Electronic Supplementary Material (ESI) for Lab on a Chip.

Supplementary Information

dDrop-Chip: disposable film-chip microfluidic device for real-time droplet feedback control

Jaewook Ryu, Junhyeong Kim, and Ki-Ho Han*

Department of Nanoscience and Engineering

Center for Nano Manufacturing, Inje University

Gimhae 50834, Republic of Korea

*Corresponding Author

Address: Department of Nanoscience and Engineering, Inje University

197, Inje-Ro, Gimhae, Gyongnam, 50834, Republic of Korea

Tel: +82-55-320-3715/ Fax: +82-55-320-3631/ E-mail: mems@inje.ac.kr

Table. S1 Driving pressures applied to the sample and oil inlets on each of the five dDrop-Chip to control the droplet length to 220 μm and the sample flow rate to 2 μL/min.

Case	Device number	Sample pressure (10^{-3} bar)	Oil pressure (10^{-3} bar)
With feedback control	1	249	470
	2	201	478
	3	188	486
	4	207	479
	5	183	482
Without feedback control (average values)		206	479

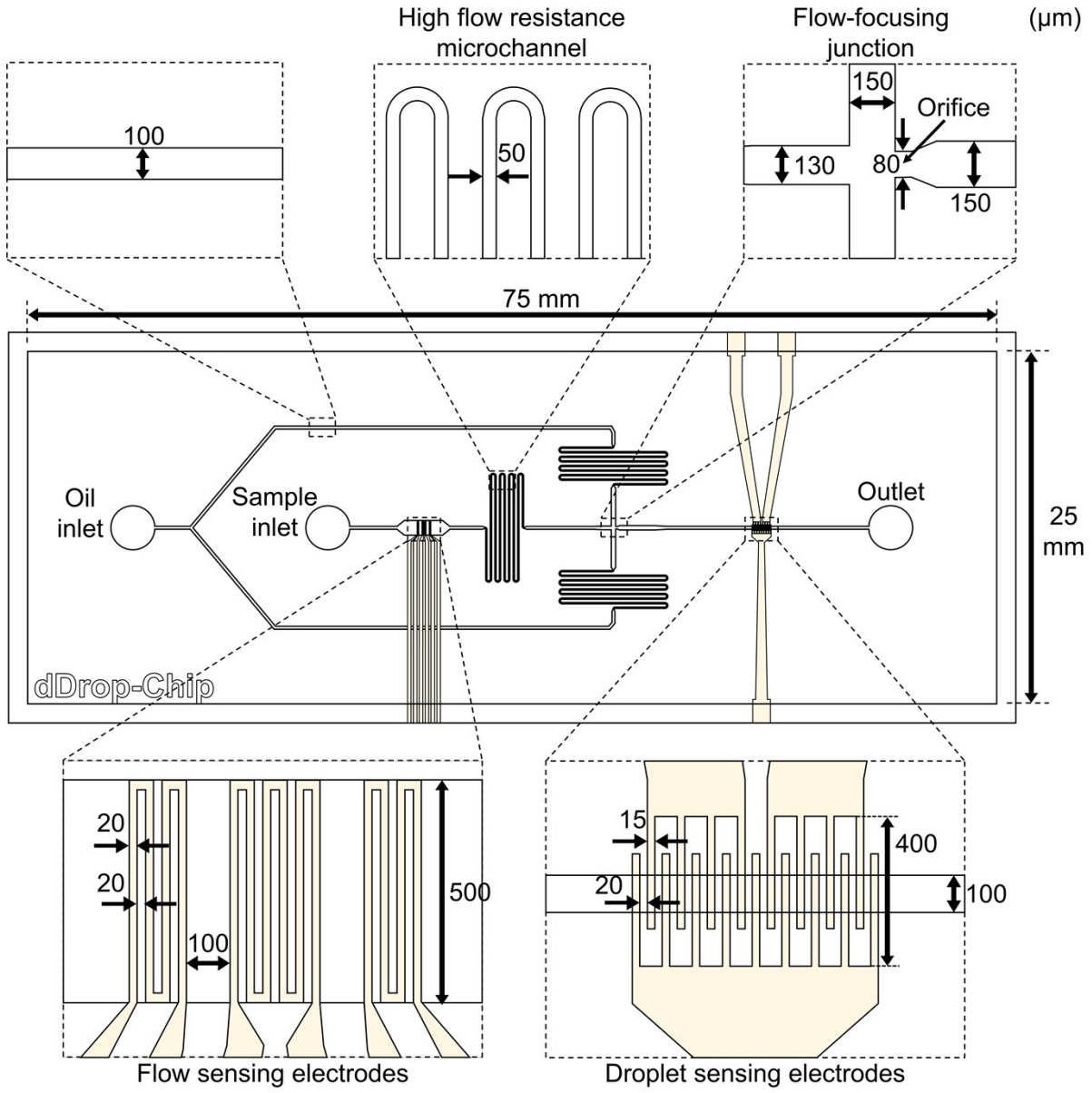


Fig. S1 Design of the dDrop-Chip, including the calorimetric flow-sensing electrodes to measure the sample flow rate, three microchannels with high flow resistance to stabilize oil and sample flow, a flow-focusing junction with an 80 μm-wide orifice to generate droplets, and the droplet-sensing electrodes to detect droplets.

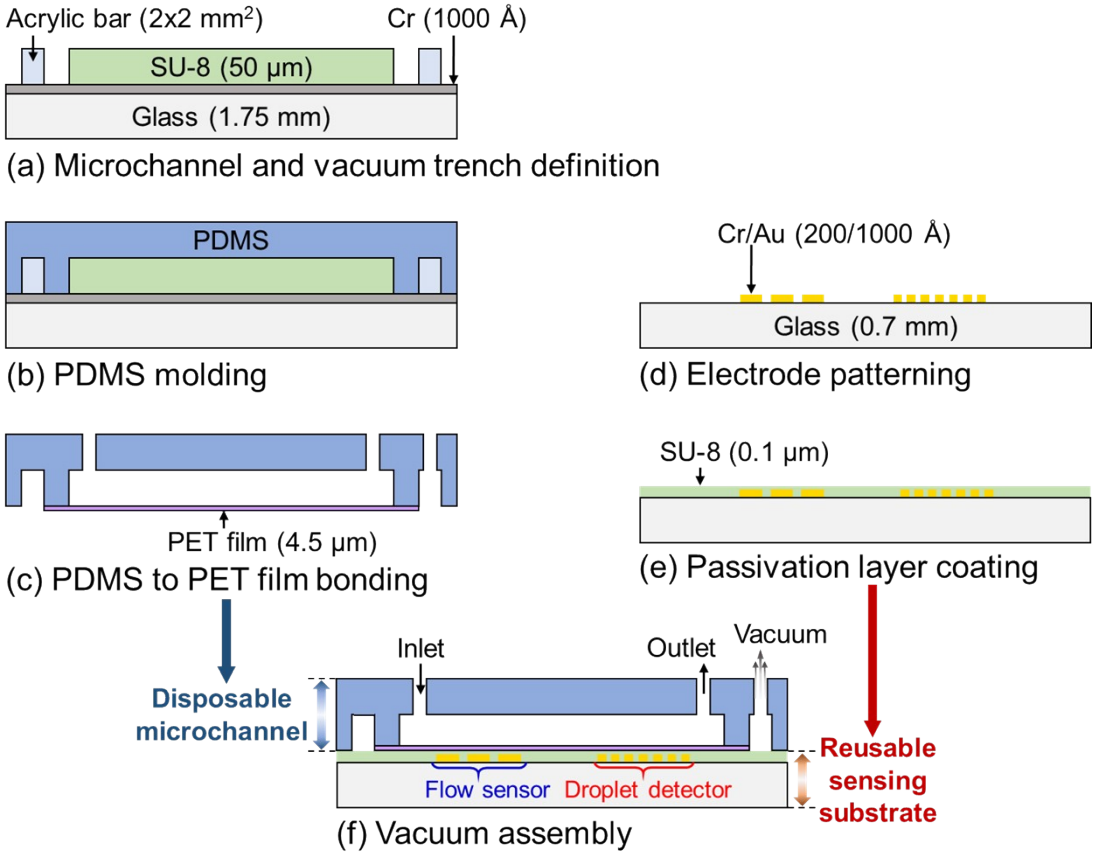


Fig. S2 Fabrication process of the dDrop-Chip. (a) Cr (1,000 Å) deposition on a glass slide, followed by SU-8 (3050, MicroChem Co.) patterning to define the microchannel (50 μm height), and an ultraviolet (UV) adhesive bonding of acrylic square bar (2×2 mm^2) to define the vacuum trench. (b) PDMS molding to produce the microstructured PDMS replica. (c) Inlet and outlet reservoirs and a vacuum hole were created by using a 1.5 mm diameter punch. Oxygen plasma bonding of the PDMS replica and the 4.5 μm thick PET film, which was superficially modified by the (3-aminopropyl)triethoxysilane, was performed to produce the disposable microchannel. (d) Cr/Au (200 Å/1,000 Å) deposition on a 0.7 mm thick glass substrate and patterning of the flow and droplet sensing electrodes. (e) SU-8 coating (0.1 μm) to passivate the electrodes. (f) Vacuum assembly of the disposable microchannel and the reusable sensing substrate to produce dDrop-Chip. Immediately before using the dDrop-Chip, the microchannels were coated with a superhydrophobic solution (Aquapel, PGW Auto Glass) for 60 s.

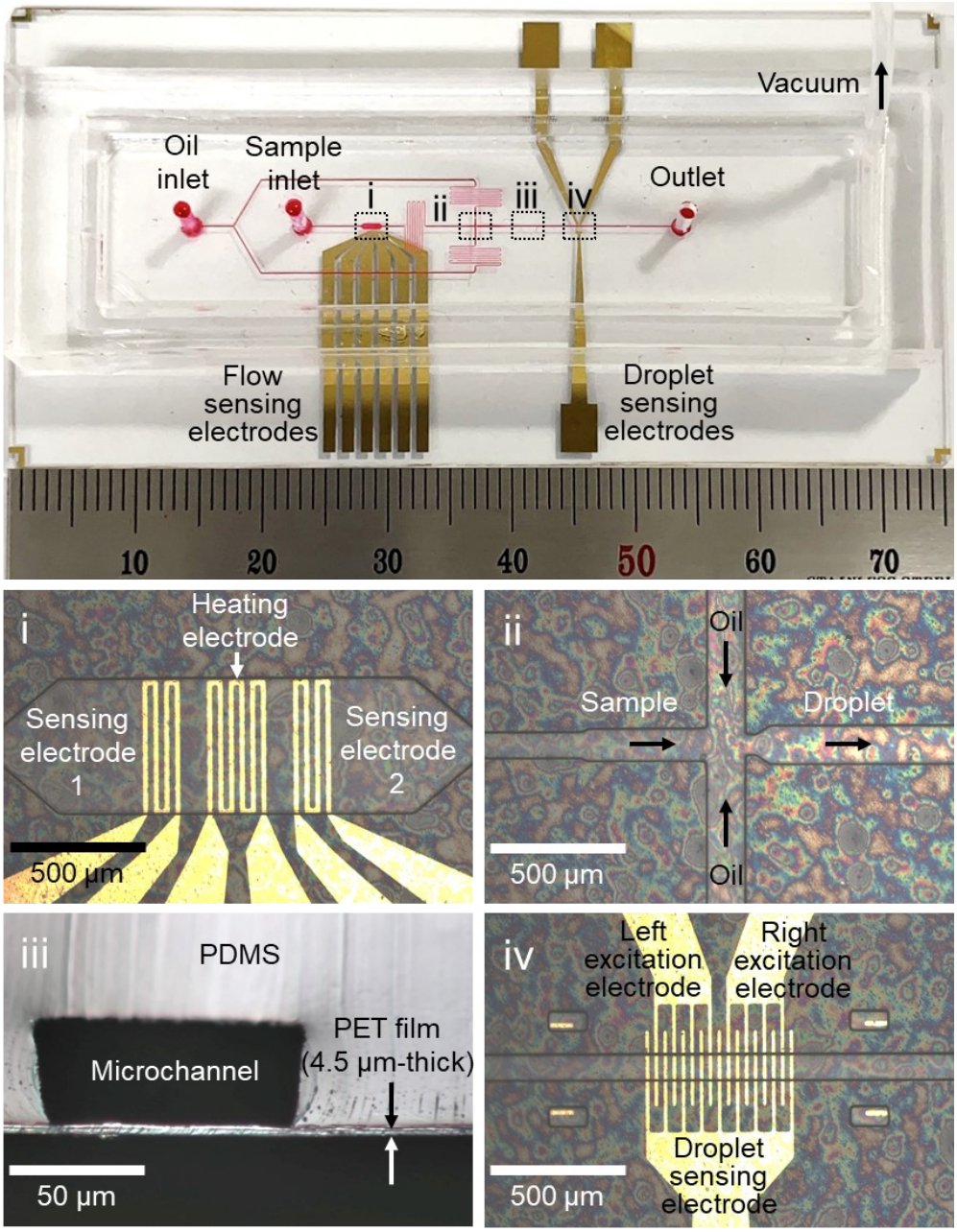
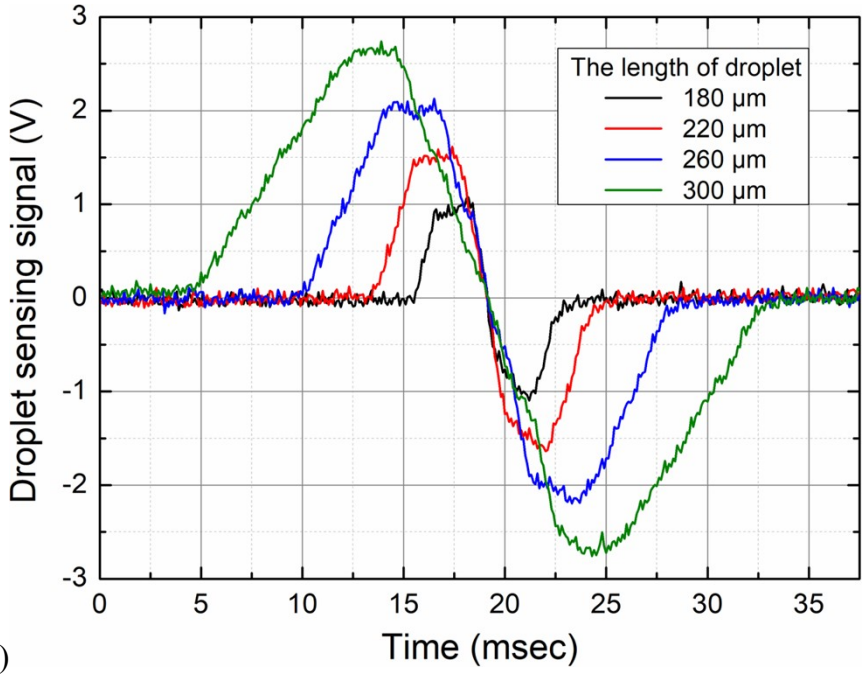
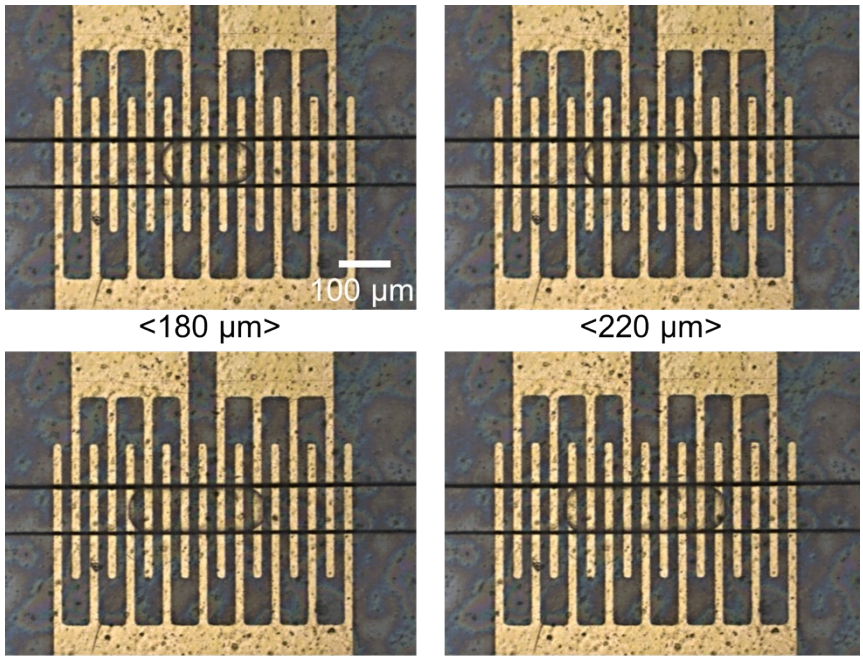


Fig. S3 Photographs of the fabricated dDrop-Chip that includes (i) the flow sensing electrodes, consisted of a heating electrode in the center and two sensing electrodes on both sides, (ii) the flow-focusing junction for droplet generation, including an 80 μm-wide orifice and two oil microchannels injected vertically from both sides into the sample microchannel, (iii) microchannels formed between the PDMS replica and the 4.5 μm-thick PET film, and (iv) the droplet sensing electrodes, composed of the left and right excitation electrodes and the sensing electrode in the form of interdigitated electrodes.

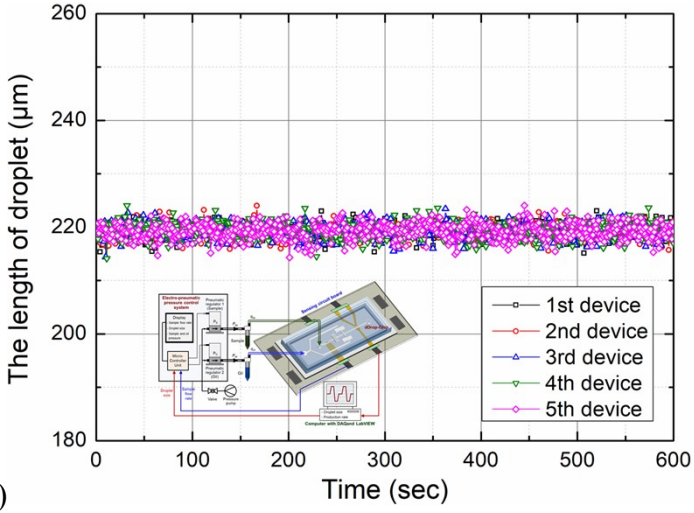


(a)

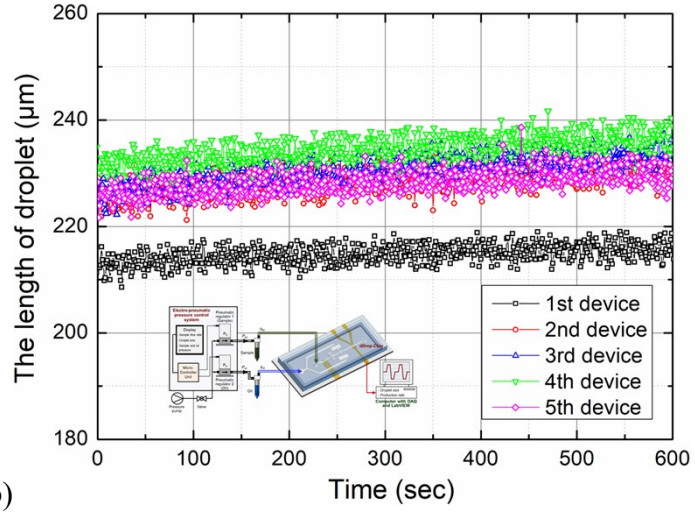


(b)

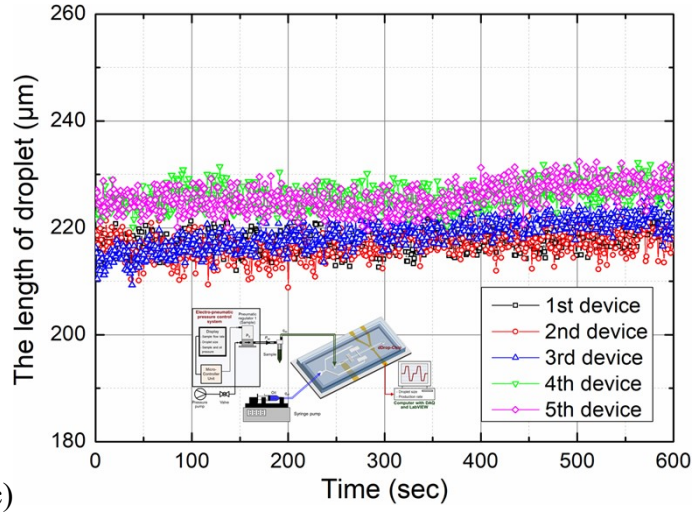
Fig. S4 (a) Droplet sensing signals according to the droplet length. (b) Photographs showing the droplets that are 180, 220, 260, and 300 μm in length that pass over the droplet sensing electrodes.



(a)



(b)



(c)

Fig. S5 Size variation of droplets generated by (a) two pressure pumps with the proposed feedback control, (b) two pressure pumps, and (c) a syringe pump and a pressure pump without feedback control for 10 min. In each case, the identical five disposable microchannels were used.

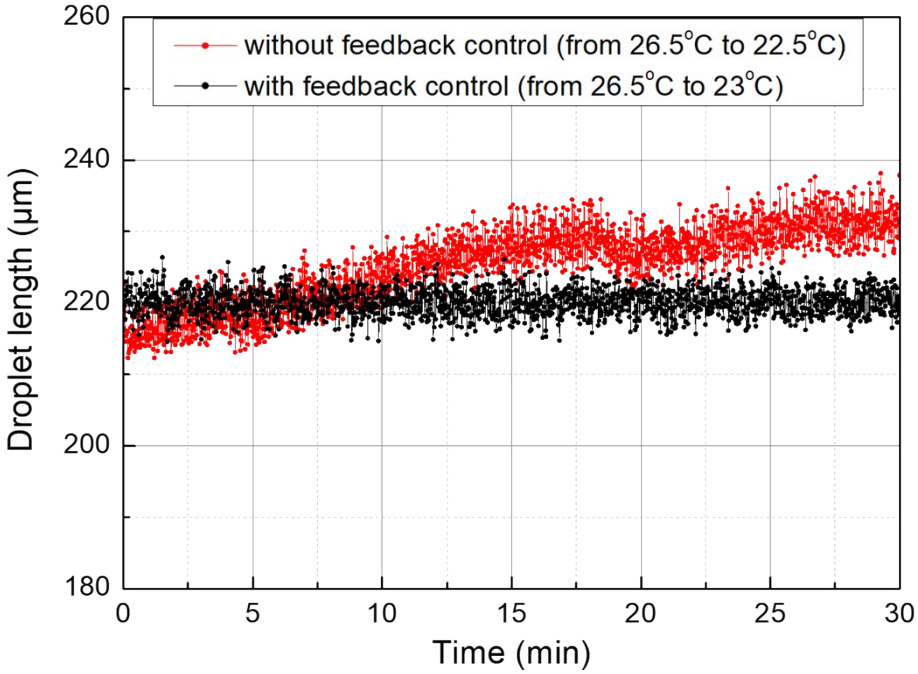


Fig. S6 Change in the length of droplets generated using two pressure pumps with ambient temperature changes for 30 min with and without the proposed feedback control. The driving pressures applied to the continuous and dispersed phases without the feedback control were 480 and 200 mbar, respectively.