Low Loss & Novel Halogen-Free Laminates for High Frequency Device Applications

Anderson Cheng, Henry H.Y. Chang, Chia-Yen Lin
ITEQ CORP.
22, Kung Yeh 1st Rd. Ping Chen Industrial Zone, Ping Chen, Taoyuan, Taiwan

Abstract

In this paper, ITEQ demonstrates outstanding performance of new halogen-free and low loss laminates, IT-258GA, IT-168G, and IT-150D, for the coming halogen free generation, and higher frequency applications. Especially, IT-258GA exhibits excellent thermal reliability, and very suitable for LCD, NB, consumer electronics. IT-168G is the pioneer product with halogen-free and low Dk/Df values,

Introduction

In the recent years, halogen-free is the main topic in electronic industry. More and more electronic products and applications are designed to meet halogen-free requirement. Indeed, it has a huge influence on the whole electronic industry chain, from upstream to downstream, especially for the PCB industry and laminate materials. Many efforts have been made by laminate vendors to improve the thermal reliability, electrical and physical properties of halogen-free laminates.

Another trend in laminate materials is the applications in high frequency and high speed products (> 10 GHz), especially in the communication devices, base station, server, etc. Although many laminates have been improved by different means, such as filler addition, resin system adjustment, the main application frequency is ranged from 3 GHz~5 GHz, especially for halogen-free materials. The Dk/Df value by Cavity method still stays around 4.3~4.7/0.010~0.015 (1GHz), which can not be applied in higher frequency products.

Most of the halogen-free laminates can only improve in the areas of thermal reliability, lower CTE value, lower water absorption and other physical properties. It is very hard to find halogen-free laminate solutions with lower Dk/Df value. We have developed new solutions for halogen-free with better electrical property, namely, IT-258GA, IT-168G, and IT-150D. The excellent properties are discussed in this paper in addition to some reliability tests that were also carried out.

Experimental Instruments

DSC Tg (TA, DSC Q10), TMA CTE/T288 (TA, TMA Q400), Anti-CAF tester (IMV, MIG 8600), Dk/Df tester (Cavity tester), IST tester (PWB Interconnect Solution Inc.), etc.

Characterizations

Laminate Properties

The basic properties of IT-258GA, IT-168G, IT-150D are summarized in Table 1. As we seen, IT-258GA meets halogen-free/lead-free/UL requirement, and exhibits very good thermal reliability. $\alpha 1/\alpha 2$ is about 40/200 ppm/°C, and can pass T260, T288 testing. IT-258GA is very suitable for LCD, NB, Mobile, consumer electronics applications. IT-150D has a Dk/Df value about 3.6/0.005. It is compatible to lead-free process, and also is UL approved.

It is designed for high-end server, high layer count applications. The water absorption is low (0.9 %), and suitable for high layer count PCB processes. IT-168G is the pioneer product combining lead free/halogen free/UL, and most of important, low Dk/Df value. Thermal properties, such as CTE, T260, T288, are also outstanding.

Table 1 Properties of various products

PRODUCTS		IT-258GA	IT-168G	IT-150D
Property	Method	Lead-free Halogen-free	Lead-free Halogen-free	Lead-free
Tg (℃)	DSC	151	153	165
Tg (℃)	DMA	165	168	180
CTE (%), 50-260℃	TMA	2.8	2.9	3.4
CTE (ppm/℃)	a1/a2	40/200	40/240	45/270
T-260 (min)	TMA	>60	>60	>60
T-288 (min)	TMA	>60	>60	40
Td-5%(℃)	TGA	370	380	350
Peeling (lb/in)	1 oz, A	8.0	7.0	6
Moisture Absorption(%)	D-24/23	0.12	0.12	0.09
Dk (HP4291B)	1GHz	4.7	3.9	3.6
Df (HP4291B)	1G Hz	0.015	0.005	0.005
Flammability	UL 94V	94V-0	94V-0	94V-0
Features		Thermal reliability	Low Dk/Df	Low Dk/Df
Applications		LCD, NB, Mobile	Middle-end, high-end server, base station, communication, smart phone	Communications, High-end server, Back-panel High layer count

Reliability Test Results

14 layer test coupon with 110 mil thickness were built for IST test. The testing condition was cycle by 30 ^{o}C→150 ^{o}C, until the change of electrical resistance > 10 %. The testing result is shown in Figure 1. Comparing to standard FR4 laminate, IT-168G and IT-258GA exhibit very reliable result. Both of them can pass more than 1,000 cycles testing. As a result, ITEQ halogen-free laminates have very excellent reliability by temperature cycling testing.

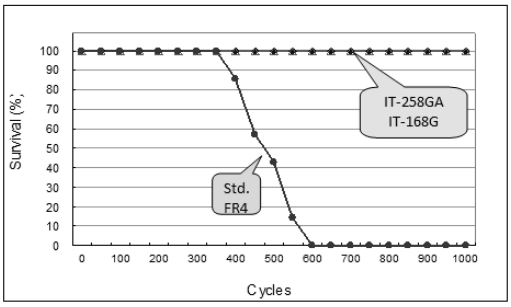

Figure 1 IST test result

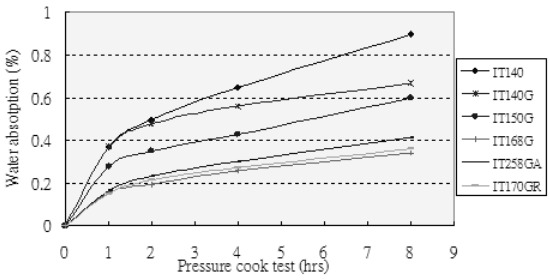

Figure 2 Water absorption testing result

Figure 2 shows the result for water absorption. Other products already in the market are compared to them, IT-168G, IT-258GA exhibit lower water absorption percentage. Water absorption is a key index for laminate property. Once the water absorption is too high, the laminate is un-stable, and less reliable in PCB manufacturing and the following SMT process. The new products, IT-168G, IT-258GA exhibit much improvement in the water absorption performance.

Solder Floating Test

Figure 3 shows the solder floating testing result. IT-150D test coupon was built with 18 layers, 2.4 mm in thickness. After Solder floating (6 cycles, 10 sec./cycle), no delamination can be found in IT-150D. It shows very stable thermal resistance, even stack up to 18 layers.

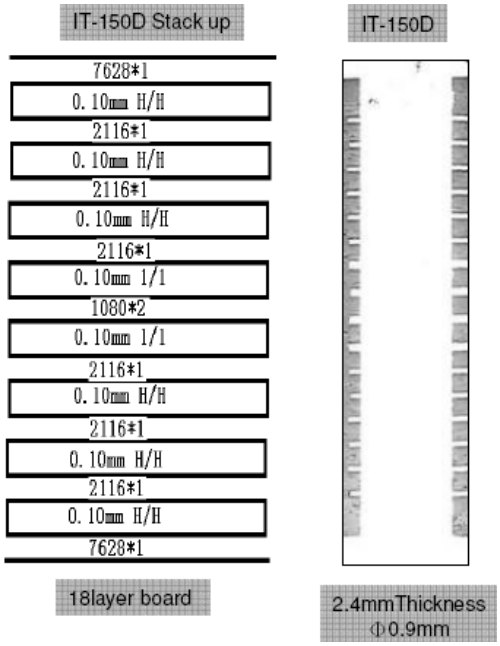

Figure 3 Solder floating test for IT-150D

Land Pull Test

Figure 4 shows the land pull test results. It is used to simulate drop test of cell phone. From the result, it can be found that, halogen free materials (IT-258GA, IT-168) exhibit reliable results. The values for them are much higher than the requirement (50 N/mm^2).

Land pull test SPEC>50N/mm^2	IT-258GA	IT-168G
Pad size 1.13mm	60~70	60~70

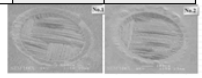

Figure 4 Land Pull Test results

Electrical Property

Figure 5 shows the electrical property (Dk/Df value by Cavity method) of various laminates. It can be found that, IT-150D exhibits very low Dk/Df value, compared to other products. IT-150D is very suitable for high end server, base station and other high frequency communications, high speed applications.

For IT-168G, Dk/Df value is higher than IT-150D, but still lower compared to other products. The advantage of IT-168G is the combination of halogen-free and low Dk/Df value.

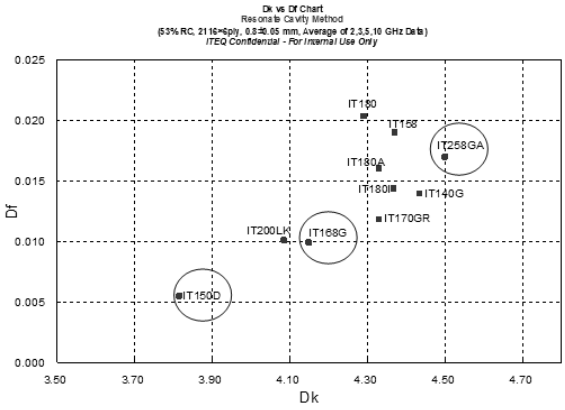

Figure 5 Dk/Df chart for products (by Cavity method).

Conclusion

1. Cavity method is the excellent way to extract Dk/Df value from materials.
2. IT-150D is very suitable for high frequency, high-end applications, owing to its outstanding Dk/Df value.
3. IT-258GA is designed for high thermal reliability applications, and also suitable for consumer electronic products.
4. IT-168G is the pioneer laminate with excellent Dk/Df and halogen-free.

ITEQ Low Loss & Halogen Free Materials

ITEQ
INNOVATION • TEAMWORK • EXCELLENCE • QUALITY

1. Halogen Free
   - IT-258GA, IT-168G
2. Low loss materials
   - IT-150D
3. Conclusion

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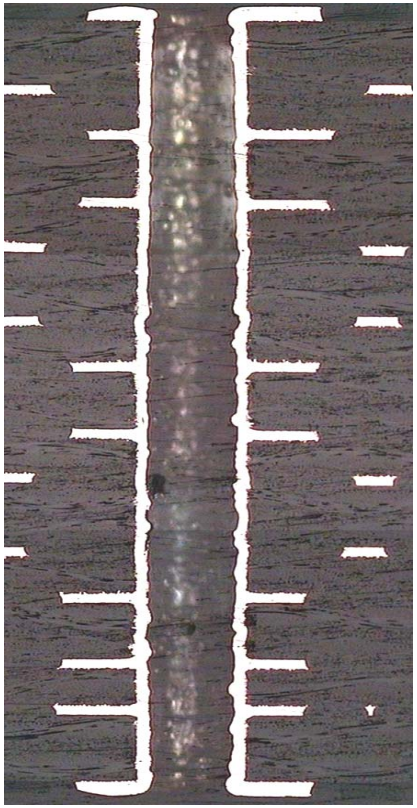
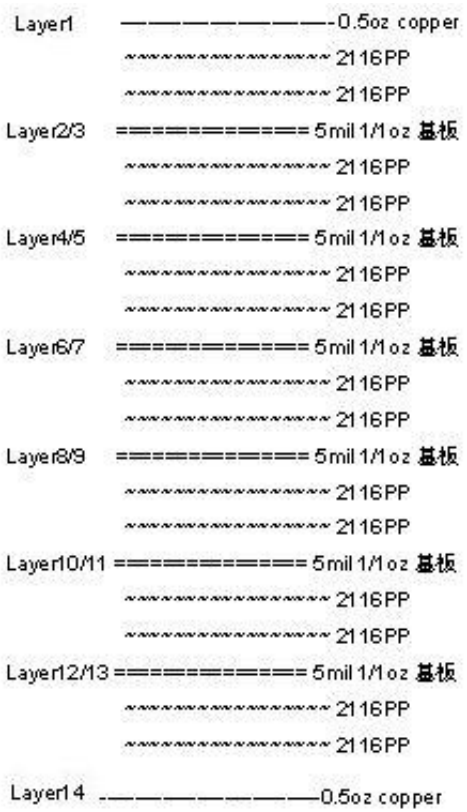
Comparison of Middle Tg HF Materials

PRODUCTS		IT258GA	IT168G
Property	Method	Halogen-free	Halogen-free
Tg (℃)	DSC	151	153
Tg (℃)	DMA	165	168
CTE (%), 50-260℃	TMA	2.8	2.9
CTE (ppm/℃)	a1/a2	40/200	40/240
T-260 (min)	TMA	>60	>60
T-288 (min)	TMA	>60	>60
Td-5%(℃)	TGA	370	380
Peeling (lb/in)	1 oz, A	8.0	7.0
Moisture Absorption(%)	D-24/23	0.12	0.12
Dk (HP4291B)	1GHz	4.7	3.9
Df (HP4291B)	1G Hz	0.015	0.005
Flammability	UL 94V	94V-0	94V-0
Features		Thermal reliability	Low Dk/Df
Applications		LCD, NB, consumer products	Middle-end, high-end server, base station, communication

Sample Stack up for IST and TCT





Coupon stack up

Materials:

FR4/IT140G/IT150G/IT170GR

Layer：14

Thickness：2.8mm

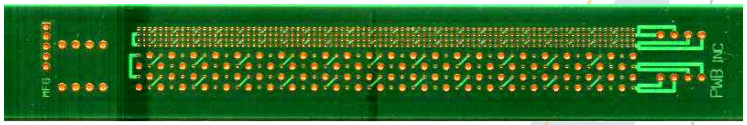
Coupon Size ：0.6” x 5.0“

Grid Spacing：0.04”

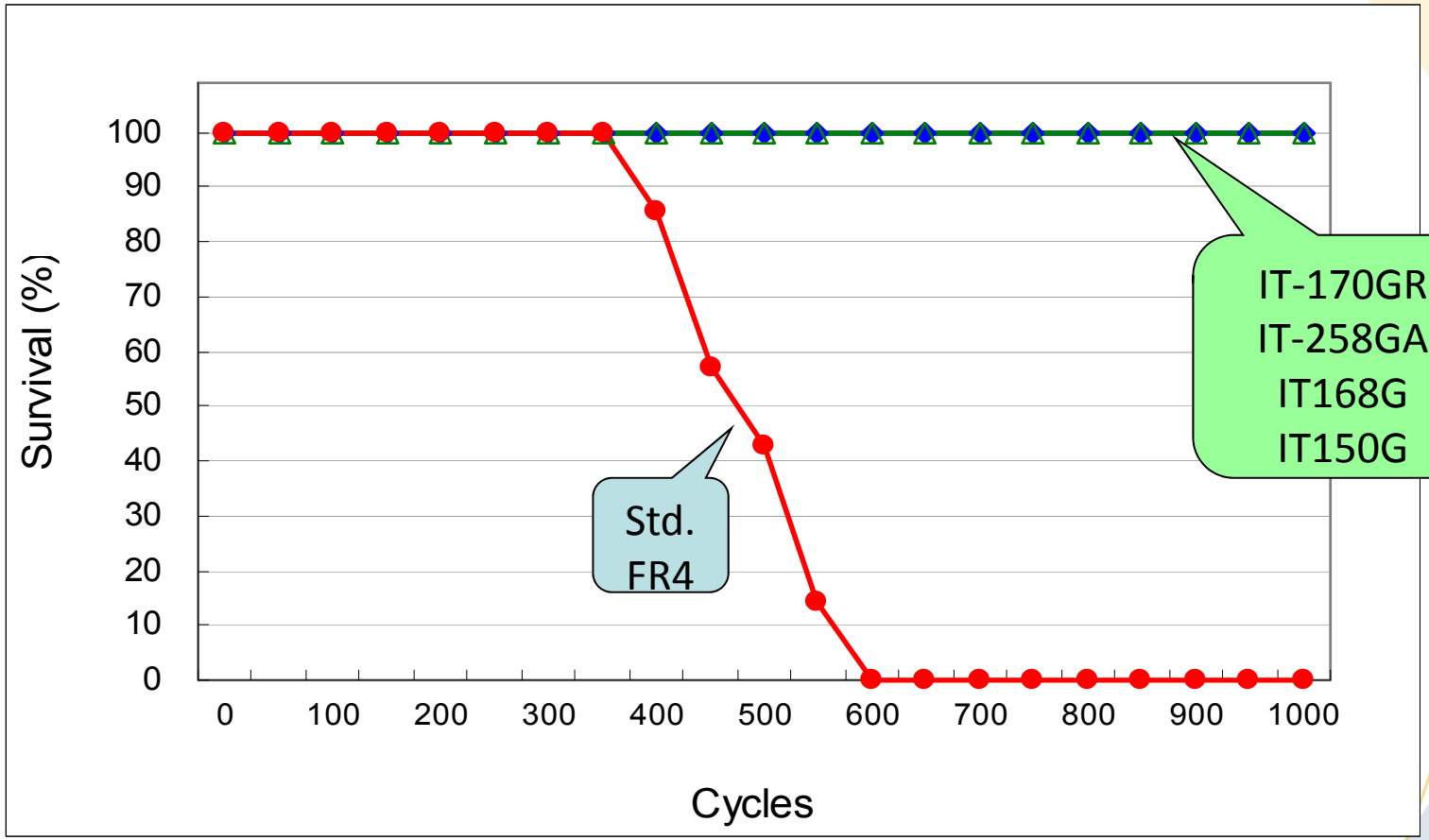
Hole/Pad：0.012” / 0.025”

Number of Holes：364

PTH Cu THK：1.2mil

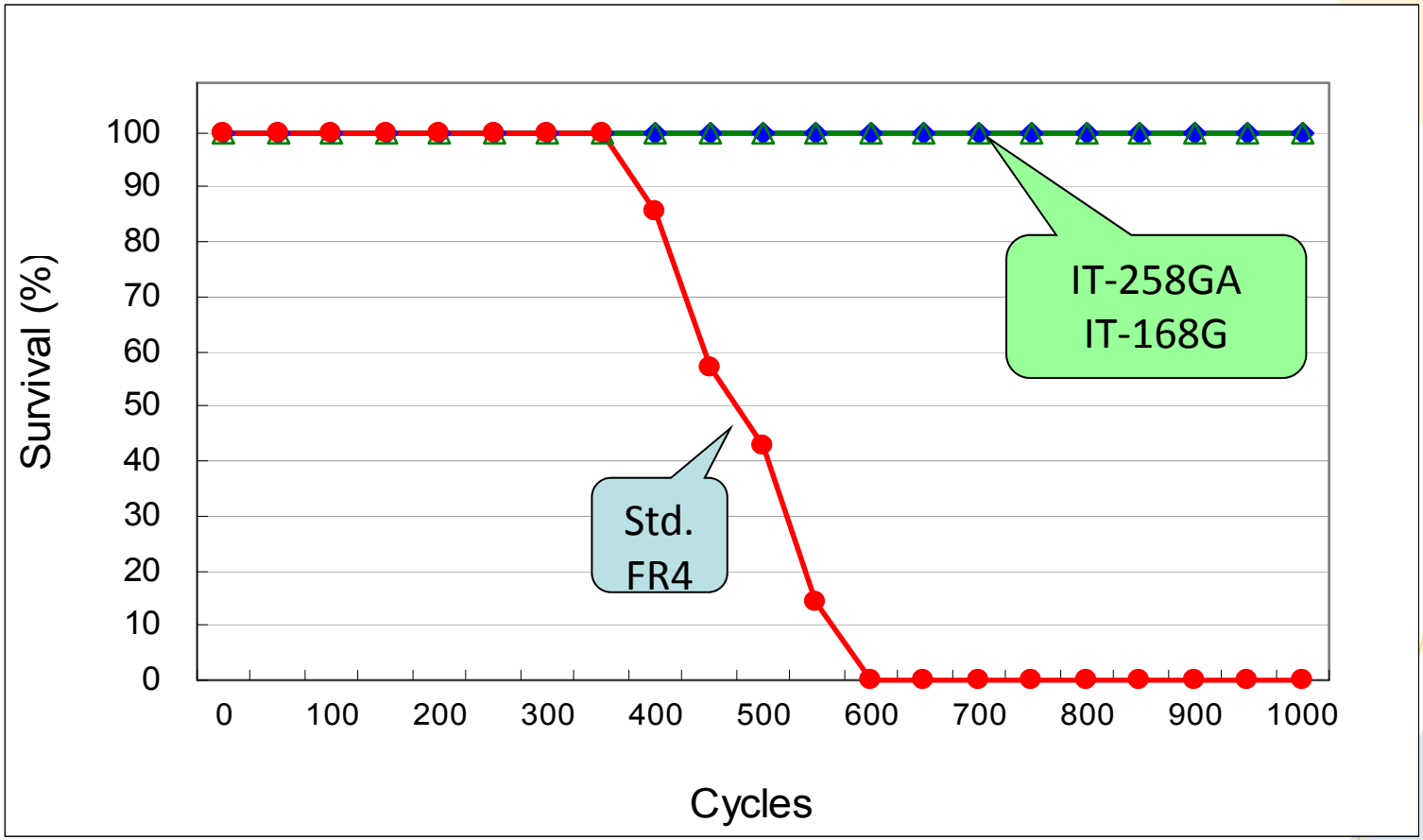


IST Test Result



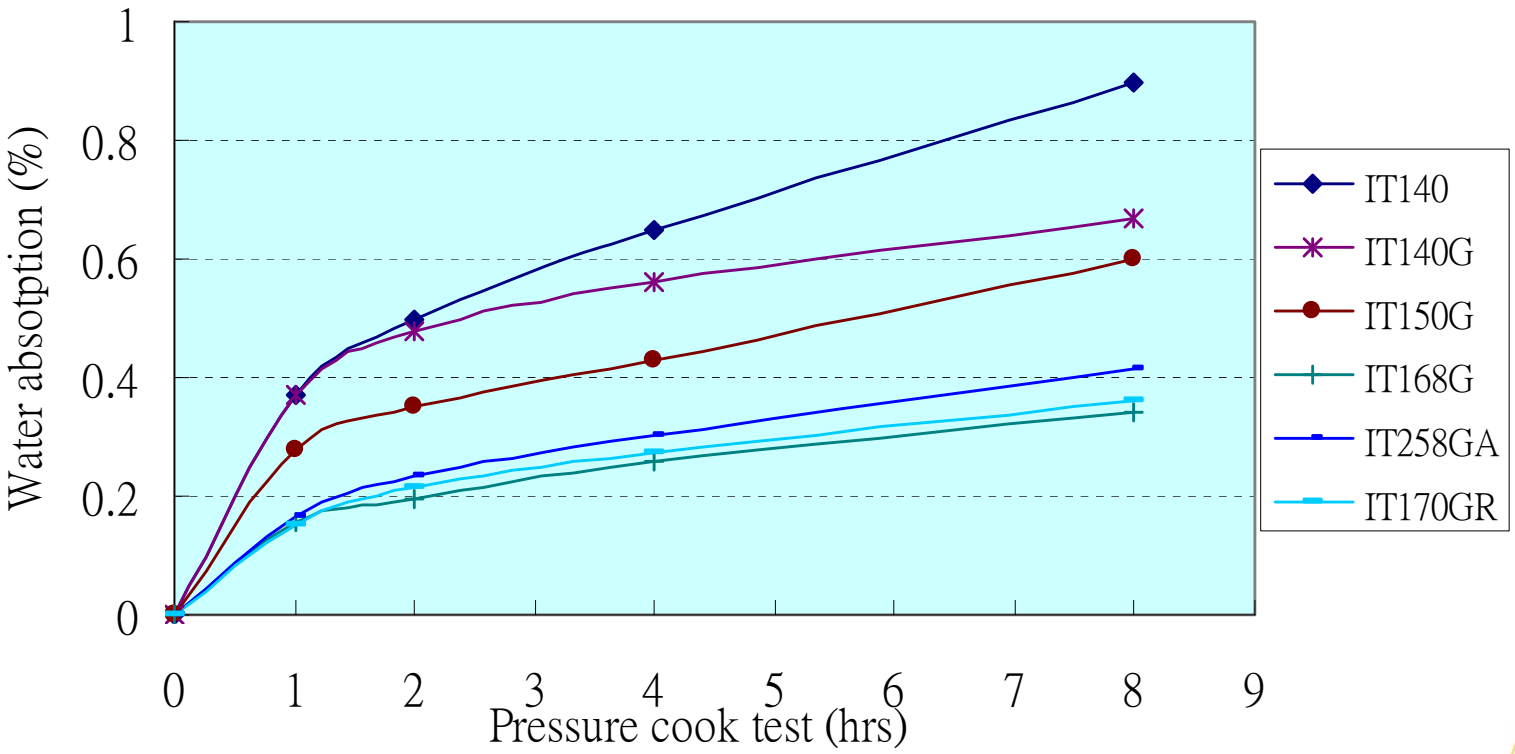
Test Coupon Thickness = 110mil, 14 Layers, as received
Hole/Pad：0.012”/0.025”, Pitch=0.040”, 364 holes
30℃←→150℃ thermal cycling test until the change of electrical resistance is over 10%.

TCT Test Results



Test Coupon Thickness = 110mil, 14 Layers, reflow 260x6
Hole/Pad：0.012”/0.025”, Pitch=0.040”, 364 holes
-55℃←→125℃ thermal cycling test until the change of electrical resistance is over 10%.

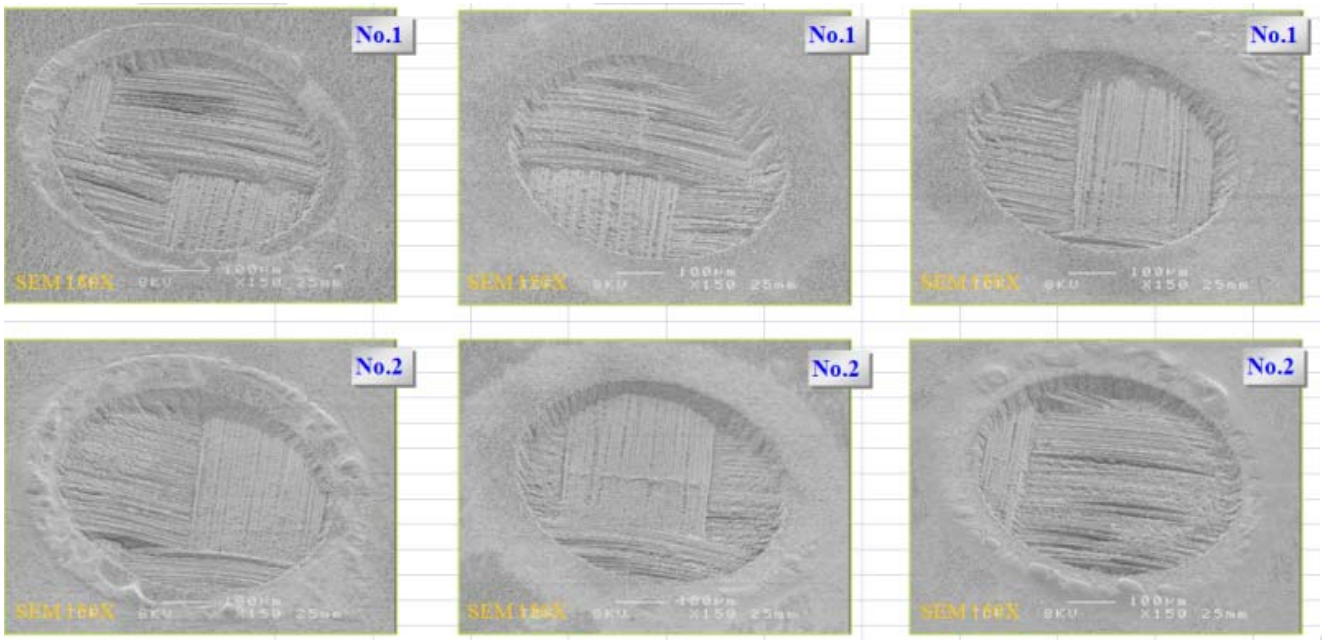
PCT Test Results



HF materials have lower moisture absorption than FR4 and IT-140.
IT-168G has lowest moisture absorption.

Land Pull Test

Land pull test SPEC >50N/mm2	IT140G	IT150G	IT258GA	IT168G	IT140
Pad size 1.13mm	55~60	60~70	60~70	55~65	70~75



All Pass!

Conclusion

1. ITEQ provides full-spectrum middle Tg HF materials.

2. IT-258GA provides low cost solution for NB/LCD/Consumer electronics.

3. IT-150G is characterized for easy drilling and punch processes.

4. IT-168G is developed by the requests of Dell and Intel, keeps the same Dk value as FR4, and lower Df value with good performance.

5. IT-168G is suitable for HDI process, and applied to halogen free high end smart phone.

6. Outstanding Dk/Df value of IT-168G has potential for the high end Server applications. It also needs OEM/PCB shops fully support.

7. IT-168G has very competitive advantages: low Dk/Df value, and almost the same price as regular halogen free materials.

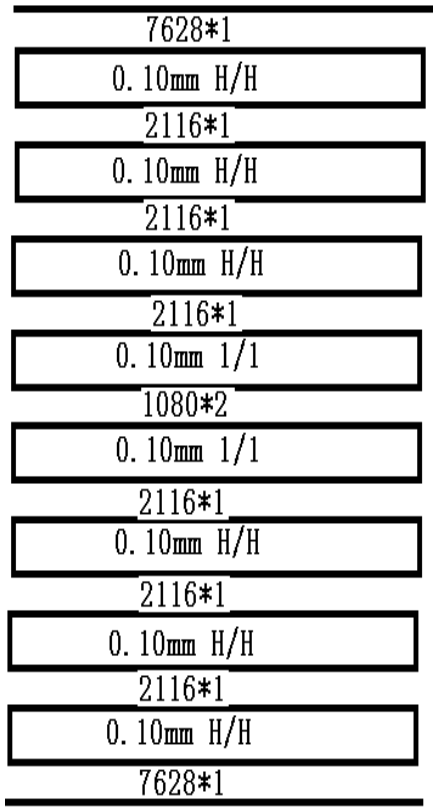
4. IT-150D
ITEQ Low Dk/Df Materials

Benchmark to same trade's relevance products

ITEQ Product	Relevance Product	Property	Product	G
IT-168G	FR-408HR N-4000-13EP	Low Dk/Df High thermal reliability Cost incentive	High-end Serve Back-plane Super computer	3~8G
IT-150D	Roger-4350B Megtron 4 Megtron 6	Very low Dk/Df Compatibility of PCB Process High thermal reliability Low moisture adsorption Cost incentive	High-end Serve Back-plane Super computer RF application Military	>6G

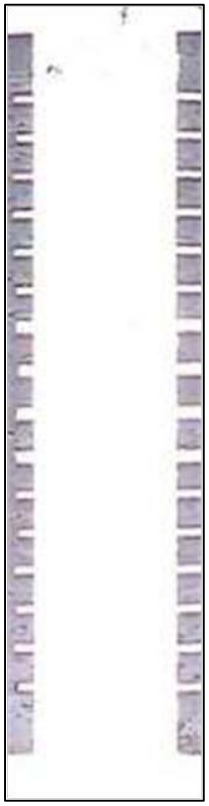
Solder floating test (Floating 6cycles<10sec/cycle>) (II)

IT-150D Stack up



18layer board

IT-150D



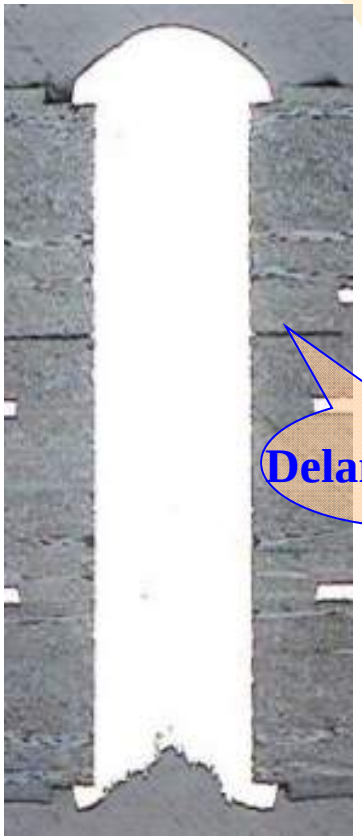
2.4mmThickness
Φ0.9mm

RO4350B Stack up

		1oz
Core	1080*6	
		1oz
PrePreg	106*1	
		1oz
Core	1080*2	
		1oz
PrePreg	106*2	
		1oz
Core	1080*2	
		1oz
PrePreg	106*1	
		1oz
Core	1080*6	
		1oz

8 layer board

RO4350B



2.4mmThickness
Φ0.9mm

No crack, recession, pad lift or delamination was observed for IT-150D after solder floating test. However, obvious delamination was observed for RO4350B.

Dk vs Df Chart

Resonate Cavity Method

(53% RC, 2116×6ply, 0.8±0.05 mm, Average of 2,3,5,10 GHz Data)

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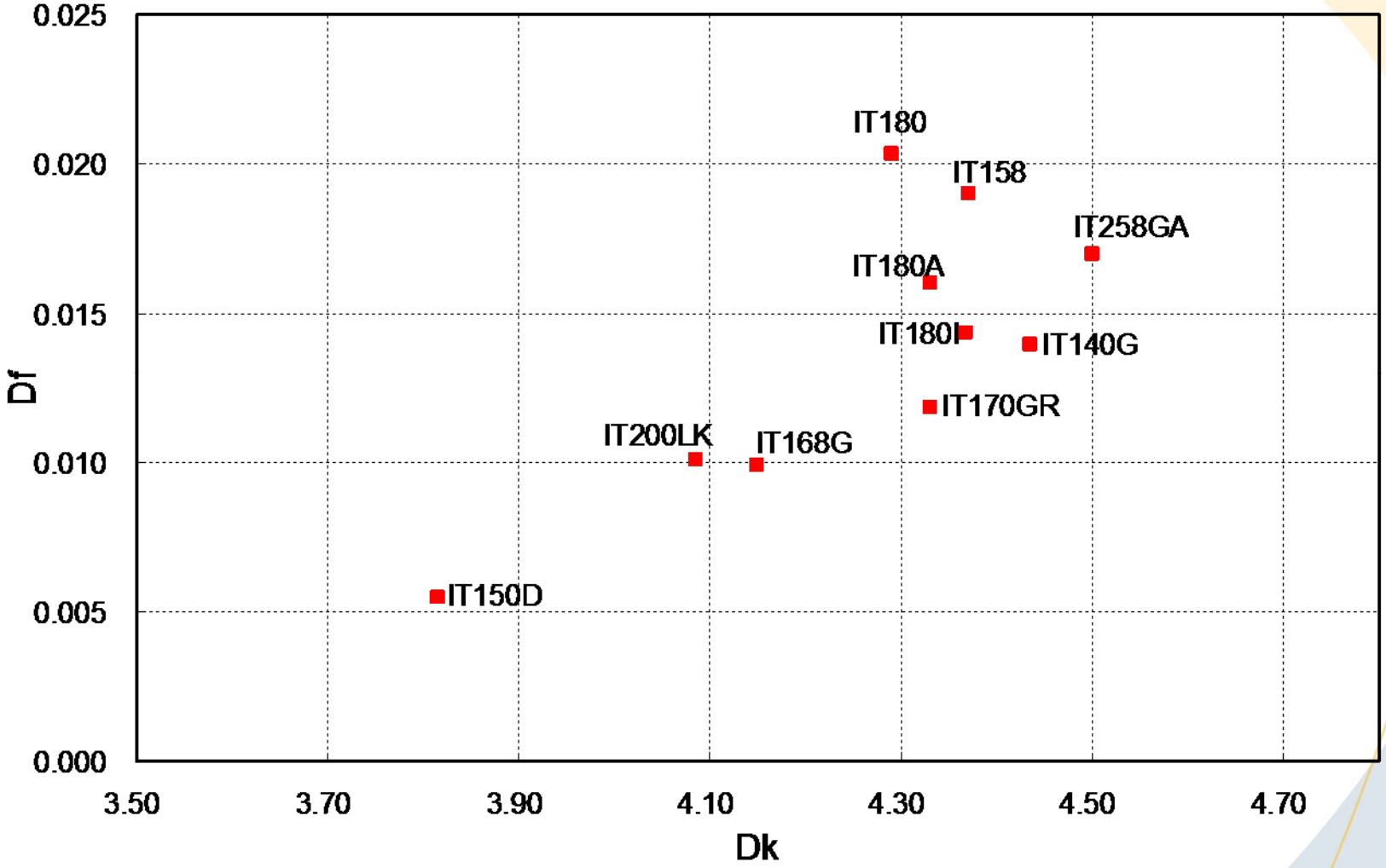

Conclusions

- IT-150D shows ultra low Dk/Df value, especially for ultra high frequency applications.
- IT-150D shows outstanding dielectric properties across the frequency range, and better thermal stability than traditional ultra low Dk materials.
- It is the only one ultra low Dk/Df material compatible with FR4-based PCB process condition. It is also suitable for high-layer count PCB without hybrid lamination with FR-4.
- It is the best Performance/Cost material for RF/Microwave applications.