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ITEQ Corporation

Your Partner of Advanced Materials & Mass Lam Service

Low CTE High Tg Material
IT-180A

Innovation, Teamwork, Excellence, Quality

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Outline

- IPC Material Specification
- Key Characteristics of Base Materials
- ITEQ Materials Property
- IT-180A Moisture Absoption
- IT-180A Drilling Test
- Product Application & Thermal Resistance
- Conclusion

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Material Specifications for Lead Free Solder Process

IPC-4101B Specification for Base Materials for Rigid and Multilayer Printed Boards was published in June, 2006. The major characteristics are defined as follows.

IPC-4101B/	*121*	*101*	*124*	*99*	*129*	*126*
Type	Normal Tg		Mid Tg		High Tg	
Tg(℃)	>110	>110	>150	>150	>170	>170
Filler (<5%)	none	yes	none	yes	none	yes
Td (℃, TGA 5%)	>310	>310	>325	>325	>340	>340
T-260 (min)	>30	>30	>30	>30	>30	>30
T-288 (min)	>5	>5	>5	>5	>15	>15
T-300 (min)	¾	¾	¾	¾	>2	>2
Z-axis CTE(%, 50~260℃)	<4.0	<4.0	<3.5	<3.5	<3.5	<3.0

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Key Characteristics: Z-axis CTE & Td

Z-axis CTE (Coefficient of thermal expansion)

Z-axis CTE means the expanding degree of base material at Z-axis direction after being heated. The expanding coefficient before Tg and after Tg, and the total dimensional change can be gotten by TMA(Thermal Mechanical Analysis) test. Commonly, the PCB's PTH reliability depends on its Z-axis CTE. And some PCB delamination issues are mainly relative to their high Z-axis CTE values.

Z-axis CTE ↓ ⟹ PTH Reliability ↑

Td (Temperature of decomposition)

Td is defined as the temperature of decomposition when 5%wt loss by TGA (Thermogravimetric Analysis) test in IPC-TM-650 specification. The thermal resistance of base material depends on its Td value. Generally, some PCB delamination issues are relative to their low Td values.

Td ↑ ⟹ Thermal Resistance ↑

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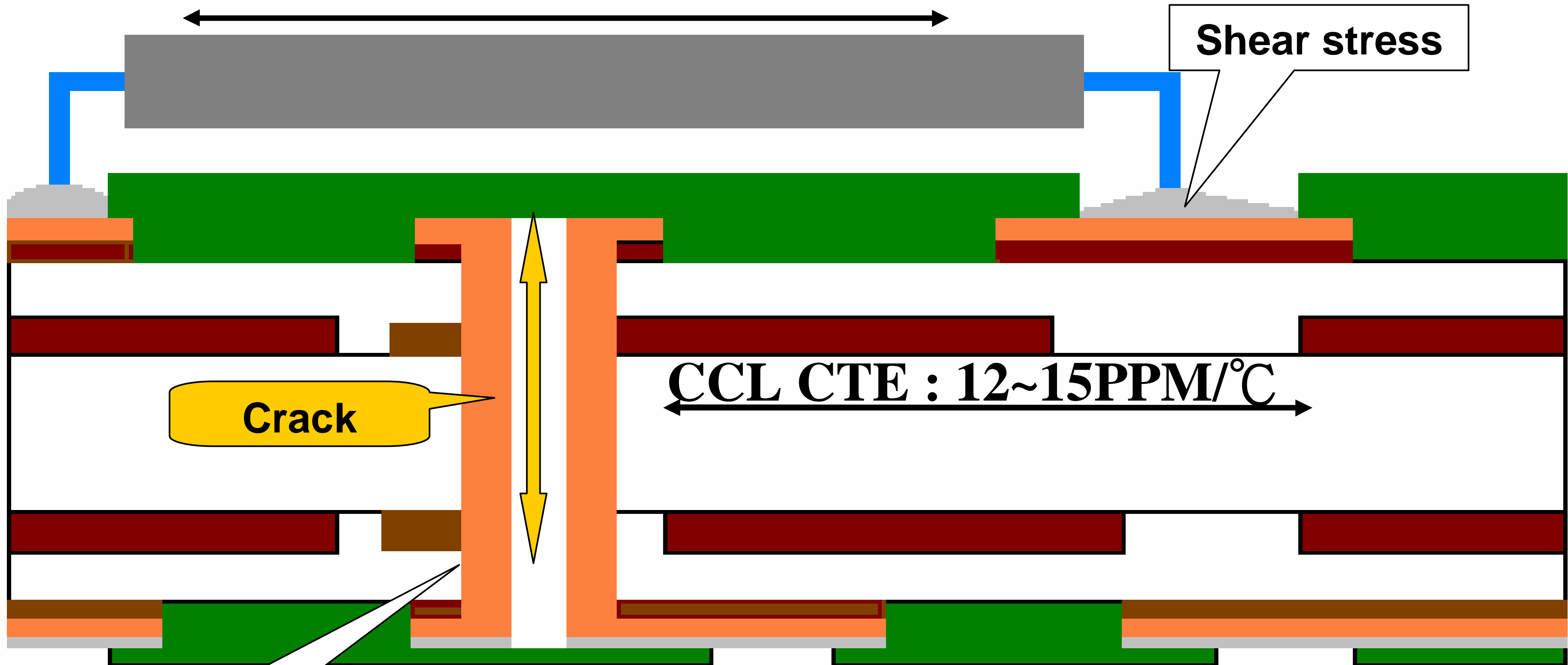
Why Low CTE

Component typical CTE: 8~12PPM/℃



CCL typical z-axis CTE: Before Tg: 40~60PPM/℃
After Tg: 280~350PPM/℃

Copper CTE : 17~18PPM/℃

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Why High Td (Decomposition)

- Higher reflow temperature (240~260℃) due to higher melting point and poor wetting characteristic of lead-free solder.
- Larger thermal mass to the PCBA
- Thermal degradation may occur during the multi-heating cycle assembly process.

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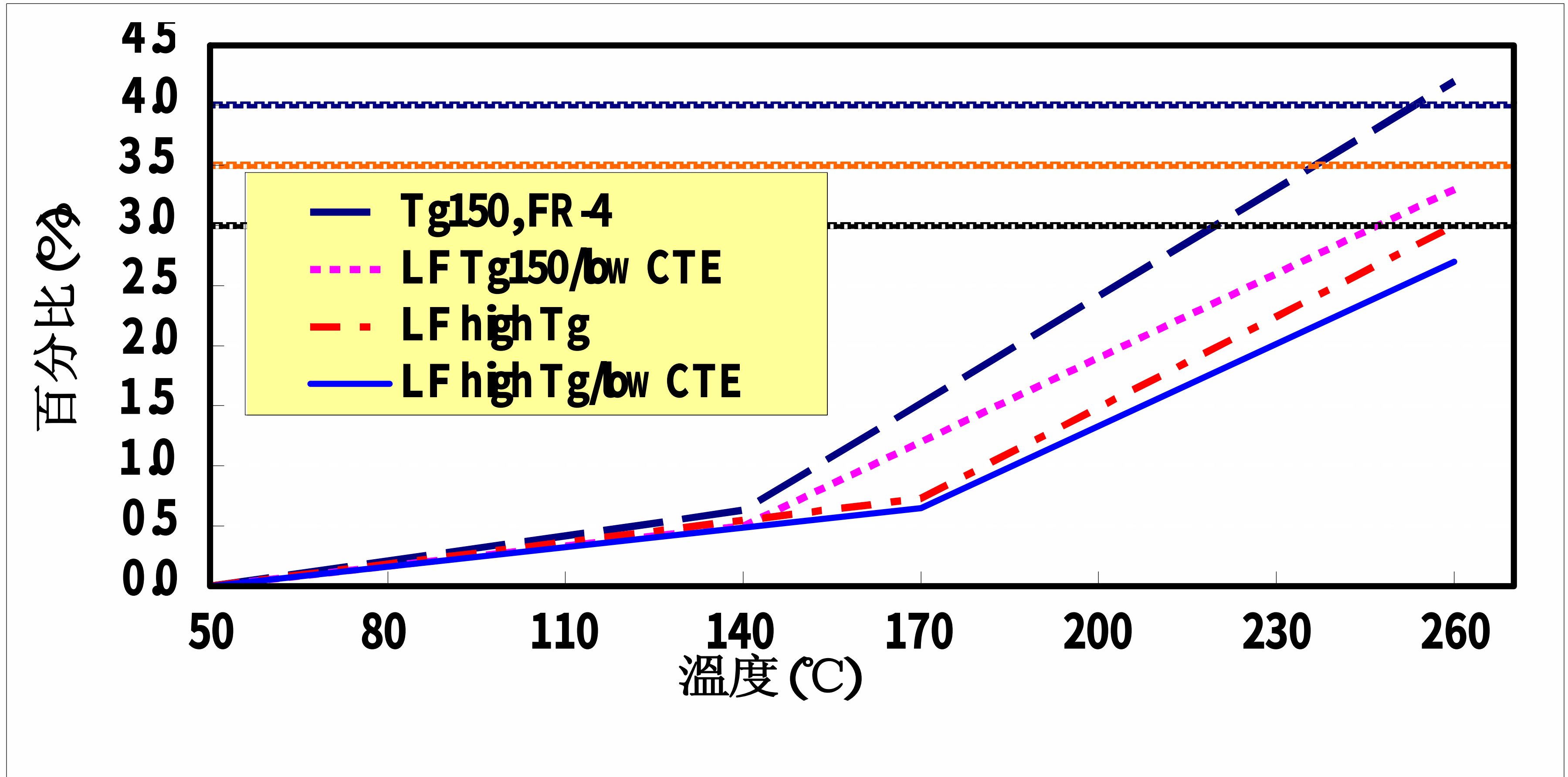
CTE Comparision



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Important Property: Tg, Td, and CTE

- Conventional way of classifying materials is mainly based on Tg. A higher Tg contributes to a lower thermal expansion in the z-axis thus better through hole reliability.
- A higher Tg does not mean a higher Td (better thermal resistance).
- Key material features: Td, CTE, and Tg

Class	Curing Agent	Tg(℃, DSC)	Td (℃)	CTE(%, 50~260℃)	Product
High Tg	**Non-dicy**	**180**	**355**	**2.7**	**IT180A**
	Dicy	175	315	3.2	**I406**
Mid Tg	**Non-dicy**	**150**	**350**	**3.2**	**IT158**
	Dicy	150	320	4.2	**N150**

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Performance For ITEQ's Product

下面是ITEQ系列产品对比IPC-4101B标准要求的性能数据

產品		4101B/	IT140	IT588	IT158	IT180	IT180A
屬性	测试方法	無鉛材料	標准 FR-4	普通-Tg	中-Tg/低 CTE	高Tg	高 Tg/低 CTE
Tg (℃)	*DSC*	*>110~>170*	*>135*	*>135*	*>150*	*>175*	*>175*
Tg (℃)	*DMA*	*	*>145*	*>145*	*>160*	*>190*	*>190*
熱膨脹系數 (%), 50-260℃	*TMA*	*<3.0~<4.0*	*4.2*	*<3.8*	*<3.3*	*<3.0*	*<2.8*
CTE (ppm/℃)	α1/α2	*<60/300*	*55/290*	*50/260*	*40/250*	*50/255*	*45/240*
T-260 (min)	*TMA*	*>30*	*<25*	*>60*	*>60*	*>60*	*>60*
T-288 (min)	*TMA*	*>5*	*<5*	*>20*	*>20*	*>20*	*>20*
Td-5% (℃)	*TGA*	*>310~>340*	*<325*	*>340*	*>340*	*>340*	*>340*
抗剝強度 (lb/in)	*1 oz, A*	*>6.0*	*11.5*	*11.0*	*10.0*	*9.0*	*9.0*
吸水性 (%)	*D-24/23*	*<0.5*	*<0.15*	*<0.15*	*<0.15*	*<0.15*	*<0.15*
Dk	*1M Hz*	*<5.4*	*4.7*	*4.7*	*4.8*	*4.7*	*4.7*
Df	*1M Hz*	*<0.035*	*0.017*	*0.017*	*0.016*	*0.018*	*0.017*
耐燃性	*UL 94V*	>	*94V-0*	*94V-0*	*94V-0*	*94V-0*	*94V-0*
STII	Spec. ≧ 215	*	*188*	*215*	*217*	*228*	*231*

基于1.6mm 厚度板材

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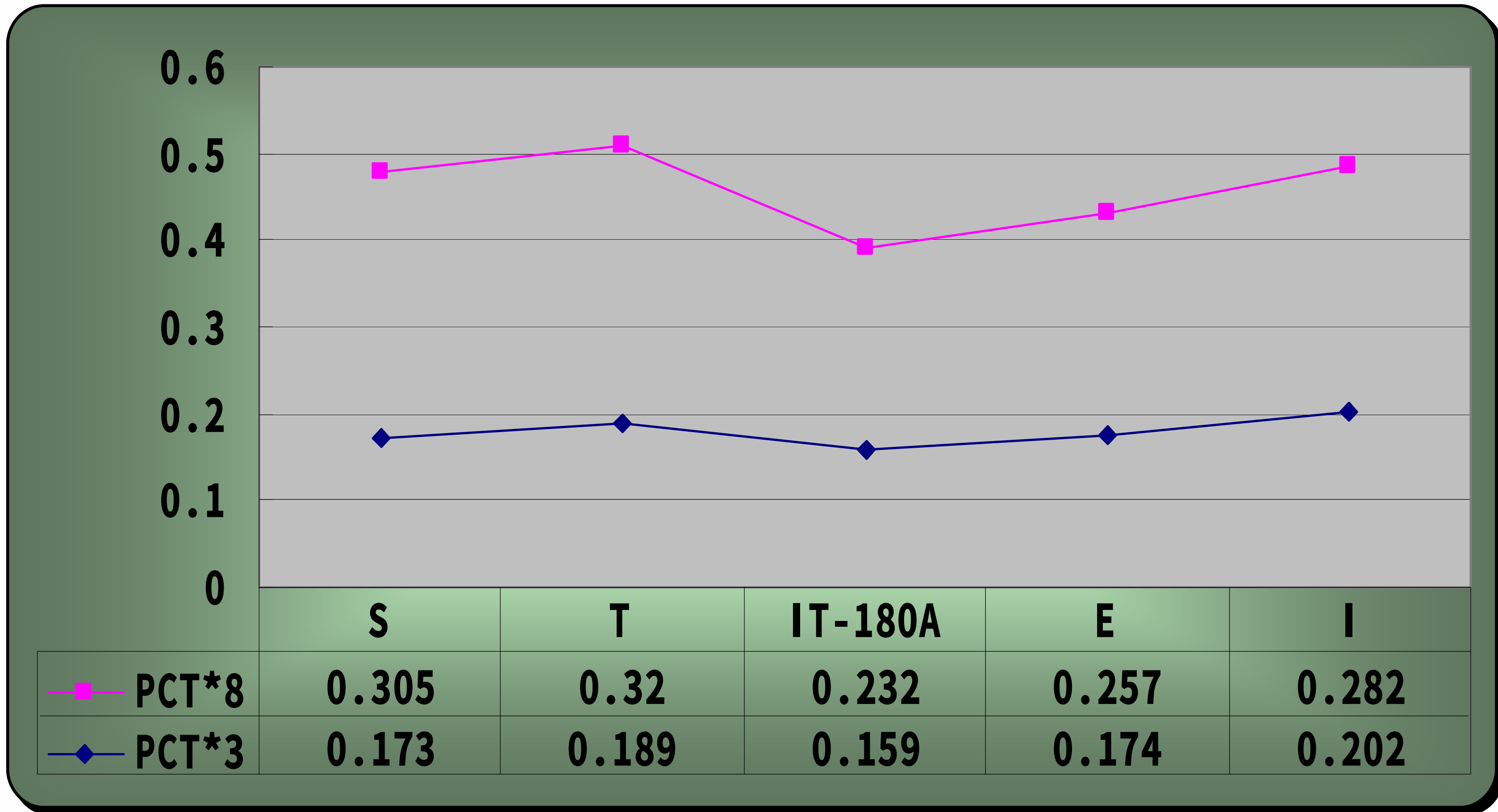
Moisture Absorption Comprision



	S	T	IT-180A	E	I
PCT*8	0.305	0.32	0.232	0.257	0.282
PCT*3	0.173	0.189	0.159	0.174	0.202

Sample:1.6mm CCL

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Pressing parameter (IT-180A)

- IT-180A pressing parameter (normal & HDI PCB):

Material:IT-180A													
pressing machine:Vigor													
Item	1	2	3	4	5	6	7	8	9	10	11	12	13
Pressure (PSI)	100	100	200	200	250	250	350	350	350	350	350	200	100
min	5	3	3	5	3	6	3	3	2	49	60	25	3
temperature(℃)	150	170	170	180	190	190	210	210	190	190	150		
min	10	2	2	5	3	8	12	53	10	60	5		

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Drill bit wearing Comprision

Ø **Drilling Parameter**

Drill size (mm)	Holes	Spindle speed (krpm)	Infeed (krpm)	Retract Feed (krpm)
0.2	1200	155	1.6	25
0.3	1200	140	3	25
0.45	1200	100	3.6	25
0.55	1200	85	3.6	25

Ø **Wearing of Drill bit**

Drill size	0.55 mm	0.45 mm	0.3 mm	0.2 mm	Grade*
IT180A	16.4%	10.9%	30.5%	10.0%	O(better)
I	14.4%	10.8%	38.2%	7.3%	O(better)
S	18.0%	18.5%	33.2%	19.7%	Δ(worse)
E	19.9%	17.4%	52.9%	26.7%	Δ(worse)

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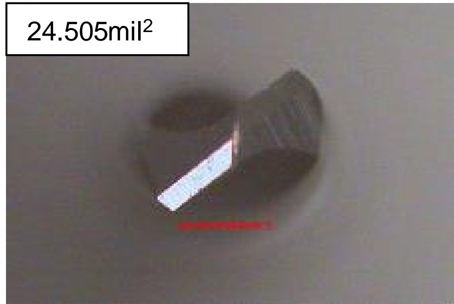
New bit

0.55mm

24.505mil^2

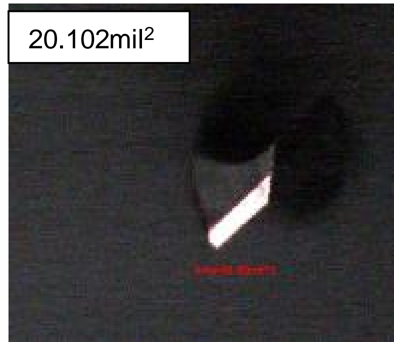


WEARING %
IT180A: 16.4%
S: 18.0%
E: 19.9%
I : 14.4%

20.864mil^2

IT180A

20.102mil^2



IT180A

20.870mil^2

S

19.321mil^2

S

19.583mil^2

E

19.681mil^2

E

21.338mil^2

I

20.604mil^2

I

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New bit

0.45mm

15.444mil²

WEARING %	
IT180A:	10.9%
S:	18.5%
E:	17.4%
I:	10.8%

13.824mil²

IT180A

13.697mil²

IT180A

12.360mil²

S

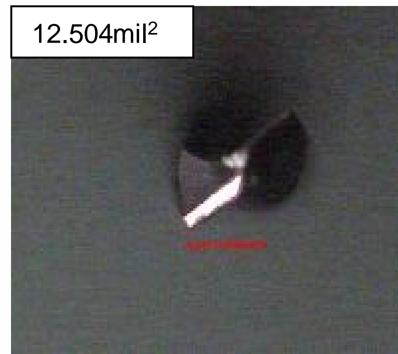
12.827mil²

S

12.990mil²

E

12.504mil²



E

13.931mil²

I

13.612mil²

I

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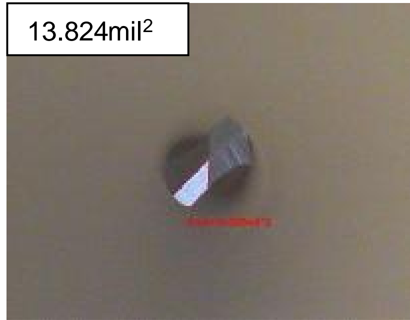
New bit

0.3 mm



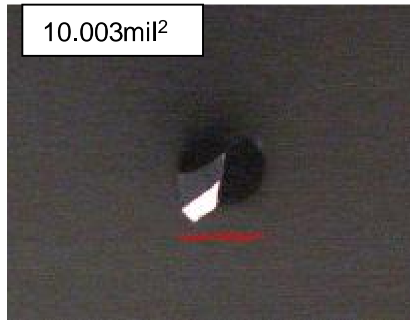
WEARING %

IT180A: 30.5%

S: 33.2%

E: 52.9%

I: 38.2%



IT180A

IT180A

S

S

E

E

I

I

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New bit

0.2 mm

5.071mil^2

WEARING %

IT180A: 10.0%

S: 19.7%

E: 26.7%

tI : 7.3%

4.408mil^2

IT180A

4.714mil^2

IT180A

3.481mil^2

S

4.660mil^2

S

3.913mil^2

E

3.519mil^2

E

4.770mil^2

I

4.634mil^2

I

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Drill bits usage suggestion

- Drill bits usage:

Drill bits type	Drill bits size	Repointed times
Common drill bits	0.15	1
	0.15＜Φ＜0.25	2
	0.25≤Φ＜0.40	3
	0.40≤Φ＜0.45	4
	0.45≤Φ＜0.60	5
	0.60≤Φ＜1.55	6
	1.55≤Φ＜2.00	7
	2.00＜Φ	9
undercut drill bits	0.15	1
	0.15＜Φ＜0.25	2
	0.25≤Φ＜0.40	3
	0.40≤Φ＜1.20	4

- **IT-158 & IT-140G & IT-180A material be recommended use ST drill bits regrinded for less than 2 times or UC drill bits regrinded for less than 3 times.**
- **For the board with Aspect Ratio ≥ 8 or layer ≥ 16, use 0.3mm drill bits regrinded for 2 times at most. (remark: Aspect Ratio= board thickness × quantity of stack ÷ 0.3mm)**

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Drilling stacks suggestion

- Drilling stacks base on board and copper thickness:

M/C type 机型	Thickness 板厚 (mil)	Drilling stacks (panel/stack) 钻板叠数（块/叠）							
		0.15≤Φ <0.2	0.2≤Φ <0.3	0.3≤Φ <0.35	0.35≤ Φ< 0.4	0.4≤ Φ< 0.5	0.5≤Φ <0.65	0.65≤ Φ< 0.8	0.8≤Φ
HITACHI SCHMOLL EXCELLON 2000 EXCELLON 2001 Giga8888	101 以上	/	1	1	1	1	1	1	1
	80~100	/	1	1	1	2	2	2	2
	70~79	/	1	1	2	2	2	2	3
	51~69	/	1	2	3*	3	4	4	4
	43~50	1	1	3*	3	3	4	4	4
	35~42	1	1	3	3	4	5	5	5
	21~34	1	2	3	3	4	5	5	6
	20 以下	1	2	3	3	3	3	3	3

Cu 厚（OZ）	Max stack (panels/stack) 钻板叠数（块/叠）					
	Φ<0.3	0.3≤Φ<0.4	0.4≤Φ<0.5	0.5≤Φ<0.65	0.65≤Φ<0.8	0.8≤Φ
δ>16	1	1	1	1	1	1
14<δ≤16	1	1	1	1	1	2
12<δ≤14	1	1	1	1	2	2
10<δ≤12	1	1	2	2	2	2
8<δ≤10	1	2	2	2	2	3
6<δ≤8	1	2	3	3	3	3
4<δ≤6	2	3	3	4	4	4
δ≤4	3	3	4	5	6	6

Remark: For the boards (outer copper thickness ≤1/8 OZ), to drill at most 2 panels/stack; the boards (outer copper thickness 2OZ), to drill at most 3 panels/stack; and the boards (outer copper thickness>2OZ), to drill at most 2 panels/stack.

- IT-158 & IT-140G & IT-180A material be recommended use ST drill bits regrinded for less than 2 times or UC drill bits regrinded for less than 3 times.
- For the board with Aspect Ratio ≥ 8 or layer ≥ 16, use 0.3mm drill bits regrinded for 2 times at most. (remark: Aspect Ratio= board thickness × quantity of stack ÷ 0.3mm)

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Peck drilling condition and parameter

- Peck drilling condition:

Stack type 叠板方式	Hole size 孔径	Layers 分层数	
Backplane (board Thk≥120mil) 背板（板厚≥120mil）	Φ≤1.0mm	Stack Thk120~179 mil 叠板厚度 120~179 mil	2
		Stack Thk180~239 mil 叠板厚度 180~239 mil	3
		Stack Thk≥240mil 叠板厚度≥240mil	4
	Φ≥4.0mm	Stack Thk <240mil 叠板厚度<240mil	2
		Stack Thk≥240mil 叠板厚度≥240mil	3
Board with board Thk 80~100mil (2panels/stack) 板厚 80~100mil 的板（2 块/叠）	0.45<Φ≤1.0mm	Stack Thk160~179mil 叠板厚度 160~179 mil	2
		Stack Thk180~200mil 叠板厚度 180~200 mil	3
	Φ≤0.45mm	3	
Board with board Thk 80~100mil (1panel/stack) 板厚 80~100mil 的板（1 块/叠）	Φ≤0.25mm	2	
Board with board Thk 101~119mil 板厚 101~119mil 的板	Φ≤0.35mm	2	

- Peck drilling parameter:

Layers 分层数	Parameter 分层参数
2	L1=0.6×(board Thickness+30mil);L2=0.4×(board thickness +30mil) L1=0.6×(板厚+30mil)；L2=0.4×(板厚+30mil)；
3	L1=0.45×（board thickness+30mil）,L2=0.3×（board thickness + 30mil）,L3=0.25×（board thickness+30mil） L1=0.45×（板厚+30mil）；L2=0.3×（板厚+30mil）；L3=0.25×（板厚+30mil）；
4	L1=0.3×(board Thickness +30mil);L2=0.25×(board Thickness+30mil);L3=0.25×(board Thickness+30mil);L4=0.20×(board Thickness +30mil) L1=0.3×(板厚+30mil)；L2=0.25×(板厚+30mil)；L3=0.25×(板厚+30mil)；L4=0.20×(板厚+30mil)；

Note/注： L0=DN+ board thickness+30mil; F=F1
L0=DN+板厚+30mil; F=F1

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Drilling parameter (IT-180A)

- Drilling parameter for high density layer PCB: (Hitachi machine) for reference

Drill (mm)	Drill (inch)	SPEED (krpm)	INFEET (ipm)	RTR (ipm)	OFFSET (inch)	MAXIMUM (hits)	CL (mil/rev)	SFM (Feet/min)
0.30	0.0118	95	50	500	0.013	900	0.53	294
0.35	0.0138	95	65	500	0.013	1200	0.68	343
0.40	0.0158	95	80	500	0.012	1200	0.84	391
0.45	0.0177	90	90	500	0.011	1200	1.00	417
0.50	0.0197	85	95	500	0.01	1200	1.12	438
0.55	0.0217	78	95	700	0.01	1500	1.22	442
0.60	0.0236	75	95	700	0.006	1500	1.27	464
0.65	0.0256	70	96	700	0.005	1500	1.37	469
0.70	0.0276	65.5	94	700	0.004	1500	1.44	472
0.75	0.0296	61	94	700	0.004	1500	1.54	471
0.80	0.0315	57	92	800	0.003	1500	1.61	470
0.85	0.0335	53	90	800	0.003	1500	1.70	464
0.90	0.0354	51	85	800	0.002	1500	1.67	473
0.95	0.0374	48	84	800	0.002	1500	1.75	470
1.00	0.0394	46	80	800	0.001	1500	1.74	474
1.05	0.0413	44	78	800	0.001	1500	1.77	476
1.10	0.0433	42	75	800	0	1500	1.79	476
1.15	0.0453	40	76	800	0	1500	1.90	474
1.20	0.0472	38	73	800	0	1500	1.92	470
1.25	0.0492	38	73	800	-0.001	1500	1.92	489
1.30	0.0512	38	73	800	-0.001	1500	1.92	509
1.35	0.0531	37	73	800	-0.002	1500	1.97	515
1.40	0.0551	36	73	800	-0.002	1500	2.03	519
1.45	0.0571	35	73	800	-0.003	1500	2.09	523
1.50	0.0591	34	72	800	-0.003	1500	2.12	525
1.55	0.0610	33	72	800	-0.004	1500	2.18	527
1.60	0.0630	32	71	800	-0.004	1500	2.22	527
1.65	0.0650	31	71	800	-0.005	1500	2.29	527
1.70	0.0669	30	71	800	-0.005	1500	2.37	525
1.75	0.0689	29	71	800	-0.006	1500	2.45	523
1.80	0.0709	28	70	800	-0.006	1500	2.50	519
1.85	0.0728	27	68	800	-0.006	1500	2.52	515
1.90	0.0748	27	66	800	-0.007	1500	2.44	528
1.95	0.0768	26	65	800	-0.007	1500	2.50	522
2.00	0.0787	25	63	800	-0.008	1500	2.52	515

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Desmear condition

- Horizontal desmear parameter (supplier:ATO):

Item		requirement	time(min)
sweller	sweller P	405-525ml/L	1.7
	PH correction	PH 10-12	
	Temperature	65-70℃	
desmear	Dose P500	48-65g/L	3.6
	NaOH	33-47g/L	
	Temperature	77-83℃	

- Vertical desmear parameter (supplier:Macdermid)

Item		requirement	time(min)
sweller	1.alkaline	0.75-0.85N	10
	2.M-79224	3-5%	
	3.Temperature	72-78℃	
desmear	1.KMnO4	55-65g/L	25
	2.K2MnO4	<30g/L	
	3.M-76224	5-7%	
	4.Temperature	75-81℃	

- IT-158 & IT-140G material desmear parameter same to normal FR-4 material.
- IT-180A material desmear should run 1.5-2.0times according to normal FR-4 parameter

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Desmear condition

- Vertical desmear parameter (supplier:Rohm Haas):

Item		requirement	time
sweller	1. alkaline	0.75-0.85N	6' 45"
	2. strength	70-100%	
	3. Temperature	75-82℃	
desmear	1. KMnO4	50-60g/L	12' 23"
	2. K2MnO4	<20g/L	
	3. alkeline	1.0-1.3N	
	4. S.G	<1.16g/L	
	5. weight loss	0.07-0.5mg/cm2	
	6. temperature	75-82℃	

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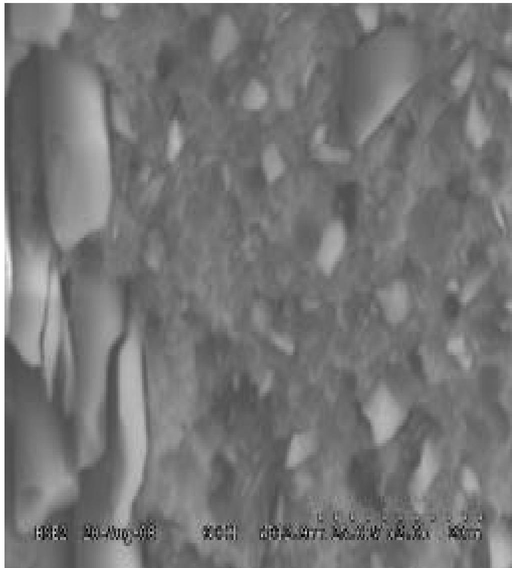
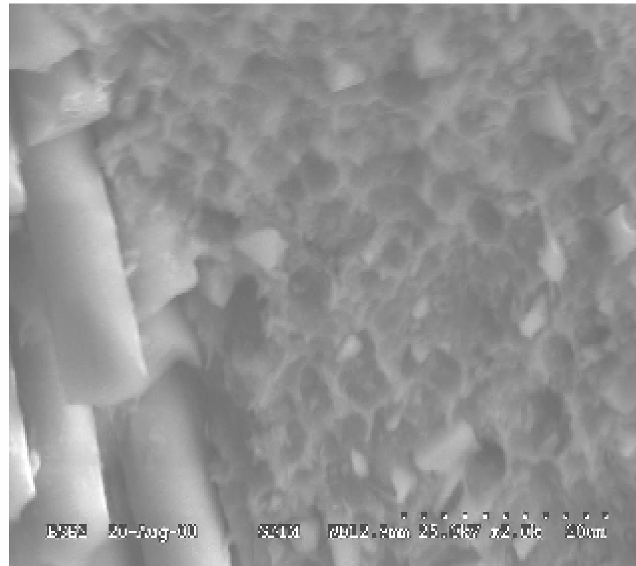
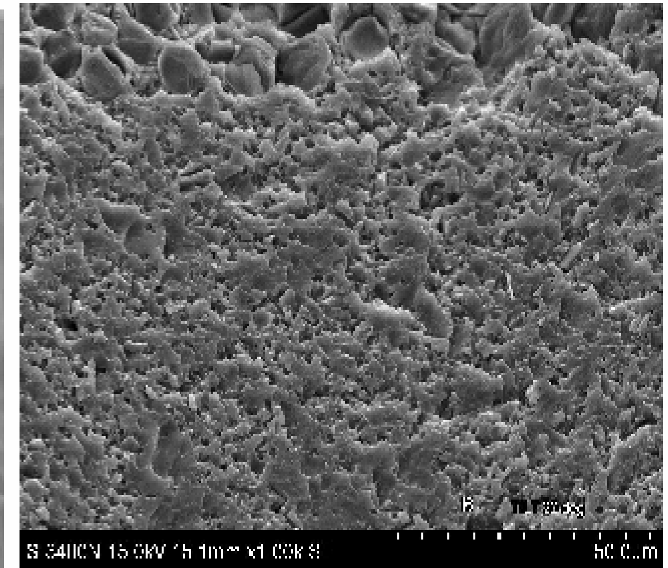
Desmear photos

- IT-158 & IT-180A & IT-140G hole wall photos by SEM:

IT-140G: (normal parameter)   IT-158: (normal parameter)   IT-180A:(1.5 times)







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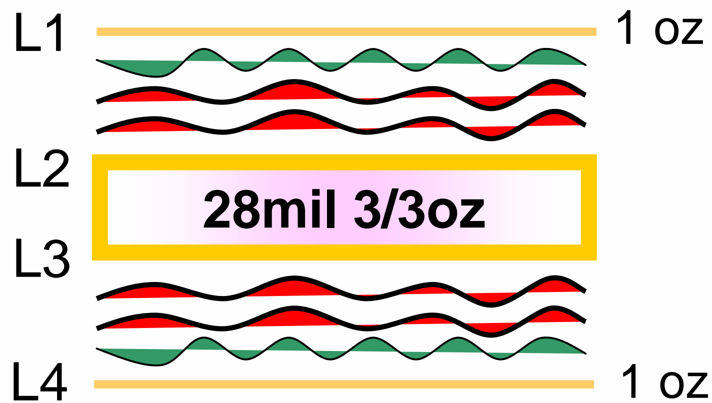
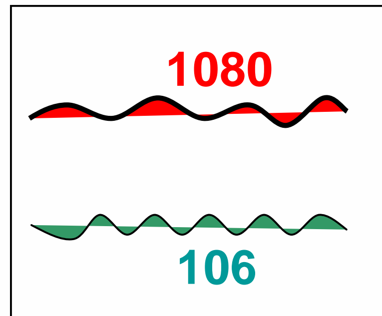
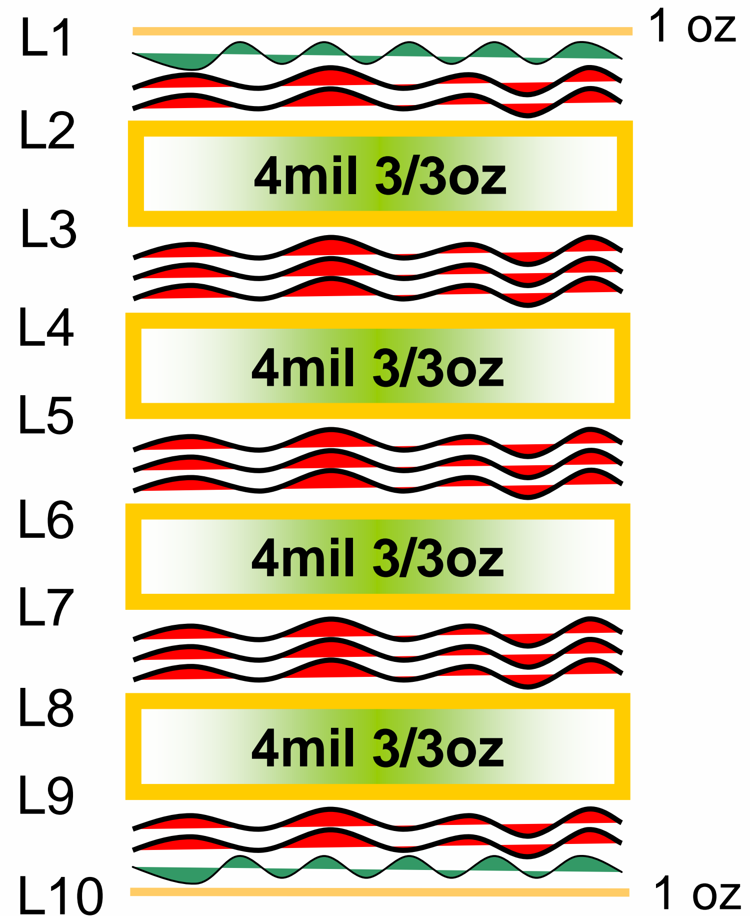
ITEQ

IT180A apply for heavy copper

壓合結構







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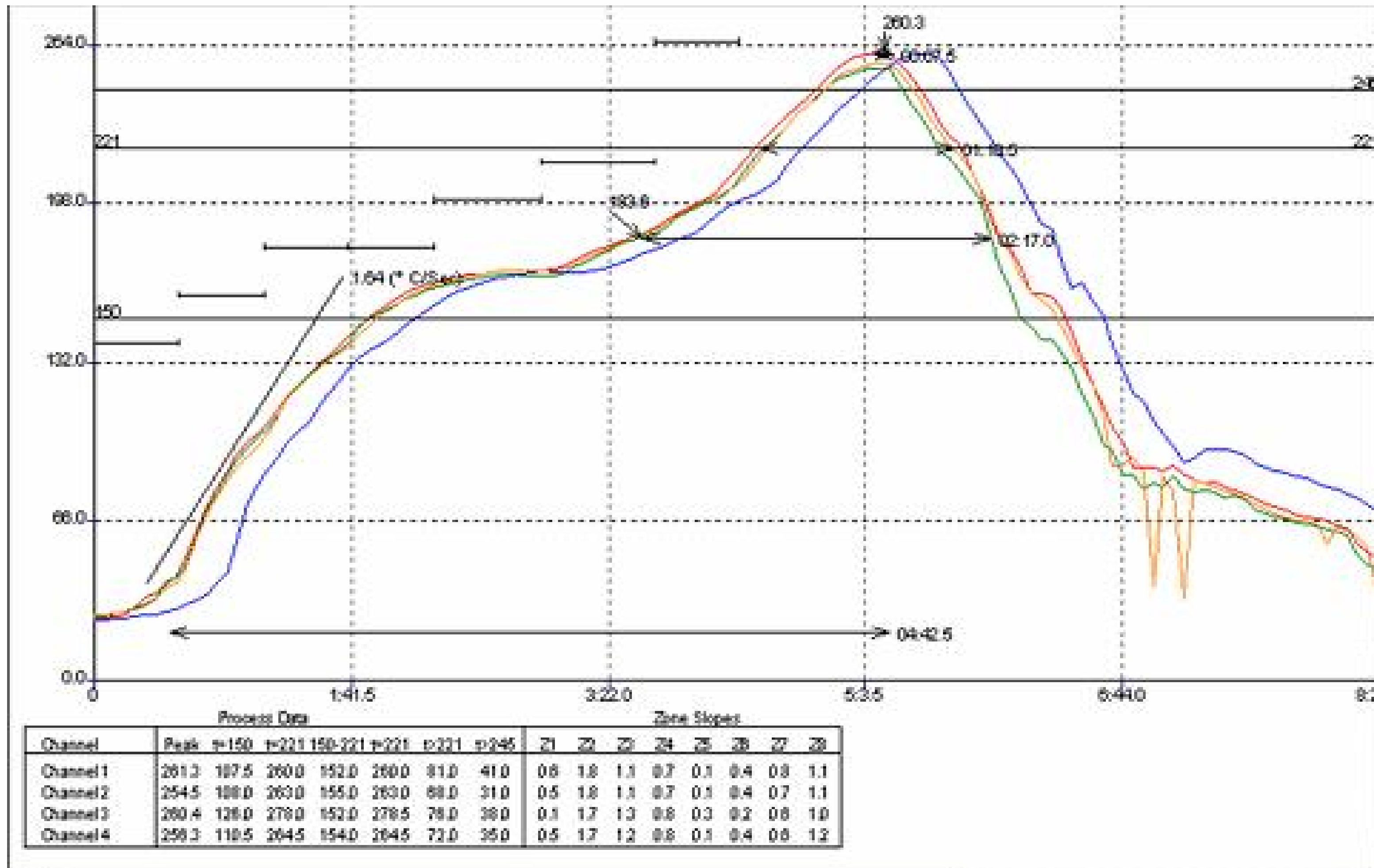
ITEQ

IT180A apply for heavy copper

Reflow Profile



Channel	Peak	t>150	t>221	150-221	t>221	t>221	t>245	Z1	Z2	Z3	Z4	Z5	Z6	Z7	Z8
Channel 1	261.3	107.5	260.0	152.0	260.0	81.0	41.0	0.6	1.8	1.1	0.7	0.1	0.4	0.8	1.1
Channel 2	254.5	108.0	263.0	155.0	263.0	68.0	31.0	0.5	1.8	1.1	0.7	0.1	0.4	0.7	1.1
Channel 3	260.4	126.0	278.0	152.0	278.5	76.0	38.0	0.1	1.7	1.3	0.8	0.3	0.2	0.6	1.0
Channel 4	258.3	110.5	264.5	154.0	264.5	73.0	35.0	0.5	1.7	1.2	0.8	0.1	0.4	0.6	1.2

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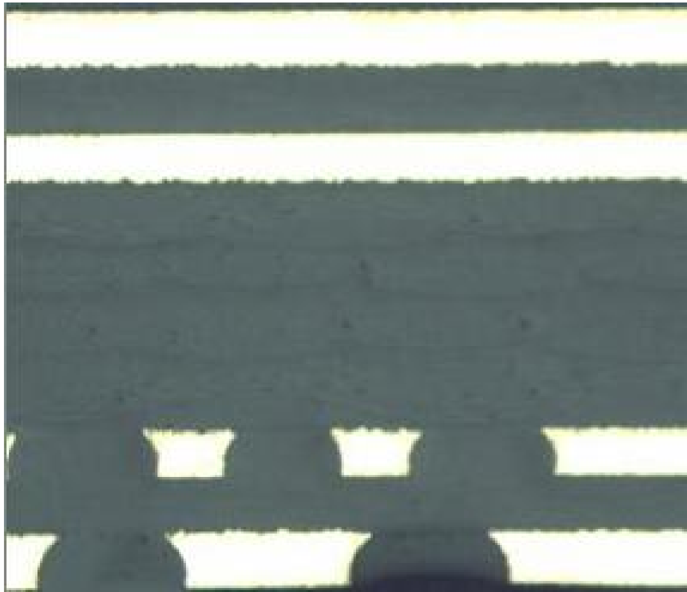
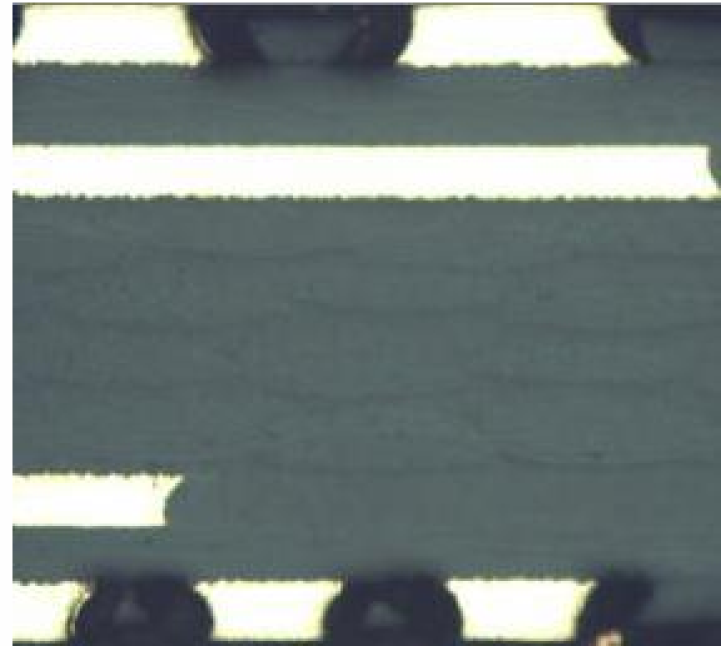
IT180A 应用于厚铜板

- 使用IT180A材料3oz 4層板過3次reflow后未發現任何分層不良，測試結果ok，圖片如下：





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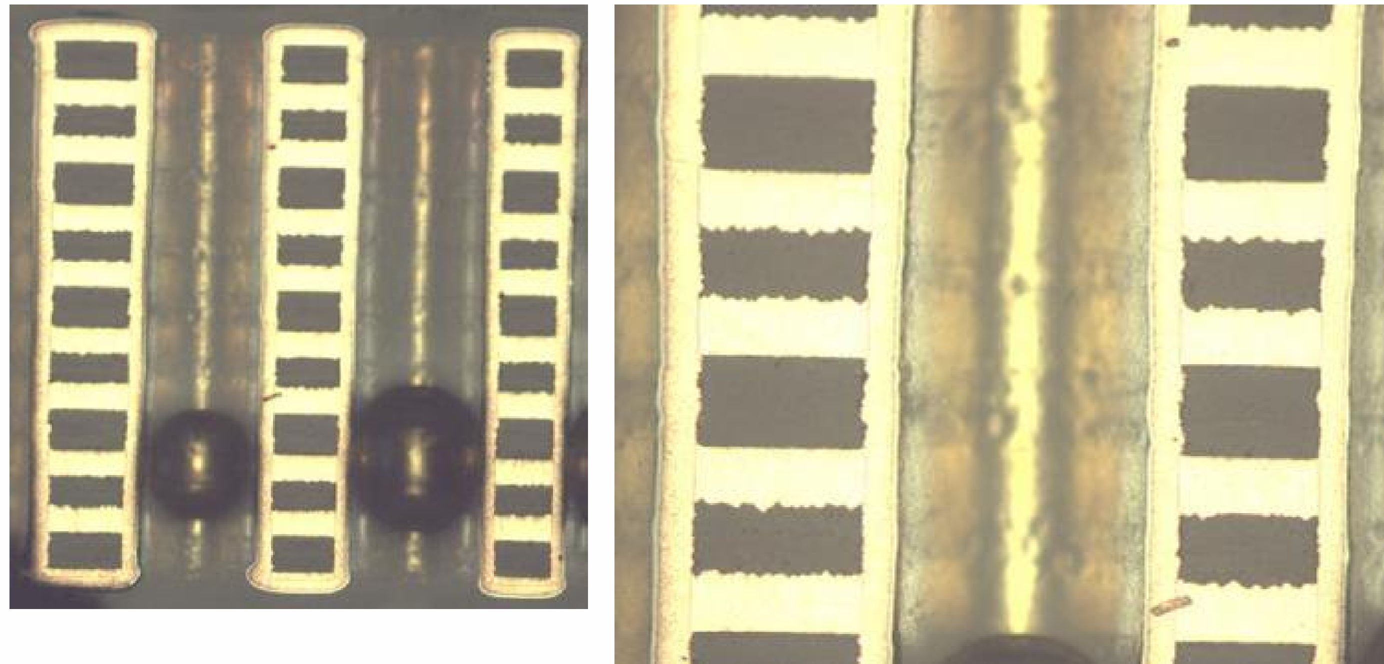
ITEQ

IT180A 应用于厚铜板

- 對于IT180A应用于厚铜板，Reflow后切片圖片如下：



6次Reflow后沒有發現任何問題，測試結果ok。

綜上所述，敝司認為IT180A材料對于密集散熱孔及厚銅板具有更好的適應性。

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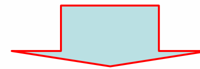
IT180A Vs Other High Tg

Laminate Performance Comparison

Characteristics	Condition	Units	IT-180A	P-HR	I-420	E-827	T-752	IT-180	I-410	P-370	G-170	T-772	S-HTg
Tg	DSC	℃	175	176	173	172	175	177	174	175	175	173	176
CTE-Z α1 (＜Tg)	TMA	ppm/℃	40	51	48	54	50	53	60	55	55	56	56
CTE-Z α2 (＞Tg)	TMA	ppm/℃	245	262	242	265	270	265	280	287	290	295	295
Z-axis Thermal Exp.	50~260℃	%	2.8	3.2	2.6	3.0	3.1	3.1	3.3	3.5	3.4	3.5	3.5
T-260	TMA	min	>60	>30	>60	>60	>60	>60	>60	>30	>30	>30	>30
T-288	TMA	min	23	8	25	25	20	22	22	10	9	10	8
Td	TGA	℃	345	320	341	350	342	345	345	325	323	329	320
Peeling Strength	1 oz	lb/in	9.0	8.0	7.5	8.5	8.6	9.0	8.3	9.0	9.0	8.7	9
Dk	1M Hz	-	4.7	4.7	4.6	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
Df	1M Hz	-	0.016	0.016	0.016	0.016	0.016	0.018	0.018	0.018	0.018	0.018	0.018

Based on 1.6mm laminate.



The comparison of high Tg properties is shown in the table. IT-180 and IT180A show low Z-axis CTE, excellent heat resistance and good toughness.

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IT180A Vs Other High Tg

PCB Reliability Comparison

Example1 (18 layers board)

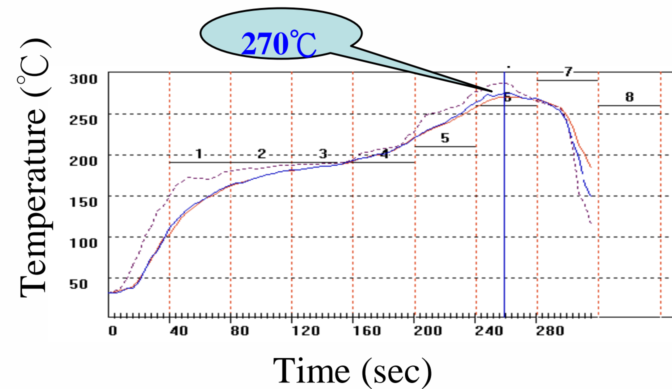
Stack up

7628*1
0.10mm H/H
2116*1
0.10mm H/H
2116*1
0.10mm H/H
2116*1
0.10mm 1/1
1080*2
0.10mm 1/1
2116*1
0.10mm H/H
2116*1
0.10mm H/H
2116*1
0.10mm H/H
7628*1

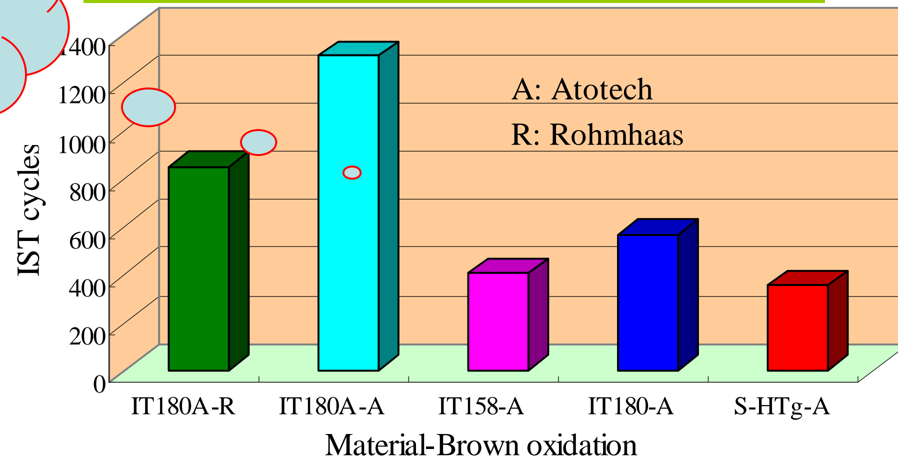
Total thickness:2.4mm

Excellent thermal resistance

Precondition: Reflow*3cycles



IST test results(25℃ ⟺ 150℃, Φ0.5mm)



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IT180A Vs Other High Tg

IT180A is one of the best choices for high-layer PCBs.

PCB Reliability Comparison

Example2 (24 layers board)

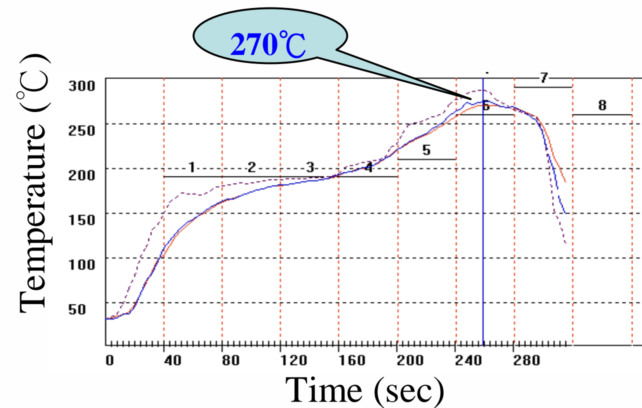
Stack up

Stack up
7628*1
0.10mm H/H
2116*1
0.10mm H/H
2116*1
0.10mm H/H
2116*1
0.10mm H/H
2116*1
0.10mm 1/1
2116*1
0.10mm 1/1
2116*1
0.10mm 1/1
2116*1
0.10mm H/H
2116*1
0.10mm H/H
2116*1
0.10mm H/H
2116*1
0.10mm H/H
7628*1

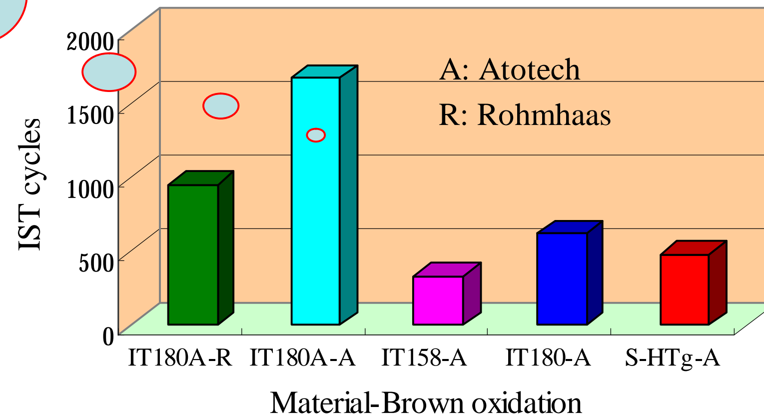
Total thickness:3.2mm

Excellent thermal resistance

Precondition: Reflow*3cycles



IST test results(25℃⟺150℃, Φ0.5mm)



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Conclusions

ITEQ has a total optimized solution of high P(erformance)/C(ost) ratio for the lead free solder processes.

- IT180A shows excellent thermal resistance & low CTE. They are the best performance/cost materials for high layer count PCBs.
- IT180A can apply for heavy copper and high density BGA PCB espcially.
- IT180A shows excellent drilling characteristic ,can replace most of high-Tg material in the market.

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