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Integrated LTCC Micro-Fluidic Modules - an SMT Flow Sensor

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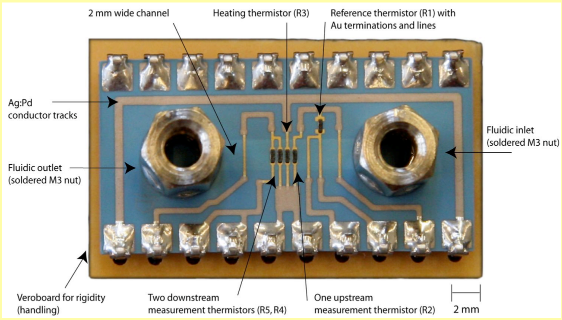
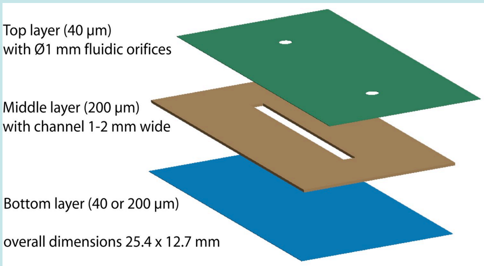
This **low-cost** flow sensor is based on the **anemometric principle**. It allows measuring **water flows between 5 and 5000 µl/min** with a power consumption of **40 mW**.

Fluidic inlet and outlet are simply soldered M3 nuts. Their **soldering process is compatible with the surface-mount technology**, thanks to an Ag:Pd metallization layer.

LTCC (Low-Temperature Cofired Ceramic) is mainly composed of alumina and glass.
It has considerable interest as a material for microfluidics due to its:
- ease of **3D structuration** (laser cut)
- possibility of **integration of functional layers** (cofiring and postfiring)
- hermeticity and outstanding **chemical and thermal stability**.

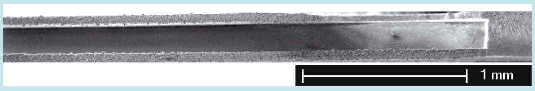


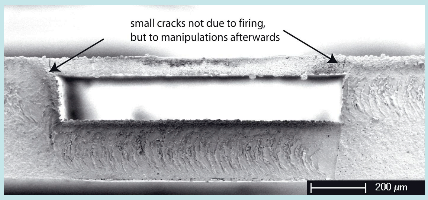
The complete flow sensor (2 mm wide channel version)



Schematics of the flow sensor made of three LTCC layers, before screen printings

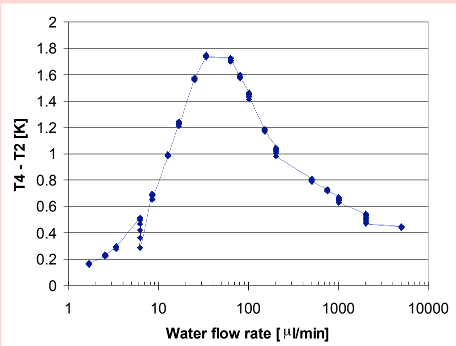
The body is made of LTCC. It consists of **two lids cofired with a thick middle layer**, where a channel has been cut out.





SEM of 1 mm channel (top picture longitudinally, transversally at bottom)

Proper manufacturing conditions ensure **absence of delamination** between the LTCC layers, and almost no sagging of the channel despite its relatively large span (1-2 mm). These are frequently encountered problems in the manufacturing of LTCC membranes.



<- Temperature difference between R4 and R2 vs. water flow rate.

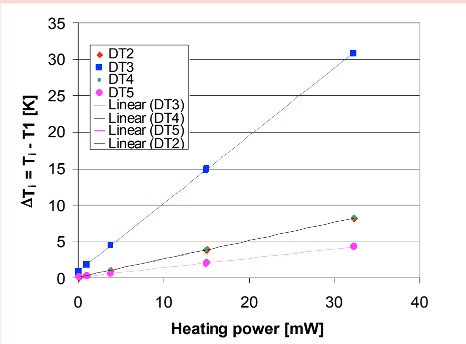
Results

The difference of temperature between T4 (downstream) and T2 (upstream) vs. water flow rate shows:
- a linear relation for flows between 6 and 33 µL/min.
- above 100 µL/min, the water does not redistribute its heat to R4 efficiently, and the sensitivity decreases.

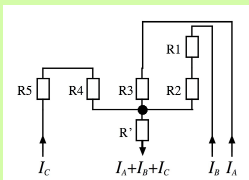
The thermal responses of R2 and R4 (located symmetrically around R3) are identical, as can be seen on the lower graph with the superposition of their measurements.

The influence of the distance from R3 is demonstrated by the lower sensitivity of R5, which is located further away than R2 and R4

<- Temperature rise of R2…R5 vs. heating power in still water.



A thick-film thermistor heating / sensing circuit is screen printed onto the surface. The sensing circuit is hermetically isolated from the medium, which allows the measurement of aggressive fluids in both directions.



Flow sensor equivalent circuit

R1: temperature reference resistor
R3: heating resistor
R2, R4, R5: measuring resistor
R': parasitic resistor (shared electrical ground path)

Example of direct application of the flow sensor in a double-input 5-layer calorimeter (here not yet screen printed). ->