UCLA

Directed Self-Assembly and Application in Nanomanufacturing

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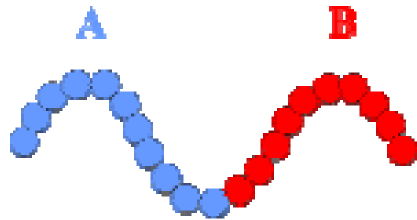
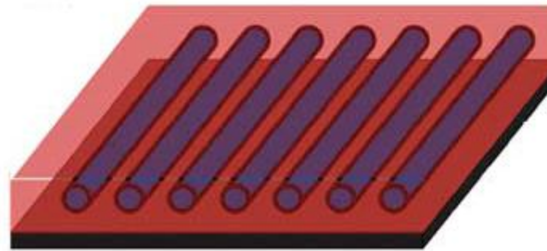
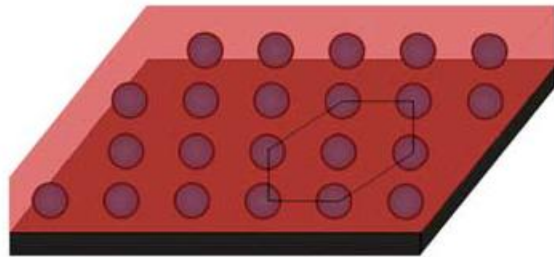
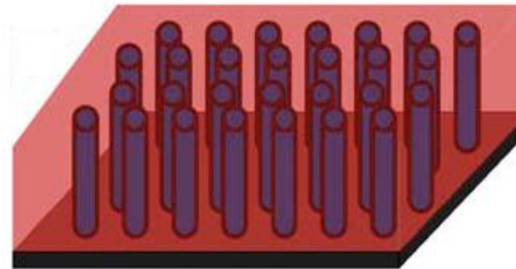
Self-Assembling Block Copolymers

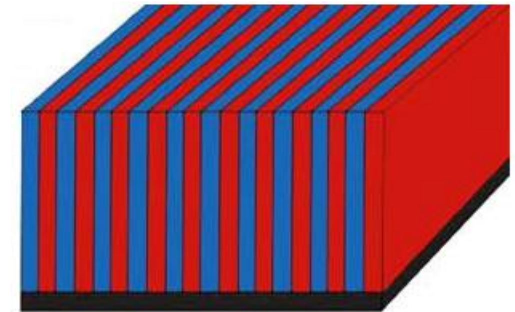




R. A. Segalman, 2005





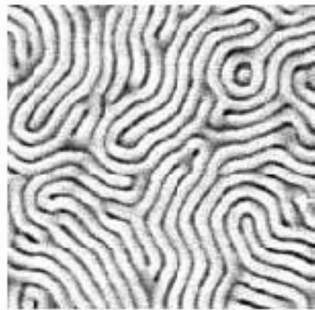


Spheres *Cylinders* *Lamellae*

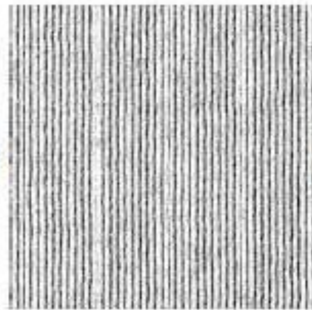
→ *Increasing volume fraction*

- Block copolymer → 2 or more polymeric chains, covalently attached and chemically different
- Structures formed naturally at thermodynamic minima (with annealing)
- Controls: molecular weight, composition, interaction parameter
- Most common blocks: PS-PMMA → 25-50nm pitch
  PS-PDMS → 14-45nm pitch

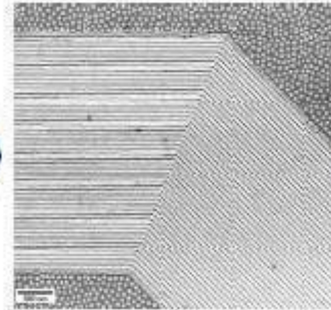
DSA and App for IC Manufacturing



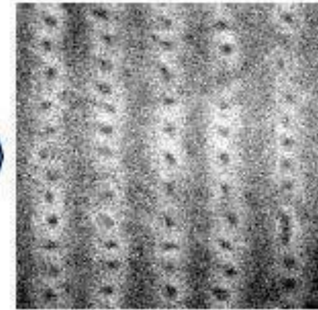
Naturally formed nanostructure with many defects



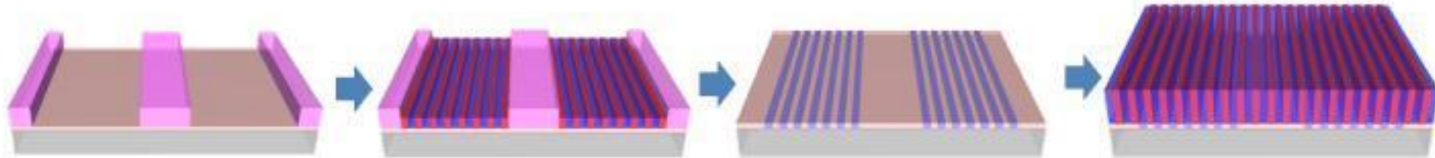
Epitaxial assembly for defect-free nanostructure
Nature, 424, 411, 2003

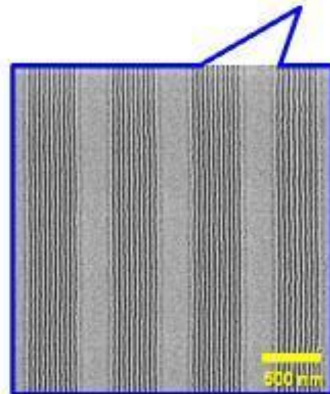


Directed assembly for device oriented nanostructure
Science, 308, 1442, 2005

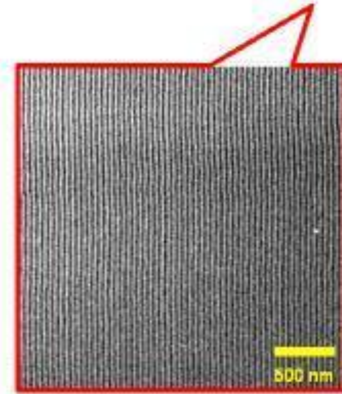


Novel complex nanostructure
Adv.Mater. 19, 3171, 2007



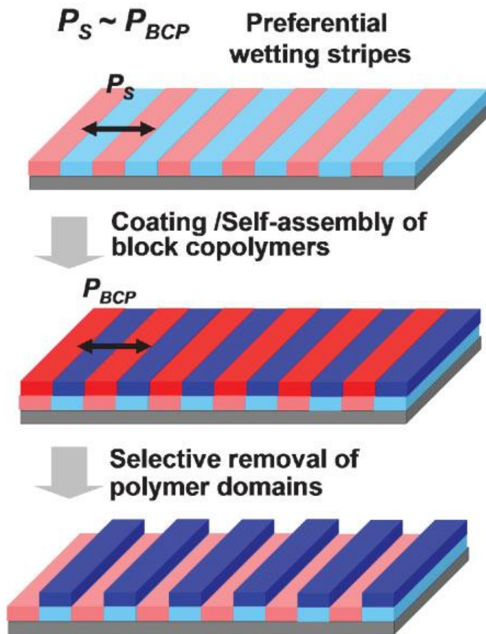


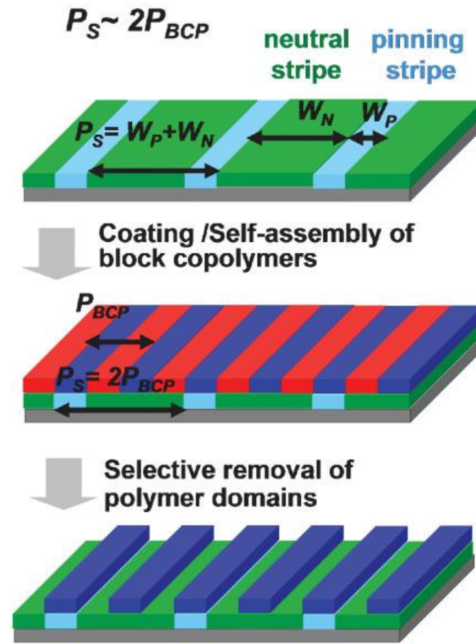
Soft Graphoepitaxy of Block Copolymer Assembly
Nano Letters 9, 2300, 2009

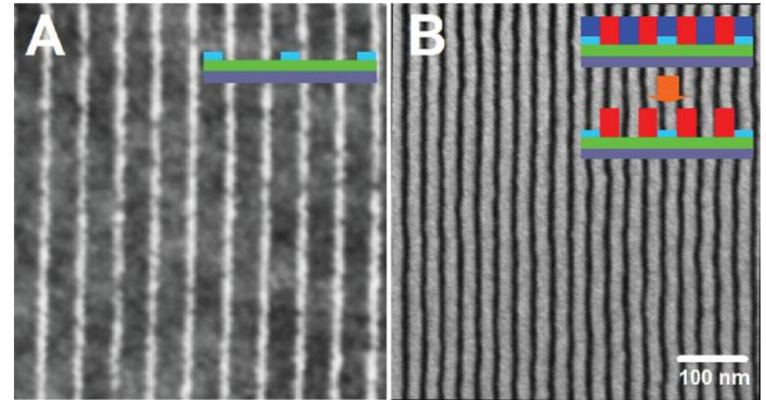


Ultralarge-Area Block Copolymer Lithography
ACS Nano 4, 5181, 2010

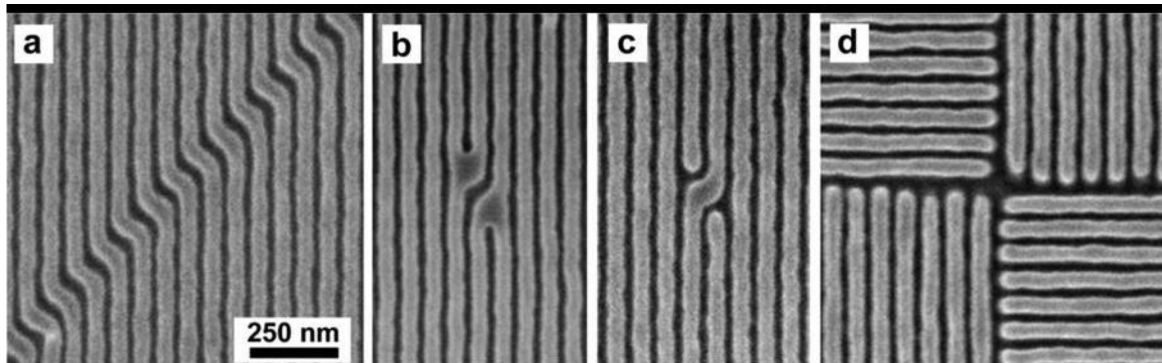
DSA and App for IC Manufacturing

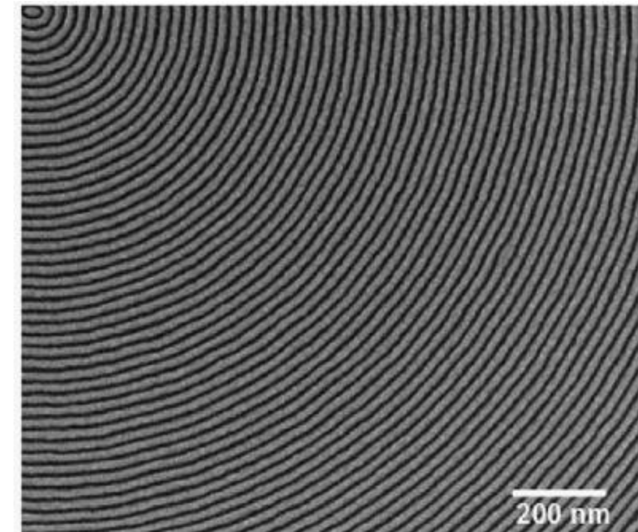






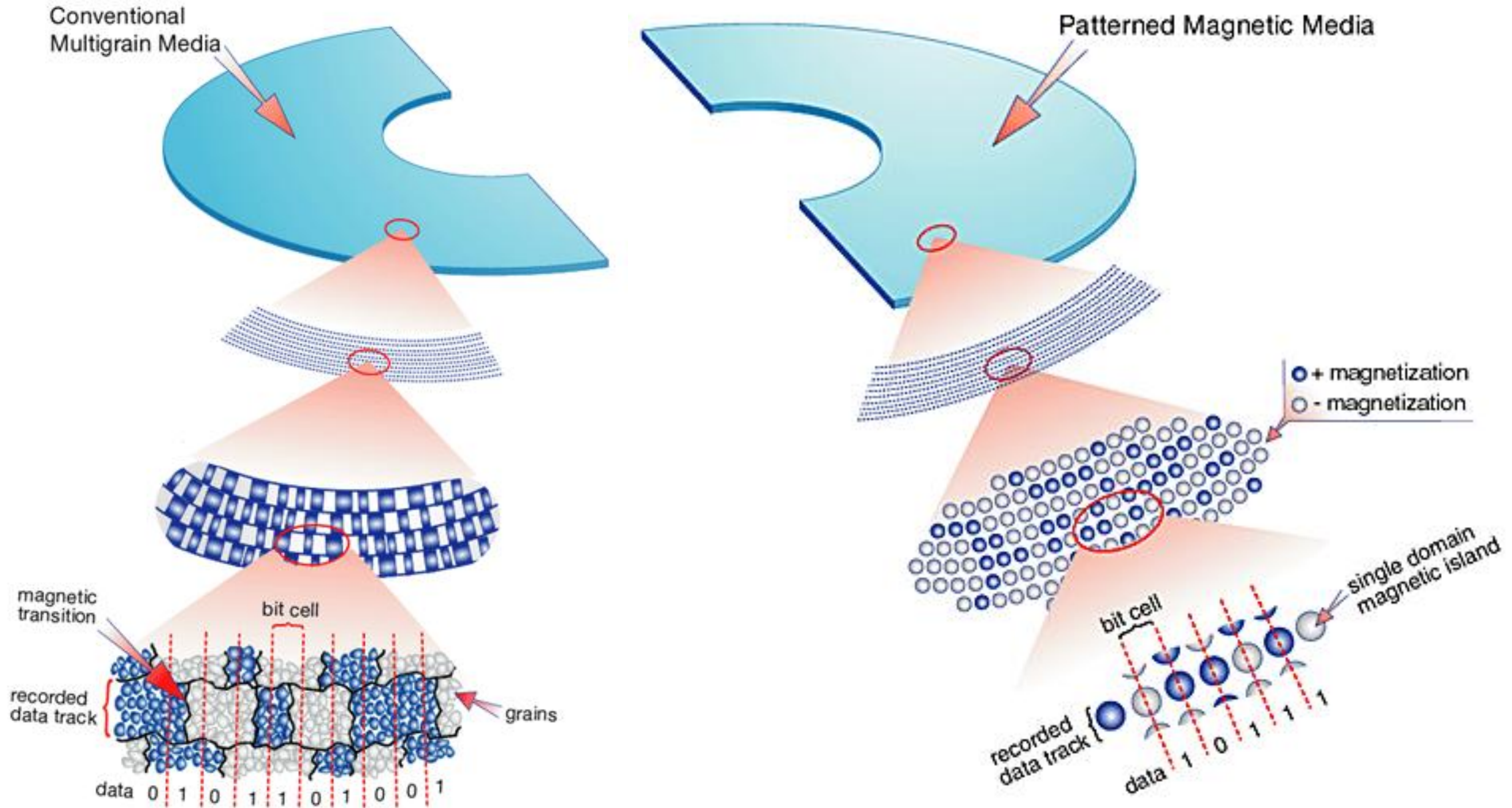
J. W. Cheng, 2008





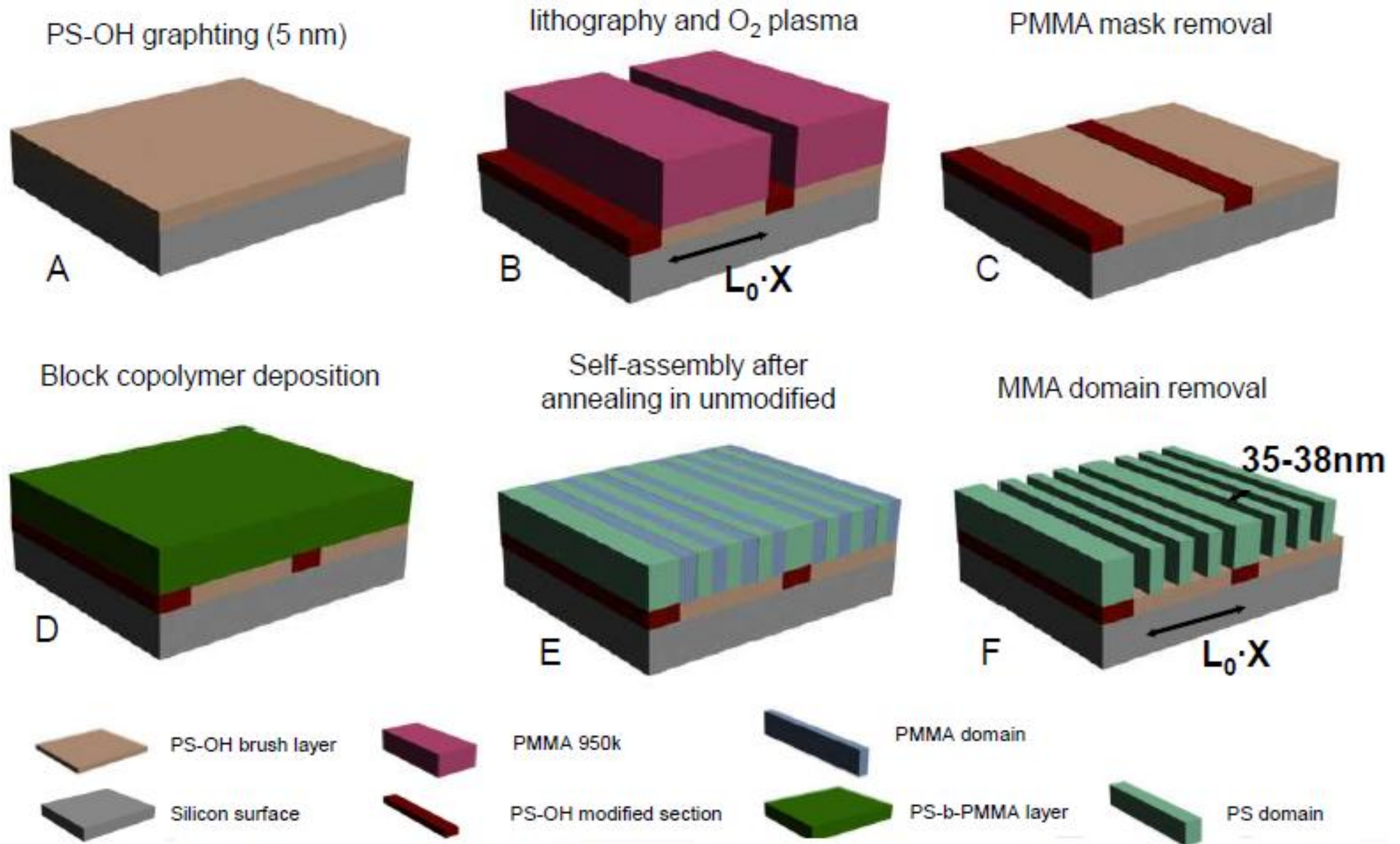
Stoykovich, 2007

Application for Data Storage



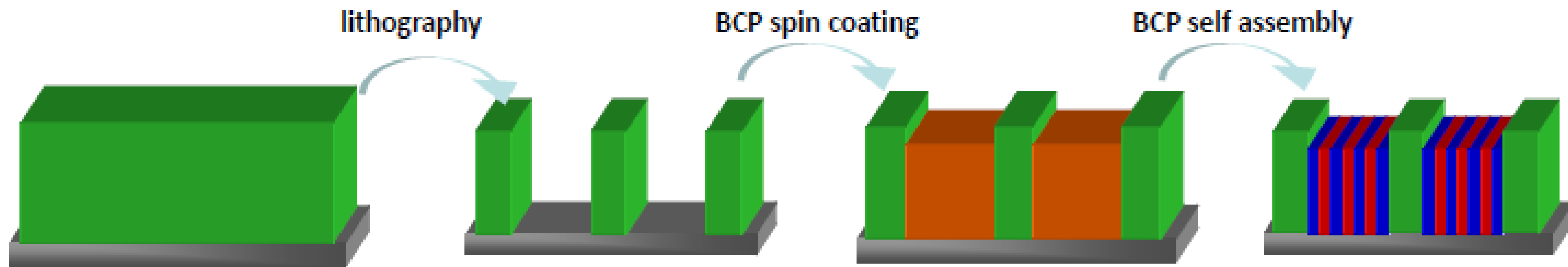
- Conventional way noisier with increasing density (need 100 grains/bit)
- DSA → 1 dot/bit → density increase by ~100X and thermally stable

Pattern Alignment – Chemical Surface Modification



R. Tiron, 2011

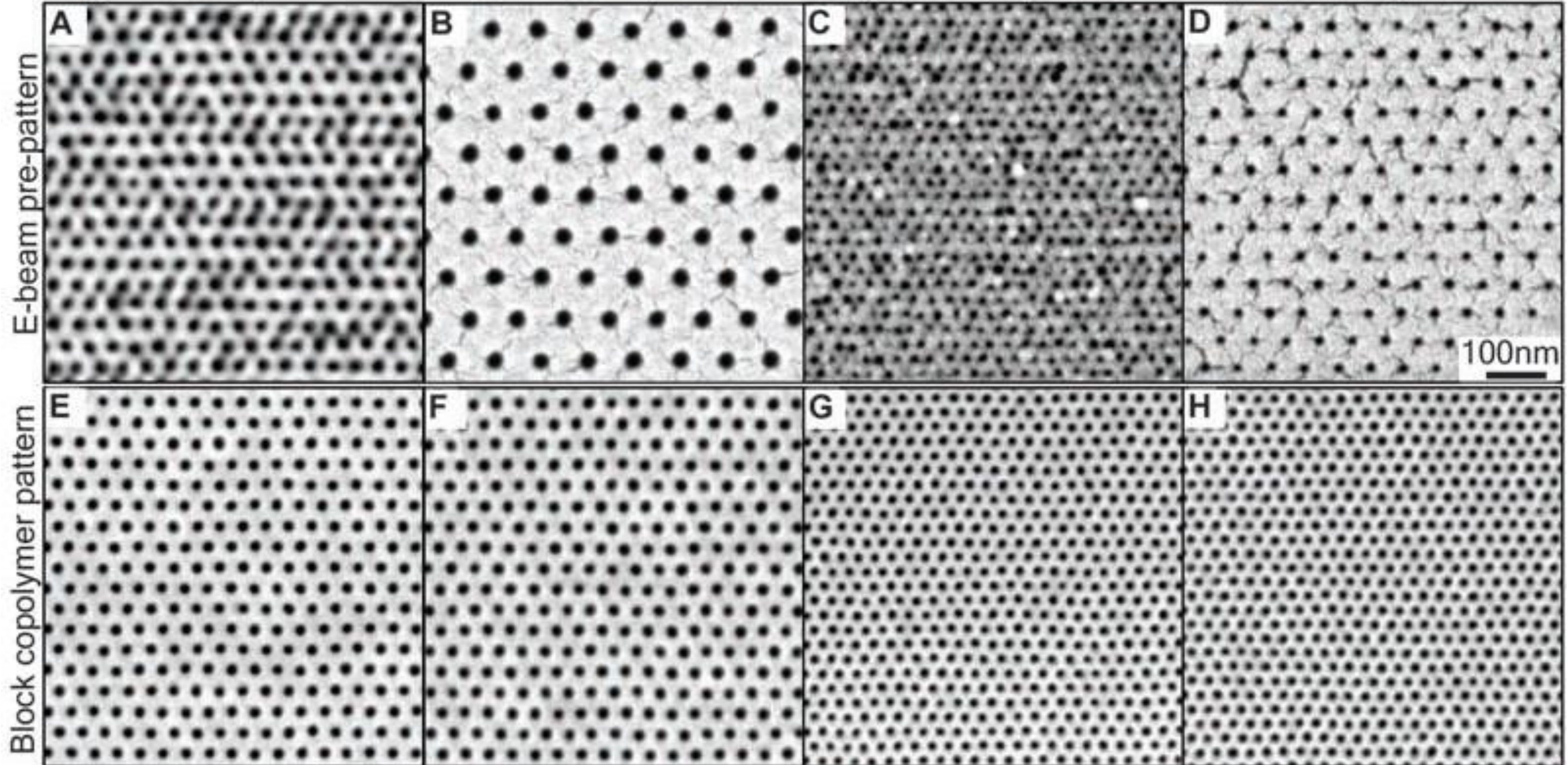
Pattern Alignment – Graphoepitaxy



- First litho patterns must be resistant to solvent & bake
- BCP orientation with respect to the substrate must be controlled
- More versatile process

R. Tiron, 2011

Pattern Multiplication and Rectification



DSA Benefits & Challenges

- Benefits
  - Density multiplication
  - Pattern rectification
  - Good for regular arrays of lines and vias
  - Improved LER (dependent on molecules sizes)
- Challenges
  - Difficult to ensure perfect patterning
  - Particle defects → larger impact than in litho
  - Limited patterns especially with density multiplication
  - Not good for isolated features
  - Design rules restrictions (e.g., no good control for spacing and width values)