Laser direct write for introduction of programmable delay in paper-based diagnostic devices

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Demand for low-cost alternatives to conventional medical diagnostic tools has been the driving force that has spurred significant developments in the diagnostics field. Paper-based fluidics, proposed by the Whitesides' group in 2007 has been regarded as one such alternative, and has been progressing rapidly. Research into the development of methodologies that control, and in particular delay the flow of fluids in these devices is an urgently needed requirement that would enable greater functionalities in such paper-based devices.
In this work, we report the use of a new laser-based direct-write technique that allows programmable and timed fluid delivery in channels within a paper-based device. The technique is based on laser-induced photo-polymerisation, and through adjustment of the laser writing parameters we can control the porosity of hydrophobic barriers which, when fabricated in the fluid path, produce controllable fluid delay. We have patterned these flow delaying barriers at pre-defined locations in the fluidic channels using a continuous wave laser at 405nm. Using this delay patterning protocol we generated flow delays spanning from minutes to over an hour. Finally, to demonstrate the usefulness of such programmable flow delays, we have successfully implemented a multi-step sandwich ELISA (enzyme-linked immunosorbent assay) for detection of CRP (C - reactive protein) using a semi-automated device, where differently programmed delay barriers were introduced into individual channels for sequentially delivery of different reagents to the detection zone.
Since the channels and flow delay barriers can be written via a common laser-writing process, this is a distinct improvement over other methods that require specialist operating environments, or custom-designed equipment. This technique can therefore be used for rapid fabrication of paper-based microfluidic devices that can perform single or multistep analytical assays.

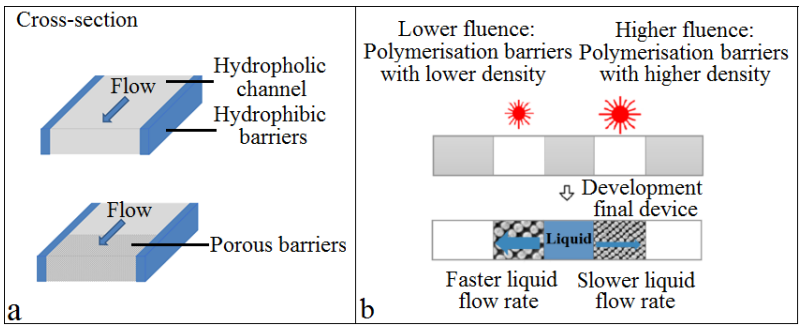

Figure 1: a) Schematic representation of a cross-section of a fluidic channel with a porous barrier; b) Schematics showing the creation of porous barriers with variable density of polymerization.