On-chip dielectrophoretic manipulation and assembly of nanoparticles, microparticles and droplets

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The functionality of many nano- and microstructures can be utilized only if these structures are assembled on, and interfaced with, electrically controlled microchips. A major tool for precise on-chip colloidal manipulation and assembly that we are studying is dielectrophoresis, the motion and interactions of particles under the action of alternating (AC) electric fields. Examples of dielectrophoretic manipulation of nanoparticles, microparticles, live cells and droplets by planar on-chip electrodes will be presented. First, the dielectrophoretic force was used to assemble conductive microwires by AC field driven aggregation of metallic nanoparticles in suspension. We modeled the dynamics of the process and learned how to form single or massively parallel microwires and connect them to objects in the liquid. AC fields were also used to assemble switchable 2D crystals from suspensions of latex or silica microspheres. The combination of dielectrophoresis and dipolar chaining leads to the formation of single-domain, centimeter sized crystals with specific orientation. The same principle was applied to make biocomposite arrays of live cells and nanoparticles, which can find applications as components of sensors and microreactors. Finally, we developed a new technique for dielectrophoretic on-chip manipulation of freely suspended droplets and particles. It can form a platform for microfluidic chips without microchannels or solid walls. Potential applications of the droplet microfluidic chips include synthesis of advanced particles and single cell bioassays.