

ELECTRONIC SUPPORTING INFORMATION

Controlling Liquid Movement on Surface with Macro-Gradient Structure and Wetting Behavior

Xiangyu Yin,^{a,b} Daoai Wang,^a Yupeng Liu,^a Bo Yu,^{*,a} Feng Zhou^{*,a}

Experimental

Materials. Aluminum foil (thickness 0.25 mm, 99.99%) was purchased from a local fabric store. 1H, 1H, 2H, 2H-perfluorooctyltrichlorosilane (PFOTS) was obtained from Sigma-Aldrich. All other chemicals were analytical-grade reagents and used as received.

Preparation of gradient surface with controllable water wettability. This gradient surface was prepared by modifying our previous anodization method⁹. Typically, aluminum foil was cut into a size of 2 cm × 8 cm, polished mechanically, and cleaned ultrasonically in sequence with acetone and ethanol to get rid of grease. The gradient surface was simply produced through two-step electrochemical processes as follows. Firstly, the pre-cleaned Al foil was electrochemically etched in 0.06 M NaCl aqueous solution at 4 V for 3 h at room temperature. A rubber tube, attached in the bottom of the reactive chamber, was connected to a micro-pump which made the solution removal from the chamber in a controllable manner. After 3 h, the gradient surface of Al was obtained and named AA1. Modification of the AA1 was achieved by dipping substrates in 0.5 wt% 1H, 1H, 2H, 2H-perfluorooctadecyltrichlorosilane (PFOTS) anhydrous hexane solution for 1 h at room temperature and heating treatment at 120 °C for 1 h to obtain the fluorosilanization modified AA1.

Preparation of gradient surface with controllable oil wettability. AA1 was further

anodized at a high constant current density of $325 \text{ mA}\cdot\text{cm}^{-2}$ in 0.3 M oxalic acid for 5 min at $10 \text{ }^{\circ}\text{C}$ to obtain nanoporous gradient surface (AA2). Then AA2 was immersed into 0.5 wt% 1H, 1H, 2H, 2H-perfluorooctadecyltrichlorosilane anhydrous hexane solution for 1 h at room temperature and heating treatment at $120 \text{ }^{\circ}\text{C}$ for 1 h to obtain the fluorosilanization modified AA2 surface.

Characterization. The surface nanostructures were observed using a field-emission scanning electron microscope (FE-SEM, JSM-6701F, Japan) at 5-10 kV. Chemical composition information was obtained by X-ray photoelectron spectroscopy (XPS), which was carried out on a PHI-5702 multifunctional spectrometer using Al $K\alpha$ radiation and the binding energy was referenced to the C1s line at 284.8 eV from adventitious carbon. Sessile contact angles (CA) were acquired using a DSA-100 optical contact-angle meter (Kruss Company, Ltd, Germany) at ambient temperature ($25 \text{ }^{\circ}\text{C}$) by injecting $5 \text{ }\mu\text{L}$ of testing liquid onto the sample, and the CA values were determined automatically using the Laplace–Young fitting algorithm. Average CA values were obtained by measuring one and the same sample at five different positions, and images were captured with a digital camera (Sony, Ltd, Japan). Along the vertical direction, surface roughness was taken with a NanoMap 500LS 3D profilometer (aep Technology, USA) in the contact mode for every 1 cm starting at 0.5 cm. The FTIR spectra were recorded on a Nicolet iS10 FTIR spectrometer between $4,000 \text{ cm}^{-1}$ and 1000 cm^{-1} with a resolution of 1 cm^{-1} .

Wettability test. The AA1 or AA2 was fixed at a slope with different angles (30° , 45° or 60°). Water or silicone oil droplets of $5\text{--}20 \text{ }\mu\text{L}$ were placed onto the tilted surface.

The sliding behavior of the droplet was recorded with a digital camera (Sony, Ltd, Japan).

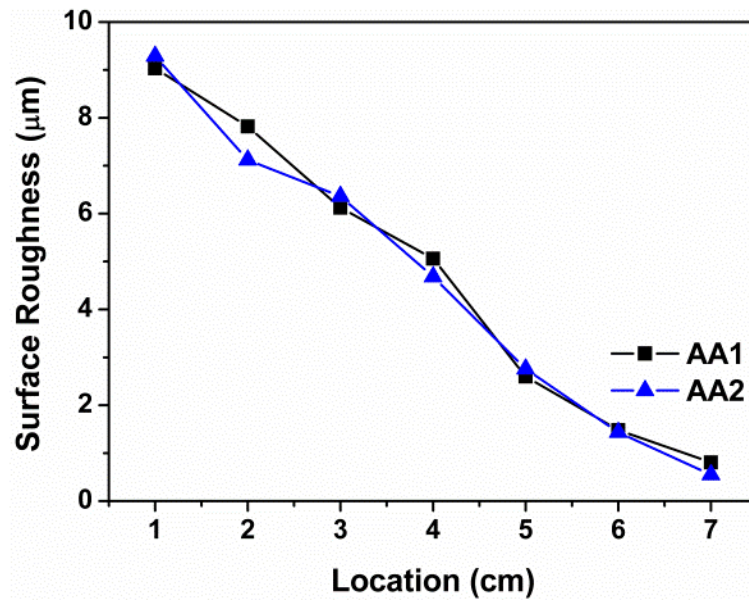


Fig. S1 The variation of AA1 and AA2 surface roughness.

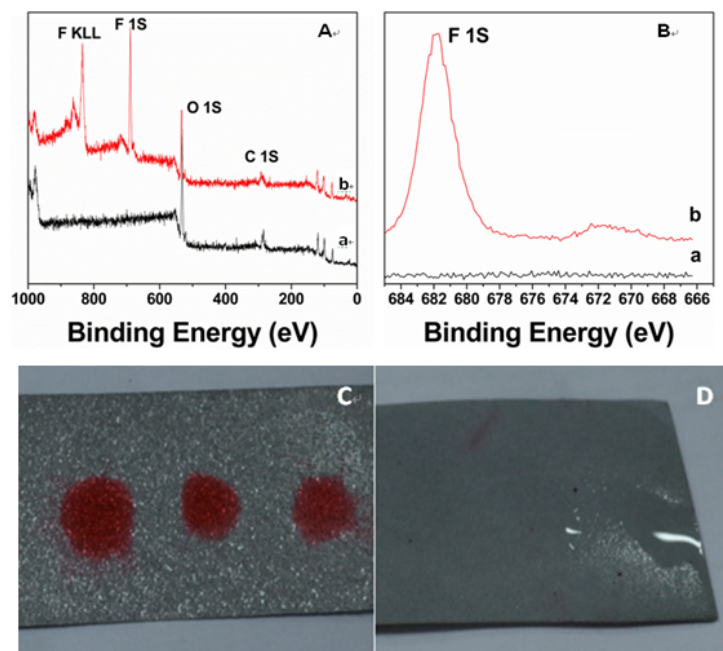


Fig. S2 XPS survey of the gradient surface before (a) and after (b) fluorinated treatment. (A) XPS full survey spectra, (B) XPS spectra of gradient surface before and after fluorinated treatment in the F1s level regions. AA1 and AA2 was wetted by water (C) and silicone oil (D).

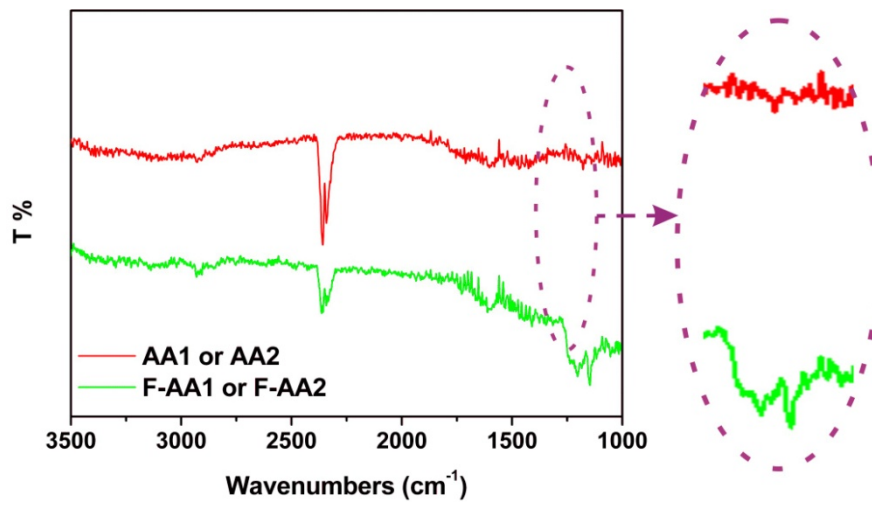


Fig. S3 FT-IR spectra of unmodified and modified surface.

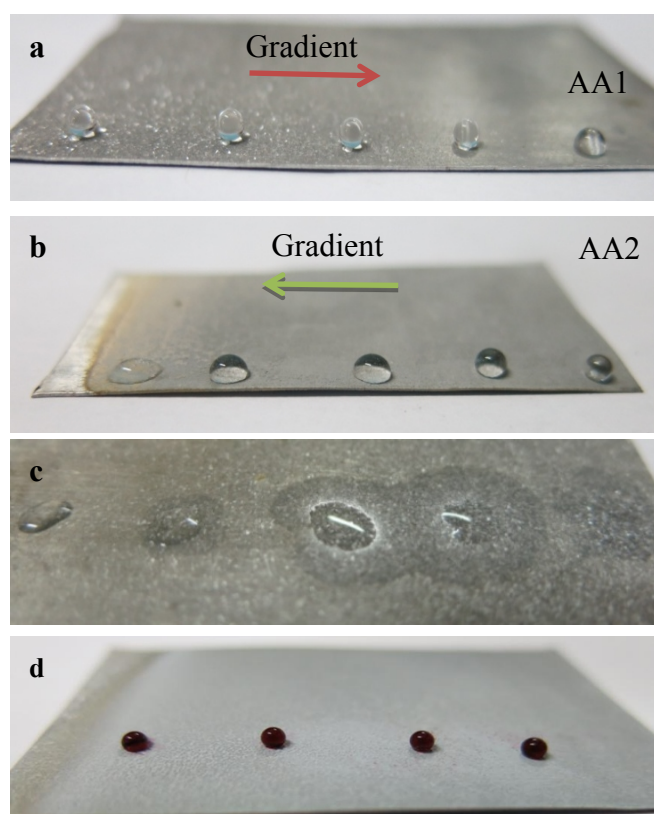


Fig. S4 Photos of the gradient wettability of water or oil droplets on AA1 (a) and AA2 (b), respectively. The wettability of oil droplets on AA1 (c) and water droplets on AA2 (d).

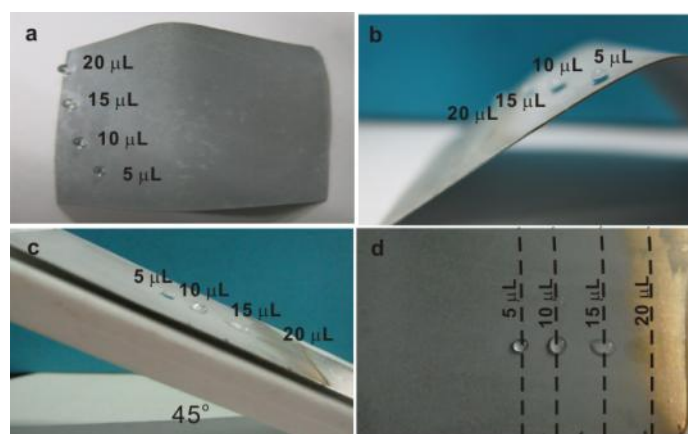


Fig. S5 The motion features of different volumes of silicon droplets at the middle of the surface (a) and the lateral view details of oil droplets (b). The wetting properties of different volumes of water droplets at AA2 for a given tilt angle 45° , (c) lateral view and (d) top view.