**Supplementary File 1**

**Theoretical background and governing equations and Graphical Desgin.**

In this section we discuss the fundamentals and governing equations of the simulation model. The simulation was setup by using three modules of COMSOL multiphysics namely fluid flow, particle tracing and Electric current.

* 1. The fluid flow was modelled using linear form of Navier-Stokes equation given by equation [1 \_ 3].

$$ρ\frac{∂u}{∂t}+ρ\left(u\_{fluid}∙∇\right)u\_{fluid}=∇∙\left[-pI+K\right]+F (1)$$

$K=μ\left(∇u\_{fluid}+\left(∇u\_{fluid}\right)^{T}\right)$$ (2)$

where ρ is fluid density, *u* is linear velocity, µ is the fluid viscosity, and p is the pressure. I is the identity matrix. The fluid was modelled as an incompressible fluid by coupling Equation 1 with the continuity equation:

$$ρ∇∙u\_{fluid}=0 (3)$$

* 1. The fluid flow inside microchannels has to be in laminar regime and this can be quantified by calculating Reynolds number (Re) for the respective microchannel. If the Re<100 flow is classified as laminar flow. When the fluid flow velocity is further reduced the Re number is Re<<1 in this case the fluid flow is termed as creeping or Stokes flow. In creeping flow regime the viscous forces dominate the inertial forces which leads to momentum being transported by using viscous diffusion rather than convection. In case of creeping flow the equation 1 can be written as

$$0=∇∙\left[-pI+K\right]+F (4) $$

* 1. The Re number for our microchannel turns out to be 3.16 × 10-4 which is less then 1. In the light of these calculations creeping flow submodule under fluid flow module was used to model the fluid flow.

The boundary condition at the inlet was set to have normal inflow velocity give by equation 5.

$$u=-nU\_{0} (5)$$

where *n* is the boundary normal pointing out of the domain and U**0** is the normal inflow speed. The boundary condition at the output was set to be pressure and the equations 6 and 7 constitute the pressure conditions at the outlet.

$$\hat{P}\_{0}n=n\left[-pI+K\right] (6) $$

$$\hat{P}\_{0}\leq P\_{0} (7)$$

* 1. The tangential component of stress is set to zero. If the value of reference pressure Pref is zero at the interface, the value of the pressure P0 at the boundary is the absolute pressure. If not, P0 represents the boundary's relative pressure.

The motion of particles (MCF-7 and healthy cells) suspended in phosphate buffer silane (PBS) was modelled using particle tracing module in COMSOL multiphysics. The particle tracing module uses Newtons first order equations of motion.

$$F\_{t}=\frac{d\left(m\_{v}V\right)}{dt} (8)$$

The boundary condition at the inlet in this case are set to release the particle with for a specific time range and with a specific time interval.

$$q=q\_{0 }(9)$$

$$ v=v\_{0} (10)$$

The Boundary condition at the outlet is set to be $ v=v\_{c}$

* 1. When the suspended particles have Re<<1 it is necessary to apply either Stokes drag or seen correction on them as they flow from inlet towards outlet. In this case we used Stokes drag on all the particles. The governing equations in this case are [11-14].

$$F\_{D}=\frac{m\_{p}\left(u-v\right)}{τ\_{p}} (11)$$

$$τ\_{p}=\frac{ρ\_{p}d^{2}\_{p}}{18µ} (12)$$

$$F\_{vm}=\frac{1}{2}m\_{f}\frac{d\left(u-v\right)}{dt} (13)$$

$$F\_{p}=m\_{f}\frac{Du}{Dt} (14)$$

* 1. In order to sort the particles based on their dielectric properties a dielectrophoretic force (DEP) also needs to be applied to them and it is done by using dielectrophoretic force node. Even an uncharged particle is subjected to a force in a nonuniform electric field if the particle’s permittivity is different than the permittivity of the surrounding fluid. An electric potential or the electric field can be used to specify the force. Depending on whether the source electric field is computed in a stationary or frequency domain manner, the force has a distinct interpretation. In this case we used frequency domain and the magnitude of DEP force I given by

$$F\_{DEP} = 2πr^{3}ε\_{0} ∙real \left(ε\_{m}\right)∙ real \left(K\right)∙∇ \left[E\_{rms^{2}}\right] (15)$$

Where ‘**K**’ is known as the Clausius-Mossotti factor and is given by

$$K=\frac{έ\_{p - }έ\_{m}}{έ\_{p + }2έ\_{m}} (16)$$

The potential on the electrodes is applied using current conservation and electric potential sub nodes under electric current module and the governing equations in this case are

$$∇.J=Q \_{j,v} \left(17\right)$$

$$J=σE+J\_{e} (18)$$

$$E=-∇V (19)$$

The continuity equation for the electrical potential is added by the contemporary node. This equation provides an interface that defines the electric conductivity and the relative permittivity. This in turn forms the constitutive relation equired for the displacement current.