Characterization of a Lab Based CDSAXS Tool

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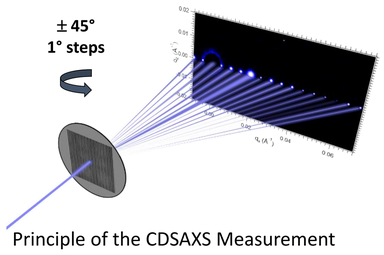
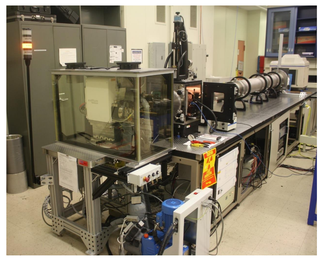
Motivation

- Metrology techniques for monitoring the critical dimensions (CDs) and pitches of future technology nodes should be capable of providing 3D structural information on small and densely packed features.
- CD Small Angle X-ray Scattering (CDSAXS) is a non-destructive, relatively large area, 3D metrology technique that shows promise for being able to meet future metrology needs .
- Newly developed compact high brightness X-ray sources have made the development of viable lab based CDSAXS tools possible.



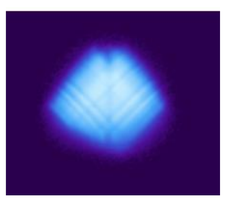
Principle of the CDSAXS Measurement



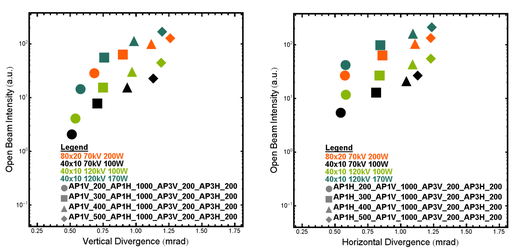
NIST CDSAXS Lab Tool

CDSAXS Lab Tool Progress

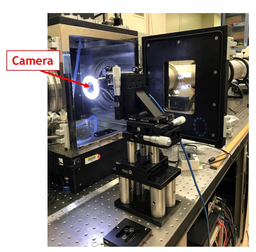
- The CDSAXS lab tool uses a high brightness liquid metal jet X-ray source, with an X-ray energy of 24.2 keV.
- Initial efforts were primarily focused on understanding how the electron beam, mirror, and slit configurations might be optimized for CDSAXS measurements on small target patterns.



Lab tool beam image on detector at a source to detector distance of 4 meters.



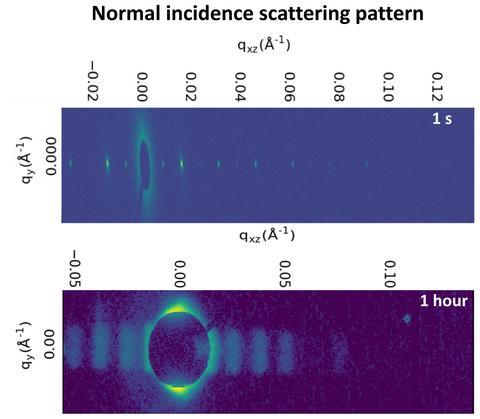
The above plots indicate how the X-ray beam divergence and intensity vary with slit opening in the vertical (left) and horizontal (right) directions.



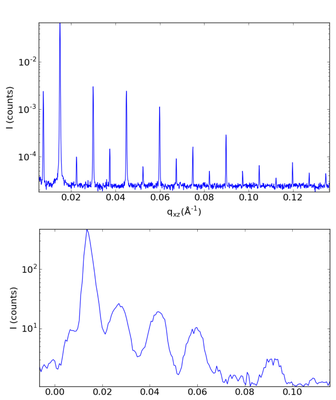
Lab tool camera setup used for aligning the sample target to the X-ray beam.

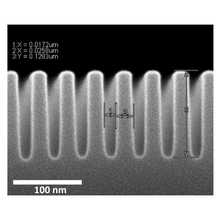
Preliminary Scattering Data

Normal incidence scattering pattern



Normal incidence integrated intensity

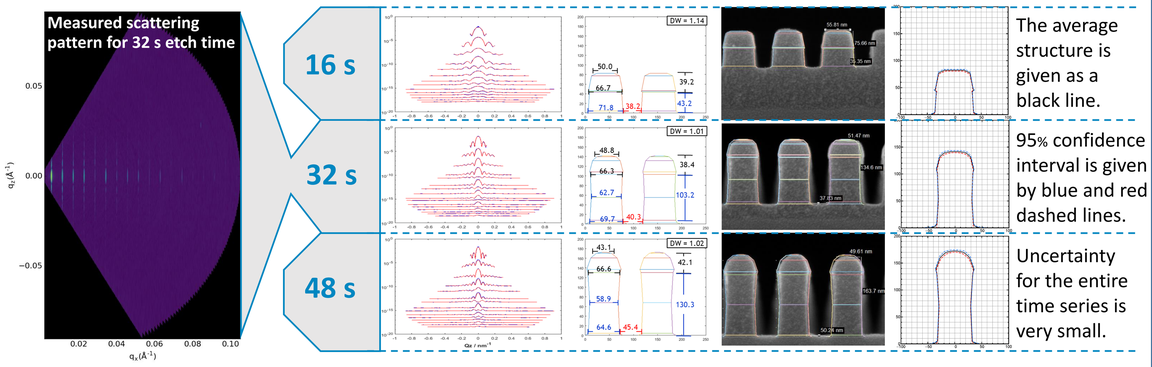




Recent Synchrotron CDSAXS Measurements

- Etch time series of SiOC on a-C film 110 nm pitch line gratings with center to edge of wafer variation:

Center:

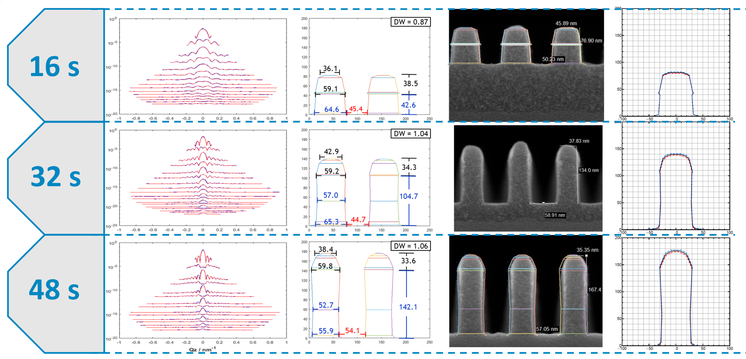


The average structure is given as a black line.

95% confidence interval is given by blue and red dashed lines.

Uncertainty for the entire time series is very small.

Edge:

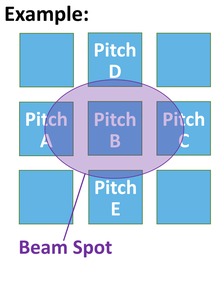


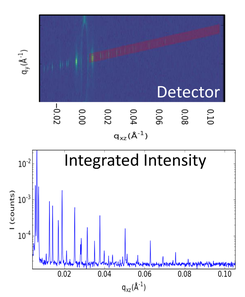
The CDSAXS results for the etch time series as well as the observed center to edge variation are in excellent agreement with X-SEM.

The modelled CDSAXS structures reproduce even the most minute details and with small uncertainties.

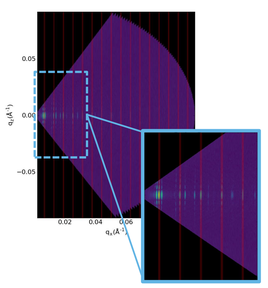
- Isolation of scattering patterns when there is scattering from multiple targets with different pitch:

Example:

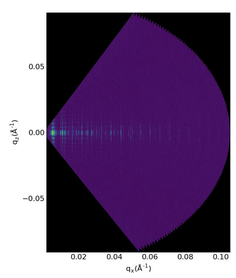




Three distinct scattering patterns are visible. These correspond to scattering by targets with three different pitches.



In the qz-qx map construction only the slices corresponding to the pitch of interest can be selected.



Selectivity is possible even in the presence of many more scattering patterns.

Conclusions

- CDSAXS measurements performed at the synchrotron show that the technique is capable of reproducing accurate 3D structural information on a variety of material and structured systems.
- Significant progress is being made in developing a lab based CDSAXS tool capable of measuring small sample target areas, with acquisition times that continue to decrease with the development of new X-ray sources.