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

Aberration-free aspherical in-plane tunable liquid lenses by regulating local curvatures

The supplementary information

Qingming Chen, Xiliang Tong, Yujiao Zhu, Chi Chung Tsoi, Yanwei Jia, Zhaohui Li, Xuming Zhang *

1. The fabricated device

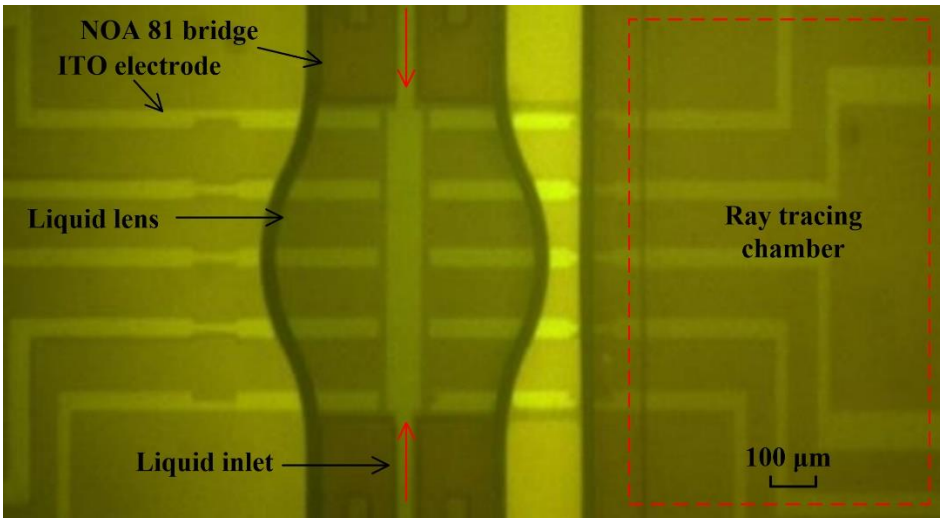

Fig. S1. Micrograph of the experimental device that clearly shows the structure of the device.

A device is displayed in Fig. S1. It clearly describes the structure of the device. As shown in Fig. S1, a biconvex lens is formed by the liquid droplet. After the lens, there is a raytracing chamber to measure the lensing effect. On the top glass, there are some electrode strips, which are used to modulate the global shape as well as the local curvature of the liquid lens.

2. The experimental results: the tunable focal length and the LSA

By applying the voltages to the electrode strips, both the focal length and the LSA can be modulated. The experimental results about the applied voltage, focal length and the LSA are listed below.

Table S1. The relationship between the applied voltages U_i, the focal length f, the LSA and the global curvature radius R_{11}.

No.	$U_1/U_2/U_3$ (V)	f (μm)	LSA (μm)	R_{11} (μm)
1	295/305/170	507.6	4.4	369
2	295/295/170	534.8	- 4.5	388
3	290/295/190	564.7	2.3	409
4	285/290/200	647.7	2.1	456
5	285/290/180	659.7	- 2.5	485
6	280/290/180	752	6.5	553
7	272/280/210	927.7	- 9.4	692
8	270/280/200	1,081	7.5	816

3. The numerical raytracing calculation process

In this work, the numerical raytracing is used to analyze the optical performance of the lens. The process of this numerical raytracing analysis is shown in Fig. S2. In this case, the lens is under applied voltages (U_1 = 290 V, U_2 = 295 V, U_3 = 190 V). At first, a lens is captured by CCD camera, see Fig. S2a. Then the image is converted into a grayscale image (Fig. S2b). As shown in Fig. S2c&d, the profile of the lens is extracted and fitted into a smooth curve shape. Now we get the shape of the lens. To numerically evaluate the lensing effect, the raytracing simulation is conducted. As a result, we can see that the rays are well focused into focal point (Fig. S2e). All the above processes are done by a home-made program.

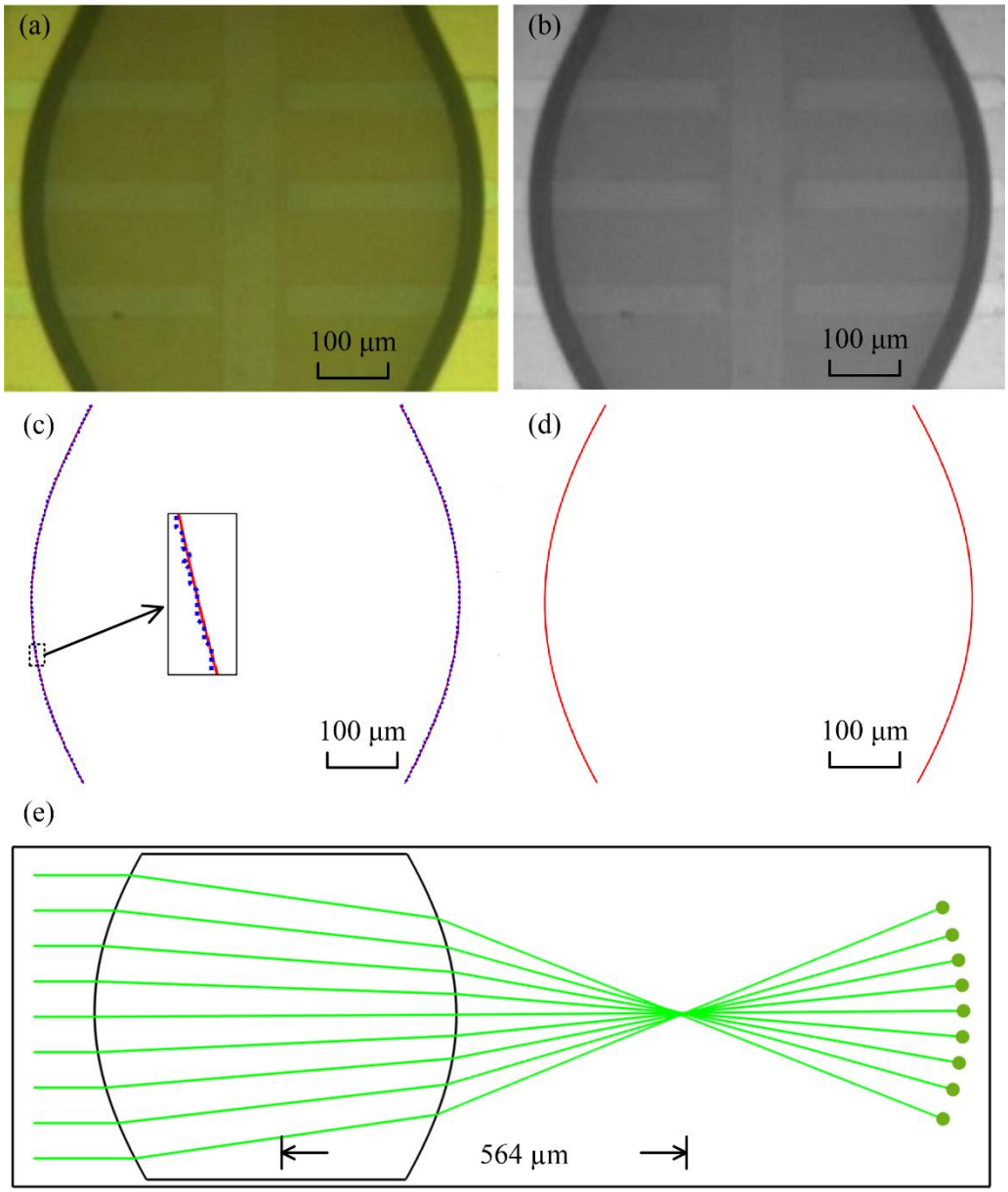

Fig. S2. The numerical raytracing analysis process. (a) Silicone oil-air liquid lens under U_1 = 290 V, U_2 = 295 V, U_3 = 190 V. (b) The grayscale image of the liquid lens. (c) The profile (blue dots) of the lens is extracted and fitted into smooth curved shape, the inset shows the numerical fitting is very closed to the initial interface. (d) The numerically fitted lens shape. (e) The numerical raytracing of the extracted lens shape.