Microfluidic integrated circuit could help enable home diagnostic tests (w/ Video)

April 21 2010

(PhysOrg.com) -- As a way to simplify lab-on-a-chip devices that could offer quicker, cheaper and more portable medical tests, University of Michigan researchers have created microfluidic integrated circuits.

Just as electronic circuits intelligently route the flow of electricity on computer chips without external controls, these microfluidic circuits regulate the flow of fluid through their devices without instructions from outside systems.

A paper on the technology is newly published online in Nature Physics.

A microfluidic device, or lab-on-a-chip, integrates multiple laboratory functions onto one chip just centimeters in size. The devices allow researchers to experiment on tiny sample sizes, and also to simultaneously perform multiple experiments on the same material. They can be engineered to mimic the human body more closely than the Petri dish does. They could lead to instant home tests for illnesses, food contaminants and toxic gases, among other advances.

“In most microfluidic devices today, there are essentially little fingers or pressure forces that open and close each individual valve to route fluid through the device during experiments. That is, there is an extra layer of control machinery that is required to manipulate the current in the fluidic circuit,” said Shu Takayama, the principal investigator on the project. Takayama is an associate professor in the U-M Department of Biomedical Engineering.

That’s similar to how electronic circuits were manipulated a century ago. Then, with the development of the integrated circuit, the “thinking” became embedded in the chip itself—a technological breakthrough that enabled personal computers, Takayama said.

“We have literally made a microfluidic integrated circuit,” said Bobak Mosadegh, a doctoral student in Takayama’s lab who is first author of the paper.

The external controls that power today’s microfluidic devices can be cumbersome. Each valve on a chip (and there could be dozens of them) requires its own electromechanical push from an off-chip actuator or pump. This has made it difficult to shrink microfluidic systems to palm- or fingertip-sized diagnostic devices.

The Takayama lab’s innovation is a step in this direction. His research group has devised a strategy to produce the fluidic counterparts of key electrical components including transistors, diodes, resistors and capacitors, and to efficiently network these components to automatically regulate fluid flow within the device.

These components are made using conventional techniques, so they are compatible with all other microfluidic components such as mixers, filters and cell culture chambers, the researchers say.

“We’ve made a versatile control system,” Mosadegh said. “We envision that this technology will become a platform for researchers and companies in the microfluidics field to develop sophisticated self-controlled microfluidic devices that automatically process biofluids such as blood and pharmaceuticals for diagnostics or other applications.

“Just as the integrated circuit brought the digital information processing power of computers to the people, we envision our microfluidic analog will be able to do the same for cellular and biochemical information."

The paper is titled "Integrated Elastomeric Components for Autonomous Regulation of Sequential and Oscillatory Flow Switching in Microfluidic Devices."

Provided by University of Michigan