4.1.8. NanoBiotech Laboratory

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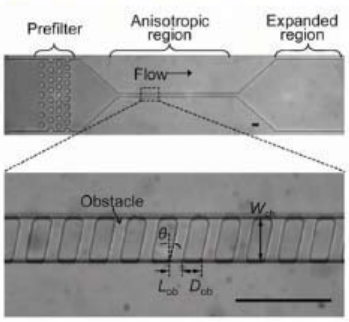
Nanobiotechnology is the application of nanotechnology into the life sciences. This research area consists of two closely related sides. One focuses on developing nanoscaled products with biologically related approaches while the other applies nanoscaled tools to biological systems. Nanobiotechnology creates new opportunities in wide areas of science and engineering based on the interplay between nanotechnology and biotechnology. Micro/nano fluidics, one of the major nanobiotechnology fields, has been a key technology for the realization of micro total analysis systems (μTAS) or lab-on-a-chip and the next generation bio-tools for drug discovery. This research covers the design and development of miniaturized devices that manipulate liquid samples at nanoliter volumes, allowing biological assays to be integrated and accomplished on a small scale with minimum time and cost. Prof. Park's research focuses on nanobiotechnology areas and covers bioMEMS, micro/nano fluidics and bioelectronics. In particular, he is interested in developing a novel nanobiosensor, microfluidic device, and lab-on-a-chip as a new platform for biological sample processing and detection, including cell-based assay, hydrophoretic separation, magnetophoretic assay, and optoelectrofluidic manipulation. From June 2008, his laboratory has been selected to receive a National Research Laboratory (NRL) Program grant funded by the Korea government (MEST).

Optoelectrofluidic Manipulation Platform

A novel programmable microfluidic platform by which particles are manipulated by electrofluidic forces such as dielectrophoretic or electro-osmotic force generated with a light, has been developed. When a dynamic image pattern is projected into a specific area of a photoconductive layer, virtual electrodes are generated, resulting in electrokinetic motions of micro/nanoparticles under a nonuniform electric field. By using a compact, integrated LCD-based optoelectrofluidic platform, we have characterized the frequency-dependent phenomena of the optoelectrofluidic concentration of microparticles due to the image-driven AC electrokinetics including dielectrophoresis and AC electro-osmosis. This new platform may be a widely usable integrated system for optoelectrofluidic manipulation of micro/nano particles including living cells and biomolecules [1].

Hydrophoretic Separation Platform



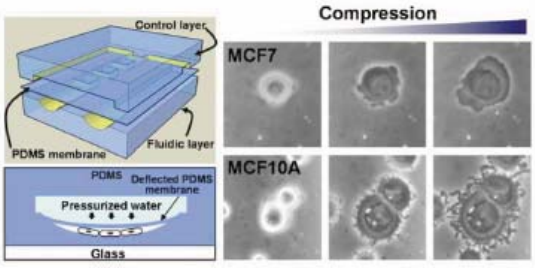
Separation and sorting of micros pheres and blood cells were achieved by using a novel microfluidic mechanism, hydrophoresis, which is hydrodynamic interaction between microfluidic obstacles and particles subject to rotational flows induced by the anisotropic fluidic resistance of the obstacles [2]. The equilibrium positions of the particles by the hydrodynamic interaction depend on their size. Recently, we report a hydrophoretic device that uses rotational flows induced by regularly patterned obstacles only on the top wall for preparing samples of biological particles, including micrometer and submicrometer particles, and DNA

molecules. Continuous separation of these particles was achieved using the obstacles, demonstrating the potential of hydrophoresis for biological sample preparation on the micro- and nanoscales, with the advantages of continuous flow and sheathless passive operation.

Magnetophoretic Assay Platform

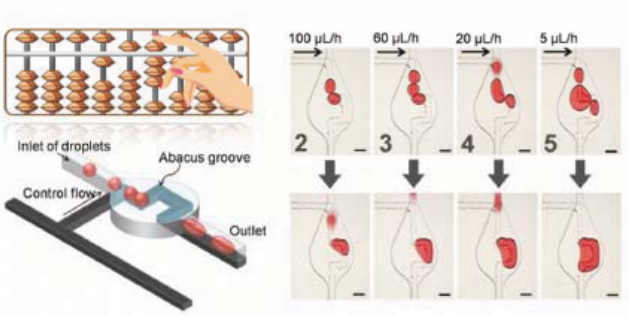
A new immunoassay system based on magnetophoretic mobility of a superparamagnetic nanoparticle conjugated microbead has been developed. By measuring the magnetophoretic deflection of the microbeads varied by the concentration of analytes, the multiple disease markers are simultaneously quantified [3a]. We have also reported a novel magnetophoretic principle, isomagnetophoresis, employing the magnetic susceptibility gradient across a microfluidic channel [3b]. By using this method, the subtle magnetic susceptibility of microparticles was successfully discriminated.

Cell-Based Assay Platform



We have developed a microfluidic device that can be used to spot the difference between cancerous cells and healthy ones by squeezing them until they deform – a discovery that could lead to a cheap tool for cancer detection [4]. Cancer cells are known to have a less extensive internal cytoskeleton than healthy cells, so behave differently when squeezed. We have exploited this property in their two-channel microfluidic device. The first channel holds the sample, and is separated from the second channel by a flexible membrane. Pressurizing the second channel compresses the cells in the sample until they deform. We found that compressed cancerous cells were left with a series of bulges across their surface. But the healthy cells looked very different, being covered with worm-like projections. The device could be used to further study cytoskeleton changes within cells, as well as other diseases, from malaria to Alzheimer's, which are associated with cell cytoskeleton changes.

Microdroplet Technology



Microfluidic abacus channels are demonstrated for the sequential addition of droplets at the desired location [5]. We created a wide microfluidic chamber with a sharply bending groove cut into it. When droplets enter the chamber, they are guided by the groove but get stuck at its rectangular corners. As more droplets enter the groove, they merge at the bend to form a bigger droplet, which is eventually forced out of the chamber as the pressure builds up behind it. Although the droplets enter the chamber at a fixed rate, we introduced a control flow to vary the number of merging droplets – as the flow rate increases, the number of droplets merging decreases because the merged droplet is forced out the chamber more quickly.?The device allows programmable

and autonomous operations of complex two-phase microfluidics as well as new applications for the method of analysis and computations in lab-on-a-chip devices.

References

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