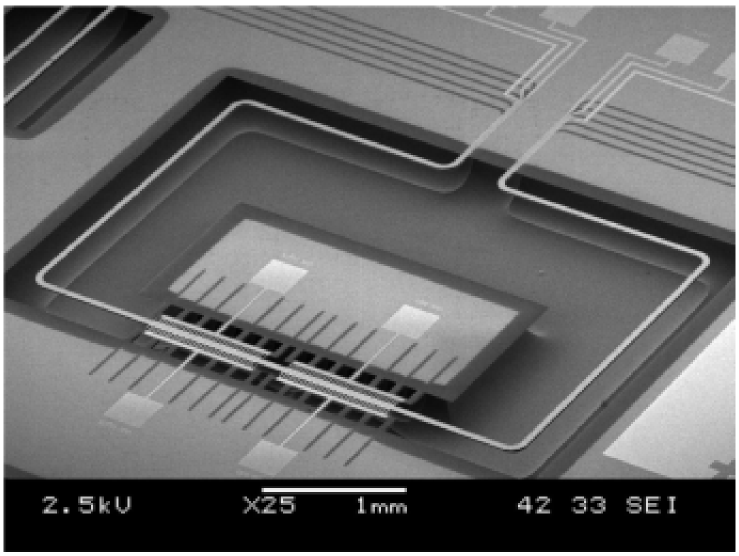
Measuring flow using a wobbling tube

December 18 2012

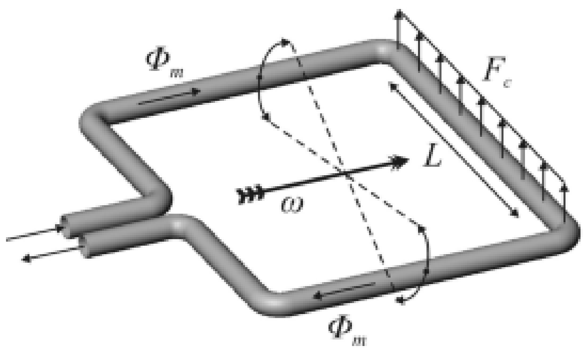


Scanning Electron Microscope image of the Coriolis mass flow sensor.

One milligram per hour: fluid flow can be measured with great precision using a tiny 'wobbling' tube with a diameter of only 40 micrometres. Thanks to a new technique, the sensor, which makes use of the 'Coriolis effect', can be made even more compact, e.g. for medical applications. Scientists at the University of Twente's MESA+ Institute for Nanotechnology have published an article on the subject in *Applied Physics Letters*.

Coriolis meters are often enormous instruments mounted in a pipeline to measure liquid flow accurately. Reduced to micrometre dimensions the result is a sensor that can measure extremely slow-moving small quantities of fluids. The fluid is passed through a tiny rectangular tube that is made to wobble. The Coriolis effect then causes the tube to move upwards as well, and this upward displacement is a measure of the amount of fluid flowing through it.

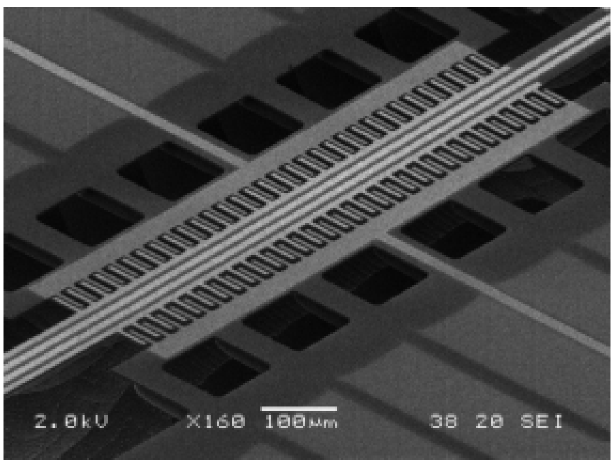
No magnets



Mechanism of action: the tube is rotated in a wobbling motion (curved arrows). As a result of the Coriolis effect the flowing fluid also experiences an upward force, which is a measure of the flow.

Until now magnets have been used to bring about the wobbling motion. One of the problems was that the magnets are far bigger than the actual sensor. In the *Applied Physics Letters* article researcher Harmen Droogendijk introduces a new method, known as 'parametric excitation'. Dozens of 'electric fingers' attached to the tube fit between identical opposing fingers mounted on supports running parallel to the tube. The extent to which these opposing sets of fingers slide between one another can be used to measure the tube's lateral displacement. But we could also use them to set the tube in motion, thought Droogendijk. He found that there is a limited area of electrical tension where the tube moves up and down much more than at a lower or higher tension, though this has to be tuned very precisely. Droogendijk carried out mathematical modelling, resulting in a new design that no longer needs magnets. More research is needed to find out whether the current lower limit of approximately 1 milligram per hour can be lowered even further.

The research was carried out in the Transducers Science and Technology group led by Prof. Gijs Krijnen, which is part of the University of Twente's MESA+ Institute for Nanotechnology. It received financial support from NanoNed NL.



Detail of the ‘fingers’ on the tube (diagonal from below left to top right, with three parallel lines on top) and on either side, for the wobbling motion.

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The Coriolis mass flow sensor is being further developed by Bronkhorst High-Tech in Ruurlo to produce a precision instrument for such things as monitoring medical IV pumps, analysing medicines using liquid chromatography, and use in microreactors and the manufacture of solar cells.

The article, ´Parametric excitation of a micro Coriolis mass flow sensor´, by Harmen Droogendijk, Jarno Groenesteijn, Jeroen Haneveld (Micronit Microfluidics), Remco Sanders, Remco Wiegerink, Theo Lammerink, Joost Lötters (Bronkhorst High-Tech) and Gijs Krijnen, has been published in *Applied Physics Letters*.

Provided by University of Twente