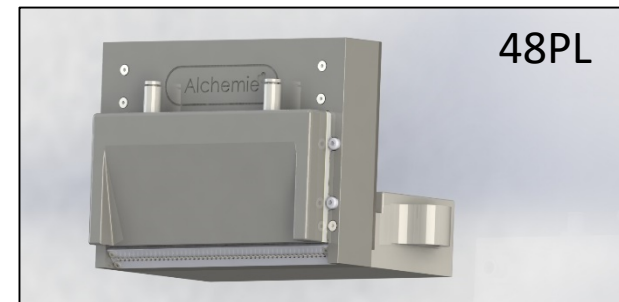


Alchemie 

The Digital Materials Science Company

Alchemie Technology: Precision Digital Coating

- Founded with the ambition to bring digital deposition capability using a much broader range of materials than is currently possible with industrial inkjet
- Our mission is to develop robust, scalable digital manufacturing technologies for materials fabrication
- We are a development-stage digital manufacturing company:
 - Based in Cambridge, UK, Europe's #1 technology cluster and within the University Of Cambridge eco-system
 - Developing unique proprietary technologies for scaled-up digital manufacturing applications
 - Applying our technology to a range of industry sectors



Delivering product differentiation



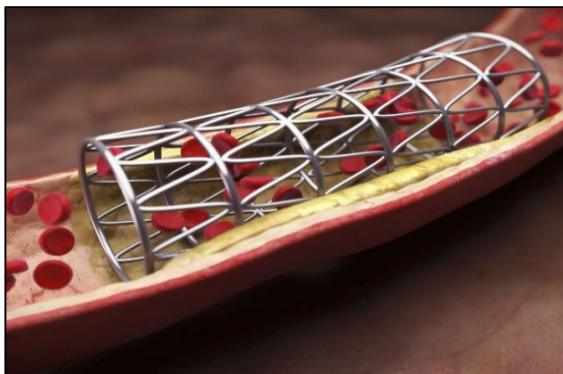
Unique 2.5D surface textures



3D effects



Advanced materials



Layered chemistry



Higher visual impact

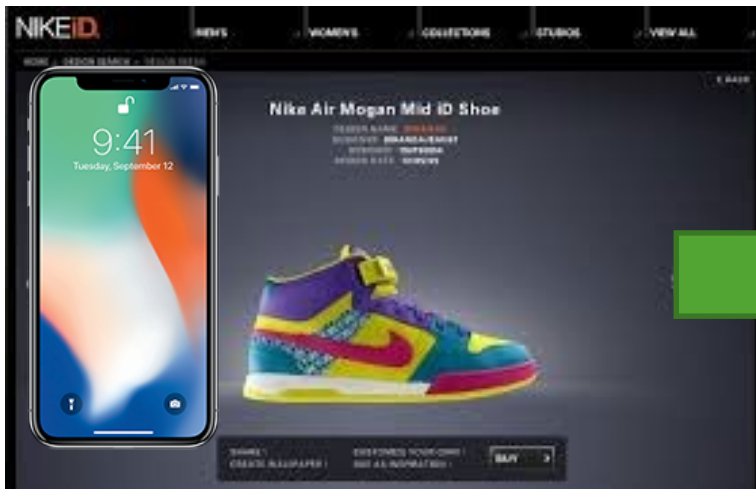


Customisation / personalisation

Delivering new digital propositions

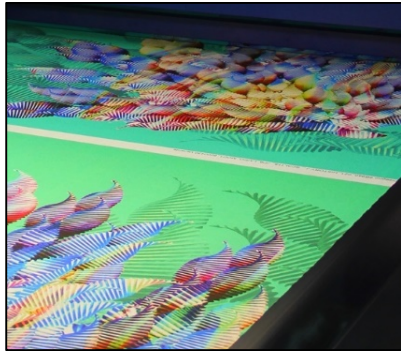
Digital

Physical



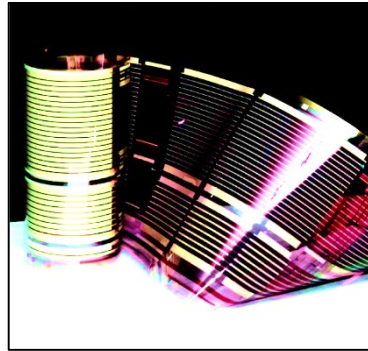
- Digital manufacturing is transforming industries - bridging the gap between the new digital world and physical products
- Enabling manufacturing process to become more flexible and better connected
- Enhancing the consumer experience

Our digital precision coating technologies



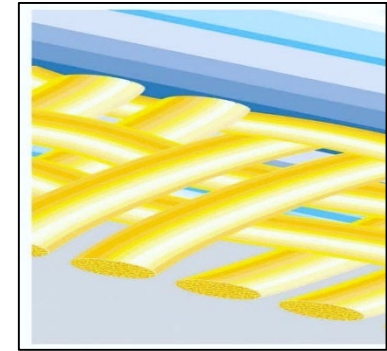
Delivering productivity through digital

- Instant on-the-fly digital control
- Customization and personalization delivered at low cost
- Instant changeovers and less materials waste



Broad materials palette

- Fluids: medium - high viscosity fluids, complex rheology, corrosive, solvents, melts, high solids, volatiles
- Powders / solids

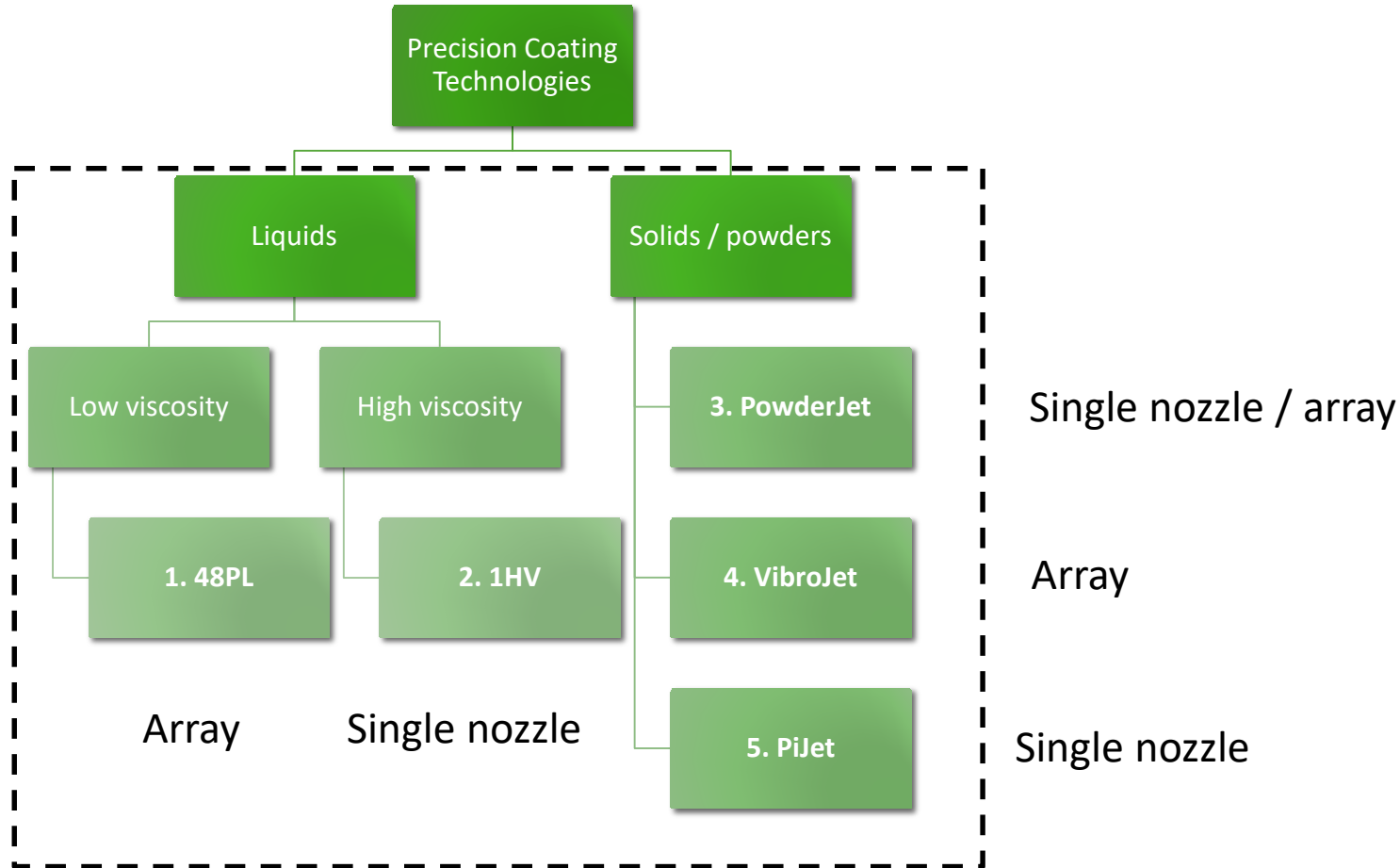


Materials deposited in 2D and 2D+

- Precise and targeted delivery of chemistry
- Unique new layered surface structures
- 2D patterning
- 2D+ texture

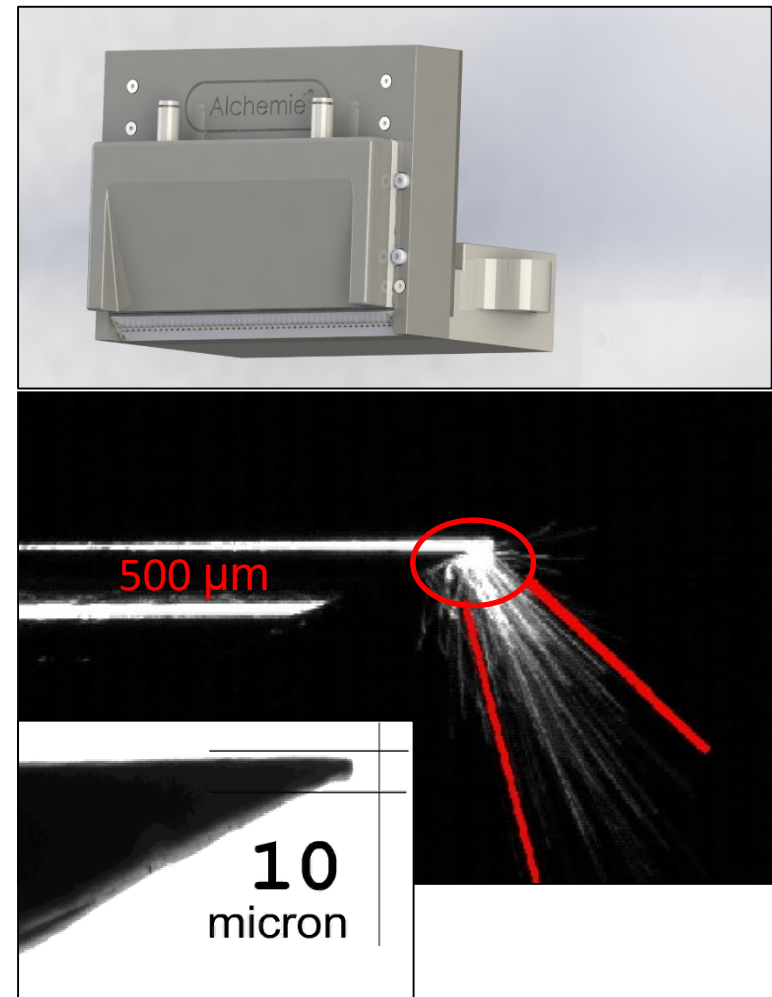
TECHNOLOGY PLATFORMS

Systems for liquids and powders



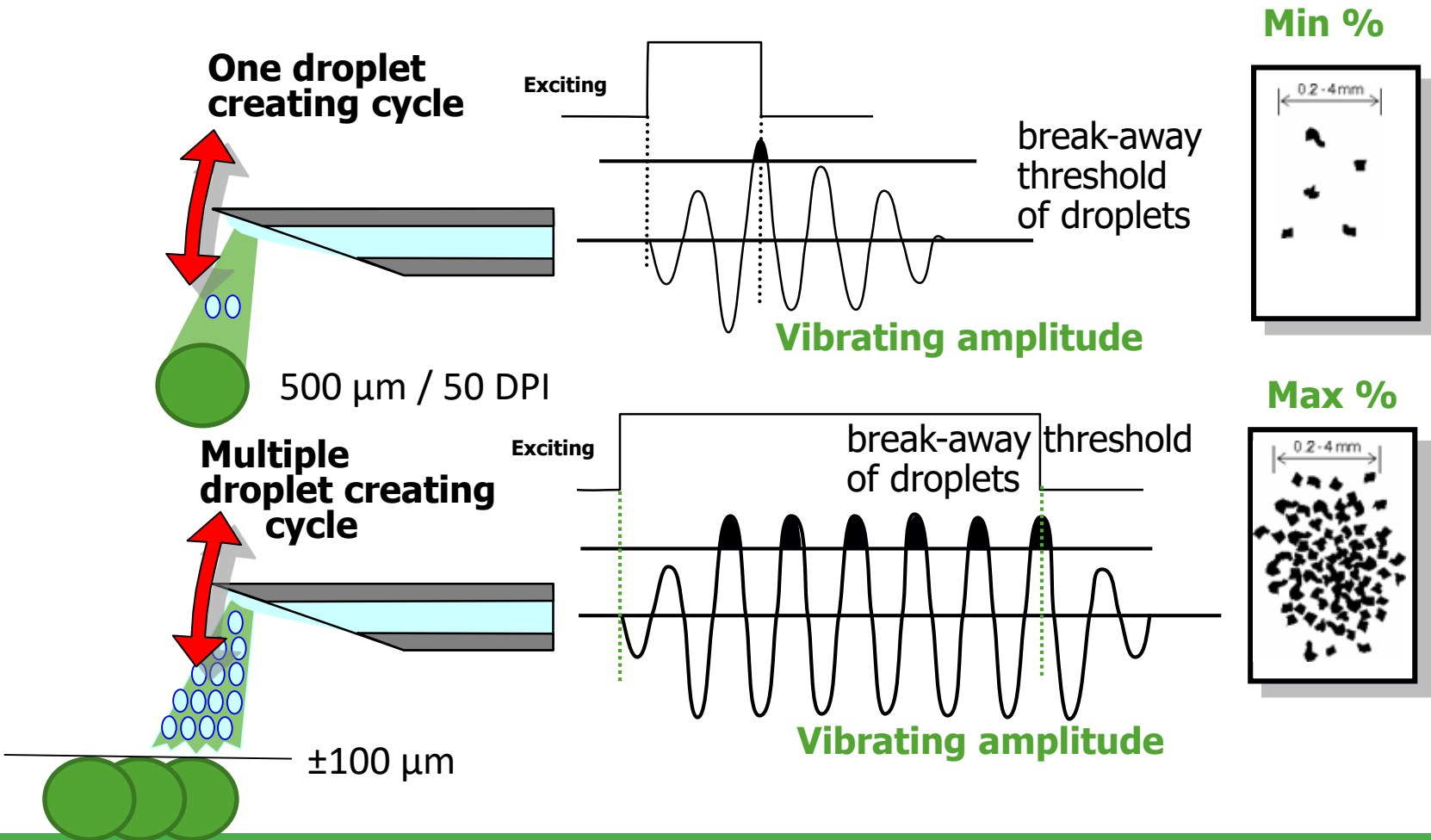
48PL: precision liquid coatings at high throughput

- Low-medium viscosity fluids via an array of hundreds of digitally controlled Piezoneedle™ dispensers
- Non-contact:
- Precise digital control:
 - 2D features sizes $\sim 500 \mu\text{m}$ / 50 DPI
 - Edge definition $\sim \pm 100 \mu\text{m}$
 - Layer thickness $0.1 \mu\text{m} - 100 \mu\text{m}$
 - Surface topography up to $\sim 15 \text{ mm}$
 - High uniformity coating $< \pm 5\%$
- High throughput:
 - Up to $\sim 20 \text{ gsm}$ at 100 m min^{-1}
 - Viscosity up to 200 cPoise



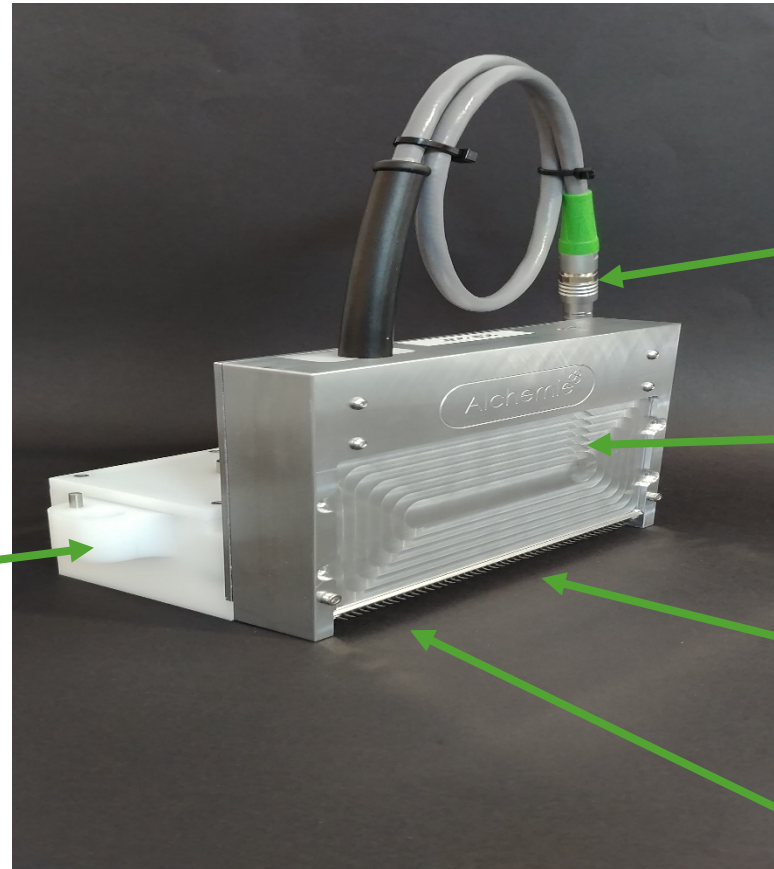
Capability to deliver precise microscale features

Resonant frequency ~ 180 kHz, switching frequency ~ 2 kHz (~ 90 cycles per dispense)



48PL coating head

The coating head is designed for low maintenance industrial use in demanding high-throughput manufacturing lines



Fluid feed tank

Off-head connector

IP rated case

48 nozzles at 10 NPI

Replaceable nozzles

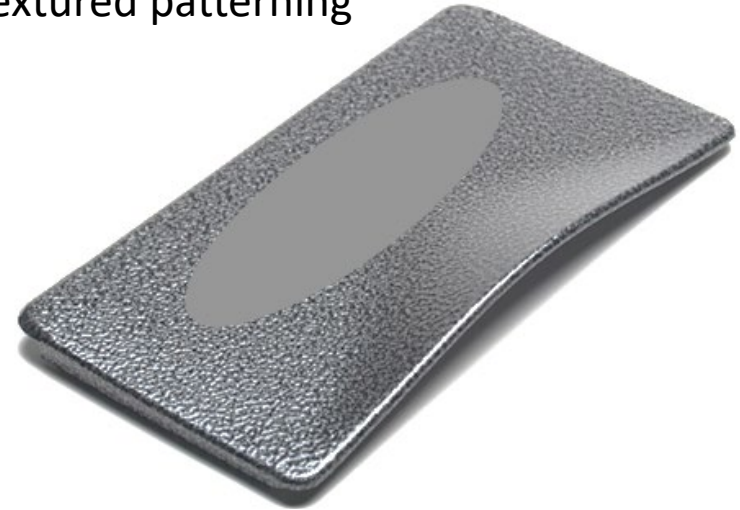
12 cm / 4.8" wide coating width

48PL digital imaging and coating capabilities

Images



Textured patterning

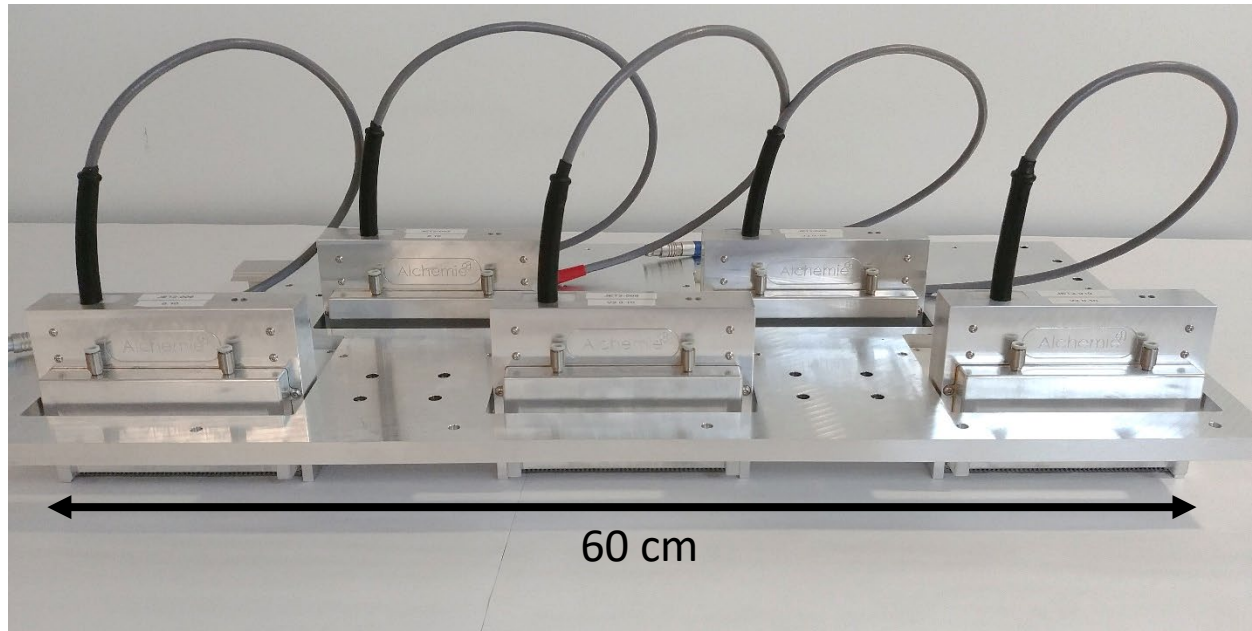


Metallics



Functional materials

48PL modules / machines



- 48PL coating heads can be configured as multi-head modules – typically as banks of printheads to cover larger areas in single pass
- Web widths over 3 m wide are feasible
- Nozzle densities up to 100 NPI can be conveniently achieved

48PL: Industrial materials supply systems

- Our material supply systems are designed for delivering complex and challenging fluids
- The systems are designed for lab development and pilot production:
 - Materials recirculation loop ~ 3 L in volume
 - Agitator for sedimenting fluids
 - Heating system to 80C
 - Vacuum meniscus pressure controller
- 1 – 5 unique materials per system
- Fully enclosed: suitable for volatile materials
- Stainless steel construction
- Manual control or PLC or PC interface
- Pharmaceutical /medical device / food material compatible

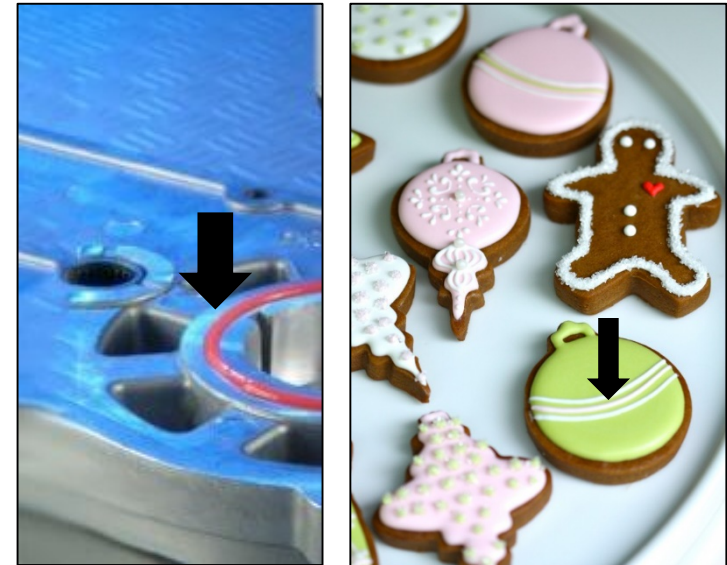


48PL vs Industrial Inkjet for Precision Coatings

Benefits of 48PL vs inkjet	48PL	Industrial Inkjet
Digitally controlled – software defined images/patterns	Yes	Yes
Wide viscosity range and suitable for complex fluids – pigment suspensions, printing inks	1 – 200 cPoise	5 - 10 cPoise
Compatible with large particles – use off-the-shelf particulates	Up to 200 μm	Up to 2 μm
Suitable for heated fluids – e.g: hot melt adhesives	20 – 150C	20 – 50C
Distance to substrate	1 – 50 mm	1-2 mm
48PL is significantly more robust than inkjet	Particulate containing environments OK IP rated enclosure	Sensitive to particulates
Maximum resolution for patterning and coating	50 DPI / 500 μm	600 DPI / 42 μm

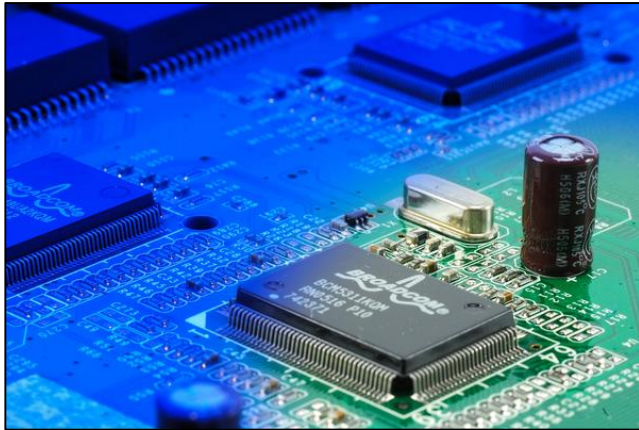
2. 1HV: precision coating with high viscosity materials

- 1HV delivers digital control using medium-high viscosity fluids using a specially designed high-intensity Piezoneedle™
- The system is designed for single nozzle application using robotics/automated motion systems:
 - Features sizes 0.5 – 50 mm
 - Viscosity > 2500 cPoise (Honey)
 - Dispenser – substrate distance 2 - 20 mm
 - Variable volume and coating thickness
 - High accuracy < 5% variation
 - High throughput: Suitable for use > 100 kg hr-1
- The system is designed for industrial use in demanding high throughput manufacturing lines

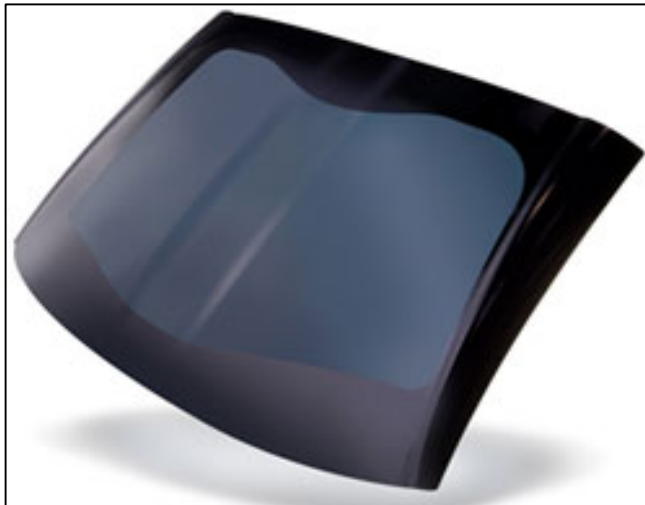


Various deposition tools

1HV coating capabilities – digitally defined coating area



PCB conformal coating on components

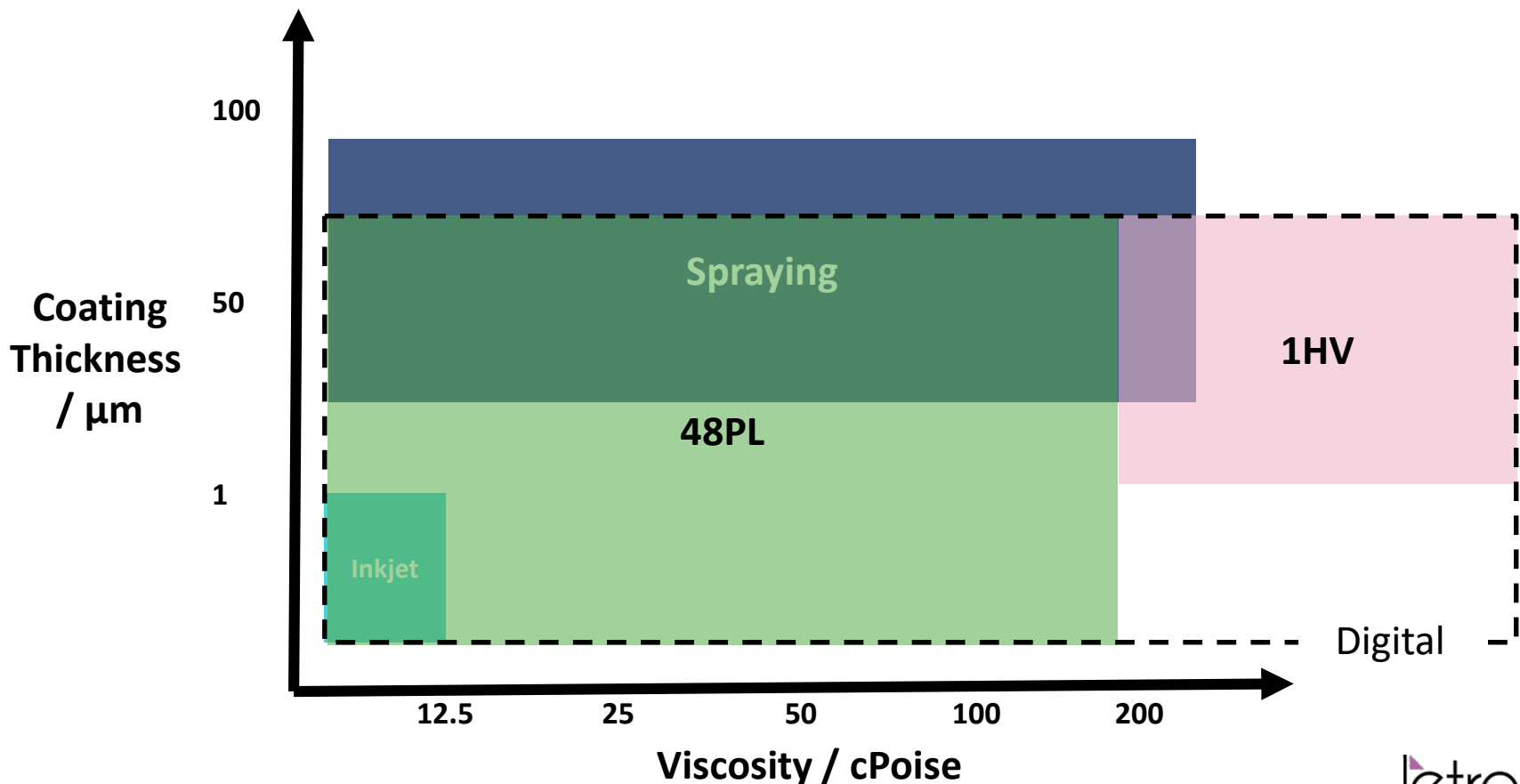


Plastic part coating on selected areas of 3D shapes



Metal coating with defined edges

48PL/1HV: A uniquely wide viscosity and coating thickness range for digital fluid application



48PL / 1 HV

R&D Development
Systems

Development systems
including prototype
printheads and materials
supply systems

Modules for pilot and
production scale

Integrated coating
modules for retrofitting
onto production lines.

Custom solutions /
machines

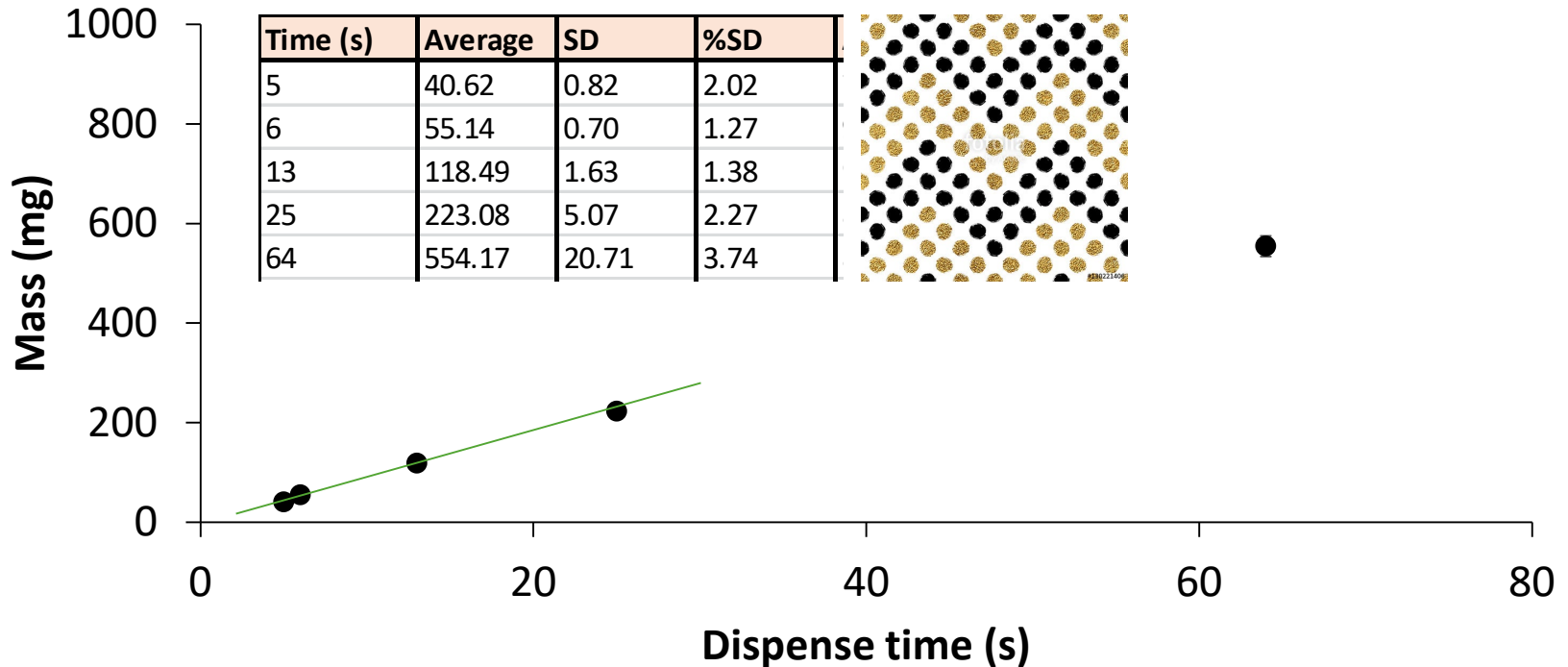
Custom engineered
solutions, including pilot
and production lines.
Scanning systems
Robotics

3. VibroJET – powder printhead

- **VibroJET** delivers digital coating capability with powders
 - We utilise our Piezoneedle™ technology to accurately deposit microgram quantities of powder to digitally-defined locations with 2D feature size >1 mm
 - Layer thickness > 50 μm
 - Non contact
- The technology is suitable for single layer 2D+ coating (e.g: Tactile printing) or multi-layer layer-by-layer deposition
- Potential to create high resolution 2D+/3D structures from a wide range of powders



Vibrojet - high dispense precision



- Dispense precision < $\pm 4\%$ (CV) n=6
- Linear time-dose response up to 30 seconds ($R^2 > 0.99$)
- Organic chemical granules particle size = 180 – 249 μm

Vibrojet application – Braille printing



- Polymer powder dispensed and thermally fused in line
- Braille printer demonstrator developed and being commercialised



bmyet

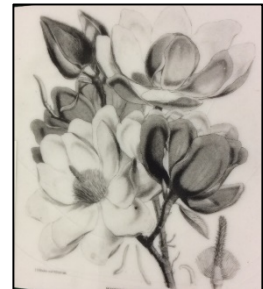
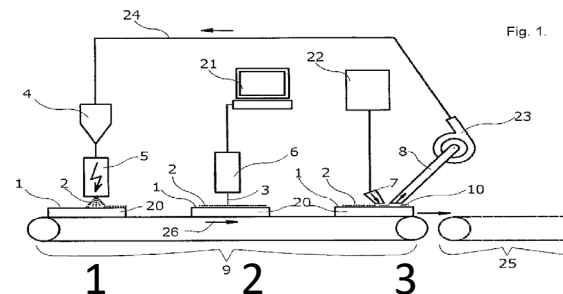
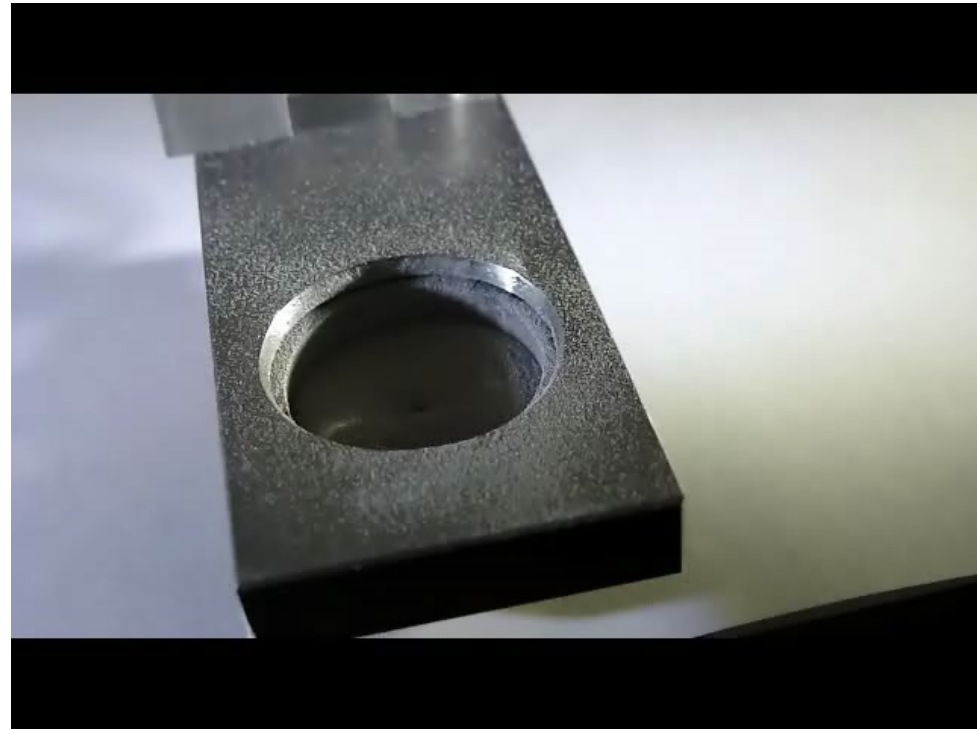
Textile applications - vibrojet

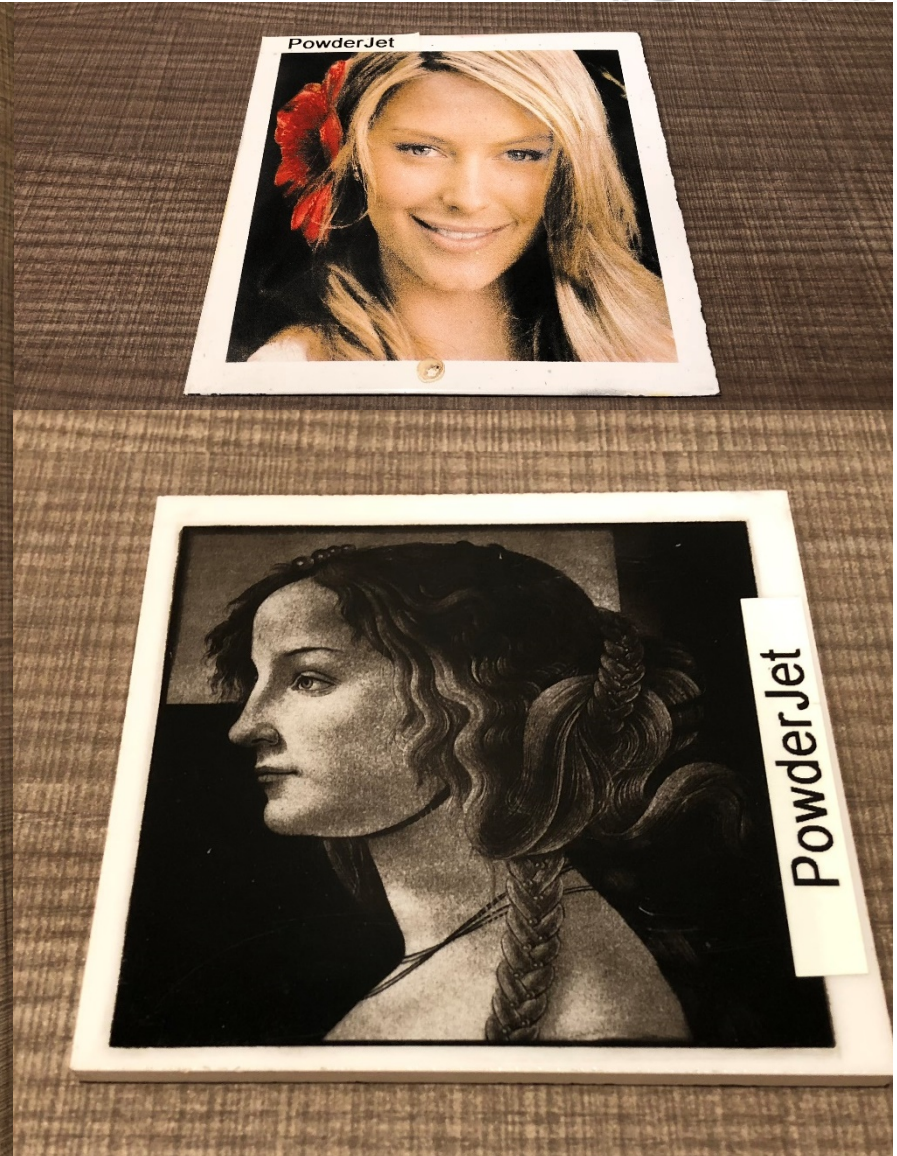


- Digital alternative to silicone heat transfers

4. PowderJET – precision powder coating

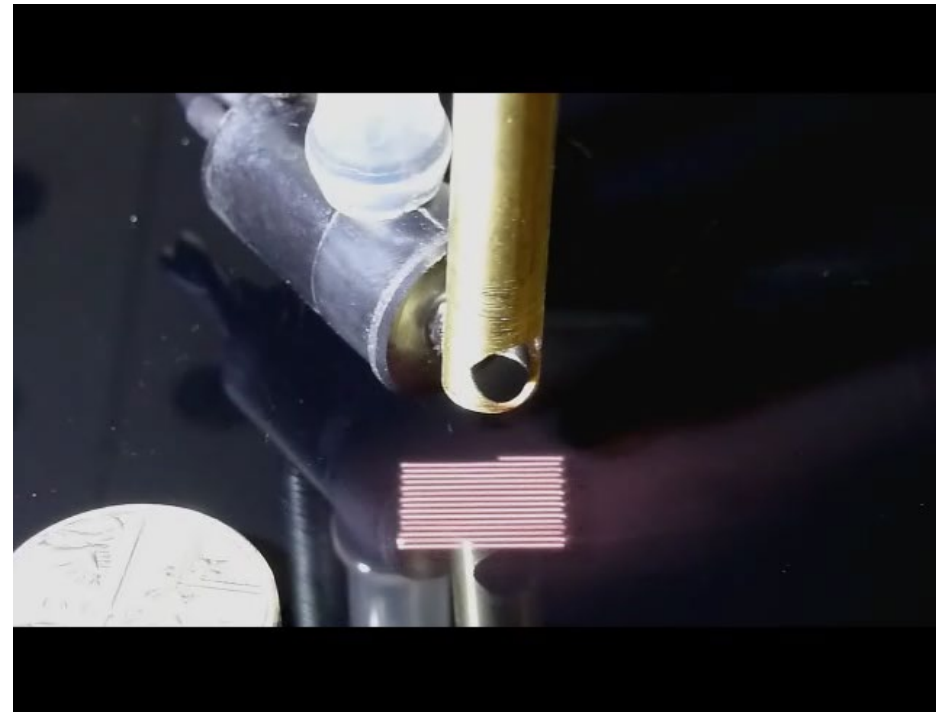
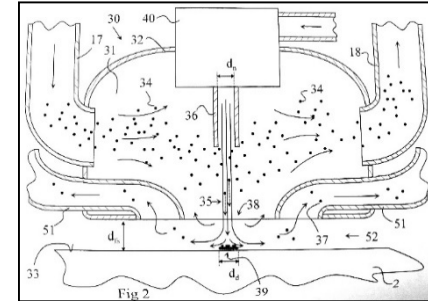
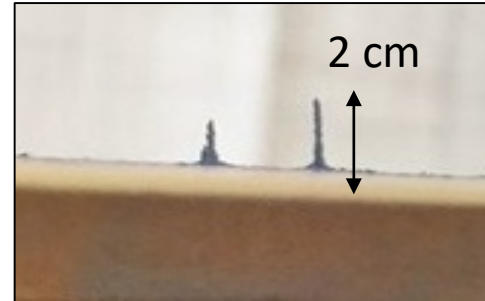
- **PowderJET** enables high accuracy deposition of homogeneous powder layers
- Suitable for multi-layer deposition
- PowderJet imaging method:
 1. Powder dispense
 2. Printing on top enables high resolution (up to 1200 DPI) application of a liquid fixation chemistry
 3. Removal of unbound powder
 - Decouples powder from binder vs printing

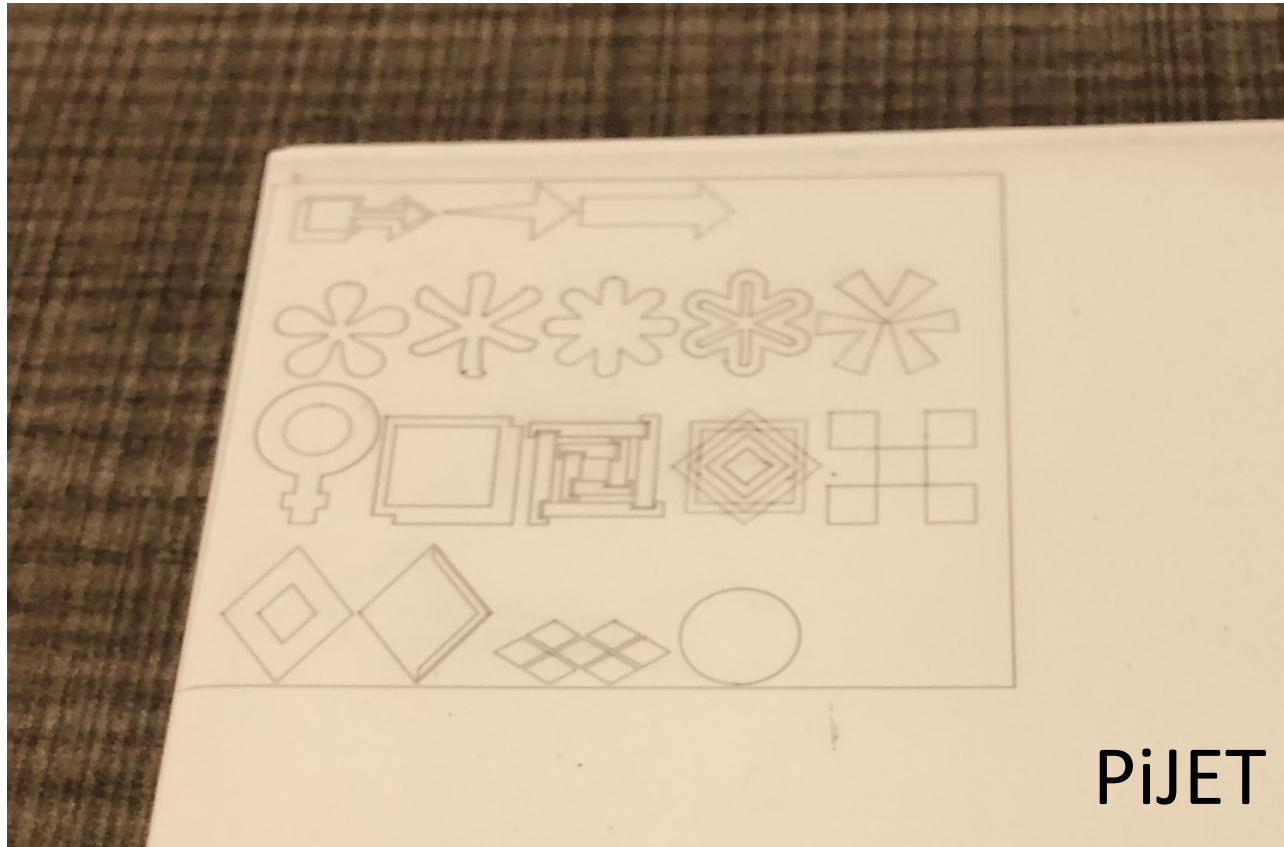


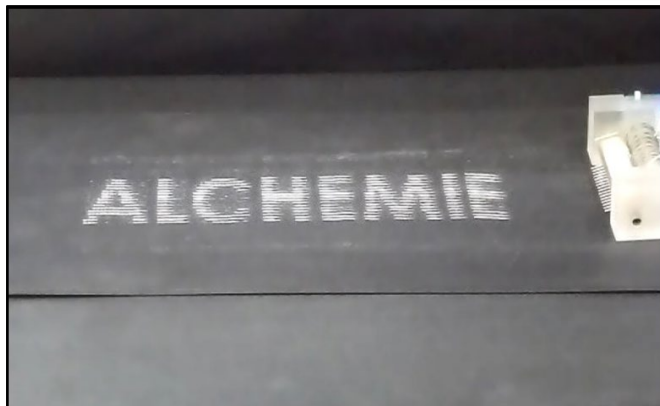
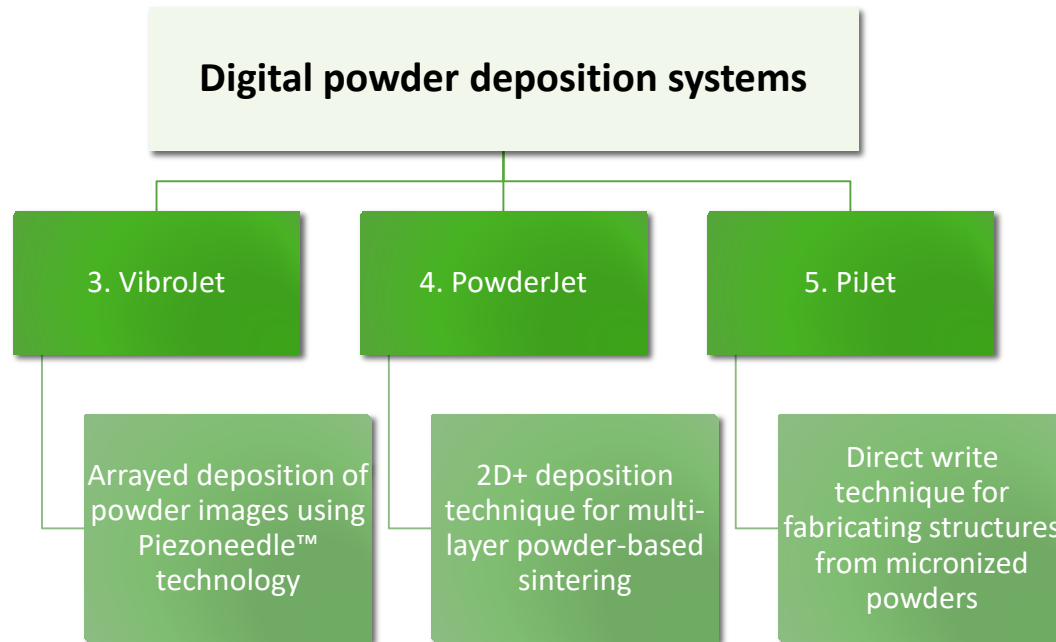


5. PiJET – direct write powder deposition

- **PiJet** directly writes stable, consolidated high aspect ratio powder structures
- The unique patented process involves the high velocity application of micronized powders
- The energy dissipated in deposition provides sufficient binding to fabricate stable structures directly from powders



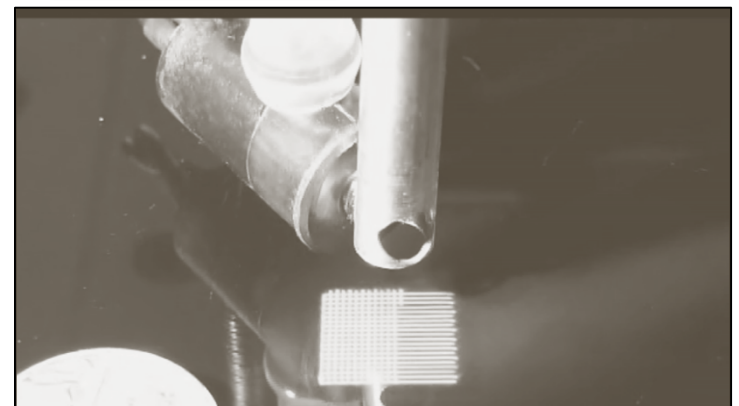




VibroJet

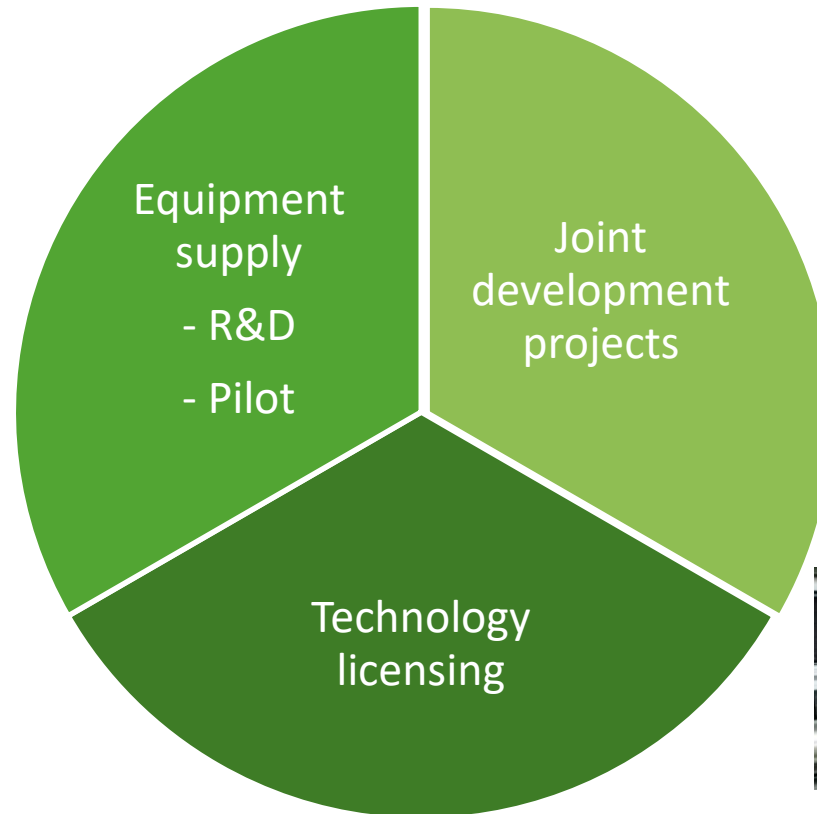


PowderJet

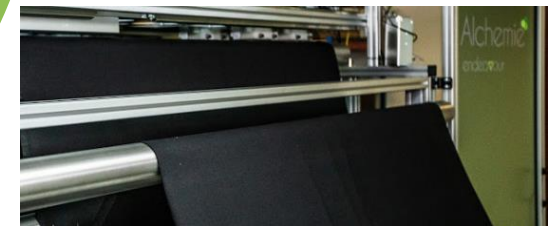


PiJet

How we work with our customers



Digital textile dyeing



- First commercial product launched in Q2 2019

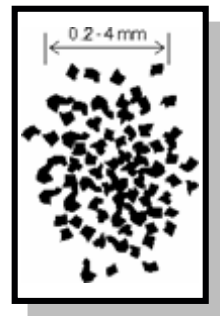
endeavour

APPENDIX

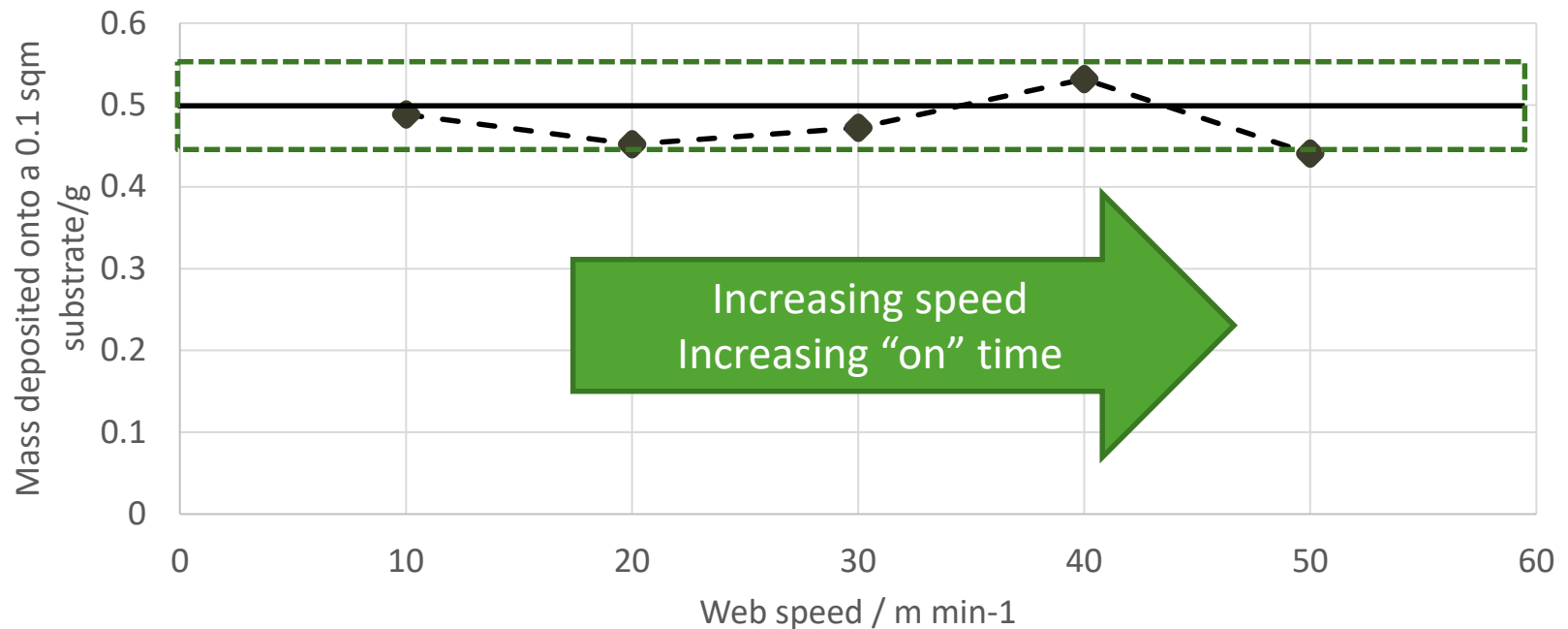
Precise control of coat weight

	Mass /g	StDev (n=10)	CV
2 cPoise	0.8729	0.0288	3%

- Typical variation in coat weight is $< \pm 3\%$ for 1 – 50 cPoise
- Coat weight is controlled by switching frequency up to 2 kHz maximum throughput
- Discrete dispense volume ~ 100 nL, composed of a population of nL drops

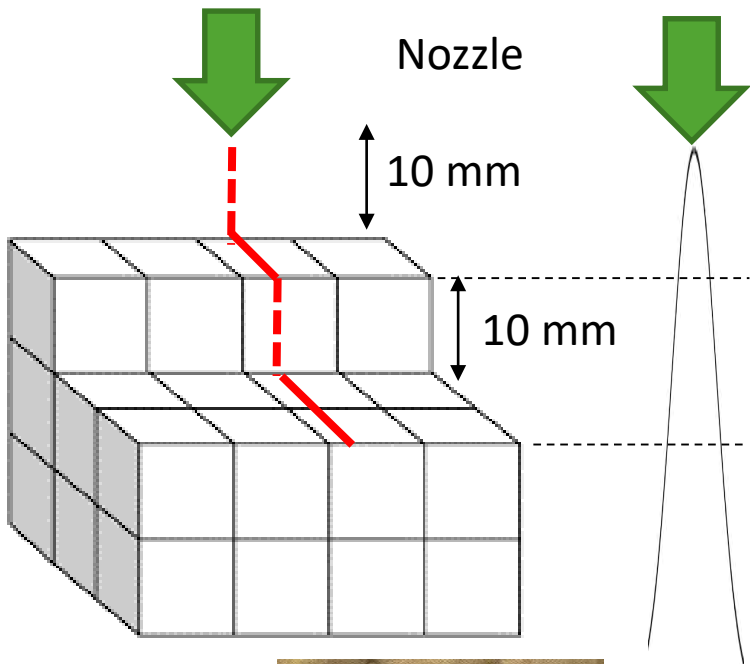
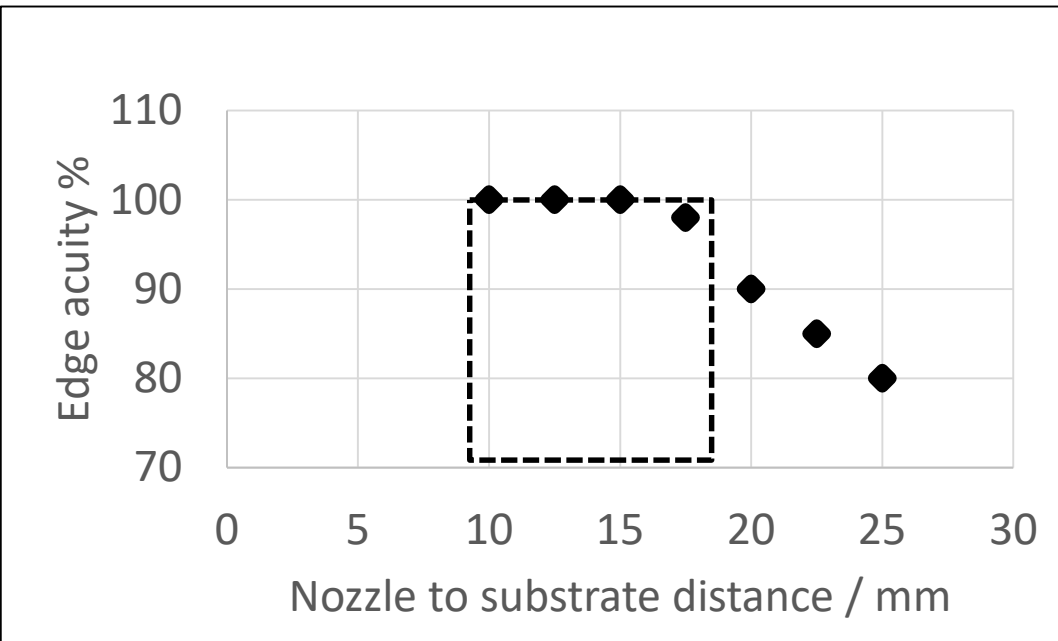


Precision coating – dynamic coat weight control



- Deposition of 5 gsm at 10 – 50 m min⁻¹, speed increase and throughput matching test (10 cPoise fluid)
- Demonstration of use of “on the fly” digital throughput control to maintain coat weight at increasing web speed $\pm 10\%$

Precision coating onto profiled surfaces



- We can deliver well defined coating edges onto topologies that vary in height by up to ~ 10 mm
- High velocity coating spray cone with very low spread
- Suitable for structured substrates such as quilted textiles

