Measuring Liquid Properties on Nano-scale Photoresist 1D Patterned Structures[1]

Juan J. Faria Briceno, S. R. J Brueck, Randy P. Schunk, Alexander Neumann
Center for High Technology and Materials, University of New Mexico, Albuquerque, NM 87106
jfaria@unm.edu

Directional wetting is a desirable materials property, particularly in the context of self-cleaning surfaces. Nature provides some very sophisticated strategies for the implementation of directional wetting. Micro-structured surfaces have been studied to explain wetting as a function of surface chemistry[2]. Experimental studies of directional wetting on 1D patterned surface have been reported for large micron-scale features, so far nanoscaled grooves are relatively unexplored. Molecular dynamics simulations have focused on wetting on nanoscale groove-patterned surfaces.[3] Nanoscale molecular models are highly dependent on the contact line pinning near plateau edges and computationally involve only a small number of atoms. Both directions have shown a small penetration of liquid on the grooves and deviation from the predicted Wenzel (liquid penetrates spaces between grooves) and Cassie-Baxter (liquid suspended above the groove) models. Both the Cassie-Baxter and Wenzel Models were formulated for randomly rough surfaces and break down when drop sizes are much larger that the patterned sizes[4]. This experiment is intended to bridge the difference between the micrometer scale micro-fluidic experimental results and nanoscale wetting simulations with showing experimental data on liquid drop statics and dynamics on nanoscale periodic surfaces.

Two sets of 1-D Nano patterned photoresist structures varying from 300- to 1000-nm pitch were fabricated using interferometric lithography to analyze liquid drop properties. The structure contained two layers: bottom antireflecting coating (BARC) and positive photoresist (SPR-505A) atop a bare silicon wafer. The first set was fabricated with fixed thickness of photoresist (h) and fixed duty cycle (a/p). The second set was fabricated with fixed aspect ratio (a/h) and fixed duty Cycle (a/p). Figure 2 shows all fabrication parameters taken in consideration. All samples were exposed to dry reactive ion etching (DRIE) of CHF_3 to ensure a uniform surface chemisry and 4μL volume deionized water drop was used to measure perpendicular and parallel contact angles; as well as, length/width ratios.

Our results show that neither Cassie-Baxter nor Wenzel models explain the wetting drop interactions with 1D Nano pattered structures. Also, we have shown that the wetting angles parallel to the grooves changes as a function of pitch three times faster than in the perpendicular direction. That is, the drop compresses faster in the direction parallel to the grooves as the pitch is reduced; shown in Figure 1. Finally, we show that the smaller the pitch the smaller are both contact angles (perpendicular and parallel) directly opposite to Cassie-Baxter and Wenzel model predictions.

---

[1] This work is based upon work supported primarily by the National Science Foundation under Cooperative Agreement No. EEC-1160494.

[2] Sonja Neuhaus, Nicholas D. Spencer, Celestino P. "Anisotropic Wetting of Microstructures Surfaces as a Function of Surface Chemistry" *ACS Applied Materials & Interfaces* 2012, **4**, 123-130.
[3] Xin Yon, Lucy T. Zhang. "Nanoscale Wetting on Groove Patterned Surfaces" *ACS American Chemical Sociaty Langmuir* 2009, **25**, 5045-5053.
[4] Seeman R., Brinkmann M., Kramer E.J., Lange F.F., Lipowsky R. "Wetting Morphologies at Microstructure Surfaces" *Proc. Natl. Acad. Sci. U.S.A.* 2005, **102**, 1848-1852.

a)  b) 

Figure 1: a) top view, 4μL drop sitting on 500 nm pitch pattern surface with 40% duty cycle b) top view, 4μL drop sitting on 1000 nm pitch pattern surface with 40% duty cycle.

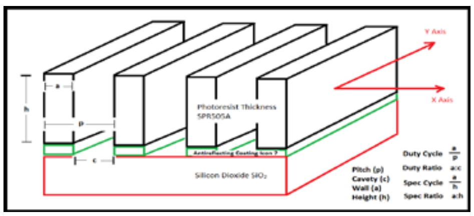

Figure 2: Fabrication parameters used for samples from 300nm pitch to 1000nm pitch.

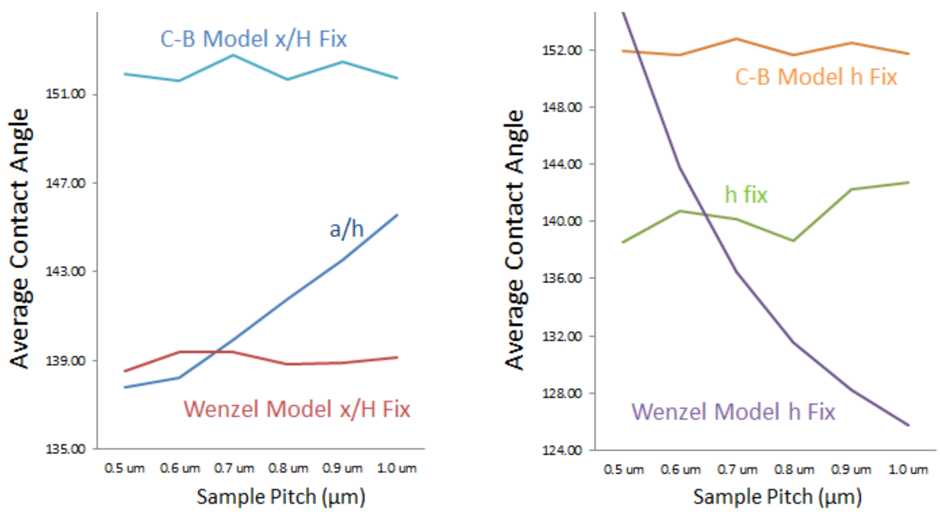

Figure 3: Comparison perpendicular contact angle under photoresist thickness (h) fixed and aspect ratio (a/h) fixed with Wenzel and Cassie-Baxter Model.