Hemiwicking effect on nanoscale; wetting of surfaces derived from in-situ nano-lithography by self-assembly of block-copolymer structures

Ludvigsen, Emil; Mandsberg, Nikolaj; Telecka, Agnieszka; Ndoni, Sokol; Taboryski, Rafael J.

Publication date:
2019

Document Version
Peer reviewed version

Citation (APA):
Hemiwicking effect on nanoscale; wetting of surfaces derived from in-situ nano-lithography by self-assembly of block-copolymer structures

Emil Ludvigsen, Nikolaj Mandsberg, Agnieszka Telecka, Sokol Ndoni, and Rafael Taboryski

Technical University of Denmark, Kgs. Lyngby, Denmark
rata@dtu.dk

We fabricated surfaces supporting hemiwicking flow on nanoscale (see Figure 1).¹ The surfaces comprised hexagonal arrays of posts in poly(methyl methacrylate) (PMMA) with an ultrathin (~10 nm) coating of tungsten to tune the surface hydrophilicity. The posts were derived from in-situ nanolithography, where self-assembly of polystyrene - polydimethylsiloxane (PS – PDMS) block – copolymer was used to define the pattern in Si as the starting point.²,³ Subsequent steps of electroforming of a Ni shim, injection molding, and sputter coating with W completed the fabrication process. Pillar-to-pillar distance of the predominantly hexagonal pillar array was ~70 nm. The samples were highly transparent, with a measured transmittance above ~85% in the visible spectrum due to the sub-diffraction limit feature-sizes and the sub-optical thickness of the W coating. This allowed a study of hemiwicking flow by means of optical transmission microscopy⁴, which was done by tracking water droplet fronts on the surface. Initially the frontline movement followed a power law \( x(t) \propto t^{\alpha} \), with \( \alpha \approx 0.85-1.00 \) for the first ~10 s after droplet launch. This near-linear behavior is consistent with a pressure-driven, Hagen-Poiseuille flow of constant channel length. Then the droplet reached a full stop and a hemiwicking film emerged with an initial speed equal to that of the droplet before stopping; eventually, the hemiwicking film slowed down. For the fabricated surfaces, we demonstrated anti-fogging behavior and stability over time during at least two months.

³ Telecka et al. 2018, “Nanotextured Si surfaces derived from blockcopolymer self-assembly with superhydrophobic, superhydrophilic, or superamphiphobic properties,” RSC Adv. 8, 4204
Figure 1: (a) Tracking of droplet front displacement ($x_1$), and displacement of the wicking film-front ($x_2$) as indicated in the picture obtained by transmission microscopy (b). (c) Picture of the injection molded ø50 mm transparent PMMA samples with the textures derived from block-copolymer nanolithography and coated with a thin layer of tungsten. The sample is placed on top of a sheet of paper with DTU logos. (d) Helium-ion micrograph showing the nanoscale texture.