Optoelectronic Trapping of Cells, Nanowires, and Nanoparticles

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Abstract: The principle and recent experimental results of optoelectronic tweezers (OET) will be presented. Based on light-induced dielectrophoresis, OET can trap and sort colloidal particles, biological cells, nanowires and nanoparticles using a digital light projector.

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1. Introduction

The ability to manipulate biological cells, micro- and nanoscopic particles plays an important role in many biological and colloidal science applications. However, conventional manipulation techniques - including optical tweezers, electrophoresis, dielectrophoresis (DEP), magnetic tweezers, acoustic traps, and hydrodynamic flows - cannot achieve high resolution and high throughput at the same time. We have proposed a new technique called optoelectronic tweezers (OET) that permits parallel addressing of individual particles over a large area (Fig. 1) [1]. Using optically induced DEP, OET combines the aspects of both optical tweezers and DEP. The optical power density requirement (~ 0.1 to 10 W/cm^2) is significantly lower than that of optical tweezers (by four to five orders of magnitude), thanks to the optoelectronic gain in OET. These optical intensities can be achieved by a computer projector, allowing the creation of complex optical manipulation patterns. OET manipulation has been demonstrated on a variety of microparticles including polystyrene beads [1-3], *E. coli* bacteria [4], red and white blood cells [3], HeLa cells [2, 5], and yeast cells [6]. Particle and cell sorting [2, 7] and concentration [8, 9] have also been demonstrated. By controlling bias voltage, we have also shown it is possible to perform light-induced electroporation [10]. A detailed description of the OET devices can be found in [2, 3]. Cell manipulation in highly conductive physiological buffer solution is achieved by replacing amorphous Si photoconductor with phototransistor, which has 100x higher photoconductivity [11]. Recently, OET has been extended to manipulate nanoscopic particles, including semiconducting and metallic nanowires [12] and gold nanoparticles with size as small as 60 nm [13]. Combining OET with surface immobilization techniques, a novel technique called NanoPen has been reported for flexible light "printing" of gold nanoparticles [14].

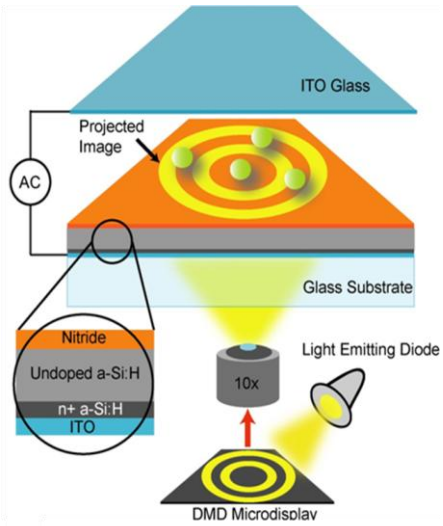

Fig. 1. OET use the selective illumination of a photoconductive layer to create 'virtual electrodes' for dielectrophoresis. Parallel manipulation of cells can be realized using projected optical images. [1]

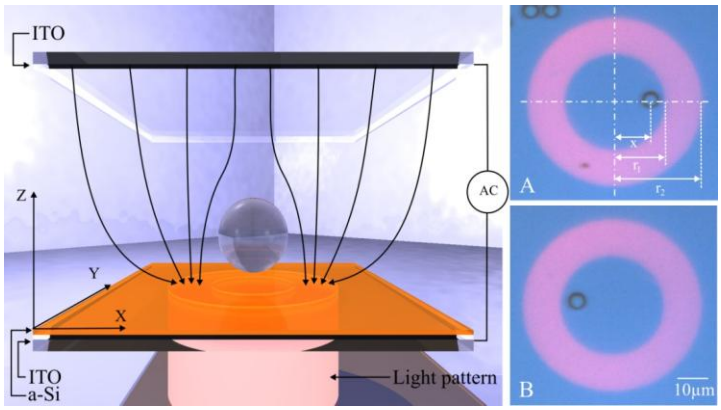

Fig. 2. An OET chamber consists of a liquid layer containing the beads sandwiched between two ITO-covered glass plates, one of which has a-Si covering it. When the stage is moved to the right (A) and then left (B), the particle is pushed in that direction. [15]