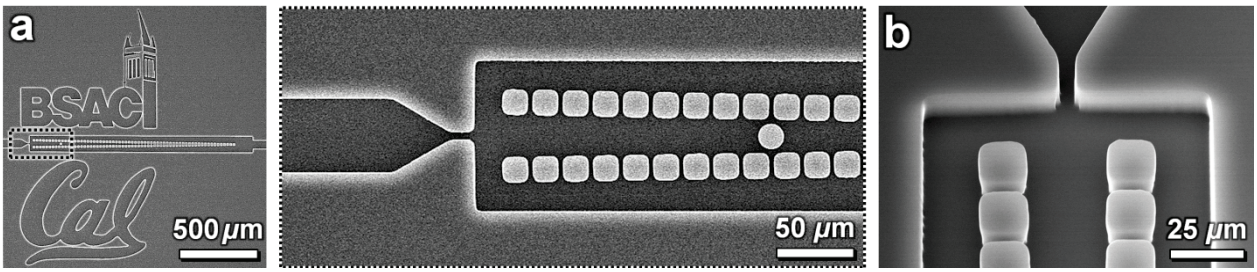
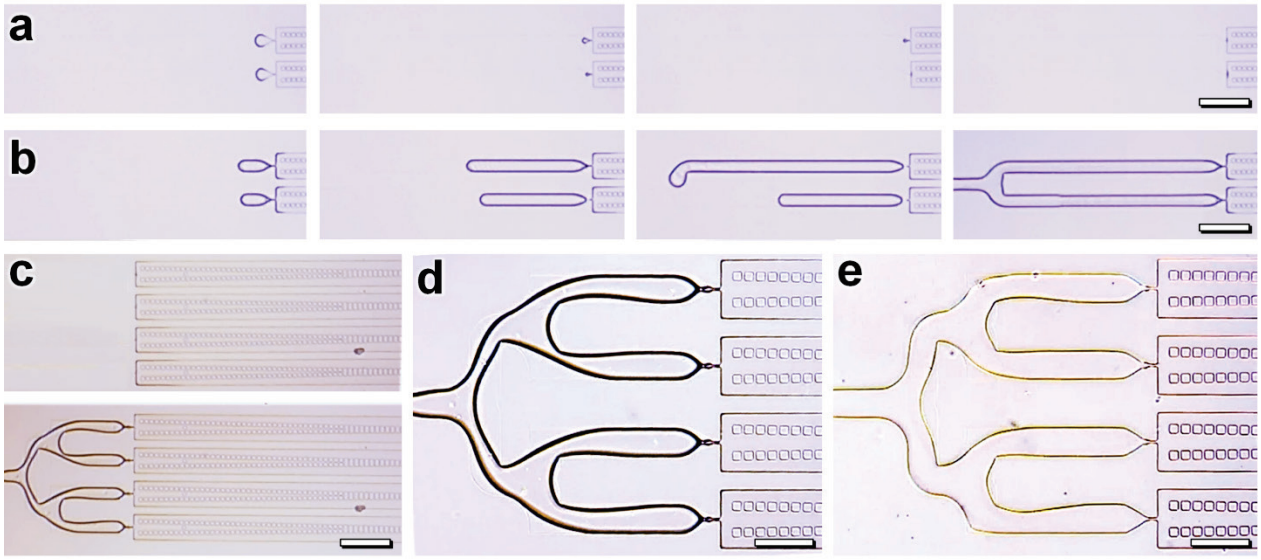
Electronic Supplementary Material (ESI) for Lab on a Chip.

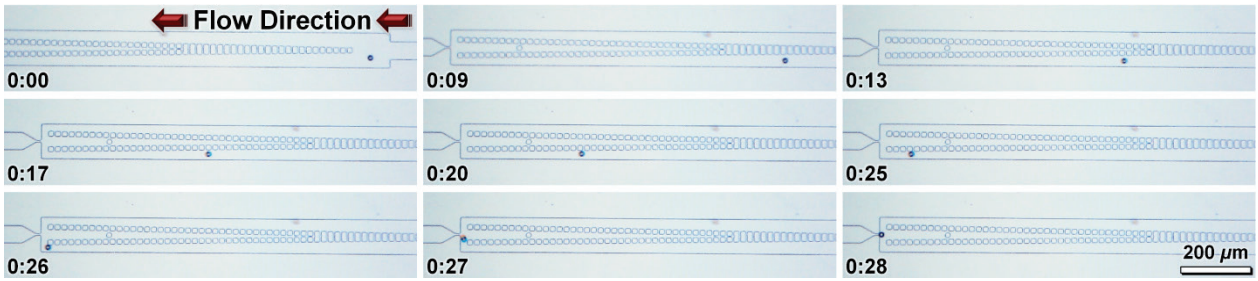
Electronic Supplementary Information (ESI)



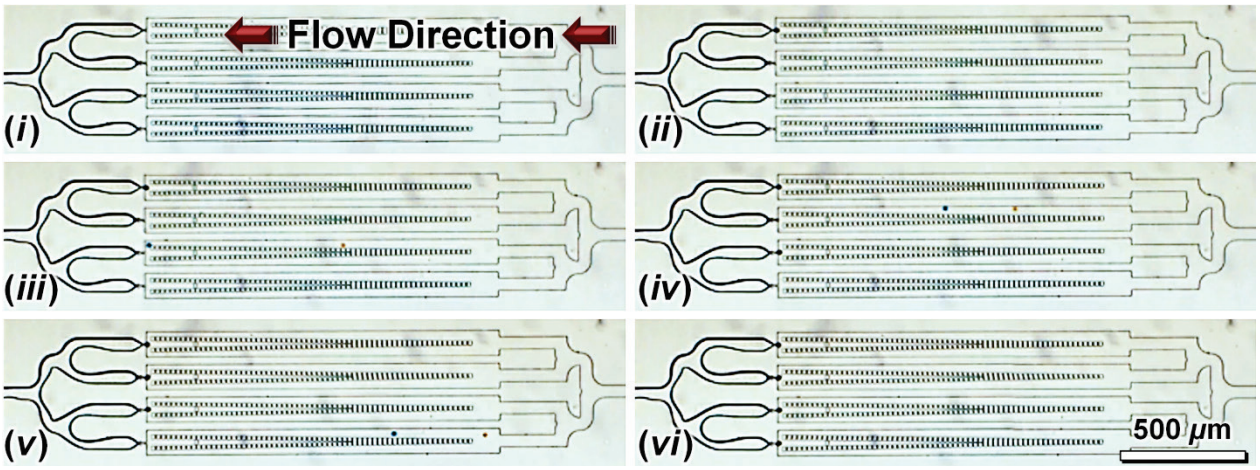
ESI Figure 1. SEM micrographs of a fabricated microfluidic bead-based diode with a rectangular docking channel. (a) Top view. (b) 30° view.



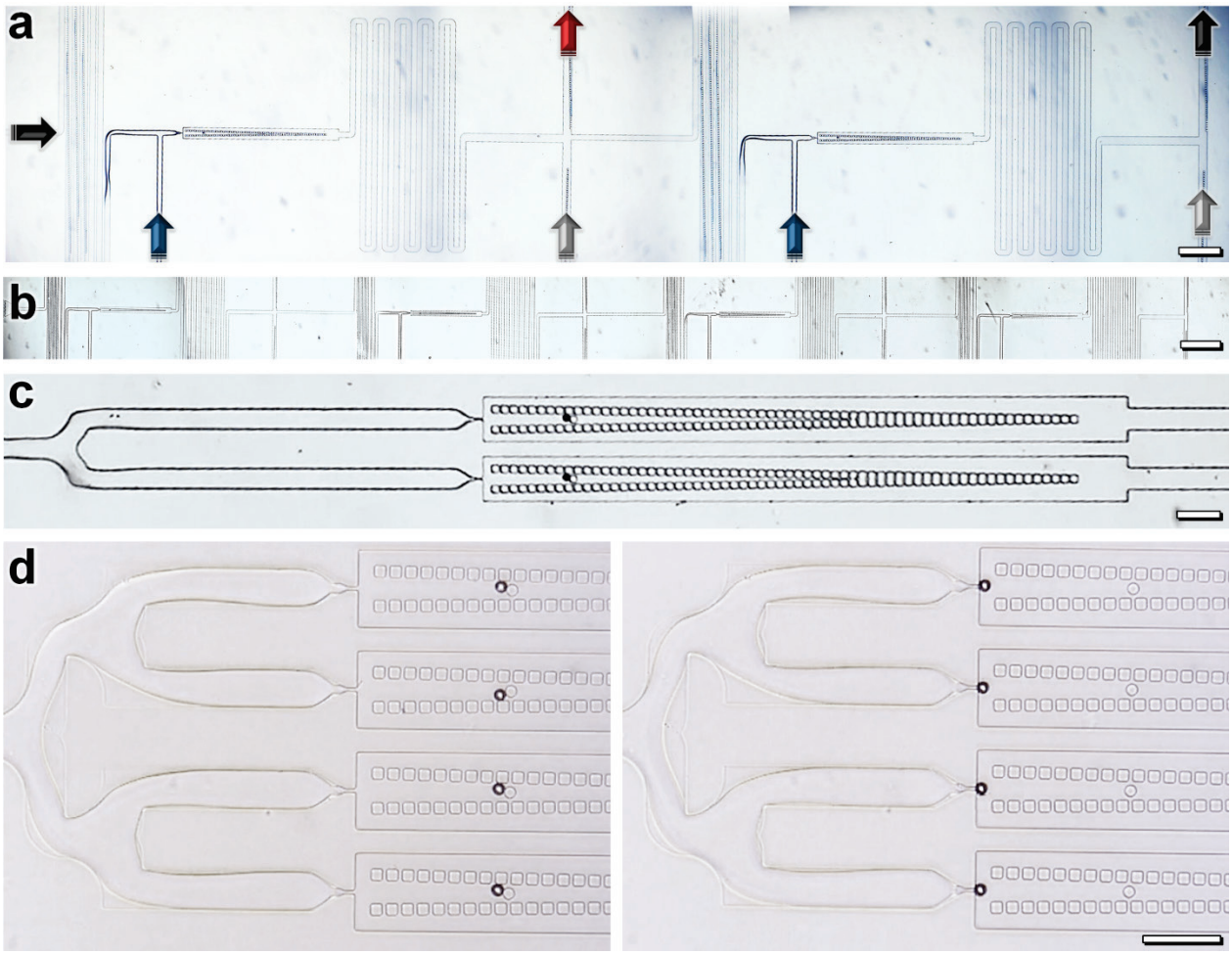
ESI Figure 2. Experimental results for selectively fabricating circular-shaped docking microchannels for systems with (a, b) two and (c-e) four microfluidic diodes in parallel. (a, c – *Top*) Uncured PDMS is vacuum-loaded into the device until it reaches the entrances of both docking channels. (b, c – *Bottom*) Pressurized air is inputted into the device during thermal curing. (d, e) Expanded views of a system with four diodes in parallel (d) before and (e) after PDMS curing. Scale Bars = (a-c) 200 μm; (d, e) 100 μm.



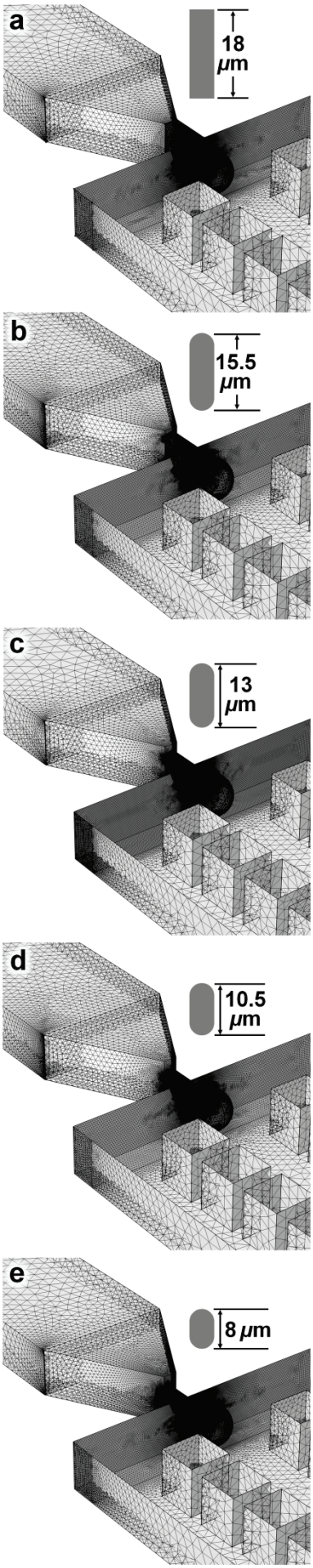
ESI Figure 3. Experimental results for pre-loading a single suspended polystyrene microbead (15 μm in diameter) into the diode chamber under reverse flow. ESI Movie 2 shows real-time video of this process.



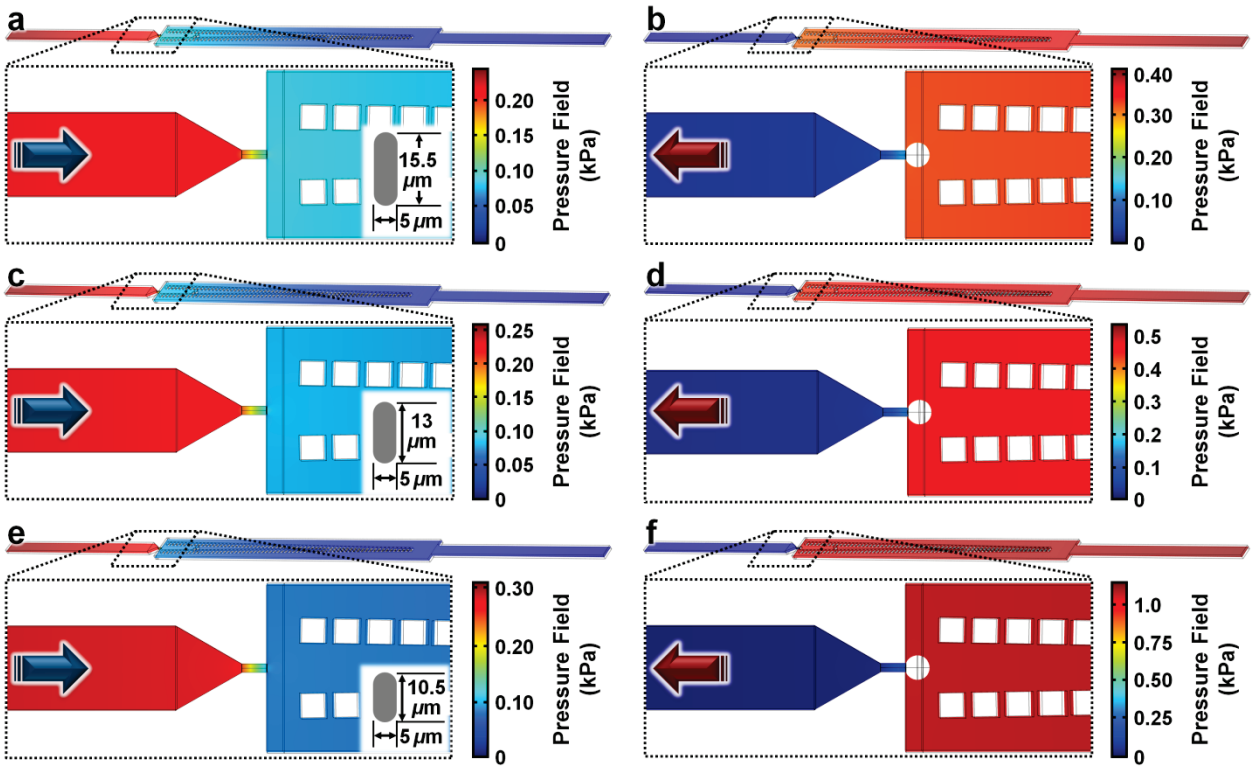
ESI Figure 4. Sequential micrographs captured during the microbead pre-loading process for a system with four diode chambers with circular-shaped docking channels connected in parallel under reverse flow. *Orange* and *blue-colored* microbeads are stroboscopic artifacts due to microbead movement within a timespan of one second.



ESI Figure 5. Fabrication results following the pre-loading of suspended polystyrene microbeads (15 μm in diameter) into systems with circular-shaped docking channels corresponding to (a) two and (b) four diodes in series, and (c) two and (d) four diodes in parallel. (a) Composite image of a system with two diodes in series. *Blue arrows* mark the PDMS inlets, which are sealed following the curing process; *Grey arrows* mark the microbead loading inlets, which were used to independently load a single microbead into each diode chamber; *Red arrow* marks an added microbead loading outlet (with micropost array rails[27] that act as a "one-way track" in the case that additional beads are unintentionally loaded), which is sealed following the microbead loading process; *Black arrows* mark the fluid inlets/outlets for the forward flow case. (b) Composite image of a system with four diodes in series. (c) Expanded view of a system with two diodes in parallel. (d) Expanded view of a system with two diodes in parallel for the (*left*) forward flow and (*right*) reverse flow cases. Scale Bars = (a) 500 μm; (b) 1 mm; (c, d) 100 μm.



ESI Figure 6. Expanded views of the docking channels of meshes for three-dimensional COMSOL Multiphysics models of microfluidic bead-based diodes with varying docking channel geometries (5 μm in width). Total number of mesh elements = $8.07\times10^6 \pm 2.73\times10^6$.



ESI Figure 7. Theoretical results for three-dimensional COMSOL Multiphysics simulations of microfluidic bead-based diodes with varying docking channel geometries. (a, b) Pressure field simulation results for a system with a 15.5×5 μm^2 obround-shaped docking channel cross-section (*inset*) corresponding to the (a) forward flow and (b) reverse flow cases. (c, d) Pressure field simulation results for a system with a 13×5 μm^2 obround-shaped docking channel cross-section (*inset*) corresponding to the (c) forward flow and (d) reverse flow cases. (e, f) Pressure field simulation results for a system with a 10.5×5 μm^2 obround-shaped docking channel cross-section (*inset*) corresponding to the (e) forward flow and (f) reverse flow cases.

ESI Movie Captions

ESI Movie 1. Experimental results for selectively fabricating a circular-shaped docking microchannel. First, uncured (liquid-phase) PDMS is vacuum loaded into the docking microchannel. Once the PDMS has reached the base of the docking channel, pressurized air is inputted into the device from the opposite direction while the PDMS undergoes thermal curing.

ESI Movie 2. Experimental results for pre-loading a single suspended polystyrene microbead (15 μm in diameter) into the diode chamber under reverse flow.

ESI Movie 3. Experimental results for microbead dynamics during the operation of the microfluidic bead-based diode. During forward flow, the suspended microbead releases from the entrance of the docking channel, but remains within the diode chamber due to the micropost array rails. During reverse flow, the microbead is transported to the entrance of the docking microchannel.