L.6 Sorting and guiding of micro- objects with evanescent optical field

Optical micromanipulation can provide a non invasive means for sorting of microscopic objects for further evaluation and analysis. One approach used for such sorting involves the use of multiple optical traps arranged in linear or three dimensional arrays. Objects of different size or composition, flowing past such trap array get sorted out due to a difference in the magnitude of optical gradient forces on these. Other recent approach uses the evanescent field generated at the surface of the Y-shaped optical waveguide. By adjusting the relative power distribution in the two branches of the waveguide, the particles could be selectively guided down the desired branch. Laser Biomedical Applications and Instrumentation Division of RRCAT has shown that microscopic objects can be sorted in a much simpler and efficient manner by use of the gradient of optical evanescent field at refractive index interfaces. The approach exploits the fact that heavier particles reside closer to the interface compared to lighter particles and therefore interact strongly with the evanescent field to experience larger optical forces.

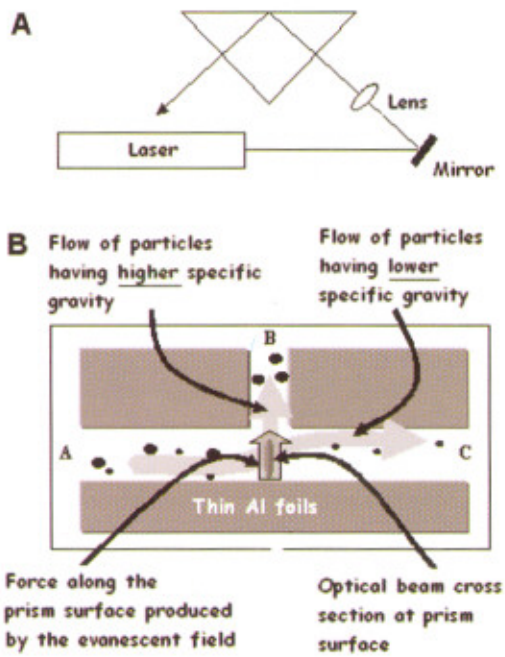

Fig.L.6.1: Experimental set-up.

The experimental set-up is shown in Fig.L.6.1. The output from a 1064 nm, cw laser was made to undergo total internal reflection at the boundary between glass (refractive index 1.51) and water (refractive index 1.33) atop a right-angle crown glass prism (Fig.L.6.1a). To construct the microfluidic channels, strips of thin (~20 μm) aluminium foils were used as spacers between the top surface of the prism and a glass cover slip. The gaps between the aluminium strips were adjusted to form a T-shaped junction as shown in Fig.L.6.1b. Typical widths of such channels were measured to be ~ 30μm. Due to oblique incidence, the cross section of the evanescent wave on the prism interface was elliptical and should result in a force along the surface as shown by the straight upward arrow. A 40X objective lens and a CCD camera were used to monitor the suspended microscopic objects in the aqueous medium flowing inside the channels. The bright field illumination was obtained using a 50W, fiber light guide illuminator placed below the prism.

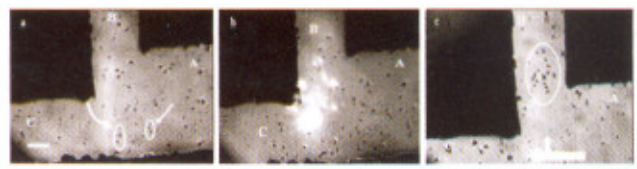

Fig.L.6.2: Sorting of 2 μm diameter polystyrene micro-spheres from a ~50:50 mixture of 1 and 2 μm diameter microspheres. a) 2 μm microspheres are shown by curved arrow and 1 μm microspheres by straight arrow. b) The bright spots are coming from the scattered evanescent field by the microspheres. c) Sorting of 2 μm microspheres into the upward channel by the action of the evanescent field. Increased population of these microspheres can be seen in the encircled region. Scale bar, ~15 μm.

In Fig.L.6.2 we show sorting of 2 μm polystyrene microspheres out of a 50:50 mixture of 1 and 2 μm diameter microspheres When a small volume of micro-particles suspension was injected into the input channel (A), heavier particles due to their interaction with stronger field got deviated by larger angles and thus got directed into the upward output channel (B). The light particles, suffering small deflection, continue to flow to the output channel (C). The power of the optical beam used for the results shown in Fig.L.6.2 was ~ 300 mW. The sorted 2 μm microspheres could be further guided along the channel B by translating the evanescent field. The population of 2 μm microspheres in channel B could be increased from ~50% to ~ 80%. The use of this method for separating red blood cells (RBCs) from white blood cells (WBCs) was also investigated. The RBCs are much heavier (specific gravity (~1.08)) than the different type of WBCs and platelets (specific gravity (~1.07-1.03)). Therefore, a larger optical force is expected on RBCs under the influence of evanescent field. It was found that at an incident power level of ~ 400 mW (1064 nm), the WBCs were observed to be nearly unmoved whereas the velocity for RBCs was ~ 6 μm/s. Therefore RBCs could be preferentially directed in the channel B.

Contributed by:
R. Dasgupta, S. Ahlawat (rsunita@cat.ernet.in), A. Uppal, and P. K. Gupta