Root Cause Stencil Design for SMT Component Thermal Lands

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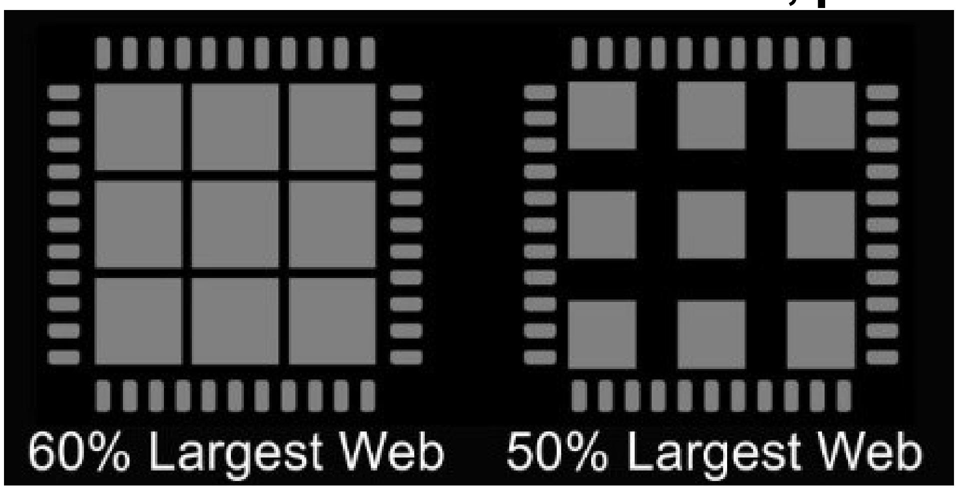
Outline/Agenda

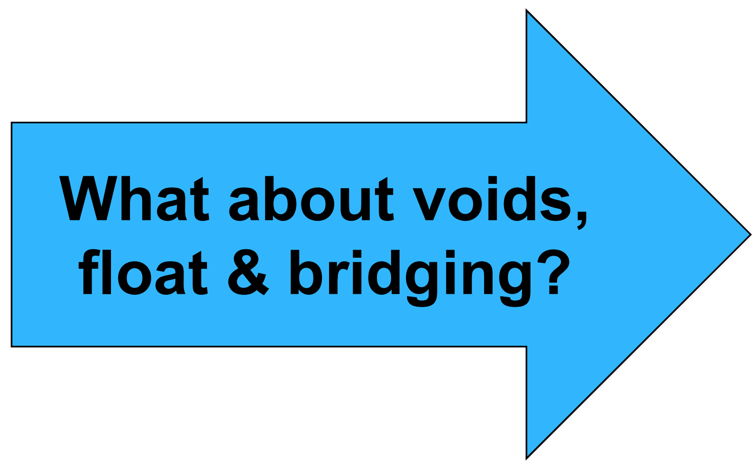
- Introduction
  - Stencil design for thermal pads
- Experimental Methodology
  - Circuit board & stencil designs
  - Process & parameters
- Results & Discussion
  - D-Paks
  - Voiding QFNs & QFPs
  - Float - Skew - Bridging
- Conclusions
- Future Work

Introduction

Stencil Design for Thermal Pads

- Reduce solder paste area by 20-50%
- Window panes are recommended
- How many bricks?
- Best width for webs, perimeters?





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Experimental Methodology

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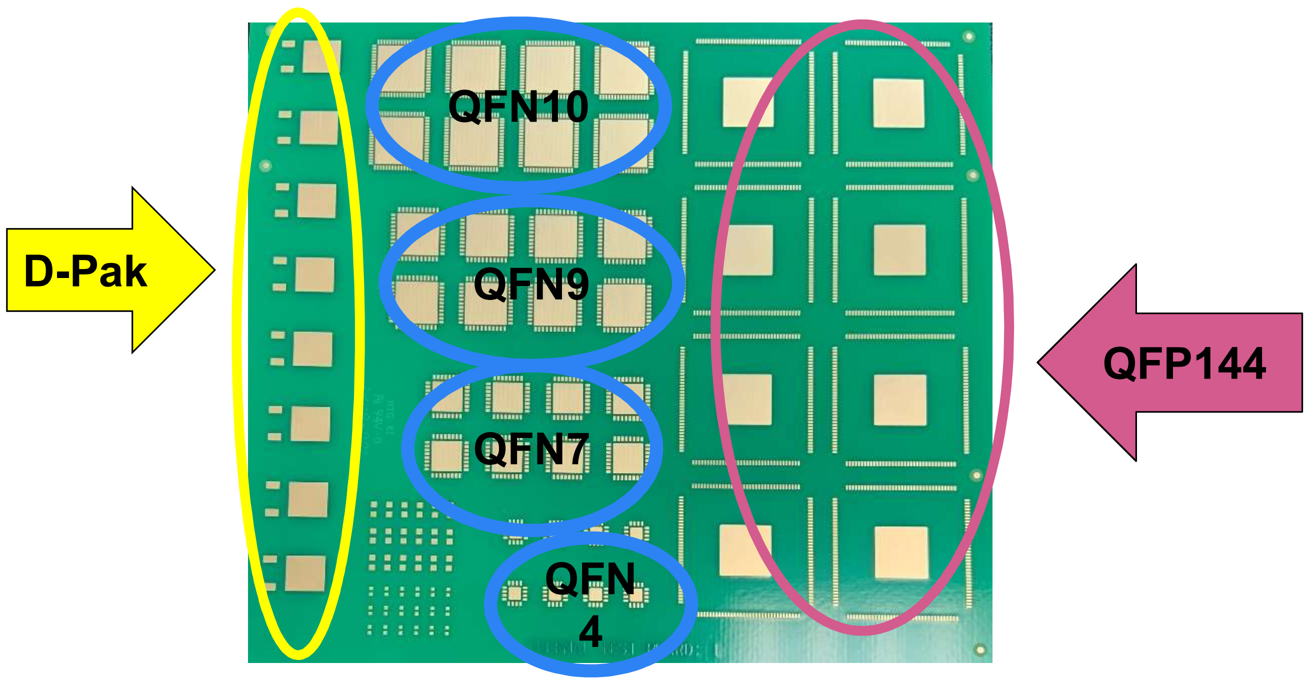
Experimental Methodology

Thermal Pad Test Board

- D-Paks, QFN 10 mm, QFN 9 mm, QFN 7 mm, QFN 4 mm, QFP144
- FR4 0.062", 1 oz copper, print and etch, ENIG finish



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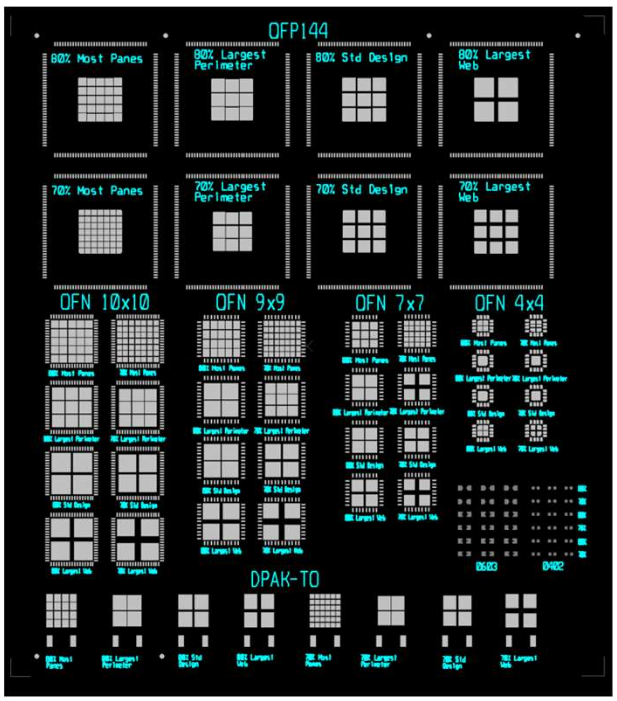
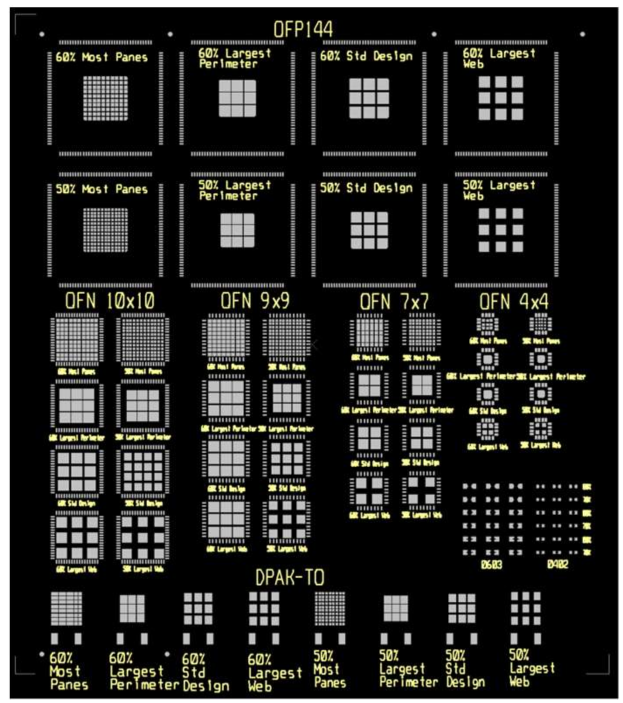
Experimental Methodology

Stencils

- 50, 60, 70, and 80% area coverage on thermal pads
- Largest web, standard web, largest perimeter, most panes

Stencil 1
70 & 80%





Stencil 2
50 & 60%

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Experimental Methodology

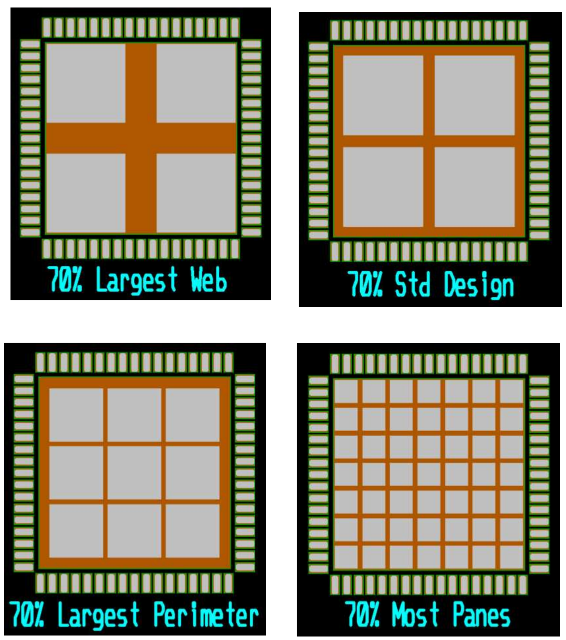
Standard Design Parameters:

Pad Dimension After Reduction	Web Width
<100 mils	None
101-150 mils	8 mils
150-200 mils	15 mils
>200 mils	20 mils

What About Different Web Widths, # Bricks & Perimeter Spacing?

Experimental Methodology

QFN 10



Paste Area (%)	Description / Design	Web Width (mils)	Perim. (mils)	Panes (#)
80	Largest Web	34	1.6	4
80	Standard Web	20	6	4
80	Largest Perimeter	8	10	9
80	Most Panes	8	1.6	20
70	Largest Web	52	1.6	4
70	Standard Web	20	16	4
70	Largest Perimeter	8	18	9
70	Most Panes	8	1.6	49
60	Largest Web	36	1.6	9
60	Standard Web	20	16	9
60	Largest Perimeter	8	29	9
60	Most Panes	8	1.6	100
50	Largest Web	47	1.6	9
50	Standard Web	20	16	16
50	Largest Perimeter	8	38	9
50	Most Panes	8	1.6	144

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Experimental Methodology

Print and Stencil Parameters

Print Speed	50 mm/sec
Blade Length	300 mm
Blade Pressure	6.0 kg (0.20 kg/cm)
Separation Speed	3.0 mm/sec
Separation Distance	2.0 mm
Stencil Thickness	102 µm (4 mil)
Stencil Material	Standard SS 6-10 µm grain
Solder Paste	No clean SAC305 Type 4

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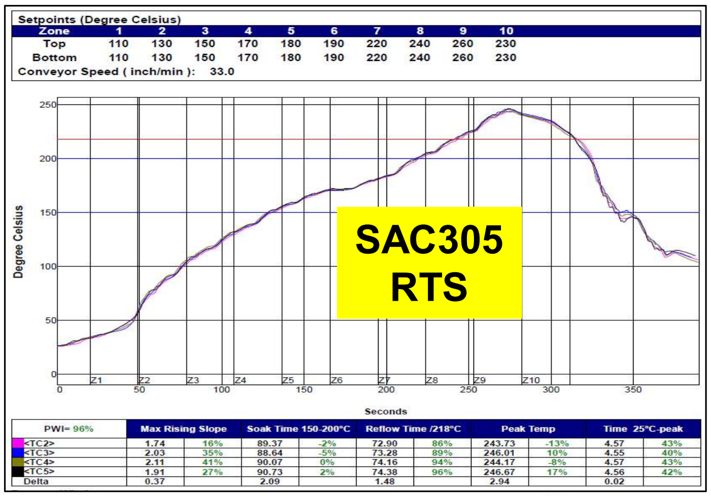
Experimental Methodology

Reflow Profile



Setting	SAC305 RTS “linear”
Max Rising Slope	1.7 – 2.1 °C/sec
Soak Time (150-200 °C)	89 - 91 sec
TAL (Reflow time)	73 – 74 sec > 218°C
Peak temperature	244 to 247 °C
Profile length (25 °C to peak)	4.6 minutes

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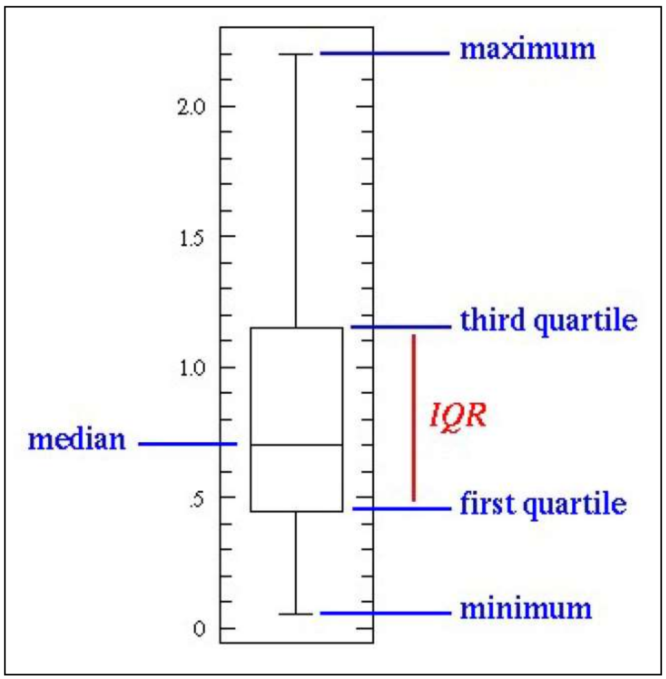
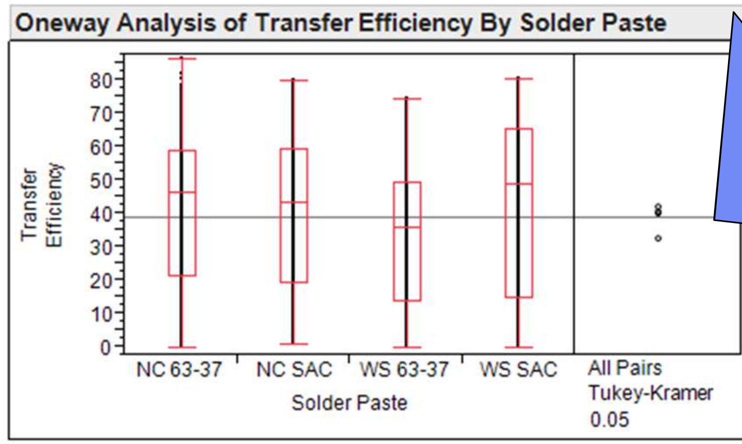
Experimental Methodology

Box Plots & Tukey-Kramer Honest Significant Difference





95% Confidence Level

Means Comparisons

Comparisons for all pairs using Tukey-Kramer HSD

Connecting Letters Report

Level				Mean
WS SAC	A			42.1
NC 63-37		B		40.7
NC SAC		B		40.0
WS 63-37			C	32.7

Levels not connected by same letter are significantly different.

Connecting Letters Shows Differences

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Experimental Methodology

Process and Data

- Print Solder Paste
- Place & Reflow
- Take Pictures
- Tally Wet/Bridge
- Measure Voiding

10 Boards Each
2 Stencils

Data

Inspection
Wetting / Solder Fillet
Bridging
Skew

Voiding
Void Area %
Largest Void %

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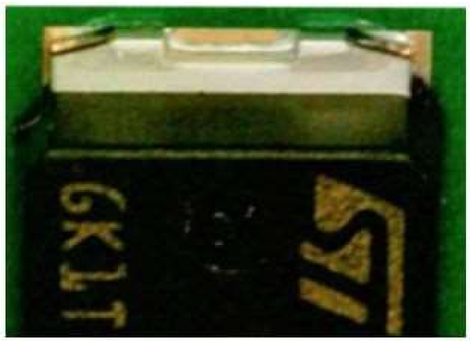
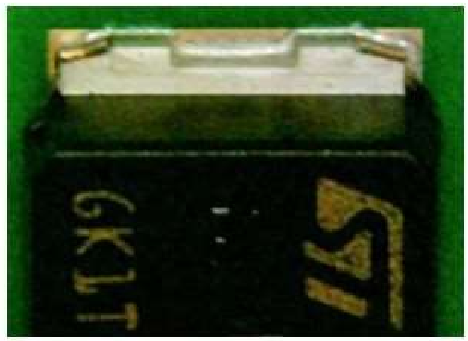
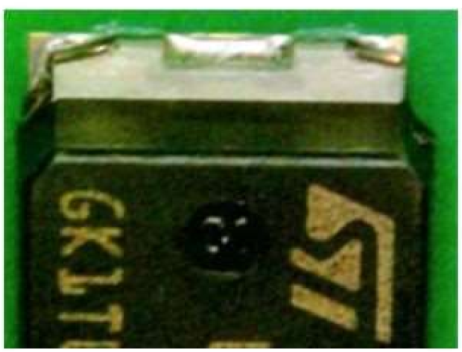
D-Pak Components



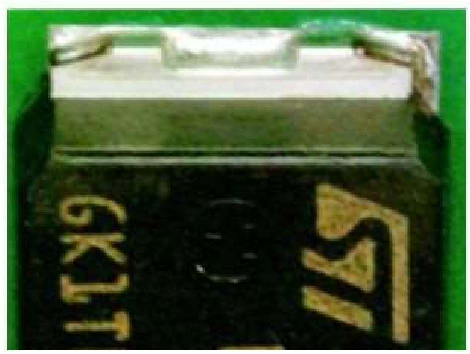
50% Coverage Std. Design



60% Coverage Std. Design



70% Coverage Std. Design



80% Coverage Std. Design

- **Voiding not able to be measured**
- **Wetting on the ground pad varied**

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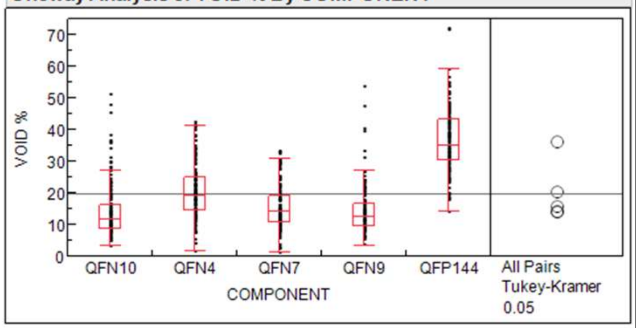
Voiding Results - Overview

Oneway Analysis of VOID % By COMPONENT



Means Comparisons

Comparisons for all pairs using Tukey-Kramer HSD

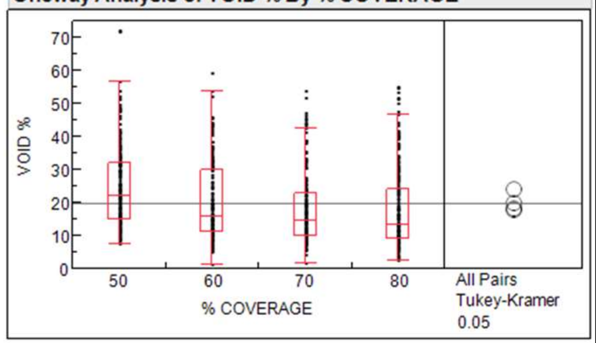
Connecting Letters Report

Level				Mean
QFP144	A			36.5
QFN4		B		20.3
QFN7			C	15.7
QFN9			C	14.3
QFN10			C	14.1

Levels not connected by same letter are significantly different.

Component

Oneway Analysis of VOID % By % COVERAGE



Means Comparisons

Comparisons for all pairs using Tukey-Kramer HSD

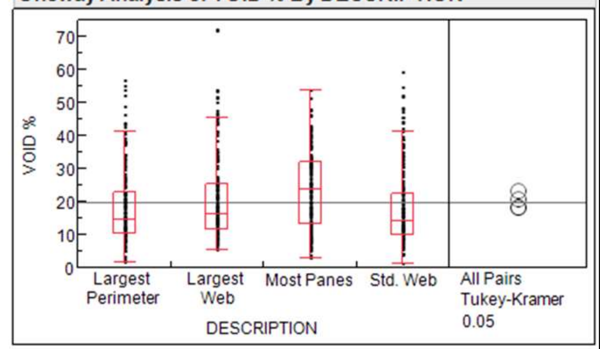
Connecting Letters Report

Level			Mean
50	A		24.3
60		B	20.2
70		B	18.3
80		B	17.9

Levels not connected by same letter are significantly different.

Coverage

Oneway Analysis of VOID % By DESCRIPTION



Means Comparisons

Comparisons for all pairs using Tukey-Kramer HSD

Connecting Letters Report

Level			Mean
Most Panes	A		23.3
Largest Web	A	B	20.7
Largest Perimeter		B	18.4
Std. Web		B	18.2

Levels not connected by same letter are significantly different.

Design

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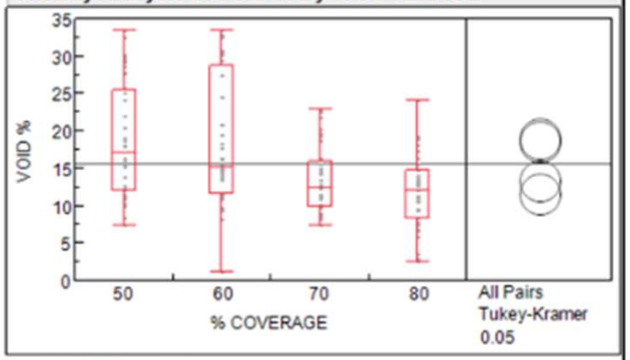
Voiding Results - Coverage

Oneway Analysis of VOID % By % COVERAGE



Excluded Rows 640

Means Comparisons

Comparisons for all pairs using Tukey-Kramer HSD

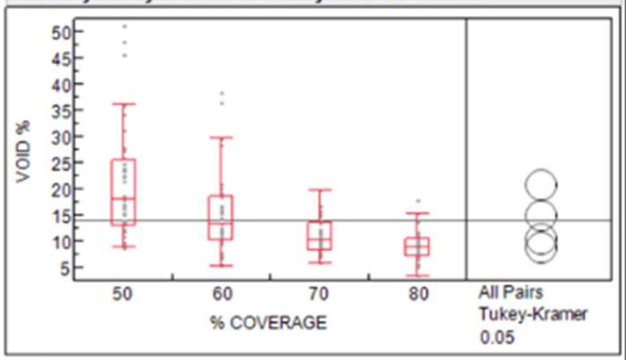
Connecting Letters Report

Level			Mean
50	A		19.0
60	A		18.6
70		B	13.4
80		B	11.7

Levels not connected by same letter are significantly different.

QFN7

Oneway Analysis of VOID % By % COVERAGE



Excluded Rows 640

Means Comparisons

Comparisons for all pairs using Tukey-Kramer HSD

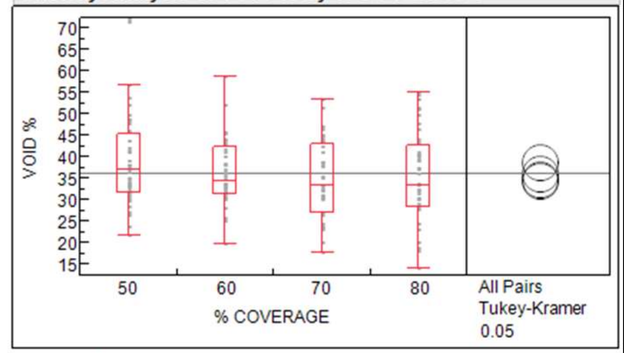
Connecting Letters Report

Level				Mean
50	A			21.2
60		B		15.3
70			C	10.9
80			C	9.1

Levels not connected by same letter are significantly different.

QFN10

Oneway Analysis of VOID % By % COVERAGE



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Means Comparisons

Comparisons for all pairs using Tukey-Kramer HSD

Connecting Letters Report

Level		Mean
50	A	39.3
60	A	36.4
80	A	35.3
70	A	34.8

Levels not connected by same letter are significantly different.

QFP144

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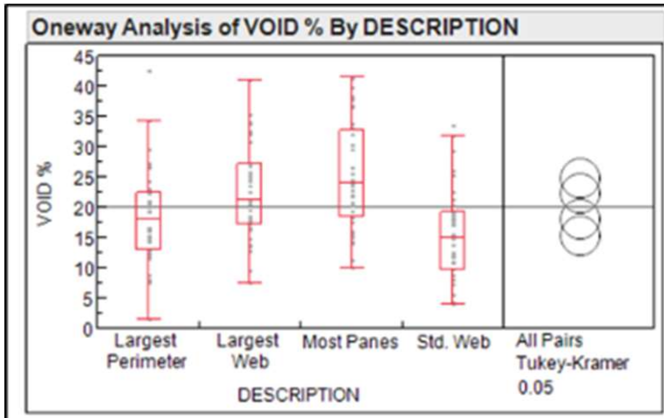
Voiding Results - Stencil Design



Excluded Rows 640

Means Comparisons

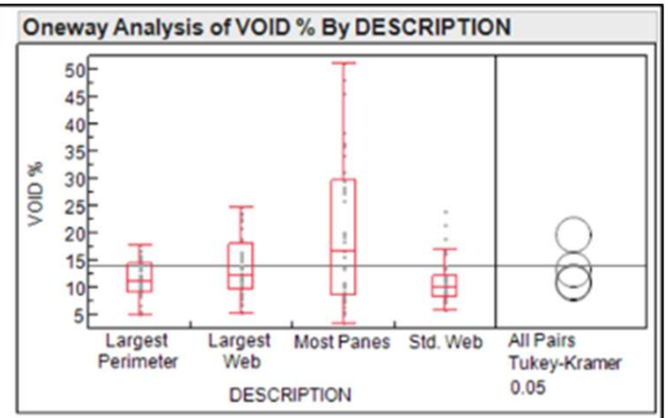
Comparisons for all pairs using Tukey-Kramer HSD

Connecting Letters Report

Level			Mean
Most Panes	A		25.0
Largest Web	A	B	22.4
Largest Perimeter		B C	18.2
Std. Web		C	15.4

Levels not connected by same letter are significantly different.

QFN4



Excluded Rows 640

Means Comparisons

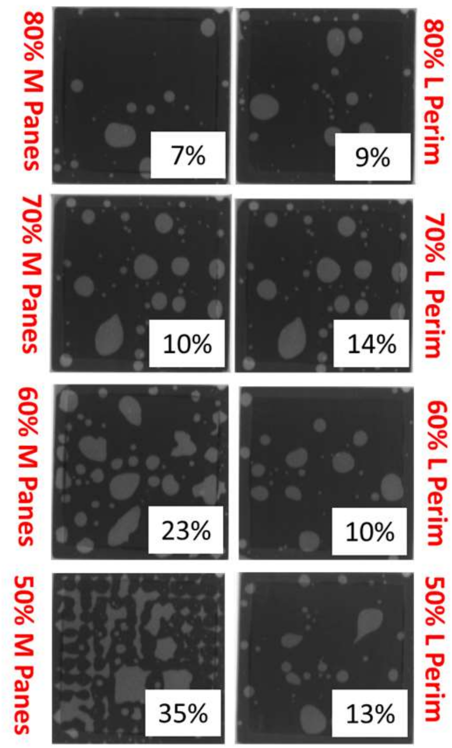
Comparisons for all pairs using Tukey-Kramer HSD

Connecting Letters Report

Level		Mean
Most Panes	A	20.1
Largest Web	B	13.7
Largest Perimeter	B	11.5
Std. Web	B	11.1

Levels not connected by same letter are significantly different.

QFN10



QFN10 Design

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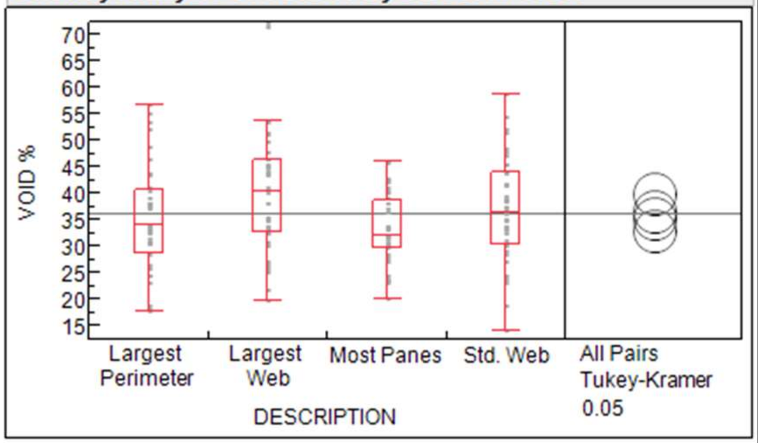
Voiding Results - Stencil Design

QFP144 Design

Oneway Analysis of VOID % By DESCRIPTION



Excluded Rows 640

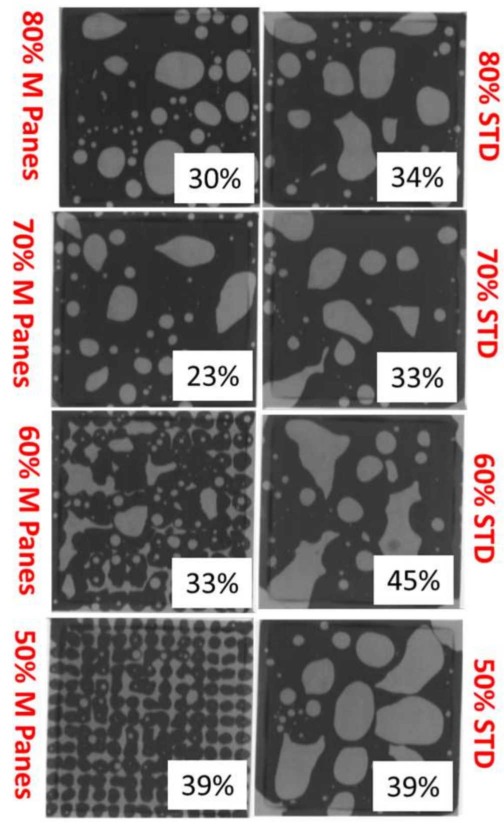
Means Comparisons

Comparisons for all pairs using Tukey-Kramer HSD

Connecting Letters Report

Level			Mean
Largest Web	A		40.3
Std. Web	A	B	36.9
Largest Perimeter	A	B	35.6
Most Panes		B	33.0

Levels not connected by same letter are significantly different.



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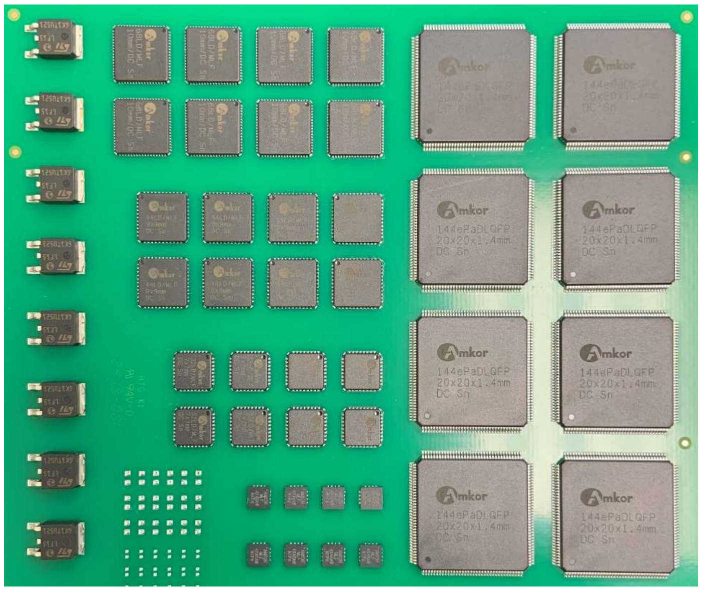
Float - Skew - Bridging



No float or skew

No bridging

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Conclusions

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Conclusions

- ✓ QFN voiding is affected by stencil design and area of coverage
  - Standard window pane and largest perimeter give lowest voiding
  - 70-80% area gives lowest voiding
- ✓ QFP voiding is high enough to be unaffected by area or stencil design
- ✓ D-Paks were too dense for void measurement
  - 70-80% area was required to give full wetting of the ground pad

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Future Work

- ✓ Measure voiding: vary stencil thickness and overall paste volume
- ✓ Modify solder volume on QFN I/O (perimeter) pads and measure voiding
- ✓ Adjust stencil patterns and reflow profiles to minimize voiding

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