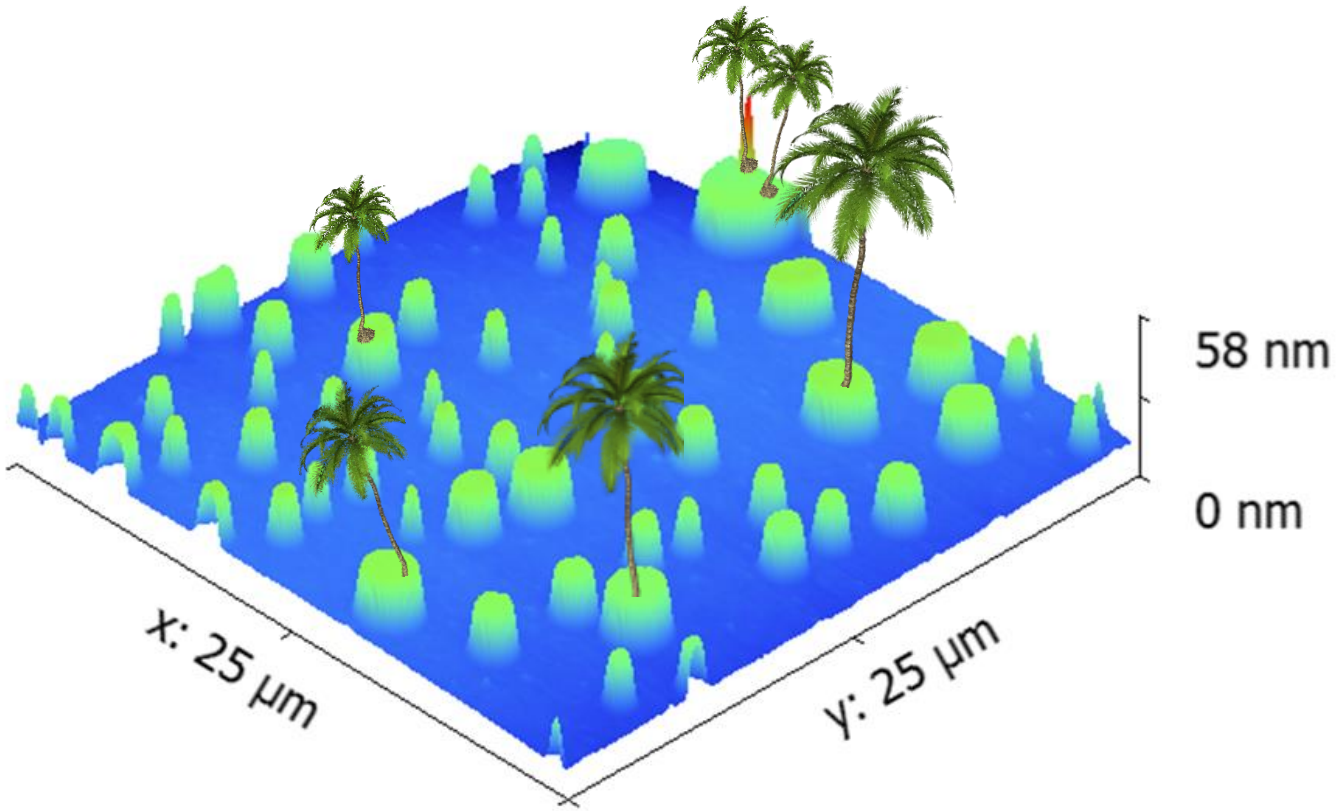
Lecture 20

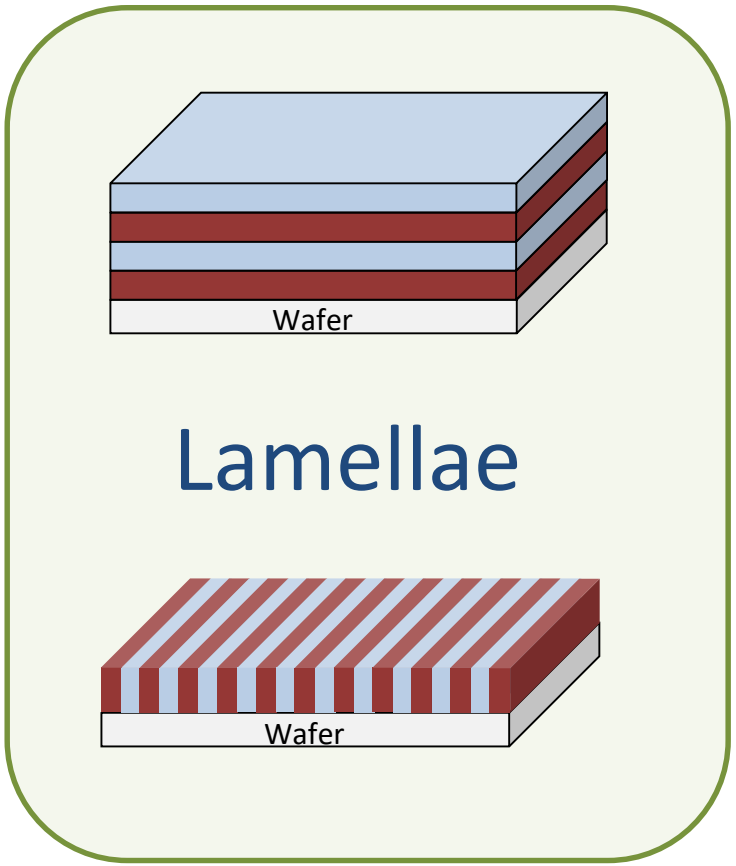
Chemical Engineering for Micro/Nano Fabrication



Islands??

Block co-polymers

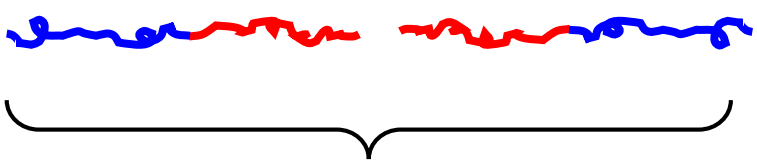
Next….The Orientation Control Challenge



Bates et al. Science **338**, 775 (2012)

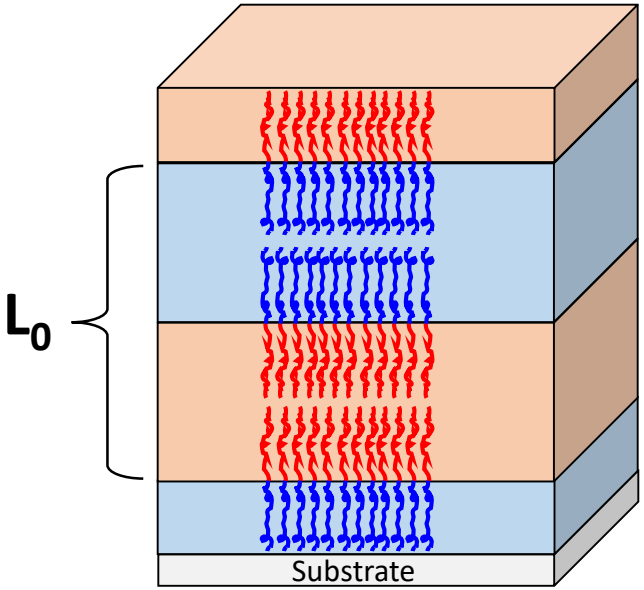
Maher et al. *Chem. Mater*. **2014,** *26*, 1471

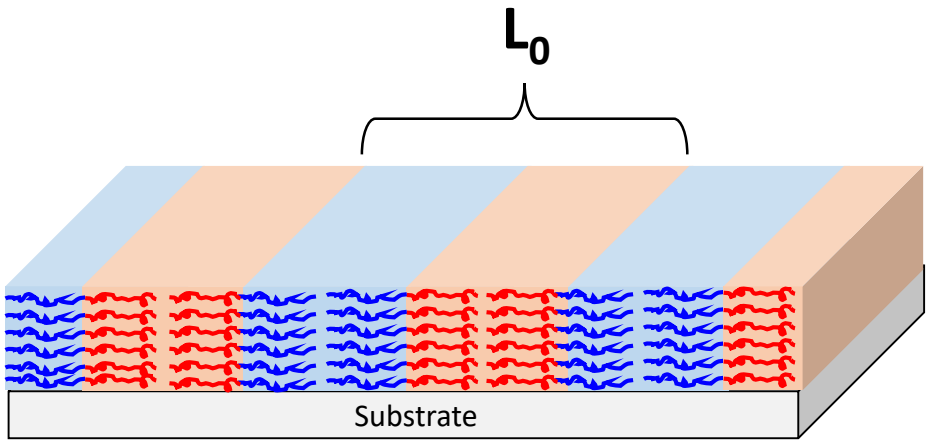
Block Copolymer Orientation



AB diblock

Periodicity "L_0" ~ 5-100 nm

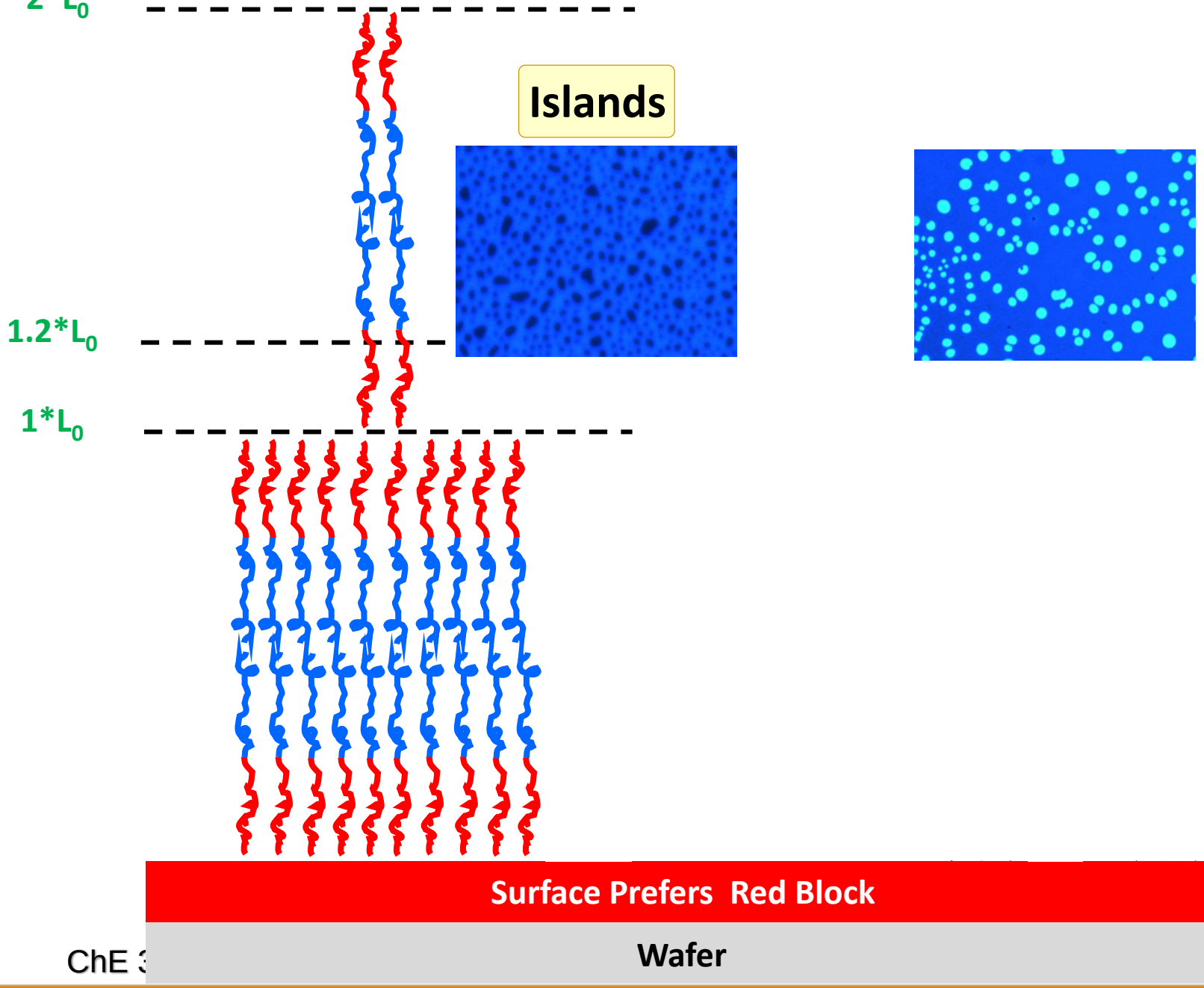




Parallel

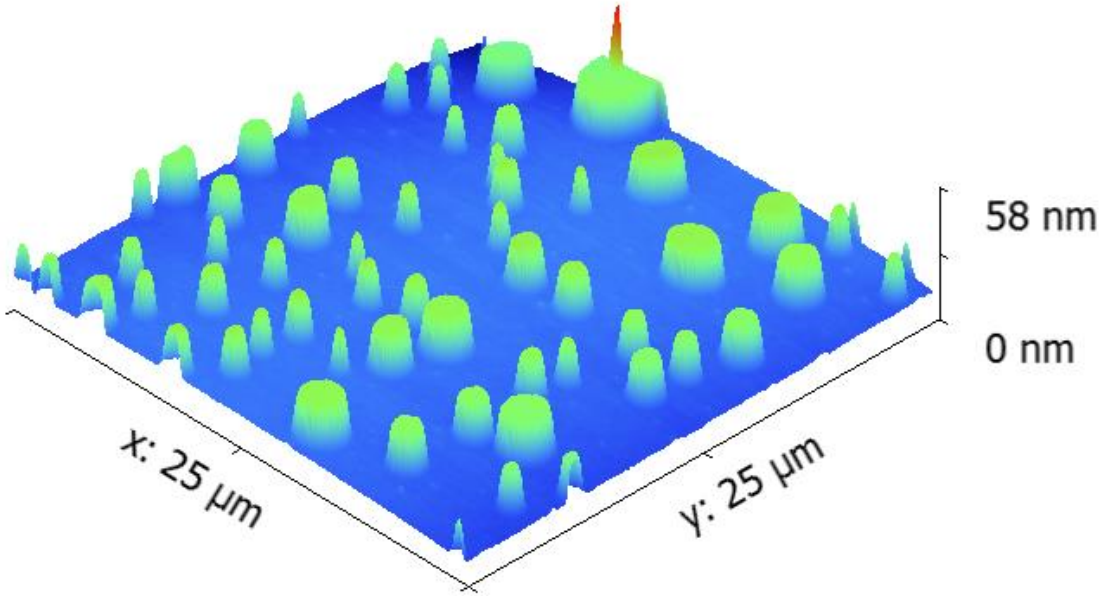
Perpendicular

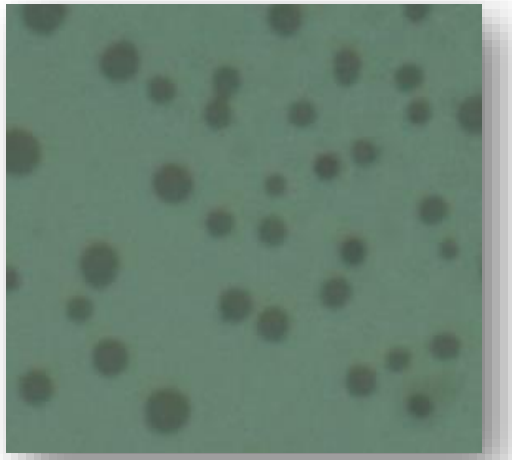
As cast film thickness > L_0?



The “island and hole” experiment

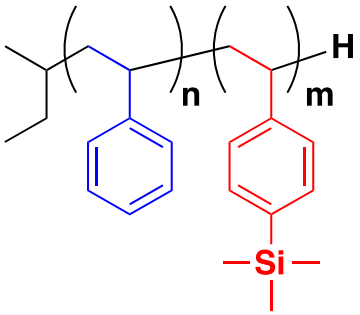
Structures are easily seem by optical microscopy

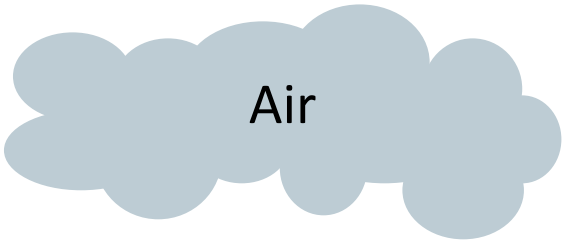


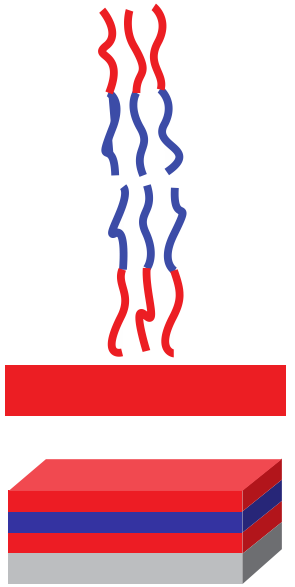


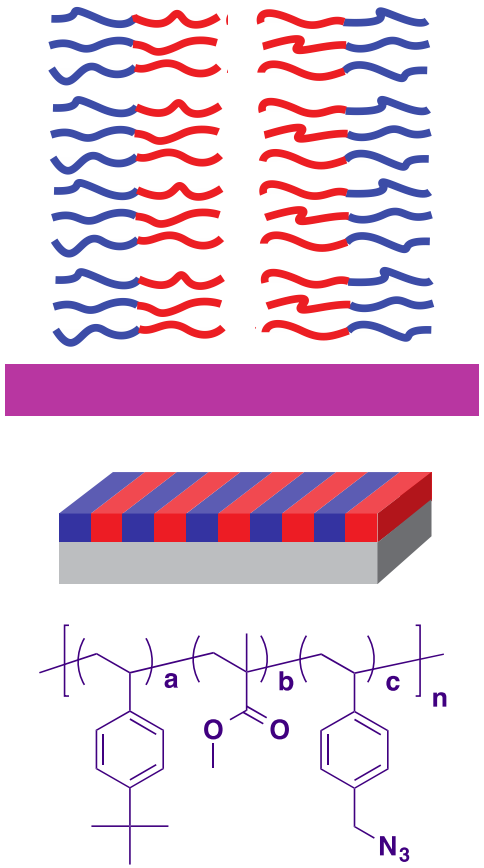
Islands

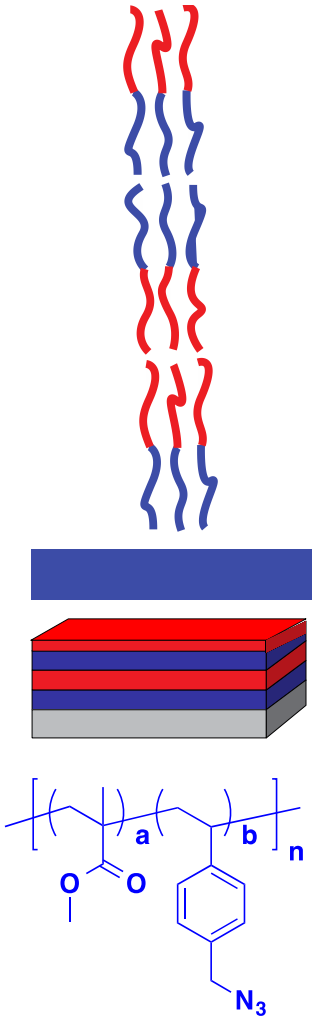
Thin film orientation





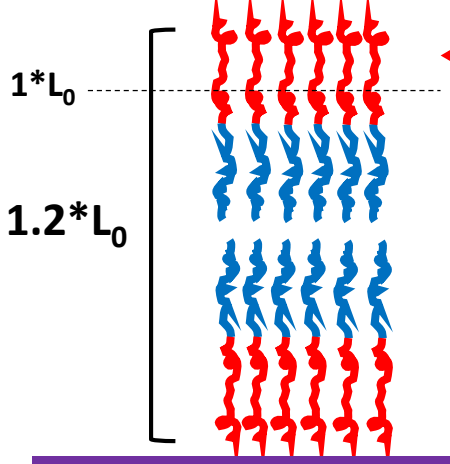






Bang *et al*. *Adv. Mater.* **2007**, *19*, 4552

Incommensurate Initial Film Thickness



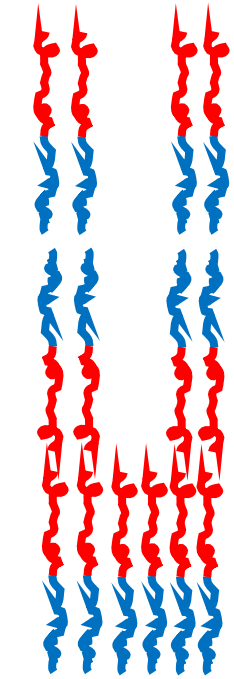
Si is always on top!

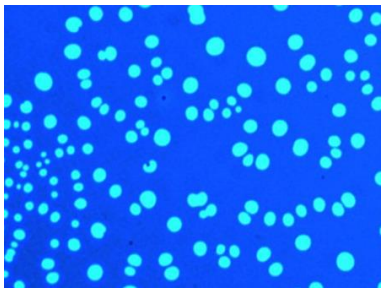
Which Block Wets?

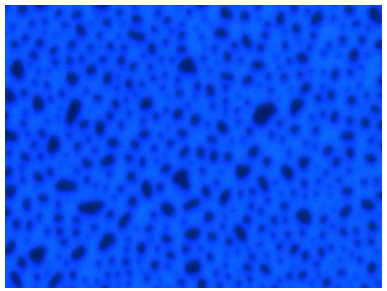
Wafer

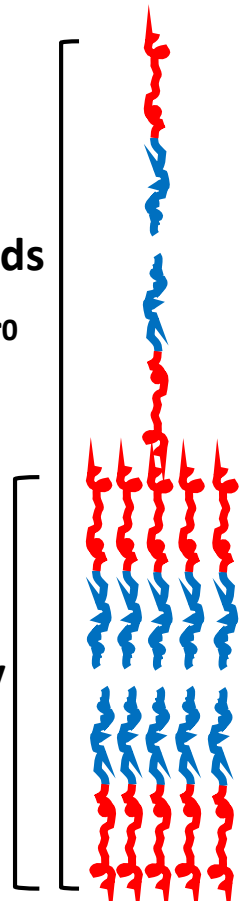
Blue Wets

Red Wets









Blue Wets

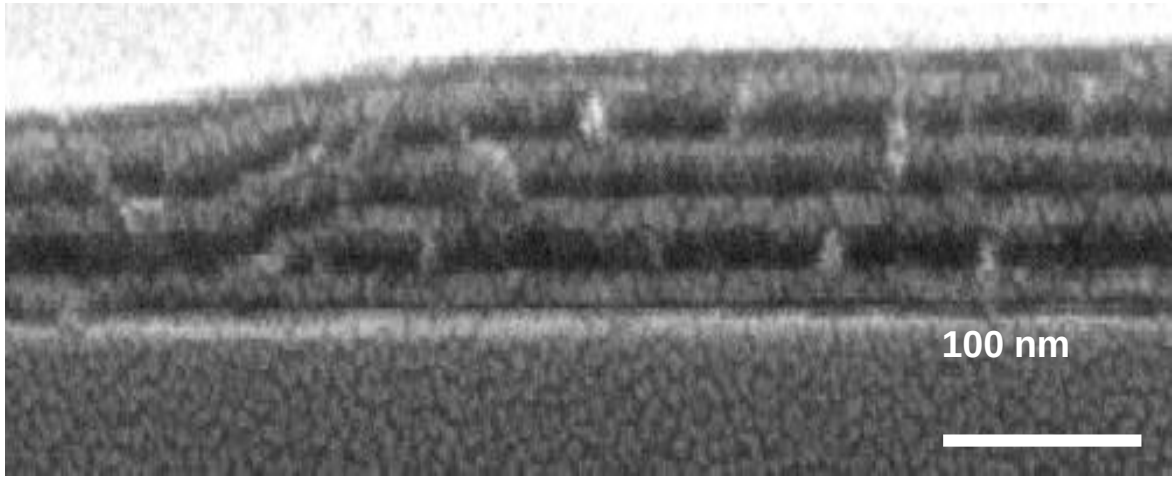
Wafer

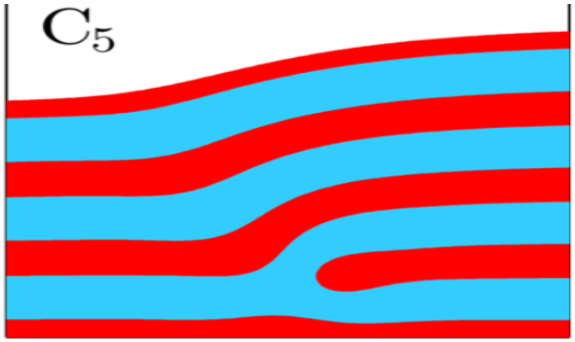
Red Wets

Wafer

Peters, R. D. et al., *Langmuir* **2000**, *16*, 4625.

Formation of Islands and Holes



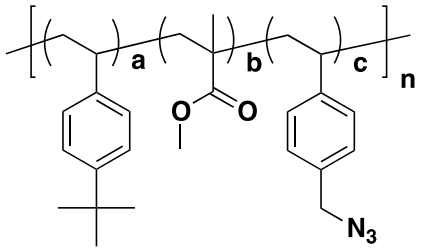


Maher, Michael, et al, J*ACS Nano* **10(11)** 10152-10160 (2016)

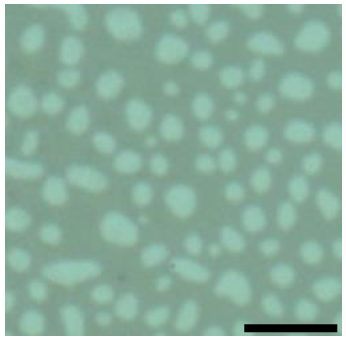
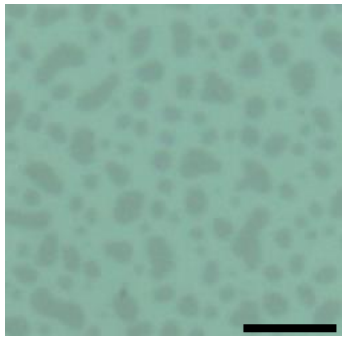
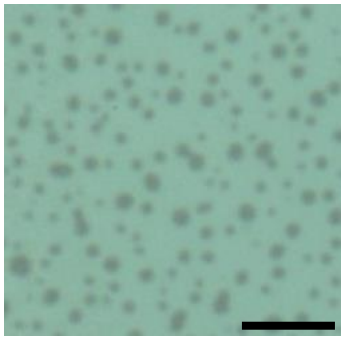
Finding the neutral composition

Surface treatment:

Initial BCB thickness: 1.15 L_0



Percent PtBuS:

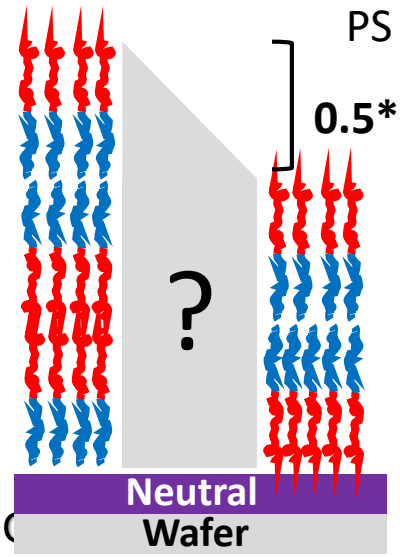
48%	52%	65%
		

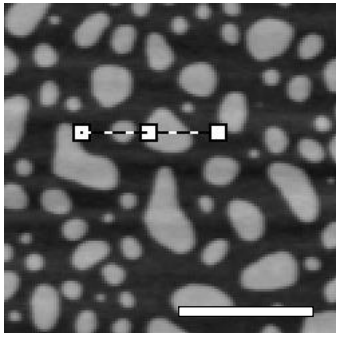
Result:

1 L_0 Holes
PS wetting

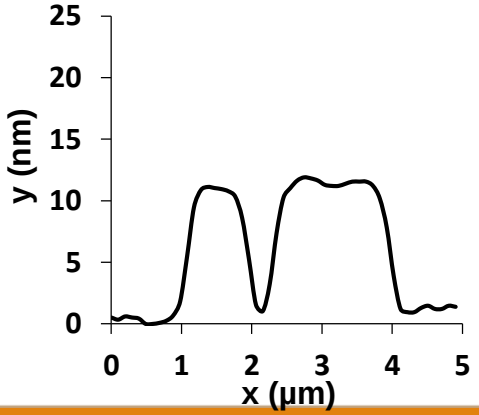
0.5 L_0 Islands
PS and PTMSS wetting!

1 L_0 Islands
PTMSS wetting



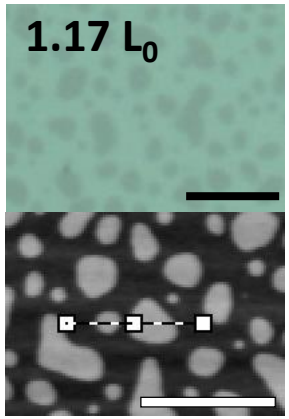


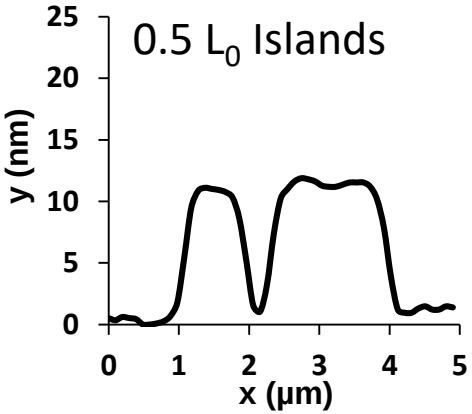
Scale bars are 5 µm

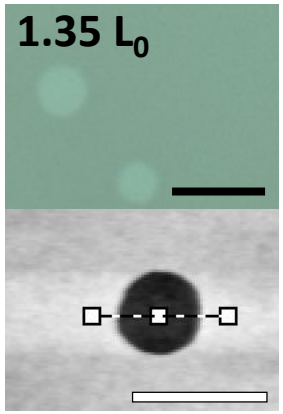


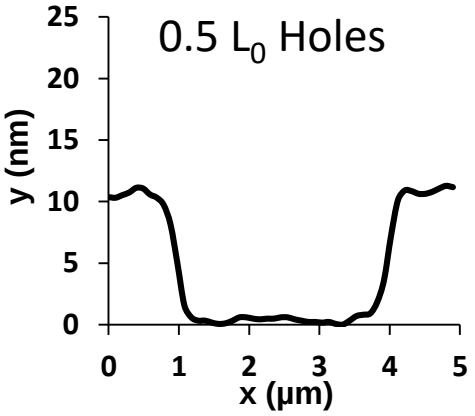
Half L_0 features on a neutral surface

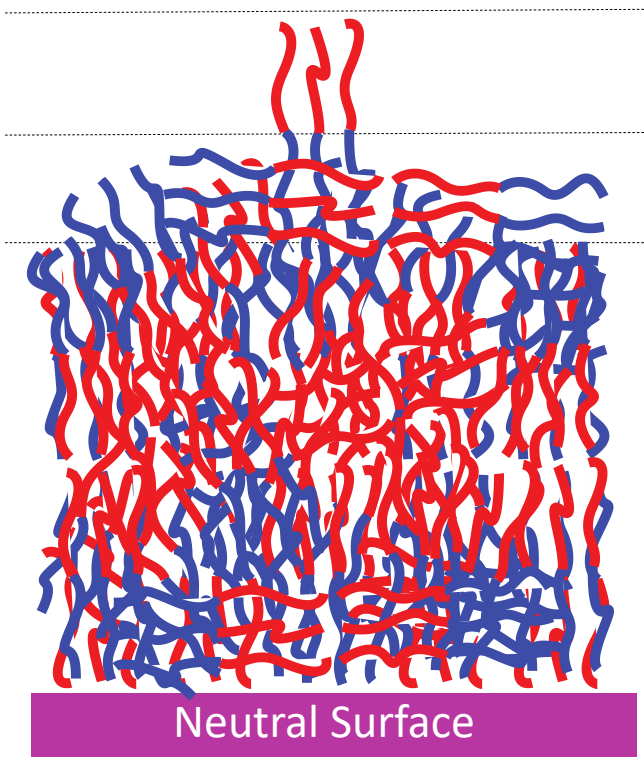
Kim *et al. ACS Nano*. **2013**, 7, 9905.



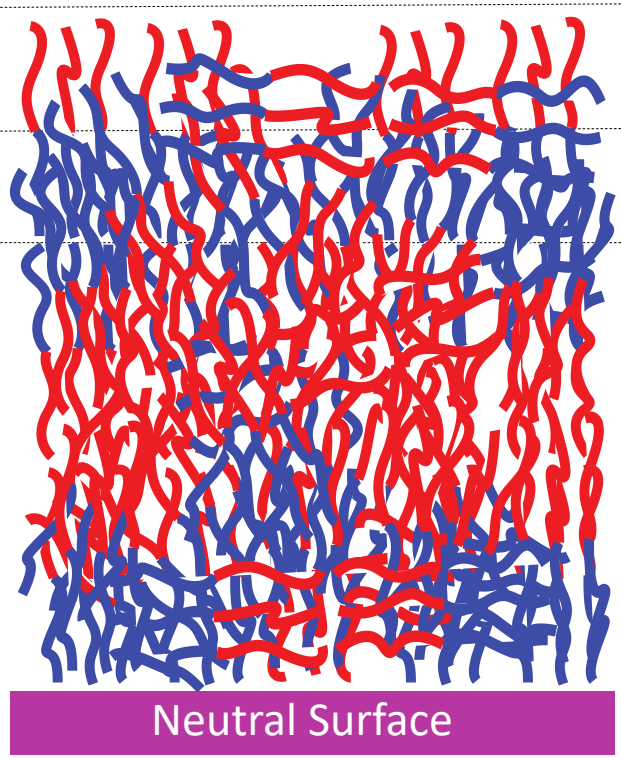




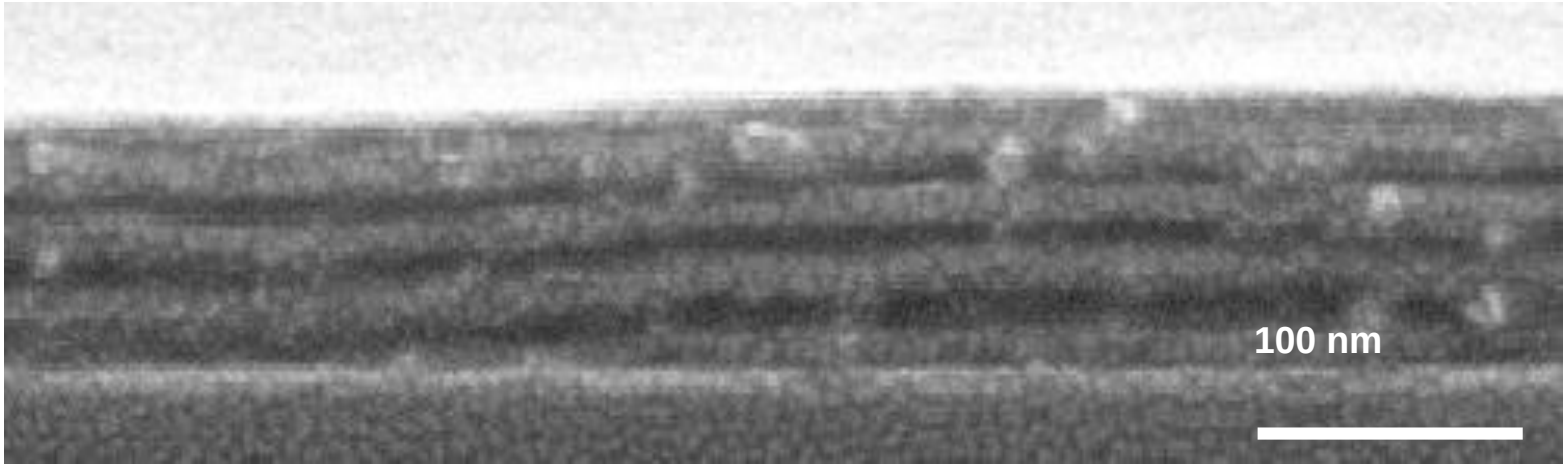


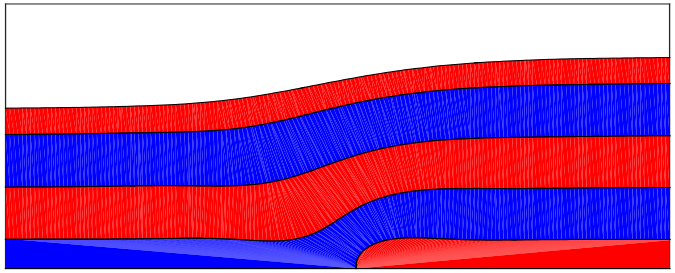


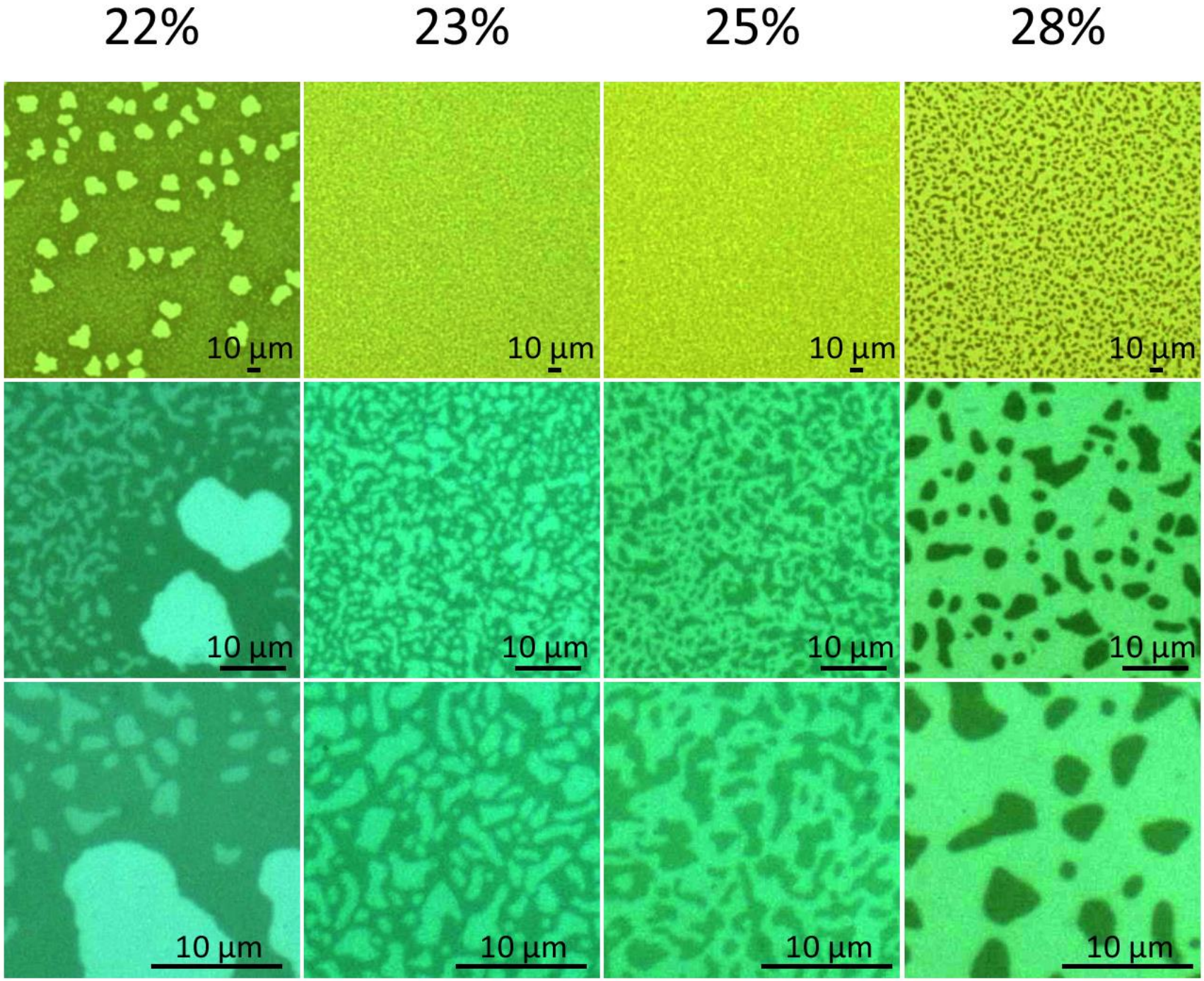
Scale bars are 5 μm



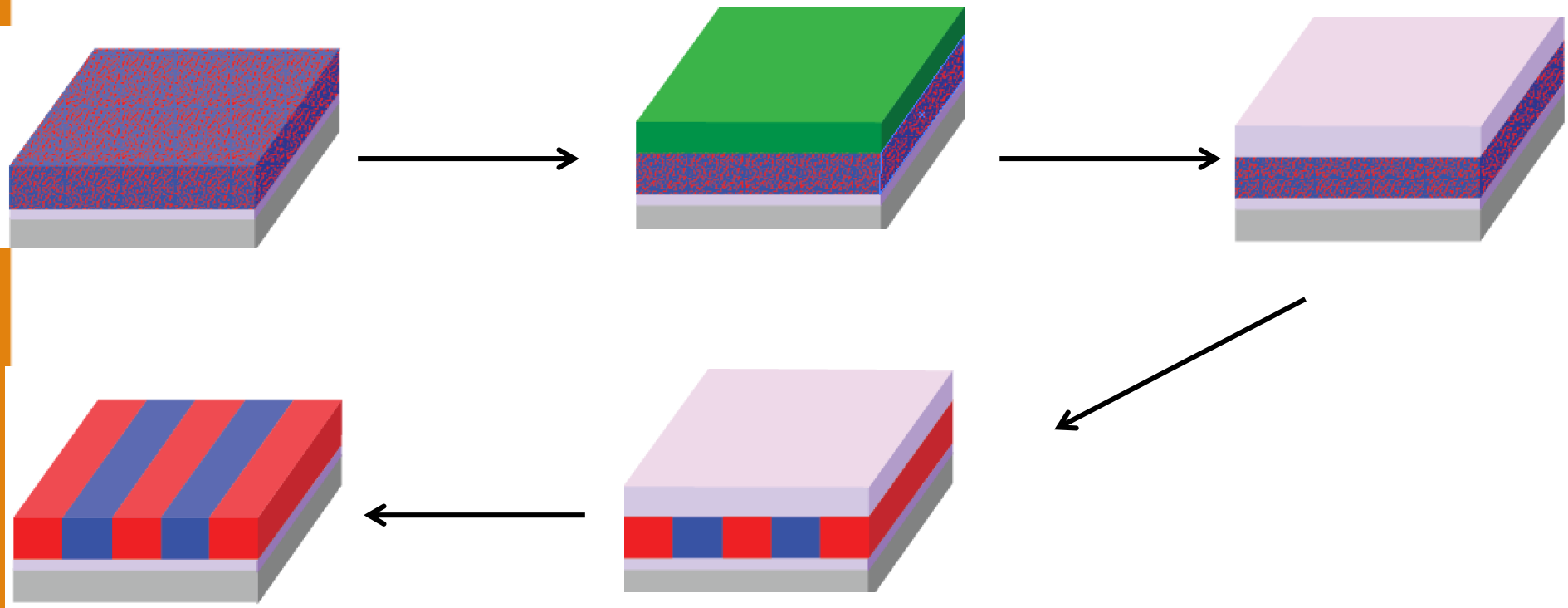
Formation of ½ Islands and holes on a neutral surface



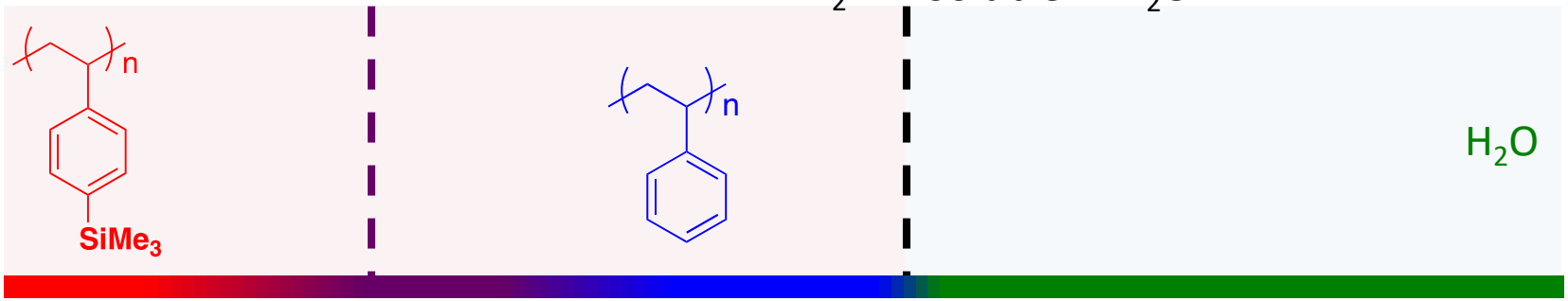



22%
23%
25%
28%
10 µm
10 µm
10 µm
10 µm
10 µm
10 µm
10 µm
10 µm
10 µm
10 µm
10 µm
10 µm

Top Interface Challenge



Not Soluble in H_2O | Soluble in H_2O



γ (mN/m)

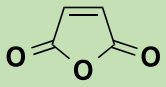
25 | 33 | 40 | Polar solvent solubility threshold

Ideal neutral surface

Top Coat Chemistry

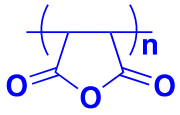
Requirements

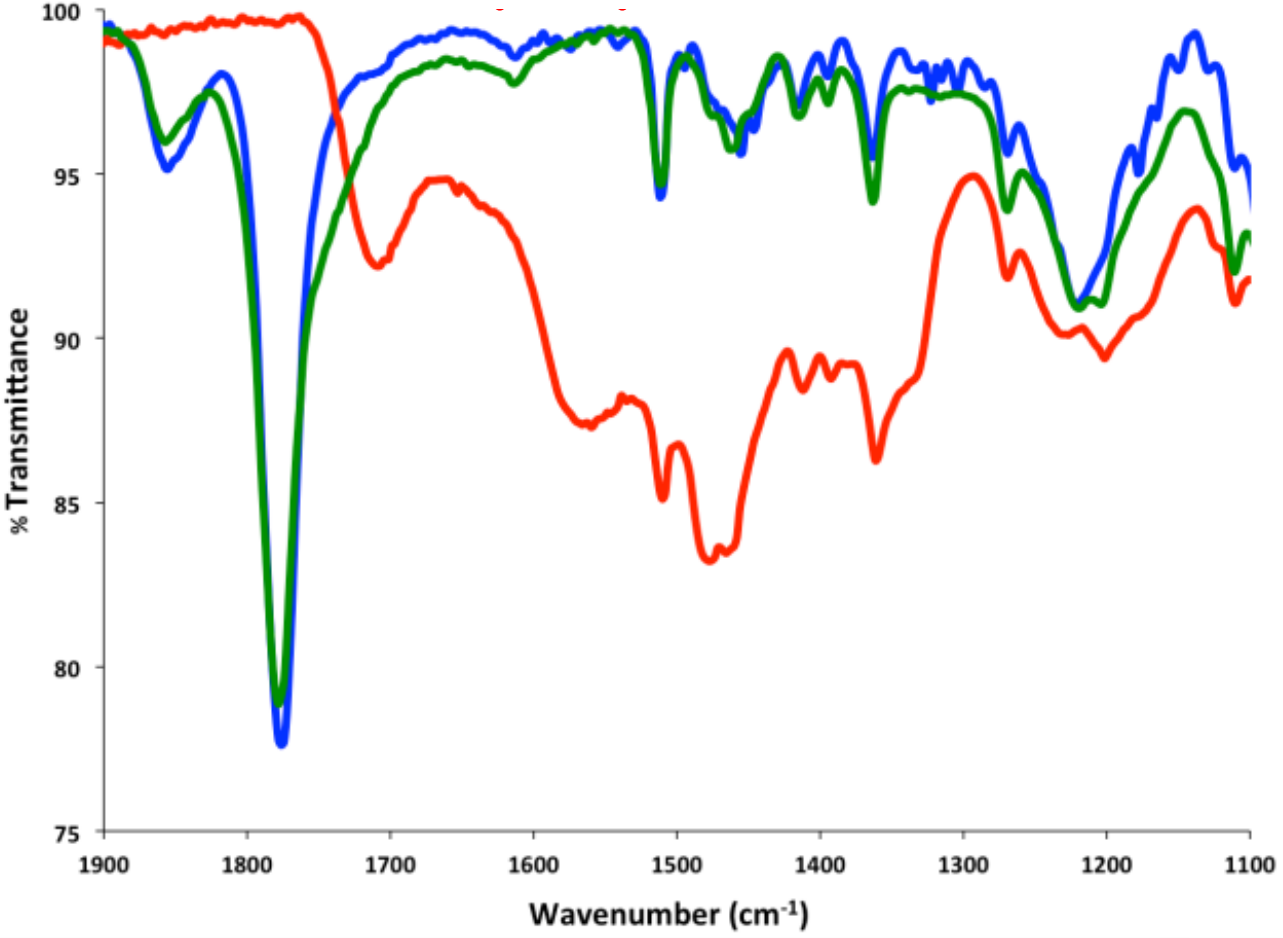
1. Polarity switch



2. T_g greater than blocks
   PS = 105 ˚C
   PTMSS = 135˚C

3. Surface energy control

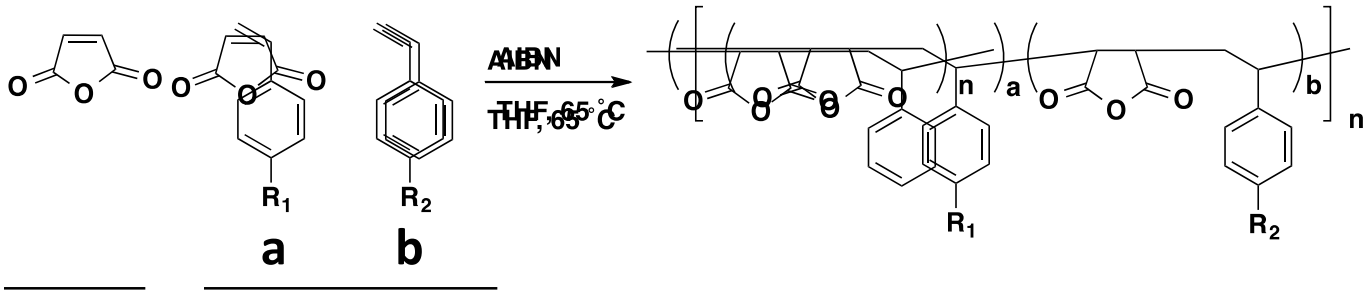




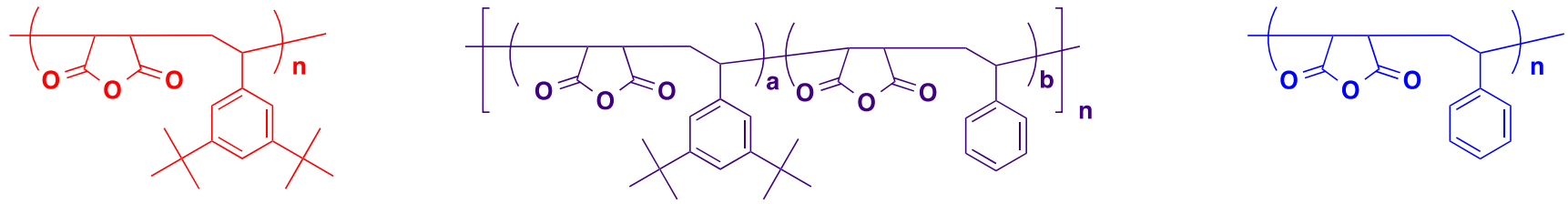
Maher, M., et al. *Chem. M* **2014,** 26, 1471

Bates, C., et al. *Science* **20** 338, 775

Top Coat Design

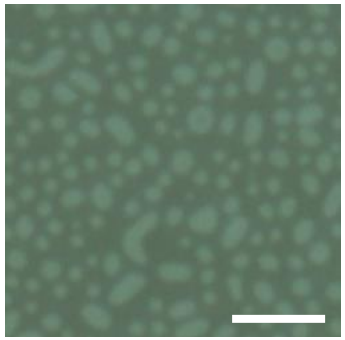


Mol fraction: 0.5 a + b = 0.5

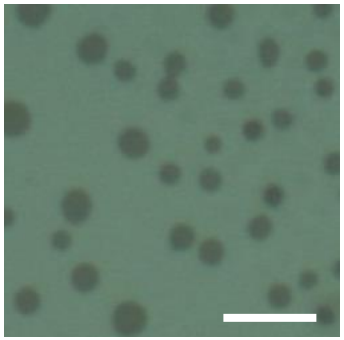


PTMSS Preferential **Neutral** **PS Preferential**

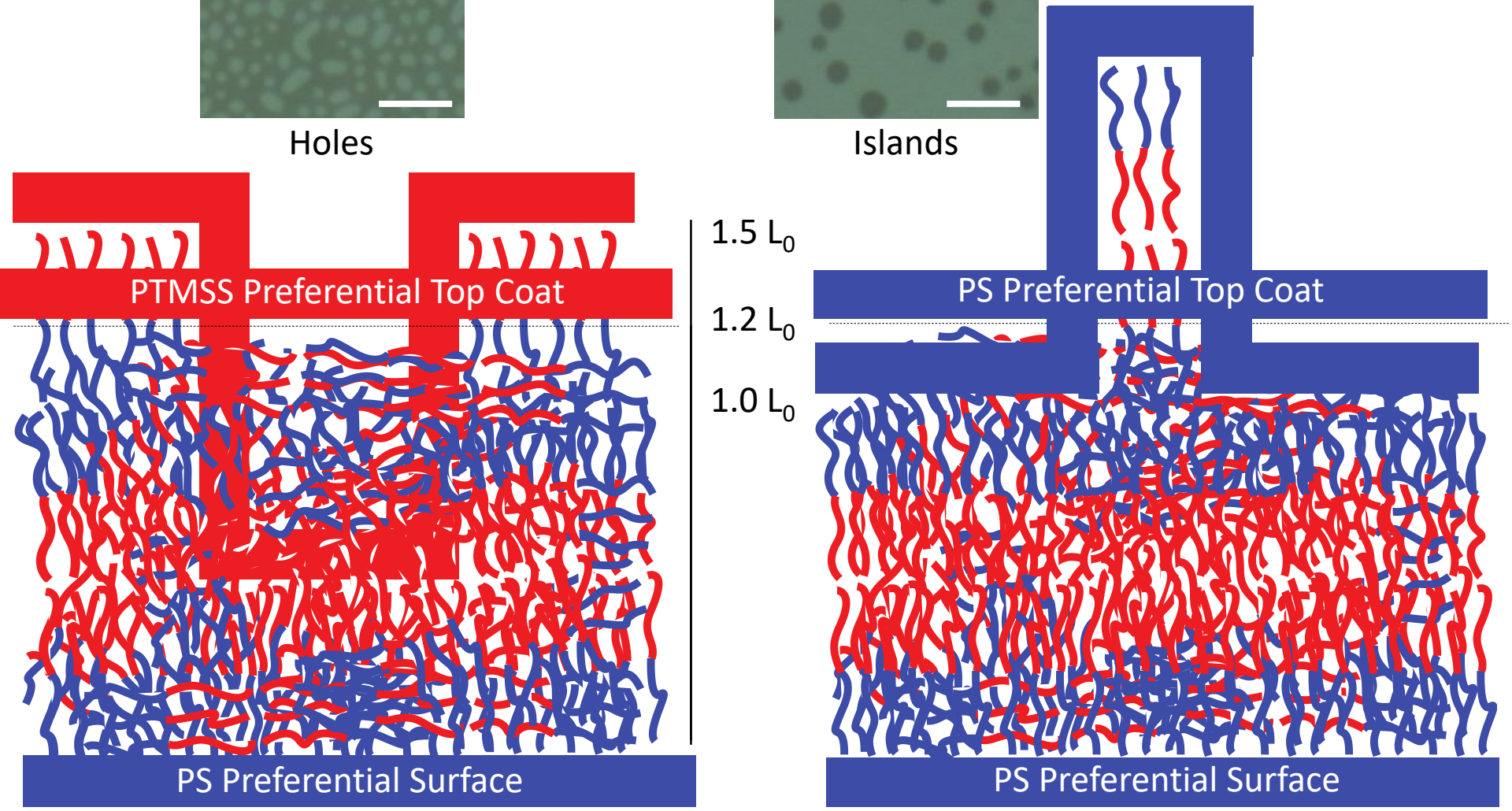
Confined Island Hole test



Holes



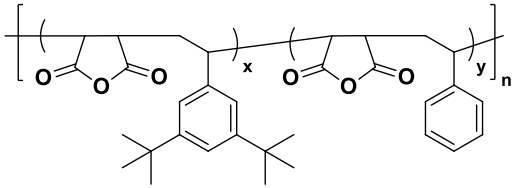
Islands



Confined island hole results for 22 nm diblock

Initial BCP thickness: 1.19 L_0

Top Coat:

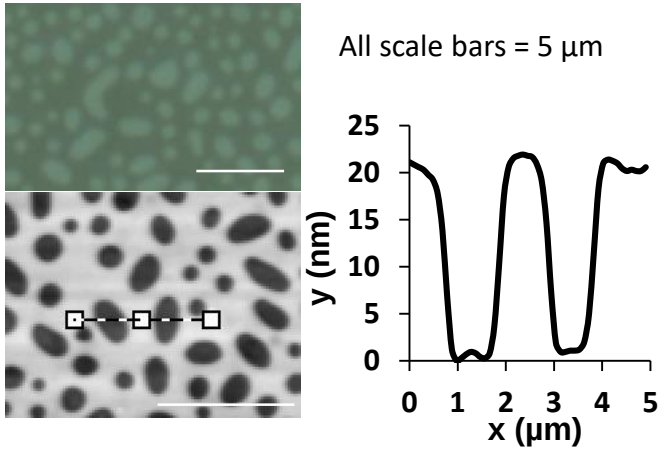


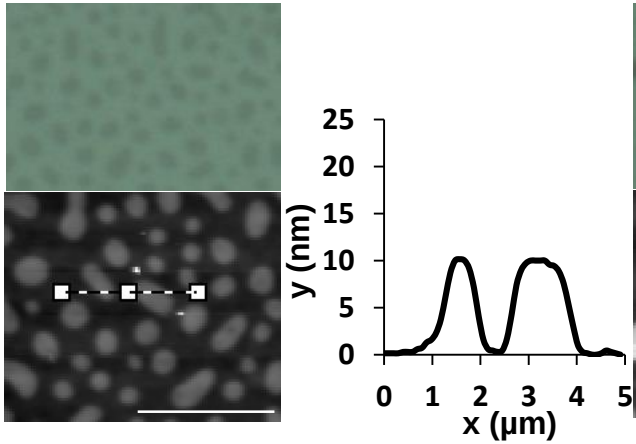
49% di-tBuS

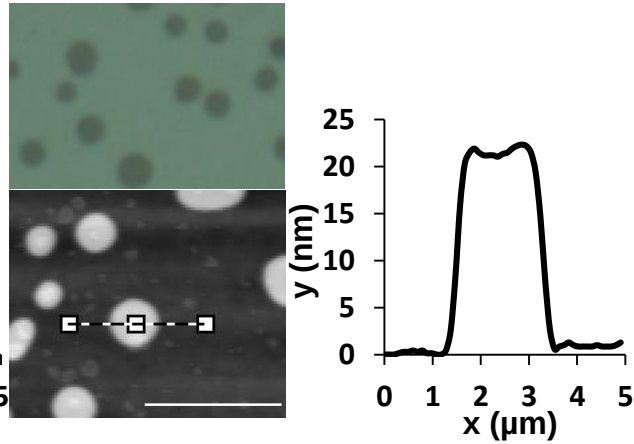
25% di-tBuS

12% di-tBuS

All scale bars = 5 µm



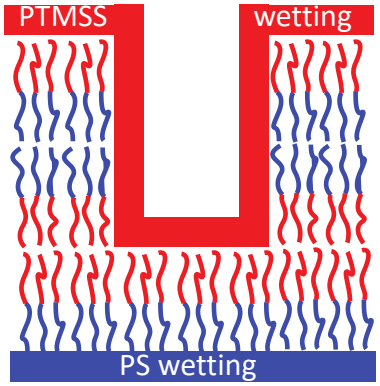


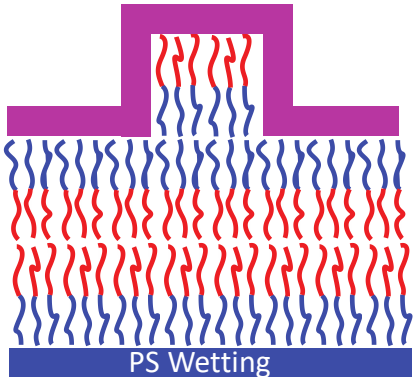


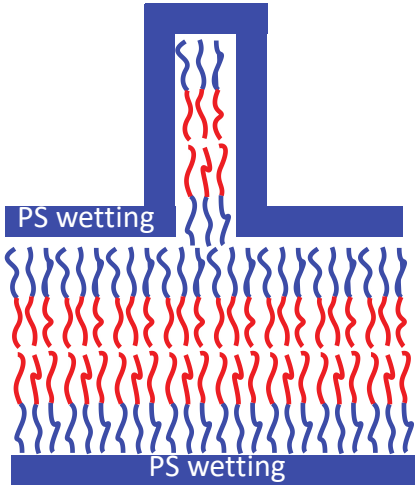
22 nm holes = 1 L_0

10 nm islands = 0.5 L_0

22 nm islands = 1 L_0

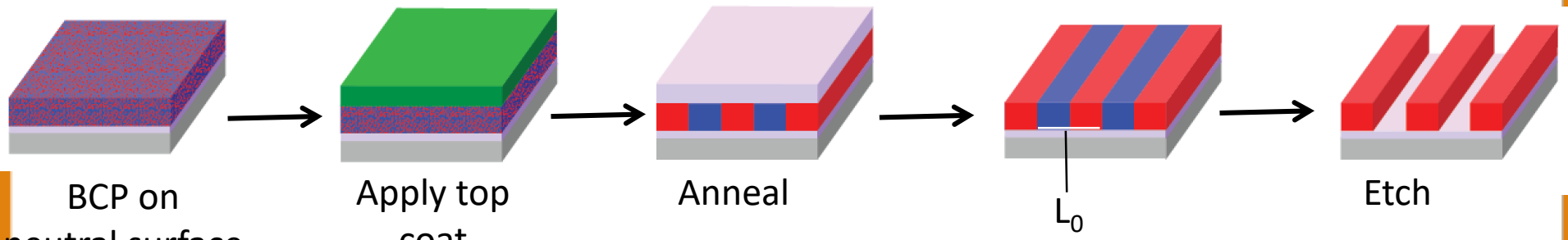






Orientation Results

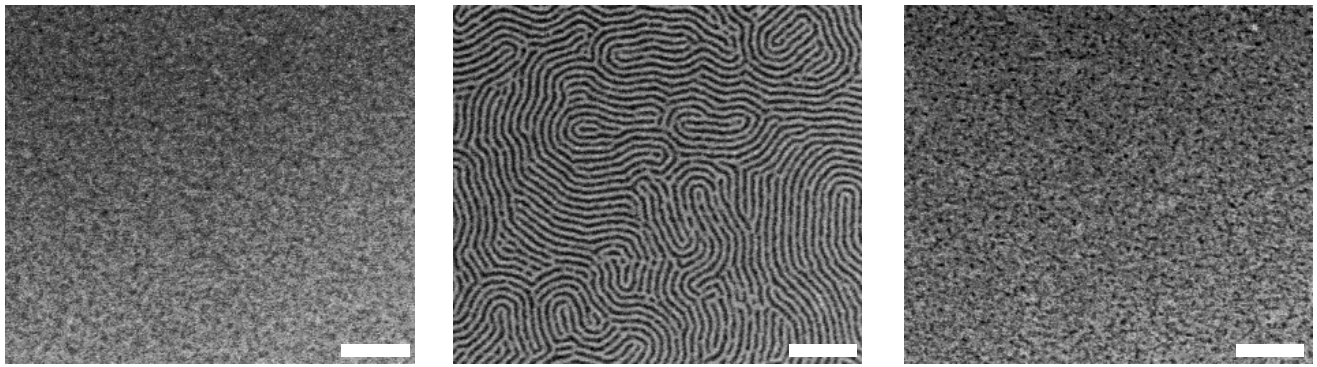
Maher et al. *Chem. Mater*. **2014,** *26*, 1471



PS Preferential Interfaces

Neutral Interfaces

PTMSS Preferential Interfaces



1.0 L_0 1.5 L_0 2.0 L_0 2.3 L_0 3.0 L_0

If both surfaces are truly neutral, alignment is perpendicular for all film thicknesses.