Droplet Generation

Explore droplet-based microfluidic solutions

High-throughput generation of monodisperse droplets in the femto- to nanoliter scale has opened up unlimited experimental possibilities. From digital PCR and single cell experiments to particle synthesis, droplet generators have found their way into laboratories.

Find out what microfluidic ChipShop has to offer to help you in successfully setting up your droplet generation experiment.

Droplet Generators
- Wide selection of chip designs and channel dimensions available off-the-shelf
- Available nozzle sizes: 10 µm - 140 µm
- Multi-function chips: Droplet generation with storage unit

Pump Setups
- Pressure-driven pump and syringe pump setups, both ensuring high monodispersity & superior flow rate control are available at microfluidic ChipShop
- Order a complete pump setup including flow controller, flow units, software and accessories to kick-start your droplet-based experiments

Droplet Generation Kit
- Everything one needs for a successful droplet experiment
- Including accessories and droplet oil suitable for digital PCR and droplet-based cell culture

Custom Designs
- microfluidic ChipShop offers manufacturing services to realize your personal design

Contact in Japan ASICON Tokyo Ltd.
www.asicon-tokyo.com / asicon-tokyo@asicon-tokyo.com
Droplet Generation - Introduction

Droplet Generation in a Nutshell

One of the fields in which microfluidics has produced innovative solutions is droplet-based microfluidics. The ability to generate a large number of droplets of very uniform size has led researchers to many new applications. By compartmentalizing a biological sample, e.g. droplet-based or so-called digital PCR became possible. Other applications comprise the generation of extremely well-defined emulsions, the synthesis of nanoparticles or the encapsulation of single cells. As the droplet volume can be very small, concentrations of e.g. cell metabolites quickly increase and can be easily analyzed. Droplet motion in the microchannel induces streaming, which allows for a rapid mixing of reagents contained in the droplets. Since the droplet contents never come into contact with the microchannel walls, there is no contamination or carry-over from one droplet to another.

For droplet generation a defined microfluidic channel-cross design, also called nozzle, is required. At the nozzle two immiscible phases, the dispersed phase and the continuous phase, meet at an angle and droplets are generated. Typically, the continuous flow rate is higher than the disperse flow rate. The nozzle size and the ratio of sample (disperse phase) to oil (continuous phase) define the size of the droplets, while flow rates of sample and oil phase define the throughput of the system.

In order to increase the stability of the generated emulsion, emulsifiers can be used. An emulsifier is a substance that stabilizes an emulsion by increasing kinetic stability. One class of emulsifiers is known as “surface active agents” or “surfactants” that typically have a hydrophilic and a hydrophobic part. Surfactants have a large say in the configuration of droplets and prevent droplet coalition. Attention should also be paid to the channel surface wettability, i.e. to produce water in oil (W/O) droplets the microfluidic channel should have a hydrophobic surface. As the majority of droplet experiments in microfluidics are based on W/O, microfluidic ChipShop’s droplet generators possess a hydrophobic surface.

Beside the droplet generator, an appropriate pump system is needed for your successful droplet generation experiment. Highly monodisperse droplets (see bottom graphs) can be generated with pressure-controlled pumps as well as with high-end syringe pumps. The quality of your droplets is a function of the microfluidic chip, its design, the reagents, in particular the surfactants, the pumping system and your experimental setup. Despite having many influencing factor, droplet generation on chip is an easy task and you will have immediate success. Promise.
Successful droplet generation does not require much! Here is what you need for droplet generation experiments on chip:

1. Microfluidic droplet generation chip
2. Fluidic accessories like
   a. Fluidic interfaces: e.g. Mini Luer or Luer fluid connectors
   b. Tubing
   c. Soft tubes (silicone) as sleeves
   d. Adapter frame for convenient handling
3. Reagents
   a. Oil
   b. Surfactant
4. Pump setup

**Chip Summary**

microfluidic ChipShop offers a multitude of droplet generator chips in microscope slide format. The chips vary greatly in design and complexity. The following design features should be considered when choosing the appropriate chip for your successful droplet experiment:

- **Interface type**
  All droplet generator chips either possess Mini Luer or Luer interfaces for a convenient connection of the chip with an appropriate pump system. Please ensure that you choose the adequate connectors and plugs when setting up your droplet generation experiment.

- **Nozzle size**
  Along with flowrates and the collection channel proportion, the dimension of the droplet creating cross junction is defining the droplet size. microfluidic ChipShop offers nozzle sizes as small as 10 µm up to 140 µm.

- **Nozzle geometry**
  At microfluidic ChipShop various channel geometries at the droplet generating side are available to enable a wide variety of options for your droplet generation experiments.

- **Droplet generator units per chip**
  One microfluidic chip in the size of a microscope slide can contain several droplet generator units. Chips with one to eight units are featured in microfluidic ChipShop’s portfolio.

- **Geometries per chip**
  A microfluidic chip containing several droplet generator units can either feature the same unit design multiple times or nozzle size and geometry are varied to offer a greater flexibility in the evaluation of droplet generation.

- **Storage option**
  Droplet generators with storage option enable generation of droplets and storage/capture of single droplets for optical analysis on the same device.

All chips are available in two materials, Topas and PC. Please be aware of material compatibility when setting up your droplet generation experiment. When utilizing silicone-based oils we recommend the use of Topas chips, while mineral oils require chips made from PC.

A comprehensive overview of droplet generators available at microfluidic ChipShop can be found in the below table.

<table>
<thead>
<tr>
<th>Fluidic Design</th>
<th>Interface Type</th>
<th>Nozzle Sizes [µm]</th>
<th>Single Cross</th>
<th>Double-Cross</th>
<th>Generator Units/Chip</th>
<th>Droplet Storage</th>
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</thead>
<tbody>
<tr>
<td>162</td>
<td>Mini Luer</td>
<td>70</td>
<td>Yes</td>
<td>Yes</td>
<td>1</td>
<td>No</td>
</tr>
<tr>
<td>163</td>
<td>Mini Luer</td>
<td>140</td>
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<td>Yes</td>
<td>1</td>
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<tr>
<td>285</td>
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<td>No</td>
<td>5</td>
<td>No</td>
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<tr>
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<td>No</td>
<td>8</td>
<td>No</td>
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<tr>
<td>488</td>
<td>Luer</td>
<td>74</td>
<td>Yes</td>
<td>No</td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td>536</td>
<td>Luer</td>
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<td>Yes</td>
<td>3</td>
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<tr>
<td>537</td>
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<td>719</td>
<td>Luer</td>
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<td>Yes</td>
<td>3</td>
<td>No</td>
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</table>
Droplet Generation - Droplet Generator Chips

**Fluidic 537 - Single Cross Geometry**

The droplet generator with design number 537 possesses a classic flow focusing geometry, perfectly suited to generate simple droplets. With four identical droplet generator units on one microfluidic chip, this device is ideal for anyone who wants to try or compare multiple experimental setups, without the need of ordering a new chip for every experiment. Please be aware that this chip is one of the few droplet generators devices with Luer interfaces and appropriate Luer compatible accessories are required.

**Chip Summary Fluidic 537**

- Interface type: Luer
- Nozzle size: 38 µm
- Nozzle type: single cross, flow focusing
- Droplet generator units on chip: 4
- Droplet storage: no

**Product Code**

<table>
<thead>
<tr>
<th>Product Code for Fluidic 537</th>
<th>Lid Thickness [µm]</th>
<th>Material</th>
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<tr>
<td>10000466</td>
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<tr>
<td>10000467</td>
<td>175</td>
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</table>

**Fluidic 912 - Single Cross Geometry**

Droplet generator chips Fluidic 912 provides eight identical droplet generator units with a nozzle size of 80 µm on one chip. The continuous phase is introduced through one Mini Luer inlet, which separates into two channels. Operation of one unit of Fluidic 912 therefore requires a microfluidic pump with the ability to control two individual flows, one for the continuous and one for the disperse phase.

**Chip Summary Fluidic 912**

- Interface type: Mini Luer
- Nozzle size: 80 µm
- Nozzle type: single cross, flow focusing
- Droplet generator units on chip: 8
- Droplet storage: no

**Product Code**

<table>
<thead>
<tr>
<th>Product Code for Fluidic 912</th>
<th>Lid Thickness [µm]</th>
<th>Material</th>
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<td>140</td>
<td>Topas</td>
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<tr>
<td>10001333</td>
<td>175</td>
<td>PC</td>
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</table>
**Fluidic 947 - Single Cross Geometry - Multiple Nozzle Sizes**

The microfluidic chip Fluidic 947 features eight flow focusing droplet generator units to evaluate the formation of various droplet sizes. With nozzle sizes as little as 10 µm, Fluidic 947 possesses the smallest nozzles within microfluidic ChipShop’s droplet generator portfolio. It is therefore the perfect chip for experiments that require droplets with particularly small dimensions and volumes. The inlet channels for both continuous and disperse phase are designed to enable stable droplet generation through a certain degree of flow restriction.

**Chip Summary Fluidic 947**

Interface type: Mini Luer  
Nozzle size: 10; 15; 20; 30 µm  
Nozzle type: single cross; flow focusing  
Droplet generator units on chip: 8  
Droplet storage: no

**Fluidic 440 - Single Cross Geometry - Multiple Nozzle Sizes**

Being the larger sibling of Fluidic 947, the droplet generator chip Fluidic 440 is also perfectly suited to evaluate droplet generation with a single cross, flow focusing geometry. The nozzle sizes, however, range from 50 µm to 80 µm on this chip. With its two Mini Luer inlet and one Mini Luer outlet ports per droplet generation unit, the chip requires a two-channel microfluidic pump, just as Fluidic 912 and Fluidic 447.

**Chip Summary Fluidic 440**

Interface type: Mini Luer  
Nozzle size: 50; 60; 70; 80 µm  
Nozzle type: single cross; flow focusing  
Droplet generator units on chip: 8  
Droplet storage: no
Droplet Generation - Droplet Generator Chips

**Fluidic 536 - Double Cross Geometry**

Droplet generator chips with a double cross geometry allow for the generation of W/W/O droplets and are therefore ideally suited for the inclusion of particles or cells, deriving from the first channel intersection, with a further droplet shell at the second channel intersection. With 38 µm nozzle diameter, Fluidic 536 offers the smallest nozzle size with double cross geometry within microfluidic ChipShop’s portfolio. Please be aware of the chip’s Luer interfaces, which require dedicated Luer-sized connectors and plugs.

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**Chip Summary Fluidic 536**

- Interface type: Luer
- Nozzle size: 38 µm
- Nozzle type: double cross, flow focusing
- Droplet generator units on chip: 3
- Droplet storage: no

**Fluidic 536 with three functional droplet generation units on one chip**

**Detailed schematic drawing of the droplet generation area of Fluidic 536**

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**W/W/O droplets with a diameter of 180 µm were generated by applying pressures of 12 mbar / 72 mbar / 99 mbar respectively.**

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**Fluidic 1032 - Double Cross Geometry**

This droplet generator chip with three identical droplet generation units of double cross geometry was specifically developed for use in single cell sequencing experiments, where single cells (W) and beads/lysis buffer (W) need to be introduced into a single droplet in an oil phase (O). Fluidic 1032 features Mini Luer interfaces and its use requires a microfluidic pump setup with the ability to control three individual flows. It is, however, also possible to use this droplet generator to generate W/O droplets by simply closing one inlet and supplying only two inlets with a liquid stream.

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**Chip Summary Fluidic 1032**

- Interface type: Mini Luer
- Nozzle size: 100 µm
- Nozzle type: double cross, flow focusing
- Droplet generator units on chip: 3
- Droplet storage: no

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**One droplet generation unit of Fluidic 536 with Luer inlets for aqueous disperse phases (1 & 2), continuous oil phase (3) and outlets (4 & 5)**

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**One of the three identical droplet generation units on Fluidic 1032 with Mini Luer interfaces**

**Schematic drawing of one droplet generation unit on Fluidic 1032 (left) and a detailed view on the droplet generating intersection (right)**

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**W/W/O droplets with a diameter of 180 µm were generated by applying pressures of 12 mbar / 72 mbar / 99 mbar respectively.**
**Fluidic 162 - Double Cross Geometry**

Droplet generator Fluidic 162 features a double channel crossing in the droplet generation region and one droplet collection channel. Like most droplet generators with a double cross geometry, Fluidic 162 can also be used for single cross experiments by simply not connecting respective channels but closing their interfaces with plugs. With a nozzle size of 70 µm droplet sizes between 80 µm (~260 pl) and 210 µm diameter can be realized. A constant droplet size can be generated in various flow speeds by preserving the oil to aqueous phase ratio. By increasing the oil phase flow rate at a constant aqueous flow rate, the droplet size can be varied.

**Chip Summary Fluidic 162**

- **Interface type:** Mini Luer
- **Nozzle size:** 70 µm
- **Nozzle type:** double cross; flow focusing
- **Droplet generator units on chip:** 1
- **Droplet storage:** no

<table>
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</table>

**Fluidic 163 - Double Cross Geometry**

Droplet generator Fluidic 163 is the larger sibling of Fluidic 162 and features a similar design with larger channel dimensions. With a nozzle size of 140 µm droplet sizes between 190 µm (~3.25 nl) and 420 µm diameter can be realized. Fluidic 163 gives the possibility to be utilized from two sides, as it features droplet generation crossings at either side of the collection channel. Both sides are similar in channel design with a slight difference in distance of the double cross intersections.

**Chip Summary Fluidic 163**

- **Interface type:** Mini Luer
- **Nozzle size:** 140 µm
- **Nozzle type:** double cross; flow focusing
- **Droplet generator units on chip:** 1
- **Droplet storage:** no

<table>
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<td>420</td>
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<td>175</td>
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</tbody>
</table>
Droplet Generation - Droplet Generator Chips

**Fluidic 488 - Droplet Generation and Storage**

Droplet generation and storage chip Fluidic 488 was specifically designed to generate and capture droplets for on-chip optical analysis of generated single droplets. It features 24 rhombic storage units, each suitable to capture 108 individual droplets. With a combination of multiple T-junctions and a flow focusing nozzle, the channel design in the droplet generating area is a versatile tool for many different experimental settings.

![Droplet generation and storage chip Fluidic 488 with multiple droplet storing units](image)

**Chip Summary Fluidic 488**
- Interface type: Mini Luer
- Nozzle size: 74 µm
- Nozzle type: double cross
- Droplet generator units on chip: 1
- Droplet storage: yes

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<th>Product Code for Fluidic 488</th>
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<th>Material</th>
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<tr>
<td>10000511</td>
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</table>

**Fluidic 719 - Droplet Generation and Storage**

Fluidic 719 possesses a storage channel design, which is suited to be used for optical analysis. Both droplet generator region and individual storage cavities are fairly similar to the ones of Fluidic 488. However, the channel design of Fluidic 719 adds an additional flow focusing junction and droplet storage is realized in one channel, rather than in rhombic units. The chip contains 2261 storage positions and can be used for a wide-range of applications including droplet-based cell culture/monitoring.

![Droplet generation and storage chip Fluidic 719 possesses a complex nozzle geometry and channel with over 2000 droplet storage positions](image)

**Chip Summary Fluidic 719**
- Interface type: Mini Luer
- Nozzle size: 82 µm
- Nozzle type: double cross
- Droplet generator units on chip: 1
- Droplet storage: yes

<table>
<thead>
<tr>
<th>Product Code for Fluidic 719</th>
<th>Lid Thickness [µm]</th>
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<tr>
<td>10000751</td>
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<td>Topas</td>
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<tr>
<td>10000752</td>
<td>175</td>
<td>PC</td>
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</tbody>
</table>
Fluidic 285 is a true playground for anyone who wants to start with droplet generation and requires a microfluidic chip with various different droplet generation units. The chip features five different droplet generation units with multiple channel designs and sizes, enabling a large set of experiments. Channels/ports not in use can easily be closed by means of Mini Luer plugs.

**Accessories - Lab-on-a-Chip Handling Platform**

microfluidic ChipShop’s handy Lab-on-a-Chip Handling Platform (LOC HP) is a versatile device to enable quick and easy fluidic interface connection. The LOC HP can be obtained with adapter plates for three microfluidic interface configurations: two interface configurations with the fluidic interfaces at the shorter sides of the microfluidic chip and one at the longer sides, addressing openings with a 4.5 mm spacing. With this, the LOC HP is compatible with all our off-the-shelf droplet generator chips with Mini Luer interfaces. A heatable version for cell culture experiments is also available.
**Droplet Generation - Accessories**

### Connectors: microfluidic ChipShop offers a multitude of connectors, facilitating fast and convenient connection of droplet generation chips with e.g. pumps, valves or collection reservoirs via tubing. All connectors are designed to fit standard microfluidic interfaces, such as Luer and Mini Luer, while retaining a minimum dead volume. Please always double-check the interface type (Luer or Mini Luer) of your droplet generator and obtain connectors and plugs accordingly.

### Plugs: Oftentimes, our droplet generators possess surplus in- and outlet to ensure maximal experimental freedom. However, not in every experimental setting all interfaces need to be addressed. Mini Luer plugs and Luer plugs are the dedicated mean to securely close fluidic interfaces on your droplet generation chip, which are not in use.

### Tubing: Tubing is needed in most cases to link the droplet generator chip with an external pump, which drives removal or delivery of liquid. For most droplet applications microfluidic ChipShop recommends the use of PTFE tubing in combination with a silicone sleeve, prepared from soft silicone tubing. Soft silicone sleeves are the perfect interconnection of relatively hard PTFE tubing with the Mini Luer or Luer fluid connectors. Silicone sleeves are cut from longer silicone tubes.

### Handling Frames: For secure handling and positioning of chips we offer dedicated handling frames into which microfluidic chips can be easily clicked in.

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**Comparison of Mini Luer and Luer interfaces, both of which can be found on microfluidic ChipShop’s droplet generator chips. If used in suction rather than in pumping mode, interfaces can also serve as liquid reservoirs.**

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**Product Code | Fluidic | Description | Color | Material**
---

| 10000032 | Micro tube, ID: 0.5 mm, OD: 1.0 mm | PTFE Micro tube | PP |
| 10000031 | Silicone tube, ID: 0.76 mm, OD: 1.65 mm | Silicone tube | TPE |
| 10000033 | Silicone tube, ID: 0.5 mm, OD: 2.5 mm | Silicone tube | PP |
| 10000041 | Handling frame with reduced skirt height (orange)* | Handling frame | PP |

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* other colors and options available

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**Tubing:** Did you know?

**It’s all about the right cut**

Attaching silicone sleeves to fluid connectors can be a bit tricky. Cut the silicone tube in a slight angle and it will work a lot easier.
Together with our partner Fluigent, we offer everything you require for a droplet experiment with two flow channels of a pressure-driven pump. This setup is ideal to create droplets with e.g. a single cross, flow focusing droplet generator. Here is what your droplet generation setup will contain:

**Microfluidic Pressure Pumps - LineUp Flow EZ™**:
- Highly advanced system for pressure-based flow control
- Stand-alone units for use near the microfluidic setup
- Independent control flows of disperse and continuous phases
- Available in a variety of pressure ranges from -800 to +7 000 mbar

**LINK**:
- Provides connection of LineUp Flow EZ™ series modules to a PC for software control

**Flow Units**:
- Flow sensors that allows real-time flow rate measurements
- Enables to switch from pressure control to flow rate control
- Guarantee reproducibility of long-term droplet production

**All-in-One (A-i-O) control software**:
- Real-time control of pressures and flow rates
- Modular interface
- Independent monitoring of all parameters for each connected channel

**Product Content**

<table>
<thead>
<tr>
<th>Product</th>
<th>Content</th>
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</thead>
<tbody>
<tr>
<td>Fluigent pump setup for droplet generation with two individual flow channels</td>
<td>LineUP Flow EZ™ modules (2x), LineUP LINK module, LineUP power supply kit, Pressure CAP for 15 ml tubes (2x) with support rack (1x), Flow Unit S (0-7µL/min for water or 0-70µL/min for hydrocarbons) (2x), A-i-O software, Droplet generation - Droplet variation kit (product code 10001476)</td>
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</table>
Droplet Generation - Kits and Oil

Droplet Kit and Droplet Oil

Our droplet kit is the perfect way to start your droplet-based experiment without further ado. The droplet variation kit contains everything needed to generate W/O droplets of multiple sizes and in various settings. The kit will help you to determine your optimal experimental layout, without the need for extensive background research. The provided items are perfectly suited to be used with a Fluigent pump setup or a high-end syringe pump, both available with microfluidic ChipShop.

Droplet generation - Droplet variation kit

The droplet variation kit contains everything needed to generate W/O droplets of multiple sizes and in various settings. The kit will help you to determine your optimal experimental layout, without the need for extensive background research. The provided items are perfectly suited to be used with a Fluigent pump setup or a high-end syringe pump, both available with microfluidic ChipShop.

Did you know?

Application note available

You want to start your droplet experiment right away, but you are looking for a little more technical information to succeed? Contact us for a application note on droplet generation or visit our website www.microfluidic-ChipShop.com

Manufacturing Services

We offer a large variety of off-the-shelf droplet generator and our team is happy to advise. Still not exactly found what you are looking for? No problem - we are specialized in custom manufacturing of microfluidic devices and can tailor custom fabrication exactly according to your experimental needs and design requirements. Contact us with your individual droplet generator specification at asicon-tokyo@asicon-tokyo.com.

<table>
<thead>
<tr>
<th>Product Code</th>
<th>Kit Name</th>
<th>Contents</th>
<th>Amount</th>
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<td></td>
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<td>Droplet Oil (2% surfactant in fluorinated oil)</td>
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microfluidic ChipShop’s droplet oil (fluorinated oil with 2% surfactant) is optimized for the generation of highly monodisperse microdroplets. It convinces through biocompatibility, long-term stability and compatibility with standard droplet PCR dyes like FAM™, HEX™, VIC® and EvaGreen®.

<table>
<thead>
<tr>
<th>Product Code</th>
<th>Description</th>
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<tr>
<td>10001548</td>
<td>Droplet Oil (2% surfactant in fluorinated oil) - 3 x 4 ml</td>
</tr>
</tbody>
</table>

Colored connectors demonstrate inlet ports for dispersed phase (red), continuous phase (yellow) and the outlet port (blue) of a droplet generation unit of Fluidic 440

On-chip generated droplets visualized on a microscope glass slide

The droplet generation - Droplet variation kit is suitable for generating W/O droplets of different sizes and in a variety of settings.

The provided items are perfectly suited to be used with a Fluigent pump setup or a high-end syringe pump, both available with microfluidic ChipShop.