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

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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 microscopy[4], 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.

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[1] Telecka et al. 2018, "Mapping the transition to superwetting state for nanotextured surfaces templated from block-copolymer self-assembly," Nanoscale **10**, 20652-20663.
[2] Tao Li et al. 2016, "Substrate tolerant direct block copolymer nanolithography," Nanoscale **8**, 136-140.
[3] Telecka et al. 2018, "Nanotextured Si surfaces derived from blockcopolymer self-assembly with superhydrophobic, superhydrophilic, or superamphiphobic properties," RSC Adv. **8**, 4204
[4] Søgaard et al. 2014, "Study of transitions between wetting states on microcavity arrays by optical transmission microscopy," Langmuir **30**, 12960-12968.

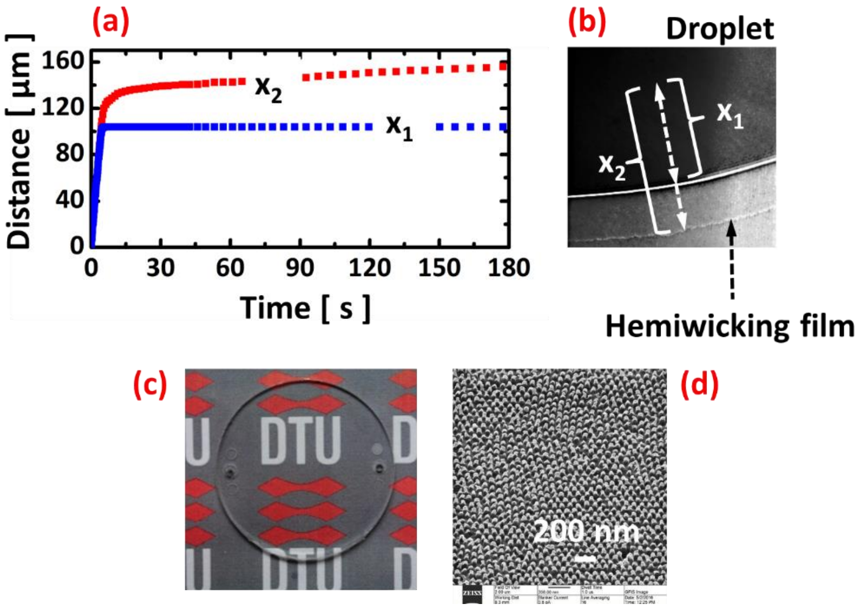

Figure 1: (a) Tracking of droplet front displacement (x_1), and displacement of the wicking film-front (x_2) as indicated in the picture obtained by transmission microscopy (b). (c) Picture of the injection molded ø50 mm transparent PMMA samples with the textures derived from block-copolymer nanolithography 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.