Optoelectronic Tweezers for Particle and Cell Manipulation

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Abstract: Optoelectronic tweezers is a new tool for parallel optical manipulation of colloids and cells. Using a digital projector to pattern dynamic virtual electrodes on a photoconductive surface, we demonstrate parallel trapping, transporting, and sorting of micro/bio-particles.

Optical manipulation of biological cells in microfluidic devices is a powerful technique for high-throughput cell-based assays. It offers several advantages compared with other techniques: it is non-invasive, contamination-free, and needs no or minimum fabrication for the microfluidic devices. The most well-known optical manipulation tool is optical tweezers [1, 2]. To achieve array format manipulation for high-throughput assays, holographic optical tweezers [3] and vertical cavity surface-emitting laser (VCSEL) array traps [4] have been reported. However, these systems require very high optical power since the total amount of optical power is proportional to the number of traps. In addition, the manipulation area is limited by the tight focusing requirement.

Recently, we reported a massively parallel optical manipulation tool called optoelectronic tweezers (OET) [5]. The schematic of OET is illustrated in Fig. 1. It uses direct optical images to create high-resolution dielectrophoresis (DEP) virtual electrodes on a photoconductive surface. The optical images are generated by a digital micromirror device (DMD) spatial light modulator, which enables us to dynamically change the electrode pattern in real time. Each trapping site can be as small as a single pixel (~ 1.5 μm in our current system), sufficient to manipulate single cells or micrometer-sized particles. Thanks to high resolution optical projection, the OET is particularly suited for array-based cell manipulation. We have demonstrated

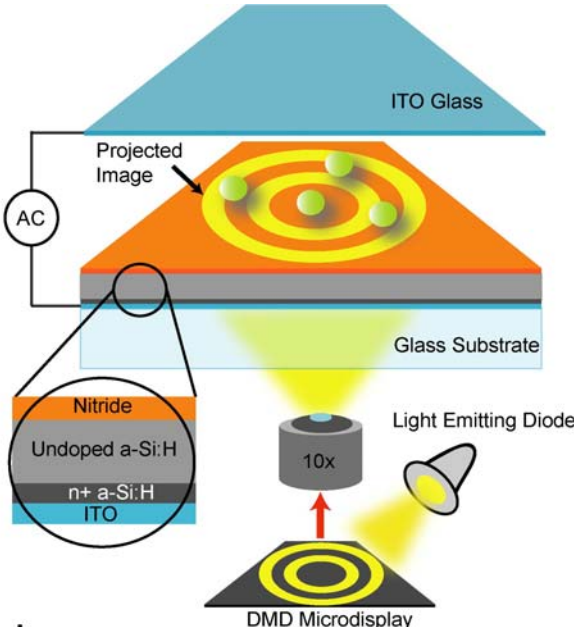

Figure 1 Schematic of optoelectronic tweezers (OET)

15,000 individually addressable traps.

Another important aspect of OET is the low power requirement. Since the light beam is only used to address the virtual electrodes, the optical power density requirement is 100,000 lower than that of optical tweezers. The OET can be powered by an incoherent light source such as light-emitting diodes (LED). We have successfully used OET to trap *E. coli* bacteria [6] and red and white blood cells [7], as well as the automated concentration of HeLa cells [8].

Similar devices have recently been reported by other research groups [9]. Photoelectrophoretic localization and transport (PELT) used light pattern on photoconductive semiconductor electrode to transport proteins (and other charged particles) without attachment to larger particles [10]. In this talk, we will review the current state of the art of optoelectronic manipulation in microfluidic devices.

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