Impact of Stencil Foil Type on Solder Paste Transfer Efficiency for Laser Cut SMT Stencils

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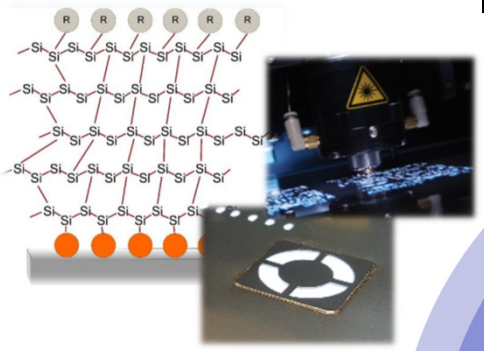
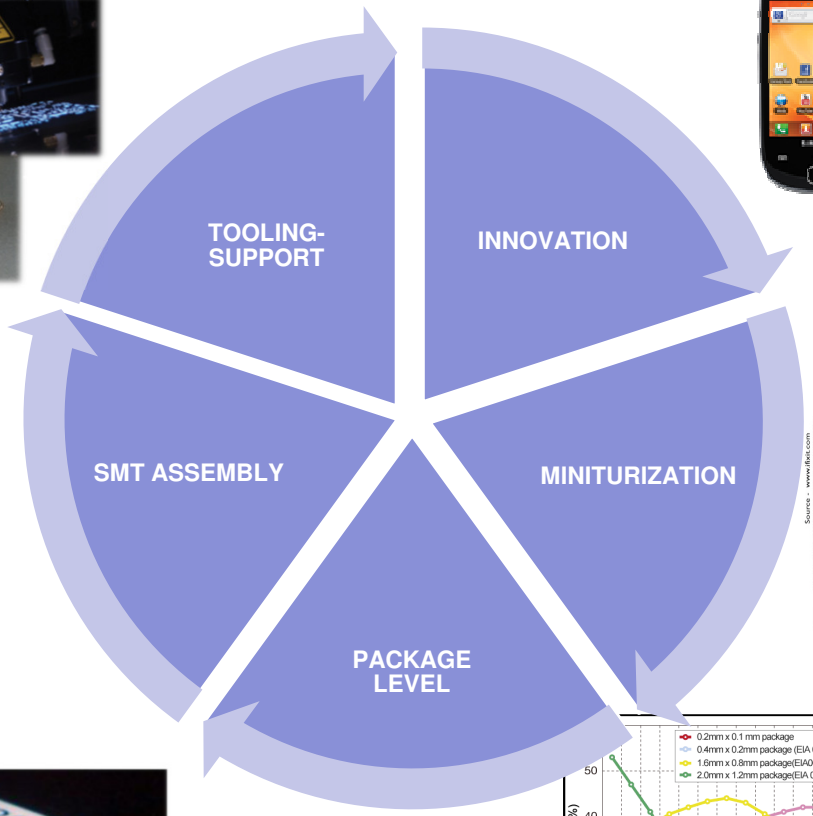
Originally published in the Proceedings of SMTA International, Rosemont, IL, Sept. 17 – 21, 2017

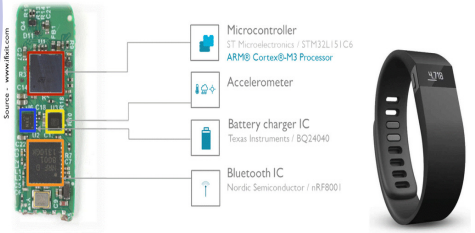
Outline/Agenda

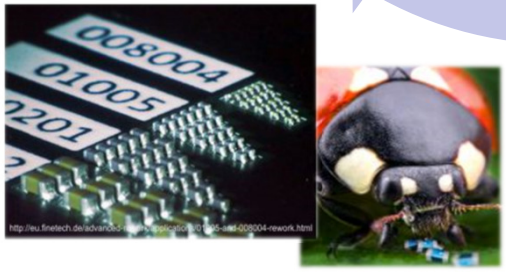
- Introduction
- Experimental Methodology
- Results of Experiments
  - Transfer Efficiency-Uncoated Stencils
  - Transfer Efficiency-Coated Stencils
  - Grain Size and Transfer Efficiency
  - Print Process Variation
  - SEM Evaluation
- Conclusions
- Q & A

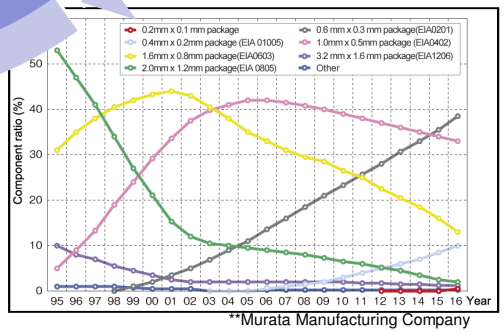
Introduction





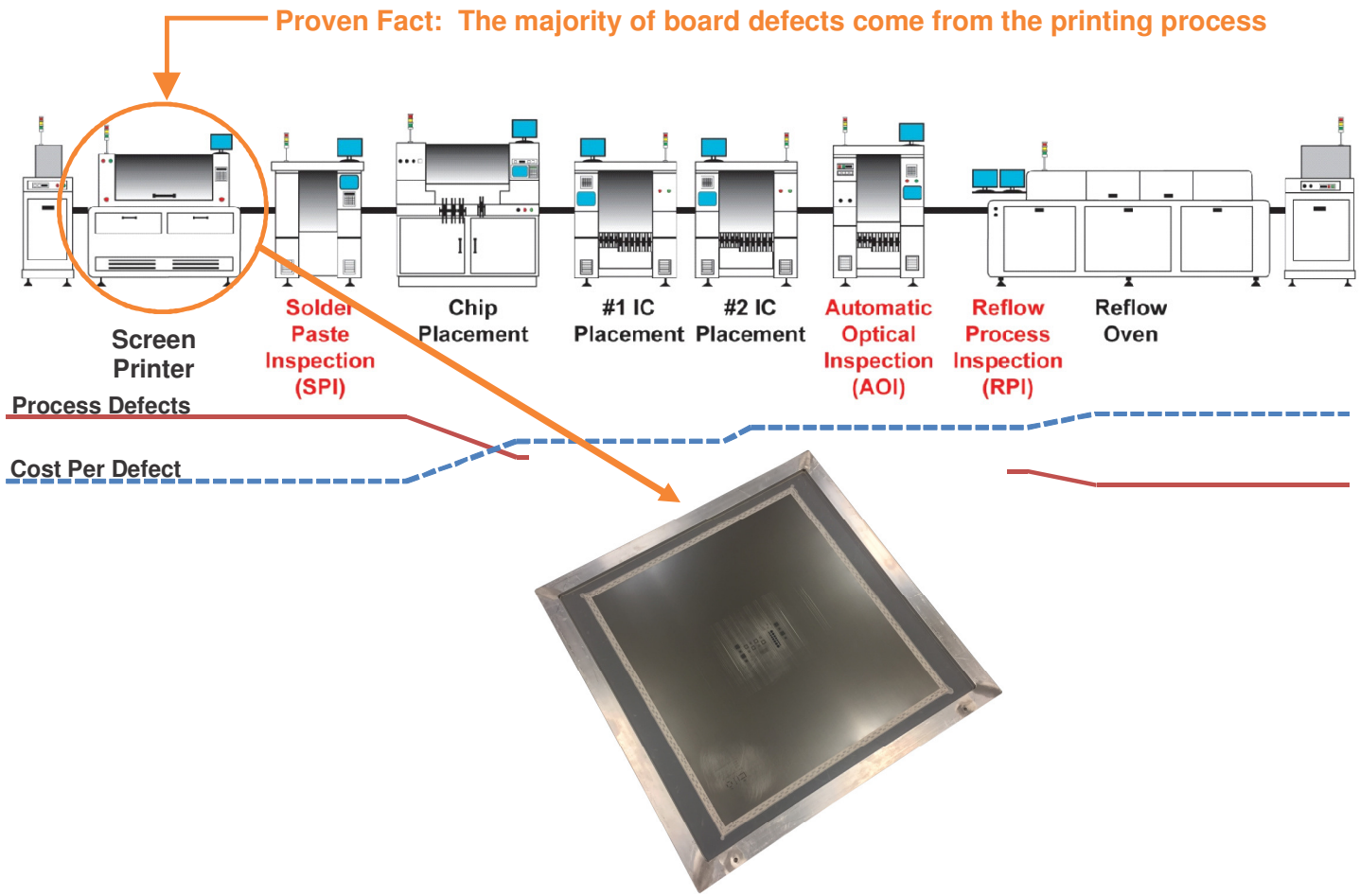




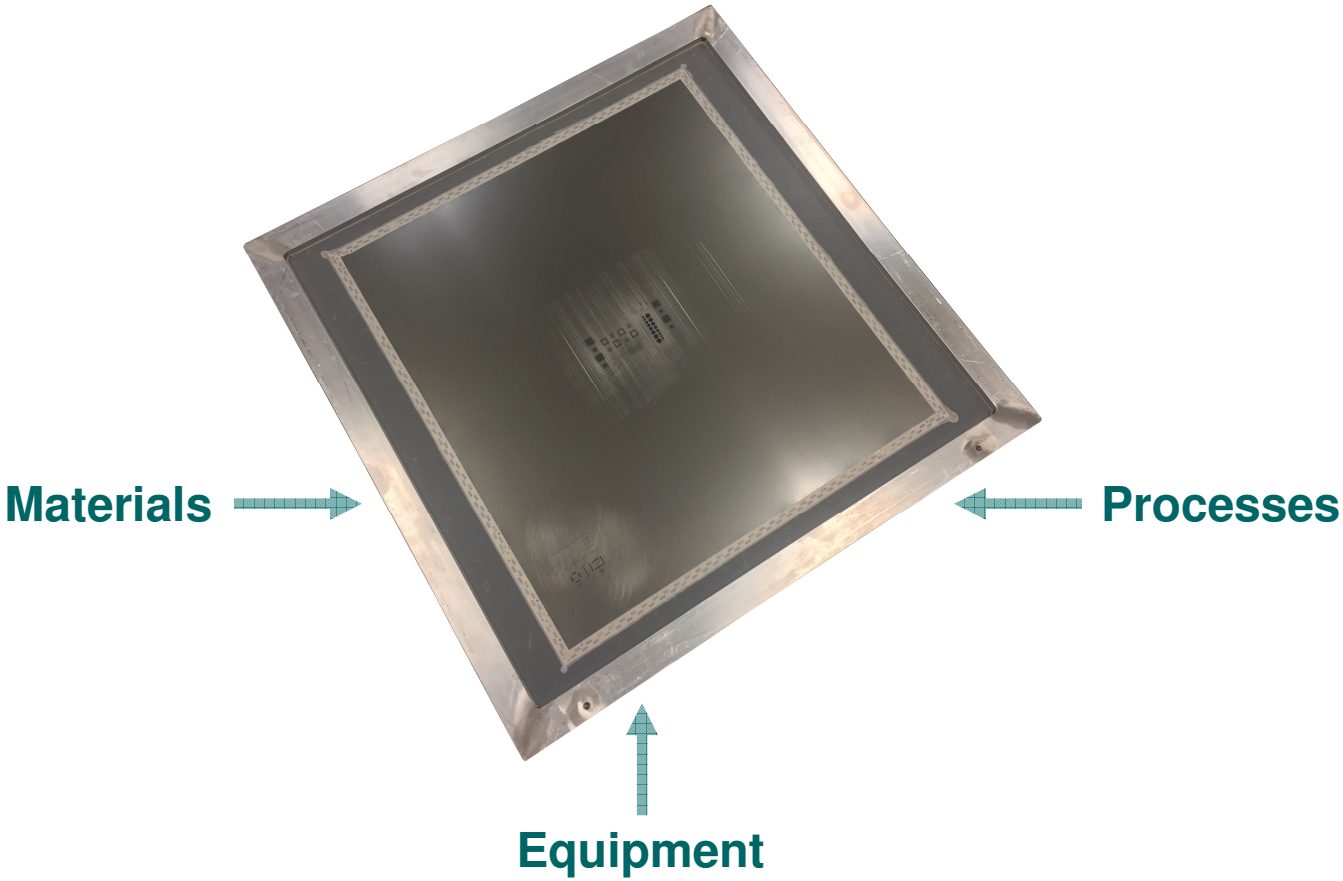


**Murata Manufacturing Company
http://www.murata.com/products/article/pp09e1/3.html

Introduction



Introduction



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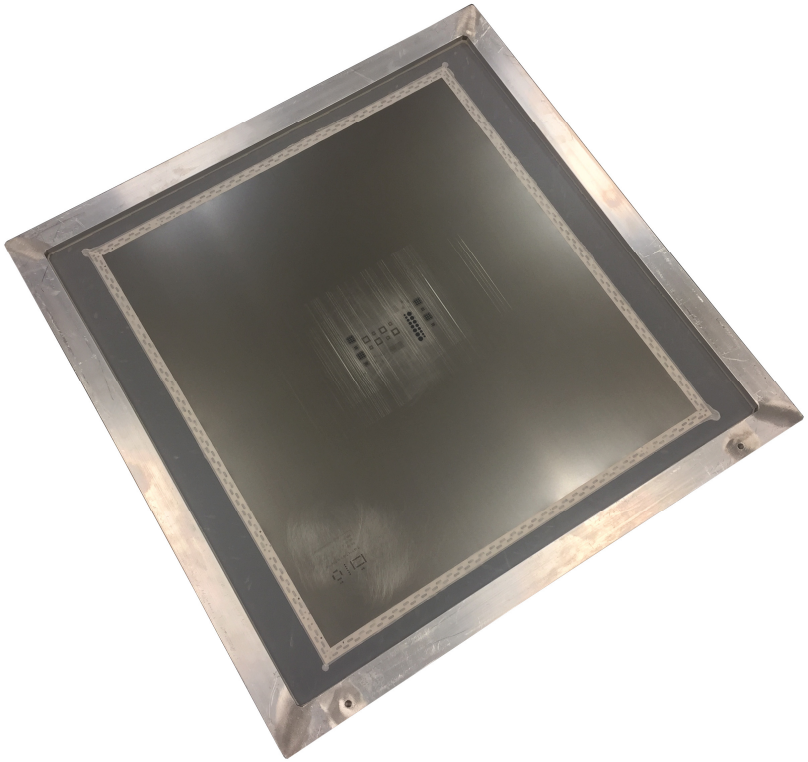
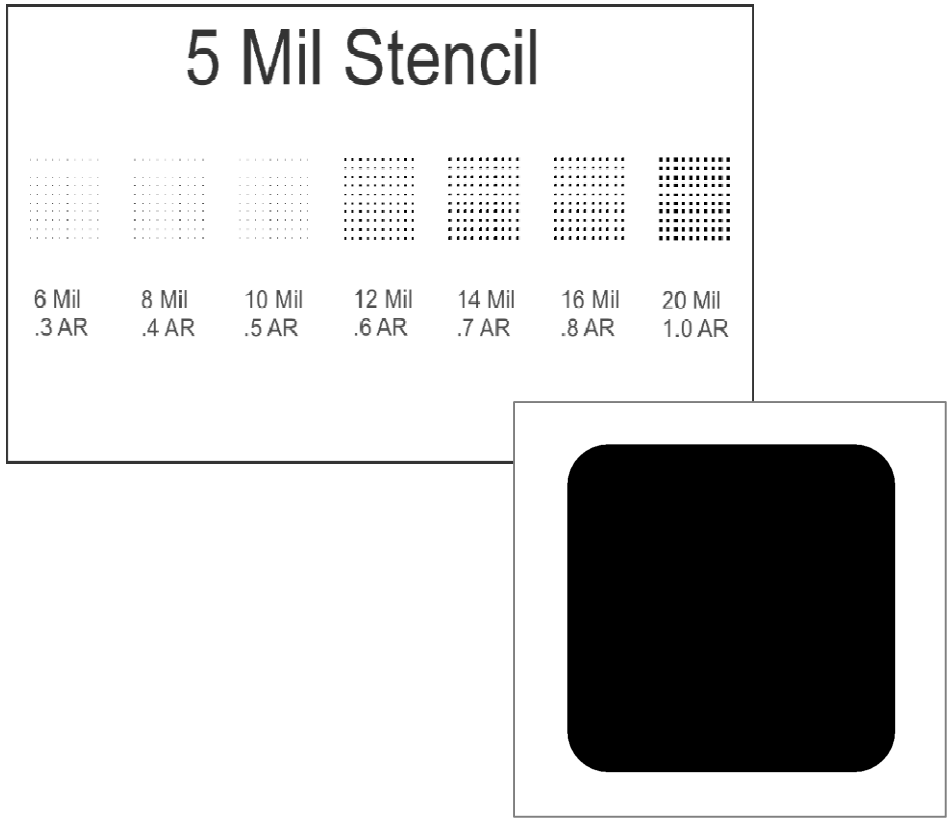


Does the foil material influence transfer efficiency and print variation?

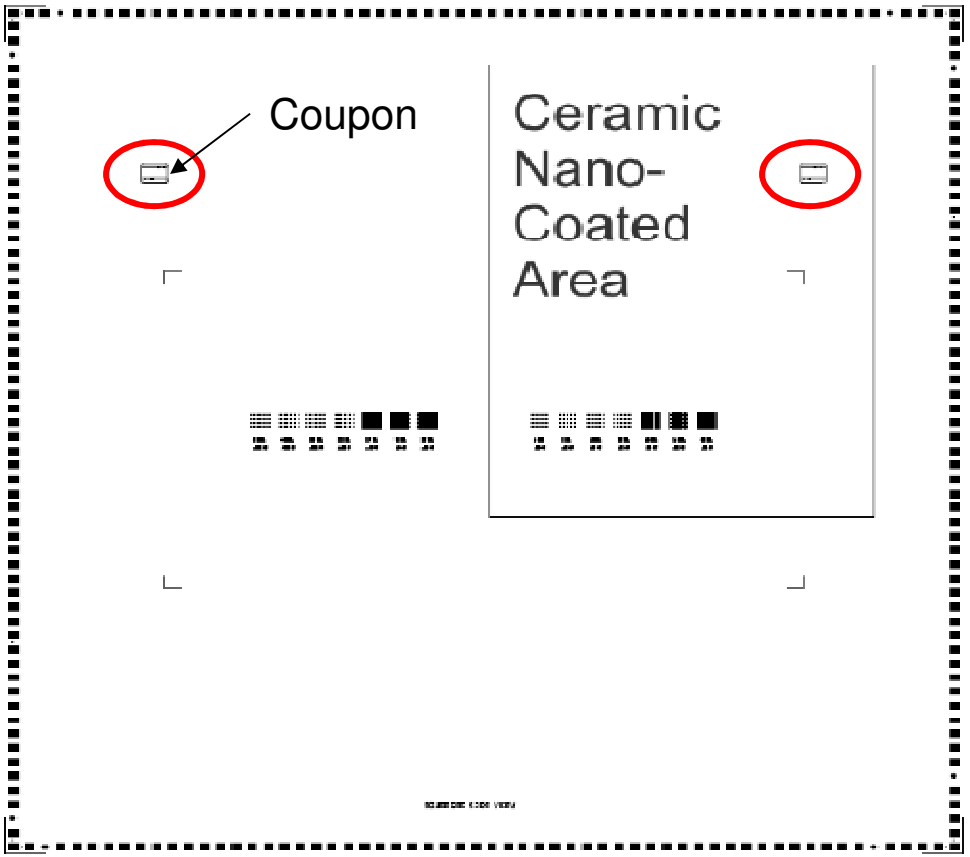
Experimental Methodology



Test Vehicle:

- 7 Area Ratio Apertures
- 5 Mil (125mm) Foil
- All square with rounded corner
- 100 Apertures per group

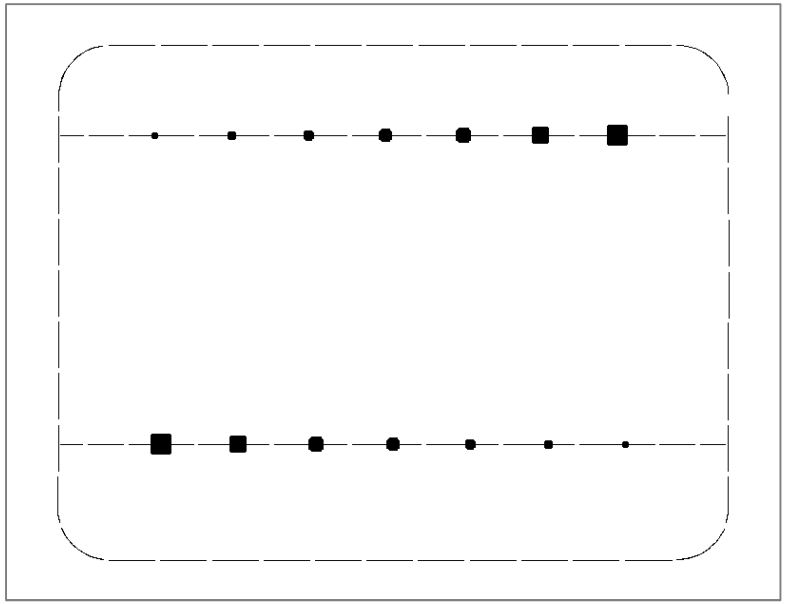
Experimental Methodology



Test Vehicle:

- 2 Patterns Per Stencil
- 1 Pattern Coated with Ceramic Nano-Coating
- 2 Coupons Per Stencil
- Cut Same Day/Same Laser

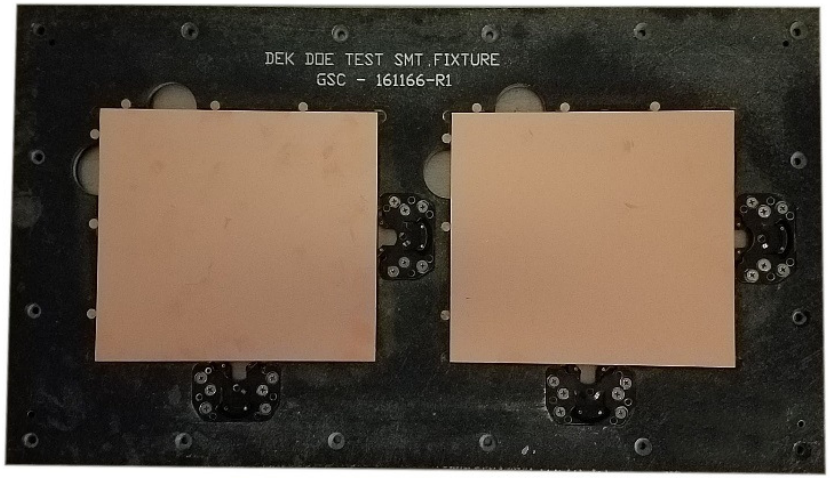
Experimental Methodology



Test Vehicle:

- 2 Coupons with 2 Apertures Per Area Ratio
- Outlined With Perforated Pattern
- Perforated Pattern Thru Apertures

Experimental Methodology



Parameter	Value
Squeegee Length	600 mm
Squeegee Pressure	10 Kg
Squeegee Speed	30 mm/sec
Squeegee Angle	60 degrees
Separation Speed	1.0 mm/sec
Cleaning Solvent	IPA
Solder Paste	NC SAC305 T4

- .062” (1.6mm) Copper Clad
- 2 Boards Printed Each Pass
- Printed 10 board uncoated and coated for each material.

Experimental Methodology

7 Materials Tested

Material	"FG"	Description	Grain Size Category
1	Yes	Stainless	A
2	No	Stainless	B
3	N/A	Ni	N/A
4	N/A	Ni	N/A
5	No	Stainless	C
6	Yes	Stainless	A
7	Yes	Stainless	A

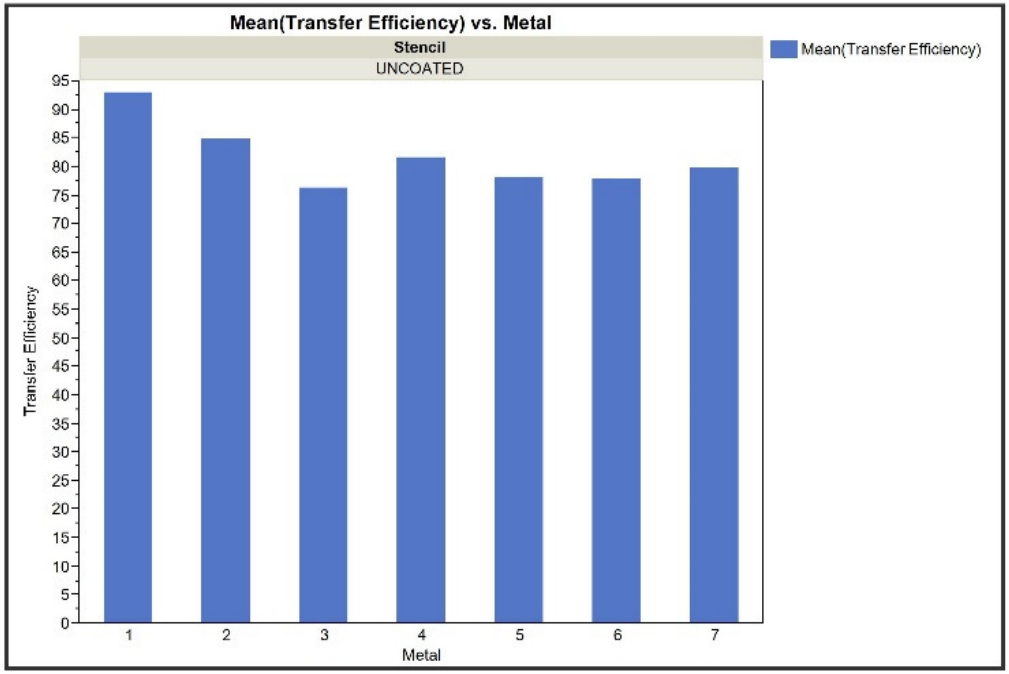
Grain Size "A": 1-5 Microns
Grain Size "B": 6-10 Microns
Grain Size "C": >10 Microns
Nickel Grain Size: Unknown

Experimental Methodology

- 10 Boards Printed on the Uncoated Side and 10 Boards Printed on the Coated Side of Each Stencil at same time
- No Clean, SAC 305, Type 4 Paste
- New Paste Used for Each Material Type Tested
- Printer was a common fully automated printer
- Solder paste volumes measured using a 3D solder paste inspection system (SPI)
- Data analyzed using statistical analysis software

Results

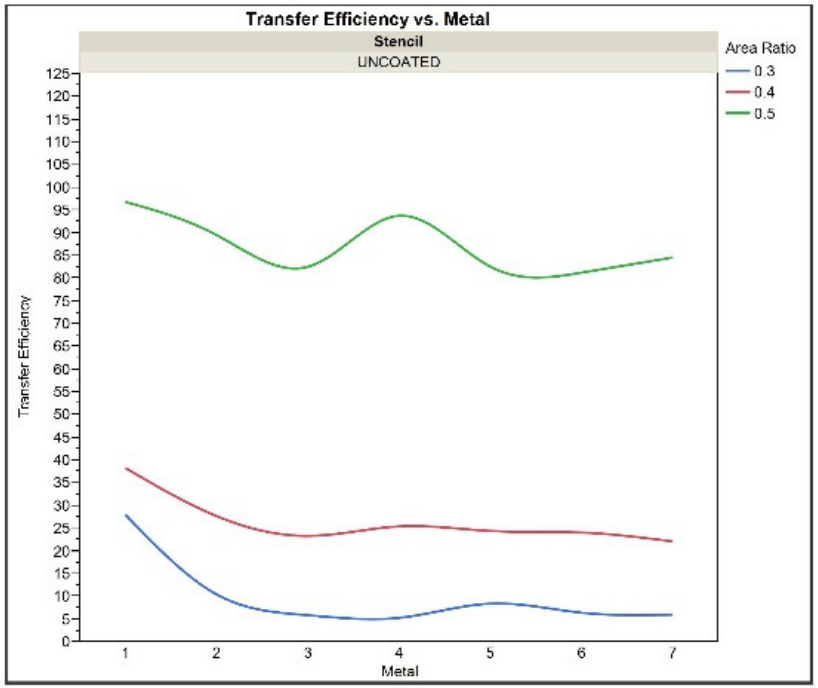
Transfer Efficiency-Uncoated Metal Stencils



Transfer Efficiency of Uncoated Stencils: All area ratios and metal types.

Results

Transfer Efficiency-Uncoated Metal Stencils



Transfer Efficiency of Uncoated Stencils: All metals, 0.3, 0.4 and 0.5 area ratios (Small Area Ratios).

Results

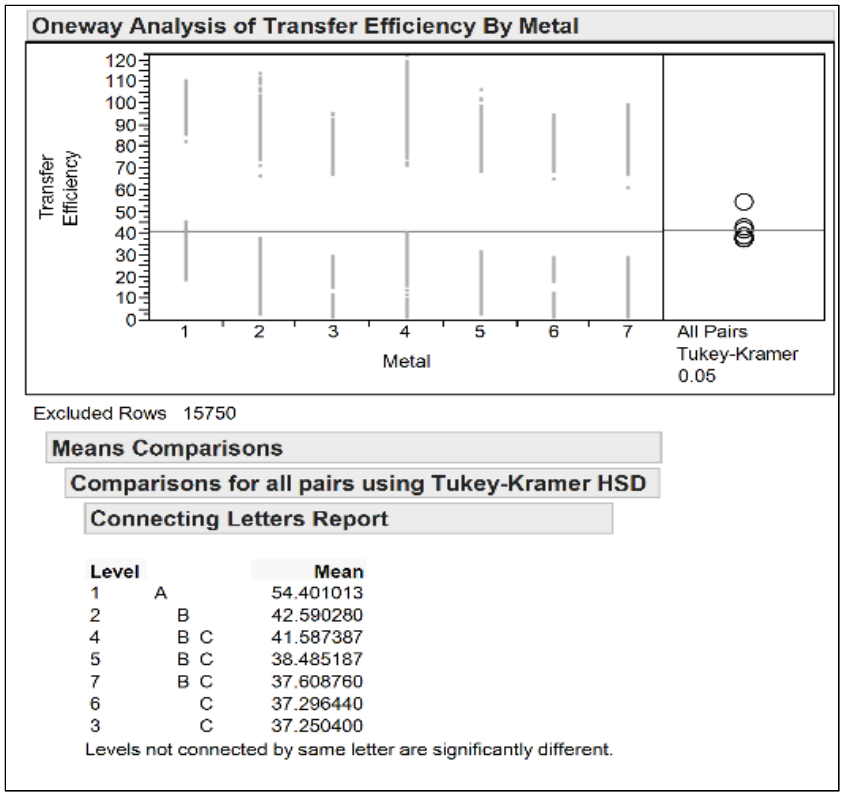
Transfer Efficiency-Uncoated Metal Stencils

Material	0.30 Area Ratio	0.40 Area Ratio	0.50 Area Ratio
1	28.04	38.31	96.85
2	10.45	27.71	89.6
3	5.94	23.35	82.46
4	5.31	25.49	93.95
5	8.49	24.44	82.52
6	6.45	24.12	81.32
7	6.05	22.14	84.63

Mean Transfer Efficiency of Uncoated Stencils for 0.3, 0.4 and 0.5 Area Ratios (Small Area Ratios) for all metal types.

Results

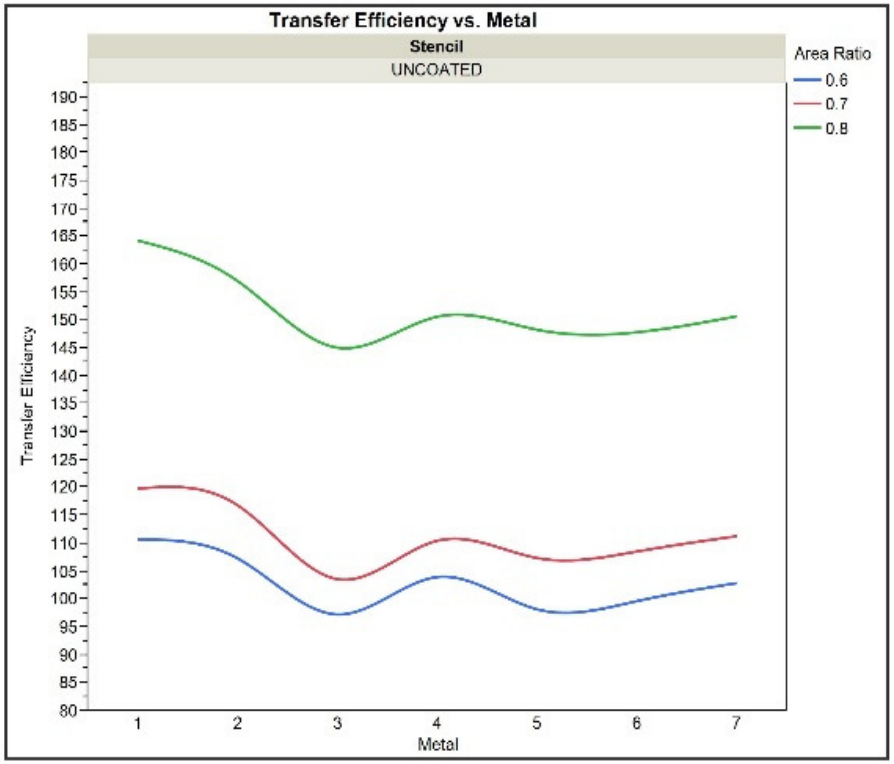
Transfer Efficiency-Uncoated Metal Stencils



Tukey-Kramer HSD on Transfer Efficiency for Area Ratio 0.3, 0.4 and 0.5 (Small Area Ratios).

Results

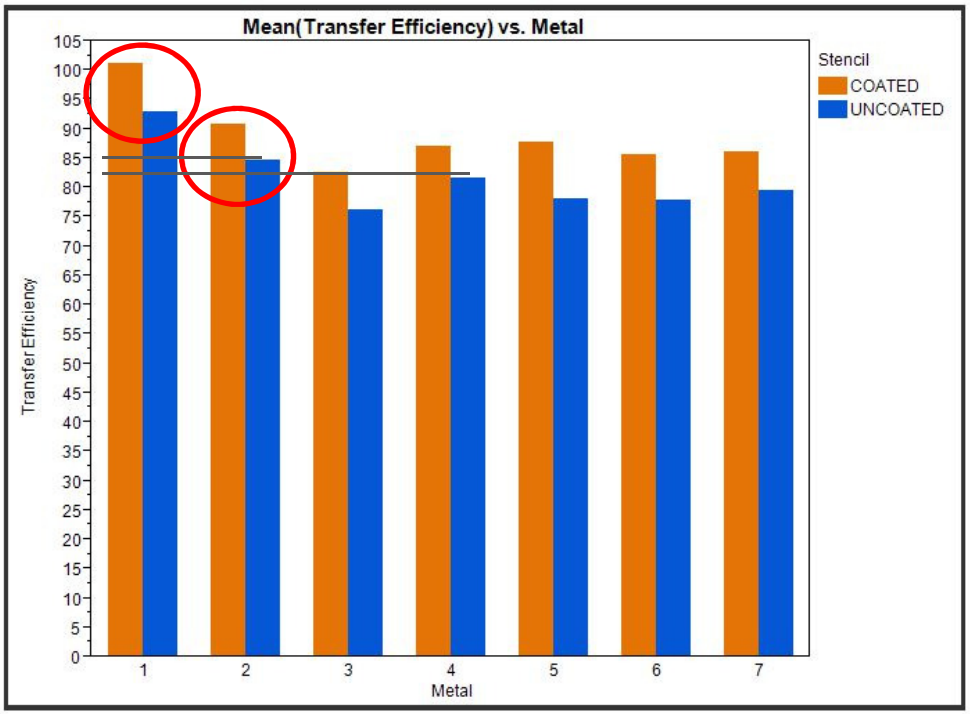
Transfer Efficiency-Uncoated Metal Stencils



Transfer Efficiency of Uncoated Stencils: All metals, 0.6, 0.7, and 0.8 area ratios.

Results

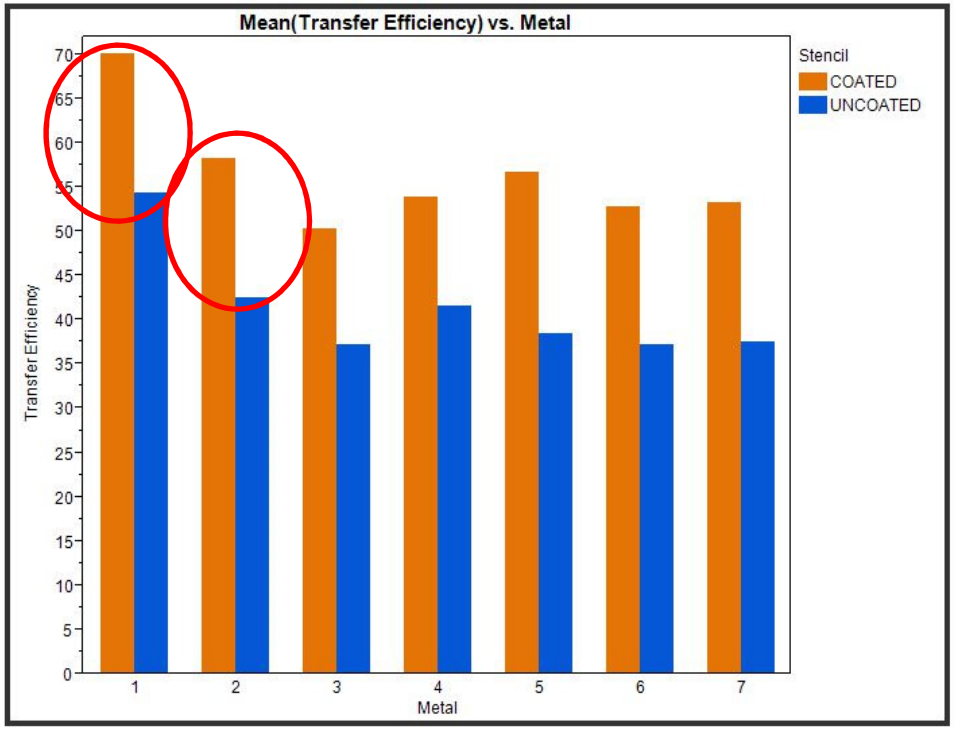
Transfer Efficiency-Ceramic Nano-Coated Metal Stencils



Transfer Efficiency for Coated and Uncoated Stencils for All Metals and All Area Ratios.

Results

Transfer Efficiency-Ceramic Nano-Coated Metal Stencils



Transfer Efficiency for Coated and Uncoated Stencils for All Metals with 0.3, 0.4, and 0.5 Area Ratios (Small Area Ratios) Combined.

Results

Transfer Efficiency-Ceramic Nano-Coated Metal Stencils

Material	0.30 Area Ratio	0.40 Area Ratio	0.50 Area Ratio
1	32.42	43.36	110.92
2	16.38	33.38	101.51
3	10.74	28.71	92.06
4	11.65	32.12	99.52
5	15.30	31.58	95.91
6	12.12	29.53	93.50
7	11.37	28.92	96.10

Mean Transfer Efficiency of Coated Stencils for 0.3, 0.4 and 0.5 Area Ratios (Small Area Ratios) for all metal types.

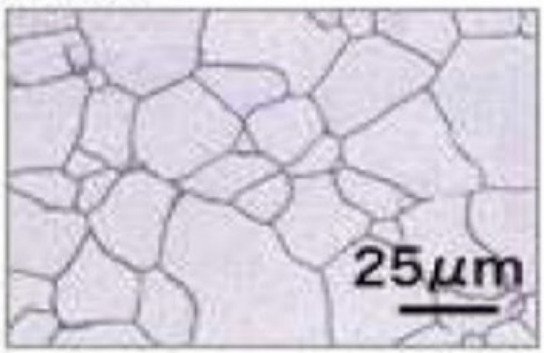
Results

Transfer Efficiency-Coated and Uncoated Stencils

- Uncoated Stencils: Material 1, Best Performer
  Material 4, 2nd Best Performer
  Material 2, 3rd Best Performer
- Coated Stencils: Material 1, Best Performer
  Material 2, 2nd Best Performer
  Material 4, 3rd Best Performer

Results

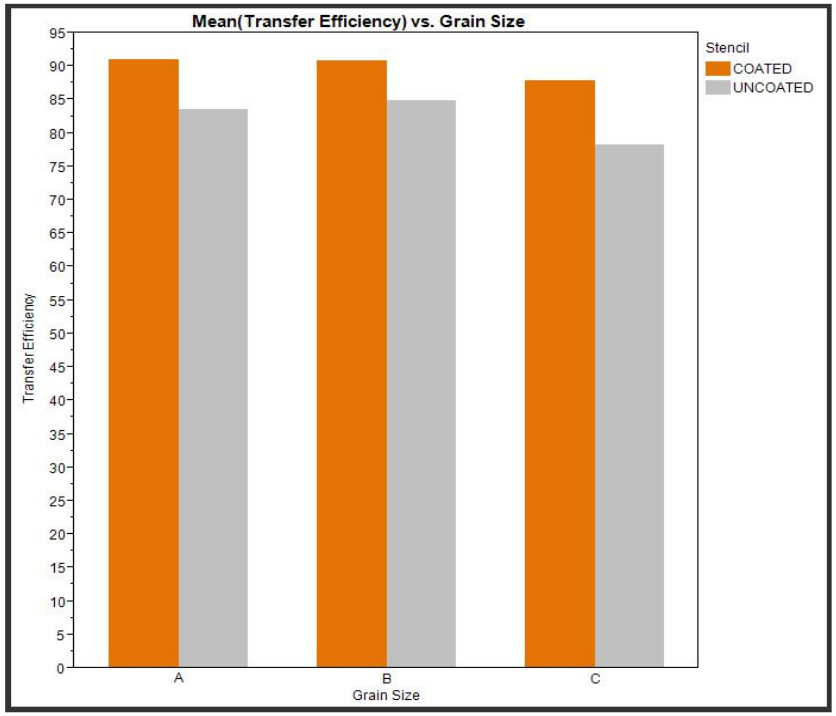
Transfer Efficiency-Grain Size Comparison



- Metals are crystalline
- During processing, atoms line up in a pattern
- Heat treatment, cooling rates, extrusion process, etc. affect grain size
- Atomic orientations form internal boundaries
- Generally accepted-mechanical properties improve as grain size decreases
- ASTM has a standard for measuring grain size

Results

Transfer Efficiency-Grain Size Comparison

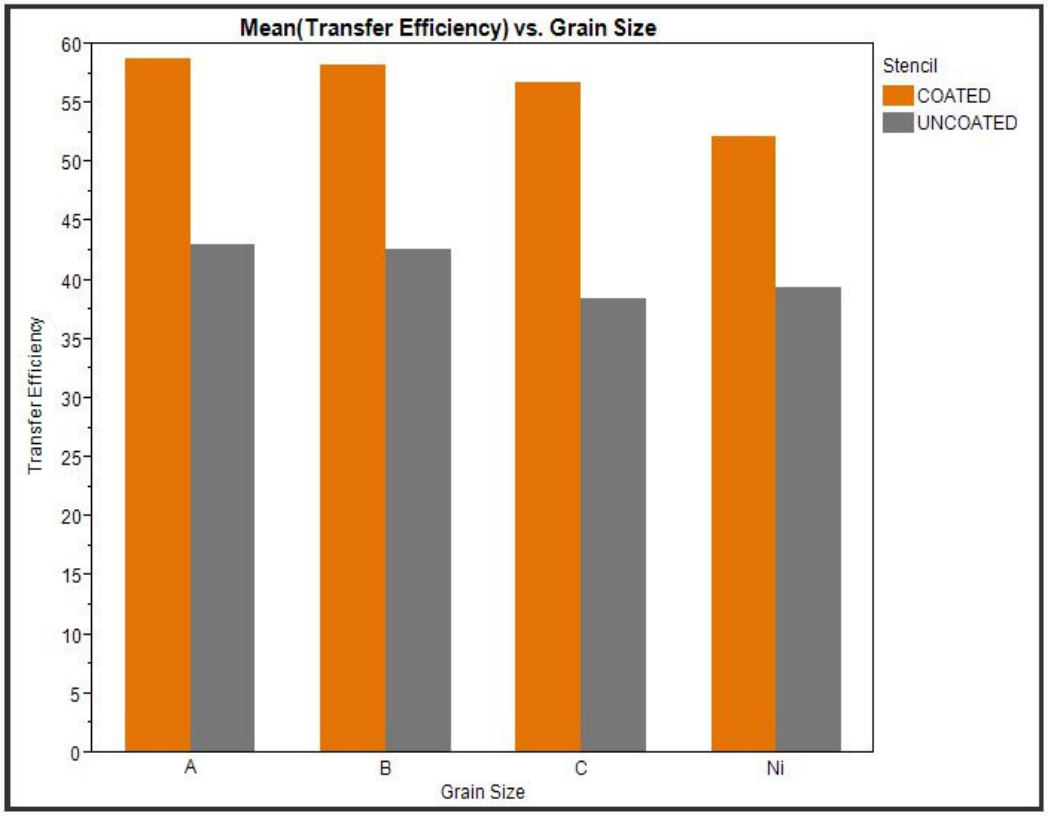


Transfer Efficiency vs Grain Size for all Area Ratios.

A: 1-5 Microns
B: 6-10 Microns
C: >10 Microns
Ni: Nickel

Results

Transfer Efficiency-Grain Size Comparison

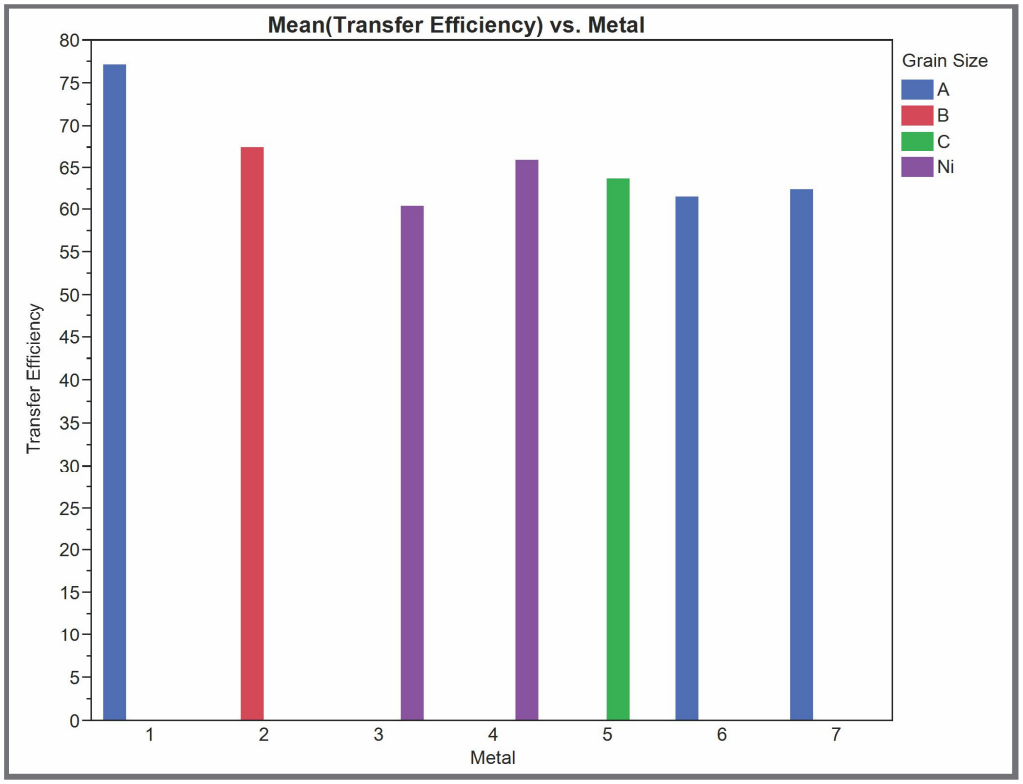


A: 1-5 Microns
B: 6-10 Microns
C: >10 Microns
Ni: Nickel

Transfer Efficiency by Grain Size for 0.3, 0.4, 0.5 Area Ratios (Small Area Ratio Printing).

Results

Transfer Efficiency-Grain Size Comparison

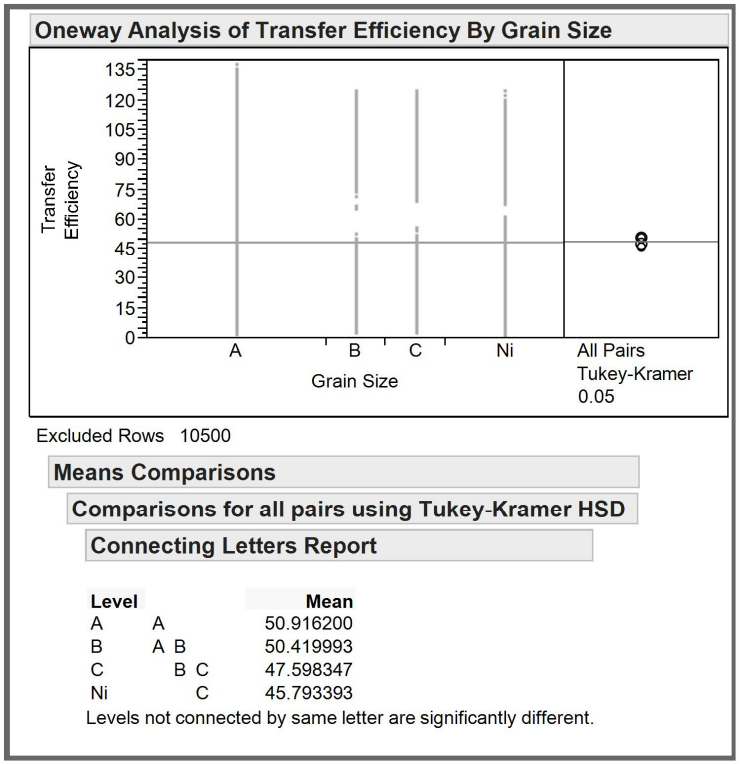


A=1-5 Microns (FG)
B= 6-10 Microns
C= >10 Microns
Ni= Nickel

Transfer Efficiency by Metal by Grain Size for 0.4, 0.5 Area Ratios (Small Area Ratio Printing).

Results

Transfer Efficiency-Grain Size Comparison



Tukey-Kramer HSD by Grain Size for 0.4, 0.5 Area Ratios (Small Area Ratio Printing).

- Material 1, Grain Size A Statistically Best
- Other Grain Size A materials were no better than Grain Size B
- Grain Size B not statistically better than Grain Size C
- Ni material statistically was the worst performer

mean .[1]. It shows

Results

Variation in Print Process

Coefficient of Variation (CV)=
Standard Deviation of Print Volume Measurement (σ) Divided By the Mean of the Measurement (μ)

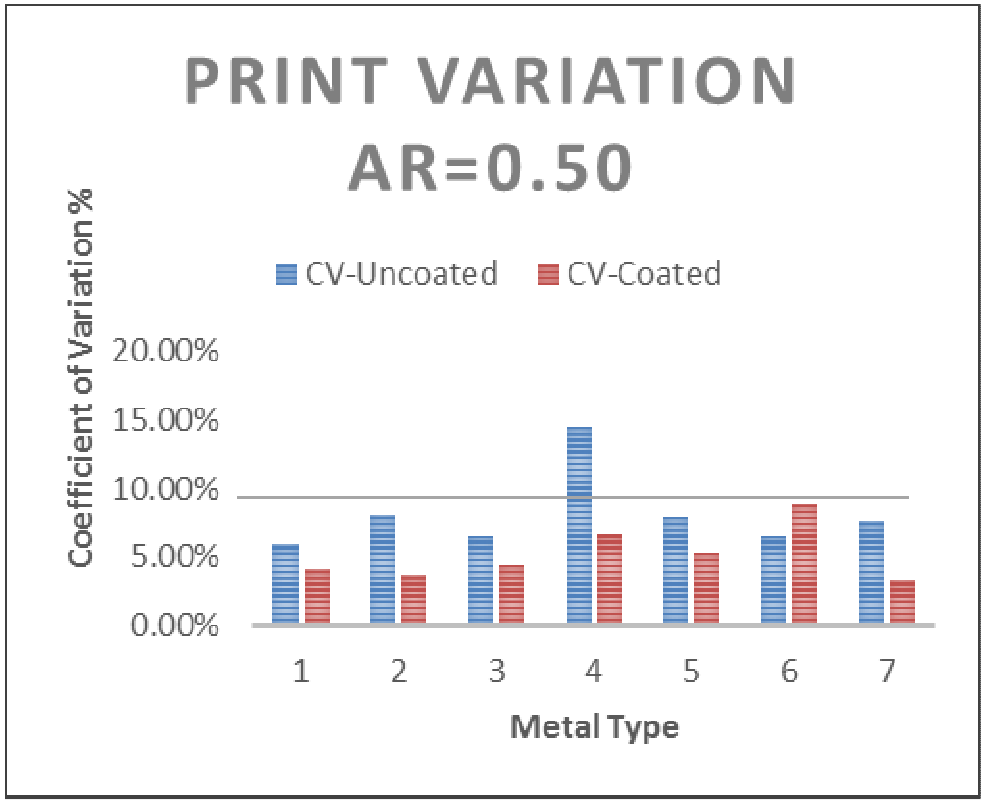
$$c_v = \sigma/\mu$$

≤ 10% Considered Acceptable*

**Shea C. and Whittier R., "The Effects of Stencil Alloy and Cut Quality on Solder Paste Print Performance" Proceedings of SMTA International, Oct. 2014*

Results

Variation in Print Process



Coefficient of Variation by Metal Type.

Results

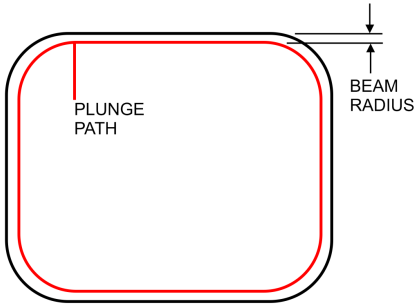
Variation in Print Process

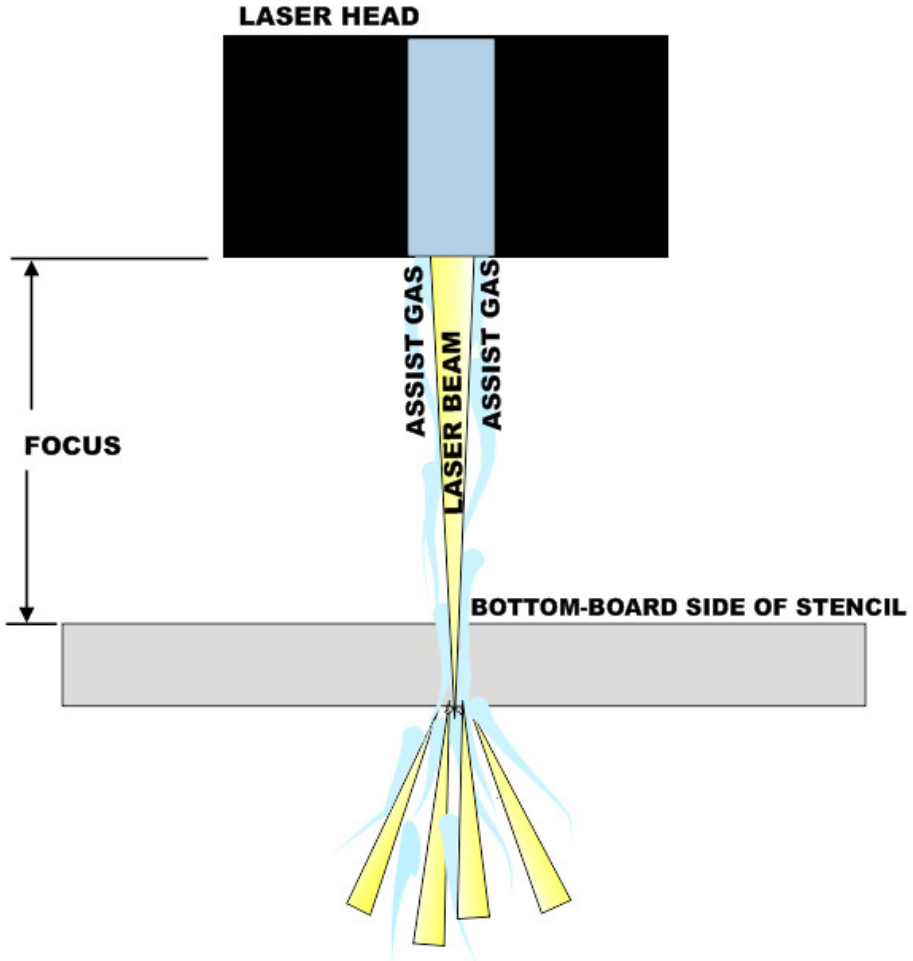
Material	TE-Uncoated	CV-Uncoated	TE-Coated	CV-Coated
1	96.85	5.99%	125	4.06%
2	89.6	8.10%	113.4	3.67%
3	82.46	6.48%	101.59	4.38%
4	93.95	14.56%	105.08	6.65%
5	82.52	7.88%	109.3	5.22%
6	81.32	6.54%	105.68	8.88%
7	84.63	7.68%	107.57	3.25%

Transfer Efficiency (TE) and Coefficient of Variation for all metals with 0.5 Area Ratio

Results

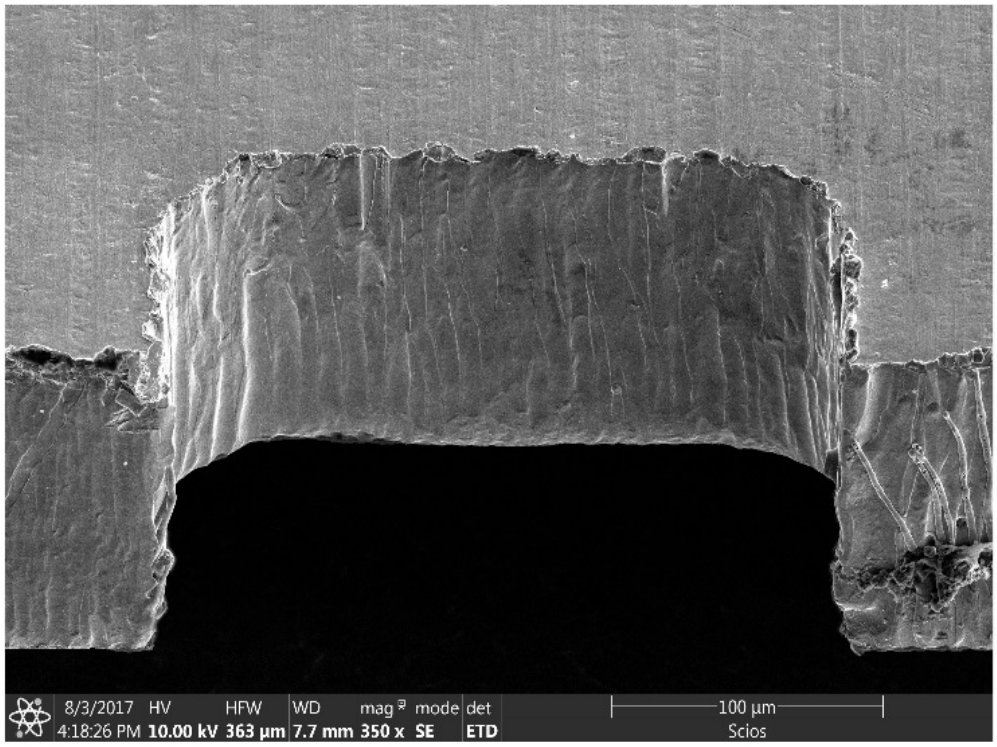
Understanding the Laser Cut Process





Results

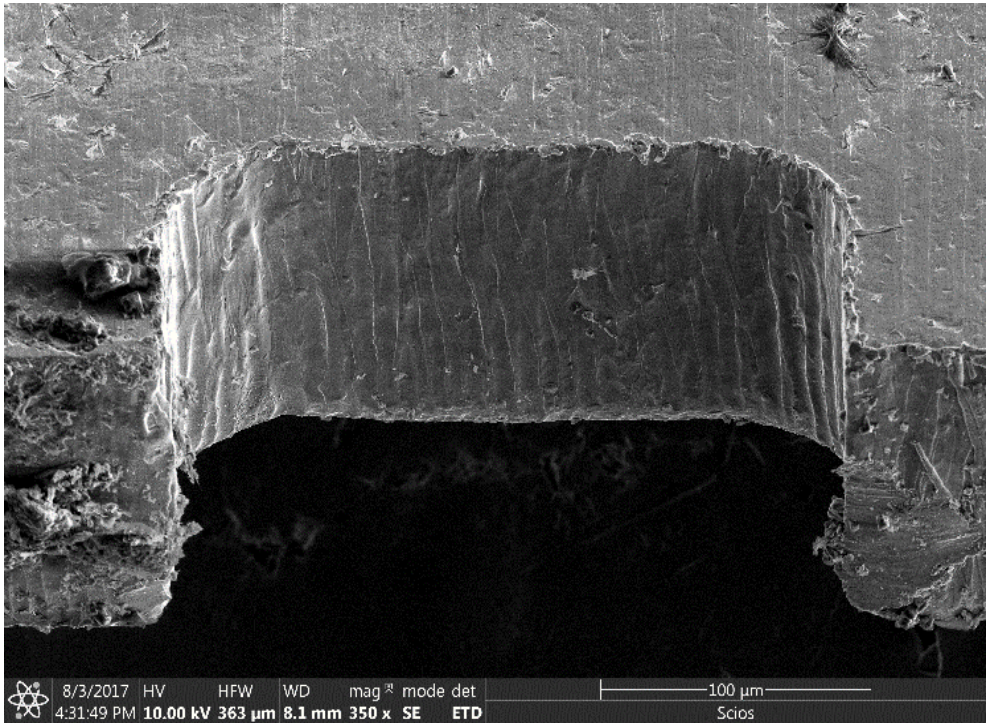
Aperture Sidewall Images



SEM of Uncoated Aperture Sidewall, Material 1

Results

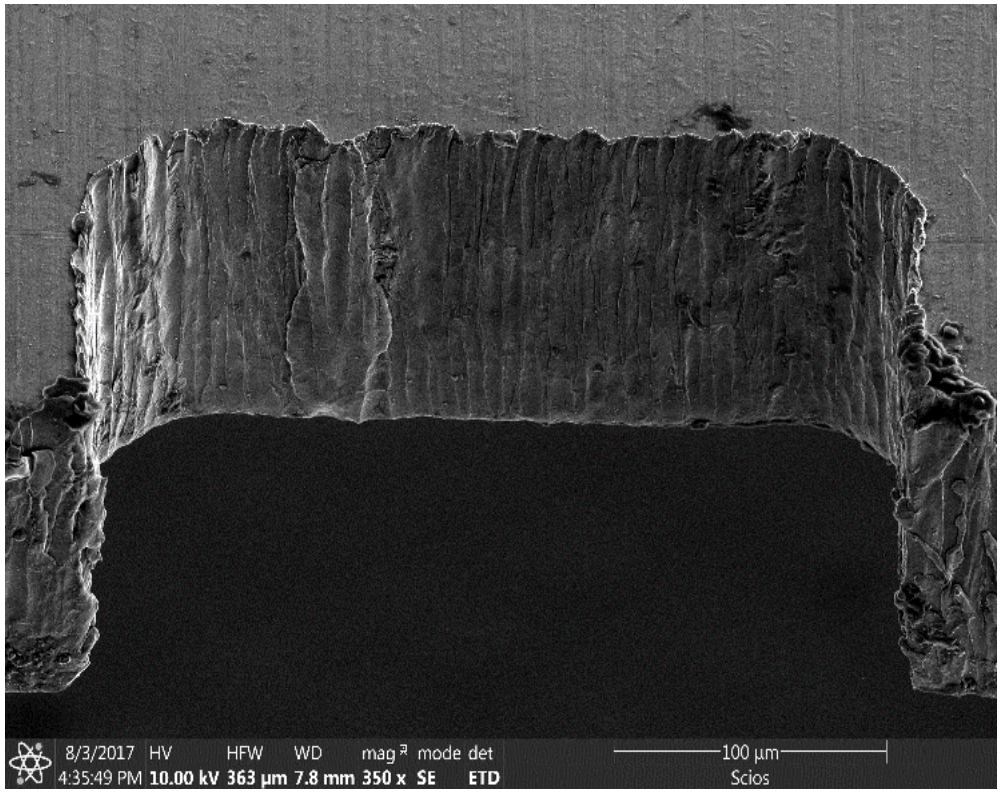
Aperture Sidewall Images



SEM of Uncoated Aperture Sidewall, Material 2

Results

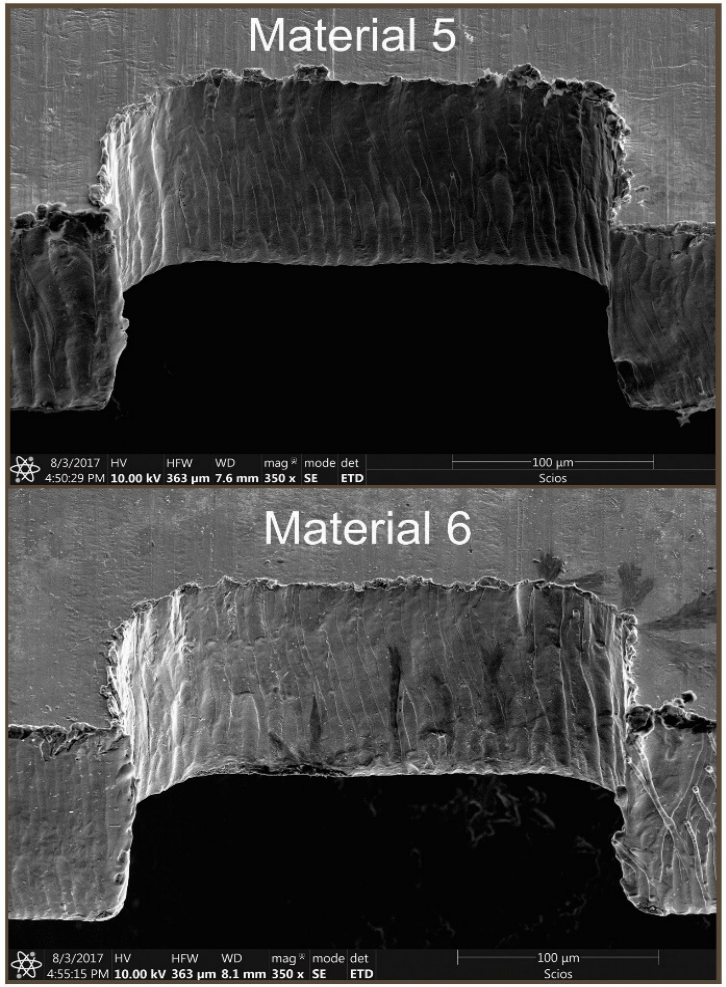
Aperture Sidewall Images



SEM of Uncoated Aperture Sidewall, Material 3

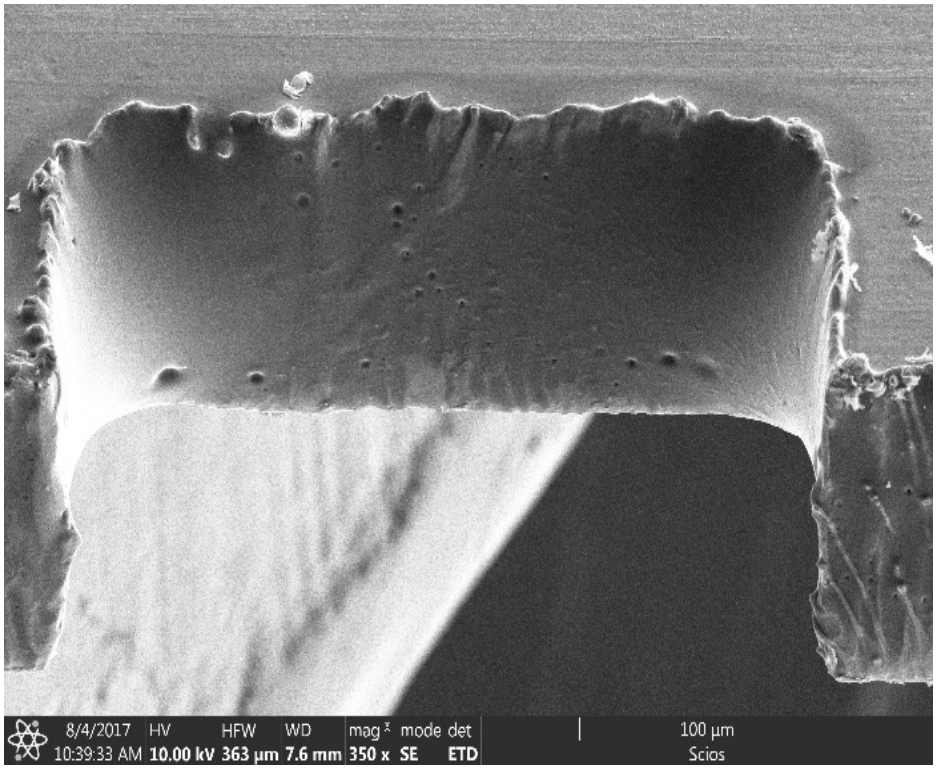
Results

Aperture Sidewall Images



Results

Aperture Sidewall Images



SEM of Ceramic Nano-Coated Aperture Wall

Conclusions

- Not all Fine Grain (FG) materials perform the same
- Material 1 (FG) and Material 2 (Not FG) were determined to outperform the other 5 materials when comparing Transfer Efficiency and Coeficient of Variation
- Ceramic Nano-Coating Technology improves transfer efficiency for all materials tested.
- Ceramic Nano-Coating Technology reduces coefficient of variation for all but one material tested.

Conclusions

- Laser cutting the material with the highest transfer efficiency and the lowest coefficient of variation and applying a Ceramic Nano-Coating produces the best printing process
- SEM Analysis shows that base materials cut differently and some materials exhibit smoother sidewalls than others.
- Smoother sidewalls produce better print transfer efficiency and also exhibit lower print variation in the process.

Thank You!

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