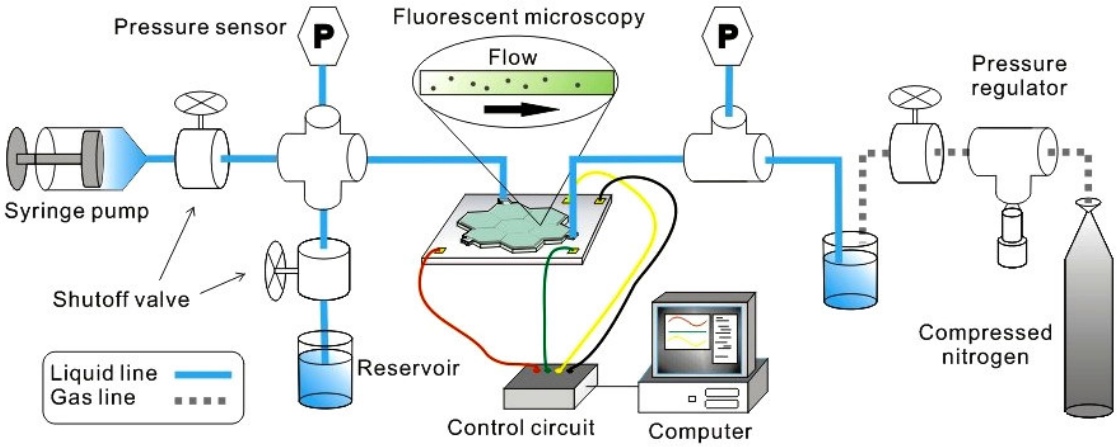


Fig. S1 Experiment apparatus. A syringe pump is connected at the upstream to flush/fill the system prior to any test. Two pressure transducers are installed to measure the pressure difference across the chip. A nitrogen bottle is used as pressure source to generate backpressure for pressure characterization. The flow velocity is measured by detecting the displacement of 0.5 μm microspheres.

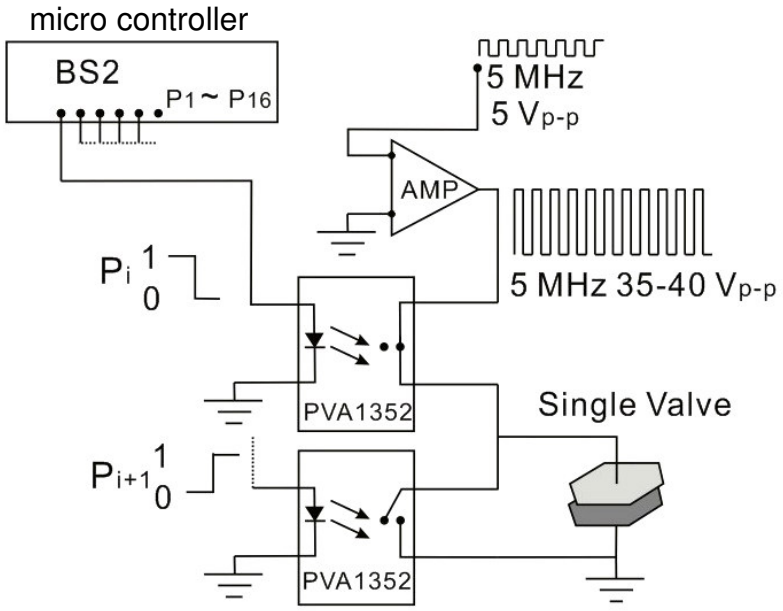
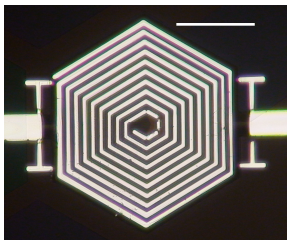


Fig. S2 Control circuitry. Photovoltaic relay is controlled by a signal from the BS2 microcontroller. Signals from two adjacent ports Pi and Pi+1 in BS2 are always out of phase, so the 5 MHz signal can be periodically switched between 15-20 V and ground.

(a)



(b)

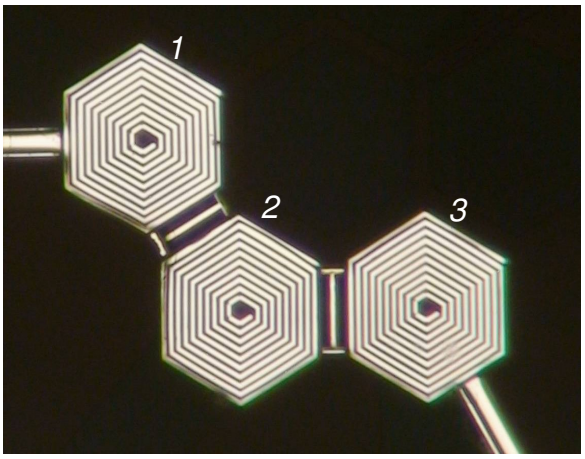


Fig. S3 White-light micrograph of (a) a single hexagon valve and (b) a peristaltic micro pump. Scale bar is 200 μm. Peristaltic pumping is achieved by actuating the valves in the following sequence: *1* → *1+2* → *2* → *2+3* → *3* → *1+3*. The order is reversed when pumping from right to left.

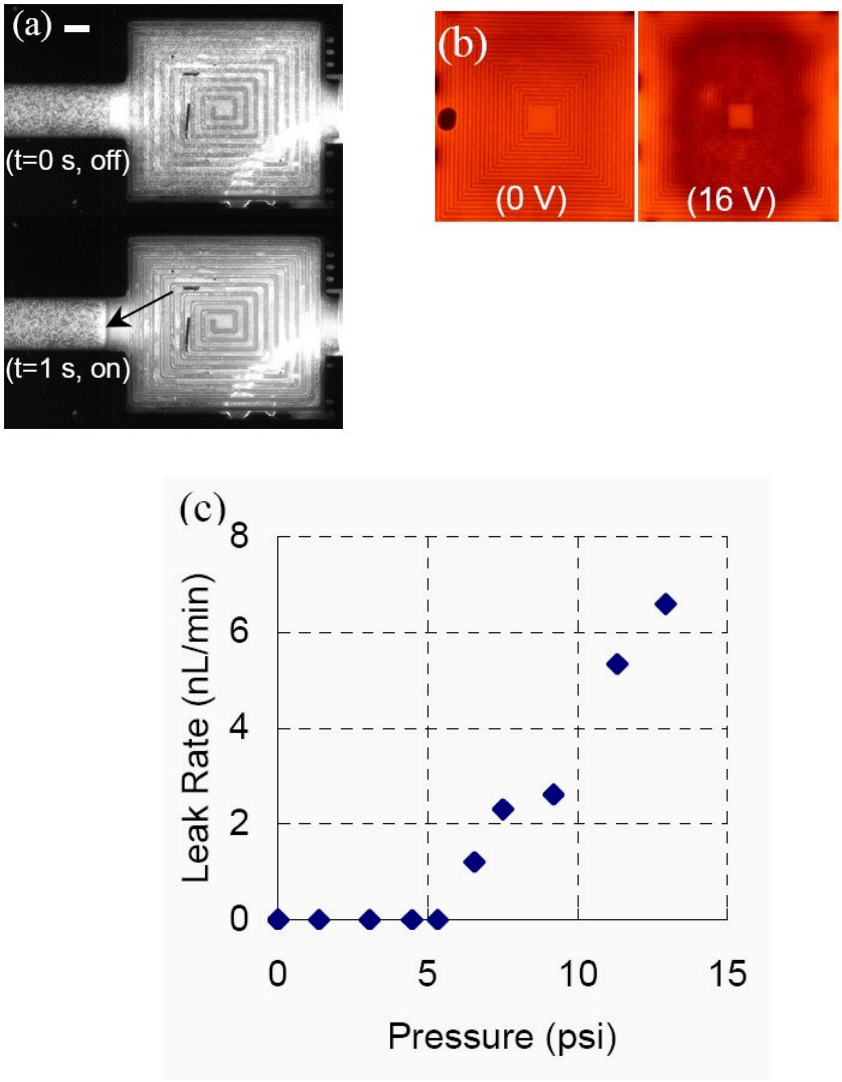


Fig. S4 Valve characterization. (a) Inverted microscopy of open and closed valve. The valve was off at t = 0 s. Microspheres flow freely. The valve was actuated at t = 1 s. The PDMS-metal roof collapsed and the microspheres were trapped under the PDMS-metal membrane. When closed, the microspheres outside the valve chamber accumulated at the entrance of the valve chamber (arrows.) Scale bar, 20 μm. (b) Fluorescent image of fluorophore-filled open and closed valve showing valve deflection. (c) Leak rate vs. pressure. The valve is effectively closed till the pressure is above 6 psi (41.37 kPa).