Spatial heat distribution of inkjet printed heaters in comparison to planar milled circuit board heaters for biosensing applications

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Abstract: The heat transfer method can be used in biosensing applications to detect analytes. Until now, the heater module always consisted of a heating element and copper heat-spreader. In order to improve the sensitivity of the sensors, a planar heating- and sensing element is proposed. Milling of circuit boards is an established method for creating planar heaters. An alternative has recently emerged in the form of inkjet printing. In this work, a comparison of the heat distribution is made between milled circuit board heaters on a fibreglass substrate and inkjet printed heaters on a flexible PET substrate. [1]

Keywords: Thermography, Inkjet Printing, and Biosensors

Introduction

In order to detect analytes, a substrate is covered with a receptor layer, such as a molecular imprinted polymer. When the receptor layer captures the target molecule, the thermal insulation of the substrate will increase and so will the temperature of the heater. The temperature of the heater is proportional to the current flowing through the conductor. This process is known as joule heating, and described by the following equation:

$$H \propto RI^2t$$

The heat distribution of flexible inkjet printed heaters differs from the planar milled circuit board heaters. This is due to, among others, the homogeneity of the printed structure, the specific electrical resistance of the path, the specific thermal resistance of the substrate, *etc.* [1-3]

Results and Discussion

The flexible printed heaters are inkjet printed with a Fujifilm Dimatix DMP-2800 series with a 10 pl cartridge. The ink used in the printing process is SunTronic Cabot from SunChemical. The substrate used for printing these heaters is a flexible PET foil with a thickness of 120 µm. The traces of the heater itself have a thickness of 120 nm and a width of 100 µm. The spacing in between two traces is 100 µm. The total length of the trace is 22 mm and the overall size of the heater is 2 x 2 mm. Together this results in a total resistance of 90 Ω. [3]

A LPKF Protomat S63 is used to machine the planar heater with a 100 µm mill out of copper clad (5 µm) on a fiberglass reinforced circuit board. The resulting planar circuit board heater has identical dimensions as the inkjet printed heater. Together this results in a total resistance of 0.8 Ω. The substrate here is a non-flexible FR4 board with a thickness of 1.55 mm. [1]

Thermal measurements of both heaters have been carried out with a FLIR X6580sc infrared camera. The camera has a number of effective pixels of 640 x 512. Combined with a microscope lens, the resolved pixel size equals 3 µm with a noise equivalent temperature difference of 20 mK. A frame rate of 355 Hz (full frame) up to 4500 Hz (sub framing) allows us to capture high-speed temperature changes. An infrared image, acquired with the infrared camera, is shown in figure 1. [2]

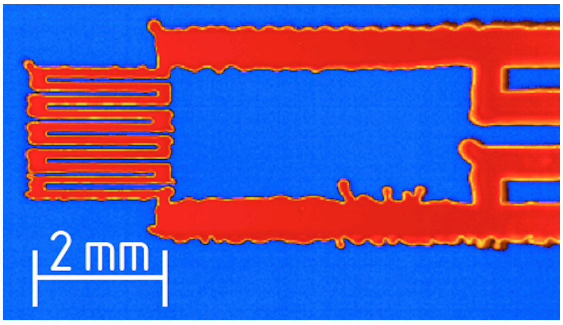

Figure 1: An infrared image of an inkjet printed heater, as can be used for the heat transfer method.

Conclusions

Inkjet printing is a very promising technology for rapid development of heating and sensing structures on flexible substrates. However in terms of spatial uniformity and homogeneous heat distribution, the circuit board heater still has the upper hand.

References

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