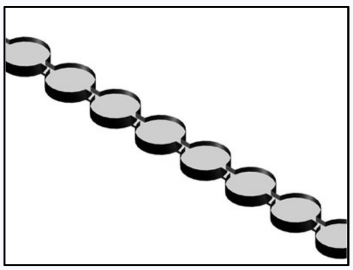
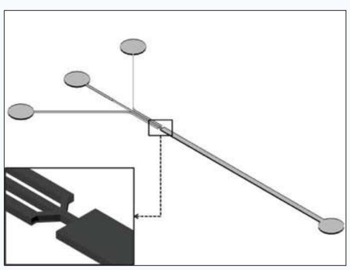
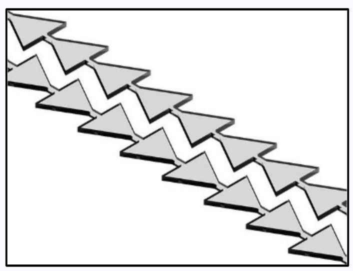
# 2024 PRODUCT GUIDE







FlowJEM
Polymer Microfluidic Technology

# CONTACT INFORMATION

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# 1. DROPLET GENERATORS

FlowJEM offers standard microfluidic droplet and bubble generators for a variety of applications in chemistry, materials science, biology, diagnostics and pharmaceutical science (see Applications). Microfluidic droplet generators can be fabricated in PDMS or thermoplastic materials (see Materials).

FlowJEM also offers droplet generators with custom-based designs in PDMS and thermoplastic materials with different types of surface modification.

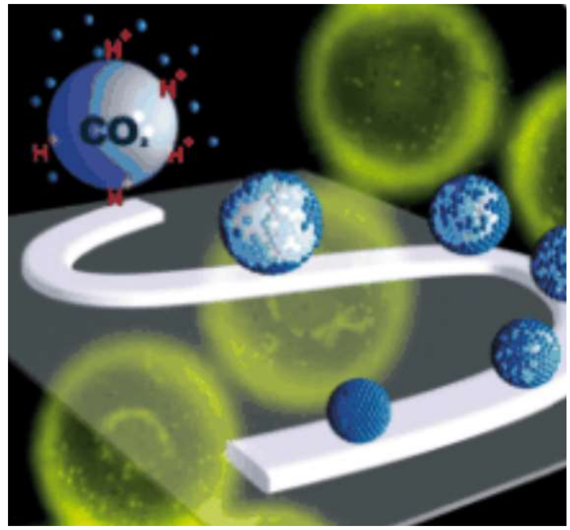
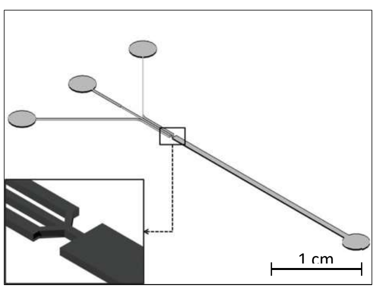
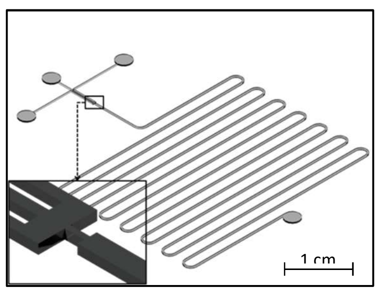


Image is acquired from Angew. Chem. Int. Ed. 48, 5300-5304 (2009).

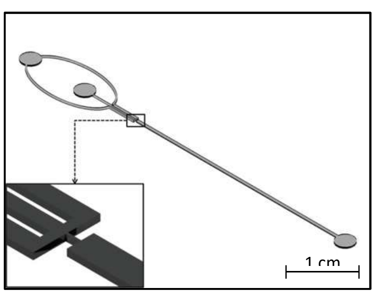
## 1.1 – SINGLE DROPLET GENERATORS



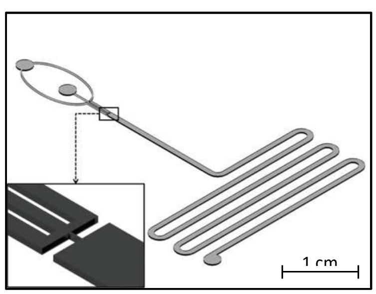

SDG-1001




SDG-1002



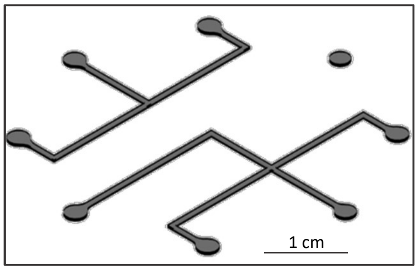

SDG-1003




SDG-1004

Typical standard designs of single droplet generators designs are reported the literature[1-4] for extremely monodispersed water-in-oil (W/O) and oil-in-water (O/W) droplets, and bubbles. Product numbers are SDG-1001 to SDG-1004 (left)

Any design aspect can be customized. These include changes to the in flow focusing area (inset sub figures left) such as approach angle between dispersed and continuous phases (eg., SDG-1001 vs. SDG-1002), and thickness or length of neck. Channel modifications can include length/width, of downstream channels, inclusion of upstream pressure-drop channels, etc.



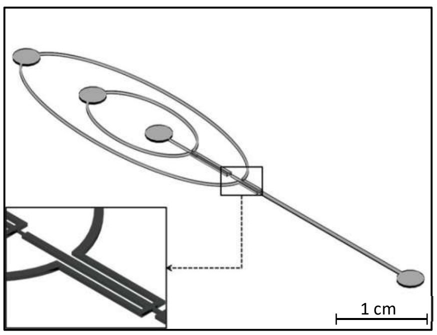
STC-1001

Other designs are available such as three-way T-junctions, or 4-way junctions. The design on the left shows a standard two-in-one design featuring one of each junction along with peripheral inlets for FlowJEM world-to-chip interface accessory (see section 7)

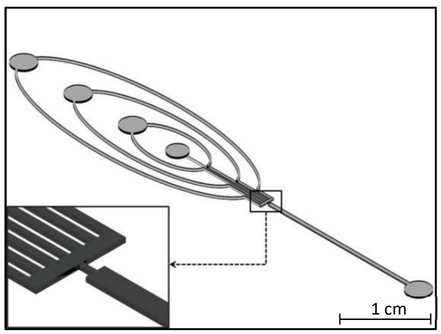
## 1.2 – DOUBLE DROPLET GENERATORS

Typical designs of double droplet generators are reported in the following publications[5-8] and are used for the generation of double emulsions, e.g., water-in-oil-in-water (W/O/W), oil-in-oil-in-water (O/O/W), water-in-water-in-oil (W/W/O), and oil-in-water-in-oil (O/W/O)). These emulsions (also known as 'emulsions of emulsions') are extensively used in formulations in food, cosmetic and pharmaceutical industries. Customizations discussed in the previous section are also applicable.

Two design examples include DDR-001 and DDR-002 (below).



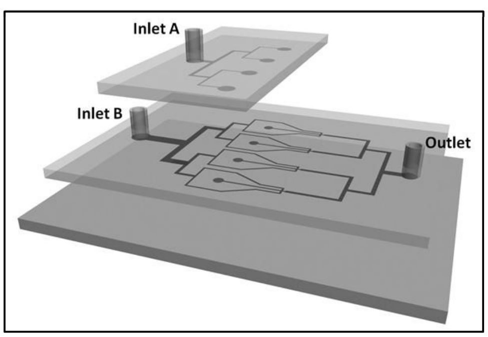
DDR-001



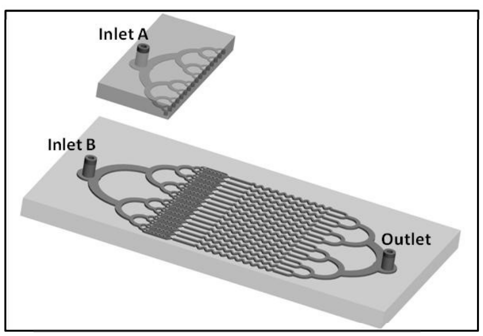
DDR-002

## 1.3 – DROPLET MODULES

The inclusion of an alighted manifold layer paralyzes each process (MMG-001 and MMG 002). Connecting multiple modules in parallel can significantly increase throughput.[9,10]



MMG-001



MMG-002

## 2. DROPSEQ DEVICES

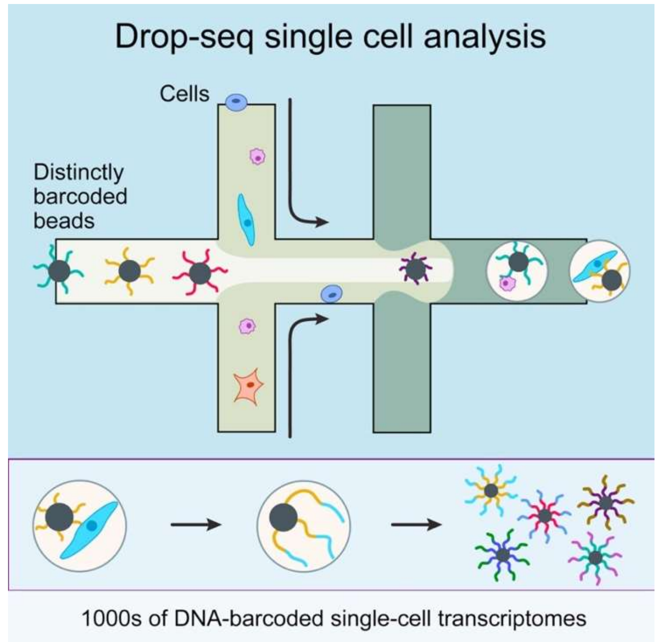
DropSeq devices are used for the analysis of RNA expression. DropSeq technology is developed to enable biologists to analyze RNA expression genome-wide in thousands of individual cells at once. It is reported by McCarroll et al. in Cell 2015, 161,1202-1214.

FlowJEM is an endorsed supplier of DropSeq devices fabricated in PDMS.

Standard DropSeq design: 26 droplet generators per device.

Standard bonding: oxygen plasma bonding to glass slide.

Customization includes the change in the dimensions and number of droplet generators per chip, the size of inlet/outlet holes, and different types of surface modification.





*"FlowJEM caught our attention based on positive customer feedback on their fabrication process and competitive pricing for PDMS chips. Based on our experience, the ease of use and high quality of FlowJEM's DropSeq devices allow one to perform and reliable and reproducible experiments for DropSeq applications with next-generation sequencing (NGS) protocols"*

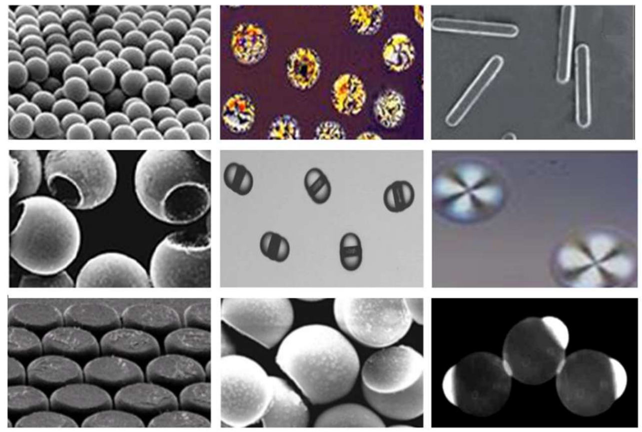
*-Adam Meziane, Product Manager for Droplet Based Solutions, Fluigent*

# 3. MICROFLUIDIC REACTORS

FlowJEM offers droplet and continuous microfluidic reactors for inorganic, organic, and bioorganic syntheses and for the generation of polymer microbeads and microgels.

Microfluidic droplet reactors can be fabricated in PDMS and thermoplastic materials.

FlowJEM also provides prototyping of microfluidic droplet reactors and various types of their surface modification.



Images of polymer particles are reported in Angew. Chem. Int. Ed. 44, 724-728 (2005), Langmuir 21, 4773-4775 (2005), J. Am. Chem. Soc. 128, 9408-9412 (2006), and J. Am. Chem. Soc. 127, 8058-8063 (2005).

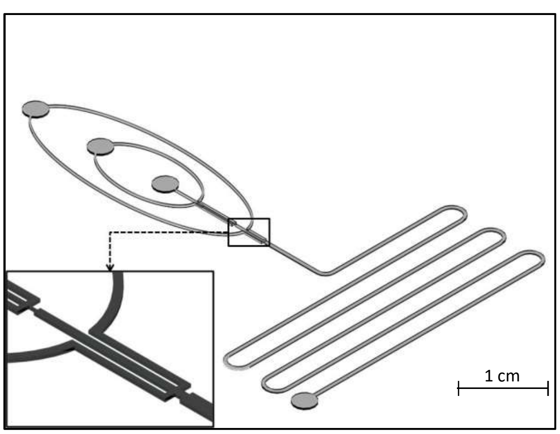
## 3.1 – DROPLET MICROREACTORS

Standard designs of droplet microfluidic microreactors are reported in the following publications[11-17] and used for

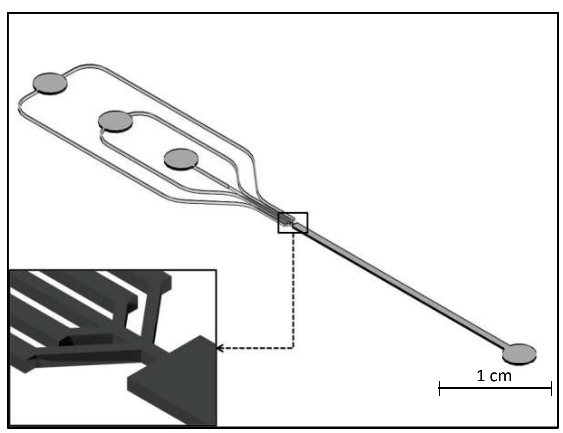
(i) generation of polymer particles with exquisite control of dimensions, compositions, shapes, and morphologies;

(ii) organic and inorganic chemical reactions conducted in droplets (solution chemistry);

(iii) DNA analysis and polymerase chain reaction (PCR).



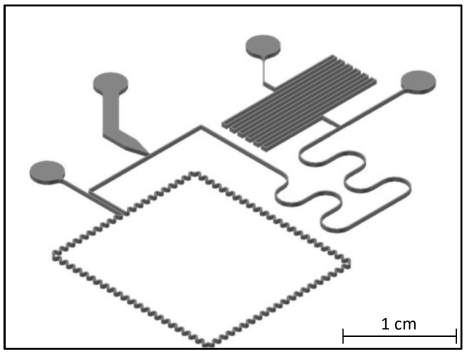

DMR-001




DMR-002

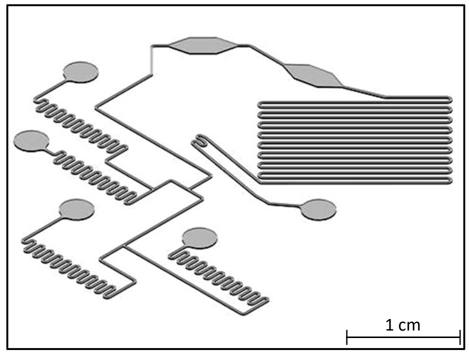
## 3.2 – CONTINUOUS MICROREACTORS

Typical designs of continuous microreactors are reported in the following publications[18-20] and are used for the synthesis of organic and inorganic compounds, polymers, biomaterials, nanoparticles, and drugs, all with excellent control of mass and heat transfer.



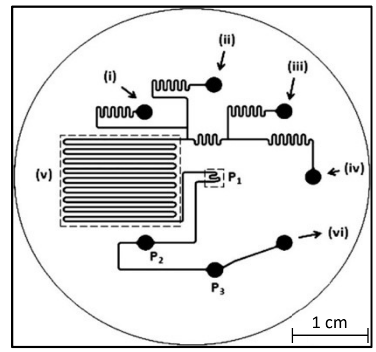

CMR-002-01 (H:0.1 mm)

CMR-002-02 (H: 0.2 mm)




CMR-001-01 (H:0.1 mm)

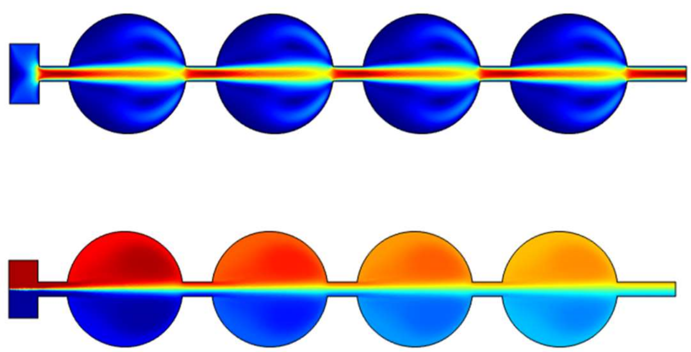
CMR-001-02 (H: 0.2 mm)




CMR-003

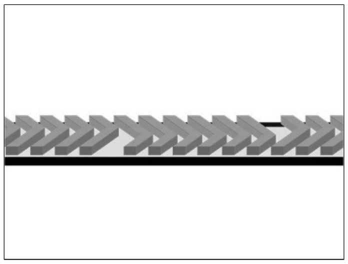
## 3.3 – PASSIVE MICROMIXERS

FlowJEM offers micromixers for rapid mixing of multiple components in microfluidic channels. Typical designs of passive micromixers, e.g., 3D serpentine, twisted, or zigzag structures are reported in the following publications21-24 and are used to increase the surface area of microfluidic channels, in which laminar flow is dominant

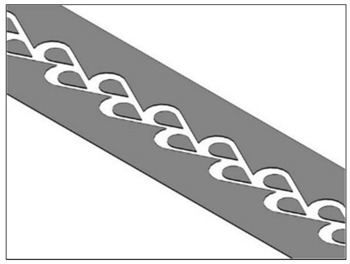


Micromixers can be fabricated in PDMS or thermoplastic materials.

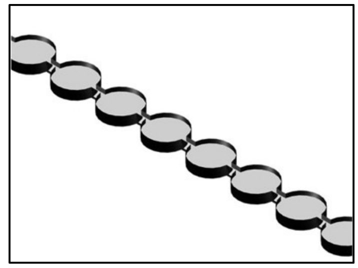
FlowJEM also offers customized surface modification of microreactors.



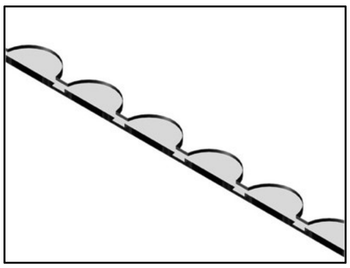
PMR-001



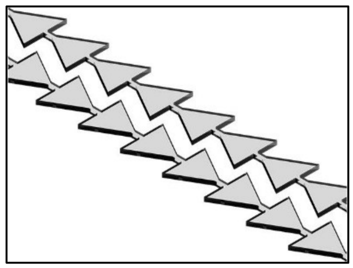
PMR-002



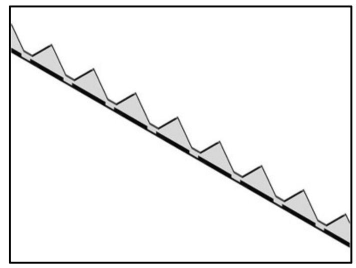
PMR-003



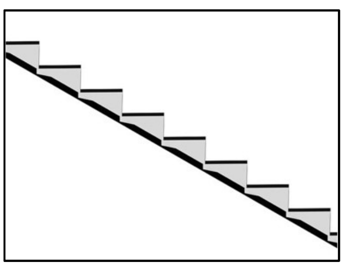
PMR-004



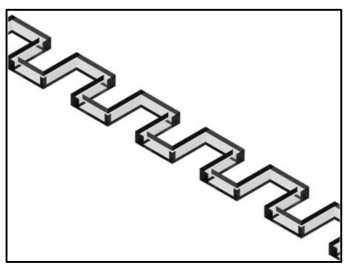
PMR-005



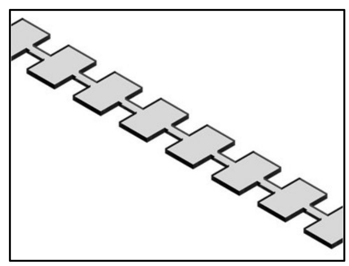
PMR-006



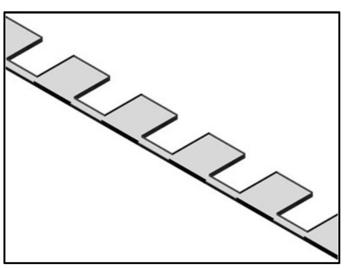
PMR-007



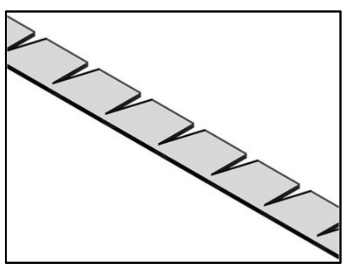
PMR-008



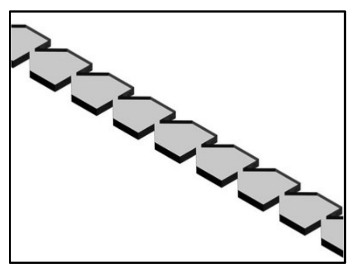
PMR-009



PMR-010



PMR-011

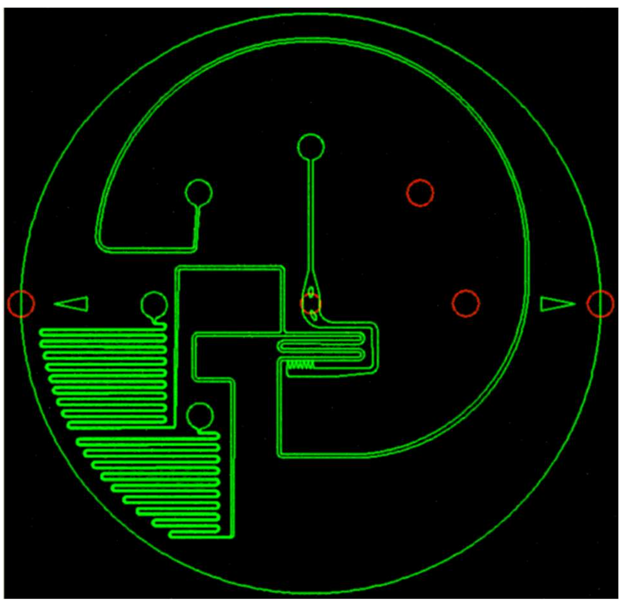


PMR-012

# 4. CUSTOMIZED DESIGN

Customers can take advantage of FlowJEM prototyping services. These services include fabrication of microfluidic devices with new designs. Alternatively, customers can send their own drawings, following the requirements listed below.

- Minimum feature/gap size: ≥ 2 μm
- Tolerance in feature height: ±15% of the channel height (or ±8% with our premium service)
- For silicon wafers, all features should be placed in a 3.5" circle (for 4" wafer), or 4.5"-6.0" circle (for 6" wafer).



## Accepted file formats:

Preferred file format: .dxf and .dwg. Other AutoCAD-compatible file formats (e.g., .sldprt and .gds) are acceptable.

Note that a different CAD format may not be compatible with FlowJEM graphical systems. The rules listed below will enable FlowJEM to complete your order in the timely and cost-effective manner. If design changes are needed to meet FlowJEM's requirements, an additional fee may apply and the turnaround time may increase.

Regardless of the type of CAD software, zero-width closed polylines should be used for boundaries. Hint: use a "Close" command to ensure that the area is completely closed.

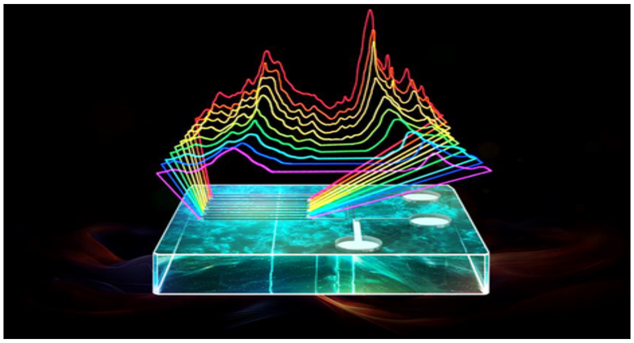
- Do not use hatching to identify filled surfaces on the mask.
- Use a grid and turn on snap function.
- Ensure that "User Coordinate System" is set to "World".
- Do not allow boundaries to overlap or self-intersect. Touching, or "re-entrant" boundaries are acceptable.
- Purge all unused layers, objects and text before creating a .dxf file
- Units should be either millimeters, or micrometers.

*"We switched to FlowJEM from another company in 2018 and have been really happy with their products ever since. We find that FlowJEM products are consistently high quality and they are very receptive when it comes to manufacturing custom devices. Overall, we've had a wonderful experience."*

*-Deepti Pant, Beth Israel Deaconess Medical Centre, Harvard Medical School*

# 5. ANALYTICAL MICROFLUIDIC DEVICES

## Unlock the Secrets Inside Your Microchannels with Chemical Characterization by FTIR Spectroscopy



We are excited to introduce our groundbreaking microfluidic product line, FlowSPEC. Our newest capabilities provide you with device equipped with an embedded ATR (Attenuated Total Reflectance) element, revolutionizing the way you analyze and understand on-chip chemical compositions. FTIR (Fourier Transform Infrared) spectroscopy is the ultimate tool in the arsenal of analytical chemistry, and here's why.

FTIR spectroscopy works like a molecular fingerprint scanner. By measuring how molecules interact with infrared light, FTIR reveals a wealth of information about chemical composition, functional groups, molecular structures and biological substances. With FlowSPEC, you can now introduce this capability with virtually any microchannel design.

With FTIR spectroscopy, you can:

- Identify Compounds: Quickly and accurately identify unknown substances in your samples. FTIR can distinguish between different compounds, even in complex mixtures.

- Monitor Reactions in Real-Time: Watch chemical reactions unfold in real-time, allowing you to optimize processes, ensure product quality, and save time and resources.

- Quantify Components: Determine the concentration of specific components within your samples, crucial for quality control and research.

- Investigate Molecular Structures: Understand the structure of organic and inorganic compounds, helping you to design better materials and products.

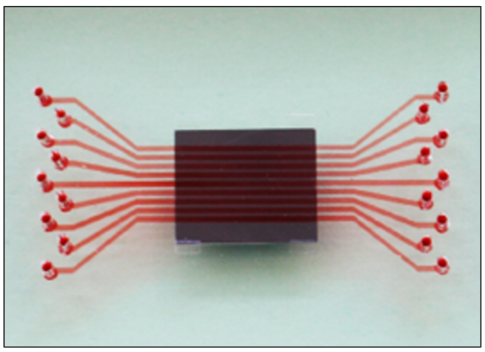
- Non-Destructive Analysis: FTIR spectroscopy is non-destructive, meaning you can analyze samples without altering or damaging them.

- Units should be either millimeters, or micrometers.

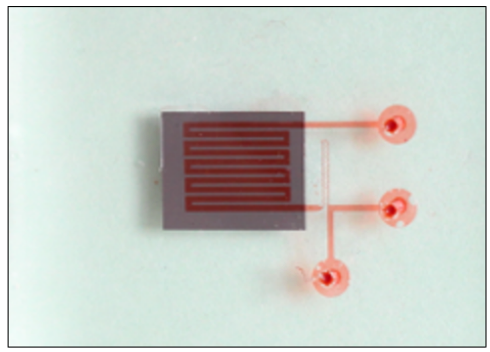
Incorporating FTIR spectroscopy into our microfluidic device opens up a world of possibilities for scientists, researchers, and industries across the spectrum. Whether you're in pharmaceuticals, environmental science, materials science, or any field that requires precise chemical characterization, our product will empower you to achieve more.

Consider your microfluidic design with embedded ATR-FTIR spectroscopy and uncover the hidden stories within your samples!

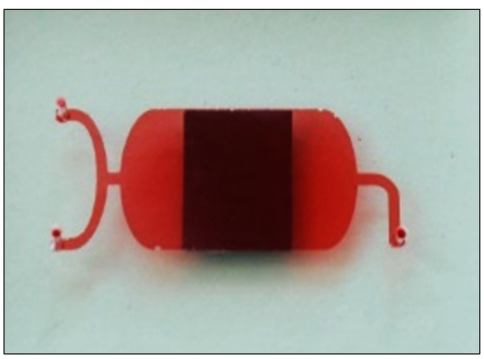
As an example, we present four FlowSPEC devices that have been recently featured in the literature: https://pubs.rsc.org/en/content/articlelanding/2023/lc/d3lc00388d/unauth AND https://pubs.rsc.org/en/content/articlelanding/2023/ay/d3ay00842h/unauth



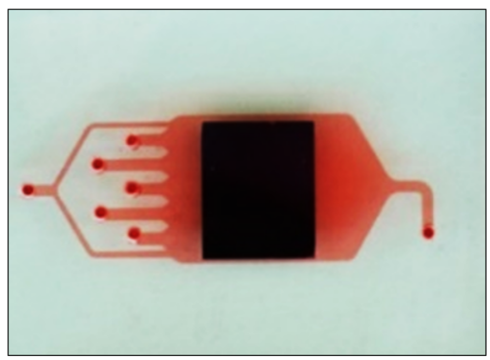
AMD-001



AMD-002



AMD-003



AMD-004

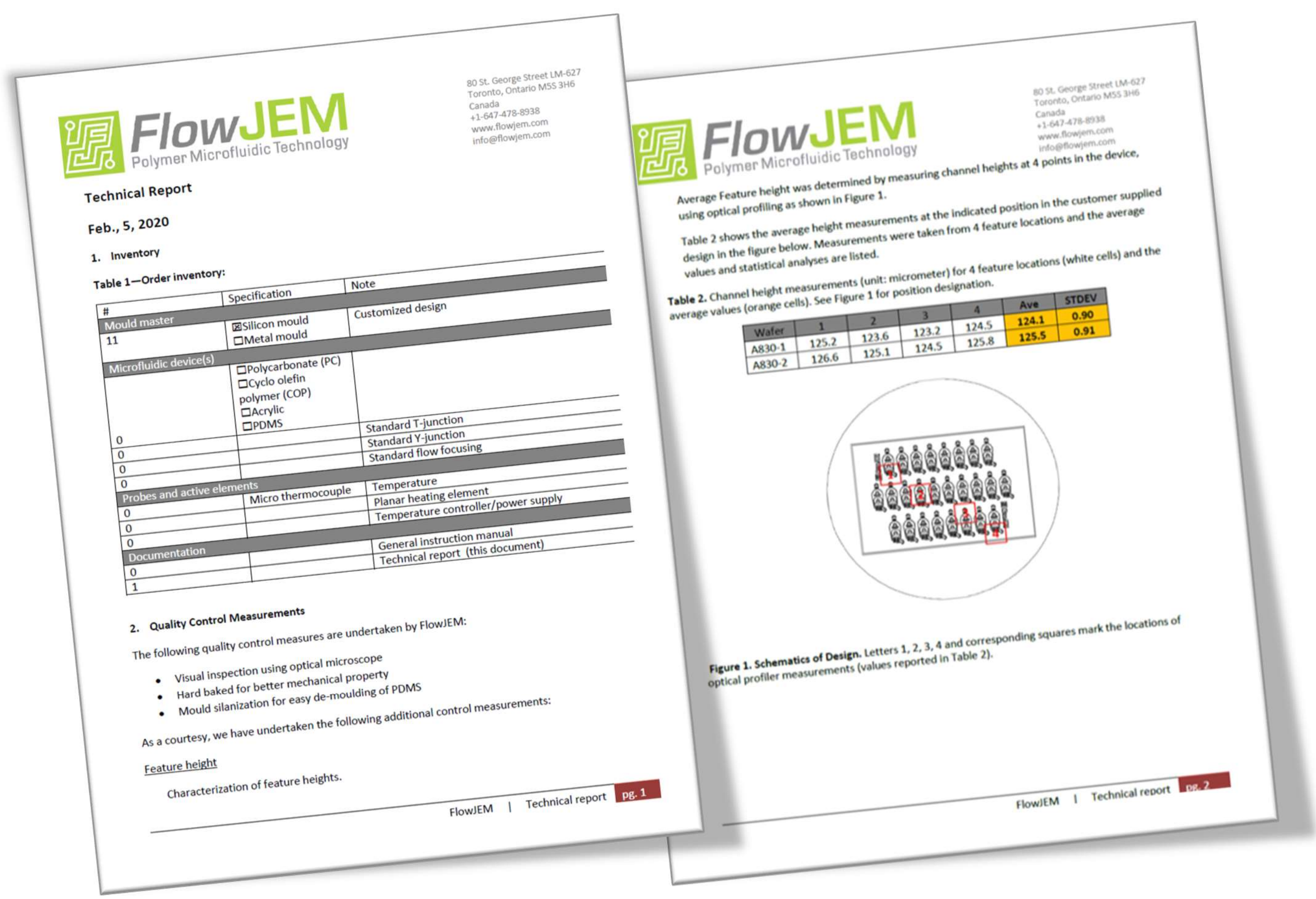
# 6. QUALITY CONTROL

FlowJEM adheres to strict quality control to ensure all jobs fit within the required design tolerances. Every mould part produced by FlowJEM is rigorously analysed to eliminate defects and to quantify the 3D channel environment. A technical report accompanies each report. These data are guaranteed to be accurate and can be used with 100% confidence by customers in their technical reports and journal submissions.

Custom reports, including 3D imaging of channel dimensions and higher measurement densities can easily be accommodated.

Reports include:

- A list of specific quality control measures that were used to ensure quality.
- A table of z-profile measurements from optical profilometry and reference image indicating measurement locations.
- (optional) 3D channel imaging



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Technical Report

Feb., 5, 2020

1. Inventory

Table 1—Order inventory:

| # | Specification | Note |
|---|---|---|
| Mould master | | |
| 11 | ☒Silicon mould ☐Metal mould | Customized design |
| Microfluidic device(s) | | |
| | ☐Polycarbonate (PC) ☐Cyclo olefin polymer (COP) ☐Acrylic ☐PDMS | |
| 0 | | Standard T-junction |
| 0 | | Standard Y-junction |
| 0 | | Standard flow focusing |
| Probes and active elements | | |
| 0 | Micro thermocouple | Temperature |
| 0 | | Planar heating element |
| 0 | | Temperature controller/power supply |
| Documentation | | |
| 0 | | General instruction manual |
| 1 | | Technical report (this document) |

2. Quality Control Measurements

The following quality control measures are undertaken by FlowJEM:

- Visual inspection using optical microscope
- Hard baked for better mechanical property
- Mould silanization for easy de-moulding of PDMS

As a courtesy, we have undertaken the following additional control measurements:

Feature height

Characterization of feature heights.

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Average Feature height was determined by measuring channel heights at 4 points in the device, using optical profiling as shown in Figure 1.

Table 2 shows the average height measurements at the indicated position in the customer supplied design in the figure below. Measurements were taken from 4 feature locations and the average values and statistical analyses are listed.

Table 2. Channel height measurements (unit: micrometer) for 4 feature locations (white cells) and the average values (orange cells). See Figure 1 for position designation.

| Wafer | 1 | 2 | 3 | 4 | Ave | STDEV |
|---|---|---|---|---|---|---|
| A830-1 | 125.2 | 123.6 | 123.2 | 124.5 | 124.1 | 0.90 |
| A830-2 | 126.6 | 125.1 | 124.5 | 125.8 | 125.5 | 0.91 |

Figure 1. Schematics of Design. Letters 1, 2, 3, 4 and corresponding squares mark the locations of optical profiler measurements (values reported in Table 2).

FlowJEM | Technical report pg. 2

# 7. MATERIALS

FlowJEM fabricates microfluidic devices in different materials. These materials have different characteristics, e.g. chemical resistance, gas permeability, surface properties, or softening temperature.

The choice of material depends on the application of microfluidic device (see e.g. Thermoplastic microfluidic devices for targeted chemical and biological applications. RSC Adv., 2017, 7, 2884).

Polydimethylsiloxane (PDMS) is an organosilicon polymer. It is optically clear, non-toxic, and gas-permeable. It is not stable in aromatic and hydrocarbon organic solvents and is typically used as a material of microfluidic devices working in aqueous systems.

FlowJEM offers different kinds of PDMS modification to fabricate microfluidic devices with hydrophobic, hydrophilic, or fluorophilic surfaces.

PDMS can be bonded to glass, silicon, or thermoplastic polymers.

Thermoplastic polymers. Microfluidic devices fabricated in thermoplastic polymers are stable in nonpolar, polar aprotic, and polar protic solvents, stable up to 100-120 $^{o}$C, have low gas permeability, are optically clear, and are biocompatible. FlowJEM offers microfluidic devices fabricated in:

- Polystyrene
- Polypropylene
- Polycarbonate
- Cyclic olefin copolymer (COC)
- Poly(methyl methacrylate)
- Poly (vinyl chloride)

# 8. INTERFACE ACCESSORIES

FlowJEM's offers accessory packages to enhance functionality of microfluidic reactors.

## Connection package includes:

- Ferrules
- Threaded connectors
- Inlet/outlet tubing (1/16") with inlet syringe adaptor

Optional interface systems can accommodate up to 8 fluidic connections and provides:

- Interfacing of fluidic connections with a microfluidic reactor.
- Interfacing of miniaturized probes with a microfluidic channel.
- Reinforcement of the sealed microfluidic reactor with O-rings to operate at high pressures and flow rates with no leaks.

Optional interface systems can accommodate up to 8 fluidic connections and provides:

- Interfacing of fluidic connections with a microfluidic reactor
- Interfacing of miniaturized probes with a microfluidic channel
- Reinforcement of the sealed microfluidic reactor with O-rings to operate at high pressures and flow rates with no leaks.

# 9. PRESSURE ADAPTER

FlowJEM offers a 3D printed multilevel pressure adapter which can be integrated with a multiplexed (multichannel) microfluidic device to operate it using a single pressure-driven source. This adapter is used to supply different liquids to multiple microchannels for e.g., optimization of chemical formulations.

An exemplary pressure adapter shown below has 3 inlets that can be connected to 4, 8, or 16 reservoirs to supply distinct liquids to 4, 8, or 16 channels, respectively, of the microfluidic device.

Customized adapters with a single inlet and 4, 8, or 16 outlets are available.

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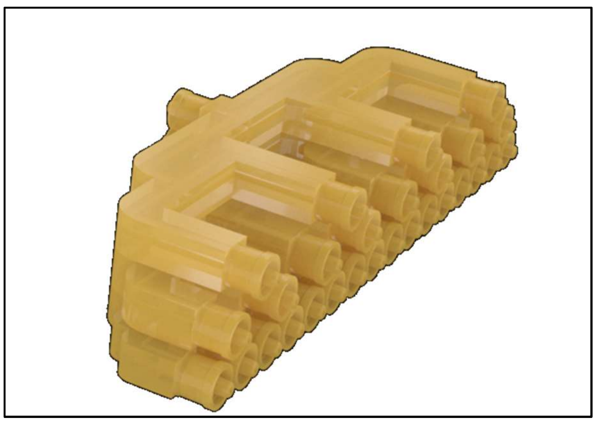

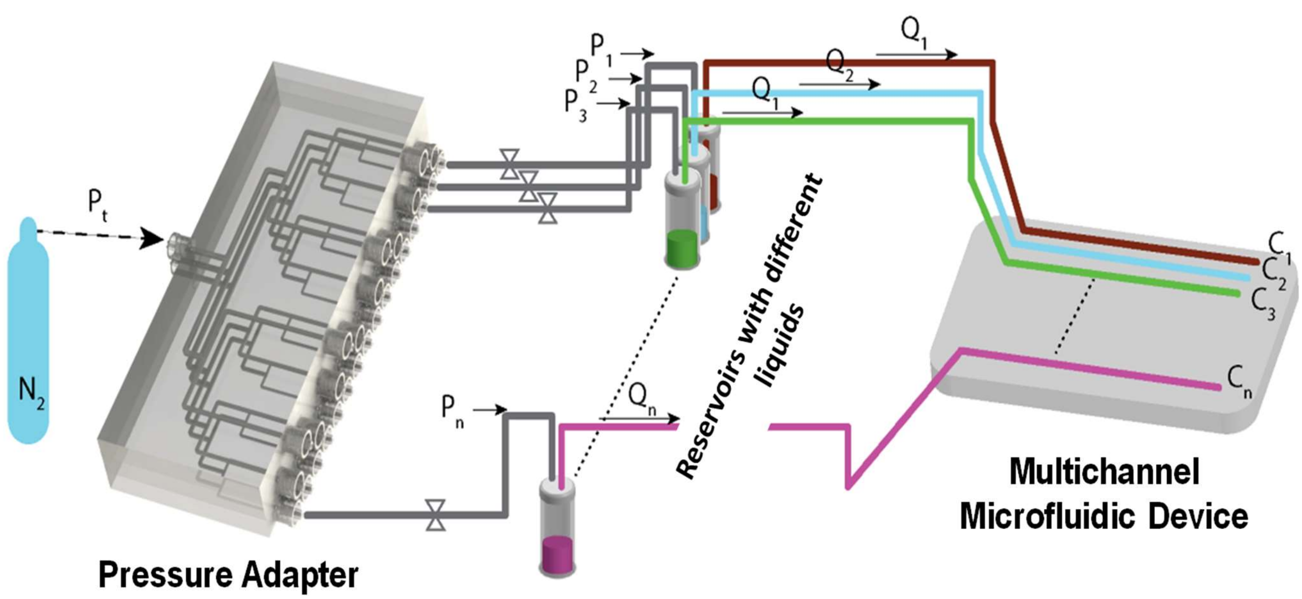

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