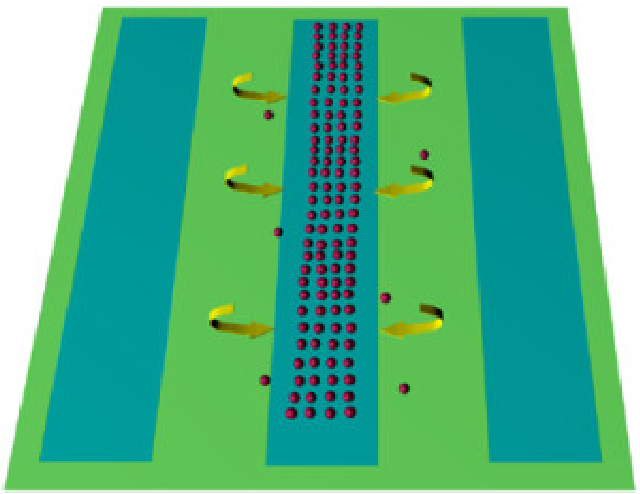
Floating electrodes to manipulate small-gravity particle samples in modern microfluidic systems

Many biological samples such as bacteria and biomacromolecule are of negligibly small gravity due to their submicron size. To flexibly manipulate small-gravity particle samples dispersed in liquids is a challenge that has vexed researchers for years. But researchers from Xi'an Jiaotong University and Harbin Institute of Technology have now reported a hybrid electrokinetic technique that can flexibly trap and assemble small-gravity colloidal particles around floating electrodes, which has potential applications in biosensors, microactuators and microfluidics.



Floating electrode configuration for on-chip flexible particle manipulation

In a paper published online in *Soft Matter*, Researchers from the group of Prof. Jinyou Shao at XJTU and Prof. Hongyuan Jiang at HIT describe the method that allows them to manipulate, trap and assemble small-gravity colloidal particles in a controllable manner.

The method works as simply as filling the device channel with an aqueous suspension of target particle samples and applying a low-frequency AC voltage difference along the longitudinal channel. Floating electrode-a planar metal strip that is floating in potential and deposited inside the background AC electric field—serves as the core structure of this method. As compared to most previous methods that utilize driving electrodes, floating electrode provides a much higher degree of flexibility. To generate strong electrohydrodynamic (EHD) flow, gap size between a driving electrode pair must be less than 100?m, while for floating electrode configuration there is no such requirement. Floating electrode does not need direct electrical contact with external wiring and can be arbitrarily disposed, says Dr. Shao, Professor of Mechanical Engineering at XJTU, therefore it can achieve flexible control over local EHD fluid flow.

When they first started investigating the transportation process of colloidal particles from surrounding liquid medium to the surface of floating electrode, no particle trapping behavior took place. “However, while observing particle motion within distinct field frequency ranges, we came with something interesting. We discovered that it is impossible for mere EHD flow originated from the polarizable metal surface to stably manipulate and collect small-gravity colloidal particles,” Dr. Jiang said, Professor of Mechatronics Engineering at HIT, “We didn’t quite have the exciting field frequency set perfectly at that time. If you get the frequencies right, particles can be effectively trapped on the electrode surface and even form colloidal crystals due to a combined effect of long-range EHD flow and short-range interparticle dipolar interaction.”

Though a single colloidal particle is often of small gravity, particle chaining phenomenon at very low field frequencies enhances the effective gravitational force of the overall colloidal assembly structure to enable a stable trapping process. At much higher frequencies, repulsive dipolar interaction facilitates the formation of colloidal crystals with hexagonal close-packed structure above the electrode surface. “Such frequency-dependence of this hybrid electrokinetic technique provides great flexibility in particle manipulation. If a series of parallel metal strips rather than an individual floating electrode are disposed, we may further extend this method for particle manipulation on a massive scale”, said Weiyu Liu, a graduate student of Prof. Shao, “If necessary, a second AC signal can be applied to the central gate electrode to achieve a flexible adjustment in particle trapping position”

EHD flow can be either originated by double-layer charging or Joule medium heating, therefore determines the common applicability of this method to any type of particle suspension. “Since electrothermal flow takes effect in physiological buffer of high conductivity, we now manage to embed such floating electrode into a continuous-flow on-chip diagnostic platform for timely disease detection,” Dr. Shao said. This method of both high flexibility and common applicability points out a way for the development of future on-chip biomedical devices.

Publication

Trapping and chaining self-assembly of colloidal polystyrene particles over a floating electrode by using combined induced-charge electroosmosis and attractive dipole-dipole interactions.
Liu W, Shao J, Jia Y, Tao Y, Ding Y, Jiang H, Ren Y.
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