Vapor Deposited Stencil Nano-Coatings- A New Break Thru or Just Another Coating?

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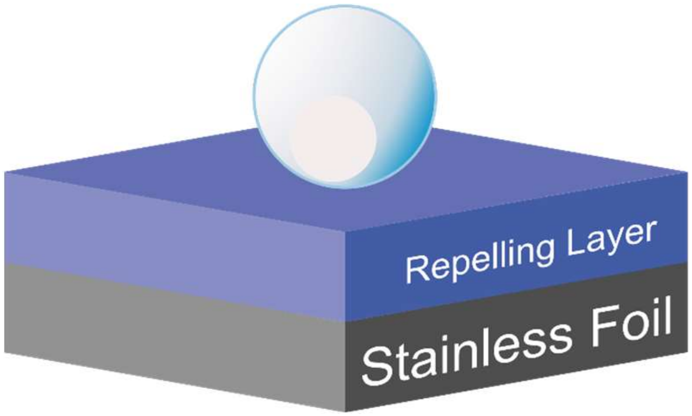
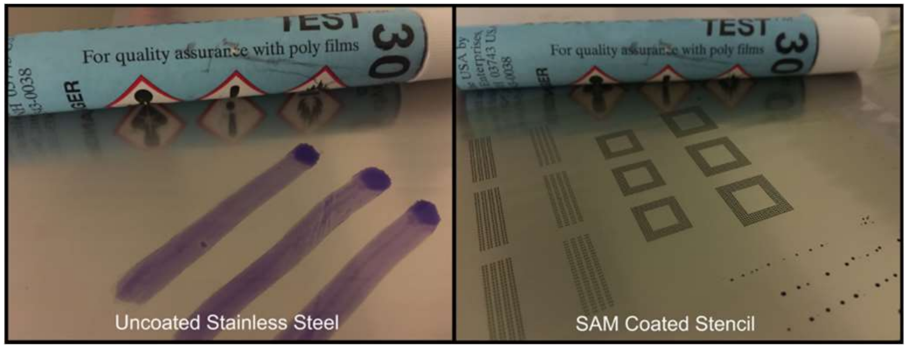
Outline/Agenda

- Introduction
- Methodology
- Experimental Procedure
- Results and Discussion
- Conclusions
- Q & A

Introduction

Current Nano-Coatings available for SMT Stencils

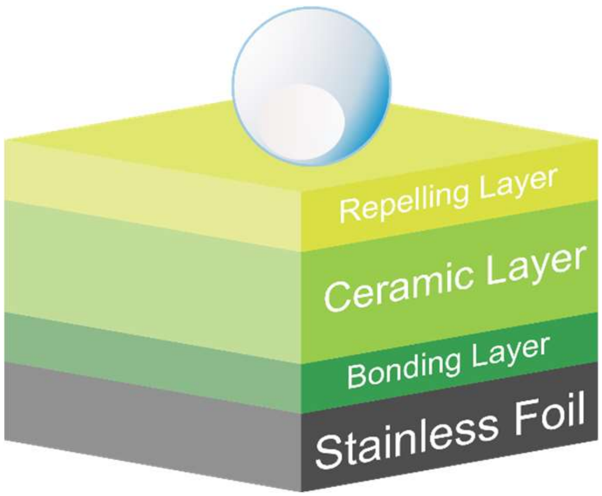




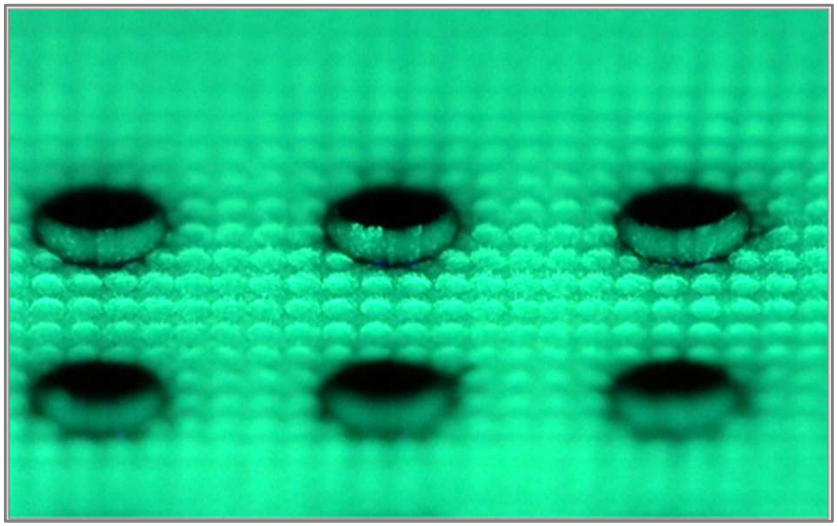
Self-Assembled Monolayer - Wipe-On Coating (2-4 nm)

Introduction

Current Nano-Coatings available for SMT Stencils

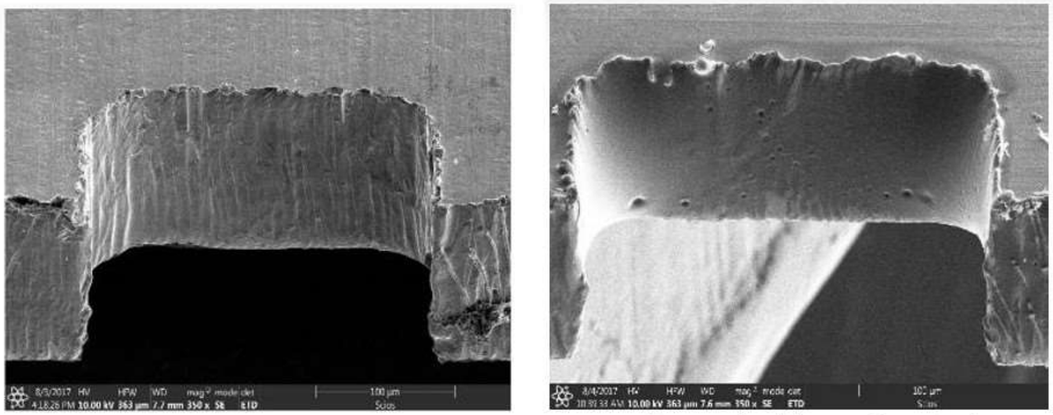


Ceramic Nano-Coating
Sprayed/Cured (2-4 µ)



Introduction

Current Nano-Coatings available for SMT Stencils



Uncoated-Laser Cut Aperture

Ceramic Nano-Coated
Laser Cut Aperture

Ceramic Nano-Coating Sprayed/Cured (2-4 μ)

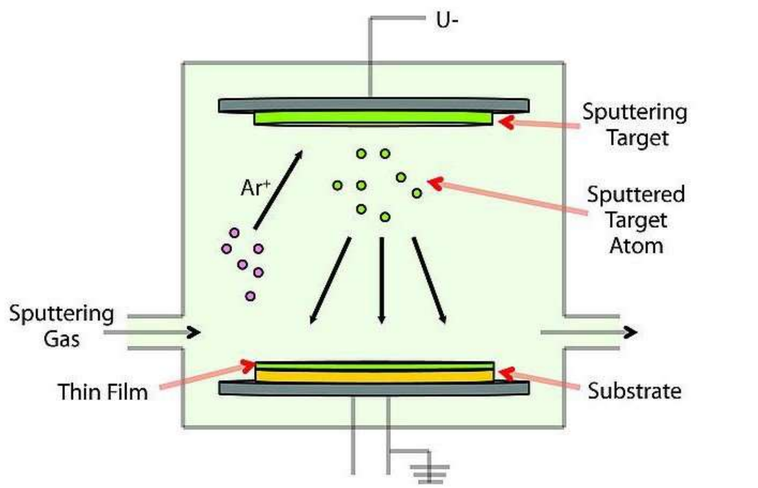
Introduction

New Potential Coating: Chemical Vapor Deposition

“a vacuum deposition method used to produce high-quality, and high-performance, solid materials. The process is often used in the semiconductor industry to produce thin films. In typical CVD, the wafer is exposed to one or more volatile precursors, which react and/or decompose on the substrate surface to produce the desired deposit.” *Wikipedia*

Introduction

New Potential Coating: Chemical Vapor Deposition

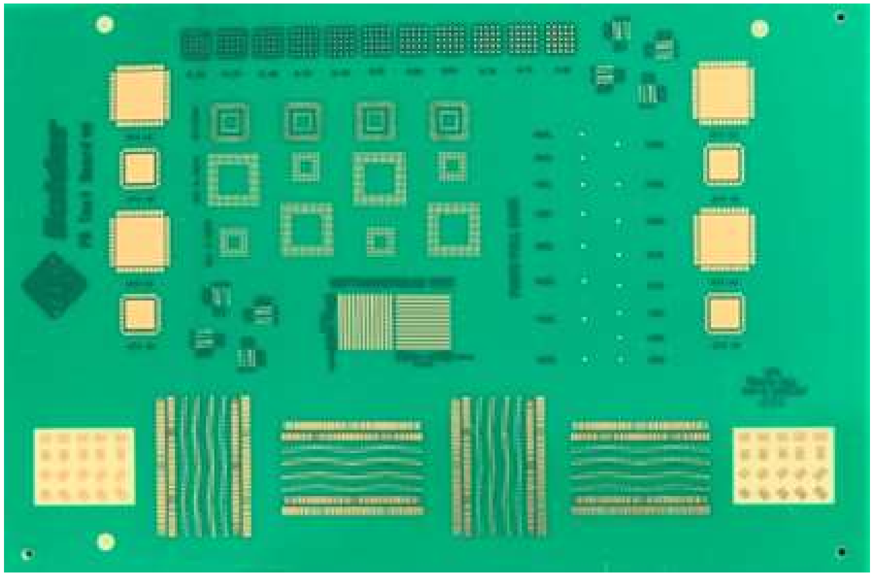


https://en.wikipedia.org/wiki/Physical_vapor_deposition#/media/File:Physical_Vapor_Deposition_(PVD).jpg

- Targets/Precursors rotate in chamber
- Vacuum/Heat introduced
- Proprietary materials vaporized and re-deposited on stencil
- Layers of material create Hydro/Oleophobic coating

Methodology

Materials: PCB



- PCB
- FR4 Print and Etch
- 1 oz. Copper
- ENIG (Electroless Nickel Immersion Gold)

SMTA International

Methodology

Materials: Stencils

	Foil Thickness	Coating
Stencil 1	5 MIL (.127mm)	None
Stencil 2	5 MIL (.127mm)	CVD1
Stencil 3	5 Mil (.127mm)	CVD2 (PP)
Stencil 4	5 MIL (.127mm)	NSG

- Four Stencils Tested
- 29x29 Spacesaver
- Material: 5 mil Fine Grain (<5μ Grain Structure)
- Only difference-Coating

Methodology

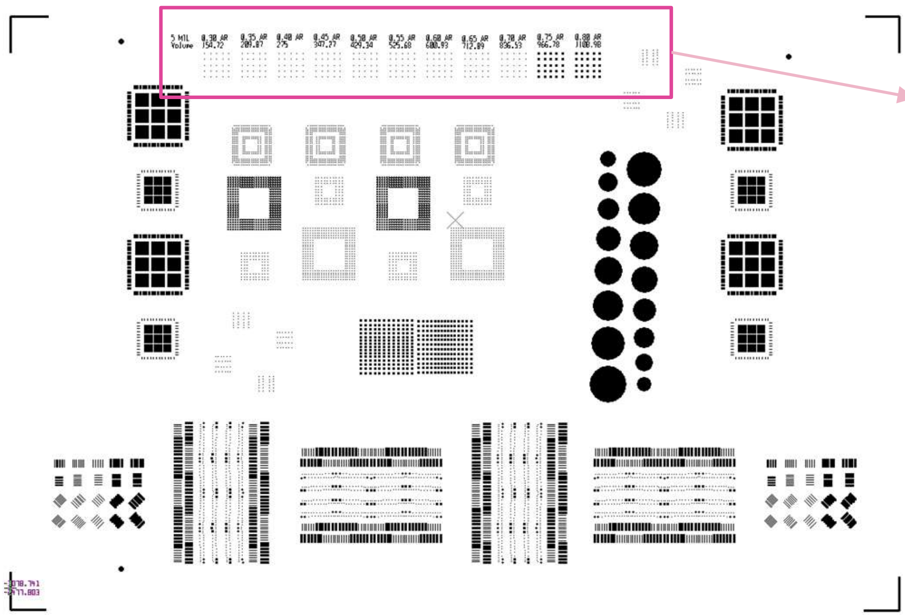
Materials: Initial Observation-CVD Coating

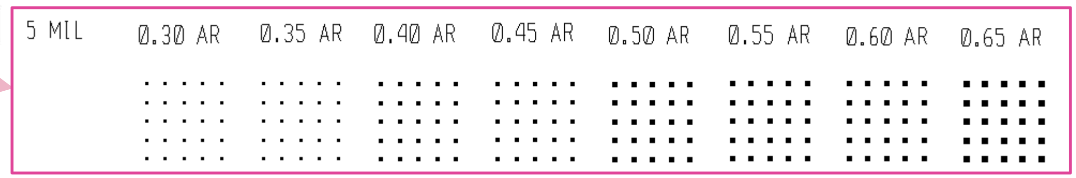
- Slight purple iridescent coating on the bottom/contact side of the stencil
- Noticed Initial CVD Coating had different appearance than the other
- Research showed CVD2_PP Stencil had Plasma Polish prior to CVD Coating

Plasma Polish is a "surface treatment resulting in very smooth, high-gloss surfaces with improved corrosion resistance"

Methodology

Materials: Stencil Design





The area of focus/testing was for area ratio apertures of 0.30-0.65
These copper pads are mask defined.

Methodology

Materials: Solder Paste/Data Collection

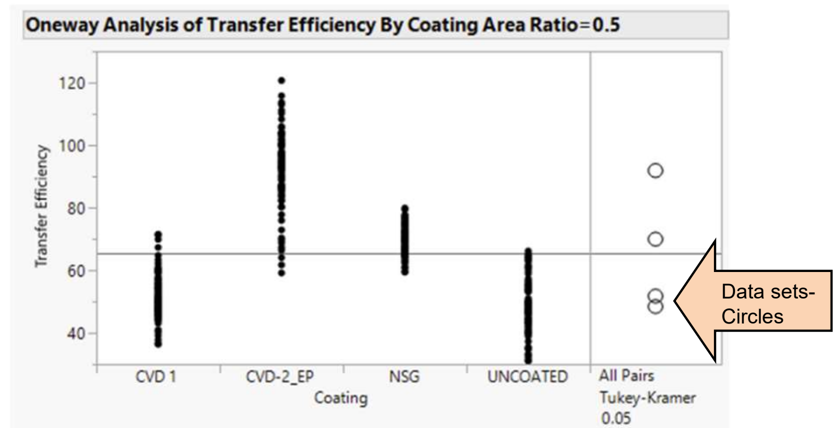
- No Clean, SAC 305 Alloy, Type 4 Solder Paste
- SPI utilized to collect solder paste deposit volume

Analysis

Significant Difference Testing

Tukey Kramer honest significant difference (HSD) testing

Determines if multiple data sets are significantly different or statistically similar



Means Comparisons

Comparisons for all pairs using Tukey-Kramer HSD

Connecting Letters Report

Level					Mean
CVD-2_EP	A				91.860625
NSG		B			69.969167
CVD 1			C		51.763021
UNCOATED				D	48.424896

Levels not connected by same letter are significantly different.

Analysis

Coefficient of Variation (Cv) - ***What is it?***

- Standard Deviation of population divided by its means

Cv = (Standard Deviation / Mean) x 100%

Analysis

Coefficient of Variation (Cv) - ***Why a Cv of <u>< 10%?</u>***

<10%: desired

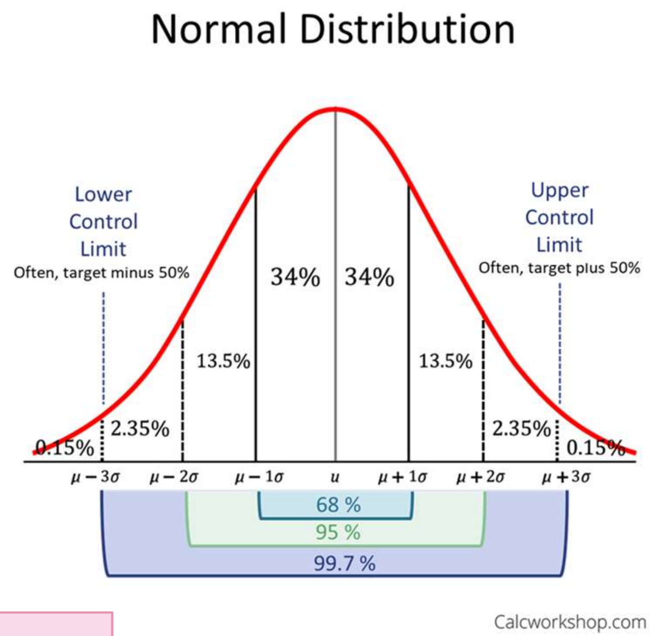
- CVs of 10% or less will produce 99.7 % of deposits within +/- 30% of the average volume

10 - 15%: acceptable

- CVs of 10-15% will produce 99.7% of deposits within +/- 30 - 45% of the target volume

Over 15%: unacceptable

- Almost ***no room*** for variation
- CVs of 16.7% or higher will produce deposits outside the control limits, indicating an out-of-control process.



With Permission: Shea Engineering

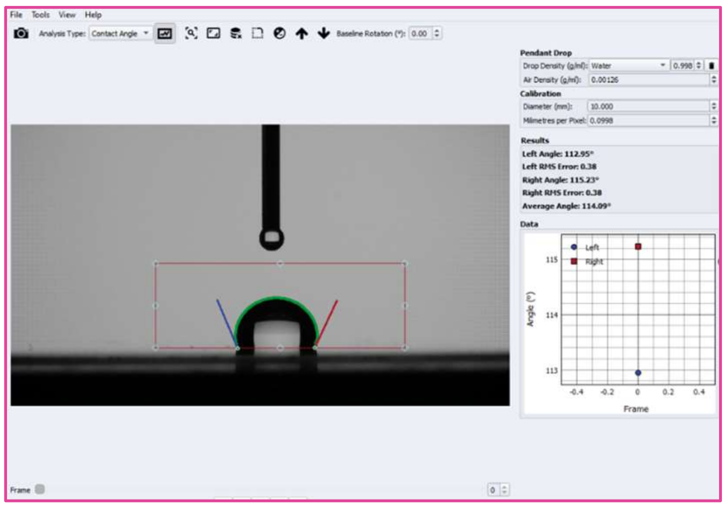
Analysis

Transfer Efficiency (Te)

Transfer Efficiency (Te) = Actual Volume Deposited / Theoretical Aperture Volume x 100%

Experimental Procedure

Contact Angle- Di Water Droplet on Coating



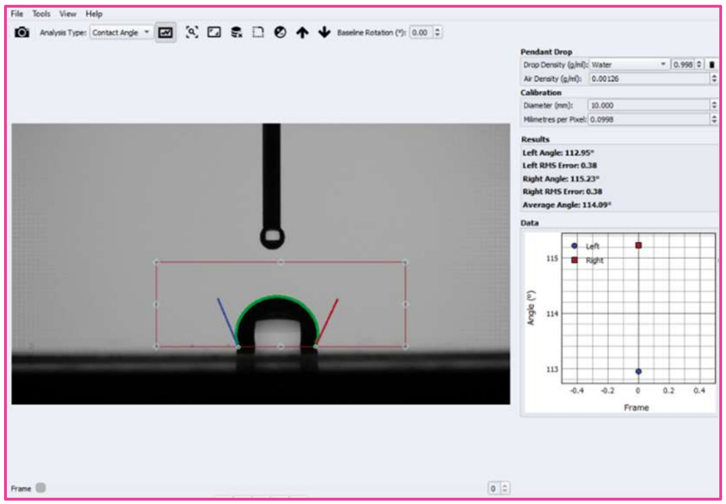
Goniometer Measurement

Hydrophobic Surface		Hydrophilic Surface
High	**Contact Angle**	Low
Poor	**Adhesiveness**	Good
Poor	**Wettability**	Good
Low	**Surface Energy**	High

Contact angle indicates a measurement of Hydrophobicity and Oleophobicity

Results and Discussion

Contact Angle- Stencil Coatings



Goniometer Measurement

	Foil Thickness	Coating	Contact Angle (H2O)
Stencil 1	5 MIL (.127mm)	None	61
Stencil 2	5 MIL (.127mm)	CVD1	107
Stencil 3	5 Mil (.127mm)	CVD2 (PP)	114
Stencil 4	5 MIL (.127mm)	NSG (Ceramic)	114

Contact Angle Measurements

- CVD Coating contact angle shows hydrophobic properties
- Without Plasma Polishing contact angle is less
- Expectation: CVD2 (PP) will offer improved transfer efficiency

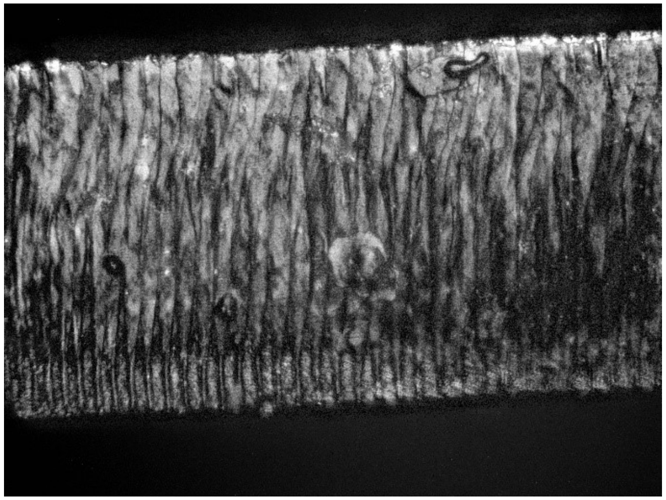
Results and Discussion

Coating Thickness

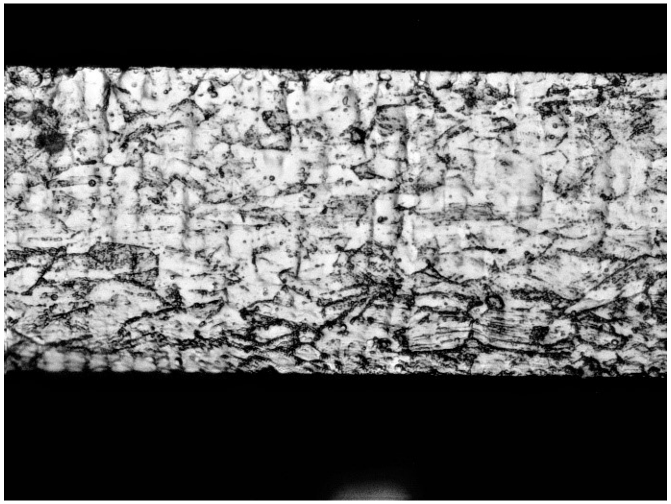
COATING TYPE	THICKNESS
Self-Assembled Monolayer	0.002-0.004 µ (2-4 nm)
CVD	0.2 µ (210 nm)
NSG (Ceramic)	2-4 µ (2000-4000 nm)

Results and Discussion

Coating Images – 800x Magnification



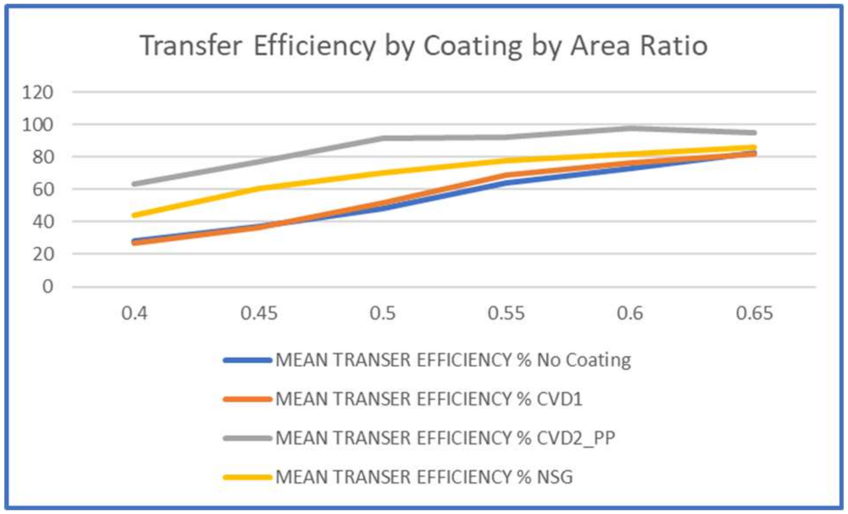
CVD1



CVD2 (PP)

Results and Discussion

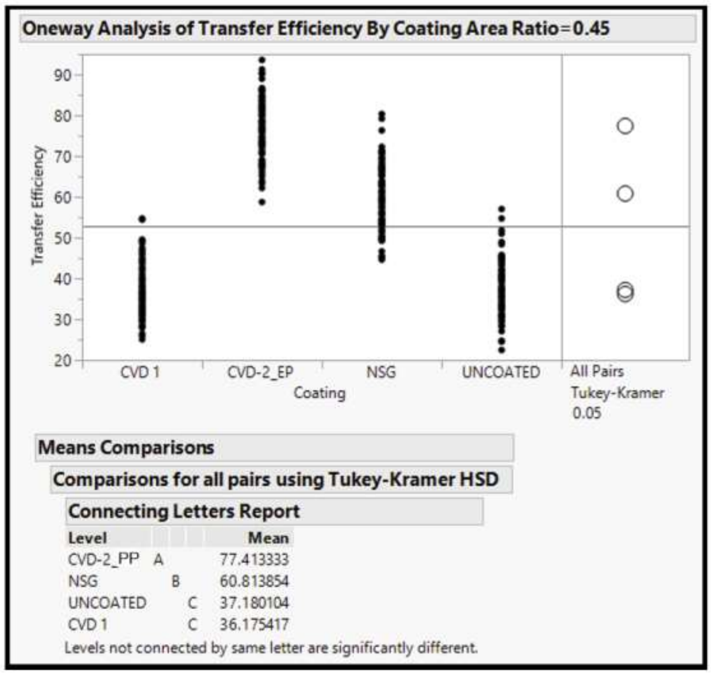
Transfer Efficiency (Te) of Solder Paste Deposit

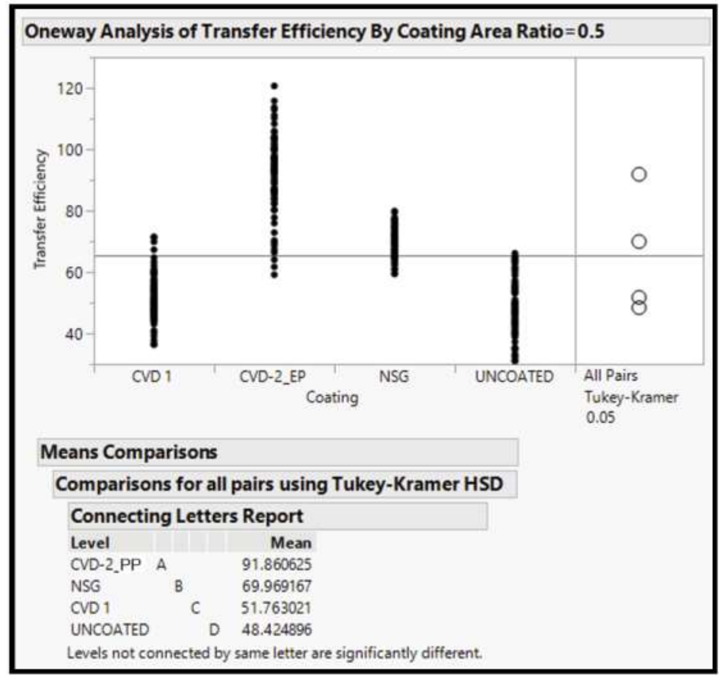


- CVD2 (PP) highest Te
- NSG Ceramic 2nd Highest Te
- CVD1 only slightly better than No Coating

Results and Discussion

Tukey Kramer HSD – Shows Statistically Significant Differences





Results and Discussion

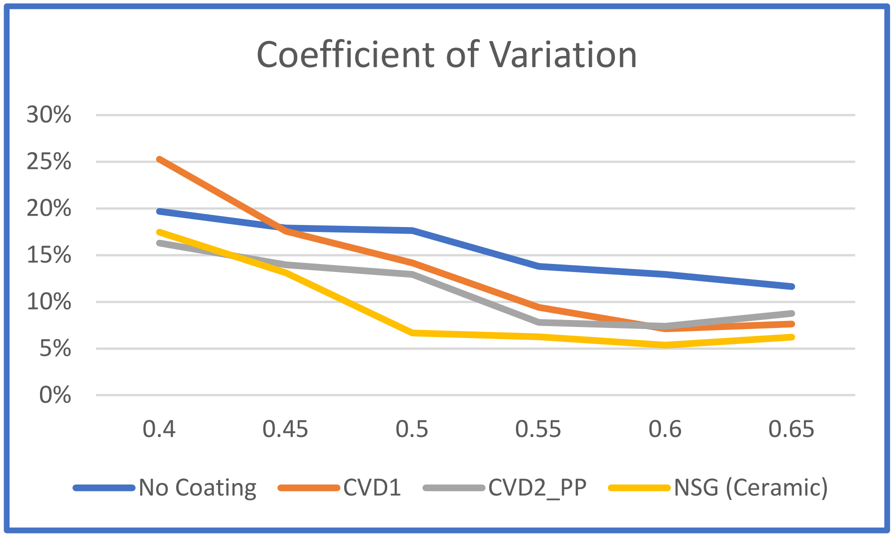
Coefficient of Variation (Cv)

	Coefficient of Variation			
Area Ratio	**No Coating**	**CVD1**	**CVD2_PP**	**NSG**
0.4	20%	25%	16%	17%
0.45	18%	18%	14%	13%
0.5	18%	14%	13%	7%
0.55	14%	9%	8%	6%
0.6	13%	7%	7%	5%
0.65	12%	8%	9%	6%
< 10% Good	10%-15% OK	>15% BAD		

- NSG Ceramic < 10% at 0.5 Area Ratio
- CVD1, CVD (PP), NSG Ceramic < 10% at 0.55 Area Ratio

Results and Discussion

Coefficient of Variation (Cv)



CVD2 (PP)-

- Highest Te
- Higher Cv at 0.5 Area Ratio than NSG Ceramic Nano-Coating

Conclusion

- Chemical Vapor deposited nano-coatings are a viable coating option for SMT Solder Paste Stencils
  - They improve transfer efficiency if plasma polishing is done prior to application
  - Without plasma polishing, transfer efficiency is not significantly different than an uncoated stencil
- Cv values with plasma polishing are higher than 10% at 0.50 area ratio vs the NSG Ceramic nano-coating which is less than 10% at 0.50 area ratio
- Cv values with plasma polishing are less than 10% for area ratios greater than 0.55 area ratios

Conclusion

- Looking at both Te and Cv, the CVD coating on a 5 mil stencil is not better than the NSG Ceramic coating, but is very close in performance.
- The application process of this coating may lend itself to very small apertures in very thin foils. This will be determined in future work.

Future Work

- Examine durability of vapor deposited nano-coating vs current coatings for hardness and scratch resistence
- Examine chemical resistance of the vapor deposited nano-coatings
- Examine cost of vapor deposited coating vs current options and as they apply to specific applications
- Identify specific criteria for vapor deposited nano-coatings

Thank You!

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