Electronic Supplementary Information For

Elastomeric microfluidic valve with low, constant opening threshold pressure

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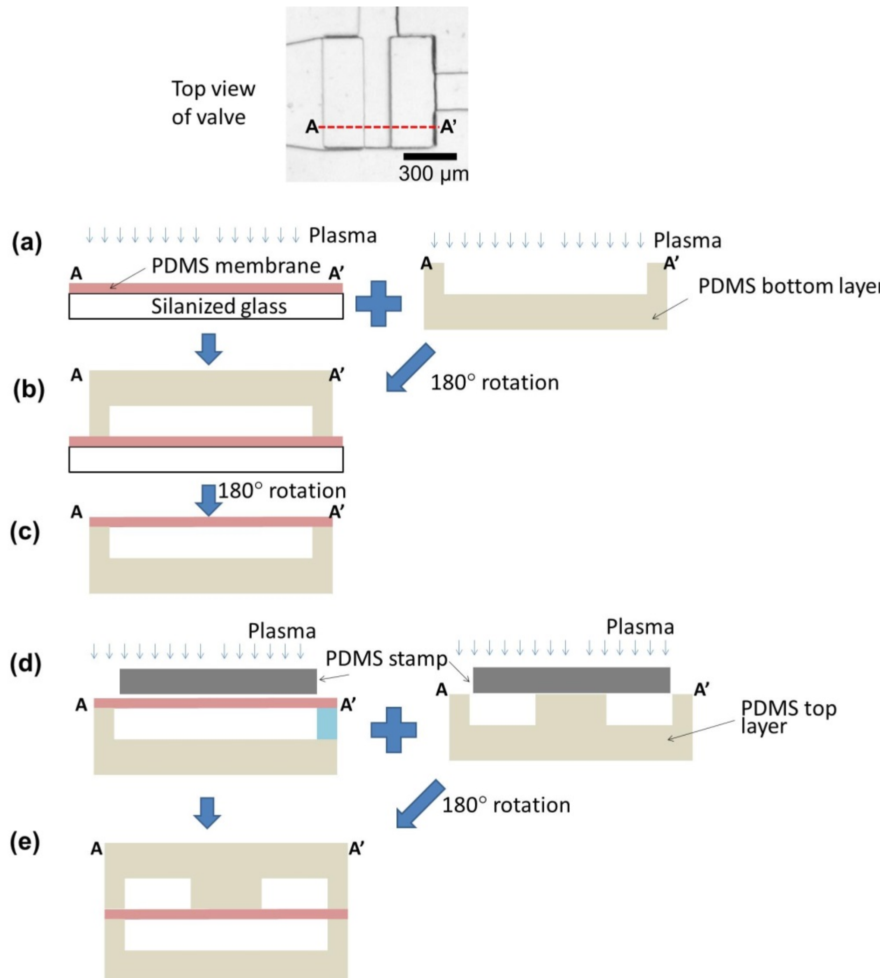
Fabrication process

The fabrication process is illustrated in Supplementary Fig. S1. The first step was to make a 20 μm thick-layer for the downstream fluidic resistor and the second step was to form a 100 μm thick-layer for the microfluidic features. The master mold was silanized with trichloro(1H,1H,2H,2H-perfluorooctyl)silane (Model 448931, Sigma Aldrich) in a desiccator for 1 h to promote the facile demolding of casting material. Then, the devices were cast against the master mold. The casting material was made from PDMS prepolymer and curing agent (Model Sylgard 184, Dow Corning) at a 10:1 ratio. The casting material on the master mold was cured in a 65 °C oven for 12 h. The middle layer was a 30 μm-thick membrane PDMS layer and was spin-coated on a silanized glass slide, and then cured in a 120 °C oven for 20 min. The PDMS stamps to prevent bonding between the valve seat and the membrane were made using a similar method to fabricate the top and bottom layers.

For the bonding of the three layers, we used a plasma oxidizer (Model Cute-1MP, Femto Science) with air for 30 s. While the middle layer was still on the glass slide, it was bonded to the bottom layer after plasma treatment of both layers. Then, the two bonded layers were cured in a 120 °C oven for 2 min. After peeling off the bonded two layers from the glass slide, we punched ~350 μm-diameter connection holes using a biopsy punch (Model 15070 Harris Unicore, Ted pella) in the middle layer. In the top layer, inlet and outlet holes were punched, and the top layer was aligned and bonded with the other two bonded layers followed by plasma treatment. To prevent bonding between the valve seat and the valve membrane, we placed PDMS stamps on the top layer of the valve seat and the middle layer of the valve area during plasma treatment.



Supplementary Fig. S1. Fabrication process of valve. Cross-sectional views are shown along lines of section A-A'. (a) Plasma treatment of middle (membrane) and bottom PDMS layer. (b) Irreversible bonding of the middle and the bottom layers. (c) Detachment of middle and bottom layer from glass slide, and punching connection holes in middle layer. (d) Selective plasma treatment of middle and top layer. PDMS stamps were temporarily placed to prevent the plasma treatment on the stamp region. (e) Alignment and bonding.

Membrane deflection

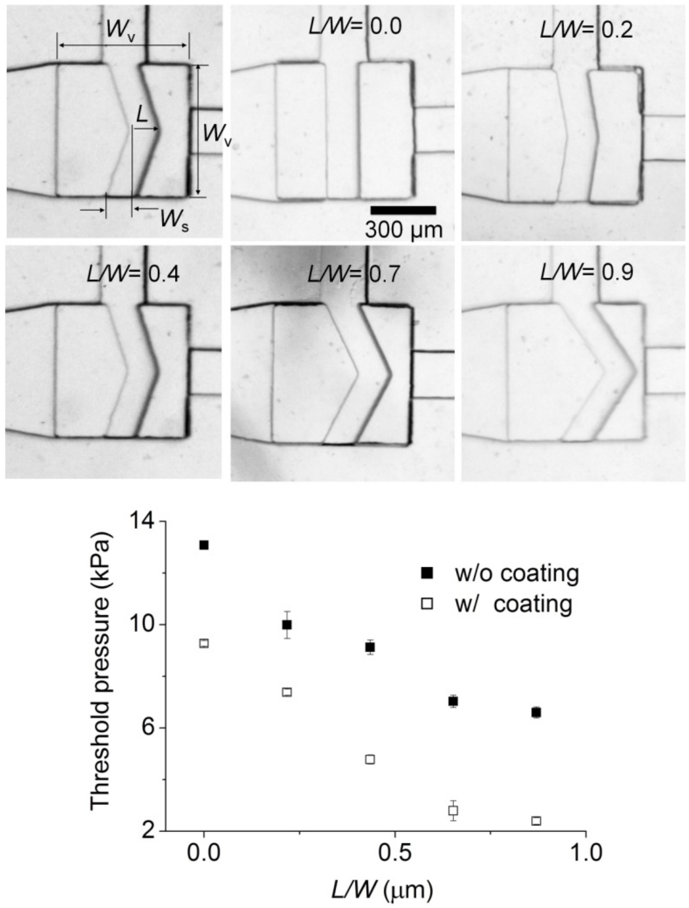
For the large deflection of a circular membrane, the membrane becomes stiff and the deflection-pressure response is nonlinear. The equation for the response is given by (ref. S1 and S2):

$$\frac{Pr^4}{Et^4} = k_1 \frac{x_{center}}{t} + k_2 \left(\frac{x_{center}}{t}\right)^3 ,$$

where P and E are applied uniform pressure and Young's modulus, respectively; k_1 and k_2 are constants; and x_{center} and t are the deflection at the membrane's center and membrane thickness, respectively. r is the radius of the circular membrane. If x_{center} is >> t, then the equation is $\frac{Pr^4}{Et^4} \sim k_2 \left(\frac{x_{center}}{t}\right)^3$. Then, x_{center} is $\propto r^{4/3}$ and r is $\propto A_c^{1/2}$, where A_c is the circular membrane area. Thus, we obtain the relation for the large deflection:

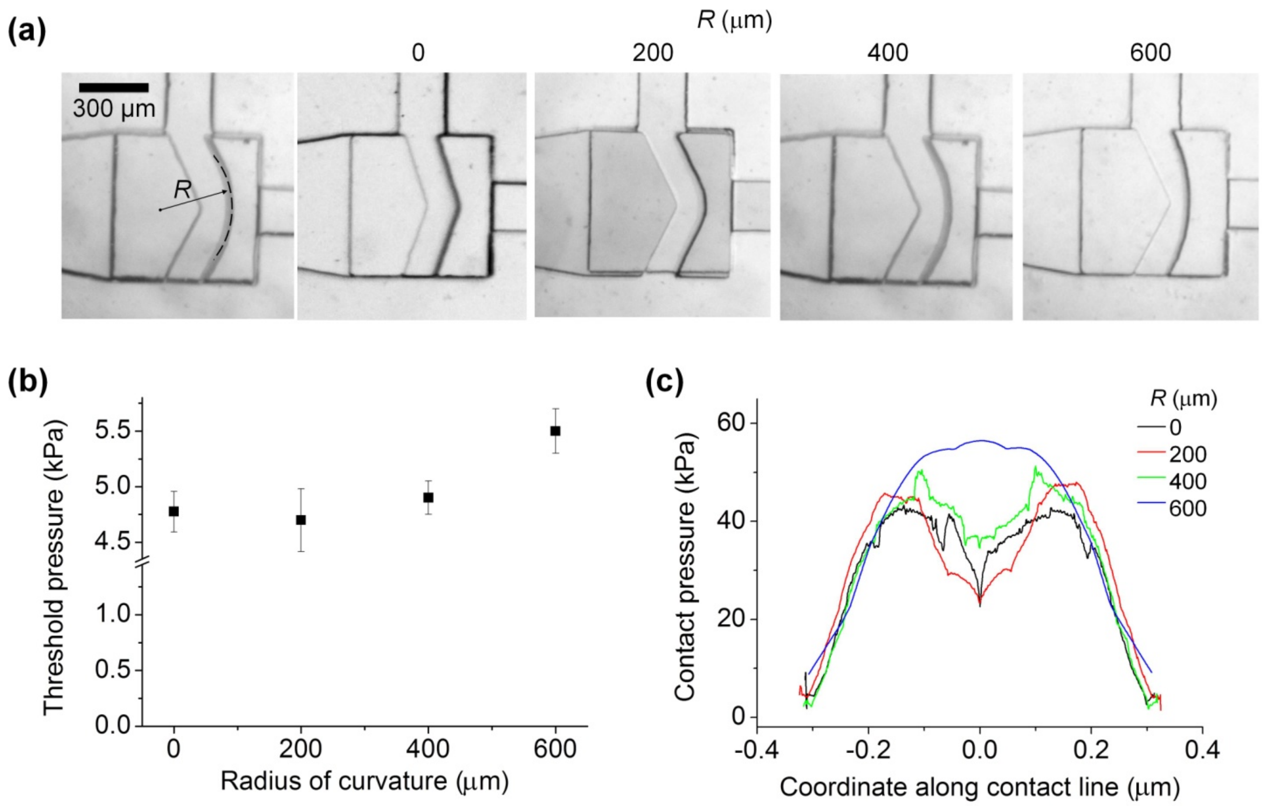
$$x_{center} \propto A_c^{2/3}$$

Influence of the biomolecule coating and *L/W* on the opening threshold pressure.



Supplementary Fig. S2. Effect of valve seat shape and biomolecule coating on opening threshold pressure. Valve width (W_v) and valve seat width (W_s) are 0.6 mm and 140 μm, respectively. W is defined as $(W_v - W_s)/2$.

Effect of the valve seat's radius of curvature on opening threshold pressures



Supplementary Fig. S3. Influence of the valve seat's radius of curvature on opening threshold pressures. Valve width W_v and *L/W* are 0.6 mm and 0.4, respectively. (a) Photographs of the valves having various radius of curvature, *R*. (b) Change of opening threshold pressure by *R*. The input flow rate is 8 μL min^{-1}. The opening threshold pressure increases with the increasing *R*, thus suggesting sharp vertex is better for low opening threshold pressure. (c) Contact pressures obtained by simulation.

References

S1 S. Way, *Trans. Amer. Soc. Mech. Eng.*, 1934, 56, 627–636.

S2 S. -H. Yoon, V. Reyes-Ortiz, K. Kim, Y. H-. Seo and M. R. K. Mofrad, *J. Microelectromech. Syst.*, 2010, **19**, 854–864.