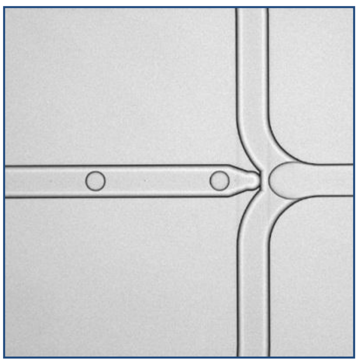
micronit

MICROFLUIDICS

A GUIDE TO DROPLET GENERATION



www.micronit.com

CONTENTS

INTRODUCTION

The use of droplet generators as a research tool ensure you have both an easy to set-up system and a versatile platform for your investigations. Droplet generator chips offer a way to create highly defined bubbles and droplets with a high uniformity at user defined production rates.

Use a droplet generator chip for fast and uniform droplet production

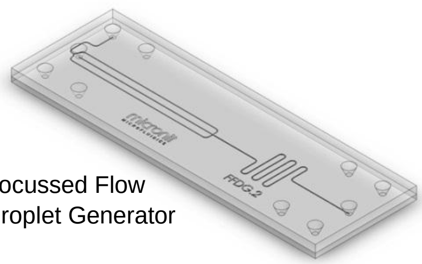
Key features of droplet generator chips:
- Selection of device for a range of droplet sizes
- Chemically inert materials
- Large viewing area of channels
- A building block in a modular system

DROPLET GENERATORS

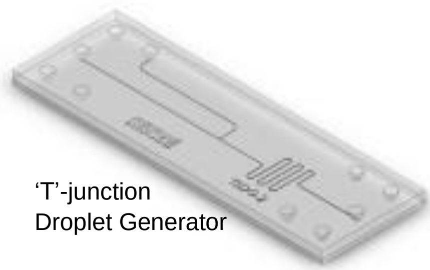
All the chips are made of borosilicate glass and are delivered in a polymer (PP) cartridge of 75 x 25 mm which is compatible with the Fluidic Connect 4515 chip holder and the Fluidic Connect PRO chip holder. These chips can be supplied as either hydrophilic or hydrophobic allowing a variety of both oil and water based droplets to be produced.

A CHOICE OF DESIGNS

Microfluidic droplet generators are excellent tools for generating reproducible micron sized droplets with much higher precision and repeatability compared to conventional methods. Two designs are available; a focussed flow and a 'T'-junction design. Typical droplet sizes, which the range of microfluidic chips can cover, are 10-500 microns in diameter.



Focussed Flow
Droplet Generator



'T'-junction
Droplet Generator

Do you want different features for your droplet generators?
- More inlets or outlets
- Different channel dimension or parameters
- Integrated electrodes
- Other material choices: Fused Silica / Quartz glass / Polymeric materials

Contact us to have your own custom made droplet generators. **See page 9 for more information.**

DROPLET GENERATION

The choice of the correct droplet generator for your application is sometimes not any easy one. There are many variables which can affect the size, frequency and consistency of the droplets produced including:

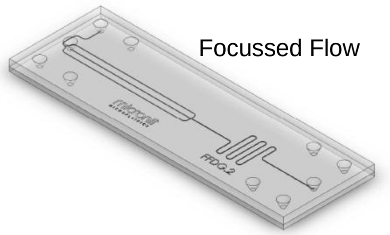
- Channel dimensions and geometry
- Flow actuation stability
- Flow rates of each fluid, both relative and total
- Channel wetting properties: hydrophobic (coated), hydrophilic (uncoated), etc.
- Miscibility of the continuous (outer) and dispersive (inner) fluids
- Viscosity and surface tension of the continuous (outer) and dispersive (inner) fluids
- Surfactant type and concentration

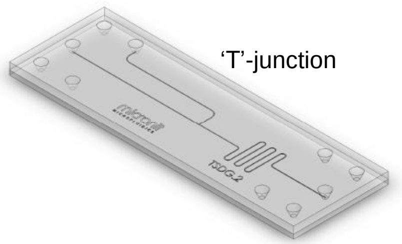
DROPLET GENERATOR GEOMETRY

Two of the standard microfluidic geometries used for the production of droplets are focussed flow and 'T'-junction.

Focussed flow geometry

The focussed flow design consists of a cross junction where the inner fluid or dispersive phase enters through a single channel and the outer fluid referred to as the continuous phase impinges on the dispersive phase from two channels diametrically opposite each other. This combination of dispersive phase surrounded by continuous phase flows through the output channel, via the orifice. The orifice is a constriction in the channel used to create a controlled break-up of the dispersive phase into droplets.


Focussed Flow


'T'-junction

'T'-junction geometry

The 'T'-junction consists of a single straight channel containing the continuous phase and a side channel from which the dispersive phase is injected into the flow as droplets. This design requires no orifice for the production of droplets, however the Micronit 'T'-junction includes a specially designed orifice to ensure the stability of the droplet production.

Ultimately, the choice of geometry is generally based on the fluids used and the production rates required. A general rule is that for higher flow rates the focussed flow geometry tends to provide a more stable droplet formation system than the 'T'-junction.

FLOW RATE CONTROL

Another key factor to the production of uniform droplets is stability of the fluid flow activation. In order to have a system running with constant throughput a settling time is needed between changing flow rate parameters and obtaining droplets with low polydispersity. This time varies dependent upon the actuations system used, with the worst case being 20 minutes wait time for a system using a coarse controlled syringe pump and large plastic syringes, with long sections of Teflon tubing for interconnection to the system. Once the system flow parameters have been set and the stabilisation period is finished, the production mechanism of the droplets shows only small variations. The time to reach stable production can be reduced by using shorter interconnection tubing, as well as pressure driven flows or syringes pumps with reduced pulsations to the flow rate pumping.

DROPLET SIZES AND PRODUCTION FREQUENCIES

Effect of flow rate ratios

The use of flow rate ratio variation as a control parameter for selecting droplet size is a well-established technique due to both its simplicity and robust repeatability. What can be seen is that the increase in the continuous phase flow rate compared to the dispersive phase flow rate enables the creation of smaller droplets and conversely a decrease will lead to an increase in size. The system will reach a natural limit in terms of the variations, as too slow a rate of flow for the inner fluid will cause droplet production to stop and two fast a rate will mean the dispersive phase will run parallel to the continuous phase with no droplets formed. A further effect of varying the flow rate ratio is to alter the production frequency. This however is not purely dependent on the flow rate ratio, but is also affected by the individual flow rates as well as the fluid parameters themselves. Depicted in figure 1 is a guide to the range of frequencies possible for our FFDG2.0 droplet generator chips when the flow rates of the fluids and the viscosity ratios are varied.

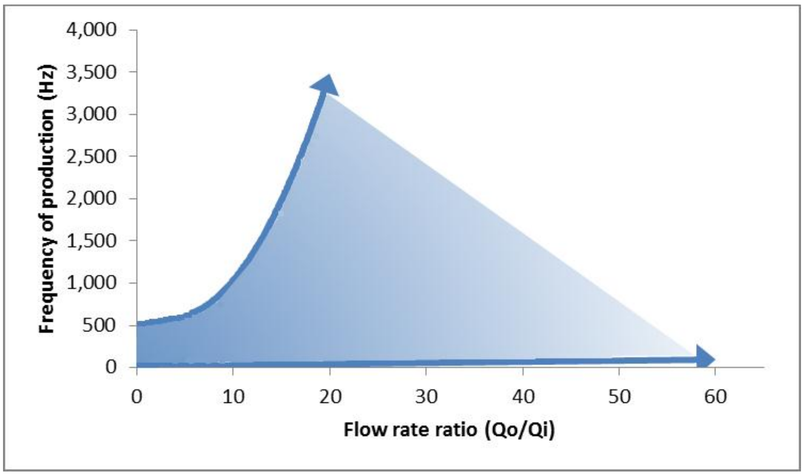


Figure 1: Frequency ranges possible for FFDG2.0 droplet generators with varying flow rate ratios and fluid viscosities.

The above range of frequencies investigated give a variation in droplet size as can be seen in the figure 2, for these measurements the error on the size is of the order of the size of the data point. What can be seen is that there is a strong relationship between the size of droplets produced and the frequency of production. A general rule of thumb for a particular microfluidic device, the smaller the droplets created the faster the frequency at which this can be achieved. Naturally, there is a lower limit to the size a particular device can achieve and this is based upon the physical size and individual geometry of that particular device.

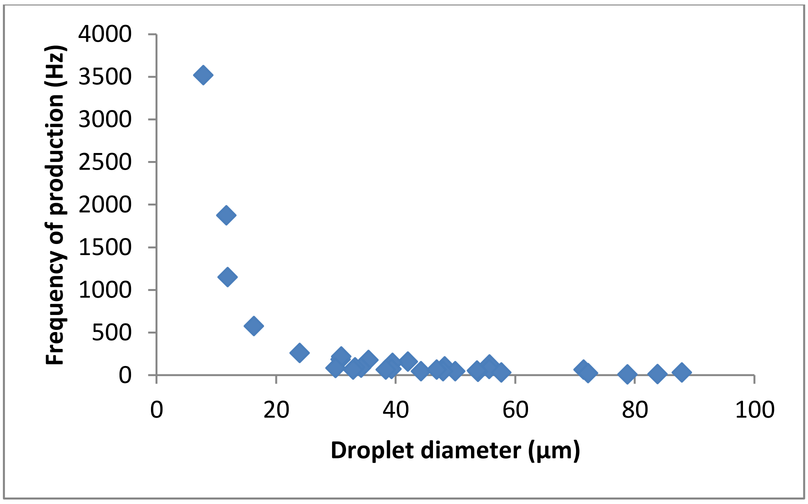


Figure 2: Frequency versus droplet sizes produced

Effect of total flow rates
As a general rule, increased total flow rates lead to increased production frequencies for the droplets. However, there is a natural limit to this trend as at sufficiently high flow rates the fluids will flow parallel to each other with no real interaction or droplet formation occurring.

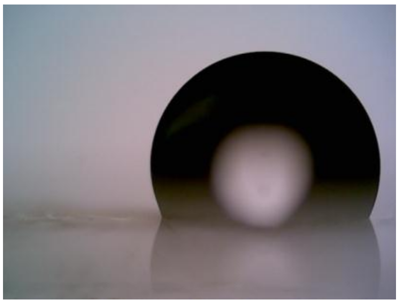
FLUID SELECTIONS

A key factor in droplet size and production is the interfacial surface tension between the continuous and dispersive phases. The interaction between the two fluids can influence the production rates and sizes of droplets produced, with rates increasing and sizes decreasing as the value for interfacial tension decreases.

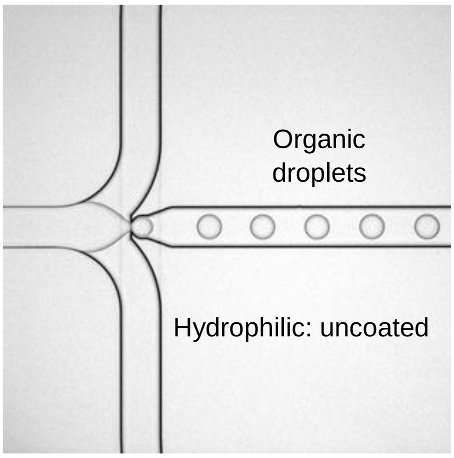
The choice of fluids used in droplet generation is generally based on what is under investigation. However, in order to ensure good droplet formation two fluids that are immiscible are necessary. It is also recommended that the use of highly viscous fluids is avoided for small channel geometries as this has an adverse effect on flow rates and pressures, as high viscosity fluids tend to break-up into larger droplets than fluids of lower viscosity.

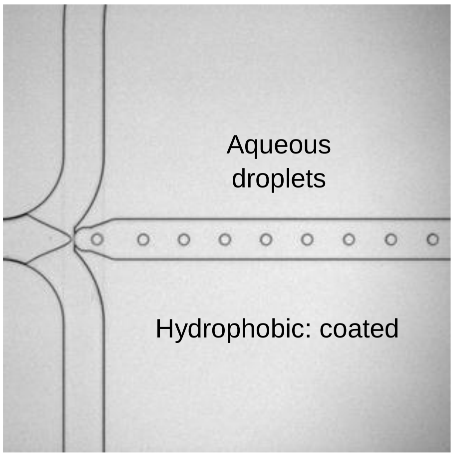
SURFACE WETTING PROPERTIES

The contact angle between the fluids and the droplet generator surface are key for defining the stability of the wetting of the continuous phase, if the wetting is more preferential for the dispersive phase then pinning of the droplets to the channel can occur. The standard uncoated droplet generators of Micronit are glass based, thus hydrophilic and are suitable for making organic droplets in an aqueous phase (oil-in-water droplets). It is possible for Micronit to provide a coating which renders the surface of the droplet generators hydrophobic, thus suitable for making aqueous droplets in an organic phase (water-in-oil droplets). This coating is based on a fluorinated polymer and ensures the coated surface has a contact angle of more than 90º with water.



Hydrophobic surface coating





SURFACTANT ADDITIONS

The use of surfactant fluids, in very low concentrations of around 1-5% v/v, aids the stability of the droplets produced and reduces the instances of droplet coalescence. The surfactant population concentrates at the interface between the two fluids as the molecules naturally orientate to have the hydrophilic head and hydrophobic tail in contact with the appropriate fluid. Choices of surfactant are dependent on the fluids used for the production if the droplets:

- Addition to organic fluids: Span 80 and Triton X-100
- Addition to aqueous solutions: Tween 80 and SDS (sodium dodecyl sulphate)

RECOMMENDED CLEANING TECHNIQUE

In general it is advisable to use pre-filtered fluids in the droplet generators, as channel sizes are small and blockages can easily occur. This should help to reduce blocked channels and prolong the lifetime of the chip. However, it is still necessary to maintain your droplet production system, including occasionally cleaning the droplet generator chip. In case this is needed we recommend to flush with deionised water, an organic solvent or another compatible fluid. Please note that the cleaning of coated chips requires special attention as the use of acids and bases can remove this coating over time. To remove larger blockages from the channels we recommend placing the chip in an ultrasound bath for 10-15 minutes before flushing fluids through the system at high pressures (15bar) or flow rates (100-200µl/min). The use of chemicals for more abrasive cleaning is possible if necessary, such as the use of sequential flushing with acetone, distilled water and finally isopropanol or another alcohol solution.

Finally for uncoated pure glass devices it is possible to use a solution of sodium hydroxide (NaOH). A solution of 1M sodium hydroxide in water is effective, however lower concentrations might also be sufficient. If traces of the cleaning solution remain inside the chip after cleaning and rinsing with water is not possible then ammonia can be used instead. Please note this should not be attempted with coated devices, as coatings may be removed.

FLUIDIC CONNECT PRO

The Fluidic Connect Pro offers a user-friendly way of creating your own lab-on-a-chip setup within minutes. The durable and robust platform design is compatible with a large variety of microfluidic chips meaning droplet generation, micro-reactions, cell analysis, and many more applications can be carried out on one single system. The chip-holders can be used in conjunction with standard laboratory equipment such as syringe pumps and upright and inverted microscopes. The load and seal design assures tight connections without the possibility of breaking precious microfluidic chips. By cleverly making use of inserts the holder can easily be adapted to chips of different sizes and thicknesses. It is even possible to connect multiple chips at the same time.

Use the Fluidic Connect Pro for your lab-on-a-chip experiments and reduce your time to obtain results!

Key features of Fluidic Connect Pro:

- Fast, easy, and leak-free fluidic connections
- Chemically inert materials
- Large chip viewing area
- Compatible with upright and inverse microscopes
- A building block in a modular system
- Standard and custom chips available
- Holder defined sealing to prevent chip cracking
- Simultaneous connection of multiple chips
- Able to connect chips from 15 x 15 mm up to 30 x 90 mm

	Fluidic Connect PRO	
Sealing Mechanism	Load ‘n' Seal	
Chipholder Material	Aluminium	
Dimensions (L, W, H)	128 x 85,4 x 20 mm	
Max. Operating Temperature	80ºC	
Max. Operating Pressure	10 bar	
Sealing Material	Perlast (FFKM)	
Compatible Chip Thickness	1.1 – 2.0 mm	
Compatible Chip Sizes	15 x 15 mm 15 x 30 mm 15 x 45 mm 15 x 60 mm 15 x 90 mm	30 x 30 mm 30 x 45 mm 30 x 60 mm 30 x 90 mm 25 x 75 mm*
Compatible Tubing	1/16 inch OD Teflon, Stainless Steel, PEEK	

* Microscope Slide Format

CUSTOM DROPLET GENERATORS

Micronit also offers the possibility for customised microfluidic chips using the Fluidic Pro prototyping service. This prototyping service means purpose-designed droplet generators can be created to match your product needs. Fluidic Pro prototyping service is an affordable way to create custom chips compatible with your Fluidic Connect PRO chip holder. The service means your microfluidic designs will be manufactured in a class 100 cleanroom by professionals, while you stay focussed on your research. It saves you time both in design and lab hours, speeds up your research, makes you more productive and allows you to publish sooner.

Fluidic Pro designs offers maximum freedom through a wide range of possibilities.

- **Customised designs**
- **Glass or fused silica**
- **Coated or non-coated versions.**
- **Wide range of channel depths and widths**
- **Thick- or thin-bottom chips, suitable for confocal microscopy**
- **Integrated electrodes (Pt, Au, etc.)**
- **Up to 4 different designs per batch**
- **Small batches starting with only 12 chips**

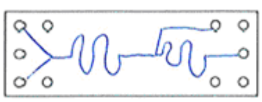
Micronit has more than a decade of experience in microfluidic chip manufacturing for science and industry, making us your perfect partner to outsource your microfluidic chip needs.

Standard options include:

- Single depth etched
- Single depth etched with thin bottom
- Single depth etched with electrodes
- Double depth etched
- Fused silica single depth etched
- Single depth powder blasted

A few simple design guidelines make these cost savings and short lead times possible:

- **Make up to 4 different designs** of a desired channel layout. These can be presented as CAD designs but simple sketches or just a written description is also fine.
- **Contact the Micronit sales team** to discuss your requirements and receive a quotation.
- After you have contacted us our microfluidics design experts will transform your concept into CAD designs.
- We will send the designs to you for a final check and after your approval we will start processing.
- **After 4 to 5 weeks**, you will receive your chips and you can start your research.



+

micronit MICROFLUIDICS

=

Micronit Microfluidics 2014

Address	Colosseum 15
	7521 PV Enschede
	The Netherlands
Phone	+31 53 850 6 850
Fax	+31 53 850 6 851
E-mail	info@micronit.com
Website	www.micronit.com
Webstore	store.micronit.com