A transparent multilevel-electrodes microfluidic chip for dielectrophoretic colloidal handling

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In modern microfluidics systems, dielectrophoresis has been widely used as a crucial technique to manipulate colloids or cells in a variety of biomedical applications such as counting, separation or accumulation [1,2,3]. For this purpose, various principles and methods have been developed in microsystems but moving dielectrophoresis manipulation [4] seems to be a promising way to achieve simultaneous particle or cell handling at the single level. In this work, we present a new approach for colloidal handling in an original manufactured microfluidic channel.

Based on previous work [5], we developed a new kind of chips whose benefits are 2 aligned levels of ITO electrodes that sandwich a height-controlled microchannel in a photopatternable silicone (Fig.1), which ensures biocompatibility. ITO electrodes allow inline visualisation of colloids. The result is a completely transparent chip that addresses up to 120 immerged electrodes in the microchannel (11 um high). The chip is then integrated in an experimental bench as presented on Figure 2. The electrical signal that ensures DEP is routed to the desired electrodes threw a high throughput electronical device so that particles trajectory can be control in real-time.

Colloidal handling is realized on 1µm polystyrene particles under constant flow (38 nL/min). Several key functions for DEP colloidal manipulation have been investigated, naming “focusing”, “stopping” or “vectorial displacement”. We achieved effective focusing and stopping of particles (Fig. 3) with a set of applied voltages. Experiments shows that the width of the focalisation beam can be modulated with the intensity of the DEP force (Fig. 4a) and the global colloidal flux can be stopped with rising DEP force (Fig. 4b).

This presentation will highlight new kind of transparent microfluidics chip fabrication. We will then detail our results on DEP effects in a confined microchannel and discuss the properties of single colloidal handling.

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[2] M. Dürr et al, Microdevices for manipulation and accumulation of micro- and nanoparticles by dielectrophoresis, Electrophoresis 2003, 24, 722–731
[3] Mario Urdaneta, The design of dielectrophoretic flow-through sorters using a figure of merit, J. Micromech. Microeng. 18 (2008)
[4] Chin Hock Kua et al, Cell Motion Model for Moving Dielectrophoresis, Anal. Chem. 2008, 80, 5454–5461
[5] T. Honegger et al, Design and realization of a microfluidic system for dielectrophoretic colloidal handling, Microelectronic Engineering 2008, 10.1016/j.mee.2008.11.060

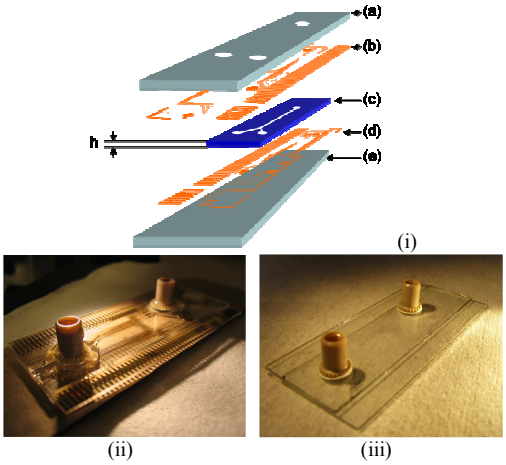

Figure 1 (i) schematic view of the manufactured chip. The photopatternable silicone (c) is sandwiched between two glass substrates (a,e) on which ITO electrodes are processed (b,d). The height h of the double side opened channel is controlled by spincoating. (ii) Picture of the old chip with gold electrodes. (iii) Picture of the new chip with transparent ITO electrodes.

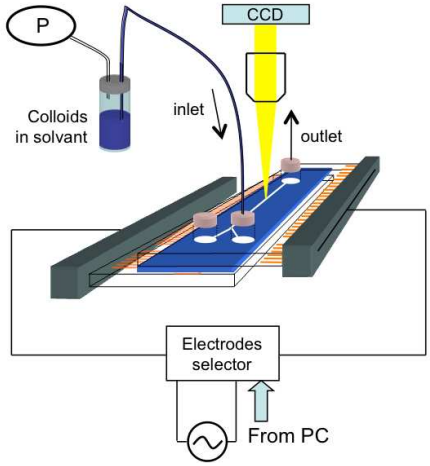

Figure 2 Schematic principle of the sealed microfluidic chip connected to a pressurized input reservoir (P=1,025 bar). The alternative electrical signal is routed to the desired electrodes via a home-made electronical device ("electrodes selector") and interfaced to a PC. Visualization is done with a long distance focal objective (50x objective) connected to the PC.

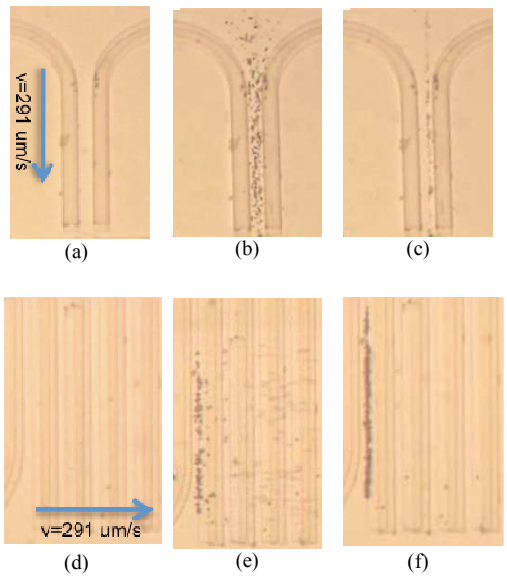

Figure 3. Pictures of the key functions with an initial particle velocity of 291 µm/s, PS colloids 1 µm diameter, objective 10x. *Focalisation* function (a) without applying DEP, (b) f = 3 MHz and Vpp = 10 V (c) f = 3 MHz and Vpp = 20 V, (c) *Stop* function without DEP, (e) f = 3 MHz and Vpp = 10 V (f) f = 3 MHz and Vpp = 20 V.

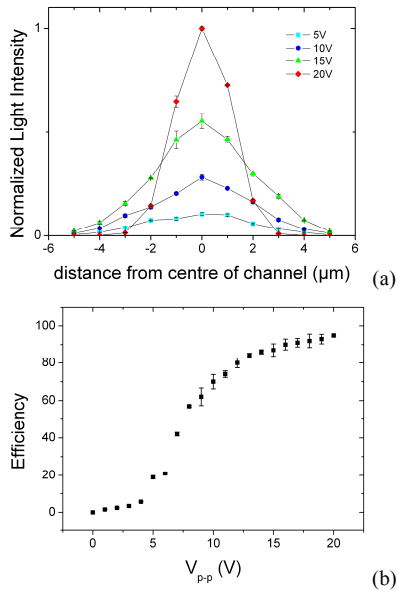

Figure 4. (a) Plot of particle distribution in central of channel with focusing function for 1 µm PS particles and f = 3 MHz. (b) Plot of the efficiency of the stop function for 1 µm PS particles for different peak-to-peak voltages with f = 3 MHz. Efficiency is the ratio of the number of stopped particles and the number of incoming particles.