POSTER #9

SWTest Conference

Wai Kit K Development & Design Division
Lincstech Co., Ltd.

UNDERSTANDING THE FACTORS FOR POWER SUPPLY CHARACTERISTICS (2ND STUDY)

Introduction

- During Our Previous Poster Presentation in SWTest Asia 2024, we concluded that the stability of power characteristics increases under the following conditions :
  - Designs : Close allocation of Power and Ground, wide & short pattern, without Anti-pad
  - Materials : High Dk insulation Material, Thick Copper Foil.
- In this presentation, we will follow up on our findings and further investigate how these conditions affect the power characteristics of a PWB(Printed Wiring Board). The controlled variable is as stated below :-

❖ **Web Width**

➢ The size of anti-pad is controlled in order to control the web width in between the anti-pad.

❖ **The Usage of Thinner Insulation Layer (50μm)**

➢ This is a follow up investigation of our previous paper regarding how thinner insulation layer affects the power characteristics.

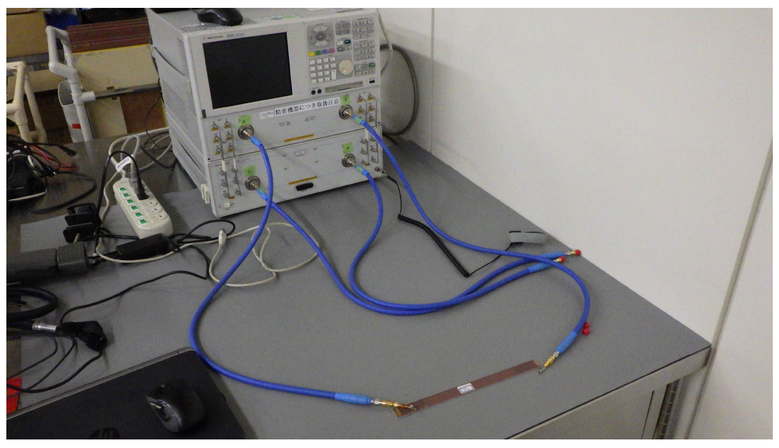
❖ **Patterns**

➢ Compare the effects of Anti-pad Number (In consideration of actual pattern.)

➢ Compare the effect of pattern width. (In consideration of actual pattern.)

➢ Compare the difference between 1x 2Oz pattern with 4 x 0.5Oz Pattern.(In consideration for ease of production.)

- **Materials and Methods**
  - As per our previous experiment, multiple different configuration of fabricated board was made and then measured using a Vector Network Analyzer(VNA)



Vector Network Analyzer (VNA)

Manufacturer : Keysight
Model : E8363B , N4420B
Measurement Range : 10MHz to 1GHz

- The Obtained data is then used to calculate the modulus impedance of the board using the equation below.

$$Z_{open} = \frac{1 + S_{11\,open}}{1 - S_{11\,open}} Z_{Line}$$

Impedance Equation for open condition

$$Z_{short} = \frac{1 + S_{11short}}{1 - S_{11short}} Z_{Line}$$

Impedance Equation for shorted condition

$$|Z| = \sqrt{|Zopen| \times |Zshort|}$$

Impedance Equation

- Below shows the different types of fabricated Boards used in this experiment.

The pattern V1 is repeated 4 times for Product 11

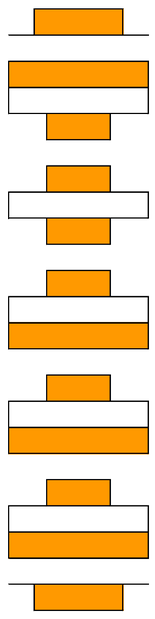
Material A Low Loss(Dk :3.6)	Product 7	Product 8	Product 9	Product 10	Product 11
0.5Oz Cu	X			X	X
2Oz Cu		X	X		
CCL Thickness	t0.05 CCL	t0.05 CCL	t0.1CCL	t0.1CCL	t0.1CCL

Power Plane patterns used in this experiment

The power plane pattern is divided as below

1) 250mm x 5mm (Without Anti-pad)
2) 250mm x 5mm (With Anti-pad)
3) 250mm x 20mm (Web width 50µm)
4) 250mm x 20mm (Web width 100µm)
5) 250mm x 20mm (Web width 160µm)
6) 250mm x 20mm (Web width 200µm)
7) 250mm x 20mm (Web width 260µm)
8) 250mm x 20mm (Web width 300µm)

Stackup used and their corresponding thickness



Name	Product 7 (PD7) Material Thickness	Product 7 (PD7) Copper Foil	Product 8 (PD8) Material Thickness	Product 8 (PD8) Copper Foil	Product 9 (PD9) Material Thickness	Product 9 (PD9) Copper Foil	Product 10 (PD10) Material Thickness	Product 10 (PD10) Copper Foil	Product 11 (PD11) Material Thickness	Product 11 (PD11) Copper Foil
L01 TOP		0.056		0.056		0.056		0.056		0.056
	0.102		0.095		0.094		0.102		0.102	
L02 GND		0.015		0.065		0.065		0.015		0.015
	0.050		0.050		0.100		0.100		0.100	
L03 VCC1		0.015		0.065		0.065		0.015		0.015
	0.101		0.092		0.091		0.101		0.101	
L04 VCC2		0.015		0.065		0.065		0.015		0.015
	0.050		0.050		0.100		0.100		0.100	
L05 VCC3		0.015		0.065		0.065		0.015		0.015
	0.101		0.092		0.091		0.101		0.101	
L06 VCC4		0.015		0.065		0.065		0.015		0.015
	0.050		0.050		0.100		0.100		0.100	
L07 GND		0.015		0.065		0.065		0.015		0.015
	0.100		0.089		0.088		0.100		0.100	
L08 VCC5		0.015		0.065		0.065		0.015		0.015
	0.050		0.050		0.100		0.100		0.100	
L09 GND		0.015		0.065		0.065		0.015		0.015
	0.100		0.089		0.088		0.100		0.100	
L10 VCC6		0.015		0.065		0.065		0.015		0.015
	0.050		0.050		0.100		0.100		0.100	
L11 GND		0.015		0.065		0.065		0.015		0.015
	0.102		0.095		0.094		0.102		0.102	
L12 BOTTOM		0.056		0.056		0.056		0.056		0.056
	0.856	0.262	0.802	0.762	1.046	0.762	1.106	0.262	1.106	0.262
Total Thickness	1.118		1.564		1.808		1.368		1.368	
Specification	1.1+/-	0.150	1.5+/-	0.150	1.8+/-	0.150	1.3+/-	0.150	1.3+/-	0.150

- To the left is the stackup used in this experiment, along with the thickness used for each layer
- Layer 3 is used as base for measurement
  - L03 VCC1
    (Close ground reference, one side)
- Product 11 has 4 x 0.5Oz VCC1 layers which is used to compare its difference with 1x 2Oz VCC1 layer.

- **Results (Layer assignment and Pattern factors)**

  In order to identify the influence of each factor, the results of the experiment were compared focusing on anti-resonance amplitude and frequency.

1) The effects of Anti-pad / Web Width (WW)

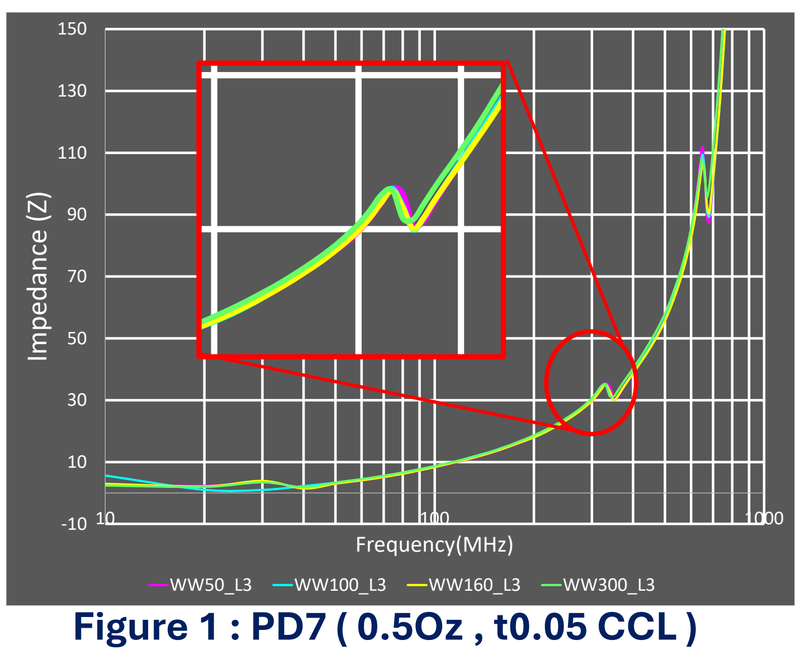


Figure 1 : PD7 (0.5Oz , t0.05 CCL)

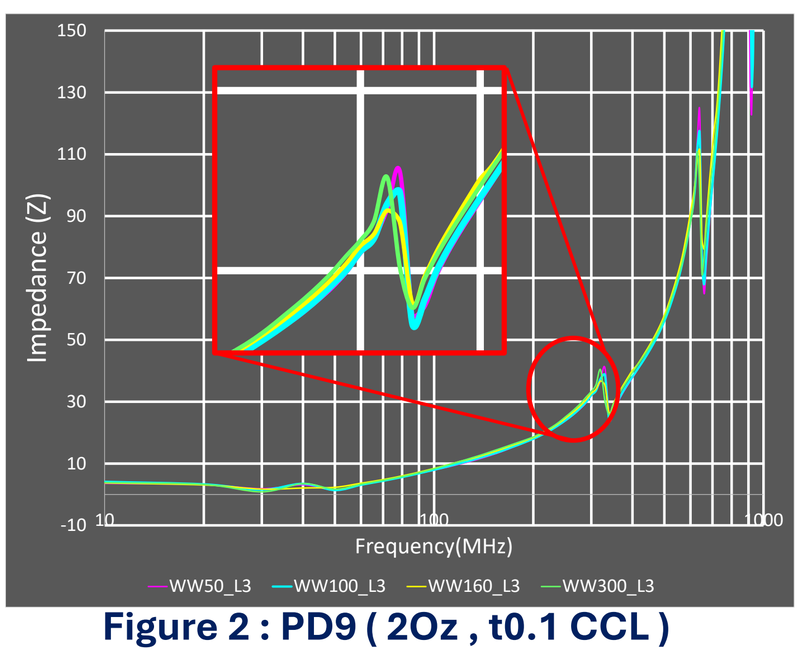


Figure 2 : PD9 (2Oz , t0.1 CCL)

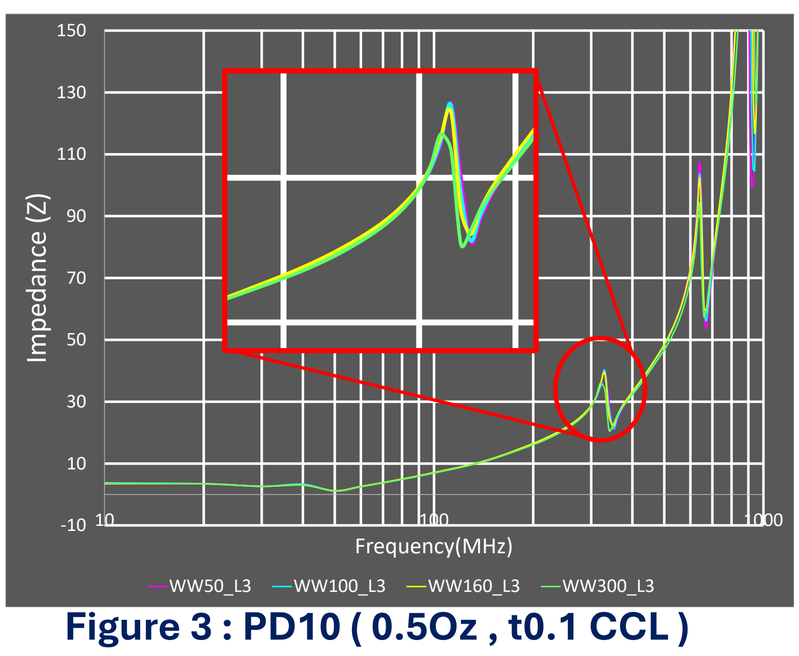


Figure 3 : PD10 (0.5Oz , t0.1 CCL)

- From the data obtained, there is a slight increase in impedance when a narrow web width design is used for t0.1CCL, while the effect of web width is less prominent when t0.05CCL is used.

  [Wider Web Width : Better during thick insulation layer, but has little to no effect during thin insulation layer]

- From the results the effects of thin insulation layer far outweighs the effects of Web width **[Thin insulation layer : Better]**

2) Anti-pad Number

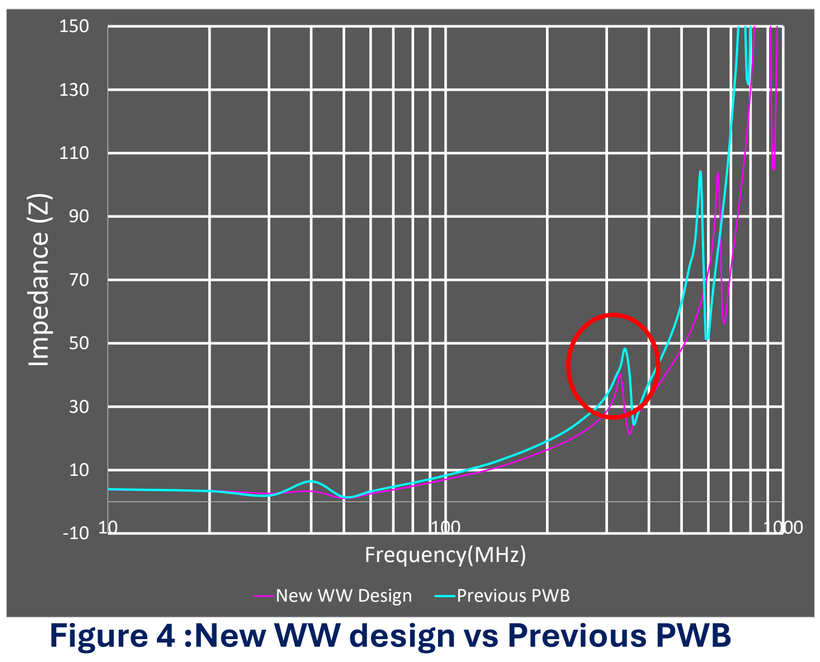
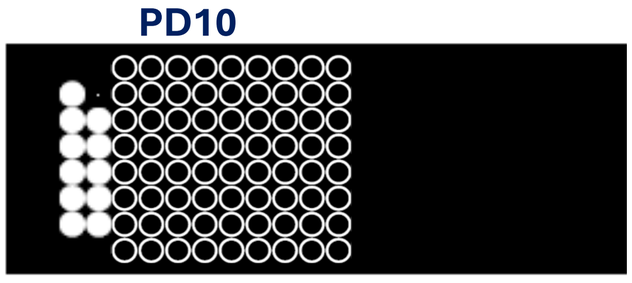


Figure 4 :New WW design vs Previous PWB

PD10



Previous PWB

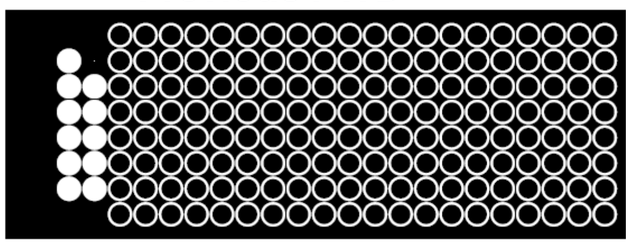


Figure 5 :Comparison on number of Anti-Pads

Anti-pad Number

The new pattern having less anti-pad shows a lower anti-resonance when compared to the PWB made previously

New Design : 9 Column of anti-pad on each side

Previous PWB : 20 column of anti-pad on each side

[Less Anti-pad : Better]

3) The effects of Pattern Width

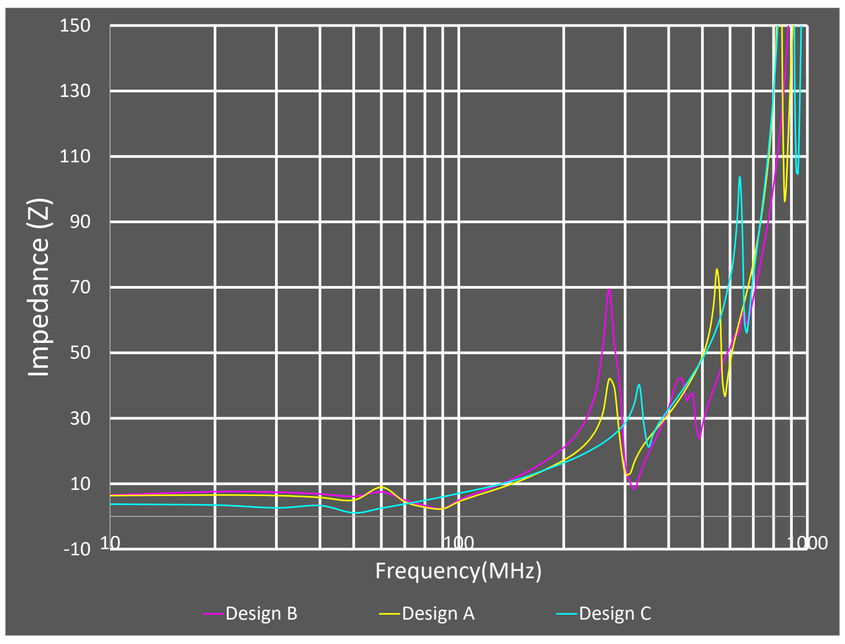


Figure 6 : Effects Plane width

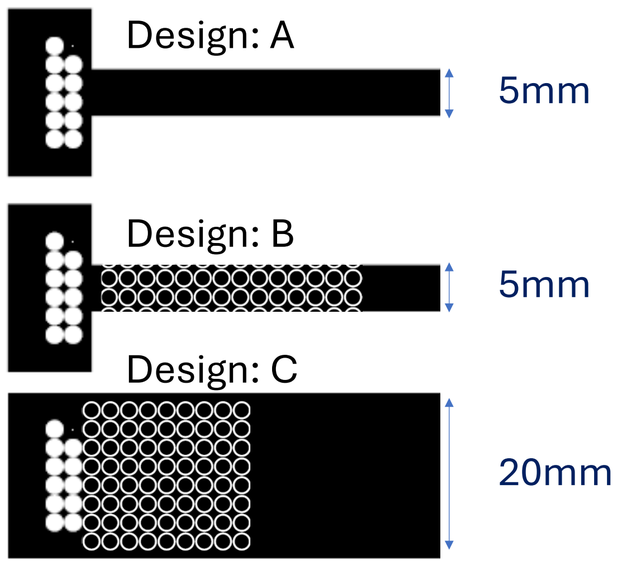


Figure 7 : Difference in plane width

From the graph, the pattern with a narrow width reaches its peak anti-resonance at a lower frequency when compared to its wider counterpart. Other than that, when Anti-pad is present in a narrow width pattern, the peak resonance is also higher.

[Wider Plane Pattern : Better]

4) 1 x 2Oz vs 4 x 0.5Oz

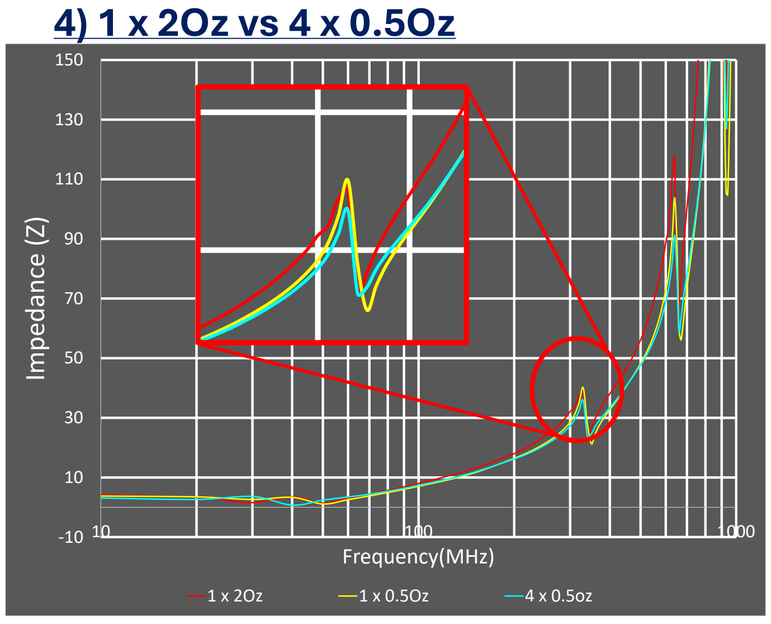


Figure 8 : One side has close reference to Ground (t0.1CCL,WW100)

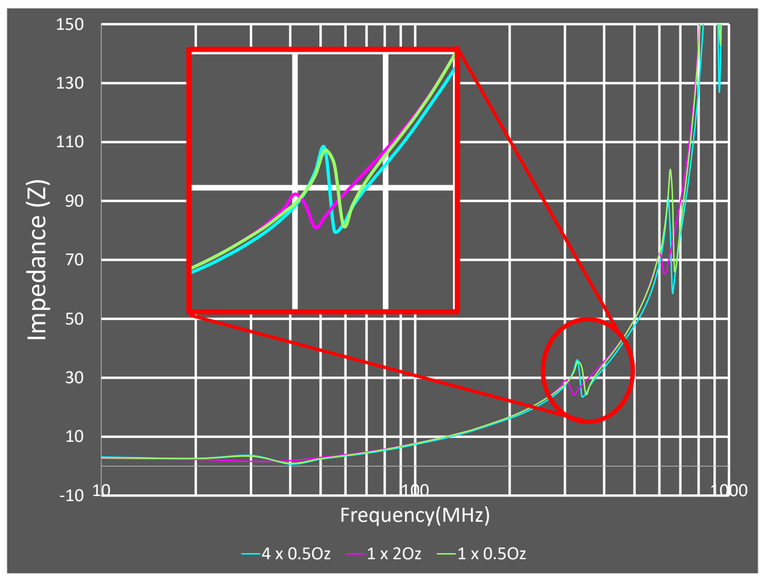


Figure 9 : Both side has close reference to Ground

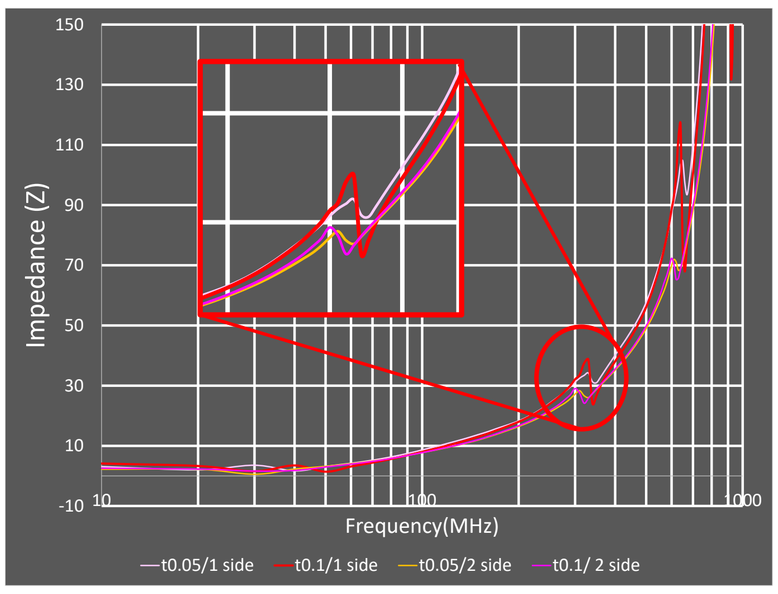


Figure 10 : Comparison between 0.05CCL and 0.1CCL in a 2Oz stackup.

- One sided ground reference : **[4 x 0.5Oz > 1x 2Oz > 1 x 0.5Oz]**
- Double sided ground reference : **[1x 2Oz > 4 x 0.5Oz = 1 x 0.5Oz]**
- Effects of CCL thickness in 2Oz stackup : **[Difference is minimal]**

Depending on the stackup configuration, 4 x 0.5Oz can be comparable to 1 x 2Oz. From the graph, there is a comparable difference between one sided ground reference and both sided ground reference. We theorize that this is due to serious resin starvation of the prepreg layer for 2Oz. As shown in figure 10, 0.1CCL stackup is as good as 0.05CCL for 2Oz.

In order to do a more accurate comparison, an additional evaluation will be needed with using a similar prepreg thickness.

*** Remark :**

As shown in Figure 11 & 12, the resin starvation will negatively impact the heat resistance and insulation properties of the PWB, hence a higher resin content prepreg must be used for 2Oz Copper application.

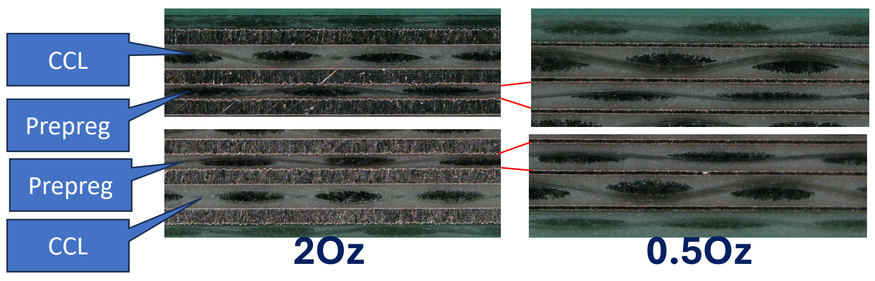


Figure 11 : Cross section image

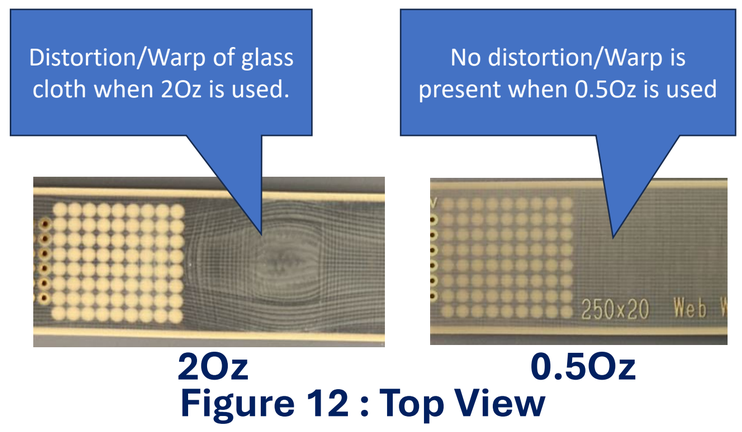


Figure 12 : Top View

Conclusion

The experimental results shows the stability of power characteristics increases under the following conditions :

- Designs : Avoiding densely congested anti-pad area on a power route.
- Materials : Thinner insulation layer (50μm) is more stable when compared to 100μm insulation layer.
- Patterns : Having a wider plane pattern.

From this experiment, we now have a better understanding on the conditions on how to make a better PWB.

Follow up Works

- Additional evaluation for 4 x 0.5Oz vs 1 x 2Oz using similar prepreg thickness.

Questions ?

If you have any questions, please contact

K Wai Kit	Kato Masahiro	Yamaguchi Hiroyuki
Author	**Co-Author**	**Co-Author**
k.waikit.yf@lincstech.com	katoh.masahiro.ut@lincstech.com	yamaguchi.hiroyuki.pf@lincstech.com