

Optimisation and miniaturisation of the HTM sensors by using the transient plane source technique

Frederik Vreys^{1,2}, T. Vandenryt^{1,2}, G. Oudebrouckx¹, J. Vliegen¹, G. Vandevenne^{1,2}, W. Deferme^{1,3}, R. Thoelen^{1,2}

frederik.vreys@uhasselt.be

1)Institute for Materials Research(IMO), Hasselt University, Wetenschapspark 1, 3590 Diepenbeek, Belgium

2)IMEC vzw – Division IMOMECE, Wetenschapspark 1, 3590 Diepenbeek, Belgium

3)Flanders Make vzw, Oude Diestersebaan 133, 3290 Lommel, Belgium

Abstract: The transient plane source technique was used to achieve the miniaturisation and optimisation of the HTM sensors. Different designs and substrates have been tested to optimise the thermal conductivity, diffusivity and distribution. The efficiency of the planar heaters as a platform for biosensors were tested with milk, containing varying amounts of fat content. The transient plane source technique can be the first step towards a ready-to-market product based on HTM.

Keywords: heat transfer method (HTM), biosensor, transient plane source technique (TPS), resistance temperature device (RTD)

Introduction

The heat transfer method (HTM) is a promising technique that is able to detect single mismatches in DNA, small molecules, the phase transition of lipid vesicles and cells without the necessity of labelling the analyte. Without the loss of specificity or sensitivity the label-free technique is easier, cheaper and less time-consuming. With HTM the thermal resistance of the bioreceptor is measured. The thermal resistance will increase upon binding the target to the receptor. It is also possible to detect several analytes simultaneously on the same substrate[1].

The current HTM setup is far from being hand-held and cumbersome to transport. The transient plane source (TPS) technique, which meets the ISO standard (ISO/DIS 22007.2.2)[2], can make it much smaller. It consists out of a planar heater (Figure 1) whose temperature is being monitored during and after high current pulses by making use of its temperature-resistance relationship. The rate of cooling down or warming up is a measure for the thermal resistivity and thermal capacity of the bioreceptor layer. By dividing the planar heater into segments several analytes can be detected at once.

Results and Discussion

Several designs have been tested extensively, in order to obtain a uniform heating pattern. The transient plane sources were inspected with a thermal imaging infra red camera (FLIR X6580sc).

The planar heaters have been developed on a multitude of substrates. Printed circuit boards which were bought commercially and flexible substrates (e.g. PET, Kapton® tape) on which a heater was printed with SunTronic Cabot silver nanoparticle inkjet ink from SunChemical.

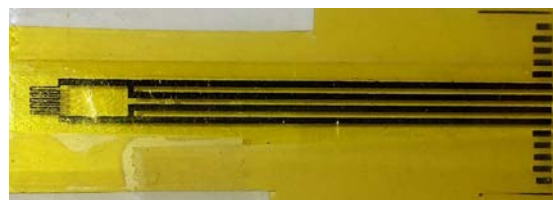


Figure 1: Transient plane source inkjet printed with silver ink onto a PET substrate and sealed with polyimide film.

The specific heat and heat conductivity of the substrate should be taken into account. During heat conductivity measurements of milk, the measured data indicates the different amount of fat content. However it also contains unwanted information about the substrate. Therefore the substrate should have a very small specific heat together with a high thermal conductivity.

Conclusions

The TPS technique optimises and miniaturises of HTM for alternatives to flowcells, e.g. dipstick devices. Different kinds of substrates can be used but the specific heat should remain small and the heat conductivity very high.

References

- [1] G. Wackers, et al., *Sensors* **2014**, doi: 10.3390/s140611016.
- [2] ISO/DIS 22007-2:2015, Plastics - Determination of thermal conductivity and thermal diffusivity - Part 2: Transient plane heat source (hot disc) method. ISO, Geneva, Switzerland
http://www.iso.org/iso/catalogue_detail.htm?csnumber=61190

Acknowledgements

This work was financed by the Special Research Funds BOF of Hasselt University.