Step Stencil Technology

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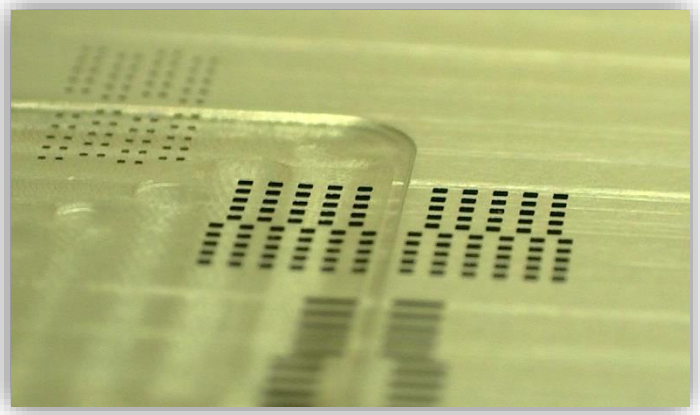
FCT Companies

Outline/Agenda

- Introduction
- Step Stencils Technologies
- Step Stencil Design
- Printing Experiment
- Experimental Results
- Future Work
- Acknowledgements
- Q & A

Introduction



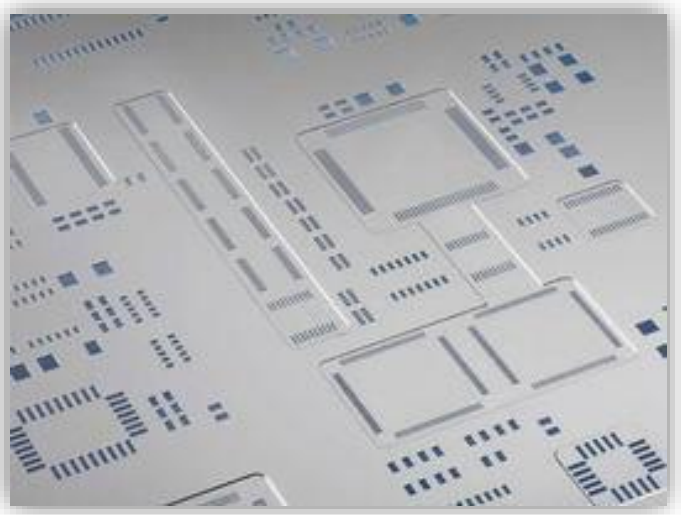
1.1.7 Relief Etch Also known as Etch Relief and Under Etch. Adding an under etch of the foil to create a pocket for raised features, labels, or a mulit-print function.

1.1.22 Step Stencil A Stencil with more than one foil thickness level.

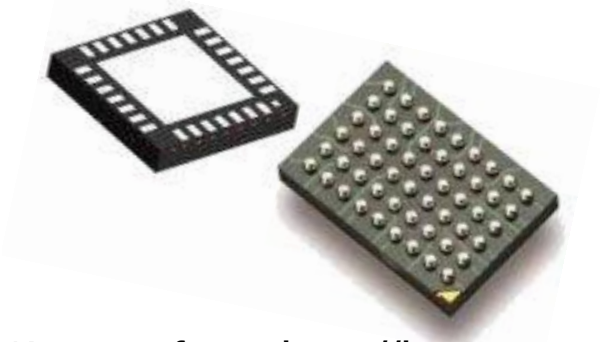
*IPC 7525B, “Stencil Design Guidelines”, 2011-October.

Introduction

Step Down Stencils:
Material thickness is reduced in areas where smaller components are placed on the PWB so that proper Area Ratios are maintained to obtain good paste release.



*Step Down Stencil



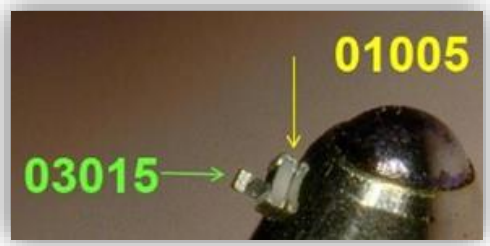
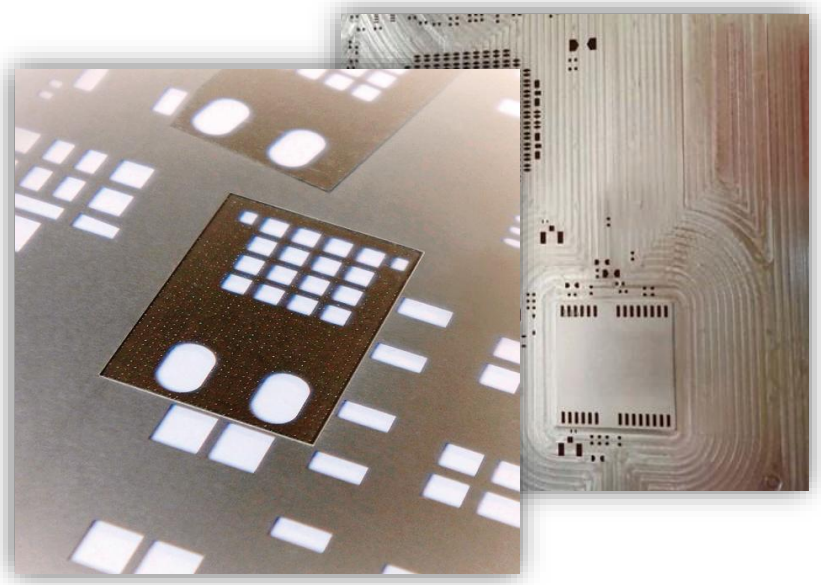


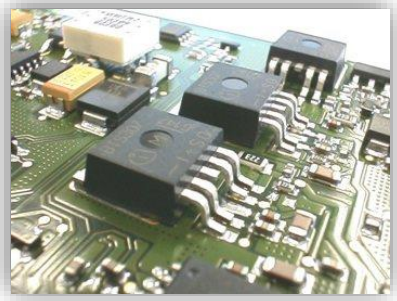
*Image from http://laser-stencil.eu/en/step_stencils/

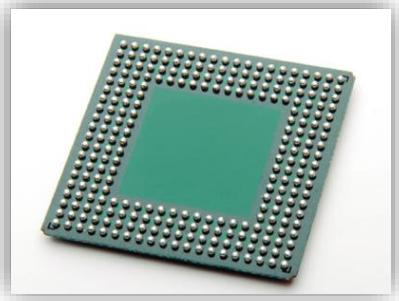
Introduction

Step UP Stencils:
Material thickness is increased around specific components such as edge connectors, large BGA's, D-PAK's and other devices to increase the volume of paste deposited.



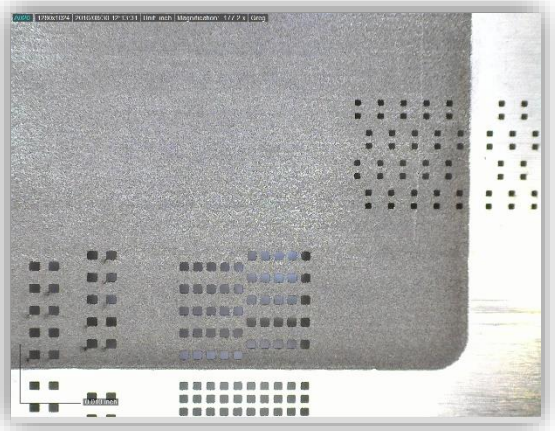
Step Up Stencil



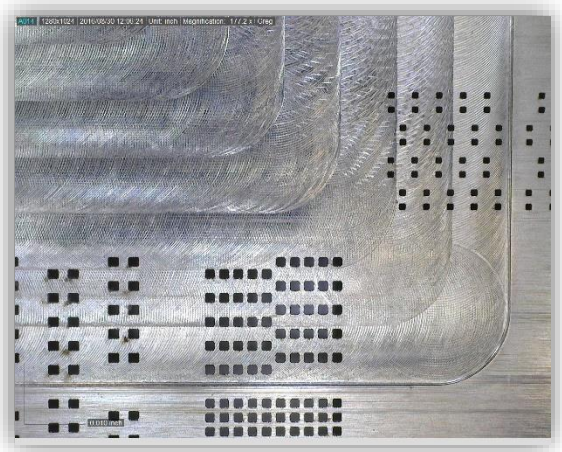


Step Stencil Technologies

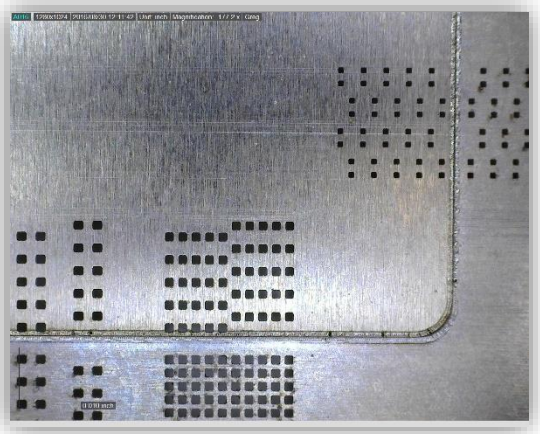
Currently there are three technologies in the U.S. to manufacture step stencils.



Etched Technology



Micro-Machined Technology

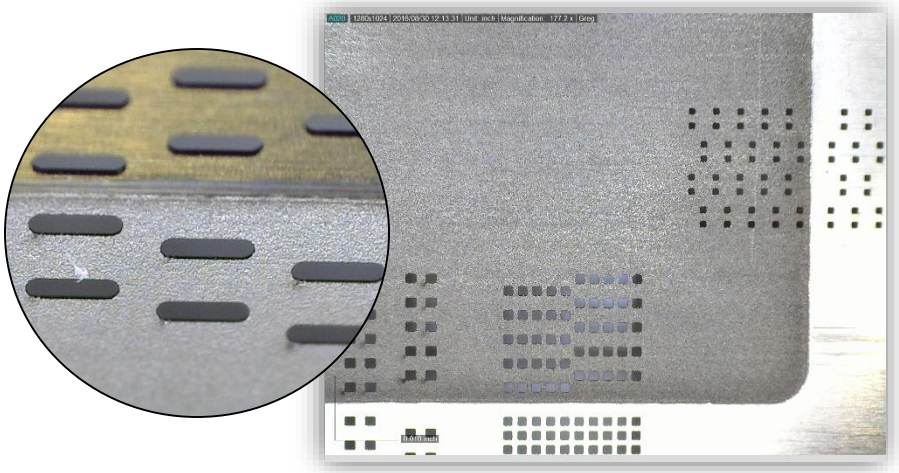


Welded Technology

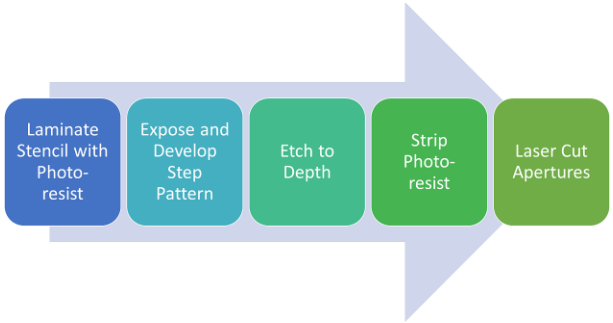
Step Stencil Technologies

Photo-Chemical Etching

- Historically, the primary method to manufacture step stencils
- Photographic process applies resist to areas that will not be etched.
- Etchant is sprayed onto surface and removes material until the desired thickness is achieved.



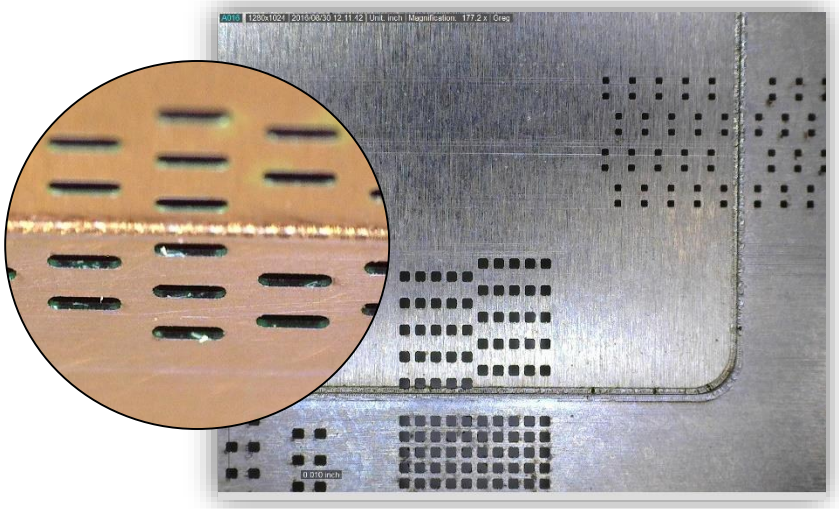
Etched Technology



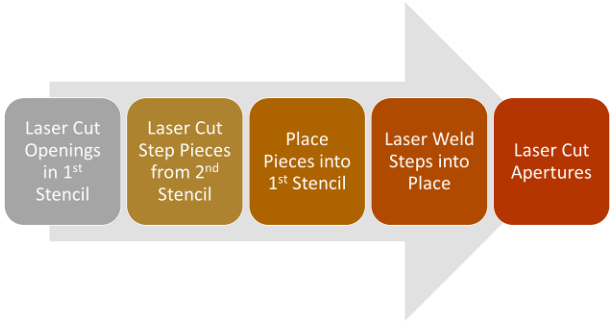
Step Stencil Technologies

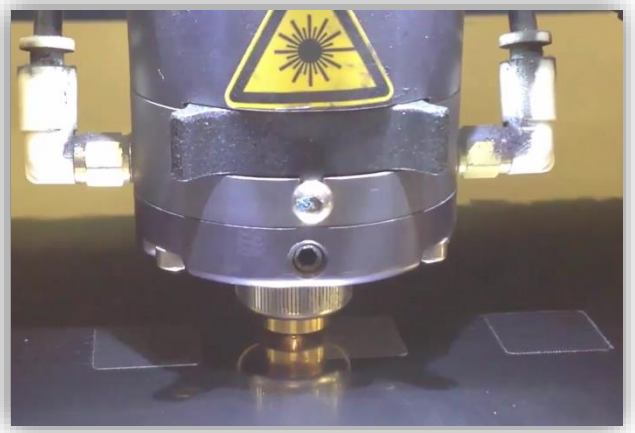
Laser Welded Technology

- The area of the step is cut from the stencil.
- The required thickness of the step area is cut from another foil the exact same size.
- The new foil blank is placed into the cut out area and the foil is welded together.
- Apertures are then laser cut.



Laser Welded Technology

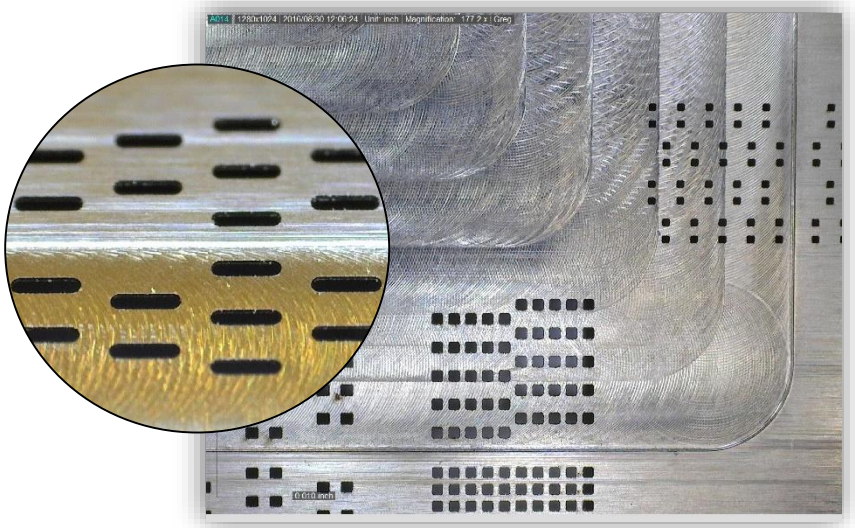




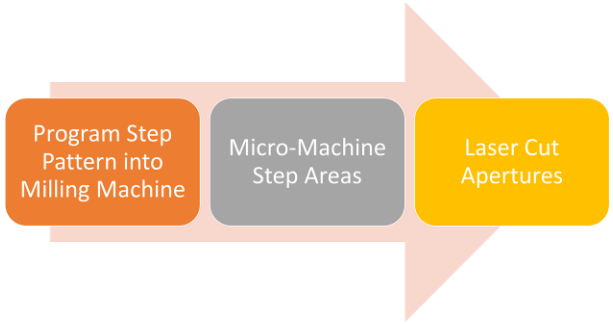
Step Stencil Technologies

Micro-Machining Technology

- Material is attached to cooled vacuum plate.
- CNC based milling machine removes very small amounts of material at a time until desired thickness is achieved.
- Stepped foil is mounted to frame and apertures are laser cut.

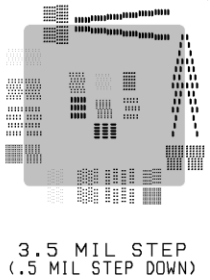


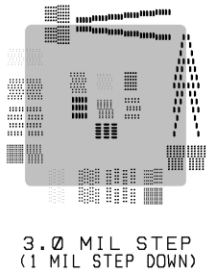
Laser Welded Technology

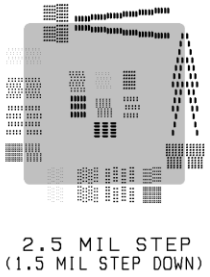


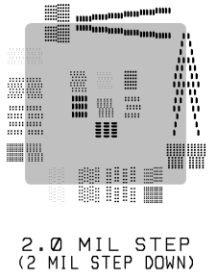
Step Stencil Design

- Base stencil thickness 4 mils (101.6 microns)
- Step Pocket Depths (Foil Thickness)
  - 3.5 mils (88.9 microns)
  - 3.0 mils (76.2 microns)
  - 2.5 mils (63.5 microns)
  - 2.0 mils (50.8 microns)
- Each step area was 1 inch square (25.4 mm) and the step design is shown here.









The 3.5 Mil Step Pocket (.5 mil step depth) was not used in this paper.

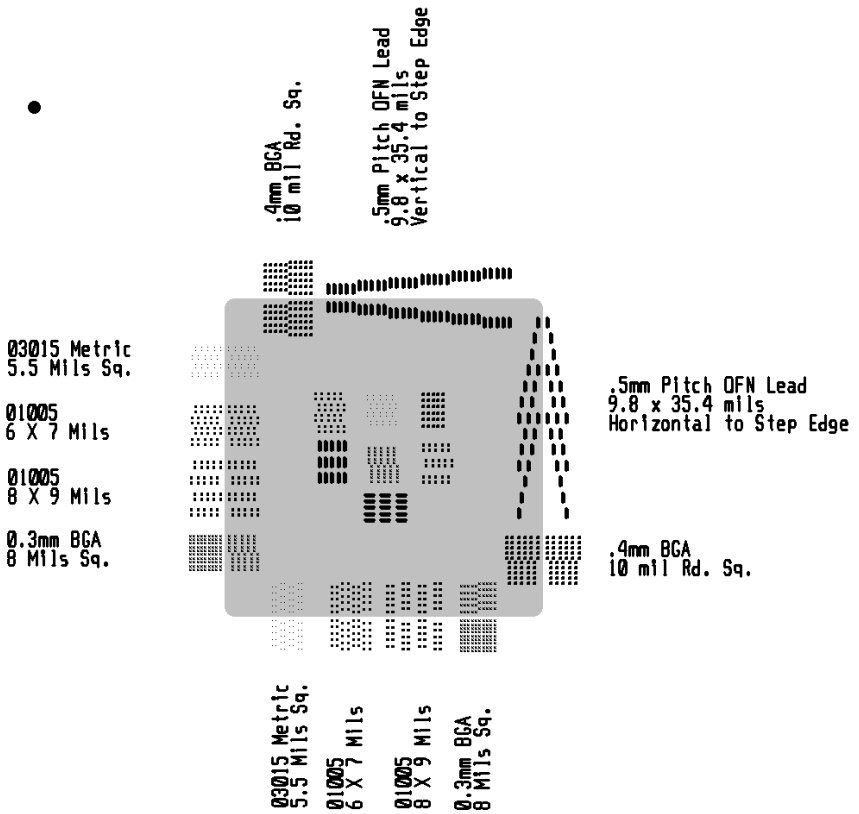
Printing Experiment

Apertures were created for the following components:

- 03015 Metric
- 01005
- 0.3 mm BGA
- 0.4 mm BGA
- 0.5 mm pitch QFNs.

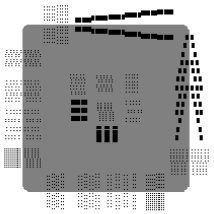
Apertures were cut at varying distances from the step edges:

10, 20, 30, 40, and 50 mils.

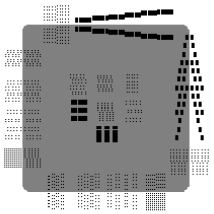


Printing Experiment

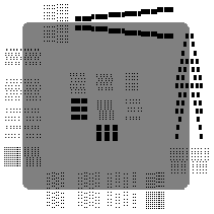
Data was collected after printing 10 boards with each stencil. The effects of the FPN coating were compared to the uncoated part of the stencil on printing of solder paste.



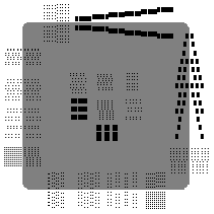
3.5 MIL STEP



3.0 MIL STEP

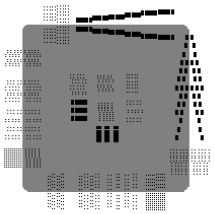


2.5 MIL STEP

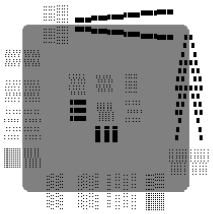


2.0 MIL STEP

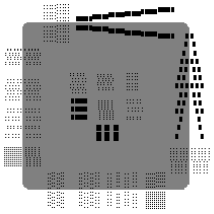
Fluoro-Polymer Nano (FPN) coating



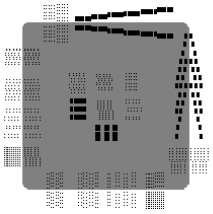
3.5 MIL STEP



3.0 MIL STEP



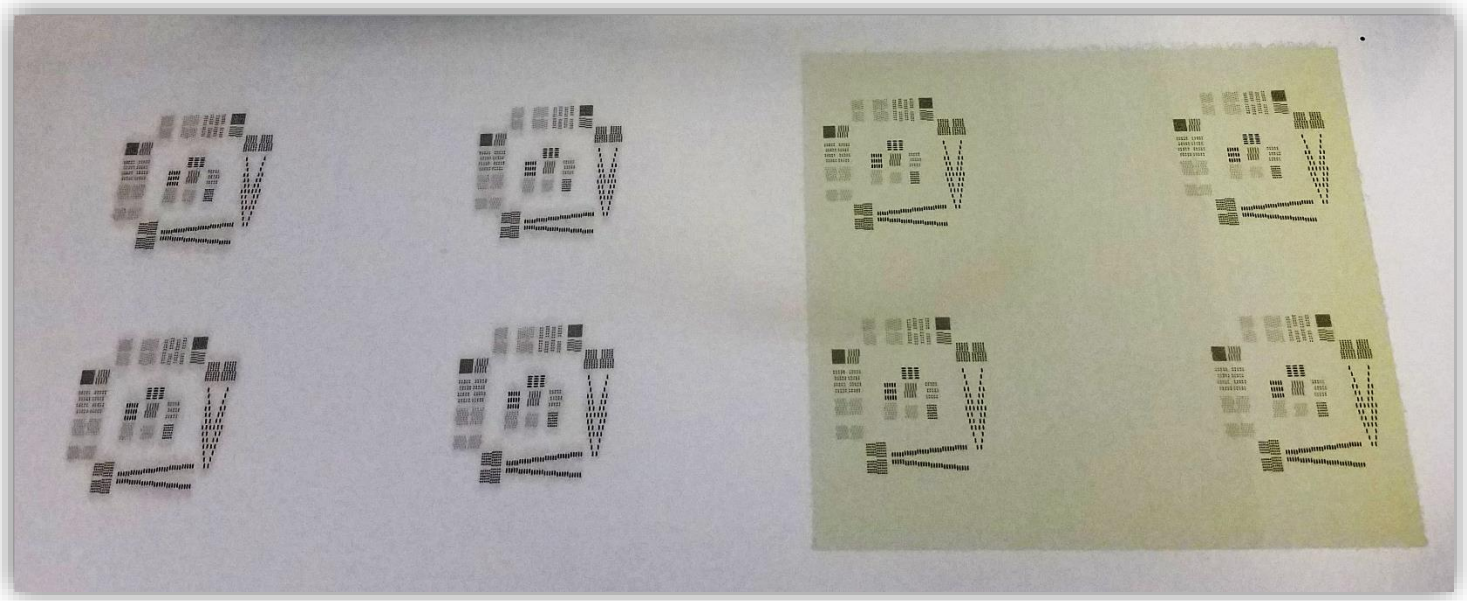
2.5 MIL STEP



2.0 MIL STEP

Printing Experiment

A 10 print study was run on each step stencil using a popular no clean, SAC305 Type 4 solder paste. The circuit boards used were bare copper clad material 0.062” (1.57 mm) thick.



Step Stencil Contact Side with FPN Nano-Coating.

Equipment

Parameter	Value
Squeegee Length	300 mm
Squeegee Pressure	0.18 kg/cm (5.4 kg)
Squeegee Speed	30 mm/sec
Squeegee Angle	60 degrees
Separation Speed	1.0 mm/sec
Cleaning Cycle	W/V/D every print
Cleaning Solvent	Isopropanol (IPA)
Solder Paste	NC SAC305 T4

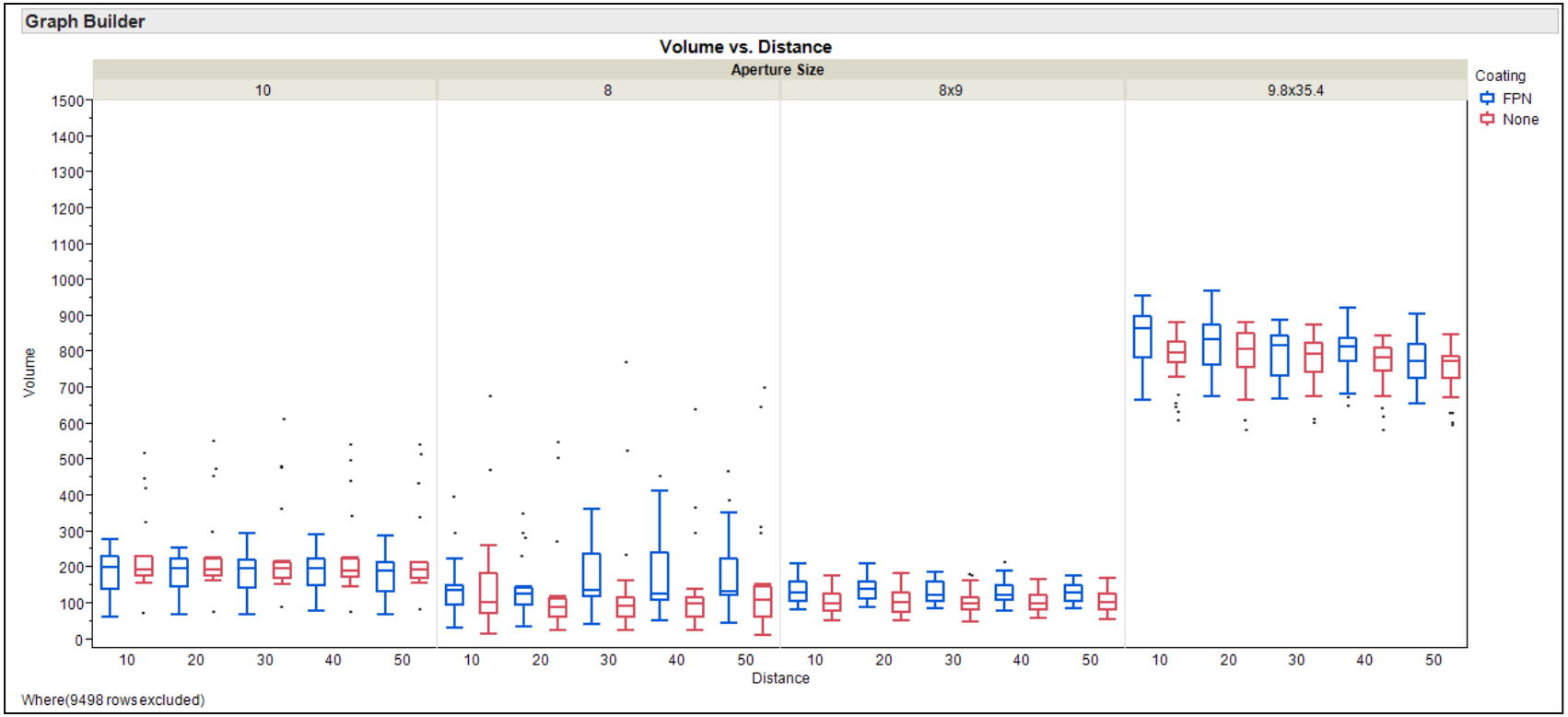
Stencil Thickness Measurements

Step Thickness (mils)	Step Depth (mils)	Etched – Depth / STDev (mils)	Welded - Depth / STDev (mils)	Machined - Depth / STDev (mils)
2.0	2.0	2.36 / 0.11	2.08 / 0.19	2.01 / 0.17
2.5	1.5	1.69 / 0.16	1.60 / 0.18	1.25 / 0.15
3.0	1.0	1.15 / 0.19	0.97 / 0.18	1.08 / 0.17

- Chemical etching process created deeper step downs than the nominal value
- Welding and Micro-Machining processes created steps that are closer to the target depth.
- Overall, the standard deviations are very similar for each technology.

Printing Results

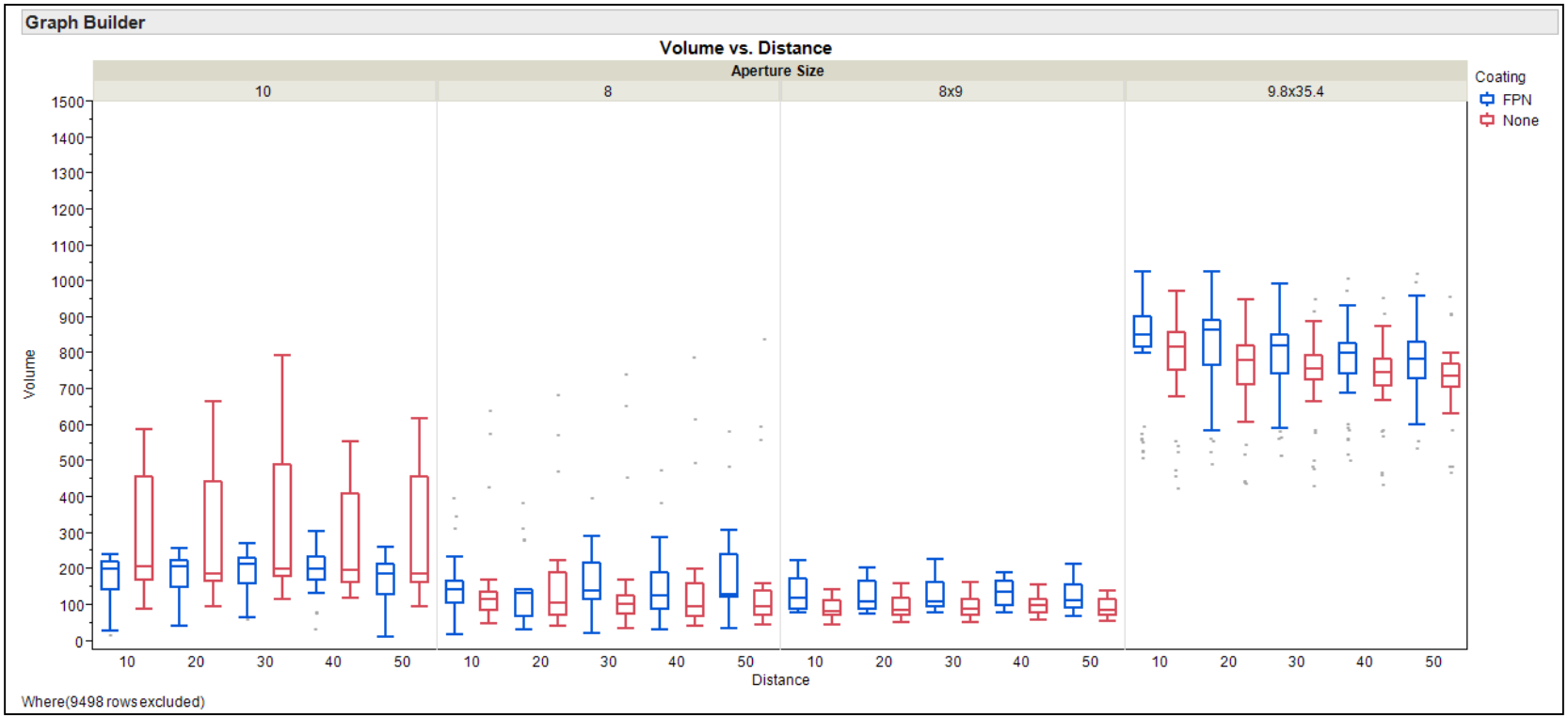
Etched Step



Solder Paste Volumes for the 3.0 mil Etched Step.

Printing Results

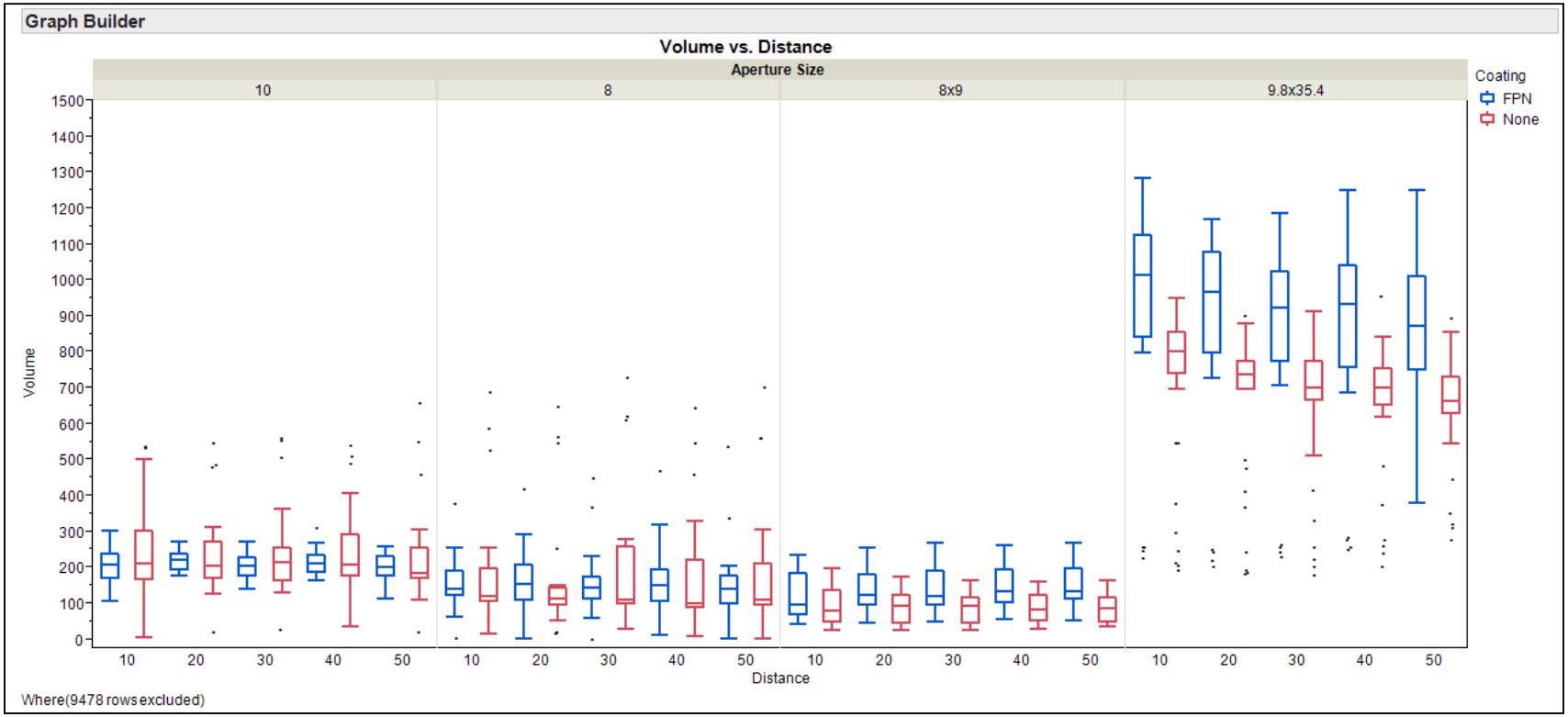
Etched Step



Solder Paste Volumes for the 2.5 mil Etched Step.

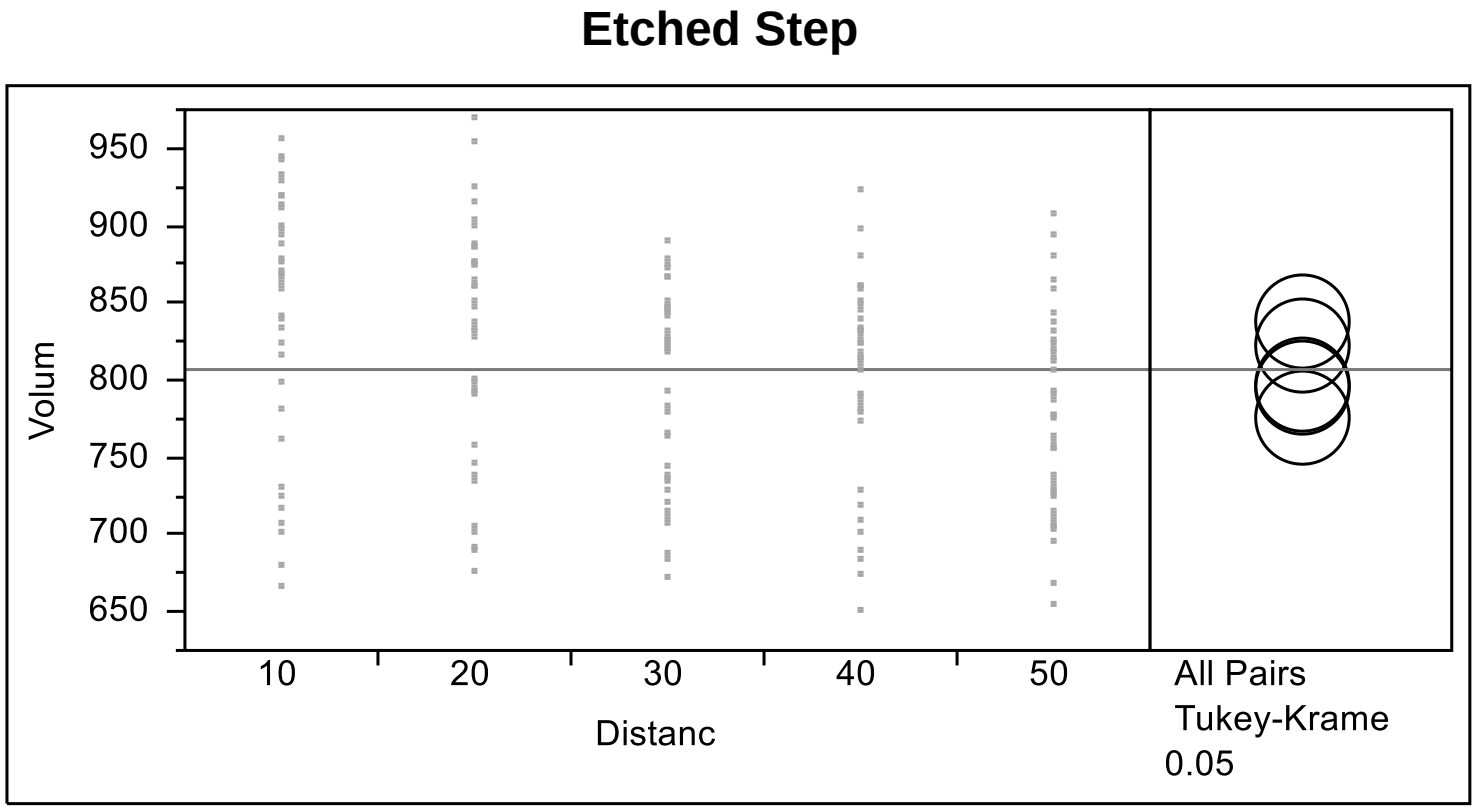
Printing Results

Etched Step



Solder Paste Volumes for the 2.0 mil Etched Step.

Printing Results



Tukey-Kramer HSD Analysis for the FPN Coated, Etched 3.0 mil Step (1 mil step down) and the 9.8 x 35.4 Aperture.

Printing Results

Etched Step

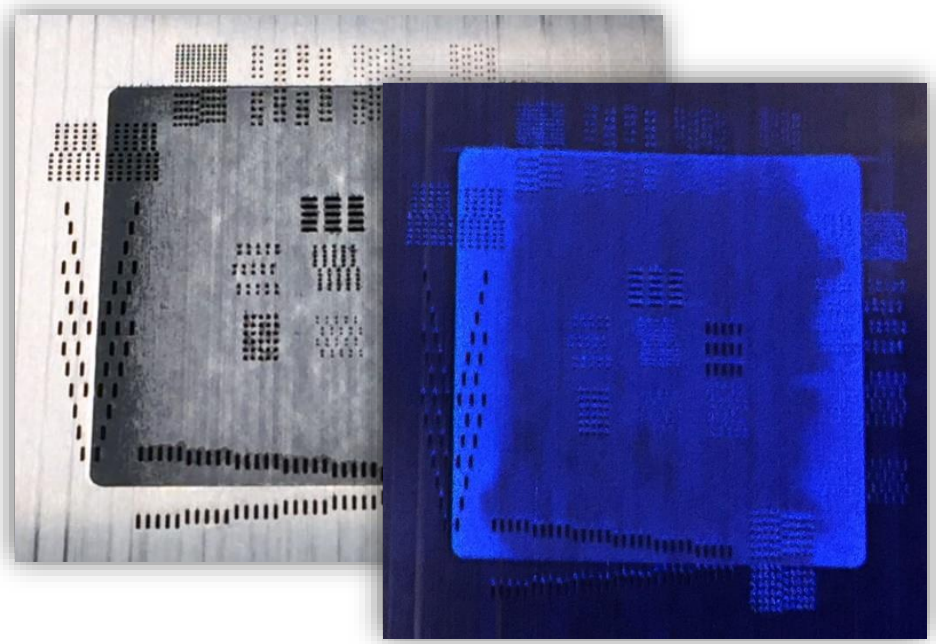
Level							Mean
10	A						839.52500
20	A						823.35000
40	A	B					798.30000
30	A	B					796.65000
50		B					776.22500

Tukey-Kramer HSD Analysis for the FPN Coated, Etched 3.0 mil Step(1 mil step down) and the 9.8 x 35.4 Aperture.

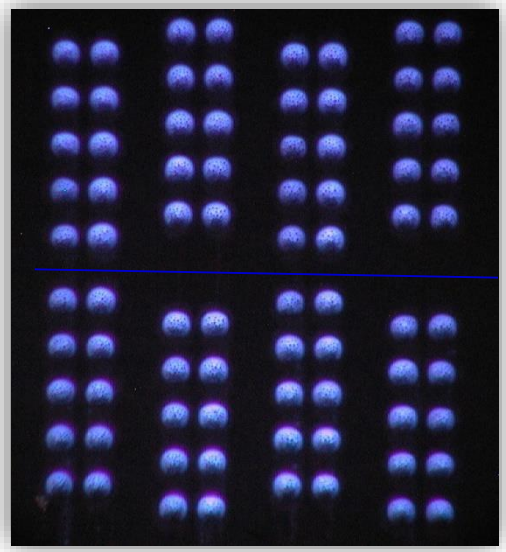
The printed solder paste volume is higher for the 10 and 20 mil distances than the 50 mil distance.

Printing Results

Etched Step



Paste w/ blue U.V. dye added

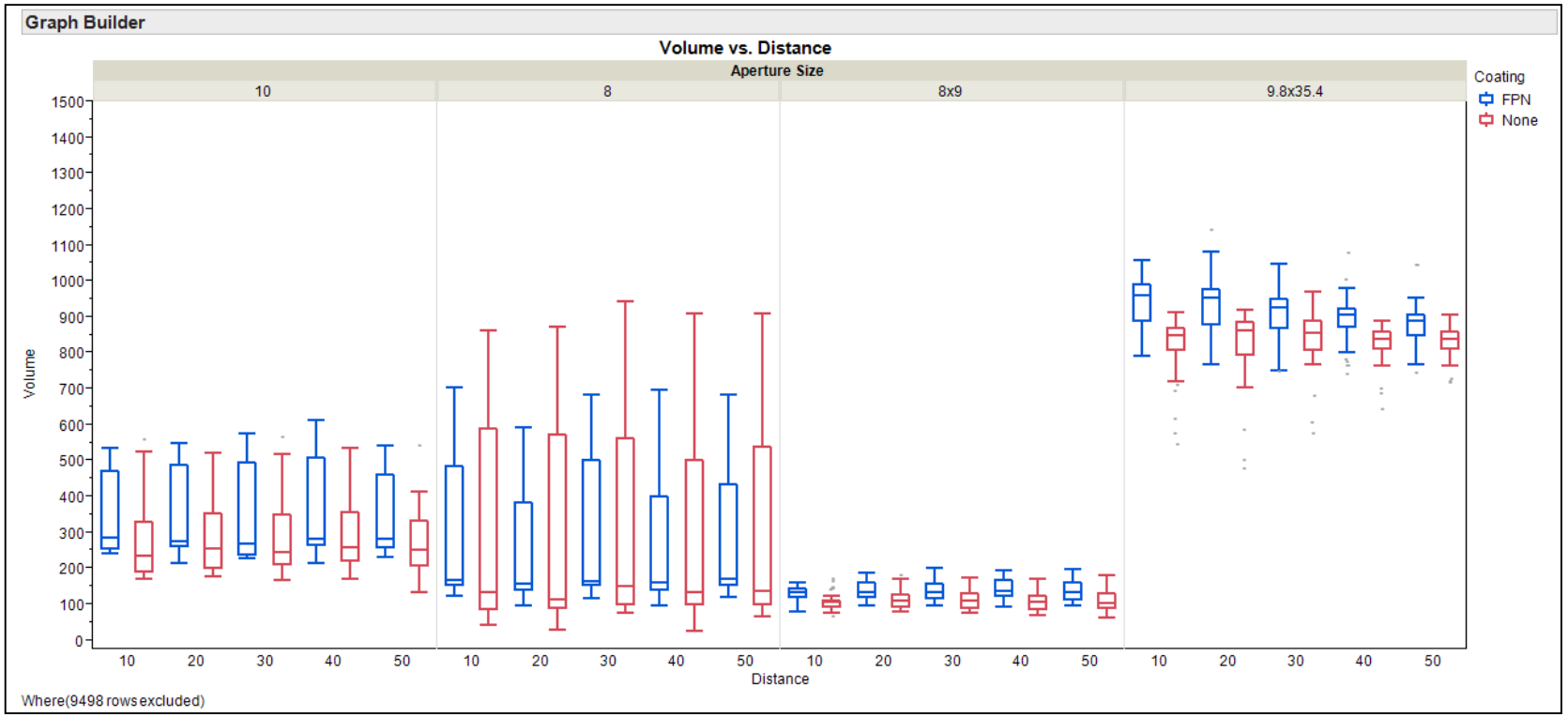


8 x 9 mil Apertures

The printed solder paste volume is higher for the 10 and 20 mil distances than the 50 mil distance for the 9.8 x 35.4 mil apertures but smaller aperture volumes seem to be consistent from 10 – 50 mils from the step edge.

Printing Results

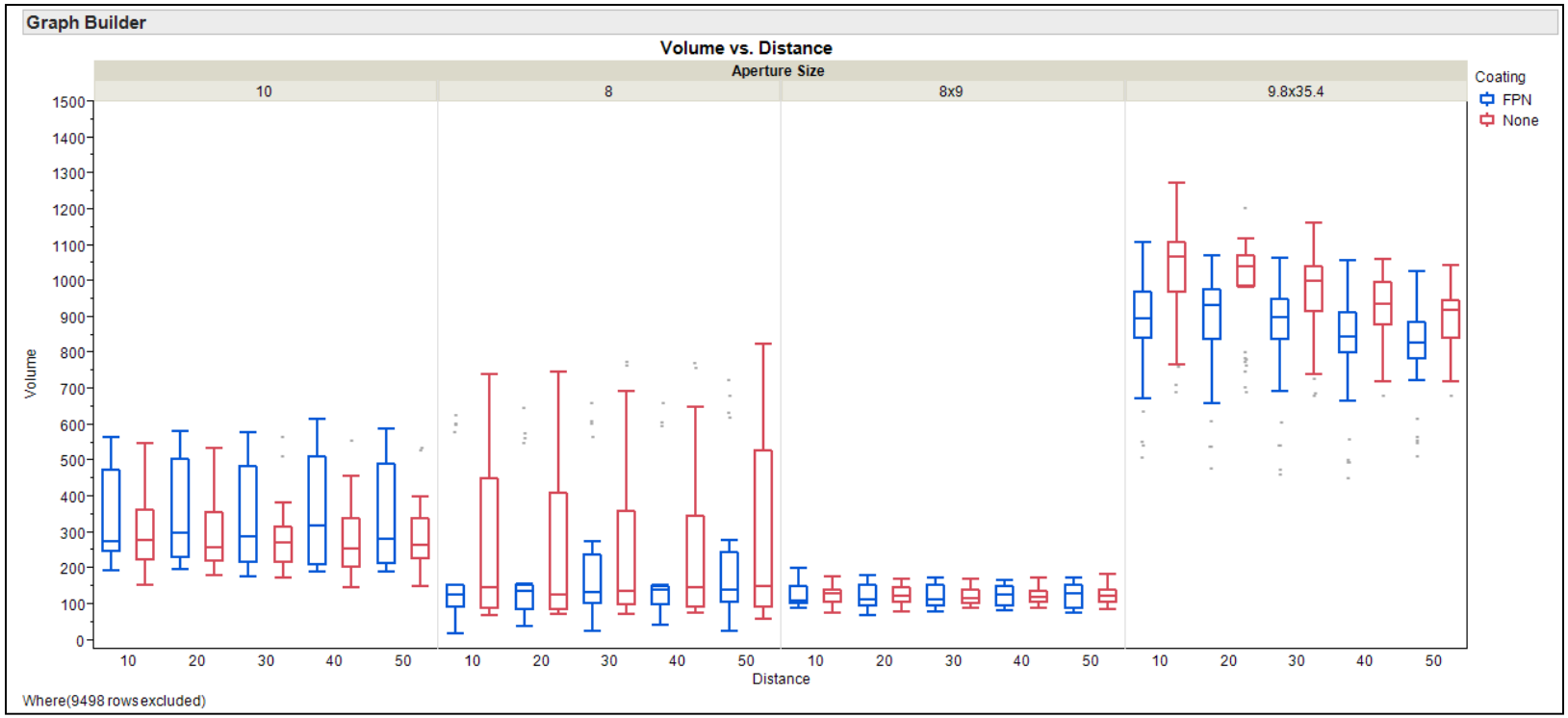
Welded Step



Solder Paste Volumes for the 3.0 mil Welded Step.

Printing Results

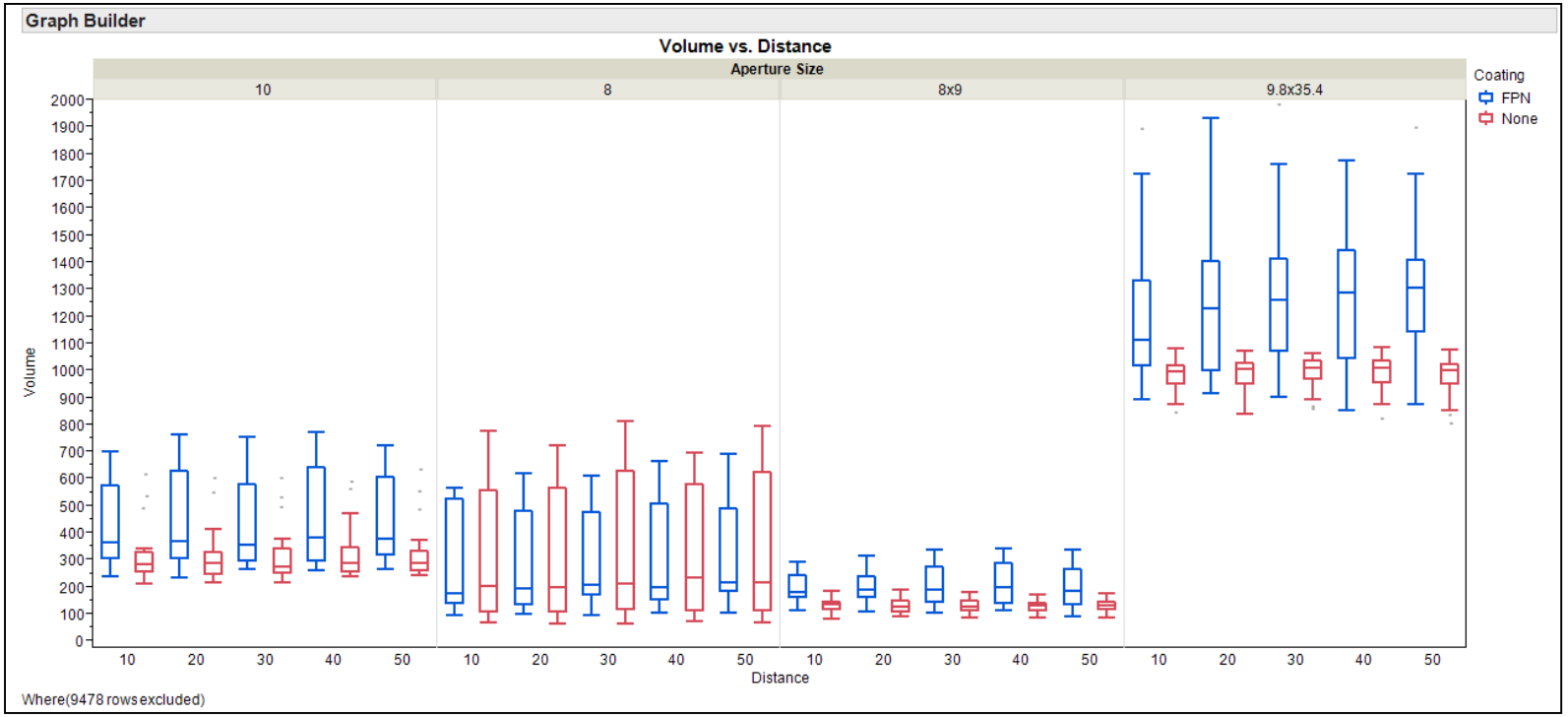
Welded Step



Solder Paste Volumes for the 2.5 mil Welded Step.

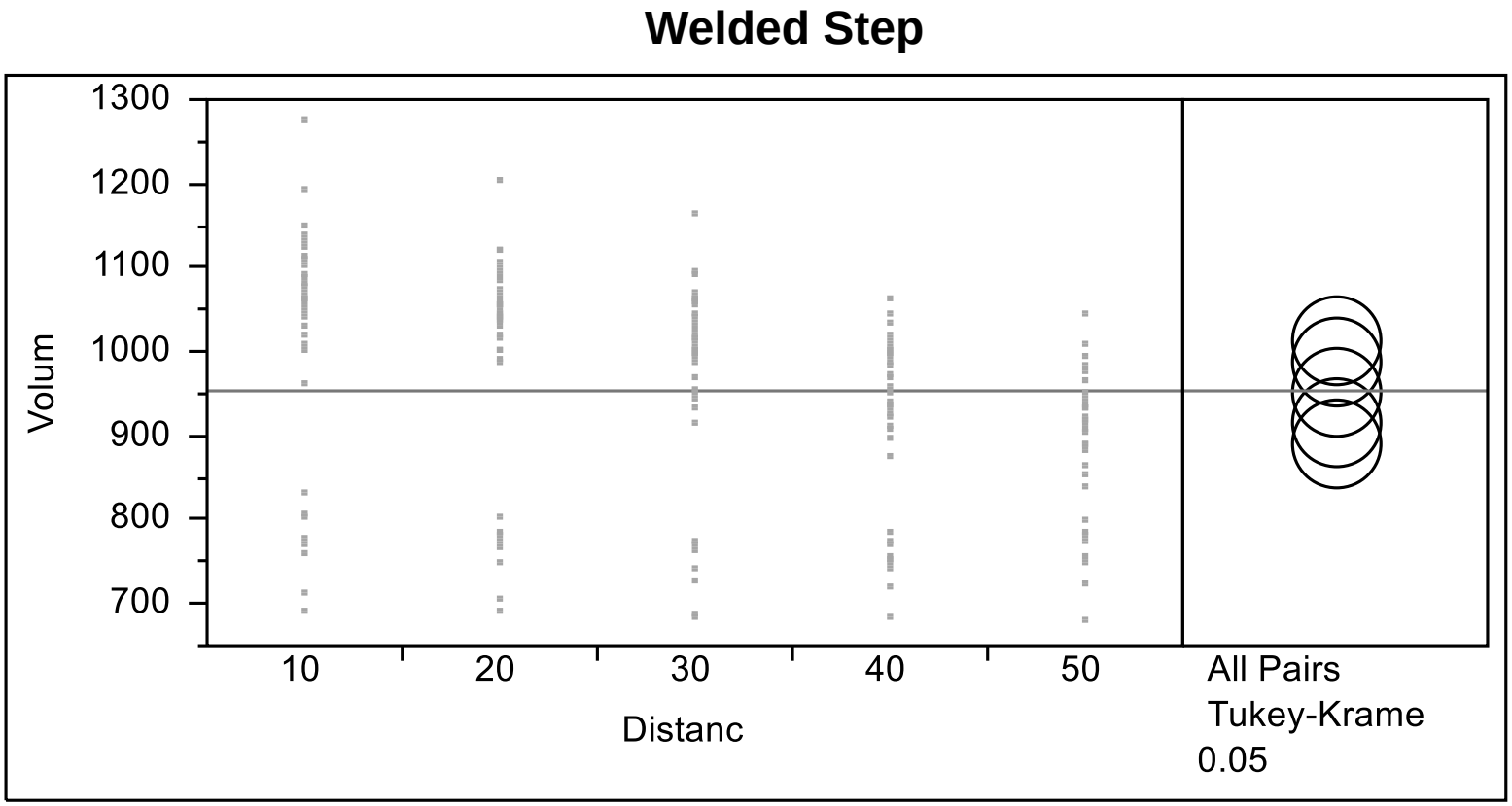
Printing Results

Welded Step



Solder Paste Volumes for the 2.0 mil Welded Step.

Printing Results



Tukey-Kramer HSD Analysis for the Uncoated, Welded 2.5 mil Step and the 9.8 x 35.4 Aperture.

Printing Results

Welded Step

Connecting Letters Report

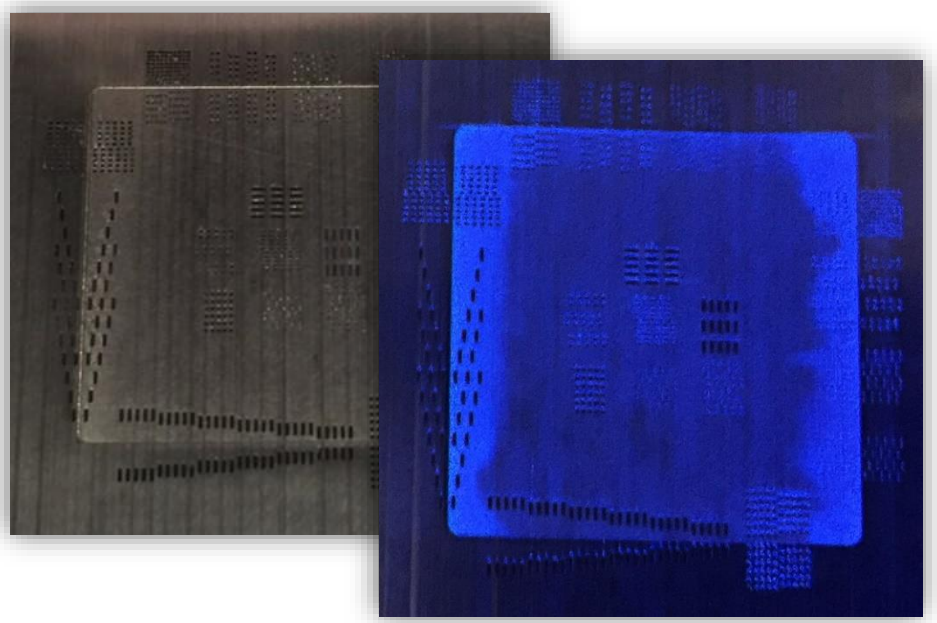
Level							Mean
10	A						1015.3250
20	A	B					988.8000
30	A	B	C				954.1750
40		B	C				916.4750
50			C				891.8500

Tukey-Kramer HSD Analysis for the Uncoated, Welded 2.5 mil Step and the 9.8 x 35.4 Aperture.

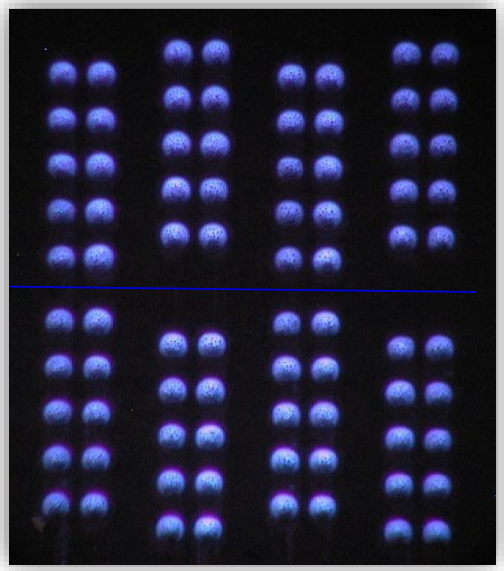
Paste volume at the 10 mil distance is significantly higher than the 40 and 50 mil distances. Paste volume is significantly higher at the 20 mil distance than then 50 mil distance.

Printing Results

Welded Step



Paste w/ blue U.V. dye added

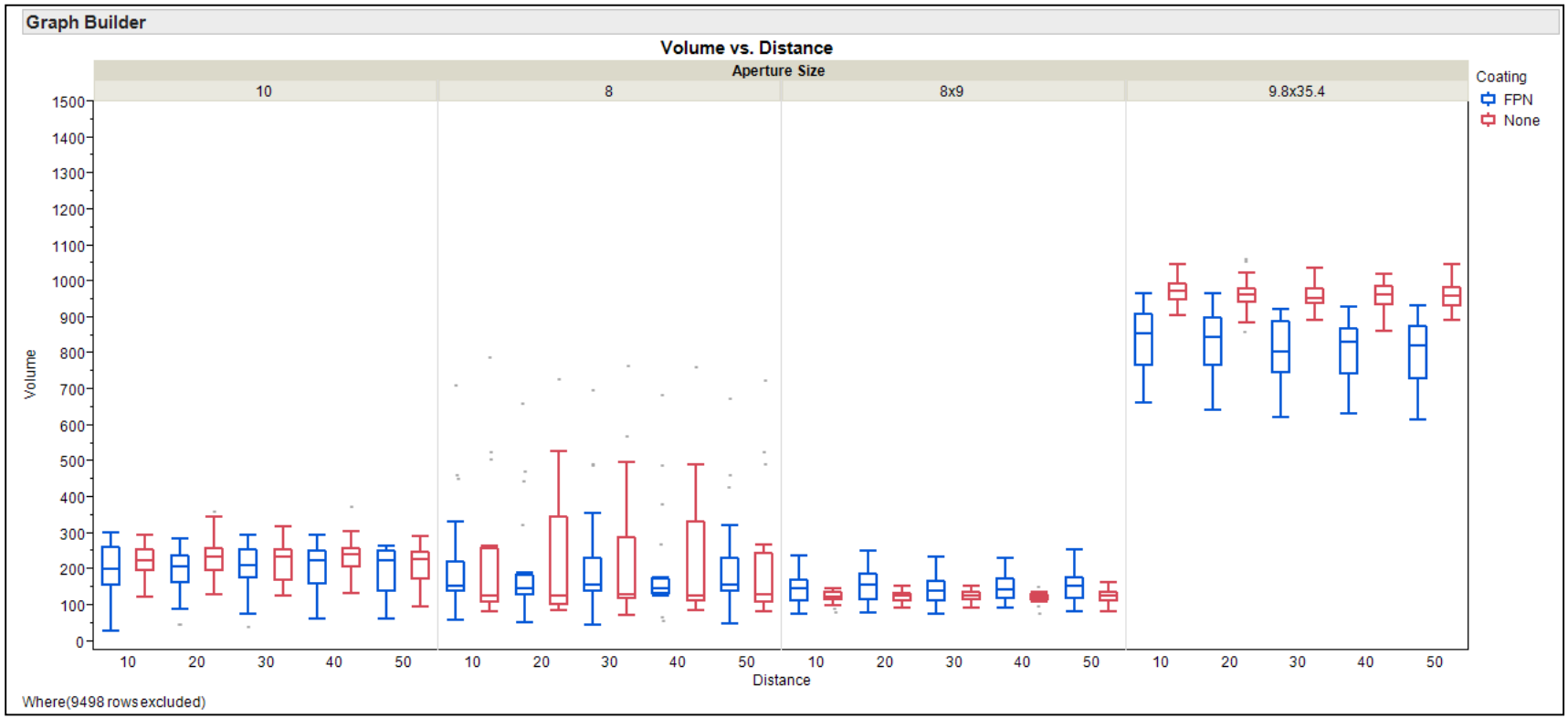


8 x 9 mil Apertures

The printed solder paste volume is higher for the 10 and 20 mil distances than the 50 mil distance for the 9.8 x 35.4 mil apertures but smaller aperture volumes seem to be consistent from 10 – 50 mils from the step edge.

Printing Results

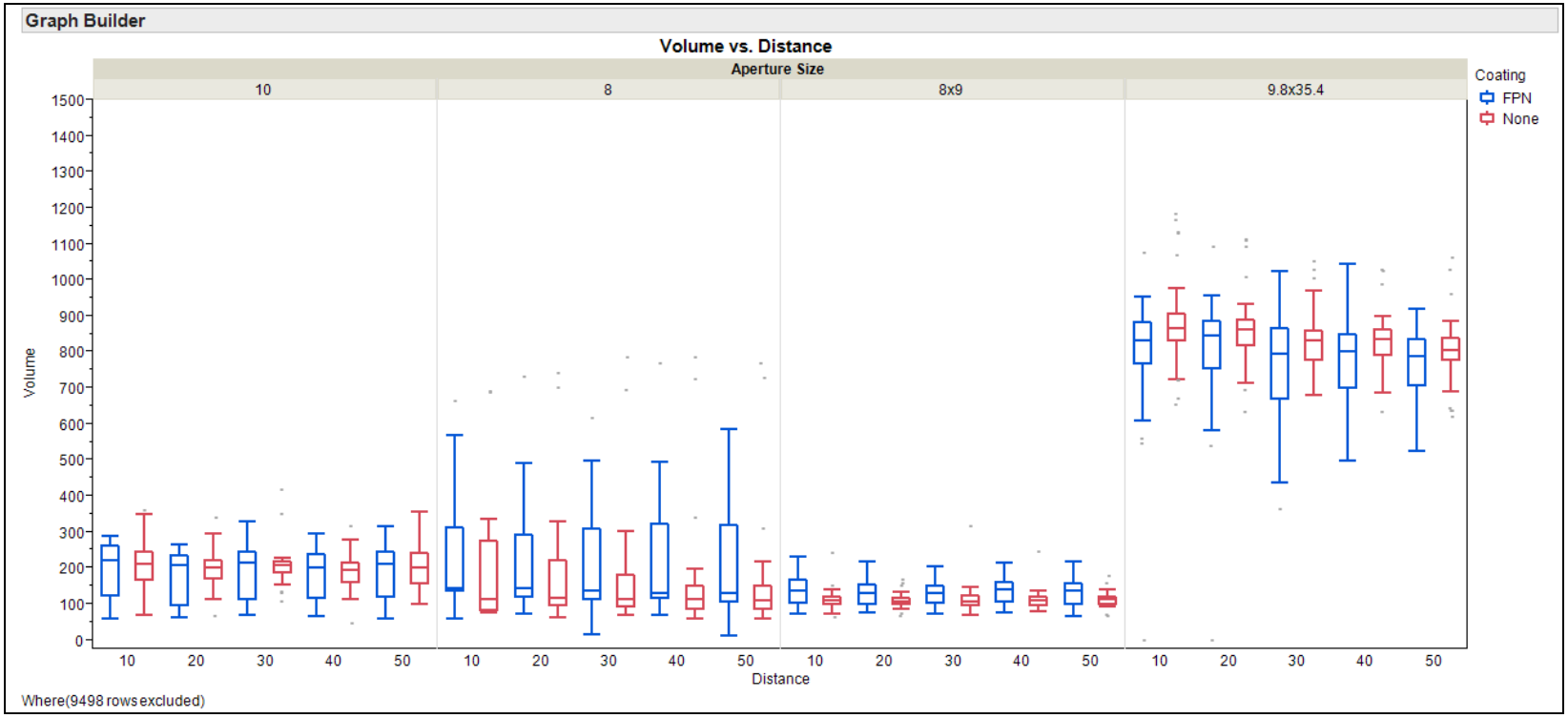
Micro-Machined Step



Solder Paste Volumes for the 3.0 mil Micro-Machined Step.

Printing Results

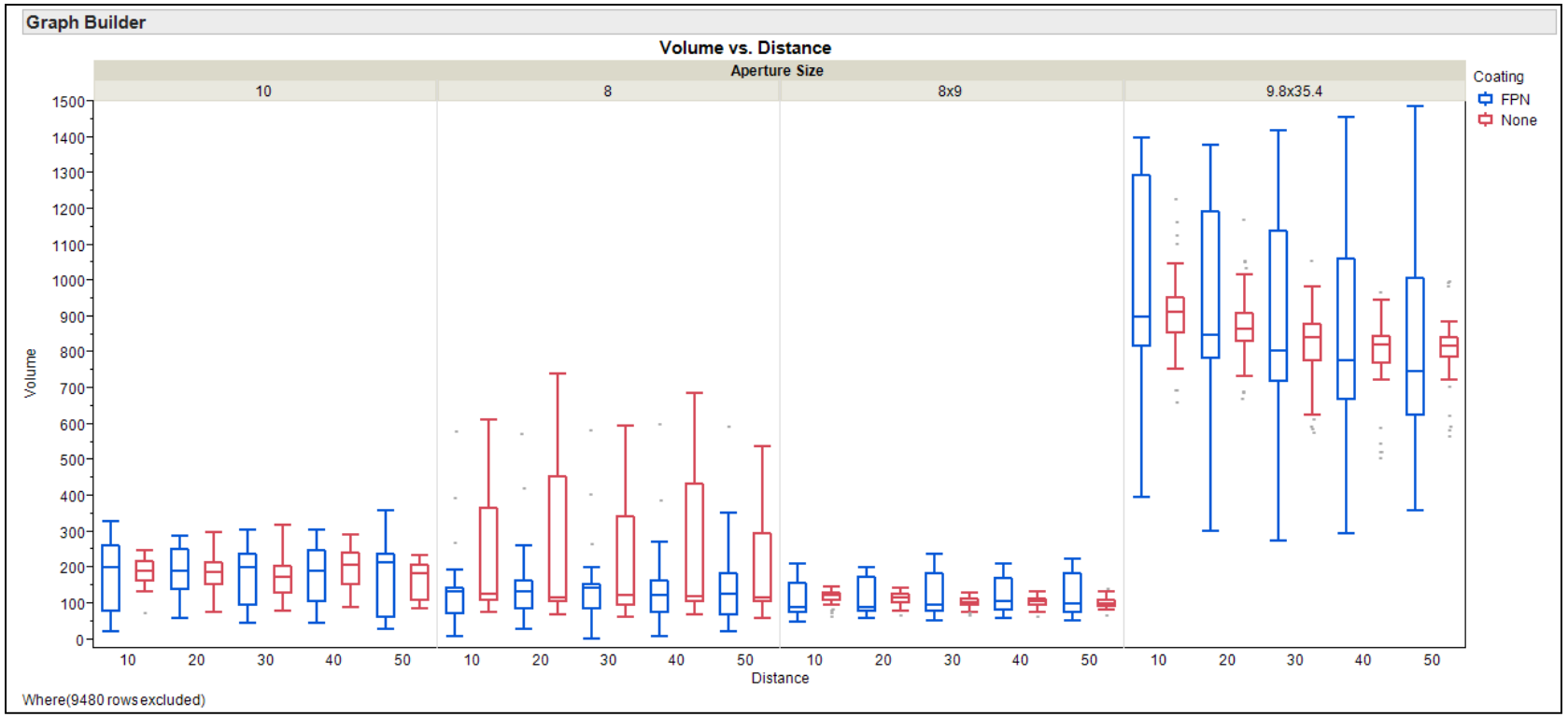
Micro-Machined Step



Solder Paste Volumes for the 2.5 mil Micro-Machined Step.

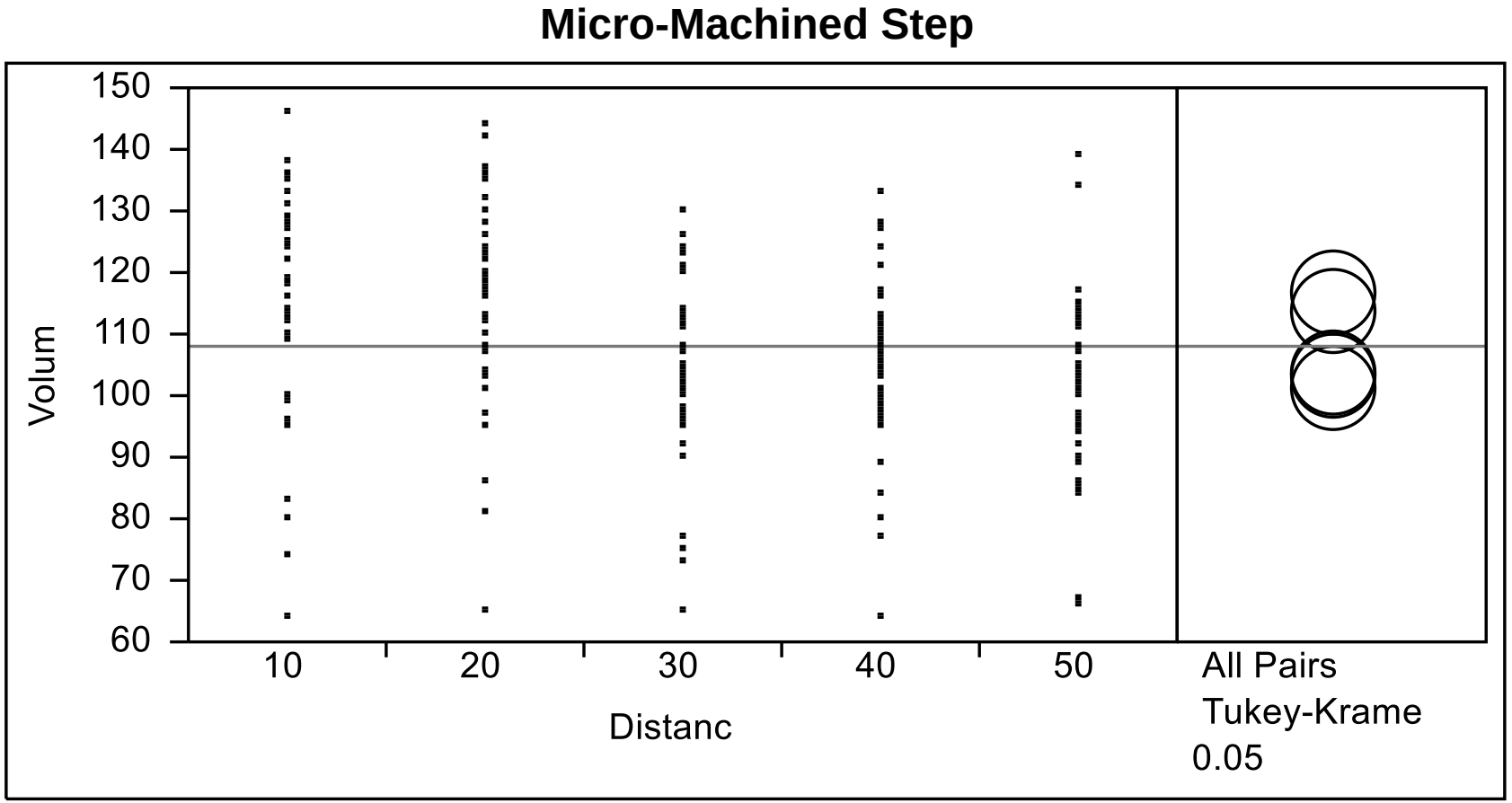
Printing Results

Micro-Machined Step



Solder Paste Volumes for the 2.0 mil Micro-Machined Step.

Printing Results



Tukey-Kramer HSD Analysis for the Uncoated, Machined 2.0 mil Step (2 mil step down) and the 8 x 9 Aperture.

Printing Results

Micro-Machined Step

Connecting Letters Report

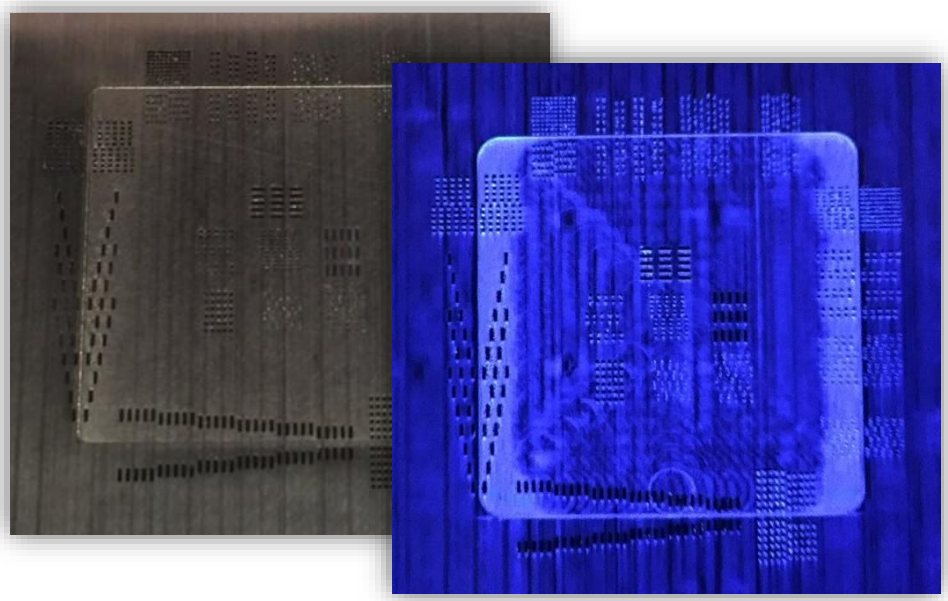
Level							Mean
10	A						116.82500
20	A						113.92500
40		B					104.20000
30		B					103.72500
50		B					101.42500

Tukey-Kramer HSD Analysis for the Uncoated, Micro-Machined 2.0 mil Step (2 mil step down) and the 8 x 9 Aperture.

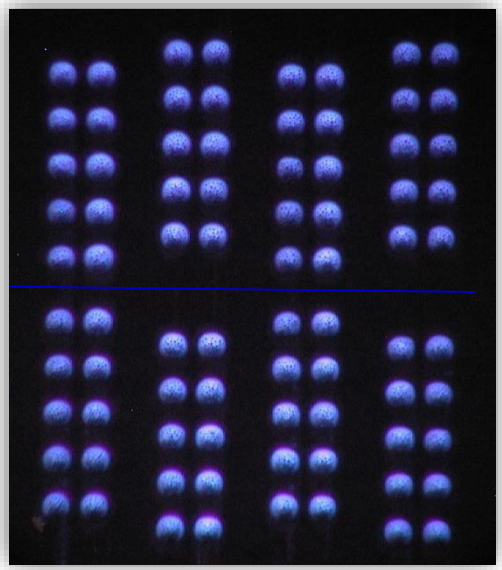
Printed solder paste volume is significantly higher at the 10 and 20 mil distances than the 30, 40, and 50 mil distances. This is also true for the 9.8 x 35.4 mil aperture with 2.0 mil and 2.5 mil machined step thicknesses.

Printing Results

Machined Step



Paste w/ blue U.V. dye added



8 x 9 mil Apertures

The printed solder paste volume is higher for the 10 and 20 mil distances than the 50 mil distance for the 9.8 x 35.4 mil apertures but smaller aperture volumes seem to be consistent from 10 – 50 mils from the step edge.

What Have We Learned About Step Stencil Technology?

- Chemical Etching, Laser Welding, and Micro-Machining are each viable methods of producing step stencils.
- The surface texture and appearance of each step technology is different
- Solder paste volumes tend to be higher 10-20 mils from the step edge than 30-50 mils away for the QFN lead designs (9.8 x 35.4 mil aperture).
- In general, standard deviation is tighter and volume greater for apertures coated with the FPN coating.
- The smaller apertures (8, 8x9, 10 mil) tend to give statistically similar results regardless of distance from the step edge.

Future Work

Step Stencil Investigations are Ongoing

- Printed paste volumes in the center of the step area will be compared to volumes near the edge.
- Non-Stepped Stencils will be made of the same thickness as the step down areas and print studies run to compare volumes.
- Printed paste volumes from horizontal versus vertical apertures with respect to the squeegee will be compared.
- Squeegee pressure and speed will be varied and the effects on printing down in step stencils studied.

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