Integration of dielectrophoresis in silicon lab-on-chip devices

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The physical manipulation of biological particles (from DNA to viruses to cells) is a vital component of miniaturized biotechnological platforms such as compact lab-on-chip devices [1]. These manipulations are useful in a variety of applications, including, for example, disease diagnostics, cell separation and analysis, food and/or water quality monitoring.

The current methodologies for cell separation are magnetic-activated cell sorting (MACS) and fluorescence-activated cell sorting (FACS), but their reported performances in the micro- and nanoscale lag behind those of their macroscopic counterparts [2].

Dielectrophoresis is an alternative potential method for the manipulation and the separation of biological cells via high-gradient electric fields [3].

A complete system to trap and manipulate biological cells using dielectrophoresis has been designed and fabricated using micro-electro-mechanical-systems (MEMS) technologies. Platinum electrodes are patterned on the silicon substrate of the microfluidic channel, while an appropriate plexiglass support stage has been designed and used to guide the fluid into the chip. The functioning of the device has been demonstrated with both polystyrene beads and human blood cells. By simple adjustment of the electrical field parameters, other cell subpopulations, such as staminal or tumoral cells, can be similarly isolated and analyzed.

A finite element modeling has been performed in order to simulate the electric field distribution of the electrode array and to quantify the consequent dielectrophoretic forces acting on the suspended particles. The experimental results and those from modeling are found to be in close agreement.

Dielectrophoresis offers the potential for automated cell sorting in a miniaturized format, as it represents the front-end sample preparation for interfacing clinical sample to the microfluidic domain of silicon lab-on-chip devices.

Keywords: cytofluorimetry, FACS, dielectrophoresis, cell sorting, miniaturization, microfluidics, MEMS

References:

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