Lead-free Processing Compatible with Halogen-free Required EM-285/ EM-285B

RD Department, Elite Material Co. Ltd.

Outline

1. Compression of Basic Material Property
2. Related PCB Processing Evaluation
3. Reliability Test
4. Conclusion

Comparing with Competitor

General property

Thickness: 1.0mm

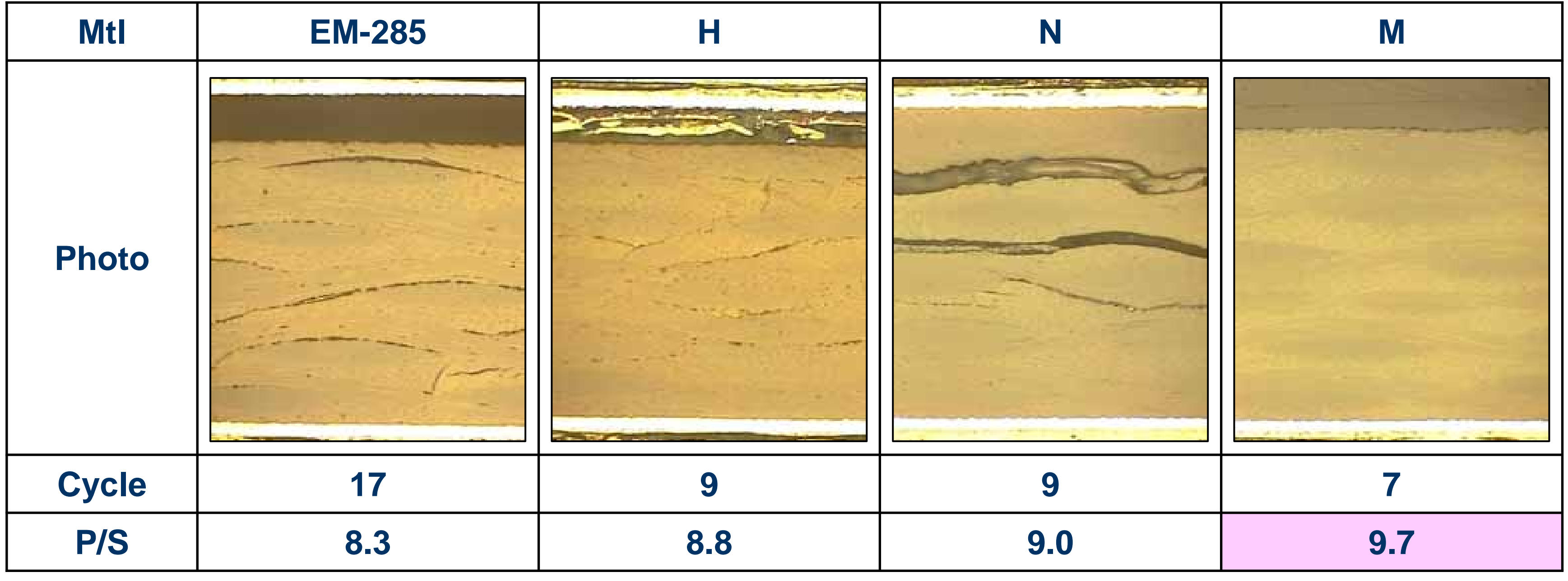
Item	Condition	Unit	EM-285	H	N	M
Tg	TMA	℃	152	152	154	156
T288(unclad)	TMA	Min	＞60	＞60	＞60	＞60
T288(clad)	TMA	Min	8	<1	3.5	3.5
Td (5% loss)	TGA	℃	364	338	349	334
α1	TMA(50~120℃)	ppm/℃	49	56	44	30
α2	TMA(180~260℃)	ppm/℃	201	220	235	202
CTE	TMA(50~260℃)	%	2.3	2.9	2.9	2.2
Dk	1 MHz	-	4.8	4.8	4.8	4.9
	1 GHz	-	4.7	4.7	4.6	4.8
Df	1 MHz	10E-3	0.007	0.007	0.010	0.010
	1 GHz	10E-3	0.009	0.009	0.016	0.012

Comparing with Competitor

Peel strength vs. thermal stress

Thickness: 1.0mm 1/1

Item	Condition	Unit	EM-285	H	N	M
Peel strength (1oz)	As received	lb/in	8.1~8.4	8.7~8.9	8.9~9.0	9.7~9.8
	After thermal stress	lb/in	8.0~8.3	8.4~8.8	8.8~9.1	9.4~9.5
Thermal stress	Solder dip 288℃ x 10s	cycle	17~20	7~9	9~11	6-8



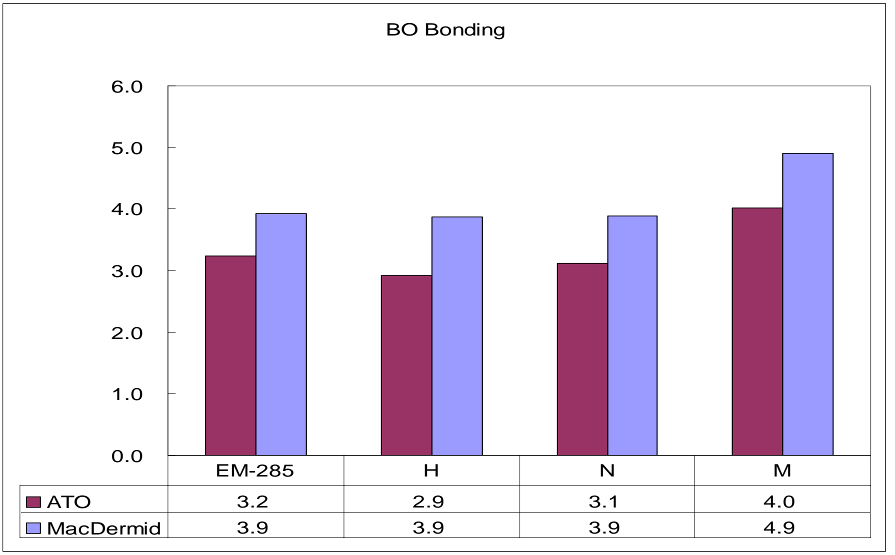
Mtl	EM-285	H	N	M
Photo				
Cycle	17	9	9	7
P/S	8.3	8.8	9.0	9.7

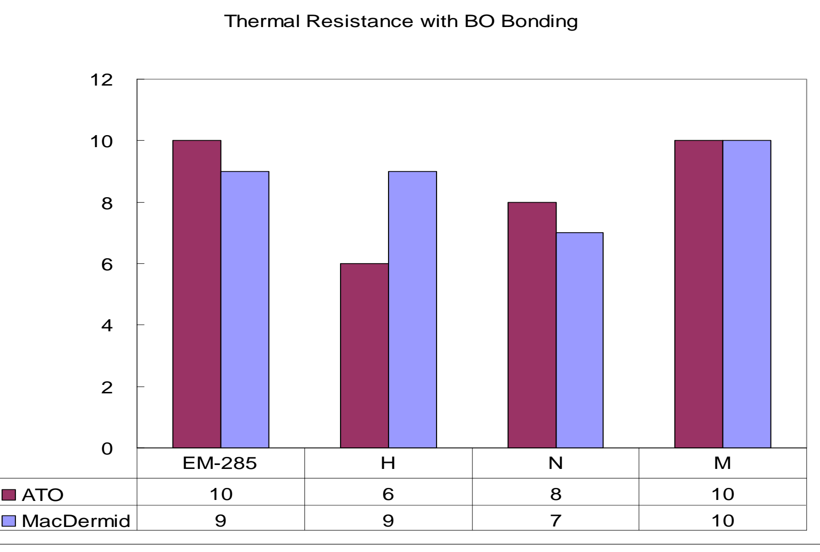
Comparing with Competitor

BO bonding vs. thermal stress

Construction: 1oz + 7628 x 5 + 1oz

Chemical	Condition	Unit	EM-285	H	N	M
ATO	As received	lb/in	3.0~3.4	2.8~3.1	3.0~3.4	3.8~4.3
	After thermal stress		3.9~4.0	3.6~4.1	3.7~4.0	4.8~5.0
MacDermid	As received		3.1~3.4	2.8~3.1	2.8~3.1	3.7~3.9
	After thermal stress		3.6~4.1	3.5~3.8	3.7~4.0	4.6~5.0
Thermal stress cycle	ATO Bond Film	cycle	8~10	5~6	5~8	9~11
	MacDermid		8~9	8~10	7~9	10~11





Comparing with Competitor

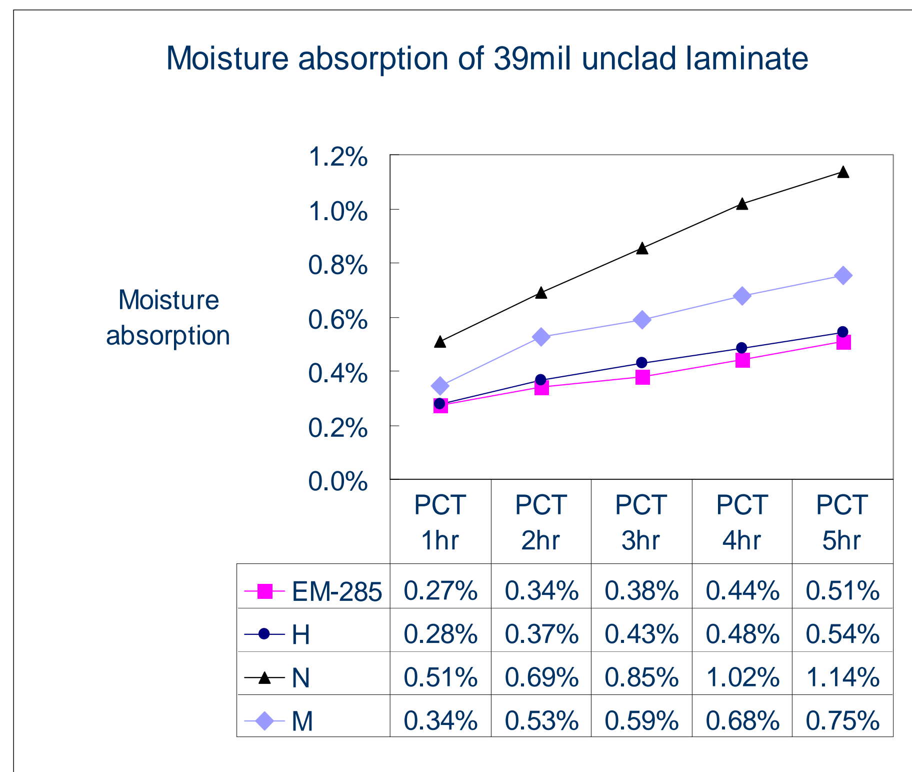
BO bonding vs. thermal stress

Mtl	EM-285	H	N	M
ATO				
Cycle	10	6	8	10
P/S	3.2	2.9	3.1	4.0

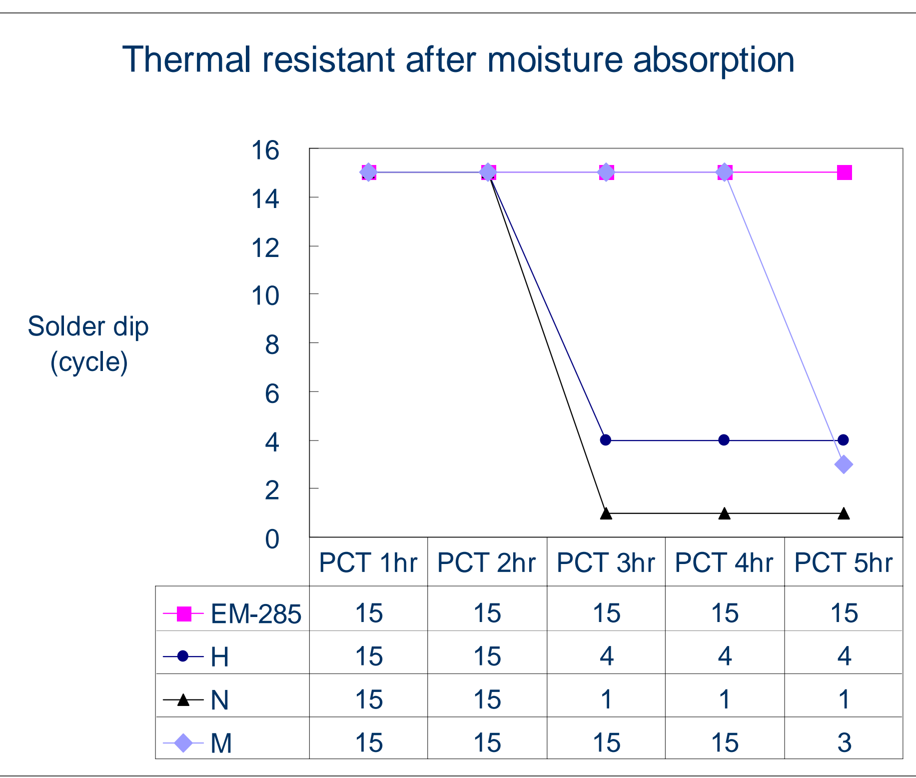
Mtl	EM-285	H	N	M
Mac Dermid				
Cycle	9	9	7	10
P/S	3.9	3.9	3.9	4.9

Comparing with Competitor

Moisture absorbed & thermal resistance



	PCT 1hr	PCT 2hr	PCT 3hr	PCT 4hr	PCT 5hr
EM-285	0.27%	0.34%	0.38%	0.44%	0.51%
H	0.28%	0.37%	0.43%	0.48%	0.54%
N	0.51%	0.69%	0.85%	1.02%	1.14%
M	0.34%	0.53%	0.59%	0.68%	0.75%



	PCT 1hr	PCT 2hr	PCT 3hr	PCT 4hr	PCT 5hr
EM-285	15	15	15	15	15
H	15	15	4	4	4
N	15	15	1	1	1
M	15	15	15	15	3

PCB Processing Evaluation

Drilling Processing

Method

Layer Count : 4 Layers

Thickness : 1.6mm

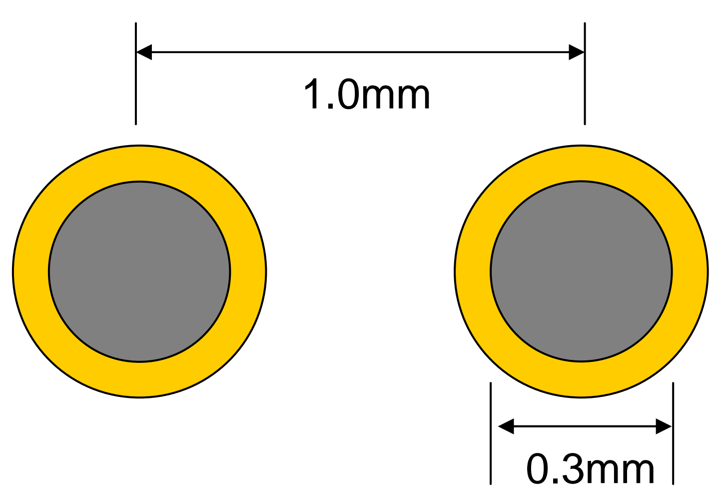
Drilling Hole Size :Φ 0.3mm

Wall to wall : 0.7mm

7628

0.039”,1/1

7628



PCB Processing Evaluation

Drilling Processing

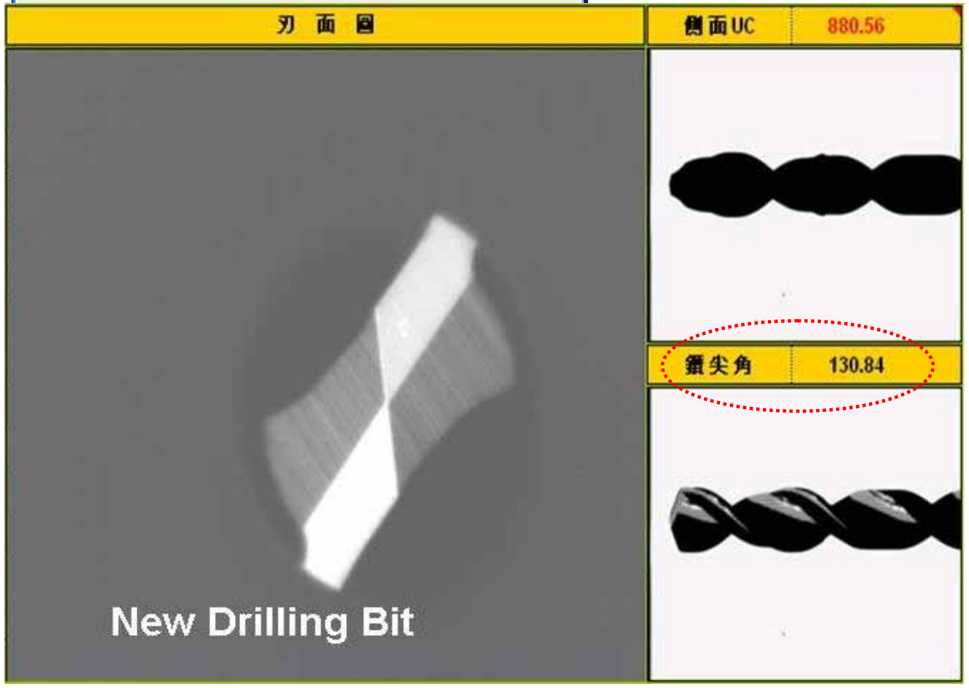
Material	Speed (krpm)	Chip load (mil/rev)	Hit
Regular FR-4	150	0.7	2500
N Company	150	0.7	2500
H Company	150	0.7	2500
EM-285	150	0.7	2500

1. Machine: Tong-Tai 160krpm
2. Taiwan Union 0.3 mm UC drilling bit
3. 0.2 mm thickness of entry, 1.5 mm thickness of urethane clad
4. Stack-up: 2 PNLs of stack height (Total 3.2 mm)

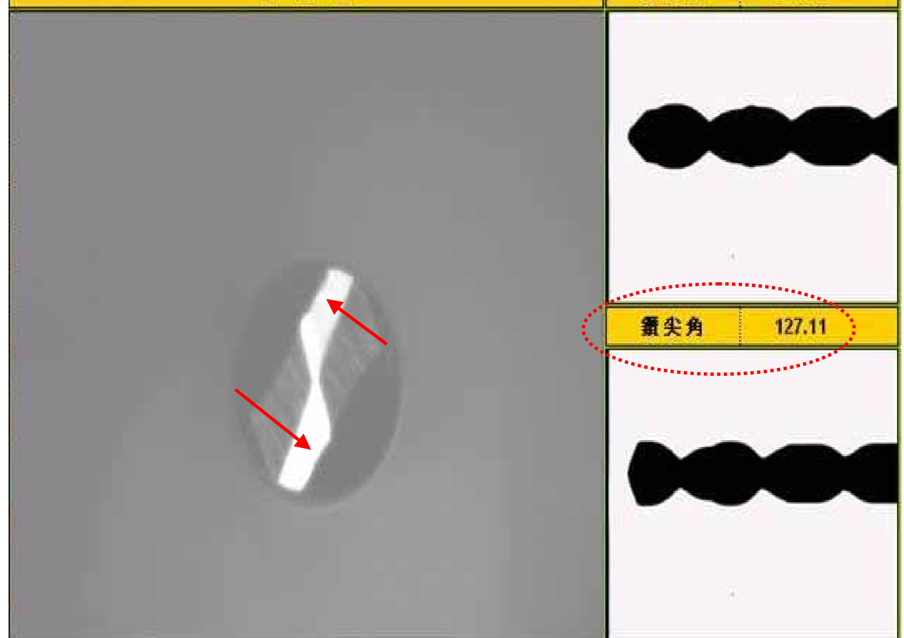
Drilling Processing Evaluation

Reducing Drilling Bit Abrasion Study

Thickness 1.6mm,
Diameter 0.3mm,
Speed 150krpm,
Chip load 0.7 mil/rev, 2500 Hit



Point Angle of New Drilling Bit : 130 degree



Regular FR-4 Material : 127 degree

Drilling Processing Evaluation

Reducing Drilling Bit Abrasion Study

刃 面 圖

側面UC 758.34

鑽尖角 121.07

刃 面 圖

側面UC 758.34

鑽尖角 125.9

N Company : 121 degree

EM-285 : 126 degree

Drilling Processing Evaluation

Reducing Drilling Bit Abrasion Study

Drilling bit abrasion ratio of EM-285 is improved 80% above than N company material

Drilling Processing Evaluation

Roughness of hole wall

Oneway Analysis of roughness By material

roughness

0.9
0.8
0.7
0.6
0.5
0.4

1 EM-285 2 H Company 3 N Company 4 M Company 5 Regular FR-4

Each Pair
Student's t
0.05

material

Performance of hole wall roughness between regular FR-4 material and EM-285 is similar

Drilling Processing Evaluation

Nail-head of hole wall

Oneway Analysis of nail head By material

nail head

1.6
1.5
1.4
1.3
1.2
1.1

1 EM-285 | 2 H Company | 3 N Company | 4 M Company | 5 Regular FR-4

material

Each Pair
Student's t
0.05

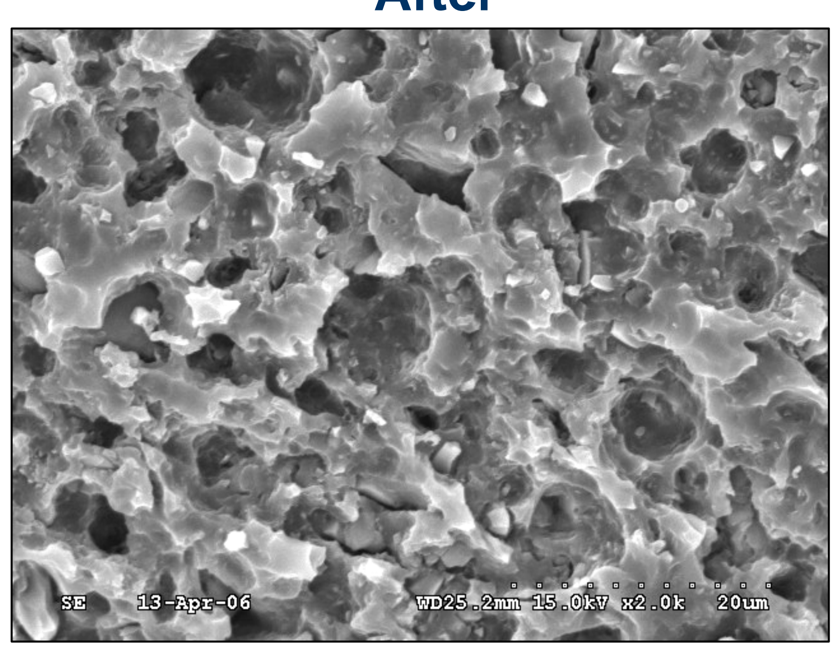
Performance of nail-head between regular FR-4 material and EM-285 is similar

PCB Processing Evaluation

Desmear weight loss

Before

After



Weight loss control at 0.20 ~ 0.40 mg / cm^2

Sweller temperature: 60℃/ time 5 minutes

Desmear temperature: 80℃/ time 9 minutes

Desmear weight loss comparison

Oneway Analysis of desmear weight loss By material

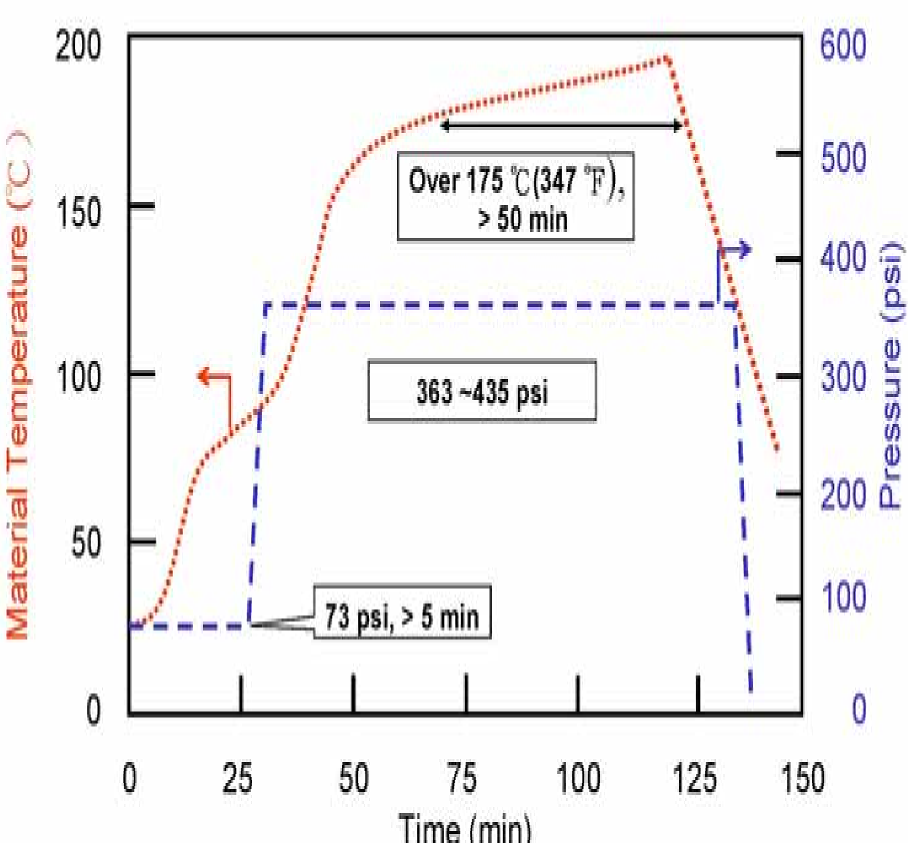
desmear weight loss: 0.36, 0.34, 0.32, 0.3, 0.28, 0.26, 0.24

material: EM-220, EM-280(H), EM-285

Level	N	Mean	StDev
EM-220	5	0.25690	0.00285
EM-280(H)	5	0.34590	0.00606
EM-285	5	0.30490	0.00781

PCB Processing Parameter Suggestion

Press cycle



Kiss pressure: 3.5~7 kgf / cm^2

Heat rate: 1.8 ~ 3.0 ℃ / min

Full pressure: 25 ~ 30 kgf / cm^2

Apply Full pressure at: 85 ~ 100℃

Curing condition: >175 ℃ / 50 min

(Minimum peak temperature in curing condition: 195℃)

*The heating rate higher will be better for peeling strength and inner layer pattern filling, while the lower will be better for press flow. Please contact us for setting suitable press cycle if necessary .

PCB Processing Parameter Suggestion

Process		Condition		
Surface Clean		Std. Practice		
A.O.I.		Std. Practice		
Oxide treatment		Std. Black or Brown		
Oxide Bake		120 ℃ 40 min		
Hole diameter (mm)		0.3	0.4	0.5
Spindle Speed (Krpm)		150	120	100
In Feed (inch / min)		120	102	90
Chip Load (mil / rev)		0.8	0.85	0.9
Number of Hits		1500	1500	1500
Sweller (Uyemura)	Vertical	60 ℃ for 5 min.		
$KMnO_4$ (Uyemura)	Vertical	80 ℃ for 9 min.		

Additional Suggestion during Processing

For improving material moisture absorbed in processing, post-baked treated would be suggested as several processing:

1. Finished board before packing

   1-1 HASL: 150 degree C for 4 hours

   1-2 ENIG finished: 120 degree C for 4 hours

   1-3 Before OSP: 150 degree C for 4 hours

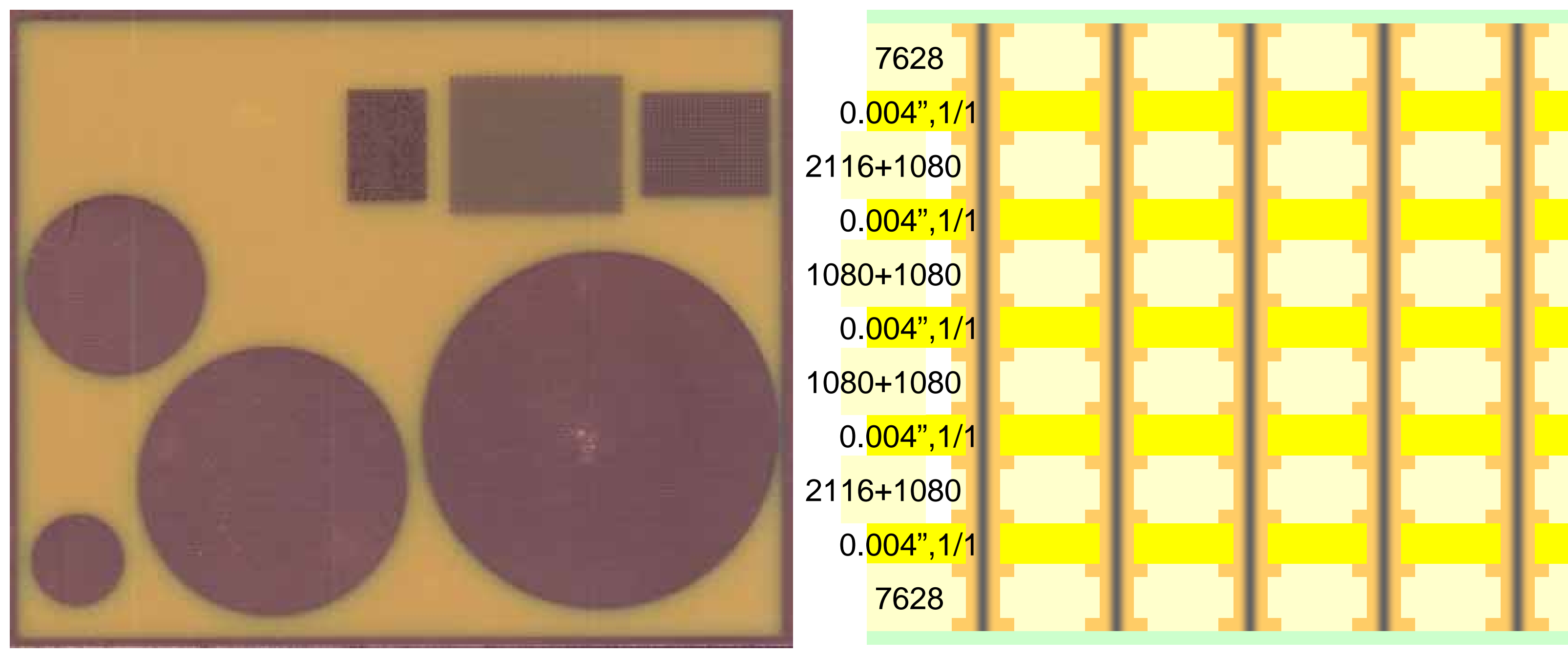
2. Solder mask re-work or WIP over 2 weeks

   150 degree C for 4 hours

Reliability Test

Test Pattern & Construction

Thickness : 2.0mm
Layer Count: 12
Hole Diameter: 0.3mm
Wall to wall : 0.3 / 0.45 / 0.7mm
Ground Copper Diameter: 0.5/ 1.0/ 1.5/ 2.0 inch



Reliability Test

IR Reflow Condition

IR Reflow溫度設定值(單位 ：℃)

設定值	第1段	第2段	第3段	第4段	第5段
上爐溫	250	230	260	250	320
下爐溫	250	230	260	250	320

IR Reflow溫度實測值

項目	IPC/JEDEC J-STD-020C	實測值
預熱段時間(150~200℃)	60~180sec	63
平均昇溫速率(200~260℃)	<3℃/sec	0.65
>217℃時間	60~150sec	112
高溫段時間(255~260℃)	20~40sec	29
最高溫度	260℃	262
降溫速率(260~140℃)	<6℃/sec	3.43
昇溫時間(25~260℃)	<8分	4.5

Reliability Test

Copper Ground with IR Reflow

N = 12

Item	Condition	Pattern	unit	EM-285	H	N	M
Copper ground	As received	0.5"	cycle	＞10	7~8	8~9	＞10
		1.0"		＞10	6~8	7~9	＞10
		1.5"		＞10	5~7	7~8	＞10
		2.0"		＞10	4~7	6~8	＞10
	85℃, 85% RH, 40hr treated	0.5"		＞10	6~7	5~8	＞10
		1.0"		＞10	5~8	6~7	＞10
		1.5"		＞10	6~7	5~6	＞10
		2.0"		＞10	5~7	4~6	＞10

Thermal resistance with ground copper area improved in EM-285

Reliability Test

Hole Wall Crack after IR Reflow

N = 45

Material	Wall to wall (mm)	Delamination Ratio (%)		
		3 cycles	6 cycles	9 cycles
EM-285	0.30	13	41	87
	0.45	0	35	77
	0.70	0	0	13
H	0.30	21	51	93
	0.45	0	48	86
	0.70	0	9	21
N	0.30	56	83	100
	0.45	33	78	93
	0.70	7	26	37
M	0.30	47	73	100
	0.45	22	60	91
	0.70	4	18	27

EM-285 Can Pass the wall to wall 0.45mm by 3 Cycles and 0.70mm by 6 Cycles of Lead-Free IR Reflow

Reliability Test

Micro-sectioning of hole wall with IR reflow 6 cycles

Wall to wall (mm)	EM-285	H	N	M
0.7				
0.45				

Conclusion

EM-285 Advantage

1. Better Thermal Resistance
   (Lead-Free Requirement)

2. Better Capability to Reduce the Drilling Bit
   Abrasion

3. Better Electrical Performance in
   High Frequency Application (Low Df)