Lab Chip

Electronic Supplementary Information (ESI)

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A robust, portable and backflow-free micromixing device based on both capillary- and vacuum-driven flows†

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1. A table of contents entry

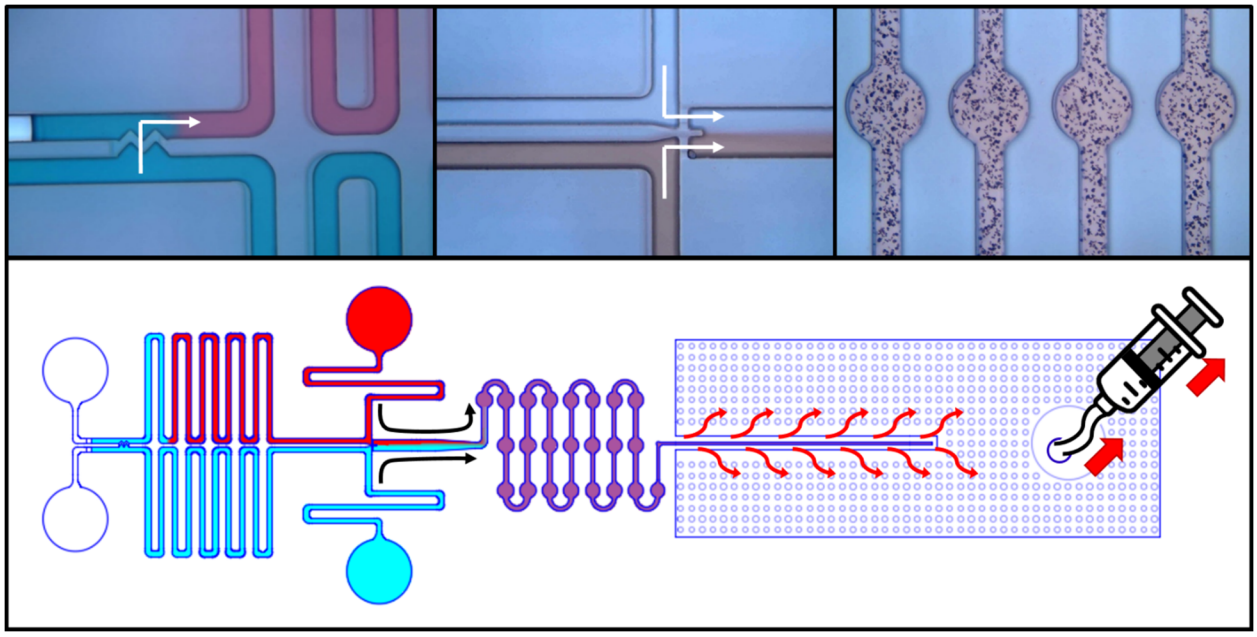

Fig. S1 A robust, portable and backflow-free micromixing device using capillary-driven bypassing and syringe-assisted vacuum-driven pumping shows great promise for a variety of blood typing assays, agglutination-based assays and point-of-care or lab-on-a-chip testing applications.

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2. Fabrication

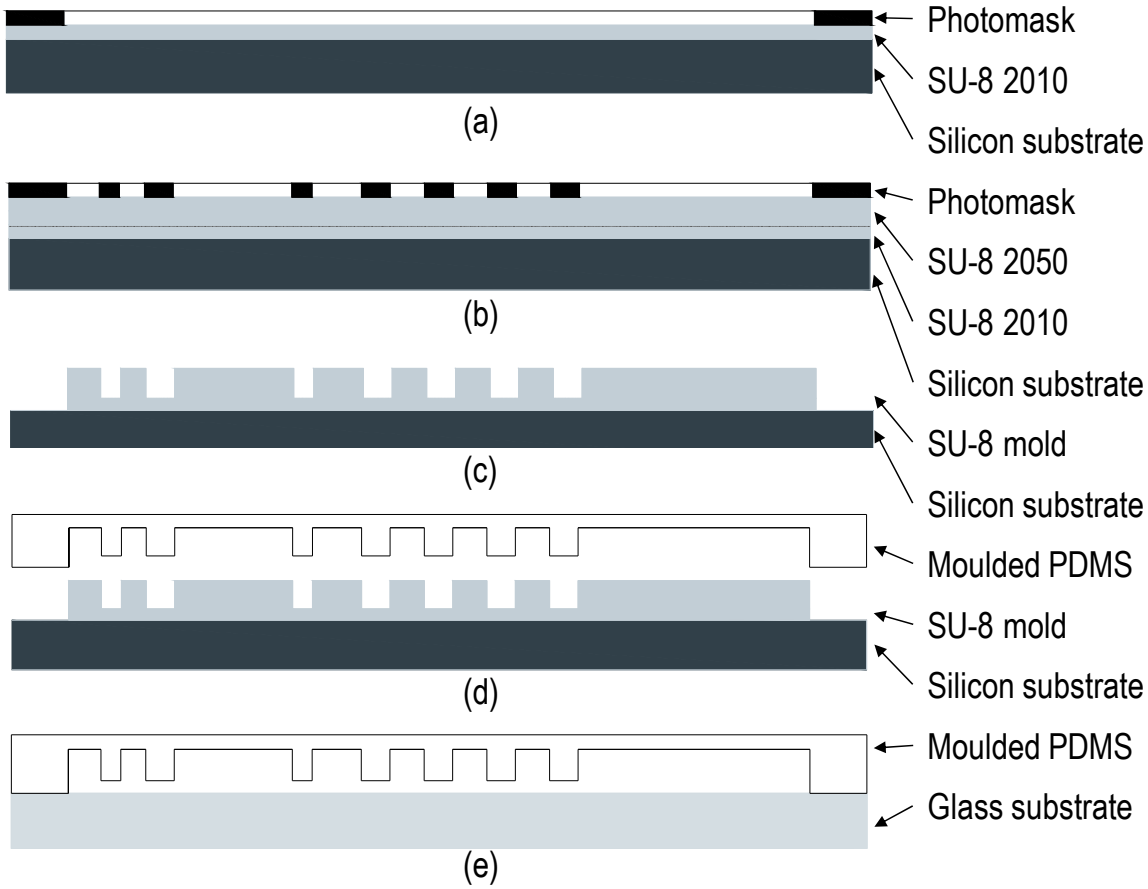

Fig. S2 Fabrication process of the backflow-free micromixing device based on capillary- and vacuum-driven systems. The main procedures in the master fabrication were (a) UV photolithography to generate the pattern in the first layer, (b) UV photolithography to produce the pattern in the second layer, and (c) development to remove the unexposed SU-8. (d) Replica moulding. (e) Device sealing and bonding.

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3. Old design vs. new design

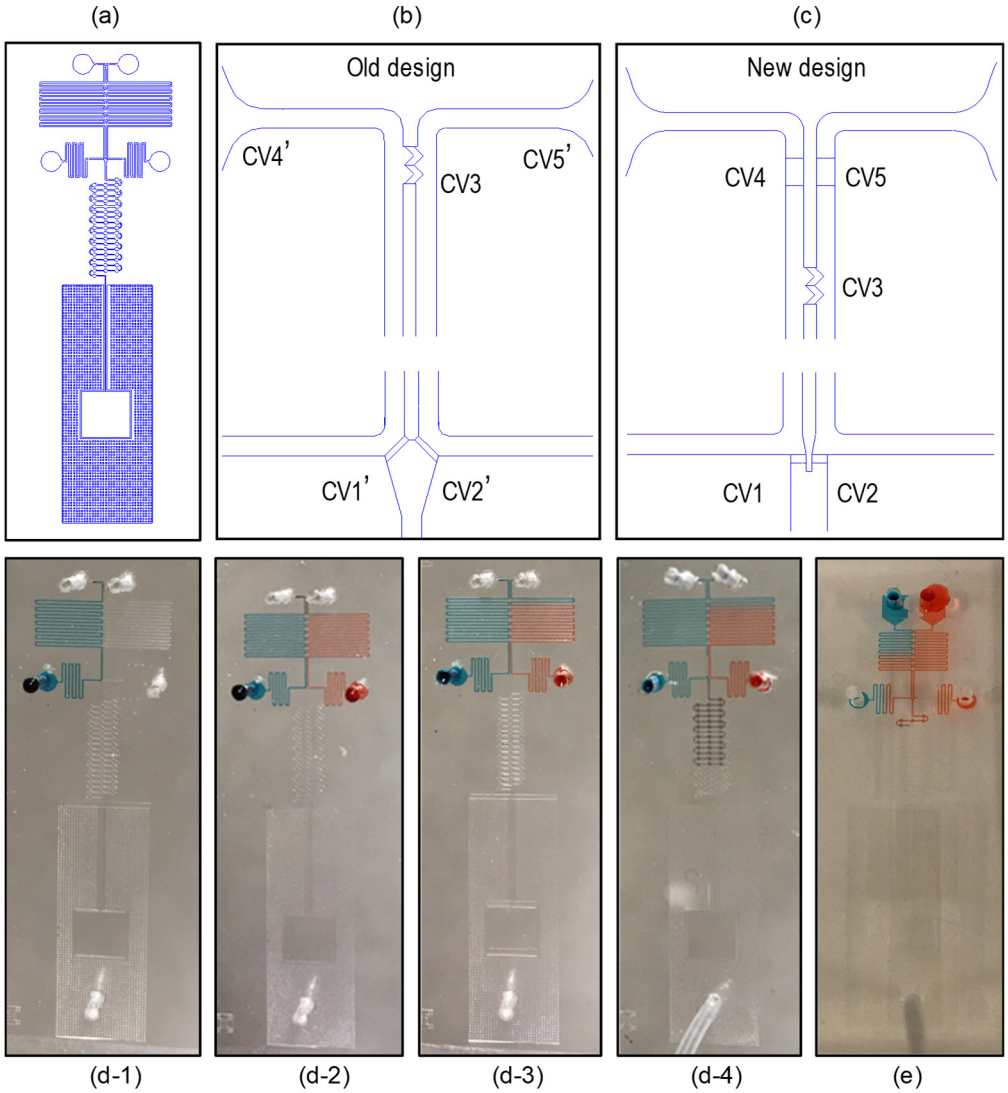
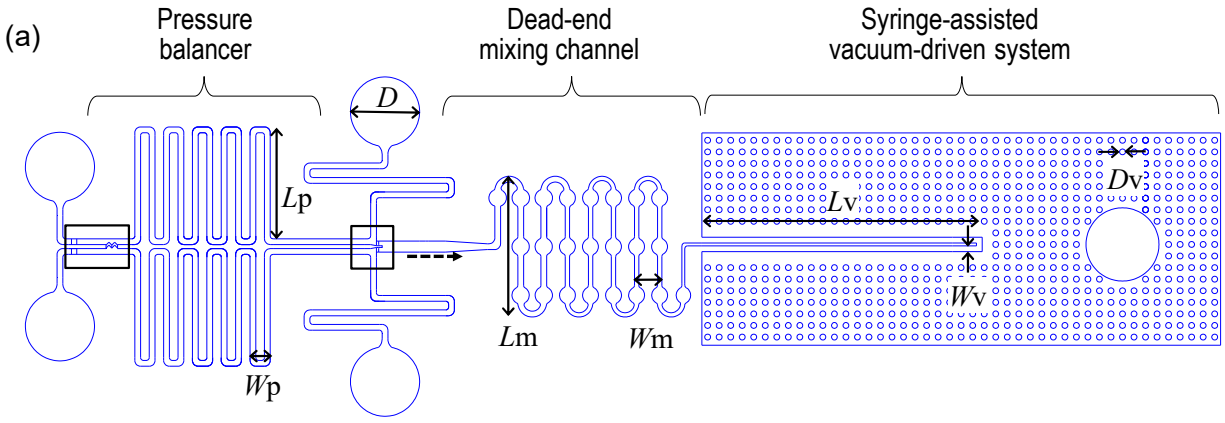


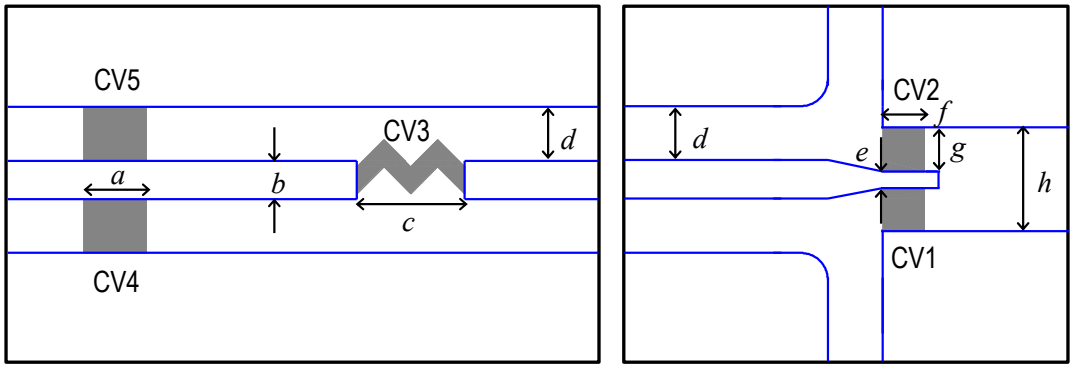
Fig. S3 (a) & (b) An old design, in which CV4' and CV5' are placed at the outlet ports and CV1' and CV2' have no separate wall. (c) A new design that was used in this work (see Fig. S4). (d) Wide-view images of the experiments using the old design, showing the same device working principle as that with the new design; (d-1) loading of blue water; (d-2) loading of red water; (d-3) surge flow across CV3 after contact of the two liquids each other during pressure self-balancing; (d-4) mixing of the two liquids by syringe-assisted vacuum-driven flow. (e) A control experiment (having similar CV1' and CV2', but without the connection CV3), showing a failure of co-flowing streams due to the backflow event.

4. Detailed geometry (new design)

(a)



(b)



(c)

	Dimension [μm]		Dimension [μm]
Lp	2200	a	100
Wp	350	b	70
Lm	2650	c	200
Wm	400	d	100
Lv	5200	e	30
Wv	110	f	40
D	1320	g	90
Dv	100	h	210

Fig. S4 Detailed geometry and dimension of the backflow-free micromixing device proposed in this study (new design). (a) Schematic diagram of the whole structure of the device consisting of a pressure balancer, dead-end mixing channel and syringe-assisted vacuum-driven system. (b) Closed-up diagram of capillary valve (CV) structures (top view). (c) Detailed dimension.

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5. Video clip

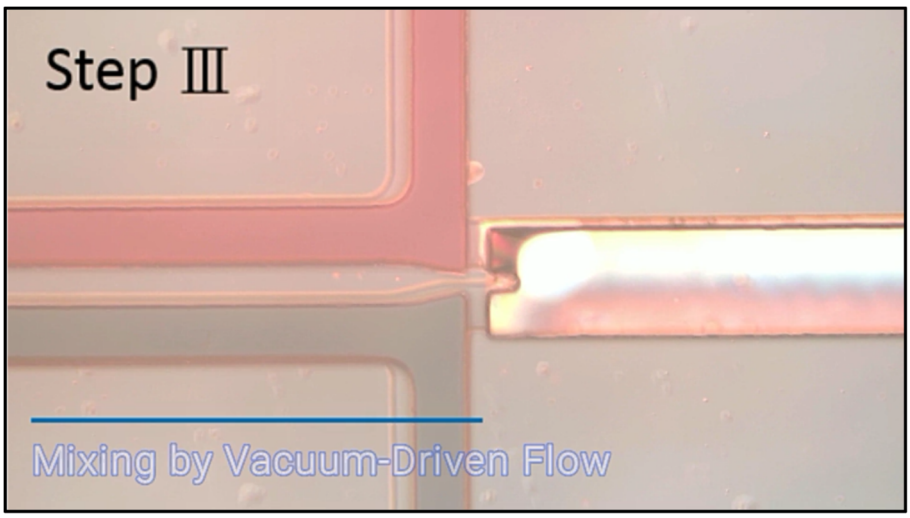

Fig. S5 A screen capture from the video clip, at the end of step II (pressure balancing) and beginning of step III (mixing by vacuum-driven flow).

Figure S5 is a screen capture from the Supplementary Video, at the end of step II (pressure balancing), beginning of step III (mixing by vacuum-driven flow). It shows that the red liquid has prematurely burst through the capillary valve (CV2). Occasionally, this happens across CV2. We observed that this happens at the beginning of the pressure-balancing process when the blue water crosses over CV3. The surge flow across CV3 after contact of the liquids with each other can generate a *reversed* burst pressure, causing the accidental overflow of the red liquid across CV2. The capillary valve structures need more optimization in order to prevent such premature events.

However, in our design, this will not disturb the performance of the backflow-free micromixing. (1) The overflow will immediately stop, due to the nature of the proposed syringe-assisted vacuum-driven system having the *dead-end* mixing channel. As soon as the CV2 is filled with the red liquid, the dead-end mixing channel is enclosed and sealed, making an immediate stop of the premature flow. Only by drawing out the plunger, the syringe-assisted vacuum-driven pumping is induced. As a consequence, the two liquid streams synchronously flow and efficiently mix with each other in the curved micromixer. (2) Also, the red liquid will not touch the blue liquid at all, due to the structure of a separate wall between CV1 and CV2. The old design (Fig. S3) does not have such structures, often causing undesirable premature mixing. The new design proposed in this paper (Fig. S4 and S5) enables a robust and portable microfluidic device for micromixing that prevents common issues such as backflow, flow crosstalk and asynchronous pumping.