Electronic Supplementary Information

Designing a slippery/superaerophobic hierarchical open channel for reliable and versatile underwater gas delivery

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Experimental section:

Preparation of SLSO hierarchical channel:

Substrate of SLSO hierarchical channel was made of thermoplastic polylactic acid material by using a commercial 3D printer (A7, Jgaurora Corp., Zhejiang, China). The wavy folding channel with 0.2mm wall thickness is made of a precision resin by using a commercial 3D printer (Inkspire Zortrax, Diyi Motor Technology Co., Ltd., Shanghai, China) to achieve higher precision. The admixture of 2.7g of VTES (97%, Aladdin Co.), 0.21g of HFS (R-972, Evonic Co.), and 0.09g of 2-Hydroxy-2-methylproplophenone (Darocure 1173, 97%, Aladdin Co.) was dropped on the inner surface of 3D printed channel, and then was cured under UV irradiation (λ = 365nm, 330 mW·m−2) for 30 min to produce the hydrophobic porous surface. After complete solidification, the unreacted chemicals are rinsed away with ethanol. The superhydrophilic modification reagent (LumiNano Co. Ltd., China) containing 3% w/w silica sol, 0.5% w/w hydrophilic cellulose-based polymer, and 0.5% w/w surfactants Triton X100, was applied on the upper surface of SLSO hierarchical channel. After the complete solidification of hydrophilic coating, deionized water is used to remove unreacted molecules.

In addition, a more corrosion-resistant PVA coating was applied to the upper surface of the SLSO channel immersed with the amine solution. This means applying a 7% PVA aqueous solution to the upper surface, waiting for it to dry and then cleaning it with water. Afterwards, the silicone oil PMX-200 (Viscosity of ≈50 mPa • S, Aladdin Co.) was incorporated to impregnate the hydrophobic porous surface, and the channel was placed vertically for 5 min to remove excess silicone oil.

Preparation of superhydrophobic channel:

Similarly, substrate of superhydrophobic channel was made of thermoplastic polylactic acid material by using a commercial 3D printer (A7, Jgaurora Corp., Zhejiang, China). The

superhydrophobic channel was fabricated via “glue + powder” strategy. The PDMS solution (Sylgrad-184, Dow Corning Co. Ltd., 10% w/v in hexane) was applied on the surface of 3D printed channel surface, and the PDMS film left after evaporation of the solvent, which is called glue. The hydrophobic fumed silica (R-972, Evonic) are then spread on the glue surface, and then curing at 60 ℃ for 24h.

Instruments and Characteristic:

Injection of air bubbles using a syringe pump (SP-2000, Annol Co.). The SEM (Apreo S LoVac, FEI Co. Ltd., America) was used to observe the surface morphology. The water/bubble contact angles of surfaces were measured by an SDC-200 geometer (SFMIT Co., China). Details of the gas transport processes in gas channels were recorded by a high-speed camera (5KF10, Revealer, China) and other videos such as silicone oil being washed away by water on a super hydrophilic surface etc. were recorded by an industrial microscope (GP-650S, Gaopin Co.). The related gas absorption device consists of a peristaltic pump (BT103S, Leadfluid Co., Hebei, China), a CO2 gas cylinder and a gas flow meter (FS4001, Yihai Co., Guangzhou, China).

Supplementary Figures:

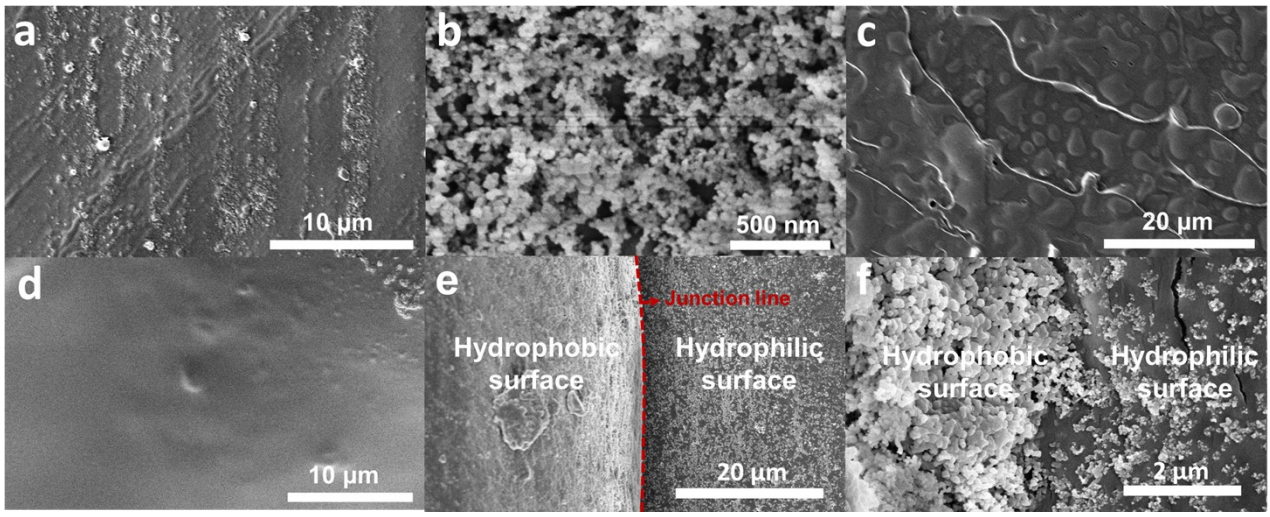

Figure S1. The images of scanning electronic microscope of SLSO hierarchical channel. (a) SEM image of PLA substrate. (b) SEM image of superaerophilic surface. (c) SEM image of superaerophobic surface. (d) SEM image of PVA membrane.

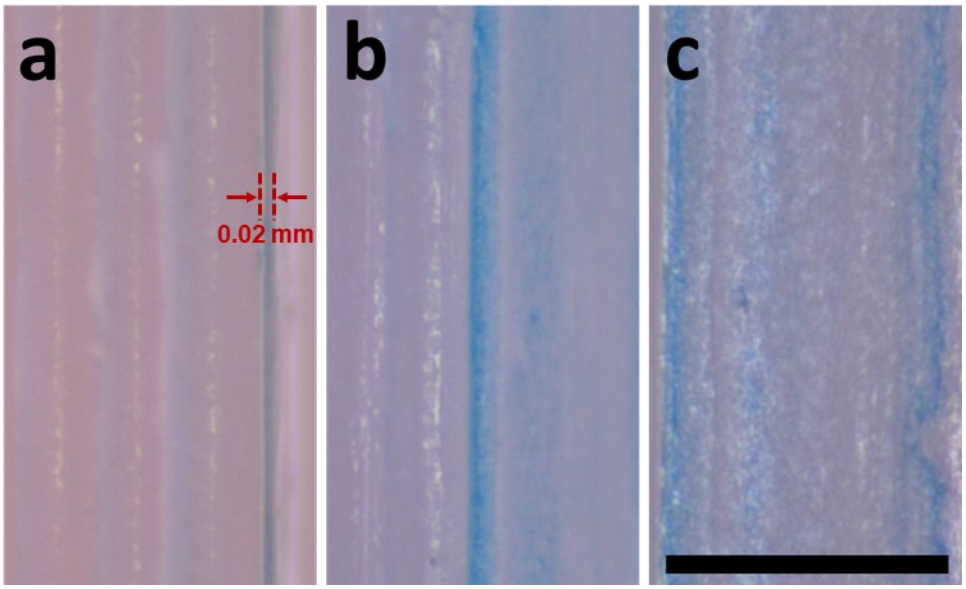

Figure S2. Microscope images of SLSO hierarchical channel. a) Upper surface, b) 45° inclined surface, c) Inner surface, Scale bar 0.5 mm.

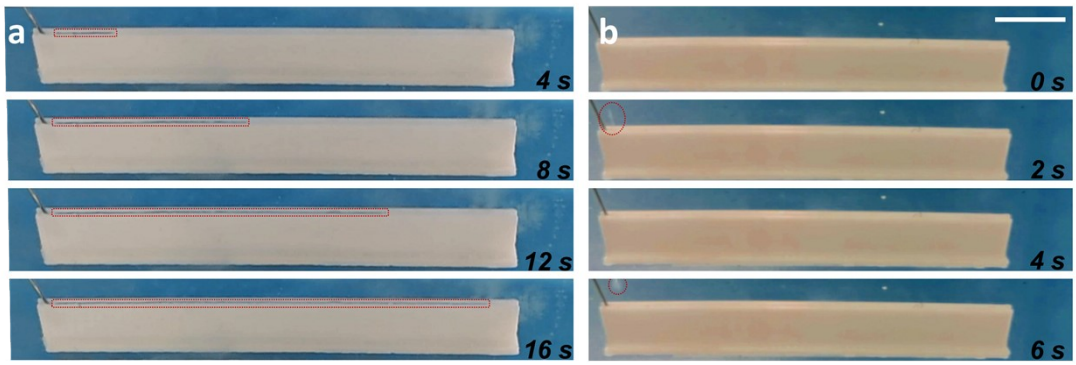

Figure S3. Gas transport in the SLSO hierarchical channel after 365 days of immersion in water (a) and in the superhydrophobic channel after 28 days of immersion in water (b), Scale bar ~1cm.

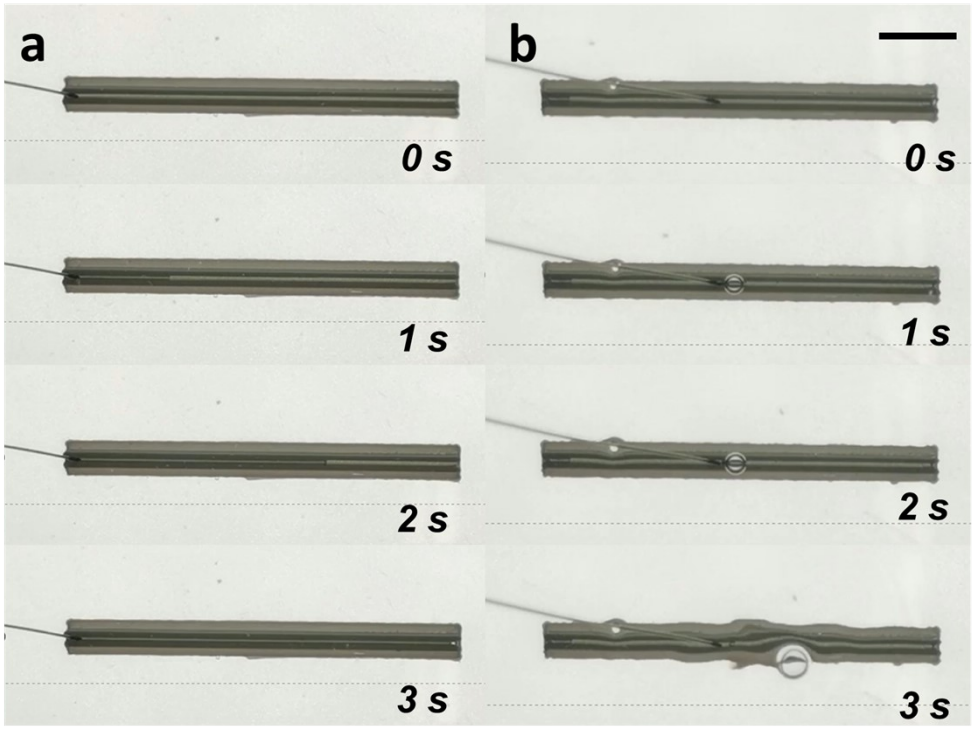

Figure S4. Comparison of gas transport processes during SLSO hierarchical channel and superhydrophobic channel after a pressure treatment of 20 kPa for two hours, (a) SLSO hierarchical channel, (b) superhydrophobic channel, scale bar 1 cm.

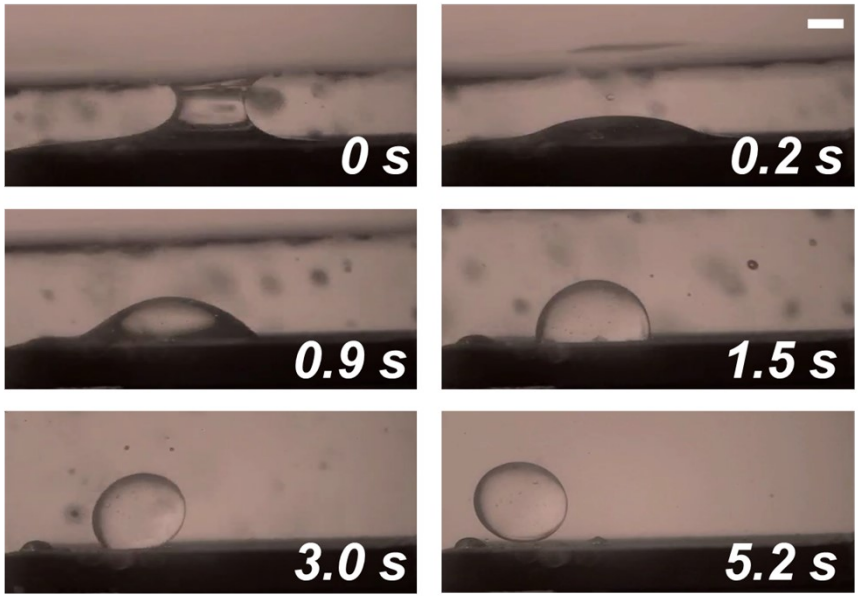

Figure S5. The process of lubricant being washed away by water from the superhydrophilic surface, scale bar 1 mm.

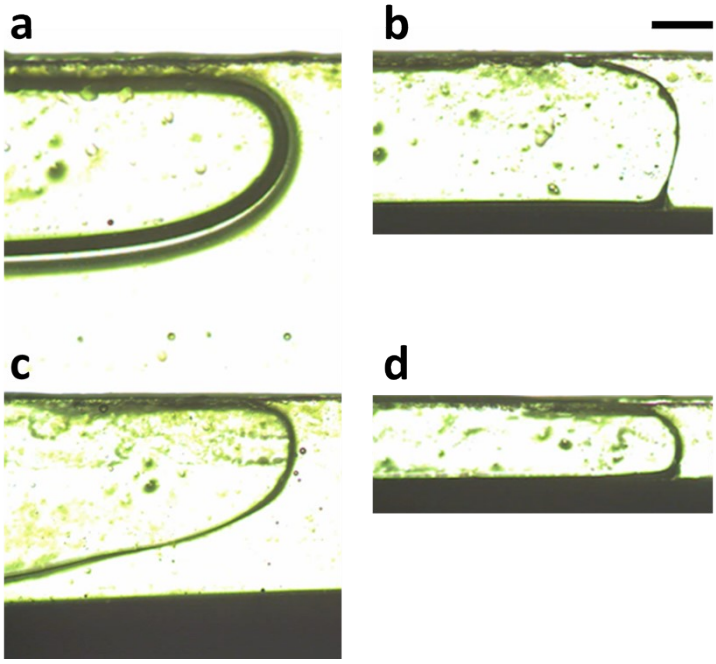

Figure S6. Forward spreading of gas in channels of different depths. (a) 5 mm channel depth, (b) 4 mm channel depth, (c) 3 mm channel depth, (d) 2 mm channel depth, scale bar 1 cm.

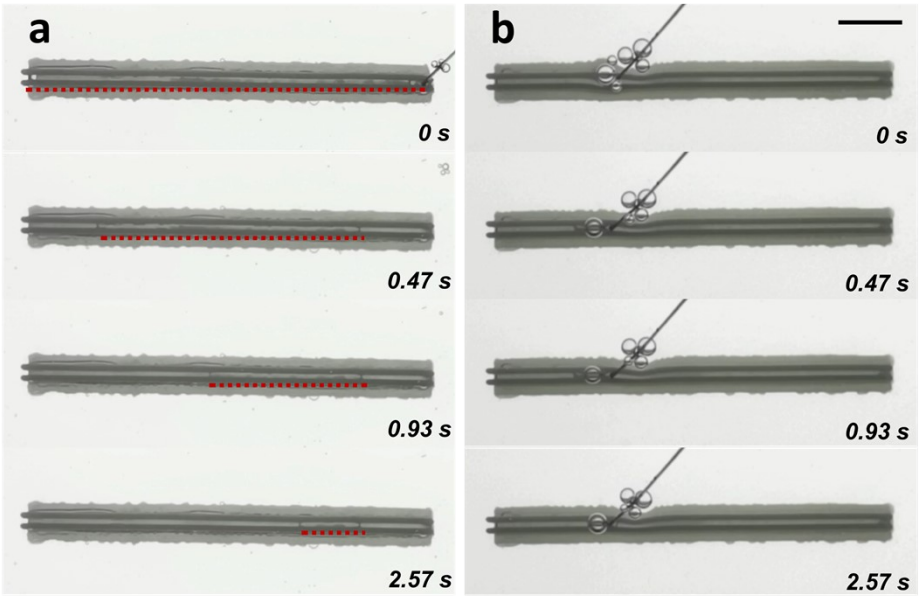

Figure S7. Gas transport in the channel after 12h immersion in 50% MDEA solution. (a) SLSO hierarchical channel, (b) superhydrophobic channel, scale bar 1 cm.

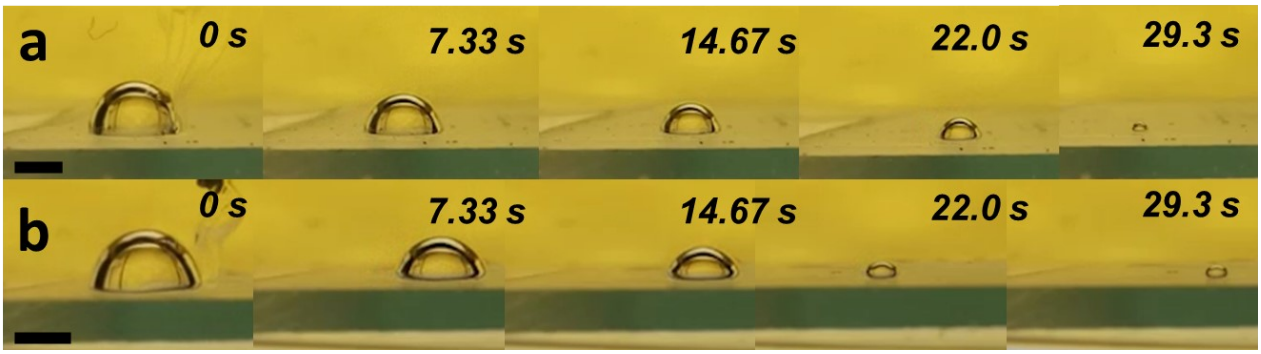

Figure S8. Absorption process of CO_2 bubbles in 50% MDEA solution. (a) PDMS surface, (b) Lubricant-infused surface, scale bar 1 mm.

Supplementary Movie:

Movie S1. Top view of the gas injection

Movie S2. Side view of bubble capture

Movie S3. Durability test by immersion in water

Movie S4. Pressure resistance test

Movie S5. Gas transport process in SLSO hierarchical channel at below and above the critical gas speed

Movie S6. The escape process of gas in the channel

Movie S7. Separation of lubricant from the superhydrophilic surface

Movie S8. Multi-model SLSO channel

Movie S9. Gas transport process in the penetrable hollow SLSO hierarchical channel

Movie S10. Gas transport process in the folded wavy SLSO hierarchical channel (2x speed)

Movie S11. Spliced SLSO channel

Movie S12. The process of absorption of CO2/air mixture in SLSO hierarchical channel

Movie S13. Gas-liquid interaction process in the device

Movie S14. The in situ replacement of liquid with gas injection (2x speed)