Simple modular systems for generation of droplets on demand

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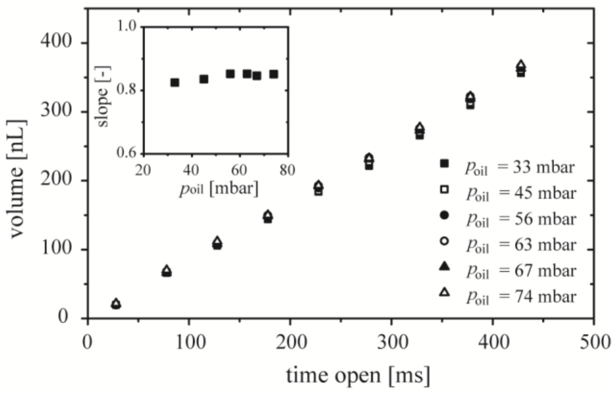

Fig. SI1 The dependence of the volume of droplets on 'time open' for five different pressures applied to the oil phase. Pressure applied to water was 100 bar.

Resistive capillary. We recorded high speed videos of the tip of the droplet phase during the process of generation of a droplet. We showed the volume in the tip as a function of time (Fig. 8). We tuned constant ratio between $p_{reservoir}$ and L ($p_{reservoir} = L_{capillary} \cdot 0.1$ bar m^{-1}) for each conditions of droplets generation, thus volumes o droplets should be identical. We noticed that together with the increase of $p_{reservoir}$ and $L_{capillary}$, droplets grow faster and them final volumes are higher. It results from neglected additional hydraulic resistance – R_{chip}. In order to eliminate the influence of R_{chip} on volumes of droplets we determined R_{chip} and found the minimal ratio $R_{capillary}/R_{chip}$, which makes volumes of droplets independent on R_{chip}.

Fig. SI2 shows dependence of Q_D on $L_{capillary}$. This relation strongly depends on $L_{capillary}$ for short capillaries, what exhibits the influence of R_{chip} on the rate of flow of liquid in the chip. Together with the increase of $L_{capillary}$, Q_D asymptotically tends to be constant.

In order to find R_{chip} (actually L_{chip} – the hydraulic resistance of the chip in unit of capillary length) we rewrote Hagen-Poiseuille equation (with assumption that $L_{capillary} \sim R_{capillary}$ and $L_{chip} \sim R_{chip}$) as a $L_{capillary} + L_{chip} \sim p_{reservoir}/Q_D$. Temporary assuming that $R_{capillary}/R_{chip} >> 1$, we plotted relation $L_{capillary} \sim p_{reservoir}/Q_D$ (Fig. SI2). If indeed Q_D on $L_{capillary} >> 1$, this linear function will cross the coordinate system in the point (0,0). The shift of the root of this function to negative values comes from influence of R_{chip} on the rate of flow of liquid in microchannels. Thus, L_{chip} (resistance of the chip in unit of capillary length) of the chip filled with a sequence of a few drops (c.a. 5-6 drops) is the absolute value of the root of this function. This calculation estimates R_{chip} to be equal to the hydraulic resistance of a steel capillary of the inside diameter of 0.205 mm and of the length of 0.1 m.

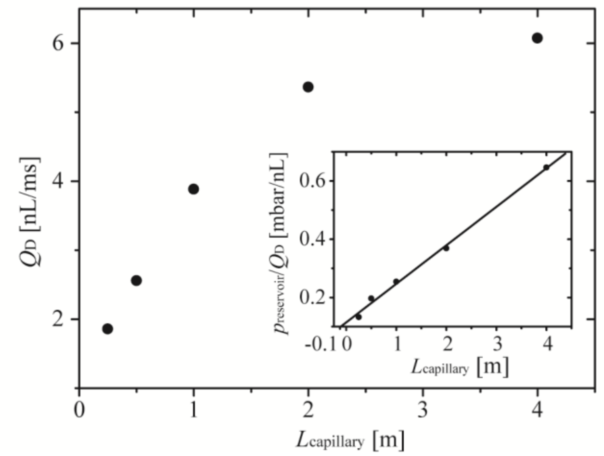

Fig. SI2 The dependence of Q_D on $L_{capillary}$. In the inset the dependence of $p_{reservoir}/Q_D$ on $L_{capillary}$ for linear parts of the evolution of volume of droplets in time, during their generation (Fig. 8). We determined R_{chip} (in unit of capillary length) as an absolute value of the root of this function.

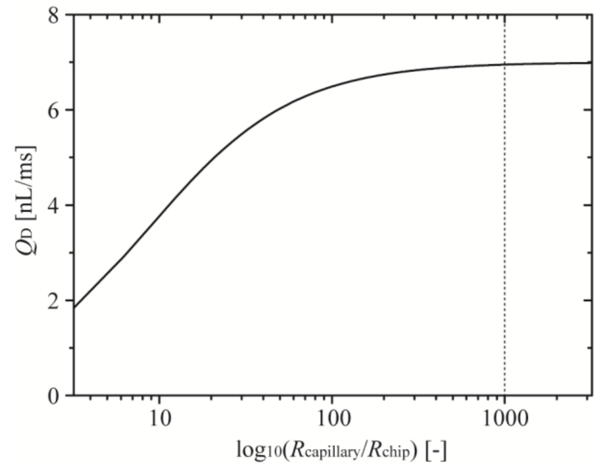

Fig. SI3 The theoretical dependence of Q_D on $\log_{10}(R_{capillary}/R_{chip})$. The ratio above 10^3 sufficiently eliminates the dependence of volume of droplet on R_{chip}.

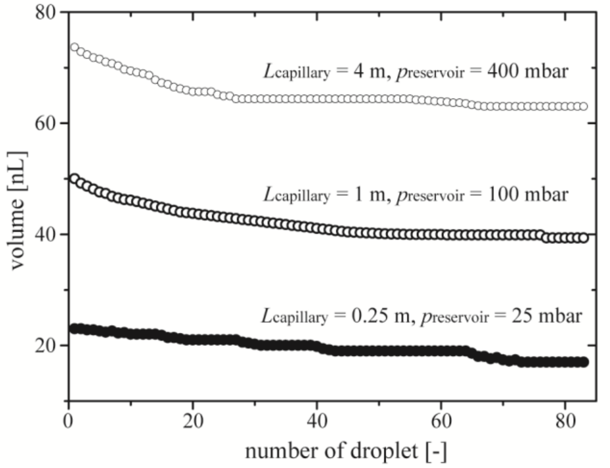

Fig. SI4 The decrease of volume of droplets as a result of the increase of the number of droplets in the microchannel. For each length of the capillary ($L_{capillary}$ = 0.25, 1, 4 m) we applied the pressure $p_{reservoir}$ = $L_{capillary}$·0.1 bar m^{-1}.

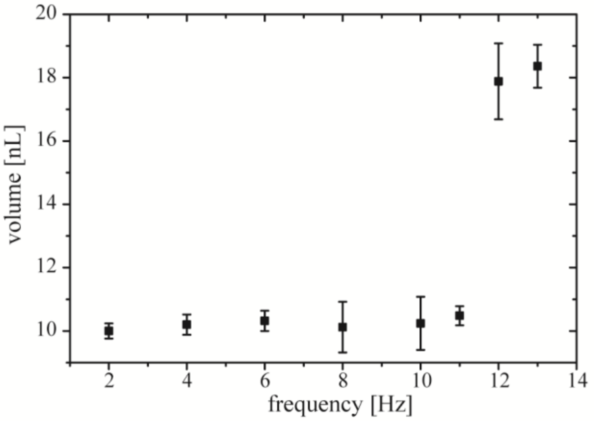

Fig. SI5 The dependence of the volume of droplets on the frequency of their generation in the system operated with a squeeze valve. Time open of the valve 8 ms, the pressure applied to water is 100 mbar.