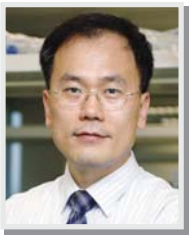
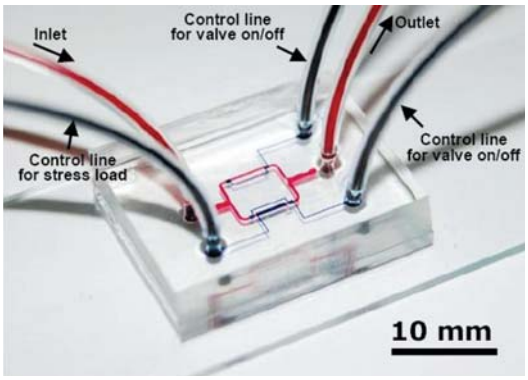
4.1.8. NanoBiotech Laboratory
(Prof. Je-Kyun Park, http://nanobio.kaist.ac.kr)



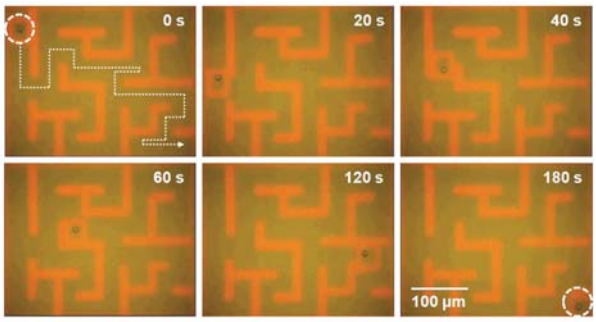
The aim of NanoBiotech Laboratory (NBL) lies in conducting research and development on nanobiotechnology as well as microsystems technology. During the last five years, NBL has interested in developing a novel biomicrofluidic devices for biotechnology and bioengineering, based on the synergetic integration of miniaturization technology to biology, chemistry, and medicine. Currently, NBL focuses on the development of a nanobiosensor, microfluidic device and lab-on-a-chip as a new platform for biological sample processing and detection. The main application areas include biomolecular diagnostics, micro total analysis system (μTAS), cell-based high-throughput screening, and nanobio device.

Cell-Based Assay Platform



The physical forces to which living cells are most commonly exposed are fluid shear, pressure, and stretch. These mechanical stimulations influence the physiological and pathological condition of the organism, which induces many aspects of human health and disease. We recently develop a new kind of microfluidic biomechanical device for compressive stimulation and lysis of cells. Mechanical stress is applied to the cells with the deflection of the poly(dimethylsiloxane) (PDMS) membrane between two microchannels, formed by multilayer soft lithography. The membrane functions as an on?off valve for closing the fluid channel and a loading membrane for applying compressive stress. As a demonstration of the feasibility of this microfluidic device, the viability of mammary gland epithelial (MCF7) cells in response to compressive stress is assessed by the change of fluorescence intensity with calcein AM [1]. It is also confirmed that the cells are deformed and lysed under compression by the deflected membrane. This device serves as an enabling tool for investigating the cellular response to mechanical stresses. Furthermore, mechanical lysis of cells can be exploited in a microchannel by the compressive force through the membrane deflection. This lysis method could be applied to develop the integrated microfluidic devices for sample preparation and cell-based assays.

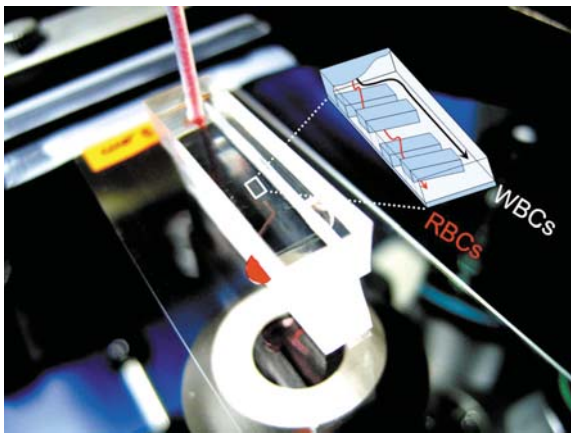
Dielectrophoretic Separation Platform



We report a lens-integrated liquid crystal display (LCD)-based optoelectronic tweezers (OET) system for interactive manipulation of polystyrene microspheres and blood cells by optically induced dielectrophoretic force. When a dynamic image pattern is projected into a specific area of a photoconductive layer in an OET, virtual electrodes are generated by spatially resolved illumination of the photoconductive layer, resulting in

dielectrophoresis of microparticles suspended in the liquid layer under nonuniform electric field. In this study, the simple-structured OET system has been easily constructed with an OET device, an LCD and a condenser lens integrated in a conventional microscope. By using a condenser lens, both stronger dielectrophoretic forces and higher virtual electrode resolution than previously reported lens-less LCD-based OETplatform are obtained. The effects of blurred LCD image and liquid chamber height on the performances of optoelectronic particle manipulation are investigated by measuring the bead velocities according to their sizes. An interactive control program for OET-based microparticle manipulation is also developed by Flash language. The integrated system is successfully applied to the parallel and interactive manipulation of red and white blood cells [2]. Due to its simple structures, cheap manufacturing costs, and high performances, this new LCD-based OET platform may be a widely usable integrated system for optoelectronic manipulation of microparticles including living cells.

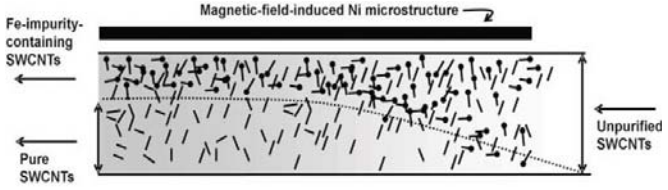
Hydrophoretic Separation Platform



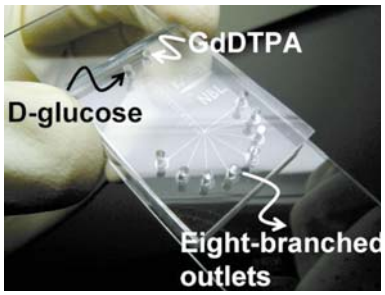
We recently report a microfluidic separation and sizing method of microparticles with hydrophoresis – the movement of suspended particles under the influence of a microstructure-induced pressure field. By exploiting slanted obstacles in a microchannel, we can generate a lateral pressure gradient so that microparticles can be deflected and arranged along the lateral flows induced by the gradient [3]. The slanted obstacle as a microfluidic control element in a microchannel is analogous to the electric, magnetic, optical, or acoustic counterparts in that their function is to generate a field gradient. Since our method is based on intrinsic pressure fields, we could eliminate the need for external potential fields to induce the movement of particles. Therefore, our hydrophoretic method will offer a new opportunity for power-free and biocompatible particle control within integrated microfluidic devices.

Magnetophoretic Separation Platform

A magnetophoretic, continuous purification platform has been developed to rid single-walled carbon nanotubes (SWCNTs) of superparamagnetic iron-catalyst nanoparticles using the enhanced magnetic force of ferromagnetic microstructures in a microfluidic device, as shown in the image. By employing microfluidics and a magnetic field-induced saw-tooth nickel microstructure, a highly enhanced magnetic force in adjoining microchannels is exploited. The iron impurities of SWCNTs are attracted towards areas of higher magnetic-flux density in the microchannels where magnetic field was asymmetrically generated perpendicularly to the streamline. We obtained highly purified SWCNTs at a rate of 0.36 mgh-1 and that are estimated to be about 99% purity [4].



Recently, we also report an improved magnetophoretic method, isomagnetophoresis, employing the magnetic susceptibility gradient across a microfluidic channel applied by magnetic field and we have successfully discriminated the polystyrene (PS; 14.78±0.20 ㎛ in diameter), poly(methyl methacrylate) (PMMA; 15.00±0.77 ㎛) and borosilicate (BS; 14.01±1.00 ㎛) microspheres, where PS and PMMA particles have similar diamagnetic susceptibility that cannot be distinguished by conventional magnetophoresis [5]. This platform can be applied to label-free discrimination of the biological cells and nanotubes.



References

1. Yu Chang Kim, Joo H. Kang, Sang-Jin Park, Eui-Soo Yoon, **Je-Kyun Park*** (2007), Microfluidic biomechanical device for compressive cell stimulation and lysis, Sens. Actuators B Chem., **128** (1): 108-116.
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3. Sungyoung Choi, **Je-Kyun Park*** (2007), Continuous hydrophoretic separation and sizing of microparticles using slanted obstacles in a microchannel, Lab Chip, **7** (7): 890-897.
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5. Joo H. Kang, Sungyoung Choi, Wonhye Lee, **Je-Kyun Park*** (2008), Isomagnetophoresis to discriminate subtle difference in magnetic susceptibility, J. Am. Chem. Soc., **130** (2): 396-397.