**Directed Self Assembly of Block Copolymers**

- Template Patterning
- Directed Self Assembly

- Potential solution for sub-10 nm patterning
- Template pitch can be amplified 4x
- Current metrologies focus on registration with template and surface structure

- Need to develop a metrology capable of evaluating the internal 3D structure of DSA BCP's!!

**Stresses on the DSA BCP**

Stresses on the DSA BCP can lead to the formation of complex buried features that may adversely affect the etch process!

- Surface enrichment of component A
- Lamellar oscillations due to stresses at the substrate and surface
- Substrate enrichment of component B

**Surface Morphology may not reflect internal morphology**

- Good DSA
- Floating Lines above Template
- Floating Lines above Substrate

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**Critical Dimension Small Angle X-ray Scattering**

**Measurement Geometry**

- Vertical (qz) cuts taken around each peak

**Enhanced Contrast via Soft X-rays**

- Contrast is enhanced by using energies near the absorption edge (~285 eV for Carbon)
- Exact location of Carbon absorption edge shifts as a function of component composition (π vs σ bonds). Scattering contrast becomes bond specific.

**Inverse Fitting Approach**

The BCP lamella shape is approximated by a stack of trapezoids. The simulated intensity is compared to experimental intensity and the structure is iterated until a satisfactory $\chi^2$ is achieved.

$$I(q) = \int \int \rho(r) \ast S(r) e^{-i q r} dr$$

$$DW = Debye Waller Factor, accounts for interfacial roughness$$

**Diagram:**

- 400+ images converted to $I(q_x,q_z)$
- $I(q_x,q_z) \rightarrow I(q_x,q_z)$
- Vertical ($q_z$) cuts taken around each peak
**Hard vs Soft X-rays**

*1:1 Template : BCP Pitch*

**Hard X-rays (17 KeV)**

![Hard X-ray image](image1)

- Small number of peaks and poor differentiation from background results in a poorly defined fit, large uncertainty

**Soft X-rays (282 eV)**

![Soft X-ray image](image2)

- Additional peaks and improved peak definition in soft x-ray measurements result in dramatic decrease in fit uncertainty

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**Complex Chemical and Topographical Template**

*4:1 Template : BCP Pitch*

**5 Primary peaks @ ~25 nm pitch**

**Satellites @ ~100 nm superlattice pitch**

**I(q_x,q_z)**

- PS enriched at surface
- 70% PS at surface confirmed via NEXAFS
- On-Template lamellar shapes remain consistent
- PMMA segregates to substrate

- Increasing template width results in the disruption of the lamellar structure and the formation of undesirable features

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