TURNING VALVES FOR LAB-ON-A-CHIP APPLICATIONS ENABLE DIRECTIONAL FLOW AND PORTION OUT PRE-DEFINED VOLUMES

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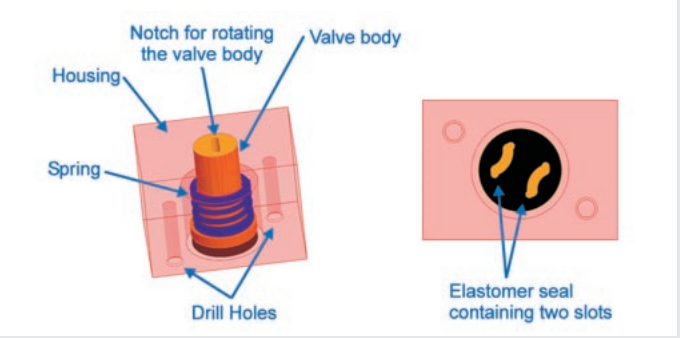
The development of preferably simple, low-cost and simultaneously reliable valve mechanisms is a challenging task during the realization of micro-fluidic and lab-on-a-chip applications. Especially when designing biological systems, the problem of contamination is always involved. So commonly polymer-based disposables are required.

A highly miniaturized lab-on-a-chip system requires fluid control and thus active and integrated valves. The metering of small amounts of liquids and the subsequent feeding of these volumes to channels inside the polymer chip is a further task which can be solved by an appropriate valve mechanism. In this study we present the design and the realization of low-cost valves suitable for the integration into disposable polymer chips. In contrast to commonly used sandwich-setups a plain design consisting of a simply structured polymer chip and a cover membrane is used.

Turning valve build-up



These CAD drawings show the build-up of the presented turning valve. A housing made of PMMA encloses a valve body (also made of PMMA), a metallic spring and an elastomer seal. The seal is glued to the valve body and contains slots. By revolving the valve body different fluidic channels can be connected. Depending on the designated purpose, slot shape and number can vary. In the drawing above, two fluidic channels are connected simultaneously.

Metering of defined volumes

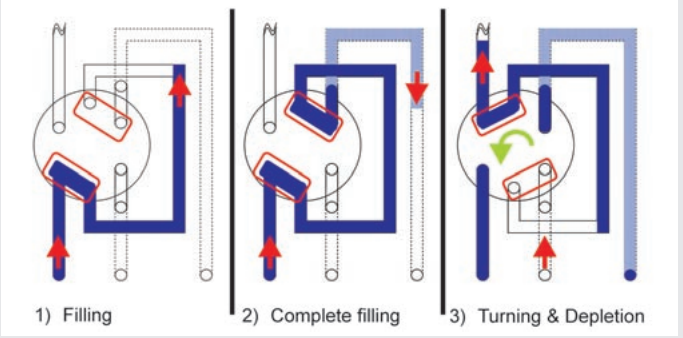
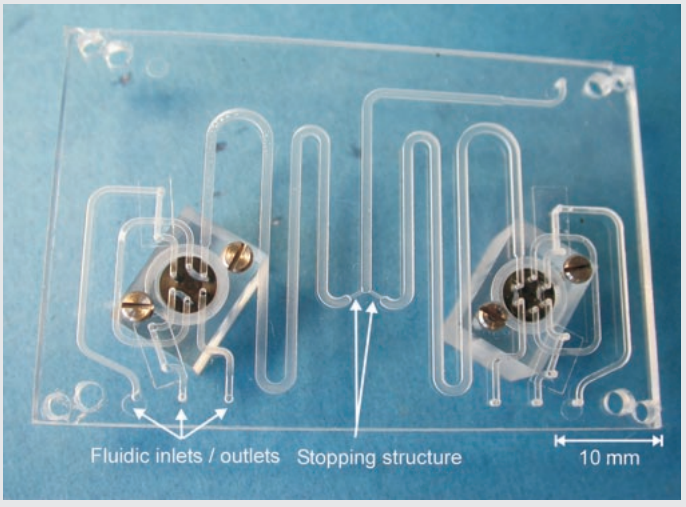


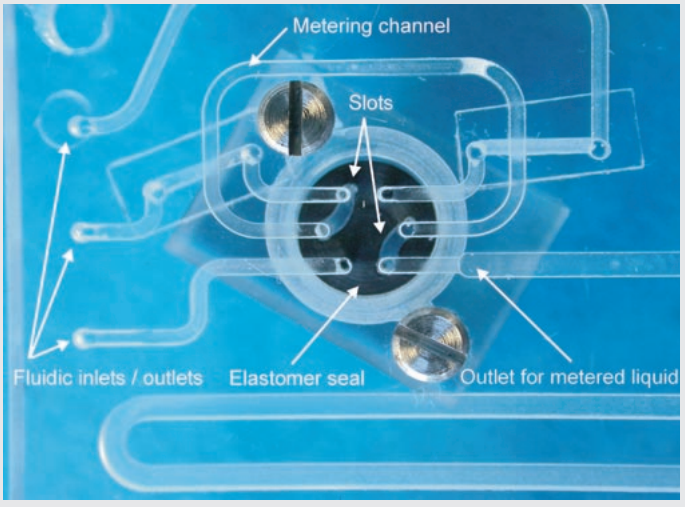
Figure 1 shows the filling of a metering channel with liquid. The red squares symbolize the rotatable slots of the turning valve. The metering channel is overfilled to avoid air bubbles. The surplus liquid is filled into a waste channel (see Figure 2). After rotating the valve it is possible to deplete the metering channel by applying a pressure (see Figure 3). The volumes of the metering channel and the two slots define precisely how much liquid is moved further on to the next task, for example merging and mixing of two measured liquid volumes.

Metering and merging chip



This picture shows a chip suitable for metering and merging two liquids by using two turning valves and a stopping structure. The chip is made of PMMA, structured by micromilling and covered with a polymer foil. The valves also consist of PMMA, bonded to an elastomer sheet working as a seal and containing two rotatable slots.

Closeup view of a metering valve



The picture above shows a closeup view of a metering structure. In this case the channels have a width of 0.6 mm. The metering channel together with the two slots possess a volume of 10 µl.

Conclusions and Outlook

The realized on-chip valves are adequate to a wide range of water flow rates up to 10 ml/min with corresponding pressures up to 2 bars (30 psi). The valves can be actuated manually for simple proof of concept applications. By using a small-sized electric motor the valves can be automatically actuated. Different valve types were successfully applied to lab-on-a-chip systems for sample preparation and DNA-amplification reactions. Therefore it was possible to meter small amounts of liquids and merge them together or divide a continuous fluid flow into different channels by rotating the valve.