Mass-produced microvalves are the key to scalable production of disposable, plug-and-play microfluidic devices

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A series of mass-produced microvalves. Credit: A*STAR Singapore Institute of Manufacturing Technology

The elusive 'lab on a chip' capable of shrinking and integrating operations normally performed in a chemical or medical laboratory on to a single chip smaller than a credit card, may soon be realized thanks to disposable, plug-and-play microfluidic devices developed by A*STAR researchers1.

Microfluidic systems use networks of channels much narrower than a human hair to control the movement of miniscule amounts of fluids.

Recent advances in microfluidics technology have proven invaluable for immediate point-of-care diagnosis of diseases and have greatly improved enzymatic and DNA analysis. High throughput microfluidic systems are also being employed in stem cell studies and for the discovery of new drugs.

A stumbling block for successful miniaturization and commercialization of fully integrated microfluidic systems, however, has been the development of reliable microfluidic components, such as microvalves and micropumps. Zhenfeng Wang and colleagues from the Singapore Institute of Manufacturing Technology (SIMTech), A*STAR have removed that obstacle by developing an efficient and scalable method to fabricate disposable plug-and-play microfluidic devices.

"Integrating valves and pumps into thermoplastic devices is usually challenging and costly because the fabrication process is very complicated," says Wang. "Mass-producing the microvalve module separately from the main device, however, makes the fabrication of the main device relatively simple and robust."

Microvalves consist of a flexible diaphragm sandwiched between a control chamber and liquid chamber, and by applying pressure from an external mechanical pump, or through electrostatic or pneumatic forces, the diaphragm can be deformed allowing for the manipulation of fluidic flow within the chamber. The researchers fabricated a micropump consisting of three microvalves, but had to find a suitable material for the microvalve membranes, which must be flexible, but also easily bonded to other parts of the microvalve without the use of adhesives.

"We found that thermoplastic polyurethane film works well as the membrane and can be bonded tightly with the main body, which is made from polymethyl methacrylate," explains Wang.

The design of the microvalve also presented a challenge to the researchers, which they overcame by using finite element method simulation—a numerical tool used to solve complex structural problems—to generate the design guidelines, which were then verified by experimentation.

Using the SIMTech Microfluidics Foundry, the researchers are currently developing a number of 'on chip' modules and are expanding their capabilities in the design, prototyping and manufacture of polymer based microfluidic devices.

"Further miniaturizing the size of microvalve modules could increase the scale of integration and broaden the range of potential applications," says Wang.

More information: Seyed Ali Mousavi Shaegh et al. Plug-and-play microvalve and micropump for rapid integration with microfluidic chips, *Microfluidics and Nanofluidics* (2015). DOI: 10.1007/s10404-015-1582-4

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