Supporting Information

In-situ Reversible Tuning from Pinned to Roll-down Superhydrophobic States on Thermal-response Shape Memory Polymer by Silver Nanowire Film

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Supporting figures

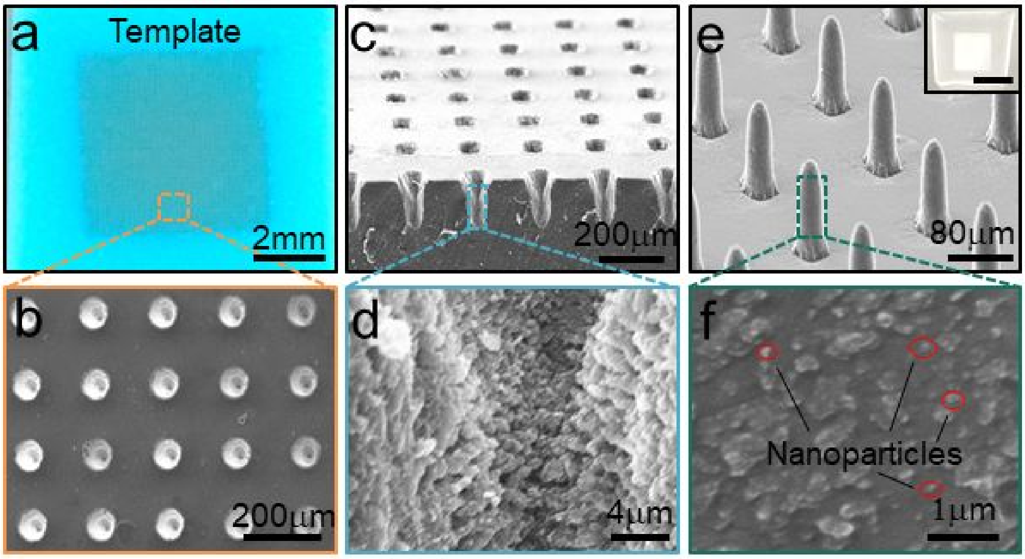

Figure S1. (a) An optical photo of the processed silicone template. As can be seen from the SEM (b), the micropores are neatly arranged on the surface. The cross-sectional SEM image of the template viewed at a tilt angle about 60^{o} (c), and there are many rough structures inside the micropores that can be seen from the enlarged SEM image (d). (e) The microcone arrays are neatly arranged on the as-prepared surface (the inserted picture is the prepared sample. Scale bar, 1 cm), and many nanoscale structures (about 300 nm) on the surface of the microcone (f).

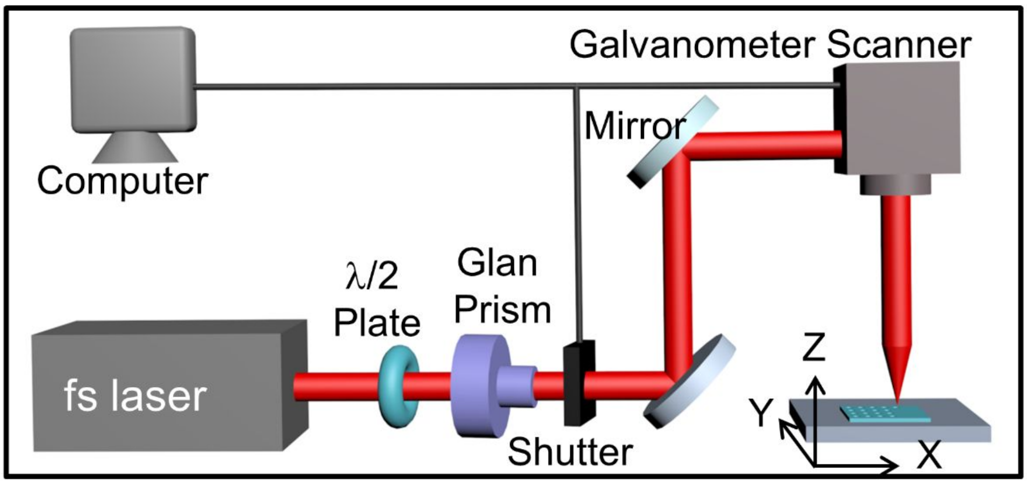

Figure S2. Schematic diagram of femtosecond laser processing system.

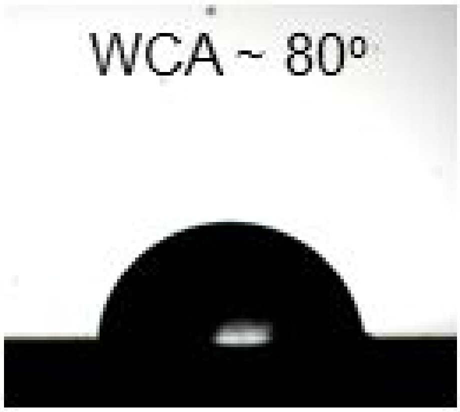

Figure S3. The water contact angle on the flat SMP surface without any modified is about 80°

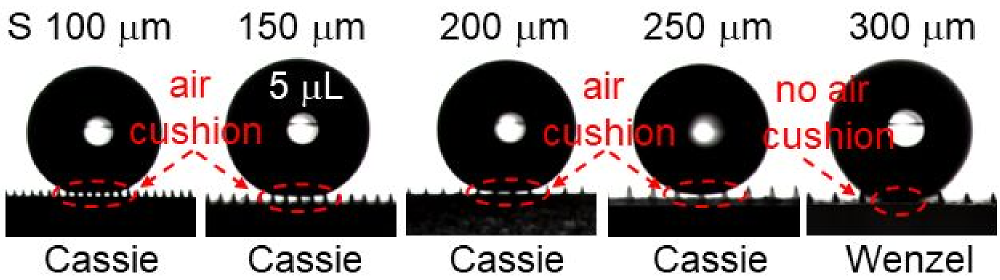

Figure S4. The contact state diagrams of liquid droplets on microcone arrays with different intervals (100 ~ 300 μm)

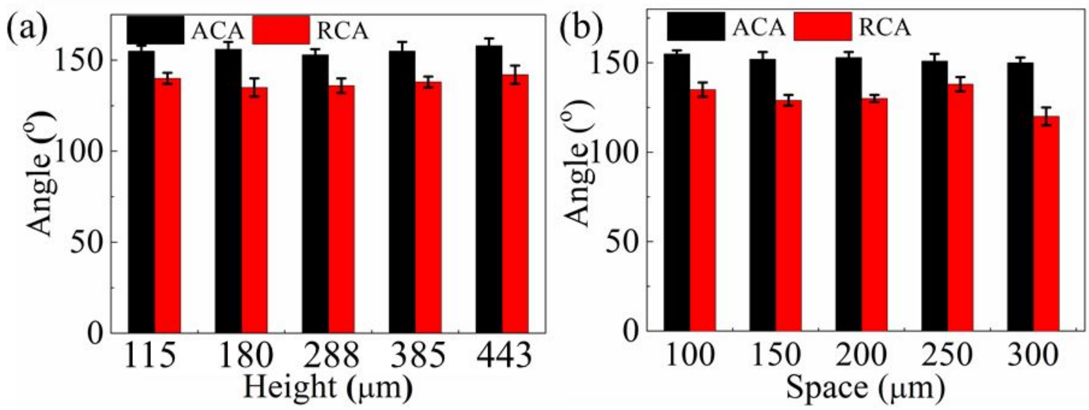

Figure S5. The advancing and receding contact angles of the water on the surface with different (a) heights (S ~ 250 μm) and (b) spaces (H ~ 280 μm), respectively.

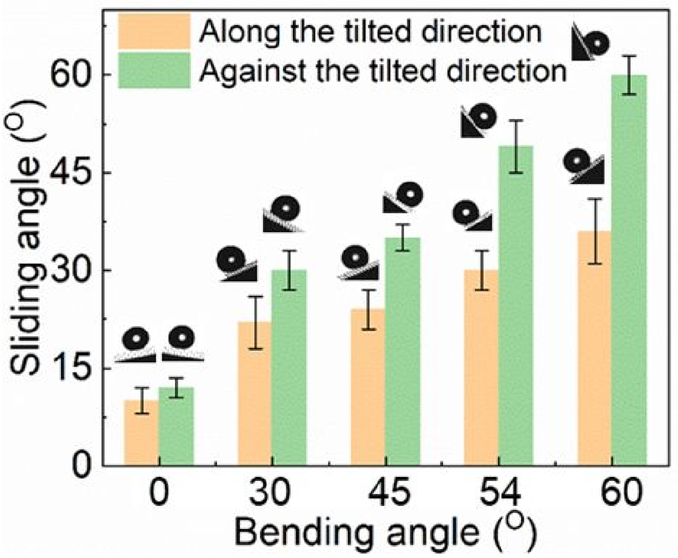

Figure S6. The sliding angle of water droplet on the deformed microcone surface with space of 250 μm

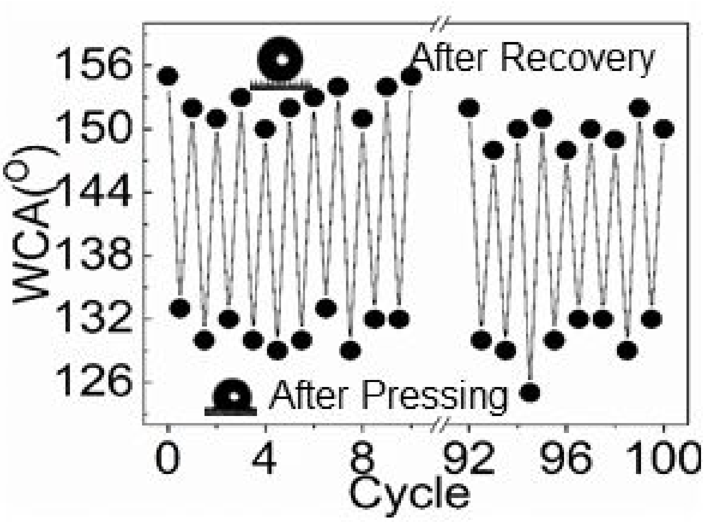

Figure S7. The change trend of water contact angle of upright and tilted microcone surface after multiple heating.

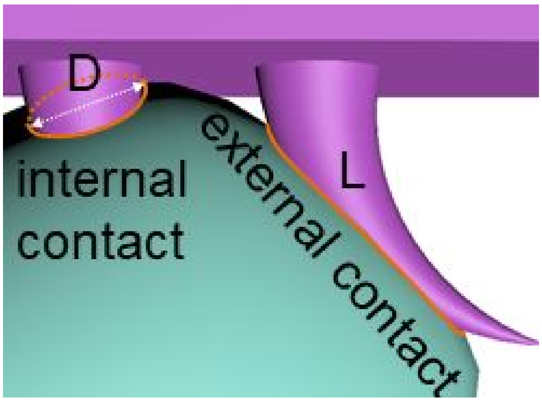

Figure S8. Definition of two contact state between the tilted microcone and the droplet.

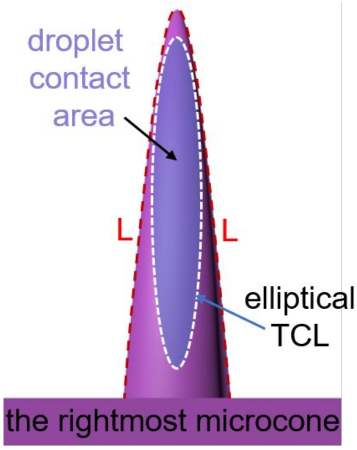

Figure S9. When the droplet is moving against the tilted direction, an approximate elliptic contact area can be formed between the droplet and the rightmost microcone. To simplify the calculation, we approximate that the length of the elliptical TCL is equal to twice the length of the microcone (2L).

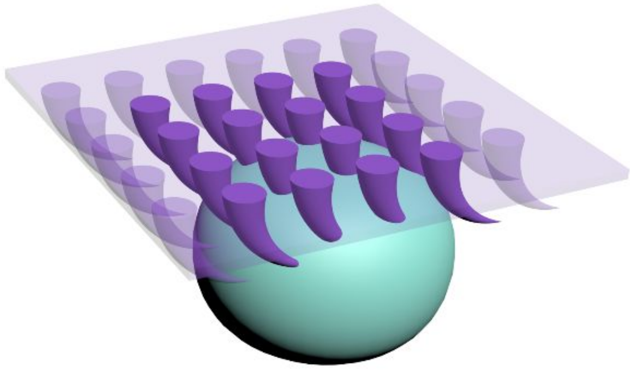

Figure S10. The contact model between the tilted microcones and the droplet in 3D perspective.

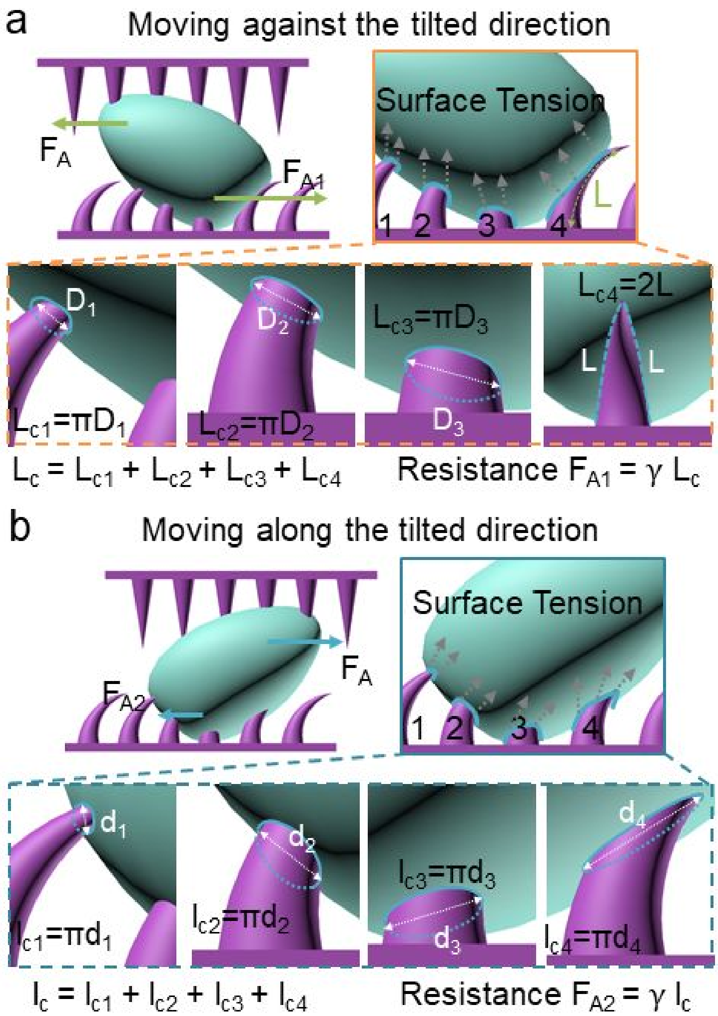

Figure S11. The different contact strategies (a, b) of the tilted microcone arrays contribute to the water unidirectional transportation

When the droplet is moving against the tilted direction (Figure S10a), the first three rows of microcones from left to right are insert directly into the droplet (internal contact), and the TCL formed with the droplets are approximately circular and the diameter is D_1, D_2 and D_3. The right-most tilted microcone is in contact with the surface of the droplet (external contact) formed a TCL is approximately twice the height of the microcone (2L). Therefore, the total length of the TCL in the "pinned state" is $L_{c1} = \pi (D_1 + D_2 + D_3) + 2L$, and the resistance $F_{A1} = \gamma \times L_c$.

In contrast, when the droplet is moving along the tilted direction (Figure S10b), the most obvious change is the the right-most tilted microcone, which changes from external contact to internal contact, so the length of TCL changes. We define the diameter of the microcones at the contact area as d_1, d_2, d_3, d_4, respectively, and the length of TCL at this state becomes $L_{c2} = \pi (d_1 + d_2 + d_3 + d_4)$, so the resistance $F_{A2} = \gamma \times L_c$.

According to the theoretical analysis, the length of TCL that against the tilted direction is longer than that of along the tilted direction, thus F_{A1} is larger than $F_{A2,}$ which contributes to the anisotropic adhesion force in the horizontal direction. Therefore, the droplet could realize unidirectional motion.

Fabrication of AgNW Transparent Conductive Films

The AgNWs were synthesized according to previous reports[1,2] through a modified polyol process.[3,4] First of all, three solutions were prepared for utilization: (A) 0.220 M NaBr, (B) 0.210 M NaCl and (C) 0.505 M PVP in ethylene glycol. Subsequently, A (2.5 mL), B (5 mL), C (25 mL) and freshly prepared AgNO3 (0.265

M) in ethylene glycol (25 mL) were added to a flask placed in an oil bath at room temperature. Stir the flask vigorously for 30 min, then heated to 170^{o} and continue stirring for 15 min. During the reaction, the nitrogen gas was bubbled. Thereafter, plug the flask with a cork and left the reaction for 1 h without disturbing. After the reaction, the flask was immediately removed from the oil bath and transferred to the water for cooling.

After the synthesis, the AgNWs were purified by positive-pressure filtration. The cleaned hydrophilic polytetrafluoroethylene membrane (diameter 100 mm, pore size 5 μm) was installed on a Mass-Filtration system. The 12 mL of AgNW reaction solution was mixed into 468 mL of ethylene glycol by an adjustable mixer, which was subsequently filtered by positive-pressure system at the pressure of 5-20 kPa. Finally, AgNWs on the membrane was redispersed into 30 mL of 0.5 wt% PVP and then transferred to acetone cleaning. It could be observed visually that the color of dispersion tends to change from green to yellow while acetone was added at a rate of 100-200□□l s^{-1}. When color change occurred, no additional acetone should be added and floc-shaped AgNWs was formed. After setting for 10 min, the AgNWs were settled to the bottom of the vessel, and the supernatant was removed with a pipet, and the above operation process was defined as 1 cycle. The floc-shaped AgNWs were redispersed in 30 mL of 0.5 wt% PVP and the AgNWs with high purity were obtained after 5-7 cycles.

Dissolve 24 mL of purified AgNWs in 16 mL of deionized water, and then blend for 1.5 h with rotating speed of 110 rpm. Finally, 1 mg mL^{-1} AgNW ink could be obtained. An automatic coating machine was utilized to coat AgNW ink on polyethylene terephthalate substrates. Spin coating after dropping 1 mL of AgNW ink and transparent conductive films were obtained after a simple annealing process.

References

(1) LI, B.; Ye, S.; Stewart, I.; Alvarez, S.; Wiley, B. Synthesis and purification of silver nanowires to make conducting films with a transmittance of 99%. *Nano letters*, **2015**, 15, 6722-6726.

(2) Chen, C.; Zhao, Y.; Wei, W.; Tao, J.; Lei, G.; Jia, D.; Wan, M.; Li, S.; Ji, S.; Ye, C. Fabrication of silver nanowire transparent conductive films with an ultra-low haze and ultra-high uniformity and their application in transparent electronics. *Journal of Materials Chemistry C* **2017**, 5, 2240-2246.

(3) Wiley, B.; Sun, Y.; Xia, Y. Synthesis of silver nanostructures with controlled shapes and properties. *Accounts of Chemical Research* **2007**, 40, 1067-1076.

(4) Wiley, B.; Sun, Y.; Xia, Y. Polyol synthesis of silver nanostructures: control of product morphology with Fe (II) or Fe (III) species. *Langmuir* **2005**, 21, 8077-8080.

Movie S1: In-situ reversibility of the microcones

Movie S2: Adhesive foece test of the tilted microcone

Movie S3: Adhesive foece test of the upright microcone

Movie S4: Droplet lossless transportation

Movie S5: Unidirectional transport of water droplet on the tilted SMP microconed surface

Movie S6: Schematic of droplets being transported precisely and continuously to the specific positions