Microfluidic Flow-Focusing Device with 3-D Geometric Confinement

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Microfluidics has attracted a lot of interests due to their ability to produce droplets with precisely controlled sizes, shapes and internal structures. Single layered microfluidic flow-focusing devices made of poly(dimethylsiloxane) (PDMS) have two-dimensional microchannels with uniform height. In this case, the dispersed phase is broken into droplets by lateral shear forces originated from the flow of continuous phase. By increasing the flow rates of the continuous phase, quasi-three-dimensional confinement of dispersed phase could be achieved. However, leakage of fluids can occur due to the high flow rates. In this work, we fabricated three-dimensional (3-D) flow-focusing devices that could achieve the 3-D confinement of the dispersed phase. We investigated the effect of flow rates, fluid viscosities, and interfacial tensions on drop formation in the various channel geometries. The geometry is advantageous to generate amphiphilic droplets without leakage due to the lower level of required flow rates. We expect that the novelty of our design can offer a potential new route toward the production of micrometer- and submicrometer-scale droplets.