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

Investigation of Particle Manipulation Mechanism and Size Sorting Strategy in Double-layered Microchannel

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Supplementary information: Boundary conditions of numerical model

Table 1. Step1: Stationary study of Laminar flow

Fluid properties		Inlet		Outlet		Initial value		Wall
Density	997 (kg/m3)	Flow condition	Fully developed	Pressure control		Velocity field	[u=0 v=0 w=0]	No slip
Dynamic viscosity	1.0016 (mPa·S)	Flow rate	1000 (μL/min)	Pressure	0 (Pa)	Pressure	0	

Table 2. Step2: Time dependent study of particle tracing

Particle properties		Releasing		Wall Condition		Forces	
Density	1050 (kg/m3)	Initial Location	Inlet, Mesh based	Side walls	Bounce	Drag force	Eqns. (1)-(3)
Diameter	Int [1,10] (μm)	Initial velocity	Laminar flow field	Outlet	Freeze	Lift force	Eqns. (4)(5)

Supplementary information: Inertial focusing validation of the numerical model.

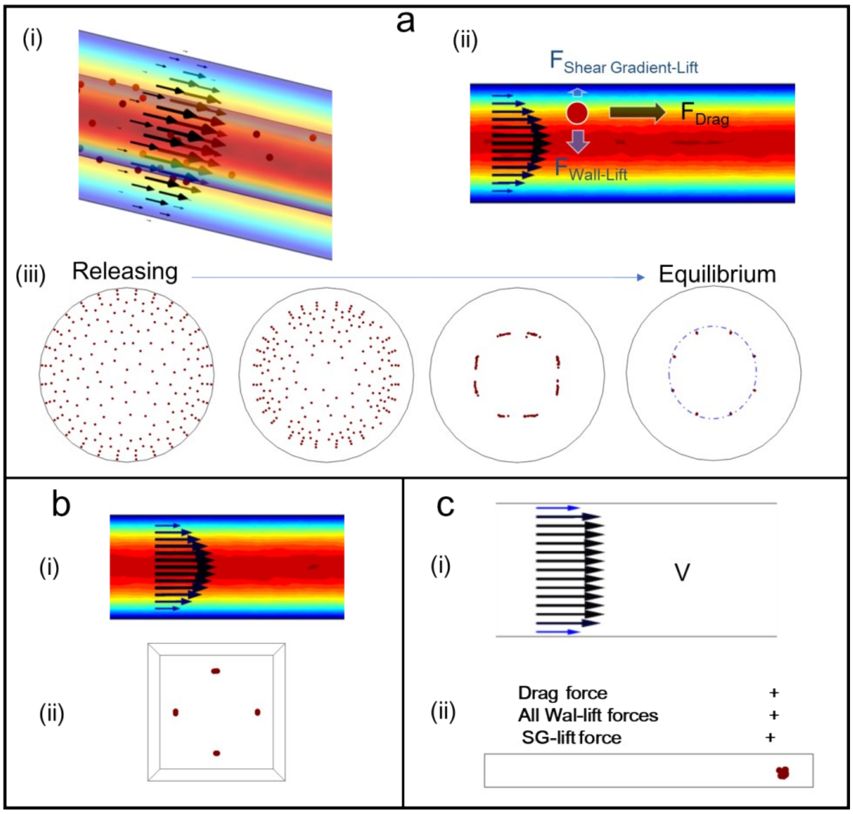

Figure S1 Numerical model validation on inertial equilibrium positions in straight microchannel. (a) Circular microchannel. *i* Velocity distribution, *ii* Hydraulic forces on a microparticle, *iii* Equilibrium positions. (b) Squared microchannel. *i* Velocity distribution, *ii* Equilibrium positions. (c) Double layered microchannel with groove arrays. *i* Velocity distribution, *ii* Equilibrium positions.

Supplementary information: Controlling equations of hydraulic forces.

The formula to calculate drag force (F_d) is associated with relative Reynolds number (Re_r) [1], which can be estimated by Eqn. (1):

$$F_d = \frac{m_p(\mathbf{u}-\mathbf{v})}{\tau_p} \tag{1}$$

$$\tau_p = \frac{\rho_p(P_d^2)}{18\mu} \tag{2}$$

$$Re_r = \frac{\rho\|\mathbf{u}-\mathbf{v}\|P_d}{\mu} \tag{3}$$

where ρ is the density of fluid, $\mathbf{u}$ is the fluid velocity vector, $\mathbf{v}$ is the particle velocity vector, P_d is the diameter of particle, and μ is the viscosity of fluid. In this study, the density of fluid (DI water), was 1000 kg/m^3. The maximum magnitude of velocity was around 1E0 *m*/*s*. The particle diameter was in E-6 order of meter, and the viscosity of DI water was considered as 1 mPa·s. Hence the relative Reynolds number was less than 1, where the Stokes Drag Law was applicable, expressed as Eqns. (2)&(3) [1]. m_p is the mass of particle, τ_p is the particle velocity response time, and ρ_p is the density of particle (1050 kg/m^3). The calculation of Wall-Lift force (F_L) was solved by the Eqn. (4) [2]:

$$F_L = \rho\frac{P_d^4}{4D^2}\alpha\left[\alpha G_1(s)+\beta G_2(s)\right]\mathbf{n} \tag{4}$$

where D is the distance between the channel walls, G_1 and G_2 are functions of nondimensionalized wall distance s as given in ref. [2], s is the nondimensionalized distance from the particle to the reference wall, divided by D. $\mathbf{n}$ is the wall normal at the nearest point on the reference wall. Coefficients like α and β were obtained by Eqn. (5):

$$
\begin{cases}
\alpha = \left| D(\mathbf{n} \cdot \triangledown)\mathbf{v} \right| \\
\beta = \left| 0.5D^2 (\mathbf{n} \cdot \triangledown)^2 \mathbf{v} \right| \\
\mathbf{u}_{\mathrm{p}} = \left[I - (\mathbf{n} \otimes \mathbf{n})\mathbf{u} \right]
\end{cases}
\tag{5}
$$

where I is the dimensionless identity matrix [2].

Supplementary information: Front view of 2μm particle trajectory.

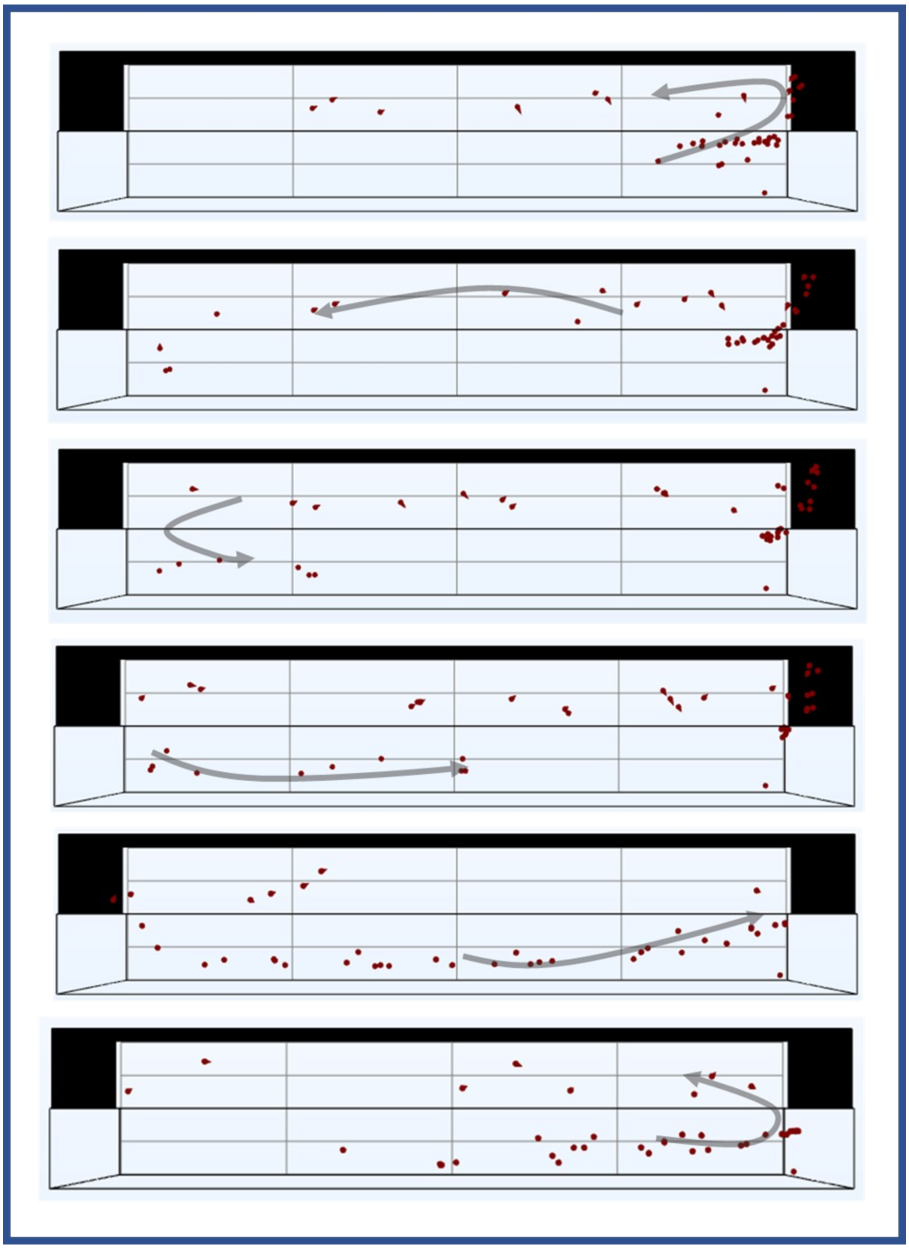

Figure S2 The trajectory of 2μm microparticles (front view).

References:

1. R. Clift, J. R. Grace and M. E. Weber, *Bubbles, Drops, and Particles*, Dover Publications, Incorporated, 2013.
2. B. Ho and L. Leal, *J. Fluid Mech.*, 1974, **65**, 365-400.