Digital acoustofluidics: contactless liquid handling device via acoustic streaming

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Value Proposition

For decades, scientists have pursued the goal of performing automated reactions in a compact fluid processor with minimal human intervention. Digital microfluidics (DMF) pioneers an appealing solution for economical automation by programmable manipulation of nano- to pico-liter droplets on a miniaturized chip using electro-wetting forces.

Although numerous liquid handling techniques technologies (*e.g.*, microfluidic chips and micro-well plates) have been developed, they generally rely on physical contact with a solid structure in order to contain, transport, or manipulate liquid reagents. This leads to the lack of fluid rewritability, and the associated benefits of multi-path routing and re-programmability, due to surface-adsorption-induced contamination on contacting structures. In addition, most current platforms are based on disposable, on-time use devices. Those features greatly limits the processing-speed, integration-scale, and complexity of reaction logics for liquid handling on a same device.

Technology

The present invention describes a system of unique contactless droplet-processing technique, Digital Acoustofluidics (DAF), which can digitally manipulate aqueous droplets (from 1nL to 100µL volumes) floating on a denser fluorinert oil horizontally *via* acoustic-streaming-induced hydrodynamic traps. These droplets are floating on an inert, immiscible layer of oil that effectively isolates the droplet above a solid surface that is custom patterned with an array of ultrasonic transducers.

DAF performed a three-stage cascade reaction protocol to rapidly detect enolase activity. Six aqueous droplets containing different reagents are sequentially combined to generate a luminescent signal that is > 3 times brighter than the standard 1 step protocol, within a shorter amount of time. DAF platform processes droplets on a rewritable fluidic carrier without cross-contamination or surface-degradation, allowing for the ability to execute reactions on overlapping fluidic paths, the potential to scale to massive interaction matrices within a small area, and the capability to perform successive experiments on a single, miniaturized device.

Advantages

- Contamination-free (< 10-10 % diffusion into carrier oil).
- Bio-compatible (> 99.2 % cell viability).

Duke File (IDF)

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- Compact, durable, programmable, and rewritable.

Publications

- Digital Acoustofluidics Enables Contactless and Programmable Liquid Handling (Nature Communications, 2018)
- U.S. Patent Application 16/700,482