Docket #: S12-313

Two dimensional magnetic trap arrays for droplet control

Researchers at Stanford have invented a platform to manipulate droplets in a synchronized manner. Magnetic fields combined with patterned soft magnet arrays on a substrate, provide a clocking signal to the magnetic droplets. Synchronous microfluidics with internal fluidic control enables ultra-large scale integration for droplet control, that has never been possible before. Position control and speed adjustment can be done for hundreds or thousands of droplets simultaneously with minimal control mechanism. Through interaction between the droplets, the platform can perform logic functions similar to electronic computers including any Boolean logic. The working assays, including cells, proteins and various chemical and biological materials, can be carried within the droplets, as the ferrofluids are bio-compatible. Apart from magnetic droplets, other entities like magnetic beads or even magnetic holes can be used with this system.

Applications

- Cellular manipulation, sorting and separation
- Microfluidic chip with minimal control mechanism that is easily programmable for selection, deployment, analysis and synthesis of biological and chemical materials in the micron scale.
- A novel biofabrication platform. Using the platform's intrinsic ability of computation work, algorithmic self-assembly of biological morphological structures at the mesoscale (1-100 microns) is possible. A new generation of high-complexity human-engineered cells and tissues.

Advantages

- Our platform has a clocking mechanism that is absent in similar technologies (electrophoresis, dielectrophoresis, pressure-driven microfluidics). The clocking in the microfluidic circuit will be utilized like a metronome to coordinate actions of different compartment of the chip, enabling higher built-in complexity and functionality and throughput than existing technologies.
- Scales favorably with size while keeping the control mechanism minimal. While our platform enables simultaneous control of hundreds/thousands of entities, other technologies have complex network of control mechanism as the control must be done per individual entity.
- The manipulation is based on magnetism. In contrast to electric manipulation, magnetic interactions are generally not affected by surface charges, pH, ionic concentrations or temperature.
- Has the element of computation so manipulation can be done without constant interference by the user. On the contrary, optical hologram technology enables simultaneous manipulation of entities, but does not have the computational ability.
- Simple to manufacture

Publications

- G. Katsikis, M. Prakash, 65th Annual Meeting of the American Physical Society (APS) Division of Fluid Dynamics, November 2012.
- Katsikis, G.; Cybulski, J.S.; Prakash, M., “Synchronous universal droplet logic and control," Nature Physics, Vol. 11, 588-596 (2015). doi:10.1038/nphys3341
- Rinberg, Anatoly and Katsikis, Georgios and Prakash, Manu, "Generation of droplet arrays with rational number spacing patterns driven by a periodic energy landscape," Physical Review E Volume 96, September 15, 2017, Pages 033108.

Patents

- Published Application: WO2014035979
- Published Application: 20150267726
- Published Application: 20170002846
- Issued: 10,316,872 (USA)
- Issued: 10,029,257 (USA)

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