Electronic Supplementary Information (ESI)

Grooved step emulsification systems optimize throughput of passive generation of monodisperse emulsions

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Critical capillary number

As a confirmation of our assumption that it is sufficient to test just one parameter included in the capillary number, we produced droplets from fluids of different viscosities in fluorinated oil of viscosity μ~2 cP. We tested pure water (μ~1 cP, λ~0.5), 50%wt. glycerol (μ~6 cP, λ~3), and 75%wt. glycerol (μ~35 cP, λ~18).[1] Results are presented in Fig. S1. Up to certain flowrate of the to-be-dispersed phase the formed droplets are insensitive to the flow rate change. Then, sharp rise of droplet size and dispersity occurs, around Ca~0.16 for each system.

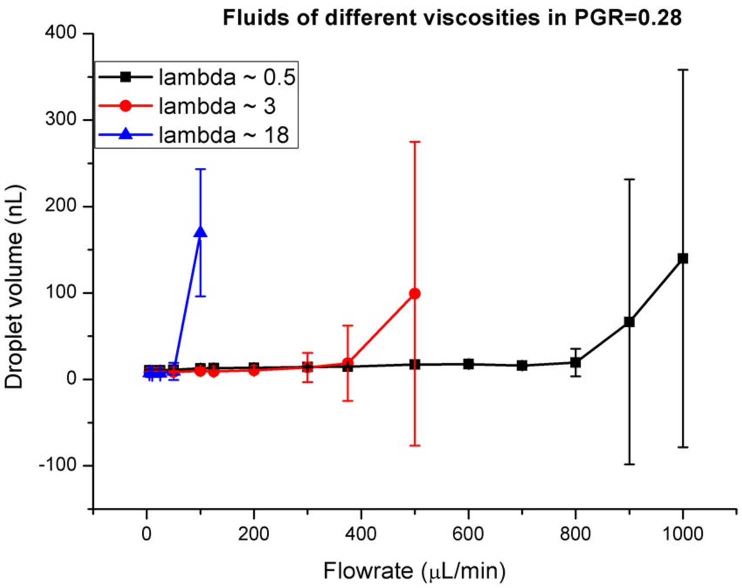

Fig. S 1 Droplet sizes formed in grooved devices. Device dimensions: number of grooves=15, groove width = 120 μm, groove height =100 μm, partition height = 28 μm, device width = 15 mm. Tested fluids were miliQ water (lambda ~0.5), 50%wt. glycerol (lambda ~3), 75%wt. glycerol (lambda ~18).

Choice of dimensionless parameters

Regarding geometrical parameters we have, $\frac{h}{H},\frac{L_g}{H},\frac{w}{H},w_g/H$. We are interested in the regime of a wide step, $\frac{w}{H}\gg 1$, and we use grooves just to impose the place where droplets are created. Therefore the value $\frac{w_g}{H}=1$ satisfy this condition and from this perspective it does not seem to be interesting to scan over this parameter. We have thus two geometrical parameters to scan, partition to groove ratio, $\frac{h}{H}$, and distance between grooves, $\frac{L_g}{H}$. These are two parameters and to systematically scan over their values requires one order of magnitude more experiments. We confined ourselves to the partial scan over L_g for h/H=0.9 and over h/H for L_g=0.5 and 0.75 mm.

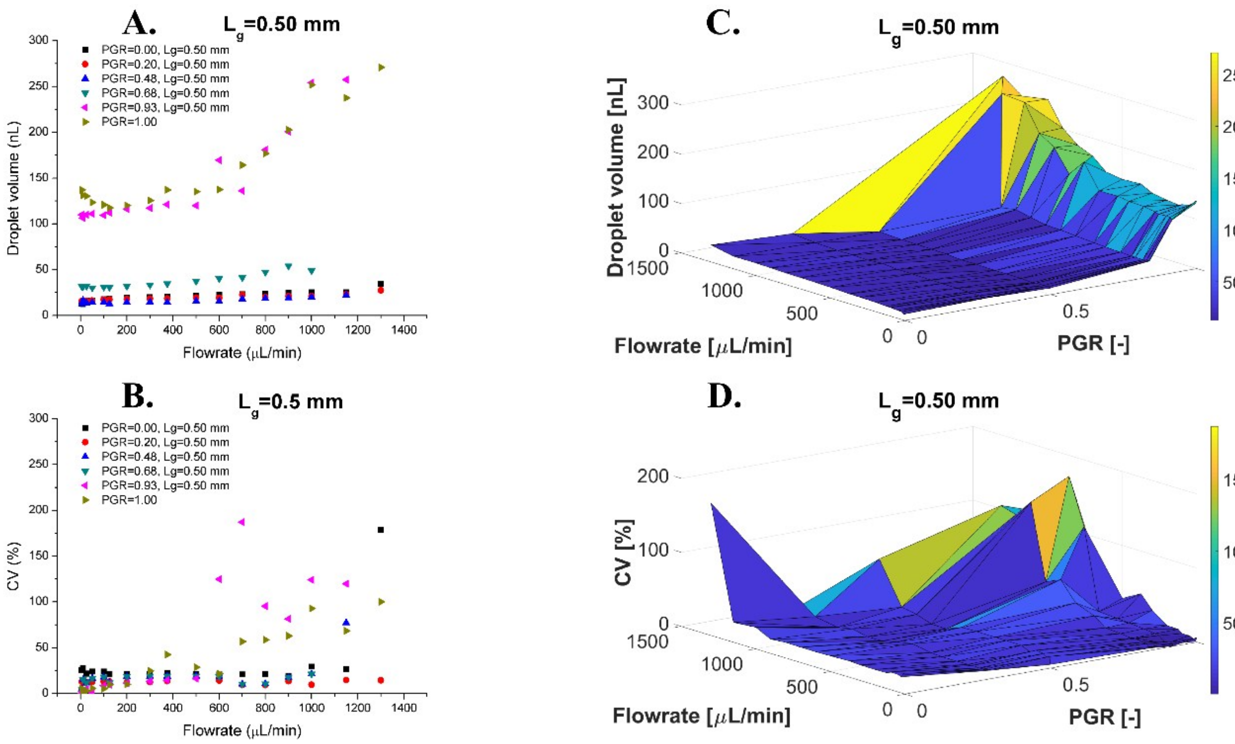

Fig. S 2 **Top:** Relationships between: droplet sizes (**A** and **C**) and droplet dispersity reported as CV of droplet volume (**B** and **D**) and the applied flow rate of the droplet phase for devices with L_g=0.50 mm. Both sizes and dispersions are represented as scatter (**A, B**) and surface (**C, D**) plots.

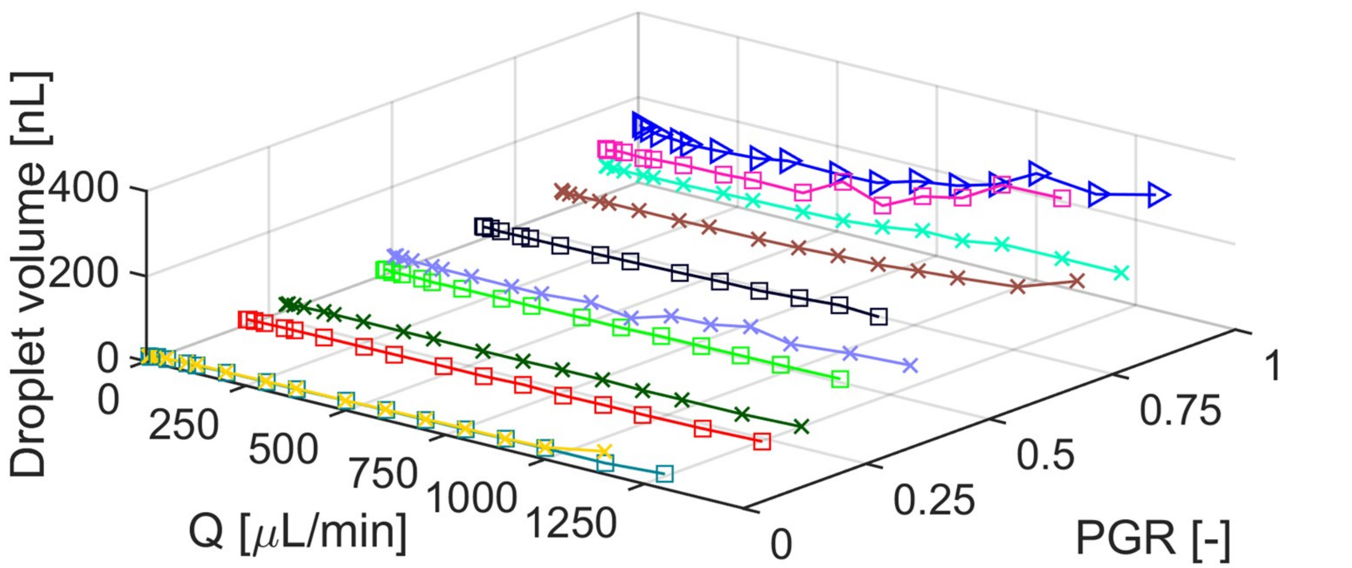

Fig. S 3 Relationship between droplet volume, the flowrate of dispersed phase and PGR. All of the investigated - devices with grooves spaced by 500 µm (squares) and 750 µm (crosses). Triangles denote EDGE-type device, the same for both plots.

Surface of the polycarbonate

In the Fig. S4 we show images optical profilometer (CountourGT-K, Bruker, USA) and extracted cross-section of a i) whole device, and ii) a single groove of that device.

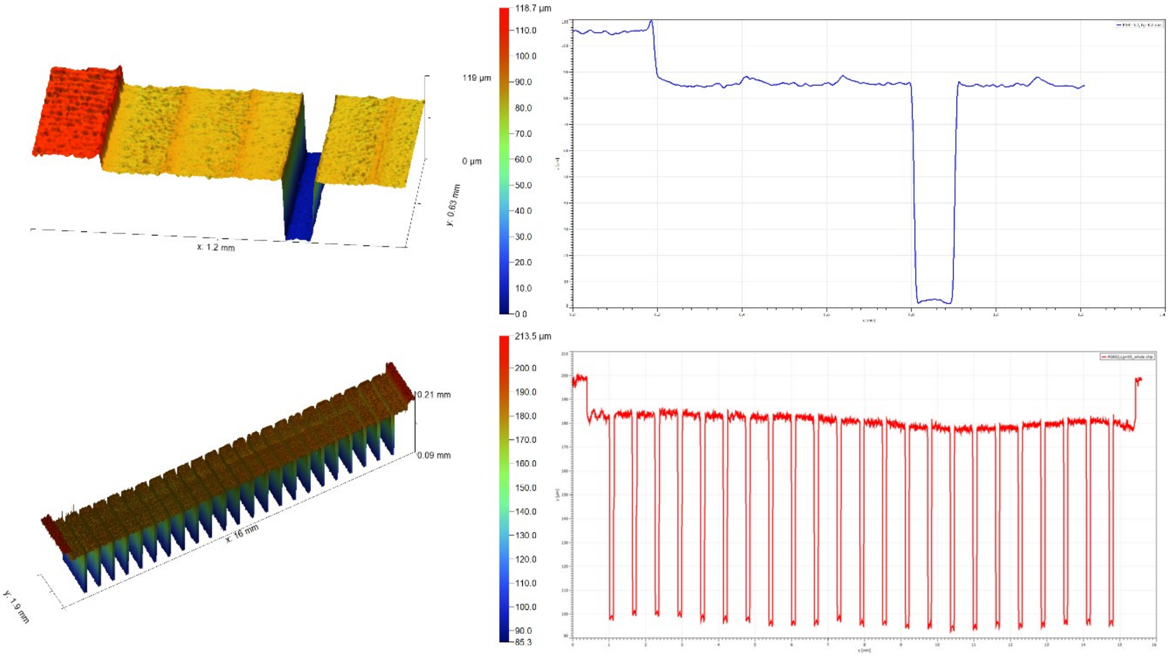

Fig. S 4 Surface characterization of the milled chips. Top: part of the chip with a single groove. Bottom: whole chip with 23 grooves. Left: images from profilometer. Right: profile of the scanned image. Shown device: PGR=0.2, L_g=0.5 mm.

In order to check influence of surface roughness on the experiment performance we ran a control experiment. We milled 4 PC plates to be flat and divided them into 2 groups of 2 plates. One group was smoothened with dichloromethane vapor[2], the other was left as was. Then, one chip from each pair was modified with fluorosilane (Novec 1720, 3M, applied to the surface, dried, baked in 75^{o}C for 1 hour, then repeated). A drop of 2 µL of miliQ water was and each of the plates was measured (Fig. S5). Smoothening of the polycarbonate surfaces led to no change in contact angle after silanization. That is most probably due to the hindered adhesion of fluorosilanes to the smoothened surface.

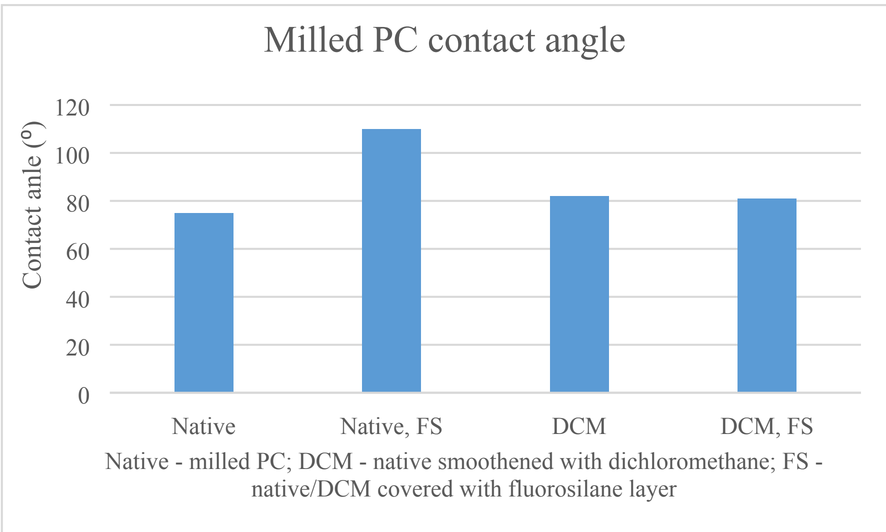

Fig. S 5 Contact angle between milled polycarbonate (native and motified with fluorosilanes, rough and smoothened by dichloromethane vapor treatment).

1 G. P. Association., *Physical properties of glycerine and its solutions.*, Glycerine Producers' Association, New York, 1963.

2 O. Cybulski and P. Garstecki, in 19th International Conference on Miniaturized Systems for Chemistry and Life Sciences (MicroTAS 2015), 2015, pp. 1398–1400.