Supplementary information.

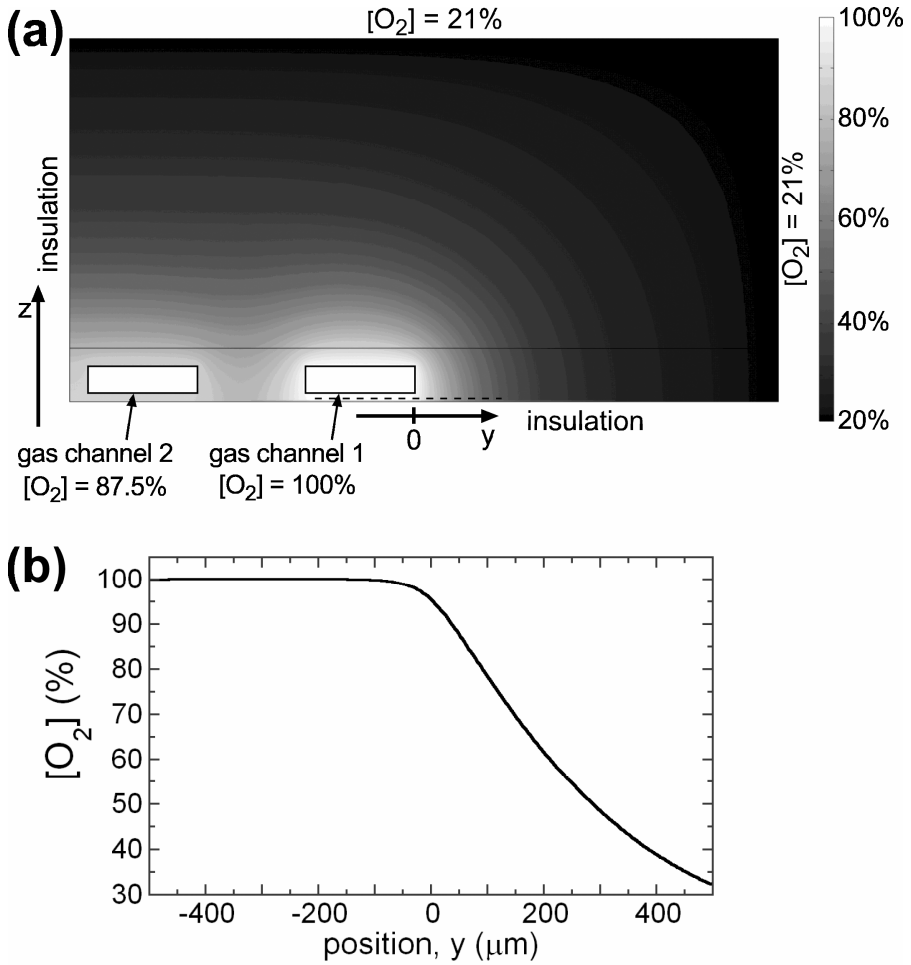

Figure S-1. Time-dependent two-dimensional numerical simulation of oxygen concentration, $[O_2]$, in a fragment of cross-section of device 1 in *yz*-plane. (a) Computational domain, 3.9 × 2 mm in size, with $[O_2]$ after 1 min coded by a grayscale, as shown by a legend bar on the right. Gas channels 1 and 2, with their boundaries at $[O_2]$ = 100% and 87.5%, respectively, are shown as white rectangles. Boundary conditions are insulation at the bottom (coverglass) and on the left (internal area of the test region) and $[O_2]$ = 21% (air) at the top and on the right. (b) $[O_2]$ under gas test channel 1 at 5 μm above the lower boundary (along the dashed line in panel (a)) as a function of position, *y*, with *y* = 0 corresponding to the right edge of the gas test channel (cf. Figure 3 in the main text).

To obtain an alternative estimate of the difference in $[O_2]$ between gas channel 1 and the flow channels under it (cf. Figure 3 in the main text), we used FemLab to perform a time-dependent two-dimensional simulation of a fragment of the *yz*-cross-section of the device (Figure S-1). The fragment included the gas channels 1 and 2 (cf. Figure 1 in the main text), with the boundary conditions of $[O_2]$ = 100% and 87.5%, respectively (Figure S-1a). The device was simulated as a monolith of PDMS with a 50 μm thick layer between the gas channel and the insulating lower boundary (cover glass) and with O_2 diffusion

coefficient $D_p = 1.3 \cdot 10^{-5}$ cm^2/s, as evaluated from the gas switching tests (Figure 2 in the main text). The flow channels and the active flow of the liquid through them were not incorporated in the simulation. The initial conditions were [O_2] = 21% everywhere in PDMS and the distribution of [O_2] was allowed to evolve for 1 min. The final distribution of [O_2] under gas channel 1 (Figure S-1b) had a shape similar to the experimentally obtained distributions of the N_2/O_2 fluorescence ratio in Figure 3 in the main text. In particular, in a 200 μm wide internal region (y from -400 to -200 μm) corresponding to the area of growth chambers in the microfluidic device, [O_2] obtained from the simulation was above 99.9%, which is within 0.01% of [O_2] in the gas channel. Therefore, the simulations indicate that [O_2] in the growth chambers of the device is expected to match [O_2] in the gas channels very closely.

A conspicuous difference between the experiment and simulations is that at $y > 0$ the fluorescence intensity ratio in Figure 3 (experiment) decays substantially faster than [O_2] in Figure S-1b (simulation). This difference is most likely due to the flow of the RTDP solution in the negative y-direction, which was not incorporated in the simulation. To estimate the effect of the flow on the [O_2] distribution, we first note that because of 6 times higher solubility of O_2 in PDMS as compared to water, the total O_2 content of a flow channel with the depth $h = 6$ μm is equivalent to the O_2 content of an $h/6 = 1$ μm layer of PDMS (which is in equilibrium with water in the channel). The characteristic time of equilibration of [O_2] in the flow channel with [O_2] in the gas channel by diffusion through PDMS with thickness $d = 50$ μm can thus be estimated as $\tau' = dh/(6D_p) \approx 38$ msec. The time of [O_2] equilibration along the vertical direction in the flow channels, which is estimated as $h^2/(2D_w) = 9$ msec ($D_w = 2 \cdot 10^{-5}$ cm^2/s is the diffusion coefficient of [O_2] in water), is substantially shorter and can thus be neglected.

For the velocity of 260 μm/s in the flow channel at the driving pressure of 1 psi, the equilibration time of 38 msec corresponds to a distance of 10 μm along the flow direction, implying that within a distance of 200 μm, the difference in [O_2] between the flow and gas channel is expected to become indistinguishable from zero. Therefore, for a driving pressure of 1 psi or less, the contribution of the liquid flow in setting the distribution of [O_2] under a gas channel is expected to be small compared with that of the diffusive exchange with the PDMS chip (Figure S-1). Specifically, the flow is not expected to have any appreciable effect on [O_2] in the regions with the growth chambers (>200 μm from the gas channel edges). We finally note that the estimated equilibration time $\tau' = dh/(6D_p) \approx 38$ msec is different from the equilibration time after switching of the gas fed to the gas channel network (Figure 2 in the main text), τ, which was measured at 0.8 sec and estimated as $d^2/(2D_p)$, because the two equilibration processes are essentially different. In the former case, only [O_2] in the aqueous solution is changing as the solution advances along the flow channel, whereas [O_2] in the PDMS membrane remains constant. In contrast, in the latter case, the O_2 content of the PDMS membrane is exchanged, which involves the diffusive transport of $6d/h = 50$ times larger amount of O_2.