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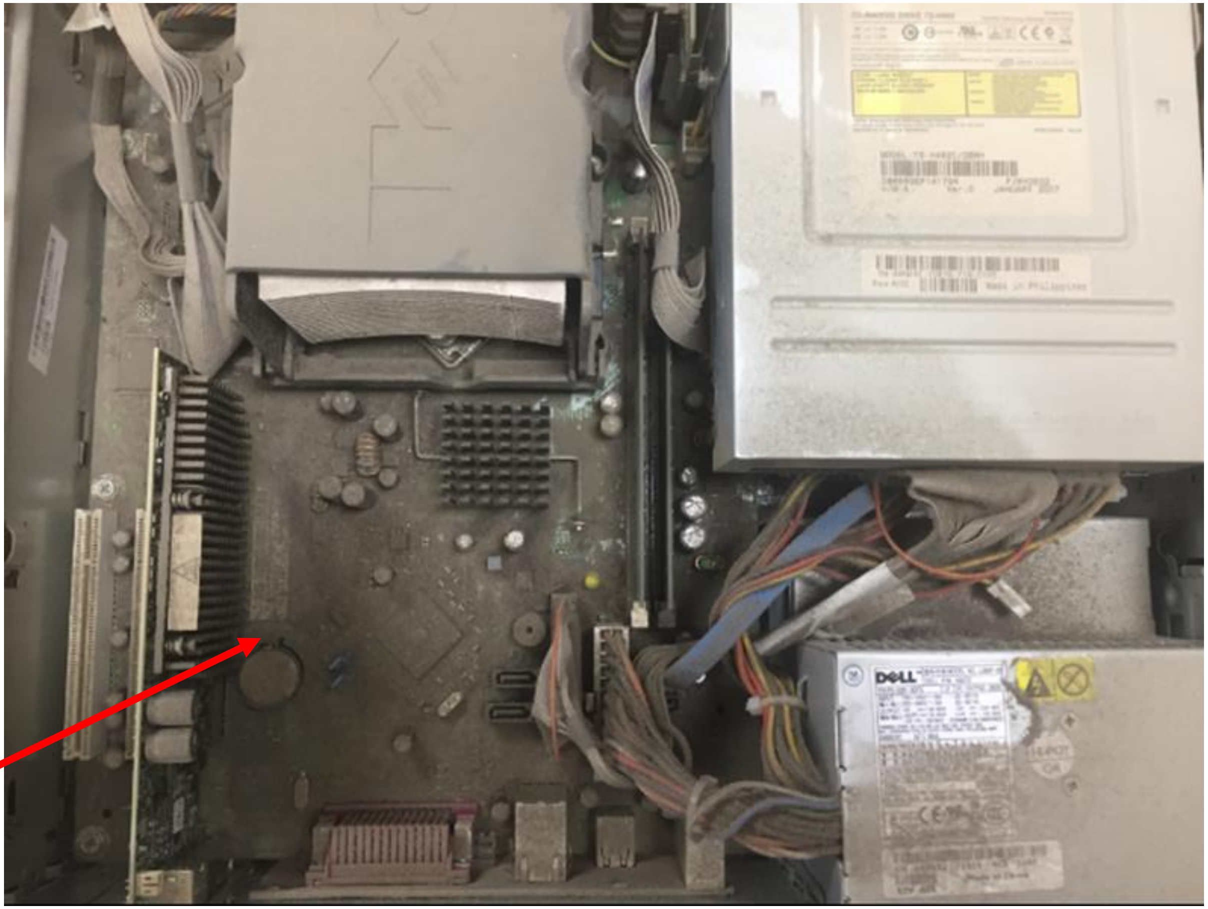
Developments in ink jettable soldermask

www.electrapolymers.com

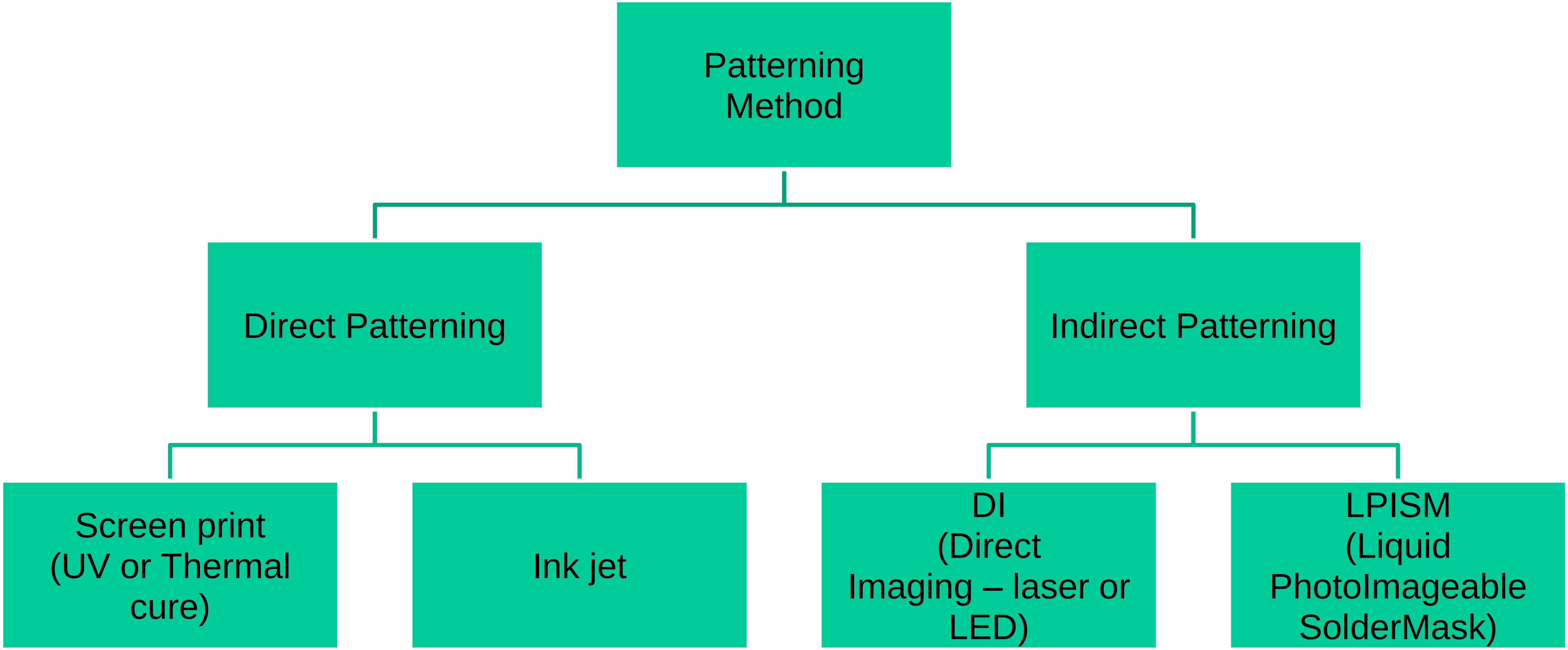
Institute of Circuit Technology
Webinar 19th Nov 2020

Why we need soldermask!

- To protect copper circuitry
  - Chemically
  - Electrically
  - Physically
- from
  - High Temps
  - Humidity & moisture
  - Corrosives
  - Dust, dirt, contamination



Soldermask Types



- Patterning Method
  - Direct Patterning
    - Screen print (UV or Thermal cure)
    - Ink jet
  - Indirect Patterning
    - DI (Direct Imaging – laser or LED)
    - LPISM (Liquid PhotoImageable SolderMask)

Direct Patterning

- Ink Jet –
  - Continuous Ink Jet (CIJ)
  - Drop on Demand (DOD)
    - thermal or
    - **piezoelectric system**
  - Print performance very dependent on printer integrators
  - Requires collaboration between ink formulators and printer manufacturers
  - Scaleable

Lab printer

MEYER BURGER

Industrial Inkjet Printers

Advantages of inkjet soldermask process

- Digital “artwork”
  - created straight from Gerber data or via bit-map
- Potential for high throughput
  - depends on number of heads, droplet size
- Additive process – minimal wastage
- Low/no solvent emissions
  - (150 kg/mth LPI ≡ 630kg/year solvent emitted
- Registration compensation
  - Image stretching and offset to allow for board distortion
- Reliability
  - Repeatable process
  - 100% solids
  - No undercut at image edges

Advantages of inkjet soldermask process

- Reduction in process steps/time compared to LPISM process

Traditional LPISM process flow

Inkjet printing process flow

- Eliminates coating, artwork, exposure and development
- Elimination of drying ovens, high power UV exposure equipment
- Smaller process line footprint
- Reduction in energy costs
- Reduced WIP

Print heads

Types of head

DOD Piezo

DOD Thermal

Recirculating

Non-recirculating

Properties influenced by head type

Droplet size

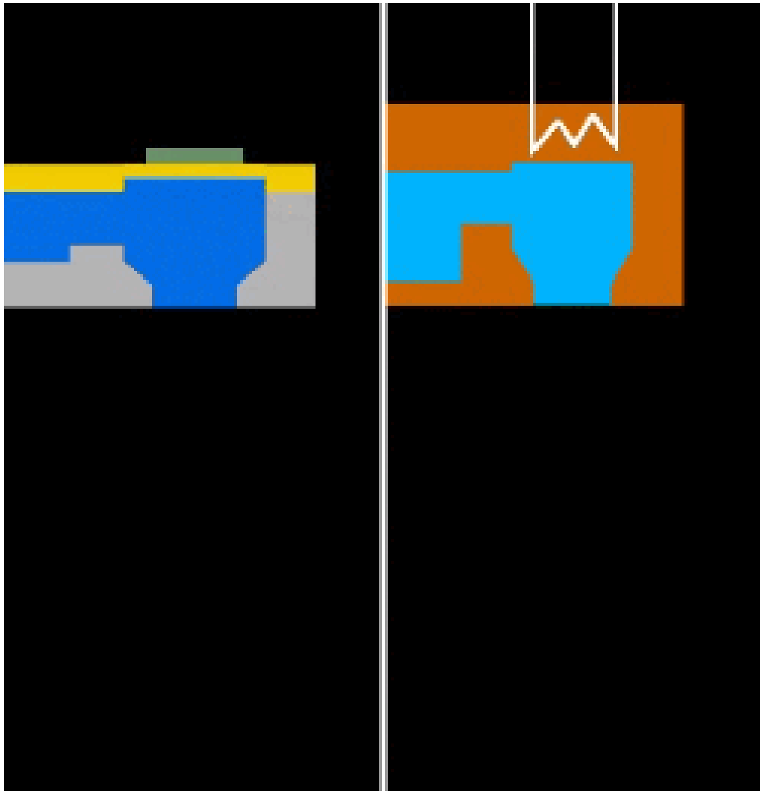
Resolution

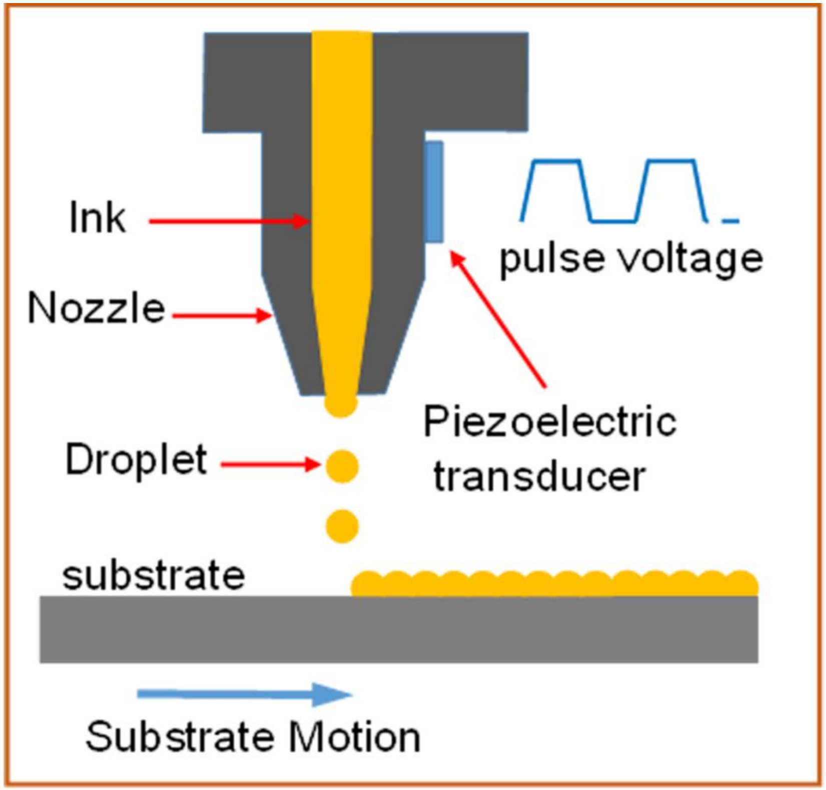
Ink Heating capability

Can be incorporated in arrays to increase throughput

Types of head

DOD Piezo DOD Thermal





Key Inkjet Soldermask characteristics

- Low viscosity, surface tension
  - Varies according to print head type

Reynolds number: $Re = v\rho\alpha/\eta$

Weber number: $We = v^2\rho\alpha/\gamma$

Ohnesorge number: $Oh = \sqrt{We}/Re$

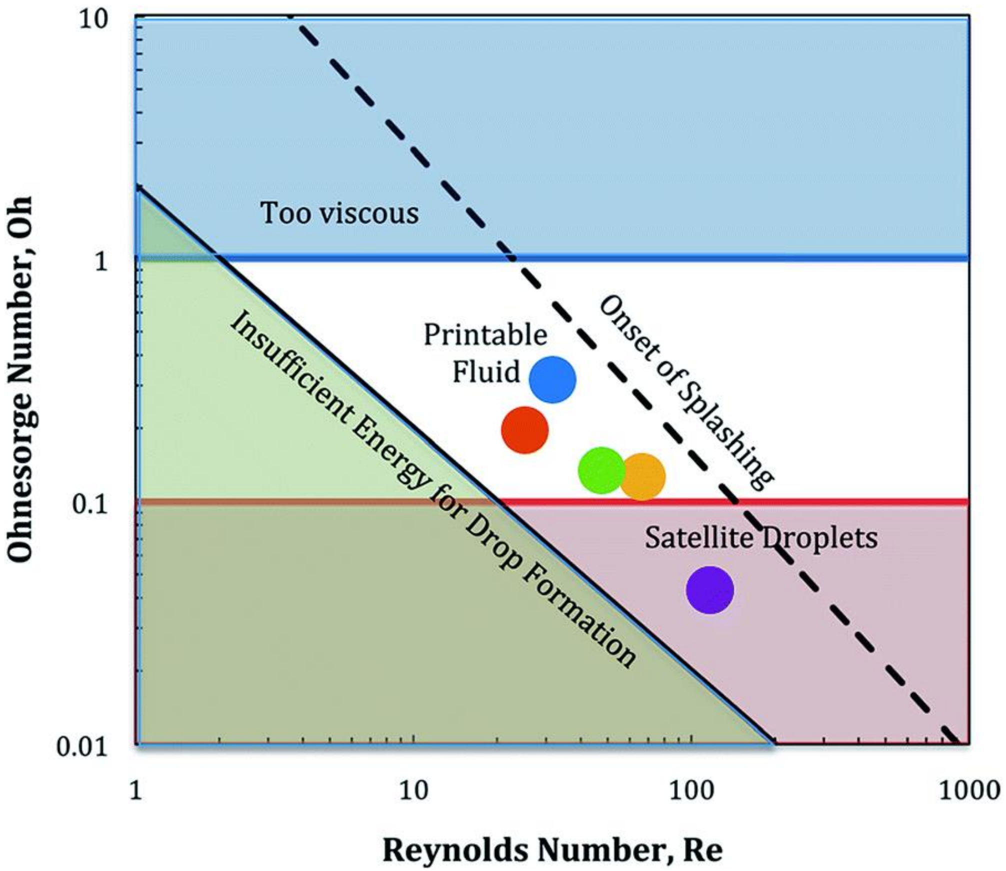
Fromm Z parameter: $Z = 1/Oh$

Stable drop formation: $10 > Z > 1$

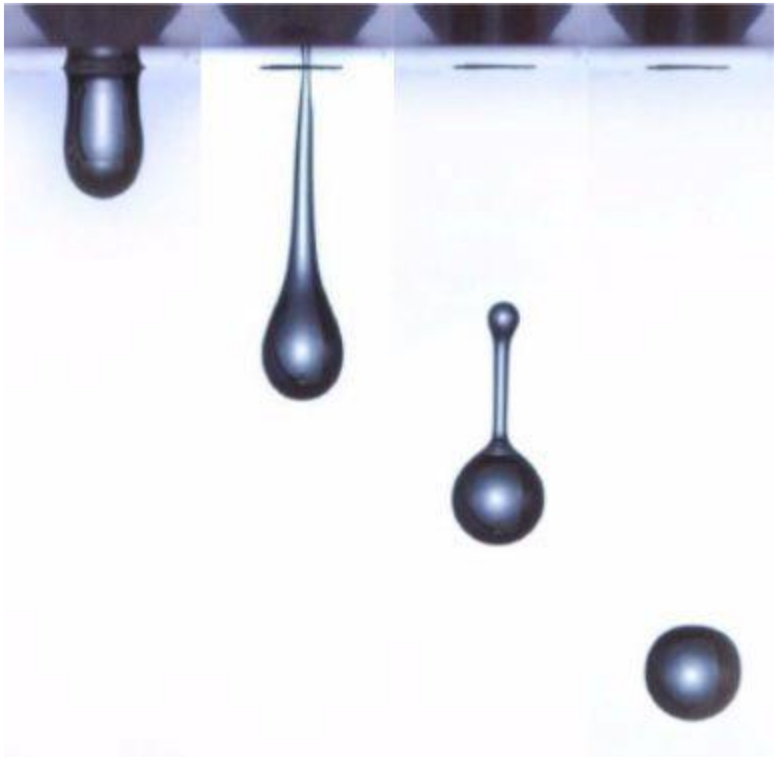
v – *drop velocity*
P – *ink density*
α – *nozzle diameter*
η – *ink viscosity*
γ – *surface tension*

- Contact angle
  - Influences coating performance of first layer on substrate and subsequent layers jetted onto pin-cured layers.

Operating regime for stable printing



The Perfect droplet

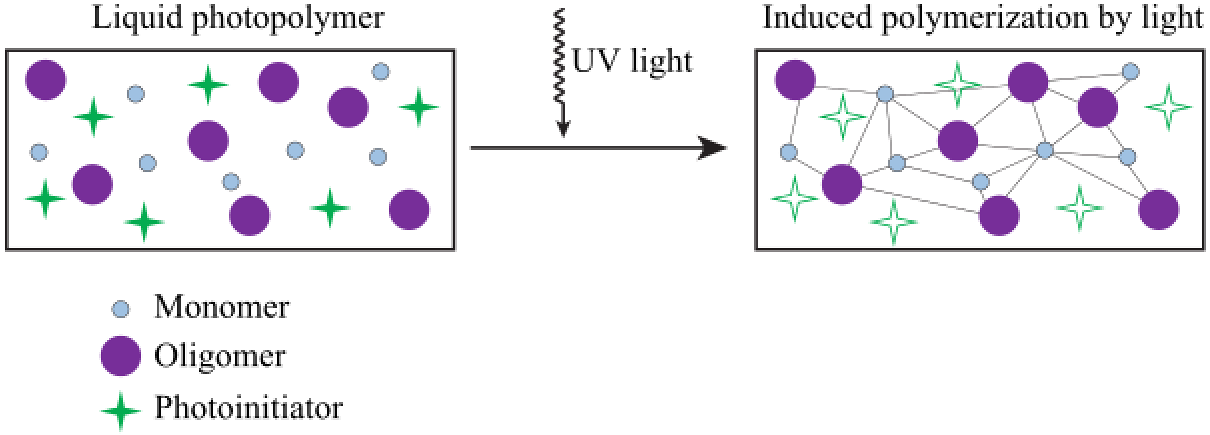


Strategies for Print Optimization

- Pin cure to fix droplets in place
  - Low level UV cure for droplets in each layer
- Specialised surface treatments to minimize droplet spread.
- Print profile(“recipes”) to suit different board designs

Strategies for Print Optimization

- UV Pin cure



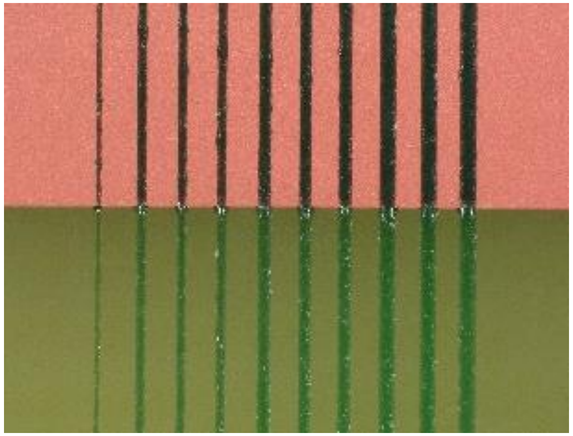
Acrylate – free radical cure
Epoxy – cationic cure
Hybrid – combination epoxy/acrylate system

- (Secondary UV cure)
- Thermal final cure

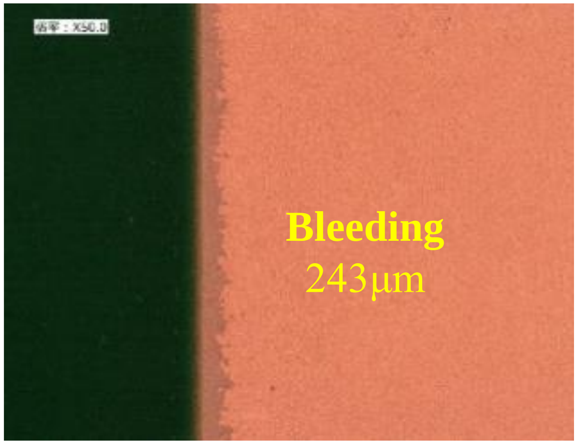
Strategies for Print Optimization

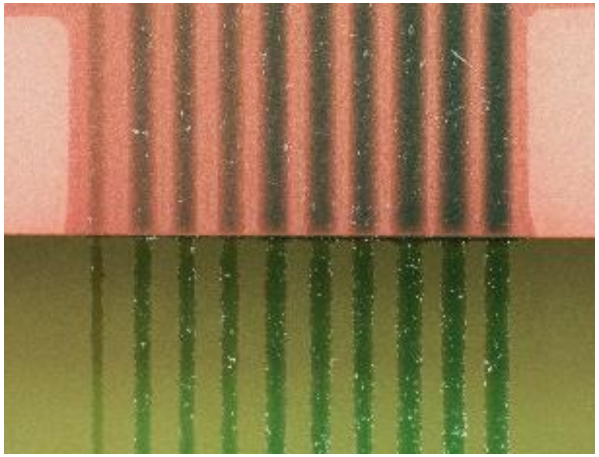
Specialised surface treatments

CZ-2001 1.0 µm
+
CL-8320C



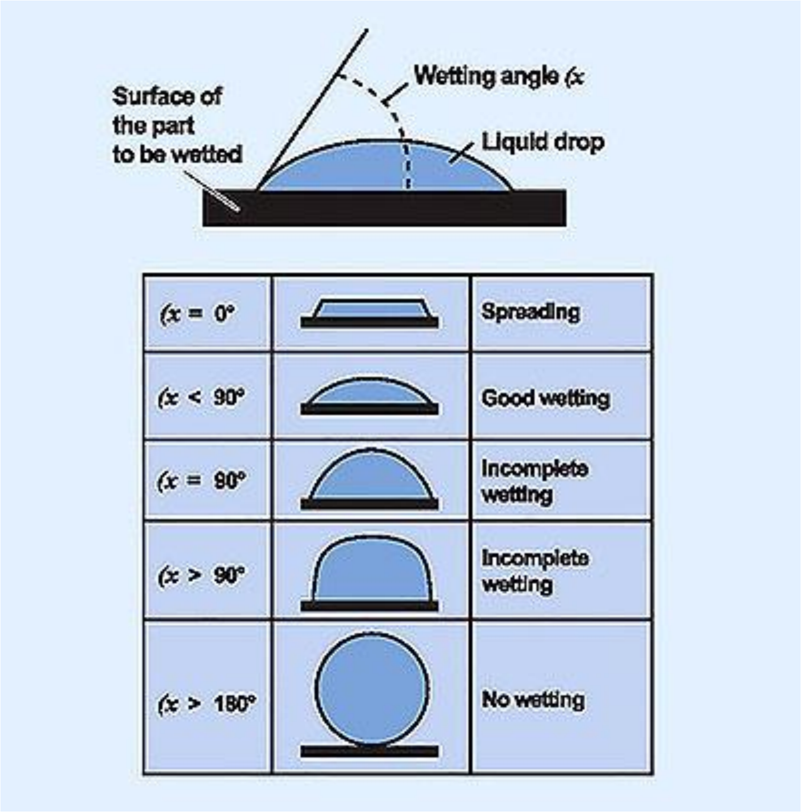
CZ-2001 1.0 µm
ONLY





Images courtesy of MEC Etch Europe

Contact Angle



α = 0°		Spreading
α < 90°		Good wetting
α = 90°		Incomplete wetting
α > 90°		Incomplete wetting
α > 180°		No wetting

Contact Angle

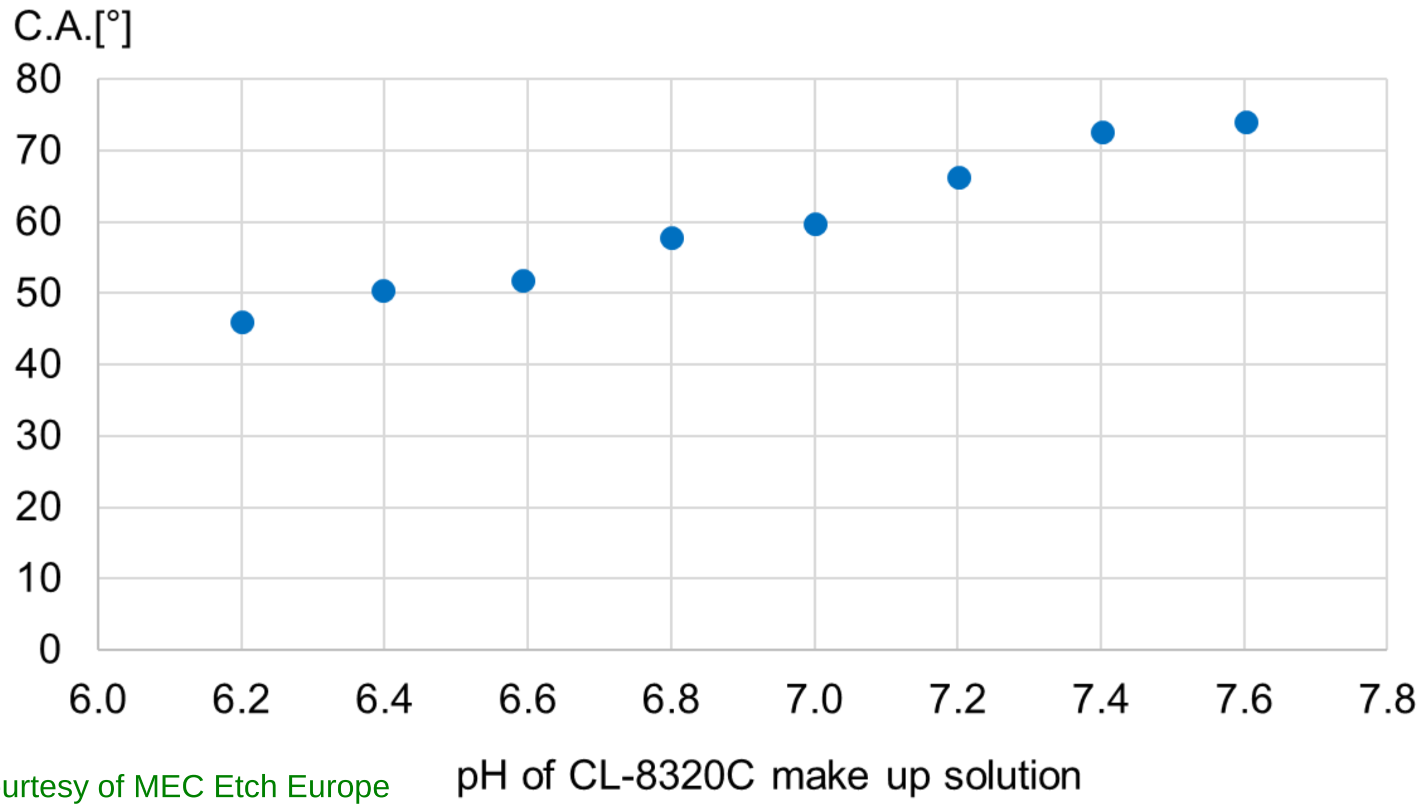
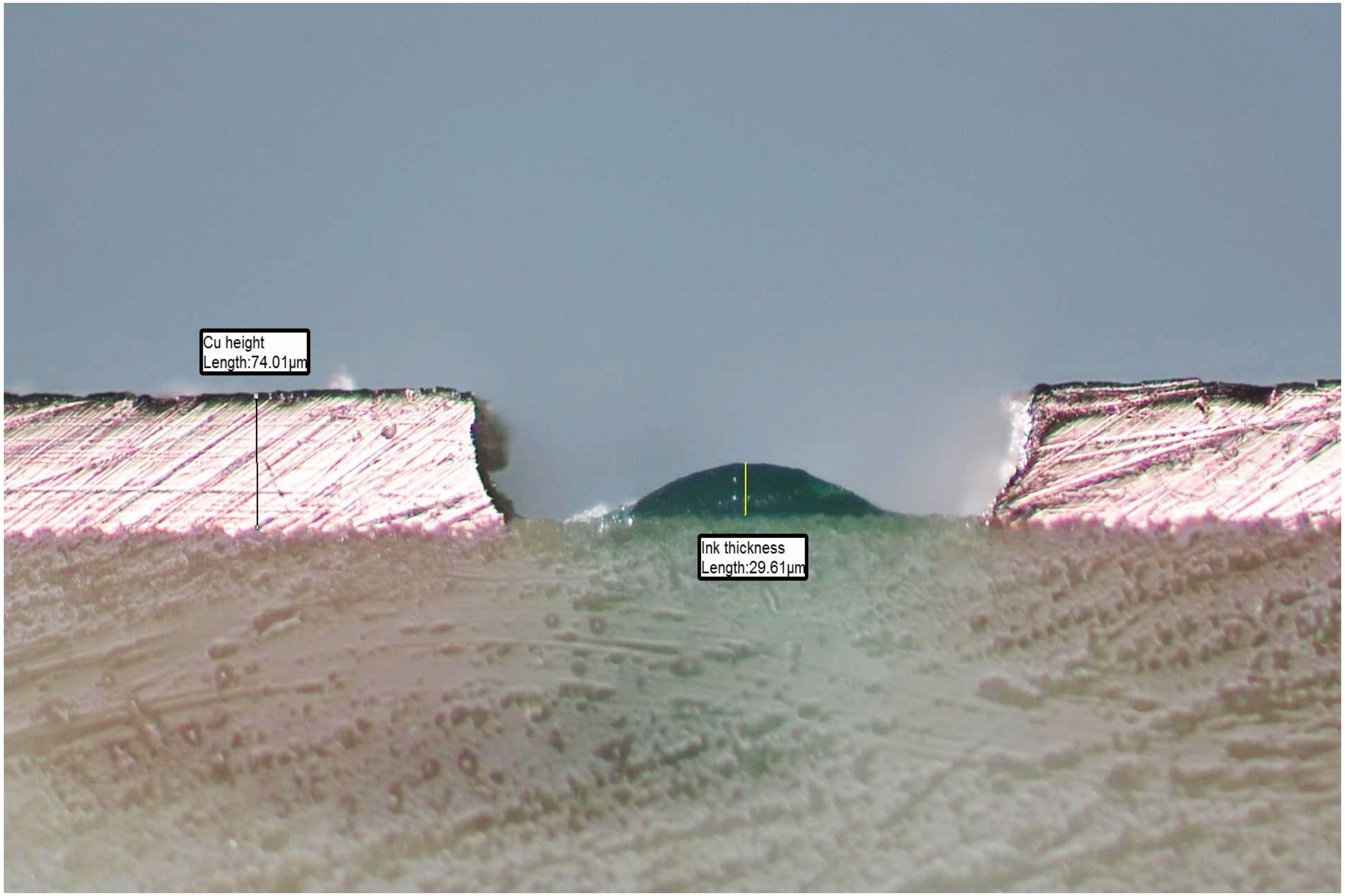


Image courtesy of MEC Etch Europe

Inkjet soldermask Electrajet ® EMJ110

EMJ110 Desired Dam shape to stop chemistry entrapment



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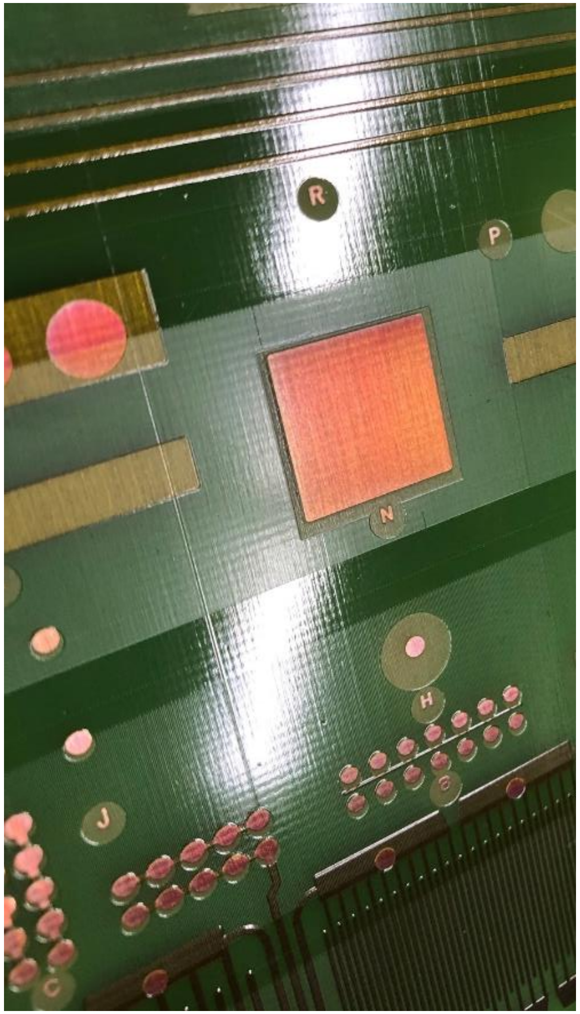
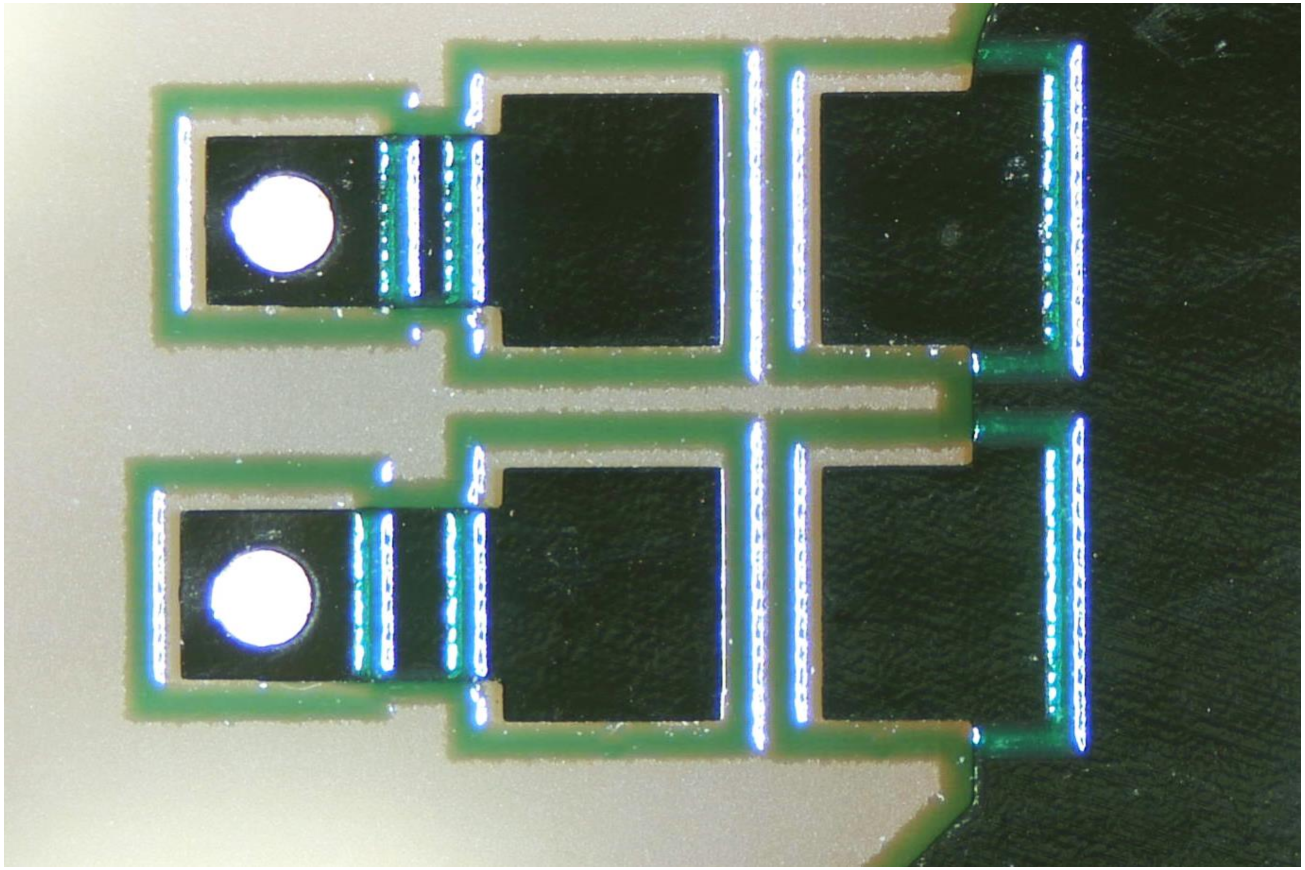
Strategies for Print Optimization

- Multilayer print profiles
  - create dams around pads and prevent thinning on track edges
  - Can be used to build thickness selectively
  - eliminate “striping” and stitch lines
  - different ink surface finishes.



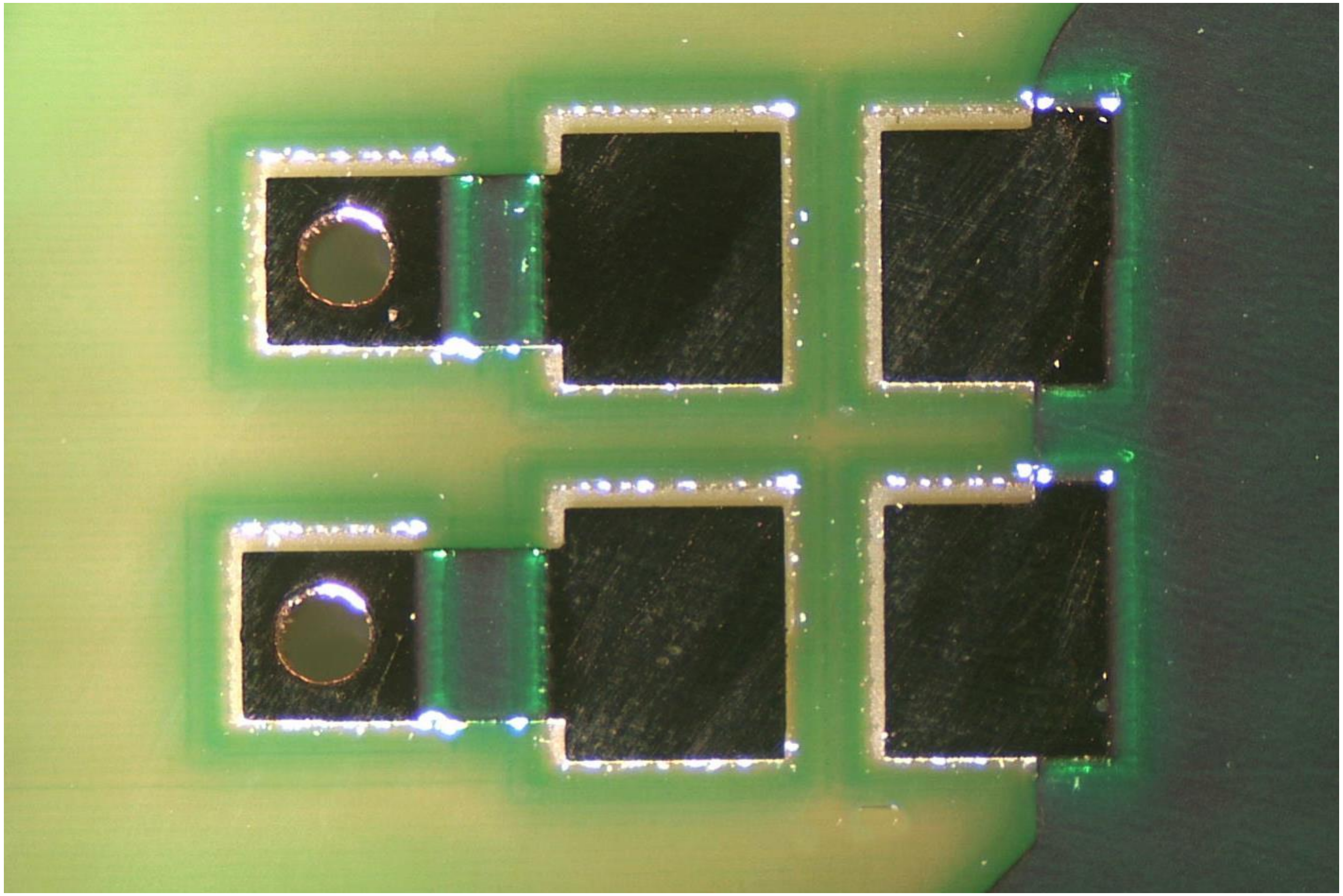
Strategies for Print Optimization

Layer 1 & 2 – dams + edges



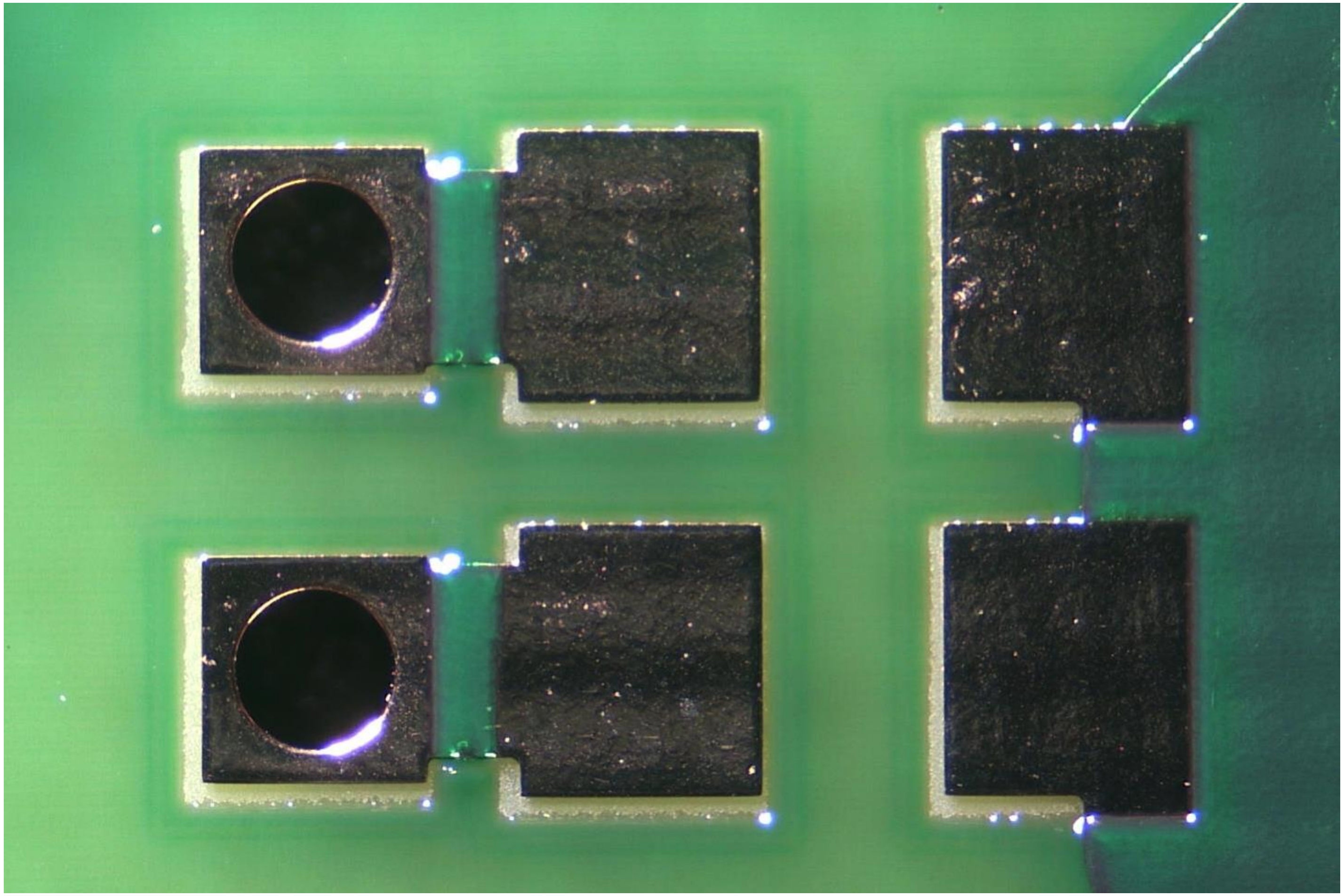
Strategies for Print Optimization

Layer 3 – print over Au and FR4



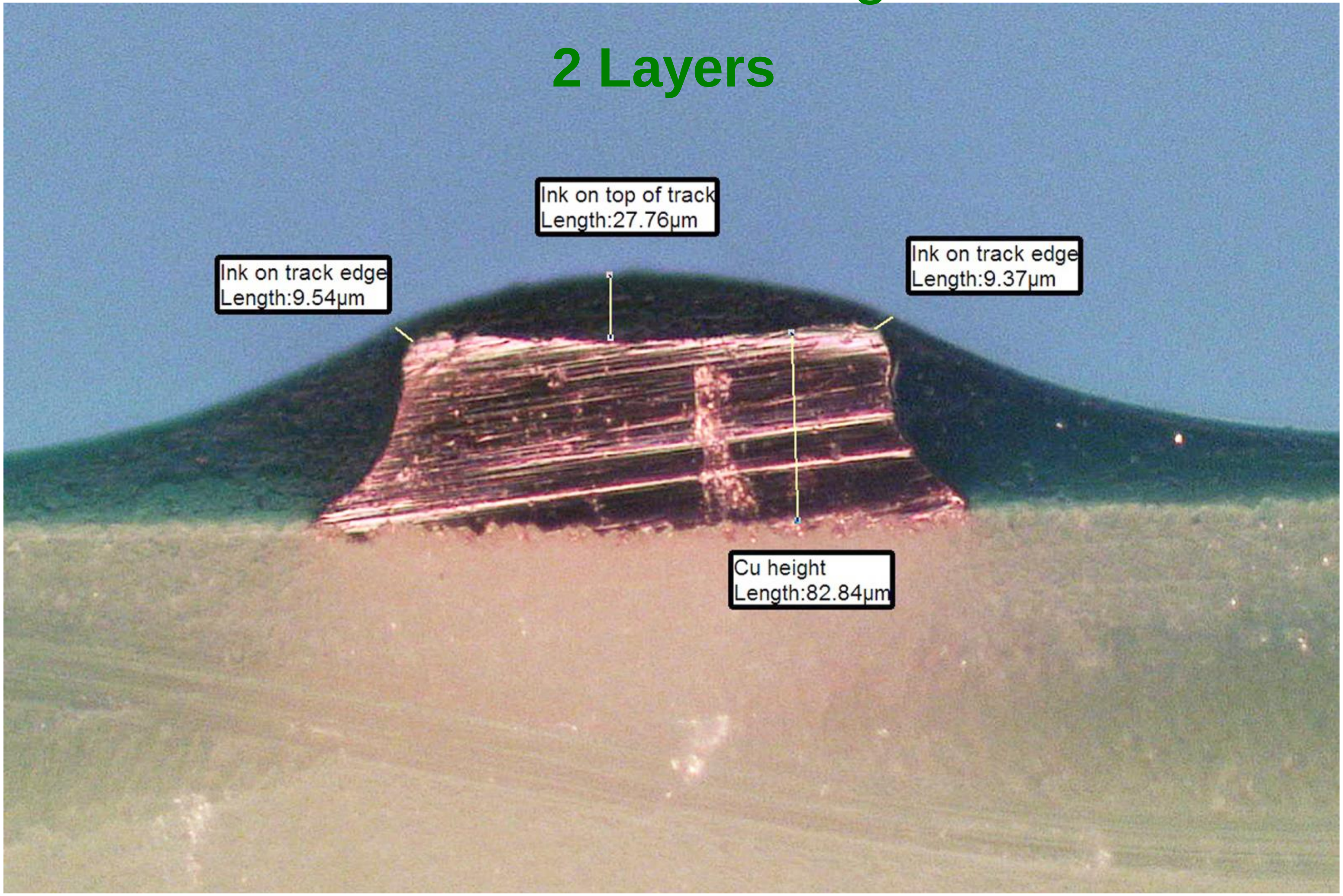
Strategies for Print Optimization

Layer 4 – final gloss finish



Inkjet soldermask Electrajet ® EMJ110

Track coverage



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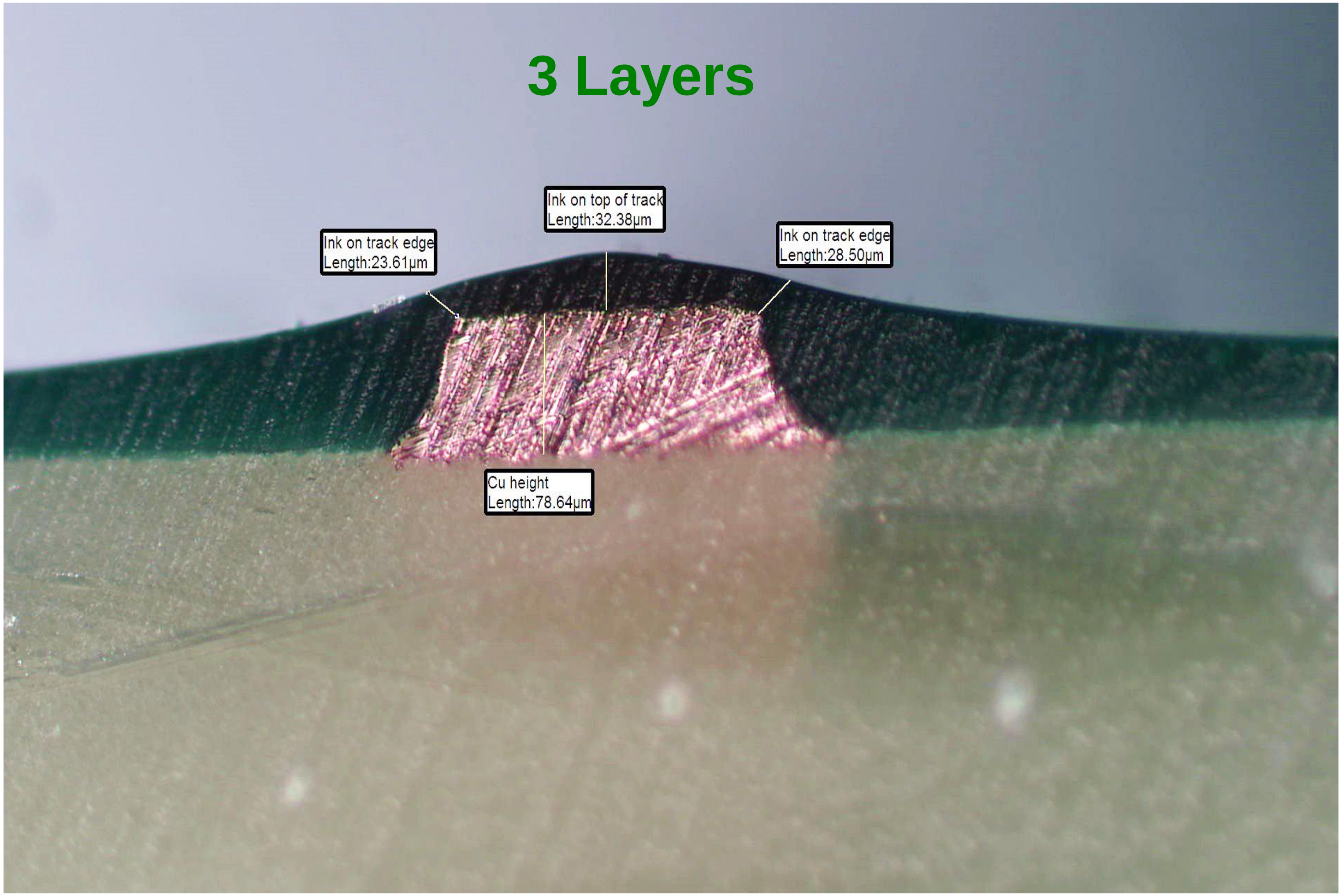
Track Coverage



Inkjet soldermask Electrajet ® EMJ110

Final properties

TEST/STANDARD	REQUIREMENT	RESULT
IPC SM-840 E	CLASS T & H	PASS
UL94	V-0	PASS
THERMAL STORAGE DIN IEC 60068-2-2	TC7 1000h at 150°C	PASS
THERMAL SHOCK DIN IEC 60068-2-14	TC7 -40°C, 150°C, 1000 cycles TC8 G3	PASS
ADHESION TO GOLD	Cross-hatch & tape test	PASS
FLEX TEST	180° crease – tape test	PASS
SOLVENT RESISTANCE	30 seconds methylene chloride	PASS

TEST/STANDARD	REQUIREMENT	RESULT
ACID RESISTANCE	10% HCl, 30 min dip at 20°C – tape test	PASS
ALKALI RESISTANCE	10% NaOH, 30 min dip at 20°C – tape test	PASS
LEAD-FREE SOLDER	3 x 10s at 288°C – tape test	PASS
ENIG RESISTANCE	Ni 5-10 microns, Au <0.1 microns – tape test	PASS
PRESSURE COOKER (PCT)	100 min at 121°C (2 atm) – tape test	PASS
DIELECTRIC CONSTANT	Measured at 10GHz, 22°C	2.99
DISSIPATION FACTOR	Measured at 10GHz, 22°C	0.0228

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Inkjet soldermask Vs LPI screen print soldermask

	ELECTRAJET EMJ110 SOLDERMASK	LPI SCREEN PRINT SOLDERMASK
IPC SM840 E Class H & T	PASS	PASS
UL 94 V-0	PASS	PASS
THERMAL STORAGE		
TC7 1000h at 150°C	PASS	PASS
TC9 2000h at 160ºC	UNDER TEST	PASS
HELLA $E3_{1000}$	PASS	PASS
HELLA $G3/4_{2000}$	UNDER TEST	PASS
THERMAL SHOCK		
TC7 -40°C, 150°C, 1000 cycles	PASS	PASS
TC9 -40°C, 160°C, 2000 cycles	UNDER TEST	PASS
HELLA $E3_{1000}$	PASS	PASS
HELLA $G3/4_{2000}$	UNDER TEST	UNDER TEST
REACH & RoHS	PASS	PASS

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Thank You!

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