dolomite

DROPLET JUNCTION CHIP

USER INSTRUCTIONS

Contents

1. Getting Started **3**

1.1 Equipment 3

1.2 Installation 4

2. Functions **5**

2.1 Junctions 5

2.2 Spitting the flow 6

3. Understanding Droplets **7**

3.1 Generation 7

3.2 Sample Case 9

3.3 Pump Pulsations 10

4. Troubleshooting **10**

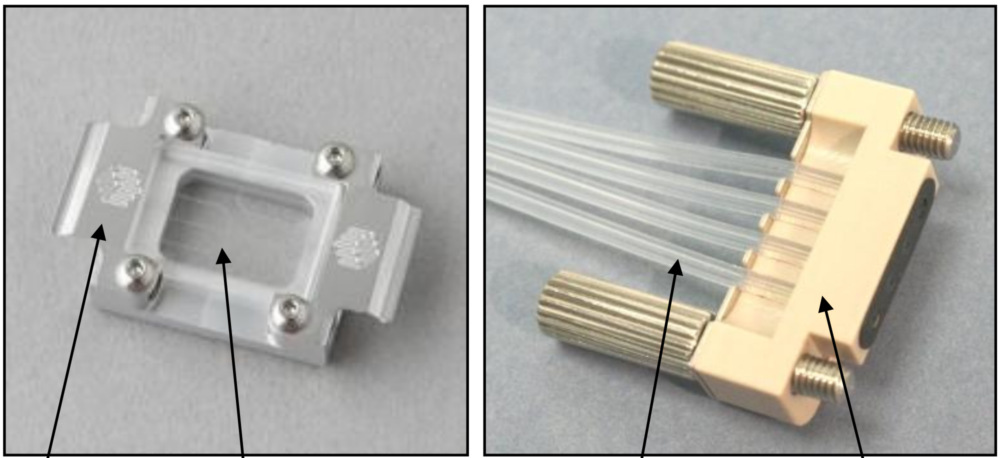
4.1 Blockages 10

1. Getting Started

1.1 Equipment

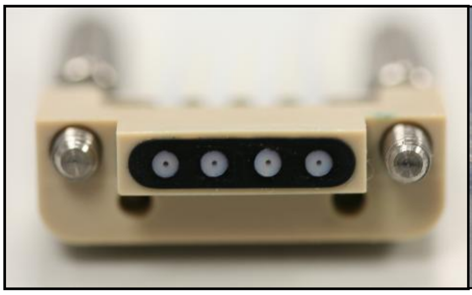
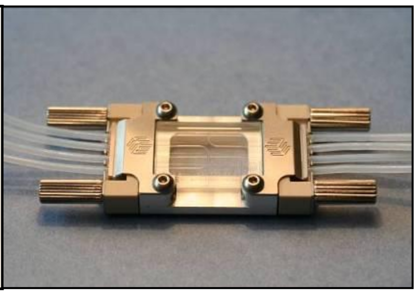
You will need the following:

- Droplet Junction Chip (Part No. 3000158)
- Chip Interface H (Part No. 3000155)
- Linear Connector 4-way with Seal (Part No. 3000024)
- 8 lengths of 1.6mm OD tubing with connectors
- A pump



1.2 Installation

1. Insert the lengths of tubing into the edge connectors. Ensure that the ends of the tubes have been neatly cut and are flush with the edge of the seal. Even if you are not using all the connections, tubes must be placed in each slot to form a good seal.
2. Place the Droplet Junction Chip into the Chip Interface and then connect the Linear Connectors. It is recommended that you tighten each connector a bit at a time until both connectors are finger tight.

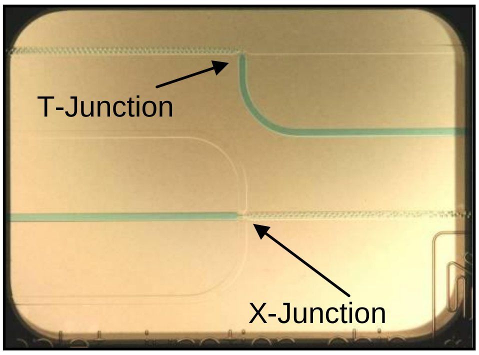



3. Connect the tubes to the pump by whatever means required.
4. Start pumping. If you find any leaks on the chip, ensure the tubes are still flush with the end of the seal and that all 8 tubes are fitted (even they are not all going to be used).

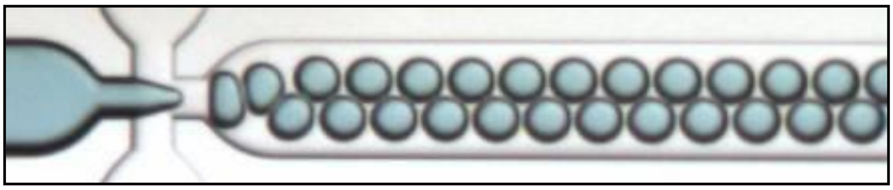
2. Functions

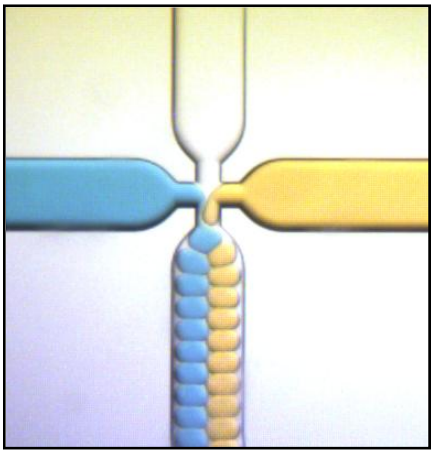
2.1 Junctions

The Droplet Junction Chip has multiple functions. Its two junctions and their uses are as follows:



- **X-Junction:** This can be used for droplet generation, or to split a flow three ways. Below are two images of different types of droplet generation that can be formed using the X-Junction.



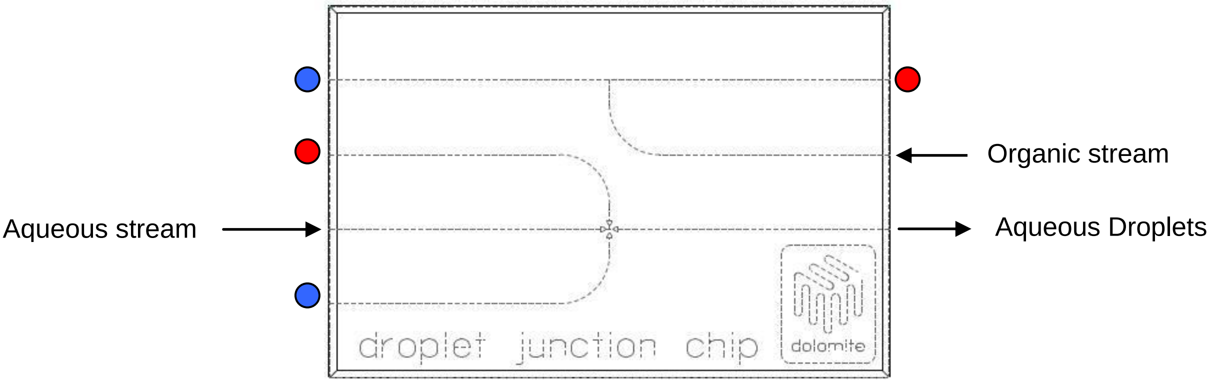


- **T-Junction:** This can be used for droplet generation, or to split a flow into two. The image shows aqueous droplets in an organic carrier phase.

The X-Junction will produce droplets in the centre of the channel whereas the T-Junction has a tendency to push them towards the top. The T-Junction is often used to split a flow from a pump, and then the split flow is fed into two of the X-Junction inputs.

2.2 Splitting the flow

The 2 junctions on the chip can be used separately for different droplet forming applications. However, in the majority of cases, optimum droplet formation is achieved by using the 2 junctions in combination. To use the droplet junction chip in this way, the connections shown below should be made. Connect red – red and blue – blue with equal lengths of tubing to ensure equal flow rates of the 2 organic streams into the X-Junction. Using this format, aqueous droplets will be formed in the organic stream.



3. Understanding Droplets

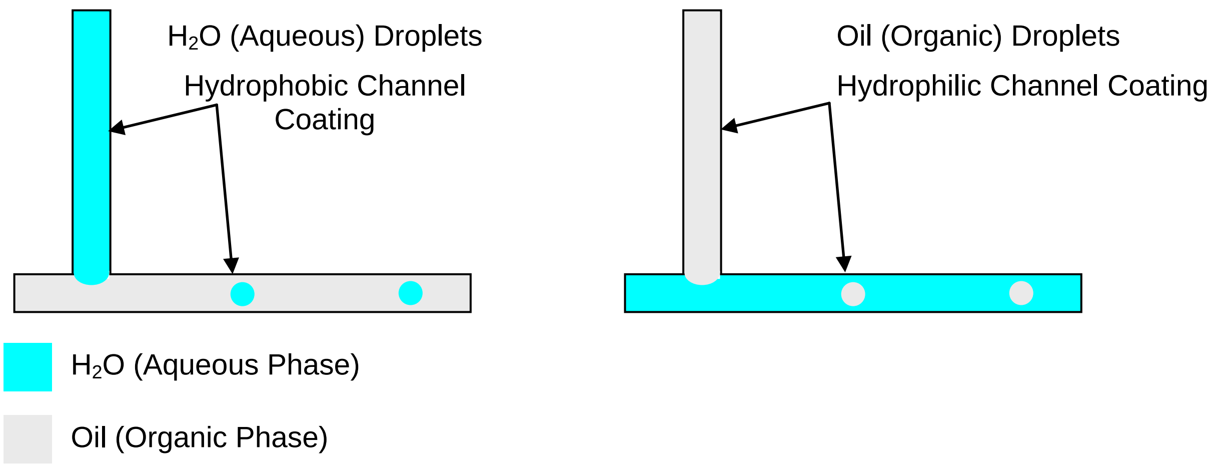
3.1 Generation

Droplets can be formed over a wide range of flow rates, viscosities and with different amounts of surfactant. However, sometimes droplet formation can be quite elusive. The following tips should help you to form droplets of the correct size and frequency.

- Ensure your chip has the correct coating. That is, to form aqueous droplets you will require a hydrophobic coating and an organic carrier phase. To form organic droplets you will require a hydrophilic coating and an aqueous carrier phase. Note that glass is naturally hydrophilic.
- Droplets will usually form when the flow rate of droplet phase is equal to the flow rate of the carrier phase. However, variations in viscosity and surfactant level can change this. If you find you are getting annular or side by side flow at equal flow rates, try decreasing the flow rate of droplet phase or increasing the flow rate of the carrier.
- Once you have droplets forming, increasing the flow rate of droplet phase will increase the size of the droplets, and decreasing the flow rate of the droplet phase will decrease the droplet size. The opposite is true for the carrier phase.
- Surfactants such as SPAN and TWEEN are often added to the organic phase to increase the stability of the droplets. If you find that your droplets quickly become unstable and merge, try increasing the level of surfactant in the organic phase. Dolomite typically uses 1% SPAN in mineral oil for the organic phase.
- With high viscosity fluids lower overall flow rates can help droplet production. For example, reducing the flow rate by a magnitude of 10, from, say, 100µl/min to 10µl/min.

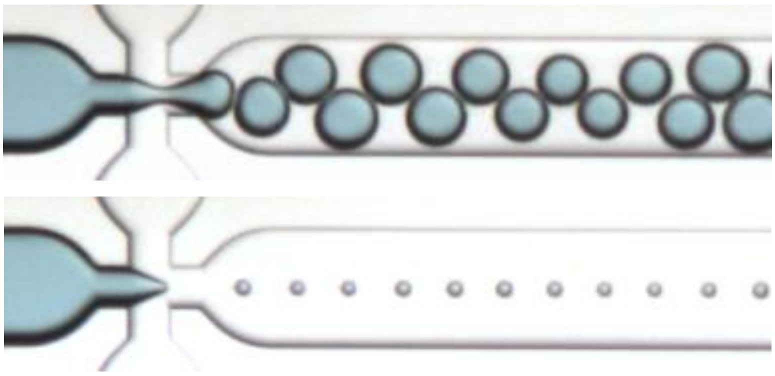
Examples:

1. Channel coatings:



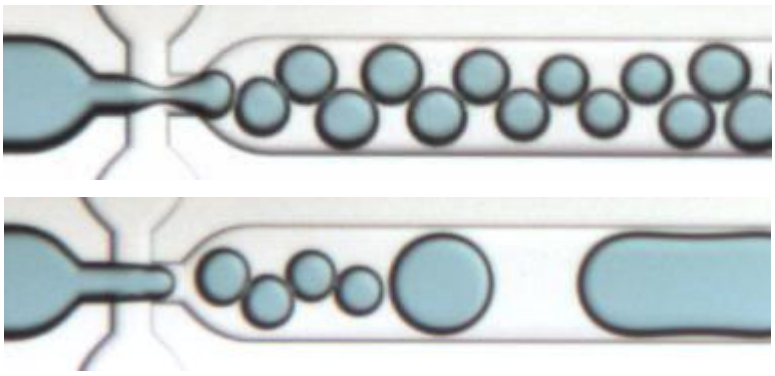
Note: Glass is naturally hydrophilic and PDMS is naturally hydrophobic.

2. Varying the flow rates:



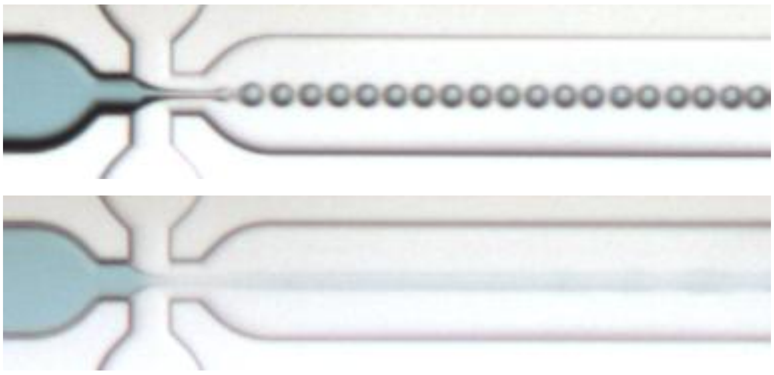
The top image show the droplets formed with the droplet and carrier phases at 2µl/min. The bottom image shows the effect of increasing the carrier flow to 50µl/min.

3. Changing the surfactant level



The top image shows the droplets formed with 1% surfactant in the organic carrier phase. The bottom image shows the effect of removing the surfactant: droplet instability.

4. The effect of viscosity

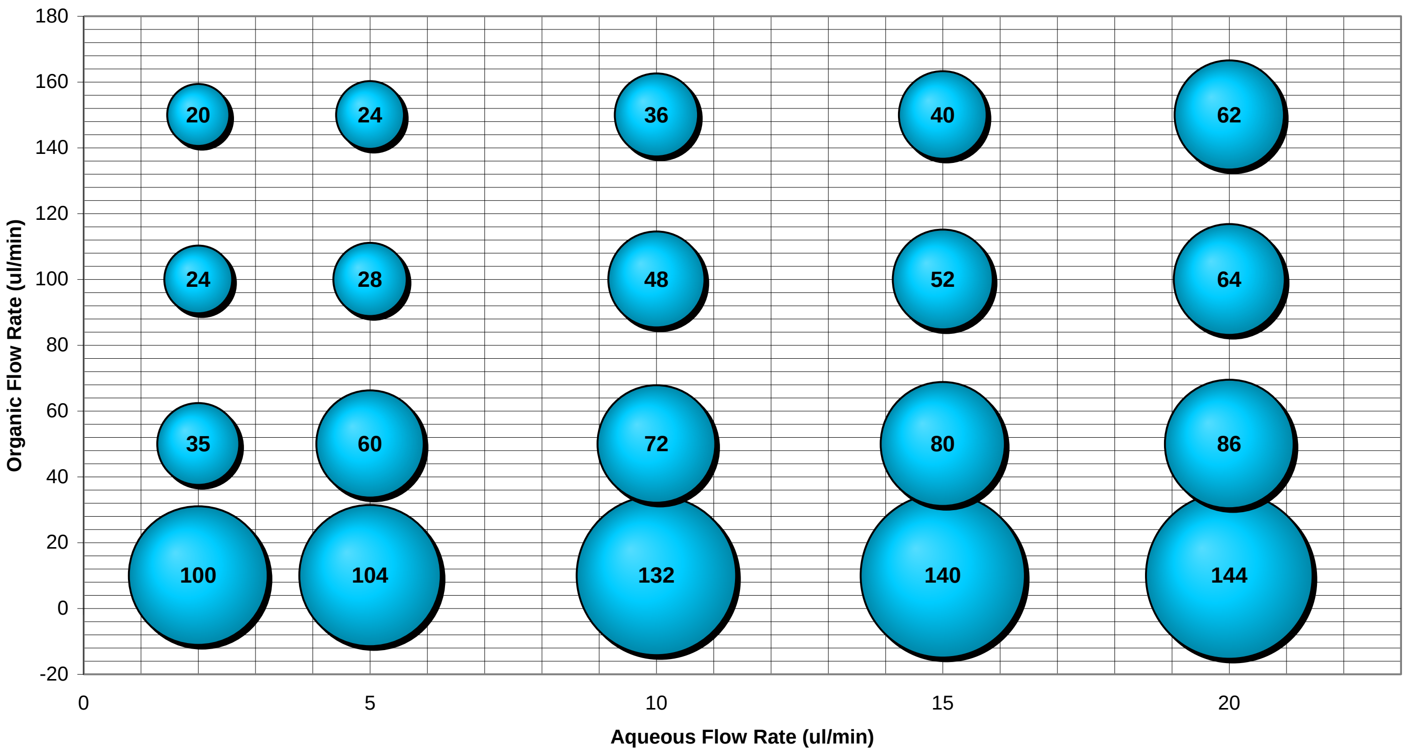


The top image shows an example of droplets formed when the droplet phase had a viscosity of 1cP and a carrier phase had a viscosity of 50cP. The bottom image shows the impact of increasing the droplet phase's viscosity to 50cP. In this case, lower flow rates were used to resolve the problem.

3.2 Sample Case

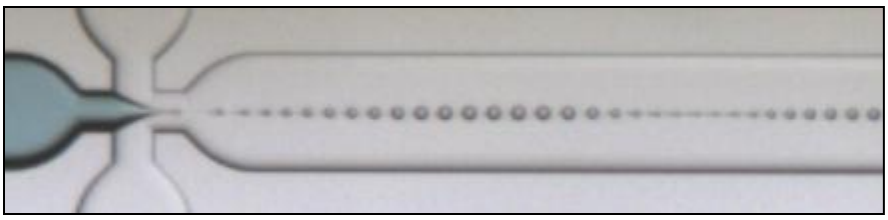
Sometimes when forming droplets it is easiest to start with a set of conditions known to form good droplets and then work from there. The following chart shows typical droplet sizes formed when using the X-Junction with water for the droplet phase and mineral oil (~50cP) with 1% surfactant for the carrier phase.

Typical droplets generated using the X-junction on the Mitos Droplet Junction Chip. The organic carrier phase is mineral oil with 1% span and the aqueous phase is H2O with blue food dye. The droplet sizes are in microns.



3.3 Pulse Pulsations

The flow rates used in microfluidics are incredibly small. This means that even very small fluctuations in a pumps output will result in droplets changing size and frequency. The image below shows an extreme example of the pulsing in droplet size caused by a pump with a fluctuating output.



The challenge of developing a pulse free pump is one that Dolomite has been working towards. Technology has shown significant improvements over the past few years, but even today's best off-the-shelf pumps have limits. If you are having problems with fluctuations in droplet size then your best options are:

a. If using a syringe pump, try using a different size of syringe (smaller is usually better).

b. Contact Dolomite, explain the flow rates you are using and find out what the latest advances are in this field. Dolomite will be releasing a new Gas Pump specifically designed for pulse free flow.

4. Troubleshooting

4.1 Blockages

The best way to avoid blockages is to filter all fluids before pumping them into the chip. The narrowest junctions are 100 x 105µm and filters should be chosen accordingly.

Despite your best efforts, blockages will occur. There are a number of methods for removing them.

- Flush the system with fluid at a high flow rate >100µl/min
- Flush the system with a chemical that will dissolve the blockage. For example, Dolomite often uses acetone.
- Out think the blockage. That is, strategically pump fluids down different channels to force it out.
- If available, place the chip in a sonication bath for 10 minutes to dislodge the blockage, and then flush the chip with a fluid. Repeat sonication for a longer time period if necessary.
- BEST OPTION. If available, connect the chip to a pressurised gas canister and pump high pressure gas though the chip. Chips are tested up to 30bar, but it is recommended that pressures of 10bar are used. At Dolomite nitrogen is used.

REMEMBER: Whether pumping a chemical to dissolve the blockage or a gas to force it out, exercise all necessary precautions. Also, remember to clean the chip out afterwards.

The Dolomite Centre Ltd.
Unit 1, Anglian Business Park, Royston,
Hertfordshire, SG8 5TW, United Kingdom

T: +44 (0)1763 242491
F: +44 (0)1763 246125
E: info@dolomite-microfluidics.com
W: www.dolomite-microfluidics.com

Dolomite Microfluidics
29 Albion Place
Charlestown, MA 02129

F: 617 848 1211
F: 617 500 0136
E: salesus@dolomite-microfluidics.com
W: www.dolomite-microfluidics.com