IOTECH

AN INNOVATIVE DEPOSITION TECHNOLOGY

FOR CONDUCTIVE & DIELECTRIC MATERIALS

CONTACTLESS, HIGH RESOLUTION, HIGH SPEED

CONFIDENTIAL - MARCH 2024

DIGITAL MANUFACTURING

Agenda

- Short Company Profile
- ioTech CLAD Technology
- From Single Material 2D
  To Multi Material & 3D
- Use Cases

FOR ELECTRONICS

IO TECH - AT A GLANCE

Founded 2016

58 patents
39 granted

Team of 28 highly skilled professionals

Prestigious POs & industry awards

1st prize winner productronica fast forward the start-up platform powered by Elektor

Winner of the LOPEC 2022 Start-up Forum Award Most Impactful Technology

Winner of the productronica innovation award 2021

PROBLEM: ELECTRONICS MINIATURIZATION & RESHORING

SMALLER

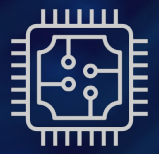
Deposition technologies in semiconductor packaging & assembly are reaching their **limits,** hindering electronics miniaturization

CLEANER

Many **semiconductor packaging technologies** cannot be re-shored due to **environmental issues**

UNMET NEED

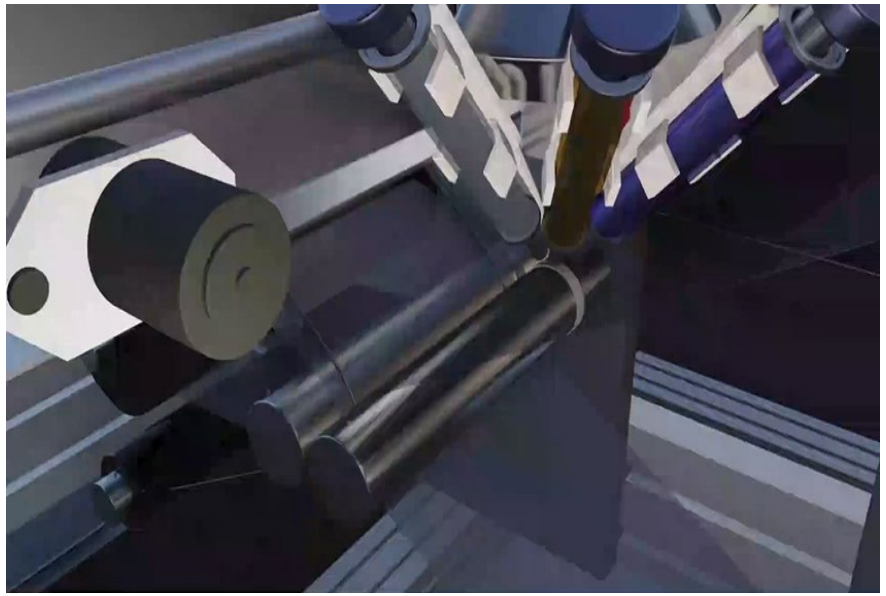
Semiconductors	Semiconductor to memory	Smart watches	Mobile acoustic	Semiconductor packaging
more chips per wafer	faster data transfer	4K display	smaller	Re-shore to OECD

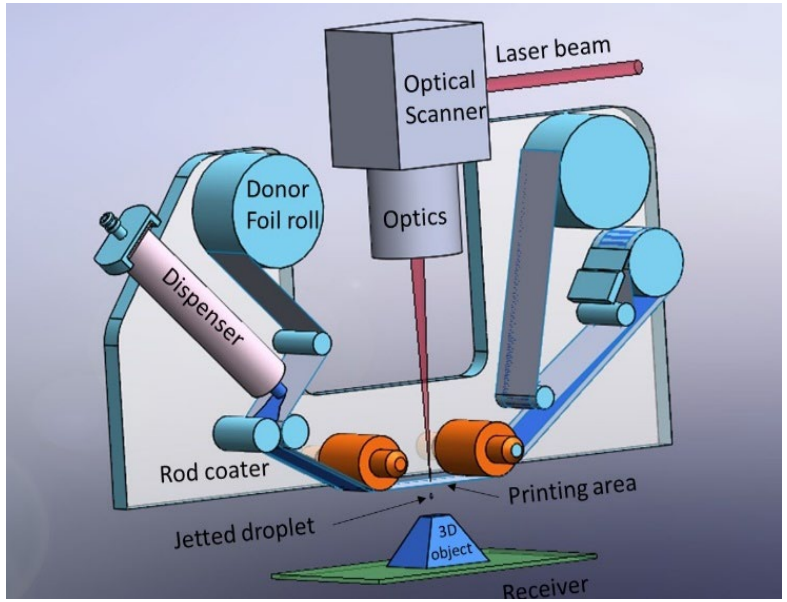




CLAD - non-contact & no mechanical motion

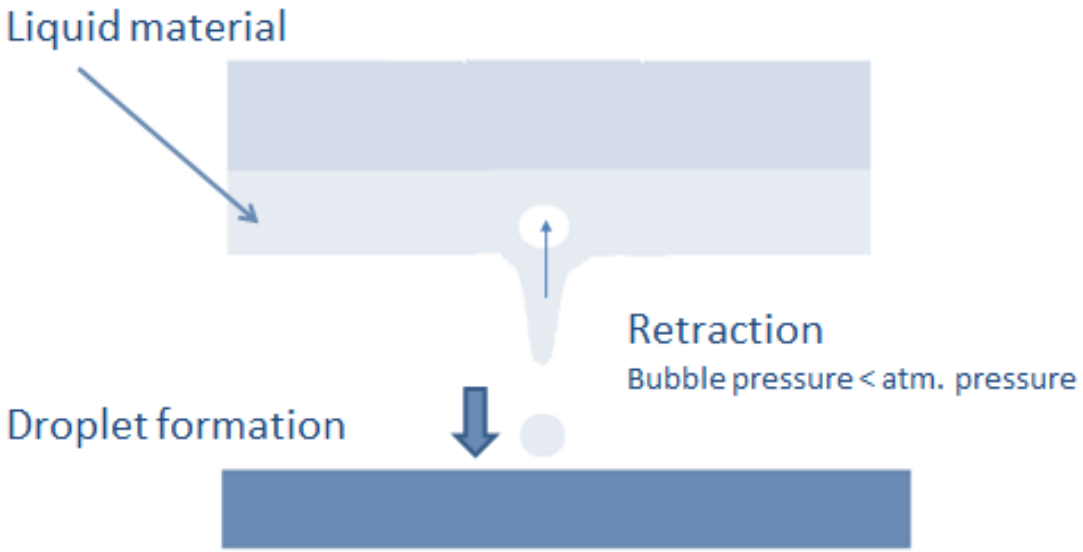
Full flexibility

- Low to high viscosities
- Filled Materials
- High Resolution
- High Speed
- Multi Layers
- Multi Materials





High-performance CLAD technology



Frictionless jetting,
=> No Stress
=> No Heat

Laser can jet materials with 3,000 times higher viscosity than Inkjet

Laser can pulse up to 10,000 dps

Integrated post-processing

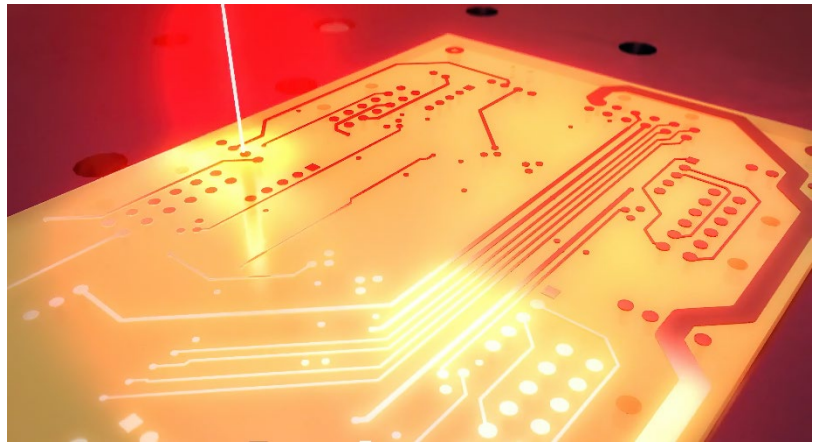
Complete workflow to address complex structural builds

Multi Curing

- UV curing
- Thermal curing

Finishing

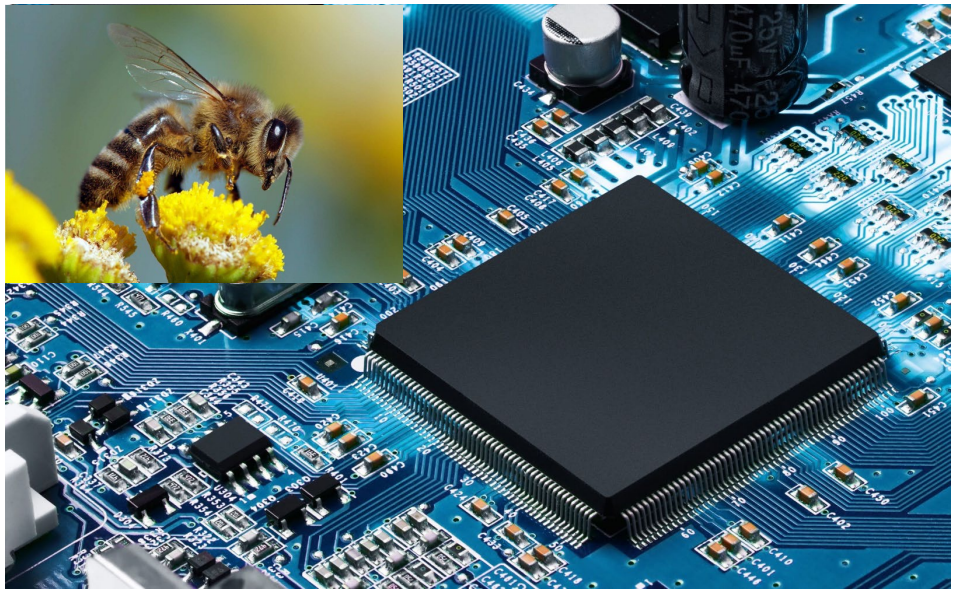
- Laser sintering
- Laser ablation



iotech increases sustainability

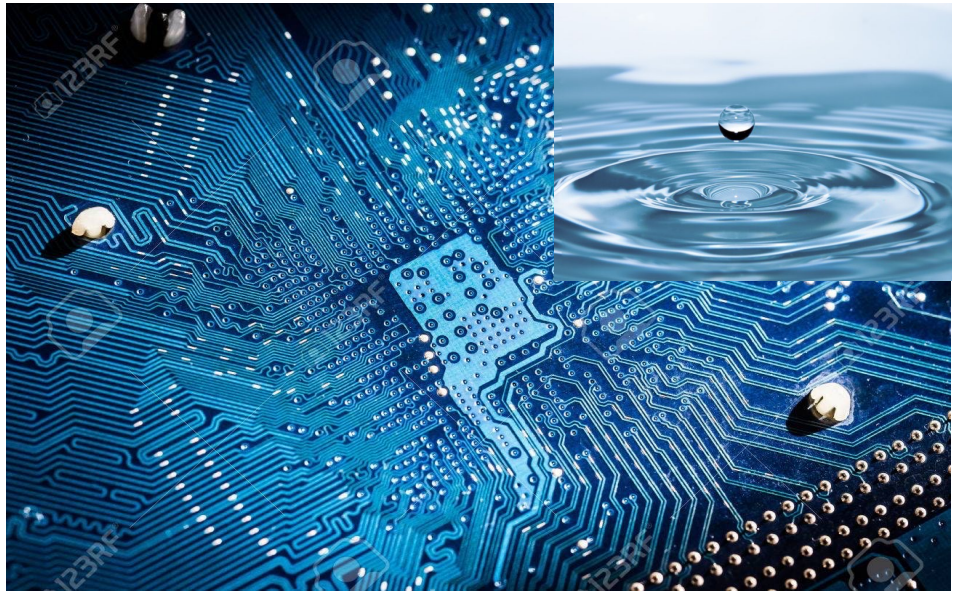
Replacing chemical subtractive processes

ACID & SOLVENT-FREE CHIP INTERCONNECTION



N-methyl-2-pyrrolidone

ONE TON OF WATER SAVED PER M^2 OF PCB



Standard materials printed using one single hardware setup

Material	Viscosity range (KcPs)	Cure type	Resolution	Filler size
Acrylate & Methacrylate	0.5-70	UV	40 µm	up to 2 µm
Epoxy - including Underfill & Flux	5-70	UV & heat	50 µm	up to 2 µm
Silicone - including Phosphor filled	10-300	UV & heat	100 µm	up to 2 µm
Metal paste (Ag & Cu)	5-40	Sintering	80 µm	0.1-5 µm
Solder paste - type 4 to 9	20-40		50 µm - 250 µm	3-35 µm
Solder mask	20-40	UV / heat	40 µm	up to 2 µm
Polyurethane (acrylate)	0.5-70	UV	40 µm	up to 2 µm
Ceramic paste	0.5-70		40 µm	up to 2 µm
Carbon paste	20-40		100 µm	wires of ~10 µm
Polyimides	0.5-2	UV	40 µm	up to 2 µm

*For all materials, resolution depends on filler size

Comparative table

	Any Industrial Material	Digital & Multi-Layer	Resolution (1)	Throughput (drops/hour) (2)	CAPEX vs Throughput
Screen printing	Y	N	50µm	15sec per screen	$
Jet	N	Y	200µm	200Kdph drops/hour	$$$
Needle-dispense	N	Y	150µm	10Kdph - 45 mm/sec	$$$$
Micro-dispense	N	Y	3µm	2Kdph – 10 mm/sec	$$$$
Inkjet	N	Y	30µm	2Mdph – 500 mm/sec	$$
Aerosol jet	N	Y	25µm	500dph – 5mm/sec	$$$$$
IOTECH CLAD	**Y**	**Y**	**30µm**	**7.5Mdph – 1,000 mm/sec**	**$$**

(1) Resolution depends on the specific characteristics of each material.
(2) Throughput indicated is throughput that can be achieved, as opposed to “headline” throughput.

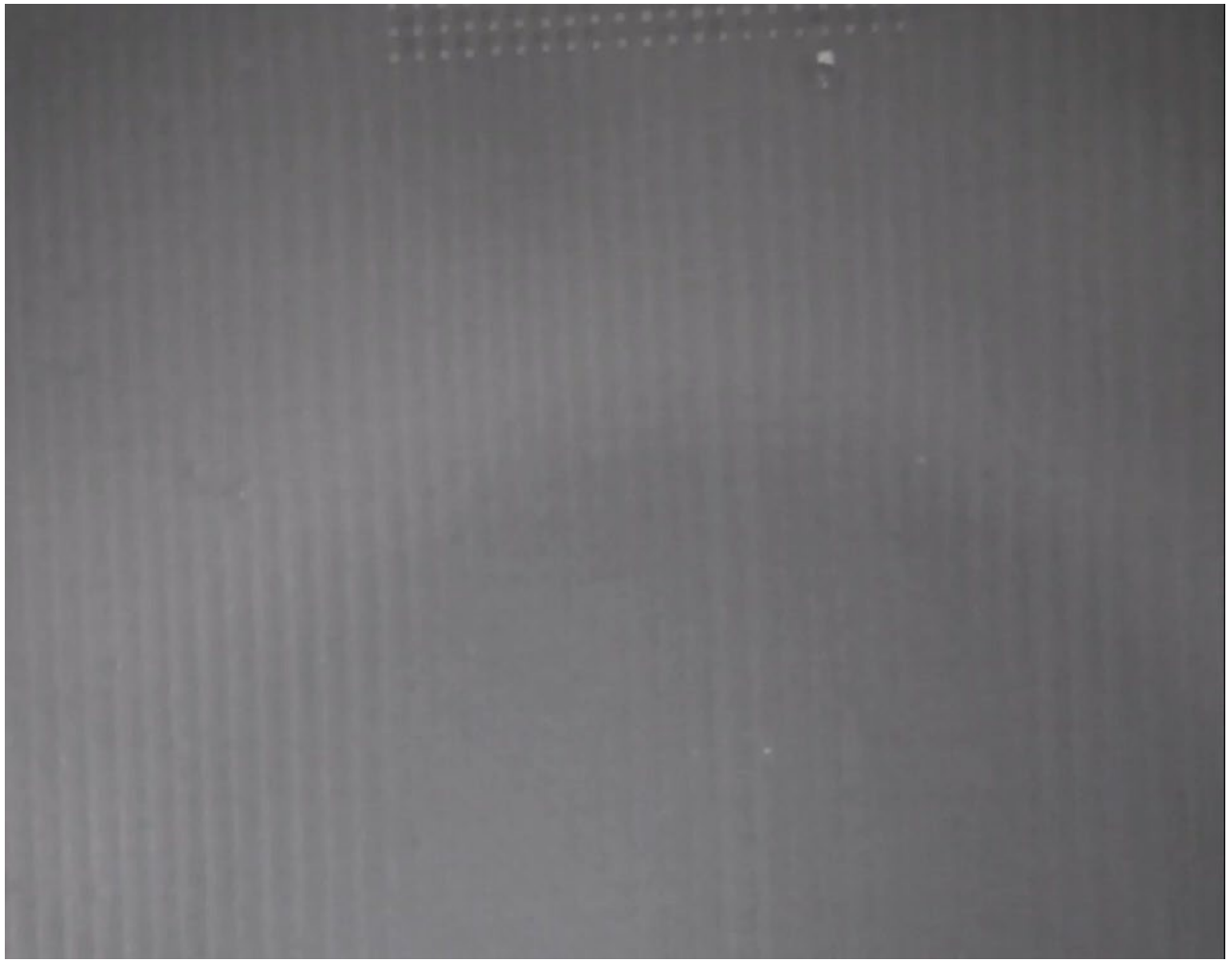
It all starts with dots

7,5M DPH
⇔ to over 1 meter/sec
line making

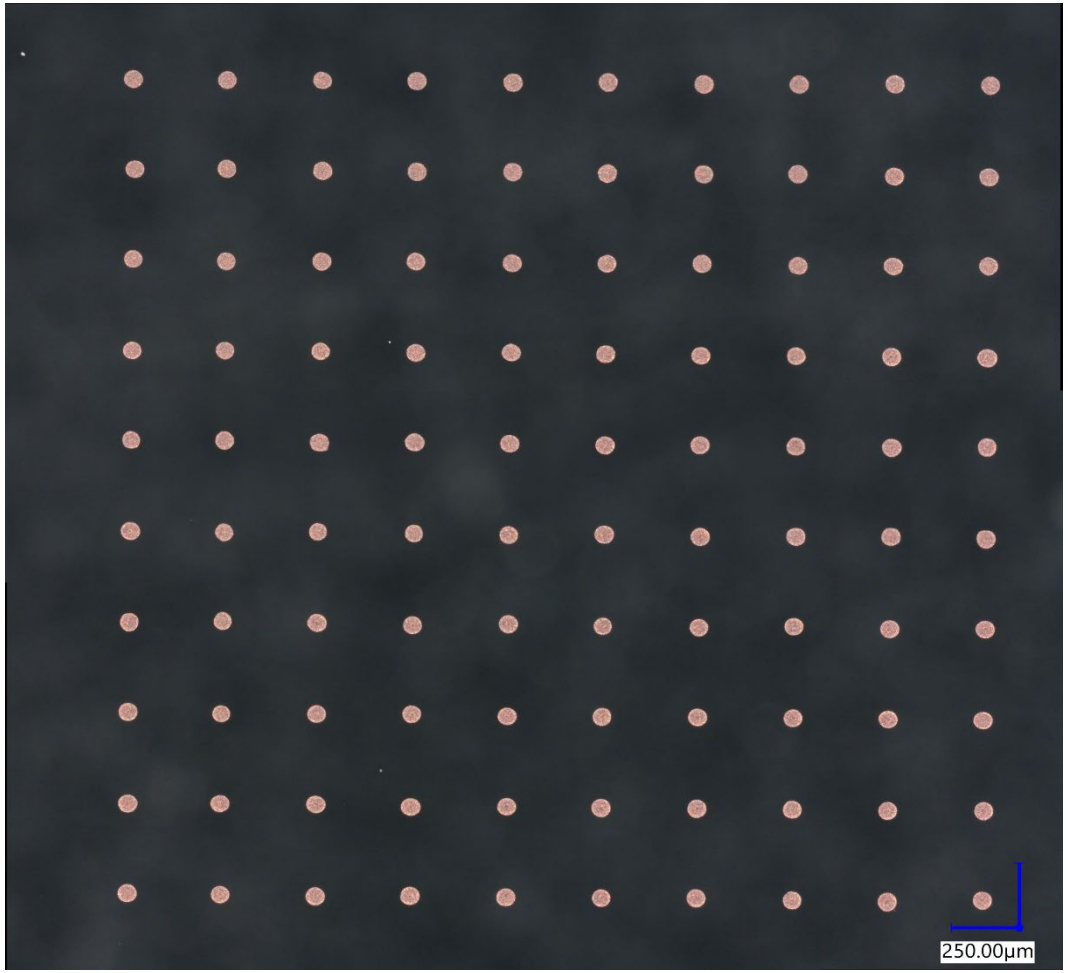
As the feature sizes get smaller stenciling cycle rate gets slower and has higher yield losses.

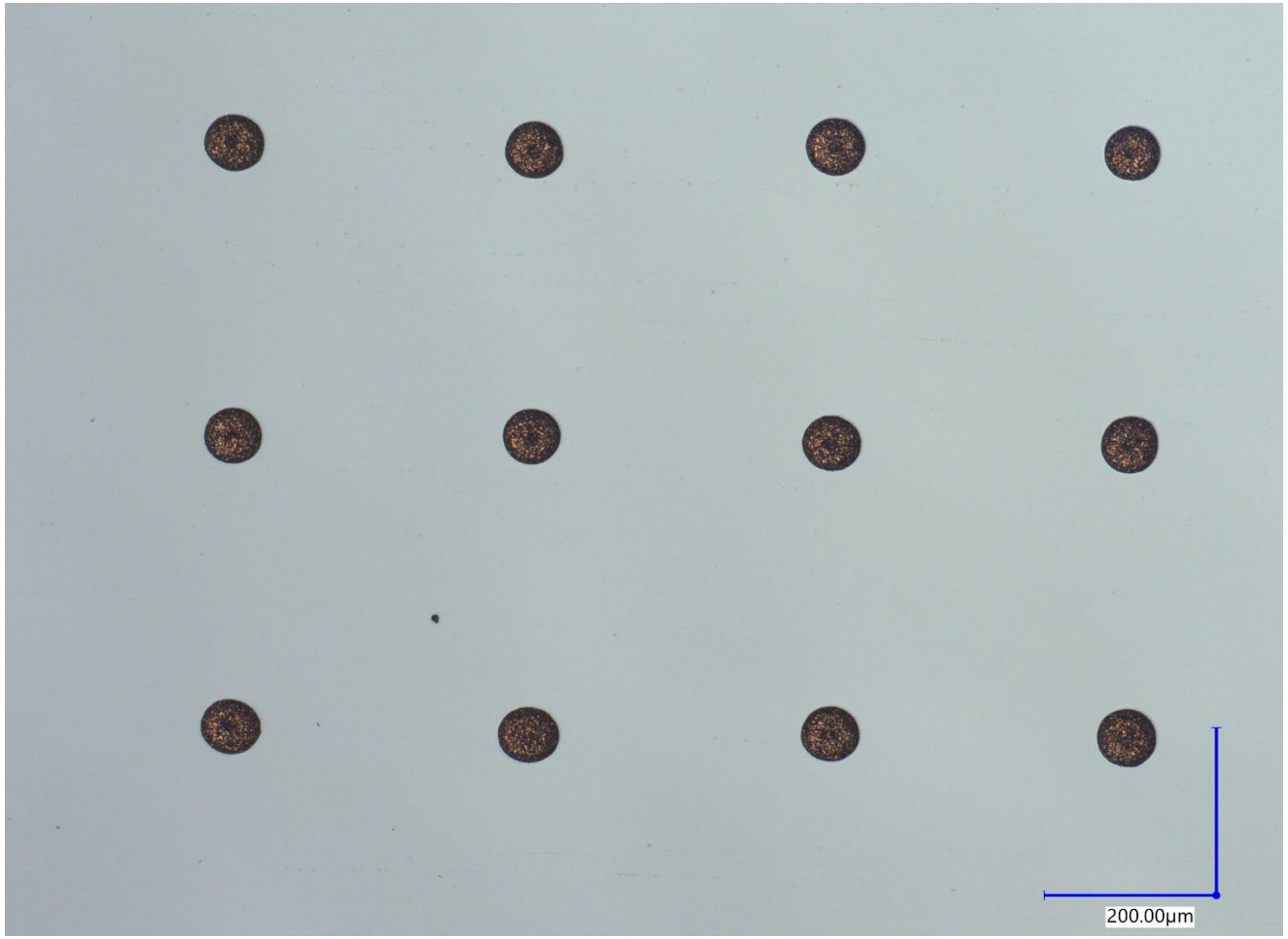
As feature shapes get more complex, robotic motion slows the cycle rate and generates dispensing inconsistency when doing patterns direction changes

Video is slowed down 8 times

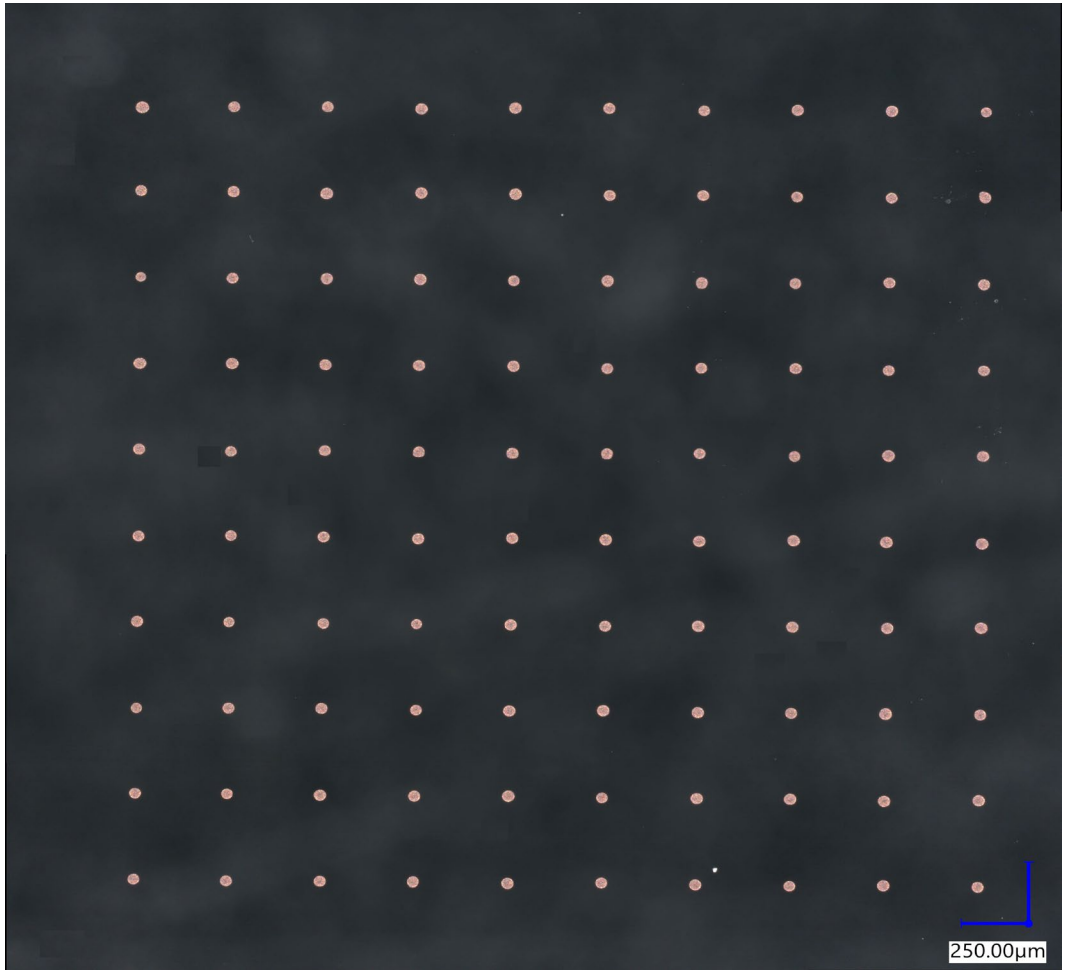


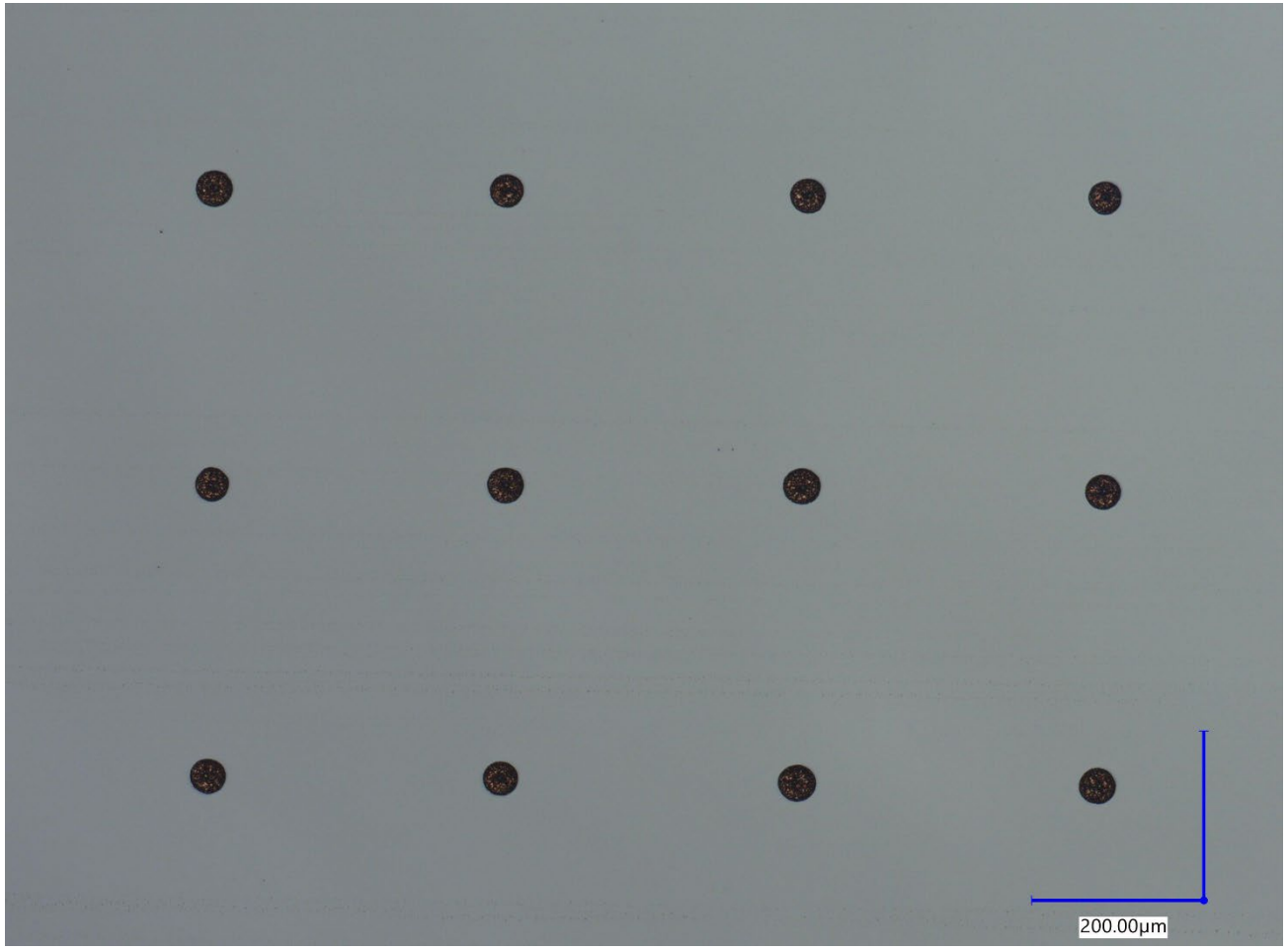
70-micron copper paste (Copprint)





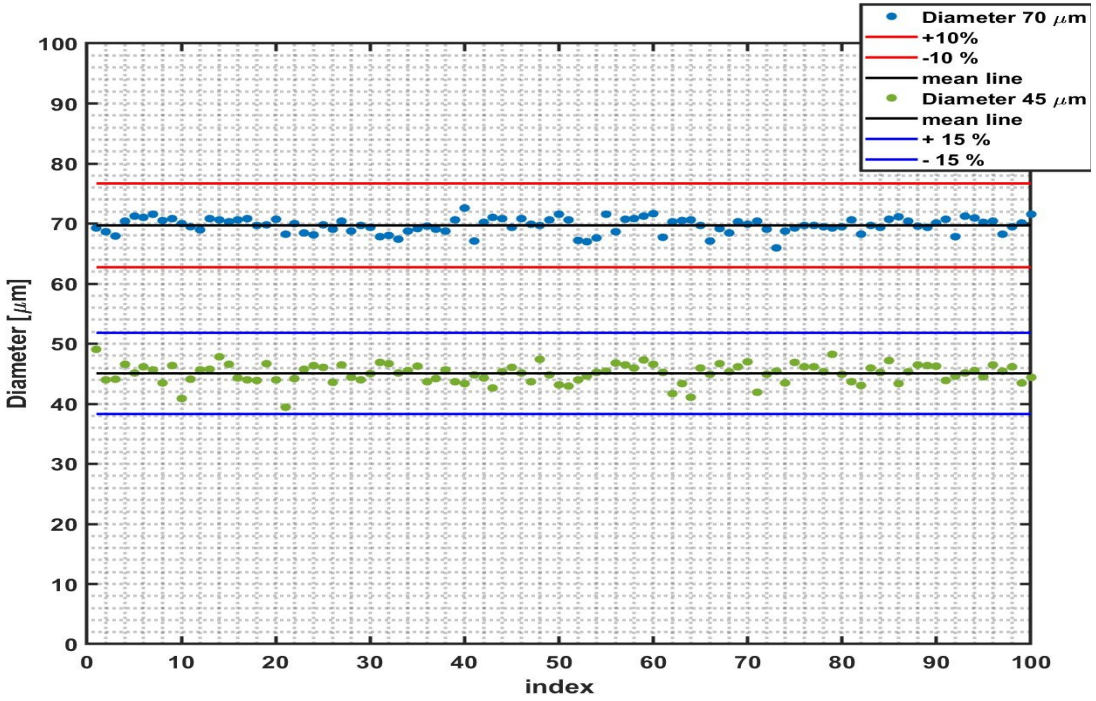
45-micron copper paste (Copprint)

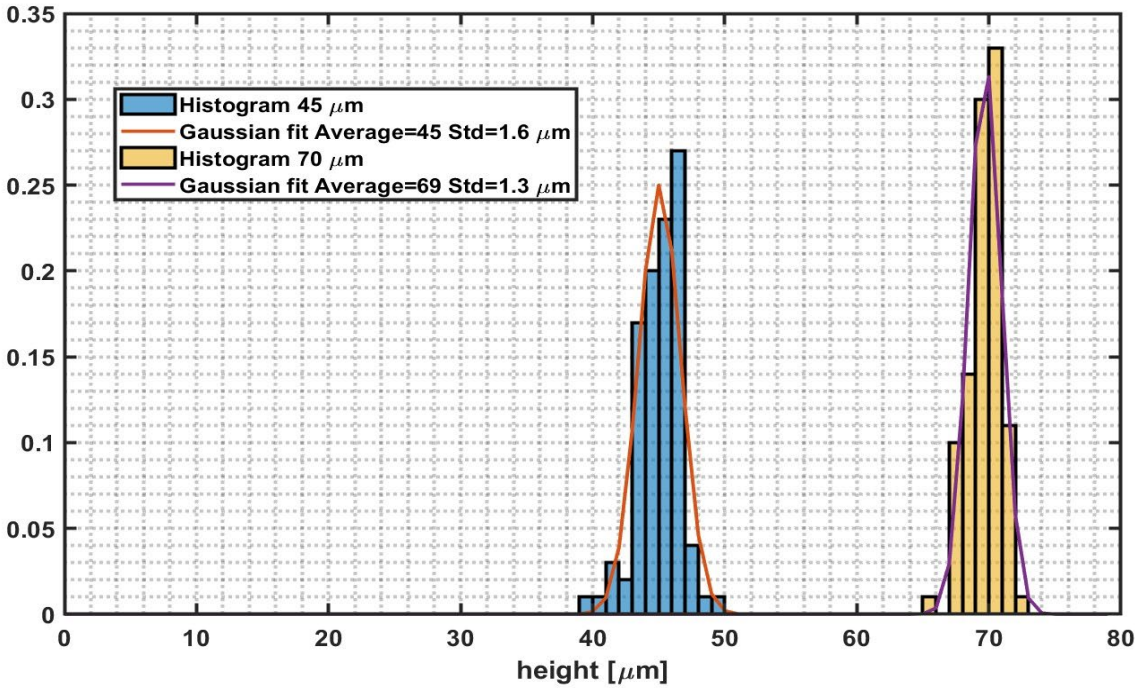




45- & 70-micron diameter copper paste (Copprint)

statistical results over a population of 100 drops

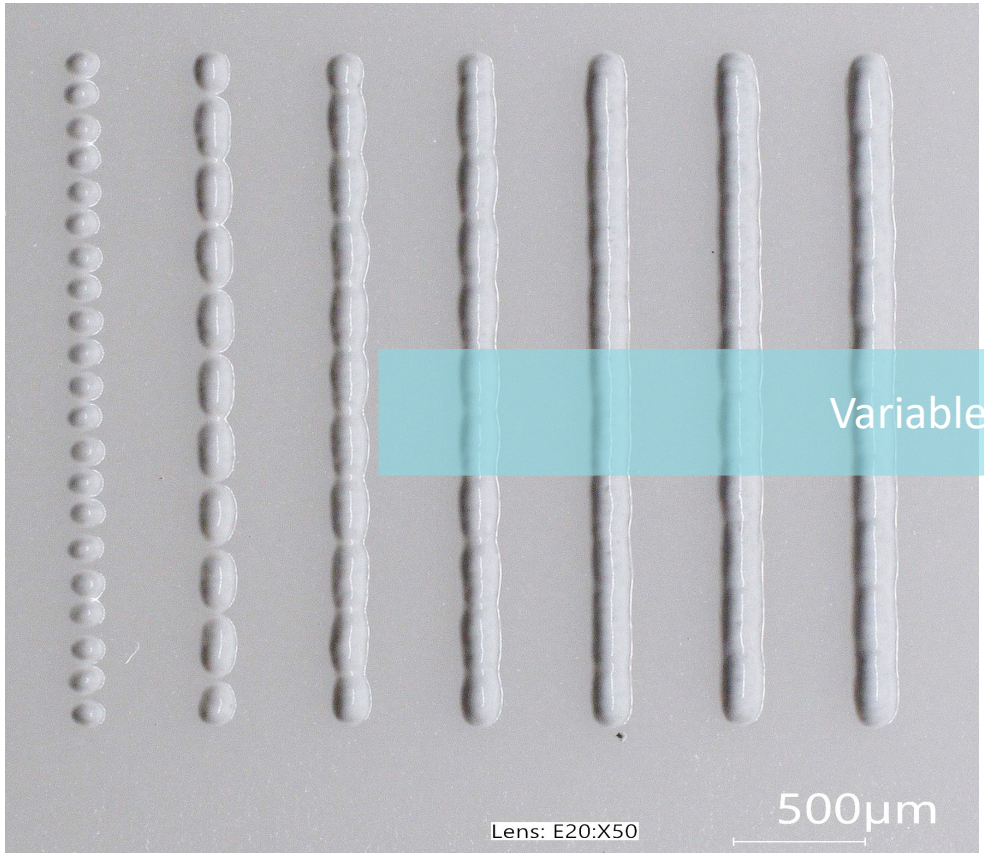




	Diameter [µm]	STD[µm]	Cpk +/-15%	Cpk +/-10%
Case 1	45	1.6	1.4	0.93
Case 2	70	1.3	2.7	1.8

Making lines & the role of drops overlap

Width 150µm H=50µm



Variable overlap, 0 to 80%

Width 1500µm H=100µm

High resolution 2D

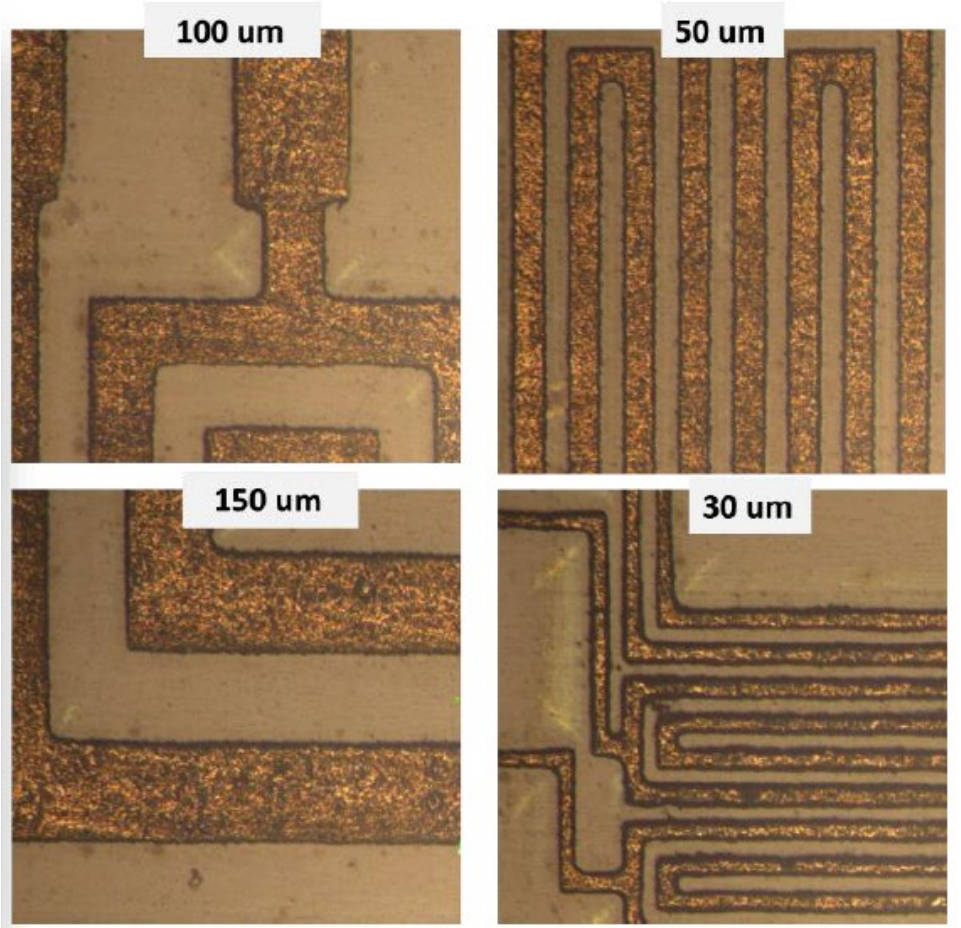
- Dynamic line resolutions down to 40µm
- Positioning wet accuracy 10µm

Here a standard silver ink from Henkel is applied with different laser power and laser beam settings

30 µm line width:

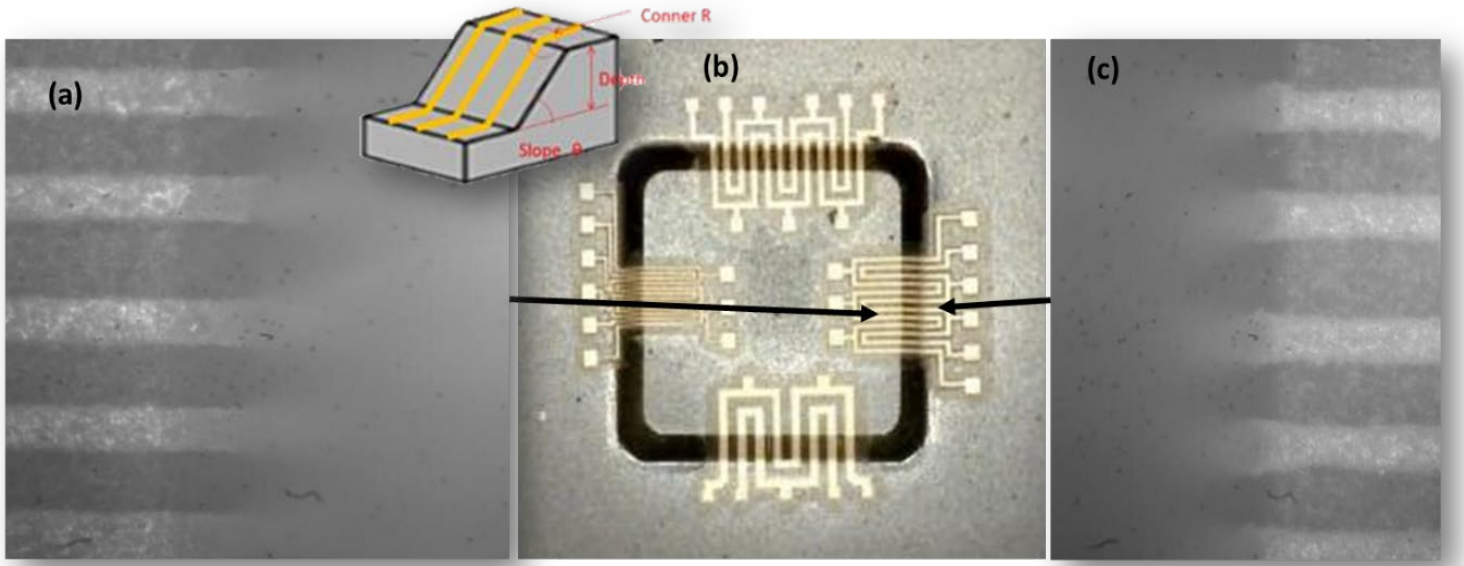
5 times smaller than jetting

2 times smaller than stenciling



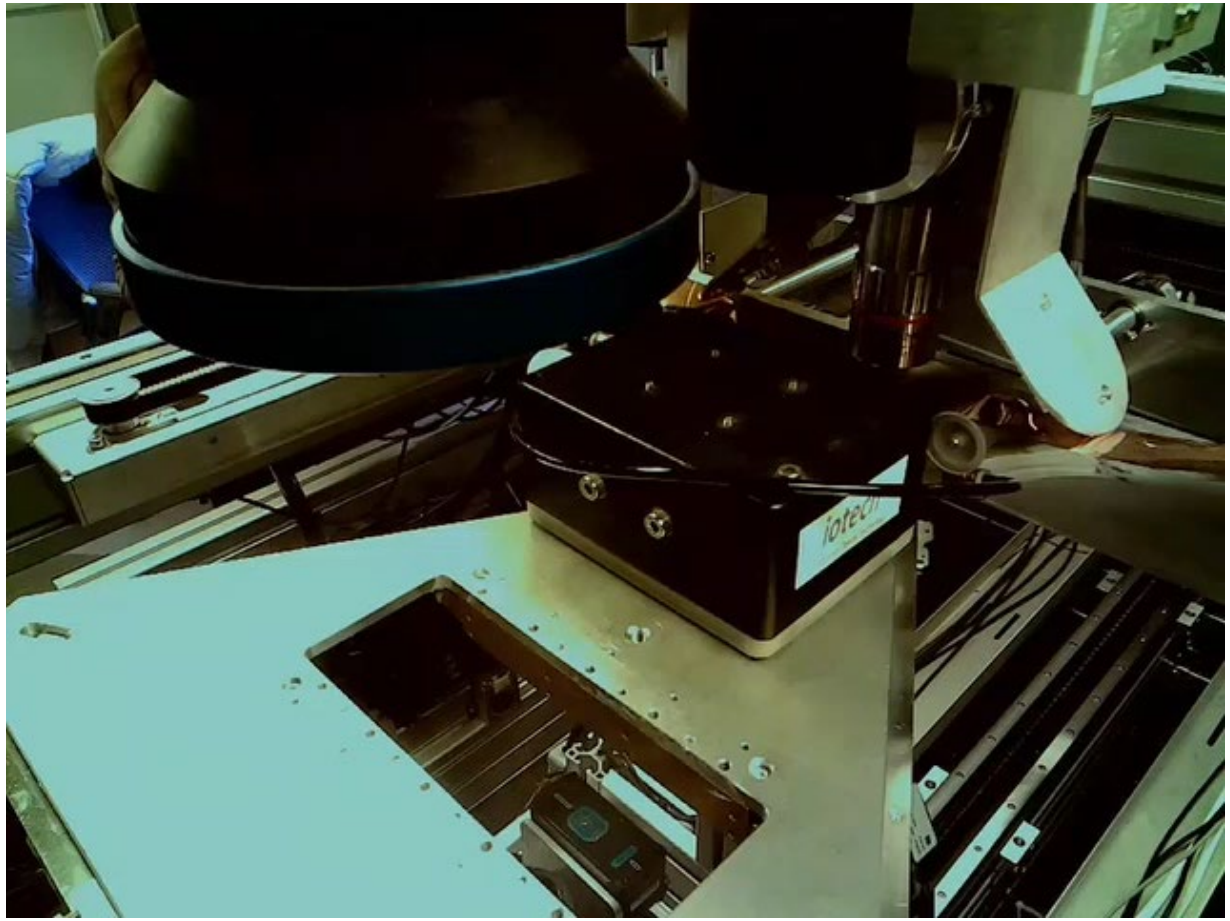
Conductive interconnect on a slope

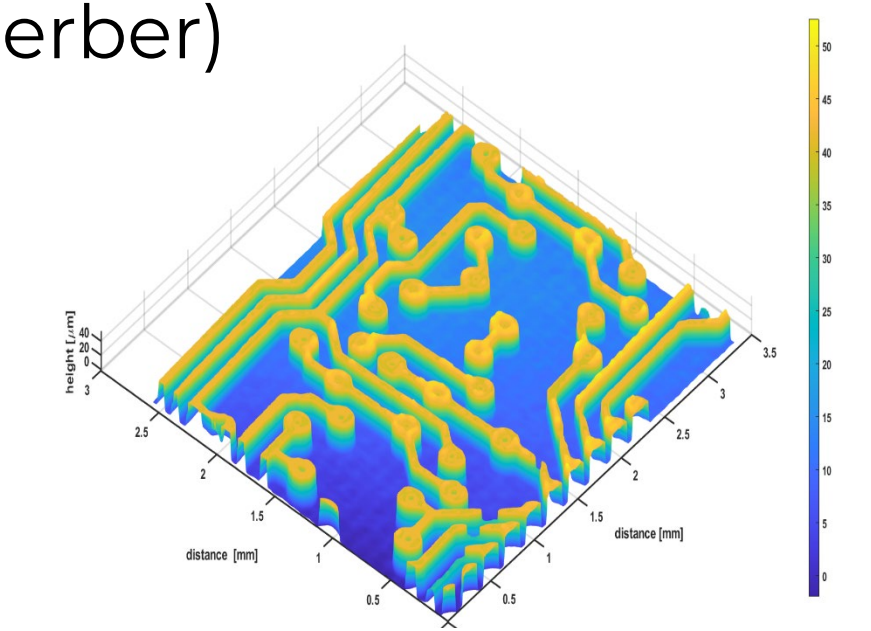
- Line width down to 20µm with laser ablation
- Inline laser sintering of the line
- Standard commercial metallic pastes, copper, silver,.
- Printing on non-conformal substrates with slopes of up to 70%
- Designs combining dielectric and metal

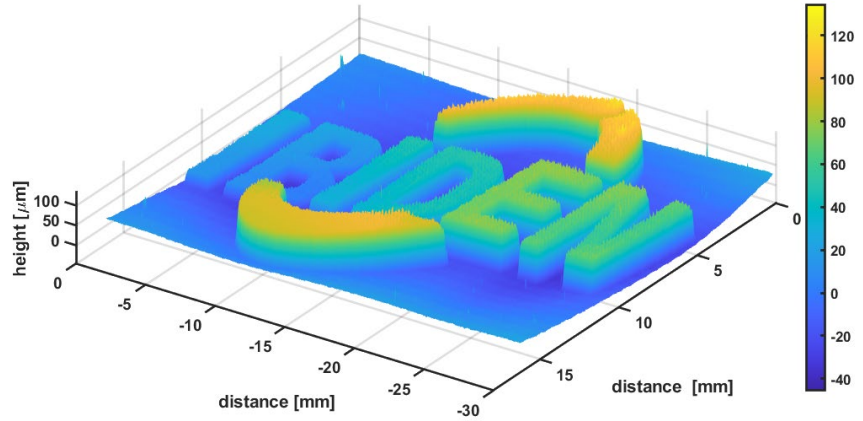


(b) conductive pattern printed in a cavity with a slope of 70%
(a) microscope picture of the bottom of the cavity and
(c) of the top of the cavity

Copper Based Conductive Material Deposition
of Complex Geometry from a CAD File (Gerber)



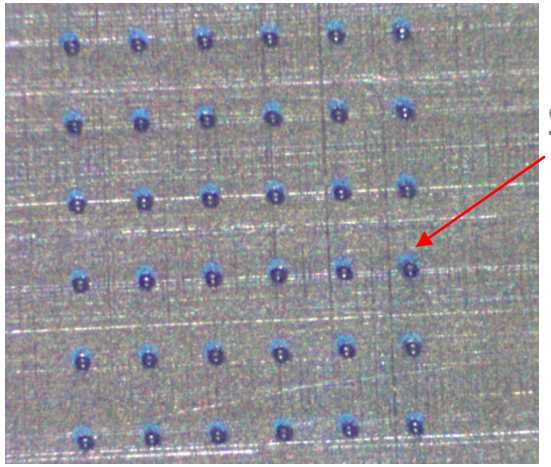




Multi layers capability offering 3D variants

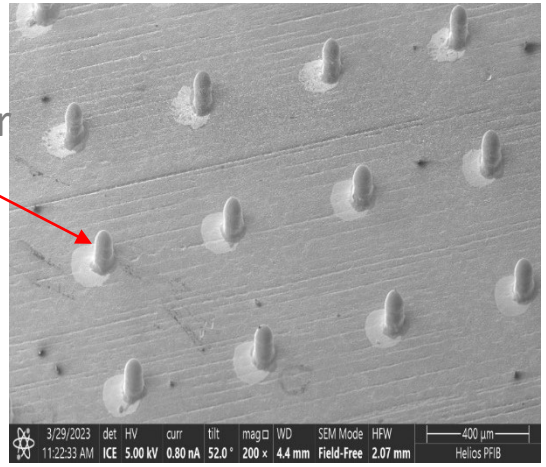
High resolution 3D

Microscope top view

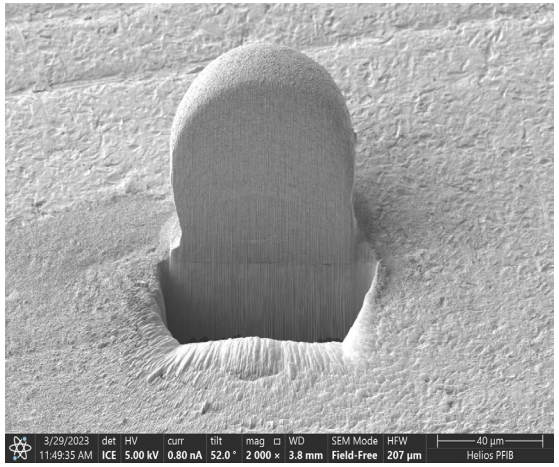


Silver

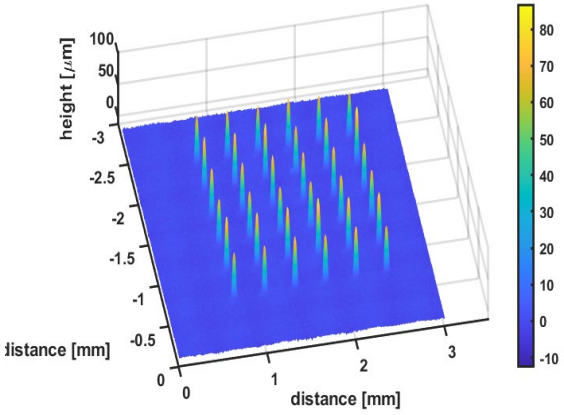
SEM side view



Cross Section



Topography



Vertical interconnexions down to 50 µm diameter up to x2 form factor

Vertical Interconnect

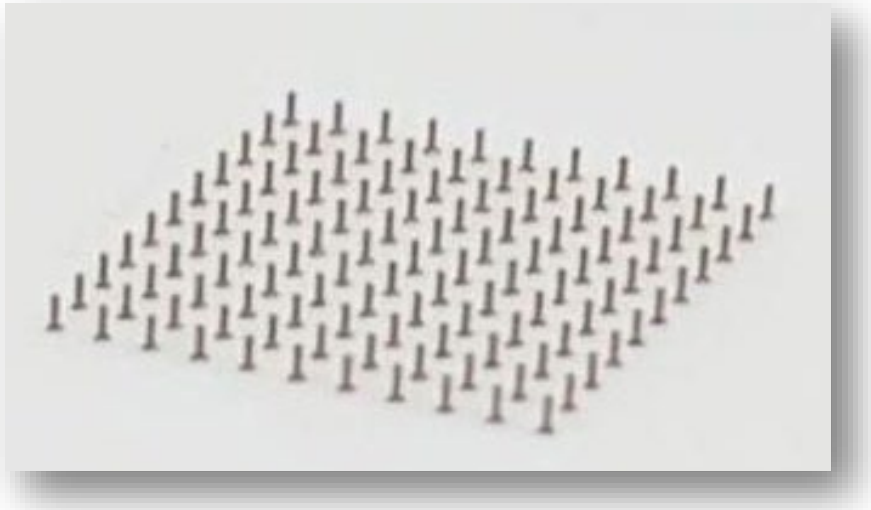
Multi-Material

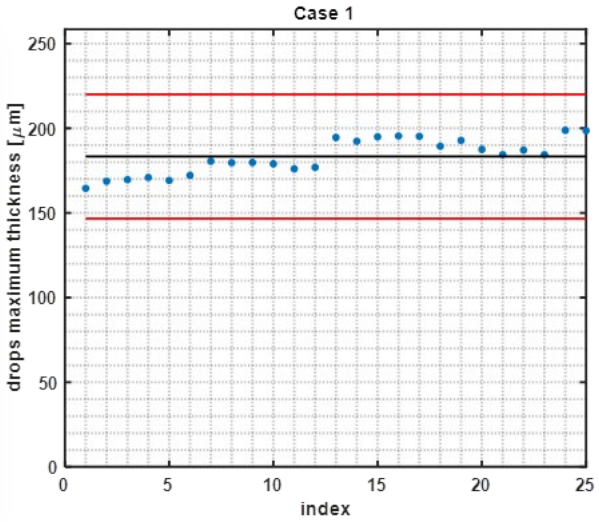
Copper – Silver – Nickel - SAC

Iterative Multi-Process

Laser Deposition
Heat Cure

Example of pillar printed on ceramic





Multi-material stacking:
- Copper
- Silver
- Nickel
- SAC 305

High-resolution
Hmax = 183 +-15 micron
Radius = 87+-10 micron

Next Generation will use close loop iterative droplet deposition

High productivity:

Stack of 32 droplets (70µm diam)
Using a 200 mm wafer, pitch of 200 µm between pillars, print speed @ 10k drops/s
=> 100s per layer and additional drying time of 10s per layer.

=> **1M pillar/hour**

Bridge / Interconnect build

Multi-Material

Copper – UV Curable Dielectric – Silver

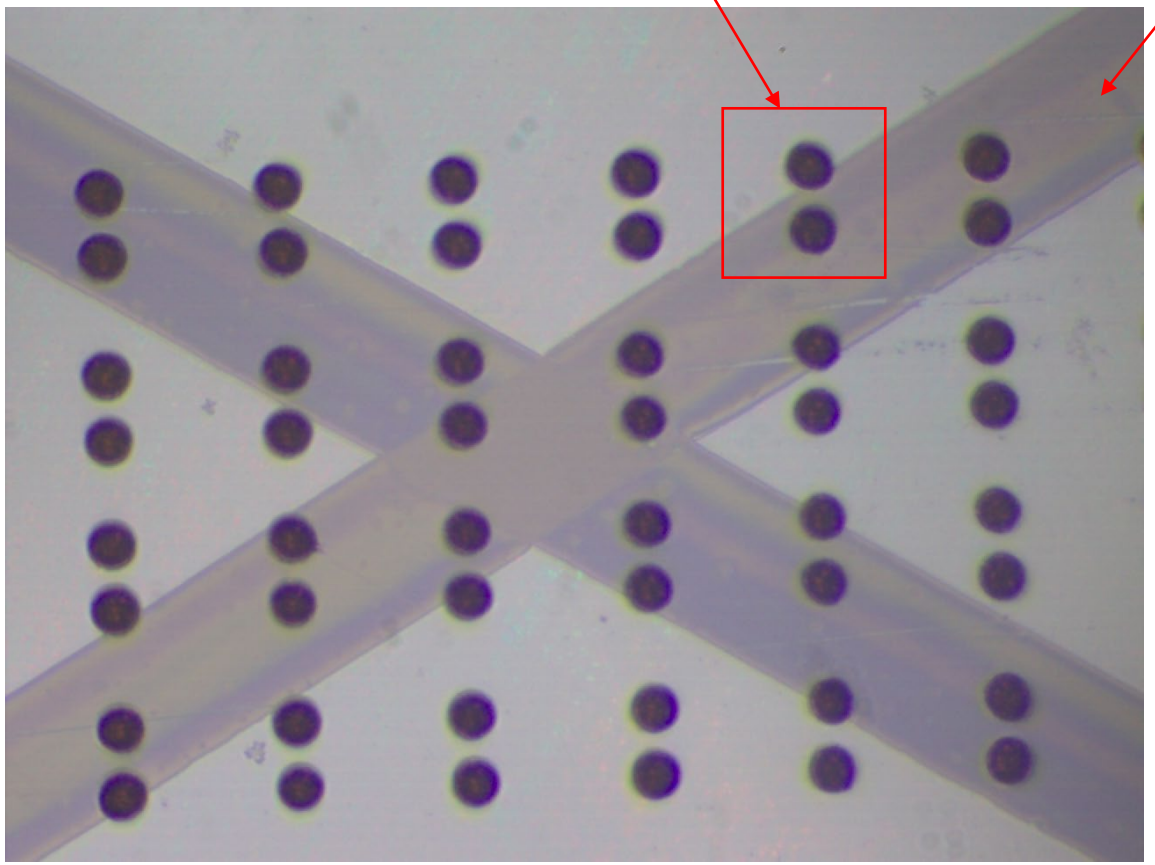
Multi-Process

Laser Texturation
Laser Deposition
Laser Ablation
Heat Cure
UV Cure

Printing of drops

One cell of two pads

Manual cross mark in the bottom of the glass



140 µm Diameter – 15 µm Thickness

Parameters
Drop volume (pulse energy, layer thickness, spot size)
Number of drops
In case of multiple drops shift/pattern between drops
Material, it possible to add silver coating
Distance between the center of the drops

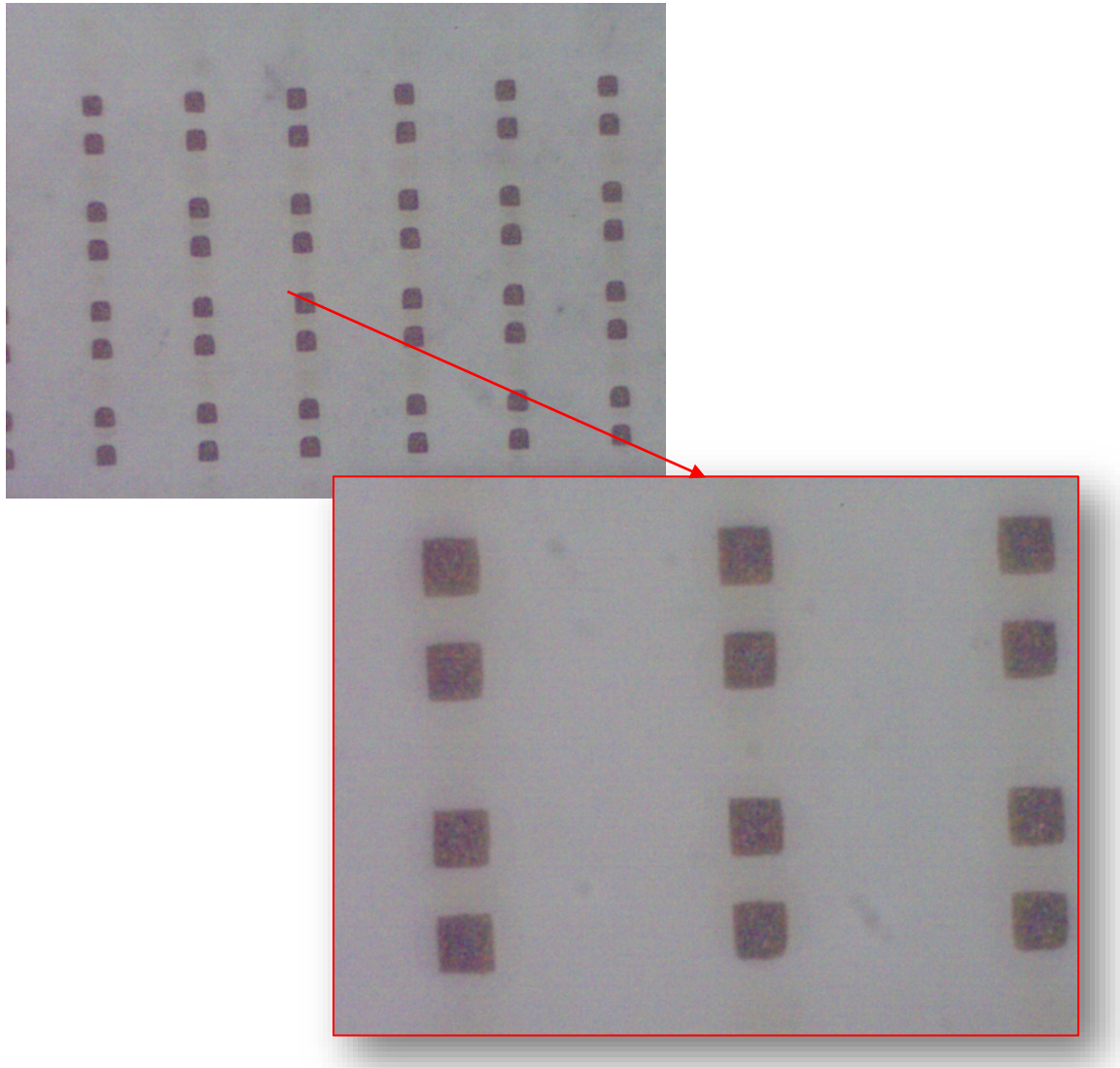
Procedure

Coat a layer of material on the foil

Bring the sample in front to the foil at the right distance

Print with the laser

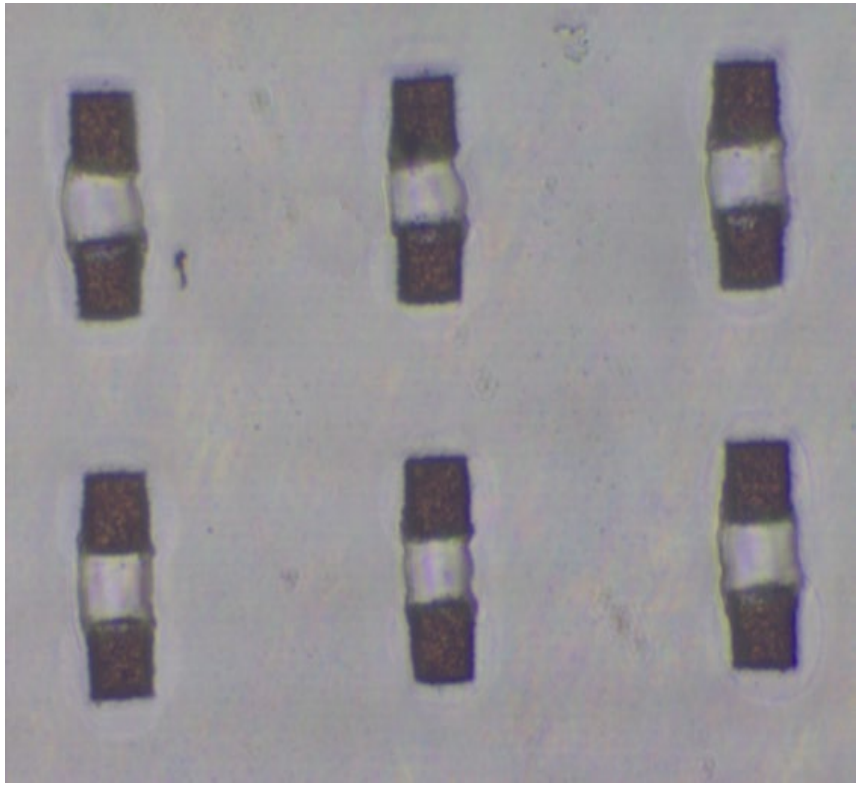
Laser Ablation



Parameters
Scanning speed
Pulse energy
Number of pass
Pulse density
Procedure
Print head move, sample is in front of the laser scanner
Laser Ablation

80 x 80 µm squares – 15 µm thickness

Dielectric Printing



100 x 100 µm – 15 µm thick

Parameters
Drop volume (pulse energy, layer thickness, spot size)
Number of drops
In case of multiple drops shift/pattern between drops
Material type
UV irradiance and time between drops
Air temperature/flow and time

Procedure

Coat a layer of material on the foil

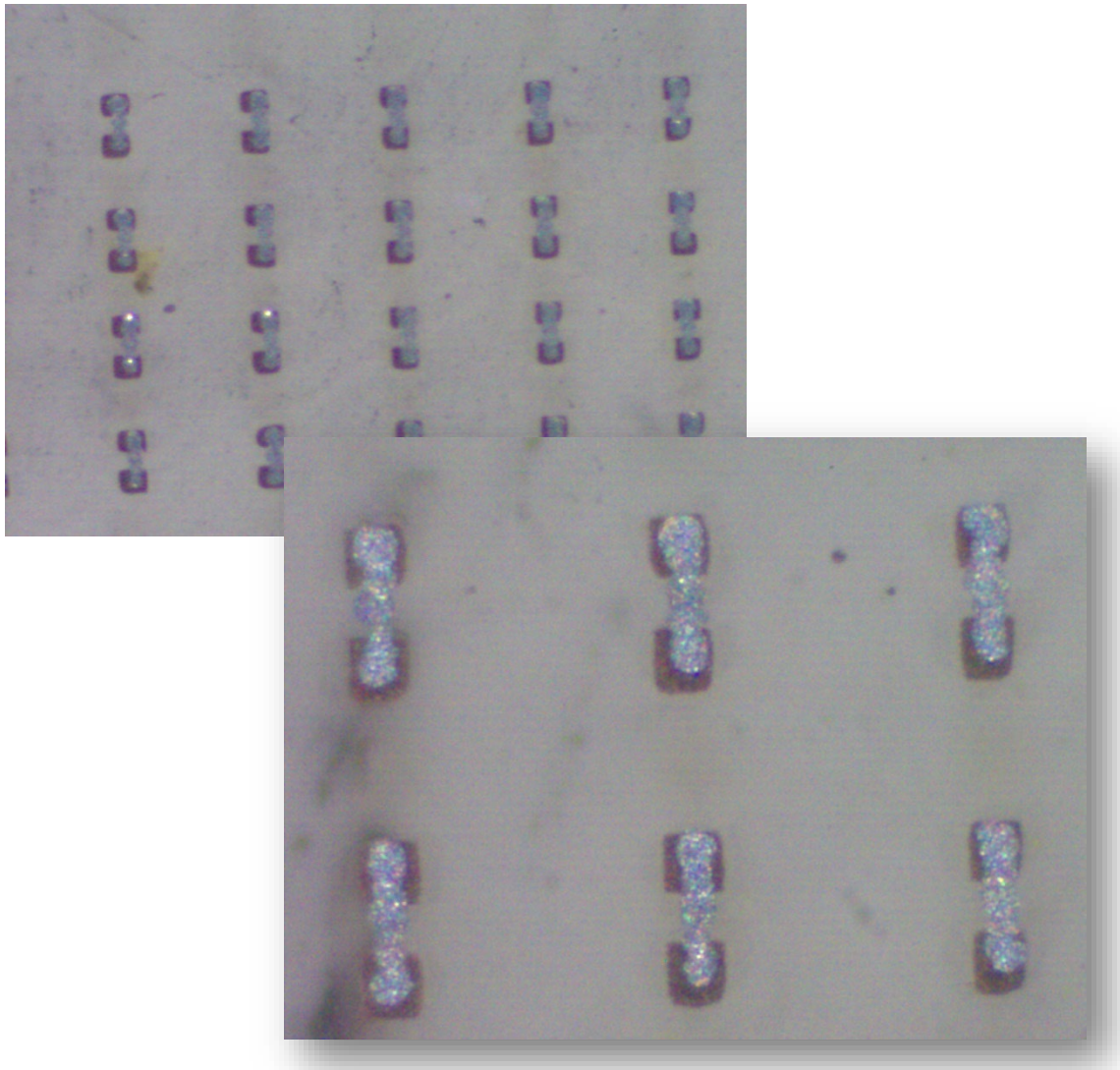
Bring the sample in front to the foil at the right distance

Print with the laser

Remove print head and bring UV head in front of sample and UV cure

At the end of the multi-drop procedure bring heat cure head in front the sample and heat cure

Interconnect Printing (Bridge)



Parameters
Drop volume (pulse energy, layer thickness, spot size)
Overlap of the drops
Printing strategy
Material, it possible to add silver coating
Number of layer
Procedure

Coat a layer of material on the foil

Bring the sample in front to the foil at the right distance

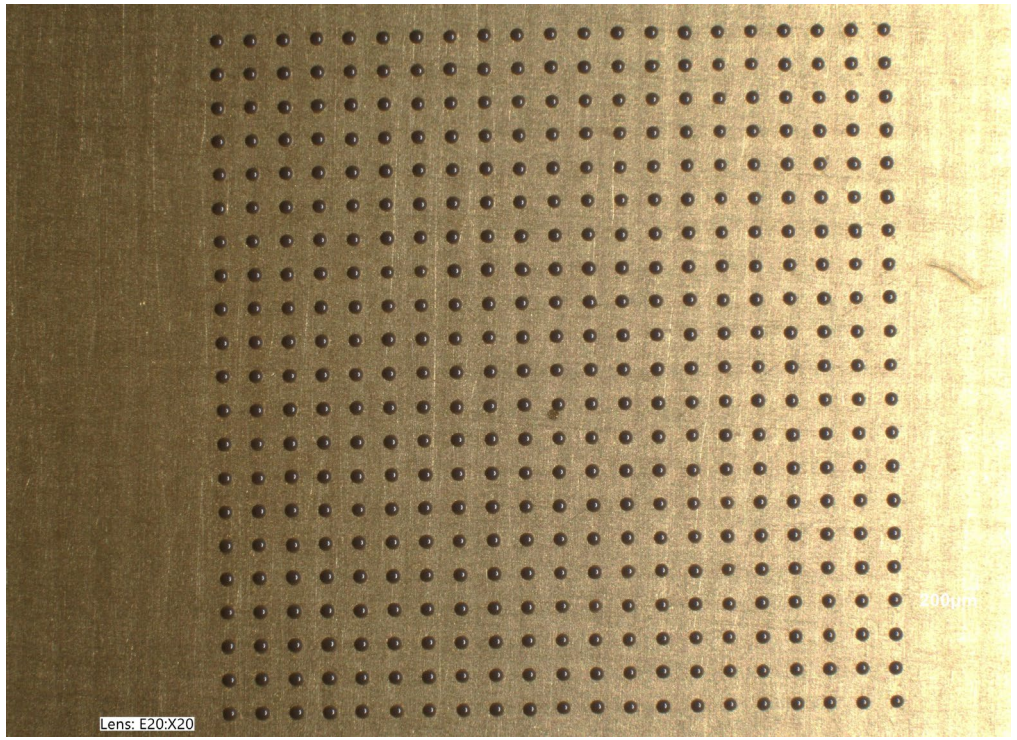
Print with the laser

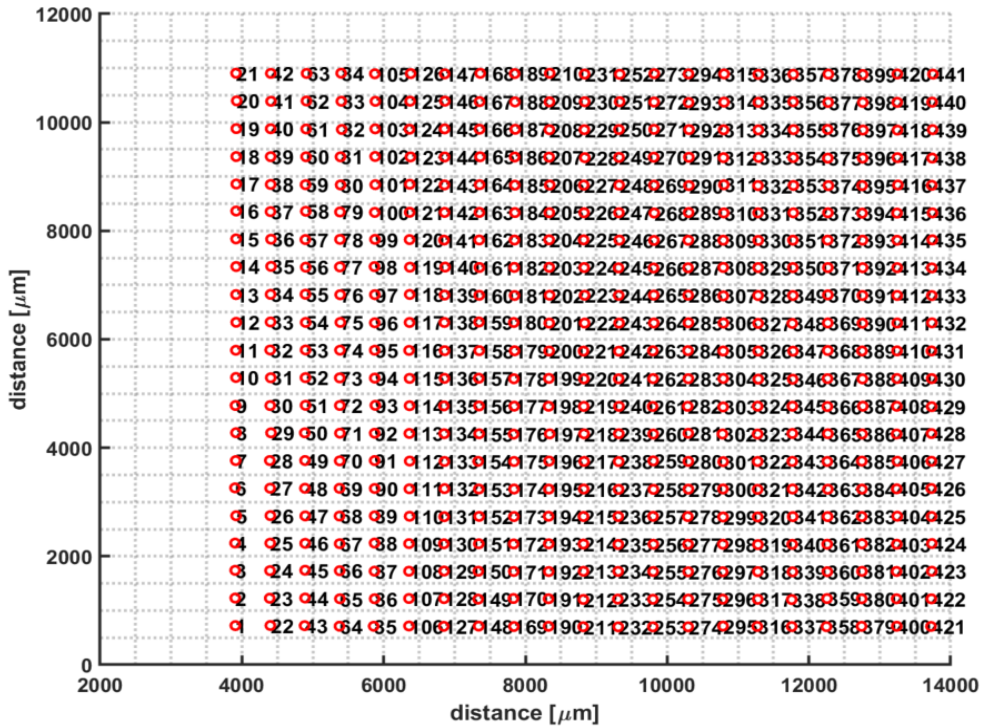
Line width 60 µm – line length 250 µm – thickness 8 µm

Use case 2 – semiconductor packaging

Low Viscosity Epoxy Base Materials : UNDERFILL / Flux

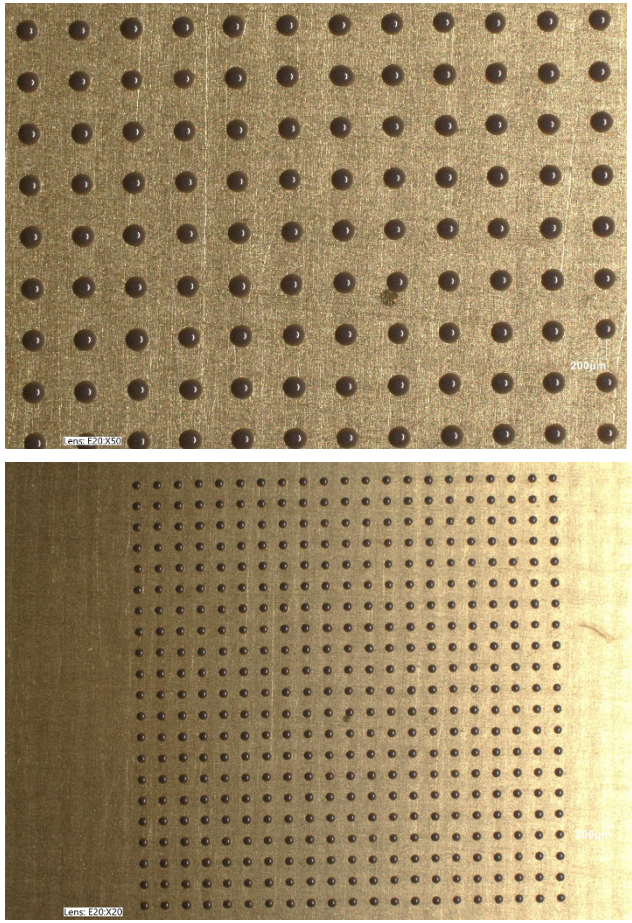
150 µm dots - pitch 0.5 mm Standard Namics Ref.

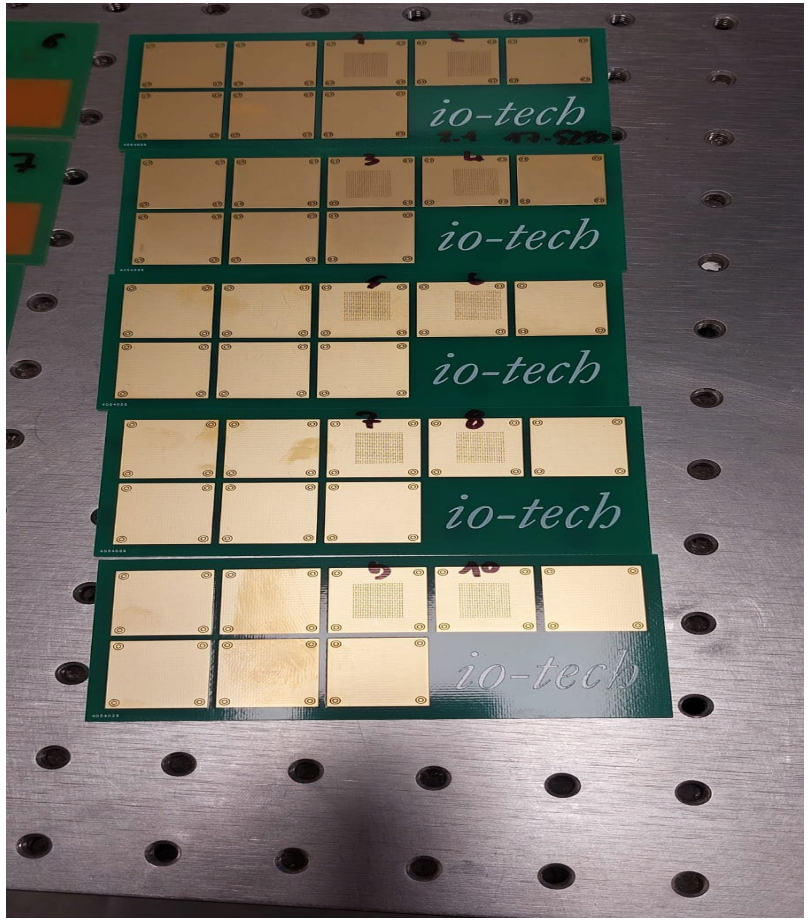




	AVERAGE	STD	3sigma
POSITION X	509.29	6.37	9.55
POSITION Y	491.04	5.64	8.46
DIAMETER	212.76	7.00	10.50

Weight test results: 21x21x9 = 3,969 drops





#	Printed materials
	Weight [mg]
1	2.2
2	2.2
3	2.2
4	2.3
5	2.2
6	2.2
7	2.1
8	2.1
9	2.1
10	2.2
STD	0.0632
3sigma	0.0948
drop weight [µg]	0.5492

Use case – semiconductor packaging
Flip chip underfill @ wafer level

UNDERFILL MATERIAL	CLIENT NEED	CURRENT DISPENSER	IOTECH
Systems		**500 Jet dispensers**	**20 CLAD systems**
Productivity	100M drop/hour	200,000/hour	5,000,000/hour
Keep-Out Zone (KOZ)	**<400µm**	**650µm**	**350µm**
Design flexibility *	Square Corners No Satellite's	Not Possible	Full Match
Clean room		1,000m2	80m2
Employees		250	20

* Reducing the KOZ allows to increase the die density per wafer by 10%

A DISRUPTIVE TECHNOLOGY FOR ELECTRONICS MANUFACTURING

THANK YOU

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