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

Supplementary Information

Size-based microfluidic multimodal microparticle sorter

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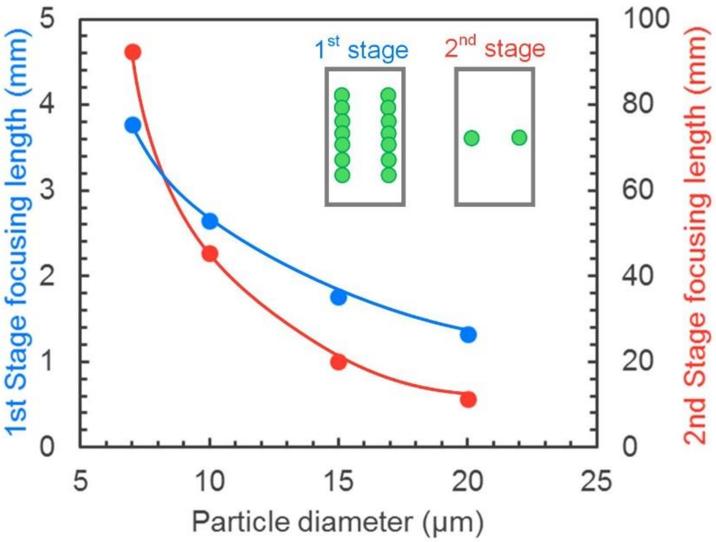
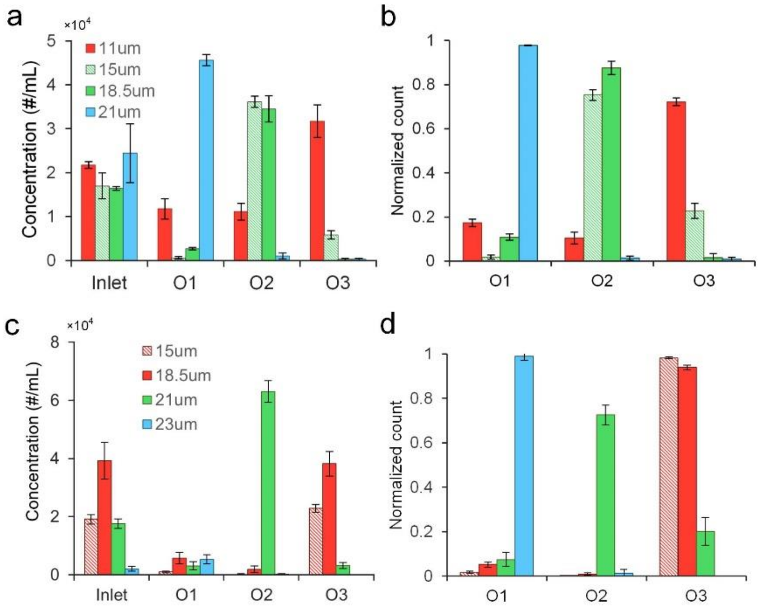


Supplementary Figure 1: Theoretical calculation of focusing length vs. microparticle diameter. The calculation shows that larger particles require much less focusing length than the smaller ones. The focusing length for first stage focusing is much shorter than completing second stage focusing. The cross-section of the channel is 50µm×100µm *w*×*h*.



Supplementary Figure 2: Quantitative measurements of concentration and efficiency. (a) The concentration plot shows the concentrations of 21µm, 18.5µm, 15µm and 11µm diameter particles are enriched 1.9×, 2×, 2× and 1.5× correspondingly after multimodal separation (n=3). (b) The normalized count shows that the separation efficiencies for 21µm (from O1), 18.5µm (from O2), 15µm (from O2) and 11µm (from O3) diameter particles are 98%, 87%, 75% and 72% respectively indicating successful separation after tuning bandwidth (n=3). (c) The concentration plot indicates obvious enrichment of 23µm and 21µm diameter particles by 2.6× and 3.6×. (d) The normalized count shows that the separation efficiencies for 23µm (from O1), 21µm (from O2), 18.5µm and 15µm (from O3) diameter particles are 99%, 73%, 98% and 93% indicating successful separation after tuning the passband location.

Supplementary Note 1: Design details of focusing channel

We used the two-stage inertial migration model[1] to guide the design of focusing channel. The downstream length L for particles of diameter a to fully focus and equilibrate at the center of side walls can be calculated as

$$L = \frac{3\pi\mu D_h^2}{4\rho U_f a^3}\left(\frac{w}{C_L^-} + \frac{h}{C_L^+}\right), h > w \tag{1}$$

where μ is fluid viscosity, ρ is fluid density, U_f is the average flow velocity, and D_h is the hydraulic diameter ($D_h = 2wh/(w+h)$ for a channel w wide and h high). C_L^- is the negative lift coefficient related to the first stage migration and C_L^+ is the positive lift coefficient related to the second stage migration. The equation illustrates a strong dependence of the focusing length on particle diameter ($L \sim a^{-3}$) indicating larger particles will require much less focusing length than the smaller ones. Besides, channel with smaller hydraulic diameter can focus particles with shorter focusing length ($L \sim D_h^2$).

Using equation (1) and lift coefficients we presented in our recent work,[1] we calculated the focusing length for completing 1st stage and 2nd stage focusing of 20μm, 15μm, 10μm and 7μm in a microchannel with cross-section dimension 50×100 μm^2 ($w \times h$) (Supplementary Fig. 1). The calculation indicates the channel lengths required for completing 1st stage migration of 20μm, 15μm, 10μm and 7μm are 1.3mm, 1.8mm, 2.6mm and 3.7mm correspondingly, while the channel lengths for completing 2nd stage migration increase dramatically to 11mm, 20mm, 45mm and 92mm. We designed a 10mm focusing length so that particles within our test size range (10~27 μm diameter) can fulfill 1st stage focusing as two bands along the side walls. This consistency in vertical focusing position allows uniform distance between particles and separation boundary. Although, fully focusing of particles at the center of side walls can provide both vertical and horizontal consistency to maximize device performance, the required length is ~50mm for 10μm diameter particles which inevitably increases the device footprint.

Supplementary reference

[1] J. Zhou, I. Papautsky, *Lab Chip* **2013**, 13, 1121.