3D flow focusing chips

Product Datasheet

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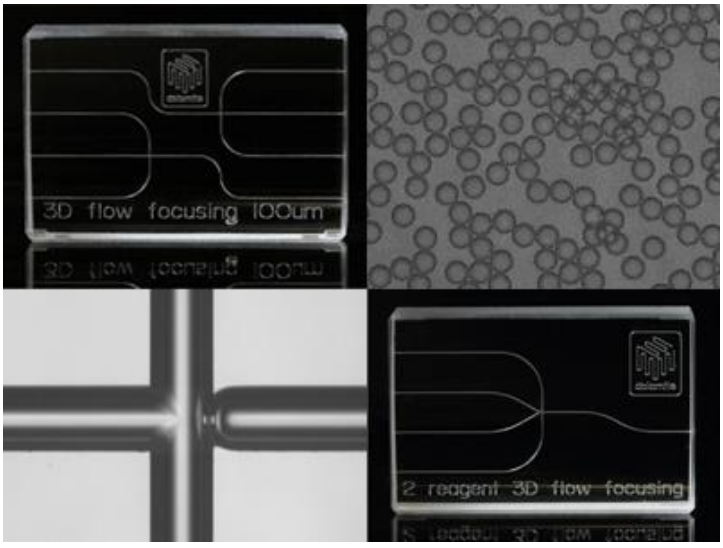


1 Description

3D flow focusing chips are glass microfluidic devices designed for generating droplets and bubbles. They are produced by wet etch lithography and feature channels that are 14 µm, 30 µm, 100 µm and 170 µm in etch depth. The precision of fabrication allows for creation of extremely monodisperse droplets and bubbles.

Certain fluids such as polymer solutions can cause surface fouling in standard flow focusing chips, reducing production run duration and chip lifetime. 3D flow focusing chips reduce this fouling by utilising a “pore” structure on the outlet side of the droplet-forming junction. This induces the droplet fluid to detach from the top and bottom walls well upstream of the breakoff point. As the length of the interface in contact with these walls is reduced, the rate of surface fouling is reduced, allowing much longer production runs.

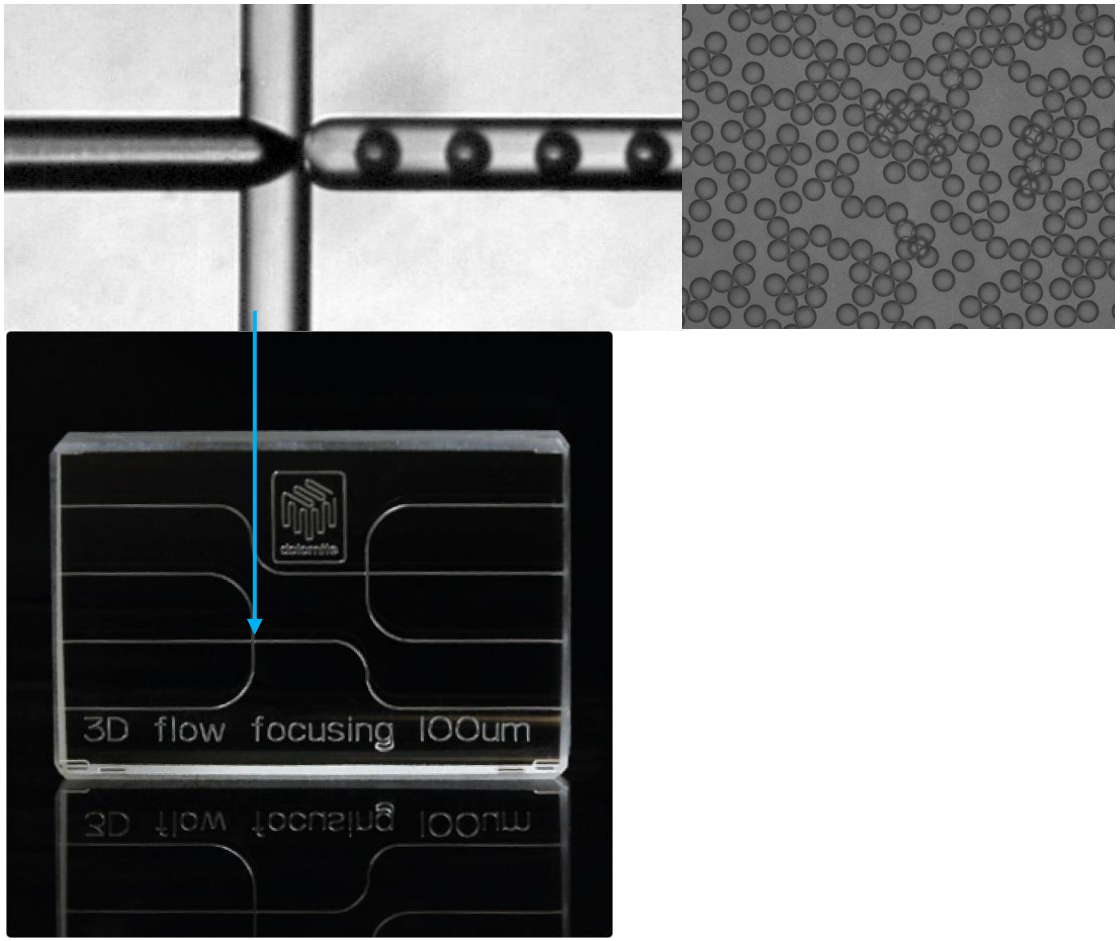
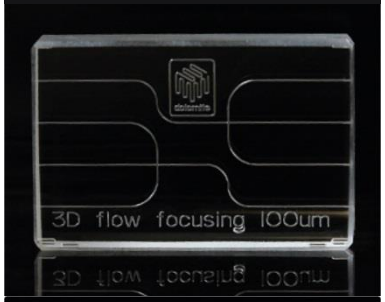


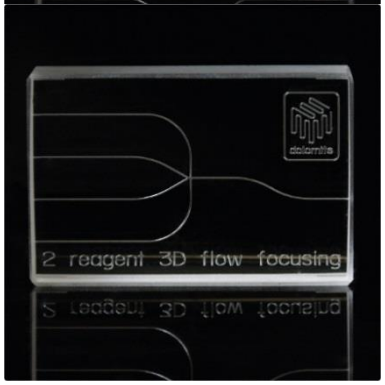
Figure 1 X-junction of 3D Flow Focusing Chip - 100 µm

This range includes the following chips:

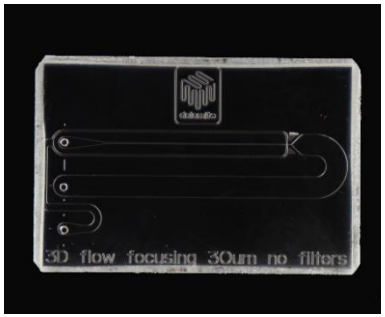
3D Flow Focusing Chip - 65 µm: suitable for generating droplets around 65 µm depending on fluid properties. Available in Hydrophilic (Part No. 3200958), Hydrophobic (Part No. 3200959) and Fluorophilic (Part no. 3200960) versions.



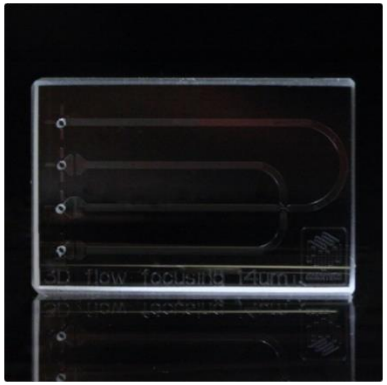
3D Flow Focusing Chip - 100 µm and 170 µm: suitable for generating droplets between 25-70 µm and 50-140 µm depending on fluid properties. Available in Hydrophilic (Part No. 3200433 and 3200835), Hydrophobic (Part No. 3200434 and 3200836) and Fluorophilic (Part No. 3200515 and 3200837) versions for generating organic-in-aqueous, aqueous-in-organic oil and aqueous-in-fluorocarbon oil emulsions respectively.



3D Flow Focusing Chip - 100 µm - 2 Reagent: similar to the 100 µm chip above, this chip features two separate inputs for the droplet fluid, allowing in-droplet mixing, in-droplet reactions or formation of Janus particles. Available in Hydrophilic (Part No. 3200435) and Hydrophobic (Part No. 3200436) versions.



3D Flow Focusing Chip - 30 µm: suitable for generating droplets between 10-28 µm depending on fluid properties. Available in Hydrophilic (Part No. 3200934), Hydrophobic (Part No. 3200935) and Fluorophilic (Part no. 3200936) versions.



3D Flow Focusing Chip - 14 µm: suitable for generating droplets between 5-12 µm depending on fluid properties. Available in Hydrophilic (Part No. 3200437) and Hydrophobic (Part No. 3200438) versions.

N.B. *It may be possible to generate droplets of larger diameter than stated above. However, droplets with diameter near to or greater than the channel depth are likely to make contact the channel walls, leading to surface fouling in the outlet channel.*

The 100 µm and 170 µm depth variants are compatible with our H Interface (Part No. 3000155) and Linear Connector 4-Way (Part No. 3000024). The 14µm and the 30µm depth variants are compatible with our Top Interface 4-Way (4mm) (Part No. 3000109) and Linear Connector 4-Way (Part No. 3000024).

2 Benefits

- Extended lifetime when working with polymerising or surface fouling droplet fluids
- Quick connection using Dolomite Interfaces and Connectors
- Simple to use
- High visibility
- Good accessibility for microscope objective
- Extremely consistent droplet size
- Wide temperature and pressure range

- Excellent chemical compatibility
- Hydrophilic, Hydrophobic and Fluorophilic versions available

3 Specification

Specification	170 µm 3D Flow Focusing Chip		100 µm 3D Flow Focusing Chip		2 Reagent 100 µm 3D Flow Focusing Chip		30 µm 3D Flow Focusing Chip		65 µm 3D Flow Focusing Chip		14 µm 3D Flow Focusing Chip	
	3200835	3200836 3200837	3200433	3200434 3200515	3200435	3200436	3200934	3200935 3200936	3200958	3200959 3200960	3200437	3200438
Channel cross-section at junction (depth x width)	170 µm x 175 µm		100 µm x 105 µm				30 µm x 33 µm		65 µm x 70 µm		14 µm x 17 µm	
Channel cross-section elsewhere (depth x width)	170 µm x 175 µm		100 µm x 105 µm				30 µm x 1500 µm (after junction)		65 µm x 1500 µm		14 µm x 500 µm	
Nominal pore dimensions (depth x width)	103 µm x 140 µm		54 µm x 75 µm				23 µm x 16 µm		34 µm x 49 µm		8 µm x 12 µm	
Number of droplet phase inputs	1				2		1		1		1	
On-chip filter pore size (depth x width)	-						-		-		7 µm x 17 µm	
Channel length after junction	15.4 mm				11.5 mm		24 mm		24.6 mm		27.4 mm	
Back pressure with 100 µL/min flow (water)	100 mbar		121 mbar		116 mbar		-		150 mBar		-	
Back pressure with 10 µL/min flow (water)	-				-		280 mbar		-		640 mbar	
Surface roughness of channels (Ra)							5nm					

Specification	170 µm 3D Flow Focusing Chip		100 µm 3D Flow Focusing Chip		2 Reagent 100 µm 3D Flow Focusing Chip		30 µm 3D Flow Focusing Chip		65 µm 3D Flow Focusing Chip		14 µm 3D Flow Focusing Chip	
	3200835	3200836 3200837	3200433	3200434 3200515	3200435	3200436	3200934	3200935 3200934	3200958	3200959 3200960	3200437	3200438
Chip size (length x width x thickness)	22.5mm x 15.0mm x 4mm											
Chip top layer thickness	2.0 mm						1.0 mm		1.0 mm		2.0 mm	
Chip base layer thickness	2.0 mm						3.0 mm		3.0 mm		2.0 mm	
Max. operating pressure					30 bar							
Material					B270 glass							
Fabrication process					HF etching and thermal bonding							
Channel coating	None (Hydrophilic)	Hydrophobic/ Fluorophilic*	None (Hydrophilic)	Hydrophobic/ Fluorophilic*	None (Hydrophilic)	Hydrophobic	None (Hydrophilic)	Hydrophobic/ Fluorophilic*	None (Hydrophilic)	Hydrophobic/ Fluorophilic*	None (Hydrophilic)	Hydrophobic
Compatible interface	H Interface (Part No. 3000155)						Top Interface 4-Way (4mm) (Part No. 3000109)					
Compatible connector	Linear Connector 4-Way (Part No. 3000024)											

** The standard hydrophobic coating is not optimized for use with fluorocarbon oils. We suggest using a fluorophilic coating on the channel surface.*

4 Geometry

4.1 3D Flow Focusing Chip - 65 µm (P.N: 3200958, 3200959, 3200960)

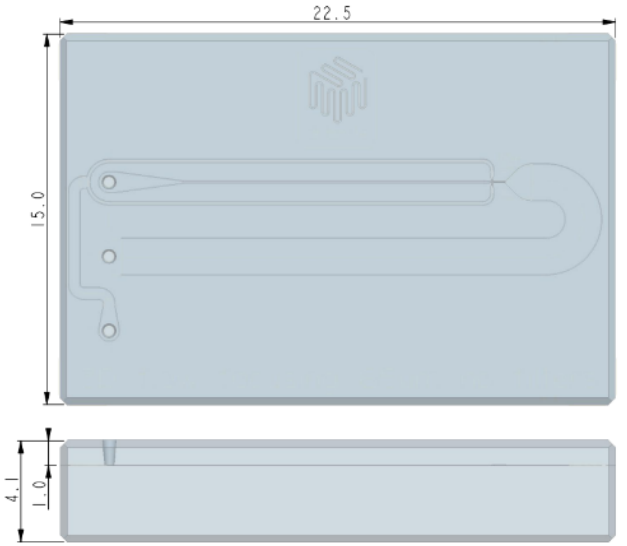
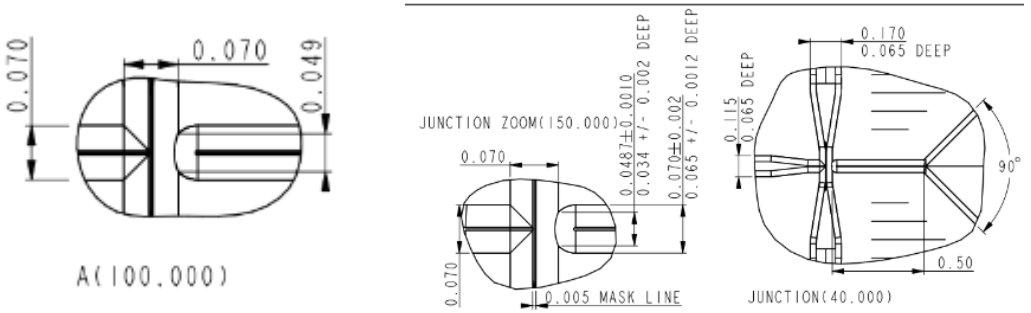


Figure 2 External dimensions



4.2 3D Flow Focusing Chip - 100 µm (P.N: 3200433, 3200434, 3200515)

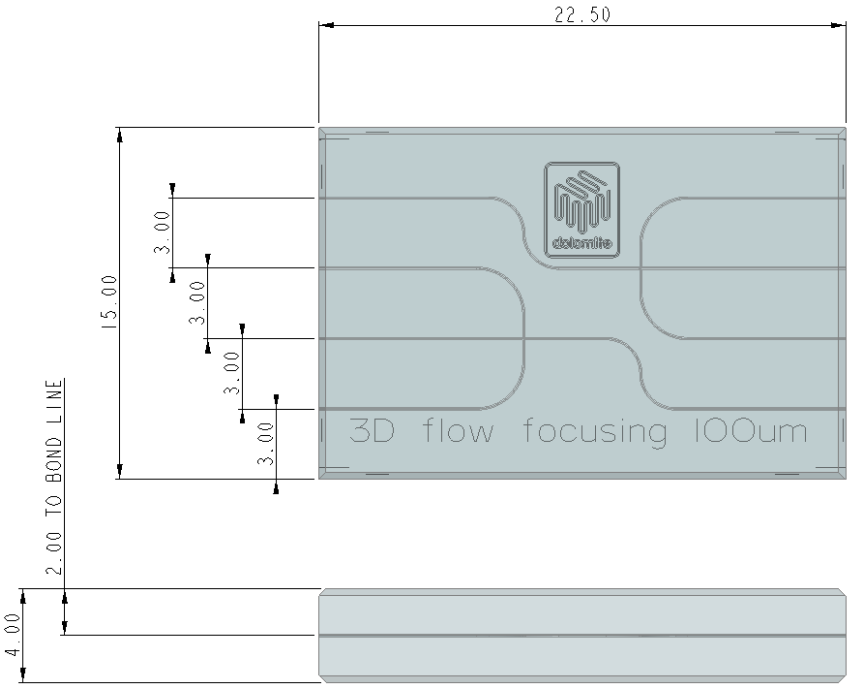


Figure 3 External dimensions

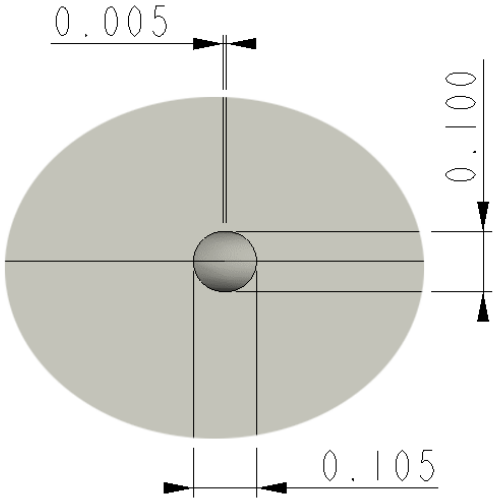


Figure 4 Channel cross section

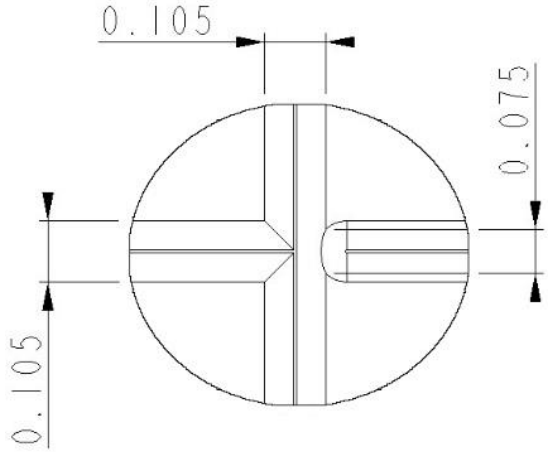


Figure 5 Junction geometry

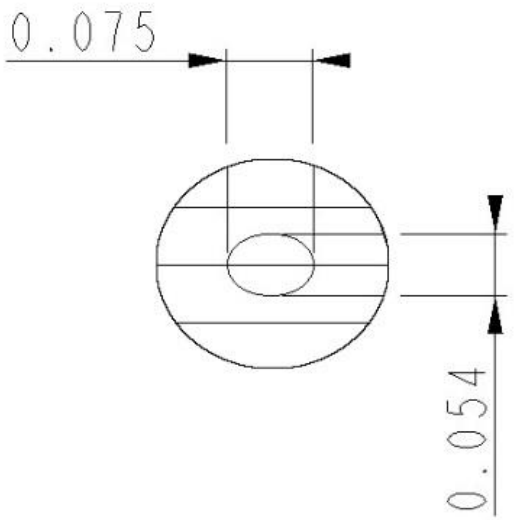


Figure 6 Nominal pore dimensions

4.3 3D Flow Focusing Chip - 170 µm (P.N: 3200835, 3200836, 3200837)

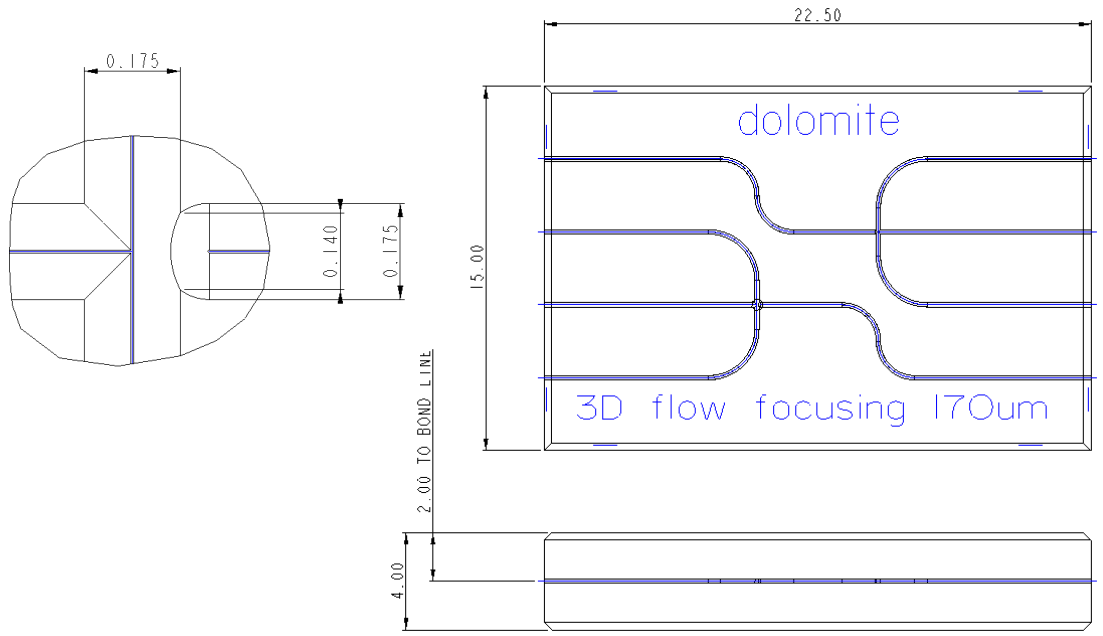


Figure 7 External dimensions

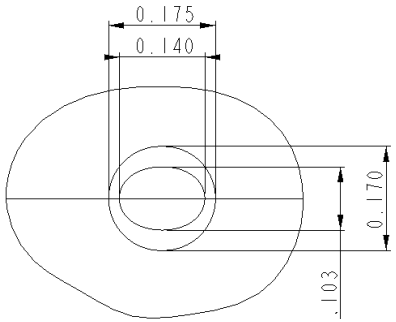


Figure 9 Channel cross section

Figure 8 Junction geometry

4.4 3D Flow Focusing Chip - 100 µm - 2 Reagent (P.N: 3200435, 3200436)

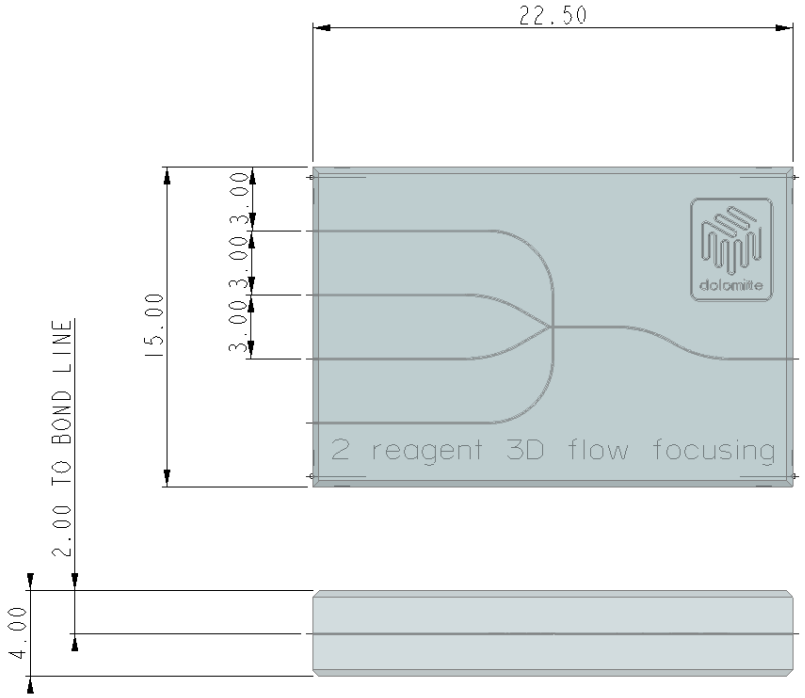


Figure 10 External dimensions

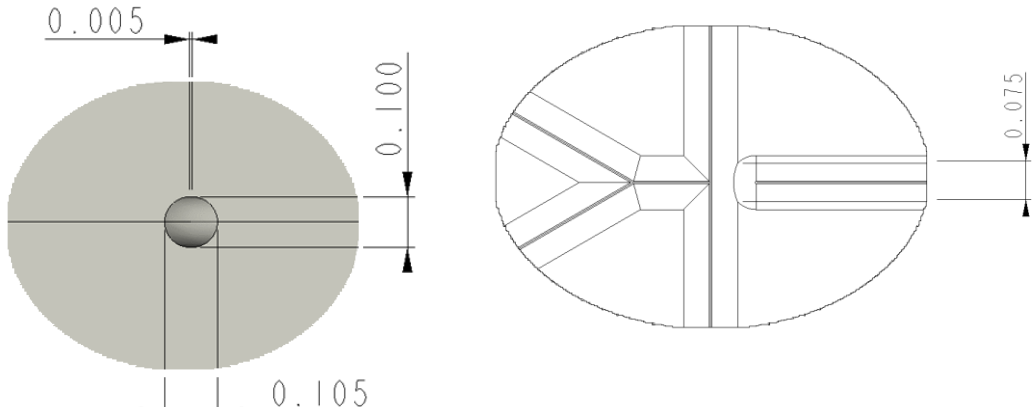


Figure 12 Junction geometry

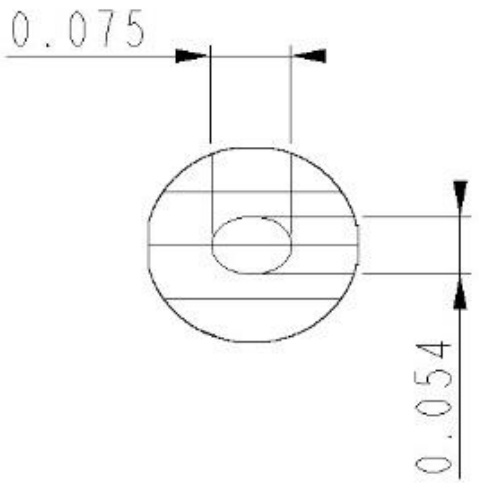
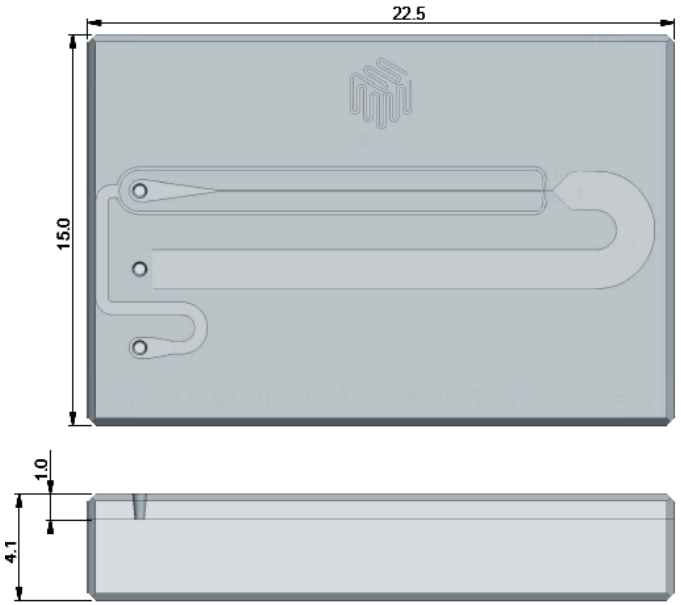


Figure 13 Nominal pore dimensions

4.5 3D Flow Focusing Chip – 30 µm (P.N.: 3200934, 3200935, 3200936)

Figure 14 External dimensions



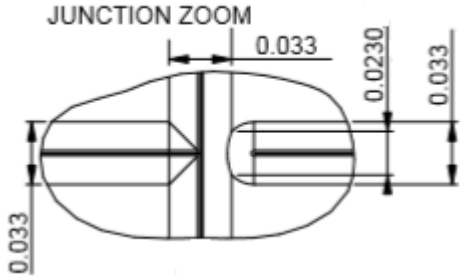


Figure 15 Junction geometry

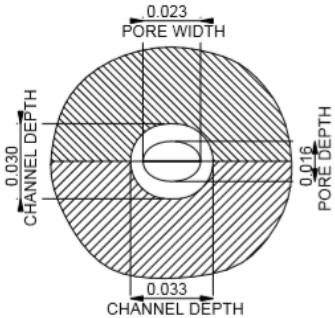


Figure 16 Channel cross-section at the junction

4.6 3D Flow Focusing Chip - 14 µm (P.N: 3200437, 3200438)

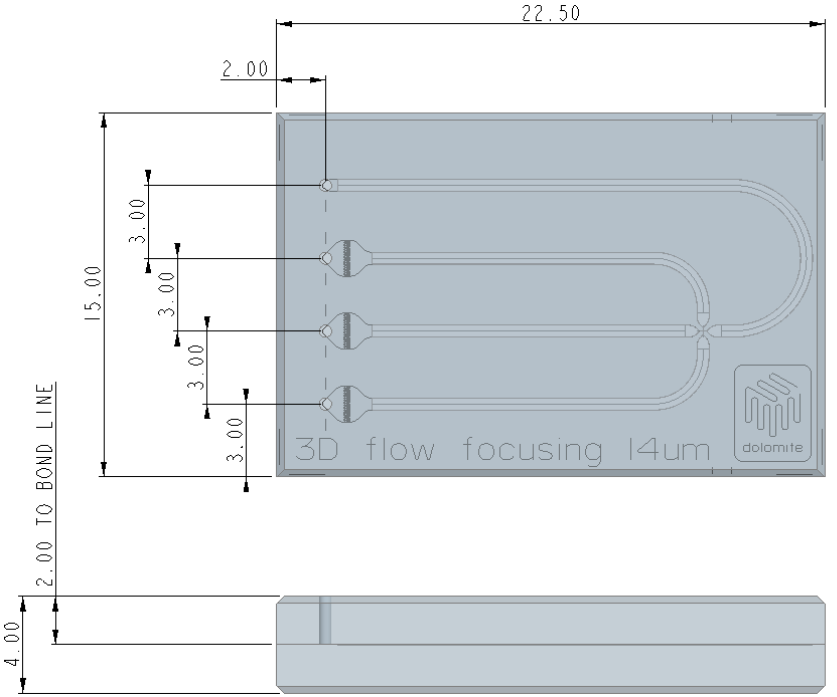


Figure 17 External dimensions

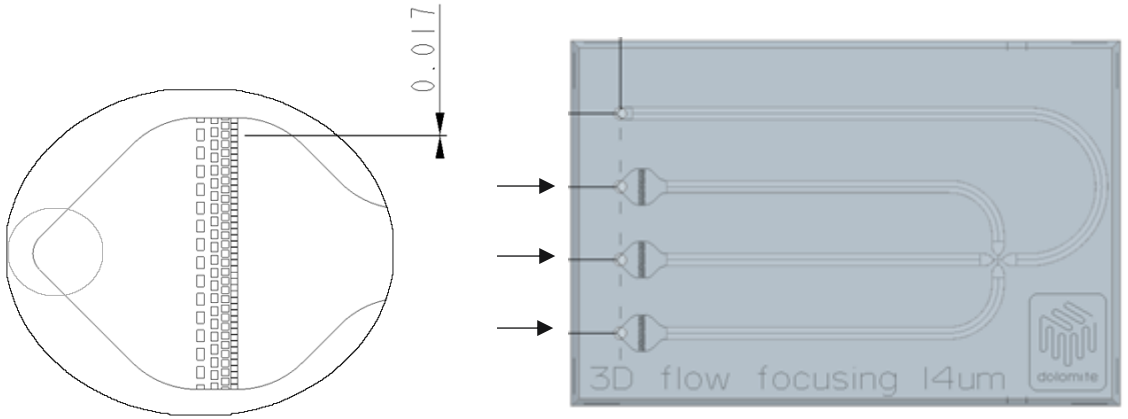


Figure 17 On-chip filter

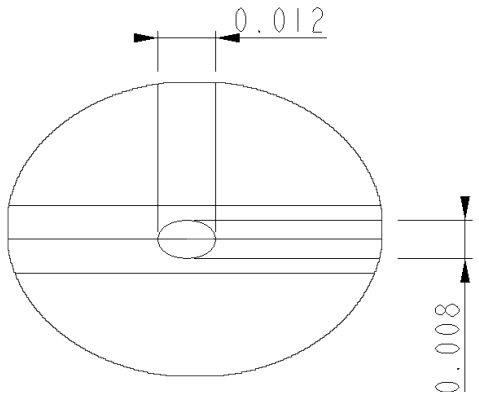


Figure 18 Nominal pore dimensions

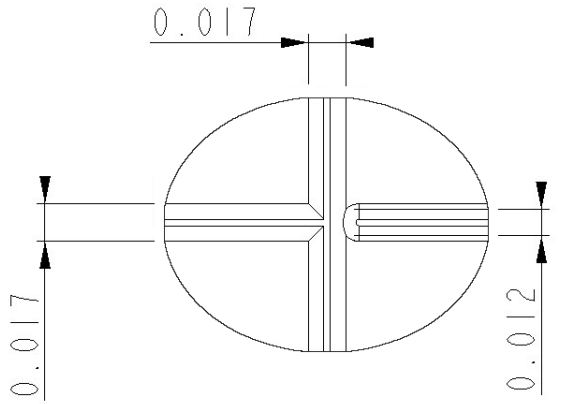


Figure 19 Junction geometry

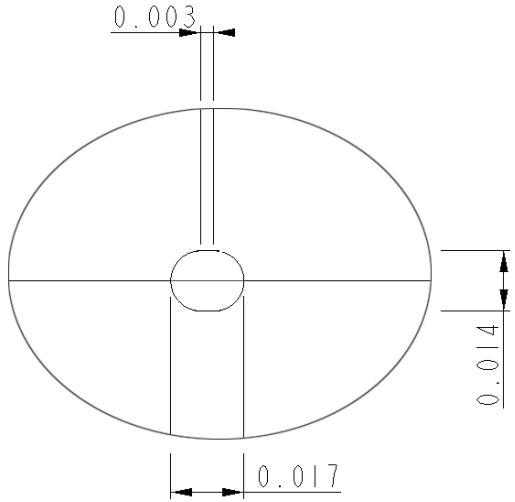


Figure 20 Channel cross-section at junction

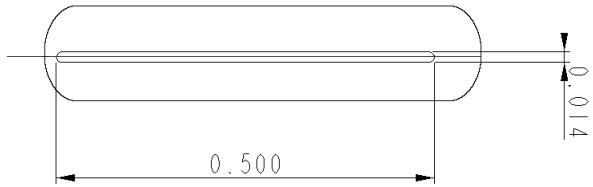
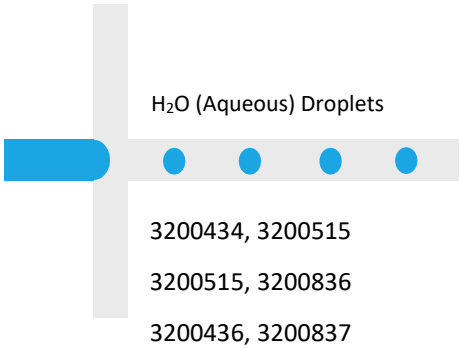
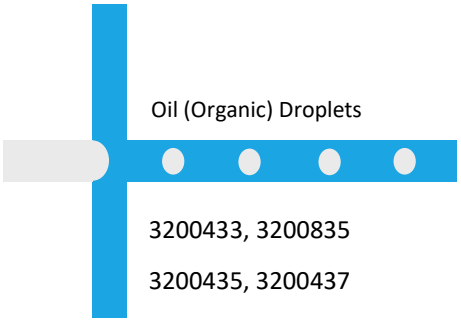


Figure 181 Channel cross-section elsewhere

5 Surface Coatings

The glass channel surface is naturally hydrophilic. This will form organic droplets in an aqueous carrier phase. To form aqueous droplets in an organic phase, hydrophobic or fluorophilic coatings are required.





The hydrophobic coating is resistant to organic solvents. The coating is vulnerable to acidic or basic solutions, such as even 0.1M NaOH.

A coating step in the fabrication differentiates between hydrophobic and fluorophilic chips. Depending on coating, users are able to create water-in-oil emulsion, oil-in-water emulsion, gas-in-water bubbles, or gas-in-oil bubbles.

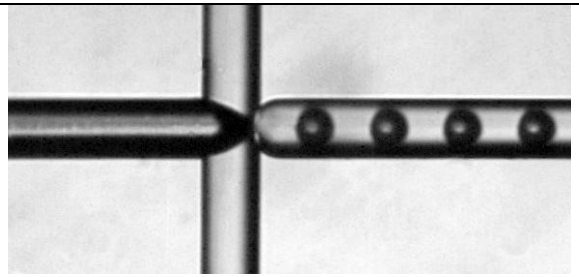
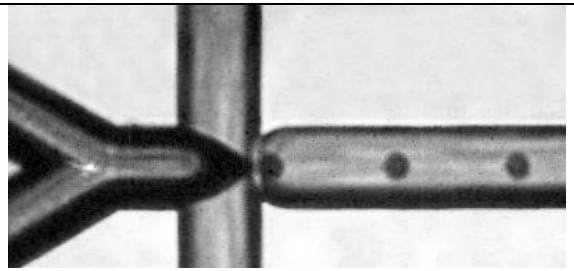
6 Droplet Formation

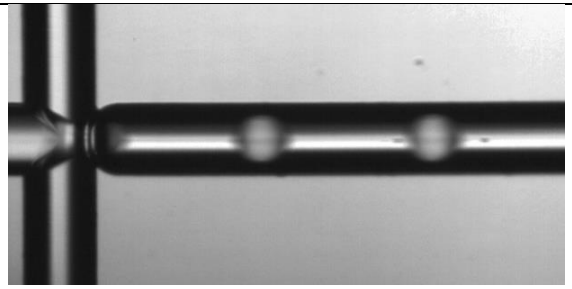
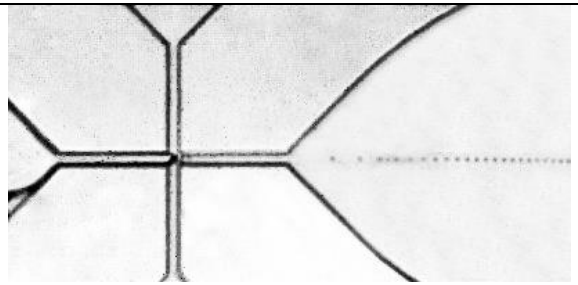
The size, consistency, and production rate of droplet formation is a function of several physical parameters, including:

- Channel size
- Viscosity and surface tension of the various fluids
- Presence of surfactants
- Miscibility of the fluids
- Use of hydrophobic, fluorophilic or hydrophilic coating on channel walls
- Total flow rate and relative flow rate of each fluid
- Flow stability

The Mitos P-Pump (Part No. 3200016) has been designed to provide stable, pulse-free flow for droplet formation. In combination with a 3D Flow Focusing Chip it is possible to generate droplets with extremely consistent diameters (monodispersed).

The 100 µm 3D Flow Focusing Chip and the 2 Reagent 100 µm 3D Flow Focusing Chip typically form droplets of around 25 – 70µm in diameter. The 170 µm 3D Flow Focusing Chip forms droplets of around 50 – 140µm in diameter. The 30 µm 3D Flow Focusing Chip forms droplets of around 10 – 25 µm in diameter. The 14 µm 3D Flow Focusing Chip forms droplets of around 5-12 µm in diameter.

Chip Name/Part No.	**Example image**	**Example droplet diameter**
100 µm 3D Flow Focusing Chip 3200433, 3200434, 3200515		65 µm
170 µm 3D Flow Focusing Chip 3200835, 3200836, 3200837	Similar droplet formation as the 100 µm 3D Flow Focusing	
2 Reagent 100 µm 3D Flow Focusing Chip 3200435, 3200436		30 µm

30 µm 3D Flow Focusing Chip 3200934/3200935/3200936		25 µm
14 µm 3D Flow Focusing Chip 3200436/3200437		~ 5µm

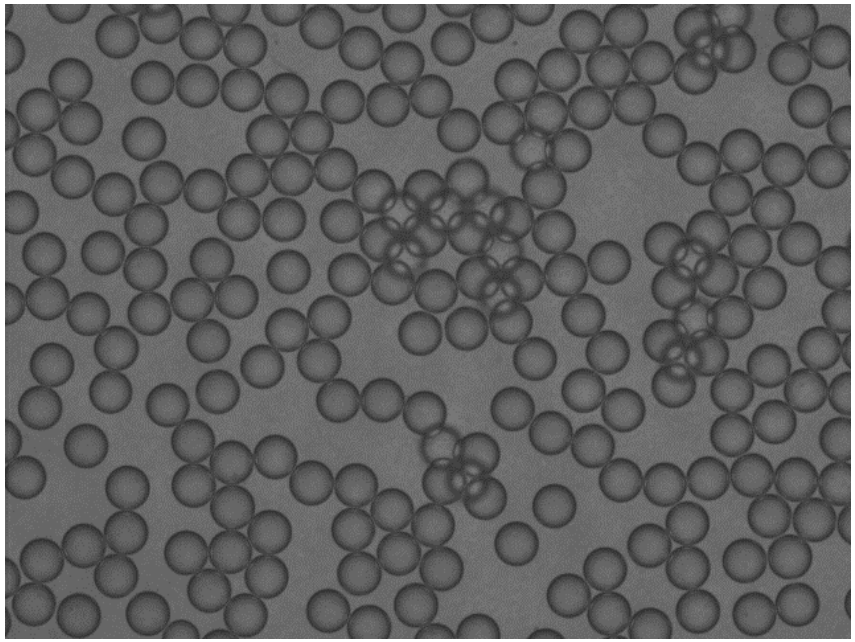


Figure 19 70um droplets collected from the output of the 100um 3D Flow Focusing Chip

It is possible to generate droplets larger than the maximum stated here, exceeding the channel depth. However, as the 3D Flow Focusing chip range is targeted at droplet fluids with channel-fouling properties, it is recommended in such cases to operate below the maximum sizes stated above to prevent droplets from coming into contact with the channel walls. When using more inert fluids, these limits need not apply.

Droplet production rates up to 12,000 droplets per second have been produced in a single channel. Dolomite has worked on many droplet forming projects, so please contact us for advice.

7 Custom Options

Dolomite can also offer additional customization, for example producing the same geometry in quartz. Other chip configurations are available on request. If you would like to generate droplets of a different size, operate with challenging fluids or perform complex droplet functions, Dolomite can design the junction geometry required. The range of Dolomite services available covers all aspects of the development process from characterization of liquids for droplet generation to the design of commercial instruments in the field of droplet microfluidics. Please contact Dolomite to discuss your application.

8 IP License

Dolomite is a licensee of Japan Science and Technology Agency (“JST”) under JST’s microdroplet generation technology.
This enables our customers to purchase and use our droplet chips for R&D purposes without any restriction from this comprehensive IP family.
Contact us for more information about licensing this IP for your custom application or chip design.