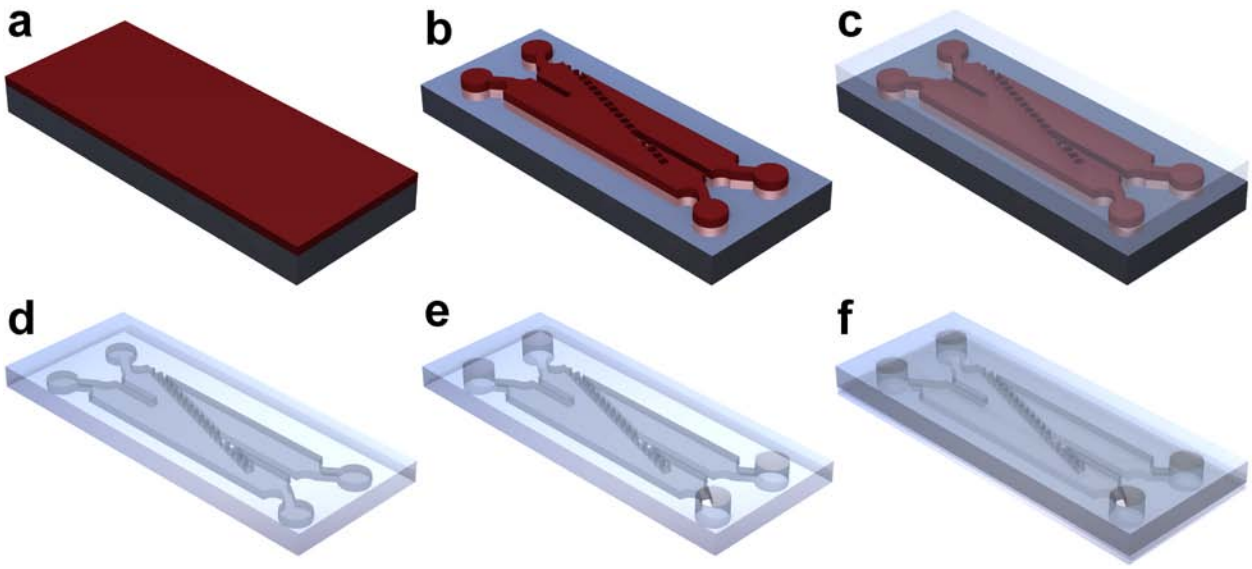
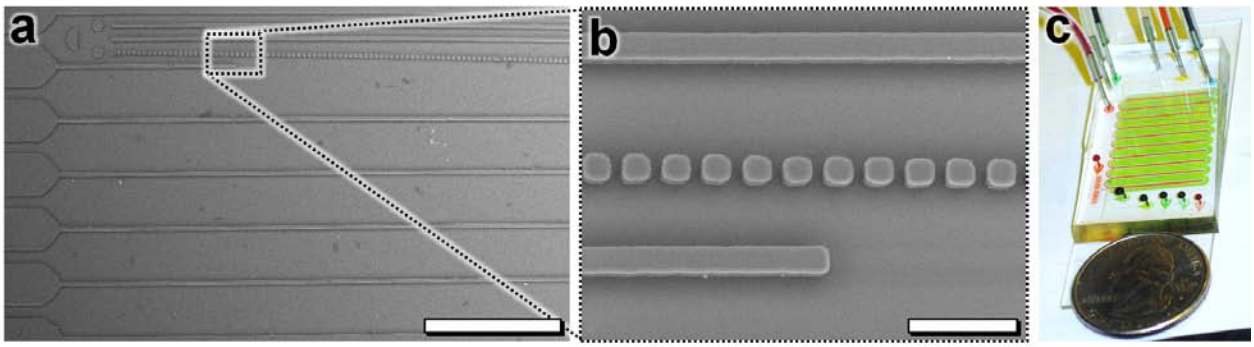
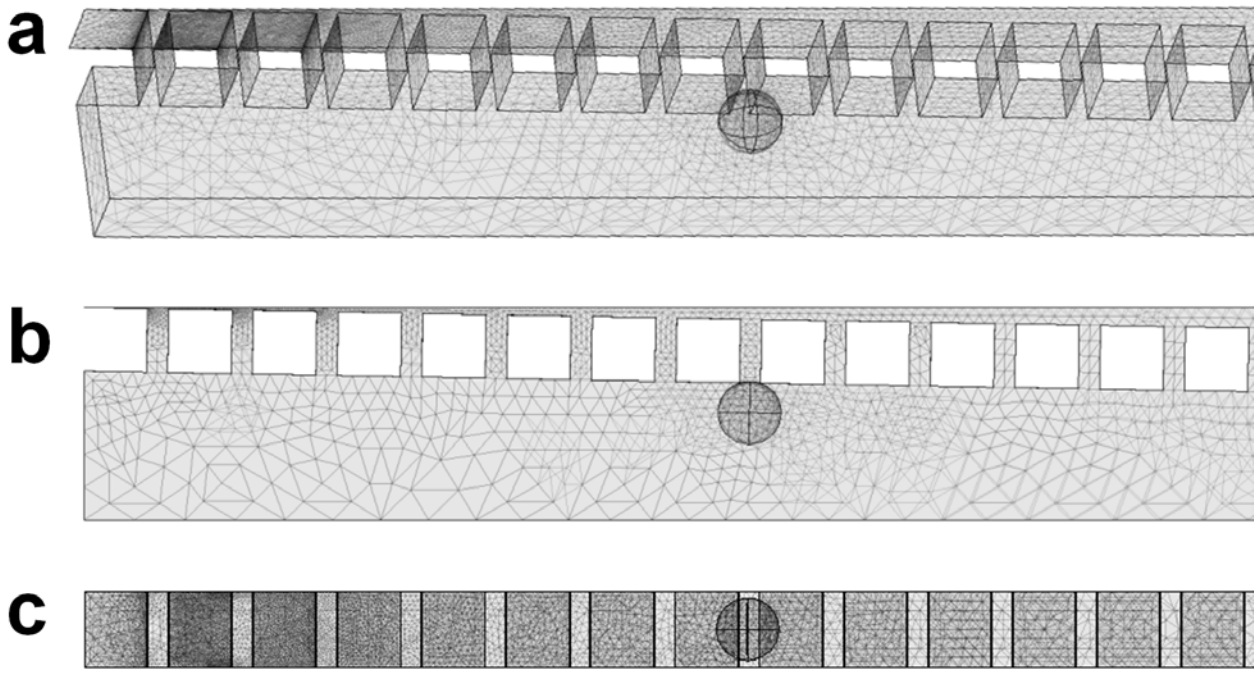
Electronic Supplementary Information (ESI)



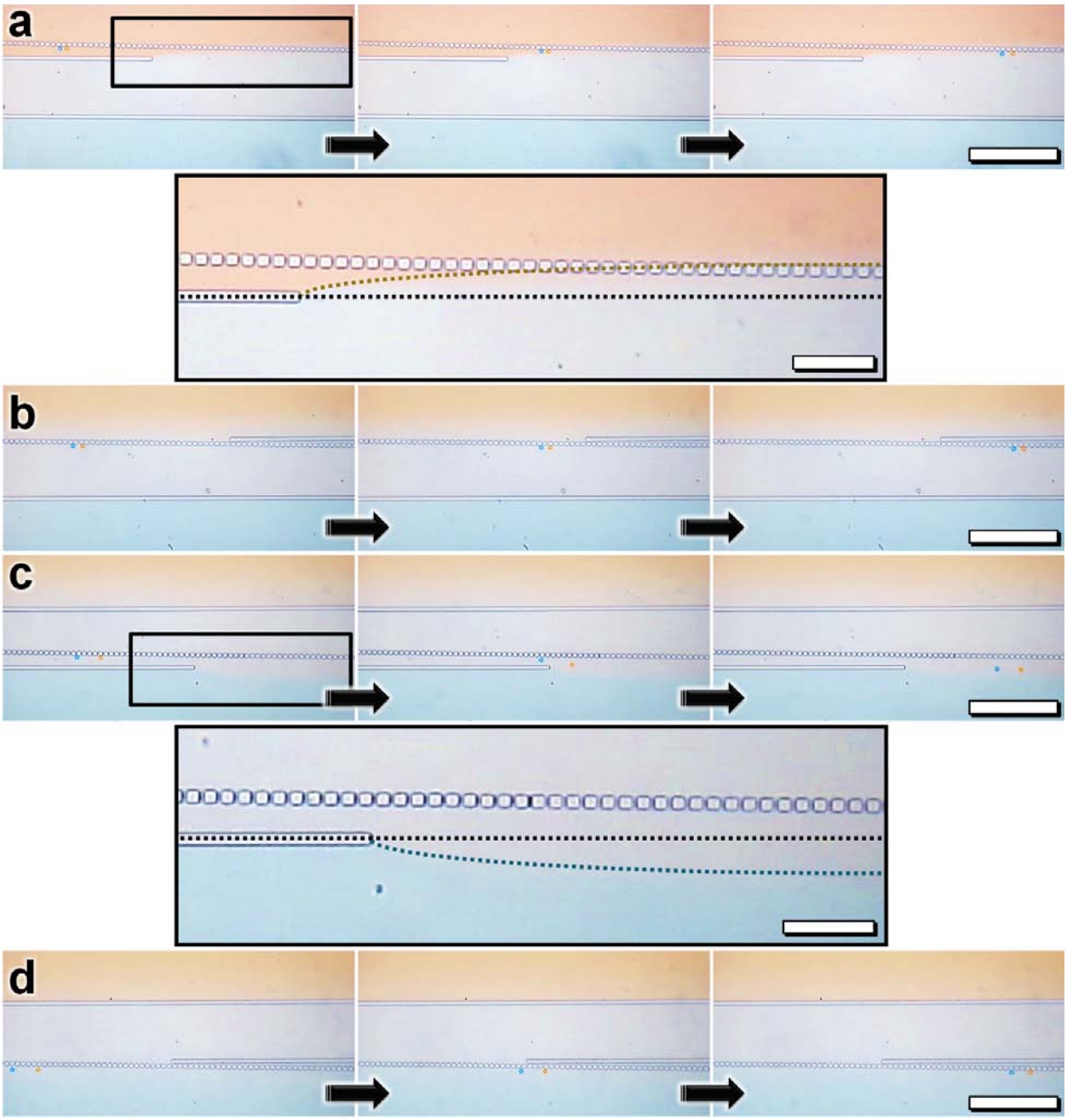
ESI Figure 1 Conceptual illustrations of the micropost array railing (*μ*PAR) microfabrication process. **(a)** The negative photoresist, SU-8 2010, was spin-coated onto clean 4" Silicon wafers. **(b)** Microfeatures were defined *via* contact photo-lithography. The developed photoresist served as a negative master. **(c)** The device was micromolded with the silicone elastomer, poly(dimethylsiloxane) (PDMS). **(d)** After curing, the PDMS was removed. **(e)** Ports for the catheter couplers were punched at inlet and outlet locations. **(f)** The PDMS devices were bonded to glass slides.



ESI Figure 2 Microfabrication results for the multiplexed *μ*PAR system. **(a, b)** SEM micrographs captured at magnifications of: **(a)** 100X, **(b)** 1,000X. **(c)** Photograph of the multiplexed *μ*PAR system filled with coloured dye solutions next to a US Quarter (approximately 24.3 mm in diameter). Scale Bars = **(a)** 500 *μ*m, **(b)** 50 *μ*m.

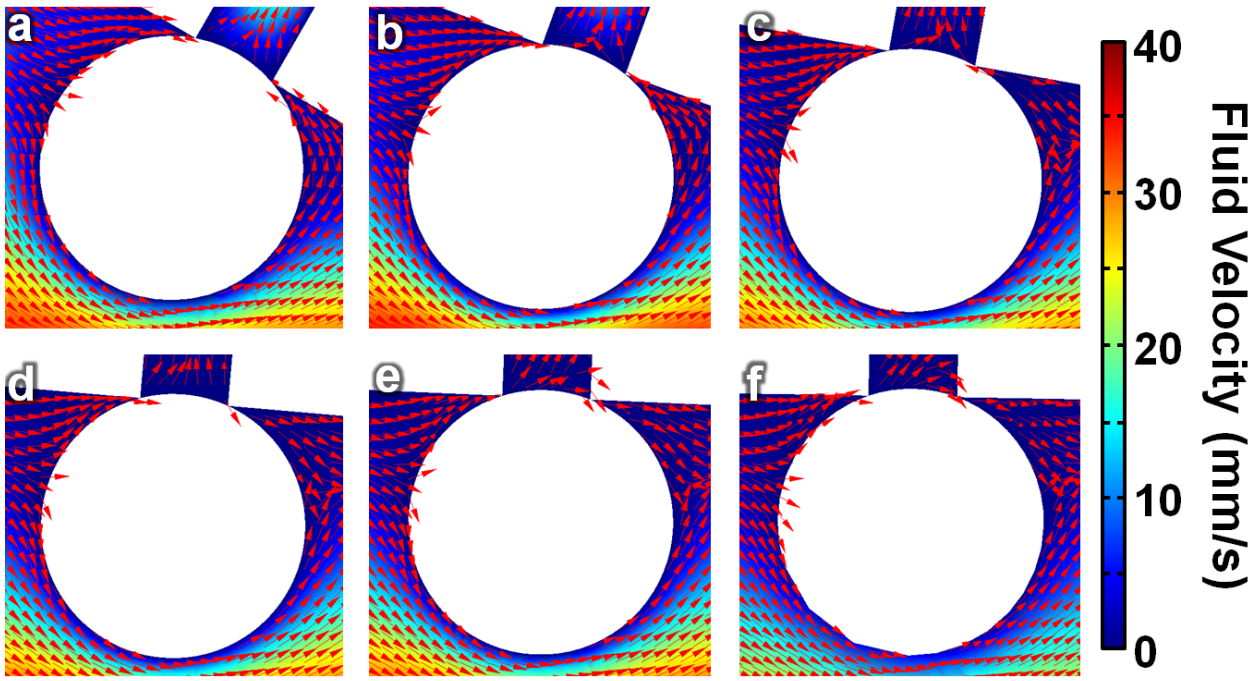


ESI Figure 3 Expanded views of a meshed three-dimensional COMSOL Multiphysics model of a spherical microparticle (15 μm in diameter) immobilized within a μPAR system with α = 1°. **(a)** Three-dimensional view. **(b)** Top view. **(c)** Side view.

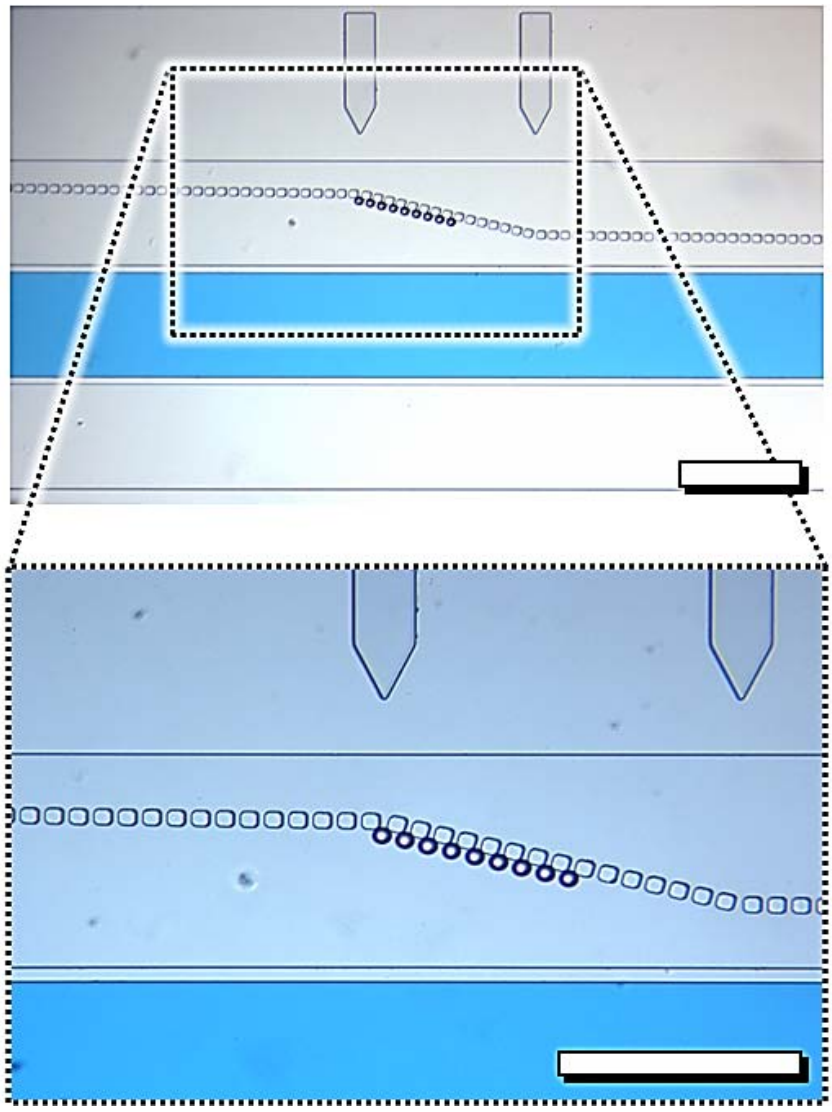


ESI Figure 4 Experimental results for limiting biotin and avidin diffusion into the wash solution within the multiplexed *μ*PAR system. **(a, b)** Suspended streptavidin-coated polystyrene microbeads (15 *μ*m in diameter) are transported from the biotinylated bovine serum albumin (BSA) solution (*yellow*) to the phosphate buffered saline (PBS) wash solution (*white*). The higher input flow rate for the PBS wash solution (*i.e.*, *versus*

the biotin solution) enhances diffusion based mixing within the *biotin channel* rather than within the *PBS wash channel*. **(c, d)** Suspended microbeads are transported from the PBS wash solution (*white*) to the NeutrAvidin solution (*green*). The higher input flow rate for the PBS wash solution (*i.e.*, *versus* the avidin solution) enhances diffusion based mixing within the *avidin channel* rather than within the *PBS wash channel*. The *dotted yellow* and *green curves* in the *expanded views* **(a, c)** mark the displaced mixing zones; the *dotted black lines* mark the mixing zones for cases where all of the input flow rates are equivalent; *Orange* and *Blue* microbeads show a singular mobile microbead captured at two time-points within one second; Scale Bars = 100 μm for the *expanded views*; Scale Bars = 300 μm for all other micrographs.



ESI Figure 5 Top views the center cross-section of three-dimensional COMSOL Multiphysics fluid velocity field simulation results for *μ*PAR systems with: **(a)** *α* = 30°, **(b)** *α* = 20°, **(c)** *α* = 10°, **(d)** *α* = 5°, **(e)** *α* = 2.5°, and **(f)** *α* = 1°. Spherical microparticles (15 *μ*m in diameter) were modelled in all of the simulations. The overlaid *red arrows* denote the direction of the fluid velocity field vectors.



ESI Figure 6 Experimental results for varying α from 1° to 15° to 1° in order to immobilize a select number of microbeads within a μPAR system. Scale Bars = 200 μm.

ESI Movie Captions

ESI Movie 1 Real-time experimental results for microbead dynamics in the multiplexed *μ*PAR system. Suspended streptavidin-coated polystyrene microbeads (15 *μ*m in diameter) are transported from: (*i*) the microbead suspension (*blue*) to the biotinylated bovine serum albumin (BSA) solution (*yellow*) (100X magnification), (*ii*) the biotinylated BSA solution (*yellow*) to the phosphate buffered saline (PBS) wash solution (*white*) (100X magnification), (*iii*) the PBS wash solution (*white*) to the NeutrAvidin solution (*green*) (200X magnification), (*iv*) the NeutrAvidin solution (*green*) back to the PBS wash solution (*white*) (200X magnification), and (*v*) the PBS wash solution (*white*) back to the biotinylated BSA solution (*yellow*) (100X magnification). *Orange* and *blue* microbeads show a singular microbead captured at two time-points within one second.

ESI Movie 2 Real-time experimental results for cell handling in a *μ*PAR system with $\alpha = 1°$. **(a-d)** Suspended bovine aortic endothelial cells (BAECs) are transported from: **(a)** the cell media suspension (*white*) to a blue-dyed PBS wash solution, **(b)** a blue-dyed PBS wash solution to a red-dyed PBS wash solution, **(c)** a red-dyed PBS wash solution back to a blue-dyed PBS wash solution, and **(d)** a blue-dyed PBS wash solution back to the cell media (*white*). All videos were captured at 100X magnification. *Orange* and *blue* cells show a singular cell captured at two time-points within one second.