Optimization and miniaturization of HTM sensors by using in plane heaters

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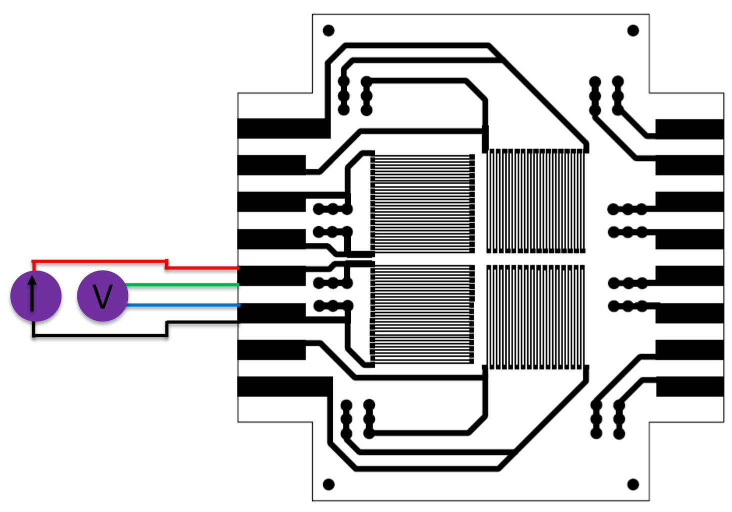
Introduction

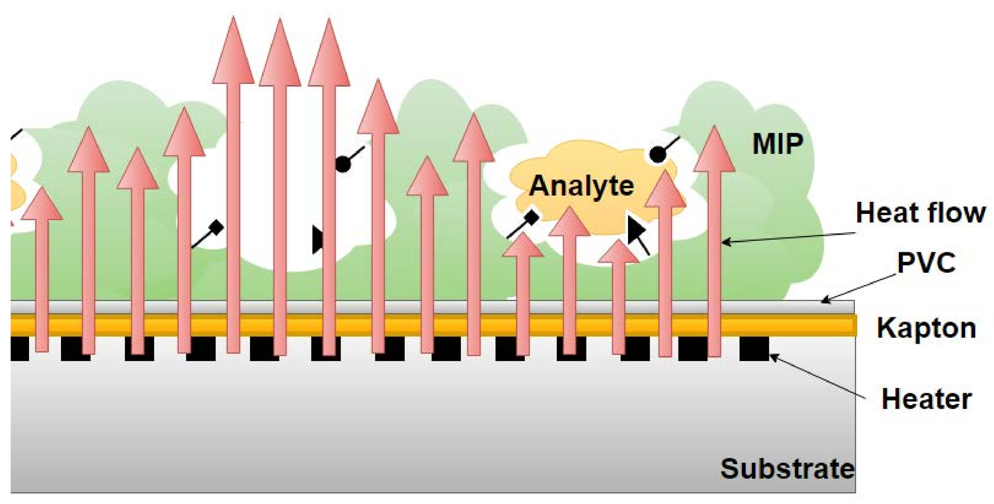
Heat transfer method (HTM) based biosensors make use of the change of **thermal resistance (R_{th})** of the recognition layer as transducer. The previously developed HTM sensor has proven itself in multiple areas of biosensor research, e.g. detection of small molecules, however this setup suffers from large overall dimensions. An improved setup has been designed, which utilizes the **transient plane source (TPS)** technique. This sensing method makes use of an **in plane heater that also functions as a resistance thermometer**, thereby shrinking the overall dimensions of the setup. By **monitoring the change in electrical resistance (R)**, a receptor-target binding event can be recorded. The functionality of the new setup has been verified by performing **steady-state** measurements after coating the sensor with **molecularly imprinted polymers (MIPs)** for **chloramphenicol**.

Materials & Methods

Heater design

- In plane heaters have been developed on an etched copper clad printed circuit board
- Multiple heaters are integrated to allow multichannel measurements
- 4 wire sensing method eliminates the leads' and contact resistances
- Over a small range, the ΔR is linear depending on the change in temperature (ΔT)



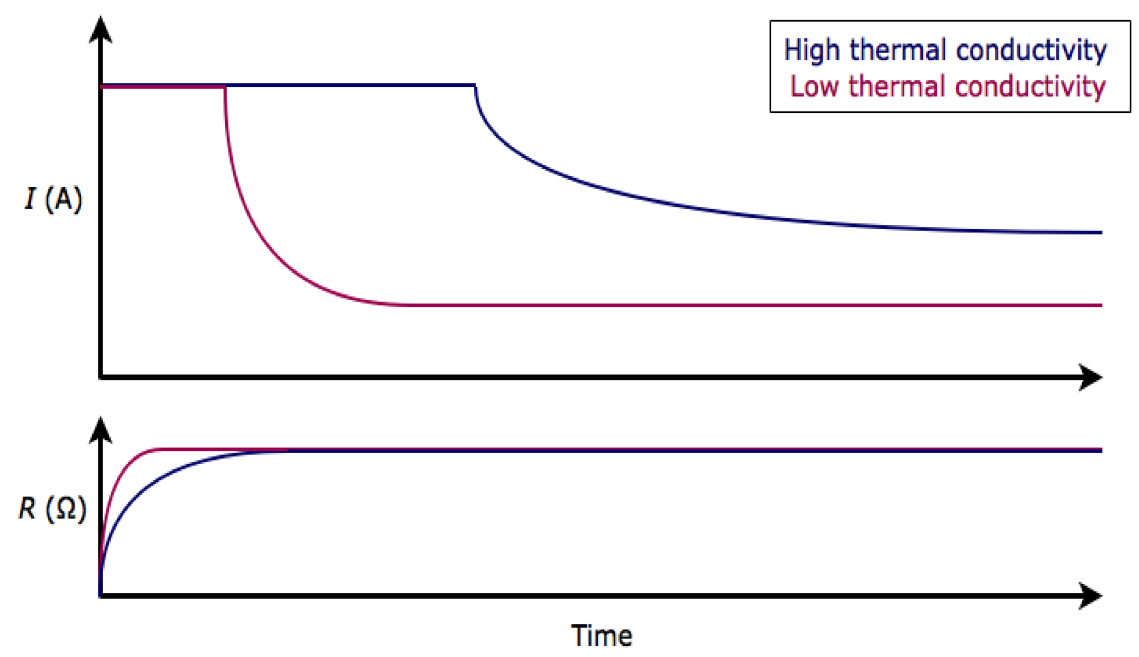


Surface preparation

- Kapton smoothens and electrically insulates the heater, is chemically inert and has an acceptable thermal conductivity
- A PVC layer of 350nm is spincoated on top of the Kapton and functions as the adhesion layer for the MIPs
- MIPs (Ø20-40µm) are stamped onto the PVC and subsequently baked to 120°C

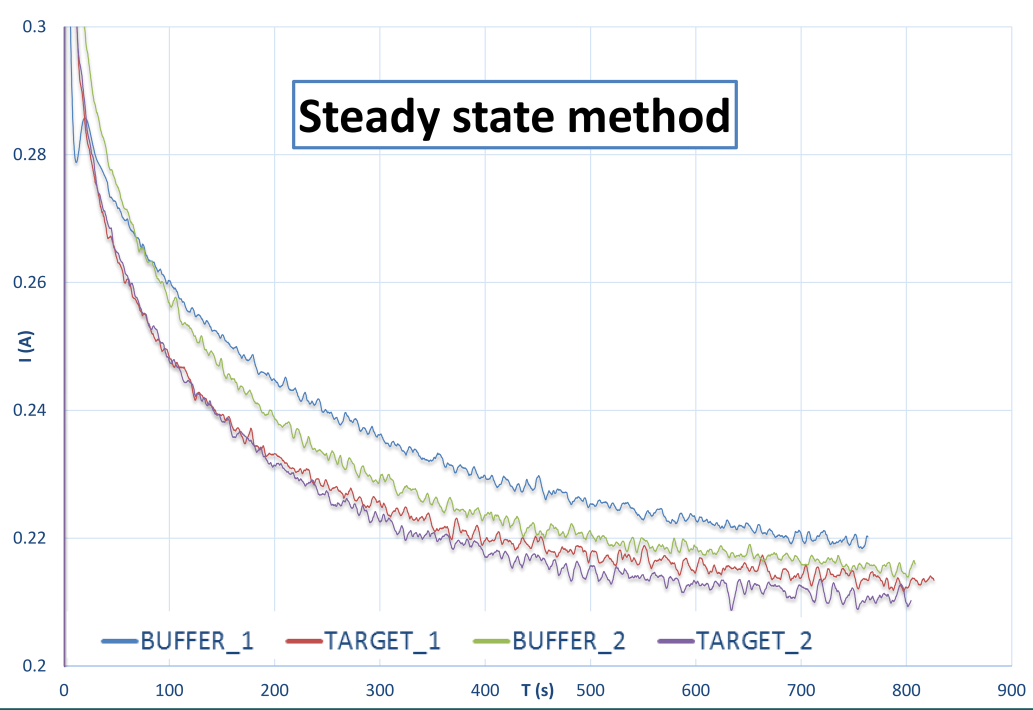
Steady state method

- A feed forward controller regulates R, by controlling the amount of current
- A target-receptor binding event results in an elevated R_{th}, thus a lower current is required to keep the R at the predefined level.
- The recorded current provides a measure for the thermal resistance of the bioreceptor



Results & Discussion

1. Buffer_1: $(0.1M\ Na_2HPO_4\ .0.1M\ HCl\ ,pH = 7)$ was applied to achieve a reference level
2. Target_1: Chloramphenicol solution of 0.5mM is applied, the solvent was from the same buffer batch
3. Buffer_2: $(0.1M\ Na_2HPO_4\ .0.1M\ HCl\ ,pH = 7)$ chloramphenicol molecules left behind
4. Target_2: Chloramphenicol solution of 0.5mM is applied



- Required current decreases after addition of target molecules
- After flushing with buffer, the signal almost recovers to the initial level, due to the trapped chloramphenicol molecules
- Usable results are obtained after 800s for each step

Conclusion

- Proof of principle: an in plane heater to optimize and miniaturize the HTM sensor
- Faster measurements compared to the old setup on a vastly decreased footprint
- Future potential:
  - → measuring multiple samples simultaneously
  - → inkjet-printed heaters on flexible substrates

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