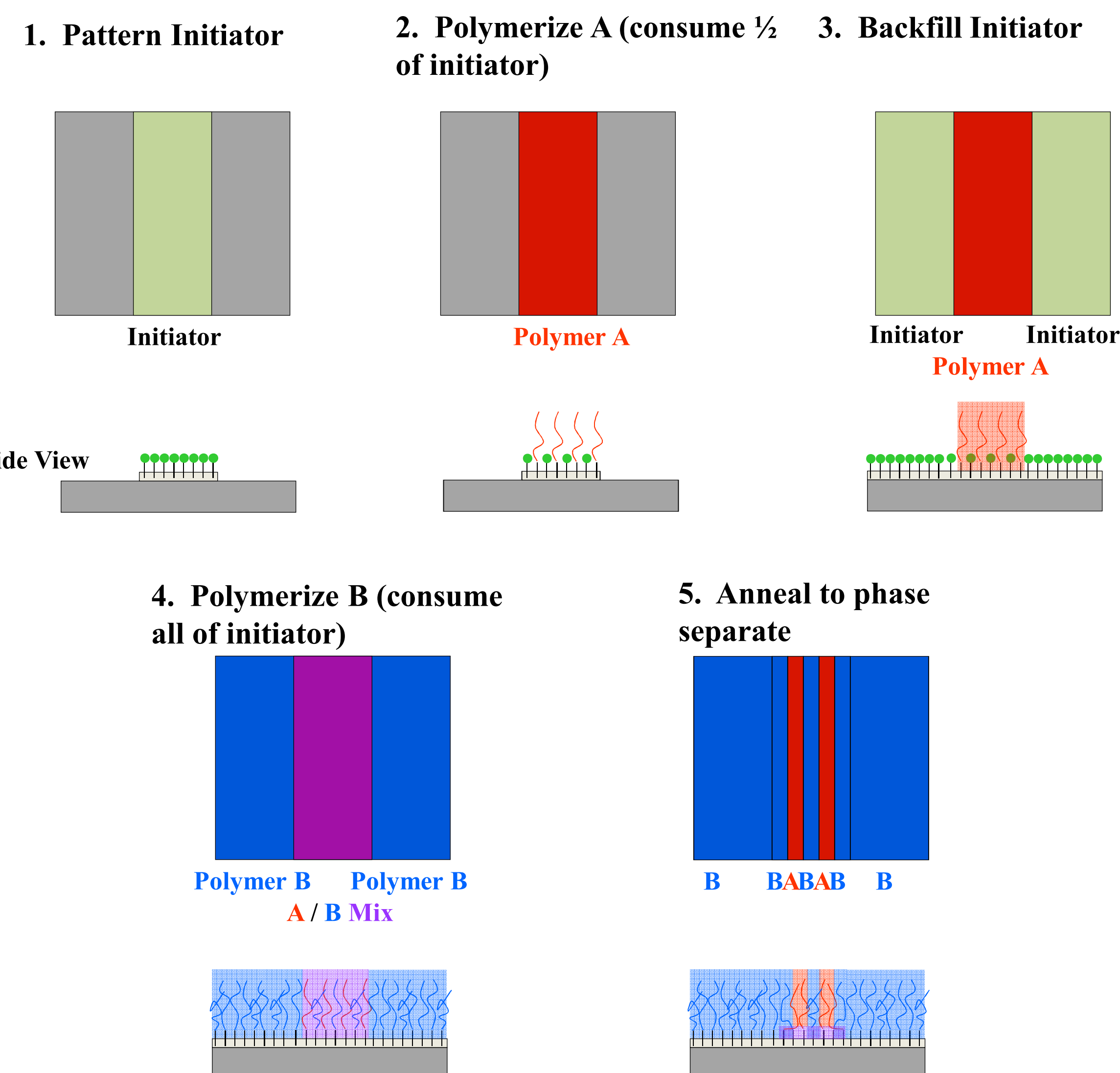


Motivation: Nanolithography by Directed Assembly

There is a shortage of methods to produce controlled, directionally-aligned nanoscopic features on surfaces. The current method of choice is electron beam lithography, an extremely expensive, time-consuming technique that can only be used on a limited range of materials. In contrast, self-assembly approaches are fast and relatively easy ways to make nanopatterns, but they typically lack directional control. A method that combines the structural control of photolithography with the size-scale and ease of use of self-assembly would be highly desirable. Here we explore the directed assembly of mixed polymer brushes as a possible nanolithography tool, using self-consistent field theory and experiment.

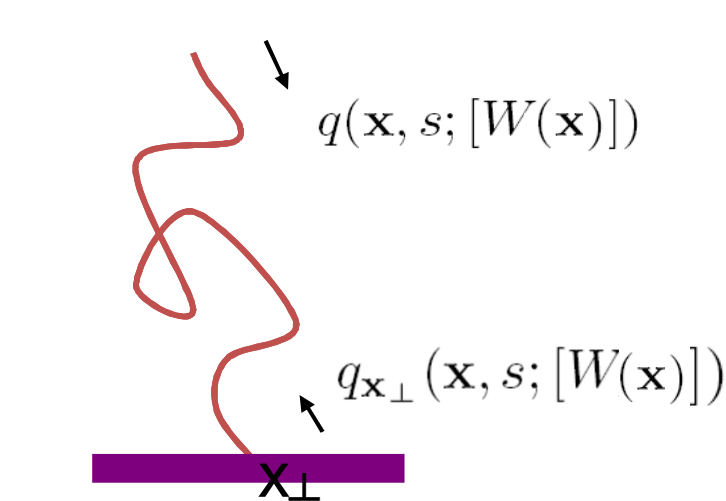
Idea for Nanolithography



Method: Self-Consistent Field Theory

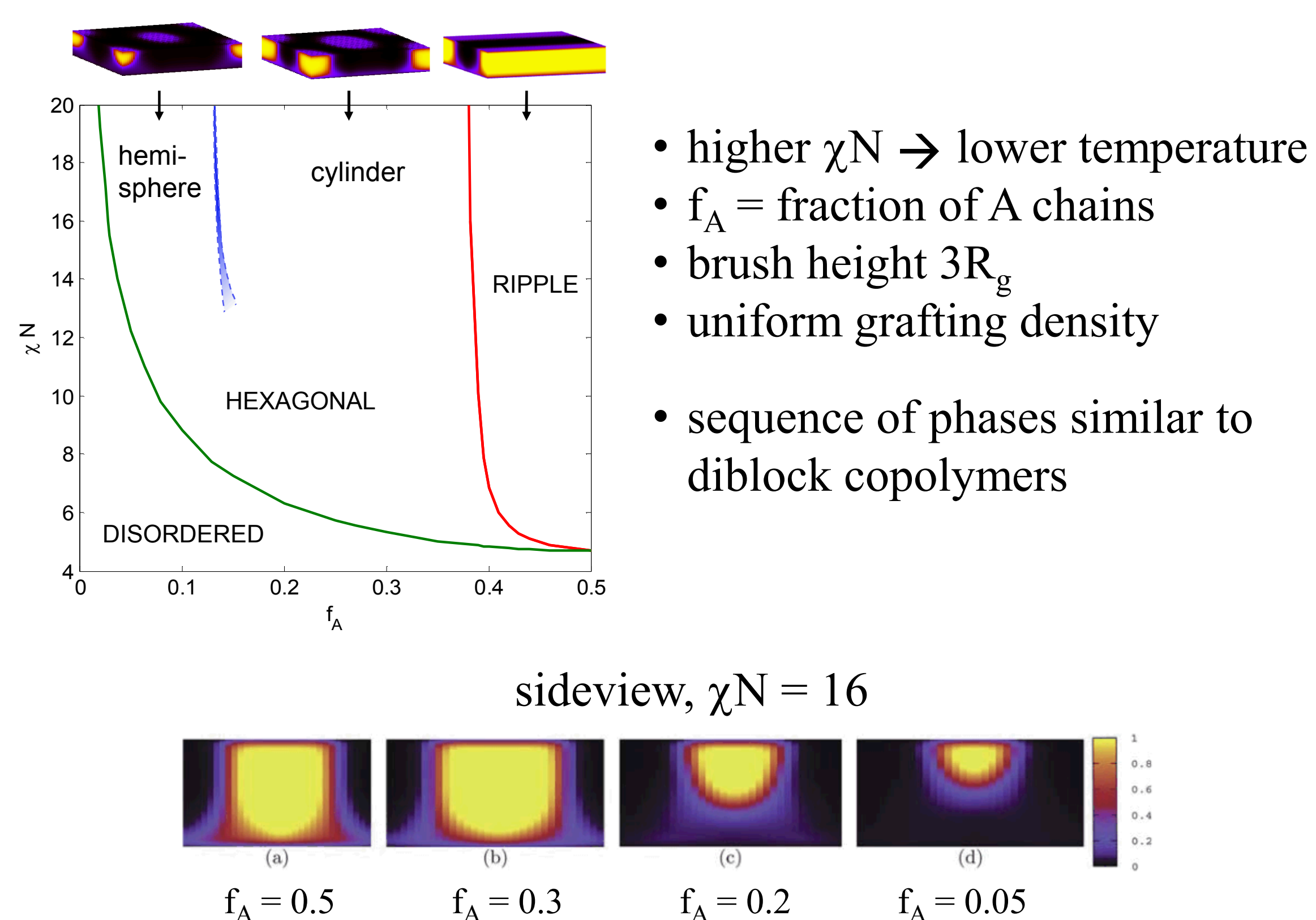
SCFT: standard mean-field theory for polymer melts

- melt with high grafting density
- brush chains A, B: Flory interaction energy χ
- large polymer/air surface tension: flat top surface
- “walls” in z-direction (substrate + top surface)
- periodic boundaries in (x,y)

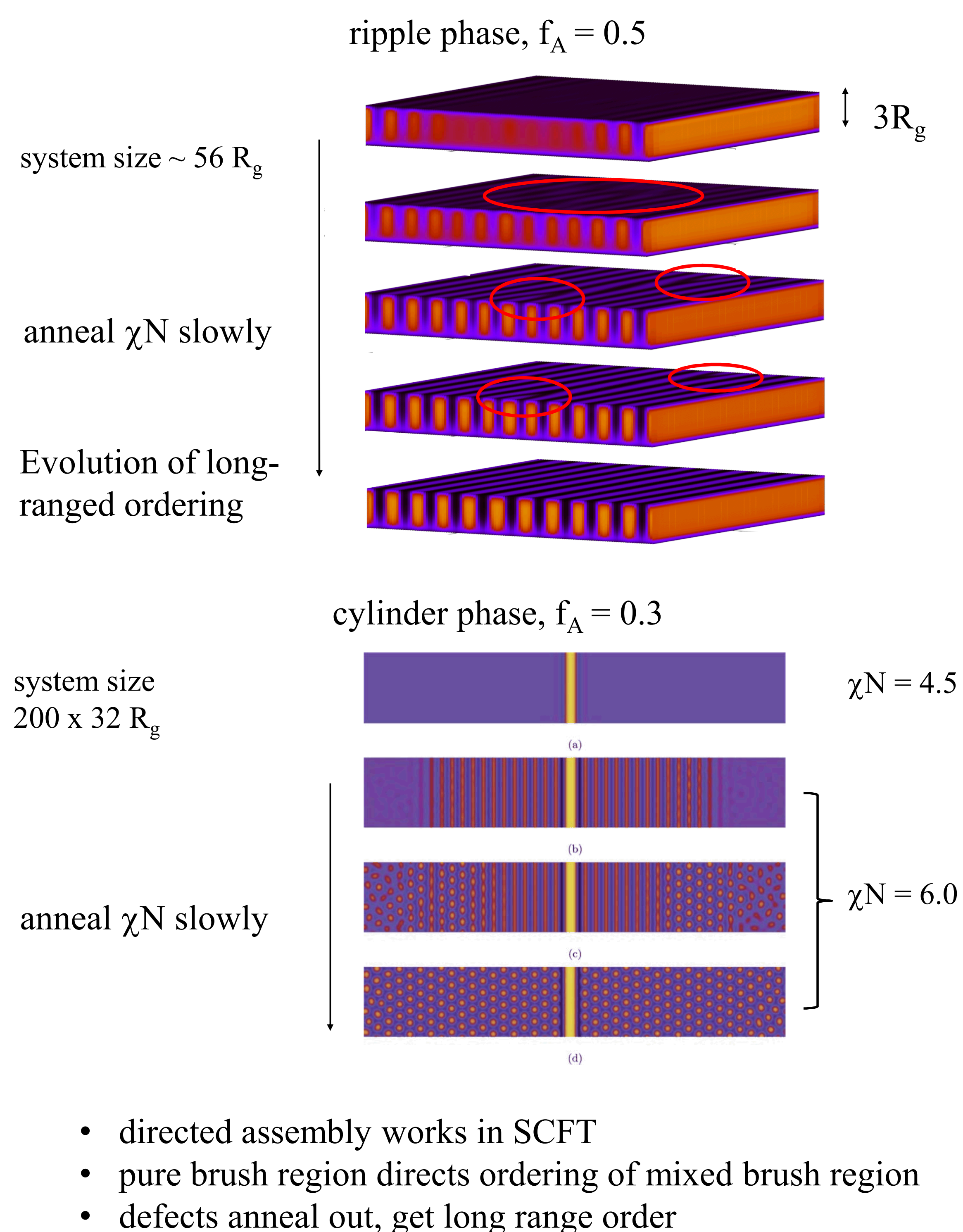


- Free-end: uniform initial condition
 - Tethered-end: initialized with a delta function
 - Generalize to arbitrary grafting density distribution
- $q_{x_\perp}(\mathbf{x}, 0; [W]) = \delta(\mathbf{x} - \mathbf{x}_\perp)$
- $g_{A,B}(\mathbf{x}_\perp, z)$

SCFT Phase Diagram

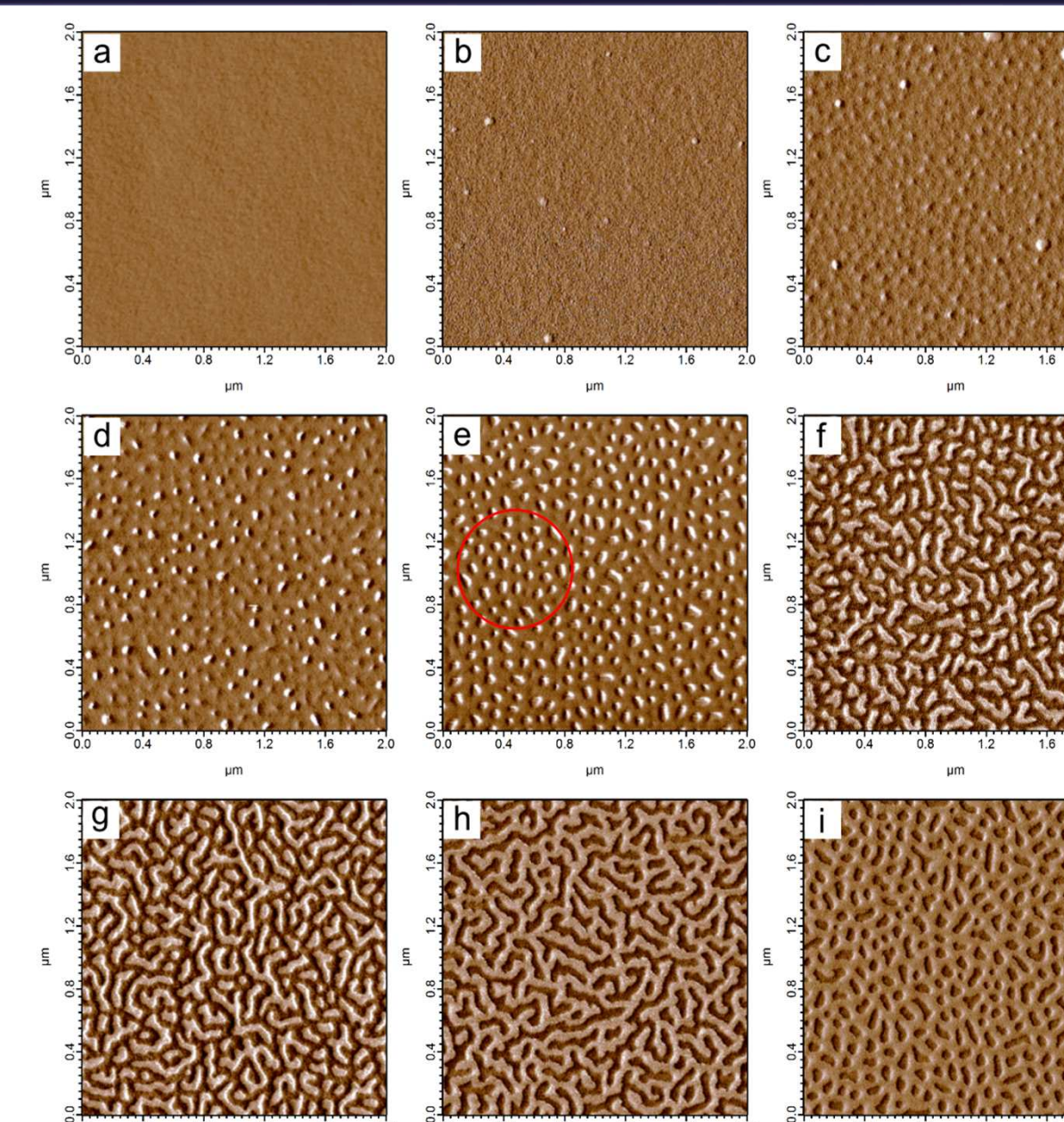


SCFT: Directed Assembly

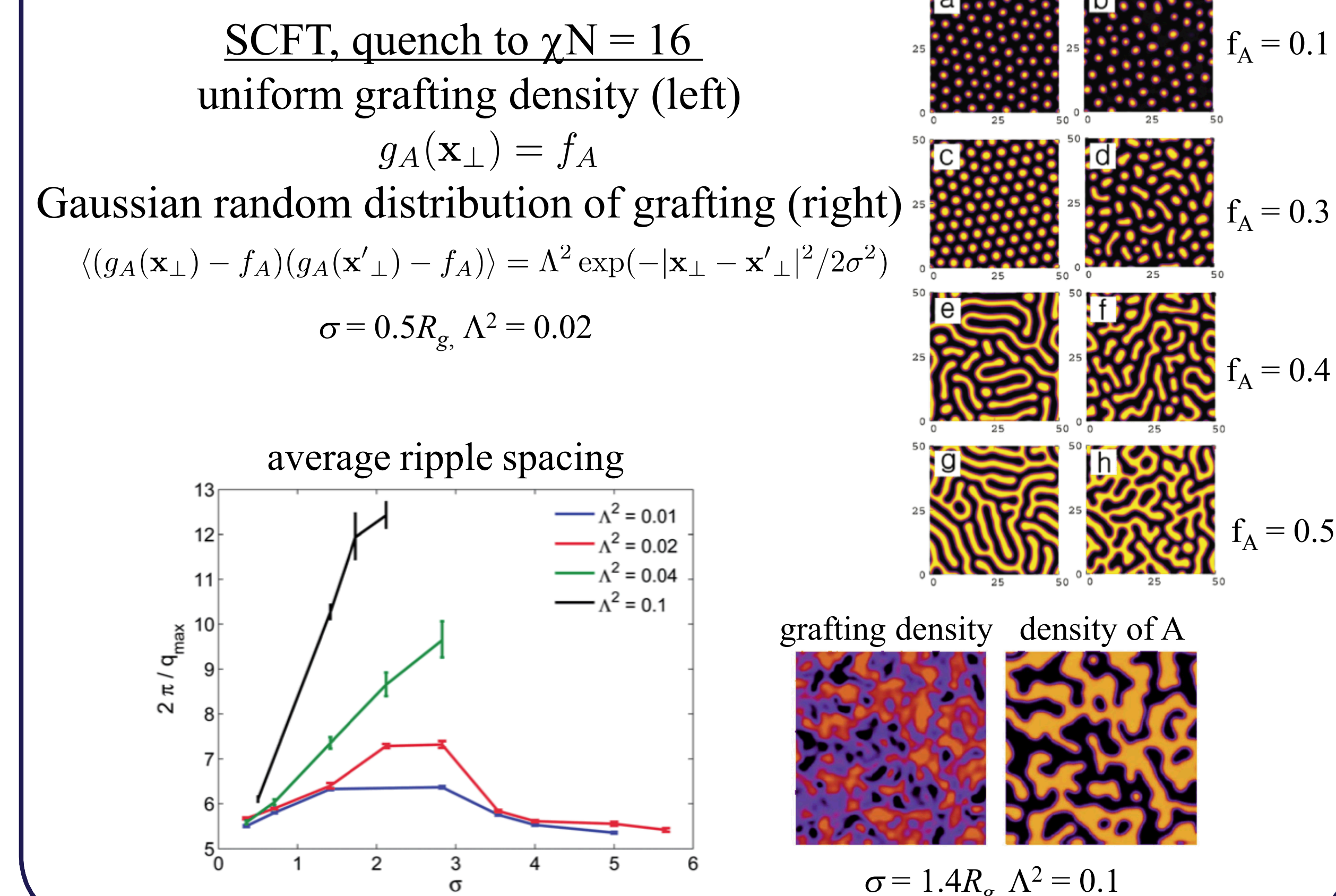


Comparison with Experiment

- PS-PMMA mixed brushes
- solvent anneal
- PS volume fraction from 0.0 to 0.68
- AFM phase contrast images
- phases follow SCFT phase diagram
- no long-range ordering



why no long-range ordering?
 \rightarrow spatial variations in grafting density



Conclusions

- qualitative agreement between theory and experiment for mixed brush phase diagram
- SCFT predicts directed assembly with long-range order
- lack of long-range order in experiment due to spatial variations in grafting density
- future: develop synthesis techniques with more uniform grafting density

CINT Users: Glenn Fredrickson and Su-Mi Hur, UCSB

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2. A. D. Price, S.M. Hur, G. H. Fredrickson, A. L. Frischknecht, and D. L. Huber, *Macromolecules* **45**, 510 (2012)
3. S. M. Hur, A. L. Frischknecht, D. L. Huber, and G. H. Fredrickson, *Soft Matter* **9**, 5341 (2013).