Electronic Supplementary Material (ESI) for Nanoscale.

A Dual-Mode Laser-Textured Ice-Phobic Slippery Surface: Low-Voltage-Powered Switching Transmissivity and Wettability for Thermal Management

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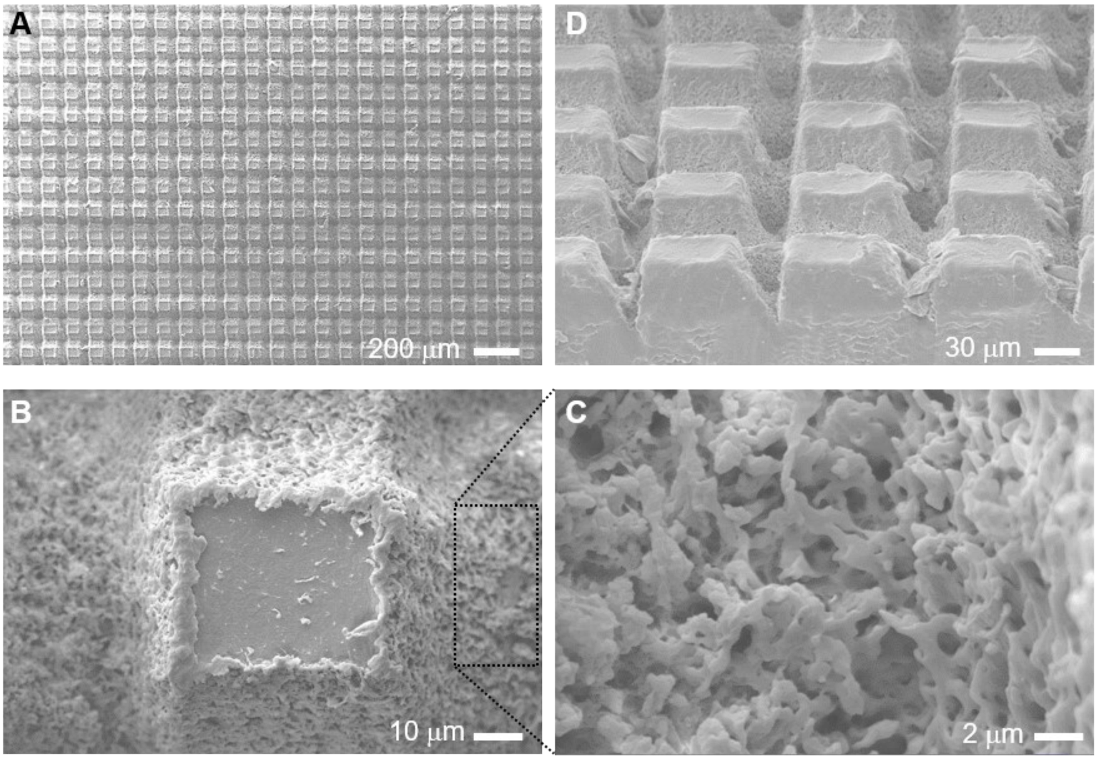


Figure S1. (a-c) Top-view SEM images with different magnifications for the laser-textured PTFE platform. (d) Oblique view SEM clip for the resulted LA-PTFE. SEM pictures suggest that laser-ablated PTFE is a hybrid of the uniformly-arrayed micro-pillars together with the micro/nano-porous topography. Accordingly, the superhydrophobic LA-PTFE exhibits remarkable capability of absorption and storage over lubricated paraffin wax depending on a giant capillary force arising from the micro/nano-structures.

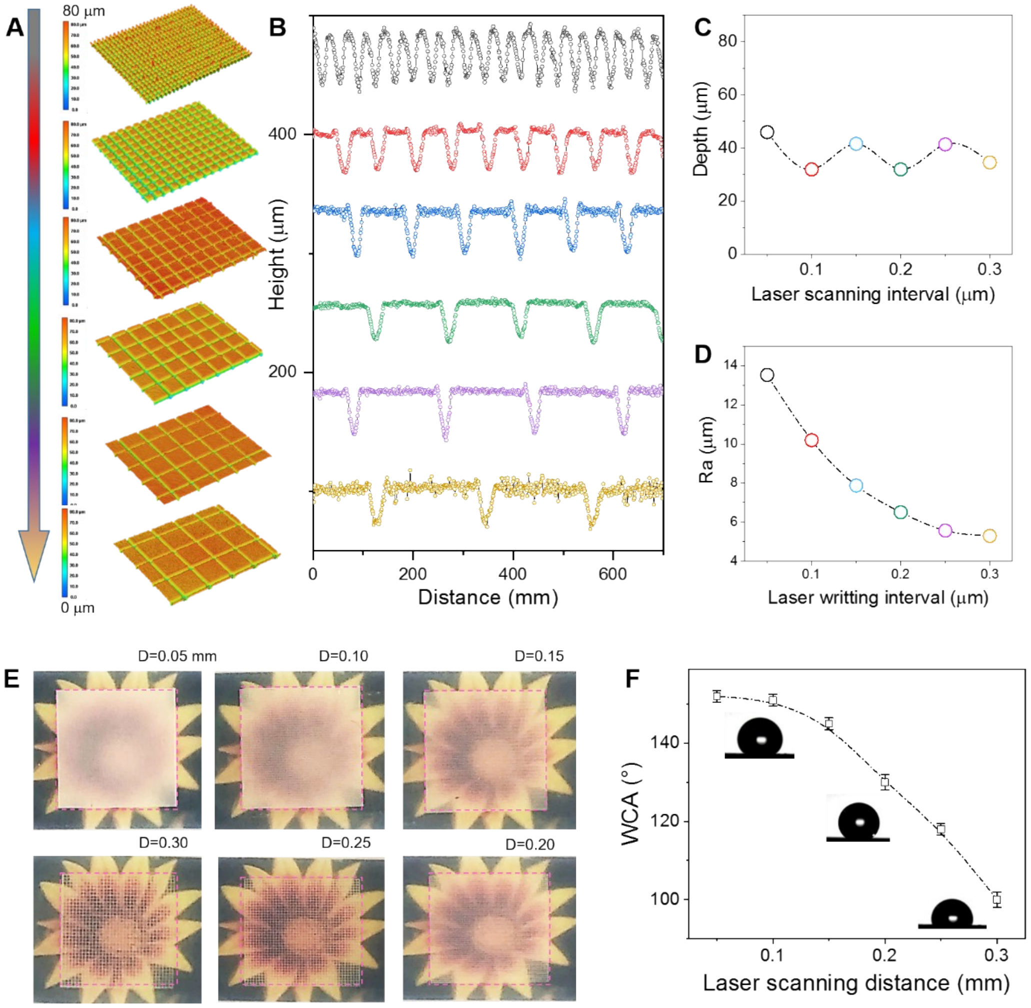
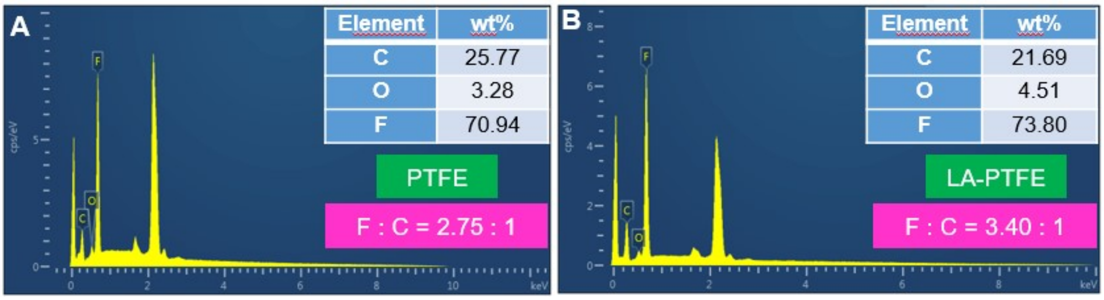


Figure S2. (a) 3D images captured by laser microscopy, (b) line-scanning profiles, (c) ablated micro-pillar depth, (d) surface roughness R_a, (e) Optical visibility, and (f) surface wetting evolution for the six LA-PTFE platforms that were manufactured with fs laser scanning intervals of 0.05, 0.1, 0.15, 0.2, 0.25 and 0.3 mm, respectively. Considering that, a robust slippery surface requires a superhydrophobic porous and reflective platform. In this regard, we select an optimized LA-PTFE ablated with an interval of 0.10, which exhibits an excellent hydrophobicity as well as a moderate light-reflectivity.



Element	wt%
C	25.77
O	3.28
F	70.94

Element	wt%
C	21.69
O	4.51
F	73.80

Figure S3. EDS mapping for displaying the evolution over the relative atomic ratio of F and C elements in (a) the pristine PTFE and (b) the laser-ablated PTFE. The decrease of C element in LA-PTFE evidenced that fs laser manufacturing technique is not only competent for ablating highly arrayed micro-pillars, but also responsible for inducing a large amount of nano-porous morphology.

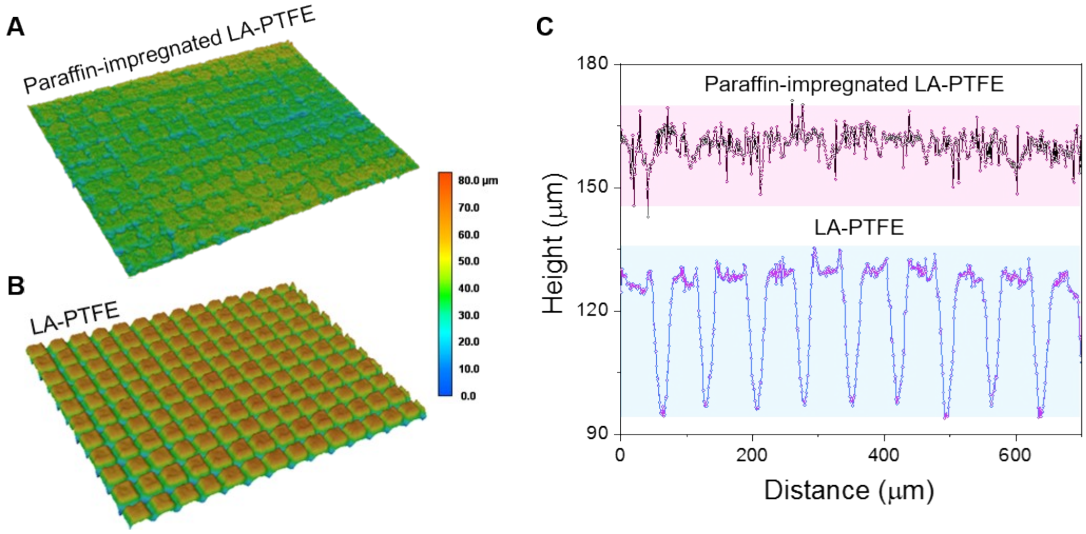


Figure S4. 3D imaging photos for the laser-textured PTFE substrate with the interval of 0.15 mm (a) with and (b) without paraffin impregnation. (c) Line scanning profiles for the as-prepared LA-PTFE and the paraffin-impregnated LA-PTFE. By subtracting the paraffin-impregnated LA-PTFE by the LA-PTFE counterpart, we can harvest the thickness of the impregnated paraffin, which is roughly estimated as 33.5 μm.

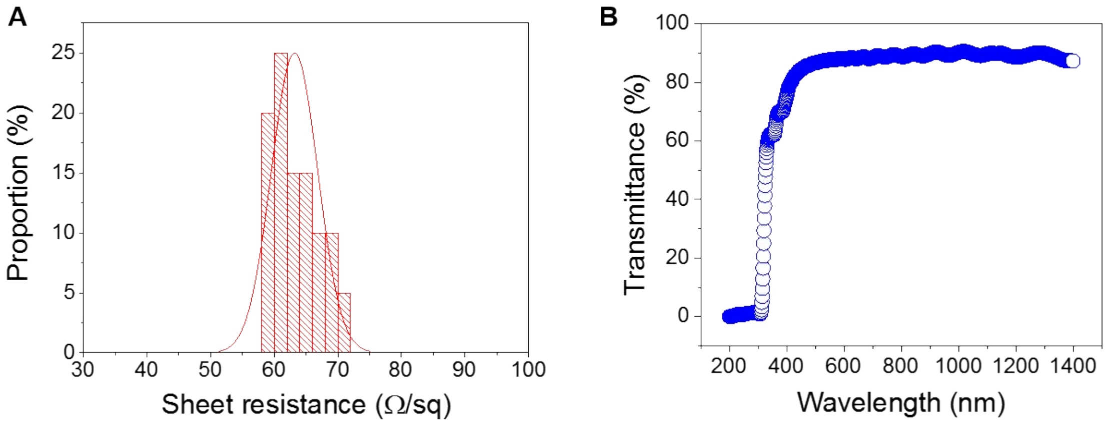


Figure S5. Measurements of (a) sheet resistance and (b) transmittance in a wavelength range of 180-1400 nm for the silver nanowires woven thin-film heater. The result shows that current heater is highly transparent and conductive for serving as a flexible/portable electric-induced-heating source.

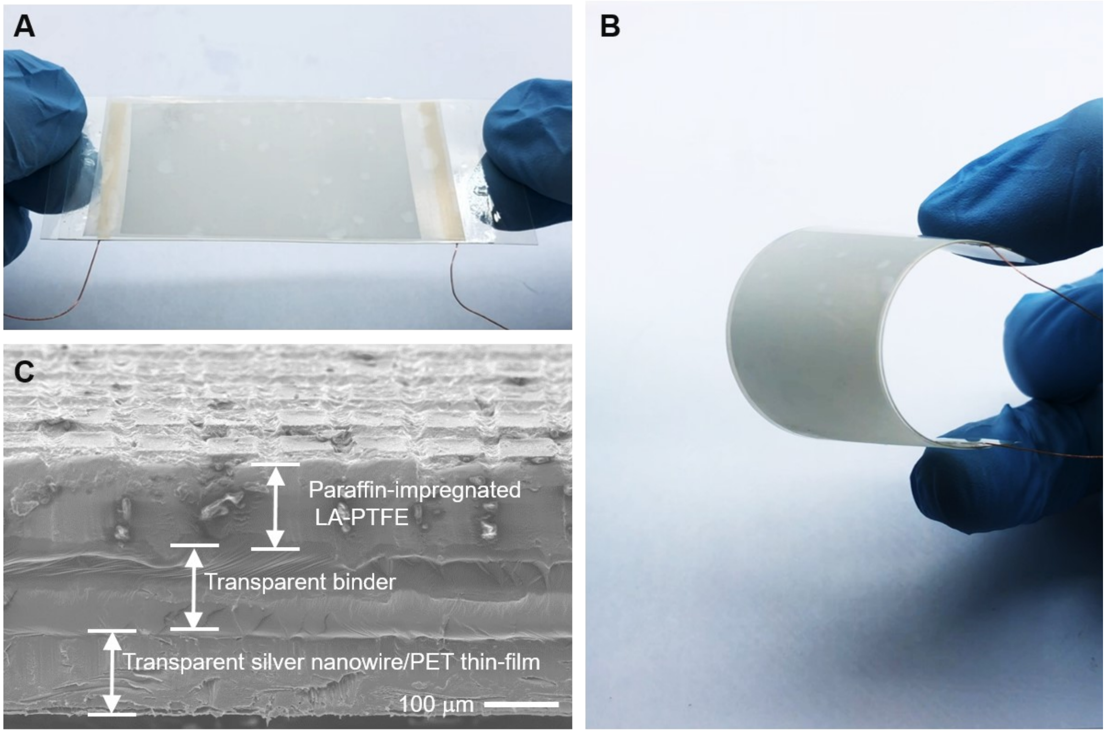


Figure S6. Digital pictures for displaying (a) the planar and (b) the bent electric-powered DM-SLIPS. (c) SEM clip for characterizing the architecture of DM-SLIPS composed of top-layer paraffin-impregnated LA-PTFE, middle-layer adhesive tape and bottom-layer silver nanowires thin-film heater. They have the identical thickness of ~100 µm, signifying the DM-SLIPS has a total height of ~300 µm.

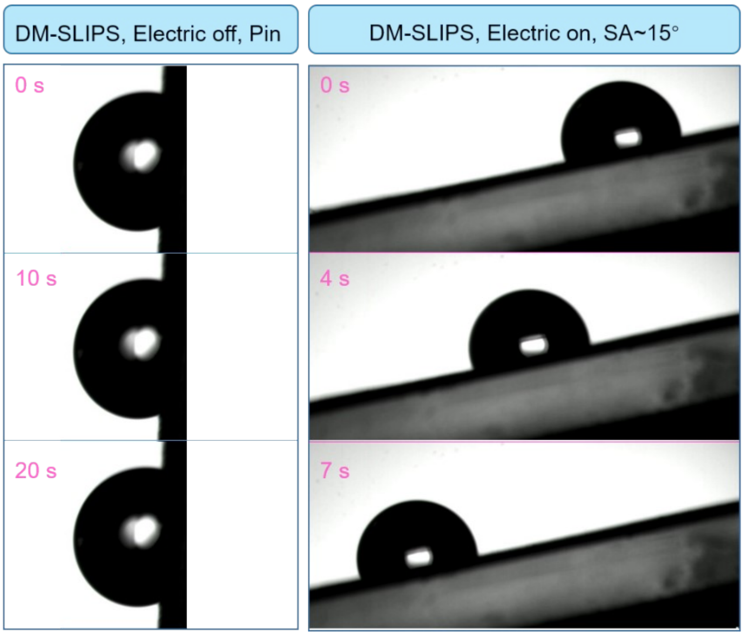


Figure S7. Time-lapse clips for displaying the typical droplet (10 μL) sliding behavior on DM-SLIPS without (left one) and with (right one) Joule-heat. The result showcasing that the rough ASS system presents ultra-adhesive force and the smooth ALS system unfolds a lower hysteresis.

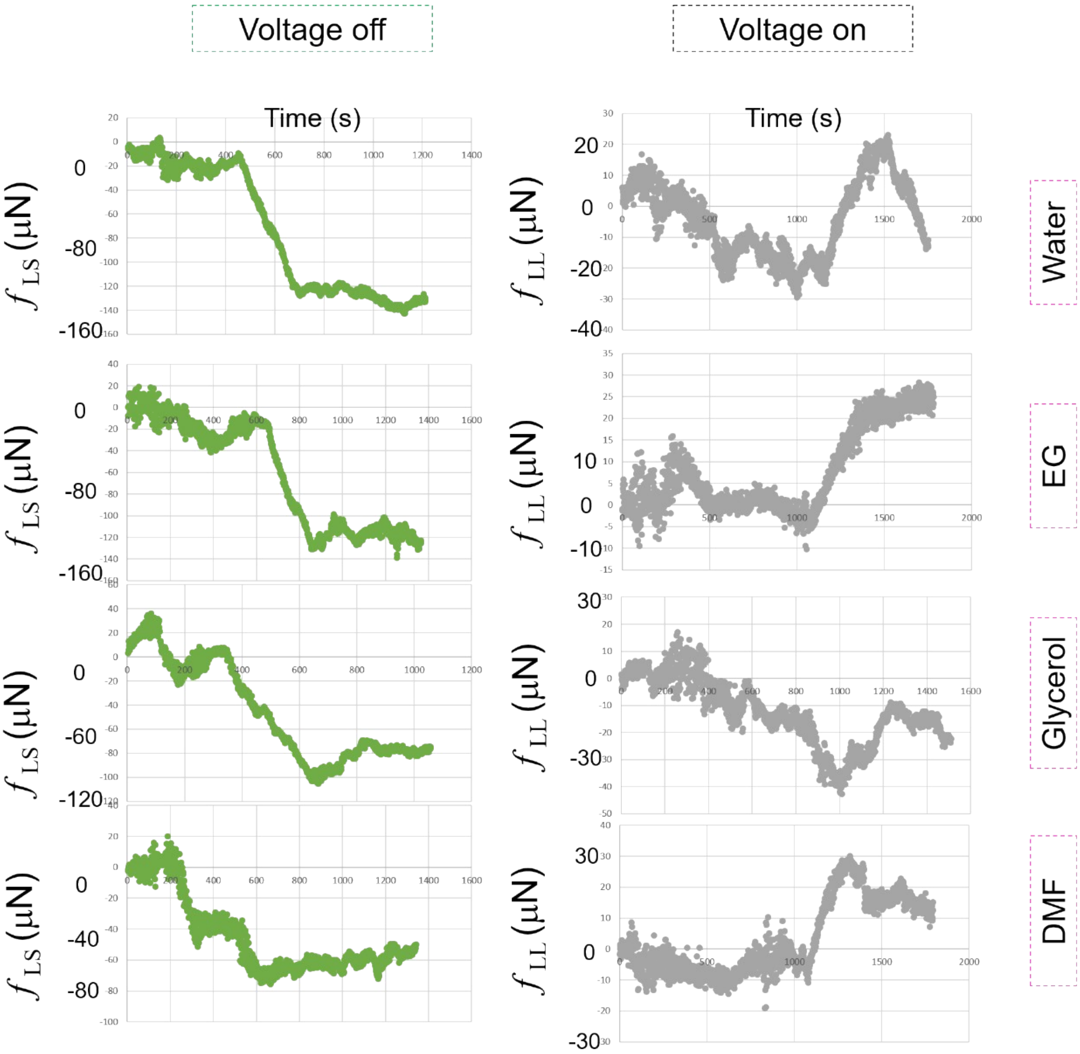


Figure S8. Quantitative measurements for recording the f_{LL} and f_{SL} over diverse liquids on horizontal charging/discharging DM-SLIPS, including water, glycerol, ethylene glycol (EG) and dimethyl formamide (DMF).

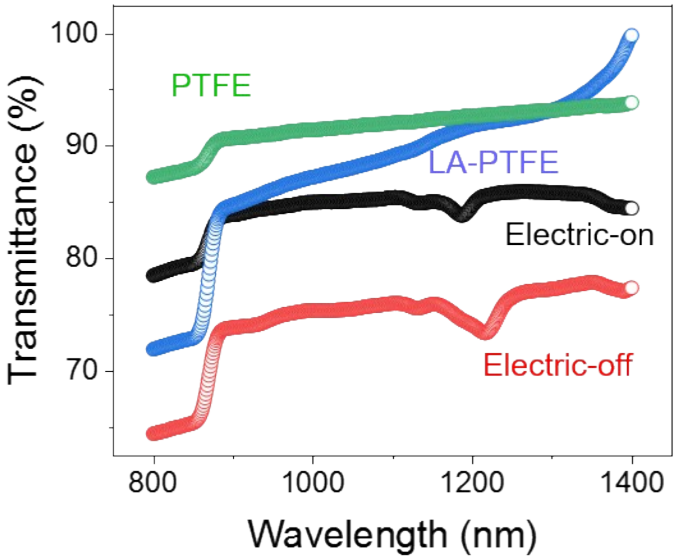


Figure S9. Transmittance spectrums for pristine PTFE, laser-ablated PTFE, and DM-SLIPS with and without Joule-heat. The DM-SLIPS has a minimum transparency compared to the pristine PTFE and LA-PTFE, thereby displaying a best cooling performance. In addition, light irradiating on DM-SLIPS can be switched between release mode and lock mode so as to realizing the controllable solar energy input according to the user's request.

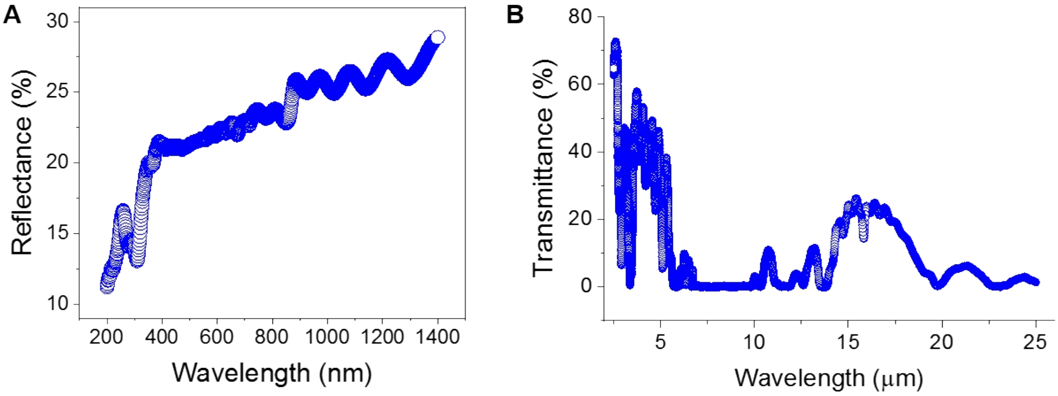


Figure S10. (a) Reflectance spectrum in a wavelength range of 180-1400 nm and (b) Transmittance spectrum in a wavelength range of 2-25 μm. The result unfolds that silver nanowire thin-film heater is a transparent feature in the visible range but a reflective appearance in the MIR scope (8-13 μm), signifying the thermal insulation property assigned on DM-SLIPS is derived from the embedded silver nanowires with far smaller IR emittance (~0.03). In ultra-cold winter, the electricity-induced Joule-heat could replenish the indoor temperature and meanwhile the release mode of electric-powered DM-SLIPS allows the solar energy entrance but reject its leakage towards outer space (lower IR emittance), so these merits enable DM-SLIPS to cope with energy crisis in some special regions having extremely-cold climates.

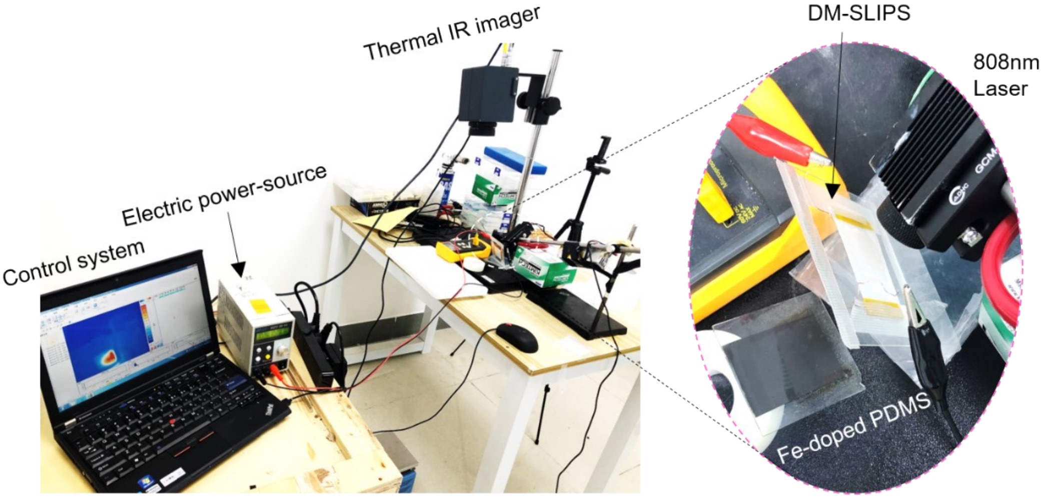


Figure S11. Digital photograph for the home-made system for a proof-of-concept thermal management, which is composed of a computer-connected thermal IR imager, an electric power source, 808 nm laser and a piece of Fe_3O_4-doped PDMS membrane. By loading/discharging the electric-stimuli, the DM-SLIPS is finely-tuned between transparent and opaque for controlling the solar energy input on demand.

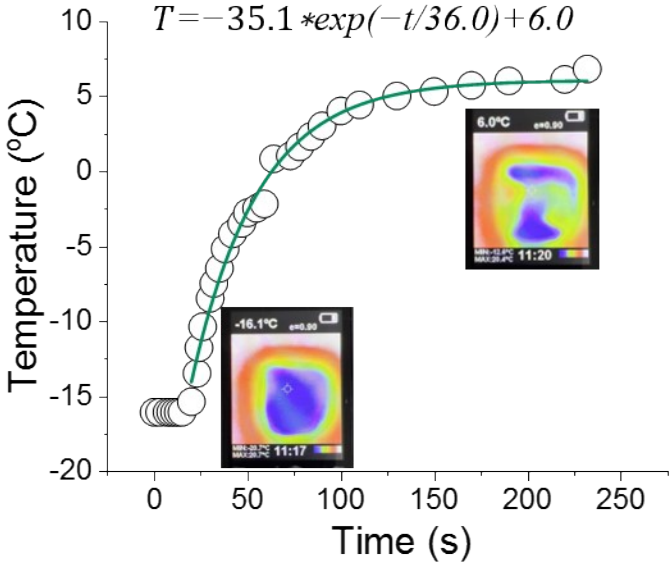


Figure S12. Temperature-time curve of DM-SLIPS recorded by Joule heating from its minimum frozen state to the ice melting state.

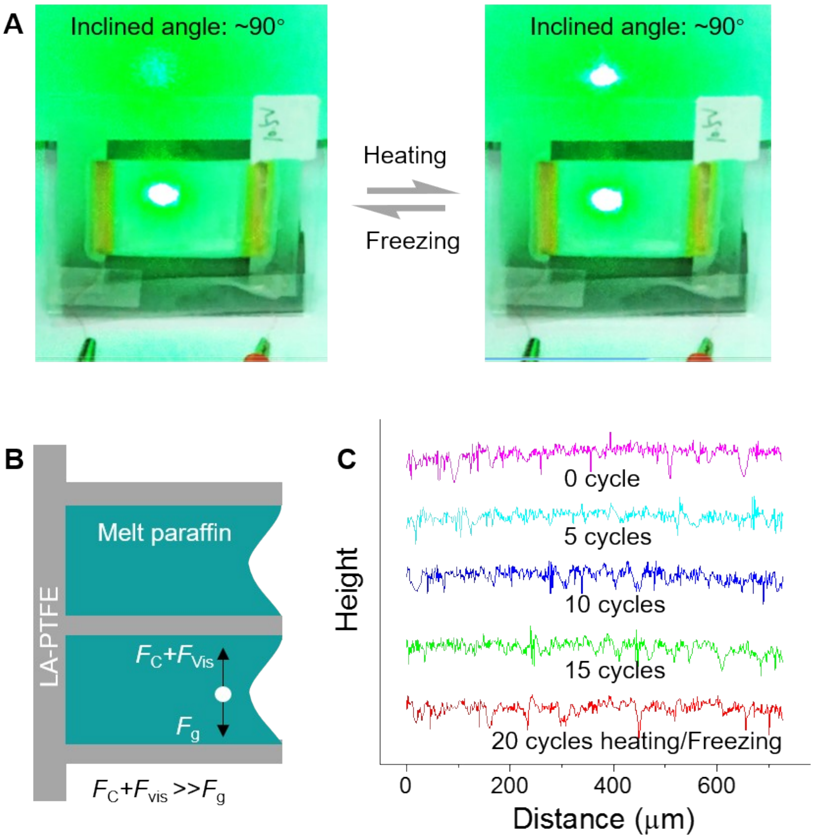


Figure S13. (a) Digital clips for evidencing the reversible transparency switching through cyclic heating/freezing operations. (b) A proposed mechanical model for the liquefied paraffin dwelling on an erect DM-SLIPS. (c) 3D laser profiles for verifying the durability of DM-SLIPS suffering from cyclic heating/freezing maneuvering.

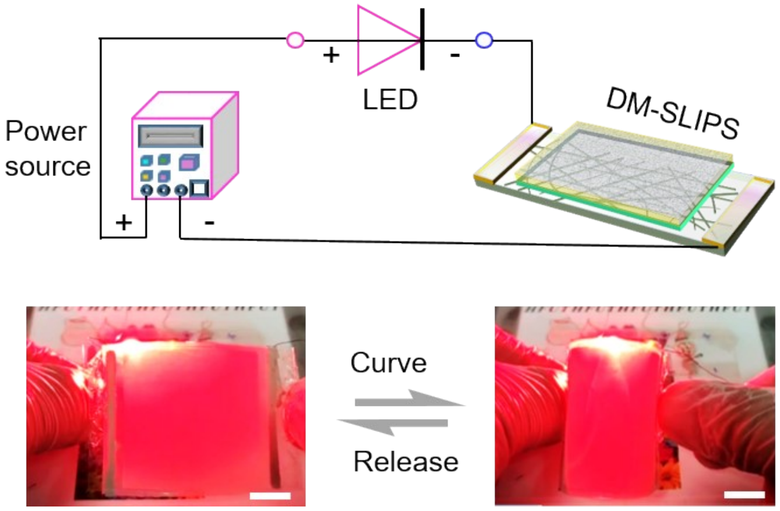
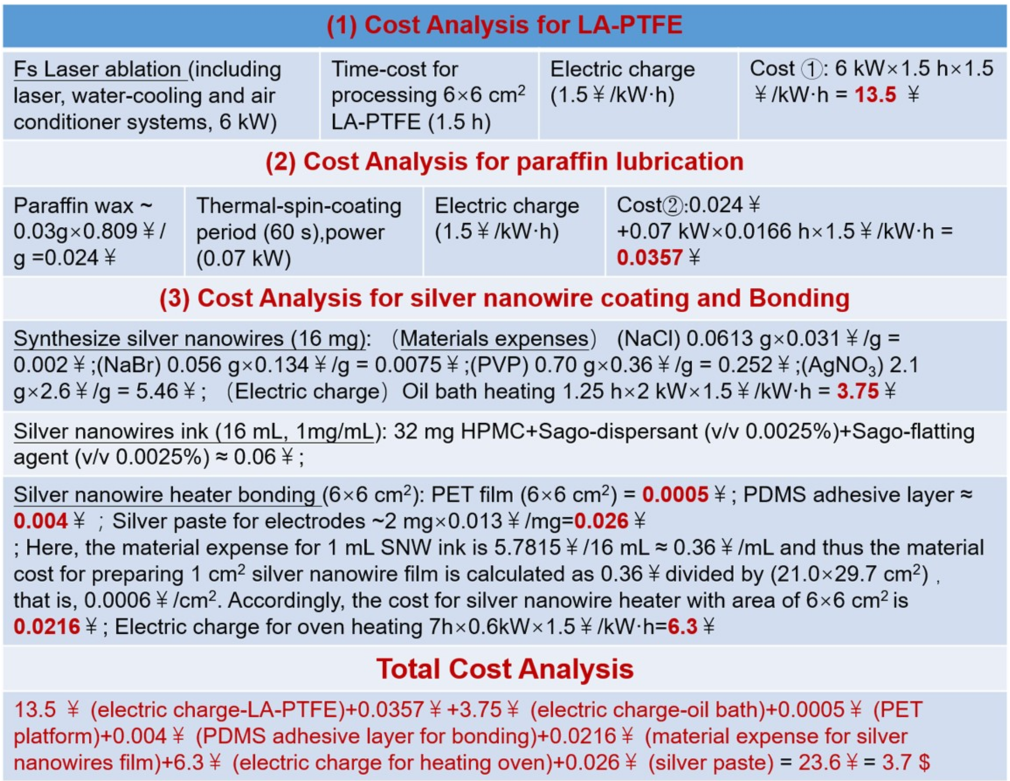


Figure S14. The upper schematic diagram displaying the home-made flexibility test system and the lower digital clips presenting the good apparent flexibility of electric-loading DM-SLIPS; The scale bar is 1 cm.



(1) Cost Analysis for LA-PTFE

Fs Laser ablation (including laser, water-cooling and air conditioner systems, 6 kW)	Time-cost for processing 6×6 cm^2 LA-PTFE (1.5 h)	Electric charge (1.5 ¥ /kW·h)	Cost ①: 6 kW×1.5 h×1.5 ¥ /kW·h = **13.5** ¥

(2) Cost Analysis for paraffin lubrication

Paraffin wax ~ 0.03g×0.809 ¥ / g =0.024 ¥	Thermal-spin-coating period (60 s),power (0.07 kW)	Electric charge (1.5 ¥ /kW·h)	Cost②:0.024 ¥ +0.07 kW×0.0166 h×1.5 ¥ /kW·h = **0.0357** ¥

(3) Cost Analysis for silver nanowire coating and Bonding

Synthesize silver nanowires (16 mg): (Materials expenses) (NaCl) 0.0613 g×0.031 ¥ /g = 0.002 ¥ ;(NaBr) 0.056 g×0.134 ¥ /g = 0.0075 ¥ ;(PVP) 0.70 g×0.36 ¥ /g = 0.252 ¥ ;($AgNO_3$) 2.1 g×2.6 ¥ /g = 5.46 ¥ ; (Electric charge) Oil bath heating 1.25 h×2 kW×1.5 ¥ /kW·h = **3.75** ¥

Silver nanowires ink (16 mL, 1mg/mL): 32 mg HPMC+Sago-dispersant (v/v 0.0025%)+Sago-flatting agent (v/v 0.0025%) ≈ 0.06 ¥ ;

Silver nanowire heater bonding (6×6 cm^2): PET film (6×6 cm^2) = **0.0005** ¥ ; PDMS adhesive layer ≈ **0.004** ¥ ; Silver paste for electrodes ~2 mg×0.013 ¥ /mg=**0.026** ¥ ; Here, the material expense for 1 mL SNW ink is 5.7815 ¥ /16 mL ≈ 0.36 ¥ /mL and thus the material cost for preparing 1 cm^2 silver nanowire film is calculated as 0.36 ¥ divided by (21.0×29.7 cm^2) , that is, 0.0006 ¥ /cm^2. Accordingly, the cost for silver nanowire heater with area of 6×6 cm^2 is **0.0216** ¥ ; Electric charge for oven heating 7h×0.6kW×1.5 ¥ /kW·h=**6.3** ¥

Total Cost Analysis

13.5 ¥ (electric charge-LA-PTFE)+0.0357 ¥ +3.75 ¥ (electric charge-oil bath)+0.0005 ¥ (PET platform)+0.004 ¥ (PDMS adhesive layer for bonding)+0.0216 ¥ (material expense for silver nanowires film)+6.3 ¥ (electric charge for heating oven)+0.026 ¥ (silver paste) = 23.6 ¥ = 3.7 $

Figure S15. Cost analysis over a typical DM-SLIPS (6 cm×6 cm) by combining the Fs laser scanning technique

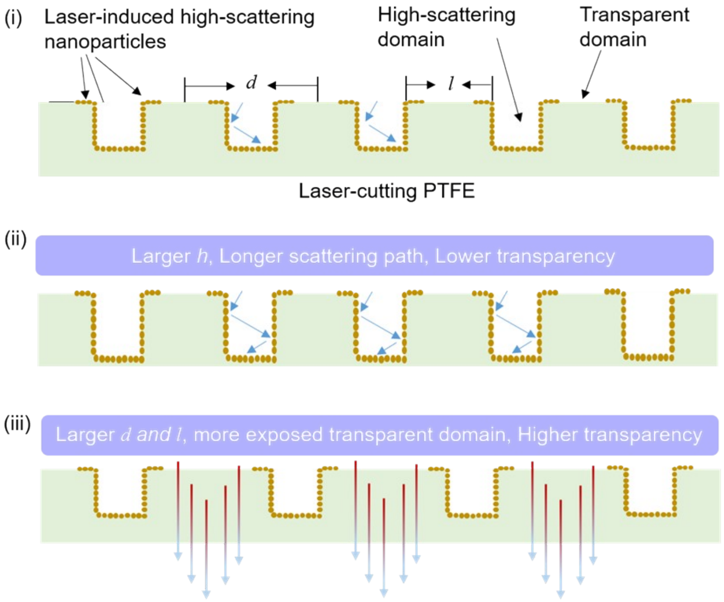


Figure S16. Schematic diagram for showing the influence of laser-cutting parameters on the topographical and optical evolution of DM-SLIPS.