Finding and tracking Bragg spots in GISAXS maps of block Co-Polymer thin films using cascade based feature extraction and circular Hough transformation

Kjeldberg, Christian; Ariaee, Sina; Chernyy, Sergey; Almdal, Kristoffer; Jung, Florian; Papadakis, Christine M.; Smilgies, Detlef-M.; Lassen, Anders; Posselt, Dorthe

Publication date:
2019

Citation for published version (APA):
**Introduction**

By vapor annealing ~100 nm disordered thin films of block copolymers it is possible to order them due to microphase separation. In order to monitor this change Grazing Incidence Small-Angle X-ray Scattering (GISAXS) can be used which produces scattering pattern maps in reciprocal space. One feature which can be seen in such images is a Bragg spot. Manually going through the images produced by GISAXS to locate and track Bragg spots is a time-consuming process which can be automated using feature extraction algorithms. A cascade based approach based on the Viola-Jones algorithm and an approach based on Circular Hough Transform have been programmed and tested.

**Pipeline**

1. **Acquisition**
   - Record and store the raw GISAXS images taken with the microscope.
2. **Segmentation**
   - Separate different materials in an image.
3. **Preprocessing**
   - Reduce noise and normalize the images.
4. **Haar-like Feature Cascade Detection**
   - Use Haar-like features to detect regions of interest.
5. **Circular Hough Transform**
   - Convert the 2D images into a 3D image where the objects are represented as circles.
6. **Post Processing**
   - Refine the detected features and generate a final output.

**Haar-like feature cascade detection algorithm**

A sample Bragg spot is chosen then for each Haar feature:

1. Start by drawing first rectangle.
2. Expand until feature is present.
3. Expand second rectangle until feature is no longer present.
4. If applicable a third rectangle is expanded until end of image.

**Results**

Using the cascade based approach Bragg spots may be found at a speed of ~18 images per second with few to no false positives / negatives.

Using Circular Hough Transform the Bragg spots can be found at a speed of ~70 images per second. No false positives / negatives were present for swelling images but the algorithm fails for the images captured during drying when the Bragg spots appear more elliptical.

**Summary:**

- Bragg spots exhibited in GISAXS maps can be found using the algorithms presented with a minimal number of false positives / false negatives under the right conditions.
- This will enable automatic postprocessing of size, shape, intensity and position of Bragg spots which would otherwise be labor intensive if done manually.
- The approaches presented could be applied to simulated GISAXS experiments and other similar image-producing experiments and simulations.