Electronic Supplementary Material (ESI) for Lab on a Chip


# Supplementary Information

## Inkjet patterned superhydrophobic paper for open-air surface microfluidic devices

Mohamed Elsharkawy    Thomas M. Schutzius    Constantine M. Megaridis*

*Department of Mechanical and Industrial Engineering, University of Illinois at Chicago, Chicago, IL 60607, USA. Fax: (312) 413-0447; Tel: (312) 996-3436; E-mail: cmm@uic.edu

# 1 Derivation

We modify Extrand and Gent's[1] analysis to accommodate a droplet moving on a spatially non-uniform surface. We consider a droplet centered over an ink-coated (wettable) track of known fixed width ($w$); the track is surrounded by the superhydrophobic paper. The advancing and receding contact angles on the ink track are $\theta_{a_{\text{ink}}}$, and $\theta_{r_{\text{ink}}}$, respectively. The corresponding values for the superhydrophobic paper are $\theta_{a_{\text{paper}}}$, and $\theta_{r_{\text{paper}}}$. This configuration is shown in (**Figure S1**), which also defines the azimuthal angle $\phi_1 = \sin^{-1}\left(\frac{w}{2R}\right)$ on the contact line where the philic line track meets the phobic domain. For the droplet domain that is in contact with the philic track (subscript 1), we consider a linear variation of $\cos\theta$ from $\cos\theta_{r_{\text{ink}}}$ at $\phi = 0$, to $\cos\theta_{r_{\text{paper}}}$ at $\phi_1$. Thus

$$\cos\theta_1 = \frac{\phi}{\phi_1}\cos\theta_{r_{\text{paper}}} + \left(1 - \frac{\phi}{\phi_1}\right)\cos\theta_{r_{\text{ink}}} \tag{S1}$$

The same approach is applied to the domain where the droplet is in contact with the superhydrophobic paper (subscript 2). We consider a linear variation of $\cos\theta$ from $\cos\theta_{r_{\text{paper}}}$ at $\phi_1$, to $\cos\theta_{a_{\text{paper}}}$ at $\phi = \pi/2$. Thus

$$\cos\theta_2 = \left(\frac{\phi - \phi_1}{\frac{\pi}{2} - \phi_1}\right)\cos\theta_{a_{\text{paper}}} + \left(\frac{\frac{\pi}{2} - \phi}{\frac{\pi}{2} - \phi_1}\right)\cos\theta_{r_{\text{paper}}} \tag{S2}$$

For the calculations in Table 1 (cyan ink at 47% intensity) we used the experimentally measured values of $\cos\theta_{a_{\text{ink}}} = 147°$ and $\cos\theta_{r_{\text{ink}}} = 108°$.

# 2 Videos

## 2.1 V1: Controlled Sliding

Two tracks of different widths and same wettability were printed on the same superhydrophobic paper. Water droplets were then deposited on the tracks, and the substrate was tilted around an axis on the substrate plane but orthogonal to the tracks. Due to the variations of surface area contact, different sliding angles were observed.

## 2.2 V2: Rapid Droplet Sampling and Analysis

Black ink was deposited at 100 % intensity (0.5 g $m^{-2}$) to form hydrophilic 1.5 mm dia. spots connected by a line serving as rail for a droplet rolling down the inclined plane. Each circular region was subsequently patterned with a separate water soluble pH indicator: alizarine yellow, bromothymol blue, and methyl red. The first (top most) spot was untreated, and thus acted as a control. The substrate was angled at 25°and a large water droplet was placed at the top spot. Due to the superhydrophobic nature of the substrate and its low sliding angle, the droplet slid upon release and rolled over the hydrophilic spots. After making contact with each spot, the droplet released a small volume and continued on to the next spot. The liquid left behind on each spot interacted with the pre-deposited pH indicator, and thus changed color accordingly.

# References

[1] C. Extrand and A. Gent, *Journal of Colloid and Interface Science*, 1990, **138**, 431–442.

# 3 Figures

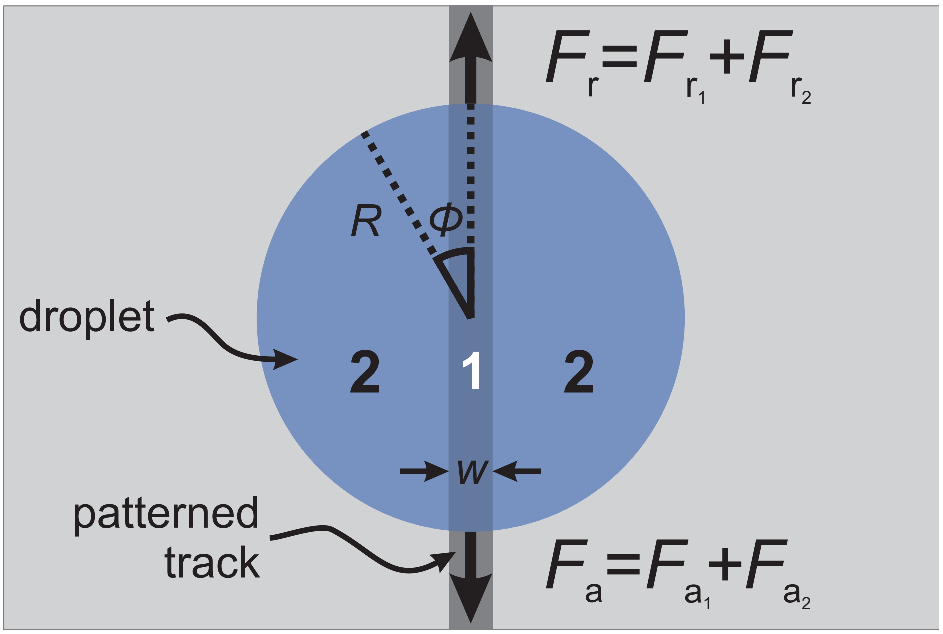


Figure S1: Top-view schematic of a water droplet (radius $R$) sliding on a wettability patterned track (width $w$). $F_a$ and $F_r$ are the forces due to surface tension in the region of an advancing and receding contact line, respectively. $\phi$ is the azimuthal angle. **1** and **2** represent two distinct solid-liquid contact regions: 1) hydrophilic track; 2) superhydrophobic coated paper.