

*Innovation
Globalization
Diversification*

**Green / High Speed
Low Loss and Very Low Loss
High Tg FR-4
with Lead Free Compatible**



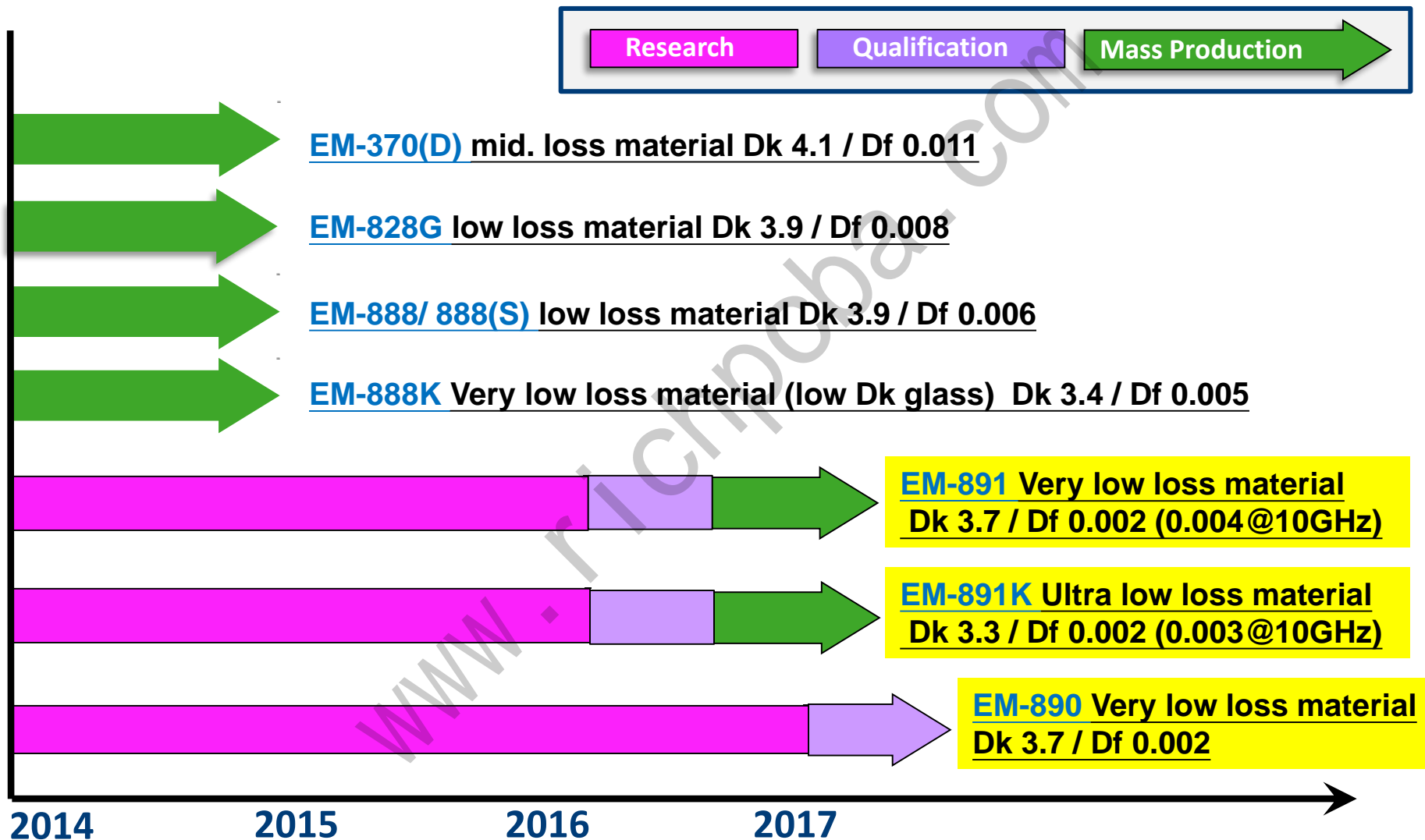
**EM-888 / EM-888(S) / EM-888K
EM-888B / EM-888B(S) / EM-888BK**



Product Benchmarking

Df Scope by Cisco S3 (@10 GHz)		Df Scope by IBM SPP (@ 1 GHz)		Tg	Benchmark Materials	EMC Proposed Materials	Sample Status	Production Site
>/= 0.020	High Loss	0.020~0.023	Standard Loss	150	IS-400/ IT-158	EM-825	OK	TWN+KS+ZS
				170	370 HR	EM-827	OK	TWN+KS+ZS
0.015~0.020	Standard Loss	0.015~0.020	Upper Mid Loss	150	R-1566	EM-285 EM-370(5)	OK	TWN+KS+ZS
					R-1555	EM-355(D)		
				170	NPG-170	EM-370(Z)	OK	TWN+KS+ZS
					Megtron2 TU-862HF	EM-370(D)	OK	TWN+KS+ZS
0.010~0.015	Mid. Loss	0.012~0.015	Lower Mid Loss	170	FR-408 IS-415	EM-390 EM-828G	OK	TWN+KS+ZS
		0.008~0.012	Low Loss		408HR/ I-Speed N-13 EP/ M-4 TU-872 SLK Megtron4	EM-888 EM-888(S)	OK	TWN+KS+ZS
0.005~0.010	Low Loss	0.004~0.008	Very Low Loss	170	Megtron6 RO4350	EM-888K EM-891 EM-890	OK OK Q1, 2017	TWN+KS+ZS TWN+KS+ZS TWN
~0.005	Ultra Low Loss	~0.004	Ultra Low Loss	170	Megtron7/ M-7(N) RO4350	EM-891K EM-890K	OK Q1, 2017	TWN+KS+ZS TWN

Product Roadmap- High Speed Application



* Except for EM-891 & EM-891K, all materials above are halogen free materials Feb 2017

** Dk/ Df data are measured with RC50% at 1 GHz

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Features

- Low Dk and Df with low moisture absorption
- Excellent CAF resistance with higher copper peel strength
- Halogen, antimony and red phosphorus free
- Lead Free compatible
- EM-888 is made of E-glass fabric, EM-888K is made of low Dk glass fabric
- EM-888(S) is a lower CTE version of EM-888 which is designed to meet fine pitch application
- EM-888K has more homogeneous Dk platform due to low Dk glass applied and is less sensitive to skew issue
- EM-888, EM-888(S) and 888K belong to the same UL product family
- For very high speed sever, back plane, network and telecom application

EM-888, EM-888(S) and M4 property comparison

Test Item		IPC TM-650	unit	EM-828G	EM-888	EM-888(S)	M-4
Construction		-	-	7628x8	7628x8	7628x8	3313x15
				(1.50mm)	(1.50mm)	(1.50mm)	(1.55mm)
Tg	DSC	2.4.25	°C	170	NA	NA	175
				(DMA 190)	(DMA 210)	(DMA 210)	(DMA 210)
Thermal resistance	T-288 (clad)	2.4.24.1	min	40	>60	>60	28
a1, before Tg	TMA	2.4.24	(ppm/°C)	50	50	45	35
a2, after Tg	TMA	2.4.24	(ppm/°C)	250	240	230	240
CTE (%)	TMA	2.4.24	%	2.6	2.6	2.4	2.4
Td	5% loss	2.4.24.6	°C	380	380	380	360
Peel strength	0.5 oz RTF	As received	2.4.8	4.2	4.5~5.0 (RTF)	4.5~5.0 (RTF)	4.2
					4.8 (VLP)	4.8 (VLP)	
Dk (R/C:50%)	2GHz	Cavity Resonator	-	3.89	3.82	3.82	3.6
	10GHz	Cavity Resonator	-	3.77	3.70	3.70	3.5
Df (R/C:50%)	2GHz	Cavity Resonator	-	0.009	0.006	0.006	0.006
	10GHz	Cavity Resonator	-	0.011	0.007	0.007	0.007

- 1: EM-888(S) has better T288 and peel strength compare to M4.
- 2: EM-888(S) and M4 have similar Df value under RC 50%.

EM-888 and EM-888(S) Materials CTE comparison

RC%	EM-888	EM-888(S)
63%	3.80	3.63
70%	4.08	3.90

EM-888(S) is a lower CTE version of EM-888 which is designed to meet fine pitch application.

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M6 and EM-888K Materials Property Comparison

30mil 1/1, 2116x6, RC54%

Test Item		Unit	EM-888K	M6
Tg	DSC	°C	NA	182.1/184.8
	TMA	°C	176/178	172.4/174.0
	DMA	°C	210.7/209.8	195.0/199.1
Td	5% loss	°C	406	406
T-288	Clad	min	>60	>60
Thermal	Dip 288°C, 10sec.	cycle	>20	>20
Stress	PCT+Dip 288°C, 20sec.	hr	>5	>5
CTE	α1	ppm/°C	57	39
	α2	ppm/°C	264	303
	CTE	%	3.05	3.20
Peeling Strength (HVLP 10z)	Universal Tester	lb/in	4.6-4.7	3.4-3.6
Dk(@10GHz) S3	RC50%	NA	3.53	3.72
Df(@10GHz) S3	RC50%	NA	0.0074	0.0072
Flexural Strength	Warp	MPa	434	370
	Fill	MPa	306	340
Storage Modulus(@250°C)	Warp	MPa	3382	3089
	Fill	MPa	2604	2551
Stiffness (@250°C)	Warp	N/m	2635	2698
	Fill	N/m	2213	2293

Thermal Reliability

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Lead-Free IR-Reflow Test Result (28 layer)

Product: EM-888

Layer count: 28 layer

Thickness: >130 mils (~3.3mm)

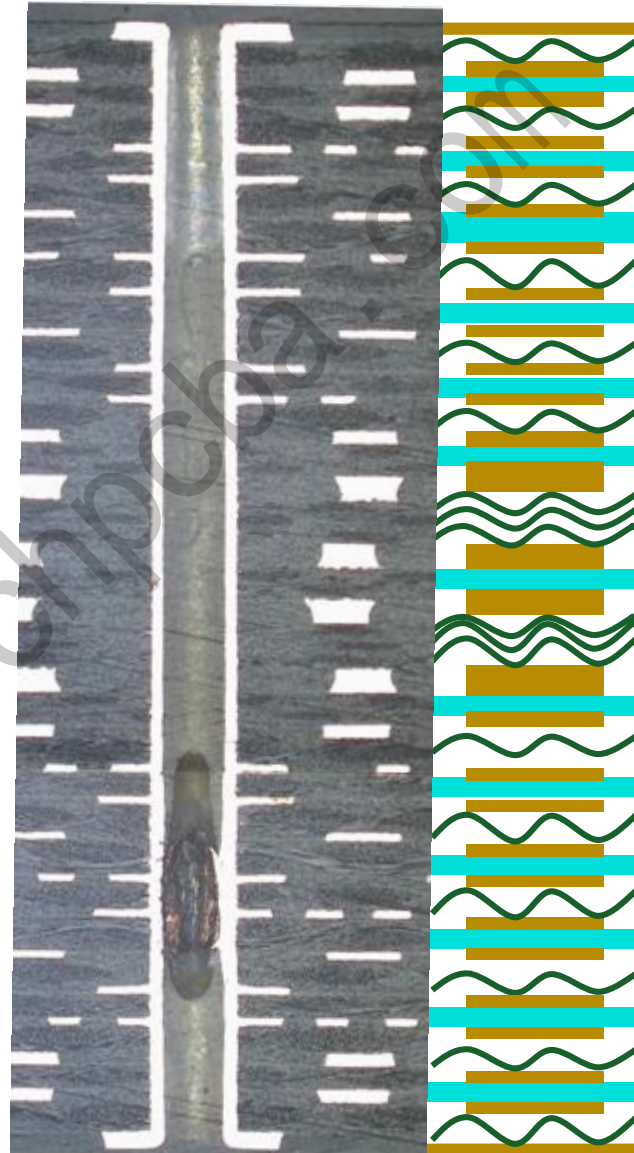
Hole diameter: $\phi=0.25\text{mm}$

Hole wall to wall 0.75mm

Reliability Test :

no delamination, crack and abnormality

- (1) 260 °C LF IR Reflow 10X
+ ATC -35 °C to 125 °C (15-5-15 min), 400 cycles
+ CAF 50V DC/ 65 °C/ 85% RH, 596 hours
- (2) Precondition at 35°C / 85%RH / 14 days,
then lead-free IR Reflow at 260°C 2 times passed



- 1/3oz Cu foil
- 1 x 3113
- 3mil 1oz/1oz
- 1 x 3113
- 3mil Hoz/Hoz
- 1 x 3113
- 4mil Hoz/Hoz
- 1 x 3113
- 4mil Hoz/Hoz
- 1 x 3113
- 3mil Hoz/Hoz
- 1 x 3113
- 4mil 1oz/2oz
- 3 x 1067
- 4mil 2oz/2oz
- 3 x 1067
- 4mil 2oz/1oz
- 1 x 3113
- 3mil Hoz/Hoz
- 1 x 3113
- 4mil Hoz/Hoz
- 1 x 3113
- 4mil Hoz/Hoz
- 1 x 3113
- 3mil Hoz/Hoz
- 1 x 3113
- 3mil 1oz/1oz
- 1 x 3113
- 1/3oz Cu foil

The above test result is under well PCB control.

Lead-Free IR-Reflow Test Result (28 layer)

Product: EM-888

Layer count: 28 layer

Thickness: >130 mils (~3.4mm)

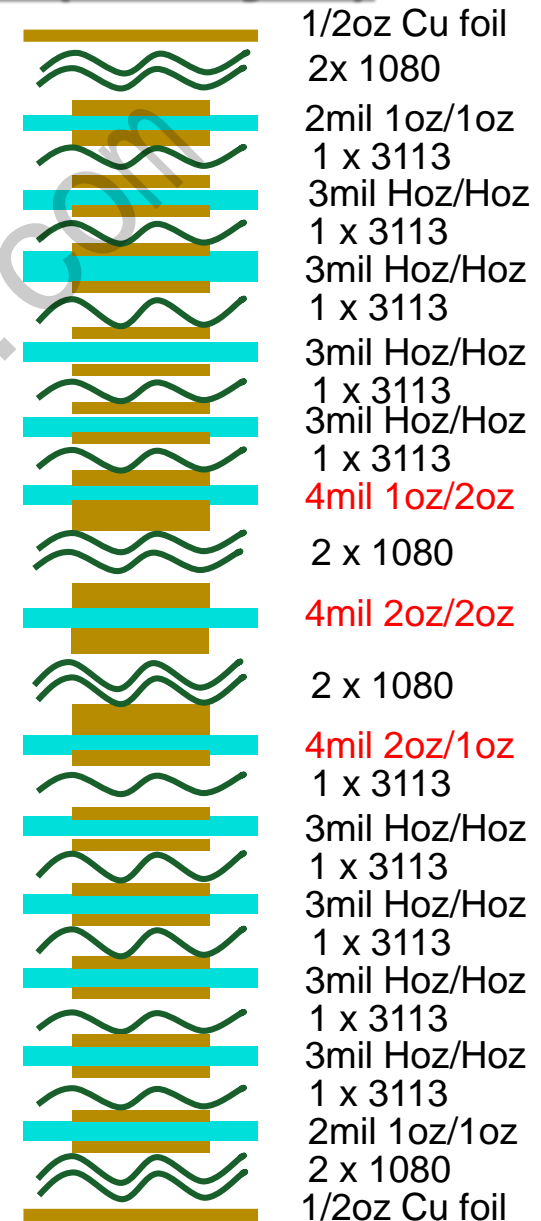
Hole diameter: $\phi=0.25\text{mm}$, 0.3mm

Hole wall to wall: 0.5mm

Reliability Test :

no delamination, crack and abnormality

260 °C LF IR Reflow 10X passed



The above test result is under well PCB control.

Rev:20170317

Lead-Free IR-Reflow Test Result (24 layer)

Product: EM-888

Layer count: 24 layer

Thickness: 120 mils (~3.0mm)

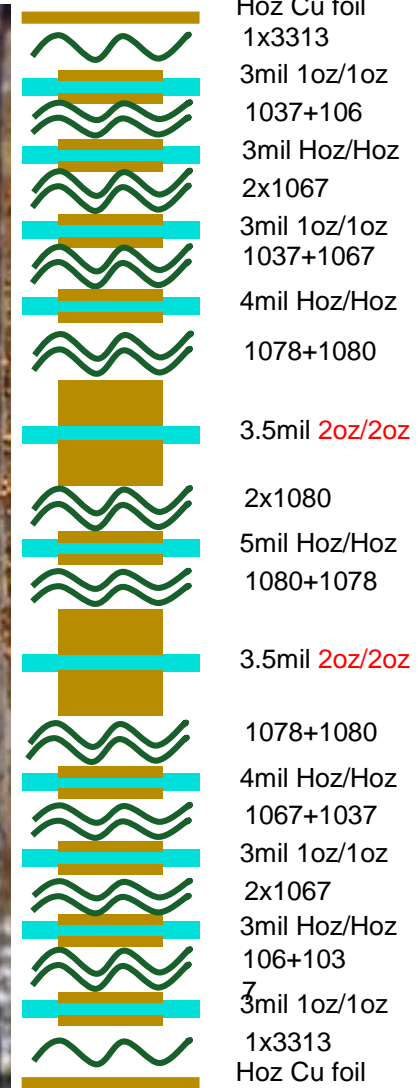
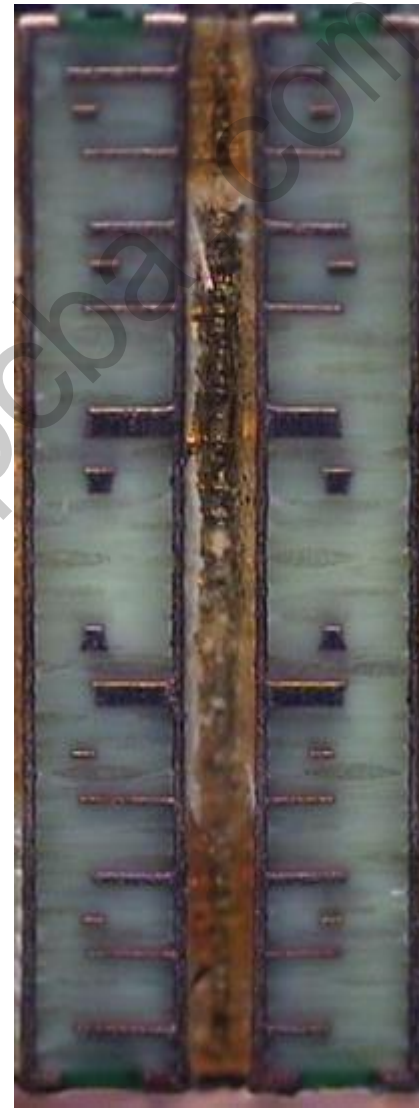
Hole diameter: $\phi = 0.3\text{mm}$

Hole wall to wall

0.35mm, 0.5mm, 1.0mm

Reliability Test :
no delamination, crack
and abnormality

260 °C LF IR Reflow 5X passed



The above test result is under well PCB control.

Lead-Free IR-Reflow Test Result (26 layer)

Product: EM-888

Layer count: 26 layer

Thickness: >130 mils (~3.3mm)

Hole size: 0.25mm

Hole pitch : 0.7mm

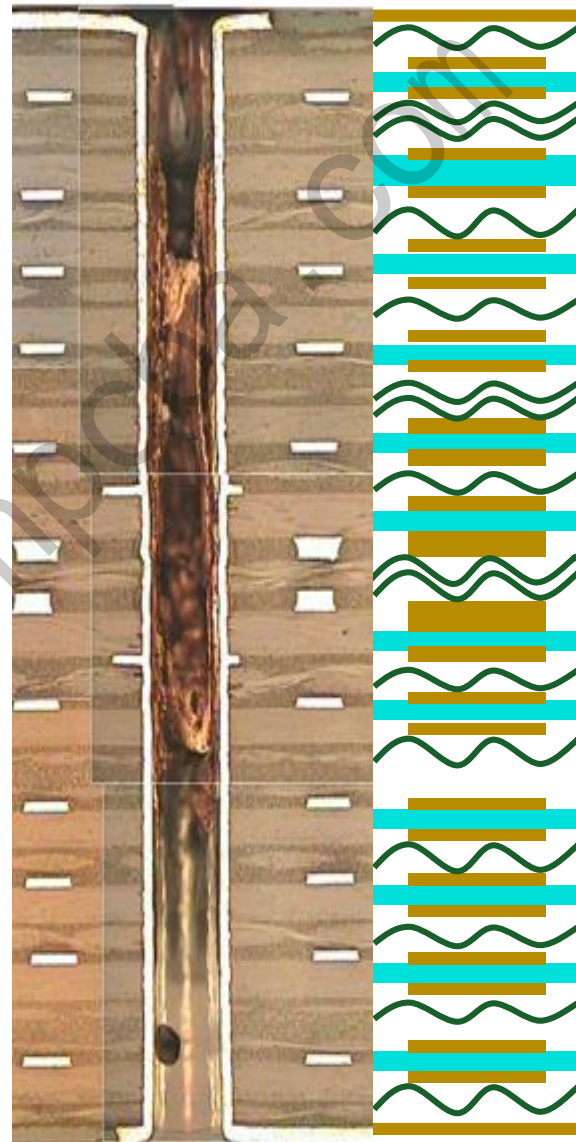
Reliability Test :

no delamination, crack and abnormality

pre-condition 3x Reflow @260°C+2x Reflow @245°C

+ ATC(-40 °C /30min~90 °C/30min) pass >600 cycles

+CAF (50C/80%RH/15VDC) pass 600hrs



Hoz Cu foil
 1 x 1080
 4mil Hoz/1oz
 2 x 1067
 4mil 1oz/1oz
 1 x 2113
 4mil 1oz/1oz
 1 x 2113
 4mil 1oz/1oz
 2 x 1067
 4mil 1oz/1oz
 1 x 2116
 5mil 1oz/2oz
 2x 1080
 5mil 2oz/1oz
 1 x 2116
 4mil 1oz/1oz
 2x 1067
 4mil 1oz/1oz
 1 x 2113
 4mil 1oz/1oz
 1 x 2113
 4mil 1oz/1oz
 2 x 1067
 4mil 1oz/Hoz
 1 x 1080
 Hoz Cu foil

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Lead-Free IR-Reflow Test Result (50 layer)

Product: EM-888

Layer count: 50 layers

Thickness: >320 mils (>8.0mm)

Test pattern: Back plane

Reliability Test :

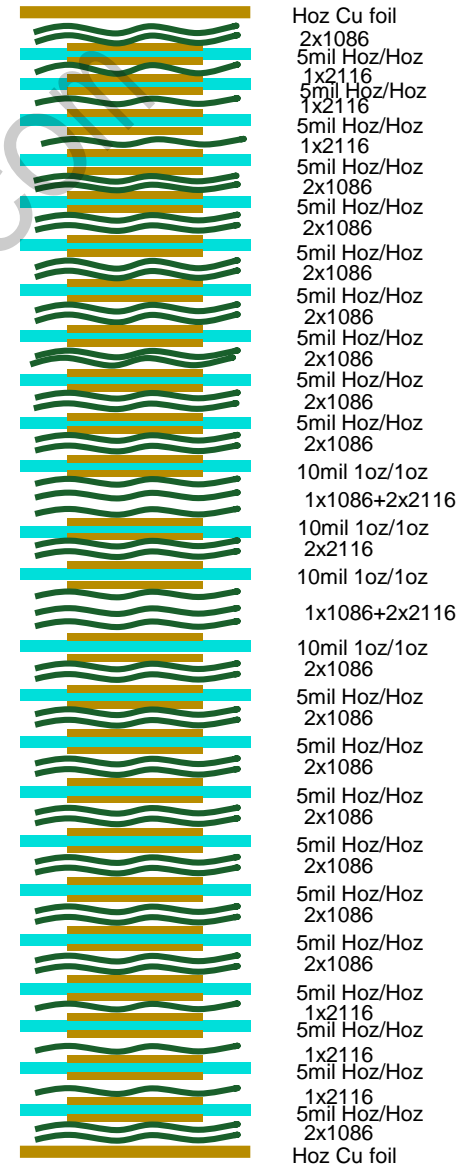
no delamination, crack and abnormality

(1) 240 °C LF IR Reflow 4X

(2) Pre-condition with 240 °C LF IR Reflow 4X

+ ATC -35 °C to 125 °C (15-5-15 min), 400 cycles

+ CAF 50V DC/ 65 °C/ 85% RH, 596 hours



The above test result is under well PCB control.

Rev:20170317

EM-888 IR-Reflow Test Result (8+8+8)

Layers	EM-888
L1	Copper foil 2116RC55%*1
L2/3	4.4milH/H 2116*1 2116RC55%*1
L4/5	4.4milH/H 2116*1 2116RC55%*1
L6/7	4.4milH/H 2116*1 2116RC55%*1
L8	Copper foil 2116RC59%*1
L9/L10	3mil 1/1 (1080X1) 1080 RC69%X1
L11/L12	3mil 1/1 (1080X1) 1080 RC69%X1
L13/L14	3mil 1/1 (1080X1) 1080 RC69%X1
L15/L16	3mil 1/1 (1080X1) 2116RC59%*1
L17	Copper foil 2116RC55%*1
L18/19	4.4milH/H 2116*1 2116RC55%*1
L20/21	4.4milH/H 2116*1 2116RC55%*1
L22/23	4.4milH/H 2116*1 2116RC55%*1
L24	Copper foil

24L 120mil

Product: EM-888

Layer count: 24 layer (8+8+8) sequential lamination

Thickness: 120 mils (~3.0mm)

Hole size: 0.25mm

DHW-DHW: 0.70mm

Reliability Test :

no delamination, crack and abnormality

255 °C LF IR Reflow 5X

EM-888 and EM-370(D) Hybrid

Layers	Hybrid EM-888 & EM-370(D)
L1	Copper foil EM-370(D) 2113 RC 57%
L2/3	EM-370(D) 5mil(2116x1) 1/1 EM-370(D) 1080 RC 63%x2
L4/5	EM-370(D) 4mil(2116x1) 1/1 EM-370(D) 1080 RC 63%x2
L6/7	EM-370(D) 6mil (1501x1) 1/1 EM-370(D) 1080 RC 63%x2
L8/9	EM-370(D) 6mil (1501x1) 1/1 EM-888 1080 RC 63%x2
L10/11	EM-888 6mil (1501x1) 1/1 EM-888 1080 RC 63%x2
L12/13	EM-888 4mil (2116x1) 1/1 EM-888 1080 RC 63%x2
L14/15	EM-888 5mil (2116x1) 1/1 EM-370(D) 2113 RC 57%
L16	Copper foil

This EM-888 and EM-370(D) 16L TV is designed with 0.7mm BGA matrix can pass IR reflow 255°C*5X per OEM requirement.

Reliability Test Result

It can pass following reliability test

IST : 150 °C / 500 cycle

TCT: -65 °C ~125C/15min 1000 cycles

CAF: Bias voltage 20V;85C/85% 500hrs

EM-888, EM-888(S) and EM-888K with EM-370(D) Hybrid construction could be considered according to this practice.

The above test result is under well PCB control.

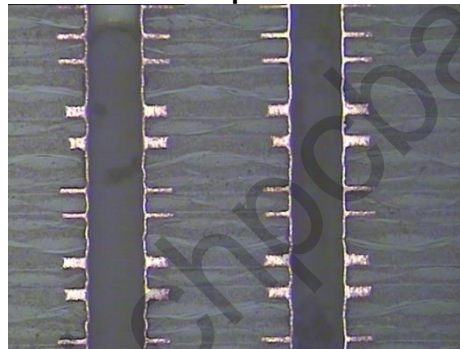
EM-888(S) IR-Reflow Test Result (24L)

Layers	EM-888(S)
L1	Copper foil 1080RC67%*1
L2/3	4milH/H 106*2 2113RC61%*1
L4/5	4.5milH/H2116*1 2113RC61%*1
L6/7	4milH/H 106*2 2116RC59%*1
L8/9	3.5mil1/1 2113*1 1080RC67%+2116RC59%
L10/11	4mil2/2 2113*1 2116RC59%+1080RC67%
L12/13	3.5mil1/1 2113*1 1080RC67%+2116RC59%
L14/15	4mil2/2 2113*1 2116RC59%+1080RC67%
L16/17	3.5mil1/1 2113*1 2116RC59%*1
L18/19	4milH/H 106*2 2113RC61%*1
L20/21	4.5milH/H2116*1 2113RC61%*1
L22/23	4milH/H 106*2 1080RC67%*1
L24	Copper foil

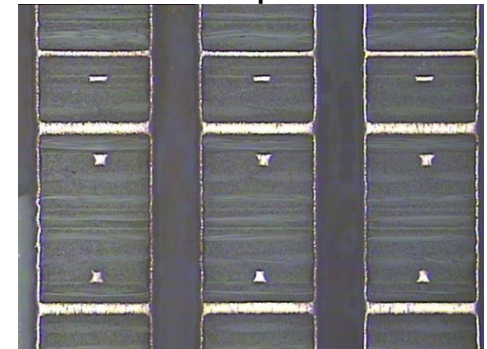
24L board 3.2mm

The reliability test result shows that EM-888(S) 24L TV with 0.65mm/ 0.8mm BGA pitch design can pass IR reflow 260°C*5X OEM requirement.

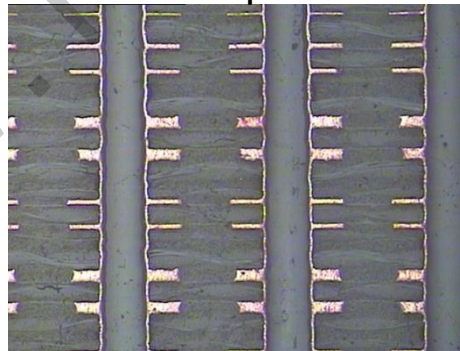
1.0mm pitch



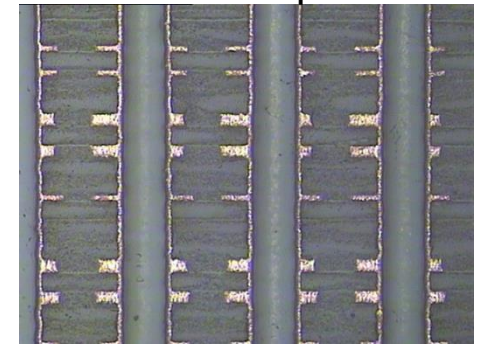
0.8mm pitch



0.8mm pitch



0.65mm pitch



There is no crack, delamination after IR reflow 260°C*5 thermal stress treatment.

The above test result is under well PCB control.

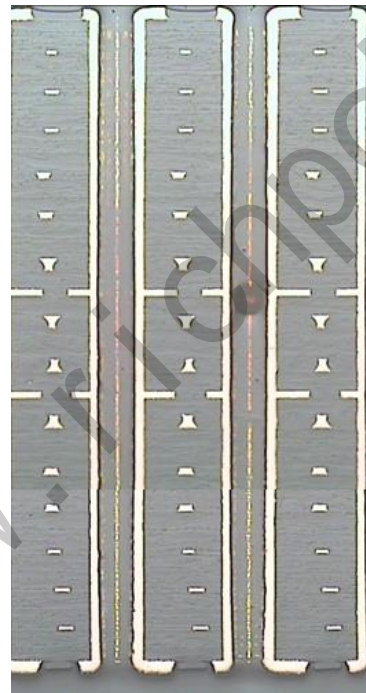
EM-888(S) IR Reflow Test Result (30L)

Layers	EM-888(S)
L1	Copper foil 1080RC65%*1
L2/3	3.5milH/H 1037*2 106 RC73%X2
L4/5	3.5milH/H 3313*1 1037 RC71%*2
L6/7	3.5 mil H/H 3313*1 1067 RC 71%X2
L8/9	4.5mil H/1 2116*1 106 RC 75%X2
L10/11	3.5mil H/1 (2113X1) 1067 RC 75%X2
L12/13	3.5mil 1/2 (2113) 106 RC 75%X2
L14/15	4.5mil 1/2 (1067X2) 1080 RC69%X2
L16/17	4.5mil 2/1 (1067*2) 1067 RC75%X2
L18/19	3.5mil 2/1 (2113*1) 1067 RC 75%X2
L20/21	3.5mil H/1 (2113X1) 106 RC 75%X2
L22/23	4.5mil H/1 2116*1 1067 RC 71%X2
L24/25	3.5 milH/H 3313*1 1037 RC71%X2
L26/27	3.5milH/H 2113*1 1037 RC71%X2
L28/29	3.5milH/H 1037*2 1080RC65%*1
L30	Copper foil

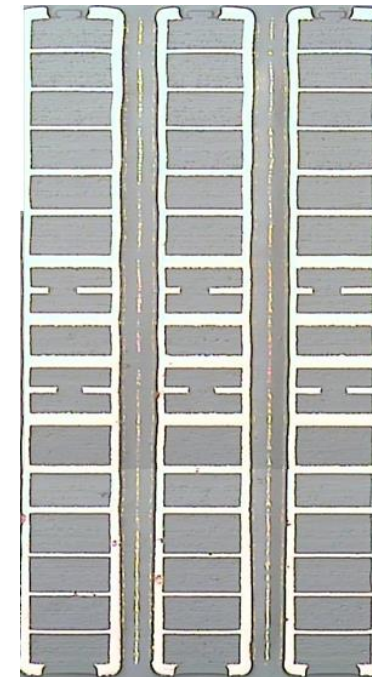
30L 148mil

The reliability test result shows that EM-888(S) 30L TV with 0.7mm BGA pitch design can pass IR reflow 245°C*5X OEM requirement.

0.7mm pitch



0.7mm pitch



There is no crack, delamination after IR reflow 245°C*5X thermal stress treatment.

The above test result is under well PCB control.
Rev:20170317

EM-888(S) IR Reflow Test Result (30L)

Layers	EM-888(S)
L1	Copper foil
	3313 RC55%X1
L2/3	2mil 1/1 106*1
	3313 RC55%X1
L4/5	4 mil H/H 3313*1
	1067 RC71%*1/3313 RC57%*1
L6/7	4 mil H/H 3313*1
	1067 RC71%*1/3313 RC57%*1
L8/9	4 mil H/H 3313*1
	1067 RC71%*1/3313 RC57%*1
L10/11	4 mil H/H 3313*1
	1067 RC71%*1/3313 RC57%*1
L12/13	4 mil H/H 3313*1
	1067 RC71%*1/3313 RC57%*1
L14/15	4mil 1/2 (3313*1)
	1078 RC67%X1/1078 RC63%X1
L16/17	4mil 2/1 (3313*1)
	3313 RC57%*1/1067 RC71%*1
L18/19	4 mil H/H 3313*1
	3313 RC57%*1/1067 RC71%*1
L20/21	4 mil H/H 3313*1
	3313 RC57%*1/1067 RC71%*1
L22/23	4 mil H/H 3313*1
	3313 RC57%*1/1067 RC71%*1
L24/25	4 mil H/H 3313*1
	3313 RC57%*1/1067 RC71%*1
L26/27	4 mil H/H 3313*1
	3313 RC55%*1
L28/29	2mil 1/1 106*1
	3313 RC55%X1
L30	Copper foil

This EM-888(S) 30L TV is designed with 1.0mm BGA matrix can pass IR reflow 260°C*5X & solder float 288*10sec*6 per OEM requirement.

Pattern no	Pitch	Drill Size	IR Reflow 260°C X5 Test Result	Solder float 288C 10sec*6 Test Result
1	1.0mm	0.25mm Through hole	Pass	Pass
2	1.0mm	0.25mm P0FV	Pass	Pass
3	1.0mm	0.5mm Back drill hole	Pass	Pass
4	1.0mm	0.5mm Through hole	Pass	Pass

Note : Back drill depth is 20mil from L1 to L56.
The via stub tolerance is controlled within 16mils .

30L Thickness:155mil

The above test result is under well PCB control

EM-888(K) IR Reflow Test Result (32L)

Layers	EM-888(K)
L1	Copper foil
	1080 RC71%X1
L2/3	2mil 1/1 106*1
	106 RC75%X2
L4/5	3 mil H/H 1080*1
	3313 RC63%*1
L6/7	3 mil H/H 1080*1
	3313 RC63%*1
L8/9	3 mil H/H 1080*1
	3313 RC63%*1
L10/11	3 mil H/H 1080*1
	3313 RC63%*1
L12/13	3 mil H/H 1080*1
	3313 RC63%*1
L14/15	4mil 1/2 (106X2)
	1080 RC71%X2
L16/17	4mil 2/2 (106*2)
	1080 RC71%X2
L18/19	4mil 2/1 (106*2)
	3313 RC63%*1
L20/21	3 mil H/H 1080*1
	3313 RC63%*1
L22/23	3 mil H/H 1080*1
	3313 RC63%*1
L24/25	3 mil H/H 1080*1
	3313 RC63%*1
L26/27	3 mil H/H 1080*1
	3313 RC63%*1
L28/29	3 mil H/H 1080*1
	106 RC75%X2
L30/31	3 mil H/H 1080*1
	1080 RC71%X1
L32	Copper foil

32L (Sipedon Version 2) 145mil

This EM-888K 32L TV is designed with 0.5mm/ 0.65mm/ 0.8mm/ 1.0mm BGA matrix can pass IR reflow 260°C*10X per OEM requirement.

Pattern no	Pitch	Drill Size	IR Reflow 260°C X10 Test Result
1	1.0mm	0.25mm	Pass
2	0.8mm	0.25mm	Pass
3	0.8mm	0.20mm	Pass
4	0.65mm	6mil uVia	Pass
5	0.5mm	6mil uVia	Pass

It indicates EM-888K has extreme robust thermal performance.

Reliability test :

CAF 50V DC/ 65 °C/ 85% RH, 596 hours passed

CAF 100V DC/ 65 °C/ 85% RH, 1000 hours passed

IST Precondition, IR reflow 260 °C 6X,

Condition: room temperature to 150 °C,
650 cycles passed

The above test result is under well PCB control

Electrical Performance

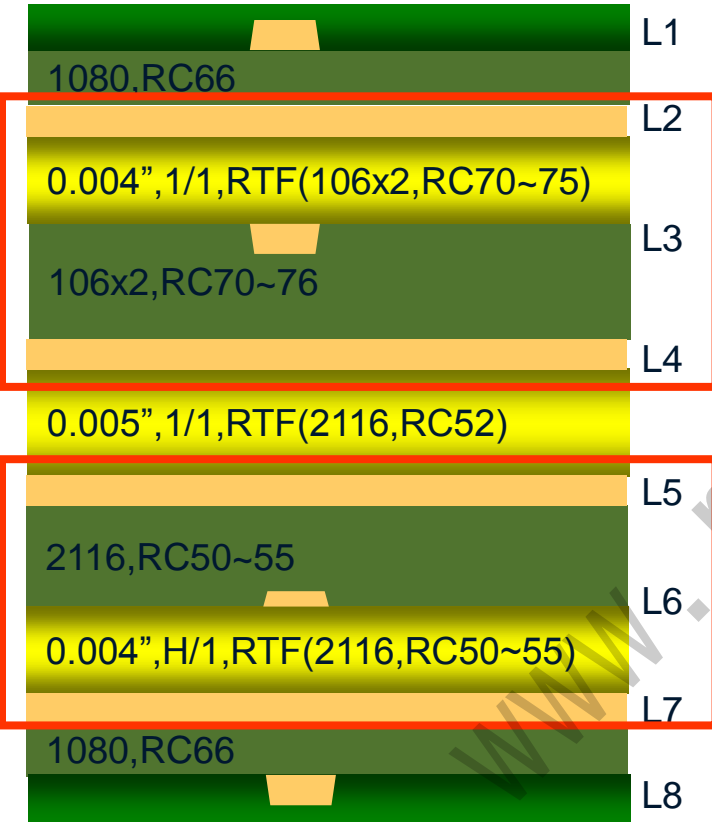
www.richmoba.com

IBM SPP (Short Pulse Propagation)

www.richmora.com

EM-888 EM-888(S) EM-888K SPP Dk/ Df measurement

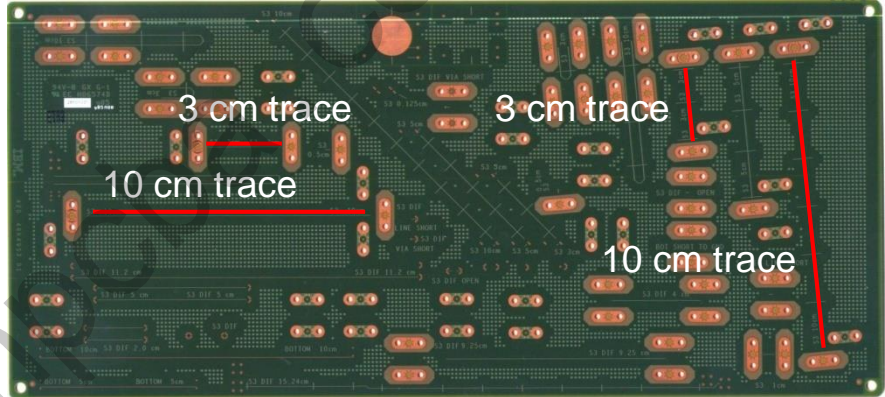
8L TV Stack up



S3
Rich RC

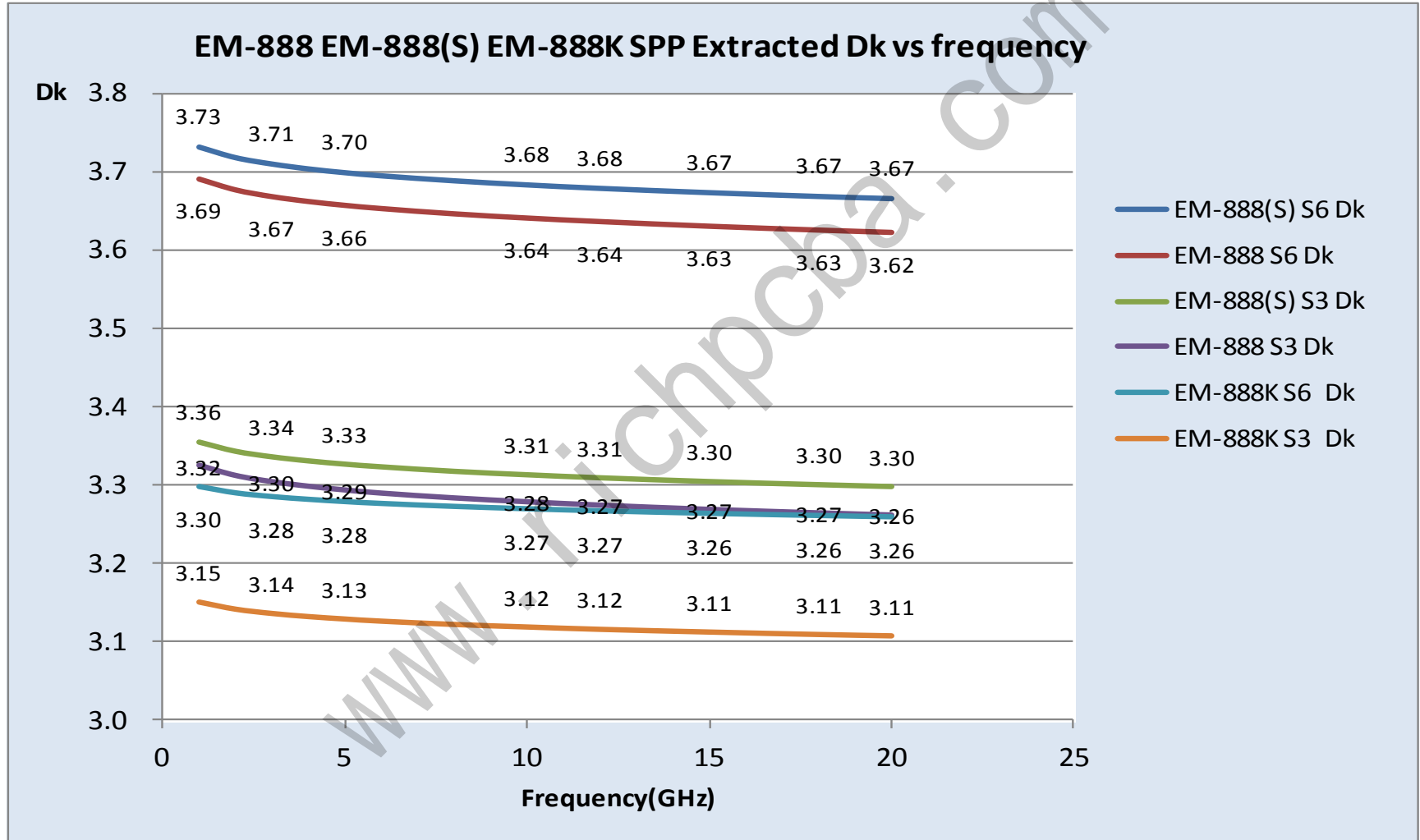
S6
Poor RC

Test coupon



L3: Line width: 3 mils/ 1 oz,
 L6: Line width: 6 mils/ H oz,
 Single end design,
 Impedance control: 50 ohm

SPP Extracted Dk Value vs Frequency

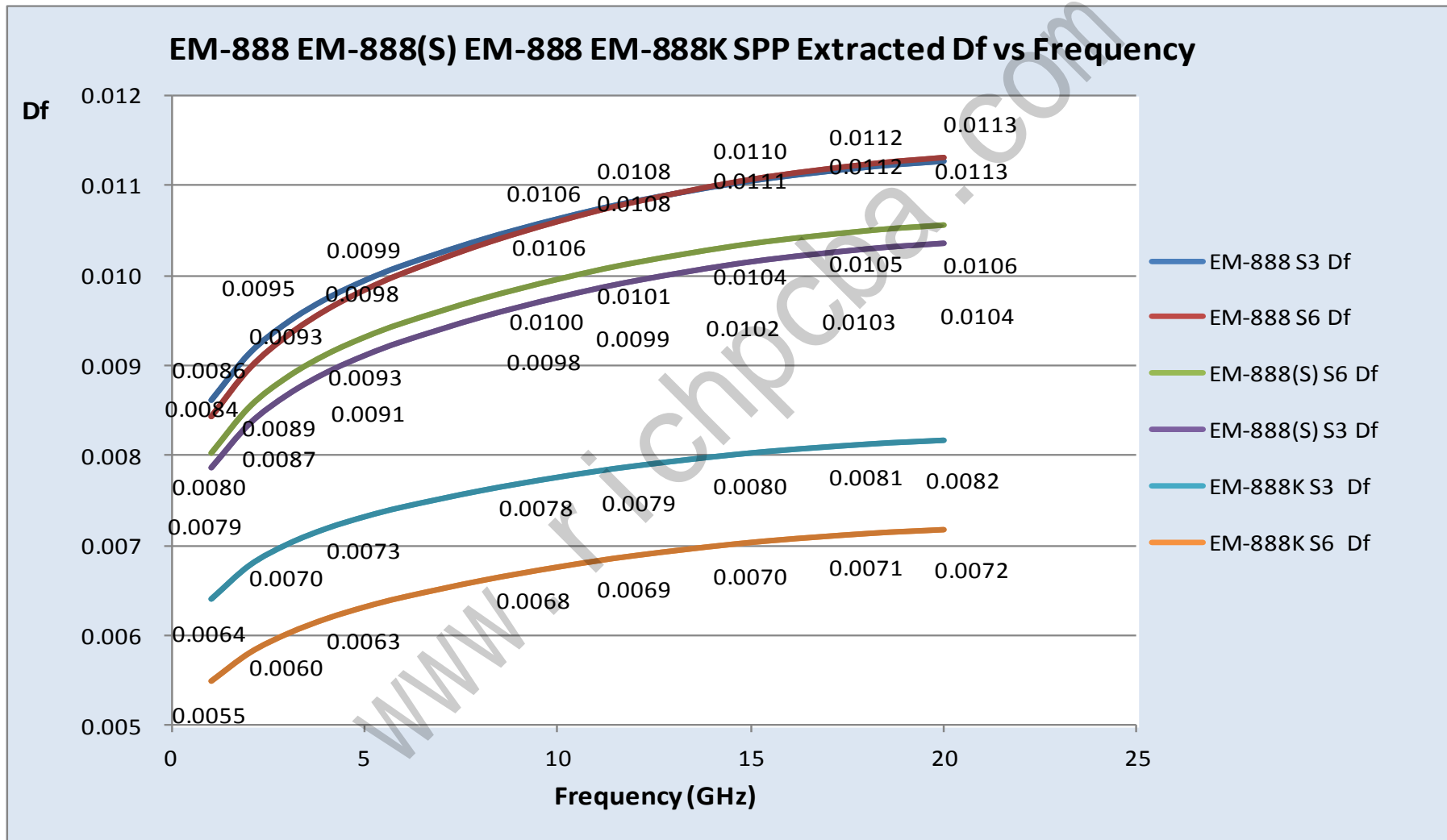


EM-888 and EM-888(S) have similar Dk value Vs frequency.

Measured by EMC SI lab

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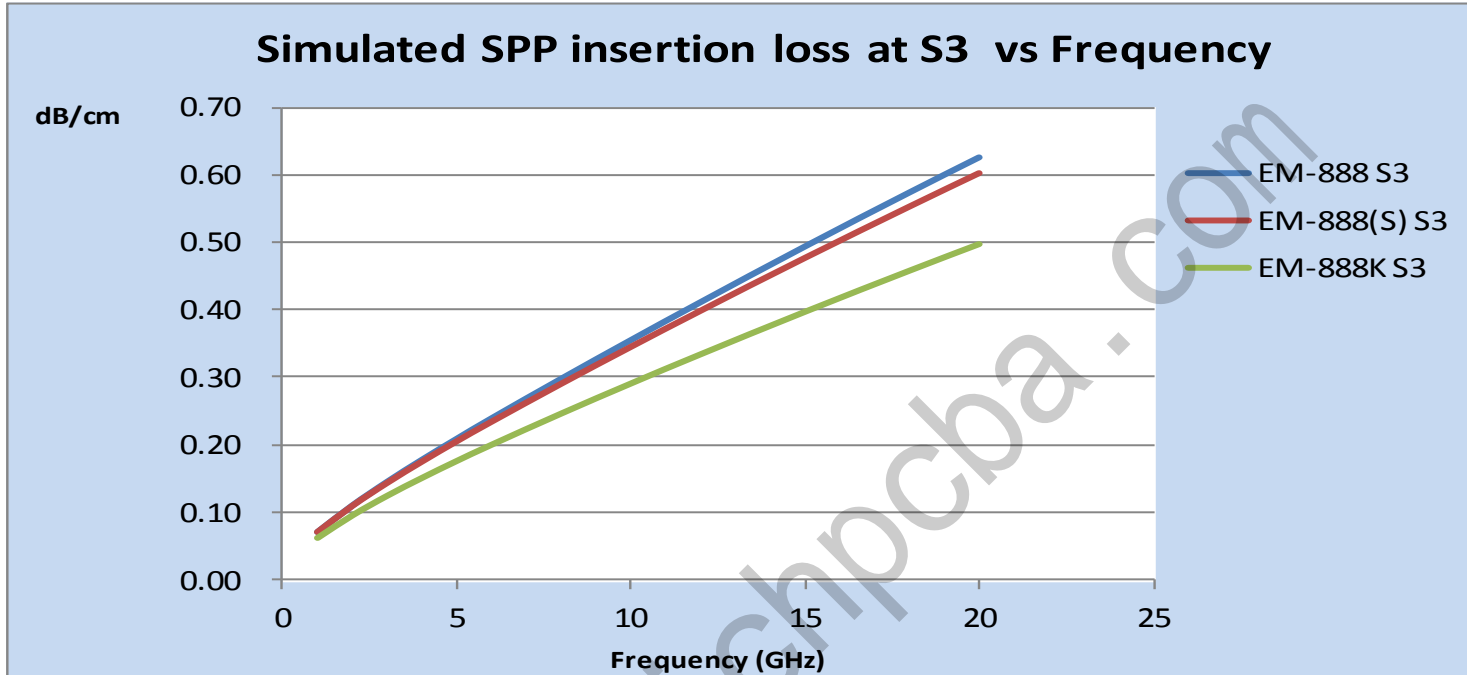
SPP Extracted Df Value vs Frequency



The Df of EM-888(S) is slightly lower than EM-888.

Measured by EMC SI lab

Simulated SPP Insertion loss at S3 vs Frequency



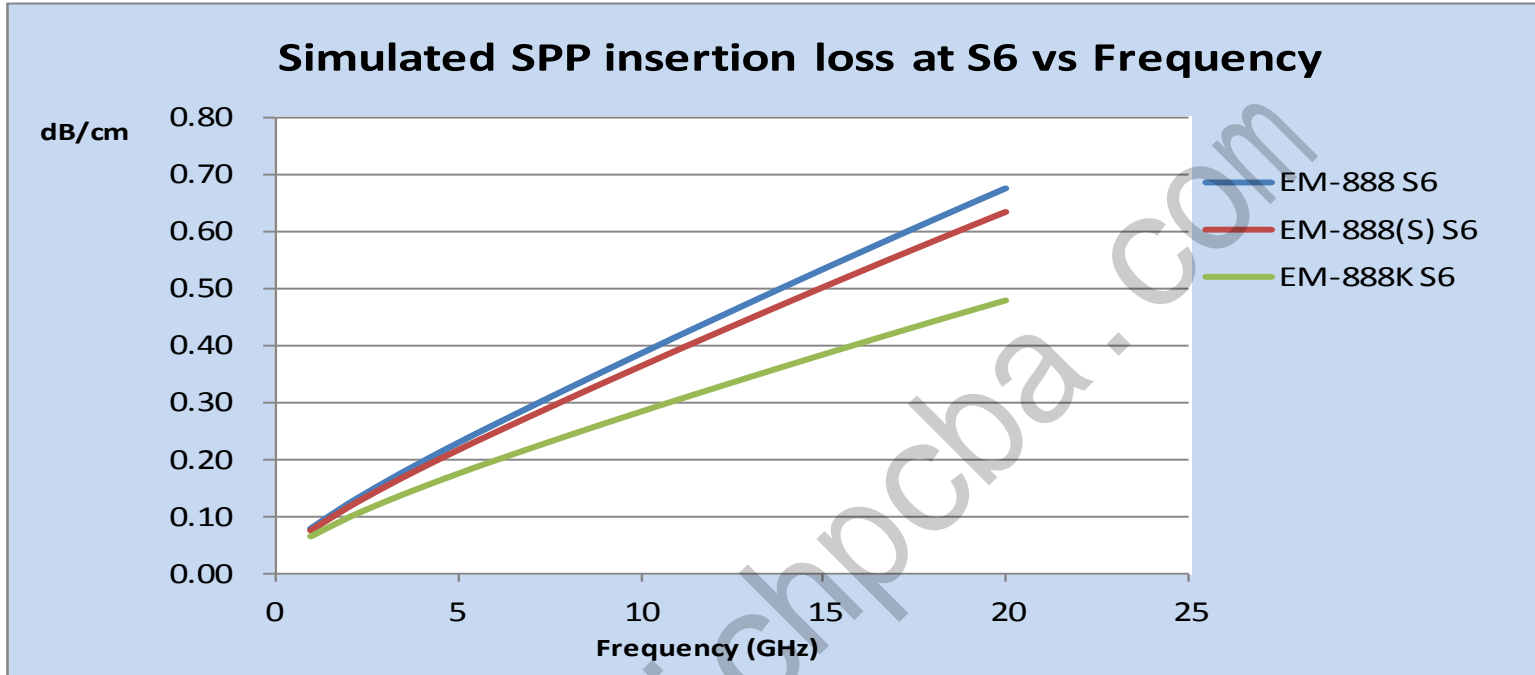
Frequency(GHz)	EM-888 S3	EM-888(S) S3	EM-888K S3
1	0.071	0.071	0.063
2	0.111	0.110	0.096
3	0.146	0.144	0.125
4	0.178	0.175	0.152
5	0.209	0.205	0.177
6	0.240	0.234	0.201
8	0.298	0.290	0.247
10	0.356	0.345	0.292
12	0.412	0.399	0.335
15	0.494	0.477	0.398
18	0.574	0.553	0.459
20	0.626	0.602	0.498

dB/cm

The insertion loss of EM-888(S) is slightly lower than EM-888 about 3.8% under 20GHz .

Measured by EMC SI lab

Simulated SPP Insertion loss at S6 vs Frequency



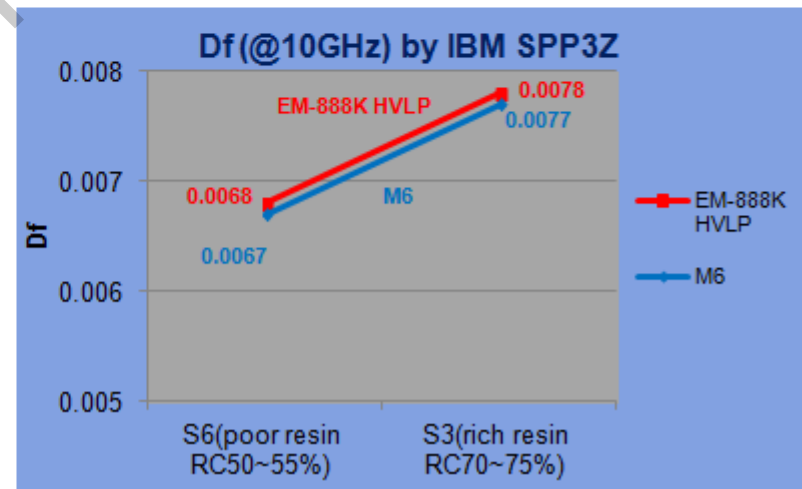
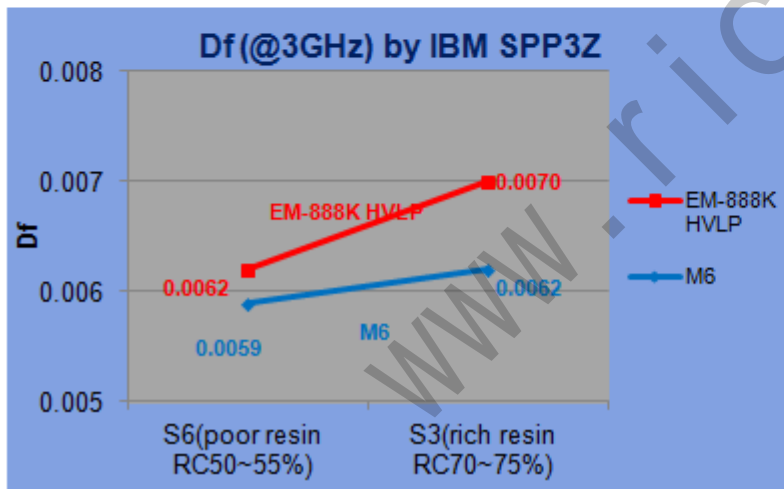
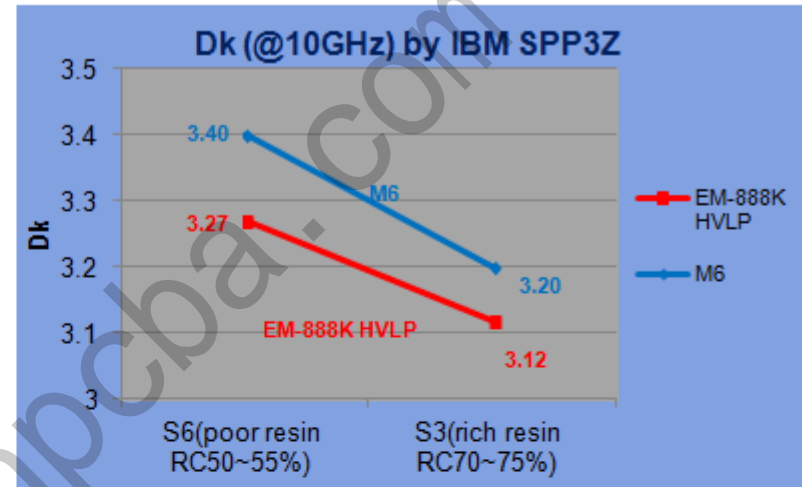
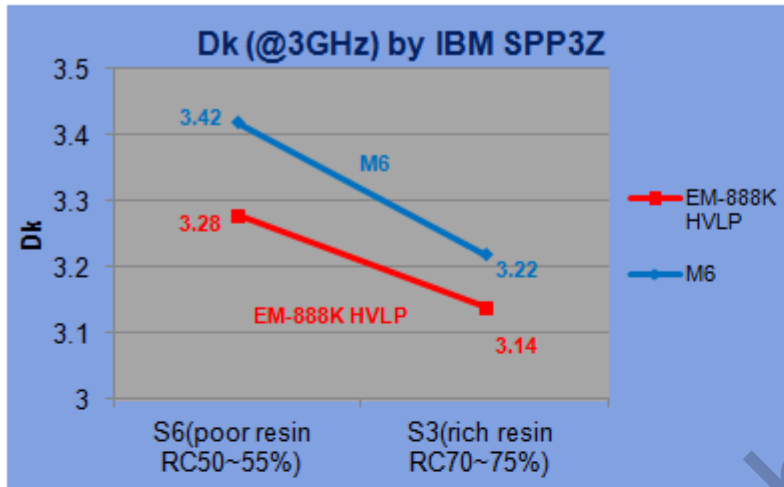
Frequency(GHz)	EM-888 S6	EM-888(S) S6	EM-888K S6
1	0.078	0.074	0.063
2	0.121	0.114	0.096
3	0.158	0.150	0.123
4	0.194	0.183	0.149
5	0.228	0.215	0.173
6	0.260	0.245	0.196
8	0.323	0.304	0.240
10	0.384	0.362	0.282
12	0.444	0.418	0.323
15	0.532	0.501	0.383
18	0.618	0.581	0.441
20	0.674	0.634	0.479

dB/cm

The insertion loss of EM-888(S) is slightly lower than EM-888 about 5.9% under 20GHz .

Measured by EMC SI lab

Test Result- SPP



Intel SET2DIL

Single -Ended TDR/TDT To Differential Insertion Loss

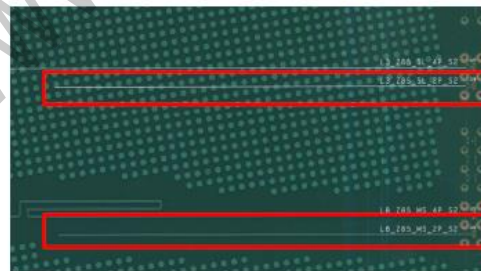
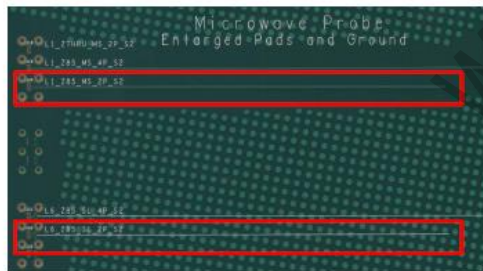
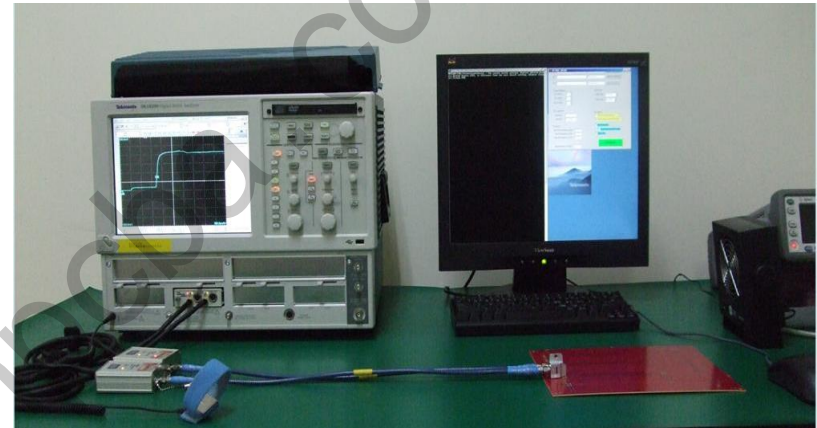
www.richicba.com

Electrical Test

Stack up of 8L for SET2DIL TV

		Nominal Board thickness 62mil	
		Solder Mask	
Poor	L1	0.5oz+plating	
	PP 50~55% resin		
Rich	L2	1oz	
	Core (1/1) 70~75% resin		
Rich	L3	1oz	
	PP 70~75% resin		
Poor	L4	2oz	
	Core (2/2)		
Poor	L5	2oz	
	PP 50~55% resin		
Rich	L6	1oz	
	Core (1/1) 50~55% resin		
Rich	L7	1oz	
	PP 70~75% resin		
		0.5oz+plating	
		Solder Mask	

Test equipment : TEK DSA8200



ature

Layer	Impedance	Trace width(mils)	Space (mils)
L1	85Ω	6.6	5.4
L3	85Ω	5.9	5.6
L6	85Ω	5.5	6.0
L8	85Ω	7.0	5.0

EM-888 8L Test Result

A PCB shop

Frequency	4GHz				8GHz			
Layer	L1	L6	L3	L8	1	6	3	8
Insertion loss (dB/inch)	-0.53231	-0.43464	-0.42286	-0.52415	-1.0004	-0.76361	-0.76646	-1.0054

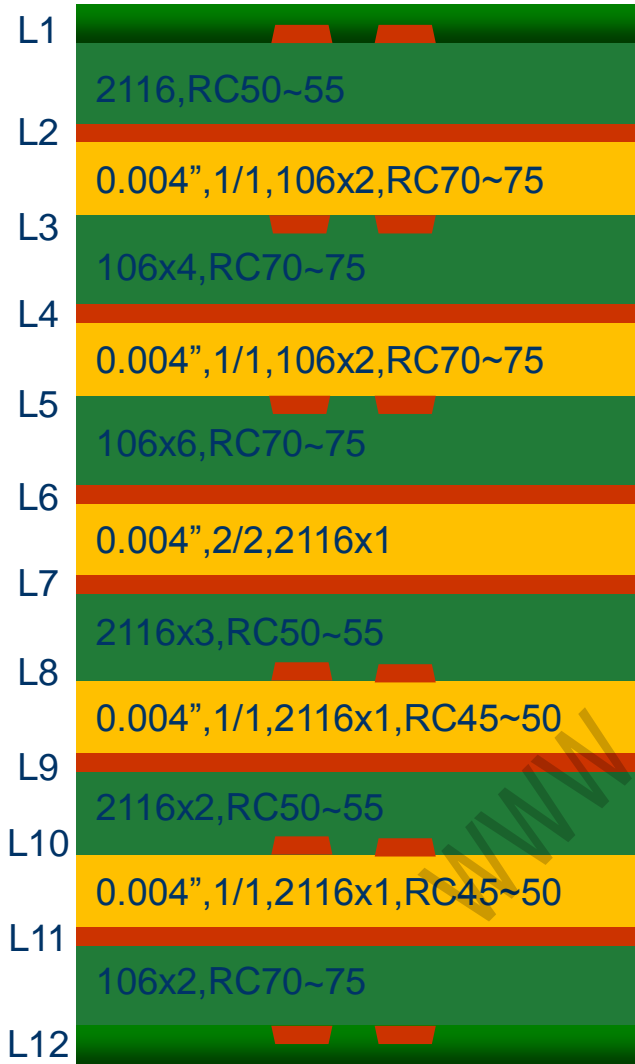
B PCB shop

Frequency	4GHz				8GHz			
Layer	L1	L6	L3	L8	L1	L6	L3	L8
Insertion loss (dB/inch)	-0.53546	-0.44279	-0.4454	-0.52375	-0.96349	-0.8339	-0.81012	-0.93426

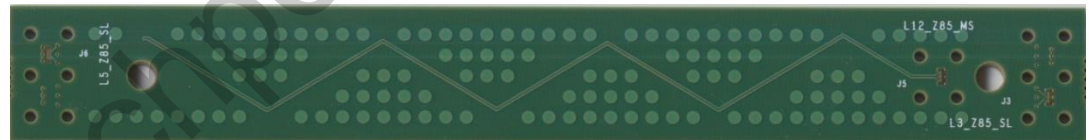
www.rchopro.com

12L Test Vehicle

- Construction



	L3/L5/L8/L10
Impedance	♦ 85Ω
Line width/space	5mil / 6.5mil



12L Test Result

Material	Copper	Layer	SDD21(dB/inch)	
			4GHz	8GHz
EM-285	RTF	L1	-0.54	-1.00
		L3	-0.66	-1.27
		L5	-0.66	-1.29
		L8	-0.62	-1.25
		L10	-0.64	-1.25
		L12	-0.54	1.02
EM-370(D)	RTF (default)	L1	-0.58	-1.01
		L3	-0.62	-1.21
		L5	-0.62	-1.20
		L8	-0.61	-1.21
		L10	-0.62	-1.19
		L12	-0.58	-1.02
EM-828G	RTF (default)	L1	-0.55	-0.95
		L3	-0.54	-1.05
		L5	-0.53	-1.06
		L8	-0.53	-1.07
		L10	-0.55	-1.05
		L12	-0.51	-0.90
EM-888	RTF	L1	-0.46	-0.83
		L3	-0.47	-0.84
		L5	-0.46	-0.86
		L8	-0.46	-0.86
		L10	-0.46	-0.83
		L12	-0.44	-0.81
EM-888	VLP (default)	L1	-0.44	-0.80
		L3	-0.45	-0.82
		L5	-0.44	-0.83
		L8	-0.44	-0.83
		L10	-0.45	-0.80
		L12	-0.43	-0.79
EM-888 K	HVLP (default)	L1	-0.39	-0.70
		L3	-0.39	-0.69
		L5	-0.38	-0.70
		L8	-0.38	-0.71
		L10	-0.39	-0.69
		L12	-0.39	-0.70

EM-888K 16L SET2DIL Test Vehicle

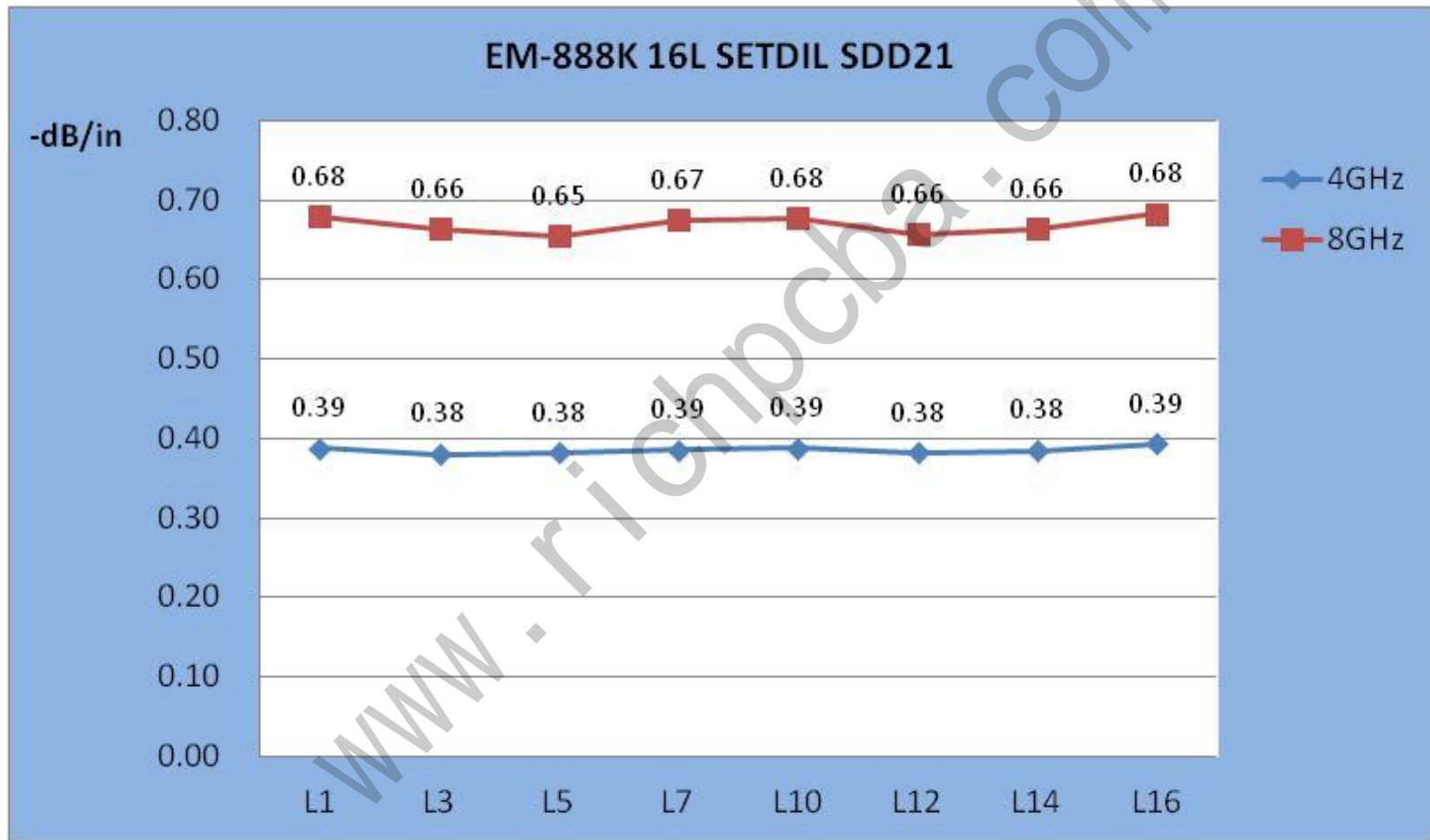
L1		H oz
L2		1080X1 RC63
L3		4.5mil, 1/1, 2116*1
L4		106*2 RC74
L5		4.5mil, 1/1, 2116*1
L6		106*2 RC74
L7		3mil, 1/1, 1080x1
L8		1080*2 RC63+2116 RC56
L9		5mil, 2/2, 2116x1
L10		1080*2RC 63+2116 RC56
L11		3mil, 1/1, 1080x1
L12		106*2RC 74
L13		4.5mil, 1/1, 2116X1
L14		106*2 RC 74
L15		4.5mil, 1/1, 2116*1
L16		1080 RC63

SET2DIL Test coupon



Layer	Line width design(mil)	Line Space design(mil)	Impedance design(Ω)
L1	5.3	6.7	85
L3	4.7	6.3	85
L5	4.7	6.3	85
L7	5.3	7.7	85
L10	5.3	7.7	85
L10	4.7	6.3	85
L14	4.7	6.3	85
L16	5.3	6.7	85

EM-888K 16L SET2DIL Test Result



Delta L

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EM-888K 20L Delta L Test Result

Layers	EM-888K
L1	Copper foil 1080 RC 73%
L2/3	EM-888K 5mil(1067x2) 1/1 1078 RC65%+1078 RC 69%
L4/5	EM-888K 5mil(1067x2) 1/1 1078 RC65%+1078 RC 69%
L6/7	EM-888K 5mil(1067x2) 1/1 1078 RC65%+1078 RC 69%
L8/9	EM-888K 5mil(1067x2) 1/1 1078 RC65%+1078 RC 69%
L10/11	EM-888K 5mil(1067x2) 1/1 1078 RC65%+1078 RC 69%
L12/13	EM-888K 5mil(1067x2) 1/1 1078 RC65%+1078 RC 69%
L14/15	EM-888K 5mil(1067x2) 1/1 1078 RC65%+1078 RC 69%
L16/17	EM-888 5mil (2116x1) 1/1 1078 RC65%+1078 RC 69%
L18/19	EM-888 5mil (2116x1) 1/1 1080 RC 73%
L20	Copper foil

Pattern design: line width/space/line width
7.1mil/10.4mil/7.1mil

Impedance design: 85ohm

SET2DIL test result

Frequency	4GHz	8GHz
insertion loss (-dB/in)	0.37	0.63

Delta L test Result

Frequency	4GHz	5GHz	6GHz	8GHz	10GHz
insertion loss (-dB/in)	0.34	0.4	0.46	0.57	0.68

We estimate that insertion loss would be about -0.82dB/in@12.5GHz.

Eye Diagram & Insertion Loss

www.richicoba.com

Insertion Loss (dB/inch) of EM-888 24L SI TV

Insertion Loss Test

Test equipment : Agilent PNA

Test Frequency: up to 12.5GHz

Test Sample:

SI TV Thickness: 140 mils/ Min. hole size: 10 mils

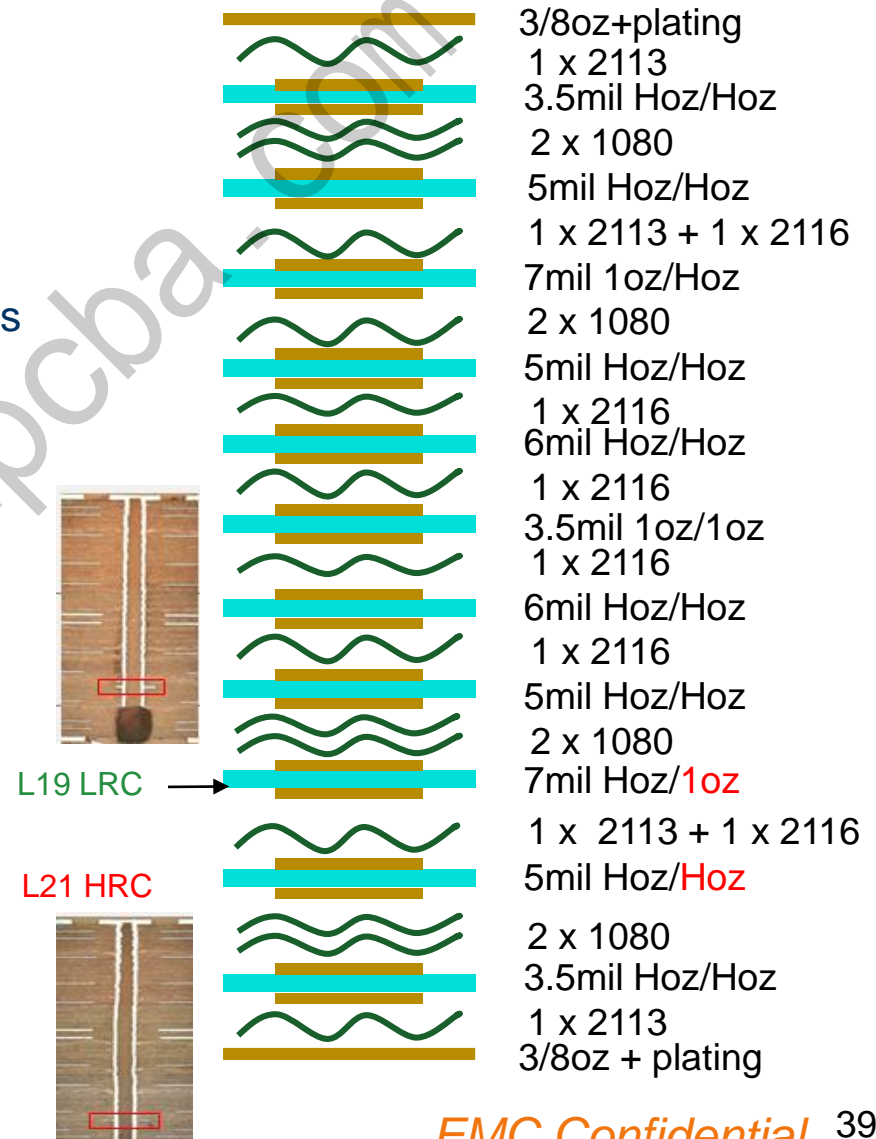
Line width/space:

6.75/ 14.25 mils for L19 (SI friendly design)

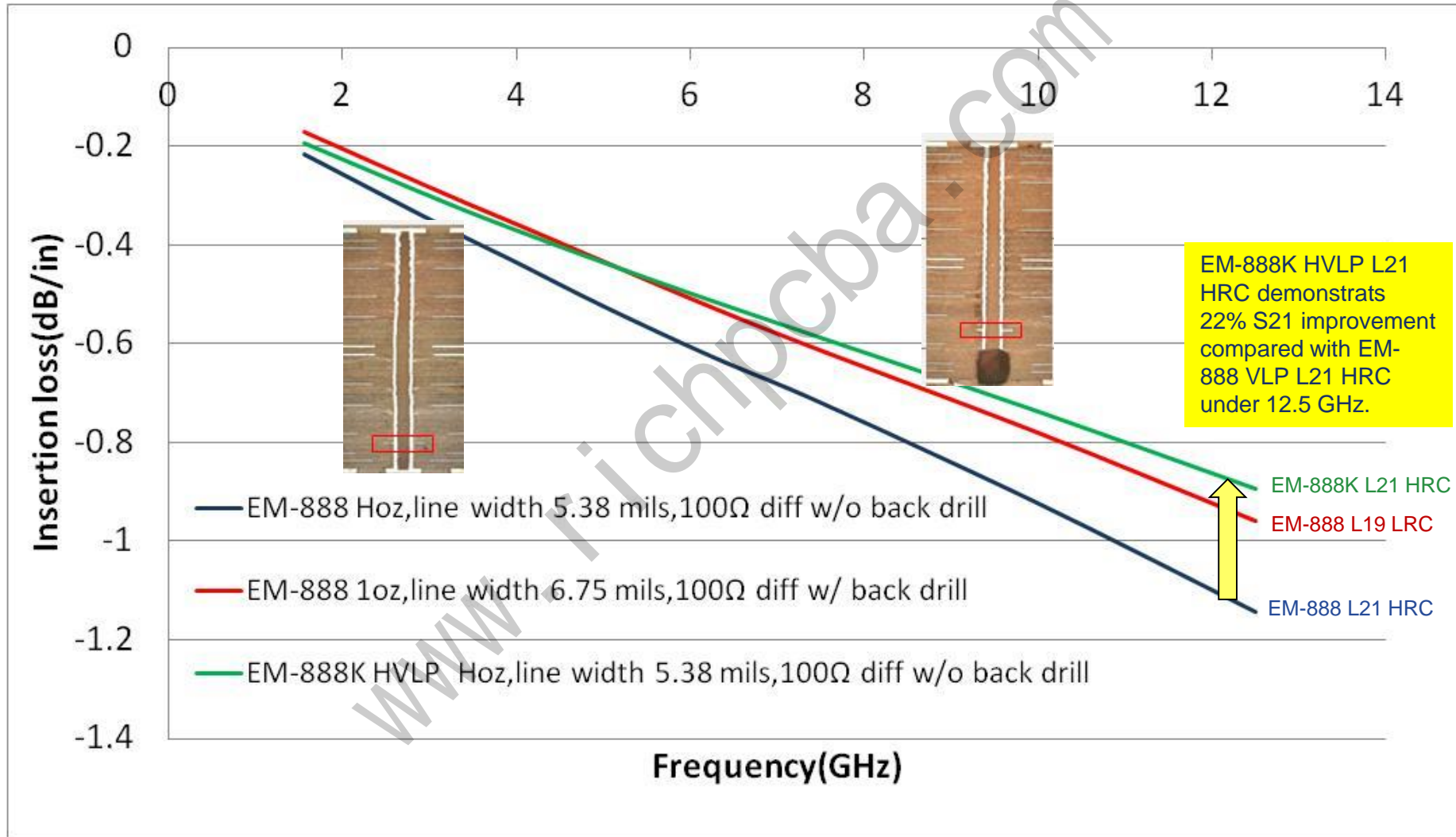
5.38/ 9.63 mils for L21 (SI harsh design)

Line length 20", 100 ohms differential pairs

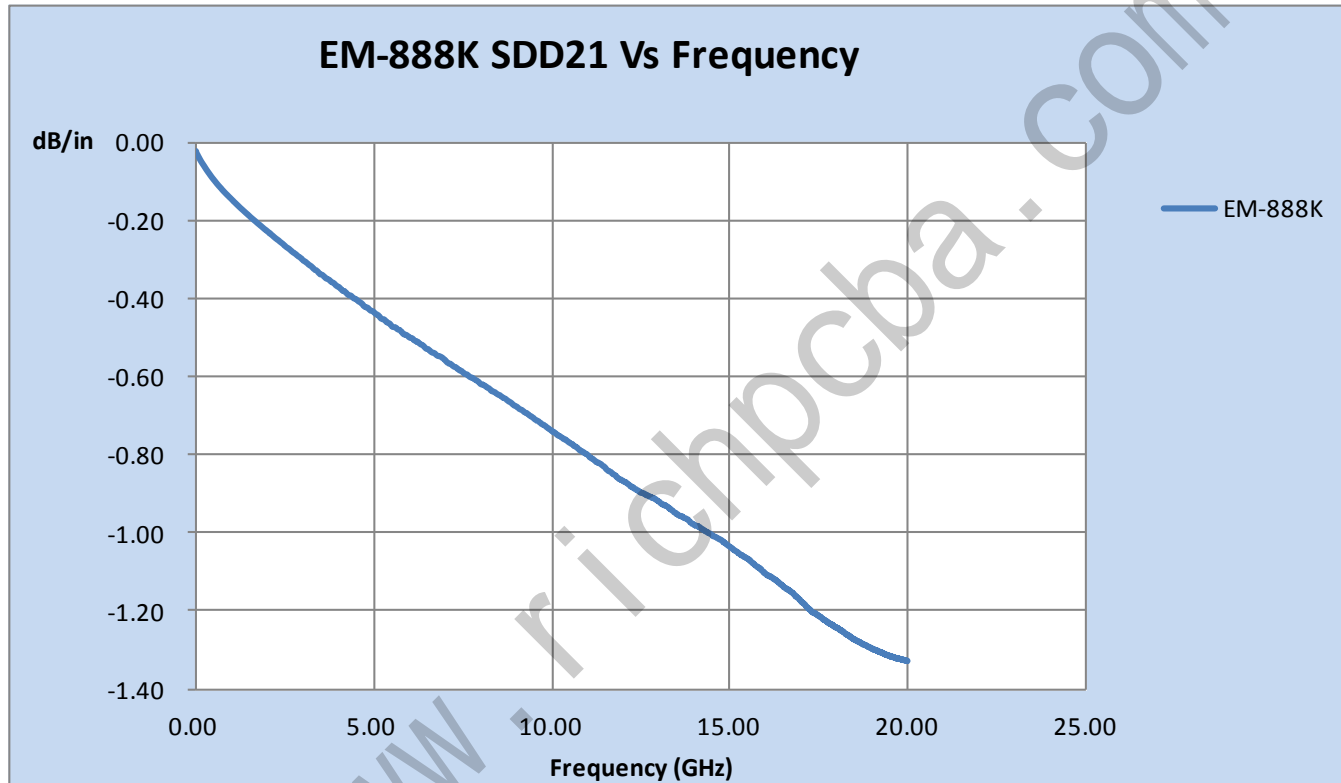
Back drill: 10 to 12 mils in depth for L19



Insertion Loss (dB/inch) of EM-888 24L SI TV



Insertion Loss (dB/inch) of EM-888K 24L SI TV



SDD21(dB/inch)				
Frequency(Hz)	5G	10G	14G	20G
EM-888K HVLP	-0.43	-0.74	-0.98	-1.33

Electrical Test

Insertion Loss Test

Test equipment : Agilent N5224A

Test Frequency: up to 20GHz

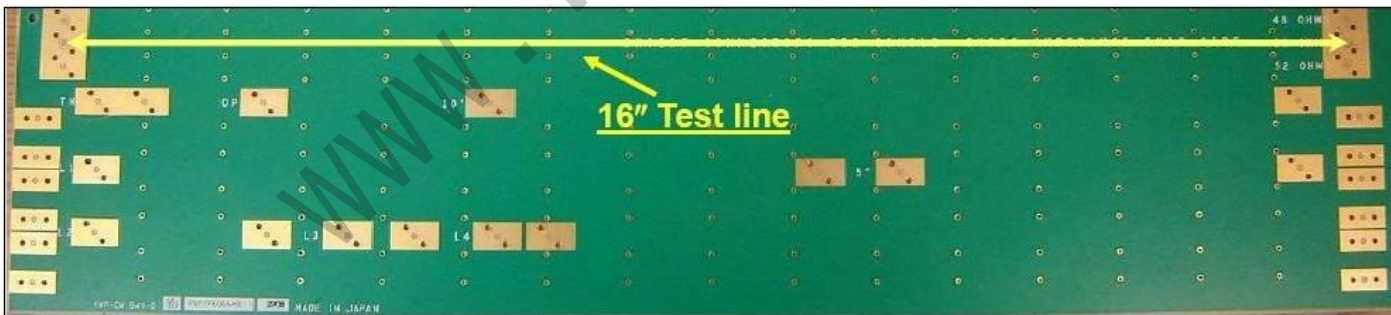
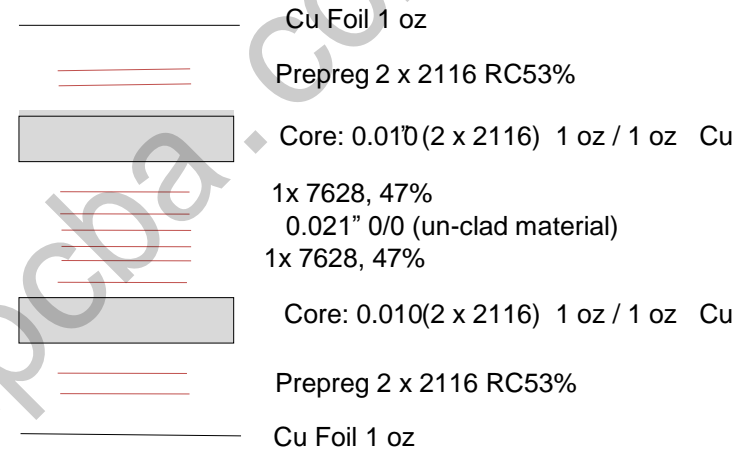
Test Sample:

Line length 16", line width 8.5mils, single ended

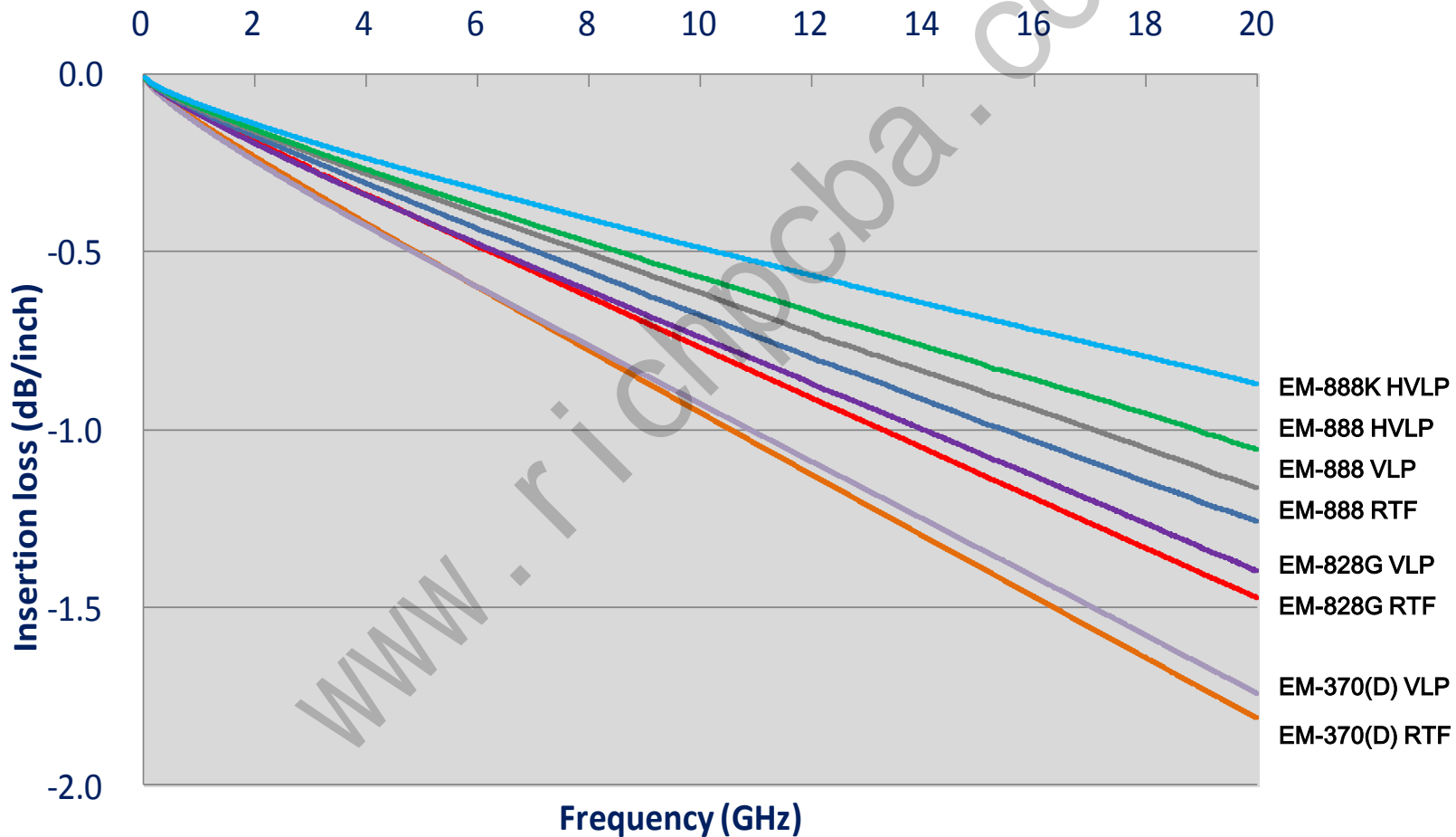
Measurement flow

- (1) TRL Calibration
- (2) S Parameter Measurement

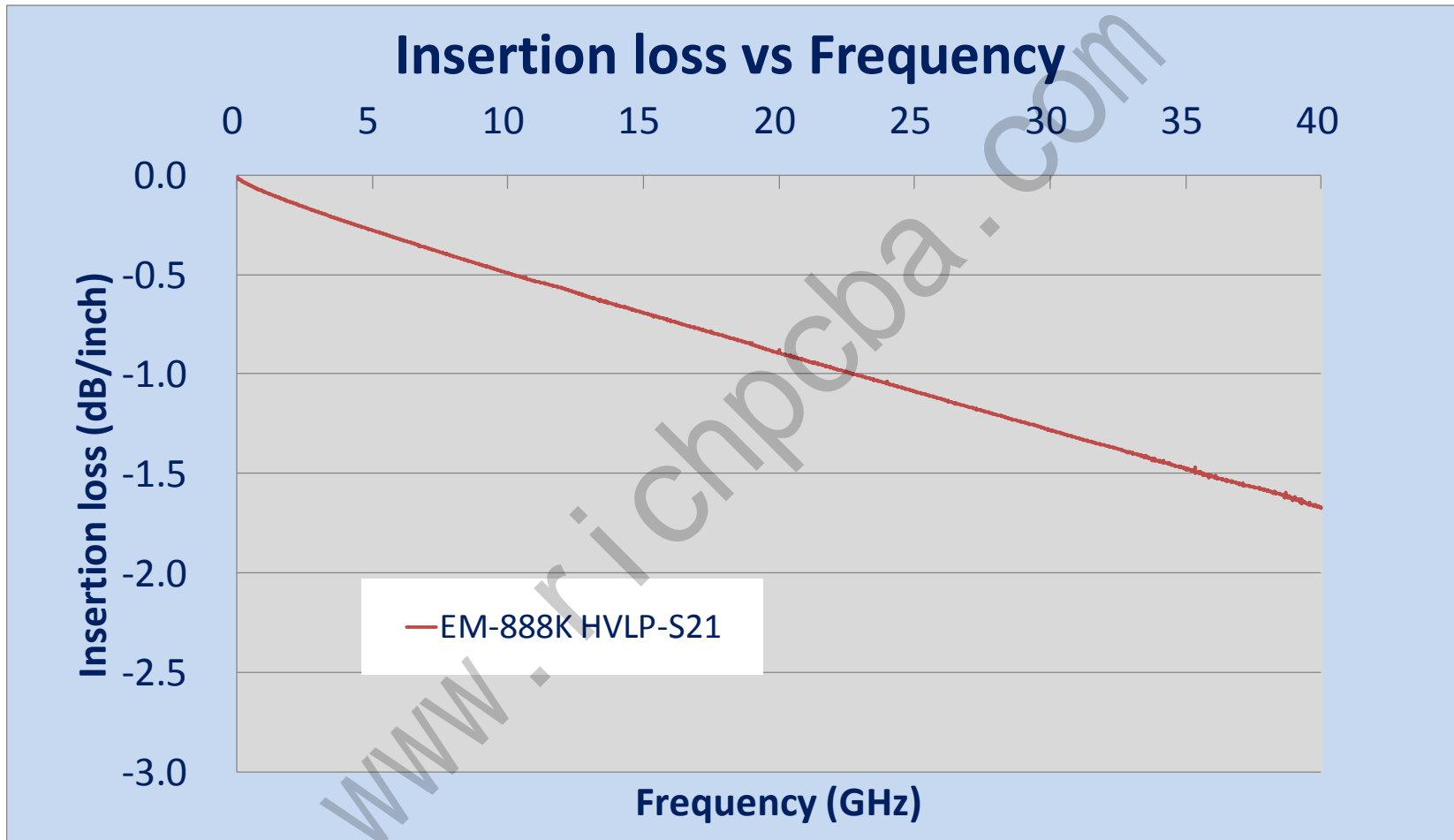
Stack up of 6L for SI TV



Electrical Test – Insertion Loss (dB/inch)



EM-888K S21 up to 40GHz



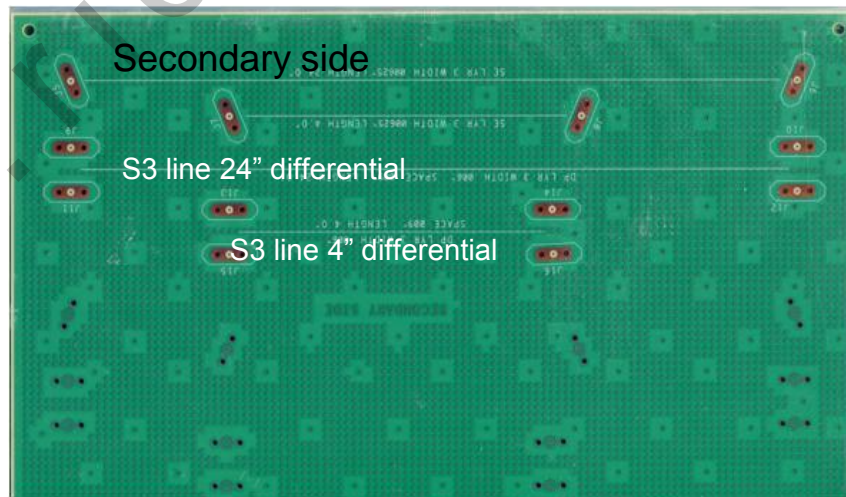
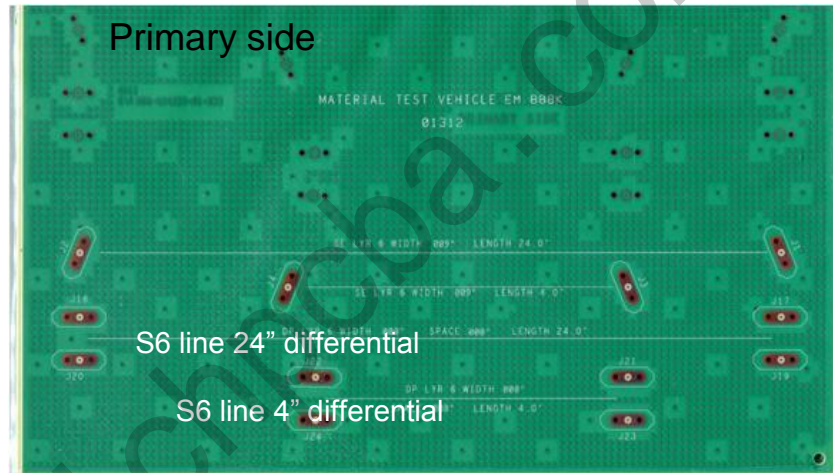
Frequency(GHz)	5	10	14	25	28	35
EM-888K HVLP-S21 (dB/in)	-0.28	-0.49	-0.65	-1.09	-1.20	-1.48

EM-888K 8L SI TV SDD21 Measurement

TV Stack up and design:

Layer	construction	RC%
1	H oz VLP	
	1078 RC 69%*3	69
2	1 oz HVLP	
	5mil core , 1067*2	73
3	Hoz HVLP	
	1067*2	77
4	1 oz HVLP	
	10mil core , 2116x2	57
5	1 oz HVLP	
	1078 RC 69%*2	69
6	H oz HVLP	
	8mil core , 3313*2	58
7	1 oz HVLP	
	1078 RC 69%*3	69
8	H oz VLP	

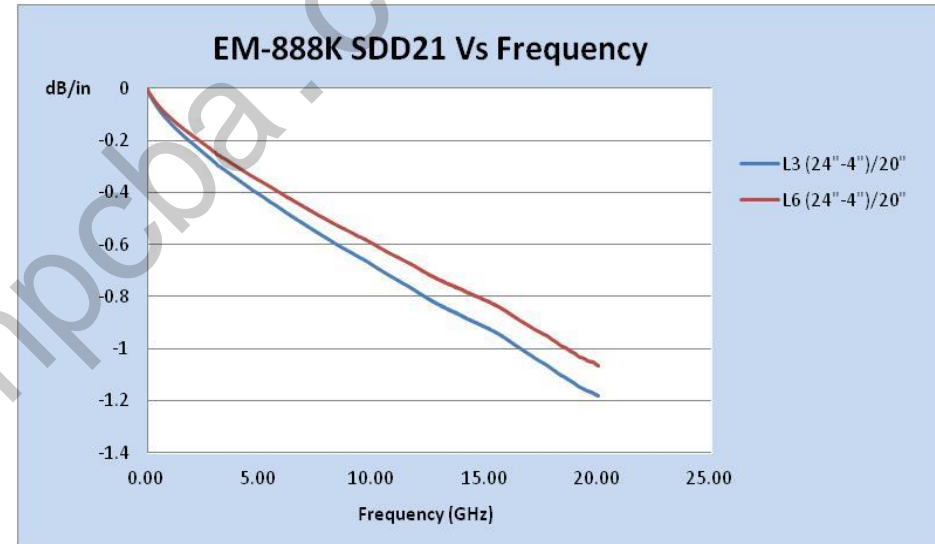
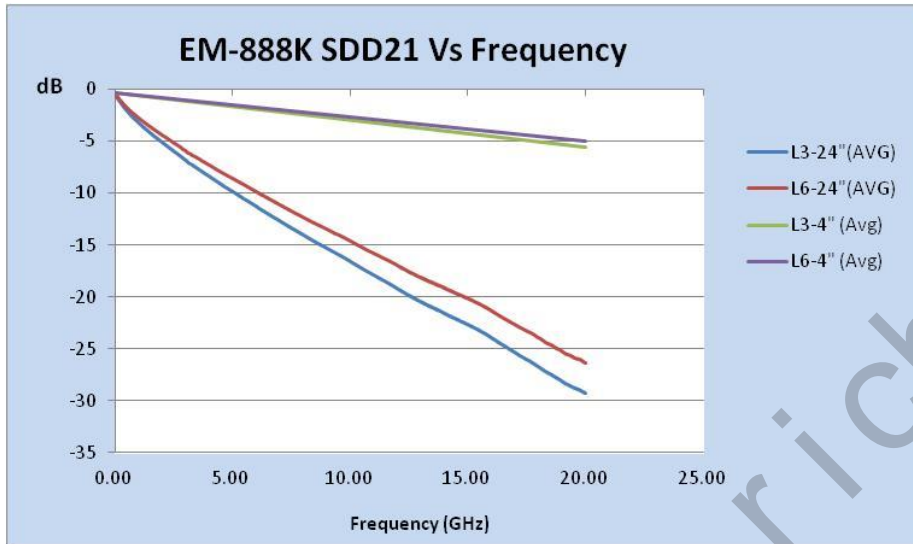
L3 line width/space : 6mil/ 9mil;
 L6 line width/space : 8mil/ 8mil;
 differential pair
 Impedance control: 96 ohm



EM-888K SDD21 Measured up to 20GHz

(1) Measure SDD21 data for both 24" and 4" ,
 (24" minus 4") data can delete the via hole and pad effect

(2) SDD21 loss/ line length (dB/in)
 = (24"(loss)-4"(loss)) / (24"-4")



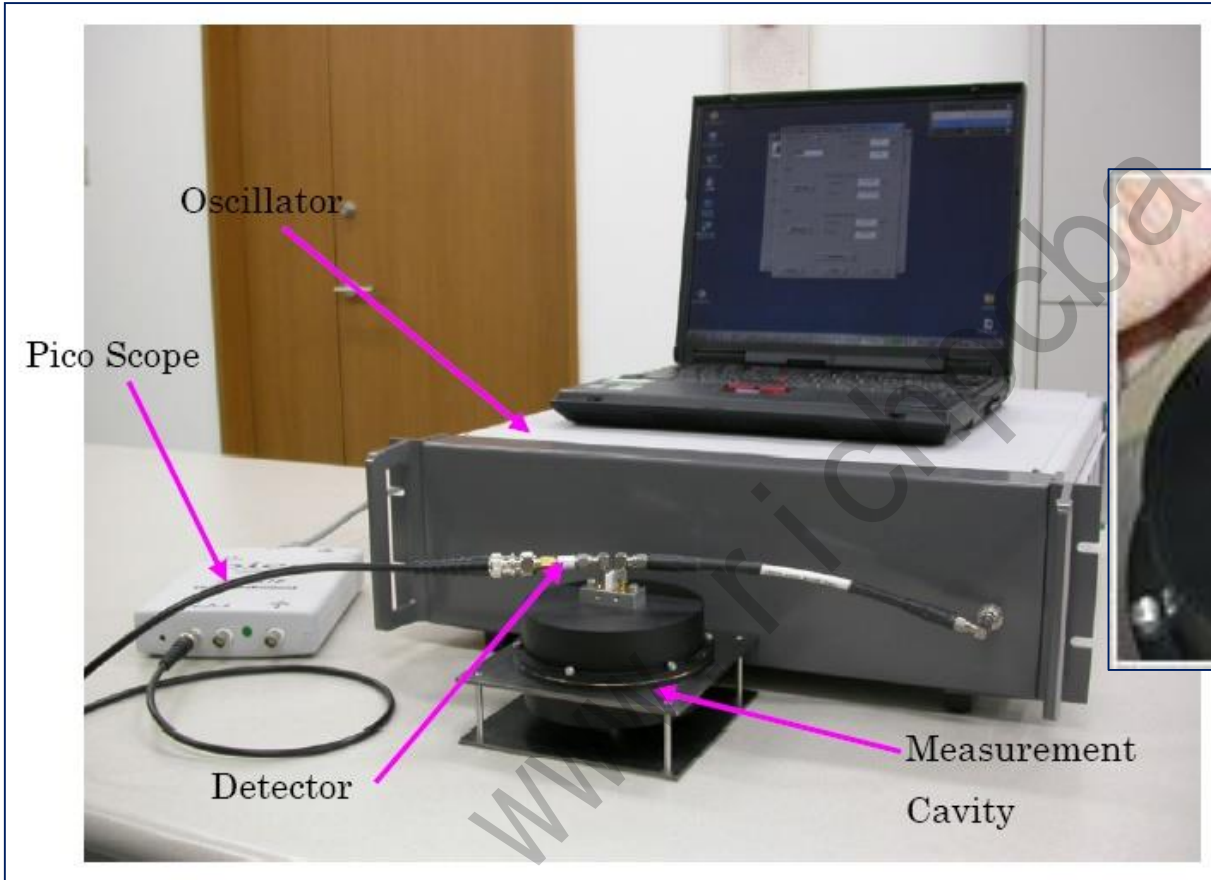
EM-888K SDD21 loss (dB/in) data measured at high frequency:

Layer/ Frequency	5GHz	10GHz	14GHz	20GHz
L3 (dB/in)	-0.408	-0.679	-0.877	-1.182
L6 (dB/in)	-0.356	-0.597	-0.777	-1.065

SPC for Dk/Df (Split Post Cavity)

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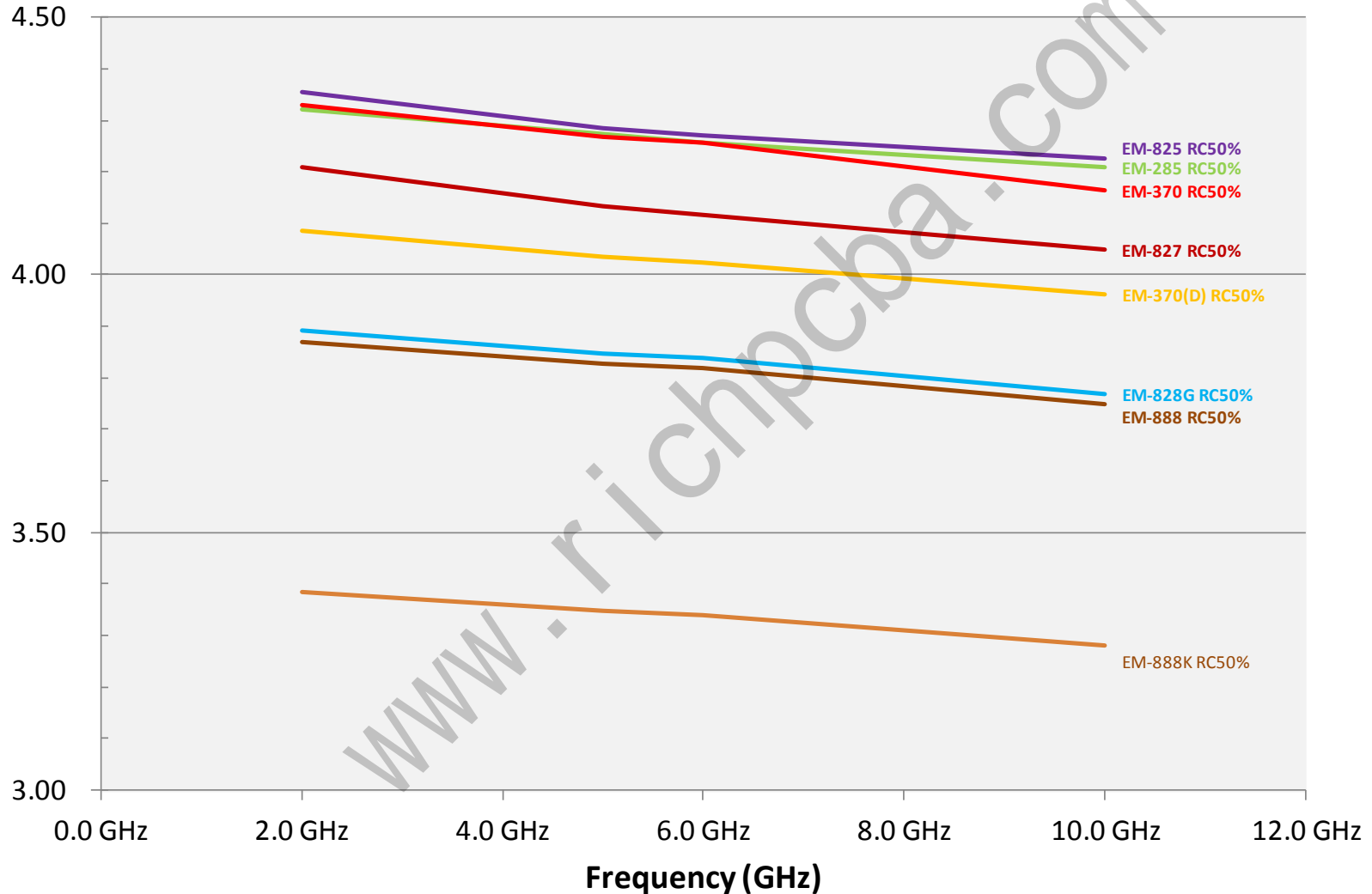
SPC Measurement Equipment Set-up



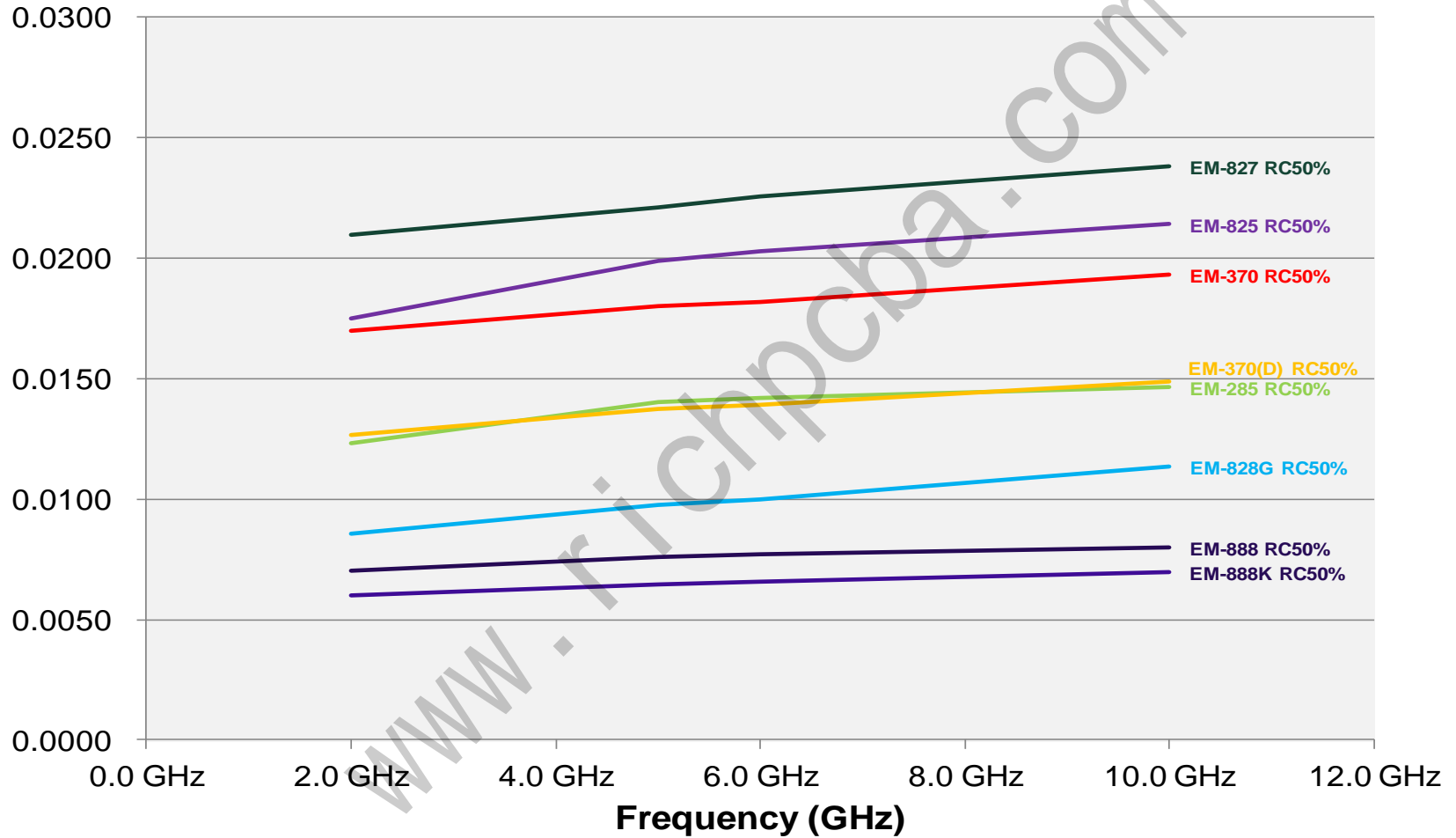
sample will be inserted into cavity



Electrical Test – (SPC RC50% Dk 2~10GHz)



Electrical Test – (SPC RC50% Df 2~10GHz)



Q&A

THANK YOU FOR YOUR ATTENTION.



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