

Simulation of Thermal Transport Based Flow Meter for Microfluidics Applications

Arpys Arevalo, Ernesto Byas and Ian G. Foulds

King Abdullah University of Science and Technology (KAUST), Computer, Electrical & Mathematical Sciences & Engineering Division
Electromechanical Microsystems & Polymer Integration Research Laboratory (EMPIRe Lab), Thuwal 23955-6900, Saudi Arabia.



Introduction

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.

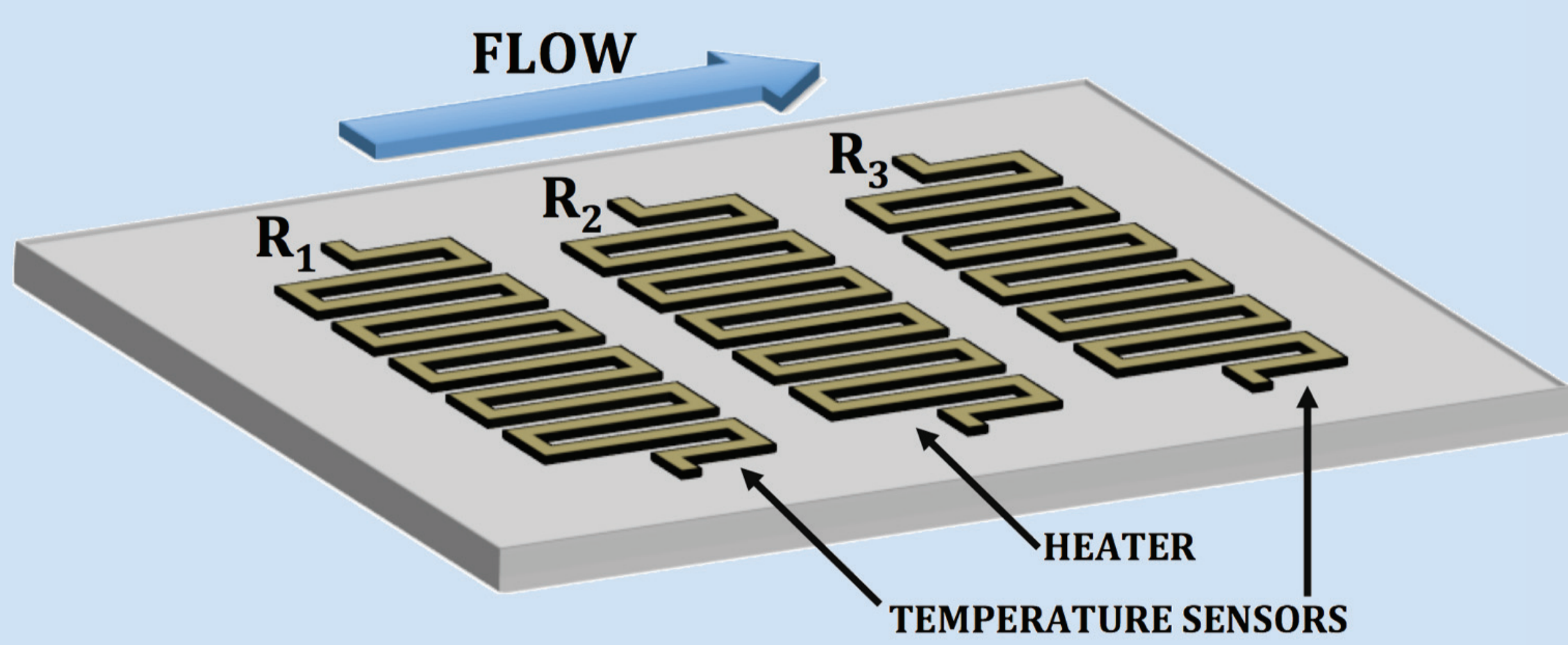


Figure 1. Calorimetric Flow Sensor

Model Desing

We used the CFD and Heat Transfer modules of COSMOL Multiphysics 4.3b. The simulations were modeled in a two-dimensional environment, as a cross-section of a micro-channel with an embedded flow meter. The dimensions of the micro-channel are: 1.2mm in length and a height of 400µm.

The sensor base (platform) has the following dimensions: height of 10µm and a length of 120µm. The sensor comprises three different metallic features: left sensor, heater and right sensor. The heater is located between the two sensors, such that the flow in the channel will displace a temperature gradient to the immediate sensor (in the flow direction). The platform of the flow sensor contributes to the overall working principle of the device. Because the substrate positions the sensor in a higher flow velocity of the fluid (towards the center of the channel, where maximum flow velocity is reached), the temperature distribution in the fluid along the channel is transferred in a better manner.

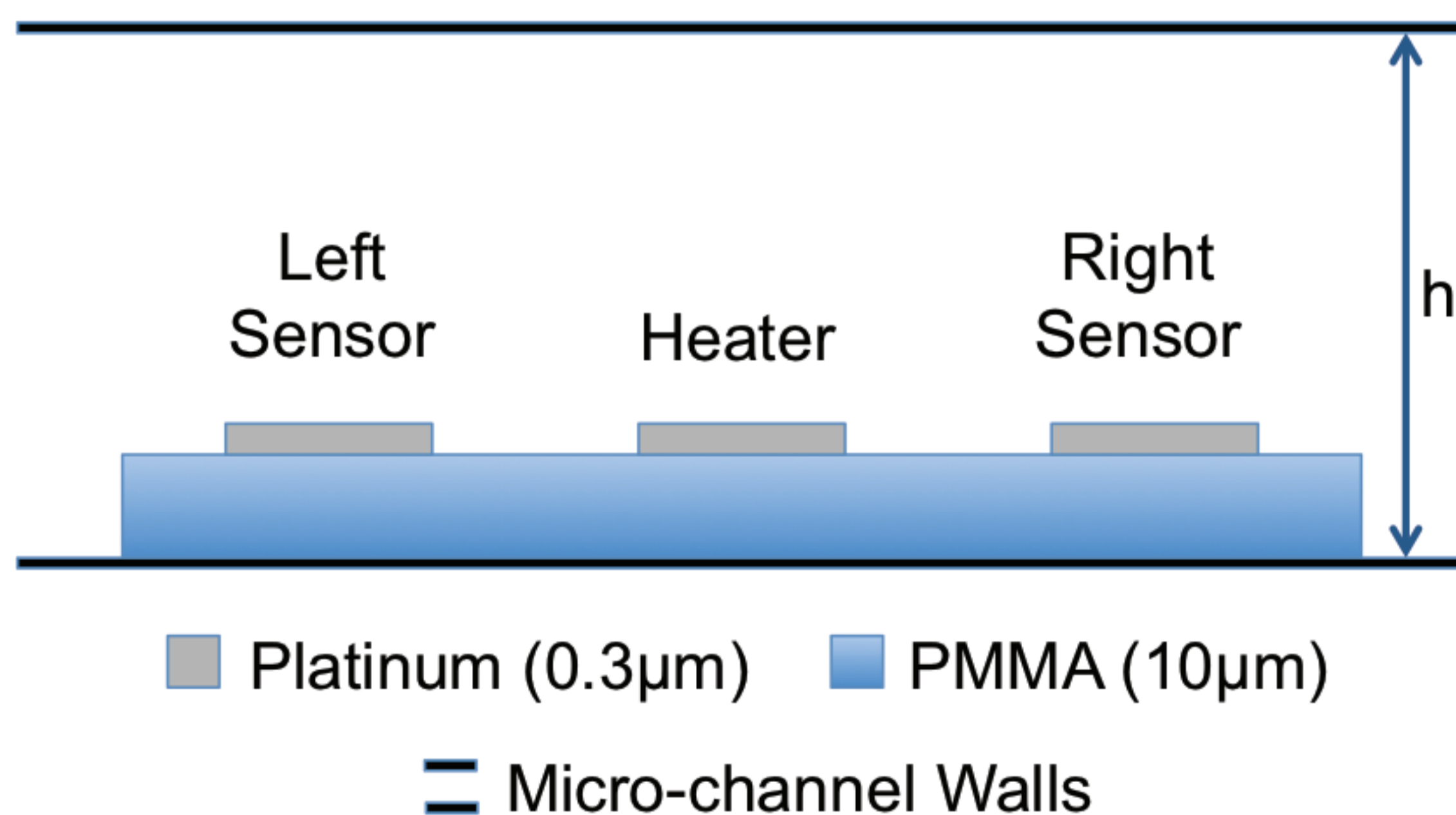


Figure 2. Two-dimensional micro-channel model, height (h) is 400µm (schematic not in scale).

Results

The platform of the flow sensor contributes to the overall working principle of the device. Because the substrate positions the sensor in a higher flow velocity of the fluid (towards the center of the channel, where maximum flow velocity is reached), the temperature distribution in the fluid along the channel is transferred in a better manner. Two simulations with same inflow parameters show the effect of sensor's position in the y-axis.

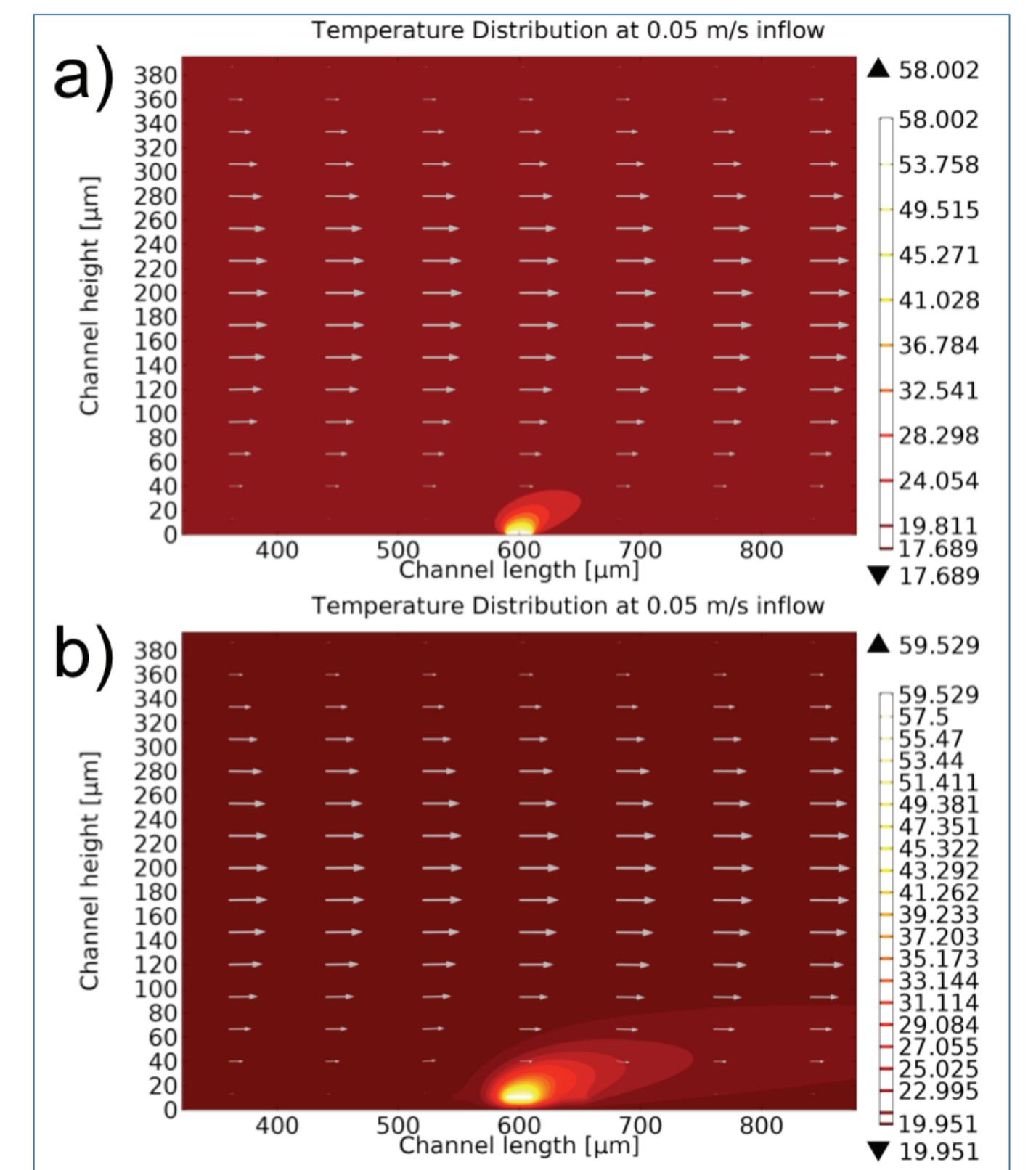


Figure 3. No PMMA platform vs. PMMA platform simulations: a) No PMMA platform b) PMMA platform. (Inflow for both: 0.05m/s).

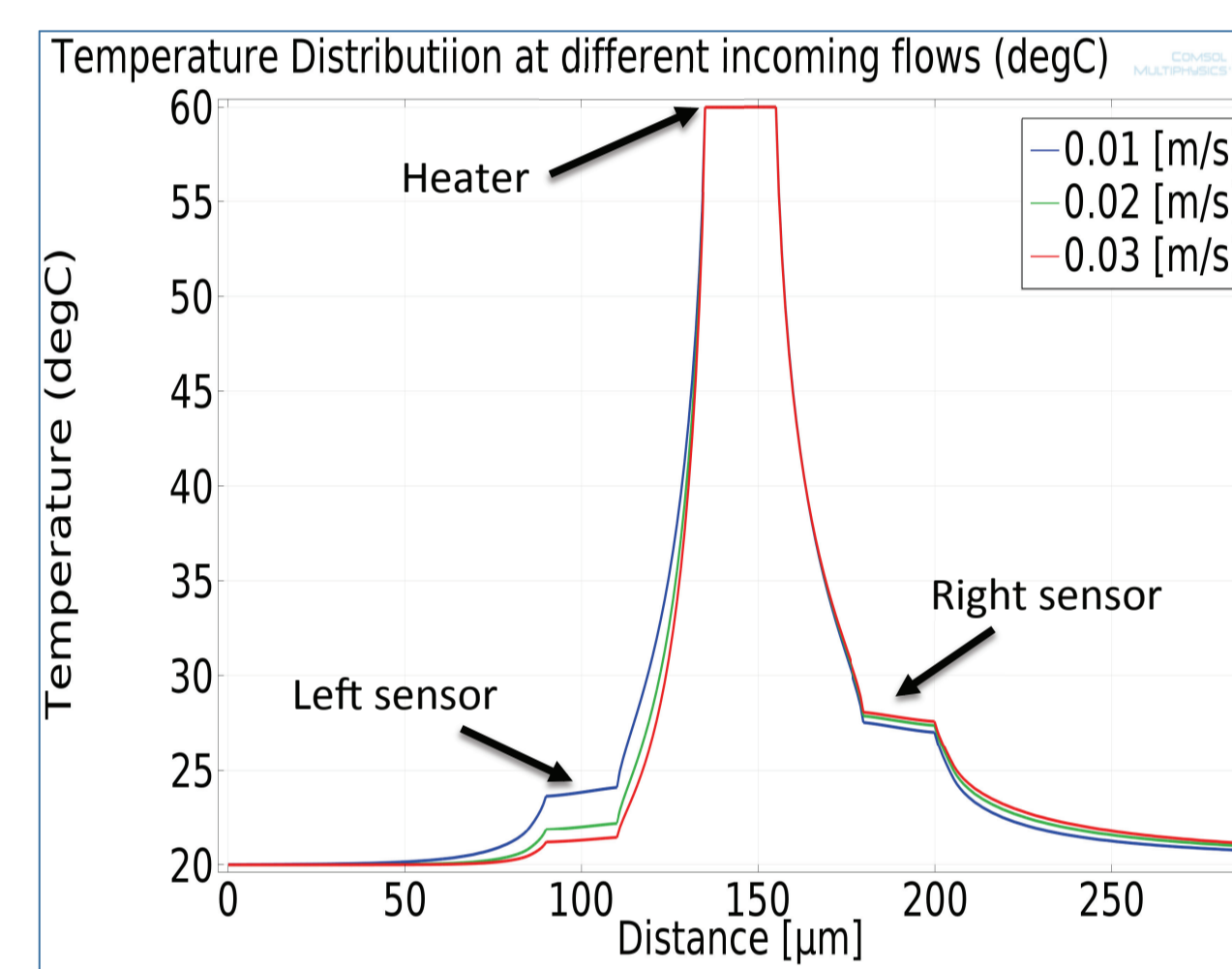


Figure 4. Temperature distribution along the PMMA platform length, above the metal layers.

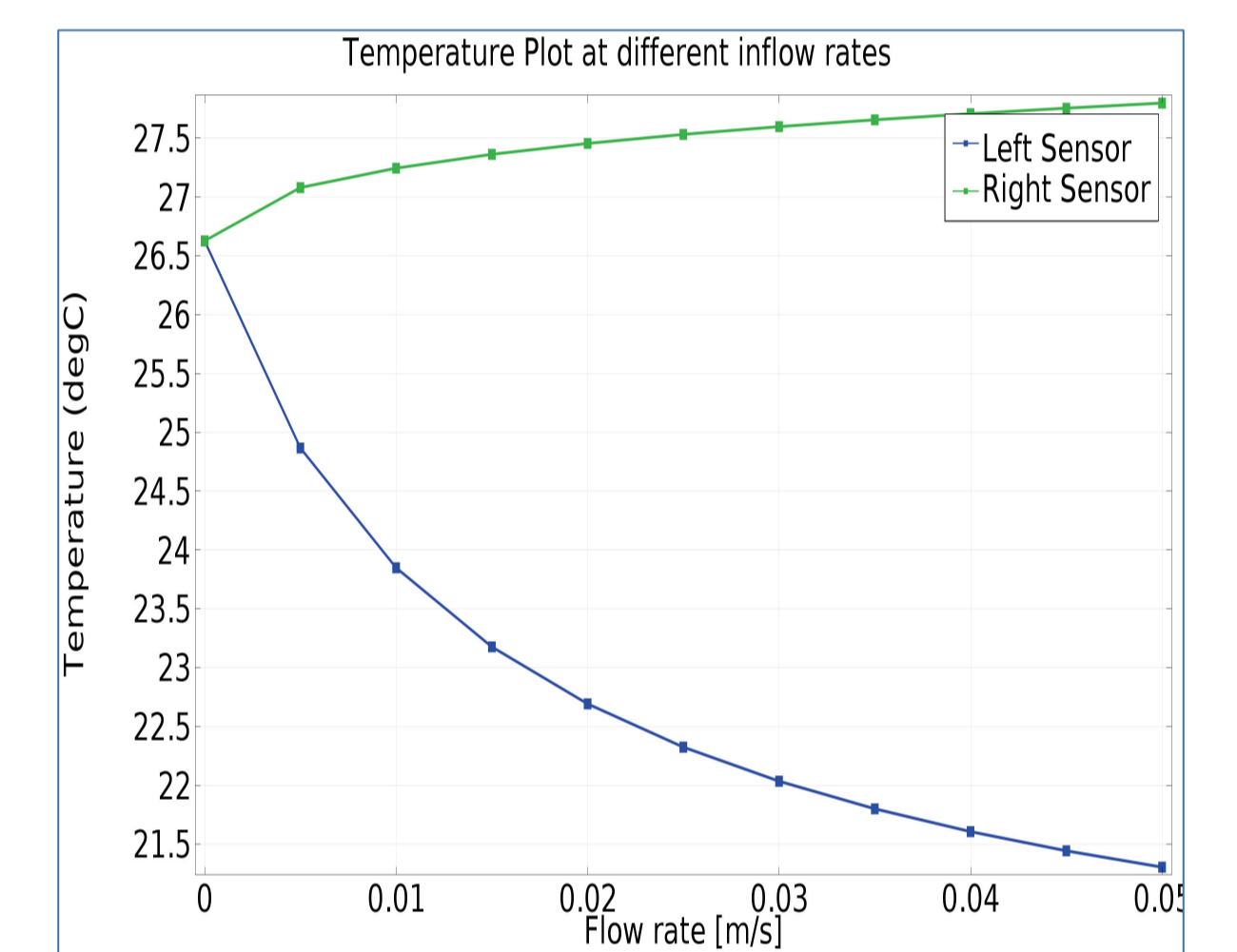


Figure 7. Temperature at top center point of the left and right sensor's surfaces.

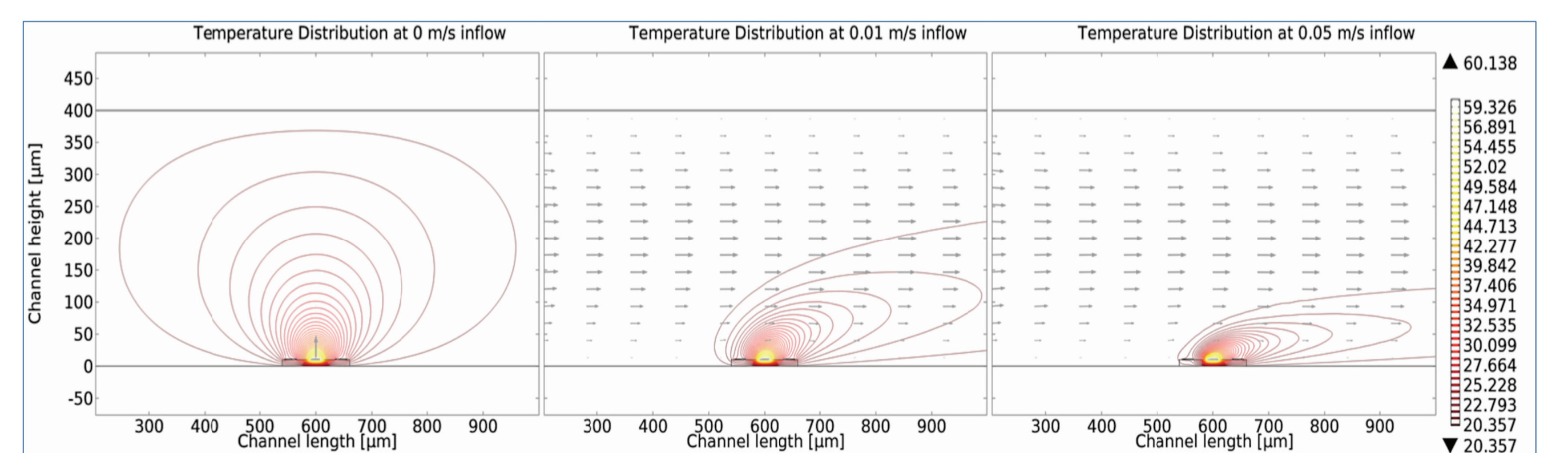


Figure 6. Temperature distribution in a channel with different inflow rates. The largest temperature difference between the two temperature-sensors is approximately 7°C, these results provide an important characteristic of the working range of the device. Simulations with modified channel height, platform height, sensors to heater gap and metal thickness, will aid in the selection of the optimal parameters for the device fabrication.

References

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