Electronic Supplementary Information (ESI)

Polymer chip-integrable piezoelectric micropump with low backpressure dependence

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Fig. S1 (a) Exploded view of the pump layers with dimensions. (b) Section view of the inlet valve seat, outlet valve seat and O-ring gland with dimensions. (c) Section view of the inlet and outlet PDMS diaphragms with dimensions.

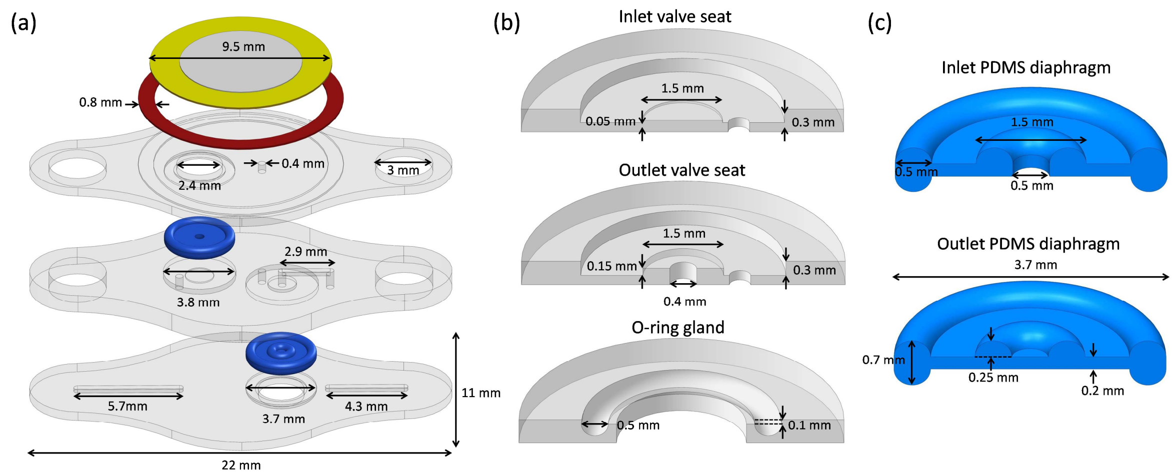


Fig. S2 The principle that yields the low backpressure dependence used in the presented micropump is based on the limitation of the outlet pressure influence (in a range) towards the pumping chamber by a membrane outlet check valve. The check valve geometrical design exposes a much smaller area to its outlet than to its inlet, limiting outlet pressure influence towards the pumping chamber, being this effect regulated by pretension applied to the outlet PDMS diaphragm. This pretension also limits direct flow avoiding unwanted leaking when the pump is not functioning. Illustration of the different pressure influence areas in the outlet PDMS diaphragm in (a) section view and (b) top view. The outlet pressure is able to act on a much smaller area (red) than the inlet pressure (green).

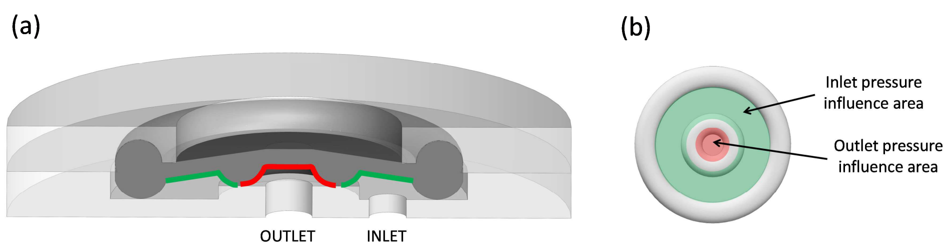


Fig. S3 (a) PDMS diaphragms fabrication steps (not to scale). The mold layers (made by CNC micromilling of PMMA) are aligned and held together by 2 mm screws in combination with 2 mm alignment pins. Once assembled, PDMS (Sylgard 184, Dow Corning, USA) mixed in a 10:1 mass ratio is injected into the mold with a syringe. The filled mold is placed in an oven and left to cure at 60 °C for 12 hours. Once the mold had cooled enough to be handled, the pins and screws are removed and the diaphragms are released. (b) Diaphragms with sprues remaining from the injection molding process. The sprues are easily removed by pulling with tweezers or cutting with a scalpel. (c) Finished (sprues have been removed) and ready for integration (c) inlet and (d) outlet PDMS diaphragms.

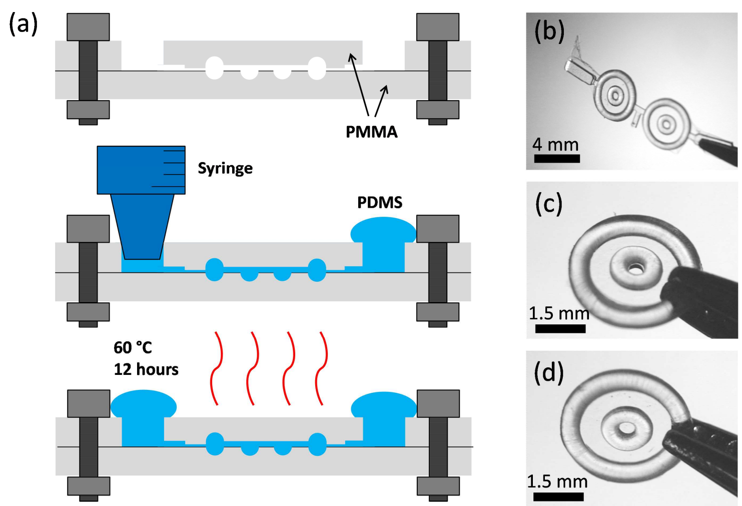


Fig. S4 Photographs of (a) bonded pump layers, (b) a finished micropump and (c) backside of the finished micropump. Scale bars are 10 mm. The fabricated arrow in the pump layers indicates flow direction.

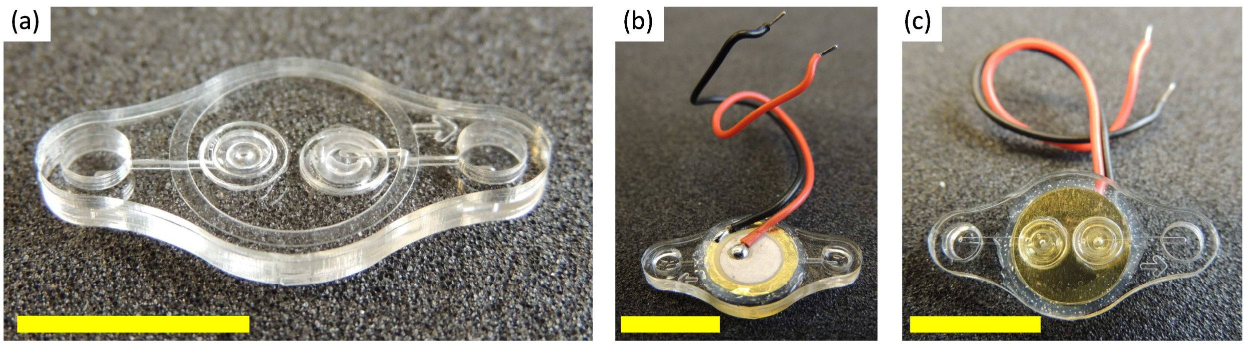
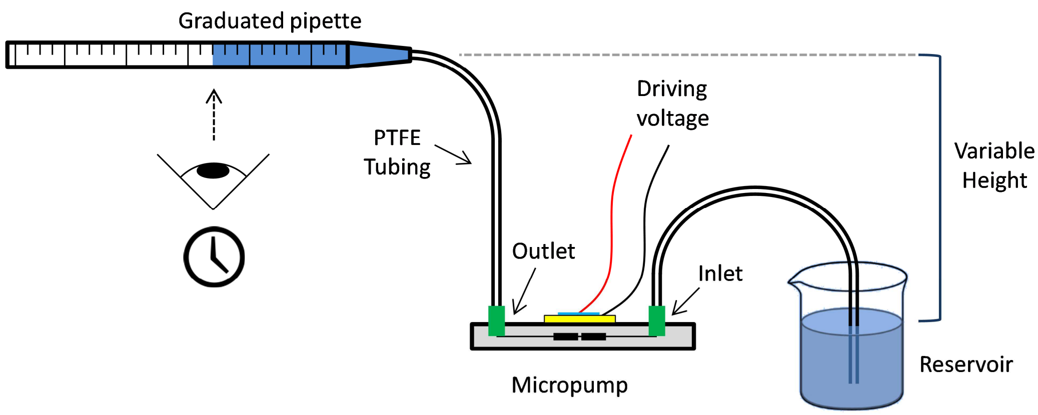


Fig. S5 Micropump characterization set-up (not to scale). In order to carry out the measurements of the flow rate versus backpressure characteristics, a static and stable pressure in the pump outlet was induced by a column of water with variable height given by the difference between the pipette horizontal level and the water level of the reservoir. The reservoir is large enough so as to diminish the error of height change during the measurements. The average flow rate was calculated from the time of the liquid-air interface to fill a fixed volume in the graduated pipette connected to the outlet of the pump via polytetrafluoroethylene (PTFE) tubing. The time was measured manually with a stopwatch. The maximum outlet pressure is measured as the maximum height which the water column is able to reach to for a given voltage and frequency.



Supplementary movie 1: This video shows the pump running and demonstrates self-priming capability.

Supplementary movie 2: This video shows the active micromixer working in a 1:1 (water : dye) ratio at 2.5 Hz.

Supplementary movie 3: This video shows the expansion chamber mixing in a 2:1 ratio (water : dye) at 3.33 Hz

Supplementary movie 4: This video shows the expansion chamber mixing in a 1:2 ratio (water : dye) at 3.33 Hz

Supplementary movie 5: This video shows the expansion chamber mixing in a 1:1 ratio (water : dye) at 5 Hz