Supporting Information

On-chip acoustic chaotic micromixer for point-of-care applications

Xian Chen,[a] Chuanchao Zhang,[b] Yaping Wang,*[b] Xuexin Duan,*[b] and Yunhua Gao*[a]

[a] Center for Advanced Measurement Science, National Institute of Metrology, Beijing 100029, China

[b] State Key Laboratory of Precision Measuring Technology & Instruments and College of Precision Instrument and Opto-electronics Engineering, Tianjin University, Tianjin 300072, China

Supporting Information Video S1

When we adopted 50 mW as the applied power of each LWR in this array, the two parallel liquids with different colors were immediately mixed and the uniform liquids with a third color was demonstrated in the microchannel.

Supporting Information Video S2

When the power of 50 mW was applied on LWR 1, the suspended polystyrene particles were immediately trapped in the acoustic vortices; afterwards, the trapped particles were transported from LWR 1 to LWR 2, LWR 3, and LWR 4 when the resonators were actuated in turn. The above phenomenon demonstrated the feasibility of chaotic particle mixing based on the LWR array.

Supporting Information Video S3

The red blood cells (RBCs) were distributed at the back of whole blood while the plasma was at the front when the flow rate was fixed at 1 μL/min. Besides, the front-end of plasma was moving continuously and the RBCs aggregates kept still for a while owning to the sedimentation effect. This boundary distribution is convenient for the plasma separation.

S1. The local region in the chaotic flow

The chaotic flow is derived from the hybrid superposition of multiple acoustic vortices in the LWR array, which includes the evident vortices near the central region, the connected streamline between LWRs and the compressed vortices outside the central region.

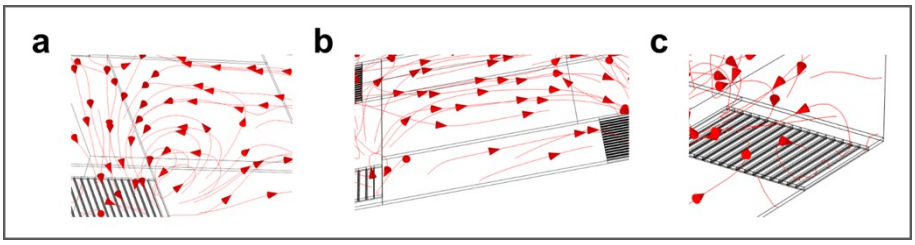

Fig. S1 The evident vortices (a), the connected streamline between LWRs (b) and the compressed vortices (c).

S2. Temperature characterization

The thermal effect is considered as one factor influencing the biological activity of proteins, therefore we demonstrate the temperature variation based on the infrared thermometer. When the low power level (from 0 to 50 mW) is applied to each LWR, the temperature does not reach 30 °C and the temperature increase does not exceed 1°C; therefore, the temperature variation does not affect the biological activity of proteins. Excessive power (over 50 mW) would induce an obvious upward trend of the temperature variation.

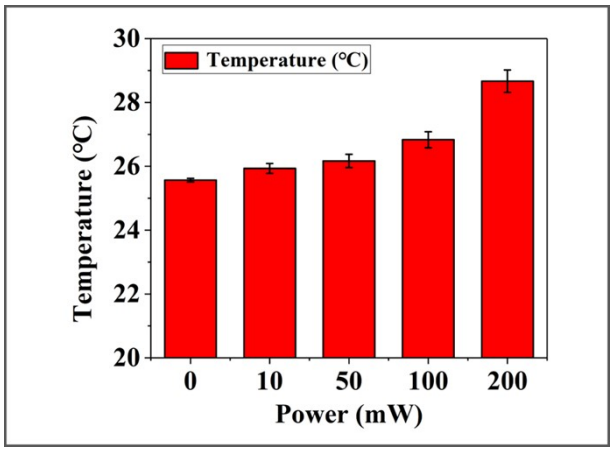

Fig. S2 The temperature characterization of different applied power.

S3. The distribution of red blood cells

The red blood cells (RBCs) were suspended uniformly in the pale-yellow plasma without the Anti RBC antibody; however, the cells would form large multi-cellular aggregates once the antibody were added into the blood samples.

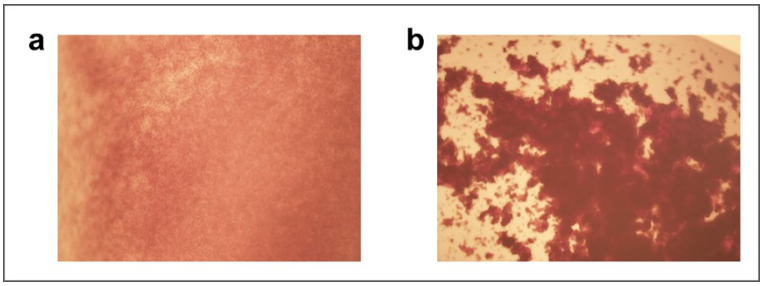

Fig. S3 The uniformly distributed RBCs (a) and the multi-cellular aggregates (b).

S4. The RBC aggregates distribution under different flow rates

The RBC distributed in the form of multi-cellular aggregates based on the aggregation antibody. Besides, the specific distribution state could be regulated by the flow rate. When the actual flow rate (e.g., 0.2 and 1 μL/min) is lower than the sedimentation rate of aggregates, the RBCs aggregates were distributed at the back of blood solution; and the proper flow pressure could compress the distributed volume of RBCs. However, exceed flow rate (e.g., 5 and 10 μL/min) would induce the mixed distribution of aggregated RBCs and plasma.

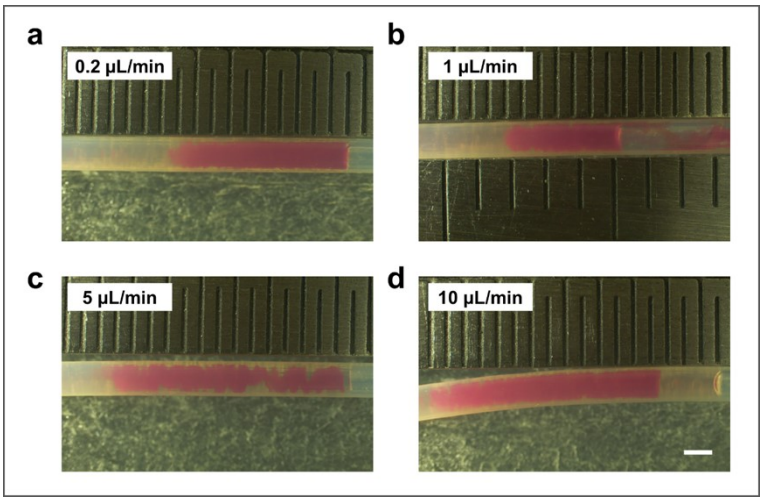

Fig. S4 The photographs of distributed RBC aggregates under the flow rate of 0.2 (a), 1 (b), 5 (c), and 10 μL/min (d).

S5. The influence of PDMS thickness on the CL signal intensity captured by CMOS optical sensor

To investigate the influence of PDMS thickness on the CL intensity captured by CMOS optical sensor, we utilized the PDMS microchannel with different thickness for the optical signal capture experiments. As demonstrated in Figure S1, the CL intensity was significantly enhanced as the PDMS thickness was gradually decreased. Therefore, the thinner PDMS is conducive for the detection of optical signals.

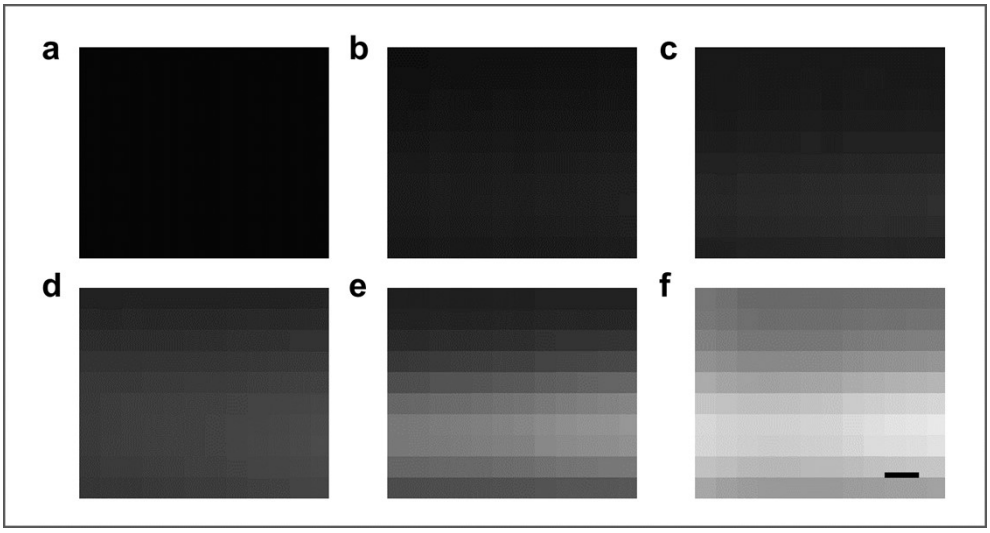

Fig. S5 The CL photographs captured by CMOS optical sensor based on PDMS with different thickness. When the thickness of PDMS was decreased from 2 mm to 0.2 mm (a-f), the gray value of CL photographs was increased from 99 to 2532. The scale bar in Figure S1f is 300 μm.

S6. The microfluidic chip fabrication process

To decrease the thickness of PDMS upon the detection region, a novel microfluidic chip fabrication process was demonstrated based on the glass sheet and the size-matched magnet. According to the actual measurement, the thickness of PDMS was decreased from 1.5 mm to 95.21 μm.

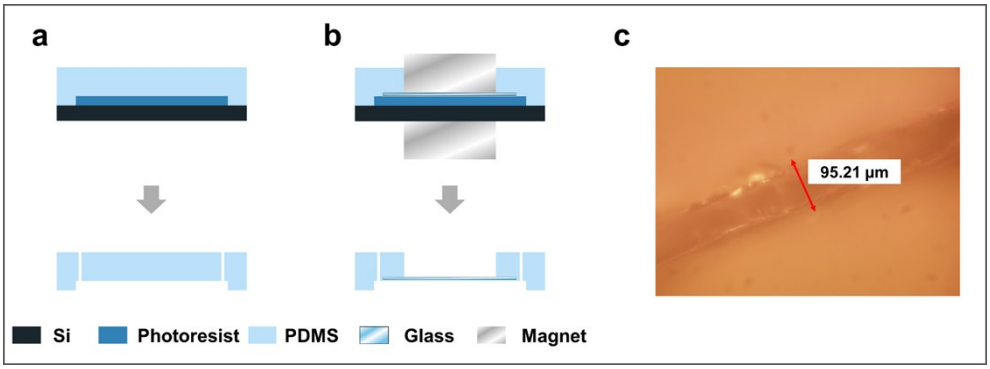

Fig. S6 The schematic diagram of microfluidic chip fabrication process for PDMS with normal thickness (a) and the reduced thickness (b), the photograph of PDMS in the side view based on the novel fabrication process (c).