

The Effects of Surface Finish on Solder Paste Performance - The Sequel

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FCT Solder



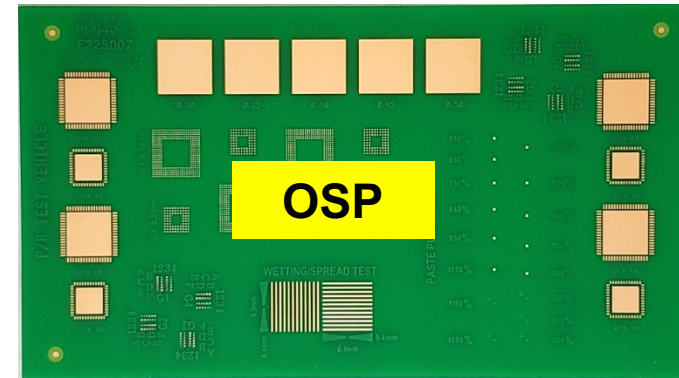
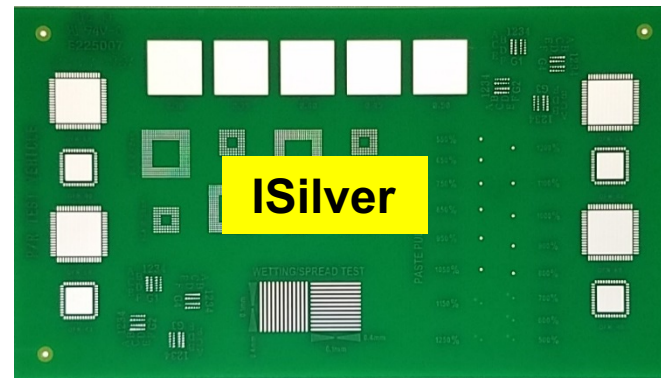
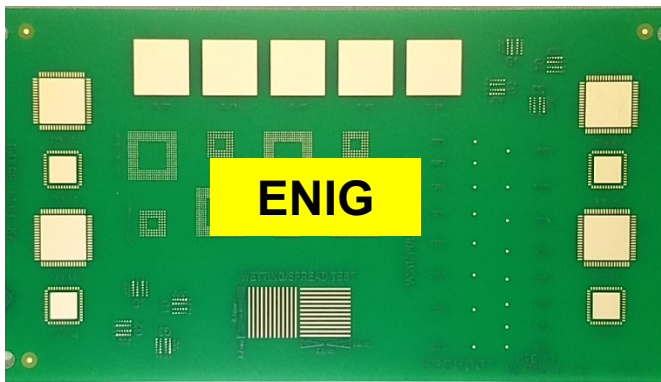
Outline/Agenda

- **Intro - Surface Finishes & Solder Pastes**
- **Experimental Methodology**
- **Results & Discussion**
 - Printing, Reflow, Voiding
 - Scoring System
- **Strengths & Weaknesses**
- **Conclusions**
- **Question & Answer**

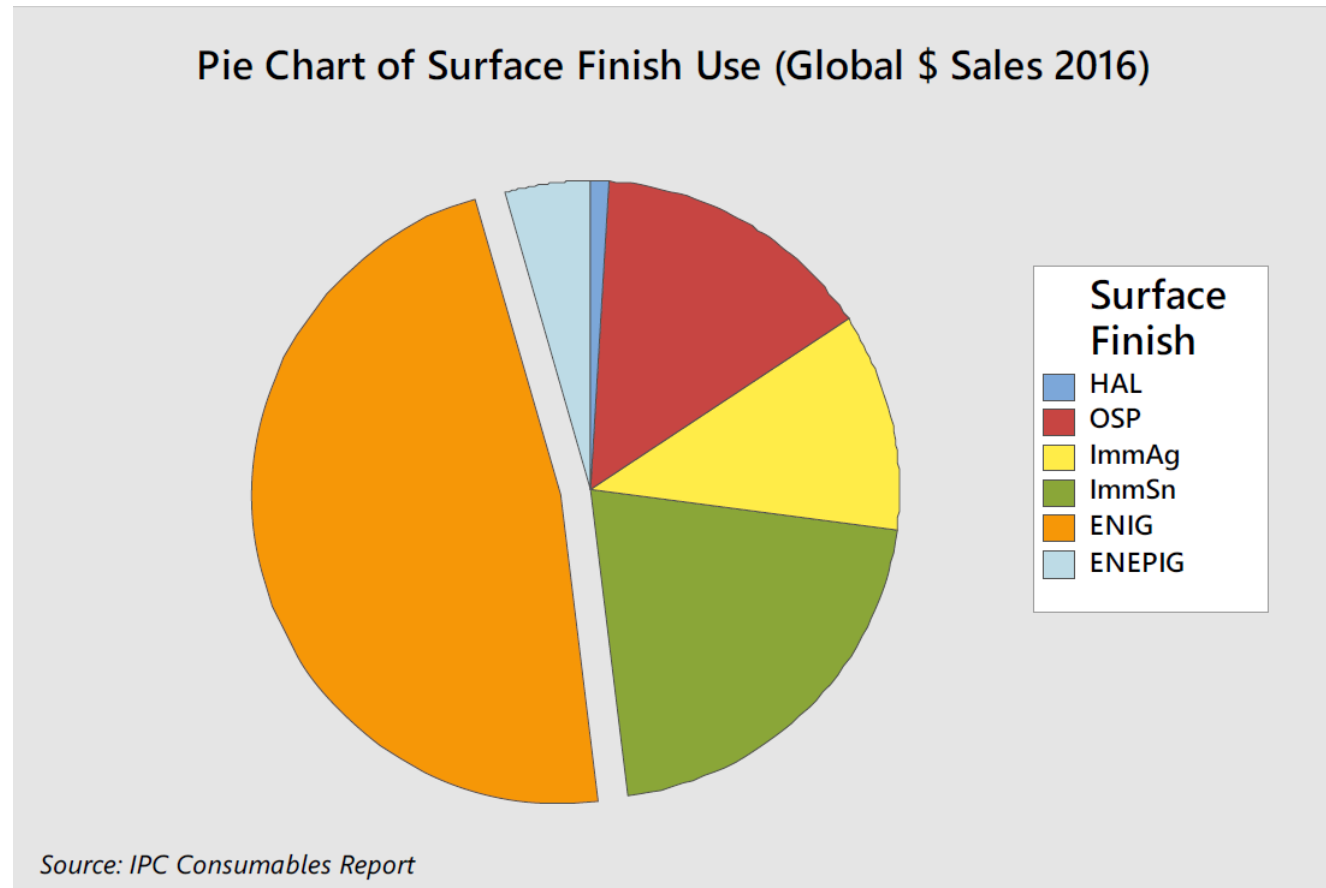
Introduction

Surface Finishes & Solder Pastes

- Must work together
- How does surface finish affect performance?



Surface Finishes Used on PCBs



*M. Bunce, L. Clark, J. Swanson, "Achieving A Successful ENIG Finished PCB Under Revision A Of IPC 4552 MacDermid Enthone", Proceedings of SMTA International, 2017

Experimental Methodology



Experimental Methodology

Surface Finish	Thickness
OSP (High Temp)	< 2 μm
ENIG	3.0 - 6.1 μm nickel 0.05 - 0.13 μm gold
ISilver	0.15 - 0.38 μm silver



Experimental Methodology

Solder Pastes

Solder Paste Flux	J-STD-004 Class	Solder Alloy	Code
Water-Soluble	ORH1	SAC305	WS SAC
No-Clean	ROL0	SAC305	NC SAC

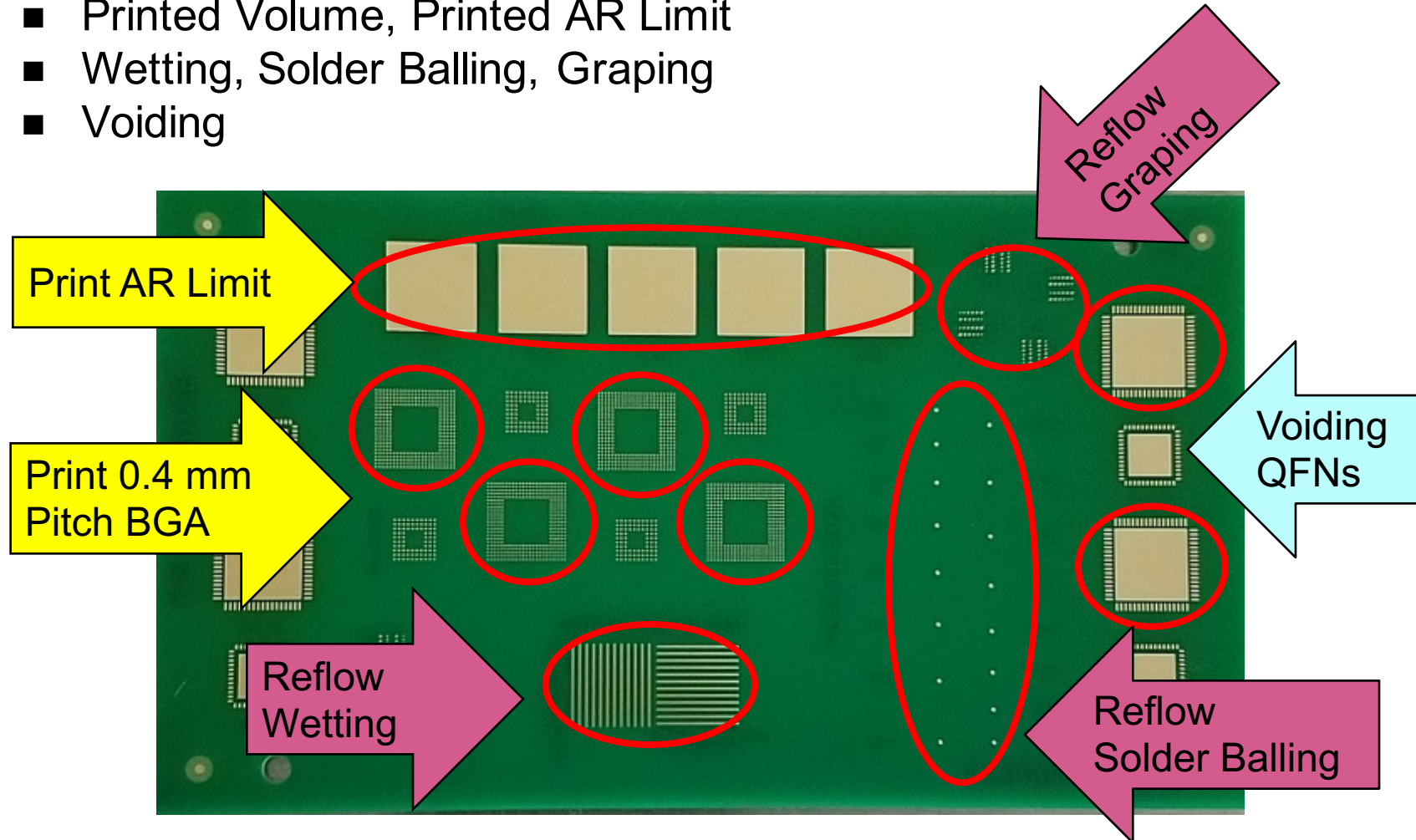


**Solder Powder Size:
IPC Type 4 (20-38 μm)**

Experimental Methodology

PR Test Board Measures:

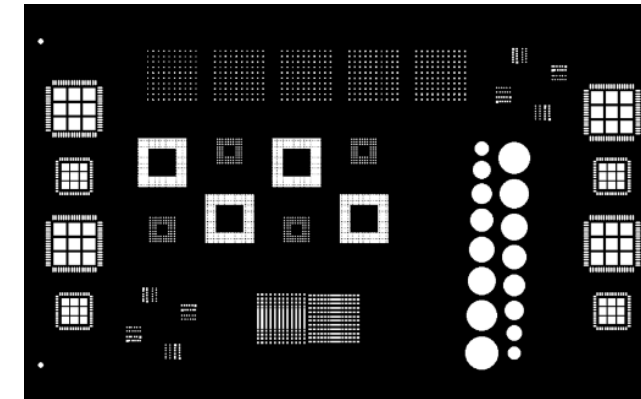
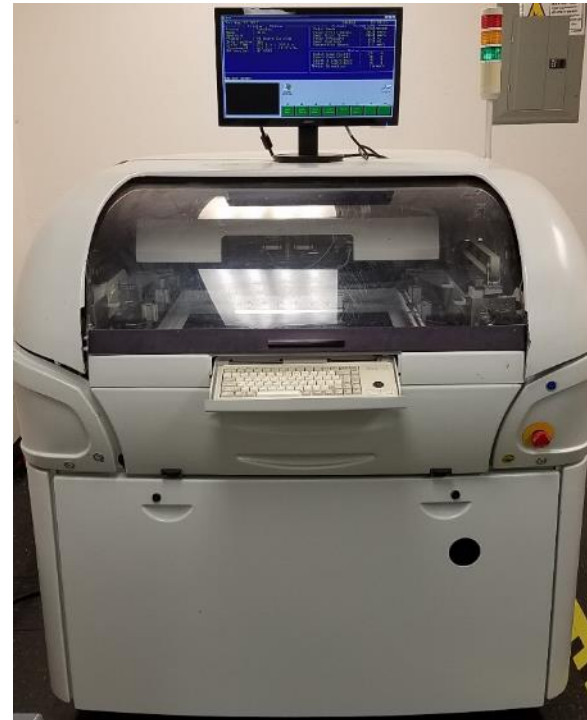
- Printed Volume, Printed AR Limit
- Wetting, Solder Balling, Graping
- Voiding



Experimental Methodology

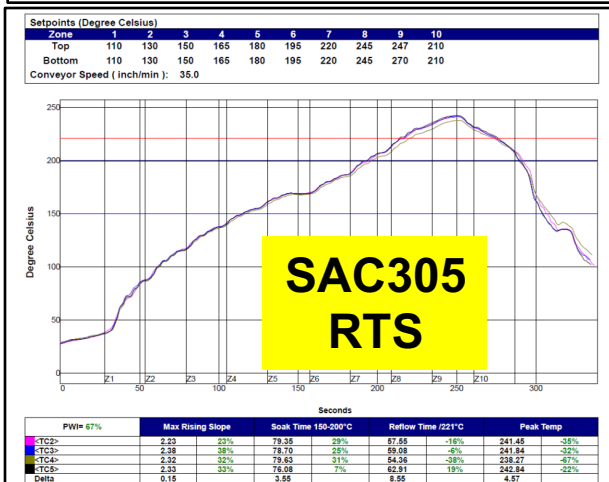
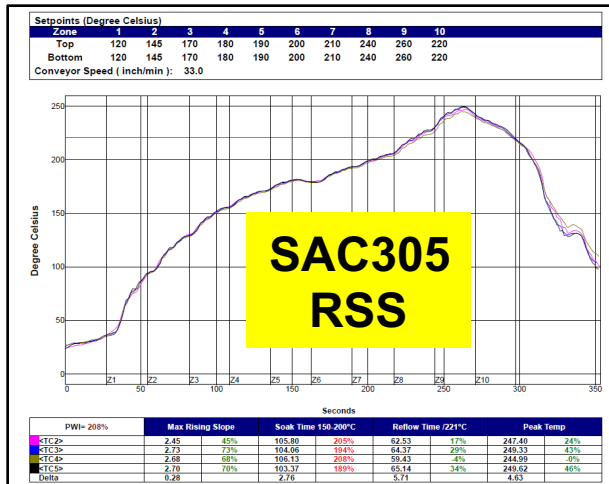
Print and Stencil Parameters

Print Speed	25, 50, 100 mm/sec
Blade Length	300 mm
Blade Pressure	5.0 kg (0.17 kg/cm) Or 8.0 kg (0.26 kg/cm)
Separation Speed	3.0 mm/sec
Separation Distance	2.0 mm
Stencil Thickness	127 μm (5 mil)
Stencil Material	Fine grain SS 2-5 μm



Experimental Methodology

Reflow Profiles

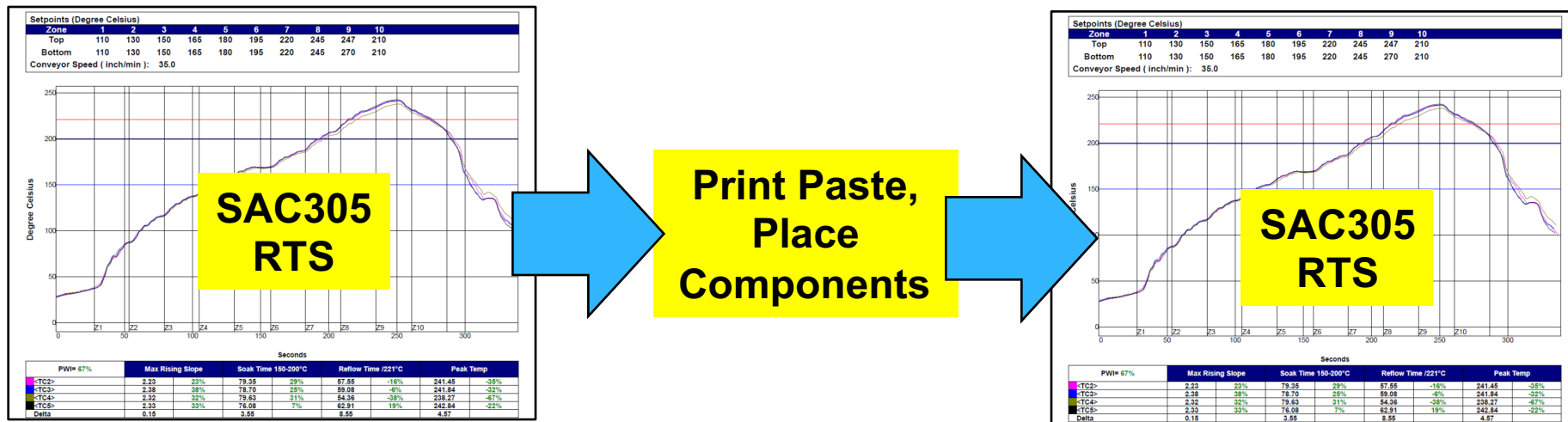


Setting	SAC305 RSS “soak”	SAC305 RTS “linear”
Max Rising Slope	2.4 – 2.7 °C/sec	2.2 – 2.4 °C/sec
Soak Time (150-200 °C)	103 - 106 sec	76 - 80 sec
TAL (Reflow time)	59 - 65 sec > 220°C	54 – 63 sec > 220°C
Peak temperature	245 to 249 °C	238 to 243 °C
Profile length (25 °C to peak)	4.1 minutes	4.1 minutes



Experimental Methodology

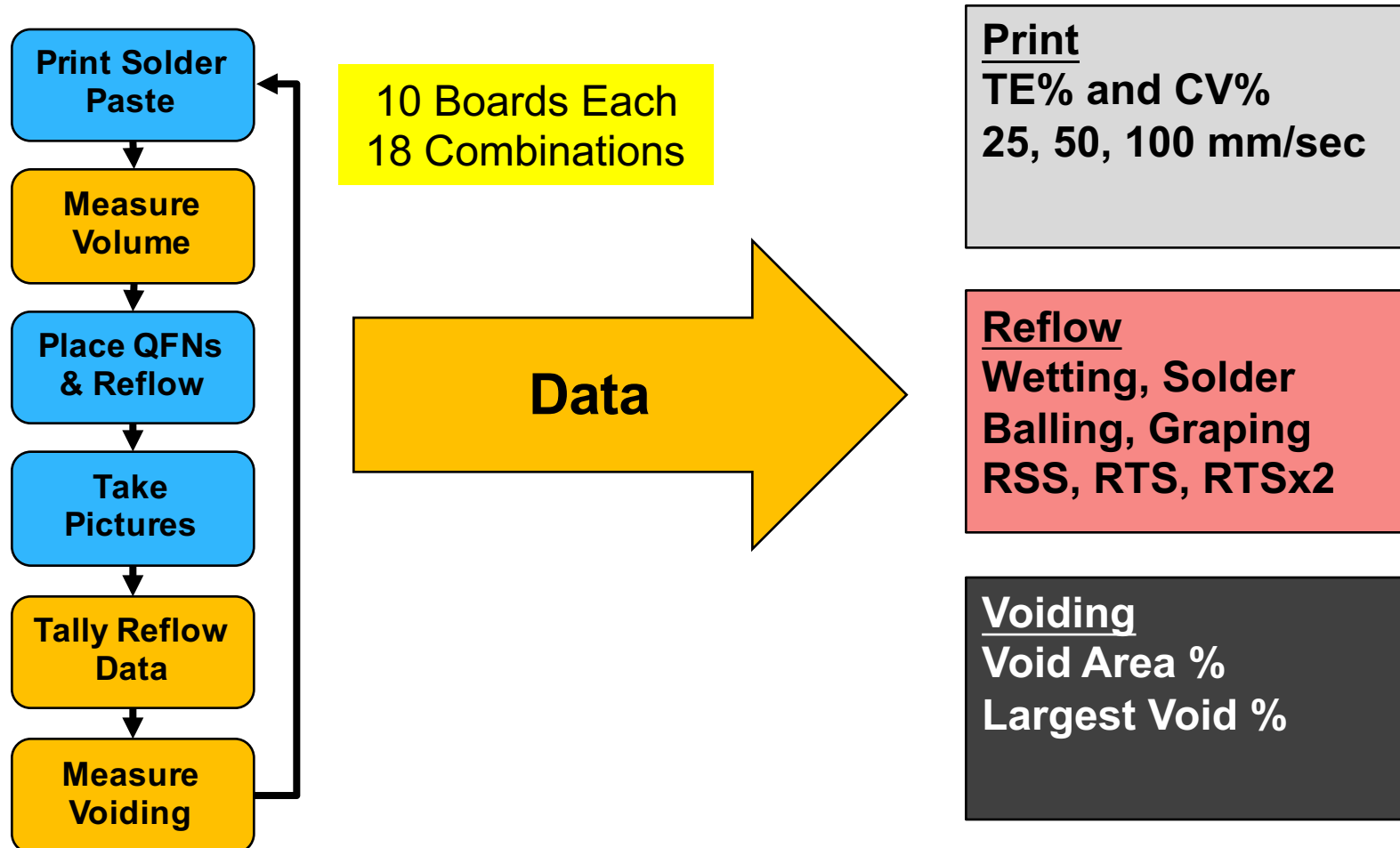
Reflow Profiles (RTSx2)



- Thermally Stresses the Surface Finish on the Bare Board
- Simulates The 2nd Side of Double-Sided SMT

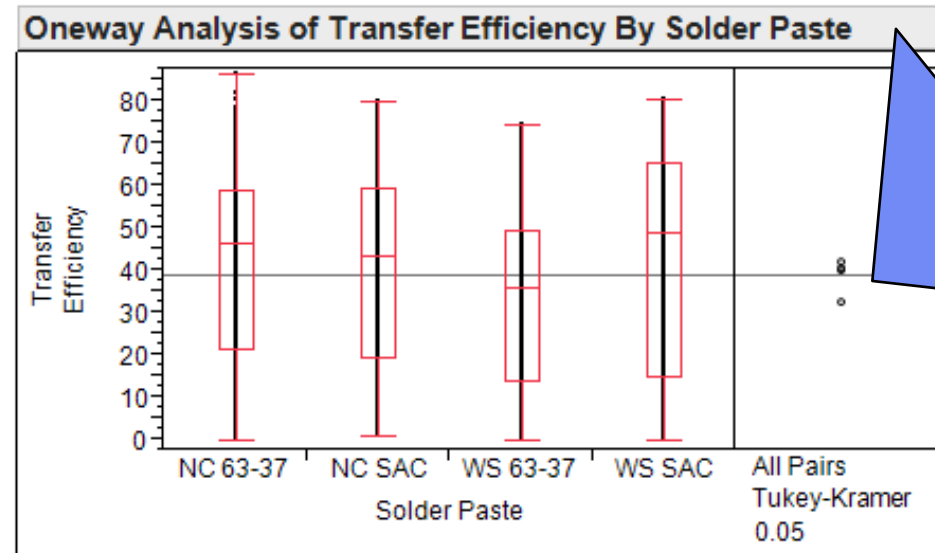
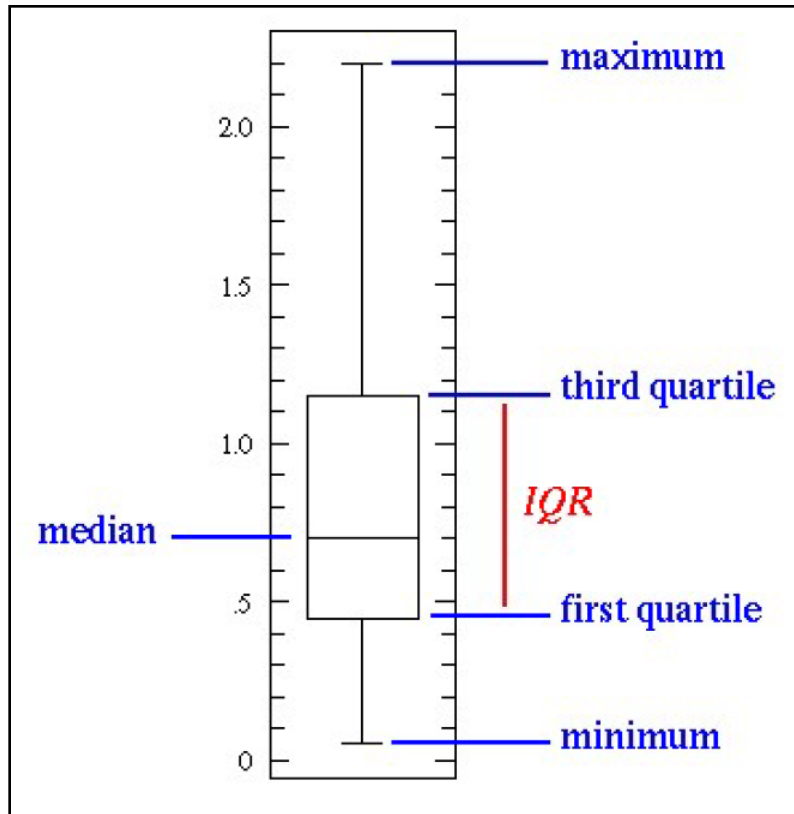
Experimental Methodology

Process and Data



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

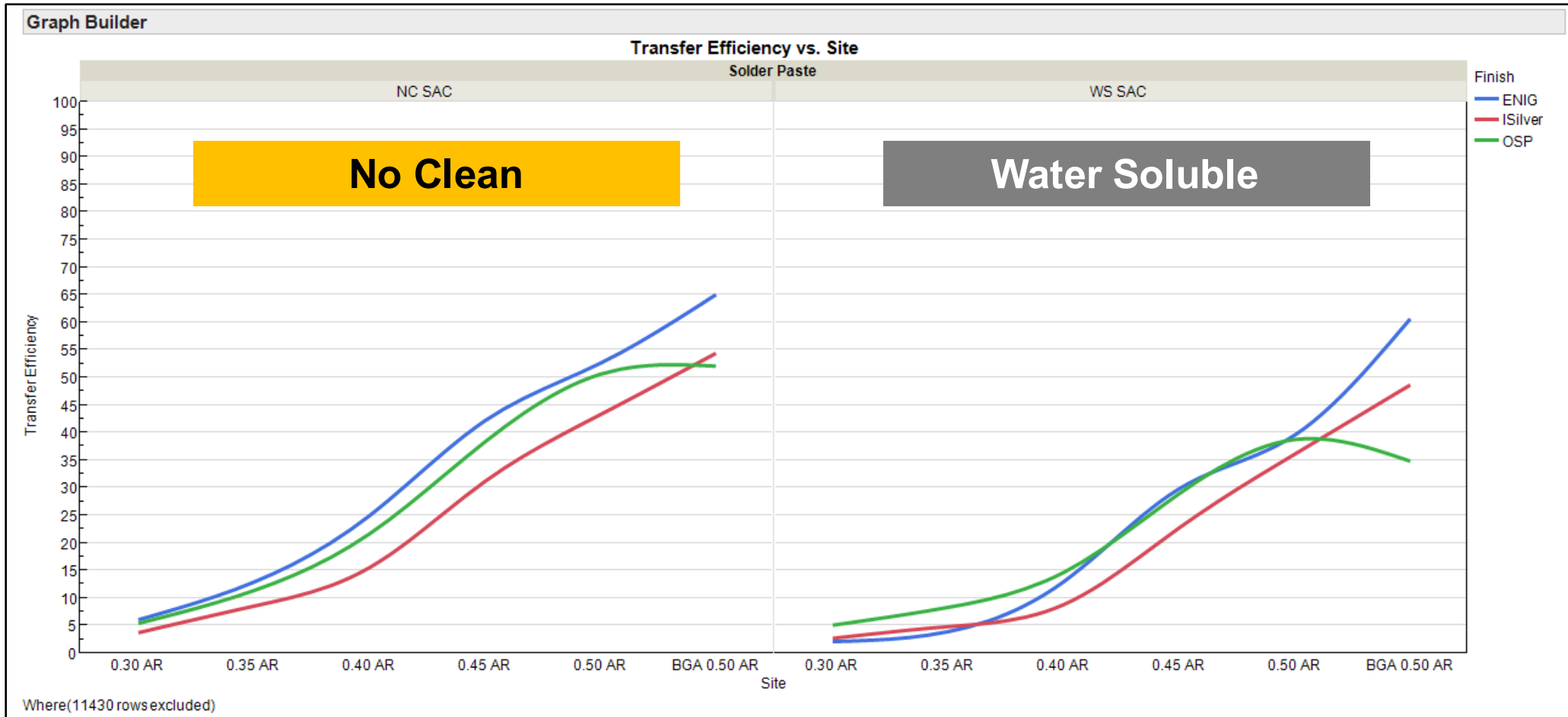
Level	Mean
WS SAC A	42.1
NC 63-37 B	40.7
NC SAC B	40.0
WS 63-37 C	32.7

Levels not connected by same letter are significantly different.

Connecting Letters Shows Differences

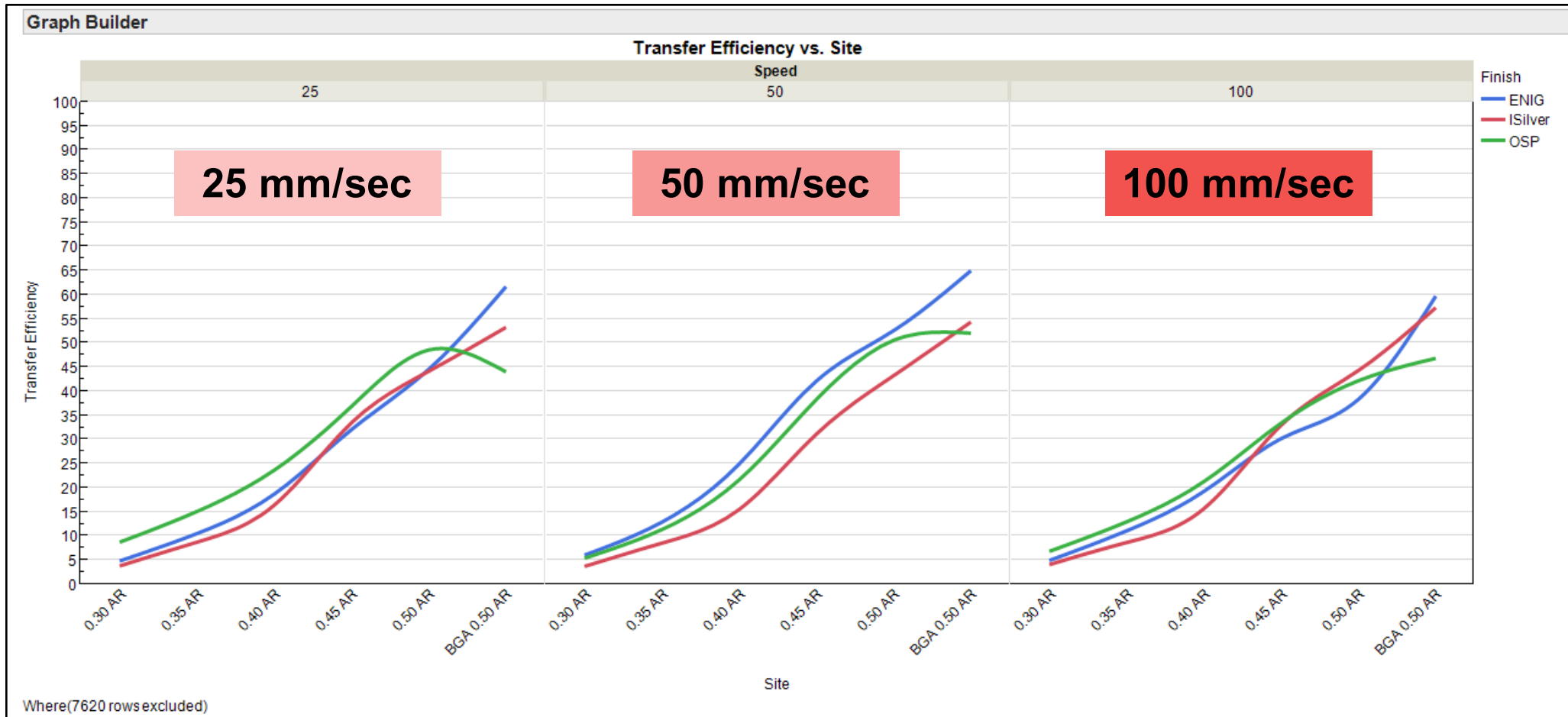


Print: TE% by Paste and Finish



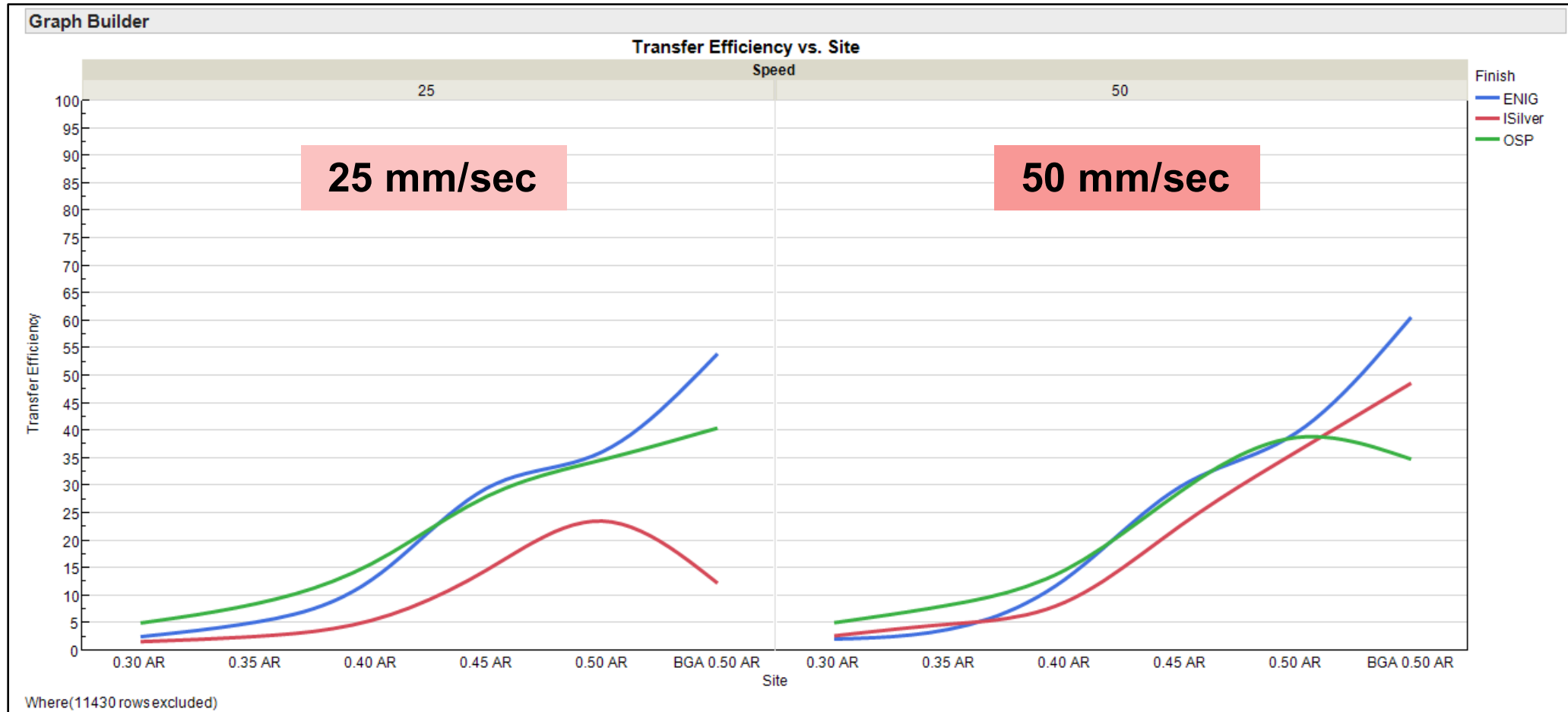
NC gives higher TE% than WS
ISilver gives lowest TE%

Print: TE% by AR & Speed - NC SAC



NC prints equally well at all speeds
ISilver gives lower TE% at some speeds

Print: TE% by AR & Speed - WS SAC



WS did not print at 100 mm/sec
ISilver gives lowest TE%

Print: TE% and CV% Summary

0.4 mm Pitch BGA - 50 mm/sec

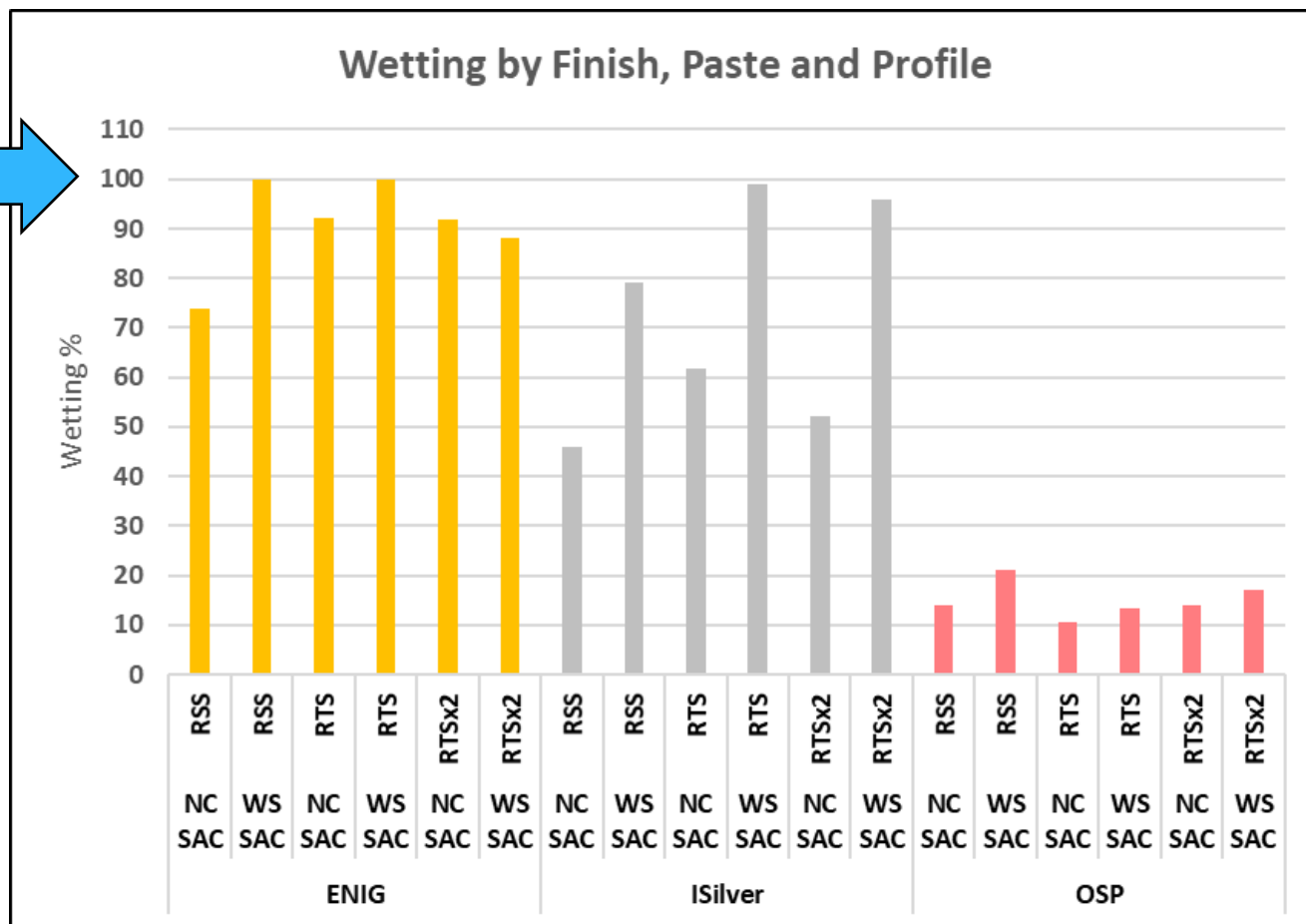
Surface Finish - Paste	Mean TE%	Standard Deviation of TE%	CV (%)
ENIG - NC SAC	65	9	15
ISilver - NC SAC	54	10	19
OSP - NC SAC	52	11	21
ENIG - WS SAC	61	17	28
ISilver - WS SAC	49	18	36
OSP - WS SAC	35	22	64

Coefficient of Variation of Less Than 10% is the Goal

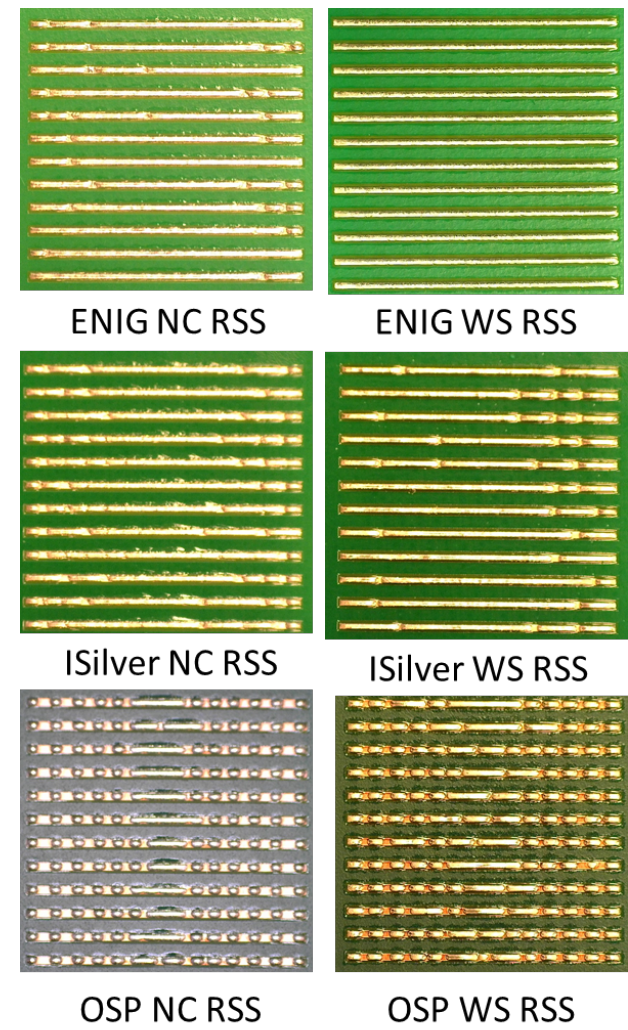
Reflow Results



Reflow: Wetting

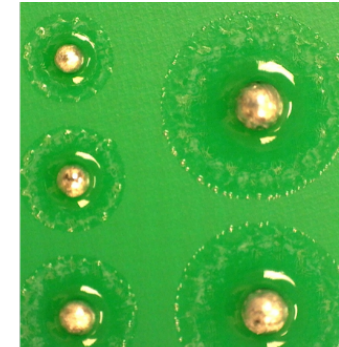
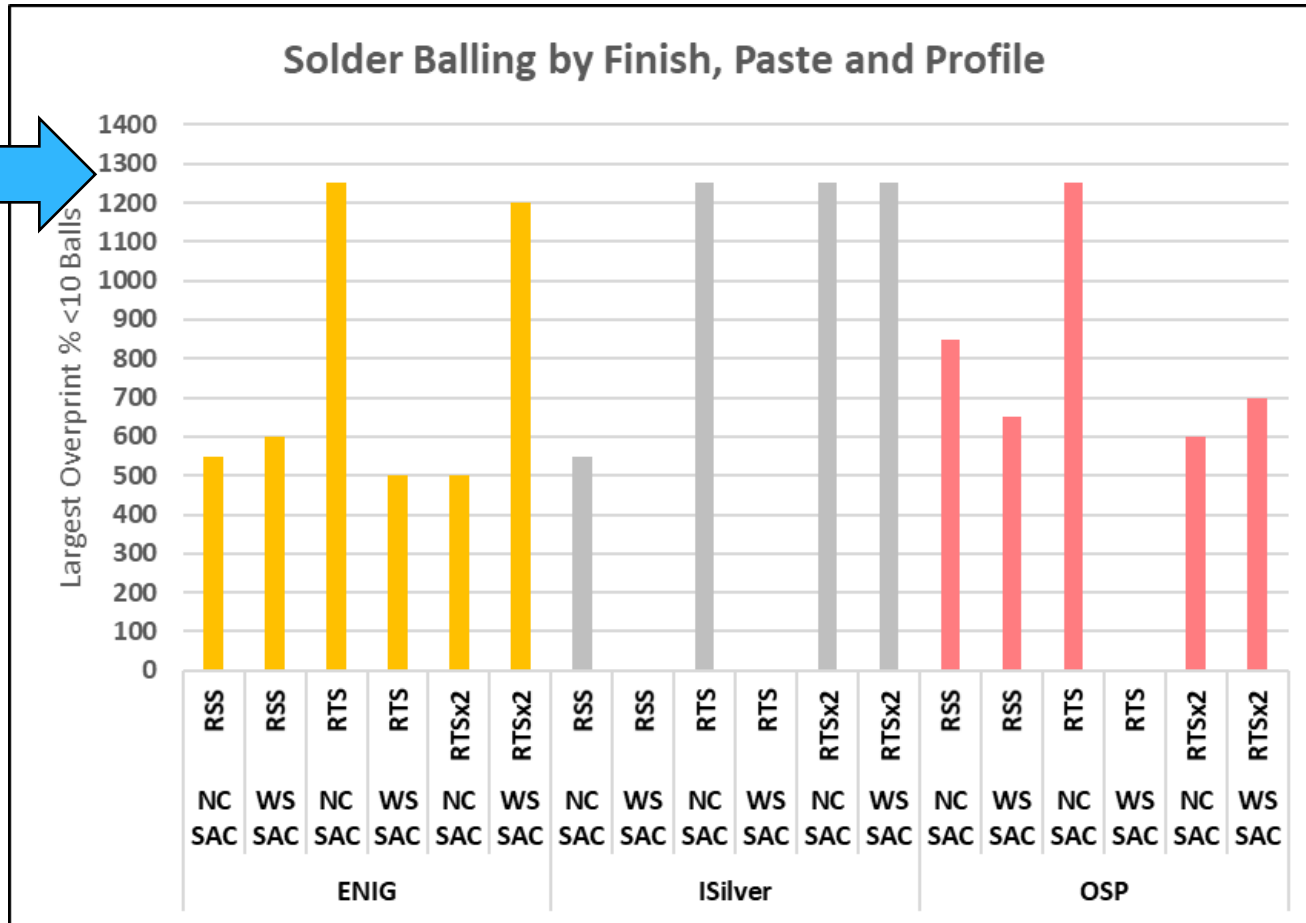


Goal = 100%

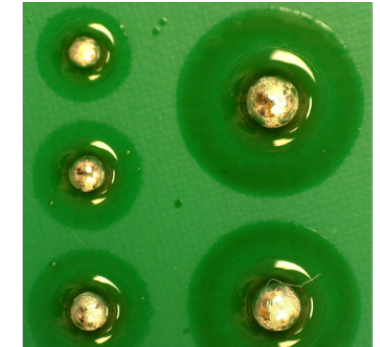


Reflow: Solder Balling

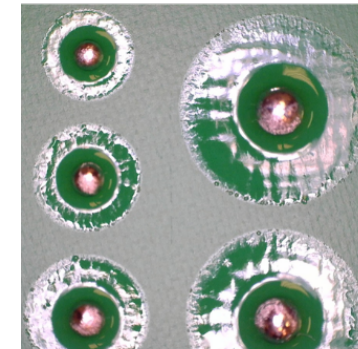
Goal



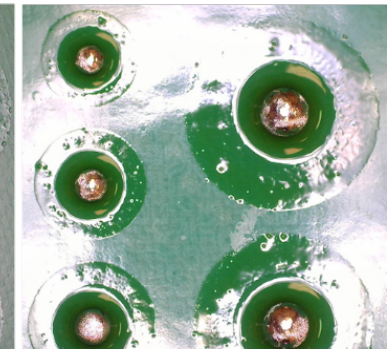
ENIG NC RTSx2



ENIG WS RTSx2



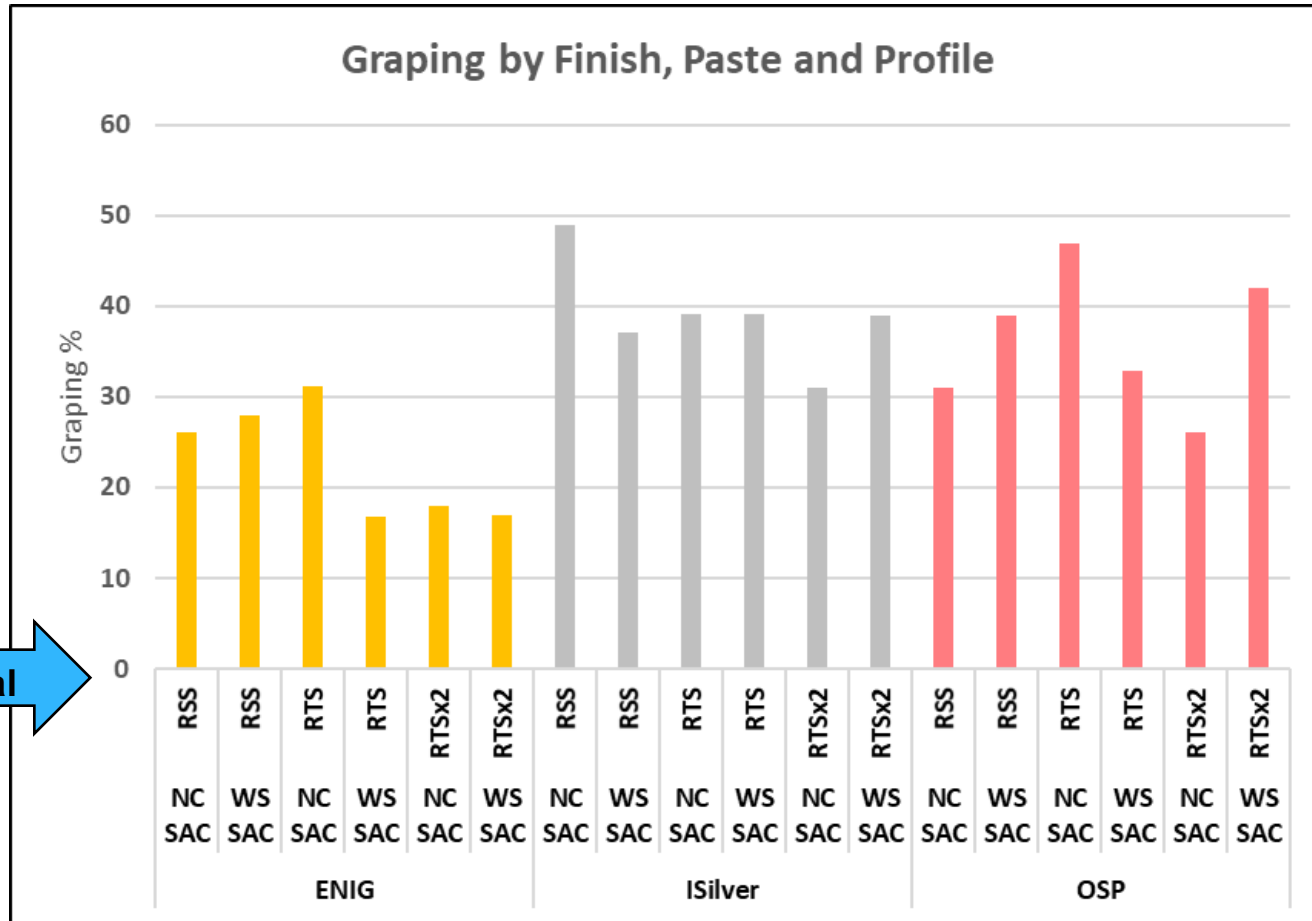
ENIG NC RSS



ISilver WS RSS

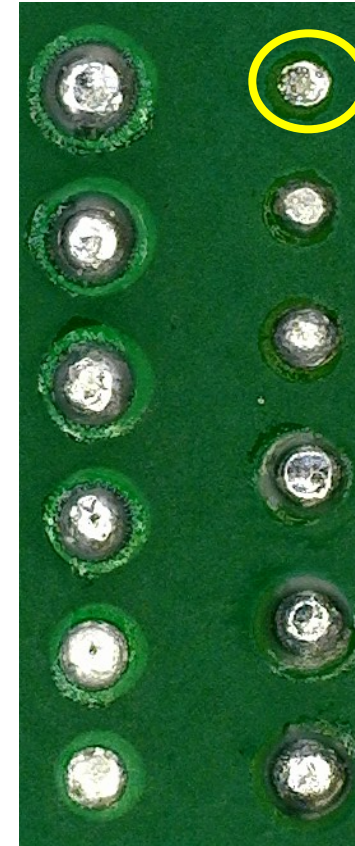
Overprint 500% to 1250%
Goal = 1250% Overprint

Reflow: Graping

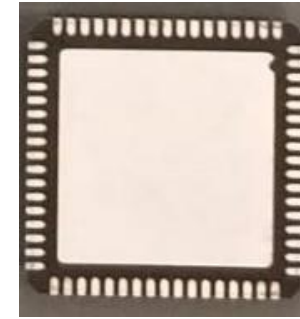
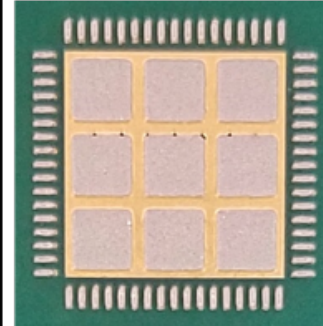
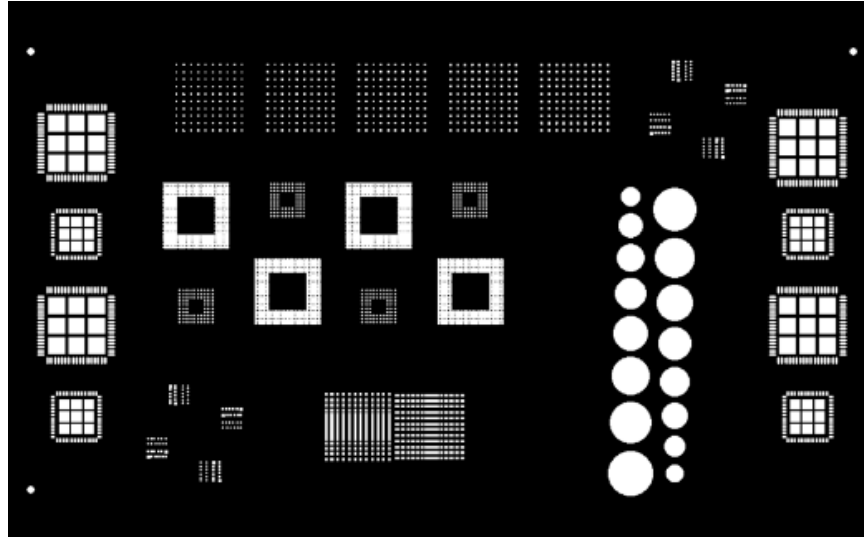


Goal

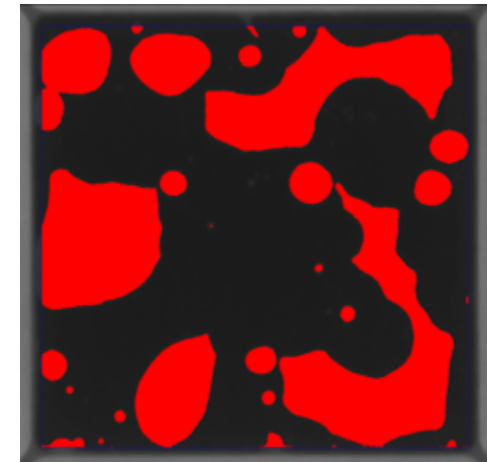
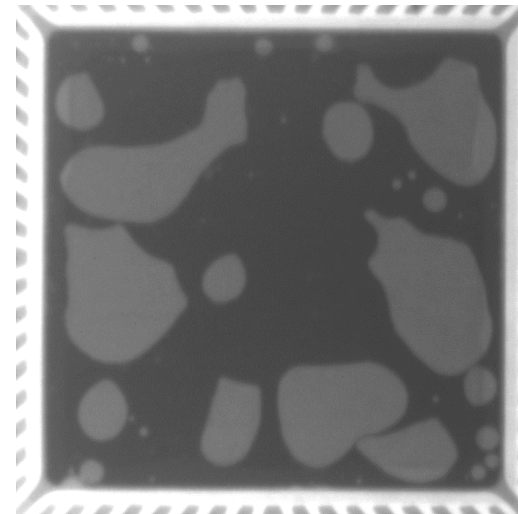
Goal = 0% Graping



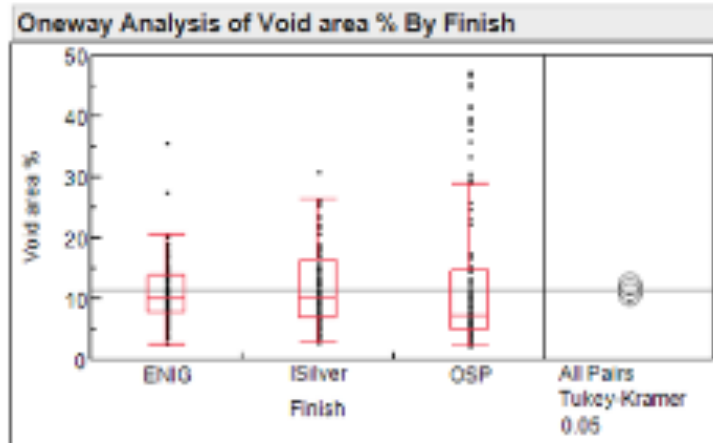
Voiding Results



Goal = 0% Void Area



Voiding: Finish, Paste, Profile



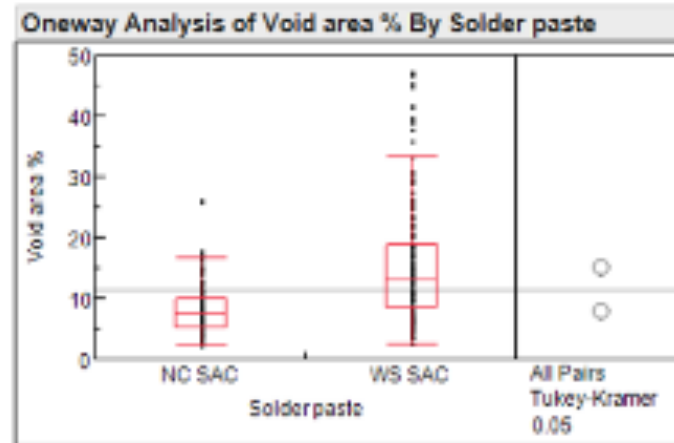
Means Comparisons

Comparisons for all pairs using Tukey-Kramer HSD

Connecting Letters Report

Level	Mean
OSP A	12.6
ISilver A	11.7
ENG A	11.0

Levels not connected by same letter are significantly different.



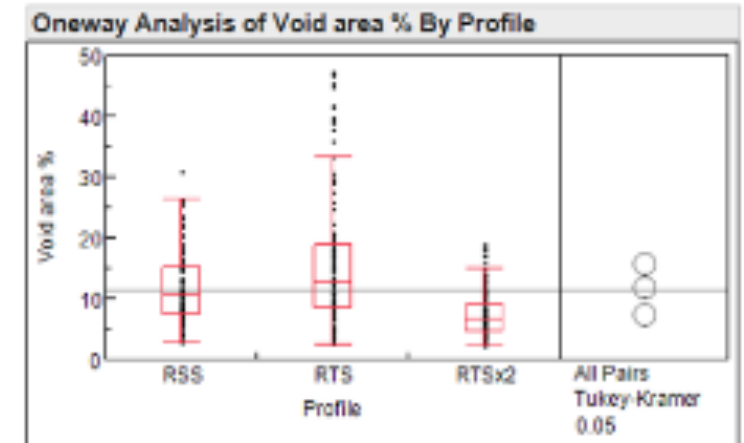
Means Comparisons

Comparisons for all pairs using Tukey-Kramer HSD

Connecting Letters Report

Level	Mean
WS SAC A	15.4
NC SAC B	8.1

Levels not connected by same letter are significantly different.



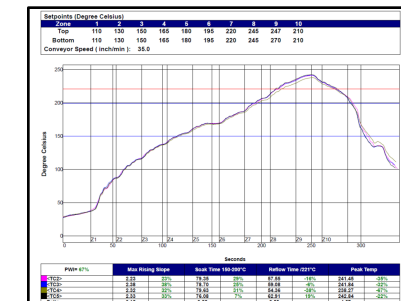
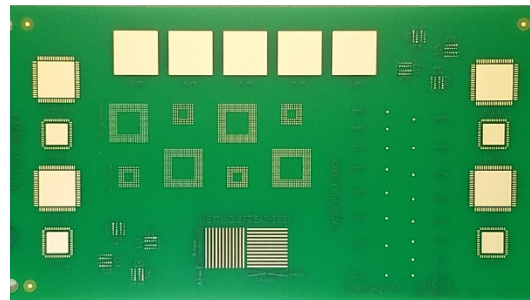
Means Comparisons

Comparisons for all pairs using Tukey-Kramer HSD

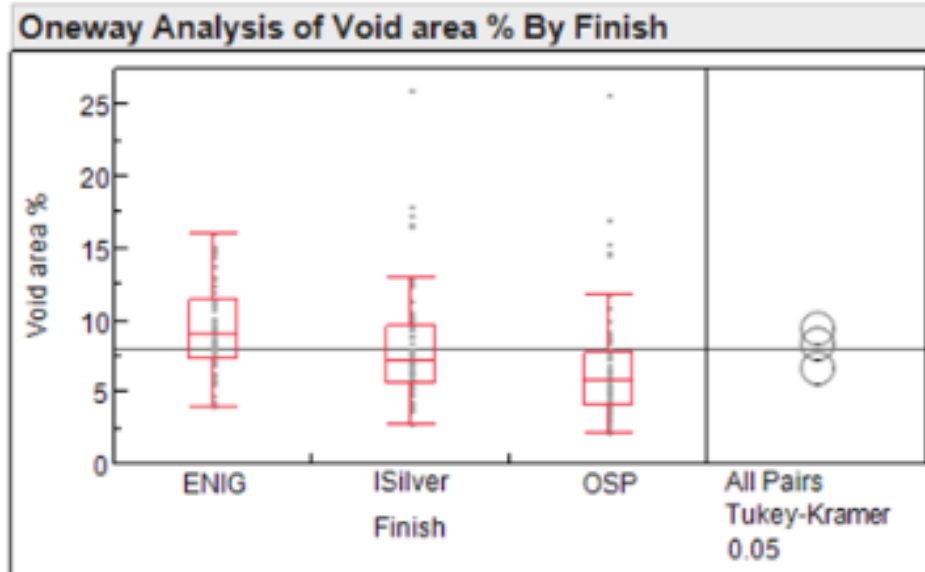
Connecting Letters Report

Level	Mean
RTS A	15.9
RSS B	11.9
RTSx2 C	7.5

Levels not connected by same letter are significantly different.



Voiding: Paste and Finish



Excluded Rows 180

Means Comparisons

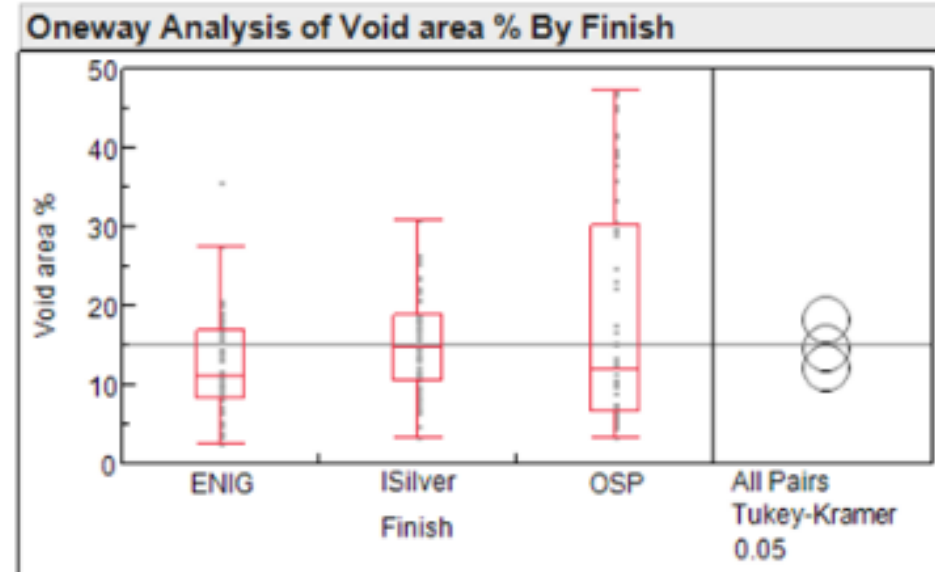
Comparisons for all pairs using Tukey-Kramer HSD

Connecting Letters Report

Level	Mean
ENIG A	9.4
ISilver A	8.3
OSP B	6.7

Levels not connected by same letter are significantly different.

No Clean



Excluded Rows 180

Means Comparisons

Comparisons for all pairs using Tukey-Kramer HSD

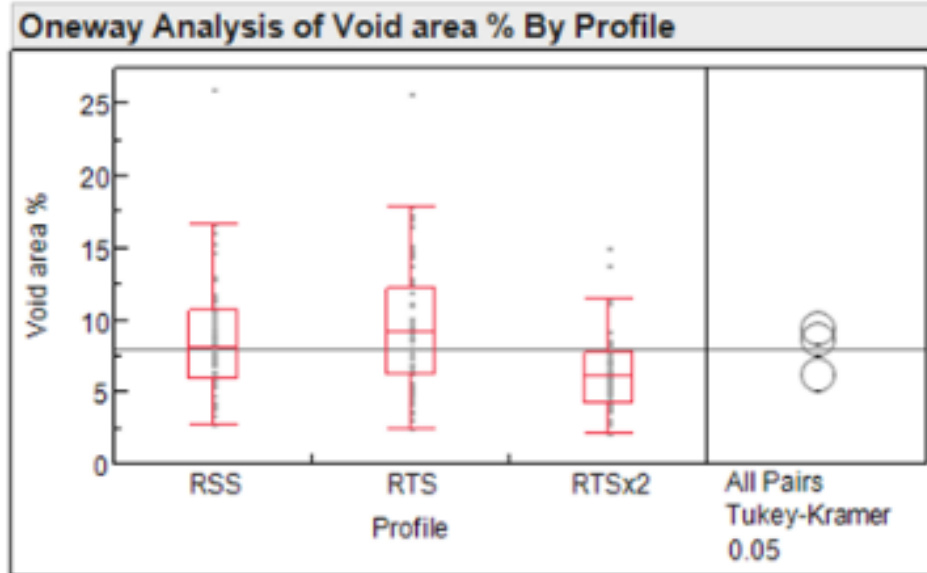
Connecting Letters Report

Level	Mean
OSP A	18.5
ISilver A B	15.1
ENIG B	12.5

Levels not connected by same letter are significantly different.

Water Soluble

Voiding: Paste and Profile



Excluded Rows 180

Means Comparisons

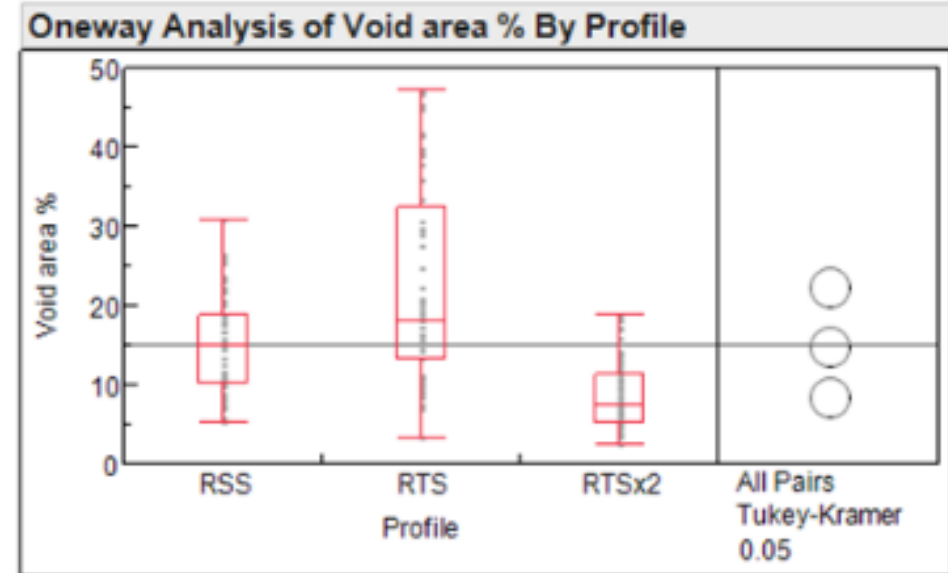
Comparisons for all pairs using Tukey-Kramer HSD

Connecting Letters Report

Level	Mean
RTS A	9.4
RSS A	8.7
RTSx2 B	6.2

Levels not connected by same letter are significantly different.

No Clean



Excluded Rows 180

Means Comparisons

Comparisons for all pairs using Tukey-Kramer HSD

Connecting Letters Report

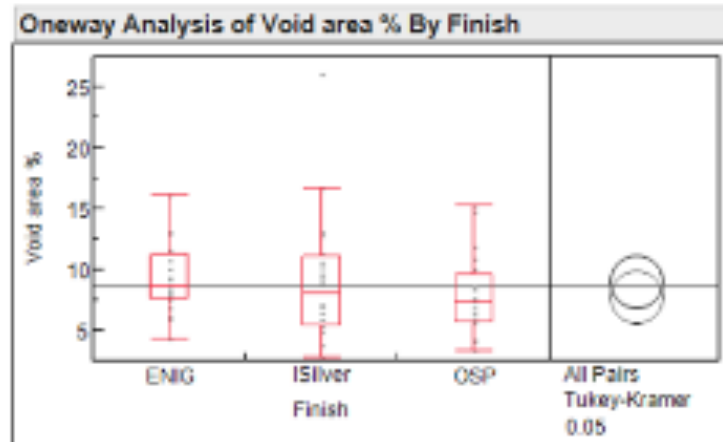
Level	Mean
RTS A	22.5
RSS B	15.0
RTSx2 C	8.7

Levels not connected by same letter are significantly different.

Water Soluble

Voiding: No Clean by Profile & Finish

RSS



Excluded Rows 300

Means Comparisons

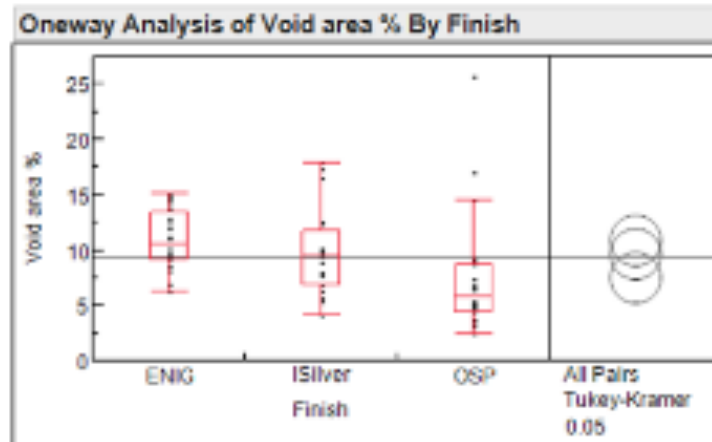
Comparisons for all pairs using Tukey-Kramer HSD

Connecting Letters Report

Level	Mean
ENG A	9.2
ISilver A	9.2
OSP A	7.9

Levels not connected by same letter are significantly different.

RTS



Excluded Rows 300

Means Comparisons

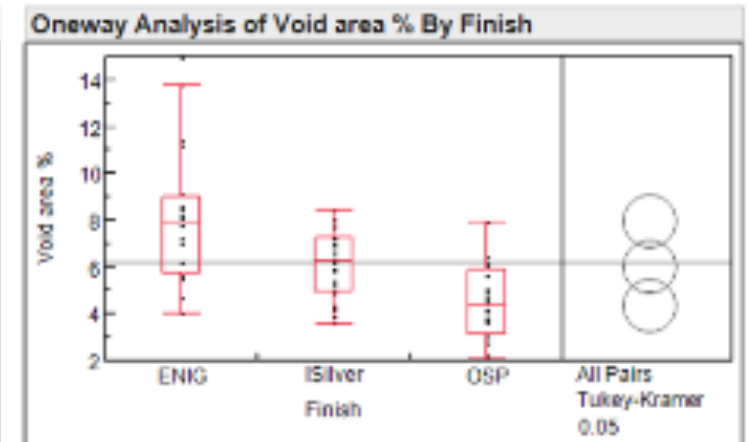
Comparisons for all pairs using Tukey-Kramer HSD

Connecting Letters Report

Level	Mean
ENG A	11.0
ISilver A B	9.7
OSP B	7.7

Levels not connected by same letter are significantly different.

RTSx2



Excluded Rows 300

Means Comparisons

Comparisons for all pairs using Tukey-Kramer HSD

Connecting Letters Report

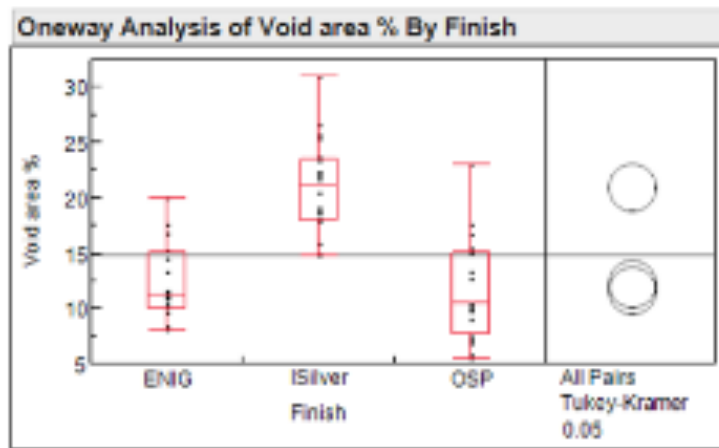
Level	Mean
ENG A	8.1
ISilver B	6.1
OSP C	4.5

Levels not connected by same letter are significantly different.

RTS and RTSx2 Profiles Gave Different Voiding by Finish

Voiding: Water Soluble by Profile & Finish

RSS



Excluded Rows 300

Means Comparisons

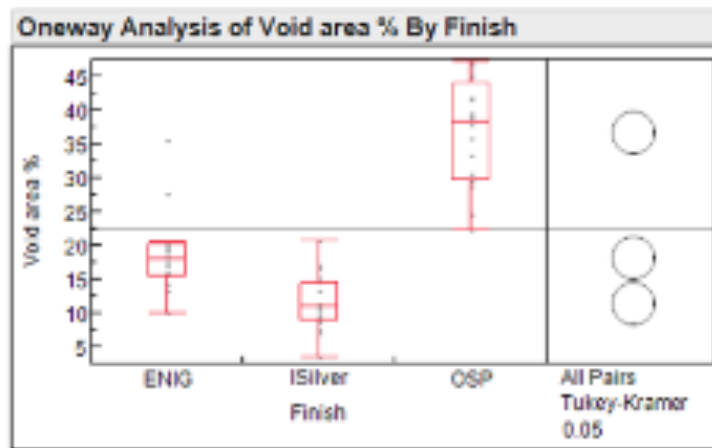
Comparisons for all pairs using Tukey-Kramer HSD

Connecting Letters Report

Level	Mean
ISilver A	21.0
ENG B	12.3
OSP B	11.7

Levels not connected by same letter are significantly different.

RTS



Excluded Rows 300

Means Comparisons

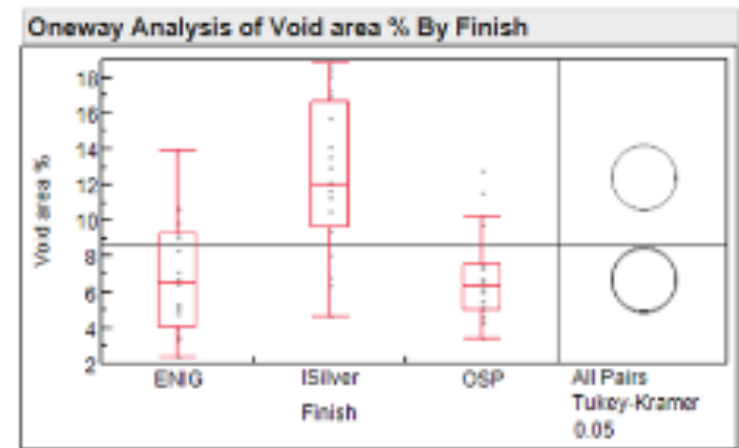
Comparisons for all pairs using Tukey-Kramer HSD

Connecting Letters Report

Level	Mean
OSP A	37.1
ENG B	18.4
ISilver C	11.9

Levels not connected by same letter are significantly different.

RTSx2



Excluded Rows 300

Means Comparisons

Comparisons for all pairs using Tukey-Kramer HSD

Connecting Letters Report

Level	Mean
ISilver A	12.4
OSP B	6.9
ENG B	6.8

Levels not connected by same letter are significantly different.

All 3 Profiles Gave Different Voiding by Finish

Scoring System

HOME **10:37** **VISITOR**

28  **QTR 4** **23**

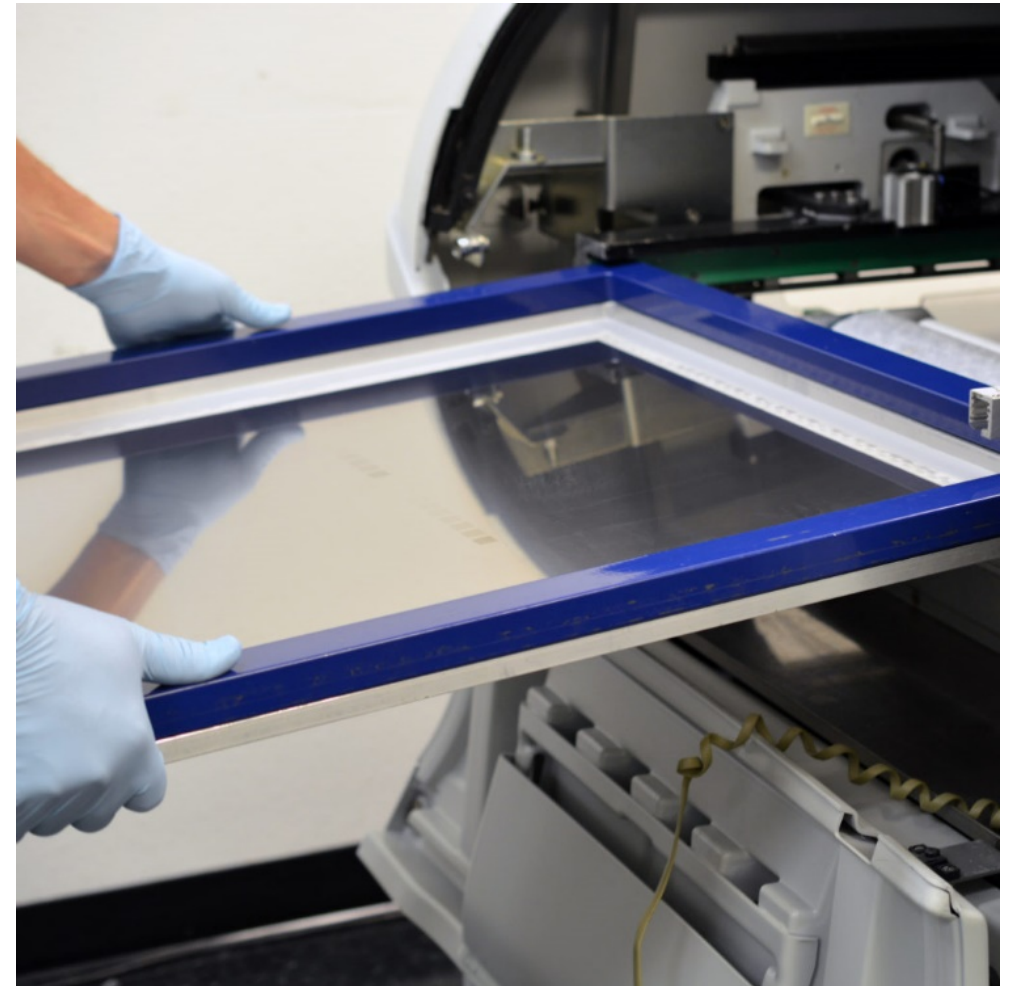
3 **DOWN** *Fair-Play* **TO GO** **10**
A TRANS-LUX COMPANY

Scoring System

	Print 0.4 mm BGA		Print 0.50 AR Pattern		Reflow			Voiding	
Score	TE%	CV%	TE%	CV%	Wetting %	Solder Balling	Graping %	Void Area %	Largest Void %
1	<50	>15	<40	>20	0-20	none	41-50	>25	>5.0
2	51-57	10-14	41-45	16-20	21-40	500-650	31-40	16-25	3.1-5.0
3	58-64	8-9	46-50	11-15	41-60	700-850	21-30	11-15	2.1-3.0
4	65-70	6-7	51-55	8-10	61-80	900-1050	11-20	6-10	1.1-2.0
5	>70	0-5	>55	<8	81-100	1100-1250	0-10	1-5	0-1.0

Scores - Printing

Print Speed (mm/sec)	Surface Finish	Solder Paste	Total Print Score
50	ENIG	NC SAC	12
25	ENIG	NC SAC	10
50	OSP	NC SAC	10
100	ISilver	NC SAC	9
25	ISilver	NC SAC	7
25	OSP	NC SAC	7
25	OSP	WS SAC	7
50	ISilver	NC SAC	7
100	ENIG	NC SAC	7
100	OSP	NC SAC	7
50	ENIG	WS SAC	6
25	ENIG	WS SAC	5
50	ISilver	WS SAC	5
25	ISilver	WS SAC	4
50	OSP	WS SAC	4
100	ENIG	WS SAC	N/A
100	ISilver	WS SAC	N/A
100	OSP	WS SAC	N/A



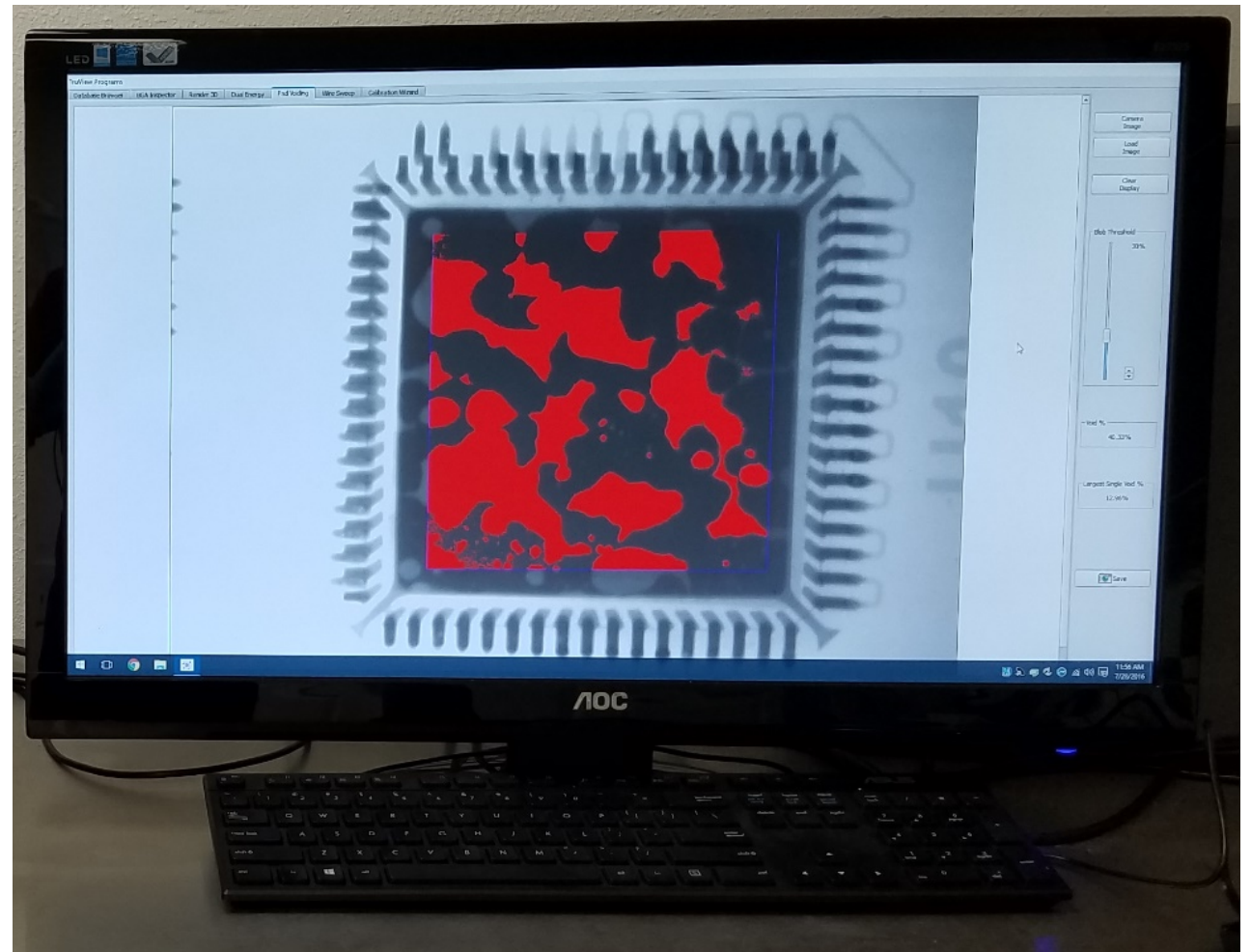
Scores - Reflow

Surface Finish	Solder Paste	Reflow Profile	Total Reflow Score
ENIG	WS SAC	RTSx2	14
ISilver	WS SAC	RTSx2	12
ENIG	NC SAC	RTS	11
ENIG	WS SAC	RTS	11
ENIG	NC SAC	RTSx2	11
ENIG	WS SAC	RSS	10
ISilver	NC SAC	RTS	10
ENIG	NC SAC	RSS	9
ISilver	NC SAC	RTSx2	9
ISilver	WS SAC	RTS	8
ISilver	WS SAC	RSS	7
OSP	NC SAC	RTS	7
ISilver	NC SAC	RSS	6
OSP	NC SAC	RSS	6
OSP	WS SAC	RSS	6
OSP	NC SAC	RTSx2	6
OSP	WS SAC	RTS	4
OSP	WS SAC	RTSx2	4



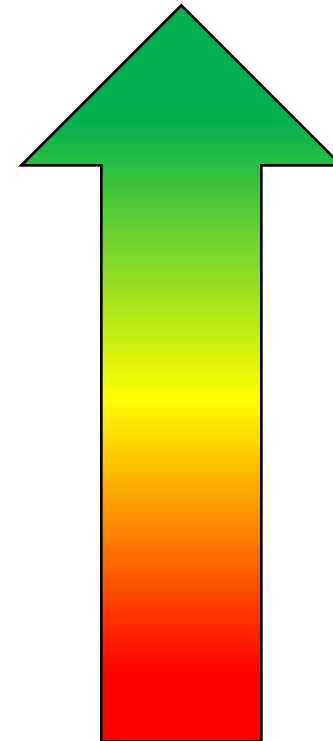
Scores - Voiding

Surface Finish	Solder Paste	Reflow Profile	Total Voiding Score
OSP	NC SAC	RTSx2	10
ENIG	NC SAC	RSS	8
ISilver	NC SAC	RSS	8
OSP	NC SAC	RSS	8
OSP	NC SAC	RTS	8
ENIG	NC SAC	RTSx2	8
ISilver	NC SAC	RTSx2	8
ENIG	WS SAC	RTSx2	8
OSP	WS SAC	RTSx2	8
ISilver	NC SAC	RTS	7
ENIG	WS SAC	RSS	7
ENIG	NC SAC	RTS	6
OSP	WS SAC	RSS	6
ISilver	WS SAC	RTS	6
ISilver	WS SAC	RTSx2	6
ENIG	WS SAC	RTS	5
ISilver	WS SAC	RSS	4
OSP	WS SAC	RTS	2



Scores - Overall



















Surface Finish	Solder Paste	Total Score
ENIG	NC SAC	82
ISilver	NC SAC	71
OSP	NC SAC	69
ENIG	WS SAC	66
ISilver	WS SAC	52
OSP	WS SAC	41



Conclusions



Strengths and Weaknesses of Each Combination

Surface Finish - Solder Paste	Printing	Reflow	Voiding
ENIG - NC SAC			
ISilver - NC SAC			
OSP - NC SAC			
ENIG - WS SAC			
ISilver - WS SAC			
OSP - WS SAC			

Conclusions

- ✓ Best Overall Performance from ENIG with No Clean SAC305
- ✓ Immersion Silver Gave Moderate Performance with Both Solder Pastes
- ✓ OSP Gave the Worst Overall Performance with Both Solder Pastes

Performance can be influenced by other factors.



Thank You!

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