Micro Coriolis Flow Sensor

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In recent years, the interest in integrated microfluidic systems has been steadily growing. In these systems (for instance (bio)chemical and DNA analysis and synthesis devices), accurate dosing of liquids and/or gases is of great importance. To achieve this, accurate (mass) flow sensing is necessary. This project is dedicated to the development of a new micro Coriolis flow sensor. The inherent characteristics of such a sensor make it suitable to directly measure mass flow, independent of the temperature, pressure, etc., of the liquid.

The Coriolis force arises when a certain fluid mass is flowing in an established direction, in a rotating system. The rotation of the system causes the mass flow to change direction. This can be expressed by:

$$\vec{F}_c = -2\vec{\omega} \times \vec{M}_f$$

Where F_c is the Coriolis force vector, ω is the fluid angular velocity, and M_f is the fluid mass flow vector (see also Fig. 1).

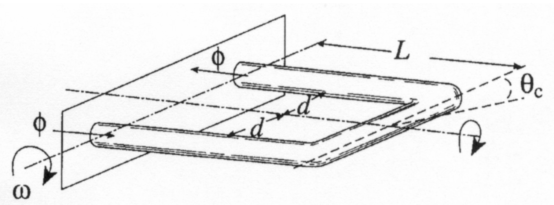

Fig. 1 *U-shaped Coriolis sensor (θ_c is the deformation due to torsion, caused by the Coriolis force) [1].*

In the past, Coriolis flow sensors have mainly been used for measuring high flow rates. Downscaling a Coriolis sensor is not straightforward, since the Coriolis force is very small and directly proportional to the mass flow, making it hard to measure low mass flow rates. As the dimensions of a system become smaller, its stiffness increases, so the already very small Coriolis force generates an even smaller displacement of the structure.

Some of the main technological challenges in this project are to minimise fabrication errors and to optimise the design of the sensor (keep the stiffness low, the mass of the tube should also be low compared to the liquid volume flowing through it).

To address these issues, a new process is proposed to fabricate the tube structures, based on the recently developed surface channel technology [2]. In short, a channel is isotropically etched in a silicon substrate, after which a thin silicon nitride layer is grown to create the channel wall and to close the channel. Then the silicon surrounding the channel is etched away, leaving a thin-walled, freely suspended structure (Fig. 2).

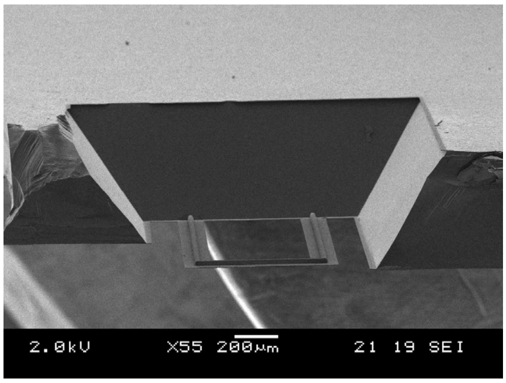

Fig. 2 Free hanging *U-shaped silicon nitride channel.*

Other vital factors in the system are for instance the excitation and detection methods (electrostatic/capacitive, thermal, optical, magnetic). Packaging of the system (vacuum bonding, fluidic connections) is to be addressed as well.

References

[1] P. Enoksson, G. Stemme and E. Stemme, J. MEMS, **6**, 119 (1997).
[2] M. Dijkstra, M.J. de Boer, J.W. Berenschot, T.S.J. Lammerink, R.J. Wiegerink and M. Elwenspoek, presented at Micromechanics Europe 2006.