

Directing the Self-Assembly of Nanoscale Polymeric Templates

S.B. Darling¹, D. Sundrani², and S.J. Sibener²

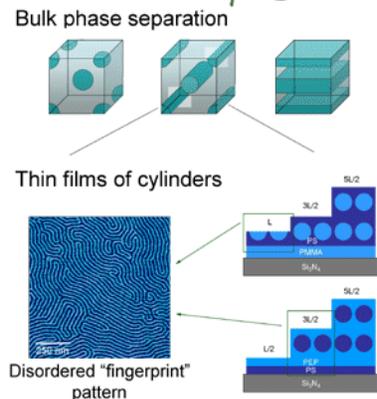
¹  **Materials Science Division**
Argonne National Laboratory

²  **THE UNIVERSITY OF CHICAGO**

Motivation

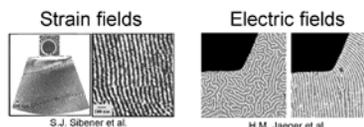
- **The Problem**
 - Top-down methods are rapidly approaching fundamental limits
 - Bottom-up methods cannot achieve long-range order
- **The Solution**
 - Combining these two techniques transcends the limitations of both
- **Tool Selection**
 - Top-down: Electron beam lithography
 - High resolution
 - Standard technique
 - Bottom-up: Diblock copolymers
 - Naturally self-organize into laterally alternating domains
 - Tunable length scale

Diblock Copolymers



Alignment Approaches

Past attempts to align cylindrical domains have met with only moderate success:



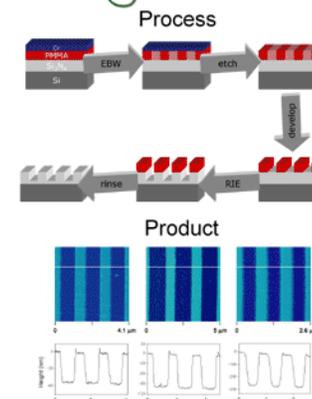
Drawbacks of current approaches:

- Only short-range order
- Alignment is pseudo-parallel
- Little control over location of oriented domain

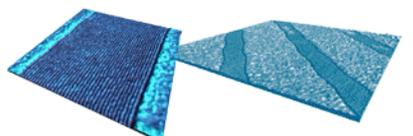
Our solution:

- Lithographically assisted self-assembly
- Following E.J. Kramer and C.A. Ross work on spherical domains

Grating Substrates

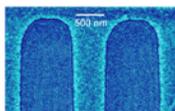


Directed Alignment



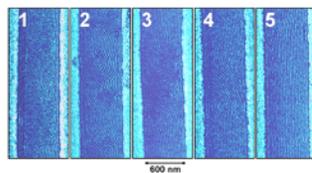
Virtually defect-free aligned structures form within the lithographic channels after annealing

Polymer domains will faithfully follow curvatures in the channel allowing for non-linear geometries



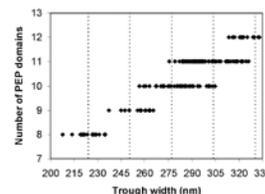
Mechanism

1. PS preferentially wets the channel sidewalls aligning one or two cylinders
2. Alignment extends across the channel at random locations
3. Aligned domains ripen along the channel length
4. Final domain convergence
5. Virtually all defects eliminated



Flexibility

Studying how channels with widths not equal to an integer multiple of the equilibrium domain spacing (27 nm) sheds light on the capacity of the system to accommodate defects



This polymer equally favors expansion and compression suggesting the entropic costs are comparable to the steric repulsion

Summary

- Simple hierarchical route to the fabrication of arrays of aligned nanoscale domains using combined top-down/bottom-up assembly of diblock copolymers
- Grating substrates template the alignment of cylindrical domains with demonstrated 5000:1 aspect ratio for 100 μm domains extendable to arbitrarily long length scales
- Alignment is nucleated by PS preferentially wetting the trough sidewalls and is thermally extended throughout the volume of the polymer

References

D. Sundrani, S.B. Darling, S.J. Sibener, Submitted to *Nano Letters*
D. Sundrani, S.B. Darling, S.J. Sibener, Submitted to *Langmuir*

Acknowledgments

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