Forward. Thinking.

Electroplating Through Holes with Different Geometry -- A Novel and High Productivity Process for Through Hole Fill Plating

October 2012

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4	PHYSICAL PROPETIES & RELIABILITY
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TOPIC

- Background
- Copper Through Hole Fill Capability
- Formulation
- Effects of hole geometry
- Effects of process parameters
- Substrate and metallization effects
- Pilot scale cycling test
- Physical properties and reliability
- Summary

Through-hole Fill Build-up Process

Conventional

Conformal plating

Cap filling

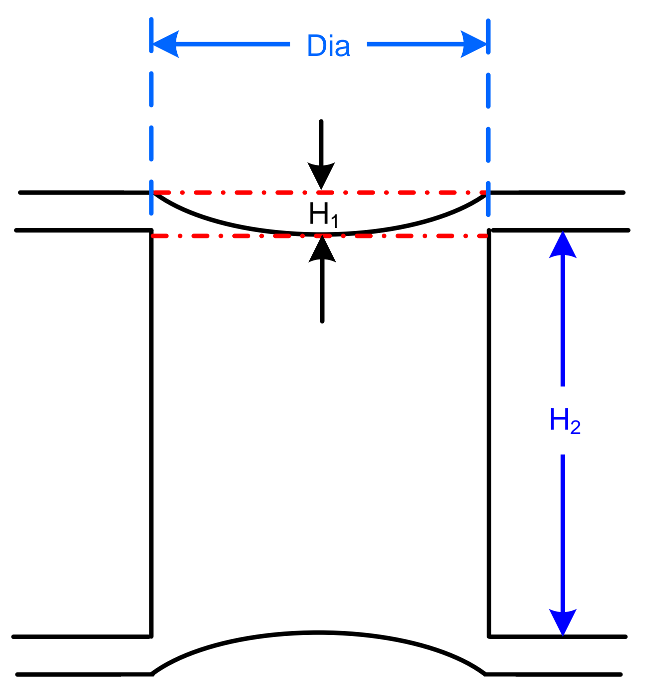
Epoxy fill

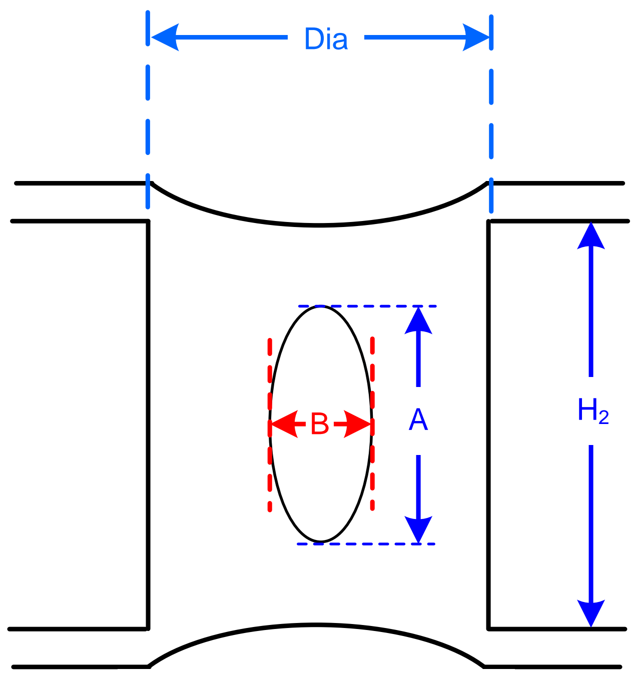
Current Technology

Copper Through Hole

- Highly conductive, improved thermal properties
- Excellent copper to copper adhesion, providing improved reliability
- No CTE mismatch within filled via structure
- Increased productivity and reduced costs

Copper Through Hole Fill Performance Metrics





- Dimple Depth = H_1
- Aspect Ratio = H_2/Dia

- Void Area = 0.5A x 0.5B x π
- Hole Area = H_2 x Dia
- % Void Area = Void Area/Hole Area x 100%

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Product Capability

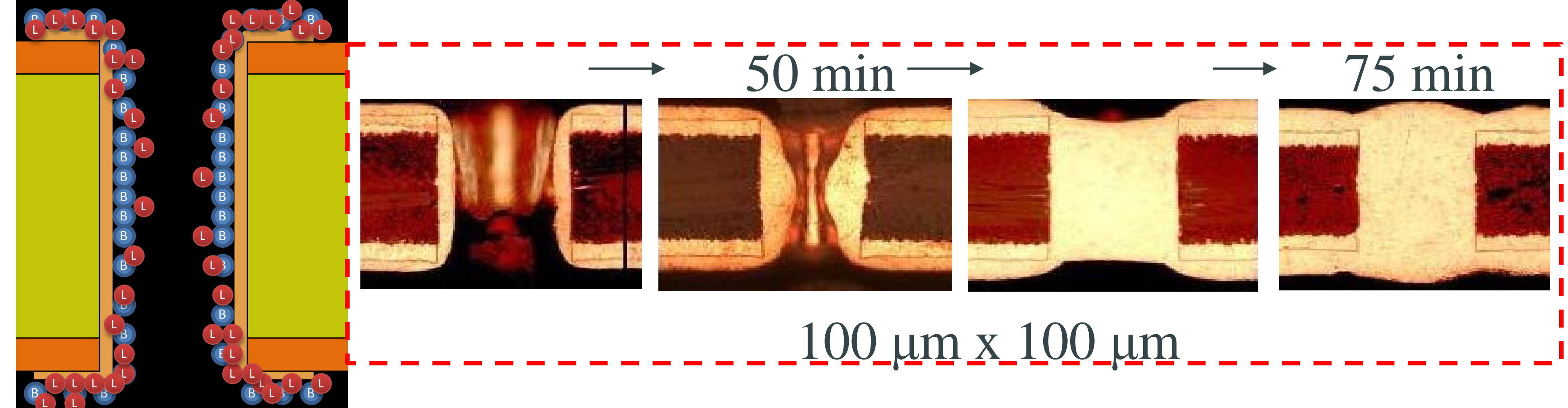
MICROFILL ™ THF Bath Key Capabilities:

- Substrate Thickness : 100 µm – 200 µm
- Hole Diameter : 75 µm – 100 µm
- Hole Geometry : Mechanical and laser drilled
- Rectification : Direct Current
- Current Density : 10 – 25 A/ft^2 (1 - 2.5ASD)
- Dimple Depth : ≤ 10 µm
- Plated Copper Thickness : ≤ 25 µm
- Temperature : 20° C to 25° C (68 – 77° F)
- Substrate Metallization : Electroless Copper
- Compatible with Insoluble Anodes
- Panel and Pattern Plate Compatible
- CVS Analysis for all Organic Components

Optimized Formulation

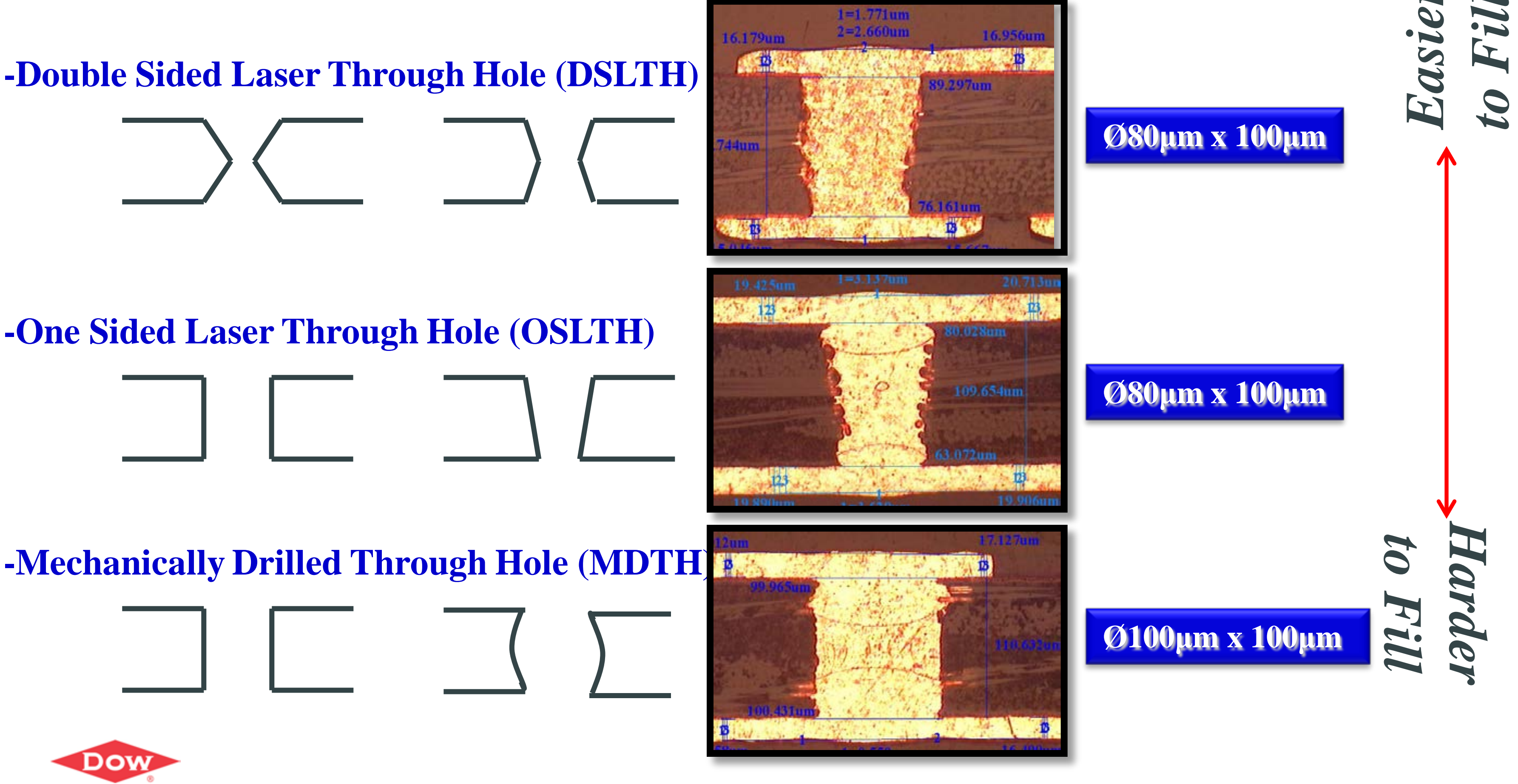
Single Step DC Plating – MICROFILL™ THF Bath

Operating Parameters	Range	Recommended
Copper Sulfate Pentahydrate	220 – 230 g/L	225 g/L
Sulfuric Acid	35 - 45 g/L	40 g/L
Chloride	40 – 60 mg/L	50 mg/L
MICROFILL™THF Brightener Solution	5.0 - 6.5 mL/L	5.75 mL/L
MICROFILL™ THF Carrier Solution	10 – 15 mL/L	12.5 mL/L
MICROFILL™ THF Leveler Solution	2.25 – 3.25 mL/L	2.75 mL/L)



Impact of Through Hole Geometry

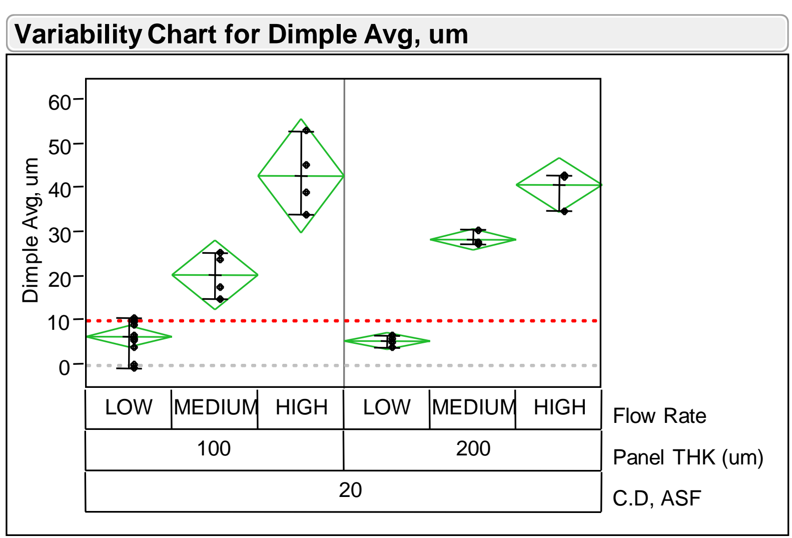
MICROFILL™ THF Bath is Capable of Filling Through Hole (TH) with Range of Different Shapes :



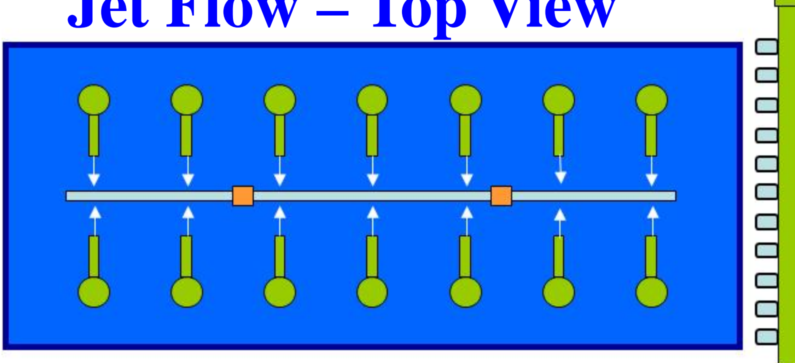
Effect of Jet Impingement Flow Rate

Excessive solution flow increases dimple depth

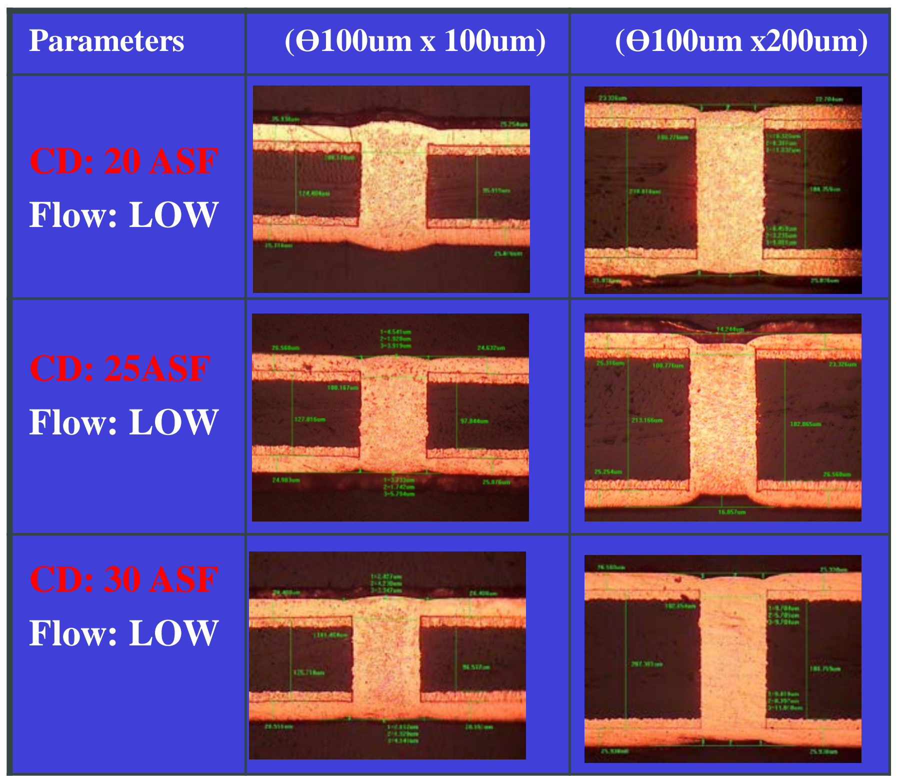
Parameters	(ϴ100 x 100 um)	(ϴ100 x 200um)
HIGH FLOW		
LOW FLOW OR FLOW RAMP		
MEDIUM FLOW		



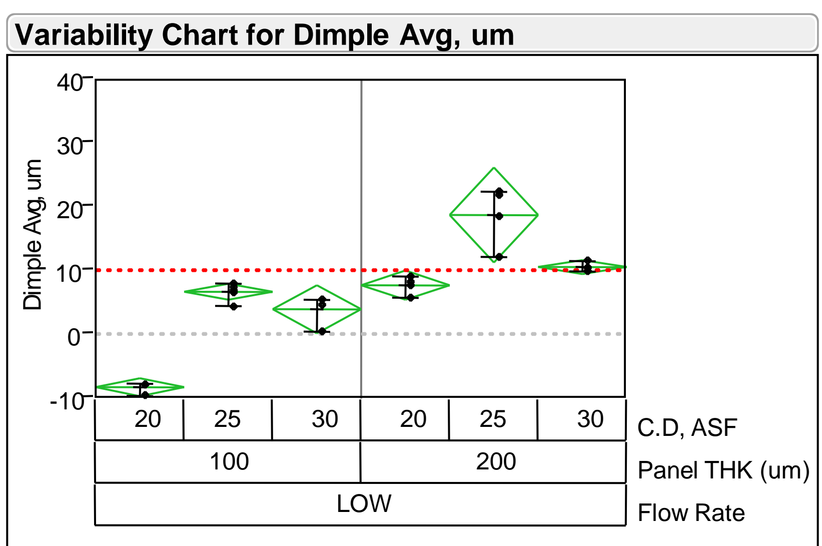
Jet Flow – Top View

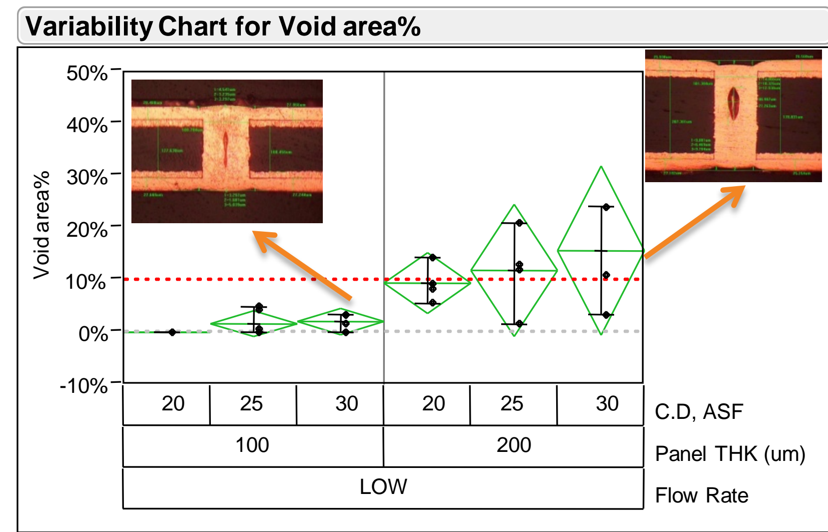


Effect of Current Density



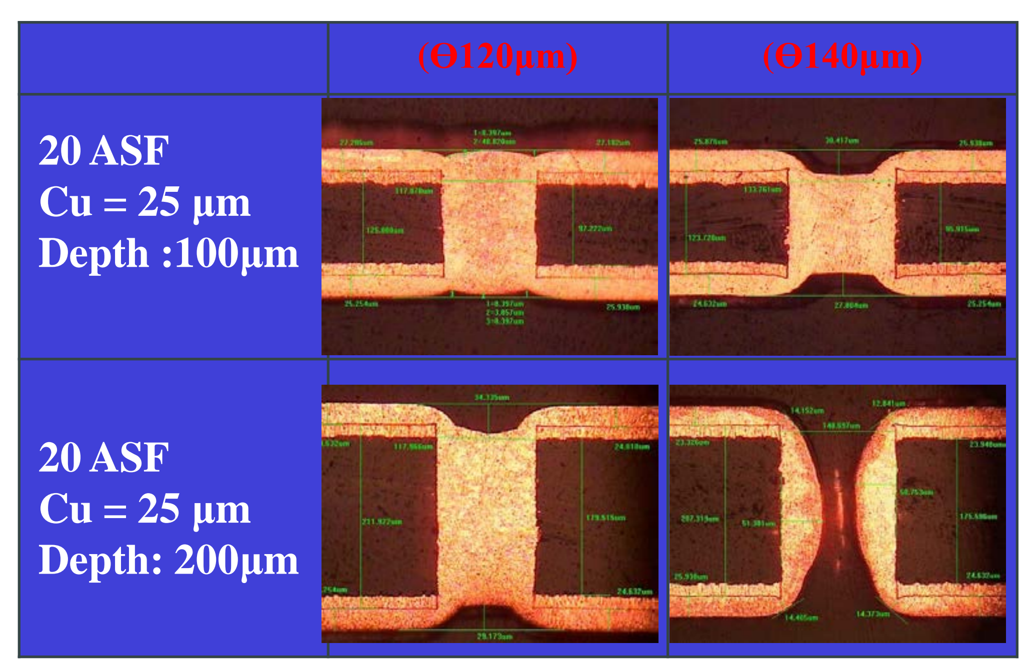
Parameters	(Ө100um x 100um)	(Ө100um x200um)
CD: 20 ASF Flow: LOW		
CD: 25ASF Flow: LOW		
CD: 30 ASF Flow: LOW		

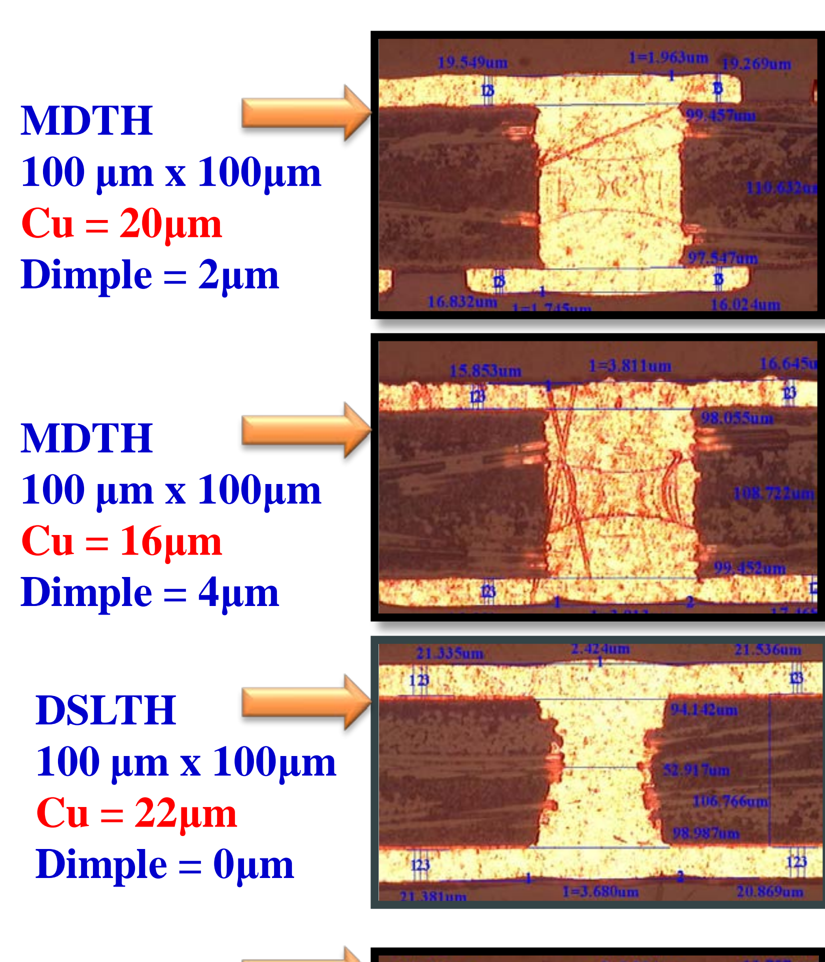




- Process performs very well at high current densities, dimple < 10 μm
- Low current density improves TH void performance with 200 μm thick panels
- The small loss of fill performance due to increasing current density is greater at higher substrate thicknesses

Effect of Hole Diameter & Copper Thickness on Fill

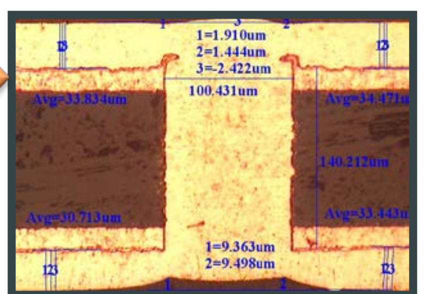




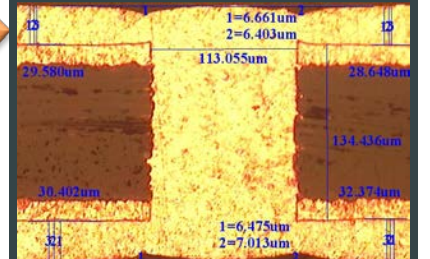
- The amount of plated copper to achieve a completely filled TH is dependent on hole size. Less plated copper is required to fill smaller diameter holes than larger diameter holes
- Depending on geometry size, MICROFILL™ THF bath is capable of filling through holes with copper thickness less than 20 µm.

Impact of Substrate Metallization on Fill

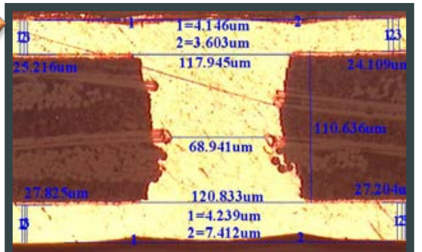
MDTH
100µm x100µm
Electroless thickness:
0.5-1.25 µm



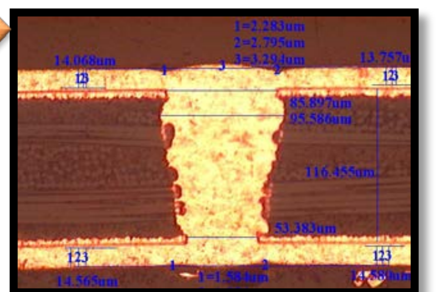
MDTH
100 µm x 100µm
Electroless thickness:
0.2-0.5 µm



DSLTH
100 µm x 100µm
Electroless thickness:
0.2-0.5 µm



OSLTH
100 µm x 100µm
Flash copper thickness:
1.0-4.0 µm



- THF performance is similar whether used with medium or low build electroless
- The quality and thickness of electroless copper affects THF performance
- THF performance decreases with decreasing electroless copper coverage
- The impact of poor coverage on THF performance is greater for low build electroless
- THF can be used also with electrolytic copper flashed substrates

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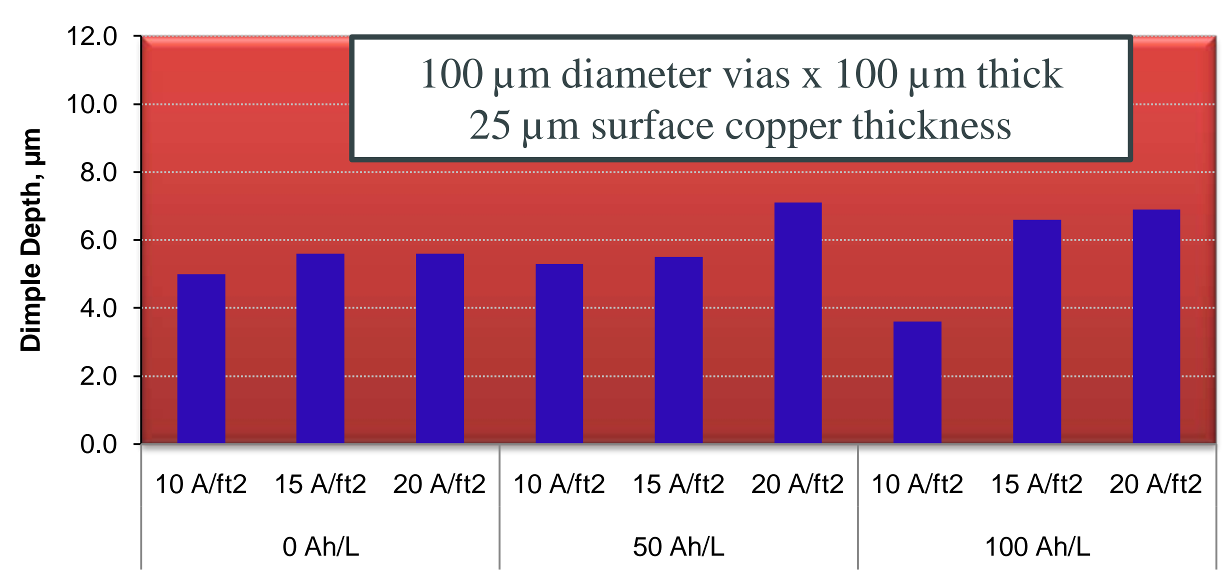
Fill Performance as a Function of Bath Age



Consistent through hole fill performance with low dimple depth < 10 µm

Bath Age	10 A/ft^2	15 A/ft^2	20 A/ft^2
0 Ah/L			
100 Ah/L			

Bath Age	100 µm dia x 100 µm thick	100 µm dia x 200 µm thick
0 Ah/L		
150 Ah/L		

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Through Hole Fill Deposit Physical Properties

	0 Ah/L	100 Ah/L	150 Ah/L
Tensile Strength, N/mm2	290.7	289.0	289.6
Elongation, %	19.8	18.9	21.3

	10 A/ft2	15 A/ft2	20 A/ft2
Tensile Strength, N/mm2	287.1	289.6	288.6
Elongation, %	24.3	21.3	18.0

Tensile Strength and Elongation measured per IPC-TM 650 2.4.18.1

Through Hole Fill Reliability

Thermal Stress IPC-TM 650 2.6.8

Hole Size	THF Bath Age			
	0 Ah/L	50 Ah/L	100 Ah/L	150 Ah/L
	Number of cracks / number of holes			
100 µm dia x 100 µm thick	0/120	0/120	0/120	0/120
100 µm dia x 200 µm thick	0/120	0/120	0/120	0/120

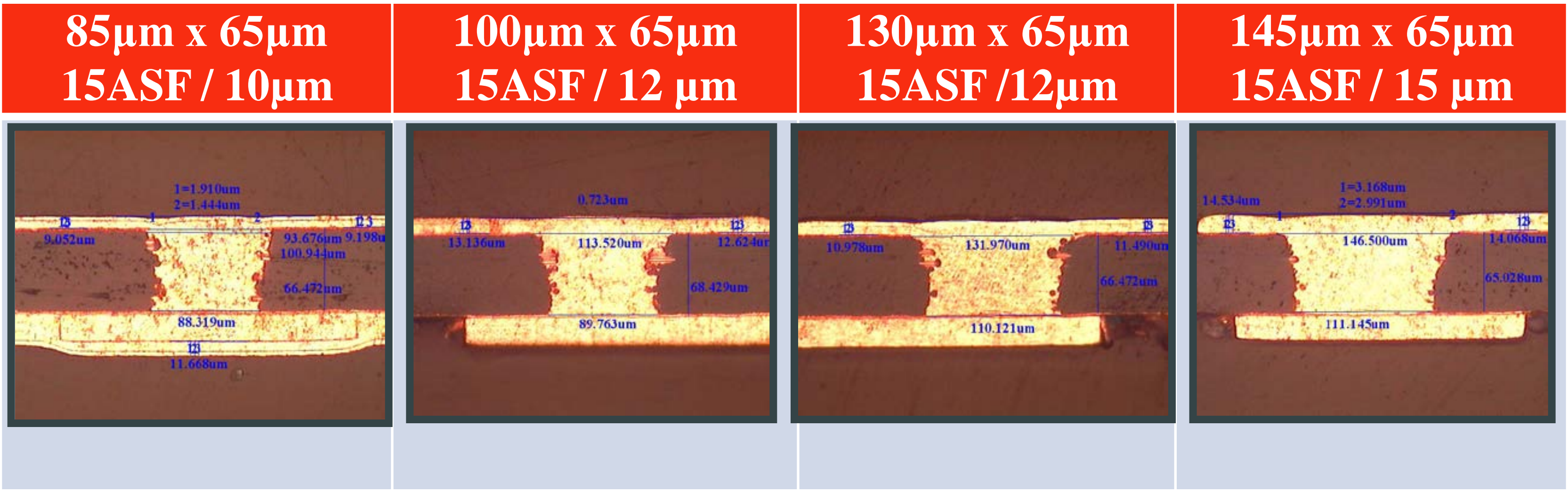
CD = 15 ASF
Cu = 25 µm

CD (ASF) / Panel Thickness	Defects/ Total Holes Inspected	Cross Section
25 / 100 µm	0 / 220	
25 / 200 µm	0 / 220	

Excellent deposit performance throughout the range of bath age and current densities evaluated

Blind Microvia Fill Performance

- MICROFILL™ THF bath can also be utilized for the metallization of Blind Micro Via (BMV) with surface copper thicknesses of less than 15 µm. This system may be utilized for BMV plating for Every Layer Interconnect (ELIC) HDI and IC substrate applications.



Conclusion

- Product is commercialized world wide. DC through hole fill process developed for HDI and IC package substrate.
- Consistent through hole fill performance with low dimple depth < 10 µm
- Excellent fill performance, with mechanically drilled holes, and laser drilled holes
- High filling performance on substrates metallized with different thicknesses of electroless copper
- Excellent fill performance with dimple < 10 µm at range of CD up to 25 ASF
- Good deposit physical properties. Solder Float results showed no cracks.
- Depending on hole geometry, the MICROFILL™ THF Bath demonstrates superb filling performance with surface copper thickness between15µm and 25µm.
- Highly leveled surface free of nodules and pits. All bath additive components can be monitored by CVS
- Excellent blind microvia fill performance.

Thank You

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