High Reliability, High Heat Resistance Glass Epoxy Laminate & Prepreg for High Count Layer PCB

MCL-E-679F(J) (Copper Clad Laminate)

GEA-679F(J) (Prepreg)

Printed Wiring Board Materials R&D Dept.
Printed Wiring Board Materials Div.
Hitachi Chemical Co., Ltd., Shimodate Works

Ver. A4.2 Oct. 2007

Features

<Features>

- *High Tg (170-175deg.C by TMA method)*
- *High Heat resistance (288deg.C/20s Dip after PCT-5hr OK)*
- *Suitable for the Lead-free process (260deg.C reflow ;8 cycle OK)*
- *Lower coefficient of thermal expansion*
- *Better IVH filling property*
- *High Reliability (Superior CAF restraining property)*

<Application>

- *High count layer PCB*
- *Automotive application*

E-679F(J) Line-up

Table 1; Laminate Line-up

Core Thickness	Actual Thickness	Glass-cloth
M0.07	0.07+/-0.03mm	#1078
0.07	0.07+/-0.03mm	#1080
0.075	0.08+/-0.03mm	#1080
0.10	0.10+/-0.03mm	#2116
0.11	0.11+/-0.03mm	#1080 x 2
Y0.11	0.11+/-0.03mm	#106 x 2
0.13	0.13+/-0.03mm	#2116
0.15	0.15+/-0.03mm	#1501
0.20	0.20+/-0.04mm	#2116 x 2
V0.20	0.19+/-0.04mm	#7629
0.30	0.31+/-0.06mm	#1501 x 2
0.40	0.39+/-0.07mm	#2116 x 2 + #7629
V0.40	0.39+/-0.07mm	#7629 x 2
0.50	0.50+/-0.08mm	#1501 x 2 + #7629
0.60	0.58+/-0.09mm	#2116 x 2 + #7629 x 2
V0.60	0.58+/-0.09mm	#7629 x 3
0.70	0.70+/-0.10mm	#1501 x 2 + #7629 x 2
0.80	0.77+/-0.10mm	#7629 x 4
1.00	0.96+/-0.10mm	#7629 x 5
1.20	1.15+/-0.13mm	#7629 x 6
1.60	1.53+/-0.15mm	#7629 x 8

Table 2; Prepreg Line-up

Type name	Cured Thickness*	Cloth-style	R.C.
JORE	0.054mm	#106	73.5+/-2%
JUME	0.075mm	#1080	65+/-2%
JUNE	0.083mm	#1080	68+/-2%
JGKE	0.108mm	#3313	59+/-2%
JSJE	0.120mm	#2116	55+/-2%
JSKE	0.140mm	#2116	60+/-2%
JQEE	0.165mm	#1501	49+/-2%
JPDE	0.192mm	#7629	45+/-2%

The dielectric thickness after lamination (Cured thickness) is defined as the thickness of one sheet of prepreg when the resin flow is within 5%. this value changes according to the press condition and inner-layer pattern.

1. Material Properties

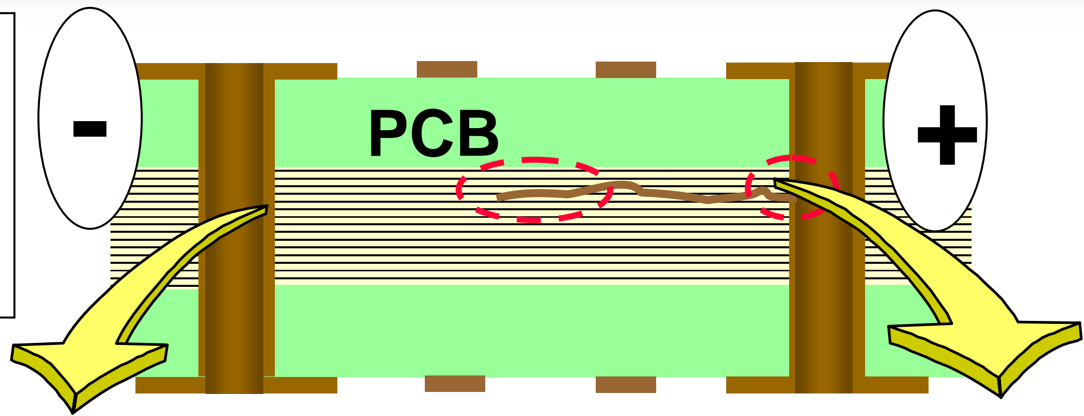
General Properties

Item		Unit	E-679F(J) New Product		E-679(W) High Tg FR-4	E-679F High Elastic High Tg FR-4
			Shimodate made	**Hong Kong made**		
Tg (TMA method)		°C	**170 - 175**	**170 - 175**	173 - 183	160 - 170
CTE	X (<Tg)	ppm/C	**12 - 15**	**12 - 15**	12 - 15	12 - 14
	Y (<Tg)		**14 - 17**	**14 - 17**	14 - 17	12 - 14
	Z (<Tg)		**35 - 45**	**35 - 45**	50 - 60	20 - 30
	Z (<Tg)		**180 - 240**	**180 - 240**	200 - 300	130 - 160
Solder Heat Resistance (288 °C, 20s/Dip)		-	**>PCT 5Hr OK**	**>PCT 5Hr OK**	>PCT 1Hr OK	>PCT 5Hr OK
260 °C Reflow Heat Cycle Test		cycle	**>8**	**>8**	>8	>8
Solder Heat Cycle Test (288°C,10s/Float)		cycle	**>10**	**>10**	7	>10
T288		min.	**>20**	**>20**	>20	>20
Decomposition temperature (5% weight loss temp.)		°C	**340 - 360**	**340 - 360**	340 - 360	340 - 360
Copper Peel Strength (18um)		kN/m	**1.1 - 1.4**	**1.0 - 1.2 (MP)**	1.2 - 1.4	1.1 - 1.2
Dk (1GHz)	Measured by Triplate-line Resonator	-	**4.2 - 4.4**	**4.2 - 4.4**	4.2 - 4.3	4.5 - 4.7
Df (1GHz)		-	**0.017 - 0.019**	**0.017 - 0.019**	0.021 - 0.022	0.013 - 0.015
Dk (1GHz)	Measured by Material Analyzer	-	**4.3 - 4.5**	**4.3 - 4.5**	4.3 - 4.5	4.6 - 4.8
Df (1GHz)		-	**0.014 - 0.016**	**0.014 - 0.016**	0.019 - 0.021	0.010 - 0.012
TCT (-55°C, 0.5Hr / 150°C, 0.5H)		cycle	**>2000**	**>2000**	>500	>2000
CAF Restraining Property *) (85°C, 85%RH, DC100V)		Hr	**>2500**	**>2500**	>1400	>2500
Inner Layer Copper Peel Strength (35um) (Oxide-reduction treatment)		kN/m	**0.7 - 0.8**	**0.7 - 0.8**	0.7 - 0.8	0.7 - 0.8
IVH Filling Property (t1.6mm / #7629prepreg x 2ply / t1.6mm)		-	**OK**	**OK**	OK	NG

*) Pretreatment; JEDEC L3 + 260°C reflow 3times

Material Technology – CAF Restraining

How does CAF occur ?



Deposition of Copper Ion

Cathode side

/ $H_2O + e^- \rightarrow 1/2H_2 \uparrow + OH^-$

/ $Cu^{2+} + 2e^- \rightarrow Cu$

Elution of Copper Ion

Anode side

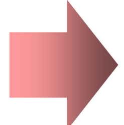
/ $H_2O \rightarrow 1/2O_2 \uparrow + 2H^+ + 2e^-$

/ $Cu \rightarrow Cu^{2+} + 2e^-$

Migration of Copper Ion

(H_2O becomes a conductor.)

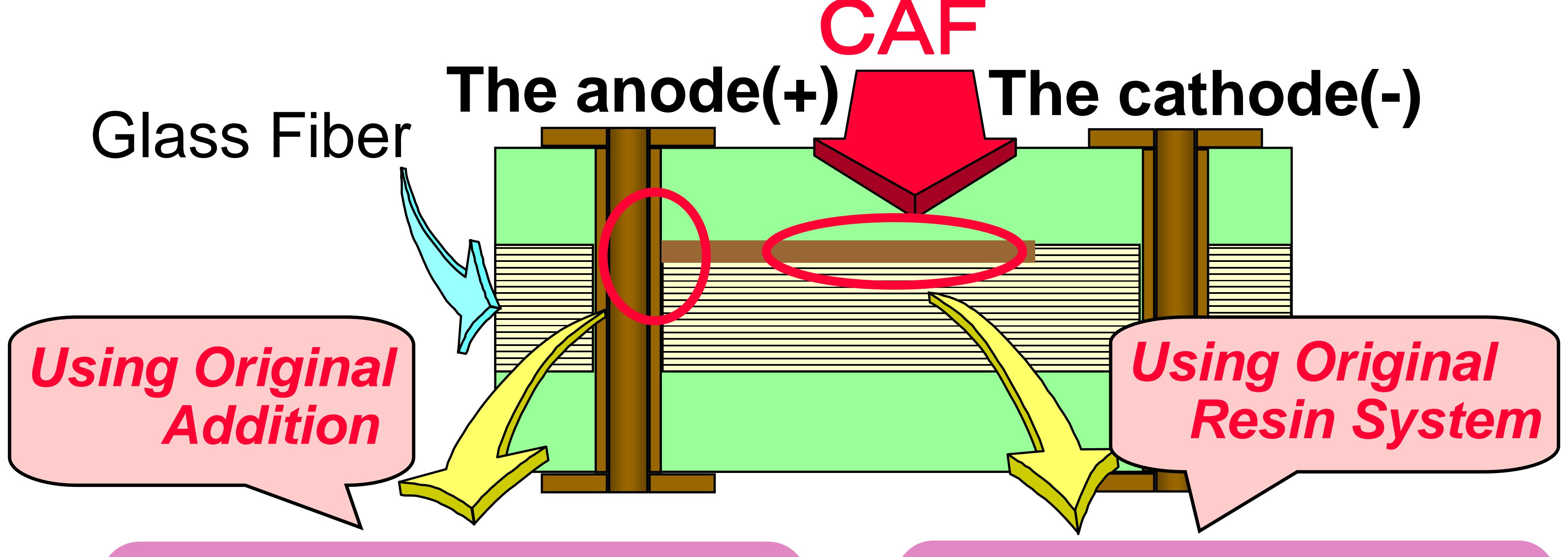
Cl^-, Na^+, OH^-, NO_3^- etc. : Glass fabric / Resin
(Ion impurities promote the migration of copper ion.)



Using high purity glass fabric(include coupling agent) and resin system

Material Technology – CAF Restraining

Technology for the CAF Defect prevention



Soluble of Copper Ion

Suppression of Copper Ion Dissolution

(SCID)

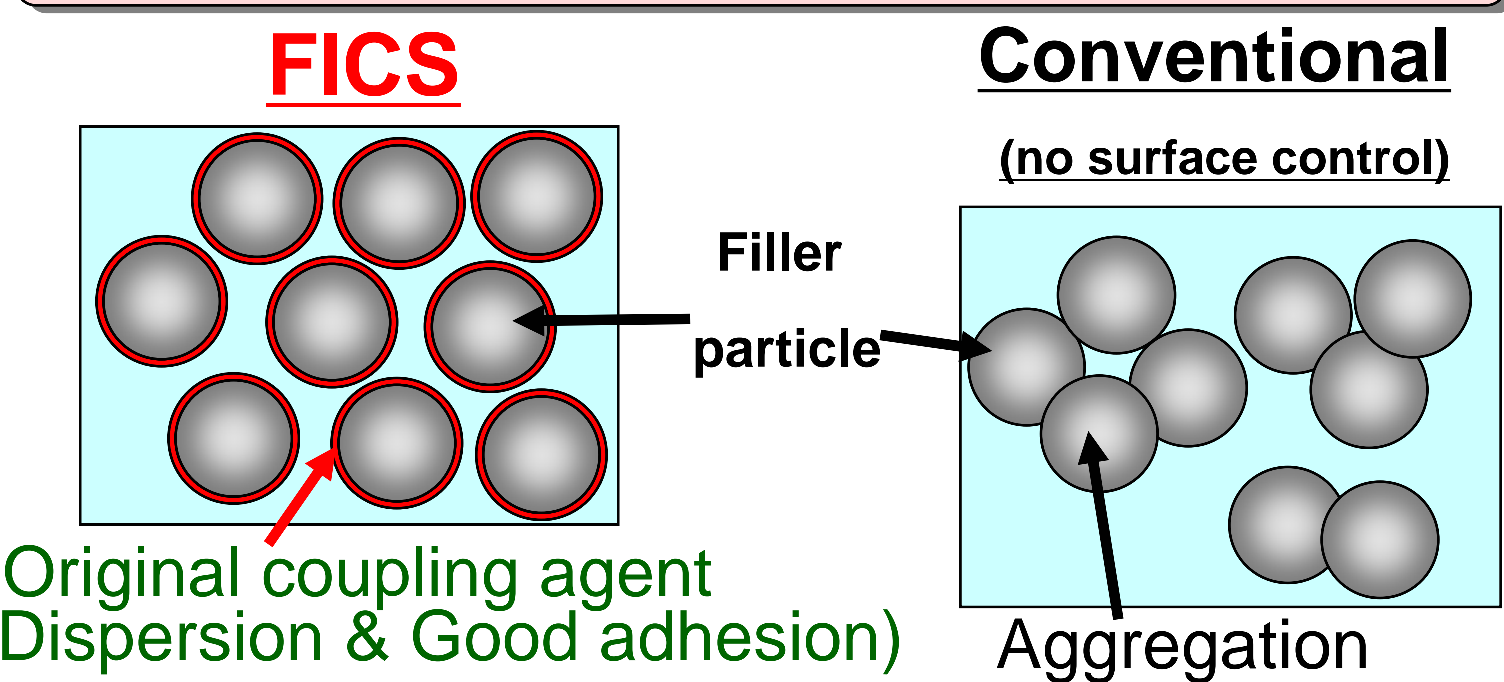
Migration of Copper Ion

Suppression of Copper Ion Migration

(SCIM)

Material Technology – Filler Technology

Filler Interphase Control System (FICS)

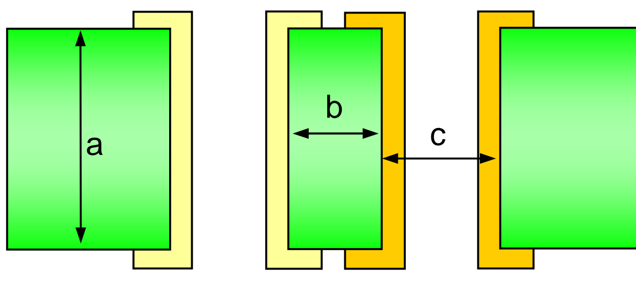


- ◆Low CTE
- ◆High modulus
- ◆Low water absorption

- ◆ Increase water absorption
- ◆ Decline of the electric insulation & CAF restraining property

CAF Restraining Property

Sample construction



Test condition

a) Laminate: t0.81mm 12/12 (#2116 x 8ply)
b) T/H wall distance: 0.3mm
c) Drill diameter: 0.4mm
d) Condition: 85°C, 85%RH, DC100V

Insulation Resistance (ohm): 1.0E+16, 1.0E+14, 1.0E+12, 1.0E+10, 1.0E+08, 1.0E+06, 1.0E+04, 1.0E+02, 1.0E+00

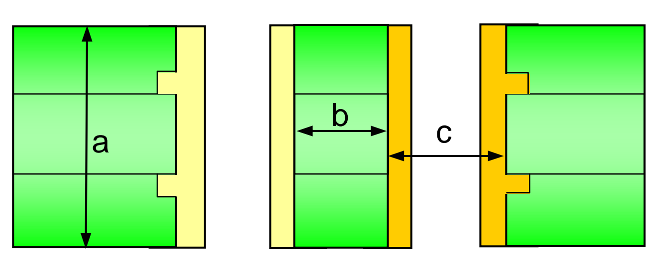
Legend: High Tg FR-4; E-679F(J); E-679F

Pretreatment; JEDEC L3(C-168/30/60) + 260°C reflow 3 times

Treating Time (Hr): 0, 500, 1000, 1500, 2000, 2500

Very Narrow Pitch CAF Restraining Property

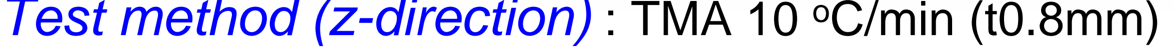
Sample construction



Test condition (HAST)

a) Laminate: t0.21mm
(core and prepreg: #1080 x 1ply)
b) T/H wall distance: 0.05mm
c) Drill diameter: 0.1mm
d) Condition: 110°C, 85%RH, DC6V

Thermal Expansion



Room Temp.

High Temp.

Expansion

Expansion (um)

40
30
20
10
0
-10

0 50 100 150 200 250 300

Temperature (°C)

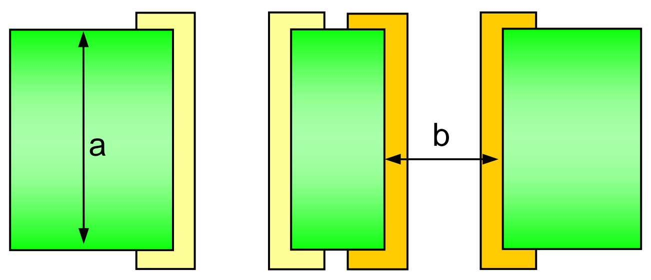
FR-4

High Tg FR-4

MCL-E-679F(J)

MCL-E-679F

T/H Reliability (1)



Test condition

a) Laminate: t0.81mm 12/12 (#2116 x 8ply)
b) Drill diameter: 0.4mm
c) Condition:
-65°C/30min ←→125°C/30min

Change ratio of electric resistance (%)

40
35
30
25
20
15
10
5
0
-5

0 200 400 600 800 1000 1200 1400

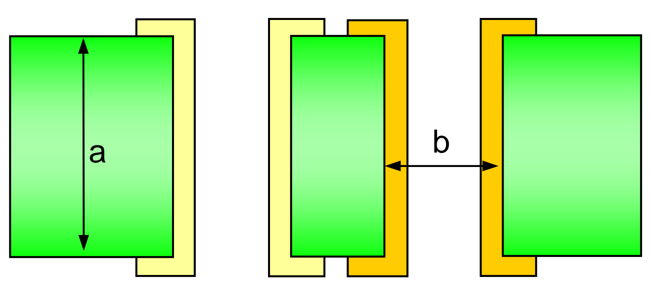
Number of cycles (cycle)

High Tg FR-4
E-679F(J)
E-679F

Pretreatment; JEDEC L3 (C-168/30/60) + 260°C reflow 3 times

T/H Reliability (2)

Sample construction



Test sample

a) Laminate : t1.6mm 18D + 20um-plating (#7629 x 8ply)
b) Drill diameter : 0.4mm diameter
c) Test pattern : 320-hole daisy-chain

Test condition: -65°C 30min / 125°C 30min
Pre treatment : E-3/130 ⇒ C-72/40/90 ⇒ max 260°C reflow, 2cycle ⇒ C-12/40/90 ⇒ 260°C solder dip

Change ratio of electric resistance (%)
40
35
30
25
20
15
10
5
0
-5

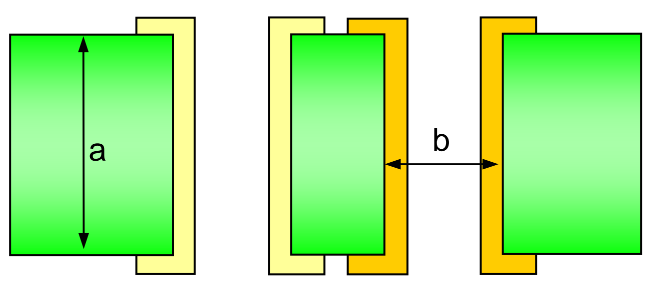
0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800

Number of Cycles

FR-4
E-679F
E-679F(J)

T/H Reliability (3)

Sample construction



Test sample

a) Laminate : t1.6mm 18D + 20um-plating (#7629 x 8ply)
b) Drill diameter : 0.4mm diameter
c) Test pattern : 320-hole daisy-chain

Test condition :-55deg C 30min / 150deg C 30min
Pre treatment :E-3/130⇒C-72/40/90⇒260Cmax reflow, 2cycle ⇒C-12/40/90⇒260C solder dip

Change ratio of electric resistance (%)

40
35
30
25
20
15
10
5
0
-5

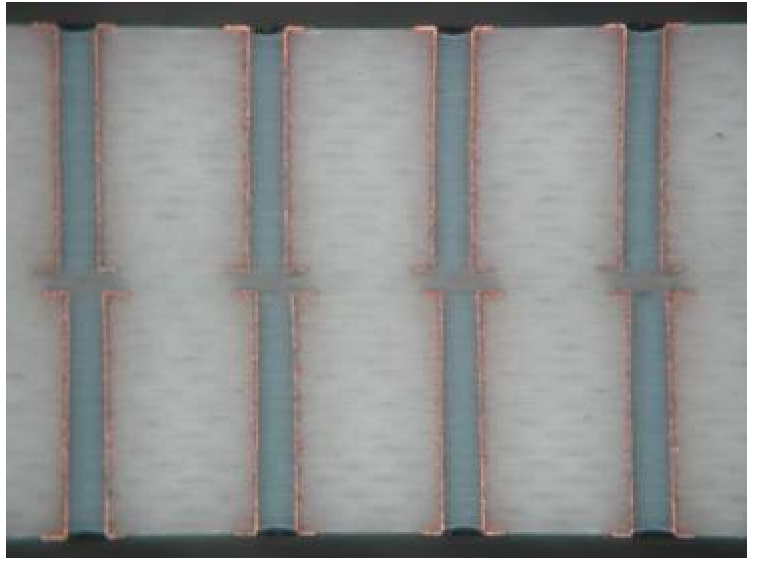
0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200

Number of Cycles

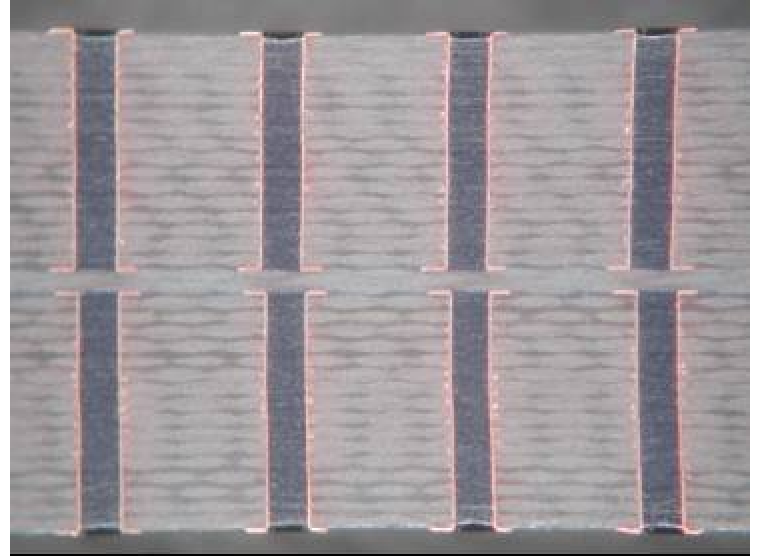
FR-4
E-679F
E-679F(J)

IVH Filling Property

E-679F(J)



High Tg FR-4



a
b
c
d

4-layer board construction (2-core)

a) Laminates : t1.6mm x 2-core
b) Prepreg : t0.1(#2116) x 2ply
c) IVH diameter : 0.3mm
d) IVH pitch: 1.27-2.54mm

General Properties

Item		Unit	E-679F(J) New Product		E-679(W) High Tg FR-4	E-679F High Elastic High Tg FR-4	#D (High Tg epoxy with filler)	#P2 (High Tg epoxy)
			Shimodate made	**Hong Kong made**				
Tg	TMA method	°C	**170 - 175**	**170 - 175**	173 - 183	160 - 170	160.6	(175 by DSC)
	DMA method		**195 - 205**	**195 - 205**	205 - 215	190 - 200	199.4	-
CTE	X (<Tg)	ppm/°C	**12 - 15**	**12 - 15**	12 - 15	12 - 14	14.2	15
	Y (<Tg)		**14 - 17**	**14 - 17**	14 - 17	12 - 14	17.0	15
	Z (<Tg)		**35 - 45**	**35 - 45**	50 - 60	20 - 30	39	50
	Z (>Tg)		**180 - 240**	**180 - 240**	200 - 300	130 - 160	268	250
T288		min.	**>20**	**>20**	>20	>20	>20	-
T260			**>60**	**>60**	>60	>60	>60	-
T288 (20L-PCB)		min.	**>10**	**-**	-	-	>10	-
T300 (20L-PCB)			**>3**	**-**	-	-	>3	-
Decomposition temperature(Td) (5% weight loss temp.)		°C	**340 - 360**	**340 - 360**	340 - 360	340 - 370	365	350
Cupper Peel Strength (18um)		kN/m	**1.1 - 1.4**	**1.0 - 1.2 (MP)**	1.2 - 1.4	1.1 - 1.2	(1.1 - 1.2)	1.25
Dk (1MHz)		-	**4.6-4.8**	**4.6-4.8**	4.7-4.8	4.8 - 5.0	(4.7)	4.80
Df (1MHz)		-	**0.011 - 0.013**	**0.011 - 0.013**	0.013 - 0.015	0.008 - 0.010	0.014 - 0.015	0.015
Dk (1GHz)	Measured by Triplate-line Resonator	-	**4.2 - 4.4**	**4.2 - 4.4**	4.2 - 4.3	4.5 - 4.7	4.34	-
Df (1GHz)		-	**0.017 - 0.019**	**0.017 - 0.019**	0.021 - 0.022	0.013 - 0.015	0.0212	-
Dk (1GHz)	Measured by Material Analyzer	-	**4.3 - 4.5**	**-**	4.3 - 4.5	4.6 - 4.8	4.52	4.60
Df (1GHz)		-	**0.014 - 0.016**	**-**	0.019 - 0.021	0.010 - 0.012	0.0176	0.0175
Thermal Conductivity		W/mK	**0.4 - 0.5**	**0.4 - 0.5**	0.3 - 0.4	0.71 - 0.75	0.48	0.36
Flexural Strength (Lengthwise)		MPa	**430 - 530**	**-**	530 - 570	430 - 530	-	518
Flammability (UL-94)		-	**V-0**	**V-0**	V-0	V-0	V-0	V-0

Note) The above-mentioned other companies material data is a catalog value.

Electric Properties

Measured by Triplate-line Resonator

Dk
4.5
4.4
4.3
4.2
4.1
4.0
3.9
0 1 2 3 4 5 6
Frequency(GHz)
#D
E679
E679F(J)

Df
0.028
0.026
0.024
0.022
0.020
0.018
0.016
0.014
0.012
0 1 2 3 4 5 6
Frequency(GHz)
#D
E679
E679F(J)

Measured by Material Analyzer

Dk
4.7
4.6
4.5
4.4
4.3
0 200 400 600 800 1000
Frequency(MHz)
E679
E679F(J)
#D

Df
0.025
0.020
0.015
0.010
0.005
0 200 400 600 800 1000
Frequency(MHz)
E679
E679F(J)
#D

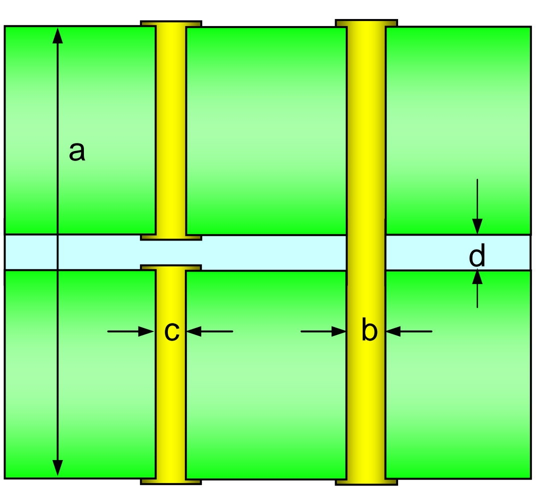
Hitachi Chemical
Working On Wonders

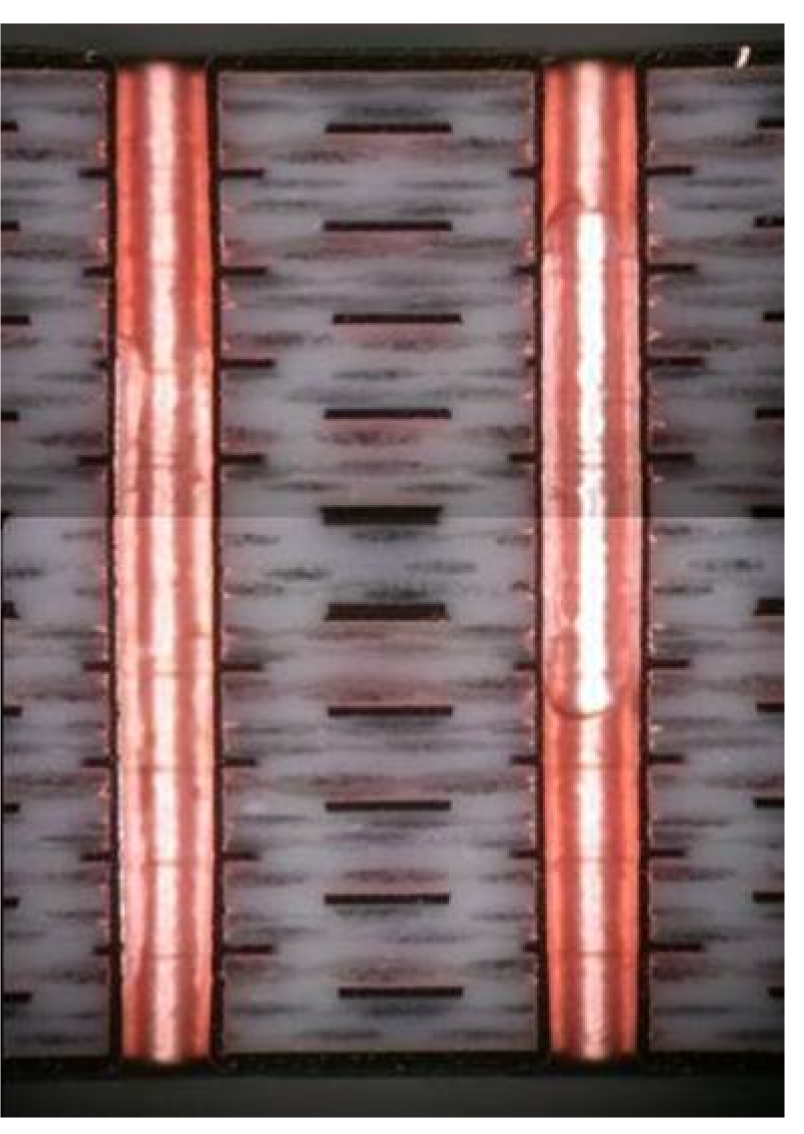
2. PCB Properties

Evaluation Result of 20L-PCB

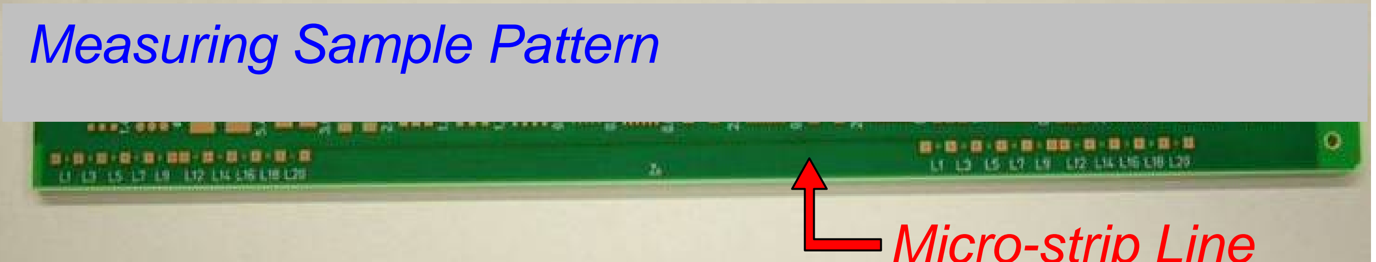
20-Layer PCB construction

a) t3.0mm 20L-PCB
   Core: t0.1mm 35/35
   Prepreg: #1080x2ply
b) T/H diameter:
   0.2mm, 0.35mm, 0.9mm
c) SVH diameter:
   0.15mm, 0.2mm
d) Prepreg L10-L11: #1080x3ply





Transmission Loss Property



Transmission Loss (dB)

0
-2
-4
-6
-8
-10
-12
-14
-16
-18

0.0 0.5 1.0 1.5 2.0 2.5 3.0

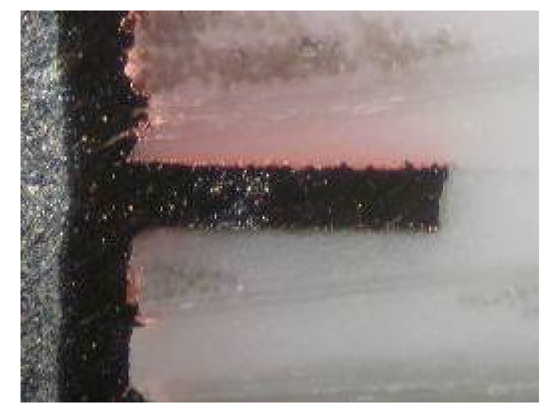
Frequency (GHz)

E679F(J)
#D

Solder Heat Cycle Test (1)

Test condition: 288deg C, 10s float x 6cycle
T/H diameter: 0.9mm

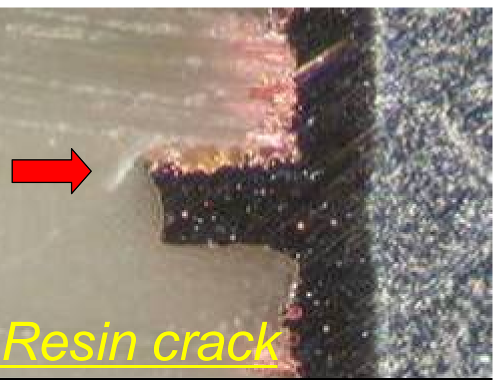
E-679F(J)



Solder Heat Cycle Test (2)

Test condition: 288deg C, 10s float x 6cycle
T/H diameter: 0.9mm

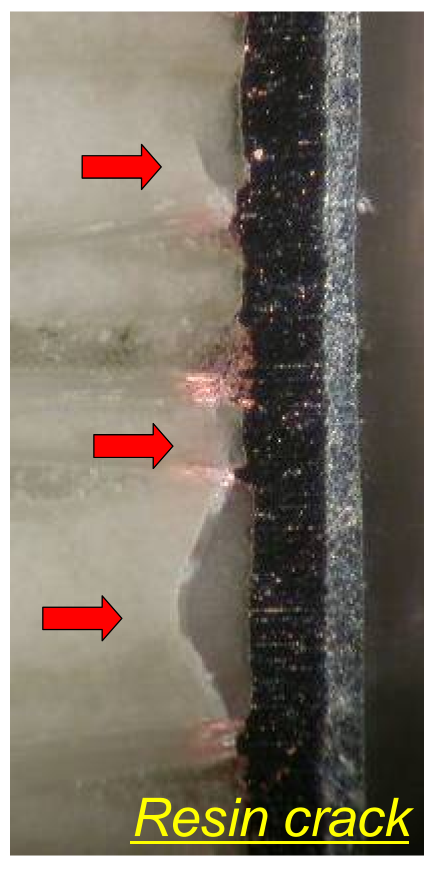
#D

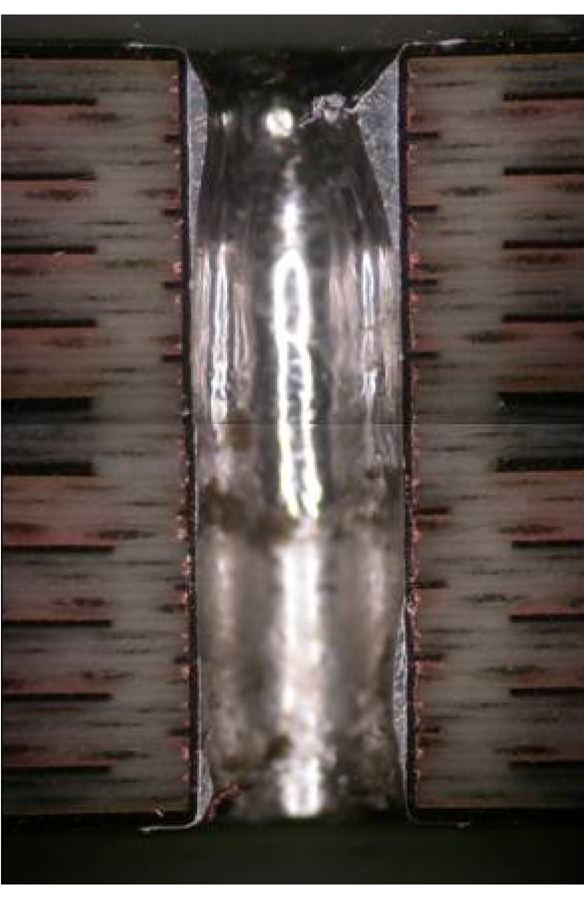


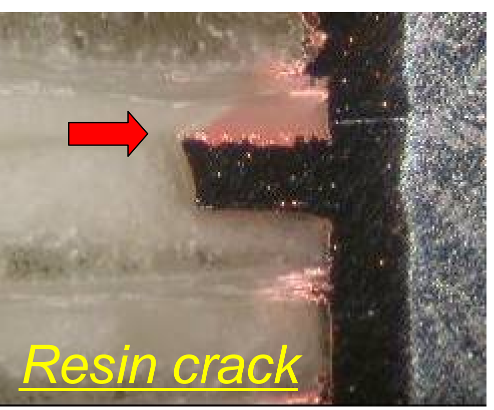
Solder Heat Cycle Test (3)

Test condition: 288deg C, 10s float x 6cycle
T/H diameter: 0.9mm

#E



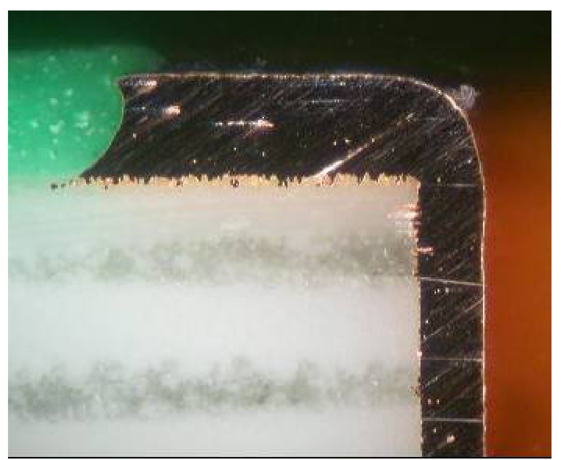


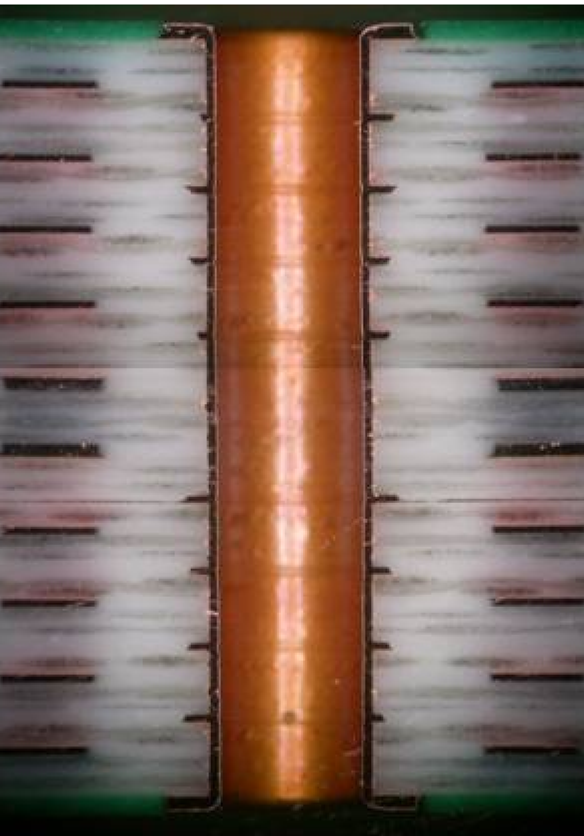


Reflow Heat Cycle Test (1)

Test condition: 260deg C max. Reflow x 8cycle
T/H diameter: 0.7mm

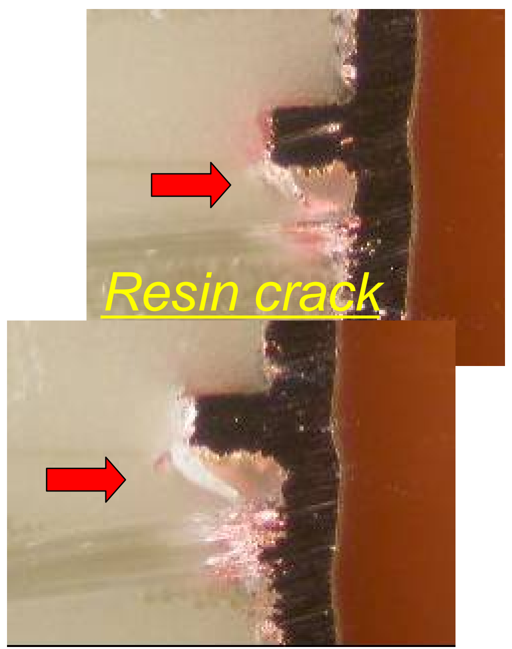
E-679F(J)

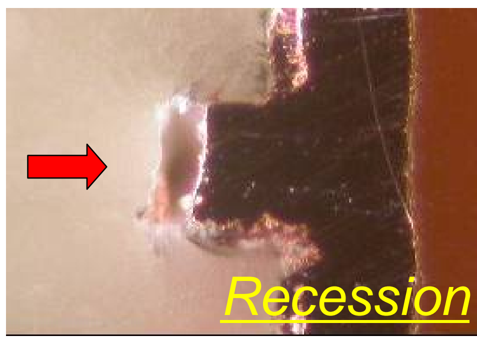


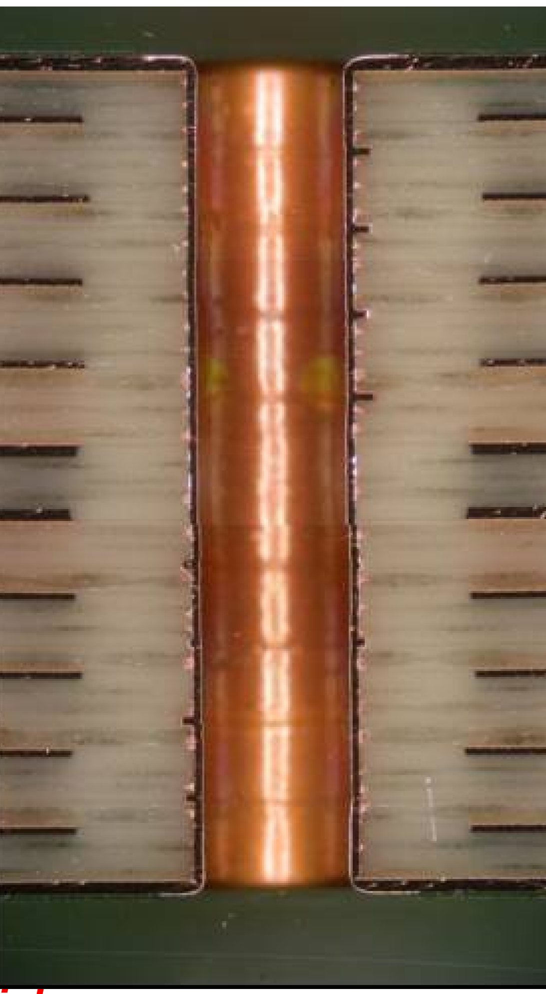


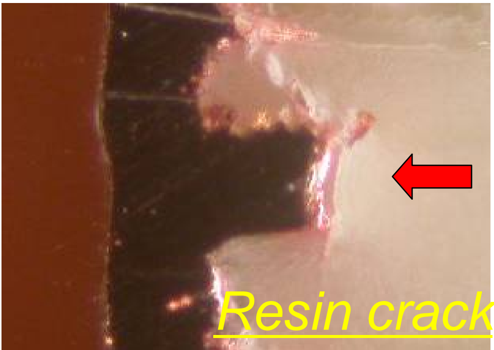
Reflow Heat Cycle Test (2)

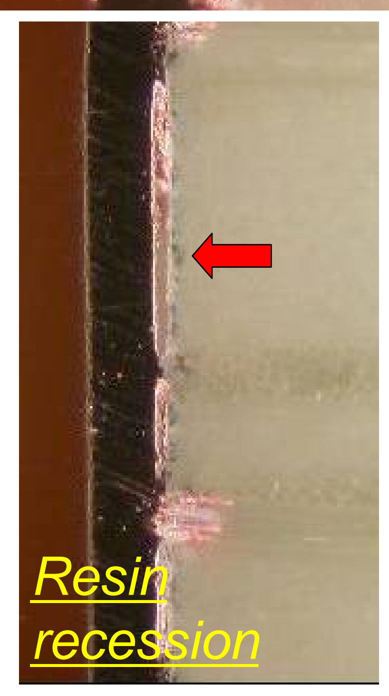
Test condition: 260deg C max. Reflow x 8cycle
T/H diameter: 0.7mm





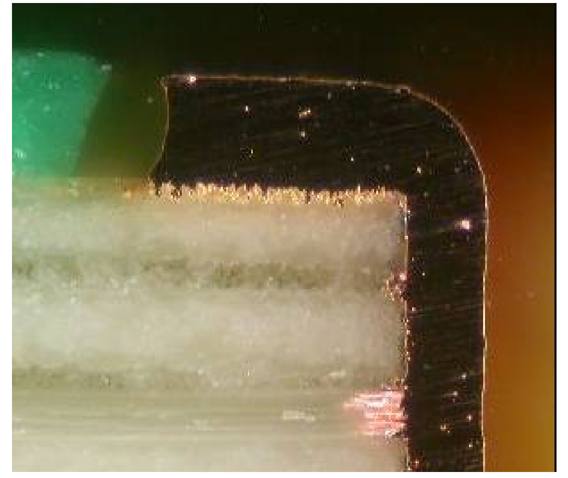


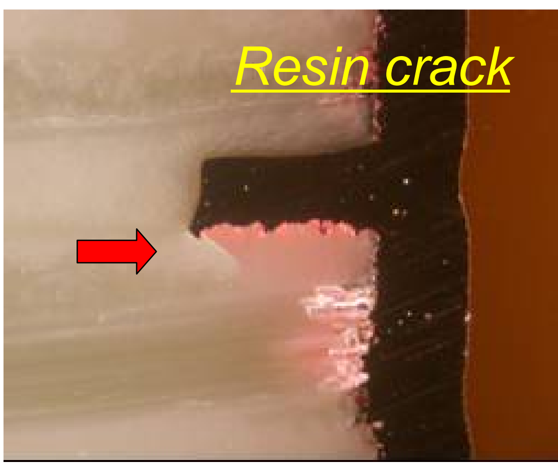


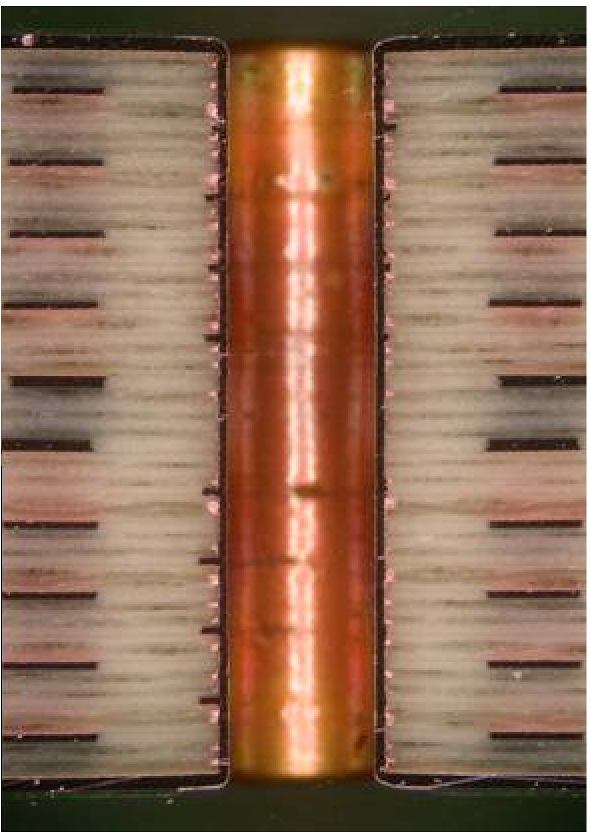


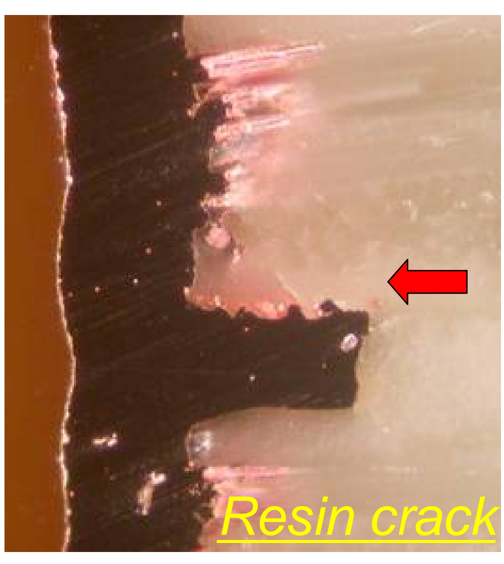
Reflow Heat Cycle Test (3)

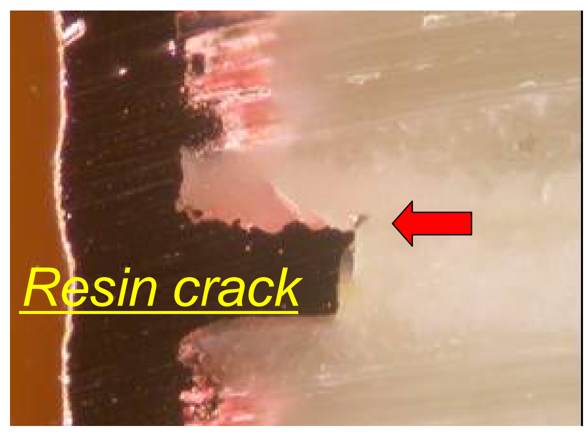
Test condition: 260deg C max. Reflow x 8cycle
T/H diameter: 0.7mm











Result of Reflow Heat Cycle

Test condition

a) Test sample: 20L-PCB (t3.0mm)
b) Drill diameter: 0.2mm, 0.35mm, 0.7mm
c) Aspect ratio: 4.3 - 15.0

260deg C max reflow * Delaminated sample / Total tested sample

Sample	***E-679F(J)***	***#D***	***#E***
3cycle	**0 / 3**	0 / 3	0 / 3
5cycle	**0 / 3**	0 / 3	0 / 3
8cycle	**0 / 3**	3 / 3 Resin crack	3 / 3 Resin crack

SVH Filling Property (1)

E-679F(J)

Diameter：0.2mm

Diameter：0.15mm

Good filling property

SVH Filling Property (2)

#D Diameter : 0.2mm

#E Diameter : 0.2mm

Separation of Filler and Resin

Conclusion

<Conclusion>

- E-679F(J) have the Superior CAF restraining property
- E-679F(J) have the High Heat resistance
  ex. 288deg.C/10s float; 6 cycle OK (20L-PCB)
  ex. 260deg.C max reflow; 8 cycle OK (20L-PCB)

➡ **Suitable for the Lead-free process**

- Lower Df; 0.018 at 1GHz

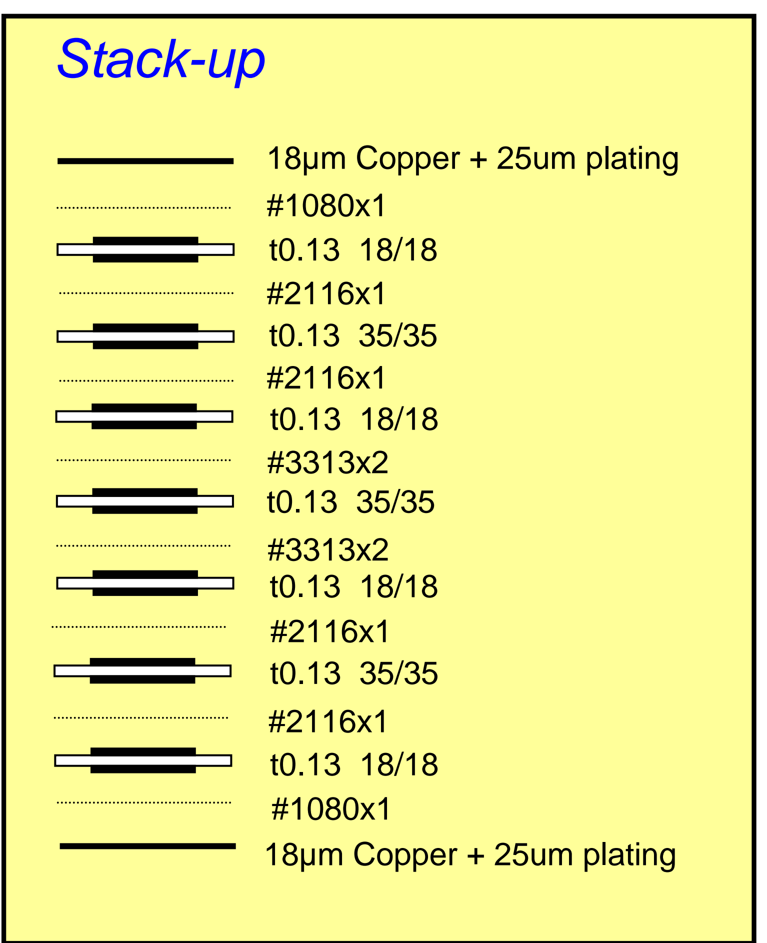
➡ **Lower Transmission Loss than High Tg FR-4**

- Better IVH filling property

Evaluation Result of 16L-PCB

16-Layer PCB construction

a) t2.2mm 16L-PCB



TMA Analysis

Measurement method by TMA

a) Test board: 16L-PCB (t2.2mm)
b) Size: 5mm square without copper foil
c) Heating rate: 10deg.C/min

Item	unit	E-679F(J)	#I No-filler type	#P filler type
Tg	deg.C	**170**	166	157
CTE (50 - 120deg.C)	ppm/C	**53.8**	93.6	74.0
CTE (200 - 240deg.C)	ppm/C	**278**	350	319
Thermal Expansion (50 - 260deg.C)	%	**3.2**	4.5	4.2

IST Result of 16L-PCB

Test condition

a) Drill diameter: 0.2mm, 0.85mm
b) Plating thickness: 25 - 30um
c) Aspect ratio: 2.6, 11.0
d) Condition: 20deg.C ←→150deg.C, 5min/ cycle
e) Criteria of failure: more than 10% change of resistance

Pre-treatment (Reflow cycle)	*E-679F(J)*	***#I*** No-filler type	***#P*** Filler type
after 260deg.C x **3cycle**	**>1000 cycle**	434 cycle	577 cycle
after 260deg.C x **6cycle**	**>1000 cycle**	270 cycle	449 cycle

n = 6pnl

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3. Process Conditions

Recommended Press Condition

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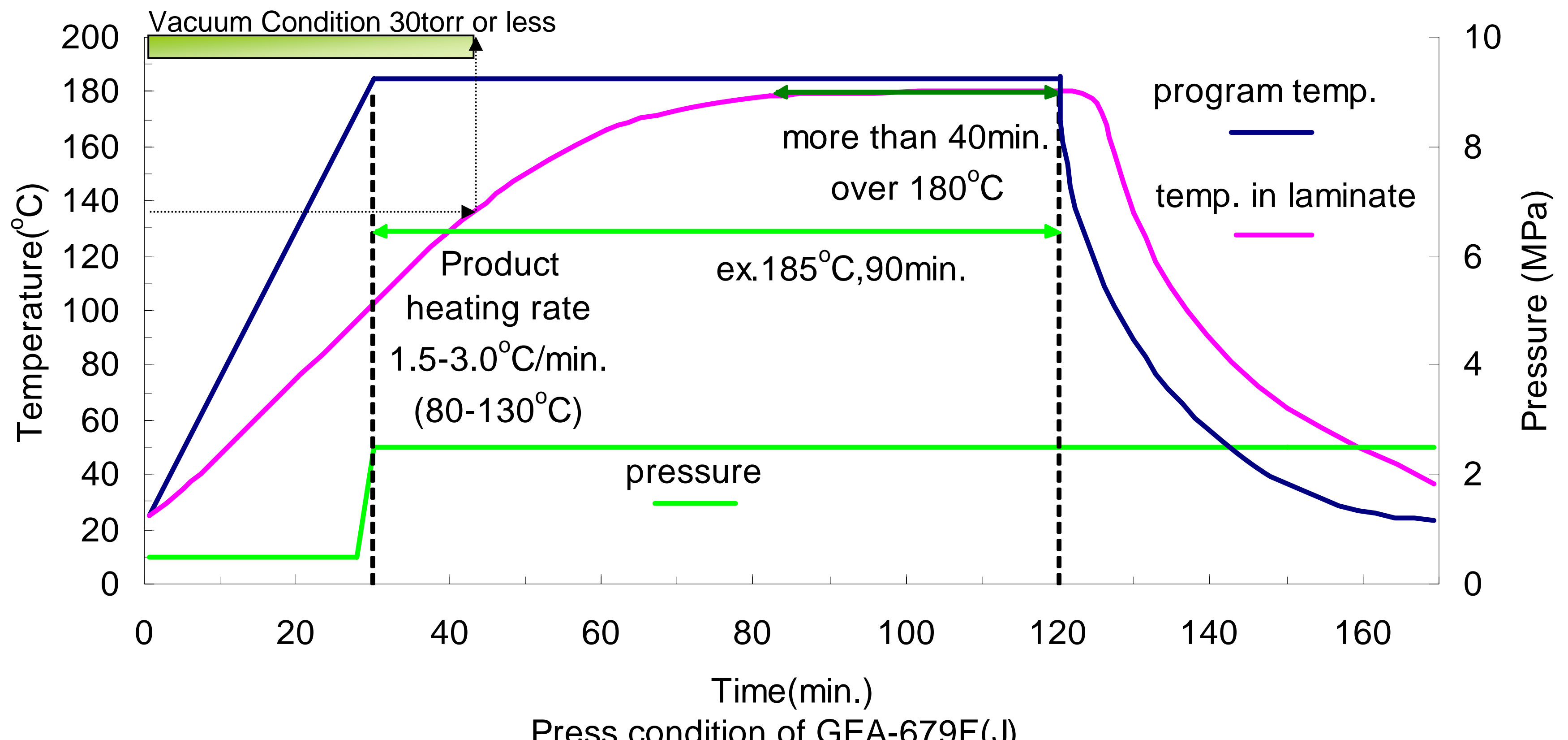
Press conditions for Multi-layer boards



Press condition of GEA-679F(J)

1) Product temp.; Heat more than 40min at higher than 180deg.C (356°F)
2) Setting max. temp. (example); over 185deg.C (365°F), 90min.
3) Product Heating Rate; 1.5-3.0deg.C /min (2.7-5.4°F/min) at 80-130deg.C (176-266°F)
4) Pressure; 2.0-3.0 MPa (290-430psi)

<u>Inner pattern filling capability of prepreg may change according to inner pattern .</u>

Drilling Condition

1) Characterize the drilling process,
Because **MCL-E-679F(J)** is not equal to conventional FR-4.

2) Please refer to example of Table1. **(Recommend)**

Table1. Example for drilling condition

Item	Diameter of drill bits			
	ϕ0.1	ϕ0.2	ϕ0.3	ϕ0.35
Drill bits	Shape : Spade type			
Entry Board	LE sheet , Al foil etc.			
Stacked panel	High Layer PWB= 1board, Low Layer PWB= 2-3board			
Revolution number	200 - 300 krpm	80 - 100 krpm	80 - 100 krpm	60 - 80 krpm
Feed Rate	1.0 - 1.5 m/min (3.3 - 4.9 ft/min.)	0.8 - 1.0 m/min (2.6 - 3.3 ft/min.)	1.2 - 1.5 m/min (3.9 - 4.9 ft/min.)	1.6 - 2.0 m/min (5.2 - 6.6 ft/min.)
Life of drill bits	About 1,500 hits			

Caution : Smear, resin cracking or nail heading may occur if drilling condition does not match.

Drilling Processability (1)

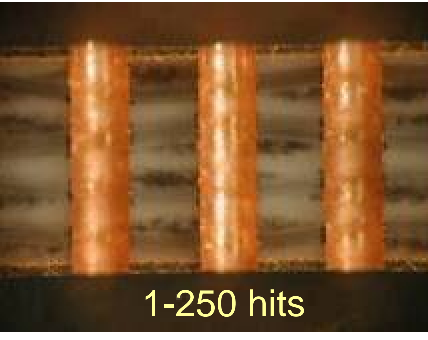
Sample construction

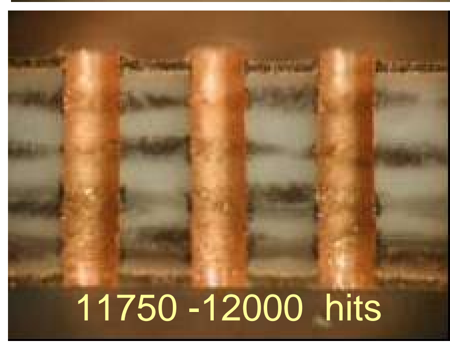
t0.41mm 18/18
(#2116 x 4ply)

Drilling condition

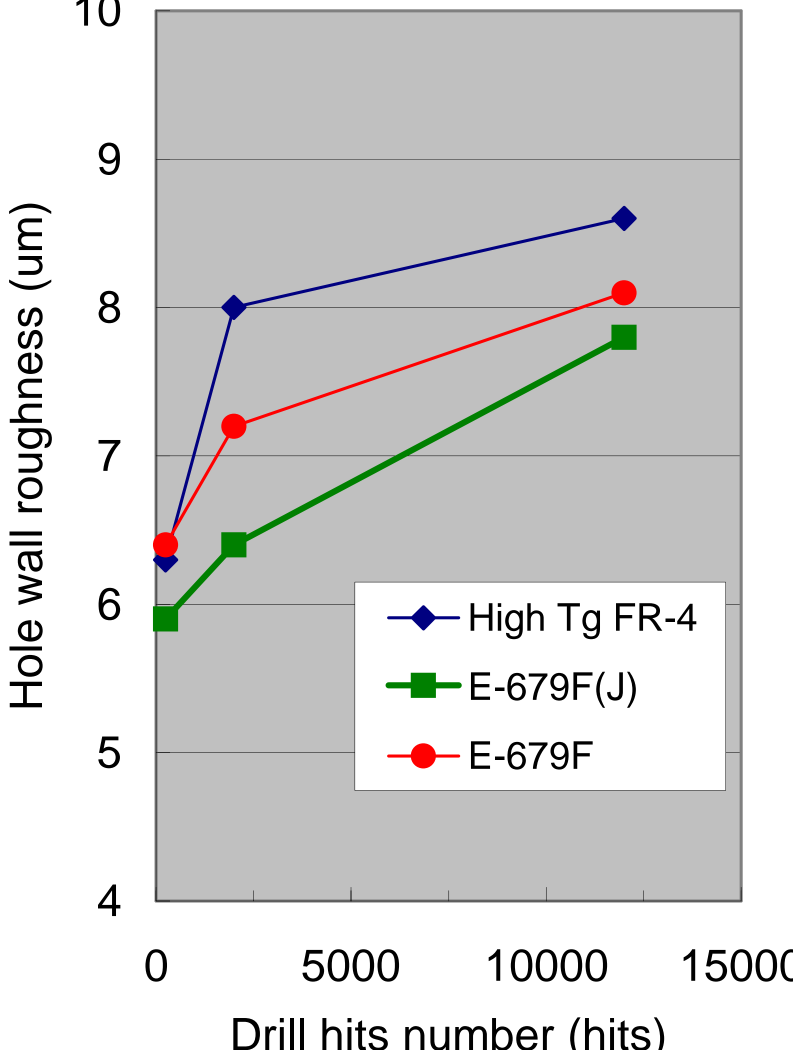
Diameter: 0.105mm
Revolution speed: 300krpm
Feed rate: 1.5m/min
Number of stack: 2 board

E-679F(J)

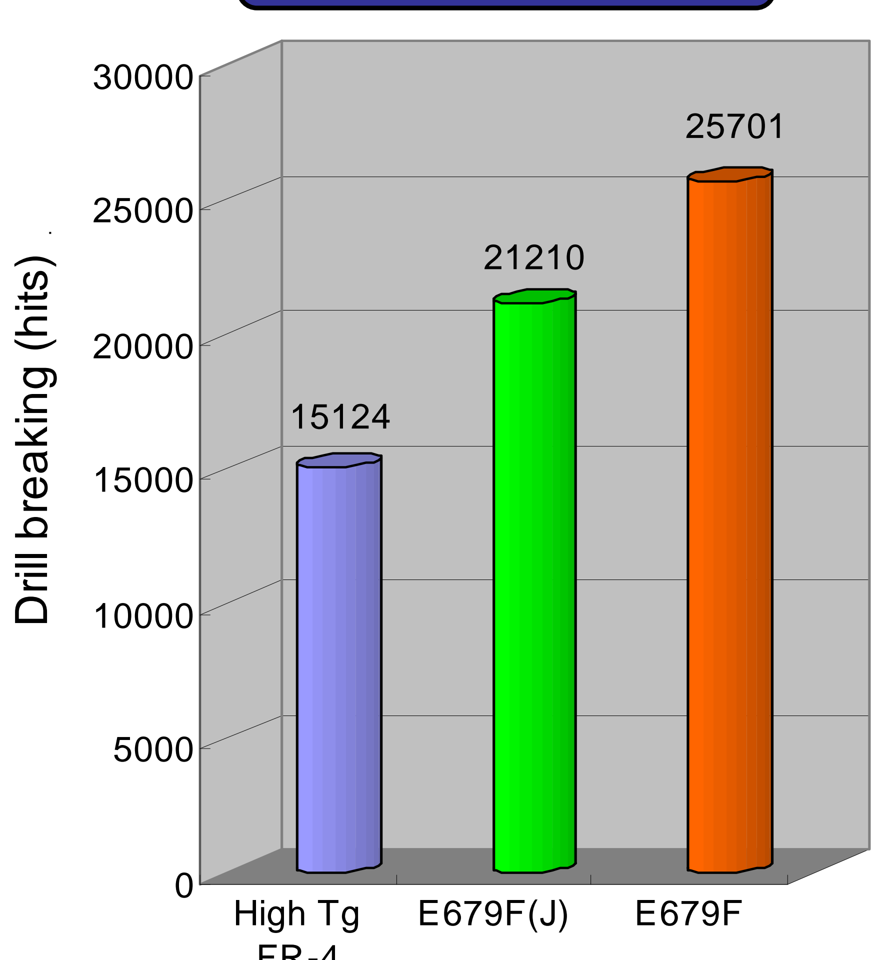




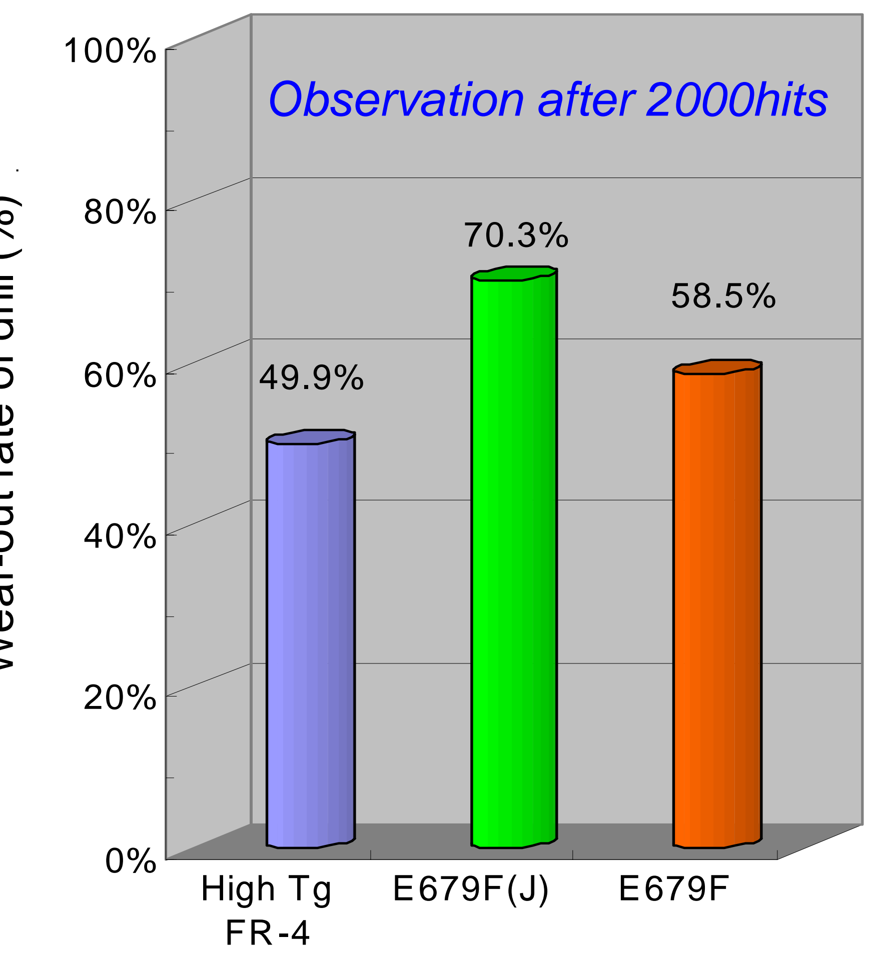
Hole Wall Roughness



Drilling Processability (2)



Wear-out Rate of Drill



Annealing and Desmearing

Annealing

We recommend to anneal the laminates just before plating to reduce residual stress. The condition of annealing is as follows.

Please heat the laminates more than 1 hr at 200 deg.C, or more than 2hr at 190deg.C in material temperature.

Desmearing

1) The desmear rate of **MCL-E-679F(J)** is inferior to that of conventional FR-4, in permanganate desmear process. Please check the smear and inner layer connection.

2) Please refer examples of desmear conditions in Table2.

The formulation of the chemical might be different in each area (US, EU, Asia), please confirm to the chemical suppliers.

Desmearing Condition

Desmearing

Table2. The example of desmear conditions

Process	Atotech			Rohm & Haas (Shipley)		
	Products	Temperature °F (°C)	Time (min.)	Products	Temperature °F (°C)	Time (min.)
Swellering	Swelling dip Securiganth P	158-176 °F (70-80)	1-3	MLB conditioner 211	167-185 °F (75-85)	1-3
Etching	Dosing solution Securighanth P	158-176 °F (70-80)	2-4	MLB promorter 213	167-185 °F (75-85)	2-4
Newtralization	Reduction solution Securiganth P	77-104 °F (25-40)	1-3	MLB newtralizar 216-2	77-104 °F (25-40)	1-3

If you use the horizontal desmear process, please contact chemical supplier.

Caution：The resin crack will take place at inner through hole after the wrong desmear treatment.

Plating Condition

Plating process

If you use only electroless plating process, it may be happened that heat resistance changes for the worse dependent on the plating condition. Please examine plating condition enough before mass production.

Regarding through hole plating copper process, we recommend **conventional plating method**. (electroless plating + electroplating) **(Recommend)**

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4. Special Notes

Precautions in Handling (1)

MCL-E-679F(J) (Copper Clad laminate)

1) Please take care to treat thin core laminates because these easily bend and break.

2) Please keep laminates out of the direct rays of the sun. The storage condition of **20+/-5deg.C(68+/-9deg.F), less than 60%RH** under control. We guarantee the laminates within **6months** after the date of production above condition.

3) There is inorganic filler into this MCL. Carefully remove inorganic filler (resin powder) occurred from laminate in cutting, punching, shearing and drilling process. Otherwise short and open circuit may occur.

4) When the foreign force is added in the condition that resin powder gets between products, the scratch on the copper surface and copper foil separation may occur. So sufficient care must be taken to prevent this (Ex; Don’t adjust the disorderly boards by beating them vertically on the stand).

Precautions in Handling (2)

GEA-679F(J) *(Prepreg)*

1) All the received prepreg should be immediately moved from the receiving area into a controlled environment.

2) All prepreg should be used as soon as possible.

3) The shelf life of prepreg is **3months** after the date of production under the storage condition of **20+/-5deg.C(68+/-9deg.F)**, less than **60%RH**,in aluminum barrier packing.

4) Please open the aluminum barrier packing just before lamination process to avoid a moisture.

Storage and Shipment of PWB

Storage and Shipment of PCB

We recommend moisture-proof packing with desiccant.
(Recommend)

If PCB absorbed moisture during transport, delamination might occur in reflow process.
If the printed circuit board has more than 0.3% moisture included, **please dry it more than 2hr at 130deg.C, before reflow process or another heating process.**

Contact Us

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Note: The entry contents of these data base to the experiment results of our company at Oct. 2007 and do not guarantee these characteristic values. The contents may be revised necessary according to new findings. Please examine process condition enough and confirm before mass production. Please make sure that some difference of practical property such as heat resistance and insulation reliability might occur by the difference design PCB making process or working condition.