Performance Enhancing Nano Coatings: Changing the Rules of Stencil Design

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LEADERS IN TECHNOLOGY

Outline/Agenda

- Introduction
- Experimental Design
- Results of Experiment
- Conclusions
- Acknowledgements
- Q & A

Introduction

- Nano coatings have been in use for a few years
- Main benefit is reduced underside cleaning
- Solder paste volume is affected by Nano coatings
- Stencil design guidelines need to be adjusted

Introduction

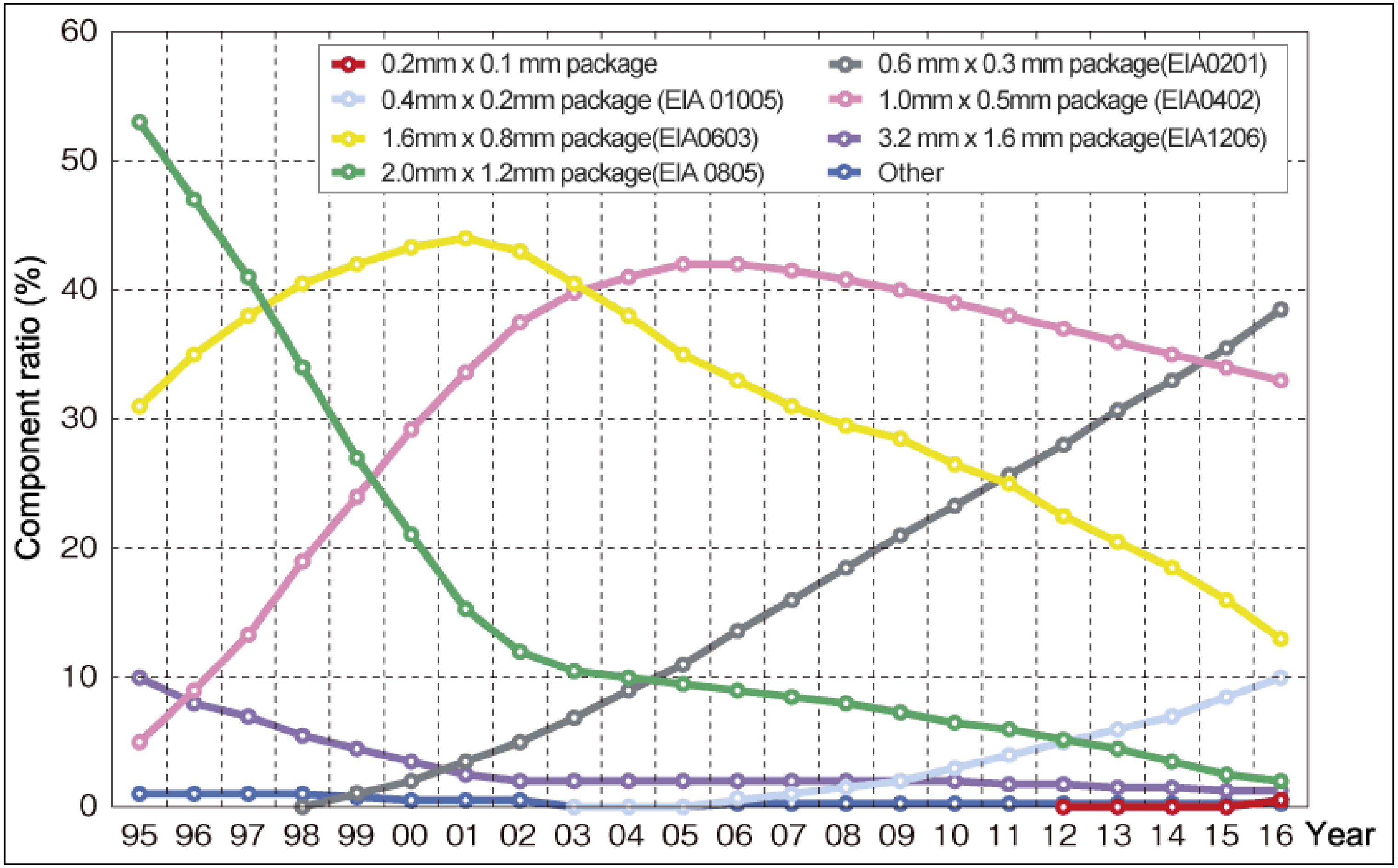
Introduction*

Nano Coating	Application	Chemistry	Surface Function	Aperture Function
Coating B	Wipe on	Self assembled monolayer	Cleaning benefit	Reduced paste volume
Coating C	Wipe on	Self assembled monolayer	Cleaning benefit	Reduced paste volume
Coating D	Spray on	Thermal cure polymer	Cleaning benefit	Increased paste volume

Note: Coating A was not evaluated in this experiment

*SMTAI 2013, Can Nano-Coatings Really Improve Stencil Performance. T. Lentz

Miniaturization Trends*



*Murata Manufacturing Company
http://www.murata.com/products/article/pp09e1/3.html

Goals

- Recommend new area ratio (SAR) guidelines for stencil design
- Give adjusted guidelines based on solder paste type
- Show how these guidelines change when Nano coatings are used

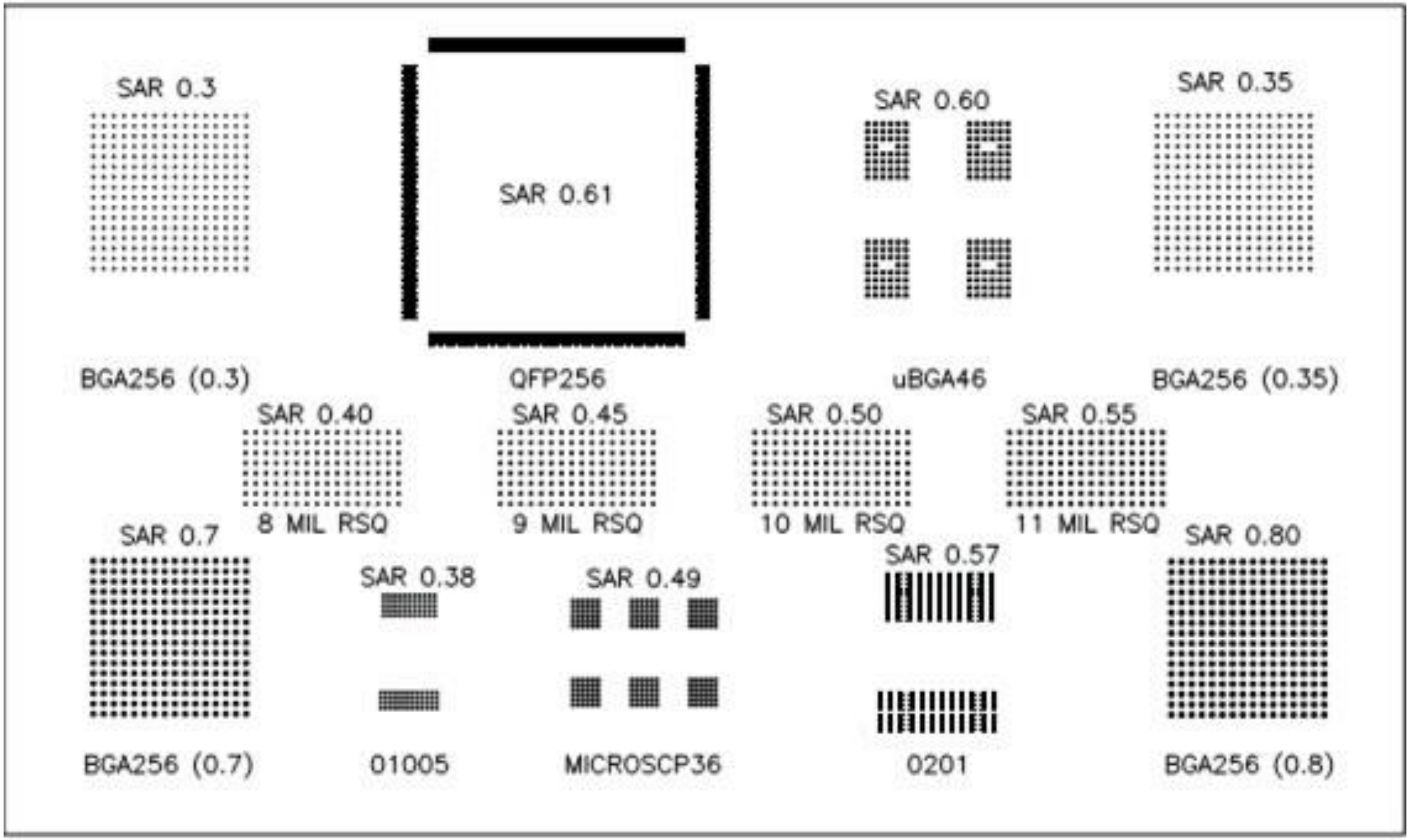
Experimental Design

- 10 circuit board print study
  - No underside cleaning
- 6 different solder pastes
  - Water soluble vs. no clean
  - Leaded vs. lead-free
  - Type 3, 4, and 5 solder powders
- 3 Nano-coated stencils vs. uncoated stencil

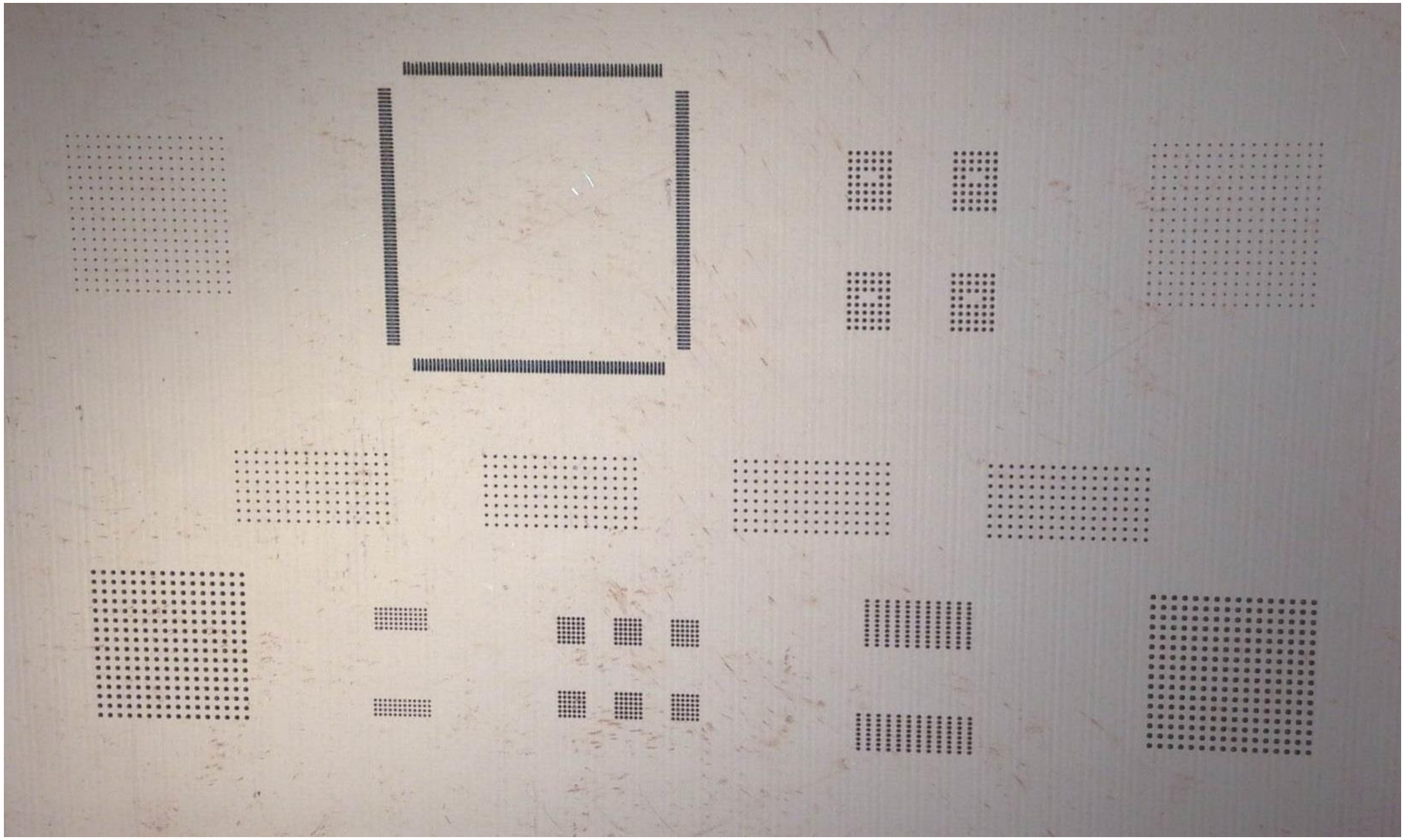
Experimental Design

- **Essemtec printer**
  - 20 mm/sec, 0.18 Kg/cm, 1.5 mm/sec
- **ASC International SPI**
  - AP212 with VM150 sensor
- **Stencils, 304 SS, 8-9 μm grain**
  - 0.005” (127 microns) thick
- **Circuit board, copper clad FR-4**
  - 0.059” thick, 0.5/0.5 oz. copper, 6.0” x 3.75”

Experimental Design



Experimental Design



Experimental Design

Area Ratio (SAR)	Component	Aperture Size (mils)	Aperture Shape	Aperture Volume (mil³)	# Bricks Measured per Print
0.300	BGA	6	RSQ	180	128
0.350	BGA	7	RSQ	245	128
0.380	01005	7.5	RSQ	281	103
0.400	BGA	8	RSQ	320	128
0.450	BGA	9	RSQ	405	128
0.490	microCSP	9.8	RSQ	480	108
0.500	BGA	10	RSQ	500	128
0.550	BGA	11	RSQ	605	128
0.570	0201	10x13	Rectangle	650	103
0.600	uBGA	12	RSQ	720	184
0.610	QFP	50x7	Rectangle	1750	128
0.700	BGA	14	RSQ	980	128
0.800	BGA	16	RSQ	1280	128

Experimental Design

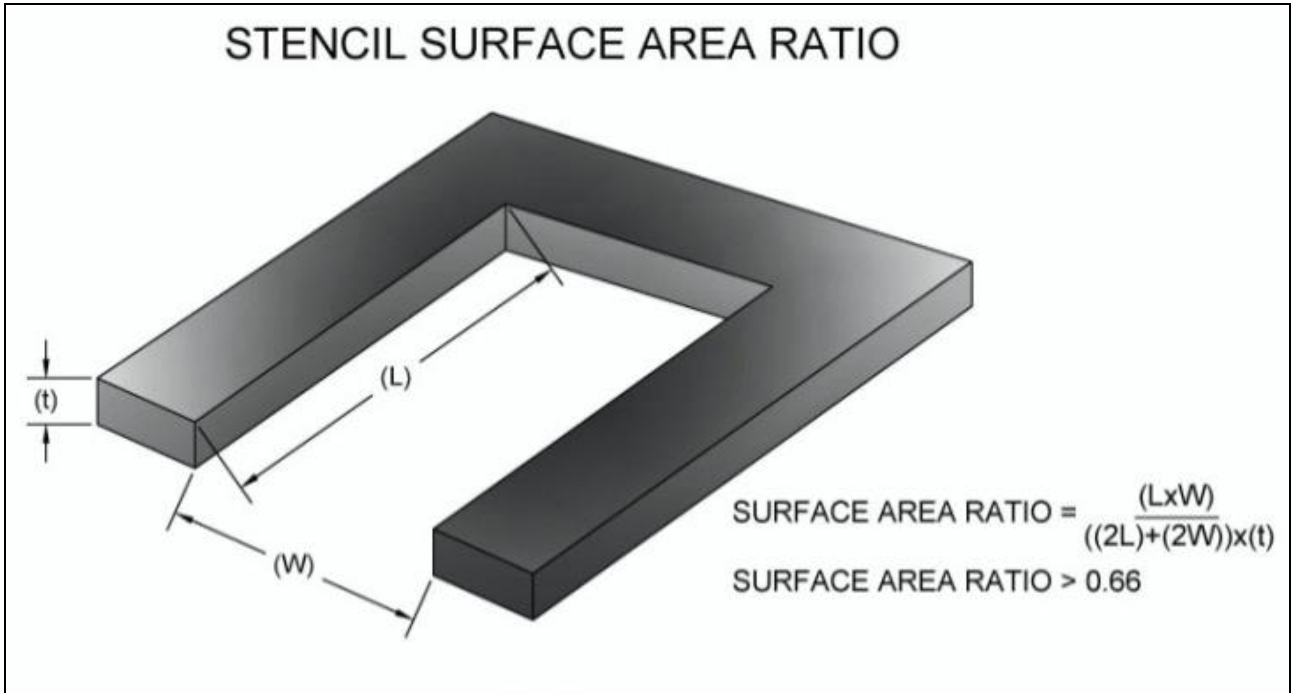
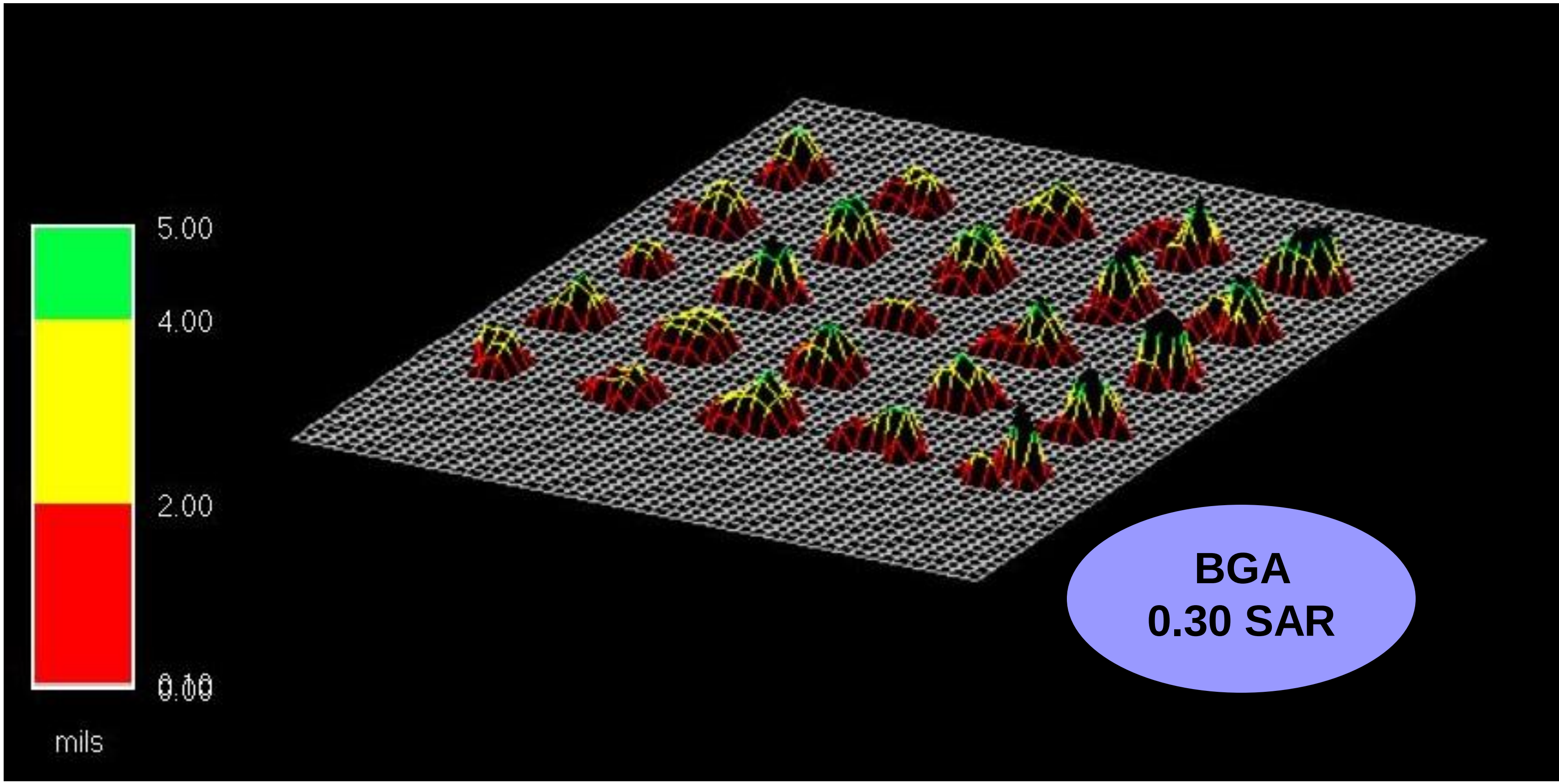


FIGURE 2

*Successful Stencil Printing: Performance is on the Surface
Robert Dervaes, FCT Assembly

Experimental Design

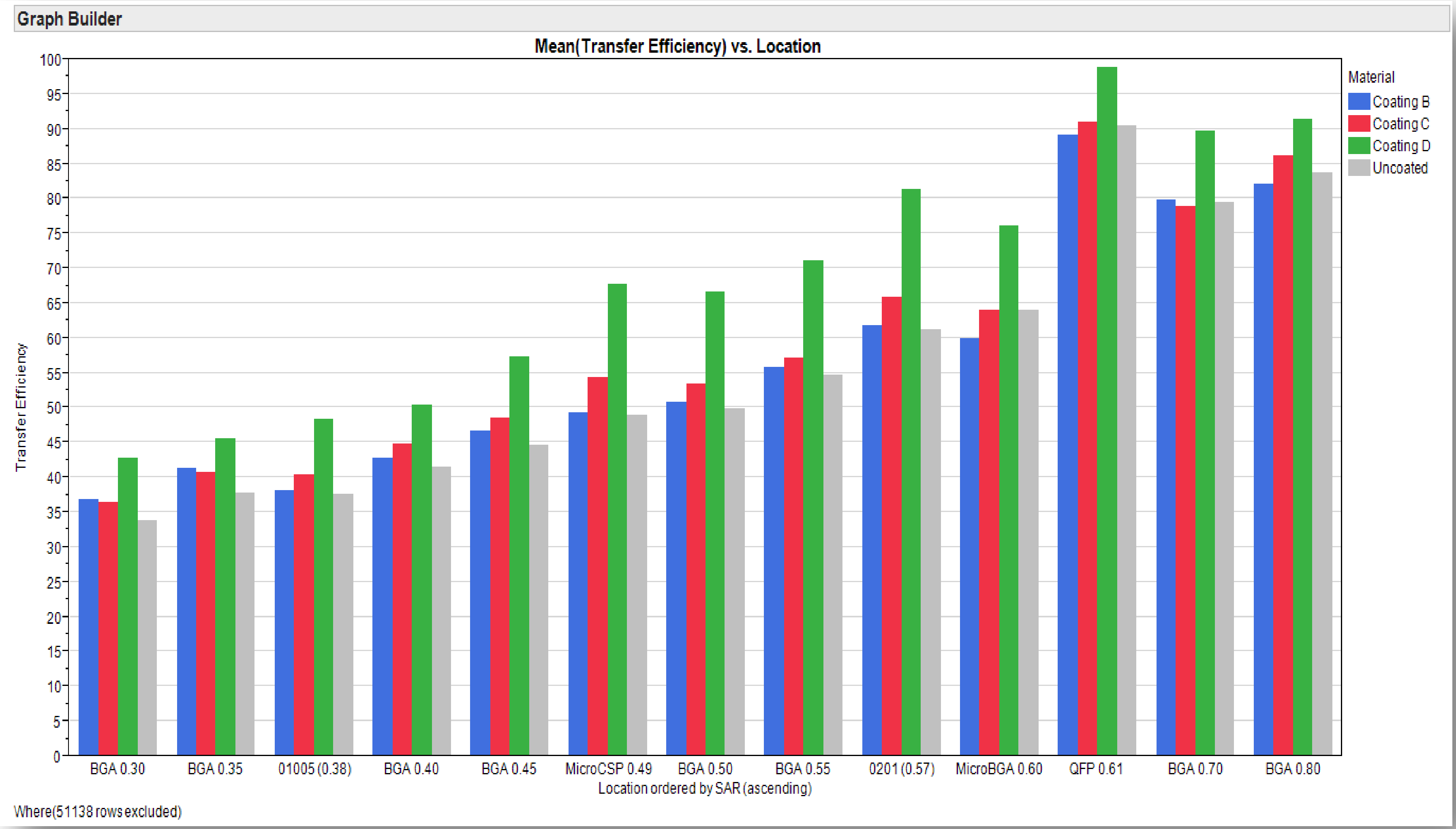


Transfer Efficiency = [(measured paste volume) / (aperture volume)] x 100%

Results of Experiment

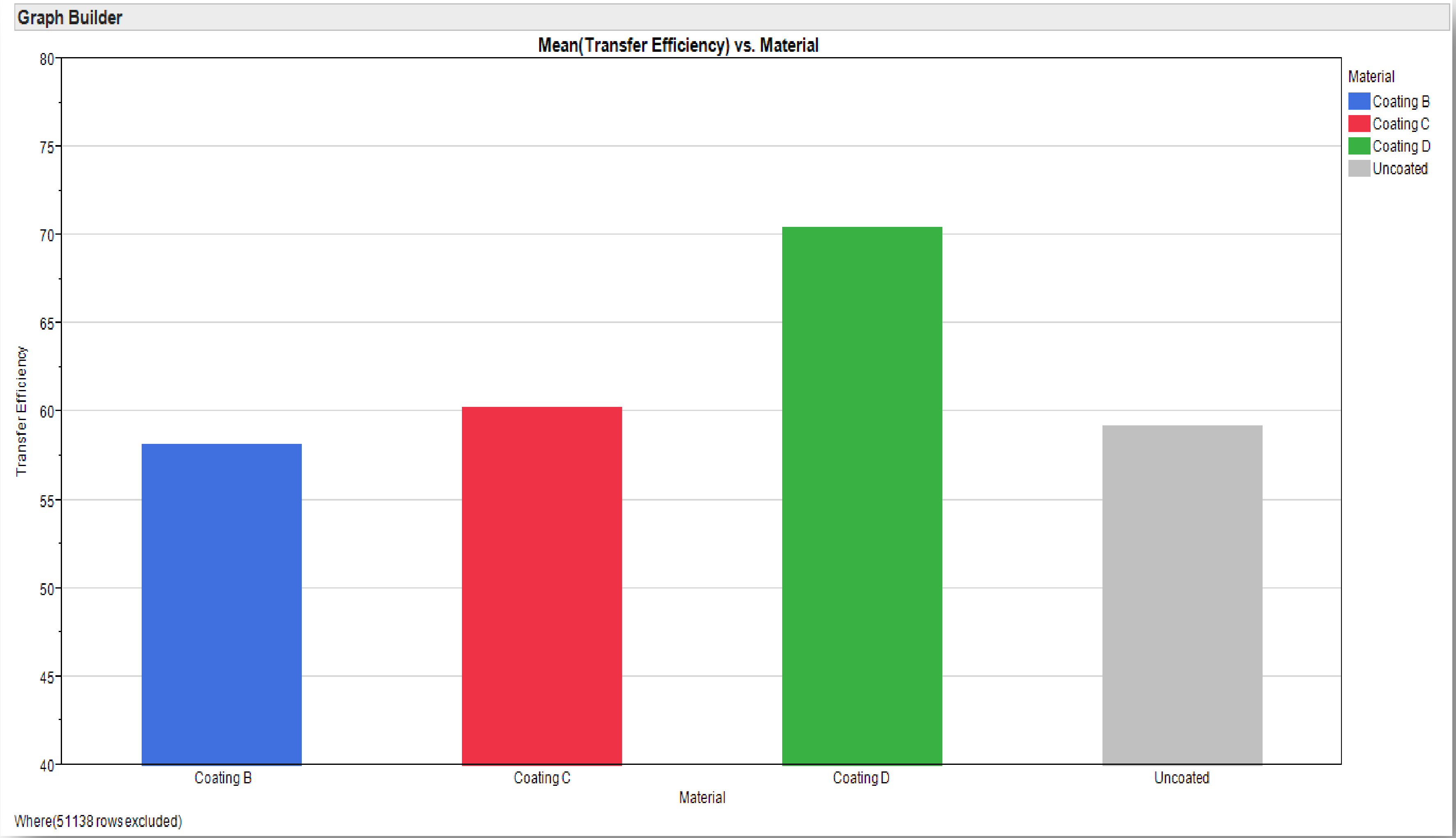
- Nano coating effects
- Solder powder variation T3, T4, T5
- No clean vs. water soluble pastes
- Leaded vs. lead-free pastes

Nano Coating Effects



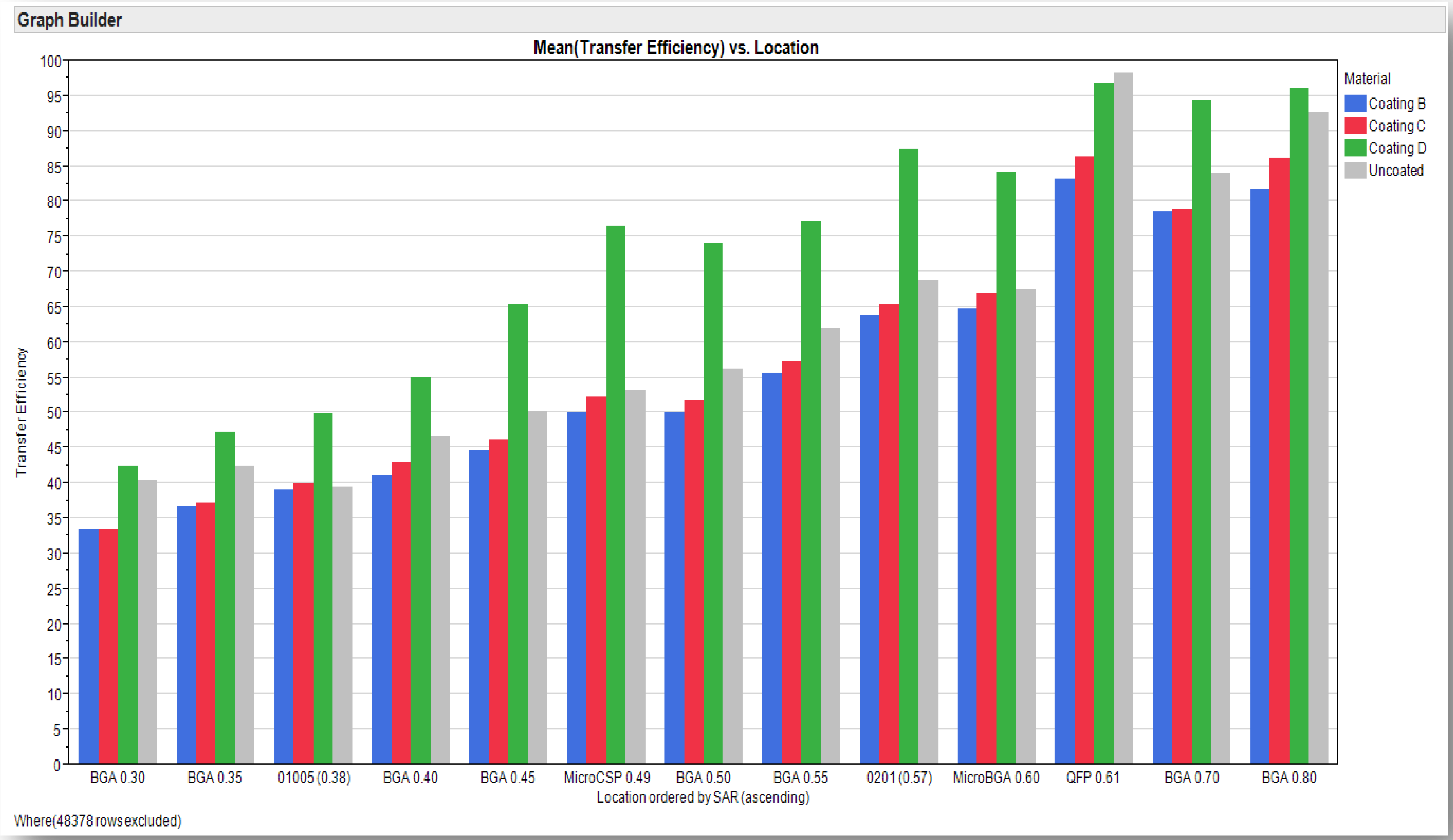
Solder paste: No Clean SAC305 Type 3

Nano Coating Effects



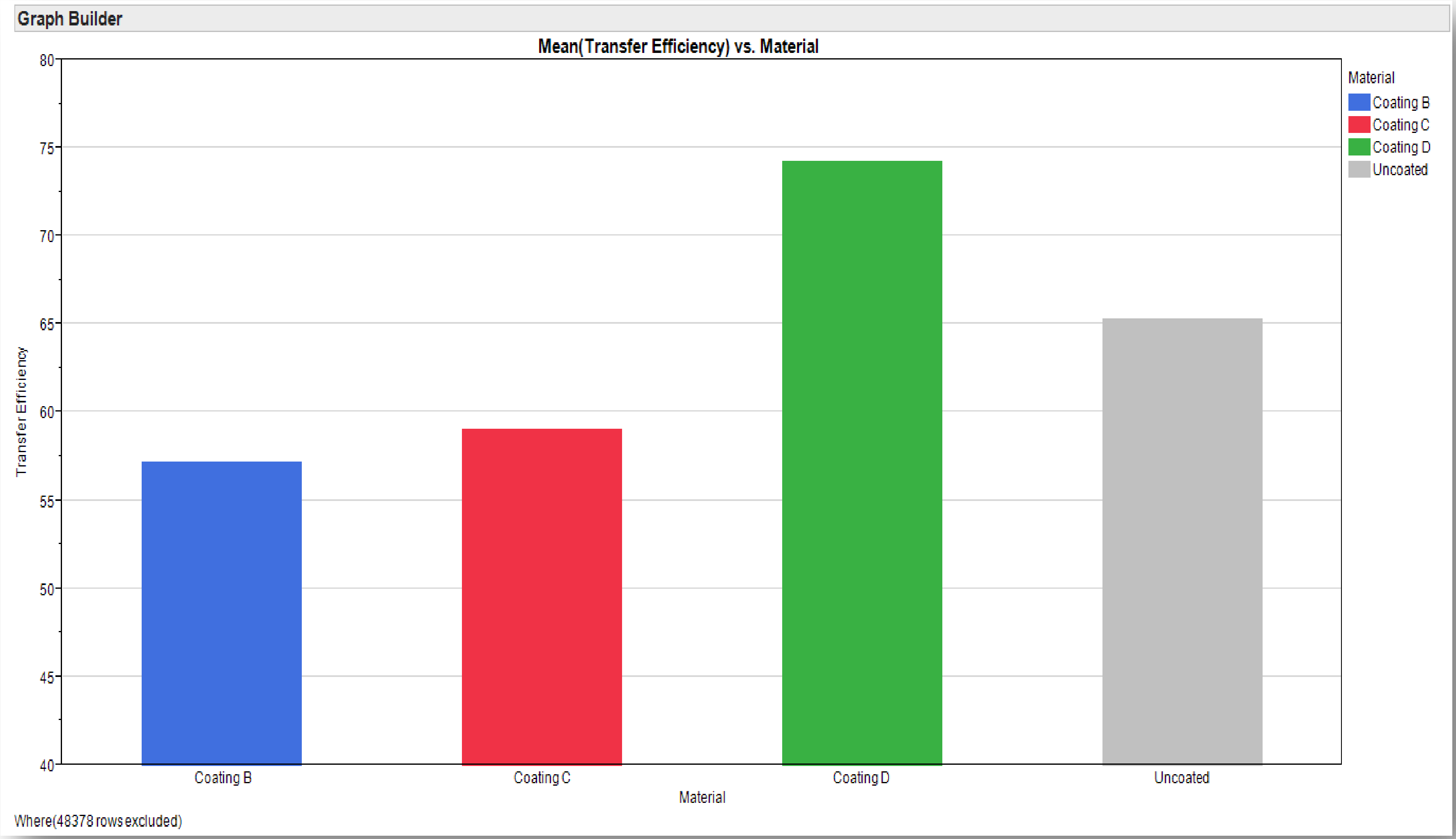
Solder paste: No Clean SAC305 Type 3 (All SARs)

Nano Coating Effects



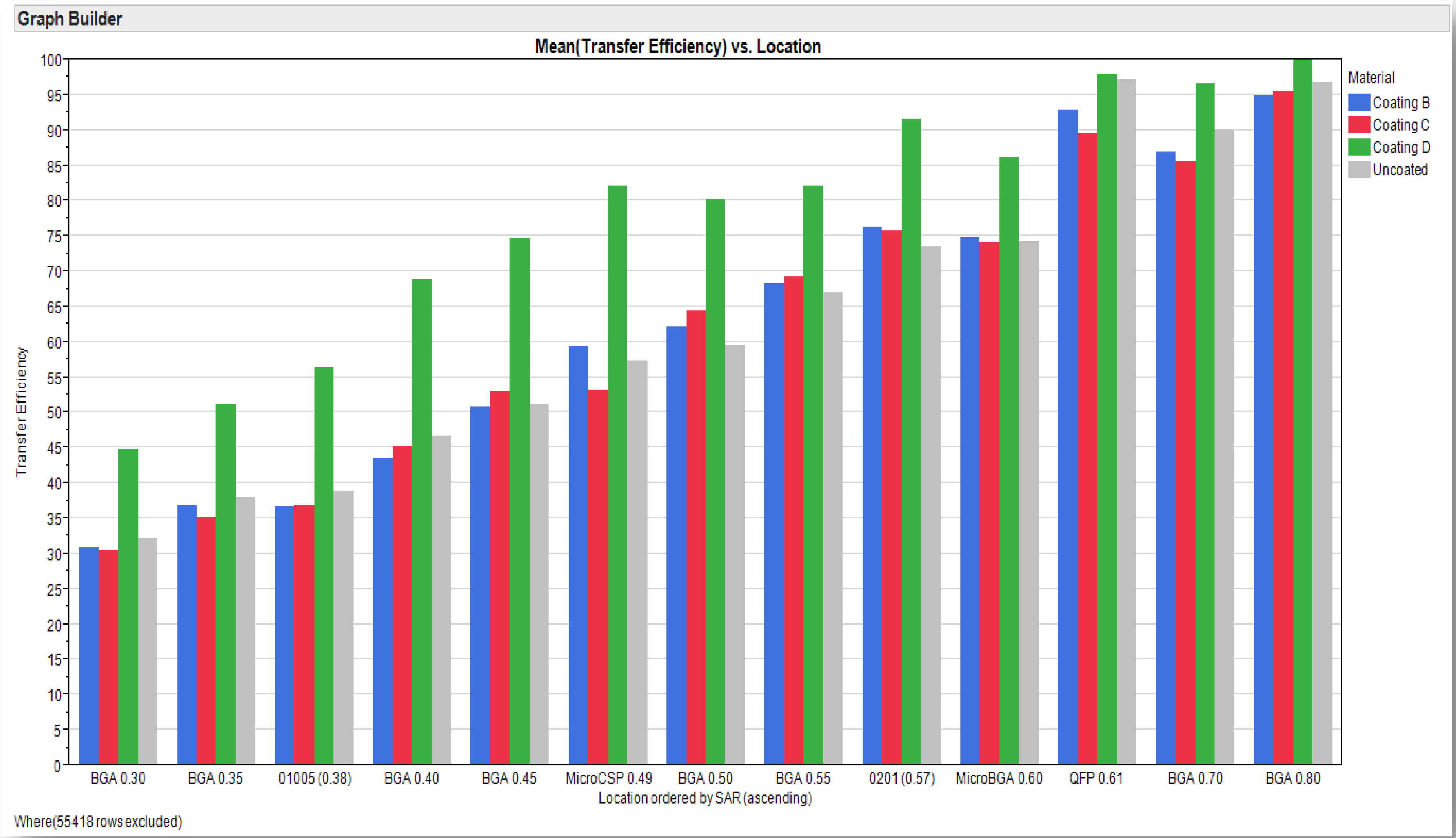
Solder paste: No Clean SAC305 Type 4

Nano Coating Effects



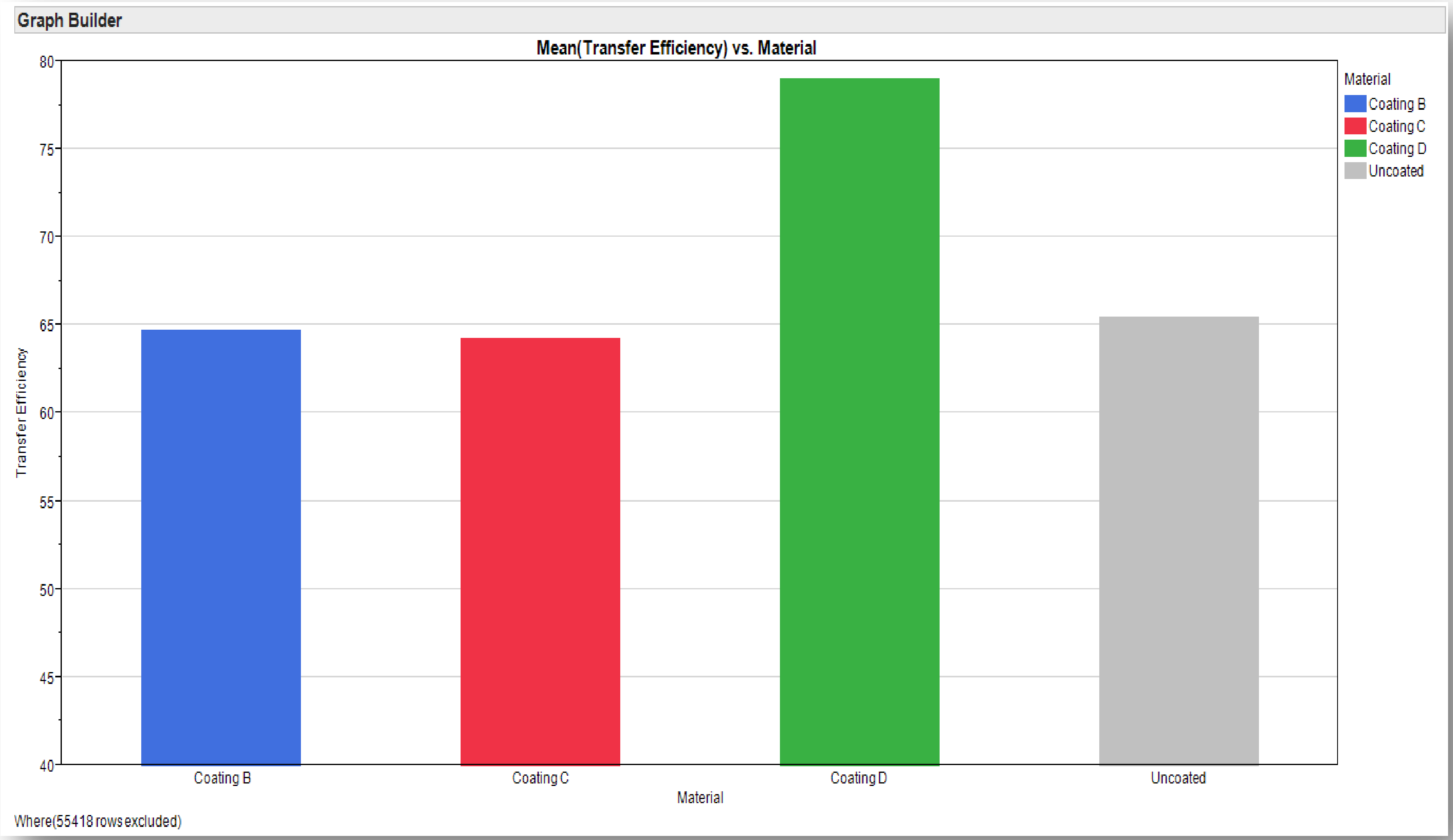
Solder paste: No Clean SAC305 Type 4 (All SARs)

Nano Coating Effects



Solder paste: No Clean SAC305 Type 5

Nano Coating Effects

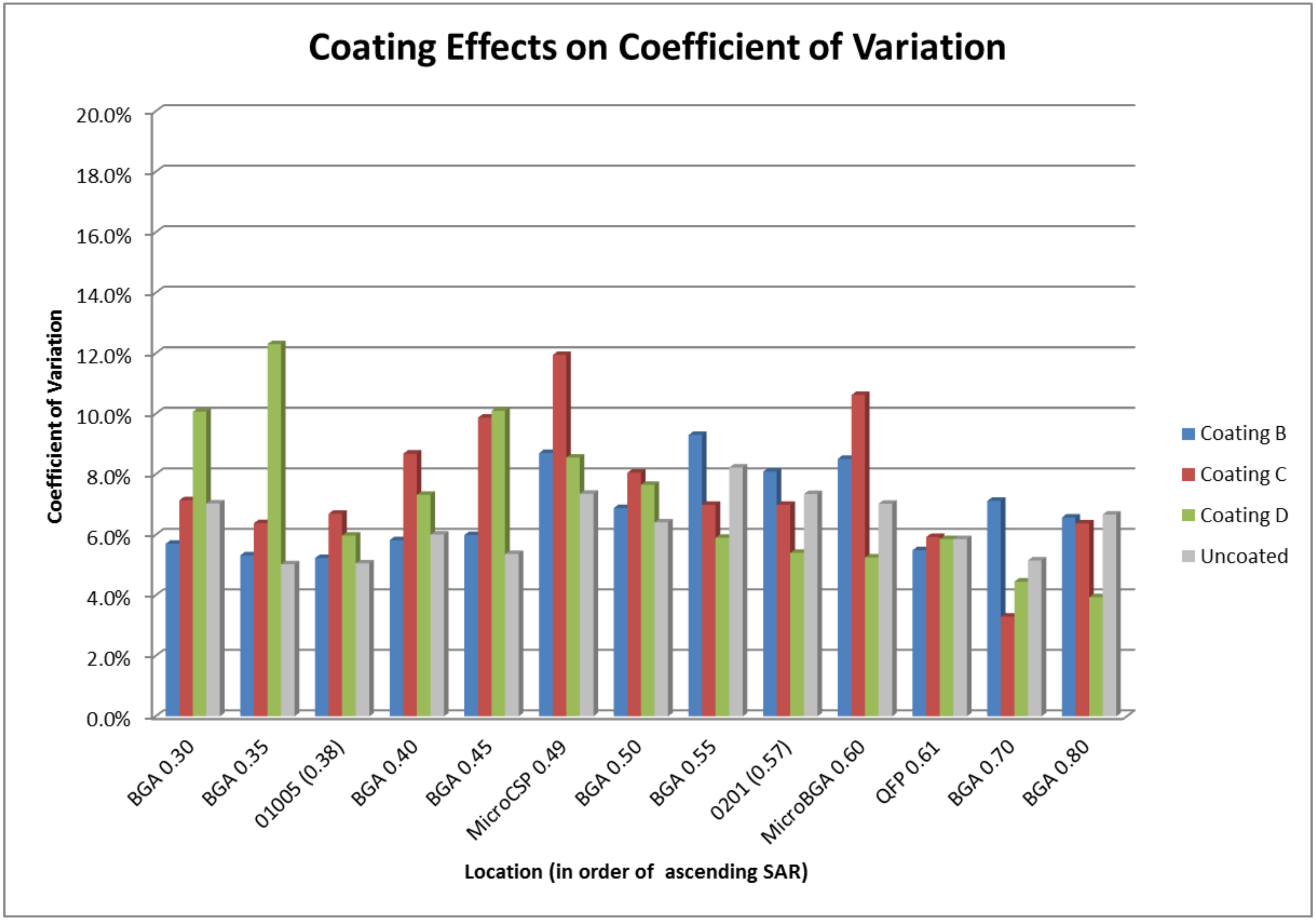


Solder paste: No Clean SAC305 Type 5 (All SARs)

Nano Coating Effects

Solder paste: No Clean SAC305 Type 3 (All SARs)

Nano Coating Effects



Solder paste: No Clean SAC305 Type 3

CV = St Dev / Mean

Nano Coating Effects

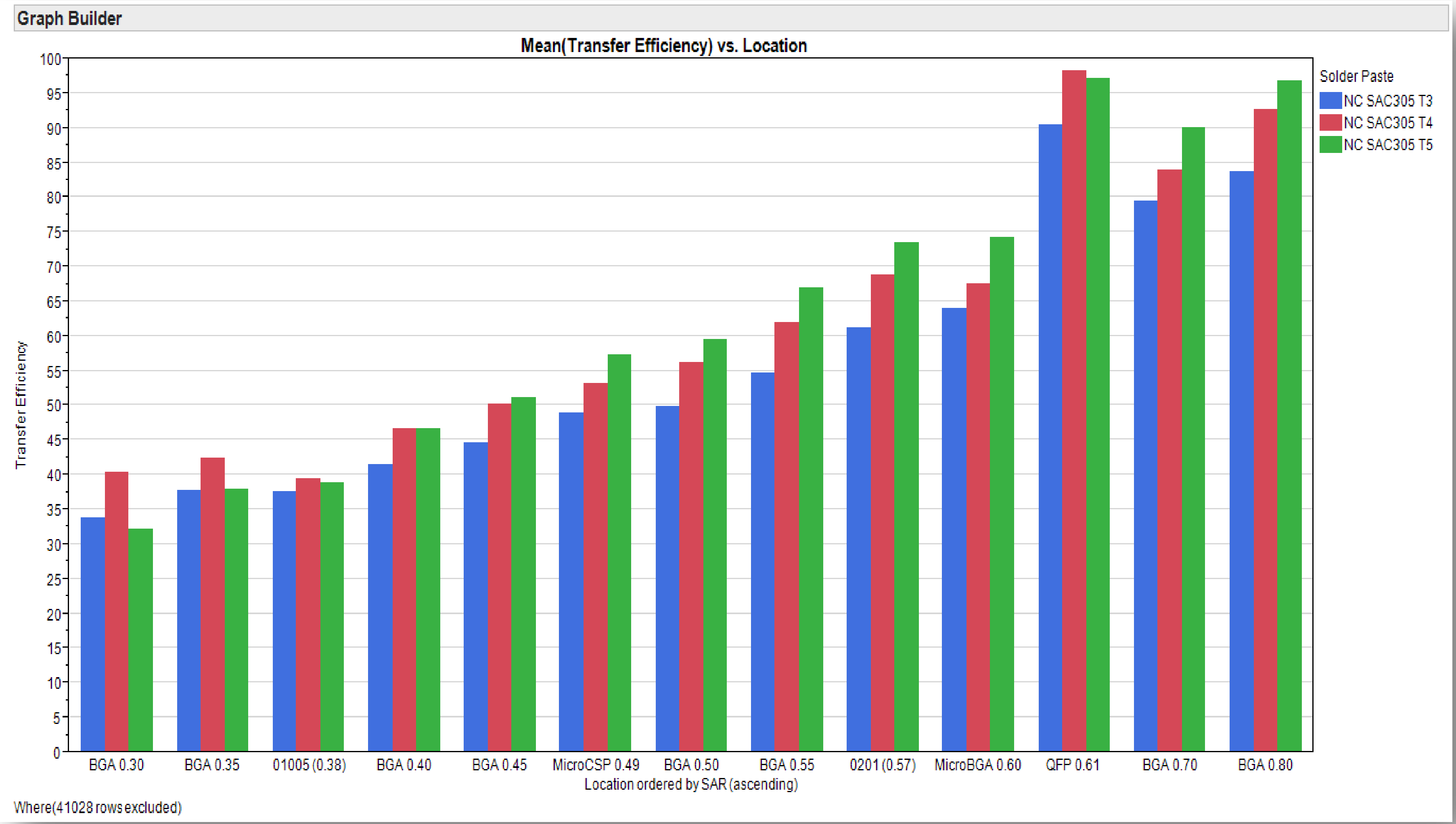
Nano Coating	Mean Transfer Efficiency (%)	Mean Coefficient of Variation (%)
Uncoated	59	6.4
Coating B	58	6.9
Coating C	60	7.7
Coating D	71	7.1

Solder paste: No Clean SAC305 Type 3

Nano Coating Effects

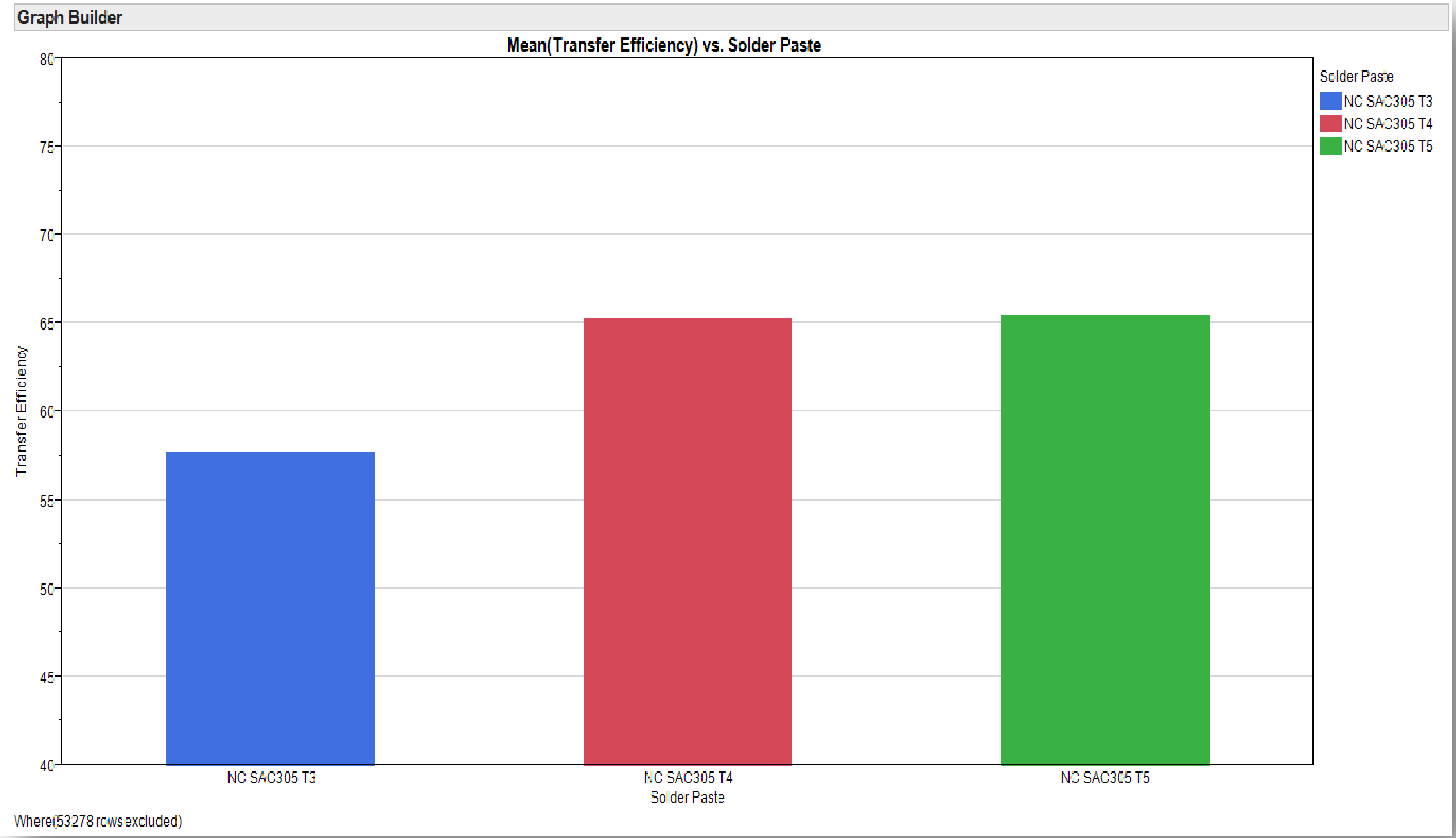
- Nano Coatings B and C have a small effect on TE%
- Nano Coating D gives an increase in TE%
- CV increased slightly by all nano coatings, but all < 10%
- Print to print variation was reduced by Coating D

Solder Powder Variation



Solder paste: No Clean SAC305 Type 3, 4, 5. (Uncoated stencil)

Solder Powder Variation

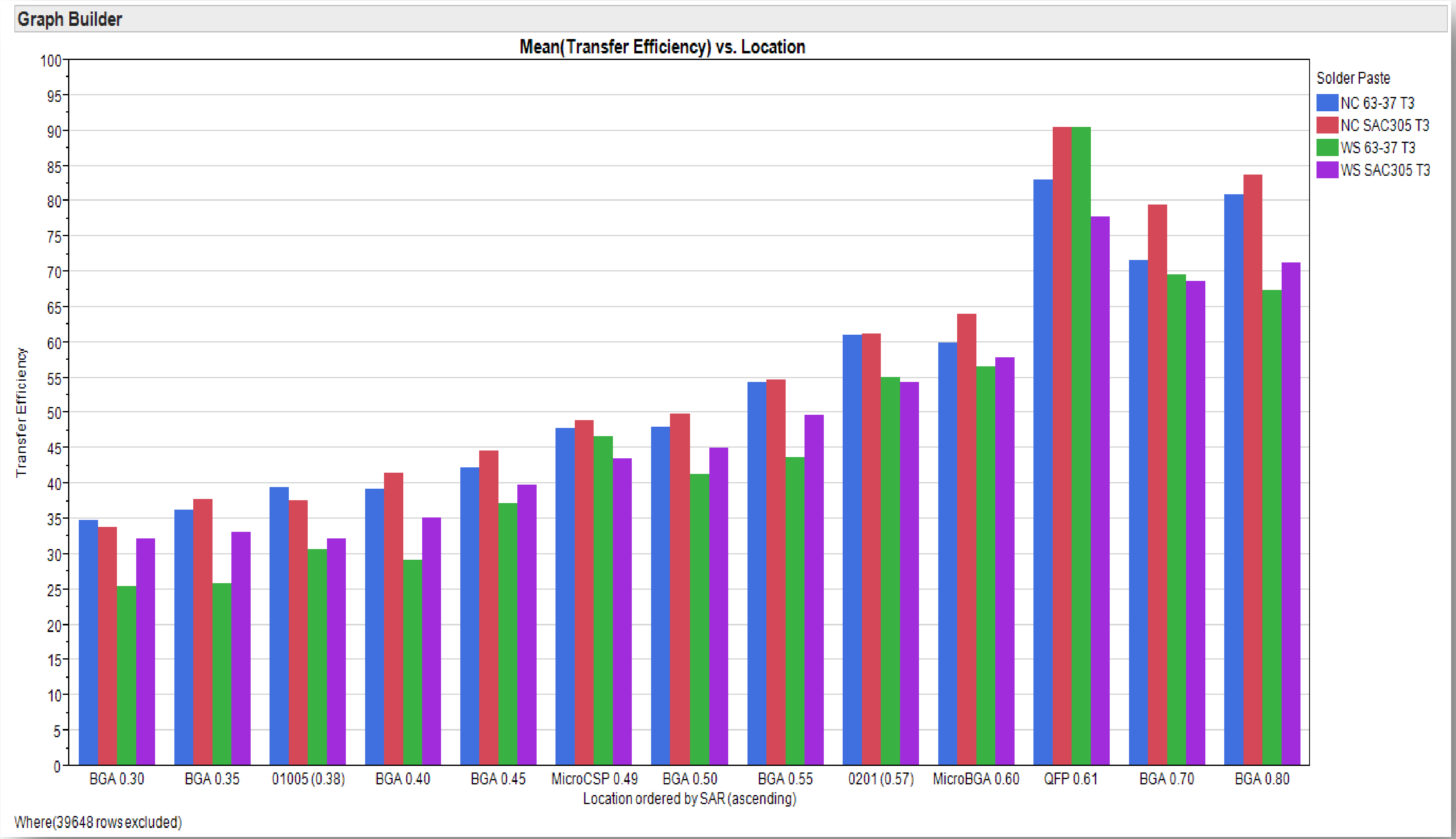


Solder paste: No Clean SAC305 Type 3, 4, 5. (Uncoated stencil)

Solder Powder Variation

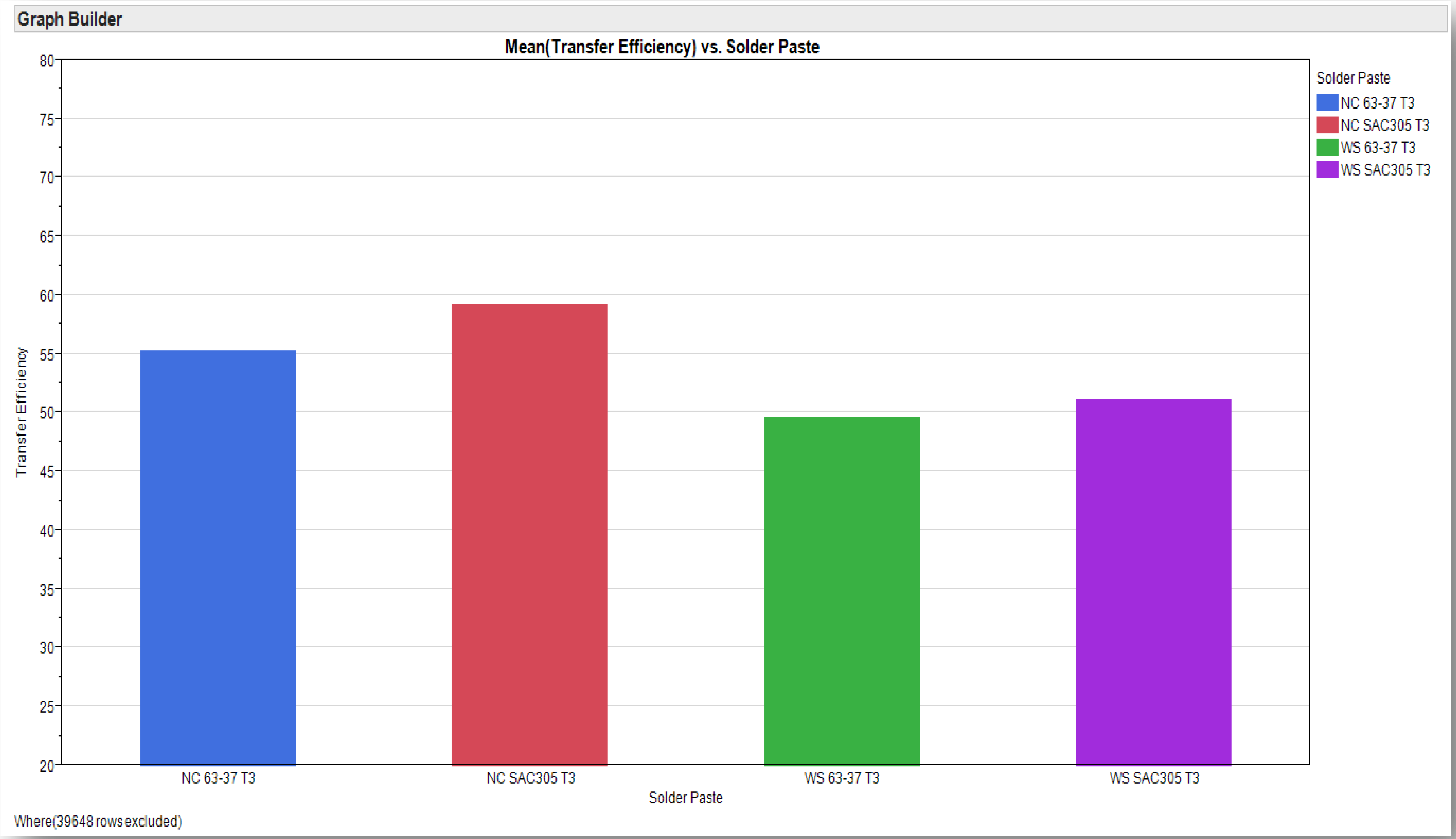
- Type 4 & 5 TE% greater than T3
- ~9% TE increase from T3 to T4
- Overall average TE% shows similar performance for Type 4 & 5

Solder Paste Effects



Solder paste: All Type 3. (Uncoated stencil)

Solder Paste Effects



Solder paste: All Type 3. (Uncoated stencil, all SARs)

Solder Paste Effects

- No cleans gave higher TE% than water solubles
- Lead free TE% > leaded
- Paste chemistry & alloy affect TE%

Stencil Design Rules

IPC-7525B 2011-October. Stencil Design Guidelines

3.2.1 Aperture Size. A typical guideline is a minimum of 4 to 5 particles of paste powder across the width of an aperture.

Type	Mesh	Size (um)	Size (mil)	Min Aperture Size (mil)
2	-200/+325	45 - 75	1.8 - 3.0	15.0
3	-325/+500	25 - 45	1.0 - 1.8	9.0
4	-400/+635	20 - 38	0.8 - 1.5	7.5
5	-500/+800	15 - 25	0.6 - 1.0	5.0

- **This does not account for stencil thickness, paste chemistry, or Nano coatings**

Stencil Design Rules

IPC-7525B 2011-October. Stencil Design Guidelines

3.2.1.2 Area Ratio/Aspect Ratio. A general design guide for acceptable paste release should be > 1.5 for aspect ratio or > 0.66 for area ratio.

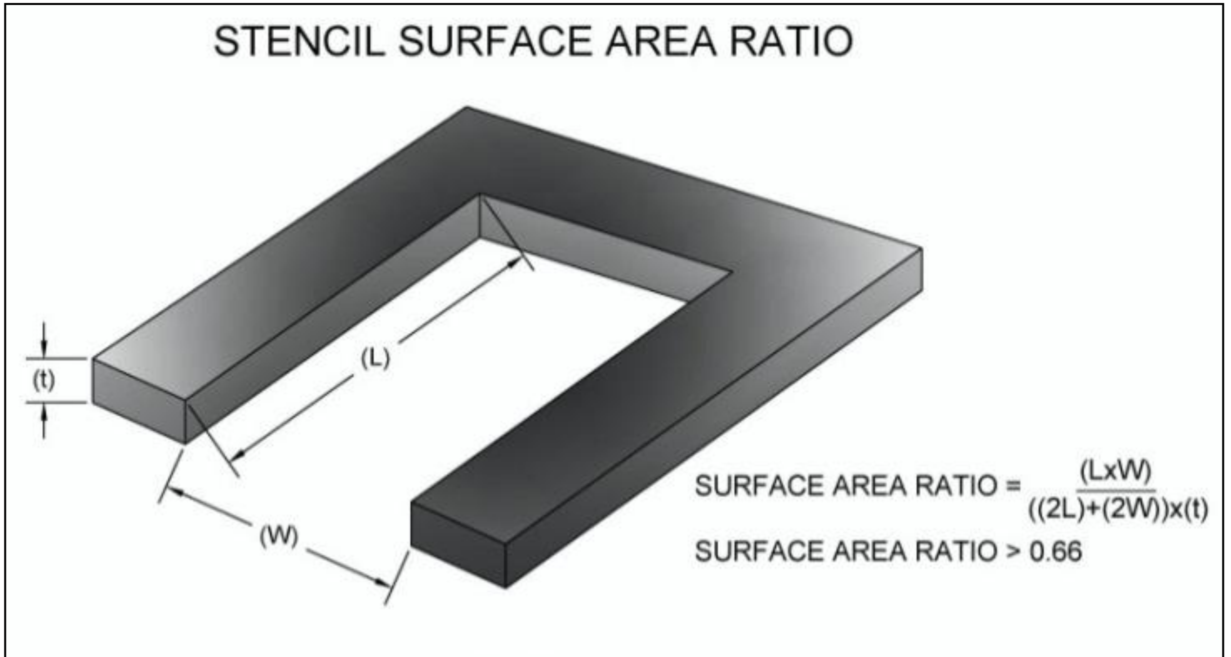


FIGURE 2

- **This does not account for solder paste and powder size (type).**

Stencil Design Rules

Table 3-2 General Aperture Design Guideline Examples for Selective Surface-Mount Devices (Tin Lead Solder Paste)

Part Type	Pitch	Land Footprint Width	Land Footprint Length	Aperture Width	Aperture Length	Stencil Thickness Range	Aspect Ratio Range	Area Ratio Range	Solder Paste Type
PLCC	1.25 mm [49.2 mil]	0.65 mm [25.6 mil]	2.00 mm [78.7 mil]	0.60 mm [23.6 mil]	1.95 mm [76.8 mil]	0.15 - 0.25 mm [5.91 - 9.84 mil]	2.4 - 4.0	0.92 - 1.53	Type 3
QFP	0.65 mm [25.6 mil]	0.35 mm [13.8 mil]	1.50 mm [59.1 mil]	0.30 mm [11.8 mil]	1.45 mm [57.1 mil]	0.15 - 0.175 mm [5.91 - 6.89 mil]	1.7 - 2.0	0.71 - 0.83	Type 3
QFP	0.50 mm [19.7 mil]	0.30 mm [11.8 mil]	1.25 mm [49.2 mil]	0.25 mm [9.84 mil]	[1.20 mm] 47.2 mil	0.125 - 0.15 mm [4.92 - 5.91 mil]	1.7 - 2.0	0.69 - 0.83	Type 3
QFP	0.40 mm [15.7 mil]	0.25 mm [9.84 mil]	1.25 mm [49.2 mil]	0.20 mm [7.87 mil]	[1.20 mm] 47.2 mil	0.10 - 0.125 mm [3.94 - 4.92 mil]	1.6 - 2.0	0.69 - 0.86	Type 3
QFP	0.30 mm [11.8 mil]	0.20 mm [7.87 mil]	1.00 mm [39.4 mil]	0.15 mm [5.91 mil]	0.95 mm [37.4 mil]	0.075 - 0.125 mm [2.95 - 4.92 mil]	1.2 - 2.0	0.52 - 0.86	Type 3
0402	N/A	0.60 mm [19.7 mil]	0.65 mm [25.6 mil]	0.45 mm [17.7 mil]	0.60 mm [23.6 mil]	0.125 - 0.15 mm [4.92 - 5.91 mil]	N/A	0.86-1.03	Type 3
0201	N/A	0.4 mm [9.84 mil]	0.45 mm [15.7 mil]	0.23 mm [9.06 mil]	0.35 mm [13.8 mil]	0.075 - 0.125 mm [2.95 - 4.92 mil]	N/A	0.56 - 0.93	Type 3
01005	N/A	0.200 mm [7.87 mil]	0.300 mm [11.81 mil]	0.175 mm [6.89 mil]	0.250 mm [9.87 mil]	0.063 - 0.089 mm [2.5 - 3.5 mil]	N/A	0.58 - 0.81	Type 4
BGA	1.25 mm [49.2 mil]	CIR 0.55 mm [21.6 mil]		CIR 0.52 mm [20.45 mil]		0.15 - 0.20 mm [5.91 - 7.87 mil]	N/A	0.65 - 0.86	Type 3
Fine-pitch BGA	1.00 mm [39.4 mil]	CIR 0.45 mm [15.7 mil]		SQ 0.42 mm [13.8 mil]		0.115 - 0.135 mm [4.53 - 5.31 mil]	N/A	0.65 - 0.76	Type 3
Fine-pitch BGA	0.50 mm [19.7 mil]	CIR 0.25 mm [9.84 mil]		SQ Overprint 0.28 mm [11.0 mil]		0.075 - 0.125 mm [2.95 - 4.92 mil]	N/A	0.56 - 0.93	Type 3
Fine-pitch BGA	0.40 mm [15.7 mil]	CIR 0.20 mm [7.87 mil]		SQ Overprint 0.23 mm [9 mil]		0.075 - 0.100 mm [2.95 - 4 mil]	N/A	0.56 - 0.75	Type 4

Note 1: It is assumed that the fine-pitch BGA lands are not solder mask defined.
Note 2: N/A implies that only the area ratio should be considered.

IPC-7525B 2011-October. Stencil Design Guidelines

Stencil Design Rules

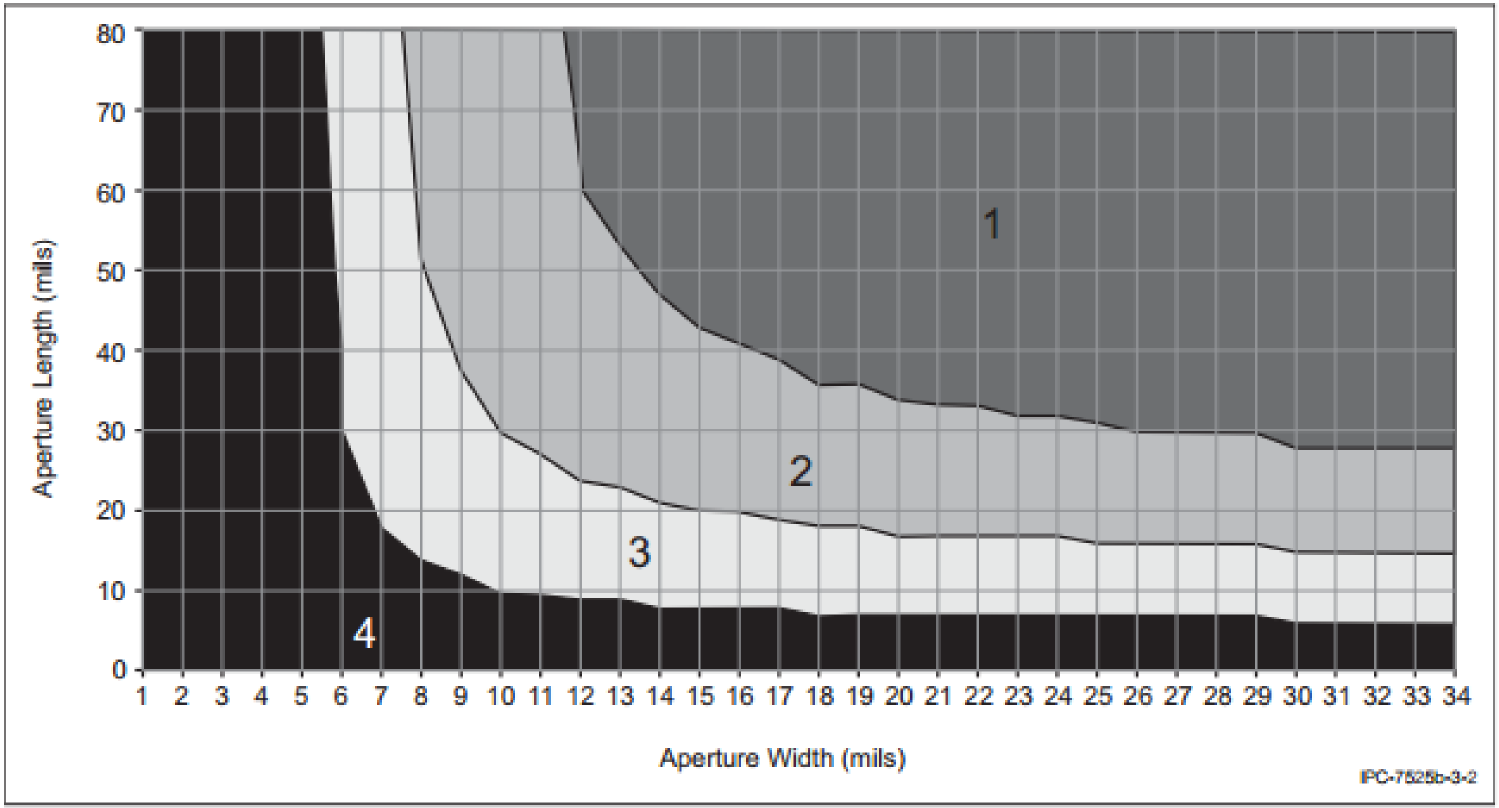


Figure 3-2 5 mil Thick Stencil Tin Lead and Lead Free

1. Electroformed, Laser, High-Precision Etch or Chem-Etch Range (AR >0.9)
2. Electroformed, Laser, High-Precision Etch (0.66< AR <0.9)
3. Electroform Range (0.5< AR <0.66)
4. Recommended Aperture Redesign or Reduce Stencil Thickness (AR <0.5)

IPC-7525B 2011-October. Stencil Design Guidelines

Stencil Design Rules

Minimum SAR Allowing 70% Solder Paste Volume

Solder Paste	Uncoated	Coating B	Coating C	Coating D
NC SAC T3	0.61	0.61	0.61	0.55
NC SAC T4	0.61	0.61	0.61	0.49
NC SAC T5	0.57	0.57	0.57	0.45
WS SAC T3	0.70	ND	ND	0.61

Variables Affecting Solder Paste Release

- Stencil design
- Stencil to PWB registration
- PWB (finish, pad size, etc.)
- Printer parameters
- Environmental conditions
- Solder paste chemistry and powder
- Nano coatings

Conclusions

- Stencil design rules depend upon:
  - Aperture surface area ratio
  - Solder paste chemistry
  - Solder powder size (type)
  - Nano coating effect
- Certain Nano coatings can change the rules of stencil design

Acknowledgements

This study would not have been possible without the assistance of Fine Line Stencil.

Many thanks to Brittney Nolan of FCT Assembly who ran much of the testing for this study.

Thank You for Your Attention!

Any questions?

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