Supplementary Information

Numerical simulations

Numerical method

Comsol Multiphysics was used for the simulations. Table S1 lists the most important parameters for the simulations and Figure S1 shows an example of a mesh used. Perfectly matched layers are used on the outer side, top and bottom of the model to absorb the light. On the inner side, which is the plane of symmetry, the boundary condition is set to be a perfect electric conductor. The field on the first input face is found by using a boundary mode analysis. A periodic boundary condition is used to map the field at the first input face to the second input face. The input power is set to 1W and only the fundamental TE-mode of the waveguide is excited. Maxwell's stress tensor is used to find the force on the sphere from the field distribution on the outer surface of the sphere.

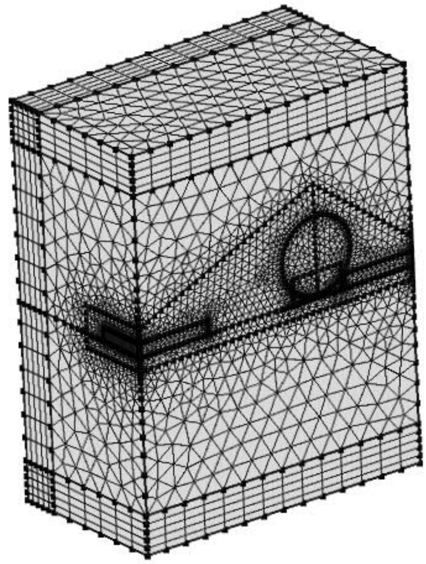


Figure S1: Mesh used to simulate forces on 1 µm sphere in 2 µm gap. A dense mesh is used in the waveguides and on the surface of the sphere. A relatively dense mesh is also used in central regions where the field is propagating towards the sphere, while a coarse mesh is used far from the sphere. A swept mesh is used on the outer side, top and bottom of the model, where a perfectly matched layer is used to absorb the field.

Table S1: Parameters used for the numerical simulations.

Parameter	Symmetric, half model	Non-symmetric, complete model	Comments
Wavelength, λ_0	1070 nm		
Refractive index of waveguide	2.15		Core, Ta_2O_5
Refractive index of substrate	1.4457		Silica
Refractive index of superstrate	1.33		Water
Refractive index of sphere	1.59		Polystyrene
Width of waveguide	1.3 µm		Total width, 0.65 µm for half
Thickness of waveguide	180 nm		
Length of waveguides	1 µm		
Height of substrate	2.5 µm		Silica
Height of superstrate	2.5 µm		Water
Length of model	4 µm		= length of gap + 2*(length of waveguide)
Width of model	2.75 µm*	6 µm**	*For the half simulated. **Maximum, depends on position (y) of sphere.
Mesh size in waveguide	71 nm = λ/7	71 nm = λ/7	
Mesh size on surface of sphere	60 nm	80 nm	
Mesh size inside sphere	100 nm = λ/7	135 nm = λ/5	
Mesh size in central regions	115 nm = λ/7	160 nm = λ/5	
Number of mesh elements	130.000	290.000	Depends on exact size of model, which depends on position of sphere.
Degrees of freedom	0.9 mill.	1.95 mill.	

Materials and Methods

Cell preparation and handling

A fresh blood sample is drawn from a healthy donor (6-10 ml) by venepuncture into EDTA tubes (ethylenediaminetetraacetic acid), which chelate calcium to prevent clotting. The blood sample was mixed with phosphate buffer solution (PBS) and centrifuged at 600 g for 10 minutes. This accumulates red blood cell (RBC) pellets at the bottom of the test tube. The supernatant liquid containing white blood cells and plasma w carefully removed from the top. This process was repeated three times in PBS to remove most of the platelets and white blood cells. The samples were stored in PBS solution and were used within a few hours. Cells were submersed into 0.25 M isotonic sucrose solution just before the experiments so that they could be propelled and trapped in a medium in which they stay healthy and alive.

Experimental apparatus

A schematic diagram of the experimental apparatus used is shown in Figure S3. The laser is a 5 W single-mode Ytterbium fiber laser, with wavelength 1070 nm. Light was coupled into the waveguide by an IR-coated objective lens (80X, 0.9 N.A, Nachet). The objective was positioned with a piezoelectric translation stage with ~ 10 nm step size. The waveguide chip was kept on a vacuum chuck to avoid any drift with time. The output light from the waveguide was collected by a 40X objective lens. A microscope with a long working distance 20X and 50X objective lens and a CCD camera was employed to capture images.

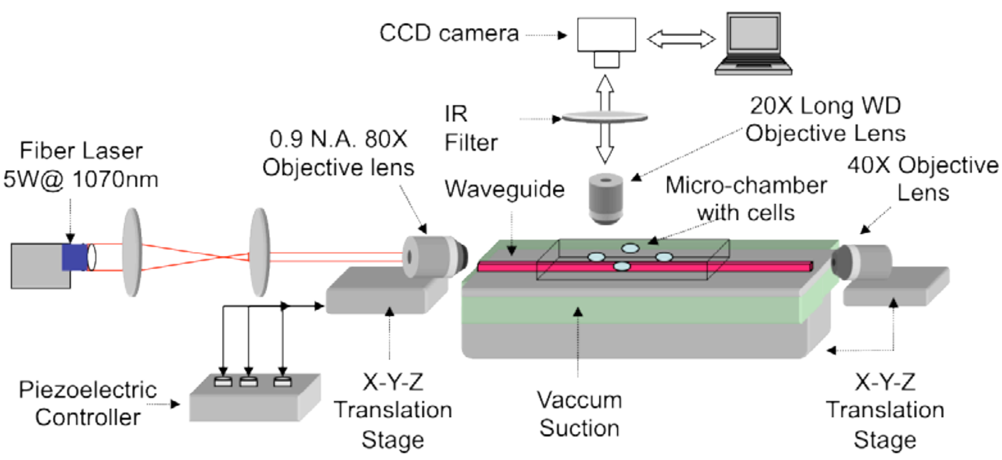
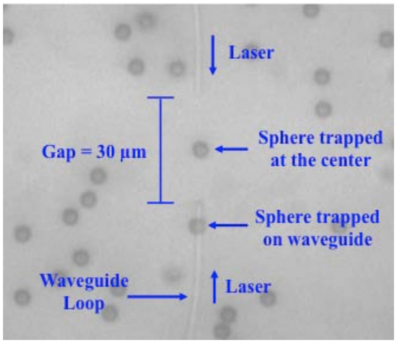
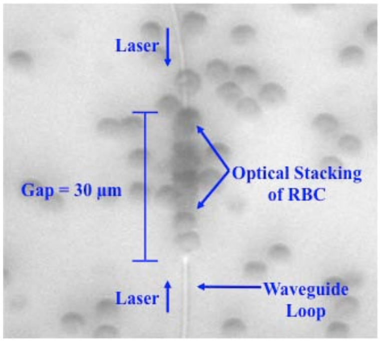


Figure S4: Schematic diagram of the experimental apparatus.

Experimental Results: Movies of trapped particles



Supplementary Movie 1: Optical trapping of a 3 µm particle in a 30 µm gap. The particle is trapped at the centre of the gap. The optical force on a particle decreases with the distance of the particle to the waveguide end. Thus, a 3 µm particle at a distance of 15 µm from the waveguide end is held by a weak trapping force. The trapped particle is easily knocked out when a new particle arrives at the gap, as shown in the movie. The movie is accelerated to 3 times real-time.



Supplementary Movie 2 : Optical stacking of red blood cells in waveguide loop with a gap separation of 30 µm. When the gap is completely filled, the cells are optically stacked. Optically stacked cells fell down when the laser was switched off, as shown in the movie. Optically stacked cells are held together by weak optical forces and are knocked out when more/newer cells are stacked. The movie is accelerated to 3 times real-time.