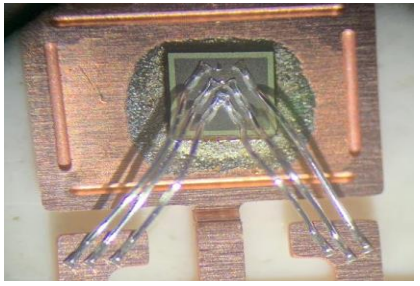
TO-252 Wire bonding 과 Clip with MPT Comparing of Electrical Curve trace

TO-252 Wire bonding Vs Clip with MPT : Diode graph



N Diode Clip MPT





N Diode Wire bonding

The Clip with MPT is better performance than wire bonded PKG

6-3. After TC 500 cyc

TO-252 Clip vs Clip with MPT

NCI vs NCIM with I社 solder (92.5Pb5Sn2.5Ag)

NCI

TC 500 cycle

Sample#	1	3	5	6	7	평균
6A input : (mV)	784	788	788	818	760	787.6
8A input : (mV)	1000	916	928	968	878	938.0
PKG Resistance (mΩ)	62.6	61.4	72.4	73.4	60.2	66.0

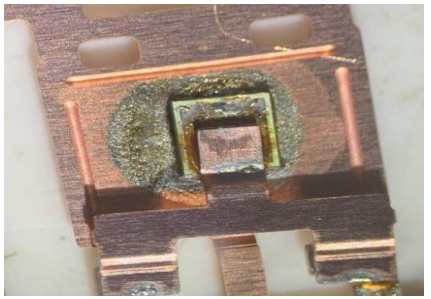
Improved registance : around – 7 mΩ

NCIM

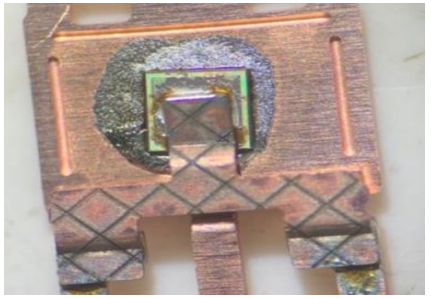
TC 500 cycle

Sample#	1	2	3	4	5	평균
6A input : (mV)	762	762	748	746	780	759.6
8A input : (mV)	876	888	878	848	910	880.0
PKG Resistance (mΩ)	56.6	59.6	63.6	53.4	61.8	59.0

Clip (No MPT)



Clip with MPT



TO-252 Clip vs Clip with MPT

NCK vs NCKM with CS社 Solder (SAC305)

NCK

TC 500cycle

Sample#	1	2	3	4	8	평균
6A input : (mV)	736	722	742	748	718	733.2
8A input : (mV)	856	840	848	858	836	847.6
PKG Resistance (mΩ)	60.4	59.4	54.6	60.8	60.2	59.1

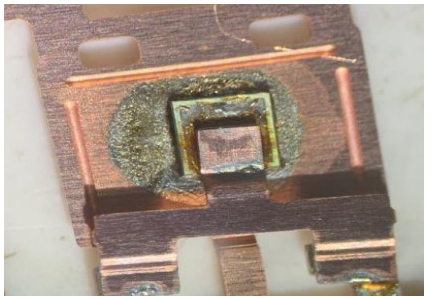
Improved registance : around – 5.4 mΩ

NCKM

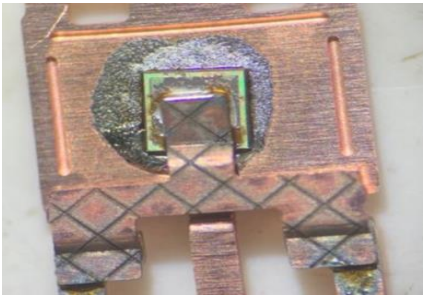
TC 500cycle

Sample#	2	5	6	7	8	평균
6A input : (mV)	758	744	750	734	734	744.0
8A input : (mV)	860	848	862	844	844	851.6
PKG Resistance (mΩ)	51.4	53.8	56.6	53.4	53.4	53.7

Clip (No MPT)



Clip with MPT



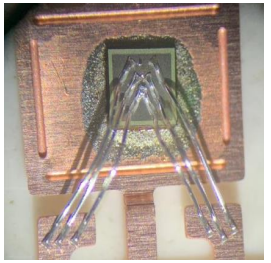
TO-252 Wire bond, Leadframe vs Leadframe with MPT

NW vs NWM

NW

TC 500cycle

Sample#	8	12	13	14	15	평균
6A input : (mV)	714	740	750	774	766	748.8
8A input : (mV)	836	860	868	918	880	872.4
PKG Resistance (mΩ)	61.6	62	63.2	68.6	55.8	62.2

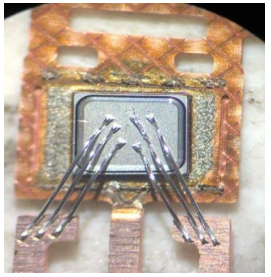


Increased registance : around +5.3 mΩ

NWM

TC 500cycle

Sample#	3	5	6	7	8	평균
6A input : (mV)		696	776	716	788	744.0
8A input : (mV)		812	922	852	930	879.0
PKG Resistance (mΩ)	DIE	58.2	71.4	68.4	72	67.5



6-4. After TC 1000 cyc

TO-252 Clip vs Clip with MPT

NCI vs NCIM with I社 solder (92.5Pb5Sn2.5Ag)

NCI

TC 1000 cycle

Sample#	1	3	5	6	7	평균
6A input : (mV)	870	770	738	786	748	782.4
8A input : (mV)	1016	914	868	940	874	922.4
PKG Resistance (mΩ)	70.8	70.2	64	77.2	65.4	69.5

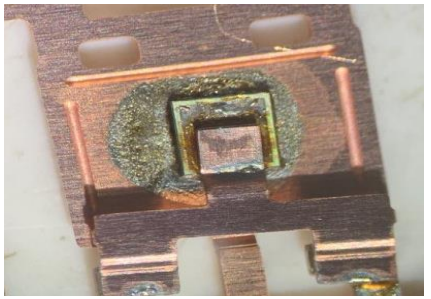
Improved registance : around – 12.7 mΩ

NCIM

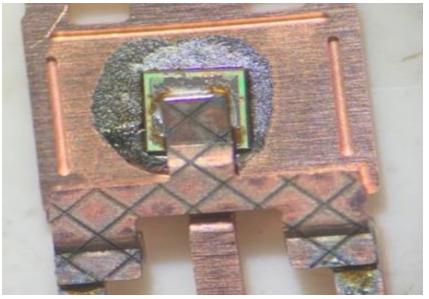
TC 1000 cycle

Sample#	1	2	3	4	5	평균
6A input : (mV)	752	742	748	728	738	741.6
8A input : (mV)	864	850	858	842	860	854.8
PKG Resistance (mΩ)	58.6	55.4	56.2	55.8	57.8	56.8

Clip (No MPT)



Clip with MPT



TO-252 Clip vs Clip with MPT

NCK vs NCKM with CS社 Solder (SAC305)

NCK

TC 1000cycle

Sample#	1	2	3	4	8	평균
6A input : (mV)	768	698	724	712	692	718.8
8A input : (mV)	914	802	818	828	806	833.6
PKG Resistance (mΩ)	72.2	55	53.8	58.8	59.6	59.9

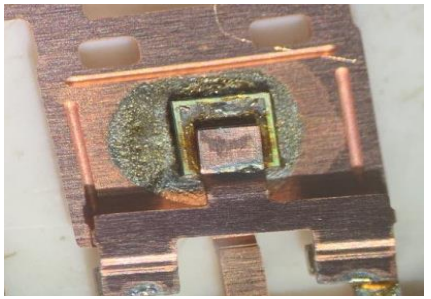
Improved registance : around – 5.4 mΩ

NCKM

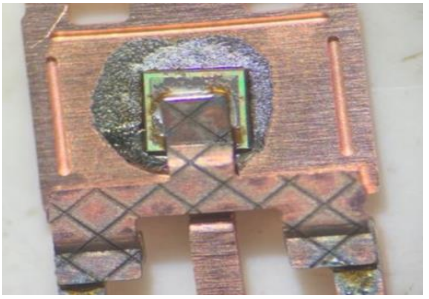
TC 1000cycle

Sample#	2	5	6	7	8	평균
6A input : (mV)	694	688	706	746	770	720.8
8A input : (mV)	802	806	828	852	888	835.2
PKG Resistance (mΩ)	53	56.8	53.2	53.2	55.6	54.4

Clip (No MPT)



Clip with MPT



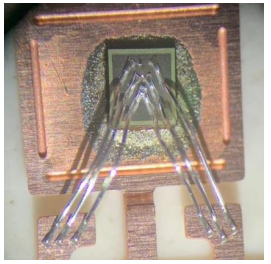
TO-252 Wire bond, Leadframe vs Leadframe with MPT

NW vs NWM

NW

TC 1000cycle

Sample#	8	12	13	14	15	평균
6A input : (mV)	730	714	790	782	798	762.8
8A input : (mV)	856	844	942	910	956	901.6
PKG Resistance (mΩ)	65.8	64	71.6	66.4	75.4	68.6

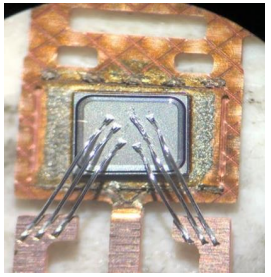


Improved registance : around – 1.5 mΩ

NWM

TC 1000cycle

Sample#	3	5	6	7	8	평균
6A input : (mV)		720	754	750		741.3
8A input : (mV)		848	894	892		878.0
PKG Resistance (mΩ)	DIE	63.4	69.2	68.6	NOISE	67.1



6-5. After TC 2000 cyc

TO-252 Clip vs Clip with MPT

NCI vs NCIM with I社 solder (92.5Pb5Sn2.5Ag)

NCI

TC 2000 cycle

Sample#	1	3	5	6	7	평균
6A input : (mV)	850	876	892	850	776	848.8
8A input : (mV)	1010	1038	1036	976	896	991.2
PKG Resistance (mΩ)	78.2	82.2	69.8	62.2	58.8	70.2

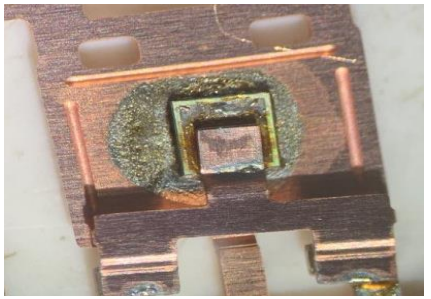
Improved registance : around – 12.2 mΩ

NCIM

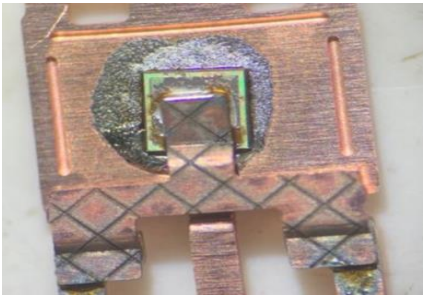
TC 2000 cycle

Sample#	1	2	3	4	5	평균
6A input : (mV)	812	806	736	800	784	787.6
8A input : (mV)	932	926	852	926	904	908.0
PKG Resistance (mΩ)	57	57.2	56.4	60.8	58.6	58.0

Clip (No MPT)



Clip with MPT



TO-252 Clip vs Clip with MPT

NCK vs NCKM with CS社 Solder (SAC305)

NCK

TC 2000cycle

Sample#	1	2	3	4	8	평균
6A input : (mV)	778	770	NOISE	706	768	755.5
8A input : (mV)	902	882		828	880	873.0
PKG Resistance (mΩ)	62.2	61.6		61.4	55.8	60.3

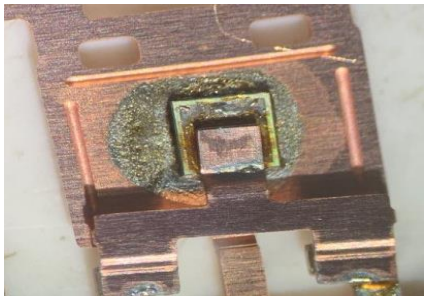
Improved registance : around – 5.6 mΩ

NCKM

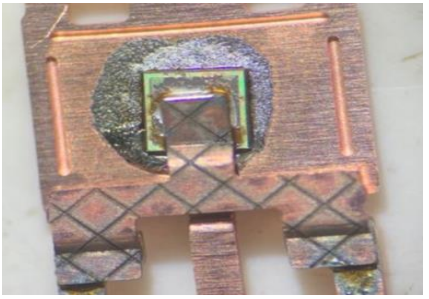
TC 2000cycle

Sample#	2	5	6	7	8	평균
6A input : (mV)	728	744	744	754	816	757.2
8A input : (mV)	836	864	862	874	914	870.0
PKG Resistance (mΩ)	54.8	57.6	57.8	57	46.4	54.7

Clip (No MPT)



Clip with MPT



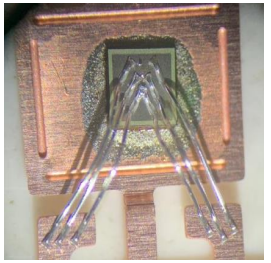
TO-252 Wire bond, Leadframe vs Leadframe with MPT

NW vs NWM

NW

TC 2000cycle

Sample#	8	12	13	14	15	평균
6A input : (mV)	830	778	824	778	836	809.2
8A input : (mV)	962	906	978	920	954	944.0
PKG Resistance (mΩ)	68.4	65.8	75	71.6	62	68.6

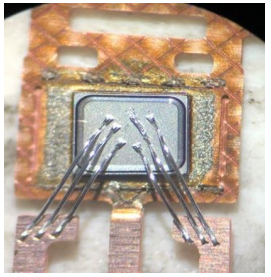


Improved registance : around – 3.4 mΩ

NWM

TC 2000cycle

Sample#	3	5	6	7	8	평균
6A input : (mV)		724	744	708		725.3
8A input : (mV)		854	844	834		844.0
PKG Resistance (mΩ)	DIE	63.2	70.6	61.8	NOISE	65.2

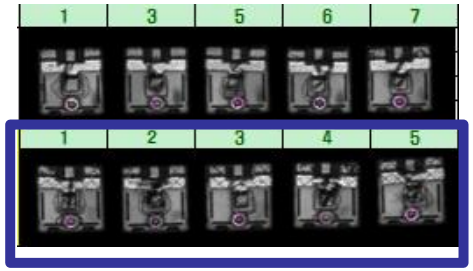


7. PKG Delamination and Resistance after TMCL (MSL1)

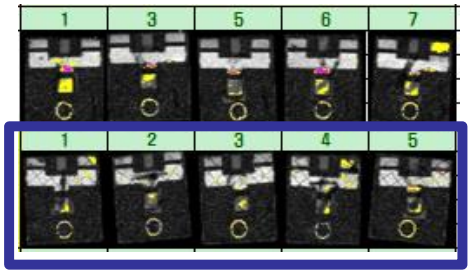
DATA & C-SAN
사진 참고

TO-252 clip bonding vs clip bonding with MPT after TMCL 2000 cyc (MSL1)

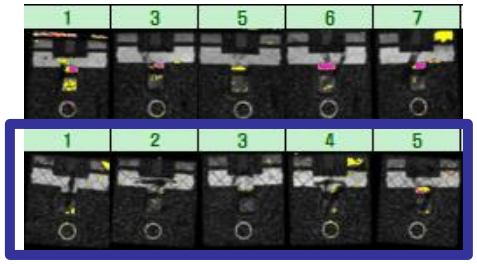
NCI vs NCIM, Clip Attach – I社 Solder (MLS1)



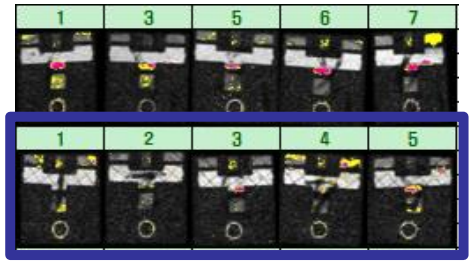
Initial



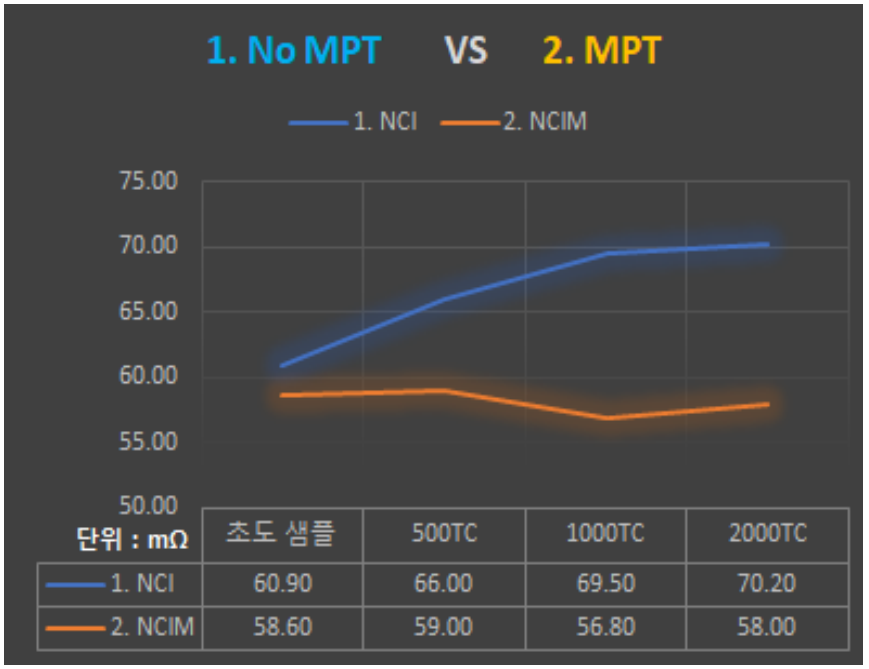
TC 500



TC 1000



TC 2000



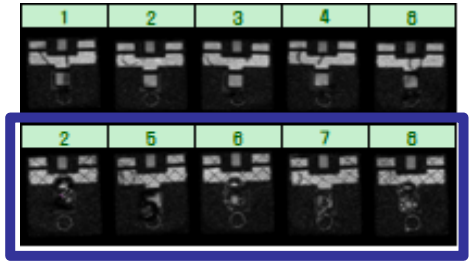
단위 : mΩ	초도 샘플	500TC	1000TC	2000TC
1. NCI	60.90	66.00	69.50	70.20
2. NCIM	58.60	59.00	56.80	58.00

MPT Sample

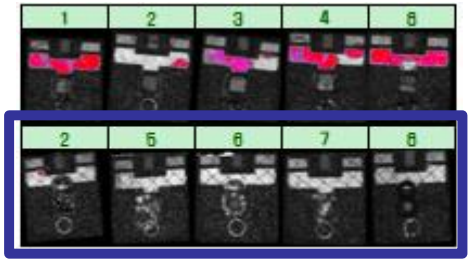
TO-252 clip bonding vs clip bonding with MPT after TMCL 2000 cyc (ML)

DATA & C-SAN
사진 참고

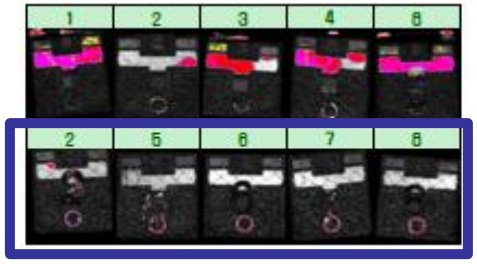
NCK vs NCKM , Clip Attach , CS社 solder



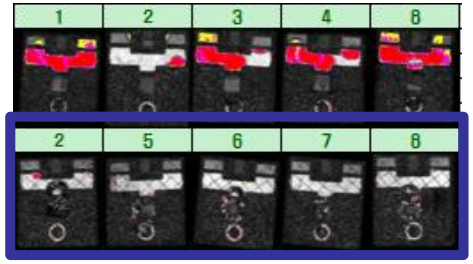
Initial



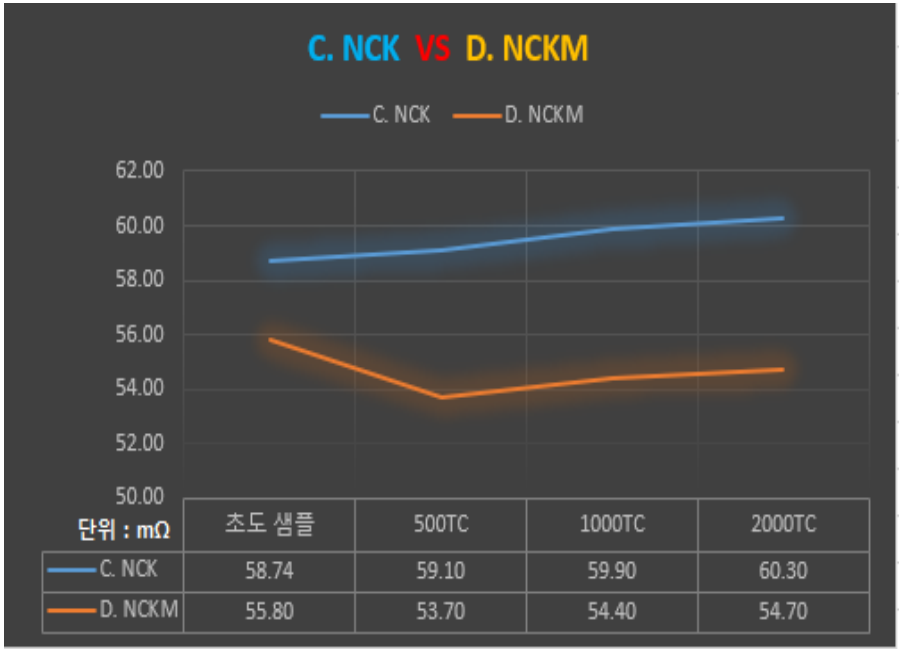
TC 500



TC 1000



TC 2000



단위 : mΩ	초도 샘플	500TC	1000TC	2000TC
C. NCK	58.74	59.10	59.90	60.30
D. NCKM	55.80	53.70	54.40	54.70

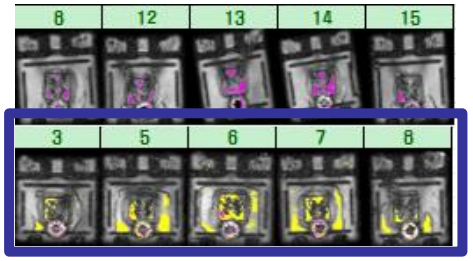
MPT Sample

TO-252 Leadframe vs Leadframe with MPT after TMCL 2000 cyc (MSL1)

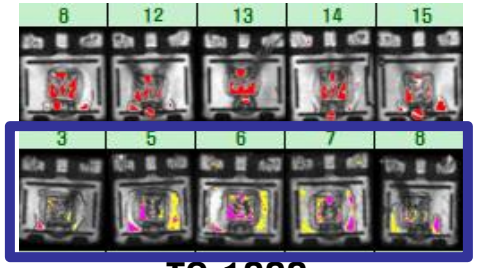
DATA & C-SAN
사진 참고

TO-252 L/F vs L/F MPT TMCL DELAMINATION (Wire bonding)

Initial

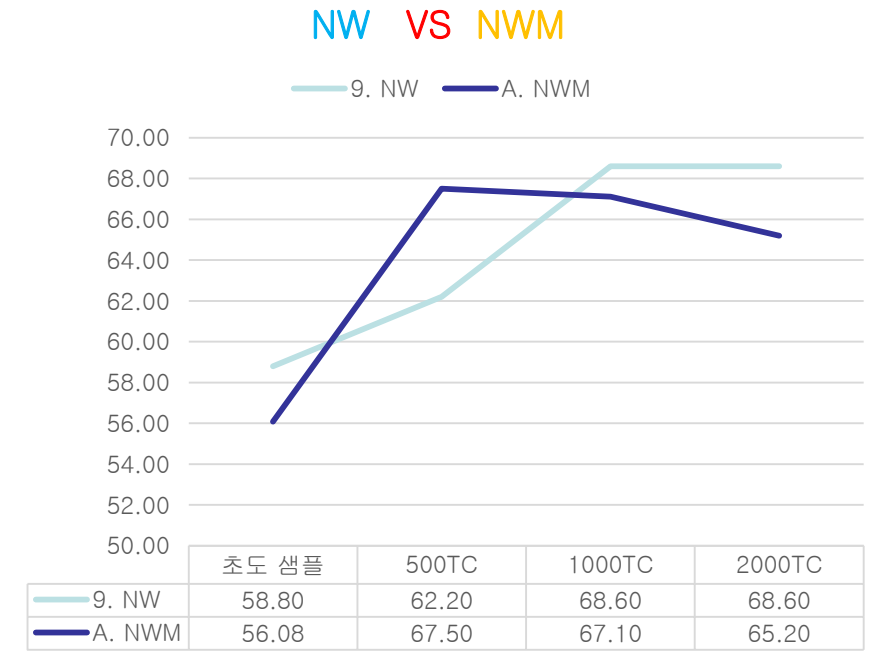


TC 500



TC 1000

TC 2000



	초도 샘플	500TC	1000TC	2000TC
9. NW	58.80	62.20	68.60	68.60
A. NWM	56.08	67.50	67.10	65.20

MPT Sample

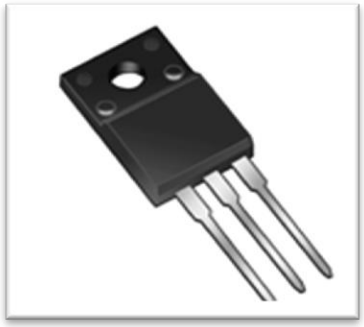
JMJ Korea
제엠제코㈜

8. Advantage of MPT and Patent

Decrease of delamination

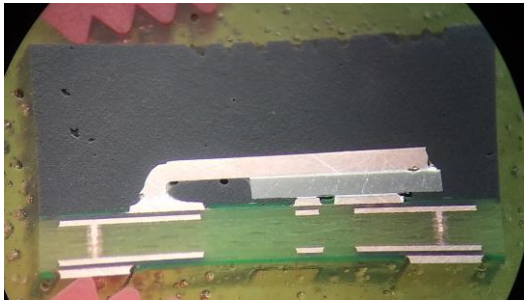
- ◆ We can use the MPT for all of PKG. : Power module for **HEV/EV**
  QFN, BGA, LGA, Discrete PKG

- ◆ Saving of process charge : We can remove the Plasma or coating process.
  Cheaper cost than Roughnened Cu
  We can use the low cost EMC.

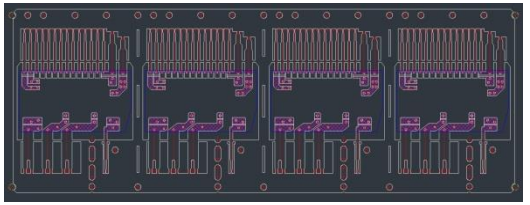


Discrete package

QFN Type package

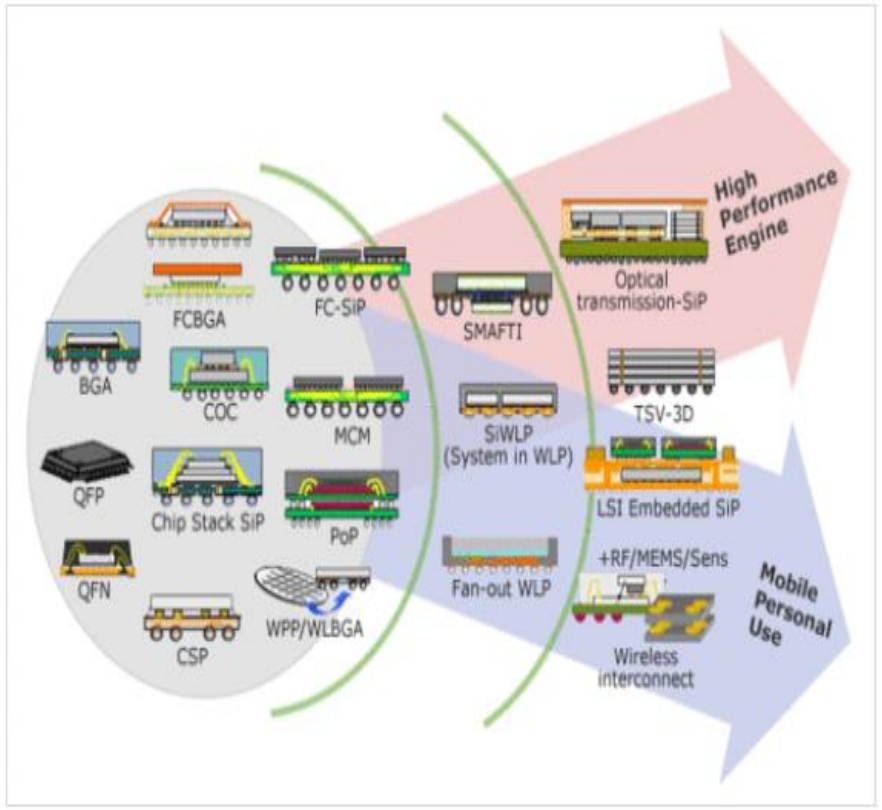


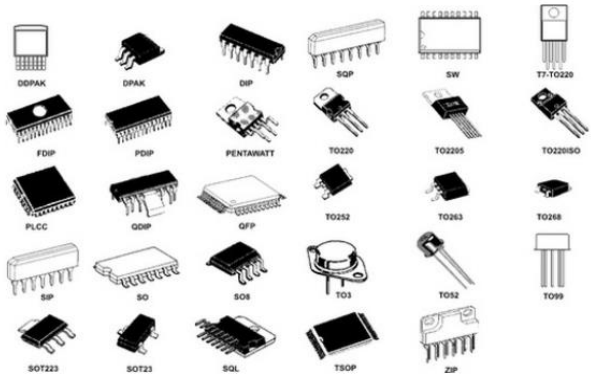
BGA, LGA package

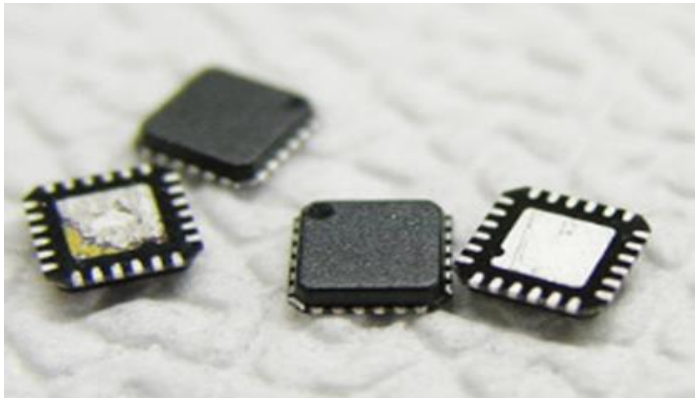


Module package

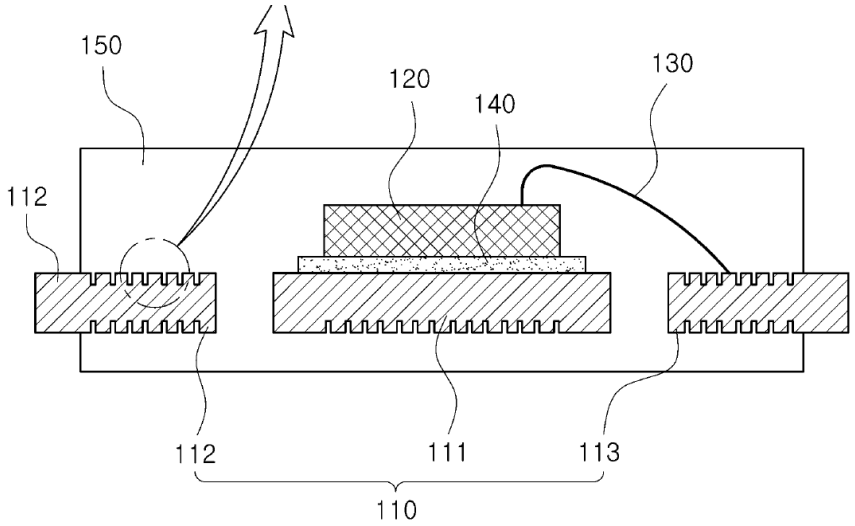
For all of PKG using DBC, Substrate, Lead frame, Clip

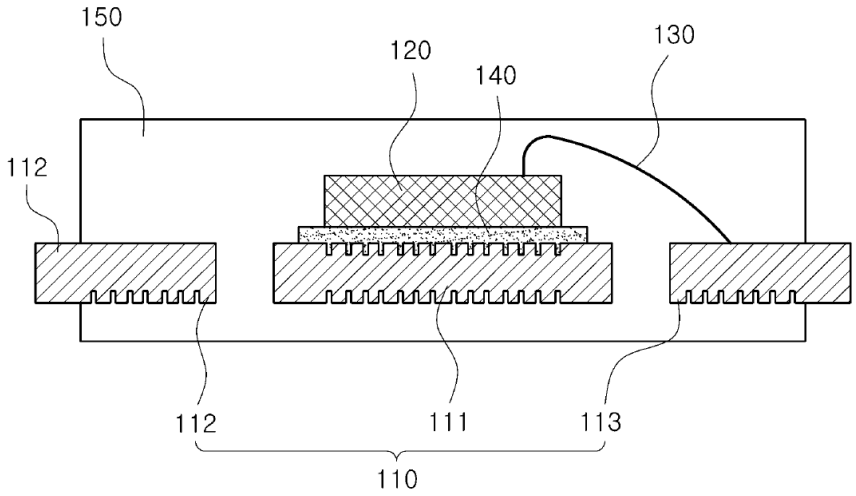


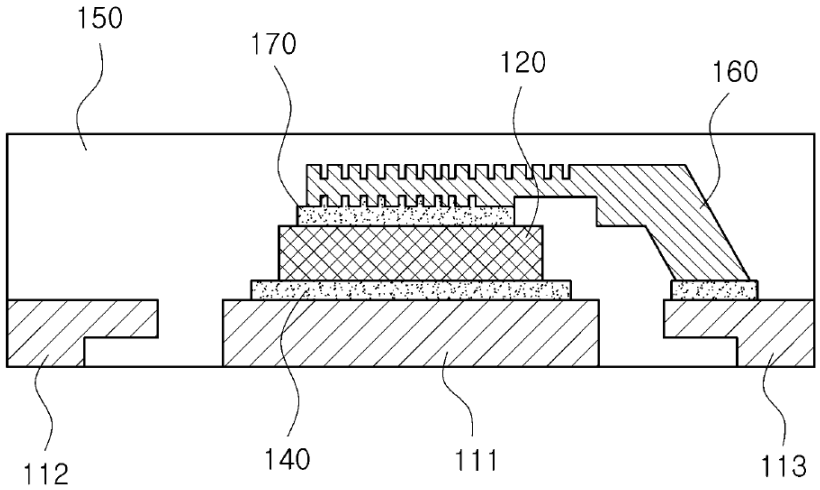


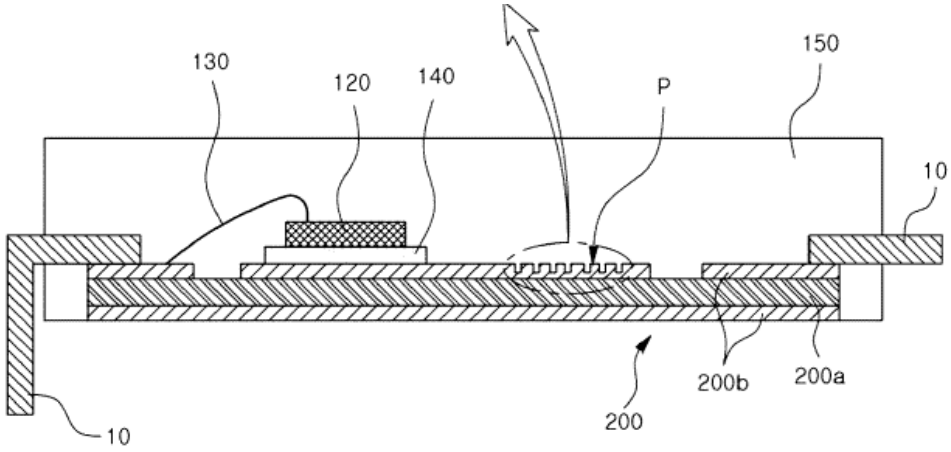


Patent









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