The impact of electrode geometry in Dielectrophoretic effect for multilayer PPyDEP-based devices

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Dielectrophoresis (DEP), the electrokinetic technique capable of manipulating polarizable particles in the presence of a spatially non-uniform electric field, has attracted significant attention from the scientific community over the past two decades. This technique has many important advantages over conventional microparticle manipulation approaches; for instance, DEP has great potential for miniaturization, it is a non-invasive and non-destructive manipulation technique, it only requires small volumes of sample, and it is a selective technique capable of separating, concentrating, filtrating, or characterizing microparticles. Research fields such as as environmental monitoring, food quality assessment, clinical analysis, among many others have already benefited from the attractive features of DEP.

Currently, two main branches exist for the design of DEP-based microdevices, namely electrode-based DEP and insulator-based DEP (iDEP). Electrode-based DEP has largely been associated with 2D electrode designs (interdigitated, polynomial, or castellated). Microfabrication techniques allow the gap between electrodes to be very narrow for these designs, lowering the requirement for large excitation voltages and therefore, decreasing the effect of Joule heating as well. Unfortunately, 2D electrodes only induce DEP in particles that are located in close vicinity to them, leaving most of the particles flowing in the bulk of the solution unaffected. In contrast, iDEP overcomes such limitations through the fabrication of 3D electrical-insulating obstacles that distort the distribution of the electric field generated within the microfluidic channel. The main drawback of iDEP devices is that very large excitation voltages (e.g., 1200V) are required to induce DEP in the particles. As a result of such excitation voltages, Joule heating is generally associated with iDEP devices. Recently, CarbonDEP and PPyDEP have emerged as promising 3D electrode-based dielectrophoretic alternatives. These techniques bring together the benefits (and overcome the limitations) of conventional electrode-based DEP and iDEP.

This work studies the impact of electrode geometry in the dielectrophoretic effect observed in multilayer PPyDEP-based devices. To accomplish this, a novel multilayer electrode design is presented, computationally analyzed, and compared to results readily available in the literature for PPyDEP devices. Characterization of the device allows predicting the location of the trapping zones for both, positive and negative DEP. Moreover, the dielectrophoretic effect over polystyrene beads of different sizes along several regions of

the device are also presented. The predictions obtained from this study demonstrate that the proposed multilayer electrode design provides significant advantages over its preceding version. For instance, the average magnitude of the dielectrophoretic force inside the microfluidic channel is increased by at least an order of magnitude, having a positive impact in the volume of sample affected by the DEP force.