Deposition of Solder Paste into High Density Cavity Assemblies

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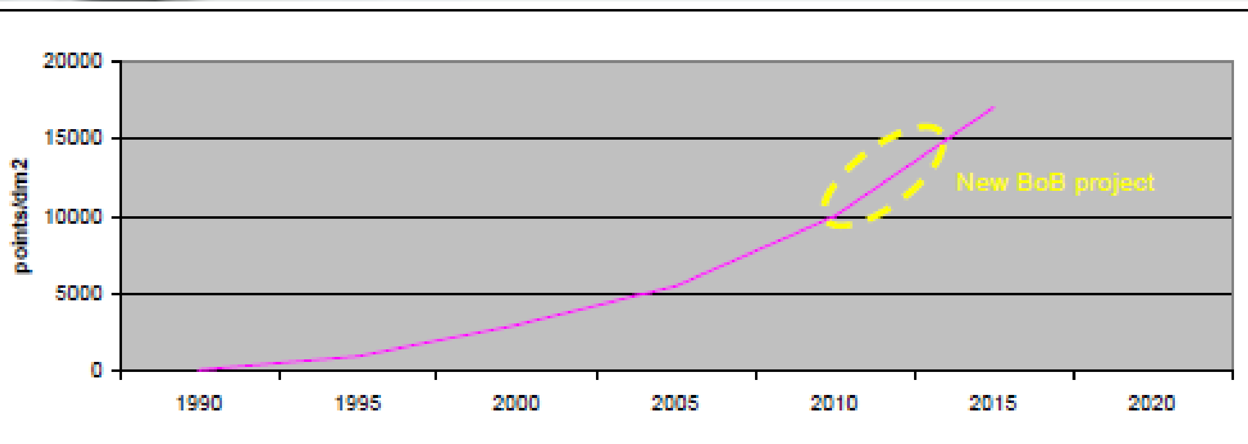
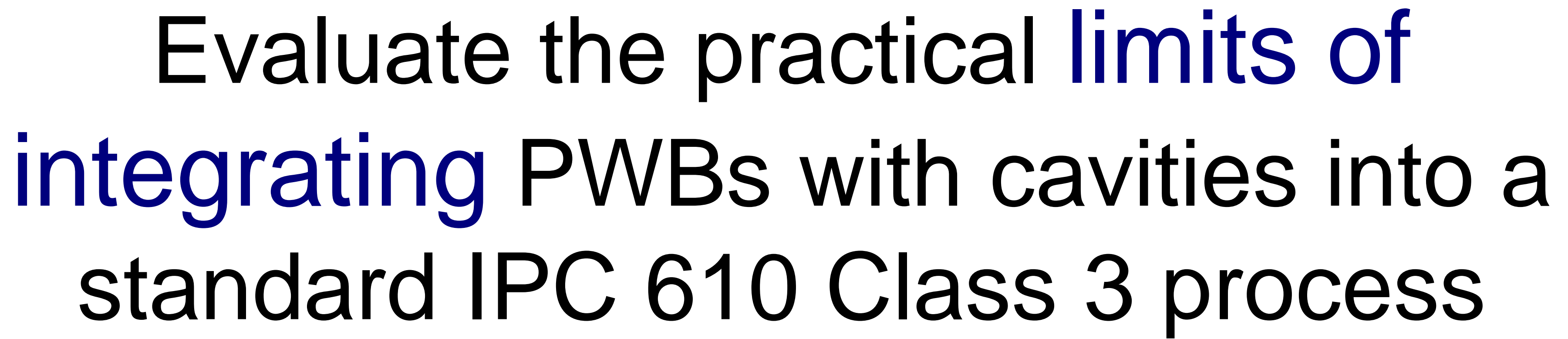
CELESTICA INC

Aggressive space reduction **and density** increase.



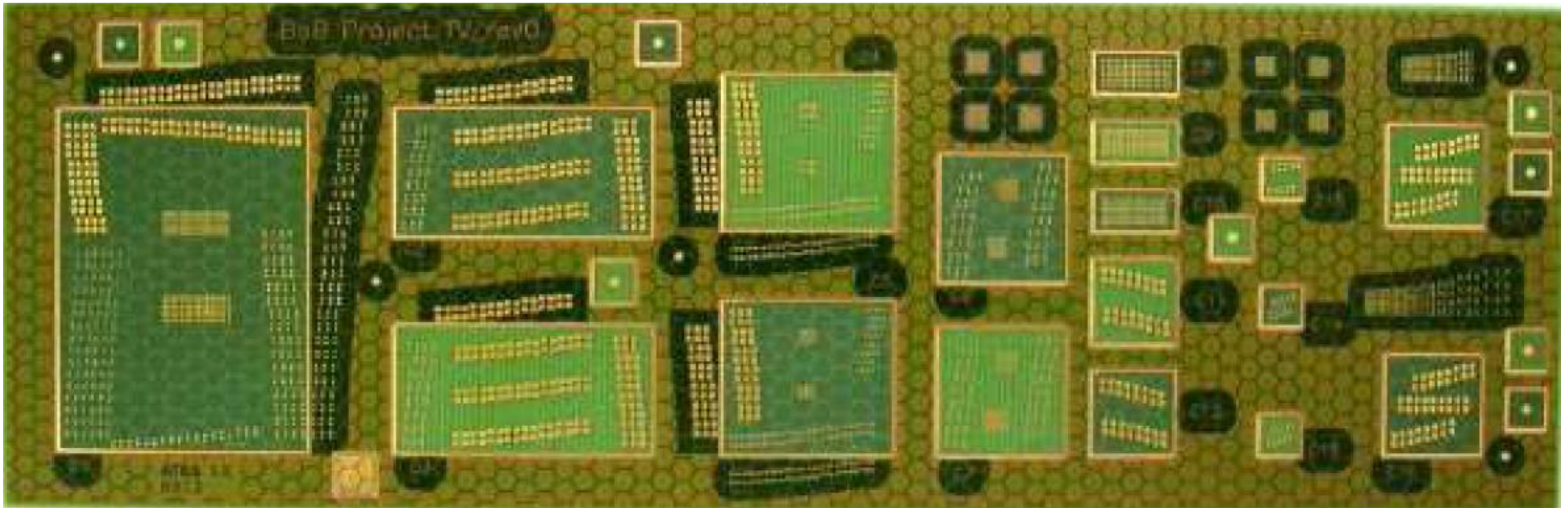

Evaluate the practical limits of integrating PWBs with cavities into a standard IPC 610 Class 3 process

Step stencil

Dispensing

Jetting

test vehicle

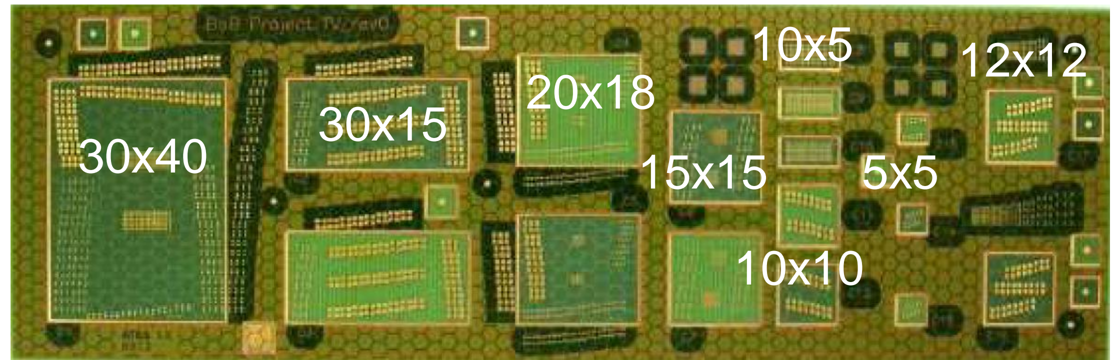


Size: 185x60 mm

17 cavities

Cavity sizes (mm):

- 30 x 40
- 30 x 15
- 20 x 18
- 15 x 15
- 12 x 12
- 10 x 10
- 10 x 5
- 5 x 5

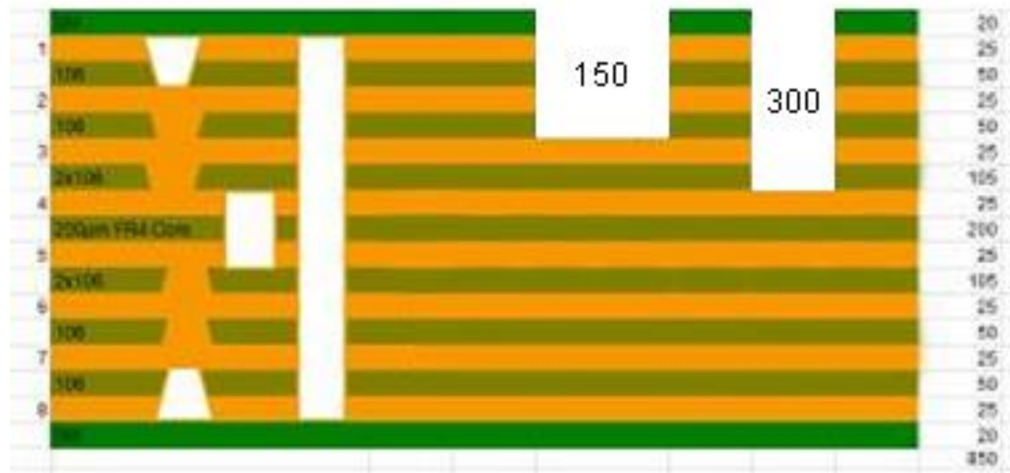


3 cavity depths

Cavities fabricated by AT&S (patented process)

Factors when choosing depth:
- Match the common thicknesses of SMT components
- Available pre-preg used in the stack-up of the PWB

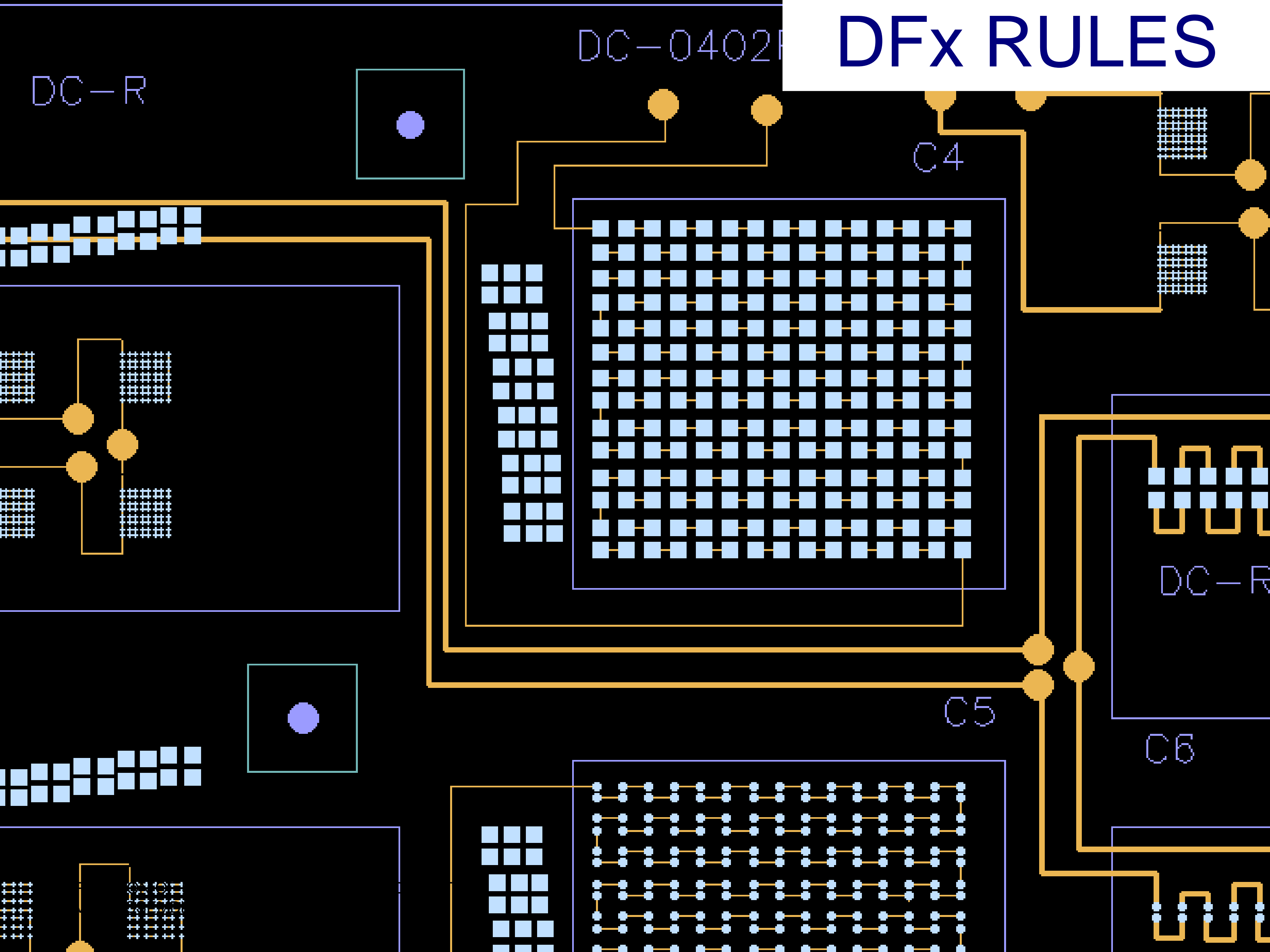
Depths:
- 0 (TOP surface)
- 150 um
- 300 um



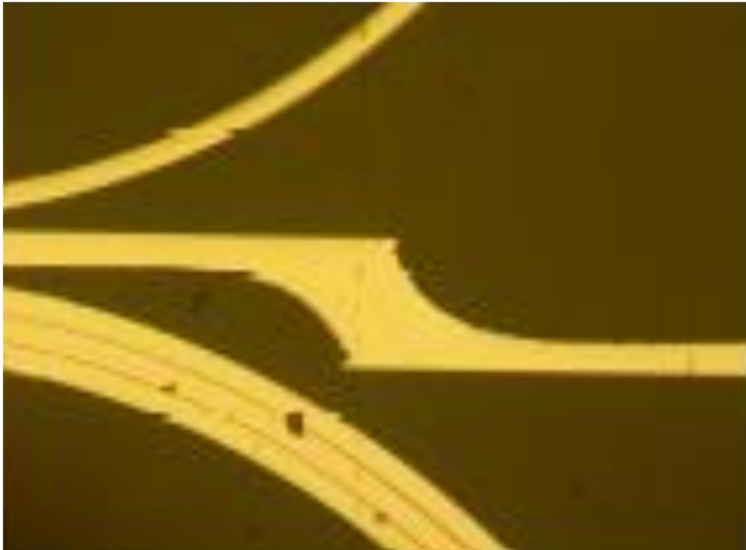
4 component types

TYPE (inches/metric)	Density / Pitch
01005 (0402)	390 um
0201 (0603)	500 um
0402 (1005)	1 mm
CSP	300 um

For chip components, “density” is the minimum spacing between devices while for CSP’s, “pitch” if the device I/O minimum pitch evaluated.


DFx RULES
DC-R
DC-0402
C4
DC-R
C5
C6

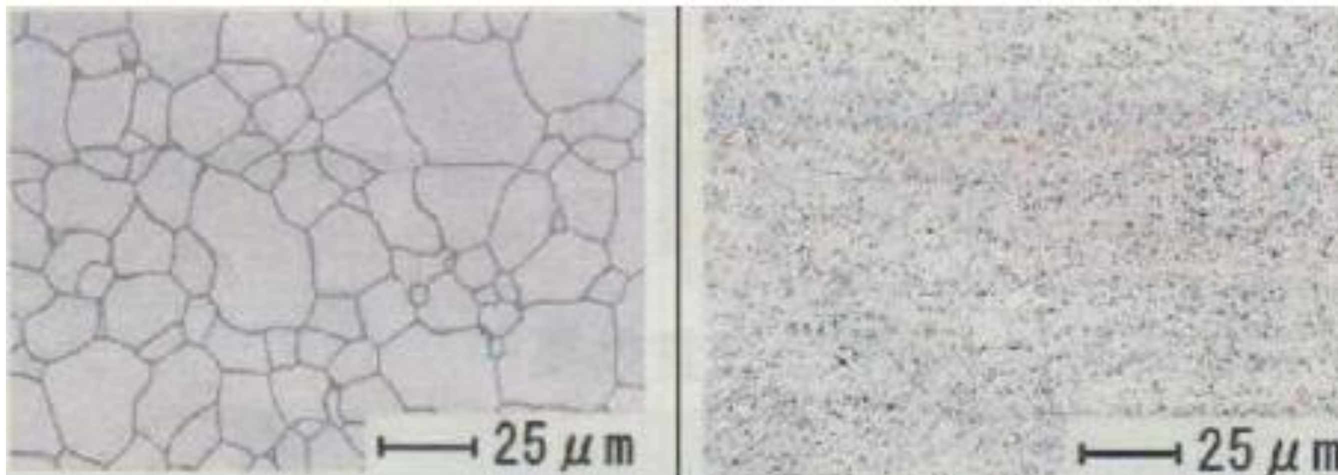
1st – step stencil



Challenges: Stencil manufacturing is key for this technology. Density into cavities is depending on stencil design.

stencil material used

- Fine grain stainless steel used for stencil



Grain Size Comparison: SS 300 Series (Left) and New Material (Right)

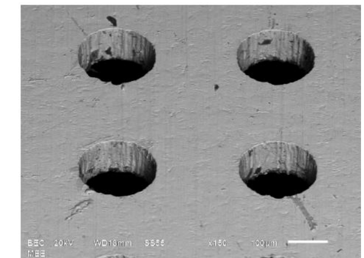


Figure 1 – Old YAG laser cut stencil aperture

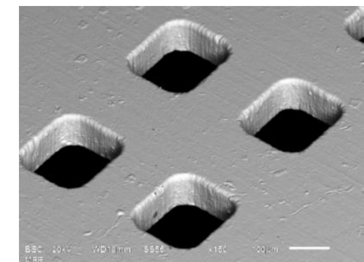
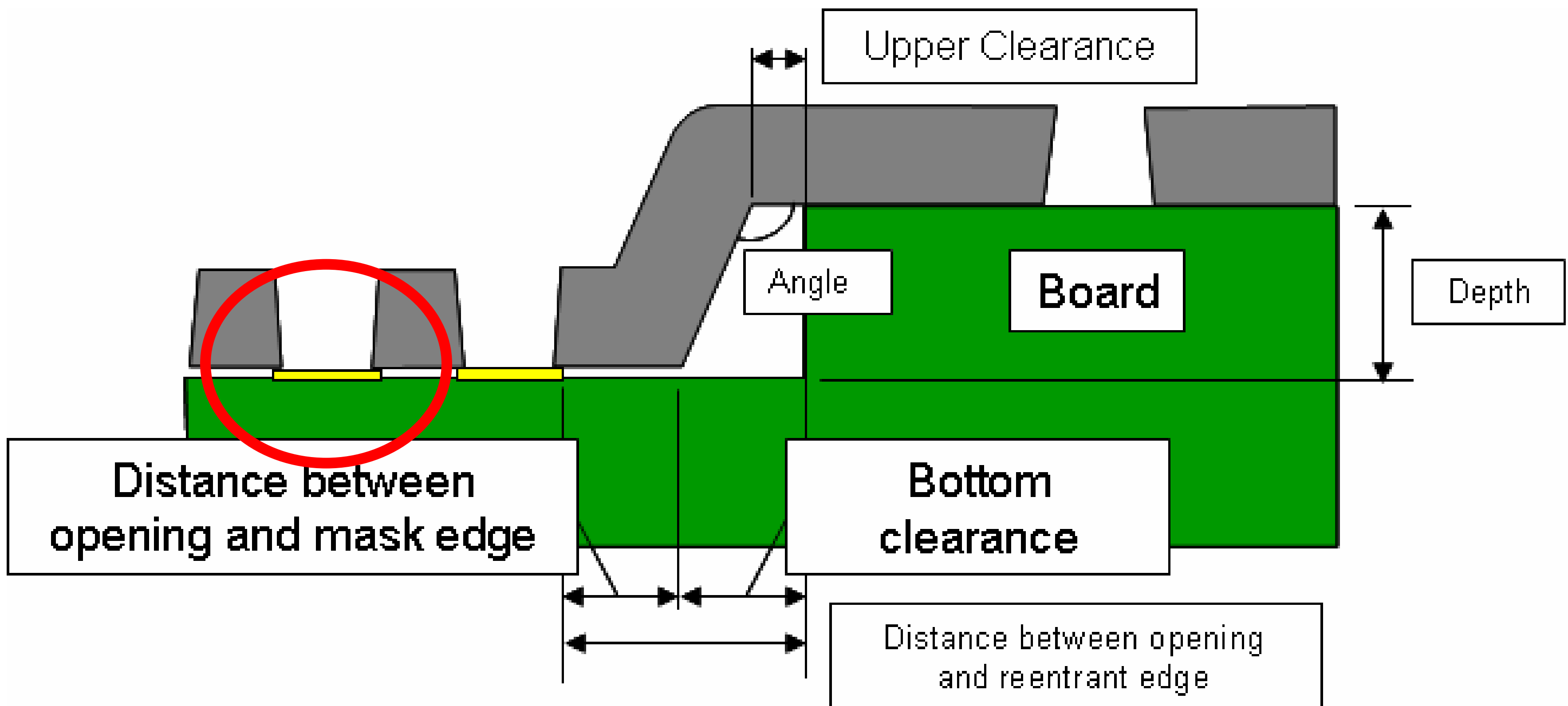


Figure 4 – Fine Grain Alloy / Laser cut and Ni Plate

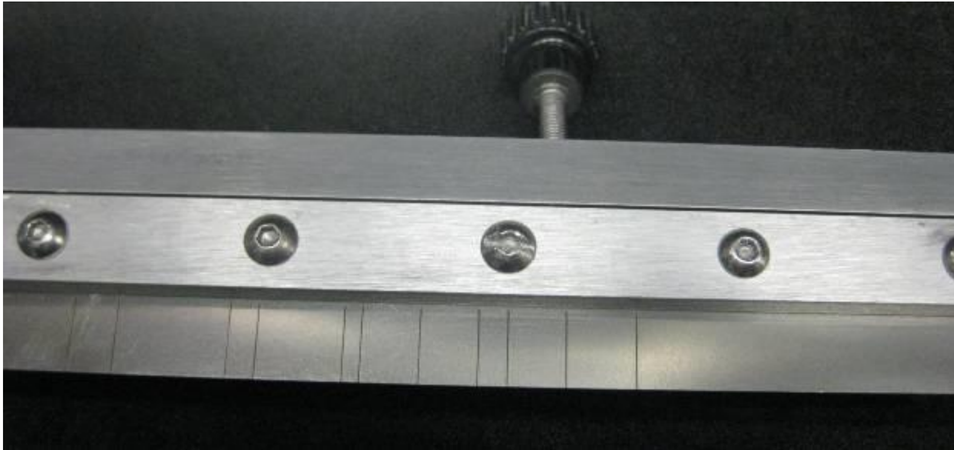
Std. 390 SS on Left and Fine Grain SS on Right

stencil

fabrication



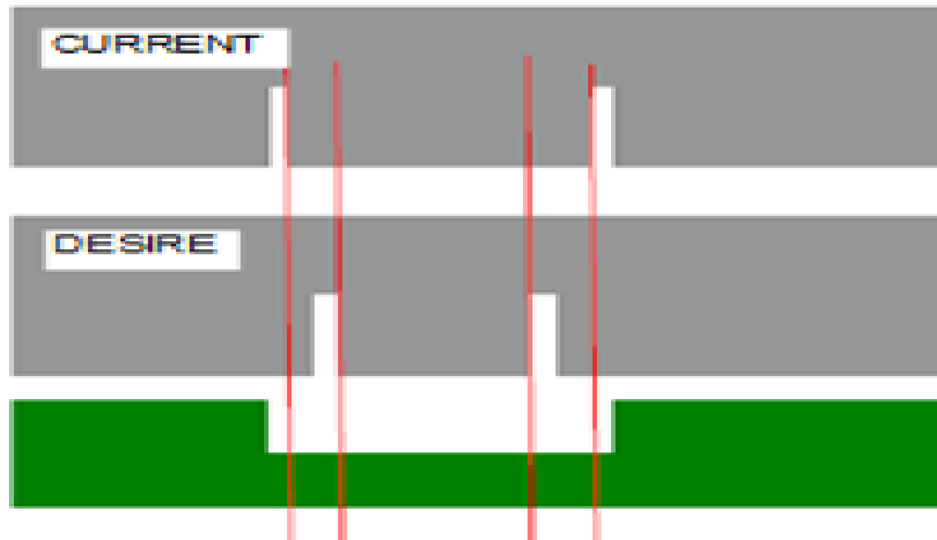
squeegees



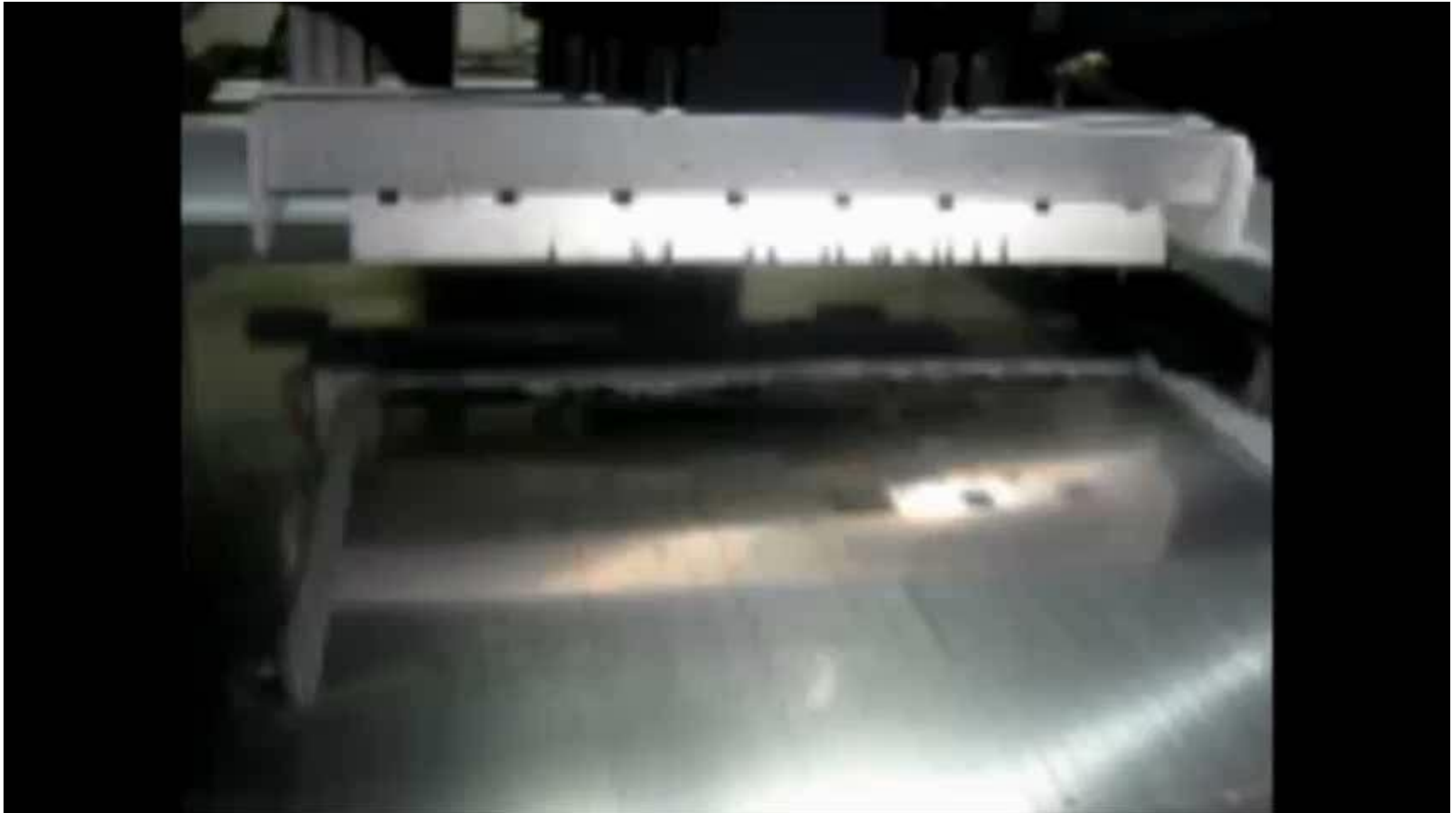
Challenges: Alignment between blade and stencil. Cuts are needed to allow blade go into the cavities. Blade support used to increase pressure into cavities.

blade alignment: stencil & PCB

- Set up considerations



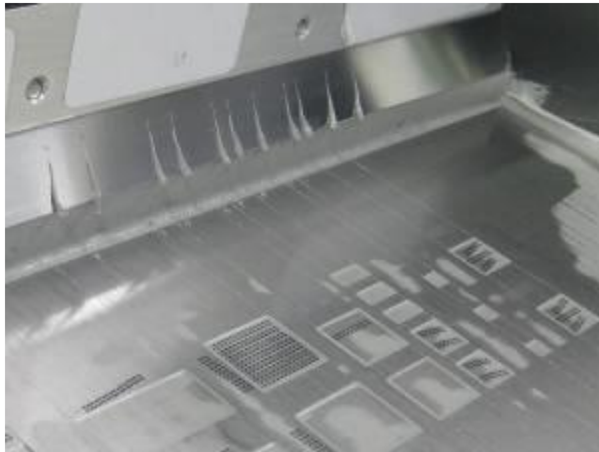
screen printer cycle



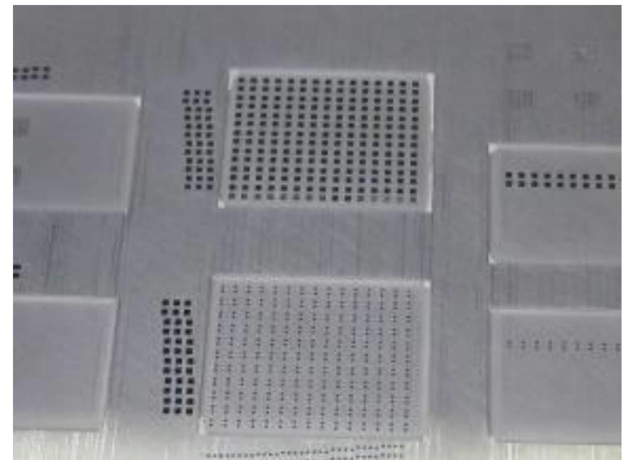
- [Screen printer video]

blade support

- Using backside squeegee blade support improves print performance significantly
- However each cavity requires different amount of backside support



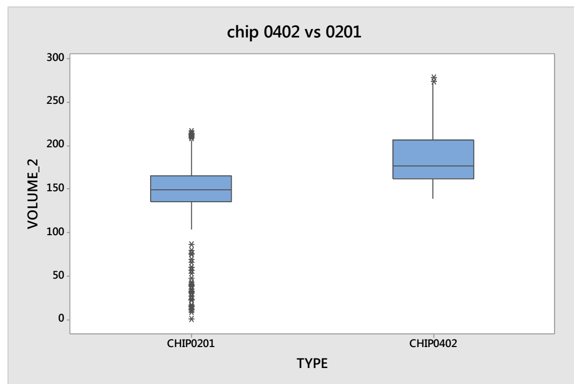
Without blade support



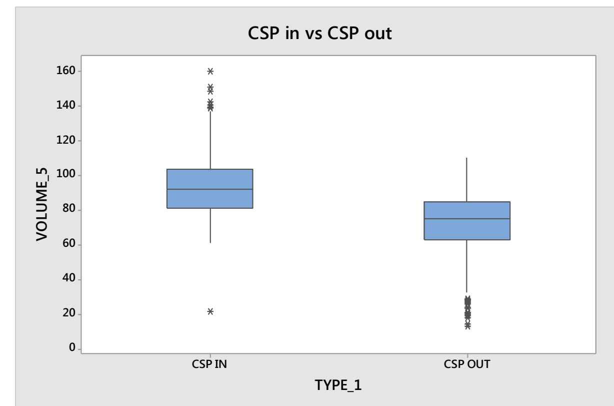
With blade support

trials

- Blade support to create pressure
- Blade behavior across the entire width of the board
- Transference into cavities [01005 (0402) / 0402 (1005) / CSP apertures]

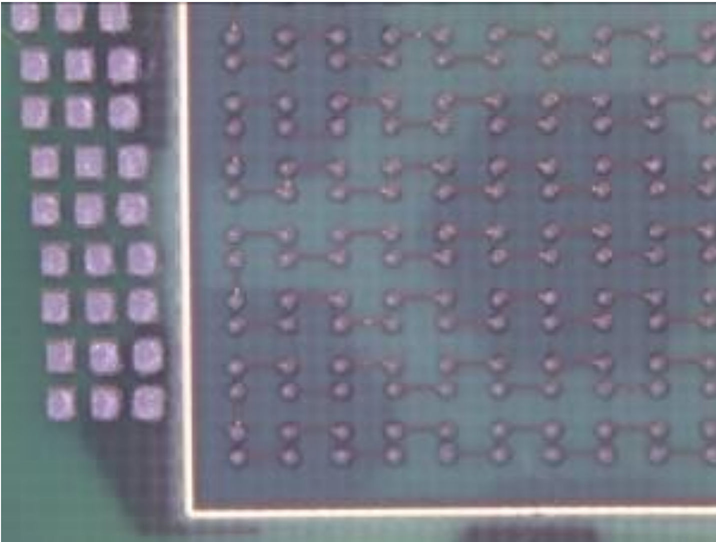


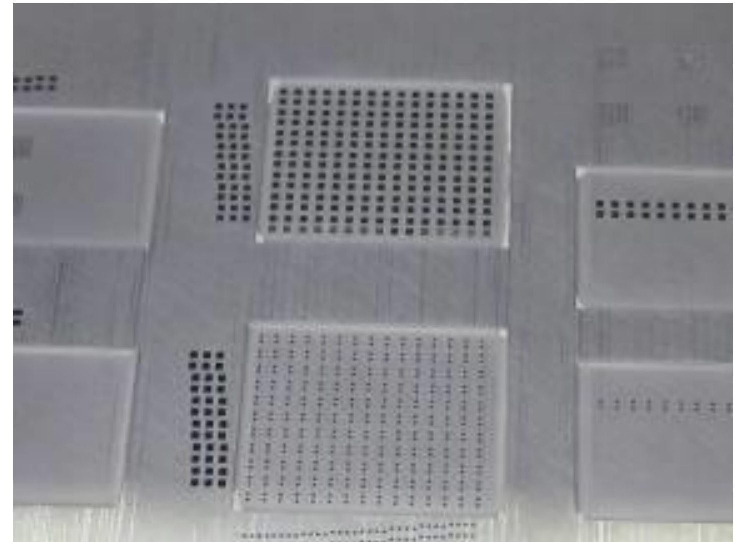
Chip 0402 & 0201 volume



CSP Inside vs Outside of Cavity

results





step stencil summary

- Possibility of soldering all chip component types into cavities [includes down to 01005 (0402) sized chips]
- Able to accommodate different depth cavities, limitations comes from stencil manufacturing.
- Low cycle time as standard screen printer is used.
- More work required to support different depths and apertures in the same stencil.

2nd - dispensing

- Micro piston used dispenses a single shot per pump cycle.
- Able to dispense dots for 01005 (0402) components.
- Programmable to dispense at any height.
- Requires the use of special solder pastes designed for dispensing.

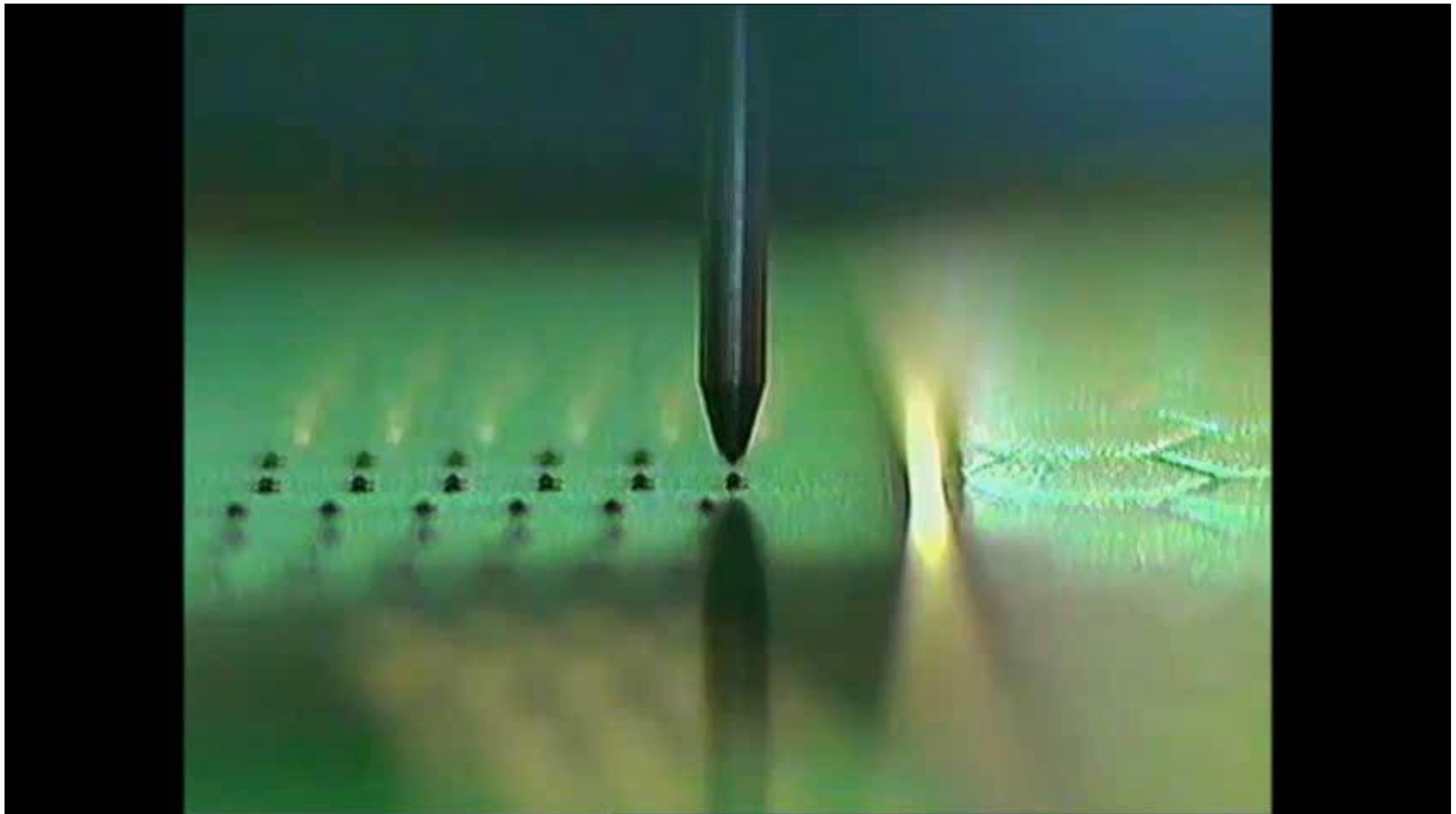
dedicated solder paste

Dedicated solder paste is required for this process as the head needs small particles, high flux content and special formulation to do the dispensing

	less than or equal to 5%	Remainder
Type 6	> 20um	5-20 um

Flux Content	Remainder
Metal Percent	81 +/- 1%

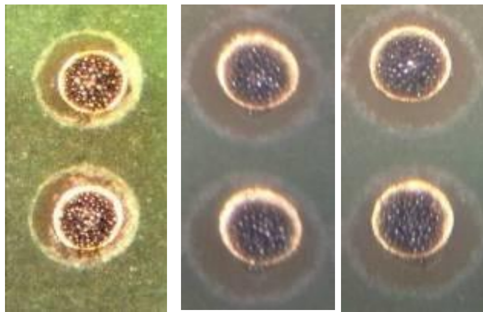
dispensing machine cycle

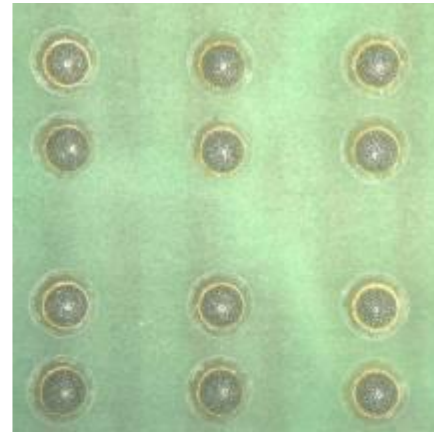


- Dispensing video

1 dot for each 01005 (0402)

5 dots for each 0201 (0603)





- Parameters defined to dispense solder paste for 01005 (0402) component.
- Same parameters were used to dispense multiple dots for large parts.
- 0402 (1005) size pads needed up to 60 single dots.

dispensing summary

- Possibility of soldering all chip component types into cavities [includes down to 01005 (0402) sized chips]
- Able to accommodate different depth cavities without any restrictions.
- For production it is ideal to choose a machine that supports multiple dispense heads to reduce overall cycle time.
- Cycle time depends on the needle used to create dispensed dot sizes.

3rd - jetting

- Requires the use of special solder pastes designed for jetting.
- Minimum dot size able to be dispensed is 300um diameter [0201 components, (0603)] Impacts ability to handle smallest parts.
- Max. dispense height limits

dedicated solder paste

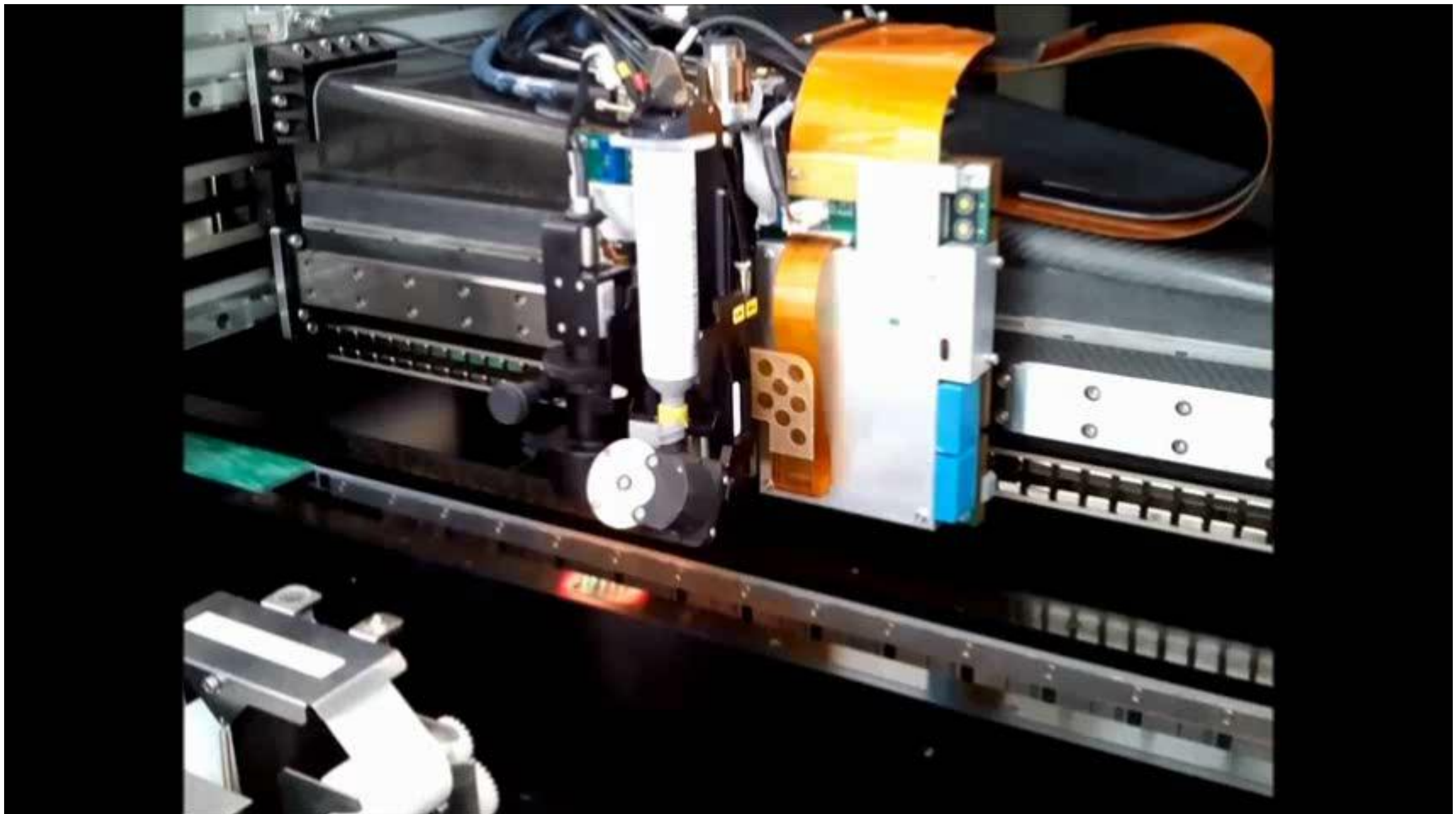
Dedicated solder paste is required for this process as the head needs small particles, high flux content and special formulation to do the jetting

% of Sample by Weight – Nominal Size

Type	None Larger Than	Less Than 1% Larger than	90% Minimum Between	10% Maximum Less Than
Type5	30 Microns	25 Microns	25-15 Microns	15 Microns

TYPE	Type 5
Flux Content	15.0 +- 0.5 (wt%)
Metal Percent	85.0 +-1.0 (wt%)

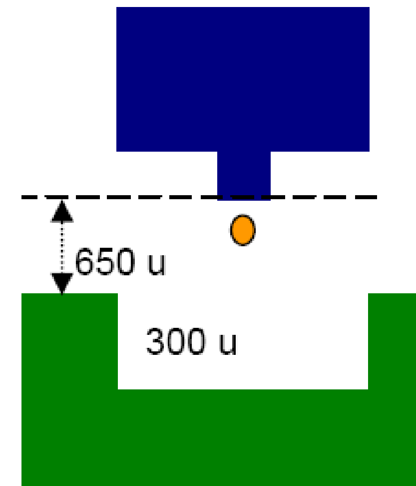
jetting machine cycle



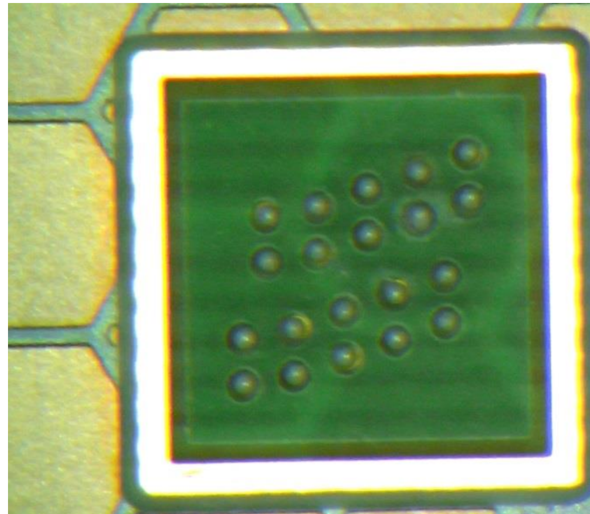
- [Jetting video]

3 heights tested

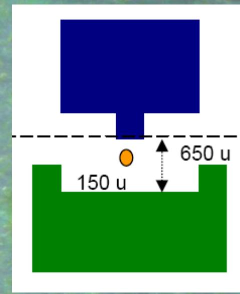
- Ideal dispense height above the board surface is 650um, although increasing distance up to 850um does not impact accuracy.
- Establishing datum to effectively jet into the cavities is critical (reference points)
- Assessed impact of dispensing into cavities from heights > 650um on deposit consistency

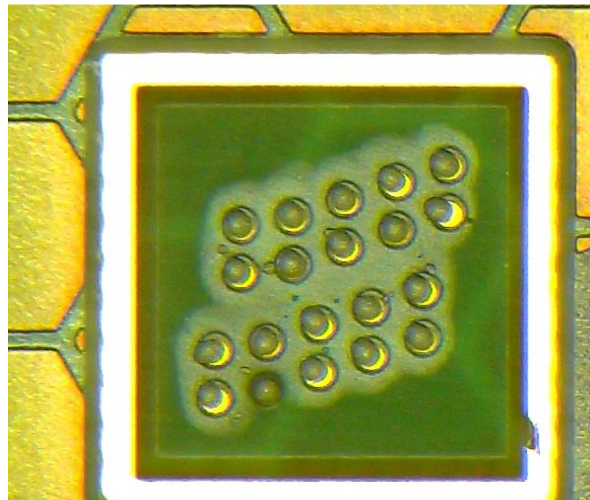


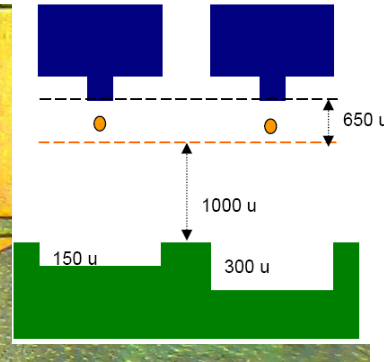
jetting height vs positional accuracy



Comp 0201 (0603)
Cavity: 150um
Dispense height: **650um**



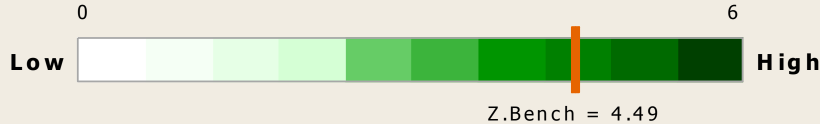




Comp 0201 (0603)
Cavity: 150um
Dispense height: **1800um**

Capability Analysis for SN 396 P1 Volume 6.8 nl
Summary Report

How capable is the process?



Customer Requirements

Upper Spec	1,156e+007
Target	6,8e+006
Lower Spec	3,4e+006

Process Characterization

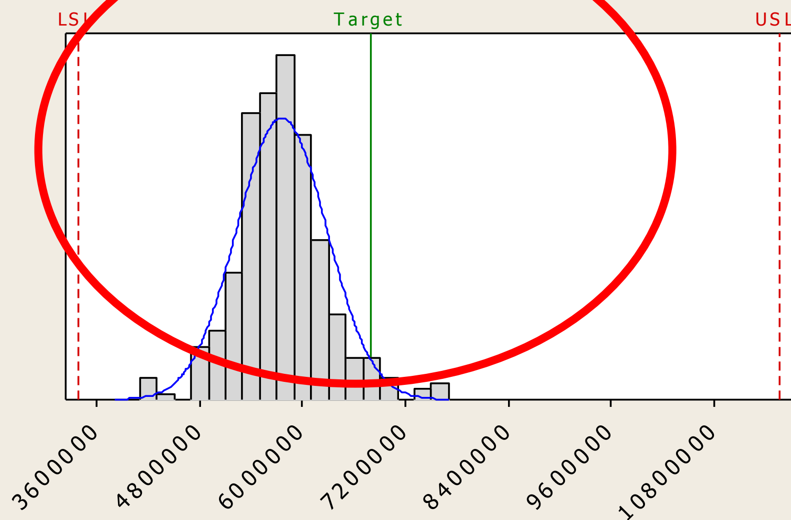
Mean	5754349

Does the process mean differ from 6800000?

	P1 (650 um)	P2 (950 um)
V1 (6.8 nl)	Cpk: 1.81 --- Ppk: 1.5	Cpk: 1.88 --- Ppk: 1.59
V2 (51 nl)	Cpk: 5.62 --- Ppk: 4.41	Cpk: 6.26 --- Ppk: 3.84

PPM (DPMO) 4

Are the data inside the limits and close to the target?



Comments

Conclusions

-- The process mean differs significantly from the target ($p < 0.05$).

-- The defect rate is 0.00%, which estimates the percentage of parts from the process that are outside the spec limits.

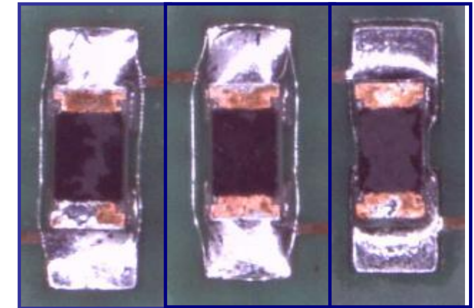
Actual (overall) capability is what the customer experiences.

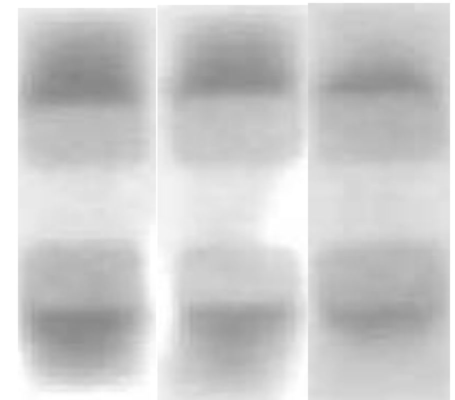
flexibility

CLASS 3

jetting summary

- Machine is capable for both processes (two head heights) and for different volumes (minimum 6.8 nl and maximum 51nl)
- IPC 610 Class 3 solder joints are achievable using jetting process for both 0402 (1005) and 0201 (0603) components
- Jetting machine is supposed to feed a pick and place machine mounting 40,000 components per hour. This data depends on the geometry of the PCB to be produced.
- Dispense strategy for each package can easily be controlled via simple software changes
- Standard jetting height is 650um, but working with the supplier this distance could be adapted to something less





summary

- Transferring solder paste into high density cavities is a process that can be done with high quality and capable of achieving IPC 610 class 3 standard solder joints.

- The most appropriate and cost effective method to use will depend on the final product configuration since each method did have its own limitations in terms of capability to support certain design features or cycle time

recommended deposition method based on package type

	01005	0201	0402	CSP 0.3	CSP 04
STEPPED STENCIL	✓	✓	✓	✓	✓
DISPENSING	✓	✓	✓	✓	✓
JETTING	X	✓	✓	X	✓

process decision matrix

- Several factors must be considered to integrate the most appropriate solder deposition method depending on product design and desired manufacturing setup

	STEPPED STENCIL	DISPENSING	JETTING
EQUIPMENT INVESTMENT	XXX	X	X
MANUFACTURING COST	XX	XX	X
CYCLE TIME	XXX	X	XX
FLEXIBILITY	X	XX	XXX
PROCESS CONTROL	X	XX	XX
COMPLEXITY	X	XX	XXX

Note: X → Advantage, positive characteristic.

Acknowledgements

- **Jeff Kennedy, Thilo Sack, Vicenta Jorge, Samuel Plasencia, Javier Canillas, Miguel Sanchez (Celestica), Euripides BOB Partners: Thales TCS & TGS, AT&S.**
- **Mydata / AB Electronics (Jetting)**
- **GPD (Dispensing)**
- **Great Lakes Engineering / Pantur (Stencils)**
- **Indium (Solder Paste)**

Questions?