Electronic Supplementary Material (ESI) for Lab on a Chip

Temperature-Controlled 'Breathing' of Carbon Dioxide Bubbles

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1. Schematic of the flow-focusing MF device

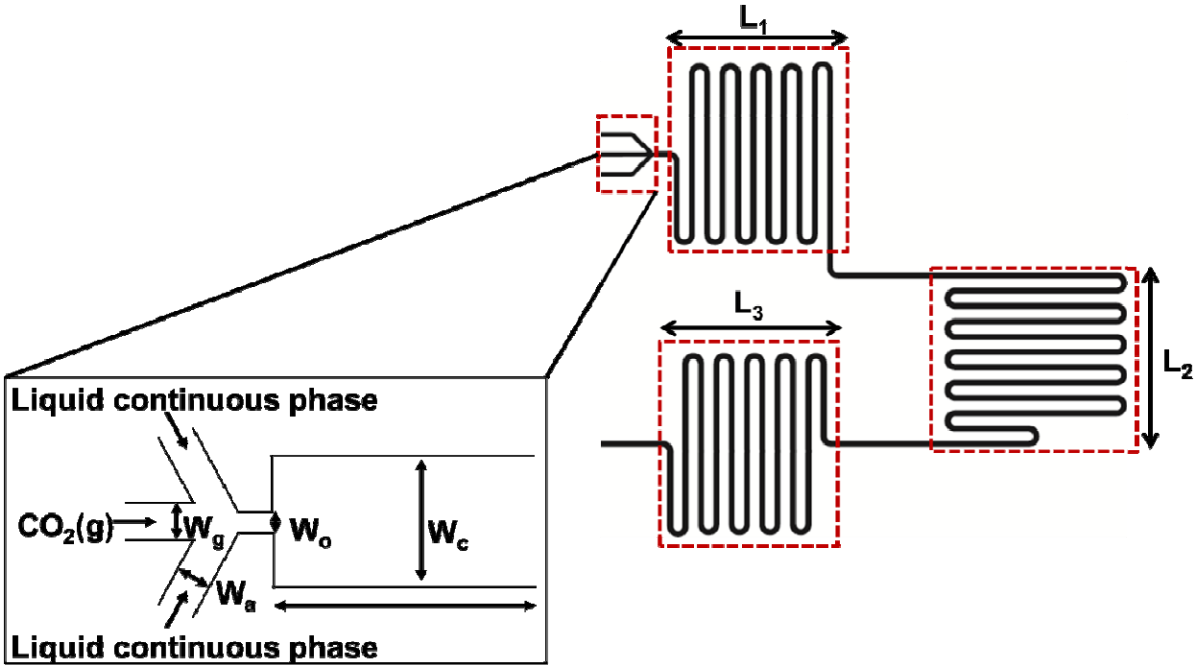

Figure S1. Schematic of the MF bubble generator. W_g=50 µm, W_a=100 µm, W_o=20 µm, W_c=200 µm. $L_1 = L_2 = L_3$ = 135 mm. The total channel length of the device (from the orifice to the outlet is 450 mm). The height of the MF device is 120 µm.

2. Design of accessories for temperature-control in the MF device

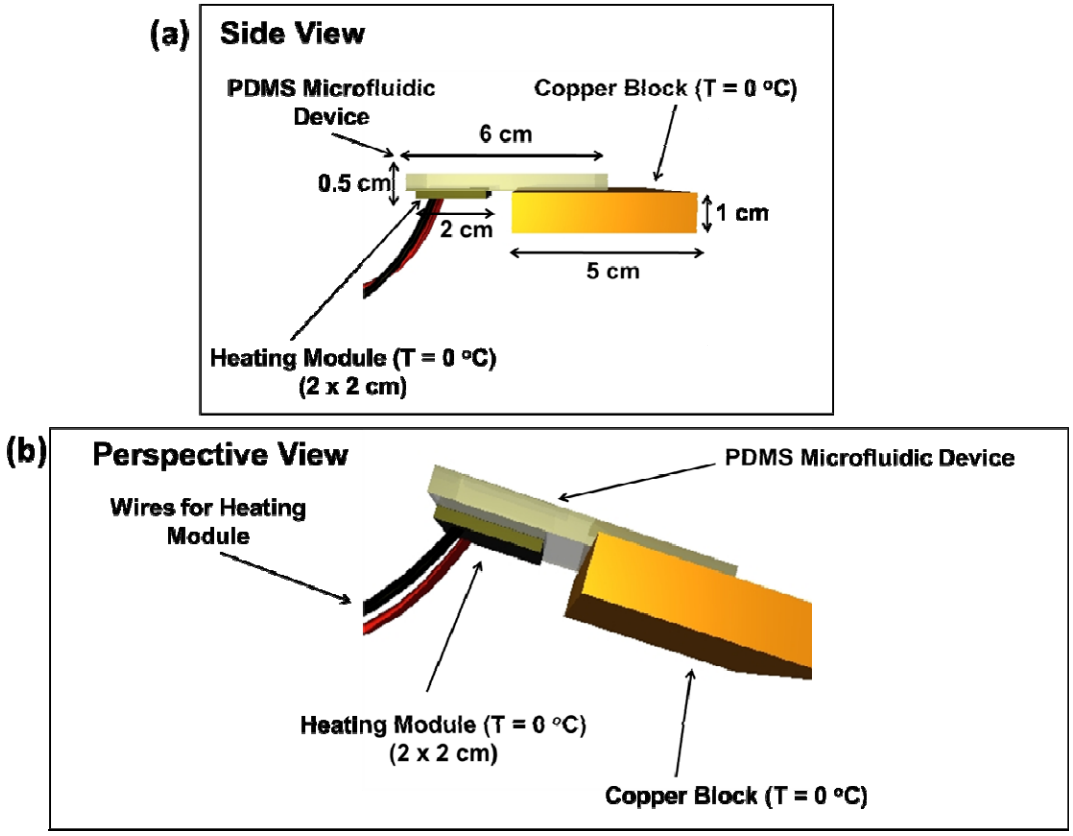

Figure S2. Schematic of the accessories for the temperature control in the MF device. The position of the heating module and the cooling module are placed below the MF device fabricated in PDMS: (a) Side view, and (b) perspective view of the setup. The cooling module is inserted underneath Regions 1 and 3, and the orifice, the heating module is applied to Region 2 (Fig. 2a). The temperature of 0 ^{o}C of the cooling module is controlled by flowing through it a mixture of glycerol and water (1:4 v/v) using a temperature-controlled water circulator (Neslab RTE-040). The temperature of the heating module of 35 ^{o}C is controlled by a temperature controller (TE-Tech).

3. Modeling of temperature of the liquid traveling through microfluidic channels

Numerical simulations of the temperature of the liquid moving through the MF device was performed using the multiphysics program Comsol (version 4.0a, Comsol, Inc., USA). An

unstructured mesh was generated using a resolution of the narrowest region of 0.5. The resultant mesh consisted of 109,324 points and 994,537 elements. Convective heat loss was considered at the outer surfaces of the MF device, that is, the top, the bottom, and the side walls of the device. Boundary conditions as follows:

Inlet liquid flow rate: 2.5 mL/hr

Outlet pressure: 1 atm, 0 kPa gauge pressure

Temperature of the liquid at the inlet: 23 ^{o}C

4. Variation in the volume of CO_2 bubbles in deionized water at constant temperature

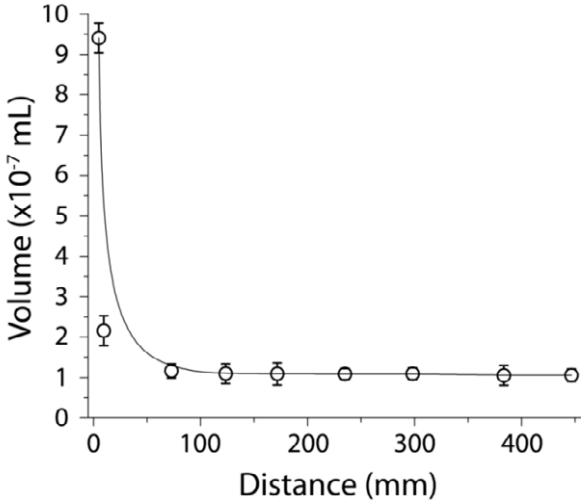

Figure S3. Variation in CO_2 bubble volume at 23 ^{o}C, plotted as a function of the distance from the orifice. The bubbles were generated at a P_{CO2}=48.3 kPa and Q_C=2.5 mL/hr.

5. Variation in bubble size in DEPG at constant temperature

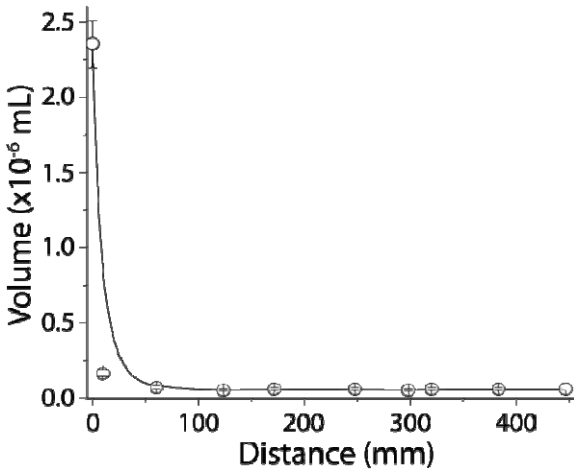

Figure S4. Variation in bubble volume in DEPG, plotted as a function of the distance from the orifice at 23 ^{o}C. P_{CO2}= 82.7 kPa, Q_c=2.5 mL/hr. The scale bar is 50 µm.