**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 \( \mu \text{m} \) microspheres.
Fig. S2  Control circuitry. Photovoltaic relay is controlled by a signal from the BS2 microcontroller. Signals from two adjacent ports $P_i$ and $P_{i+1}$ in BS2 are always out of phase, so the 5 MHz signal can be periodically switched between 15-20 V and ground.
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).