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Magnetophoretic Circuitry Elements for Digital Control of Biomolecules

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Tremendous progress is being made in the development of biosensors integrated with Lab-on-a-chip platform, driven by the advances in biotechnology, nano-/micro-technologies, and microfludics[1]. The advantage of these small, highly integrated systems play crucial role on the development of two applications; single cell analysis and next generation bioassay equipping high resolution, more rapid, and multiplexed analysis and reduced reagent sample volume. That is, the ability to analyze the cellular contents of individual microorganisms would significantly benefit our understanding of many mechanisms in the minute world of microorganism biology. Rapid developments in lab-on-a-chip technology offer significant advantages over standard techniques for the analysis of individual microorganisms. Integrating the trapping concept to current available technologies will provide the opportunity to analyze microorganisms at the micro levels.

On the other hand, even though innovative sensors have achieved specific biomolecule detection down to ~ fM resolution[2], the nm ~ um sized sensors resolution is not limited by the signal transduction limitation, but by analyte transport in solution which governs the detection time [3]. Therefore, controlling specific biomolecules to sensing site is a prerequisite in ideal Lab-on-a-chip platform for overcoming diffusive accumulation in solution, which would offer high detection resolution of analytes and short detection time.

Since late 1990, magnetoresistive sensors have been initiated for sensing the biomolecules with the help of superparamagnetic nanoparticles or micro-bead labels [4], which can play a role of bio-analytes carriers for transportation as well. Moreover magnetic transporting could offer the great advantages; i) magnetic interaction are generally not affected by surface charges, pH, ionic concentrations or temperature, and ii) bio-analytes with superparamagnetic nanoparticles or micro-bead labels are manipulated by the remote external field for their transport, trapping and positioning, separation and sorting [5]. Here, on-chip soft magnets have gained a lot of interest in trap positioning and transporting bio-agents using superparamagnetic bead carriers with appropriate surface modifications [6], rather than micro-coils which generate heat. A soft on-chip magnet is not only managed by low magnetic field, ~ a few tens of Oe, but also generate no heat, which is essential to the manipulation process for biological entities.

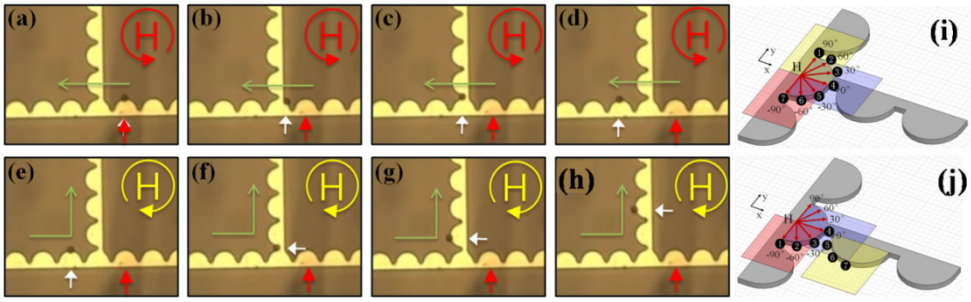

Fig. 1. (a-h) Images of irreversible movement of magnetic beads on a diode pattern and (i-j) schematic representation of magnetic bead motion on the diode pattern (*See movie in online:* http://www.nbest.org).

As for the manipulation process for biological entities, it is necessary to develop magnetophoresis circuitry elements for the completion of digital microfludics. In this talk, firstly I will overview the current status of bioassay sensors, and digital microfludics for Lab-on-chip integration. Secondly I will introduce the magnetophoresis circuitry elements; resistor, transistor, inductor, diode, capacitor for biological entities, especially focused on material diode. Thirdly, I will show on chip manipulation and trapping of individual biological agents at designated positions in a microfluidic channel, including the concentric translocation of the bio functionalized magnetic beads regulating the diffusive movement of biological entities.

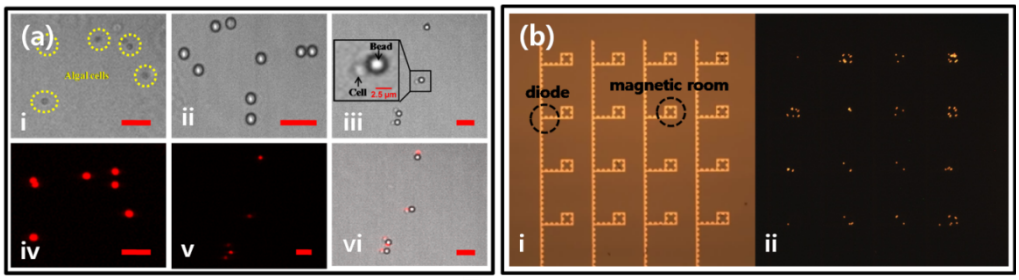

Fig. 2. (a) Characterization of transporting objects using confocal microscope (i. Bright field image of algal cells: ii. Fluoresence image of algal cells: iii. Amine beads: iv. Algal cells loading on magnetic beads: v. Fluoresence image from image iv: vi. Ovelapping image of image iv and v) and (b) magnetic room array pathway and trapping of living cells (i. Magnetic pathway with magnetic rooms array: ii. Trapped cells in magnetic room array).

Acknowledgments

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