

3-D Multiphysics Model of Thermal Flow Sensors

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Introduction: This work describes a 3-D model for the analysis of thermal flow sensors. Those devices are locally heated up using the Joule effect and contain one or more temperature sensing elements. The model can be applied to every device based on this principle, and has been validated with the structure reported in Fig.1.

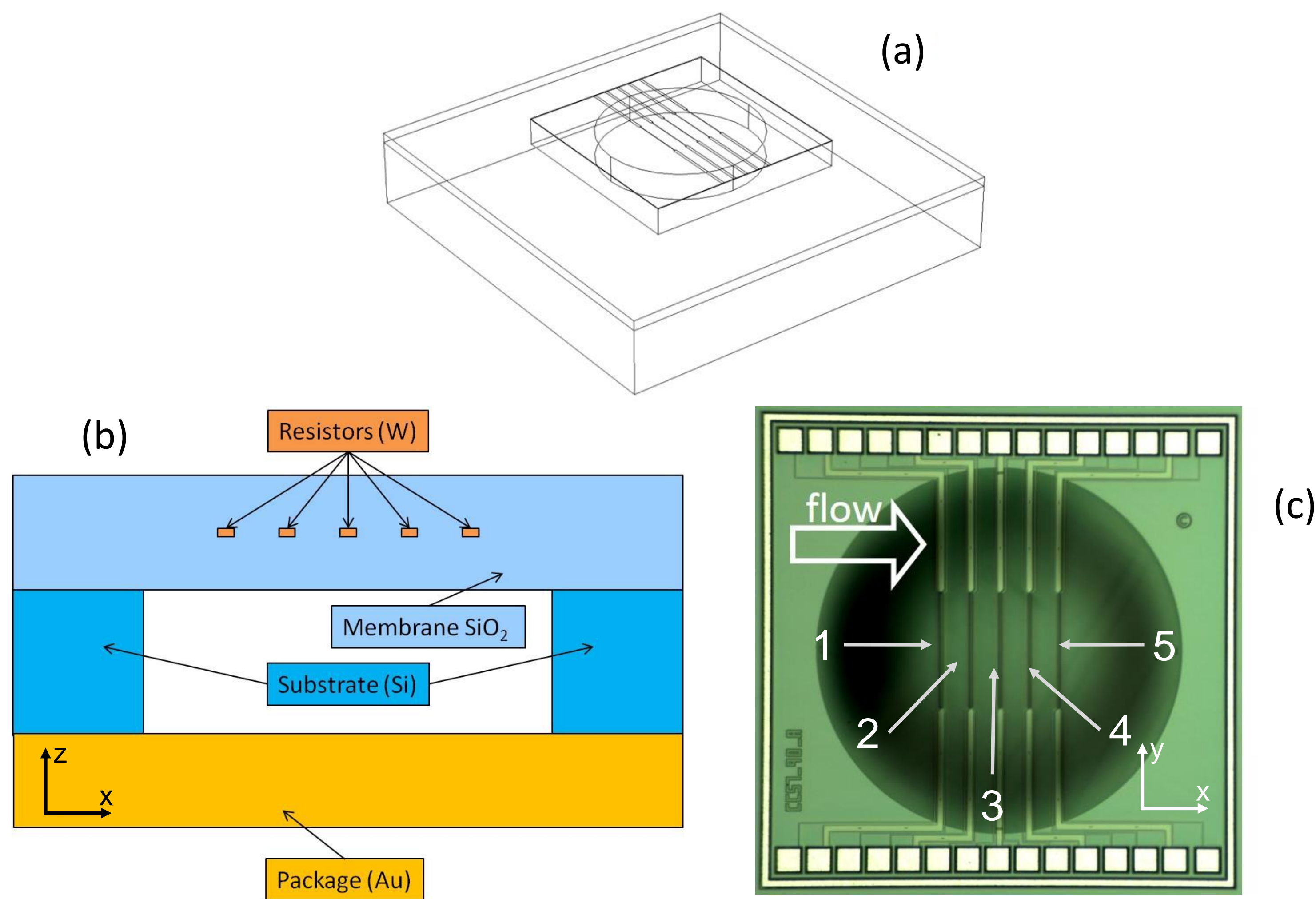


Figure 1: device geometry 3D (a), cross section (b) and top view.

Physics: The model requires the interaction of three different physical modules to include the Joule effect, the heat dissipation and the effect of the flow. The interactions between the different modules are reported in Fig. 2.

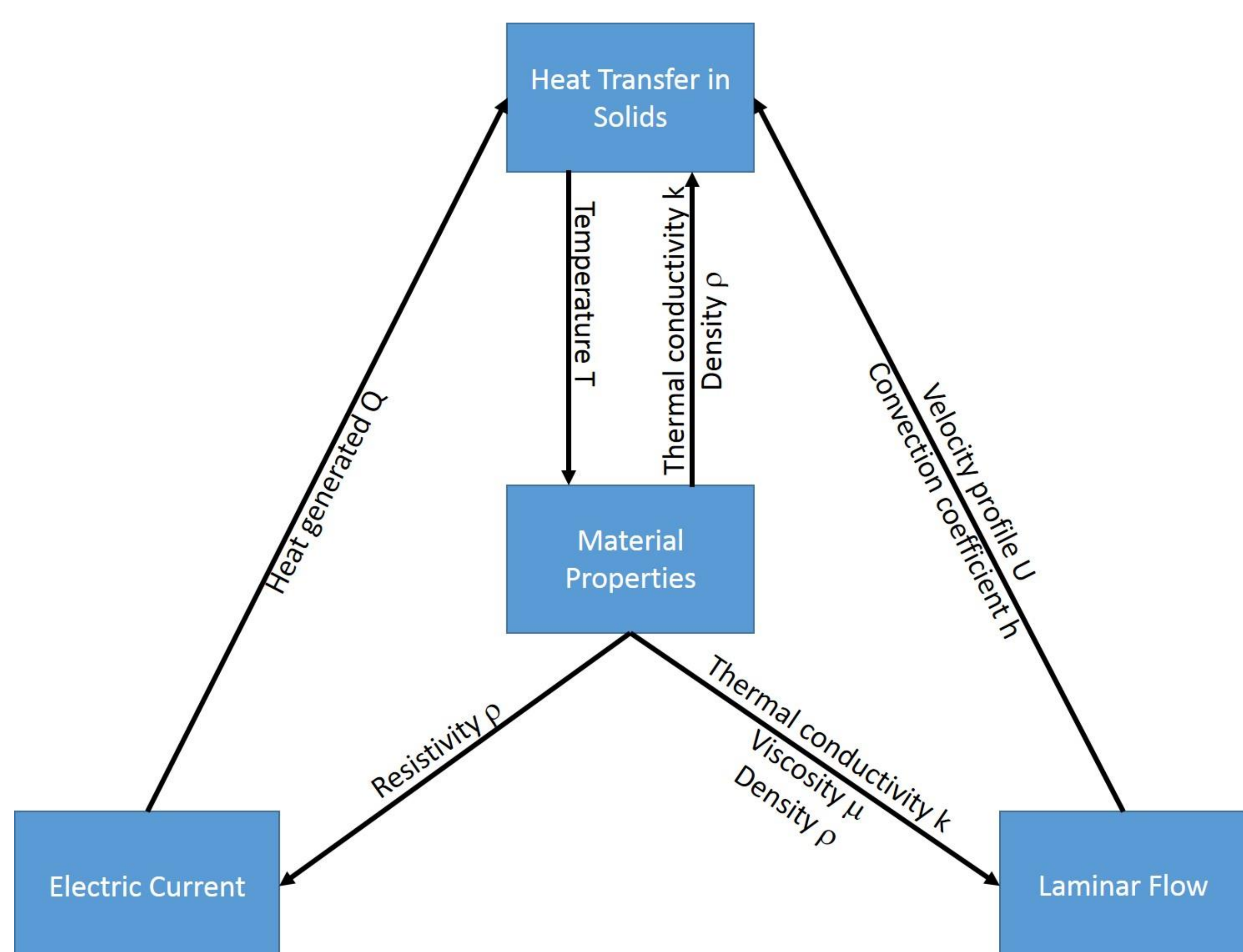


Figure 2: physic modules used and their interaction.

Results: The model has been verified first in still air, checking the temperature in all the resistors (Fig. 3). Figure 4 reports the temperature profile in the whole structure.

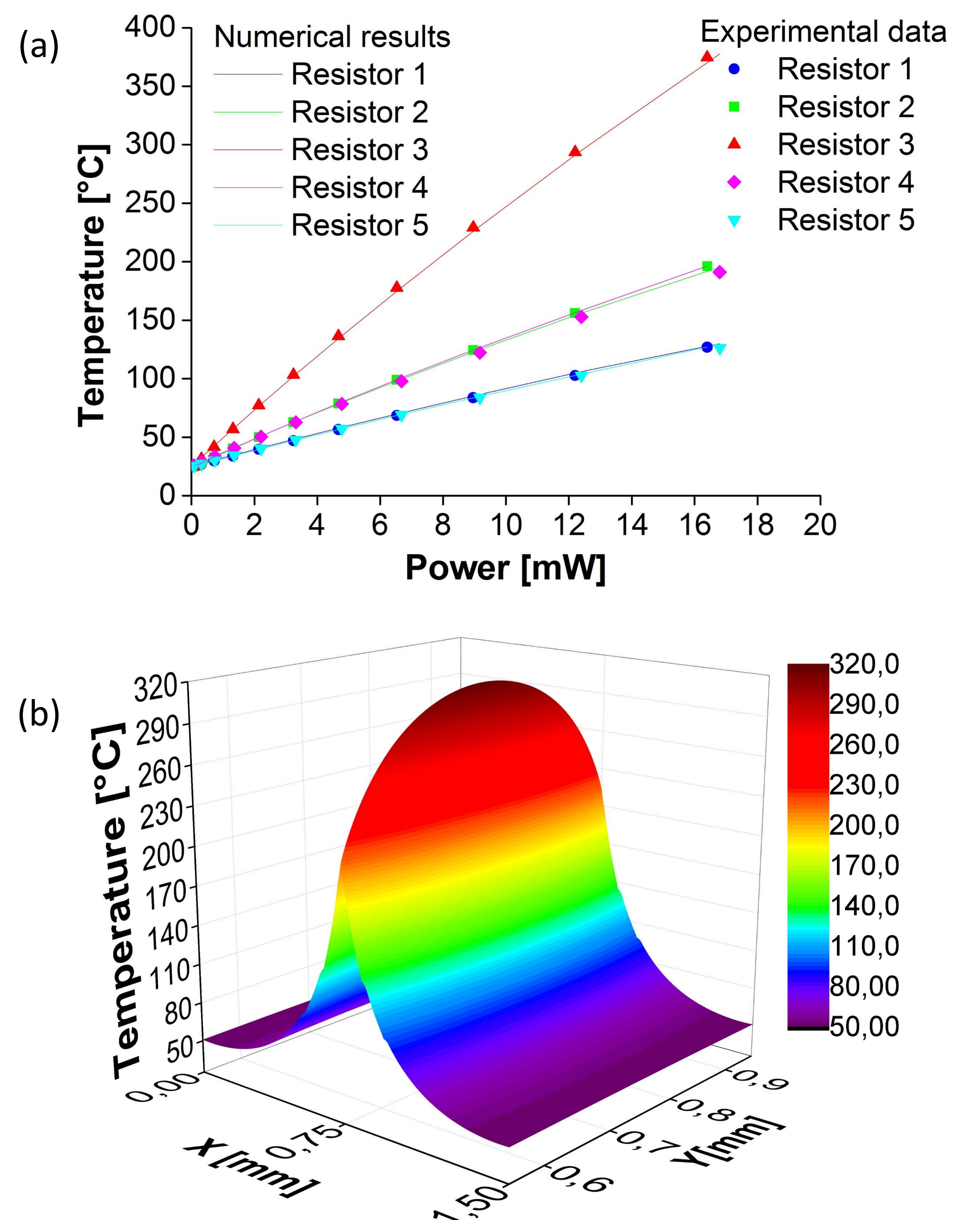


Figure 3: thermal characterisation in still air. (a) temperature in the resistors, (b) temperature profile.

The sensor has been then included in a flow, and characterised for the wall shear stress τ defined as

$$\tau = \mu \cdot \left. \frac{\partial u}{\partial z} \right|_{z=0}$$

Results are reported in Fig. 5.

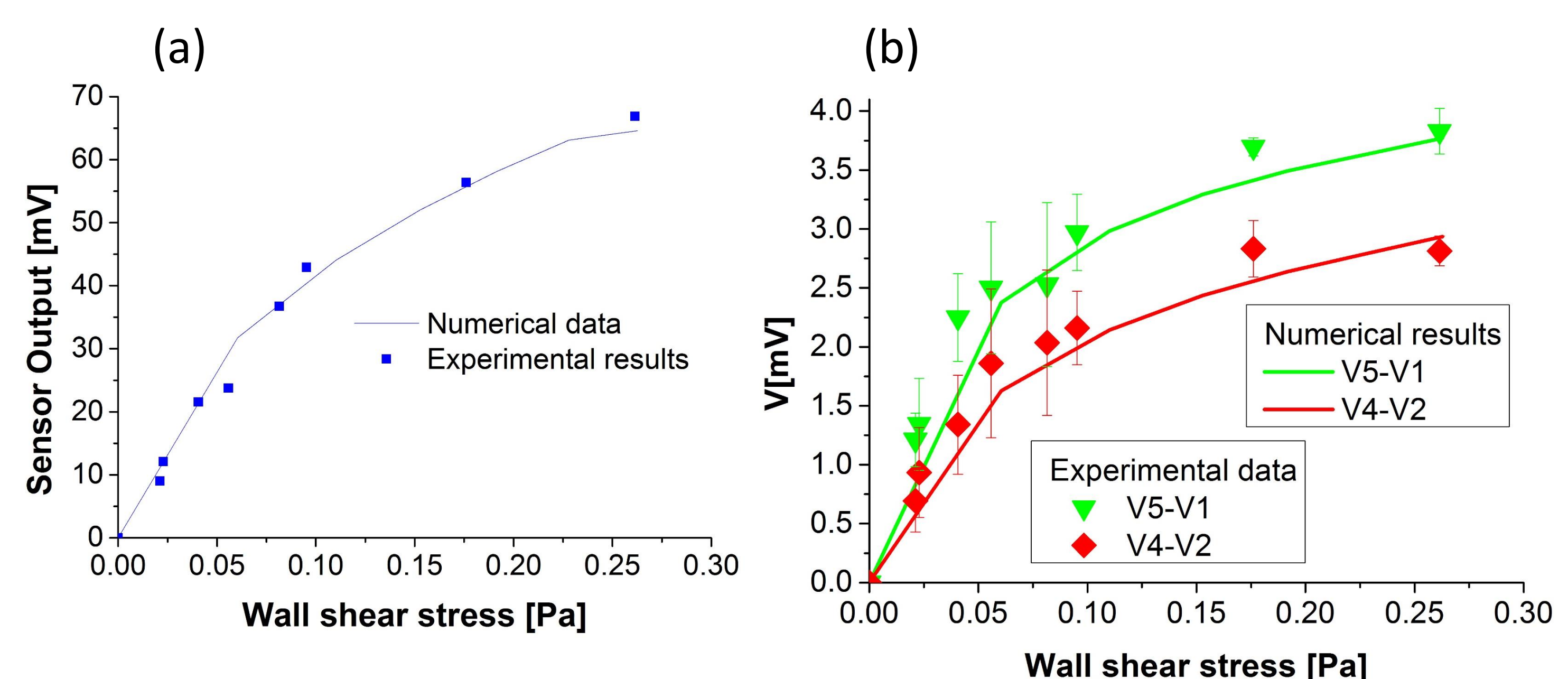


Figure 4: sensor output as a function of τ . (a) voltage across resistor 3; (b) voltage difference among the lateral resistors.

Conclusions: A complete multiphysics 3D model has been developed for the description of thermal flow sensors. The results have been compared with the behaviour of a wall shear stress sensor, giving a perfect agreement in every condition.