Electronic Supplementary Information (ESI)

Tunable optofluidic birefringent lens

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Table S1

Material properties of 5CB and the mixture of 2,2,2-trifluoroethanol and cyclohexanol

Material		Parameters
5CB	Leslie viscosities,[1] [Pa s]	α_1=-0.0060, α_2=-0.0812, α_3=-0.0036, α_4=0.0652, α_5=0.0640, α_6=-0.0208,
	Frank elastic constants,[1] [N]	$K_1 = 6.2\times10^{-12}$, $K_2 = 3.9\times10^{-12}$, $K_3 = 8.2\times10^{-12}$
	Dielectric constants,[1]	$\varepsilon_{\parallel} = 18.5$, $\varepsilon_{\perp} = 7$, $\varepsilon_a = \varepsilon_{\parallel} - \varepsilon_{\perp} = 11.5$
	Density,[1] [g cm^{-3}]	1.02
	Refractive index	$n_e = 1.7360$, $n_o = 1.5442$
Mixture of 2,2,2-trifluoroethanol and cyclohexanol	Density, [g cm^{-3}]	1.166
	Viscosity, [Pa s]	0.0047
	Refractive index[a)]	1.378

[a)]calculated by the rule of mixture from the volume fraction of mixture. The refractive indices of 2,2,2-trifluoroethanol and cyclohexanol were 1.291 and 1.4641, respectively.

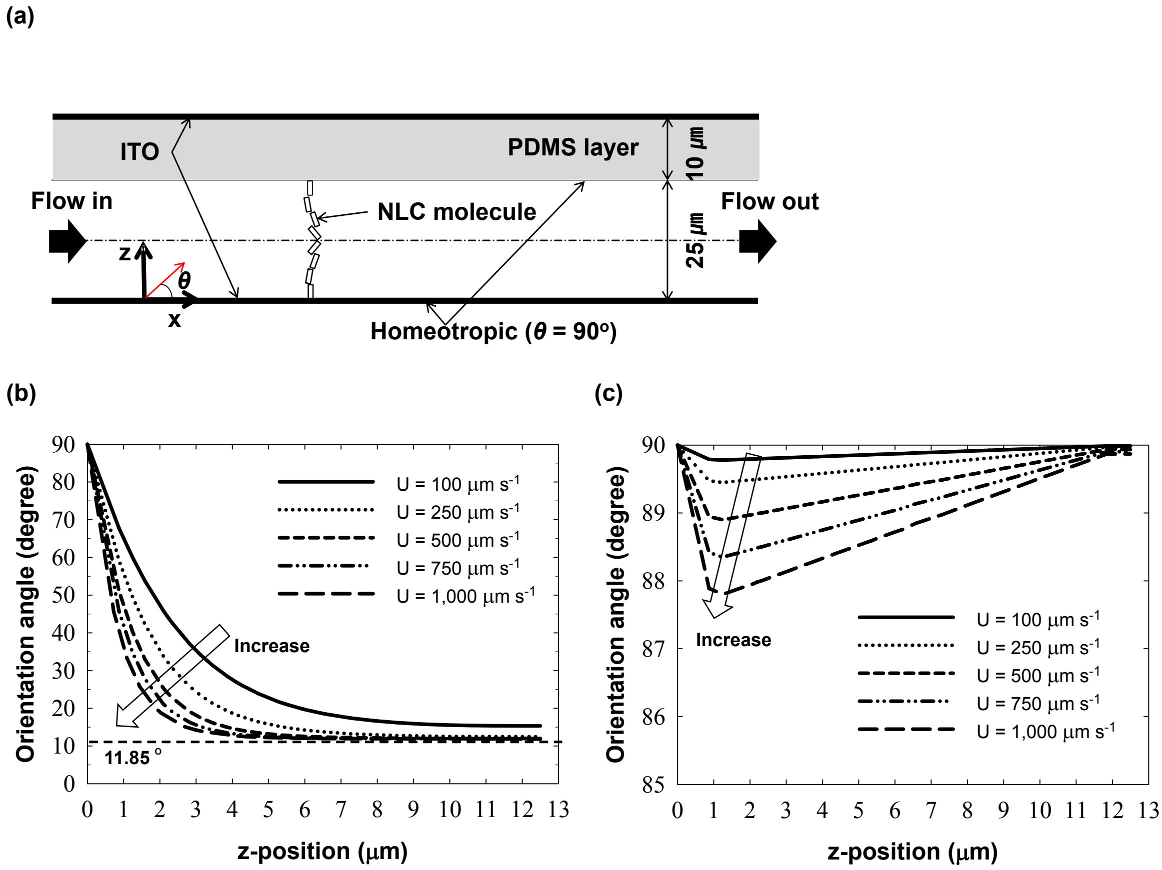

Fig. S1 (a) geometry for the simulation of the director orientation. The director orientations: (b) without and (c) with the electric field.

Fig. S2 Director orientation in a microchannel at static state without electric field. The white arrows mean the transmission axes of crossed polarizers. These figures exhibit dark images in the biconvex-shaped expansion chamber, so that the homeotropic orientation was formed at static state in the microchannel.

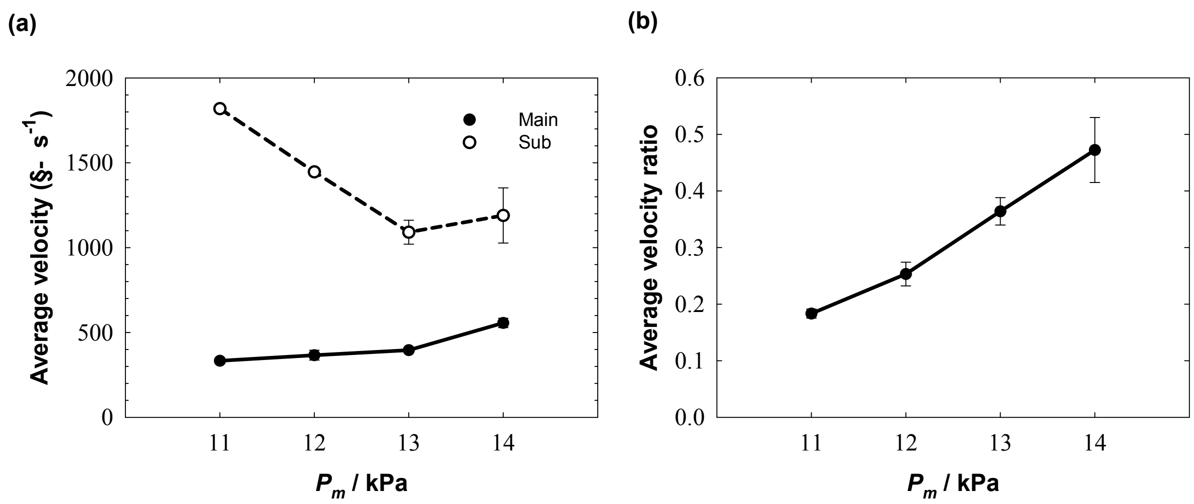

Fig. S3 (a) average velocity and (b) average velocity ratio of the main flows and the sub-flows with respect to pressure for the main stream when the electric field (150 V, 50 kHz) is applied. The applied pressure for the sub-stream was fixed at 7 kPa.

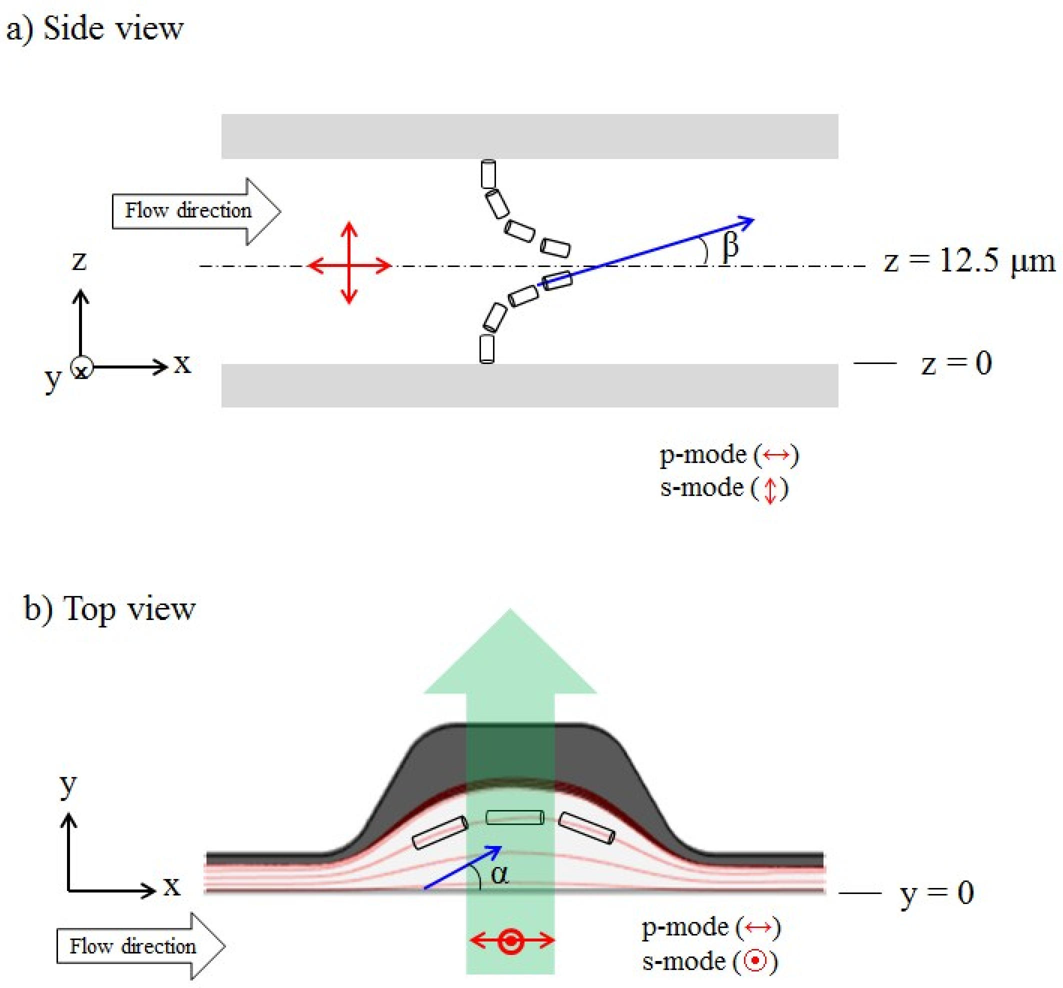

Fig. S4 Schematic description of director orientation: (a) side and (b) top views of the channel. Red lines depicted in (b) represent the streamlines of main stream (NLC).

(a)

(b)

(c)

(d)

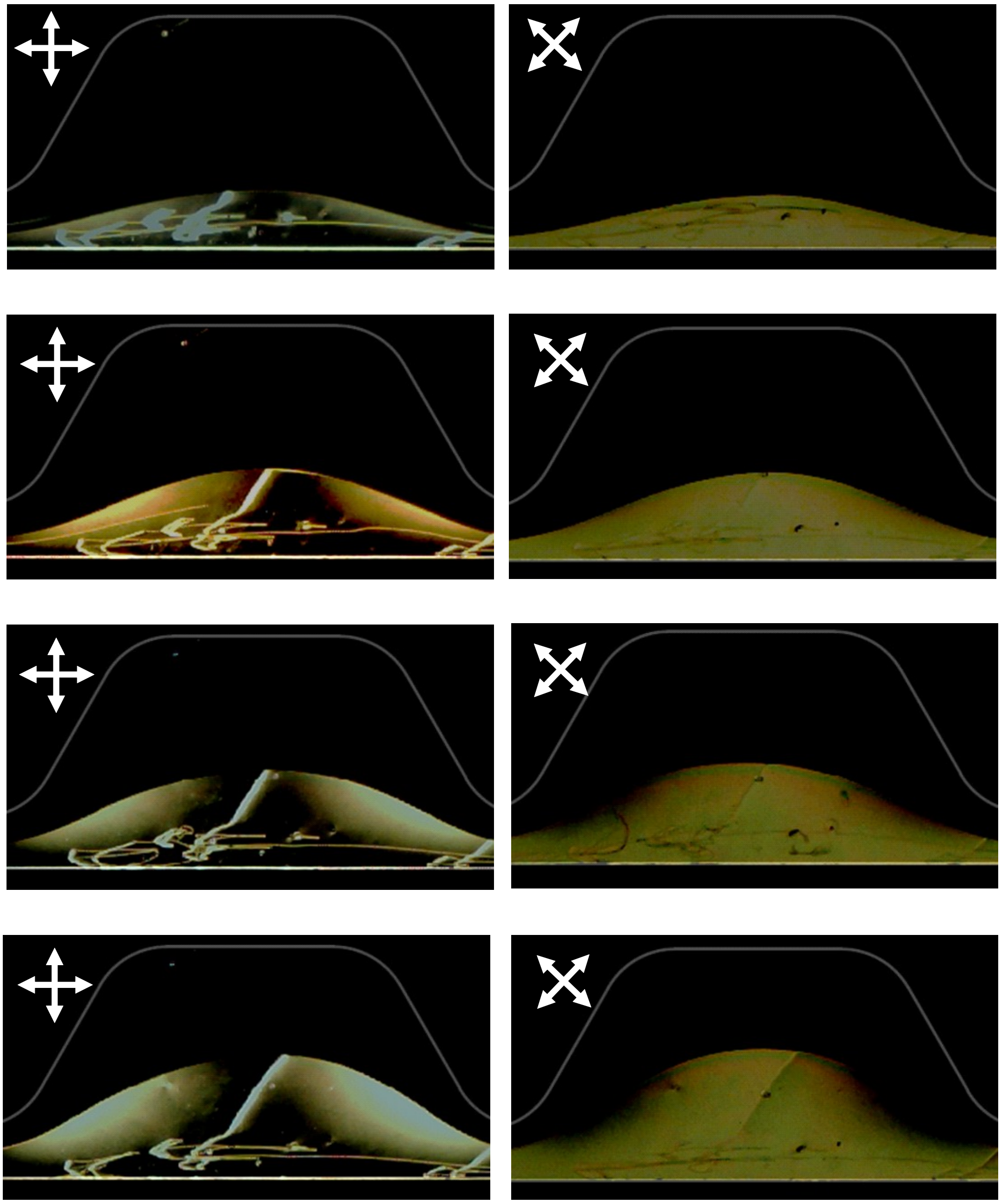

Fig. S5 Microscopic images of the expansion chamber without the electric field at (a) P_m = 8 kPa, P_s = 7 kPa, (b) P_m = 9 kPa, P_s = 7 kPa, (c) P_m = 10 kPa, P_s = 7 kPa, and (d) P_m = 11 kPa, P_s = 7 kPa, respectively. These images correspond to the enlarged images of Fig. 5b in the manuscript. The white arrows represent the transmission axes of crossed polarizers.

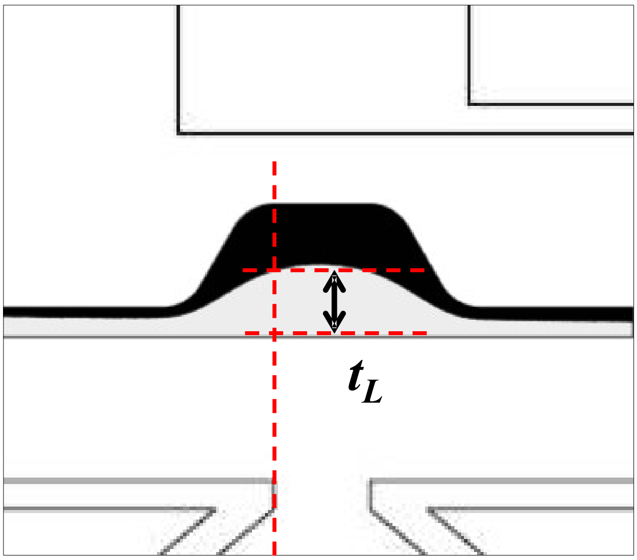

Fig. S6 Illustration for the definition of the lens thickness, which indicates the thickness of the main stream at the edge of aperture.

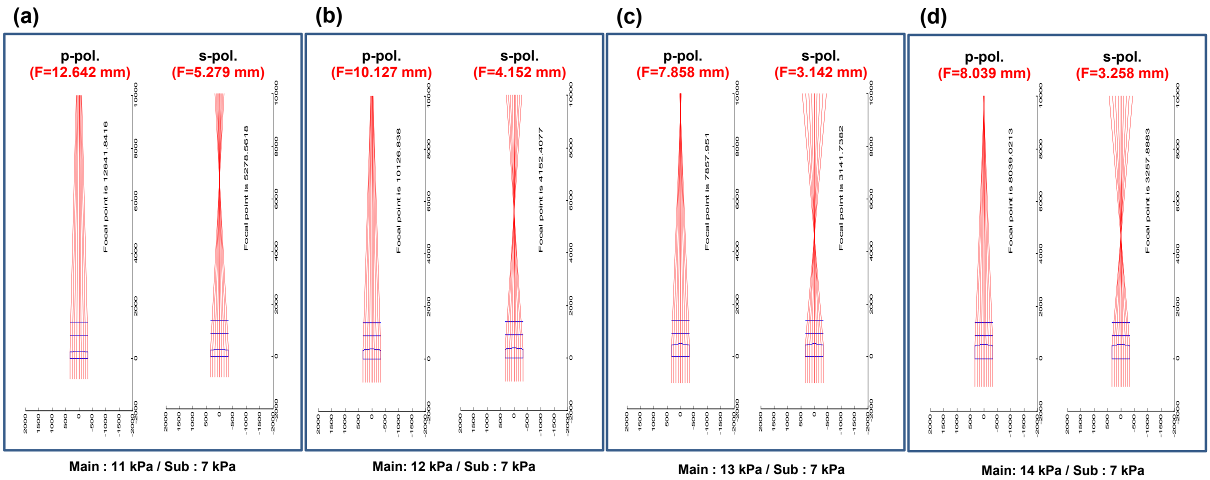

Fig. S7 The focal length (F) calculated by using MATLAB at (a) P_m = 11 kPa, P_s = 7 kPa, (b) P_m = 12 kPa, P_s = 7 kPa, (c) P_m = 13 kPa, P_s = 7 kPa, and (d) P_m = 14 kPa, P_s = 7 kPa.

Reference

1 I. W. Stewart, *The static and dynamic continuum theory of liquid crystals: a mathematical introduction*, Taylor & Francis, 2004.