Explosion on chip sets liquid in motion

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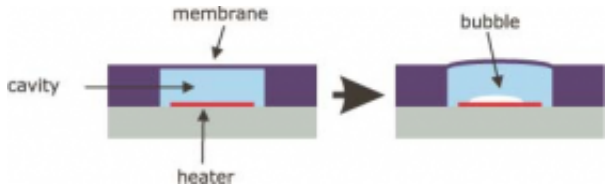

Simplified version of the micro-bubble actuator developed by Van den Broek. The right illustration shows that the membrane is deflected by the bubble formed near the heater.

(PhysOrg.com) -- PhD student, Dennis van den Broek, of the University of Twente, Netherlands, has developed a new type of miniature motor, the micro-bubble actuator. This 'motor', which can be used in laboratories the size of a chip, for instance, converts the energy released during explosive evaporation into motion. Van den Broek will be defending his PhD on 31 October at the Faculty of Electrical Engineering, Mathematics and Computer Science (EEMCS).

A (micro-)actuator is a device that converts energy, such as magnetic or heat energy into motion. There are many different types of micro-actuators, each with its own advantages and disadvantages. Often actuators are fast or powerful, but not both. However, Van den Broek has designed a micro-actuator that is fast and powerful at the same time. To this end he used heat. This heat is converted into motion by the micro-actuator.

The micro-actuator developed by Van den Broek consists of a cavity filled with a liquid (for instance, ethanol), with a heater at the bottom. The cavity is closed off by a membrane or thin skin that closes the system. Actuators can be found in various places, including in the ‘lab-on-a-chip’, a tiny chemical laboratory the size of a chip. In order to pump liquids through the tiny canals, pumps and valves of the same size are required. The micro-actuator developed by Van den Broek may fulfil a key role in this.

The micro-bubble actuator

In order to make the new actuator powerful and fast, Van den Broek used a promising technology based on explosive evaporation. Explosive evaporation takes place when a liquid is exposed to a high temperature. In a few microseconds the liquid reaches a temperature close to the critical point, far above the boiling point of the liquid in question under normal conditions. At this temperature the liquid evaporates. This is characterized by the formation of a large number of bubbles in the liquid, similar to when water boils. The bubbles formed merge almost immediately to form a layer of vapour. The resulting pressure that builds up is used to deflect a membrane. The 'bulging' of the membrane sets the liquid above it in motion.

Because the bubbles arise in a small volume, the actuator is fast. Van den Broek sent a heat impulse through the heater at least every 0.1 millisecond. This means that a bubble is formed 10,000 times a second and the membrane is deflected. Combined with the high pressure that can be generated by the heat, the actuator is also powerful.

Micro-pumps

The new actuator can be used as a tiny pump in a micro-fluidic system,

an example of which is the ‘lab-on-a-chip’. The tiny channels through which the liquid must flow are squeezed together by the bulging, so that the liquid acquires speed. If enough of these micro-actuators are placed one after the other and activated in the right order, the liquid will continue to flow.

Source: University of Twente