QFN Voiding Control Via Solder Mask Patterning On Thermal Pad

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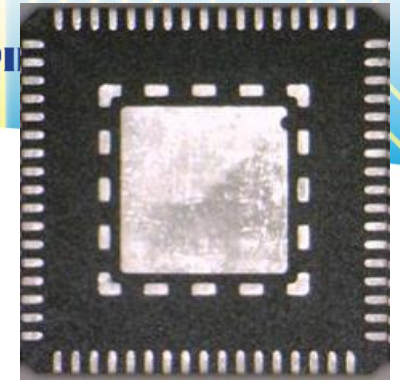
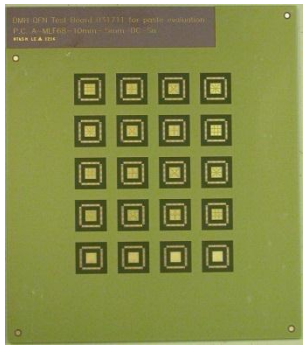
Introduction

- Voiding of QFN a concern due to large thermal pad, low standoff, and many thermal via
- Divided thermal pad preferred, with SMD better than NSMD
- This work focus on systematic study on effect of SMD divided pad on voiding

Experimental



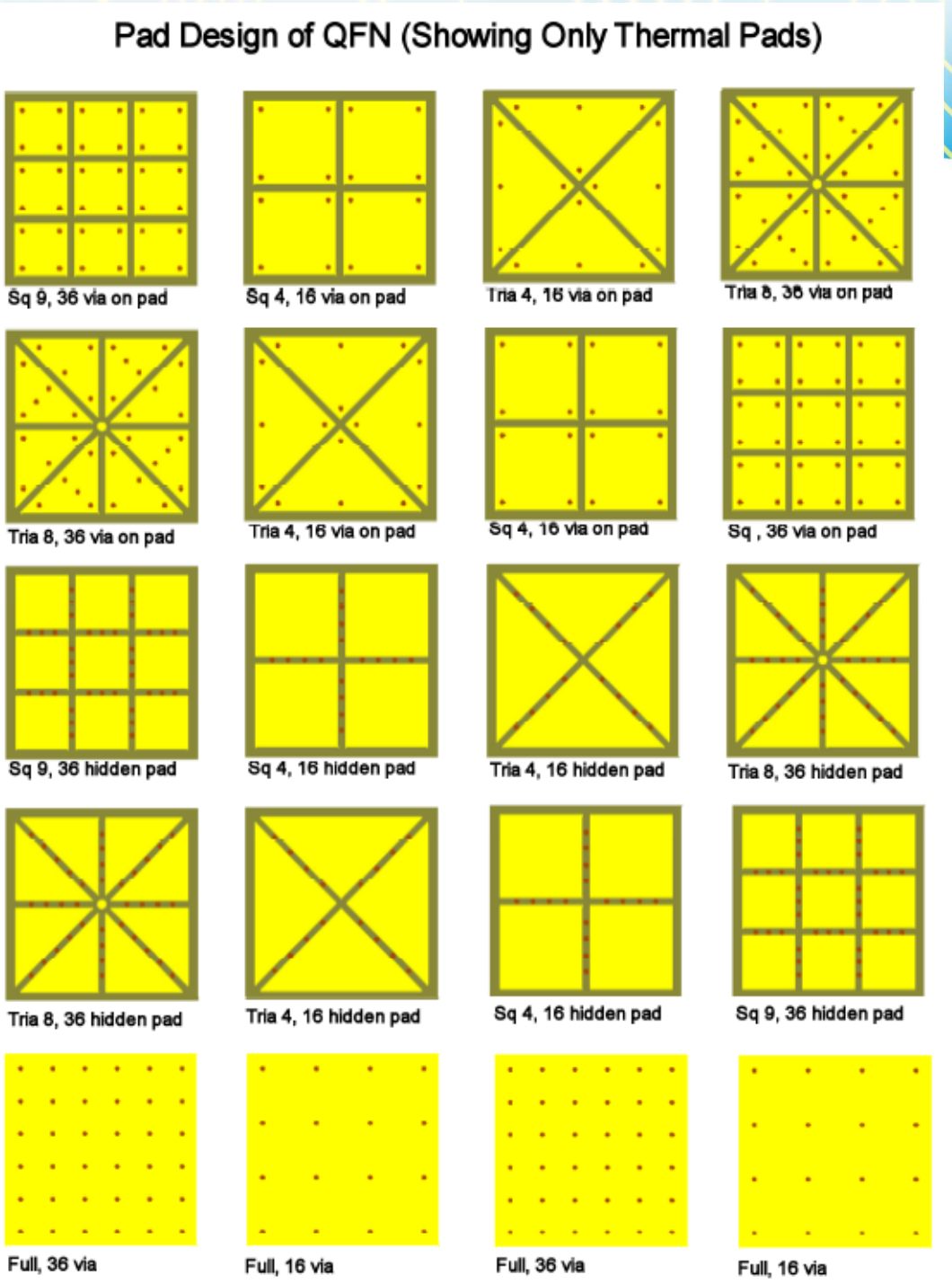
- QFN
  - A-MLF68-10mm-0.5mm-DC-Sn was used with 68 peripheral pads, 10 mm long on each side, 0.5mm pitch, daisy-chained, with a Sn surface finish
- Test Board
  - Board thickness: 1.61 mm
  - Cu pad thickness: 0.05 mm
  - Surface finish: NiAu
  - Microvia dimension: 0.1 mm width, 0.1 mm depth
  - Solder mask: wet film, 0.05 mm thickness



Experimental

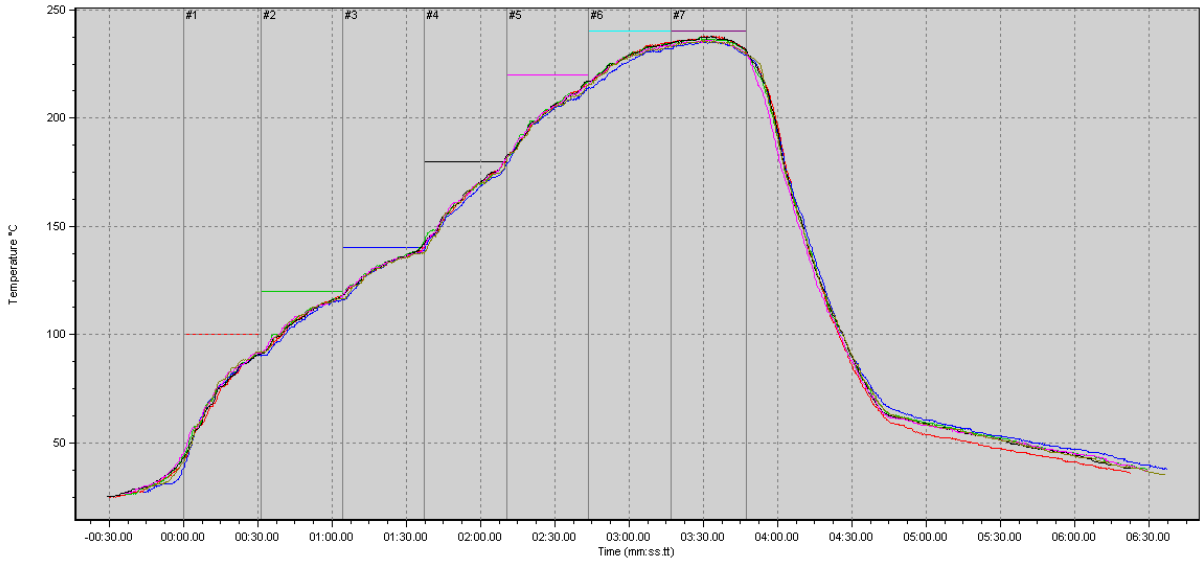
Thermal Pad Design

Parameter	Sub parameter	Layers
Thermal Pad on PCB	Thermal via number	16, 36
	Thermal subpad shape	Square, triangle
	Thermal subpad number	1, 4, 8, 9
Stencil (125 µ)	Aperture versus pad area	50%, 73%, 96%



Experimental

- Solder Paste
  - No-clean, 88.5% SAC305, T4
  - Stencil 125 micron thickness
  - BTU oven with air atmosphere
- Reflow Profile



Experimental

Characterization:

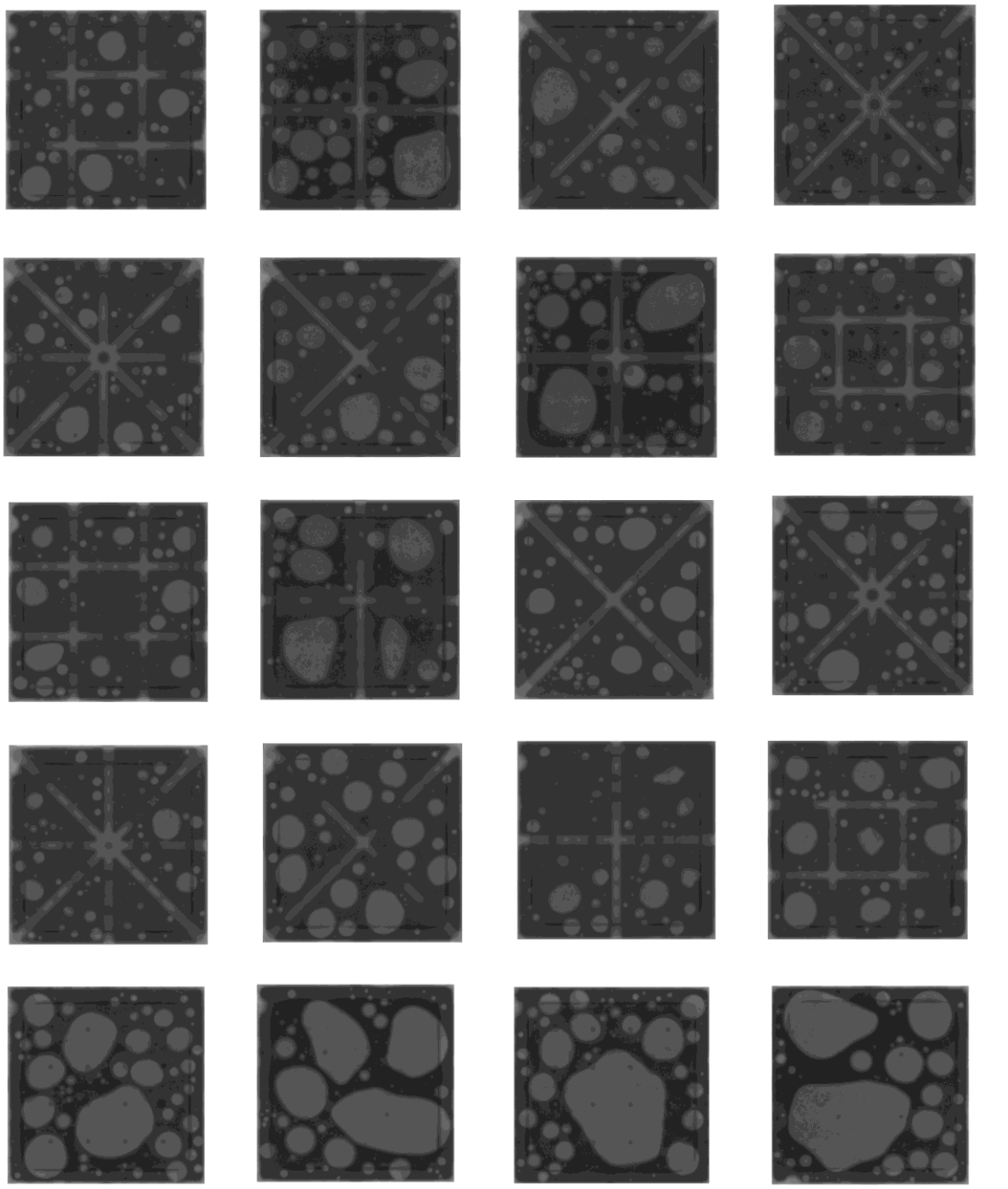
- X-ray
- Cross-sectioning

Definition of three voiding properties

Property	Definition
Discontinuity	% of area under the QFN thermal pad where the vertical metal continuity from QFN to PCB surface is interrupted
Void Average	Average of multiple QFNs for void area % within the metallic pad of QFN
Largest Void	The largest void measured for a category of QFN joints

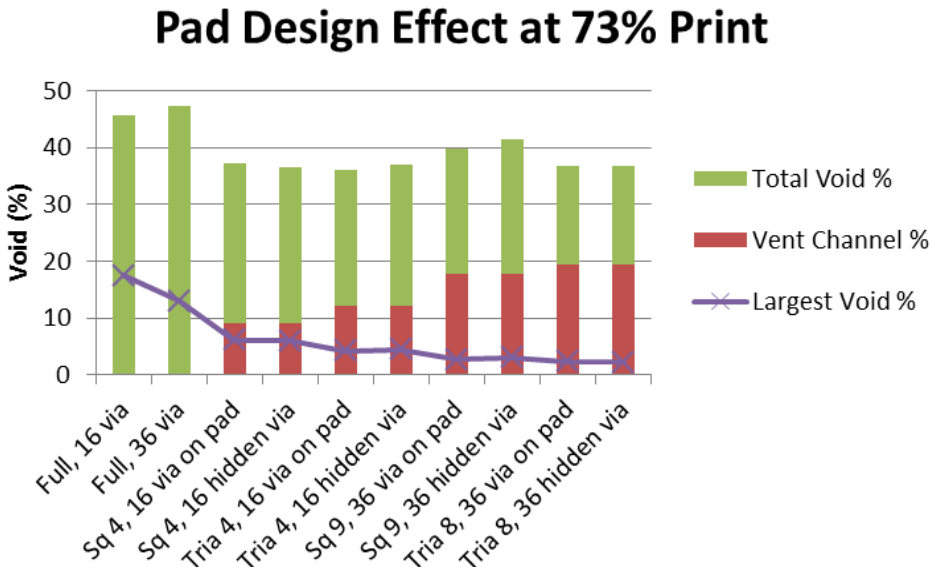
X-ray Image of QFN Solder Joints

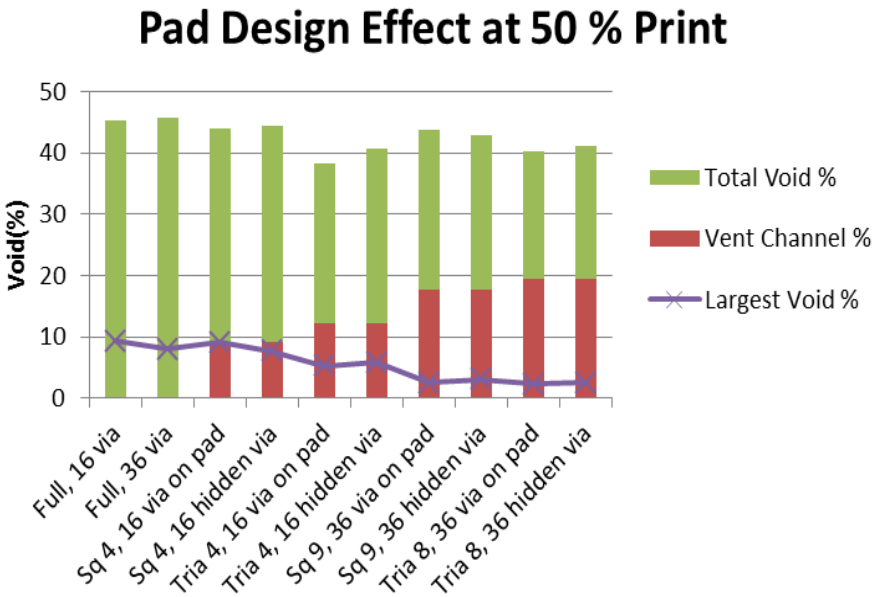
- 96% paste printed

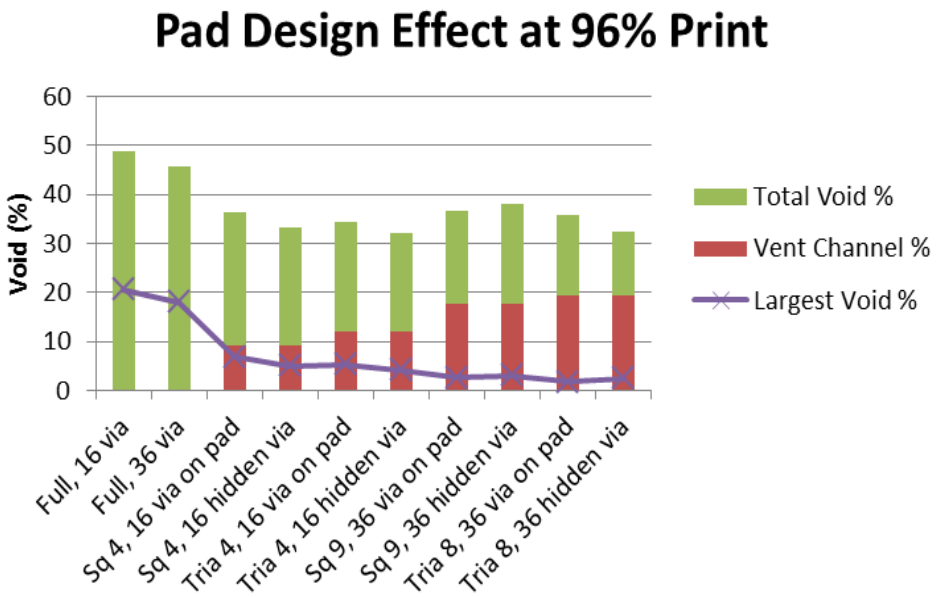


Results

- Divided pads lower in total void & discontinuity than full pad

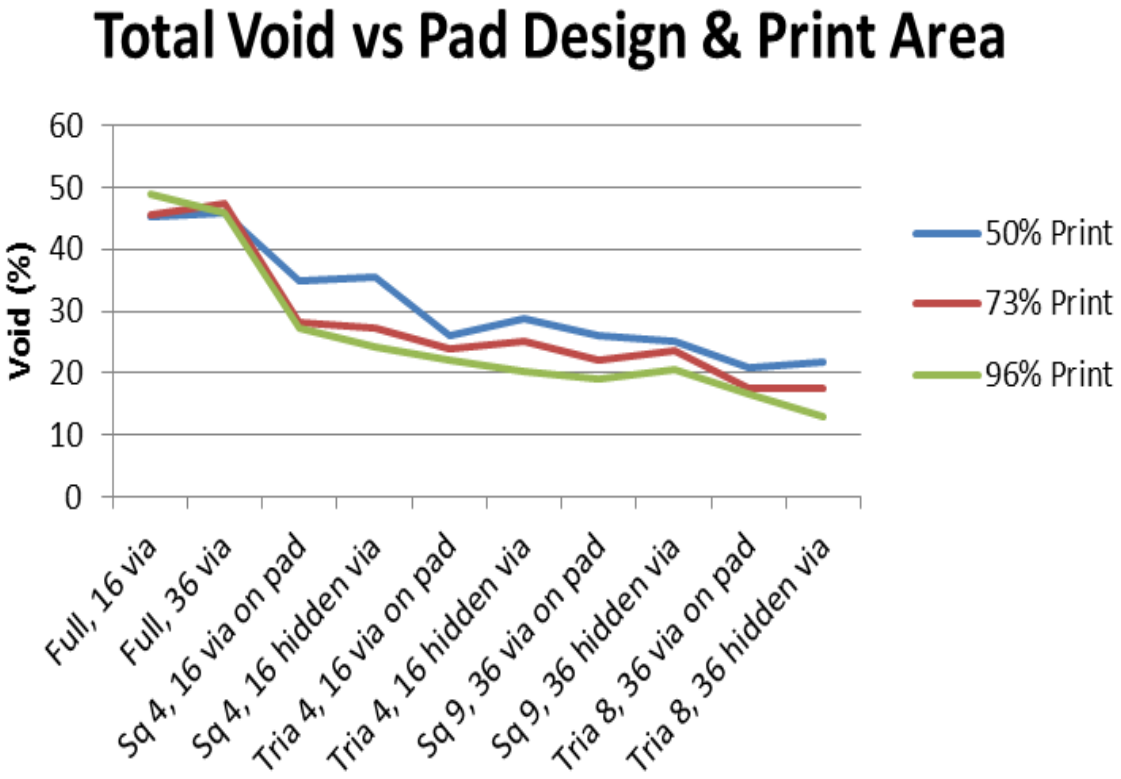






Effect of Pad Division

- The more the division number, the lower the voiding is.
- Voiding increases moderately with decreasing print coverage.

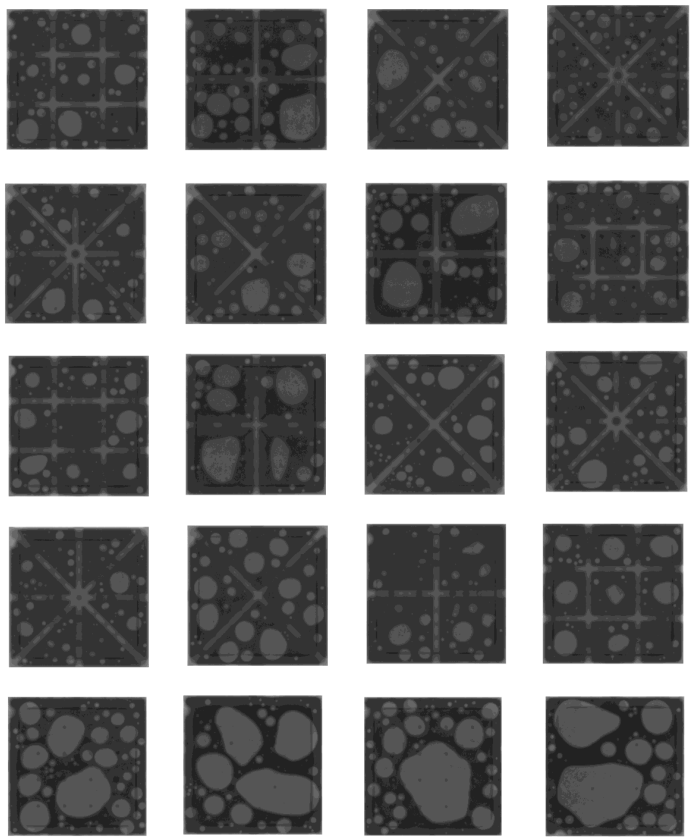


Print Coverage Effect

- The higher voiding associated with smaller print coverage is attributed to insufficient solder.
- The venting channels is very much free of solder at 50% print coverage. This insufficiency in solder volume inevitably resulted in more voiding.

X-Ray Images of QFN Solder Joints at Various Thermal Pads

90%



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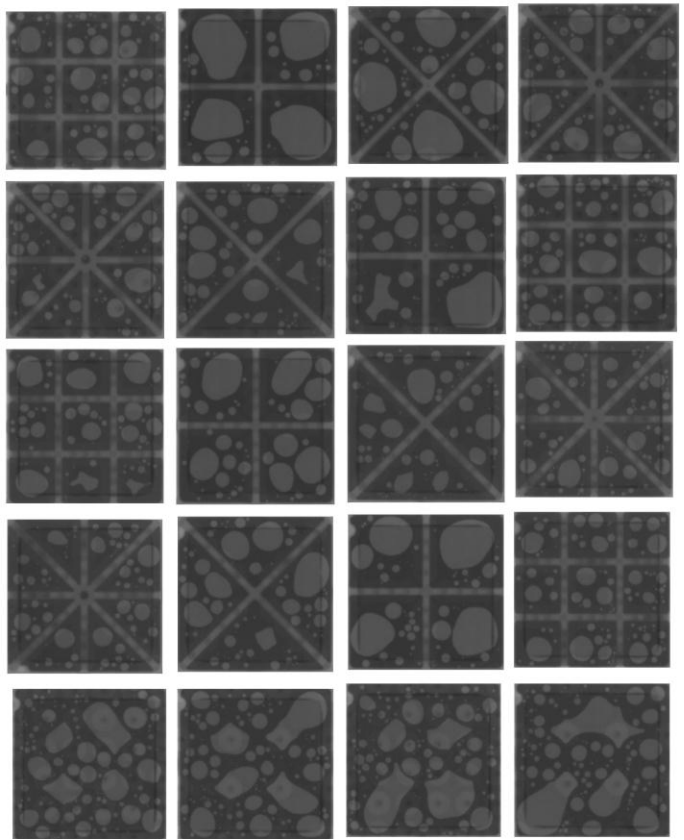
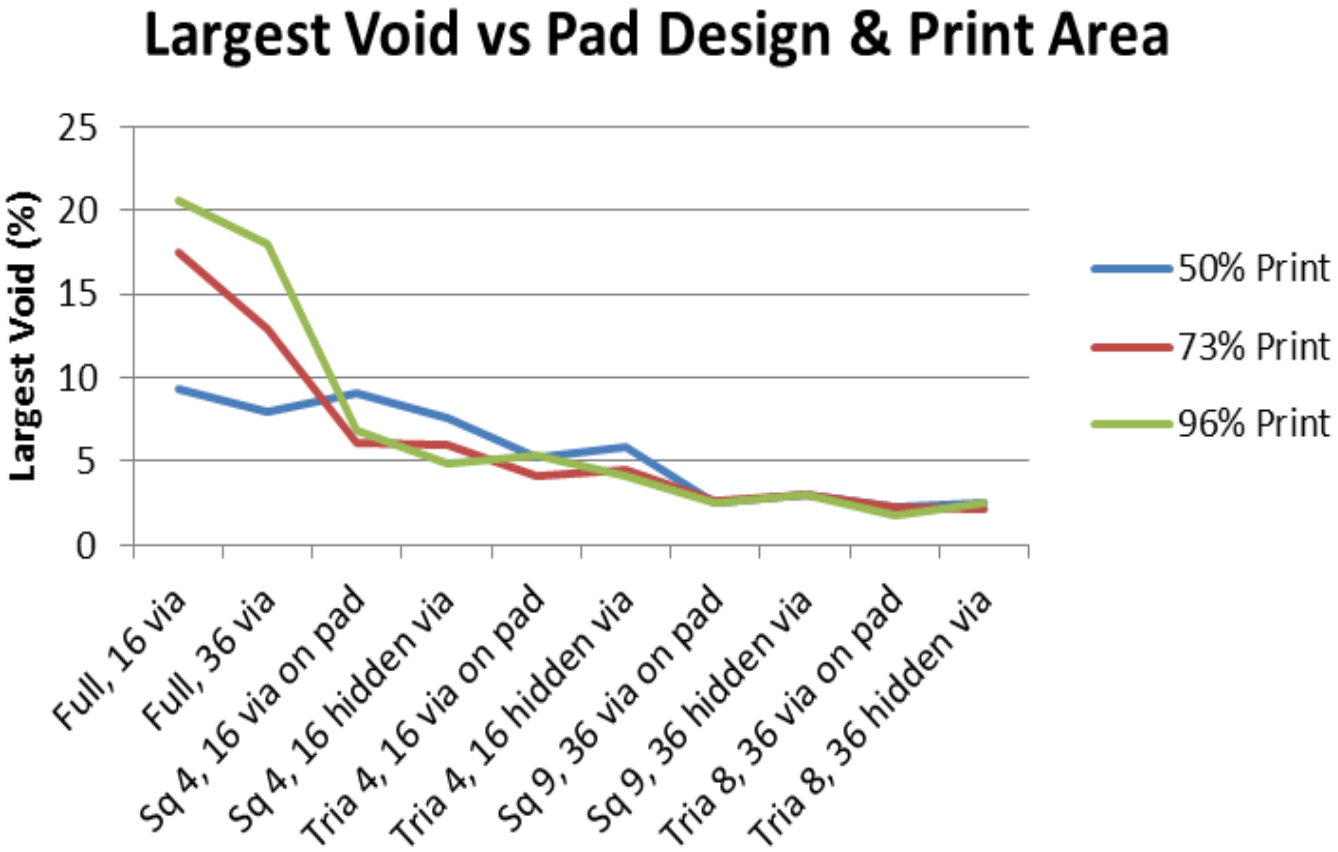


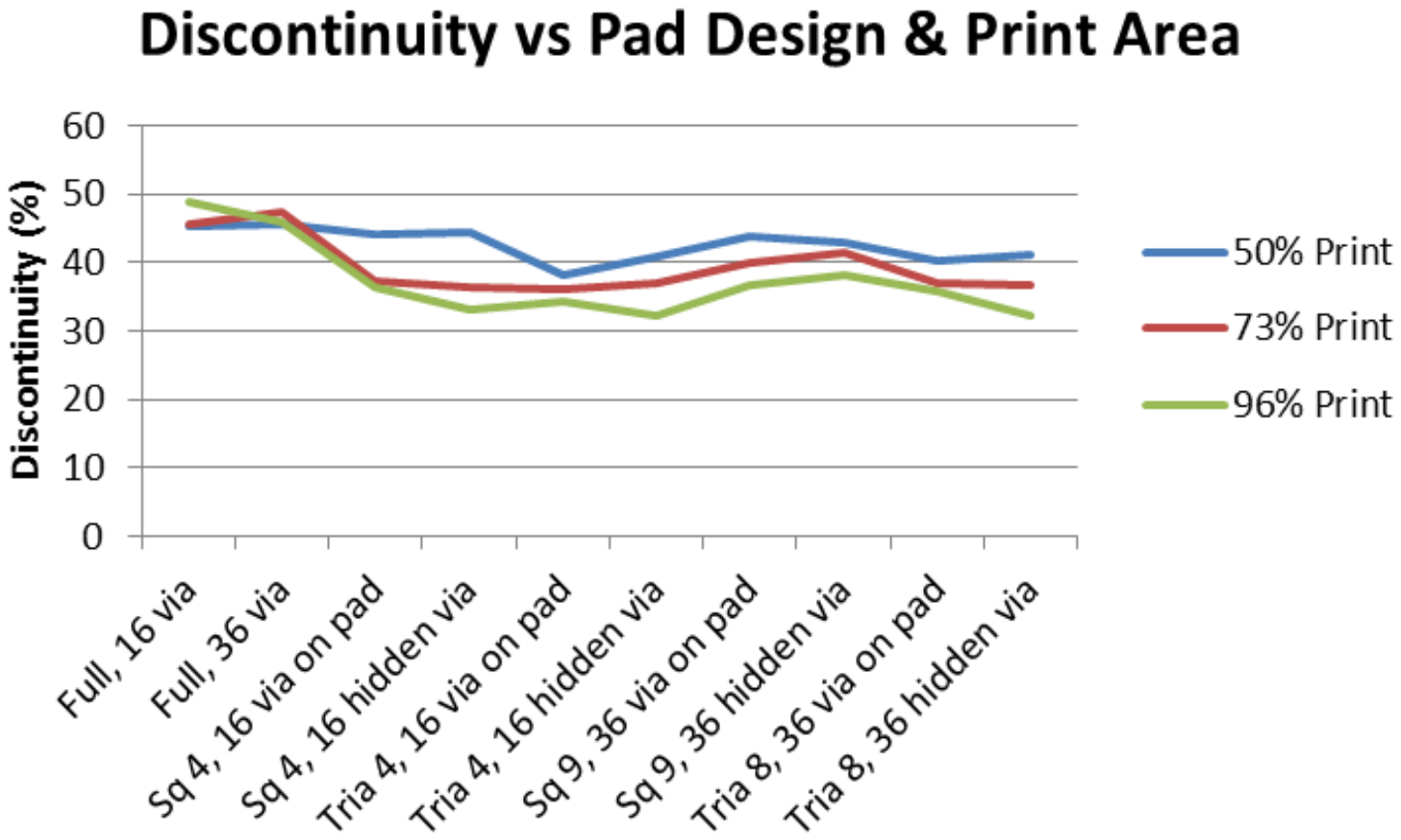
50%

Pad Division Reduce Largest Void

- A drastic decrease in the largest voiding occurs when the full pad is divided.
- Print coverage effect moderate, presumably due to the sporadic nature of largest voids.



Discontinuity Decreases Slightly with Increasing Pad Division and Increasing Print Coverage



Venting Accessibility

Venting accessibility is defined as perimeter length per unit area of metal pad

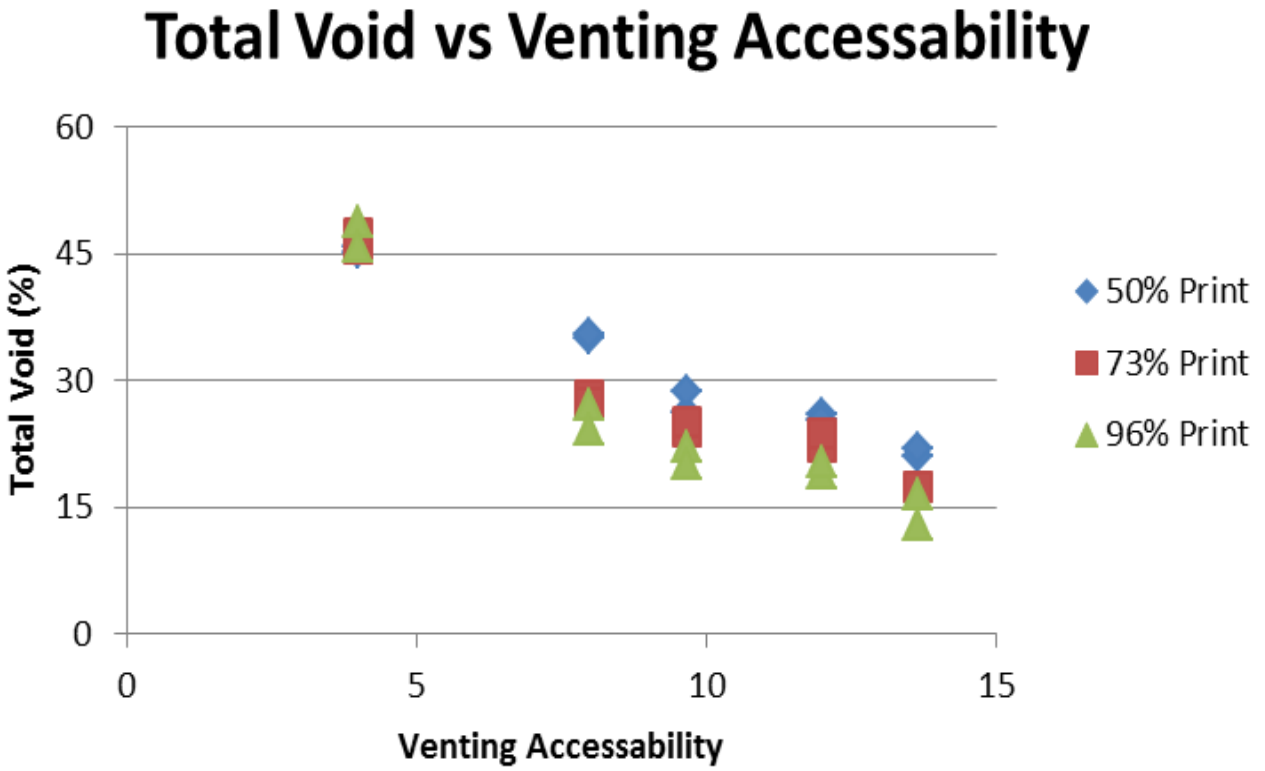
Calculated venting accessibility of thermal pad designs

Thermal pad design	Venting accessability
Full pad	4
Square 4	8
Triangle 4	9.66
Square 9	12
Triangle 8	13.66

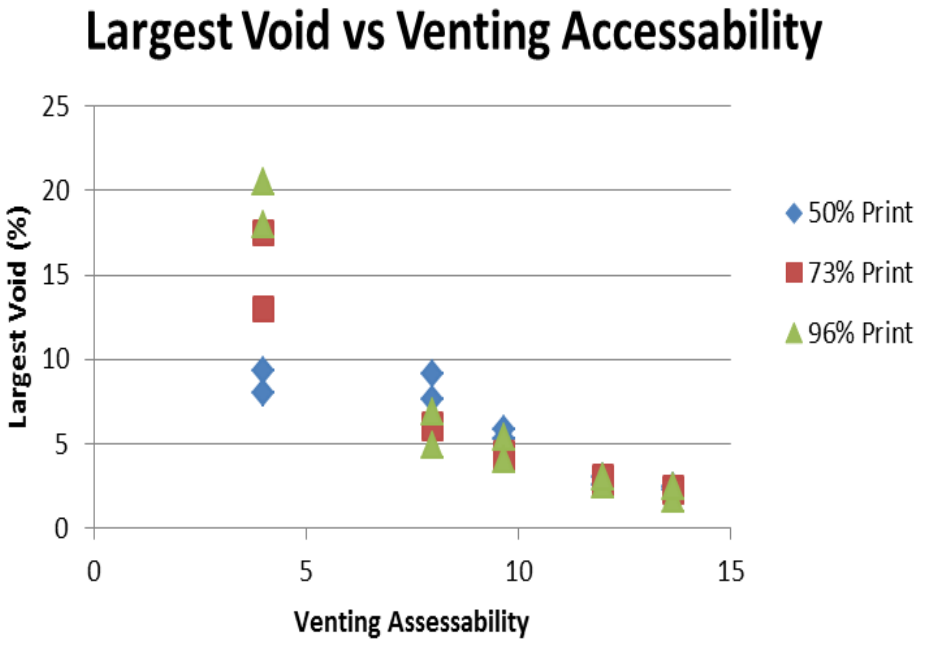
Increase Venting Accessibility Reduce Total Void

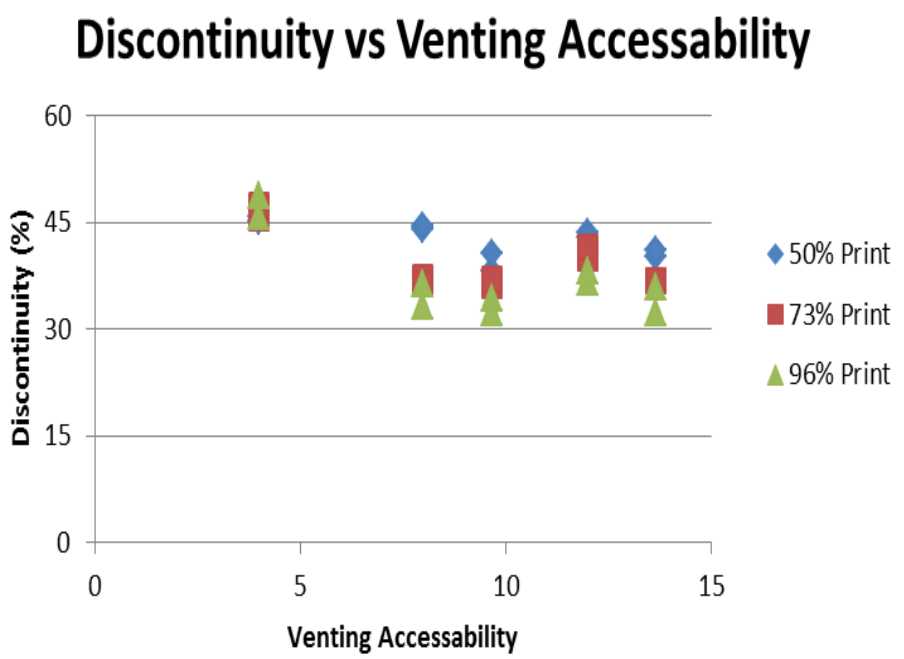
- Total void decreases almost linearly with increasing venting accessibility.
- Smaller print coverage result in more total void.

The high accuracy of voiding prediction capability using "venting accessibility" model allows industry highly accelerate the speed of thermal pad pattern design.

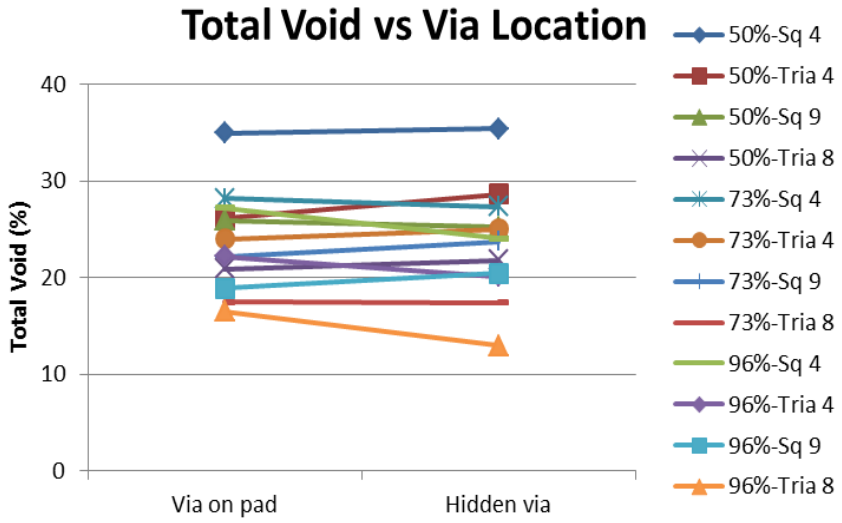


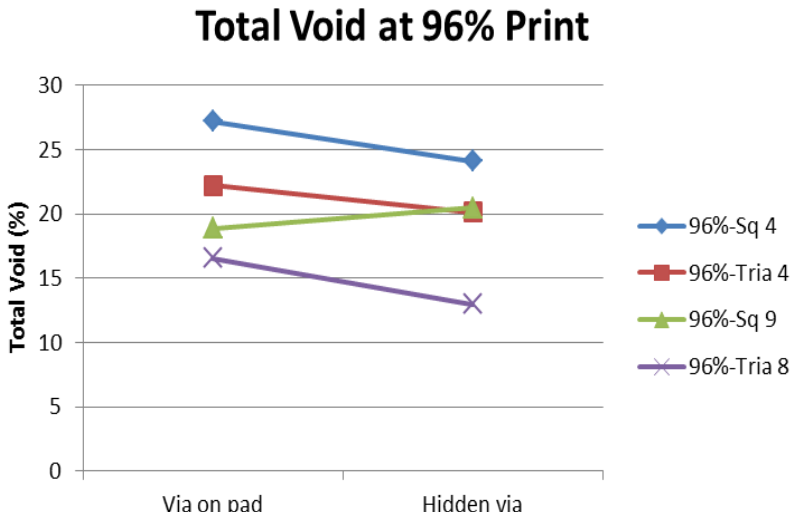
Higher Venting Accessibility Reduce Largest Void & Discontinuity

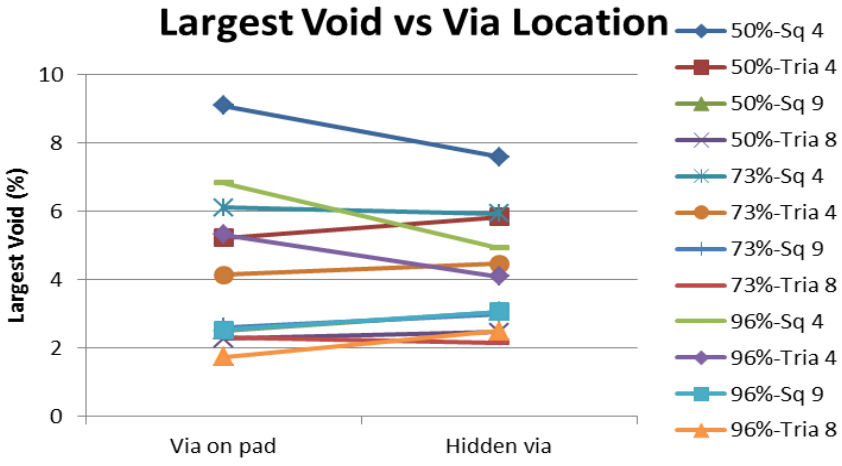


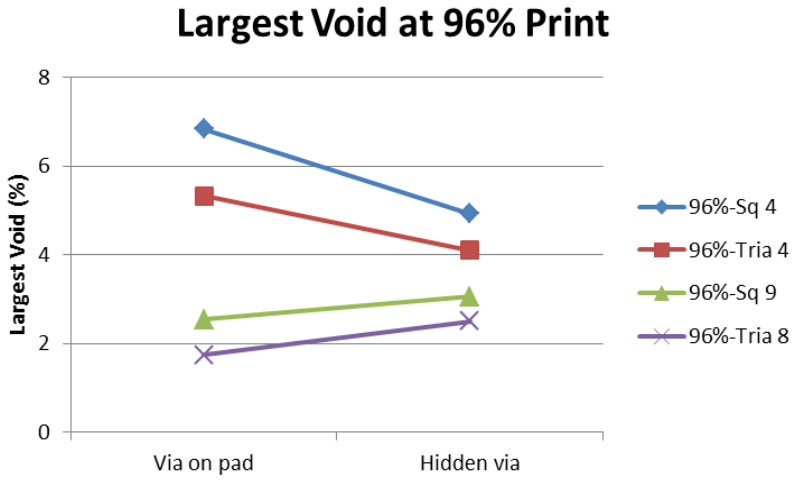


Peripheral Via ~ Hidden Via on Voiding



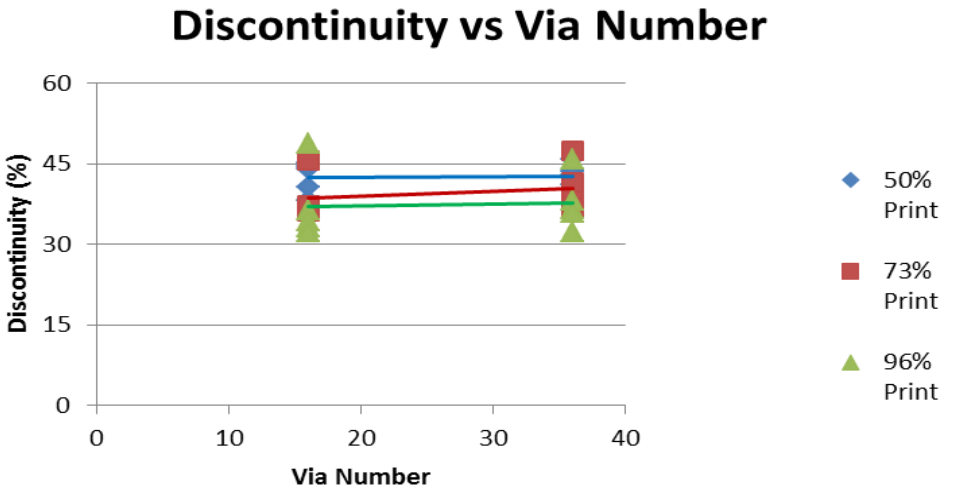


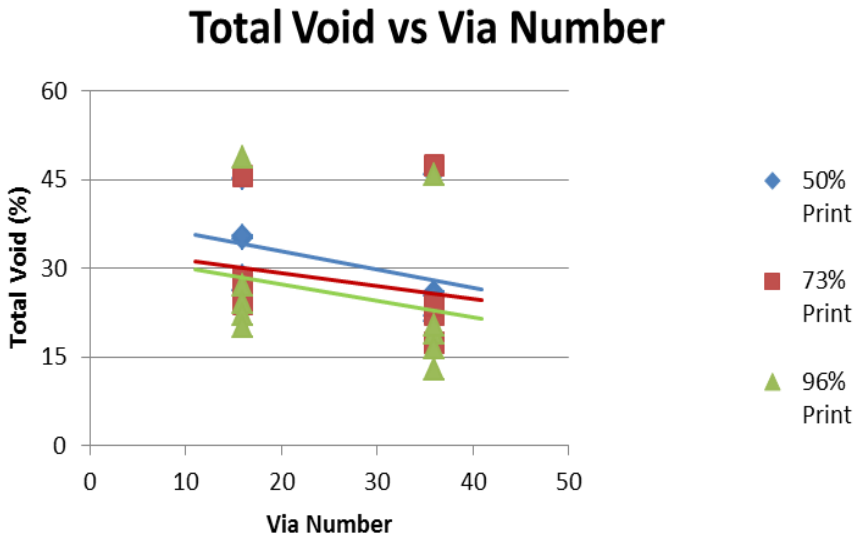


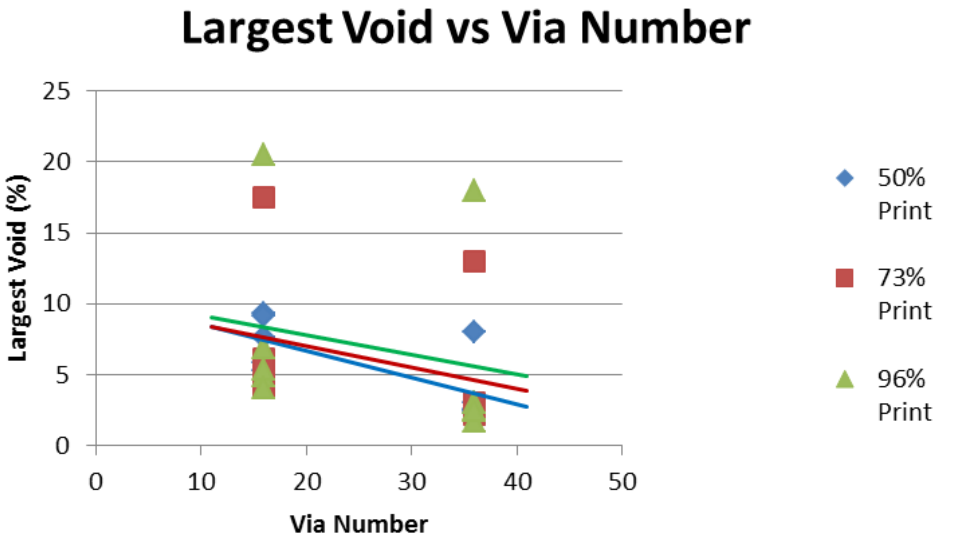


Increase Via No. Reduce Total Void & Largest Void

- A moderate trend showing voiding reduce with increasing via no.

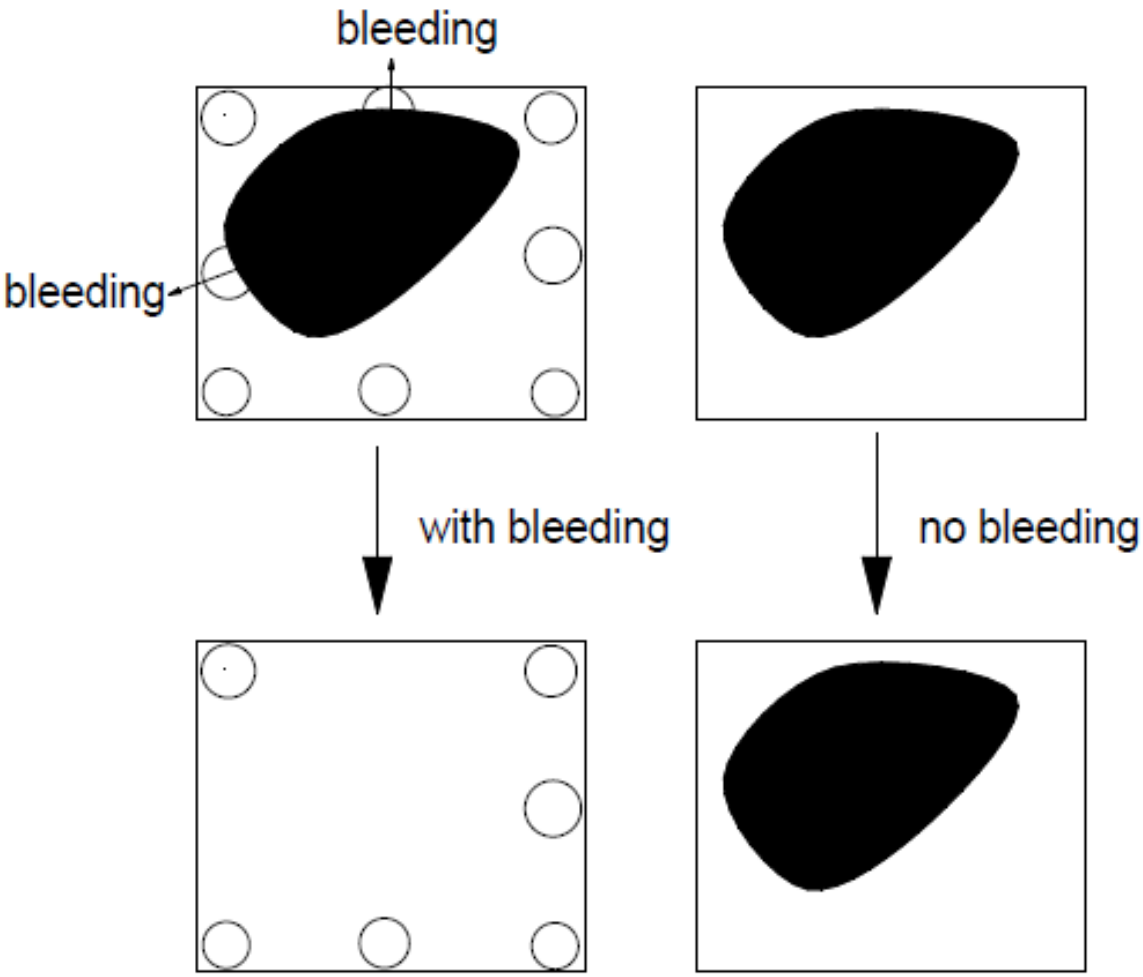






Bleeding Model on Via Role

Small void at via help large void bleed out



Discussion

- For full pad, the largest void of 50% print is lower than 73 & 96% print, perhaps due to easy escape override insufficient solder factor.
- The much higher correlation here than earlier work is attributed to the reduced variables in this study.
- Peripheral via ~ hidden via, since via at edge of pad virtually does not contribute much to voiding due to ease of volatile escape.
- But, the minor voiding associated with via can make measurable difference in bleeding opportunity.

Conclusion

- Voiding at QFN assembly can be suppressed by improving venting accessibility on thermal pad, with the use of solder mask dividing strip.
- Increase in venting accessibility results in decrease in total void, largest void, and discontinuity.
- “Venting Accessibility” model enables accurate prediction of voiding performance
- Voiding caused by peripheral via is comparable with that caused by hidden via.
- Voiding increases with decreasing print coverage, and is attributed to insufficient solder.
- Voiding also decreases slightly with increasing number of thermal via. This phenomenon is attributed to volatiles bleeding through small voids around thermal via.