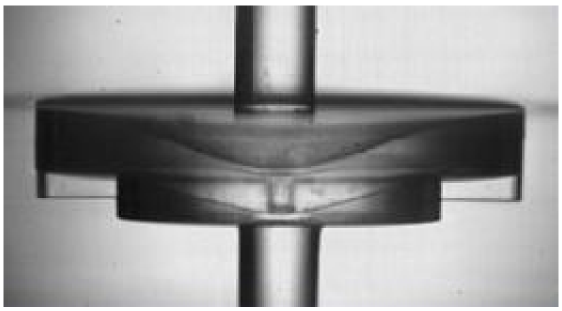
Microfluidics: Creating chaos

May 10 2012, By Lee Swee Heng



The microfluidic oscillator mixer developed at the Singapore Institute of Manufacturing Technology. Credit: © SIMTech

A quiet revolution is taking place in the fields of biology and chemistry. Microfluidic devices, which allow fluid manipulation in micro-scale channels, are slowly but surely finding their place on the lab bench. A new microfluidic device can operate as a mixer or a valve, improving the efficiency of micro-scale laboratory apparatus.

These tools are increasingly taking the place of the usual macro scale glassware and offer a number of benefits including faster processing, less reagents, less waste and greater reaction control. However, at these small scales, fluids tend to flow in parallel layers which do not interact — a phenomenon known as laminar flow — meaning that mixing of reagents becomes difficult. However, recent work by Huanming Xia and colleagues from the Singapore Institute of Manufacturing Technology based at A*STAR introduced a new microfluidic device which changes laminar fluid flow into an oscillating flow, which substantially enhances the efficiency of mixing.

The A*STAR team used the natural elasticity of a thin, flat silicone membrane freely supported on a circular stepped cavity separating two chambers through which liquid flows perpendicular to the membrane. When fluid is pumped through the chamber, the membrane deflects, becoming convex downstream of the flow, although the flow remained laminar and stable. Further deflection of the membrane occurs until the elasticity and lift forces of the silicone makes the membrane bounce back and the process then repeats, leading the generation of an oscillating fluid flow. The device can also work as a valve; at higher pressures, the membrane completely blocks the forward flow whilst reverse flow forces the membrane to the ceiling of the upper chamber, completely blocking fluid transfer.

The researchers also demonstrated the mixing behaviour of their device in a Y-shaped fluidic element in which a membrane oscillator was incorporated into one channel. When fluid was pumped into the other chamber, the presence of the membrane prevented mixing of the two liquid streams. Subsequent introduction of a second liquid at low pressure allowed the fluid streams to meet at the intersection point of the Y-shaped channel although at this point flow was laminar and no mixing occurred. However, increasing the pressure from the oscillator-containing channel led to the generation of oscillatory behavior with the result that the two fluid flows mixed chaotically.

The researchers are also working on an improved oscillator design employing a thin metal spring foil in place of the silicon rubber diaphragm. Such measures are intended to improve still further the mixing performance of the system and lead to more durable membrane mixing systems.

More information: Xia, H. M. et al. Converting steady laminar flow to oscillatory flow through a hydroelasticity approach at microscales. Lab on a Chip 12, 60 (2012).

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