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

Electronic supplementary information (ESI)

Optical micro/nanofibre embedded soft film enables multifunctional flow sensing in microfluidic chips

Zhang Zhang,[a] Jing Pan,[a] Yao Tang,[a] Yue Xu,[a] Lei Zhang*[a],Yuan Gong*[b] and Limin Tong[a]

[a] State Key Laboratory of Modern Optical Instrumentation, College of Optical Science and Engineering, Zhejiang University, Hangzhou, 310027, China

[b] Key Laboratory of Optical Fiber Sensing and Communications (Ministry of Education), University of Electronic Science and Technology of China, Chengdu 611731, China

Governing equations and boundary conditions for optics and material deformation in simulation.

For the electric field intensity simulation of the MNF, the refractive indexes of MNF and PDMS are 1.45 and 1.42, respectively. The governing equations used in Comsol Multiphysics are as following:

$$\nabla \times \mu_r^{-1}(\nabla \times E) - k_0^2\left(\epsilon_r - \frac{j\sigma}{\omega\epsilon_0}\right)E = 0$$

$$E(x,y,z) = E(x,y)e^{-ik_z z}$$

where E is the electric field intensity, μ_r is the permeability of material, σ is the electrical conductivity, ϵ_r is the permittivity of material and ϵ_0 is the permittivity in vacuum. k_0 is the wavenumber.

The boundary condition for optics simulation is the perfect matched layer (PML).

Material deformation simulations are performed using Solid Mechanics and Fluid-Solid Interaction Physics in Comsol Multiphysics.

Fluid-Solid Interaction Physics:

$$\rho\frac{\partial u_{fluid}}{\partial t} + \rho(u_{fluid} \cdot \nabla)u_{fluid} = -\nabla \cdot [pI + \eta(\nabla u_{fluid} + (\nabla u_{fluid})^T)]$$

$$\rho\nabla \cdot (u_{fluid}) = 0$$

where ρ, η, u_{fluid} and p represent the fluid density, dynamic viscosity, velocity vector field and pressure, respectively. *I* and *T* denote unit diagonal matrix and transpose operator, respectively.

The boundary condition for fluid-solid interaction physics is the flow rate at the inner wall, entrance and exit of the microchannel.

At the inner wall of the microchannel:

$$u_{fluid} = 0$$

means the flow rate is 0 m/s near the inner wall of the microchannel.

At the entrance of the microchannel:

$$u_{fluid} = u_0$$

where u_0 is the velocity at the entrance of the microchannel.

At the exit of the microchannel, boundary condition:

$$[-pI + \eta(\nabla u_{fluid} + (\nabla u_{fluid})^T)] = 0$$

means the pressure to be zero at the exit of the microchannel.

Solid Mechanics Physics:

$0 = \nabla \cdot (F\,S)^T + F_V$

$F = I + \nabla u_{solid}$

These two equations refer to the formulation of the equilibrium equations, where F is the deformation gradient, S is the second Piola-Kirchhoff stress tensor, F_V is the force per volume as function of extension' u_{solid} is the displacement vector field.

The boundary condition was immovably confined set on the left and right brims of PDMS film:

$u_{solid} = 0$

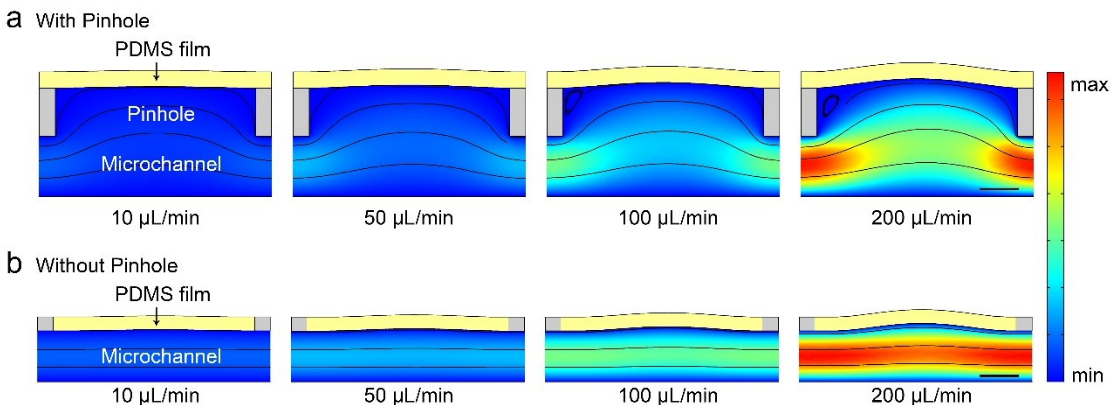

Fig. S1 Simulation of the deformation of the PDMS film without (a) and with (b) a pinhole at different flow rates. Scale bar: 100 μm.

Table S1 Deformation of the PDMS film with and without a pinhole

Flow rate (µl/min)	10	50	100	200
Deformation without pinhole (µm)	1.34	6.55	12.42	21.72
Deformation with pinhole (µm)	1.31	6.45	12.26	21.52