Supporting Information

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SI Materials and Methods

Microfabrication. The devices were made of polydimethylsiloxane (PDMS), formed using specifically fabricated molds. The fabrication of the sloped regions for Figs. 1–3 and 4*A* required a hybrid procedure that combined standard dry film soft lithography (1) and a specific method for making the slopes.

The procedure, which is sketched in Fig. S1, is as follows: Starting from a standard glass slide 1.1 mm in thickness (stage A), three layers of dry film photoresist (1 × Eternal Laminar E8013 and 2 × Eternal Laminar E8020 negative films of thickness 31 ± 2 μm and 49 ± 2 μm, respectively) are successively laminated using an office laminator at a temperature of 100 °C until the desired channel height, $h_0 \approx 130$ μm is reached (stage B). The photoresist film is then exposed to UV through a photomask of the injection network. The nozzle structures are developed by immersion in an aqueous bath of carbonate potassium at 1% mass concentration (stage C). To make the sloped reservoir, n square thin glass slides 1 cm per side and $h_g \approx 130$ μm in thickness are glued using Norland Optical Adhesives (NOA) adhesive to the base slide at a distance l from the nozzles (stage D). Then, another thin glass slide is placed just against the nozzle and rested on top of the glass pillar from the previous step (stage E). Consequently, the glass slide is inclined compared with the base structure, at an angle given by the relation $\tan \alpha = n{\cdot}h_g/l$. Finally, the gap between the inclined slide and the base slide is filled with NOA adhesive by capillary suction and reticulated with UV (stage F). For devices with structures etched into the reservoir, dry film photoresist structures are added to the sloped glass slide before gluing.

The topography of the mold was measured using an optical profilometer (Veeco Wyco NT1100). These measurements verified that the height of the reservoir increased linearly downstream of the injection nozzle. The channels were then replicated in PDMS (Dow Corning SYLGARD 184, 1/10 ratio of curing agent to bulk material), poured over the master, and cured 2 h at 70 °C. Finally, the PDMS was cut off and sealed on a glass slide by plasma bonding to obtain a device with a sloped reservoir.

The channels of Fig. 4 *B–E* were fabricated using standard soft lithography. The slope was obtained by inflating the devices, i.e., imposing an overpressure to the continuous phase, using a pressure controller (Fluigent MFCS). The dispersed phase was then injected either using a syringe pump or manually through a micropipette.

Surface Treatment. The microchannel surfaces were treated to enhance the wetting properties of the continuous phase. In the case of water as the continuous phase, the plasma exposition used for bonding the glass slide to the PDMS device made the channel surfaces hydrophylic. Hence, the devices were simply filled with water immediately after bonding to maintain this property. When the fluorinated oil FC-40 served as the continuous phase, a solution of 1H,1H,2H,2H-perfluorodecyltrichlorosilane (Sigma Aldrich) (20 μL in 1 mL of FC-40) was flowed through the device for 5 min, coating the channel with a fluorinated hydrophobic layer. The device was then rinsed thoroughly with pure FC-40 to remove bulk traces of surface treatment.

Fluid properties. Three combinations of continuous and dispersed phases were used in the experiments:

Continuous phase	Viscosity, μ_c, cP	Dispersed phase	Viscosity, μ_d, cP	Interfacial tension, γ, mN/m
H_2O + C_6E_{12}* at 1 CMC†	1	Air	2×10^{-2}	50 ± 2
H_2O + SDS at 1% mass concentration	1	FC-40 oil (3M)	4.1	12 ± 2
FC-40 oil (3M) + PEG-PFPE (2–4) at 1% mass concentration	4.1	H_2O	1	7 ± 1

*C_6E_{12}, hexaethylene glycol monodecyl ether, provided by the LPS.
†CMC, critical micellar concentration.

Experimental Protocols for Parallel Droplet Production. ***Colored droplets.*** Three solutions of water dyed with red, yellow, or blue food coloring are injected at a flow rate of 12 μL/min each. In the hexagonal network shown in Fig. S4*A*, each colored stream is split into three: one stream never in contact with the two other fluids and two streams that combine each with one of the other two colors. It forms six streams colored with the rainbow gradation purple–blue–green–yellow–orange–red that then mix as they flow along delay lines.

The six channels produce six streams of droplets in the reservoir. The droplets are propelled away from the injection nozzles by the channel slope until they reach the outlet that leads to the collection container through a teflon tube. To force the emulsion out of the reservoir, FC-40 is injected into the reservoir from two separate inlets at a flow rate of 10 μL/min each. The experimental setup and the collected emulsion are shown in Fig. S4*B*.

Alternatively, the emulsion is collected by partially cutting open the reservoir, allowing the droplets to rise by buoyancy into a syringe filled with FC-40 oil. This setup is shown in Fig. S4*C*.

Massively parallel production. The pressure in the reservoir p_o was imposed by connecting the pressure inlet and an exit hole punched in the center of the reservoir to a controllable pressure source. The pressure at the pressure inlet was set at $p = 120$ mbar and the pressure at the exit hole at $p = 80$ mbar. This 40-mbar pressure difference creates a flow from the pressure inlet to the exit hole that evacuates the droplets out of the reservoir.

The FC-40 oil was injected at a total flow rate of 20 μL/min from a single inlet into the large distribution channel that feeds all of the nozzles. As seen in Movie S3, a few nozzles are not producing droplets due to clogging of their inlet channels. Nonetheless, neighboring nozzles are unaffected and produce droplets identical in size to those of the other nozzles. This observation highlights the robustness of the drop production mechanism.

The monodispersity of the emulsion is evidenced in Fig. S5, which shows a hexagonal matrix of ∼250 droplets in the reservoir.

1. Stephan K, et al. (2007) Fast prototyping using a dry film photoresist: Microfabrication of soft-lithography masters for microfluidic structures. *J Micromech Microeng* 17(N69):74.
2. Baret JC (2012) Surfactants in droplet-based microfluidics. *Lab Chip* 12(3):422–433.
3. Clausell-Tormos J, et al. (2008) Droplet-based microfluidic platforms for the encapsulation and screening of mammalian cells and multicellular organisms. *Chem Biol* 15(5):427–437.
4. Holtze C, et al. (2008) Biocompatible surfactants for water-in-fluorocarbon emulsions. *Lab Chip* 8(10):1632–1639.

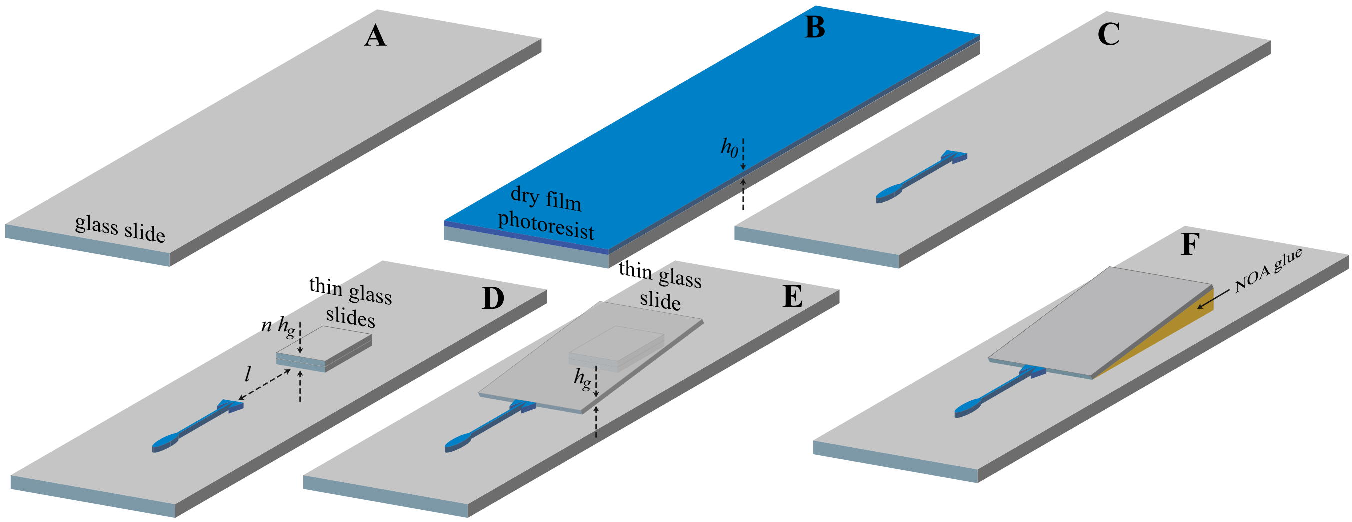


Fig. S1. (*A–F*) Sketch of the successive microfabrication steps required to produced a device with a sloped reservoir.

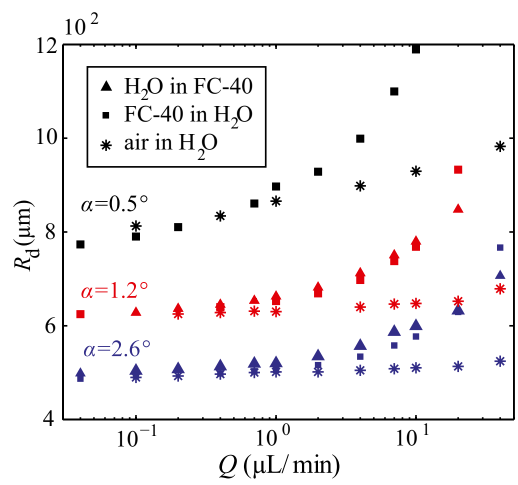


Fig. S2. Variation of drop radius R_d with flow rate Q for three reservoir slopes ($\alpha = 0.5°$, $\alpha = 1.2°$, and $\alpha = 2.6°$) and three fluid pairs: oil in water (■, $\gamma = 12$ mN/m), water in oil (▲, $\gamma = 7$ mN/m), and air in water (*, $\gamma = 50$ mN/m).

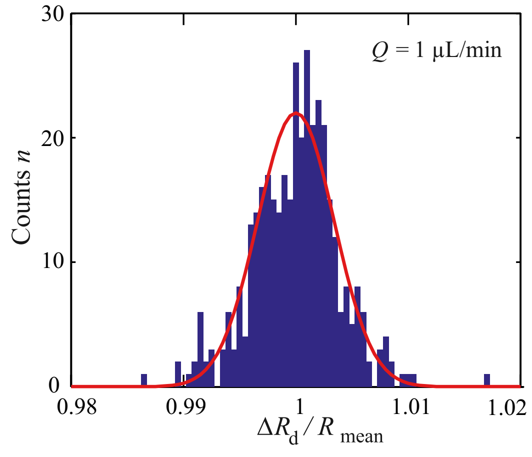


Fig. S3. Histogram of the measured radii R_d relative to the mean radius $R_{mean} = 641$ μm of 375 successive droplets produced during steady state at a flow rate $Q = 1$ μL/min with a nozzle of dimensions $h_0 = 130$ μm, $w = 250$ μm, and $\alpha = 1.2°$. A Gaussian fit (line) yields a SD of $\sigma = 0.2\%$.

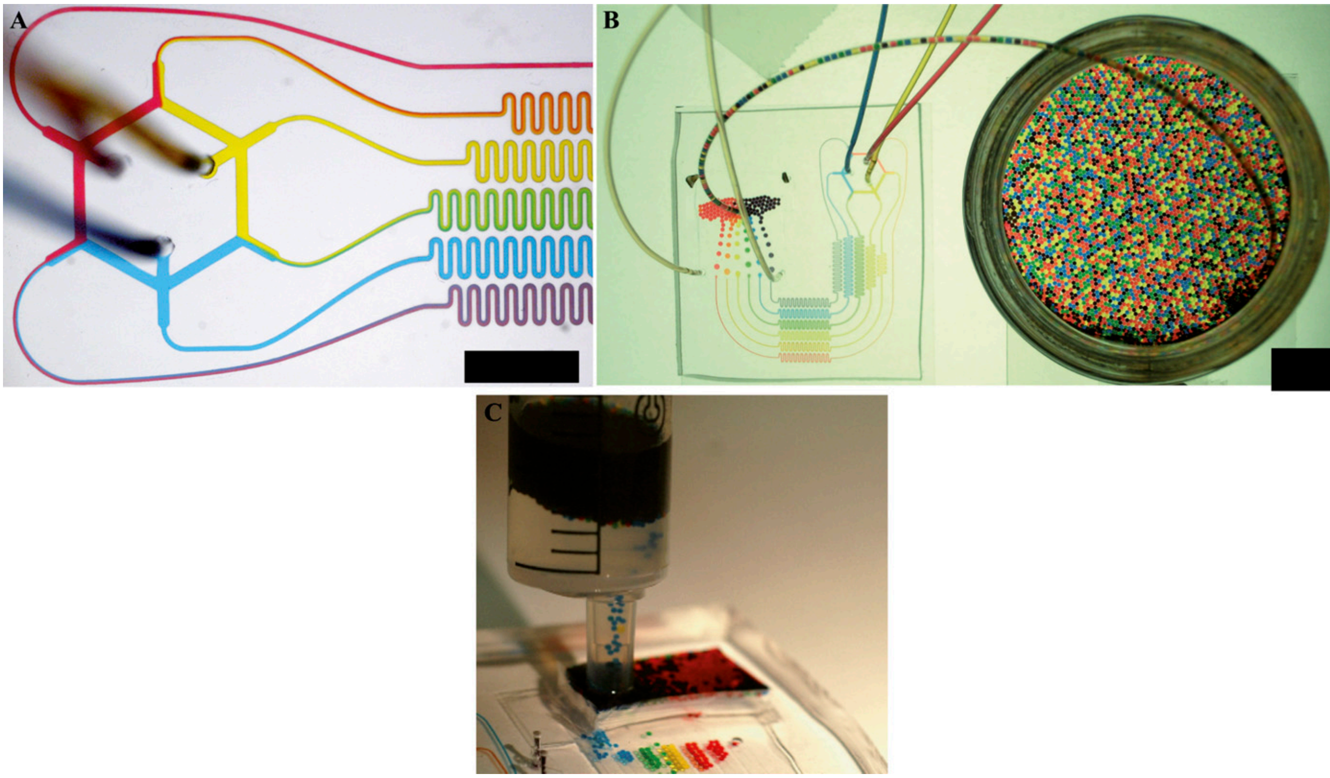


Fig. S4. (*A*) Photograph of the hexagonal network that produces six colored streams in a rainbow gradation. (Scale bar, 5 mm.) (*B*) Photograph of the microfluidic chip producing the rainbow-colored emulsion that is then collected into a large container. (Scale bar, 1 cm.) (*C*) Photograph of a microfluidic chip that has a reservoir partially cut open to access the rainbow emulsion. The droplets are collected as they rise by buoyancy into a syringe placed above the reservoir.

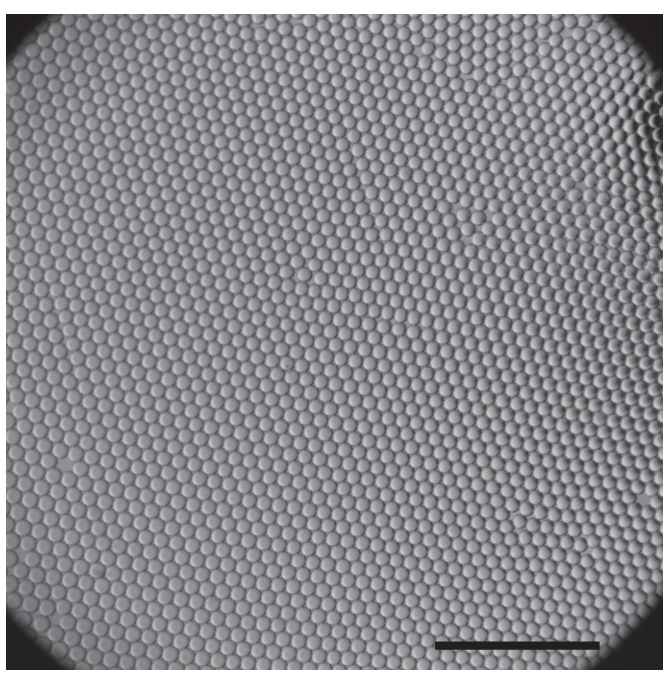
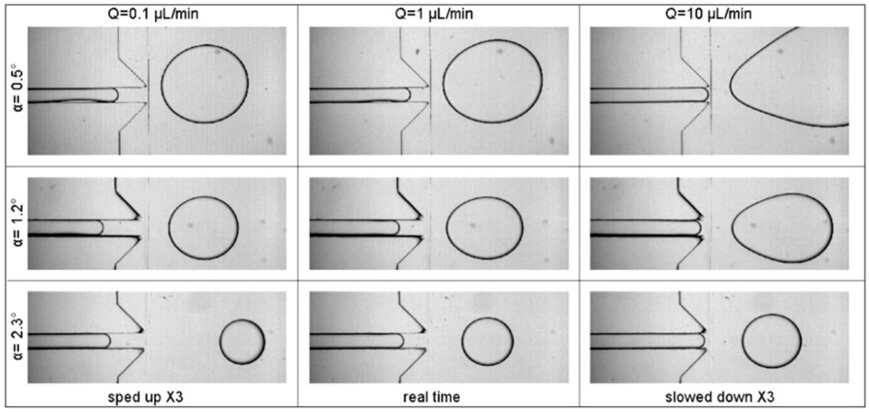
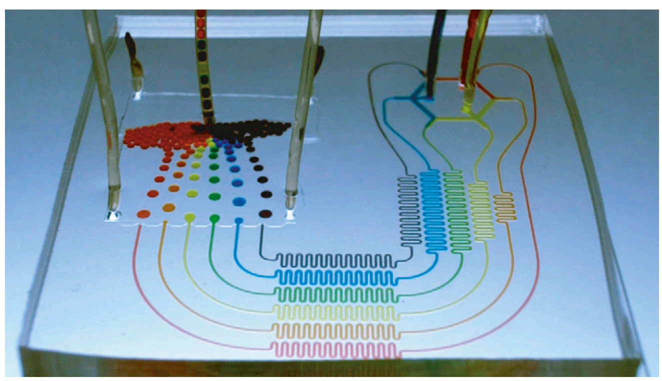


Fig. S5. Image of the emulsion in the reservoir while it is been produced. (Scale bar, 1 mm.)



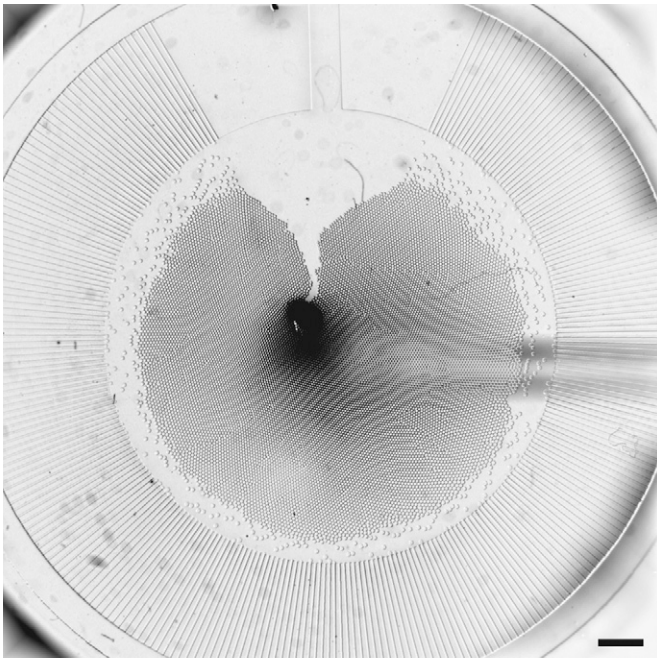
Movie S1. Nine experimental movies (60 frames/s) showing the droplet production for different slopes and flow rates. The three nozzles have a identical height $h_0 = 130$ μm and width $w = 250$ μm but different slopes $\alpha = 0.5°$, 1.2°, and 2.6°. They produce FC-40 droplets in water + SDS at flow rates $Q = 0.1$μL/min, 1 μL/min, and 10 μL/min. To facilitate visualization, frames rates have been modified:
For $Q = 0.1$ μL/min, movies are sped up 3×.
For $Q = 1$ μL/min, movies are shown in real time.
For $Q = 10$ μL/min, movies are slowed down 3×.
Highlighted is the coupled dependence of the produced drop radius R_d on the channel slope α and injection flow rate Q.

Movie S1



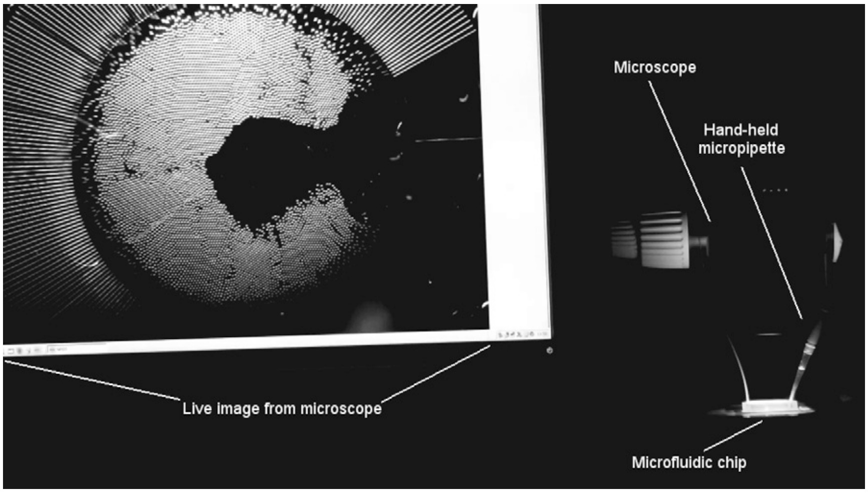
Movie S2. Experimental movie showing the production of a rainbow colored emulsion from 6 parallel nozzles of dimensions $h_0 = 130$ μm, $w = 200$ μm and $\alpha = 1.2°$.

Movie S2



Movie S3. Experimental movie sped up 2× of an inflatable device with 256 nozzles of height $h_0 = 15$ μm simultaneously producing 230 pL FC-40 droplets at a total frequency of 1.5 kHz into a circular reservoir filled with water + SDS pressurized at $p_o = 100$ mbar.

Movie S3



Movie S4. This real-time movie demonstrates the rapid partitioning of a sample into ~20,000 monodisperse droplets of picoliter volume, using only a microchip and a hand-held micropipette. The device is identical to the one described in Fig. 4 *B–E* of the main text: 256 nozzles of identical dimensions ($h_0 = 15$ μm and $w = 50$ μm) lead to a central circular reservoir 15 mm in diameter. The field of view displays the microchip placed under a Leica MZ16 FA stereomicroscope with a 0.7× magnification and the live image captured by the Spot camera mounted onto the microscope. The device is initially filled with water + SDS and inflated by connecting the outlet to a vertical tubing 10 cm in height. A 20-μL hand-held pipette is prepared by successively sucking 5 μL of water + SDS, 5 μL of FC-40, and 10 μL of water + SDS into the pipette tip. The pipette tip is then inserted into the inlet of the device and the fluids are injected by hand. During the movie, the sample of FC-40 oil reaches the nozzles and partitions into thousands of monodispersed picoliter drops that form a 2D array in the central reservoir.

Movie S4