BATTERY-POWERED MICROCONTROLLER WITH WIRELESS COMMUNICATION FOR RANDOM, OHMIC ACTUATION OF NOVEL WAX VALVES ON A LAB-ON-A-DISC PLATFORM

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ABSTRACT

Described here is a novel arrangement of electronically-actuated wax valves for "Lab-on-a-Disc" (eLOAD) centrifugal microfluidic platforms. A LoaD platform, with an integrated silver screen-printed layer, operates via a battery-powered electronic system connected to a pattern of electrical leads which is screen printed on a PET layer. The disc also incorporates an array of composite paraffin-graphite wax valves which are opened using wirelessly-triggered Ohmic heating.

KEYWORDS: Centrifugal Microfluidics, Wax Valves, Electronic-Lab-on-a-Disc, eLOAD, Battery powered

INTRODUCTION

Centrifugal microfluidics has undergone a massive growth surge over the past 25 years in academia and industry. [1], [2] The potential of such "Lab-on-a-Disc" (LoaD) systems is intimately linked to their ability to integrate common assay protocols composed of a series of laboratory unit operations (LUOs) such as plasma extraction, metering and mixing for achieving comprehensive sample-to-answer automation. The LoaD platform typically also requires modules for detection, e.g. optical and electrochemical. The work presented here constitutes a decisive milestone towards an electronically-controlled LoaD platform. The simple approach enabled by light, thin and replaceable batteries[3] can be implemented without complex systems for wireless power transfer[4] and also obviates the need for stopping the disc for detection.[5] To this end we incorporate an in-house designed, disc-mountable and battery-powered electronic system connected to a pattern of electrical leads which is screen printed on a PET layer. The disc also incorporates an array of composite paraffin-graphite wax valves which are opened using wirelessly-triggered Ohmic heating, thus significantly simplifying previously shown laser irradiation techniques for to effectuate melting.[6]

EXPERIMENTAL

The LoaD platform is manufactured from poly(methyl methacrylate) (PMMA) sheets, pressure sensitive adhesive (PSA) (ARseal™90880), paraffin wax and a polyethylene terephthalate (PET) sheets (Fig.1A-B). The PMMA sheets were cut using a CO2 laser, and the PSA and PET films were structured using a knife cutter. A wireless communication module connected to an in-house built USB dongle to exchange flow control and measurement signals while the disc is spinning. (Fig.1C-D)

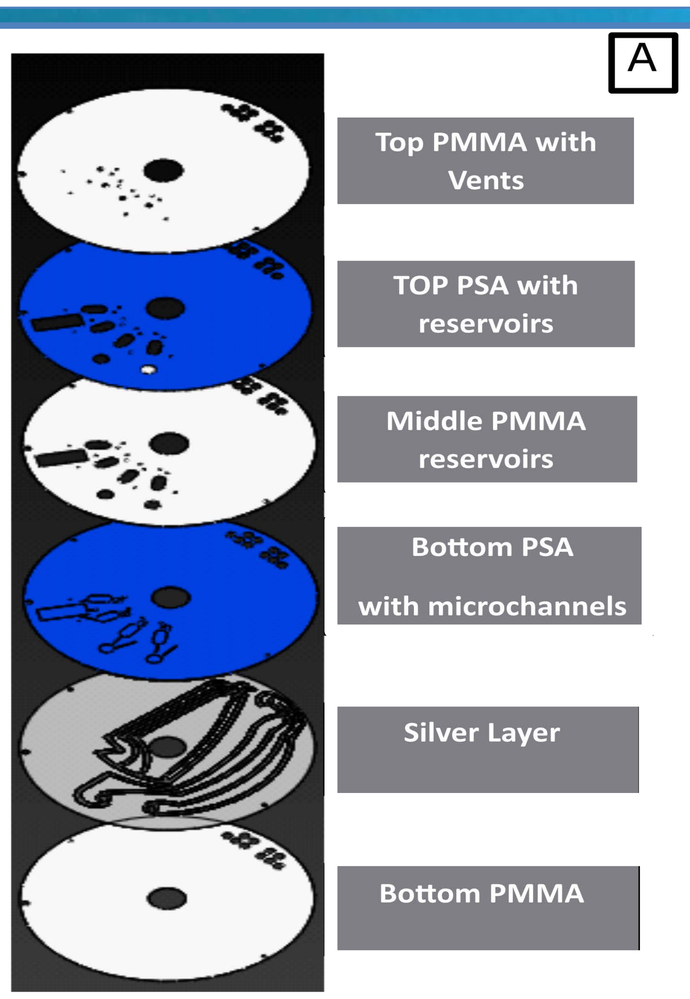
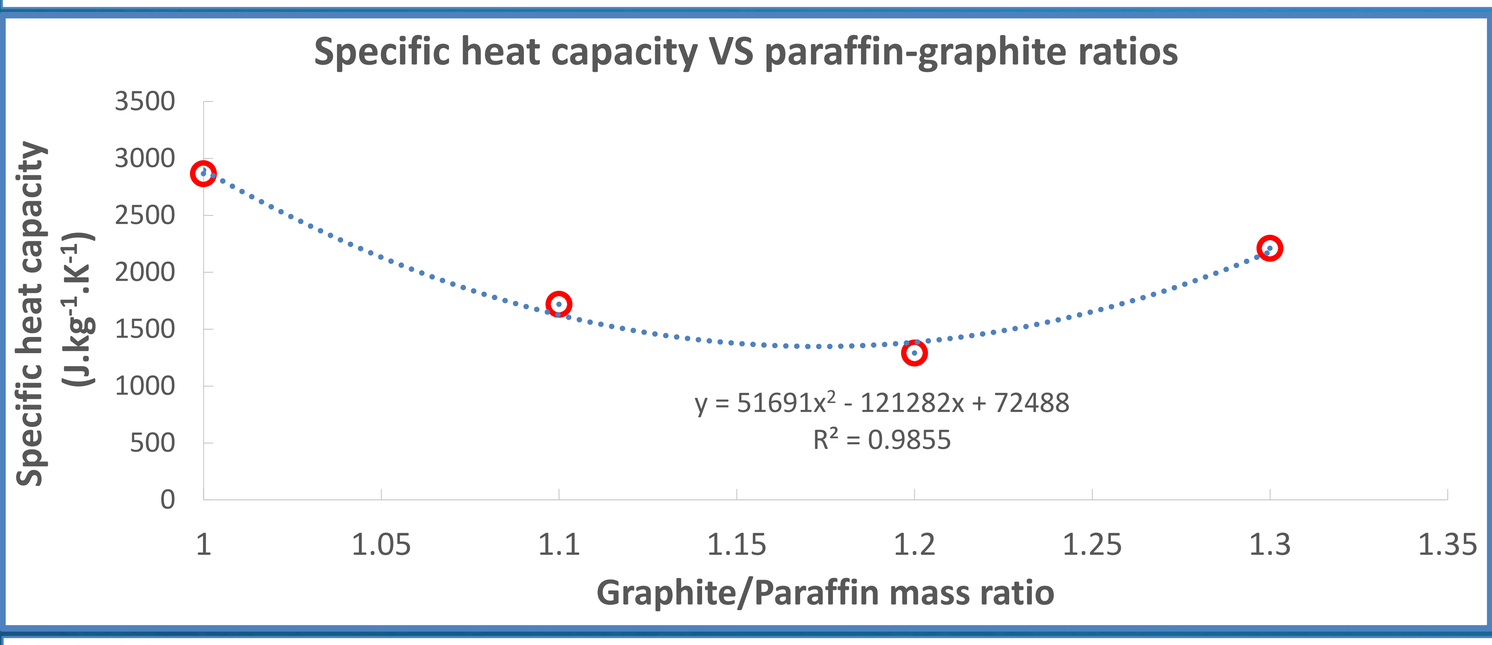


Figure 1: The eLOAD platform for heat-actuated wax valves. A) The eLOAD disc is formed from PMMA and PSA layers. B) Microfluidic feature breakdown on the eLOAD disc. C) The eLOAD circuit board mounted on the eLOAD disc D) The eLOAD circuit board (I) and disc (II) loaded on to the spin stand (III) test apparatus with camera and strobe lighting (IV). The used interface can perform real-time user inputs using the wireless, radio-frequency (Rf) transceivers (V), while the disc is in motion. This can include user defined programs (VI) for fully automotive and reliable operation.

RESULTS AND DISCUSSION

In order to minimise the electrical power requirements for wax valving, a range of paraffin:graphite ratios were tested (Fig.2). As expected, the ratios fitted a R^2 trend, by where Ohmic heating is reduced as graphite presence increases the conductivity of the wax valve, and alternatively, the overall conductivity of the wax is reduced as there is insufficient graphite present in the wax. The optimum ratio with the lowest specific heat capacity was determined to be approximately 1:**1.17** of paraffin:graphite.



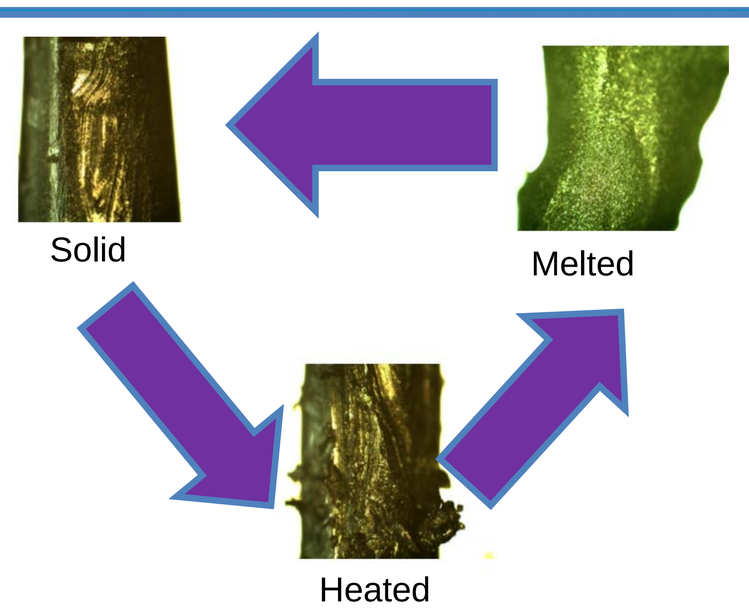


Figure 2: The Specific Heat capacity of the wax valve Vs paraffin:graphite ratio (right), with microscopic view of the wax valve actuation cycle (left).

CONCLUSION

Presented here is a novel arrangement of electronically-actuated wax valves for "Lab-on-a-Disc" (LoaD) centrifugal microfluidic platforms. While electronic valve actuation has been successfully integrated, further investigation aims to reduce the footprint of the electronic system while also exploring the incorporation of in-motion electrochemical detection the LoaD platform.

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