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# Inkjet Application Process Development Using Functional Fluids

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# Dimatix Materials Printer for R&D


## Product Description

- ✓ Self-contained deposition printer
- ✓ Disposable cartridges with user fillable 1.5 mL reservoirs
  - ✓ 16 nozzles
  - ✓ 10 pL & 1 pL drop sizes

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# Process Development Method

- ✓Define fluid variables
- ✓Confirm fluid compatibility
- ✓Establish jettability
  - ✓Focus on waveform and drop watching
- ✓Identify drop spread and resolution
- ✓Consider drop volume and fluid/substrate interaction
- ✓Measure print quality
- ✓Plan pre-treatments and post-processing
- ✓Using test and qualifications patterns

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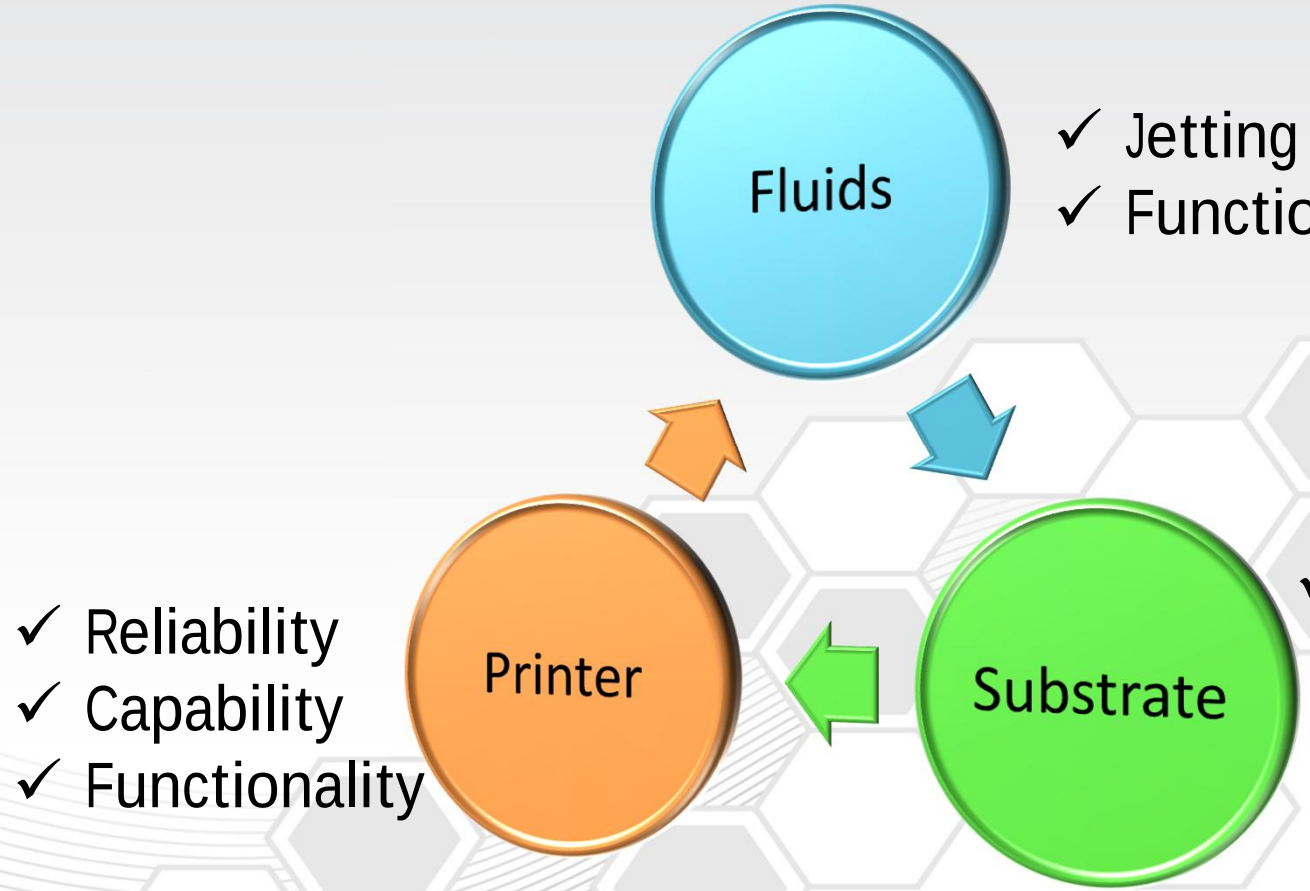
# System Functionality Development




- ✓ Jetting
- ✓ Functionality

- ✓ Reliability
- ✓ Capability
- ✓ Functionality

- ✓ Fluid+Substrate Interaction

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# Define Fluid Variables

- ✓ Viscosity – 8 to 12 cP at jetting temperature
- ✓ Surface Tension – 28 to 33 $dynescm^{-1}$
- ✓ Boiling Point(s) – greater than 100ºC
- ✓ pH – between 3 and 10
- ✓ Particle size and shape
- ✓ Concentration – dependent on jetting performance feedback and application requirements

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# Determine Fluid Compatibility

- ✓ Determine correct print cartridge components to use with fluid based on solvent compatibility:
- ✓ Dimatix Chemical Compatibility Kit (soak test)
  - ✓ Samples of all components that contact the fluid

| Material | DMC | DMCLCP | Common Name |
|---|---|---|---|
| Polypropylene | X | | Bag |
| Polypropylene | X | | Bag Fitting |
| EPDM | X | | O-Ring Seal |
| Liquid Crystal Polymer | X | X | Die Cap |
| Tecnflon PFR95 | | X | O-Ring Seal |
| Ticona Vectra | | X | Bag Fitting |
| Liquid Crystal Polymer | | X | Bag |
| E & C Epoxy Glue | X | X | Epoxy Glue |

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# Fluid Handling, Preparation, & Storage

- ✓ Determine shelf life and required storage conditions
- ✓ Determine if agitation is required
- ✓ Ultrasonic water bath
- ✓ Ultrasonic probe
- ✓ Shaking
- ✓ Filtration requirements
  - ✓ 0.2µm to 0.45µm
- ✓ Determine filter materials compatibility with fluid
- ✓ Degas fluid if required

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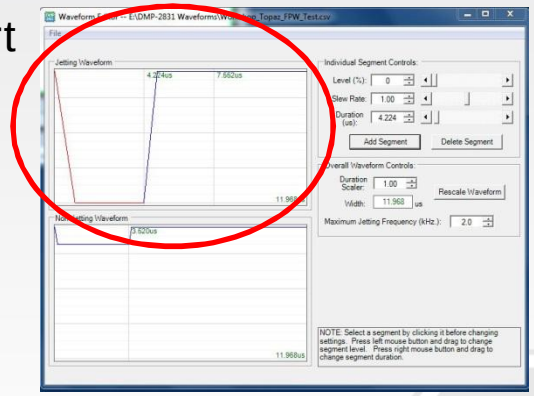
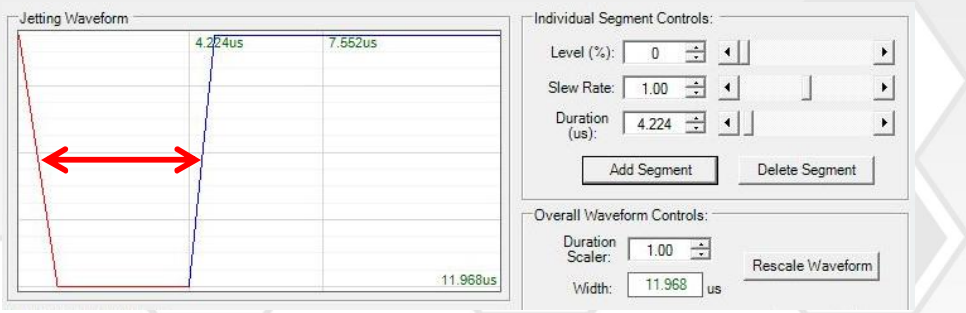
# Waveform Development- Structured Approach

- ✓ Start new for every new fluid
- ✓ Different operators will produce similar results

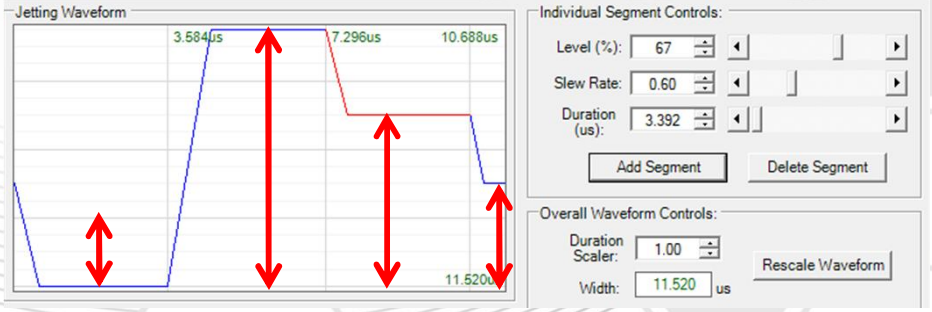
1) Create start parameters



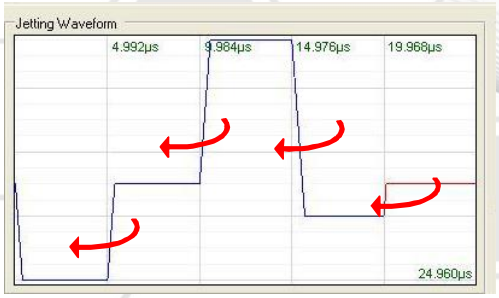
2) Adjust Pulse Width




3) Adjust Level Settings




4) Adjust Slew Rates

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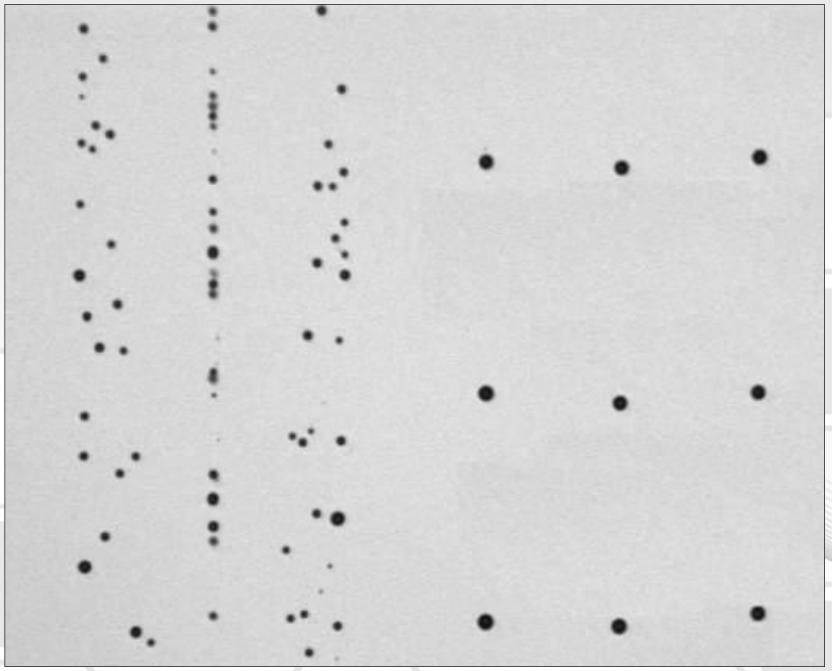
# Evaluating Jetting Characteristics

- ✓ Primary factors to scrutinize:
  - ✓ Drop formation
  - ✓ Drop stability
  - ✓ Maximum drop velocity
- ✓ Secondary Factors:
  - ✓ Nozzle on/off time
  - ✓ Printhead Maintenance
  - ✓ Leader Bar Requirement
  - ✓ Maximum Firing Frequency



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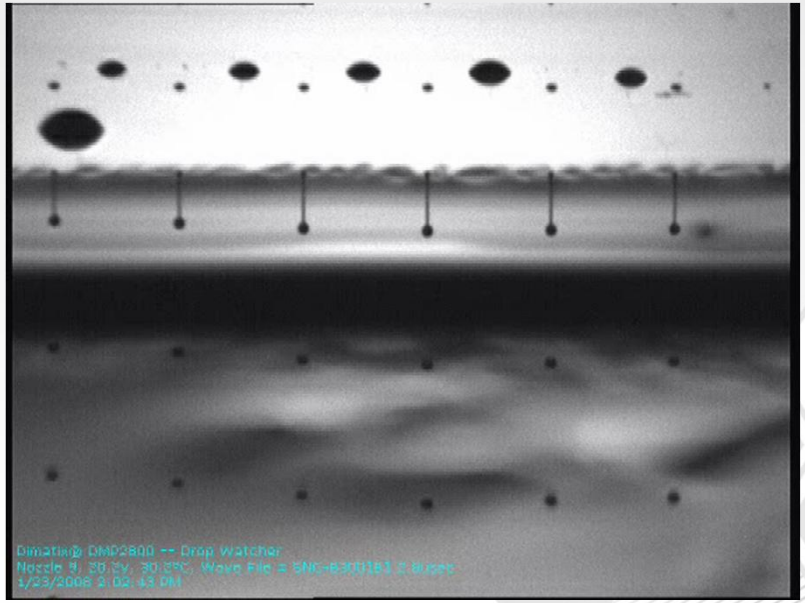
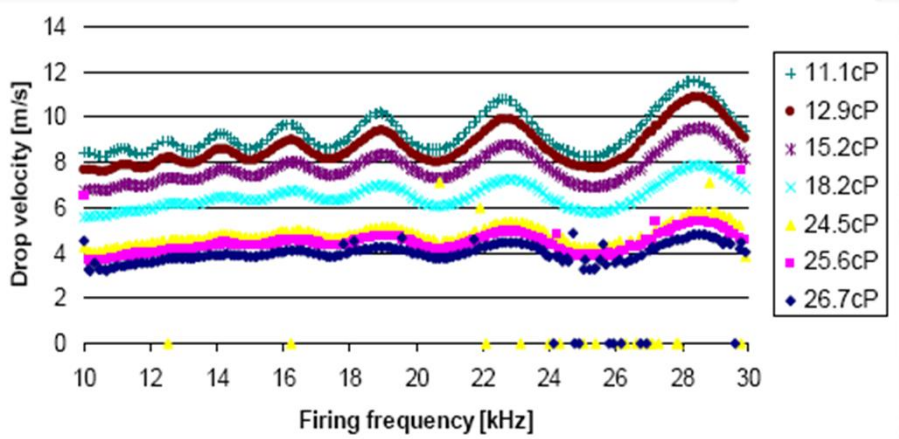
# Maximum Firing Frequency



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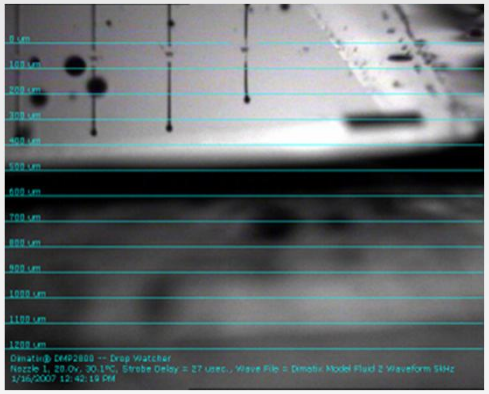
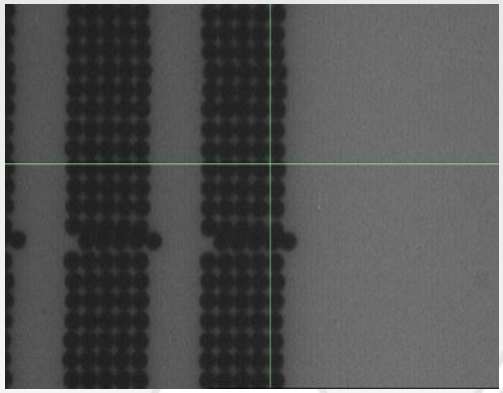
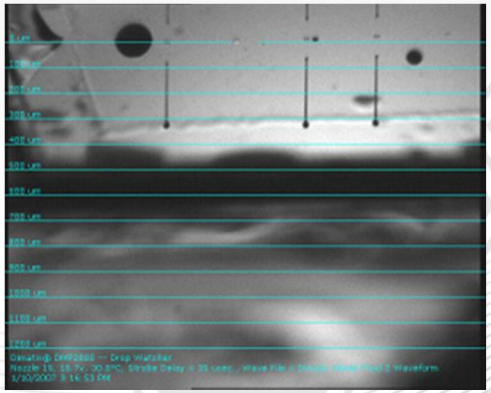
# Jetting Issues

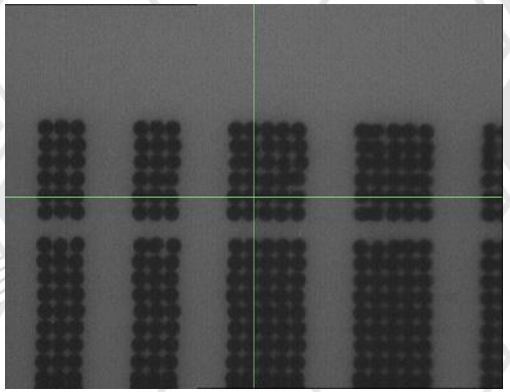
Unmatched Drop Velocities





Missing Nozzle





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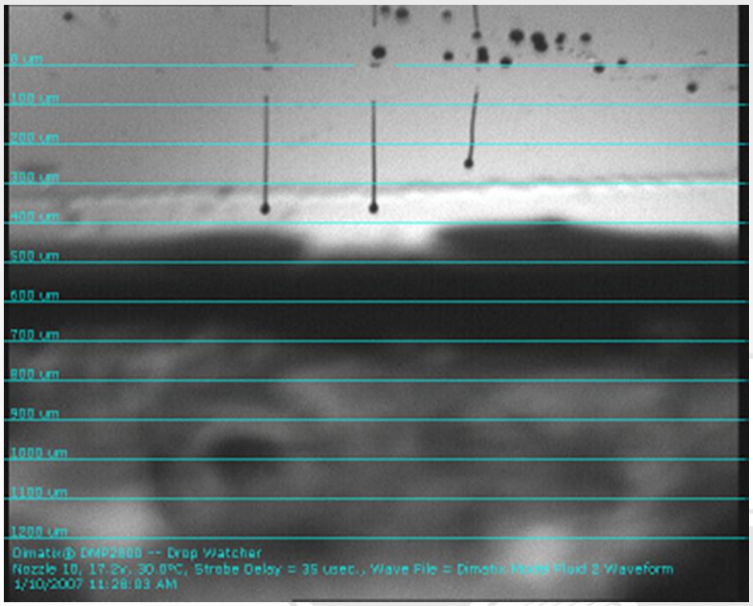
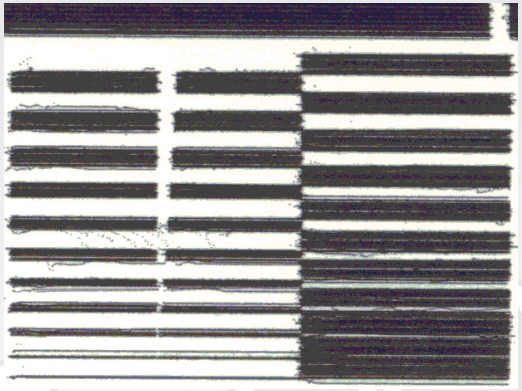
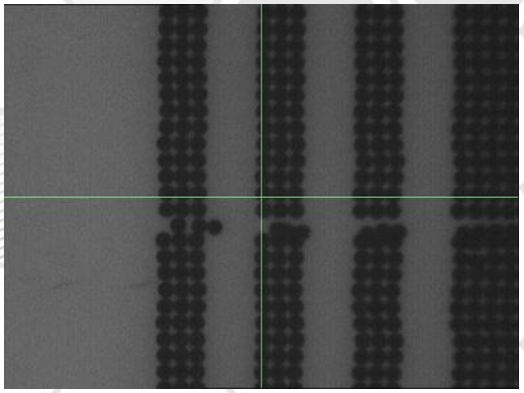
# Jetting Issues

Misdirected Jets





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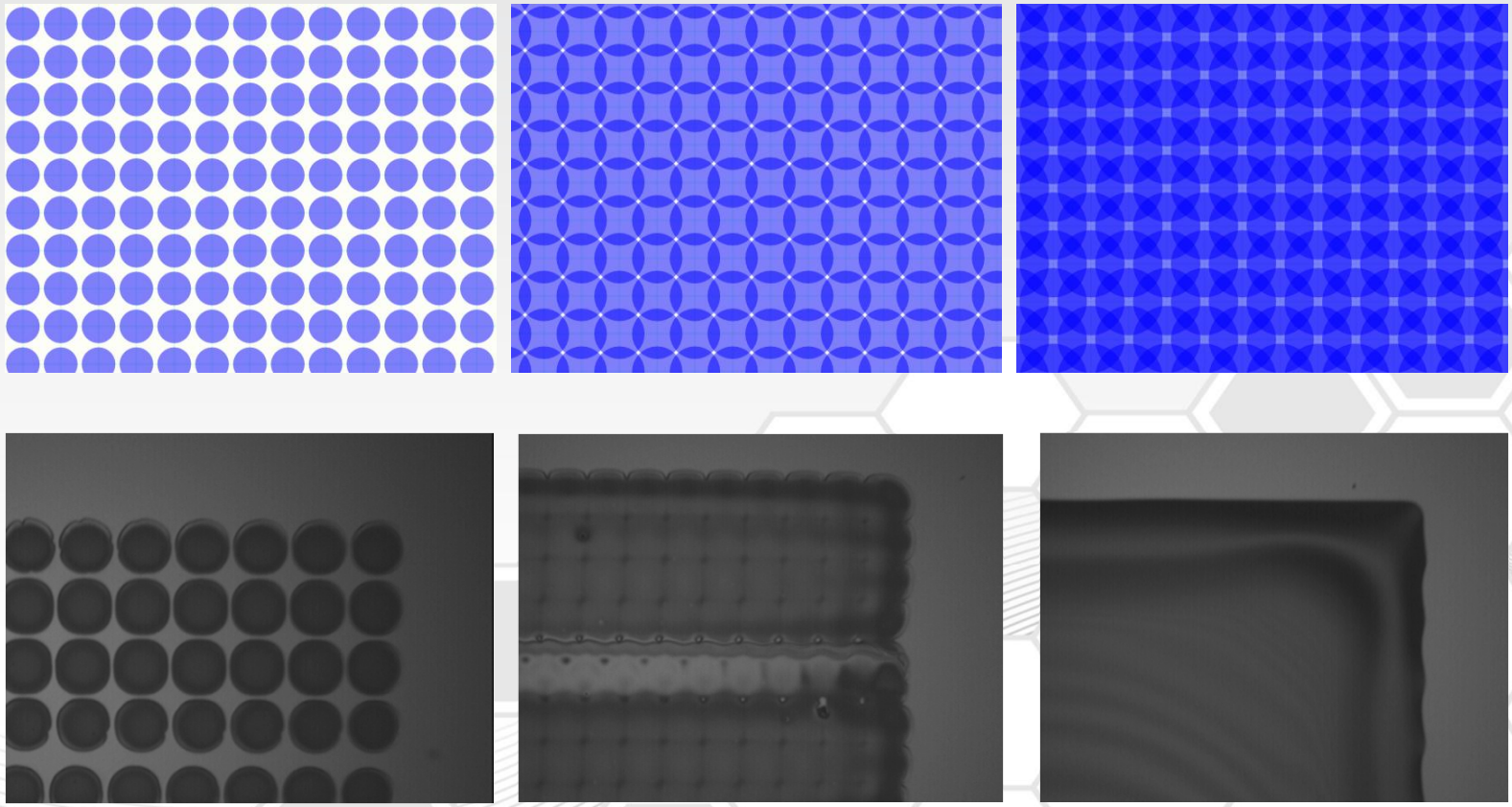
# Drop Spread vs. Resolution



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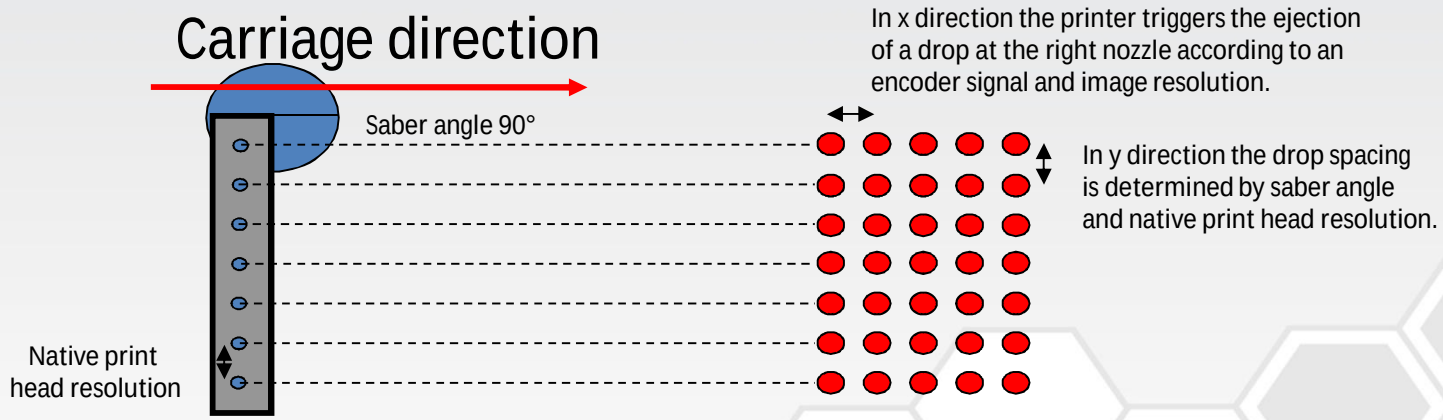
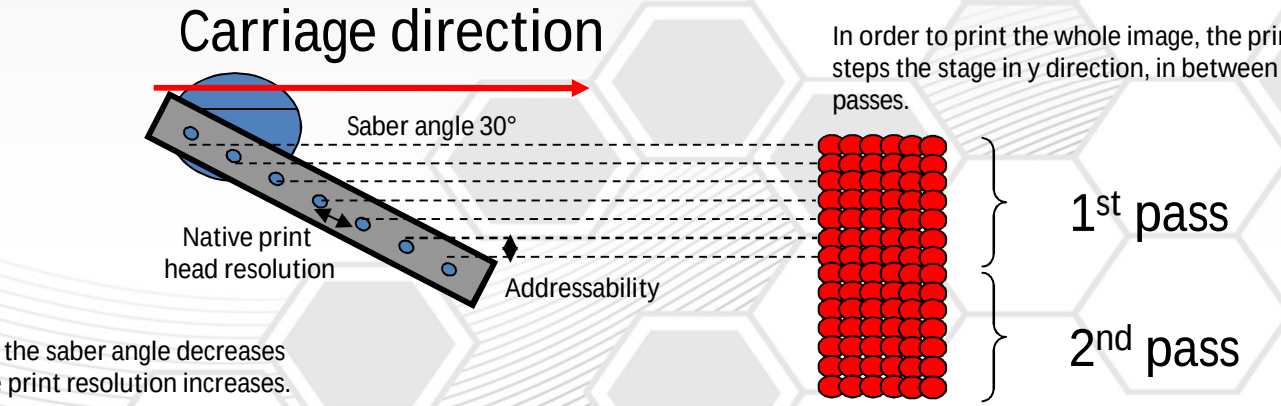
# Sabre Angle




In x direction the printer triggers the ejection of a drop at the right nozzle according to an encoder signal and image resolution.

In y direction the drop spacing is determined by saber angle and native print head resolution.




In order to print the whole image, the printer steps the stage in y direction, in between carriage passes.

1st pass

2nd pass

As the saber angle decreases the print resolution increases.

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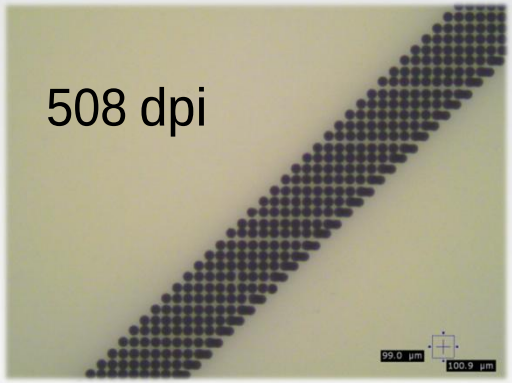
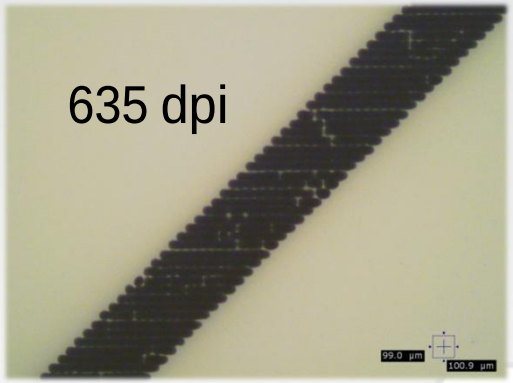
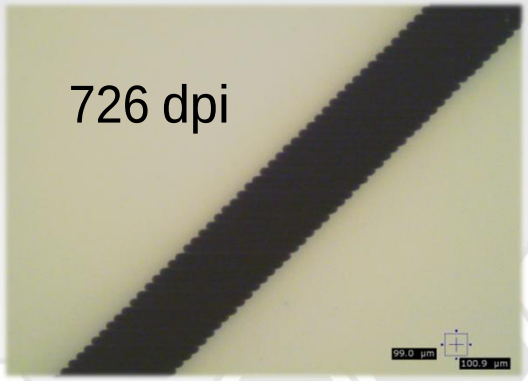
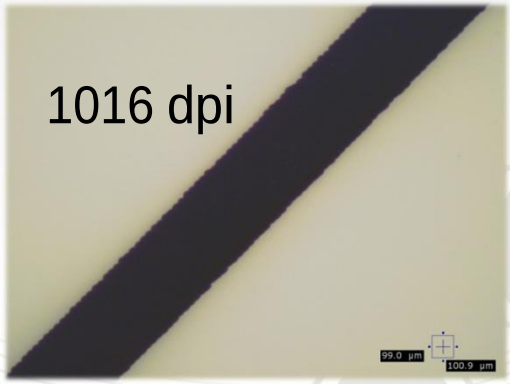
# Resolution

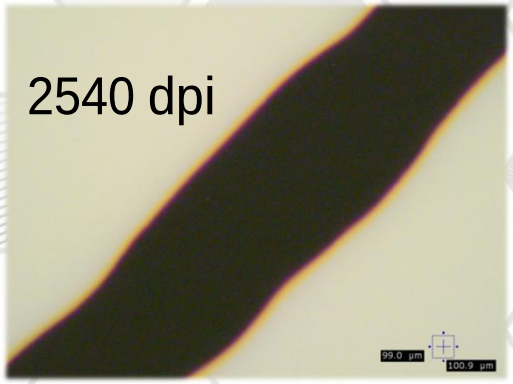




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# Process Knobs

- ✓ Drop Spacing
- ✓ Print Height
- ✓ Print Head Temperature
- ✓ Drop Velocity
- ✓ Platen Temperature
- ✓ Jetting Frequency

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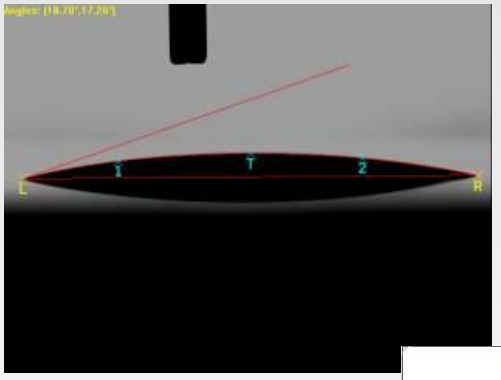
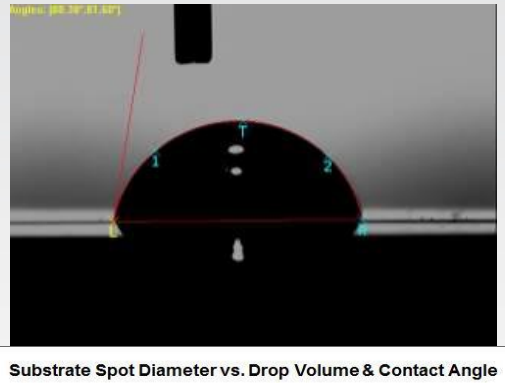
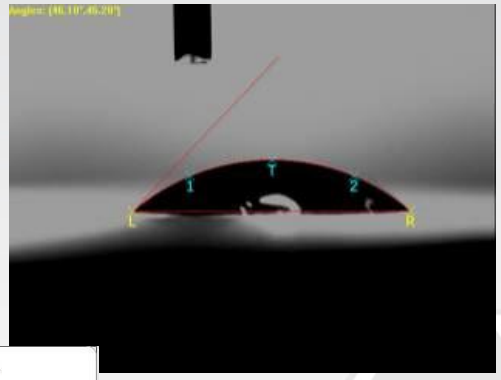
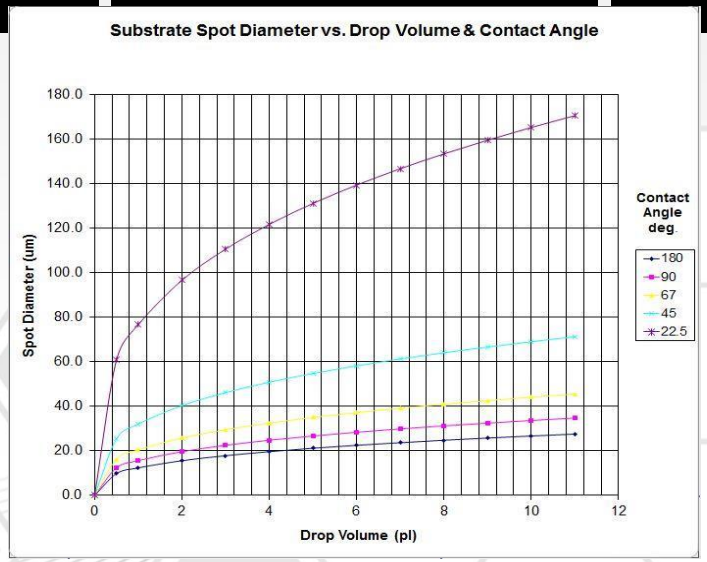
# Fluid/Substrate Interaction







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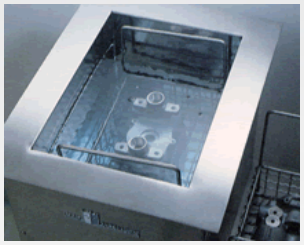
# Surface Treatment (pre-printing)

Control chemical properties of the surface:

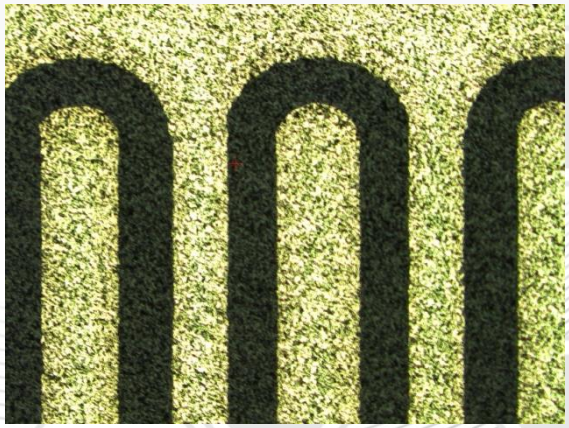
Jelight Company Inc.



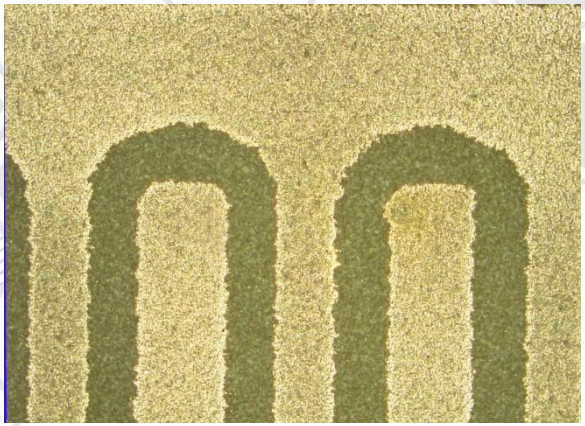
CREST ULTRASONICS THE INNOVATION CONSTANT

Chemical cleaning

Control physical properties of the surface:



Printed on polished substrate



Printed on ground substrate

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# After Printing

NOVACENTRIX


EXFO
Life Sciences & Industrial Division
putting you in control

Thermo SCIENTIFIC


LOCTITE

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# Print Quality

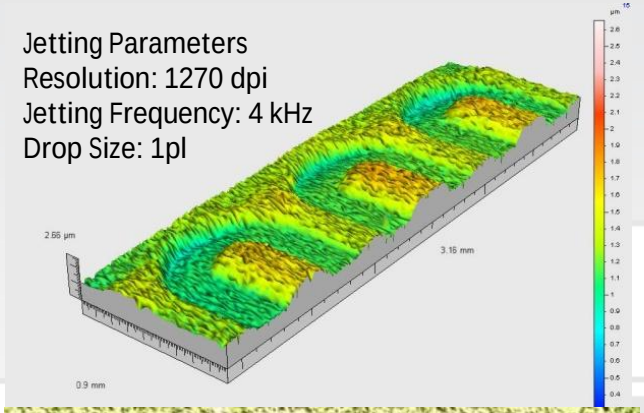
Example: Silver electrode on PZT

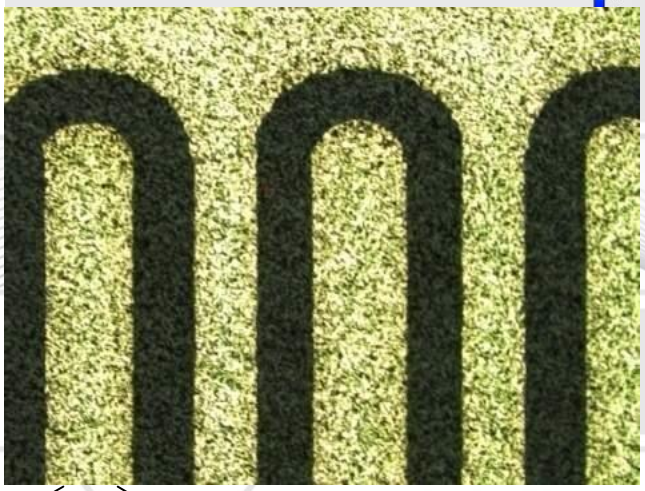
Determining print quality:

- ✓ Optical inspection
- ✓ Layer thickness
- ✓ Cross section
- ✓ Profile
- ✓ Feature tolerances

Application dependent quality measurements:

- ✓ Conductivity
- ✓ Mass of material left behind after drying/curing



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# Designing Studies to Verify Process

Setup a matrix to test the attributes of the application requirements:

- ✓ Check viscosity vs surface tension vs contact angle
  - ✓ If viscosity is “high”, the printhead can be heated to bring it down unless it causes the surface tension to become too low
- ✓ Data will have a visual observation category
- ✓ Make sure velocity is the same when comparing the drop formation of two or more fluids
- ✓ Try to design a test that will exhaust a single cartridge

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# Using Test Patterns to Verify Process

- ✓ Horizontal and Vertical Lines
  - ✓ Horizontal and vertical lines that have the same attributes proves process control
  - ✓ Be aware: the more little tricks you have to use to achieve acceptable printing the more you are probably subtracting from the overall robustness of the process
- ✓ Print Test Troubleshooting
  - ✓ Test patterns to verify printer is working correctly
- ✓ Qualification Patterns

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# Conclusions

- ✓ Define fluid variables and try to meet formulation guidelines
- ✓ Be sure the fluid is compatible
- ✓ Determine if you need to develop a strict regime for fluid storage and preparation
- ✓ Evaluate jetting characteristics and optimize
- ✓ Evaluate print quality
- ✓ Plan/add surface pre-treatments and post-print method of functionalizing the material(s)
- ✓ Design jetting studies using developed criteria
- ✓ Create qualification patterns that challenge the jetting performance

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