Development of a biomimetic paper-based lab-on-chip

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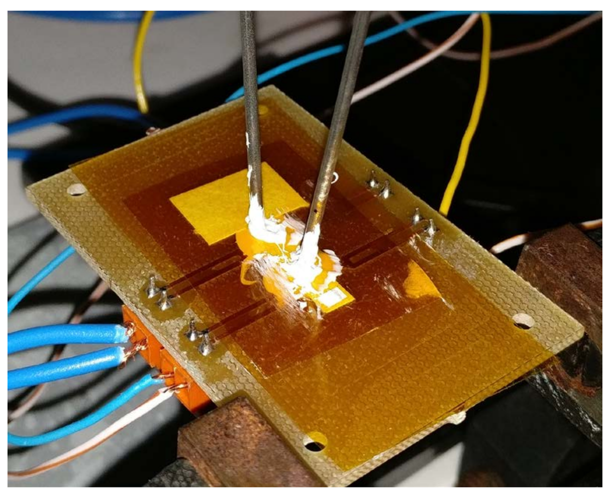
Introduction

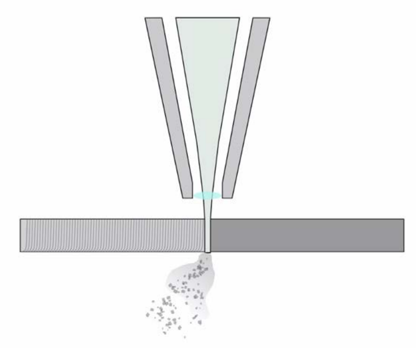
A **paper-based lab-on-chip** device was designed, combining the **heat transfer method(HTM)** with **molecularly imprinted polymers(MIPs),** for point-of-care applications. In order to deliver the sample to the receptor, an optimal paper design is needed. Several designs were tested to determine the **flow rate**, **flow duration** and **amount of volume** needed. Finally, a **microfluidic paper-based analytical device(µPAD)** was developed as a proof-of-principle. The µPADs are **disposable** and produced with **rapid manufacturing techniques**. It is functionalized with MIPs and a non-imprinted reference(NIPs). A printed circuit board heater was used as the transducer. In addition, thermocouples were used to measure the heat-transfer resistance (R_{th}).



Proof-of-principle benchtop setup

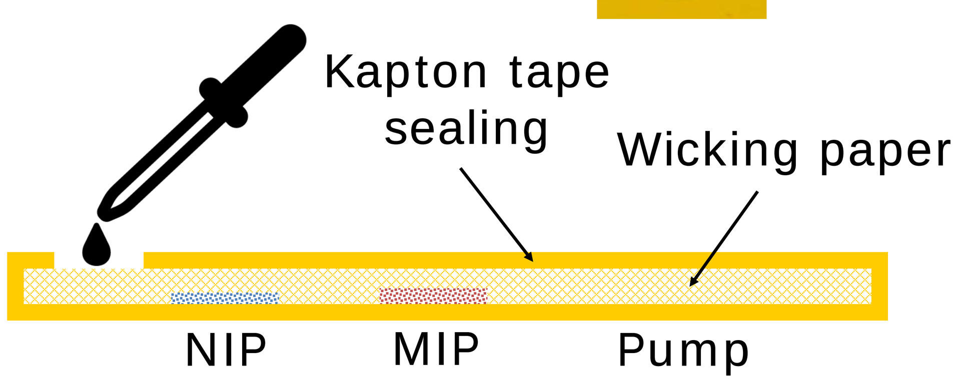
Paper-based microfluidics

- *Paper*: Whatman nr.1 filter paper
- *Sealant*: Kapton tape, prevents evaporation and has an acceptable heat-transfer resistance
- *Sample reservoir*: a cavity is foreseen on the top side of the Kapton tape
- *µPAD design*: running zone with MIP and NIP, 20µL pump
- *Development of paper*: rapid prototyping with lasercutter

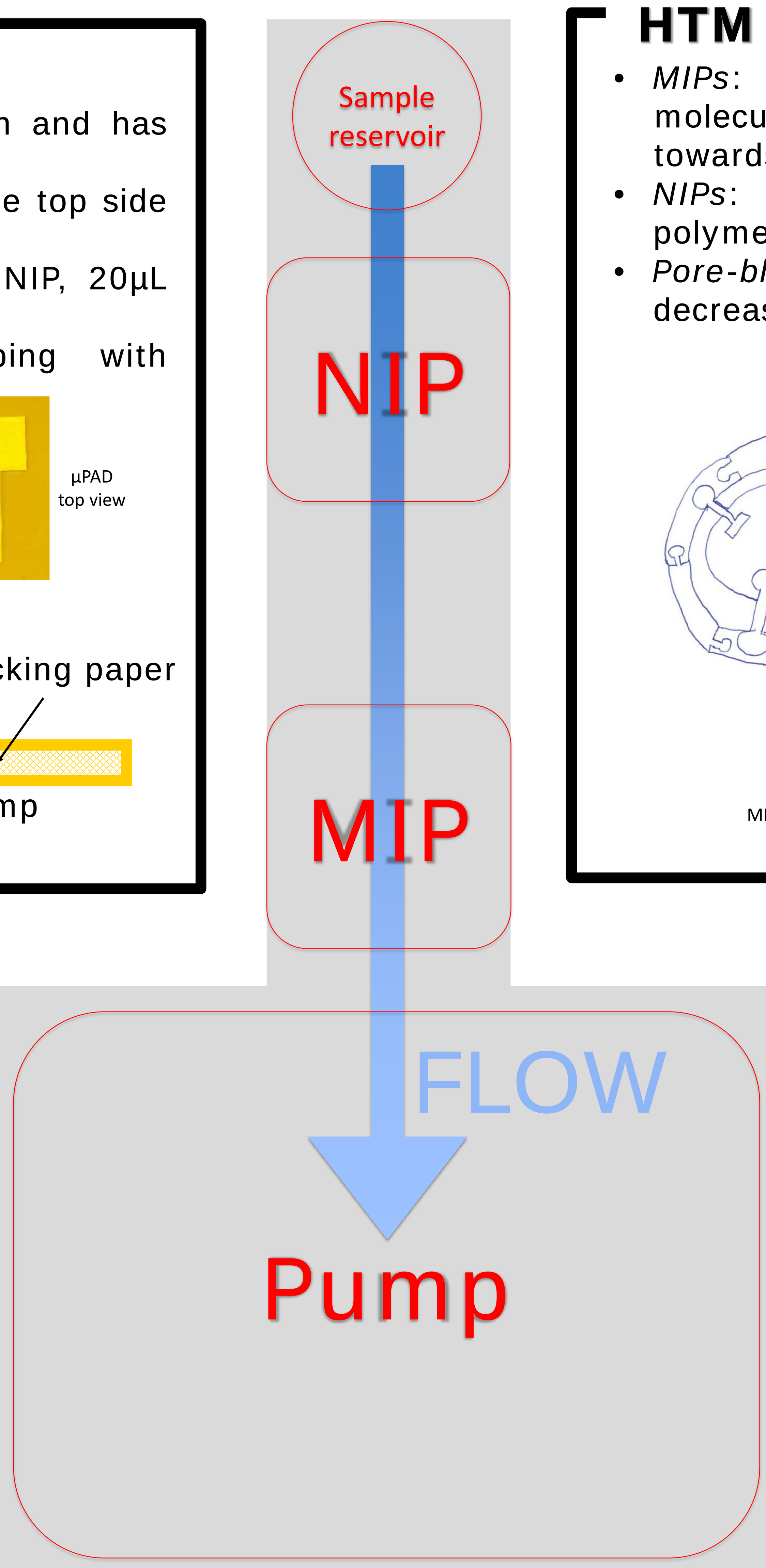


Rapid prototyping with lasercutting

µPAD top view

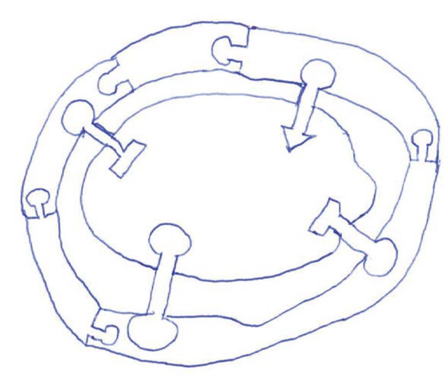


Schematic representation µPAD side view

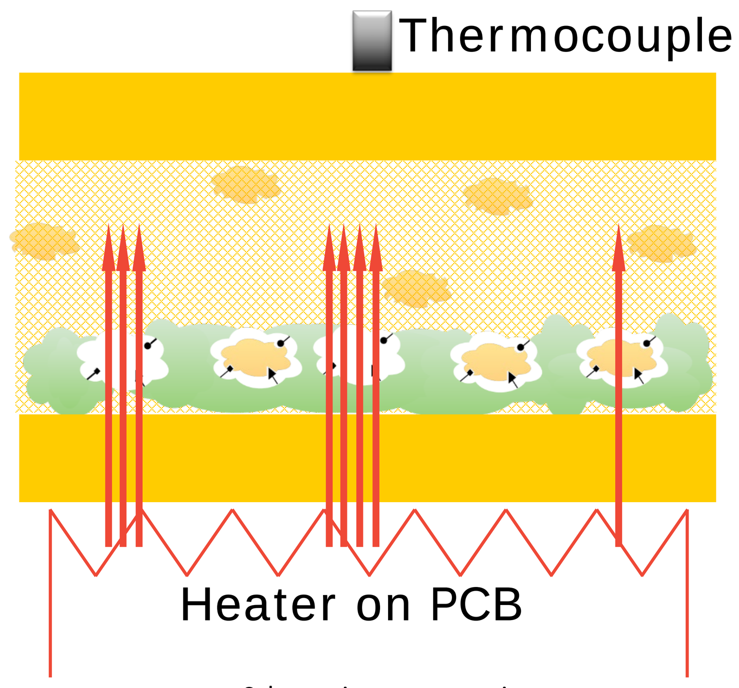


HTM & MIP

- *MIPs*: polymerization with presence of the target molecules, after washing cavities with a high affinity towards the target stay behind
- *NIPs*: no target molecules were present during polymerization
- *Pore-blocking*: after recombination heat flux decreases and heat-transfer resistance increases



Drawing MIP principle

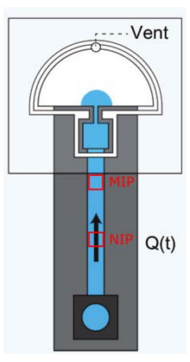


Schematic representation sensing and transducing

Alternative designs

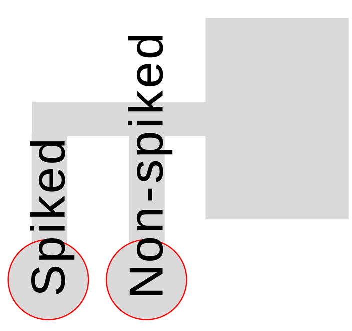
(A) Reusable receptor with capillary flowcell and replaceable pump

(B) Two-dimensional-paper-network, capable of applying non-spiked and spiked solution sequentially



(A)

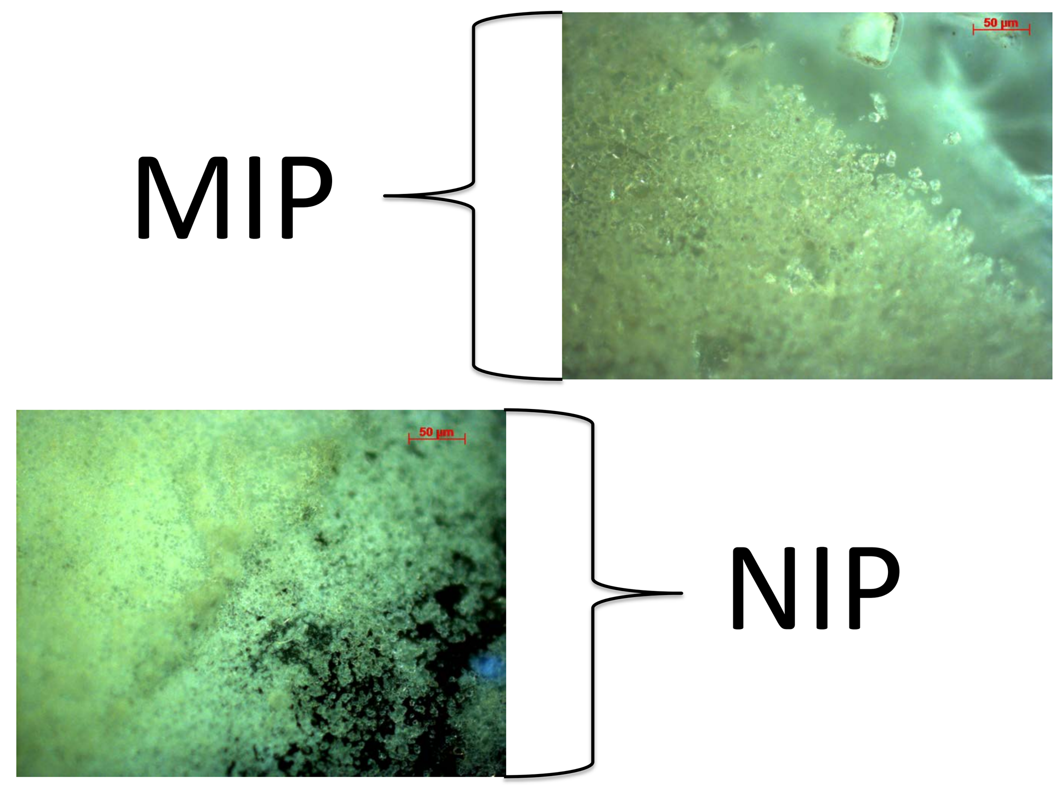
B. M. Cummins, R. Chinthapatla, B. Lenin, F. S. Ligler, and G. M. Walker *Technology*, vol. 5, no. 1, pp. 21–30, 2017.



(B)

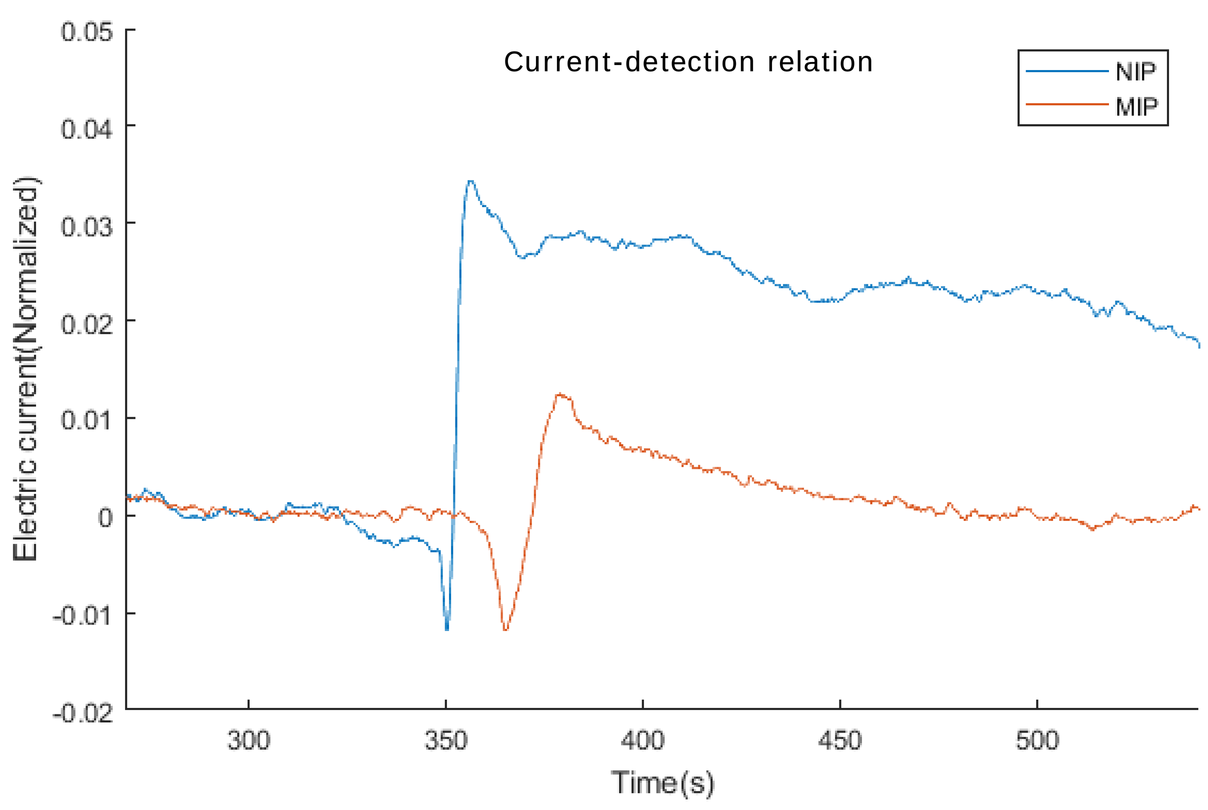
E. Fu, P. Kauffman, B. Lutz, and P. Yager *Sensors Actuators, B Chem.*, vol. 149, no. 1, pp. 325–328, 2010.

Receptor



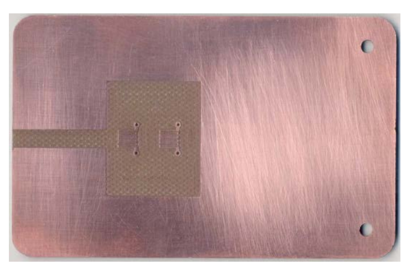
Results

- Current increase for MIP is lower than for NIP
- The sudden change in current marks the moment of wetting by the sample fluid



Conclusions & Prospects

It was noted that the heaters have influence on one another. This causes crosstalk. Hence, in future work this has to be avoided by making a physical separation in the PCB. A possible effect is a less stable and also much higher R_{th} level compared to the state of the art ($60 - 110\frac{°C}{W}$). However when examining the thermocouple temperature or electrical current conclusive results are achieved.



Creditcard-sized prototype

This work proves that paper-based microfluidics are suitable for the development of biomimetic lab-on-chips. Moreover, a prototype is already in the make and is the size of a creditcard.

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