A venous valve-like check valve for microfluidic device

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ABSTRACT

In this paper, we proposed a new venous valve-like check-valve(V^2CV) for microfluidic device which consist of two valve flaps made from PDMS. Compared to conventional check valves in microfluidic devices, this V^2CV has simpler structure and easier fabrication, make it possible to be applied in different kinds of microfluidic devices. Experiments were carried out to test its capacity of allowing forward flow and blocking reverse flow.

KEYWORDS: Venous, Check valve, Microfluidic

INTRODUCTION

Check valves are often essential components in microfluidic systems, providing one directional fluid flow and enabling staged or metered sample delivery for different devices like micro-pumps, micro-mixers and micro-reactors. The most common valves used in microfluidic devices are made from polydimethylsiloxane (PDMS), a flexible material that can be easy fabricated by photolithography, and use vacuum or pressure to occlude or open channels to flow. However, current PDMS check valves are relatively complicated since they are typically based on non-planar hybrid structures, making the fabrication and operation quite difficult [1-3]. More importantly, out-of-plane check valves are not easy to integrate with other planar microfluidic modules, which limits their application in microfluidic systems. Inspired from the structure of major venous valves, which consist of two valve flaps and contribute a lot to the efficient of venous return against gravity [4], a new kind of venous valve-like check-valve(V^2CV) which made from PDMS has been demonstrated in this paper. This planar check-valve has very simple structure without complex manipulation and easy integration with other microfluidic devices..

THEROY

Venous valves are very common and efficient check valves existing in our body. They typically consist of two elastic flaps of tissue, which enables blood to flow through the valve to another vein irreversibly (Figure 1). Based on bionic principle, we designed a venous valve-like check-valve(V^2CV) in microchannel with a pair of flaps made from Polydimethylsiloxane(PDMS), a widely used soft lithography material with good elasticity, chemical inertness as well as mechanical flexibility and durability[5].

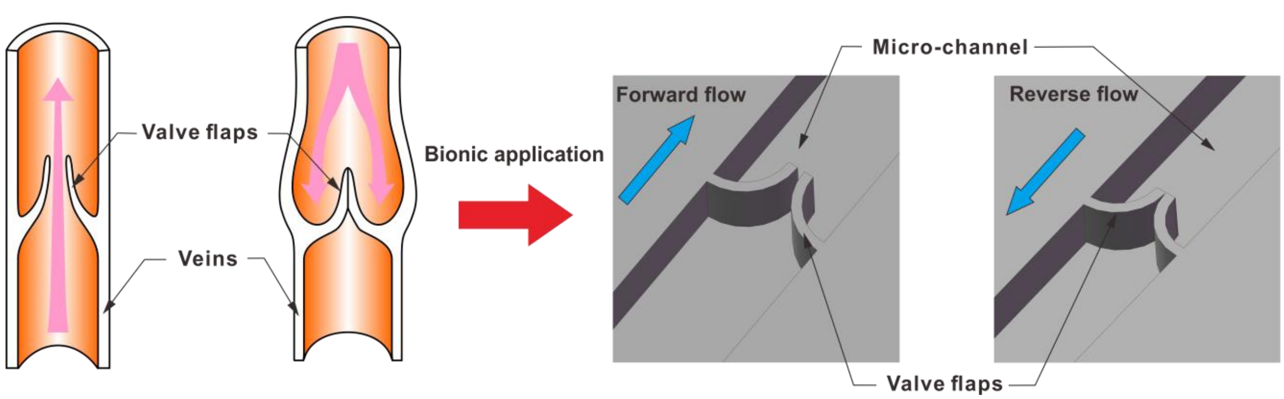
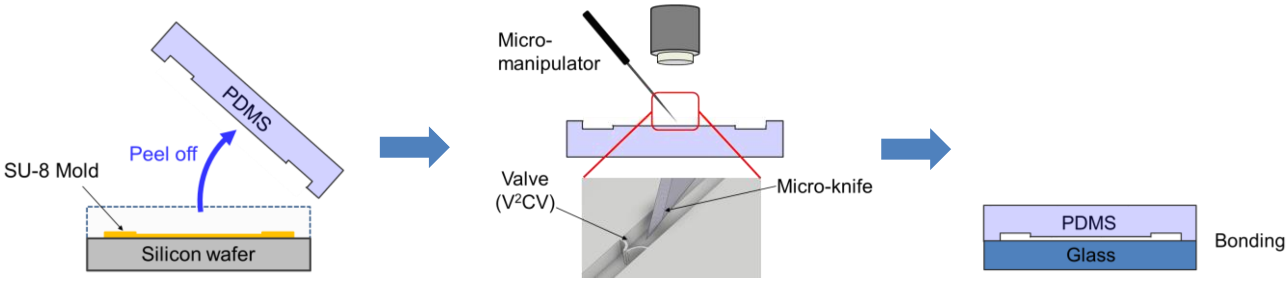


Figure 1. Working principle of venous valves in vein and valve-like check-valve(V^2CV) in microchannel.

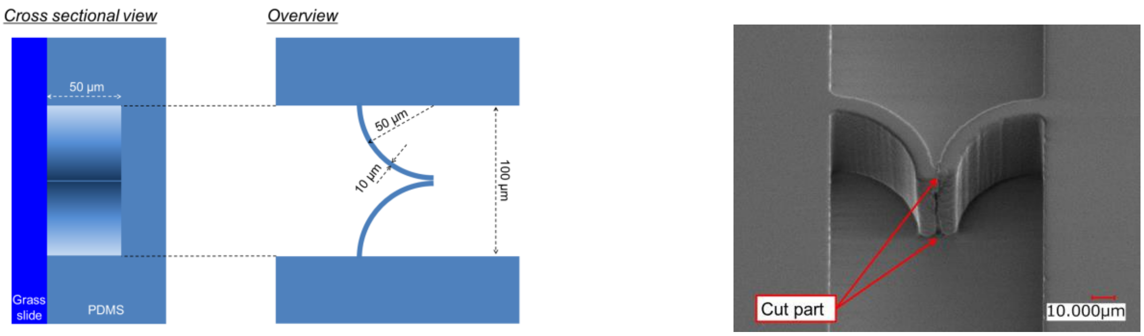
The V^2CV was installed in a straight micro-channel with a width of 100 µm and a height of 50 µm. The fabrication process is presented in Figure 2. After forming the SU-8 mold on the silicon wafer, PDMS solution, mixed with curing agent, was poured on the mold, and detached from the mold after 1 hour baking at 95℃ (a). Then the structure of valve was cut off into two flaps with a micro-knife operated by a micromanipulator (b). Finally, slide glass and PDMS were treated by oxygen plasma 10~40s under medium vacuum and bonded together (c).



(a) (b) (c)

Figure 2. Fabricating processes of micro fluidic channel and V^2CV.

Figure 3(a) shows the design size of V^2CV. The sizes of V^2CV could be adjusted according to different microfluidic devices. Figure 3(b) is the SEM image of fabricated V^2CV. PDMS flaps were cut off by a micro-knife along the line between two points indicated by arrows.



(a) (b)

Figure 3. (a) Scales of V^2CV. (b) SEM image of V^2CV.

EXPERIMENTAL

To test the performance of V^2CV, experiments were conducted in which water was flowed through the flow path with V^2CV by pressure control. Flow rates in different pressures were recorded by micro-flowmeter. The experimental setup is shown in Figure 4. Both forward and backward flow were tested and the pressure-flow rate characteristic curves are shown in Figure 5.

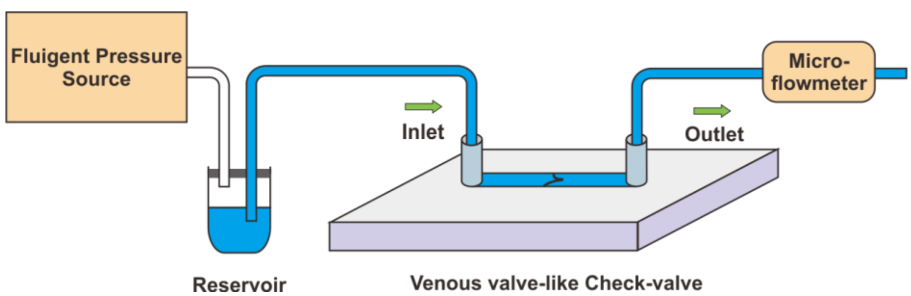


Figure 4. Schematic of experiment setup

RESULTS AND DISCUSSION

As shown in Figure 5, there was almost zero forward cracking pressure and the flow rate rose almost linearly with the pressure in the forward direction, which suggests the possibility that control of this valve for forward flow can be comparatively easy. For reverse flow, we can find that the pressure loading limit was confirmed to be higher than 30 kPa with negligible reverse, better than most existing micro check valve[2]. This result indicates that this valve can have sufficient function to apply it to microfluidic channel as a check valve.

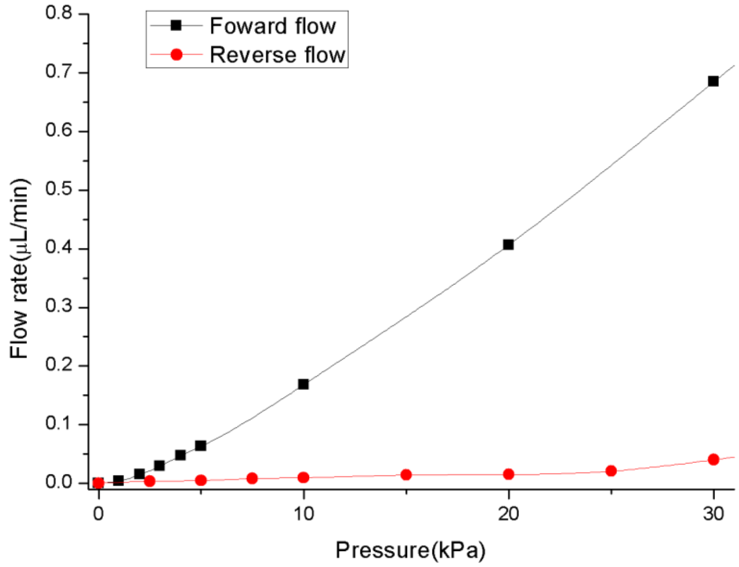


Figure 5. Pressure-flow rate characteristic curves of both forward and backward flow.

CONCLUSION

In this paper we presented a new kind of venous valve-like check-valve(V^2CV) for microfluidic devices and proved its excellent performance by experiments. Since V^2CV has a simple structure extracted from a two dimensional figure, it is not only easy to consider miniaturization of the size and optimization of its shape, but also possible to construct an integrated system in combination with this valve and other microfluidic components. It is thought that V^2CV will be applied as one of the important components of microfluidic devices.

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