iMICROFLUIDICS: SMARTPHONE CONTROLLED HANDHELD MICROFLUIDIC PLATFORM

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ABSTRACT
Here we present iMicrofluidics, a handheld microfluidic platform capable of active pumping and controlling different reagents. The platform was based on Lateral Cavity Acoustic Transducer (LCAT) pumps driven by custom driver electronics and controlled through an application implemented on a popular smartphone. As an initial demonstration of the versatility of the system, the application allowed the user to control the position of the interface of two different reagents coflowing in the main channel of a T-junction on a disposable chip.

KEYWORDS: cell phone, point of care, portable microfluidics

INTRODUCTION
Lab-on-a-Chip technologies became highly popular within academic research during the last two decades. The promise of portable microfluidic platforms, among other reasons, was integral to the surge in interest. Despite the influx of attention and effort, very few technologies have proven to be practical on portable settings. Some exceptions include paper microfluidics[1] and other technologies based on passive pumping of fluids. However these have limitations on the types of fluids they can manipulate and the degree to which they can be controlled. In order to complement the passive methods and to fulfill the promise of portable microfluidic systems, a platform with active pumping and the ability to control different reagents is needed.

THEORY
Moving reagents within microfluidic devices using Lateral Cavity Acoustic Transducer (LCAT) pumps has previously been demonstrated [2]. In these pumps air bubbles are trapped in a series of lateral cavity pairs along the main channel. The air/liquid interface on each LCAT cavity oscillates when driven by an external piezoelectric transducer (PZT). This generates acoustic microstreaming within the fluid which translates in a net flow in the direction dictated by the geometry (see Figure 1).

EXPERIMENTAL
Disposable chips were fabricated using soft lithography. The PDMS based device was plasma bonded to a 200 µm thick glass slide. These chips contained inlet reservoirs for the reagents and two LCAT pumps (Figure 2).

Figure 1. LCAT cavity pairs with trapped air bubbles. Air liquid interface oscillations generate acoustic microstreaming and a net flow in one direction (inset).

Figure 2: A PDMS chip consisting of two LCAT pumps and a T-junction allows the control of the flow rates of both the red and green reagents.
Each pump consisted of 80 lateral cavity pairs where air bubbles were trapped due to the hydrophobic nature of PDMS channels. The disposable microfluidic chip sat on top of the piezoelectric buzzers which were driven by a modulated square wave with a carrier of 35 kHz to generate controlled microstreaming.

The user could generate commands through a user interface on a smartphone. These commands were sent, using a soft OOK modulation through the audio jack, to an ArduinoMega unit which in turn controlled the modulation of two square waves used to drive two PZTs inside a PDMS encasing (Figure 3).

**RESULTS AND DISCUSSION**

Each pump was able to generate pressures of up to 300 Pa when the PZTs were driven by a 20 Vpp square wave at 35 kHz. Using these maximum settings the entire platform could be powered by a 9V battery. This would allow the platform to be used in a wide range of low pressure microfluidic applications using low power.

A user can easily hold and control the entire platform (Figure 4)

**Figure 3:** Schematic diagram of the components of the iMicrofluidics platform.

**Figure 4:** iMicrofluidics is a handheld microfluidic platform able to control multiple reagents. The user is presented with a GUI that allows the control of the flow rates of different fluids.

Figure 5 shows a sequence of images in which a user was able to control the location of the interface by moving a scroll bar in the user interface.
CONCLUSION

iMicrofluidics is a platform based on LCAT transducers. This allows other components such as micromixers to be easily integrated. In fact the authors plan on expanding the iMicrofluidics platform to show that it can be scaled by simply adding extra PZTs and tailoring the software to each application. The platform can therefore be used to implement handheld assays in which sequential delivery of reagents and rapid mixing are needed.

ACKNOWLEDGEMENTS

The authors acknowledge financial support from the DARPA S&T Program (HR0011-06-1-0050) through the Micro/Nano Fluidics Fundamentals Focus (MF3) Center.

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