Evolution and Applications of Fine Feature Solder Paste Printing for Heterogeneous Integration

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Biography

- 6 months at Indium Corporation
  - Electronic Assembly Materials Supplier
- Master of Engineering Management and Bachelor of Engineering in Materials Science from Dartmouth College
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Presentation Overview

- Introduction – History
- Printing Experiment Methodology
- Results & Discussion
- Summary
- Q&A

The Need for HI

- Physical and economic chip constraints lead to packaging innovations (System in Package), smaller components
- Smaller components lead to smaller print apertures and advanced assembly materials

Shift from SMT to SiP

SMT

- Relatively larger components
- Type 3-5 powder size
- Large gap between pads

SiP

- Small (008004; 0050025 for next-gen) components
- Type 6-7 powder size
- Small gap between pads (50 micron)

Powder Type	Powder Size (um)	Minimum Stencil Aperture (um)	Approximate Surface Area Ratio
3	25-45	270	1.0
4	20-38	230	1.2
5	15-25	150	1.9
6	5-15	90	3.7
7	2-11	66	5.6

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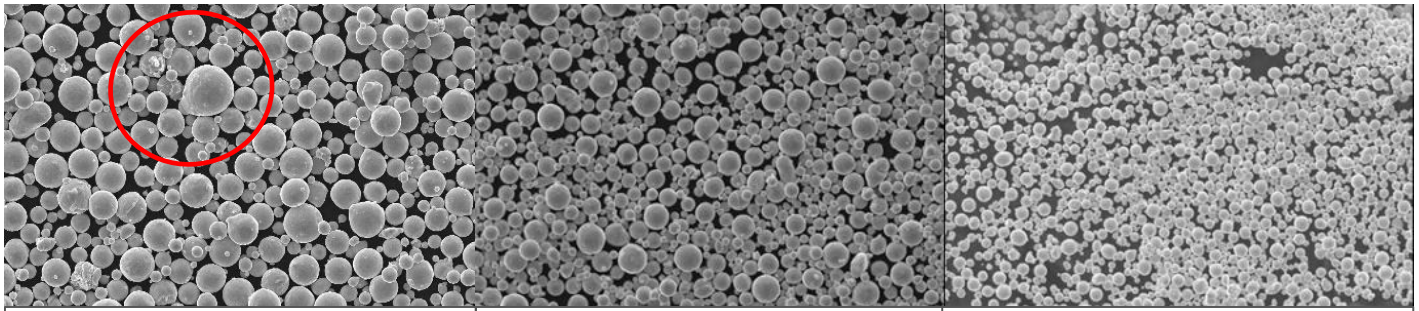
Solder Paste - Quality

Powder Quality



Normal T6 Powder	T6SG Powder	T7SG Powder

Paste Specimens

- Compared two No-Clean flux vehicles to a water soluble baseline
- Each NC paste had three powder types
- Metal load was chosen/optimized based on previous studies

Flux Vehicle	Powder Type (Type 6)	Metal Load	Viscosity (Poise)
A (No-Clean)	1	87.5%	1,643
	2	87.0%	1,946
	3	87.5%	1,981
B (No-Clean)	1	88.0%	1,682
	2	87.5%	1,875
	3	88.0%	1,921
WS	2	89.0%	3,217

Metrology Equipment

- Dek Horizon Printer

  - Print speed fixed at 20 mm/s

- Koh Young Meister SPI

  - Minitab for data analysis

Printing Experiment List

- Experiment to analyze printing performance of pastes on 6/7 mil pad size
- Experiment to analyze slump performance of same pastes
- Experiment to analyze effect of changing SPI parameters on one printed board

Printing Performance Experiment

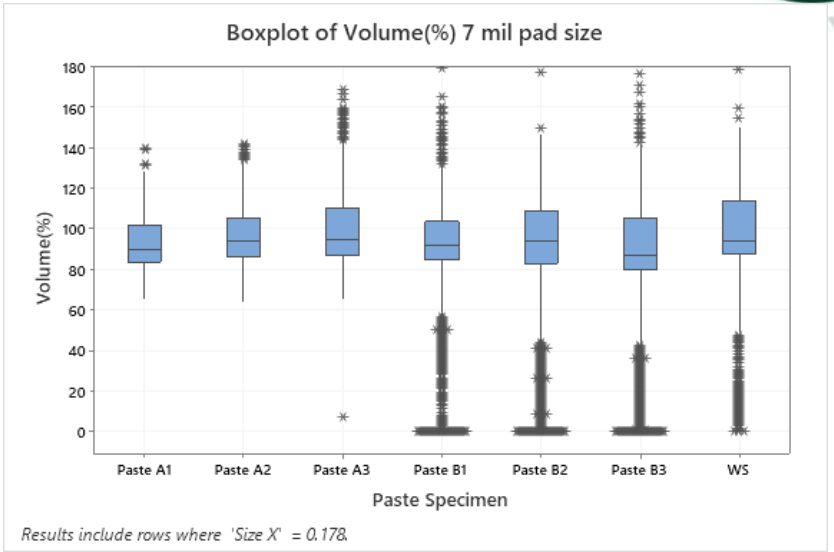
- Print 6 boards, pause 1 hour, print 20 boards for each paste specimen
- Analyze boards with SPI (Volume %)
- Squeegee pressure set at minimum pressure to achieve a clean wipe

Note for the Following Tests

- Volume % will differ between experiments due to programming differences
  - Issues arise when printing small height deposits on an SMT board due to board quality deteriorating at smaller pads
    - More work is needed to design an appropriate test SiPvehicle
  - Each test is *relative* and results should be observed accordingly

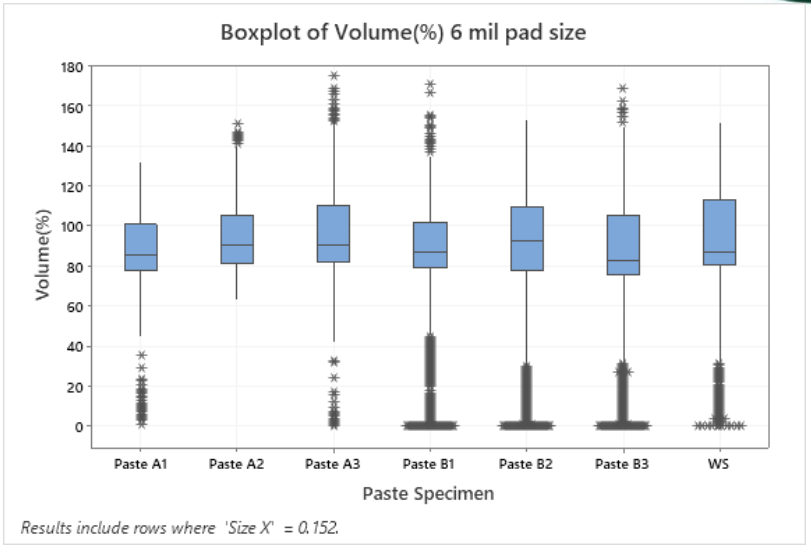
Results

- Clear difference between flux vehicle A and B with regard to insufficient prints
  - Paste A1 and A2 performed best overall



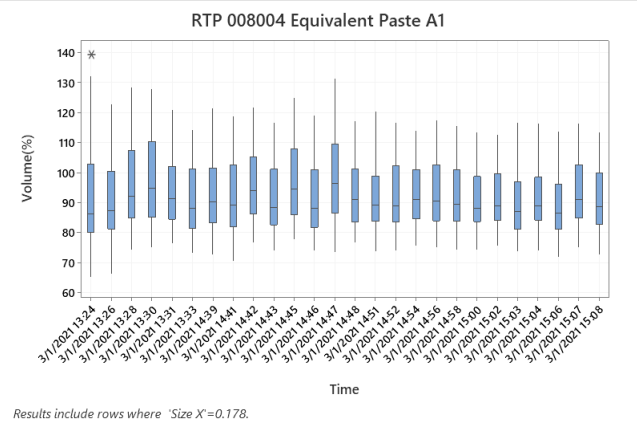
Results

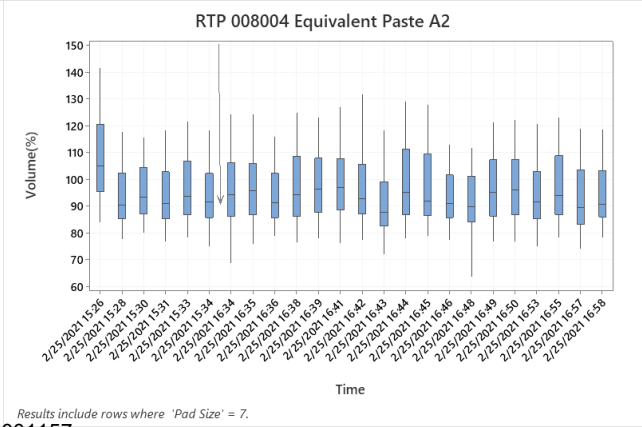
- More insufficient prints naturally form at smaller pad size
  - Paste A2 shows most consistent results



Paste A1 and A2 Response to Pause

- Although paste A2 showed consistent printing across both pad sizes, Paste A1 shows better cold start up





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Process Capability Analysis

- Cp, Cpk, Ppk values were calculated using Minitab software
- Results reflect the graphs, Pastes A1 and A2 show improvements over flux vehicle B and the water soluble baseline

Flux Vehicle	Powder Type	Pad Size (mil)	Cp	Cpk	Ppk
A	2	6	1.24	1.07	1.04
		7	1.52	1.40	1.35
	3	6	1.01	0.93	0.91
		7	1.27	1.24	1.20
	1	6	1.22	0.95	0.92
		7	1.56	1.33	1.30
WS	2	6	0.83	0.72	0.61
		7	1.00	0.97	0.85
B	2	6	0.62	0.45	0.44
		7	0.75	0.59	0.58
	3	6	0.63	0.43	0.43
		7	0.67	0.48	0.48
	1	6	0.9	0.69	0.68
		7	0.98	0.83	0.81

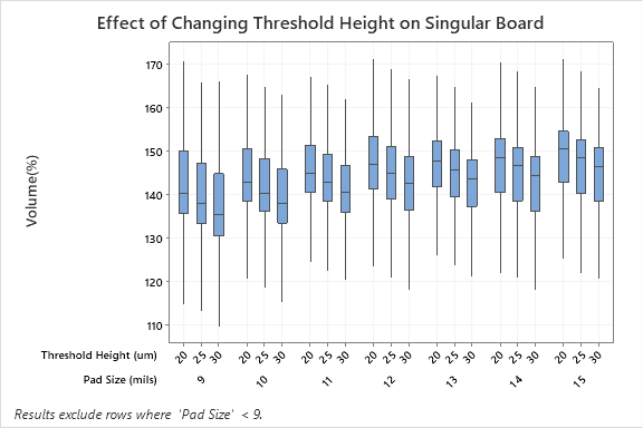
Koh Young Parameter Experiment

- Printed one board (Paste B1) and analyzed using different SPI programs
- Varied Threshold Height and Extended ROIs

Stencil Thickness (um)	Threshold Height (um)	Extended ROIs (n by n)
40	20	8
		12
		16
	25	8
		12
		16
	30	8
		12
		16

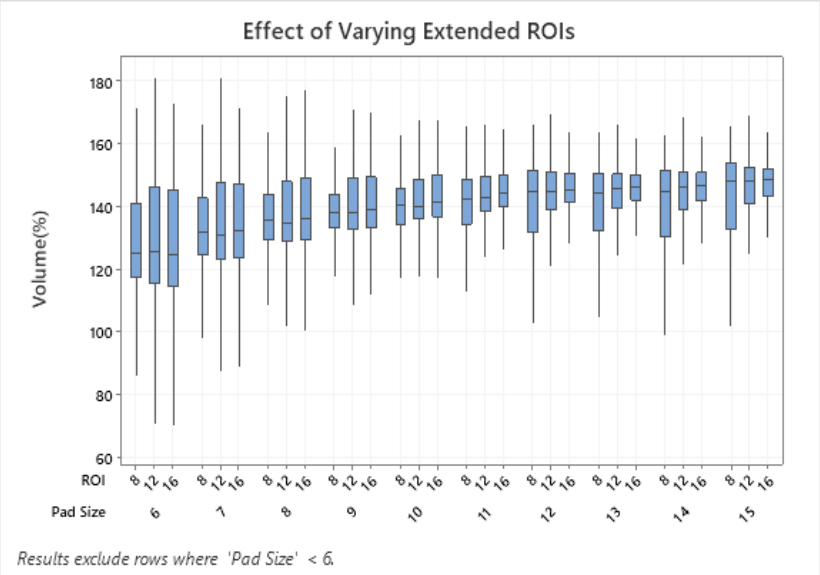
Results – Threshold Height

- Clear trend showing Volume % decreasing as threshold height increases
- Expected due to lower relative measured height of a solder deposit at a higher threshold



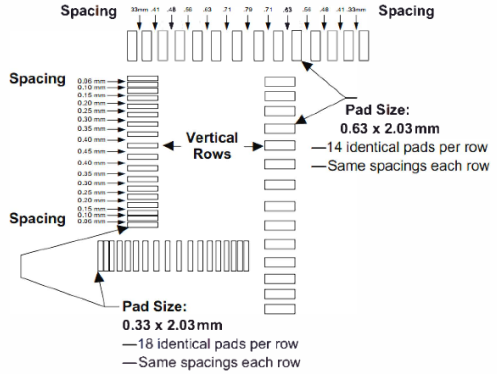
Results – Extended ROIs

- Decreasing the ROIs shows improvement at smaller pad sizes, but the reverse is true for large pads
- Solder deposit could extend outside of ROI if too small

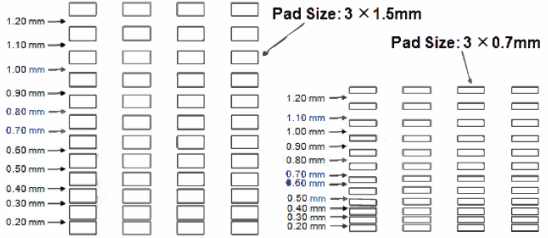


Slump Analysis

- Slump is x-y direction expansion of solder paste caused by gravity
- Printed slump patterns in accordance with IPC standards
- Analyzed both cold (25 C) and hot (180 C) slump tendencies



(a)



(b)

Fig. 1 Schematic pictures of stencils for slump tests

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Results – Slump

- Flux vehicle A shows consistent slump performance across powder types
  - Despite Paste A1 reading ~300 poise lower viscosity
- Paste B2 shows similar performance, but B1 and B3 exhibited worse slump
- The water soluble paste and Paste B1 were the only pastes that failed

Flux Vehicle	Powder Type	Temperature	Pitch/Pad Size	Orientation	Largest Bridged Gap (mm)
A	1	25 C	0.63mm/0.33x2.03mm	Horizonal	0.15
			0.40mm/0.20x2.03mm	Horizonal	0.125
		180 C	0.63mm/0.33x2.03mm	Horizonal	0.15
			0.40mm/0.20x2.03mm	Horizonal	0.15
	2	25 C	0.63mm/0.33x2.03mm	Horizonal	0.15
			0.40mm/0.20x2.03mm	Horizonal	0.125
		180 C	0.63mm/0.33x2.03mm	Horizonal	0.15
			0.40mm/0.20x2.03mm	Horizonal	0.15
	3	25 C	0.63mm/0.33x2.03mm	Horizonal	0.1
			0.40mm/0.20x2.03mm	Horizonal	0.125
		180 C	0.63mm/0.33x2.03mm	Horizonal	0.15
			0.40mm/0.20x2.03mm	Horizonal	0.15
B	1	25 C	0.63mm/0.33x2.03mm	Horizonal	0.15
			0.40mm/0.20x2.03mm	Horizonal	0.15
		180 C	0.63mm/0.33x2.03mm	Horizonal	0.2
			0.40mm/0.20x2.03mm	Horizonal	**0.2**
	2	25 C	0.63mm/0.33x2.03mm	Horizonal	0.15
			0.40mm/0.20x2.03mm	Horizonal	0.125
		180 C	0.63mm/0.33x2.03mm	Horizonal	0.15
			0.40mm/0.20x2.03mm	Horizonal	0.125
	3	25 C	0.63mm/0.33x2.03mm	Horizonal	0.1
			0.40mm/0.20x2.03mm	Horizonal	0.1
		180 C	0.63mm/0.33x2.03mm	Horizonal	0.2
			0.40mm/0.20x2.03mm	Horizonal	0.175
WS	2	25 C	0.63mm/0.33x2.03mm	Horizonal	0.15
			0.40mm/0.20x2.03mm	Horizonal	0.125
		180 C	0.63mm/0.33x2.03mm	Horizonal	**0.25**
			0.40mm/0.20x2.03mm	Horizonal	0.2

Conclusions

- To achieve consistent fine-feature printing for SiP applications, many attributes need to be taken into consideration
  - Both paste (flux vehicle, powder type) and non-paste (SPI programming, squeegee pressure)
- Test vehicle selection is important as well to ensure data reliability