Improving dielectrophoretic manipulation efficiency employing pitted and bumpy interdigitated electrodes

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One of the most attractive features of Lab on a Chip (LOC) devices is portability. In this context, portability means being able to run an experiment without the need to use external lab equipment, such as bench-top function generators, to electrically stimulate the devices. Dielectrophoresis (DEP) is an electrokinetic technique that allows manipulating (concentrating, separating, filtering, characterizing, or displacing) microparticles in the presence of a spatially non-uniform electric field according to their dielectric properties. Moreover, DEP has great potential for miniaturization, which goes in line with the concept of portability in LOC devices.

There are two main research lines in dielectrophoretic theory, electrode-based DEP and insulator-based DEP (iDEP). Electrode-based DEP is commonly associated with the development of planar 2D electrodes to generate the required non-uniform electric field within the microfluidic channel. Although several different electrode topologies (e.g., interdigitated, castellated, or polynomial) have shown to enable microparticle manipulation through DEP employing low-voltage stimulation signals, many scientific reports have shown that 2D electrode design only affect a small portion of the complete sample under analysis. This means that only particles flowing in close vicinity to the electrodes respond to DEP, leaving the rest of particles in the bulk unaffected. In contrast to electrode-based DEP, iDEP permits affecting the complete volume of sample through the fabrication of 3D insulating obstacles that distort an electric field generated throughout the microfluidic channel. Nonetheless, iDEP has an important drawback. It requires very large stimulation voltages (around 1000V) for DEP to have a significant effect over the particles. This drawback makes it very difficult to integrate with microelectronic stimulation systems for the development of a fully-integrated LOC device.

Although CarbonDEP and PPyDEP have emerged in recent years as promising techniques for the development of 3D electrode-based DEP devices (overcoming the limitations of both, conventional electrode-based DEP and iDEP), the manufacturing processes involved are more complex than those required for conventional electrode-based DEP. Therefore, this work presents a novel and simple approach for the development of enhanced electrode-based DEP devices. Interdigitated electrodes with pitted or with bumpy surfaces are presented herein. The surfaces are computationally modelled and results predict that these rough surfaces create local gradients of E^2, significantly increasing the magnitude

of the DEP force throughout the microfluidic channel when compared to conventional 2D-flat electrode-based DEP topologies. Moreover, since the voltage requirement for the stimulation signal is very low, the approach presented in this work is appropriate for integration with microelectronic stimulation systems, which goes in line with the concept of portability in LOC devices.