Theme: Innovations in fabrication and instrumentation
Preference: for oral presentation

OPTIMIZATION OF THE LORENTZ FORCE ACTUATION FOR A MICRO CORIOLIS MASS FLOW SENSOR

J. Groenesteijn[1,2], T.S.J. Lammerink[1], R.J. Wiegerink[1], J. Haneveld[1,2], J.C. Lötters[1,2]
[1]*MESA+ Institute for Nanotechnology, University of Twente, Enschede, The Netherlands*
[2]*Bronkhorst High-Tech BV, Ruurlo, The Netherlands*

Novelty:

We have optimized the Lorentz force actuation of a micromachined Coriolis mass flow sensor. The previously used large permanent magnets resulted in a large sensor and a large magnetic field outside the sensor. The location and size of the permanent magnets has been characterized and optimized using measurements and FEM simulations, resulting in a significant reduction of size of the total sensor as well as reducing the magnetic field outside the chip area by 6 orders of magnitude without reducing the performance of the sensor.

Operation principle:

The Coriolis mass flow sensor is based on a vibrating tube to measure the Coriolis force as a result of the mass flow through the tube. The tube is being actuated by a Lorentz force (F_L) caused by an alternating current (i_a) through a metal track on top of the tube which is in a static magnetic field (B) due to permanent magnets as shown in equation (1). Figure 1 shows a schematic view of these parameters, Figure 2 shows a photo of the sensor with the previously used permanent magnets.

$$\vec{F}_L(t) = L_y(\vec{i}_a(t) \times \vec{B}) \tag{1}$$

Results:

The large magnets of over 500mm^2 have been replaced by magnets of only 1mm^2. Figure 3 shows a simulation of the magnetic field of the large (fig 3a) and small (fig 3b) magnets. The relevant component of the magnetic field of both types of magnets at the location of the metal track on the tube is shown in figure 4. The consequences of the change have been characterized using several different measurements and FEM simulations. These showed a reduction of the magnetic field strength at the relevant parts of the tube of a factor between 1.6 and 2.2. After correcting the actuation current for the reduced magnetic field, the performance as mass flow sensor has been measured. The results shown in figure 5 show no deterioration of the performance of the sensor. Further characterization of the Lorentz actuation to reducing external influences is being done.

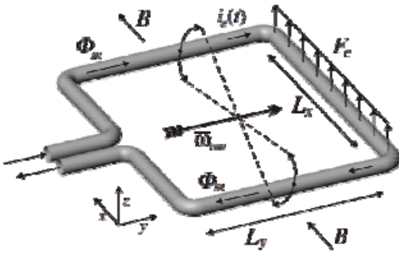

Fig. 1: *Schematic view of the operating principle of the micro Coriolis mass flow sensor.*

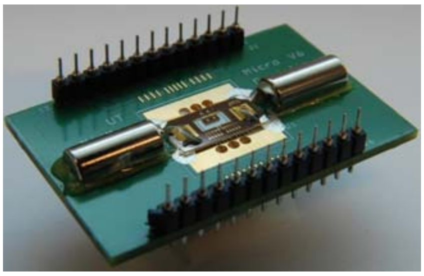

Fig. 2: *Photo of the chip mounted on a PCB. The large magnets are shown at both sides of the chip.*

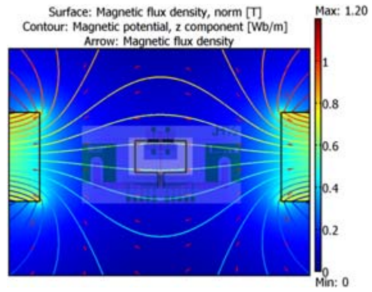

Fig 3a: *Magnetic field distribution as a result of the large magnets next to the chip. The Comsol simulation-results are overlaid by a semi-transparent image of the mask of the chip.*

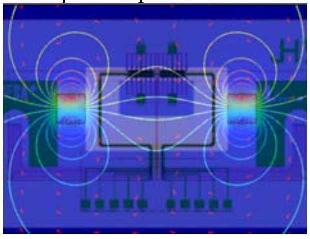

Fig 3b: *Magnetic field distribution as a result of the miniature magnets placed next to the tube. The Comsol simulation results are overlaid by a semi-transparent image of the mask of the chip.*

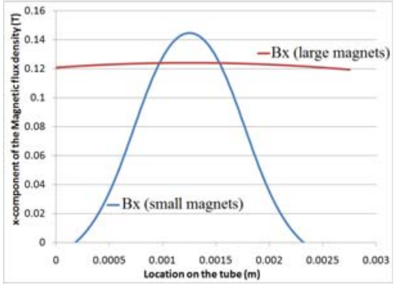

Fig. 4: *Simulated distribution of the x-component of the magnetic field along the y axis on top of the tube.*

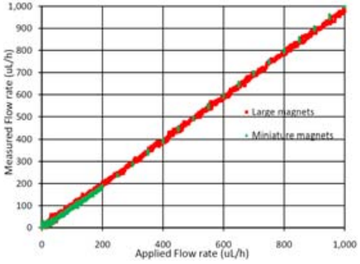

Fig. 5: *Mass flow measurements using a sensor with the old large magnets (red) and using a sensor with the new miniature magnets (green)*