Simulation of Thermal Transport Based Flow Meter for Microfluidics Applications

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Abstract

A miniaturized and non-invasive methodology for ascertaining the velocity and/or direction of different flowing media is imperative in microfluidic devices. The amount of heat removed or redistributed from a heated temperature sensor by a surrounding flow can be used to determine the flow velocity. The sensors that use the heat dissipation principle are called thermal transport flow meters [1]. The absence of moving parts in these flow meters makes them suitable for applications where small diameter tubing is required. The advantages of thermal transport sensors also include high sensitivity and broad dynamic range, compared to other types. They can be sub-classified in hot-wire based or calorimetric sensors.

In calorimetric-type thermal transport sensors (Figure 1), the device measures variations on the temperature profile around a heater, which is affected by the fluid flow. The central resistor (R2) acts as the heater, while the others are used to monitor the temperature profile around it. In presence of flow, the temperature of R1 will decrease along with its corresponding resistance value, while the temperature and resistance of R3 will increase. This calorimetric technique is widely used in micro-machined or MEMS-based flow sensors, obtaining highly compact and non-invasive flow meters [2, 3]. Also, their simplicity in structure and electrical response, as well as their well-known operation principle make them suitable for microfluidics applications.

In our study, COMSOL Multiphysics® is used to simulate a thermal transport based flow sensor, which will be embedded in a micro-channel of a Poly(methyl methacrylate) (PMMA) based microfluidic device. The channel height is 100µm and for simulation purposes the lengths has been set to 1.2mm. The heater element and the two sensors are made of platinum and were modeled using Heat Transfer in Fluids, Laminar Flow and Joule Heating interfaces. The three elements have a thickness of 300nm, which can be sputtered and patterned in the real device. Figure 2 shows an image of the heat distribution due to flowing water is presented.

From the studies result we expect to find a relationship between the flow rate and the change in temperature around the two temperature sensors. Moreover, the temperature distribution in the channel will be analyzed.

Reference

[1] J. Fraden, “Flow Sensors," in Handbook of Modern Sensors, 4th edition. New York, NY: Springer New York, 2010, chapter 11, pp. 399-429.
[2] Y.H. Wang, C.P. Chen, C.M. Chang, C.P. Lin, C.H. Lin, L.M. Fu, and C.-Y. Lee, “MEMS-based gas flow sensors" Microfluidics and Nanofluidics, vol. 6, no. 3, pp. 333-346, Jan. 2009.
[3] N. Nguyen, “Micromachined flow sensors - a review", Flow Measurement and Instrumentation, vol. 8, no. 1, pp. 7-16, Mar. 1997.

Figures used in the abstract

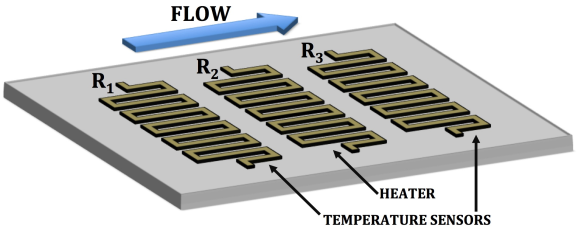

Figure 1: Calorimetric flow sensor.

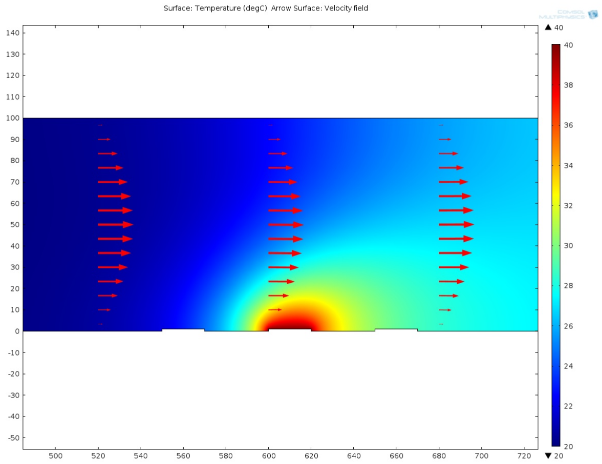

Figure 2: Temperature distribution within a micro-channel due to flowing water.