Supplementary Information:

Strong anti-ice ability as nano-hairs over micro-ratchet structures

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Supplementary Experimental Section

Preparation of surfaces: Stainless steel plates (30.0×10.0×1.5 mm) were machined to form the microscale ratchet structure with a period of ~ 130 μm, ~ 150 μm, ~ 160 μm, ~ 180 μm, ~ 190 μm, ~ 260 μm, ~ 270 μm and ~ 290 μm, the ratchet height of ~ 80 μm and a rise angle of ~ 25°. Surfaces were cleaned with ultrasonic cleaner in acetone, alcohol, diluted hydrochloric acid and deionized water 5 minutes, respectively, and then dried in a ventilation drying oven. Nanostructure could be fabricated through ZnO nano-hair planting method.[15] Crystal seed was prepared as following: 2.195 g $Zn(Ac)_2 \cdot 2H_2O$ (SCRC, A.R.), 20 mL ethylene glycol monomethyl ether (SCRS, A.R.) and 0.6108 g monoethanolamine (Beijng chemical plant, A.R.) were mixed and stirred with a magnetic stirrer for 30 minutes. Mother liquor was prepared as follow: 0.7436 g $Zn(NO_3)_2 \cdot 6H_2O$ (SCRS, A.R.) and 0.3505 g hexamethylene tetramine (Beijing YiLi fine chemicals Co., LTD, A.R.) were mixed into 100 mL deionized water and had been stirred with a magnetic stirrer for 30 min. Then dipped stainless steel surface in and out three times and kept a liquid layer on crystal seed solution. The surface was then carefully put into muffle furnace horizontally and keep it ~ 350℃ for 5 min. When cool down, these surfaces were put into teflon reactor, then pour mother liquor slowly. Object surfaces have to be put adown and also not contact with the inwall of reactor.

The reactors were put in an oven and kept 85℃ for 15 h. When reactors cool down, the surfaces were then rushed with deionized water and then dried in an oven. The surfaces were then cleaned with plasma cleaning (PDC-32G, HARRICK PLSMA) at high power grade for 10 min to enhance their chemism. These surfaces were put into a vacuum flask within which there were 2 drops of Heptadeca Fluorodecyltri-propoxysilane (FAS-17). Vacuumize the wide-mouth bottle until -0.1 MPa and kept it in an oven of 90℃ for 2.5 h without light in. Thus these surfaces had the same low surface energy chemical component so that they could be completely contrasted with structural effects on differences of icephobic property.

Measurement of water contact angles (CA) at -10℃: CAs on surfaces at different temperatures were tested with a contact angle meter (Dataphysics SCA40, German). The cold plate on sample stage in contact angle meter could be controlled to −10℃ with a digital control panel. In water contact angle experiment, surfaces were kept on the controlled cold plate at least 3 min before testing in order to keep surface temperature steady. Droplets of 10 μL pure water were placed onto surfaces by inches. When droplets were steady contact angles could be tested through contact angle system. The room temperature and humidity were 28 ± 1℃ and 60 ±10 %, respectively.

Measurement of roll-off angles: We used a miconductor cooler whose cool plate could rotate at an accuracy of 1° and the accuracy of temperature control is 1℃. The sample pieces were fixed to cool plate with well thermal conductivity copper adhesive tape. In order to eliminate the temperature error between cool plate and sample surface, a temperature detector with an accuracy 0.1℃ was set on sample surface. We could adjust sample surface temperature accurately by adjusting the cool system. Each test of the roll-off angle, the sample surface was

adjusted to −10℃. Then a water droplet of 10μL was placed on and is kept for 3 min before cool plate rotating. Through the whole testing process the ambient temperature was 26 ± 1℃ and humidity 56±3%. Two directions of roll off angle of each sample have been tested in order to assess the design overall.

Ice delay time experiment: Different surfaces were put onto cold plate of sample stage in contact angle meter with temperature controlled down to −10℃. The reference drops (10μL) were placed on these surfaces, respectively. Ice delay of different samples were observed using a CCD camera while the surface was kept at −10℃. Ice delaywas judged by the change of transparency: initially, these drops are all transparent, after a period, the drops started to just become freeze and nepheloid. During this experiment, the ambient temperature was 22 ± 1℃ and humidity 27±3%.

Frost accumulation experiment: Two icephobic surfaces had been fixed onto cold plate (Dataphysics SCA40, German) with thermal-conducting tape when the cold plate was kept to −10℃. We adhere a temperature probe on sample surface, thus we could obtain the accurate temperature with a accuracy of 0.1℃. The temperature of sample could be controlled by adjust freeze system of contact angle meter. It take about 3 min until the sample surface reach −10.0℃, at which moment we began timing. We take photos from both top and side of the samples every 5 min until the surface was covered by frost completely. The final step was to resume the cool plate to 22℃ in order to observe water survivals on sample surfaces. During this experiment, the ambient temperature is 26.4±0.7℃ and humidity is 43.8±1.6%

Supplementary Figure Legends:

Figure S1

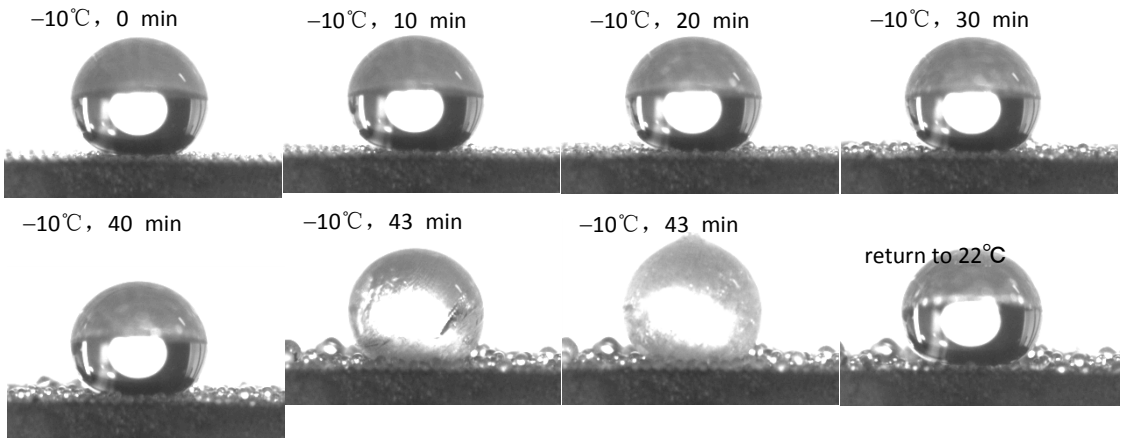

Figure S1. Reference droplet ice delay process: the cold plate is –10℃and the droplet is 10 μL. During this process the ambient temperature is 22±1℃, the room humidity is 27±3%. The periodicity of micro-structure is ~ 150 μm.

Figure S2

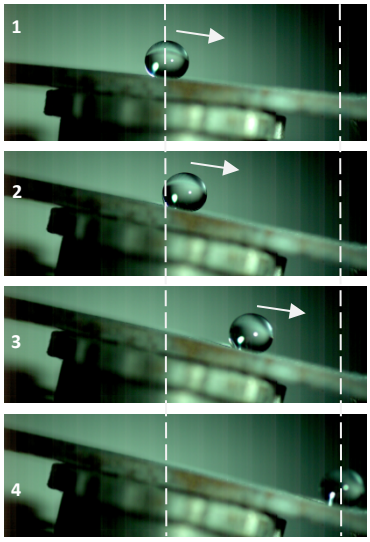

Figure S2. Drop roll-off angle testing at −10℃. The roll-off angle is ~15°. Micro-structure of substrate is ~ 150 μm in periodicity. Volume of droplet is ~ 10 μL.