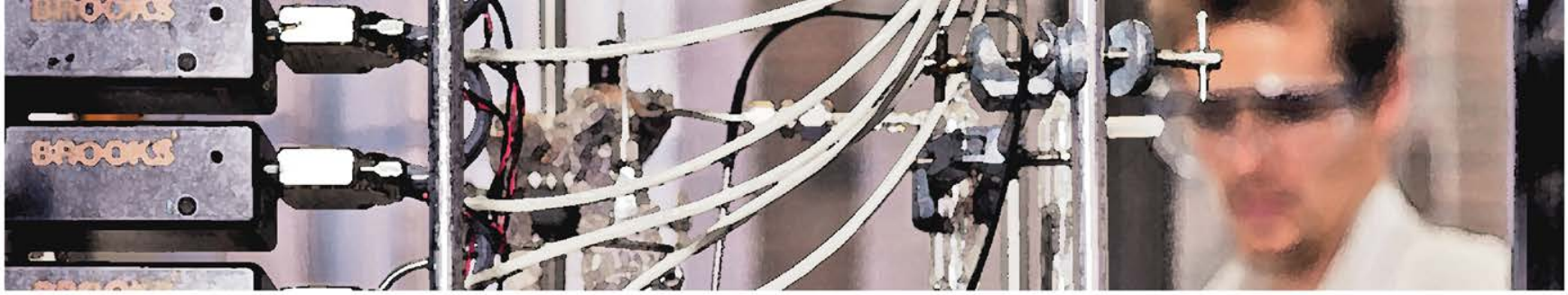
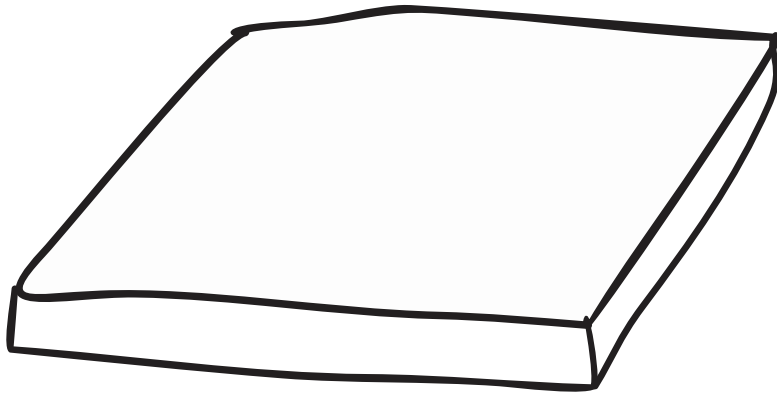
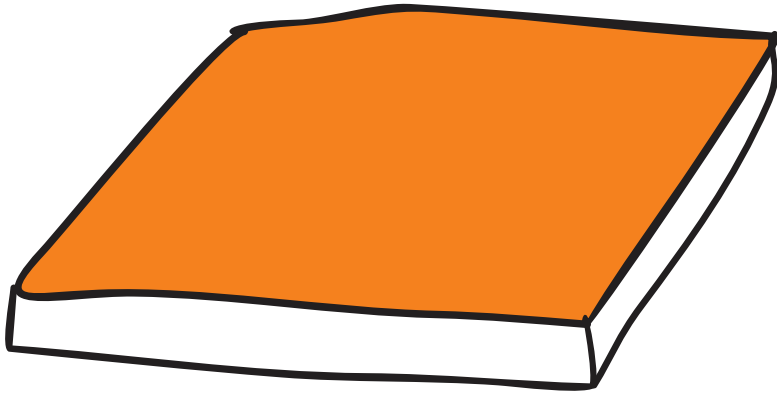


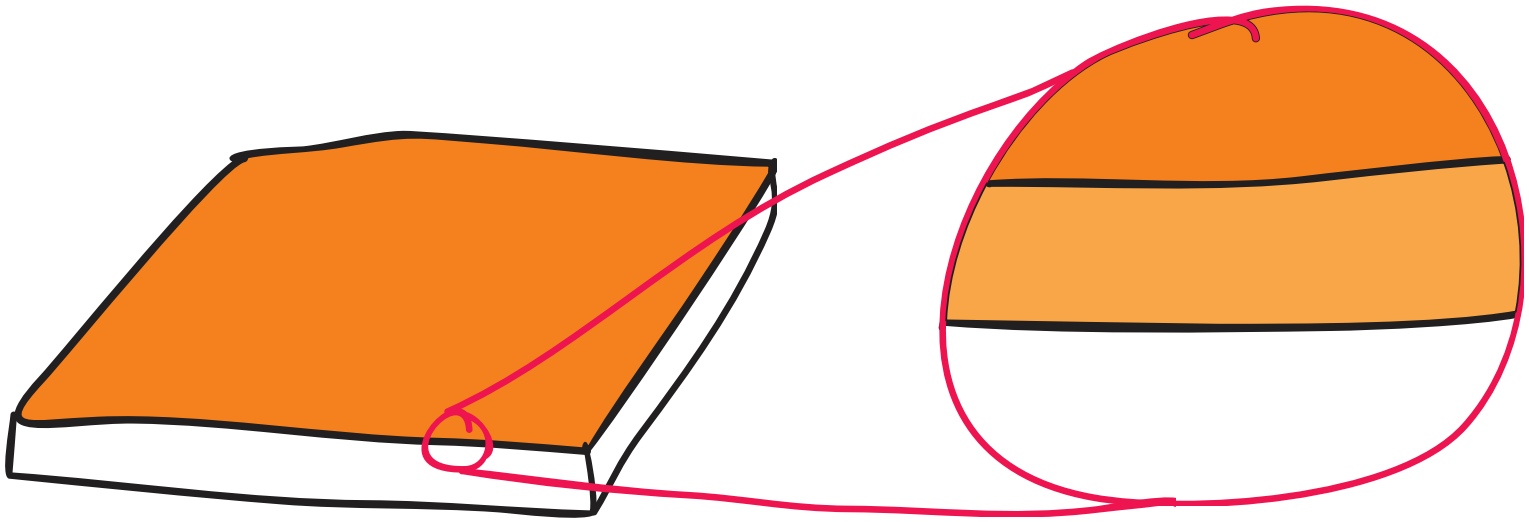
UiO : Centre for Materials Science and Nanotechnology
University of Oslo

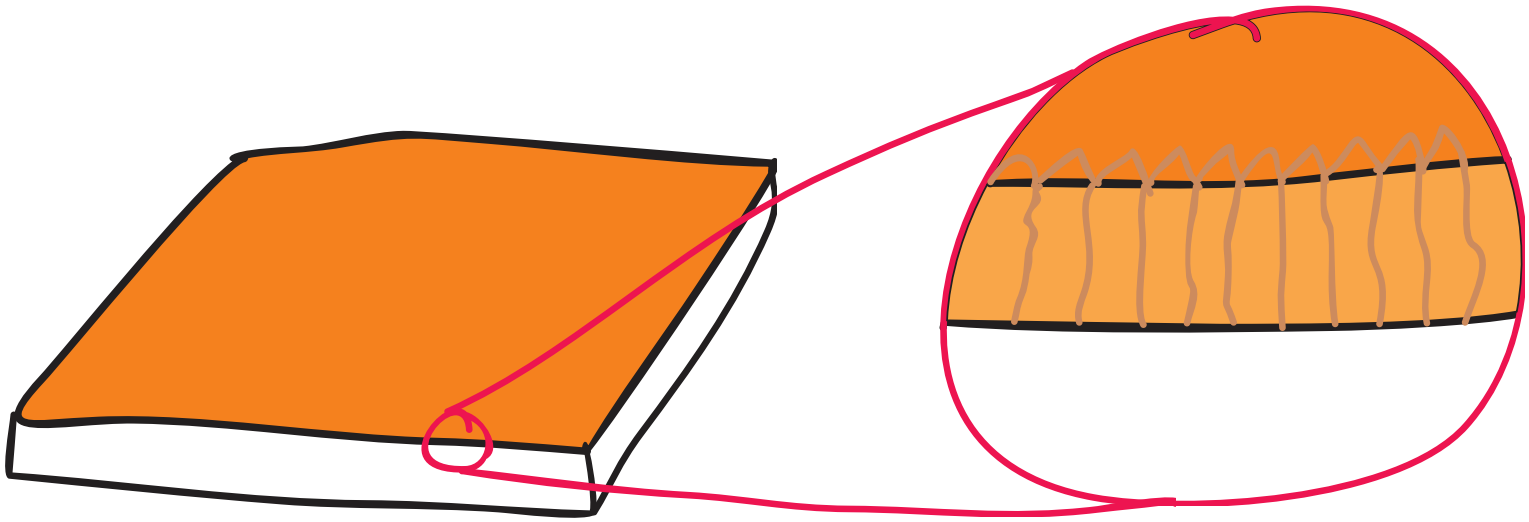
RECX

Thin film metrology










PANalytic

XRR
- Film thickness
- Roughness
- Density

GIXRD
- Enhance material probed
- Phase
- Stress
- Depth profiling

HRXRD / RSM
- Texture
- Strain
- Orientation

Phi-scan
- In plane orientation

Rocking curve
- Miscut
- Orientation

Polar plot
- Texture

XRR
- Film thickness
- Roughness
- Density

GIXRD
- Enhance material probed
- Phase
- Stress
- Depth profiling

HRXRD / RSM
- Texture
- Strain
- Orientation

Phi-scan
- In plane orientation

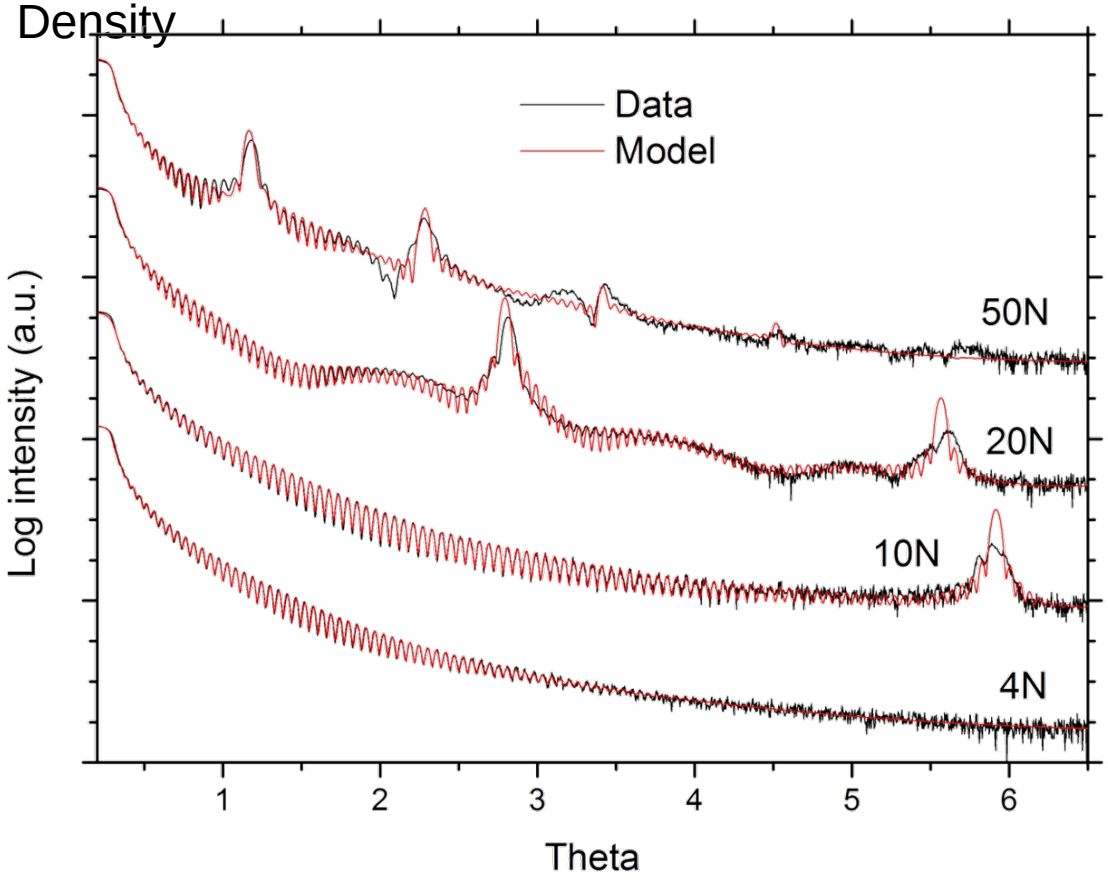
Rocking curve
- Miscut
- Orientation

Polar plot
- Texture

XRR (X-ray reflectometry)

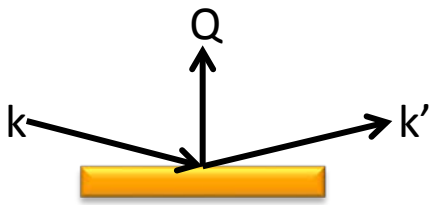
Reflectivity as function of angle to obtain information on:

- Film thickness
- Surface roughness
- Density

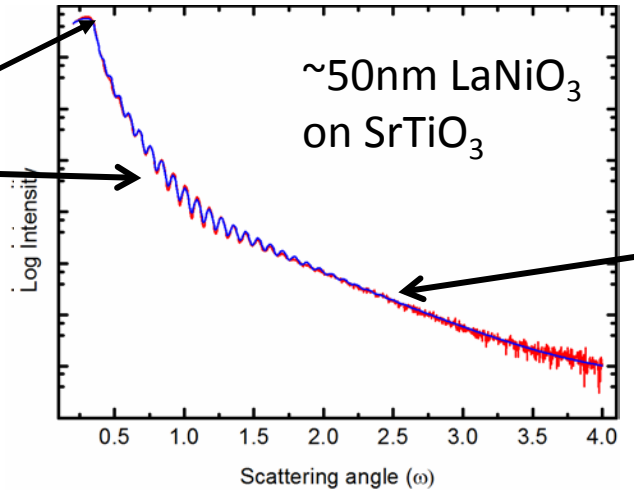


XRR (X-ray reflectometry)

Scattering from surfaces and interfaces at low angles, ~0-8°



Variations in electron density arise from film thickness, roughness and density which can be determined for each layer



Scattering occurs from variations in electron density

$$I(q_z) = \frac{1}{q_z^4}\left|\int \frac{d\rho(z)}{dz}\exp(iq_z z)dz\right|^2$$

Electron density

Fouriertransform

Refined parameters:

$LaNiO_3$ Thickness 48.98nm

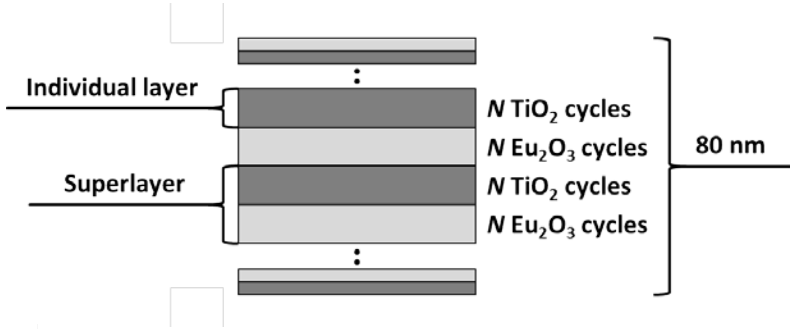
" Roughness 0.30 nm

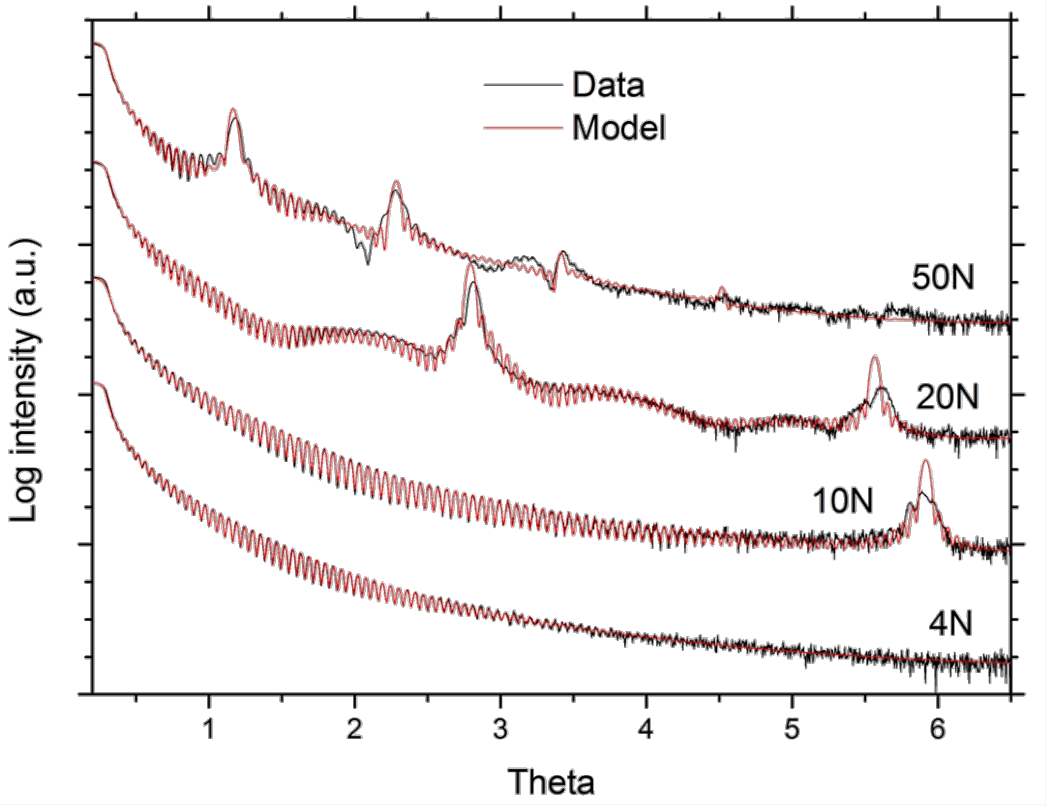
" Density 7.05 g/cm^3

A surface layer of 1.4nm is also required to fully explain the results

XRR (X-ray reflectometry)

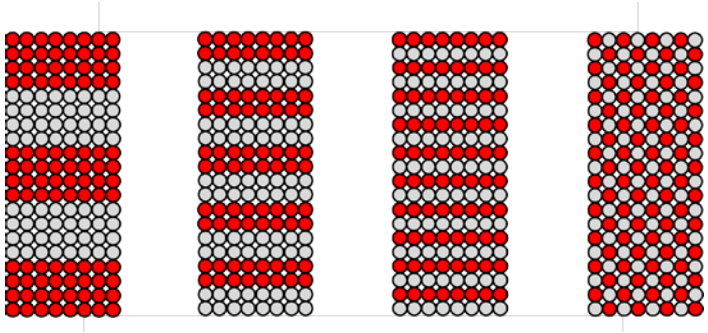
Layered thin films of Eu_2O_3 and TiO_2 grown by ALD as conversion material with the aim of controlling the Eu-Eu distance.

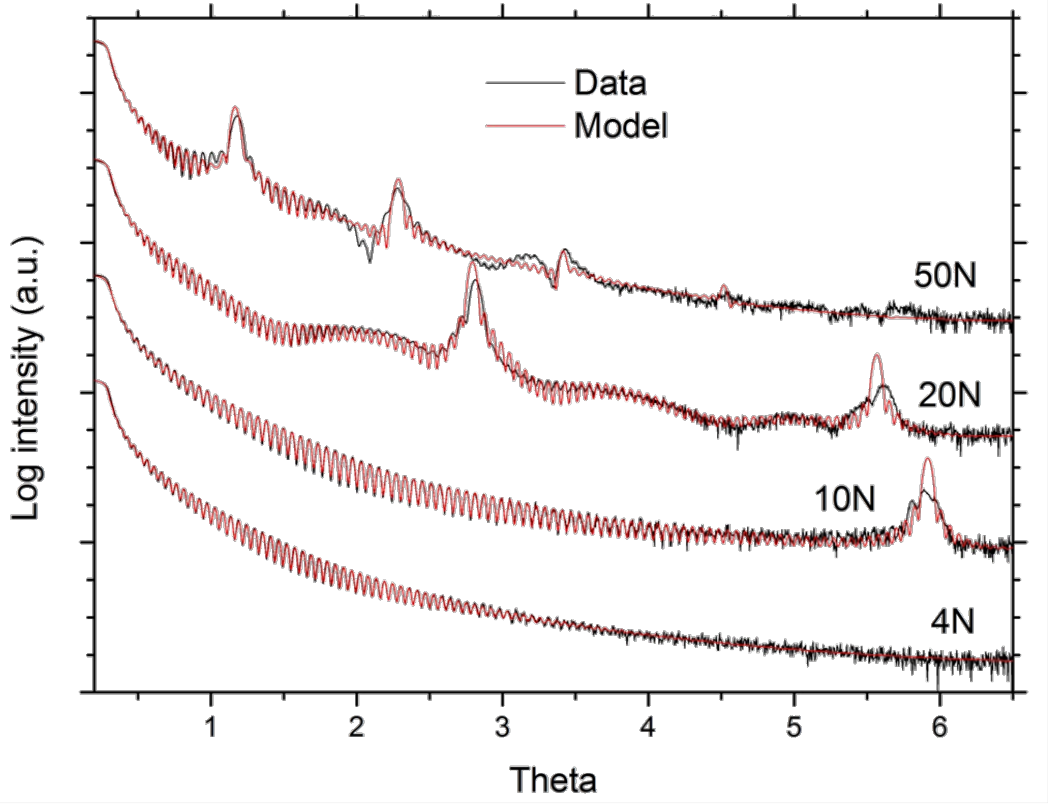




XRR (X-ray reflectometry)

Layered thin films of Eu_2O_3 and TiO_2 grown by ALD as conversion material with the aim of controlling the Eu-Eu distance.

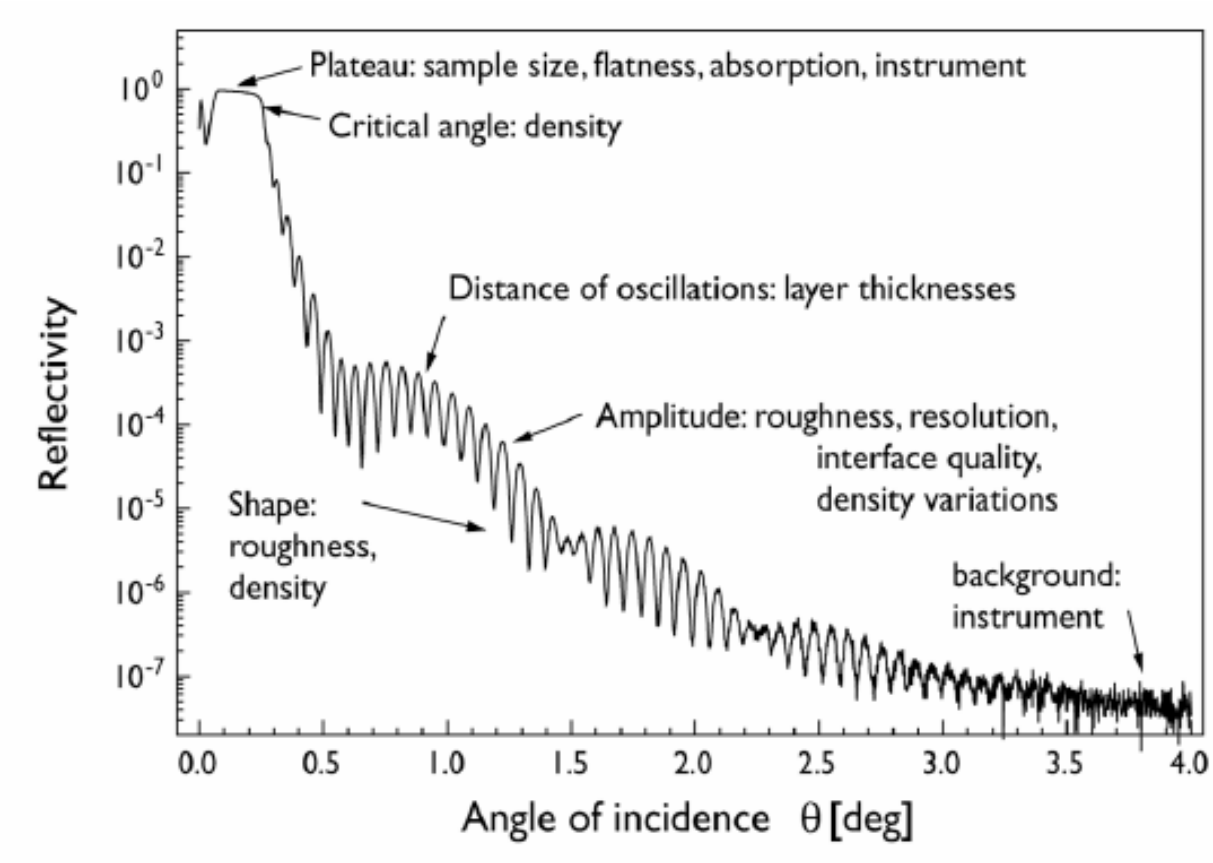




The double layer thicknesses:
10N = 7.5 Å
20N = 15.9 Å
50N = 29.1 Å

Half the double layer thickness of the 10N sample, 3.8 Å, is approx the same as the shortest Eu – Eu distance in cubic Eu_2O_3, 3.6 Å

XRR (X-ray reflectometry)



XRR
- Film thickness
- Roughness
- Density

GIXRD
- Enhance material probed
- Phase
- Stress
- Depth profiling

HRXRD / RSM
- Texture
- Strain
- Orientation

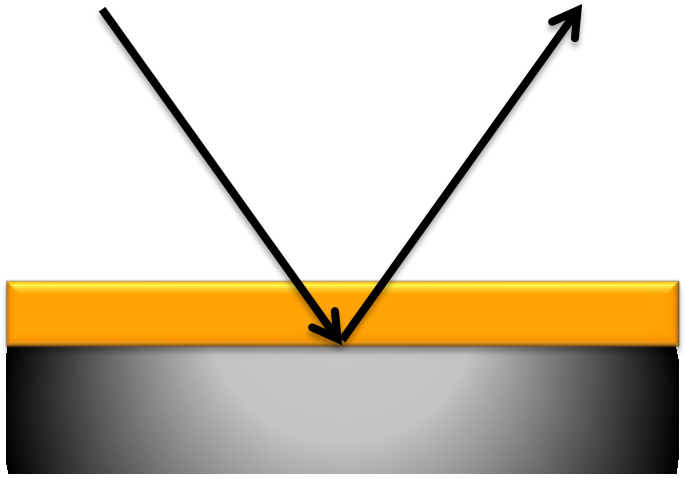
Phi-scan
- In plane orientation

Rocking curve
- Miscut
- Orientation

Polar plot
- Texture

GIXRD (Grazing incident x-ray diffraction)

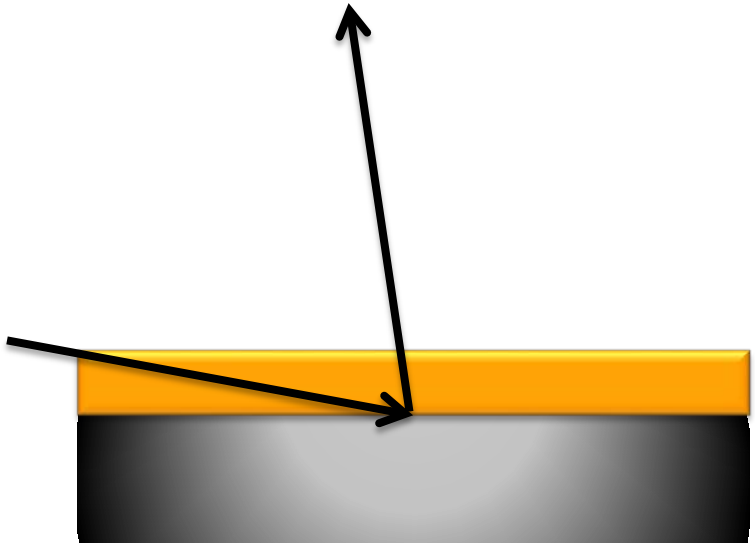
Increase the pathway through the sample



Conventional θ-2θ

GIXRD (Grazing incident x-ray diffraction)

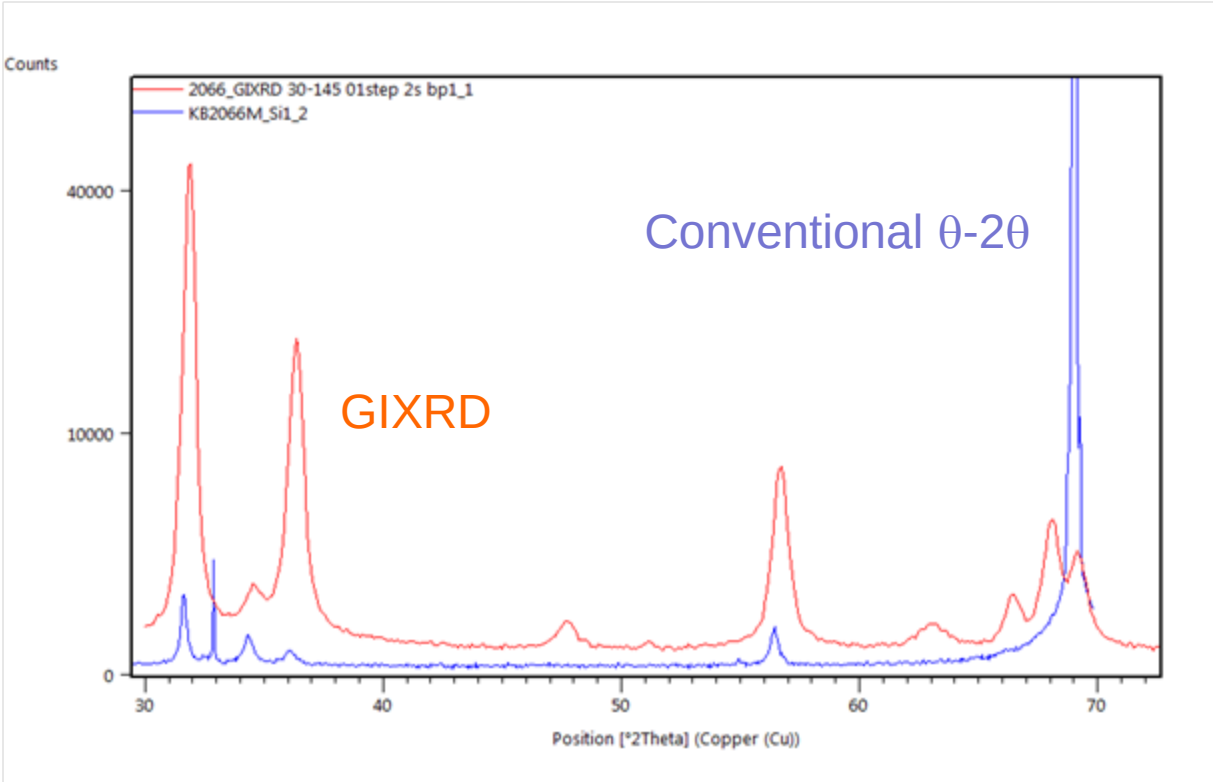
Increase the pathway through the sample



GIXRD

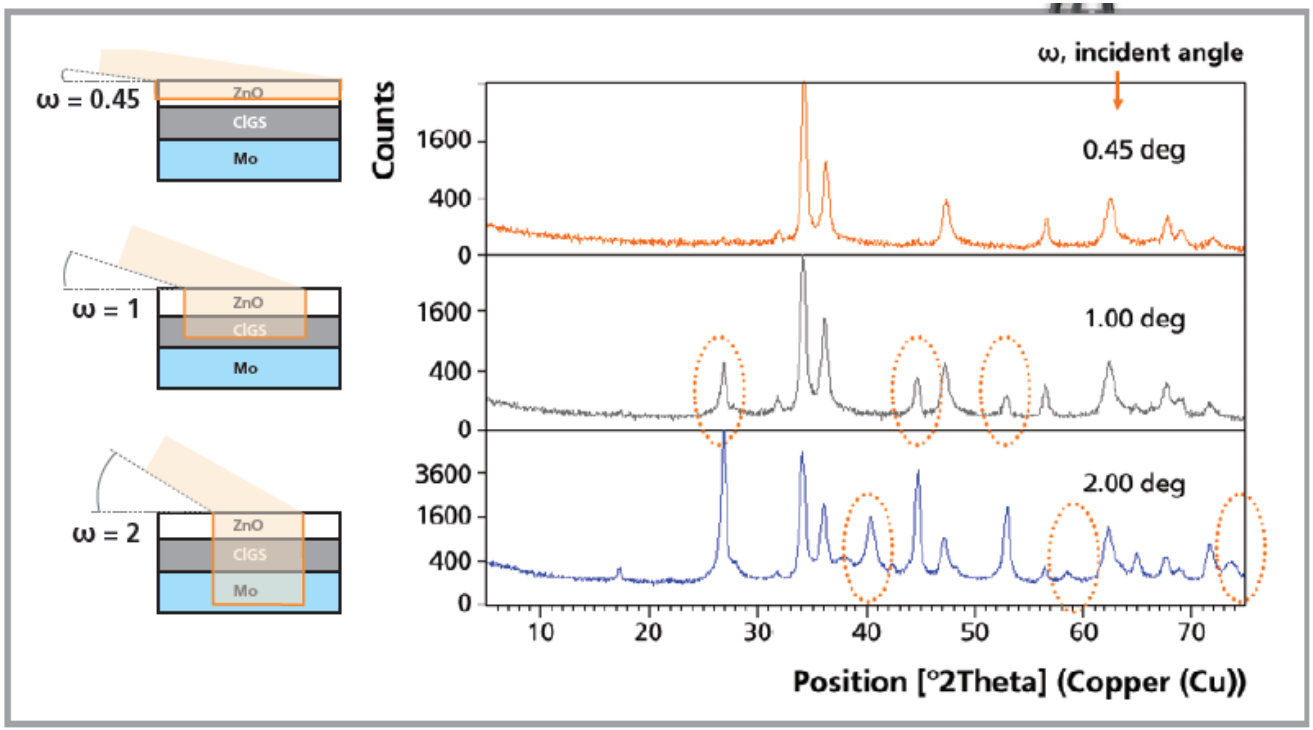
GIXRD (Grazing incident x-ray diffraction)

A ZnO film of 200 nm deposited by ALD



GIXRD (Grazing incident x-ray diffraction)

Depth profile analysis



An example of depth probing on a CIGS solar structure, showing the different layers exposed to the parallel X-ray beam in a sequential mode by varying the incident angle . Top pattern is from the conductive oxide layer only, with CIGS coming in (middle, highlighted) and next the Mo metal contact layer appearing (bottom diagram, Mo peaks highlighted).

XRR
- Film thickness
- Roughness
- Density

GIXRD
- Enhance material probed
- Phase
- Stress
- Depth profiling

HRXRD / RSM
- Texture
- Strain
- Orientation

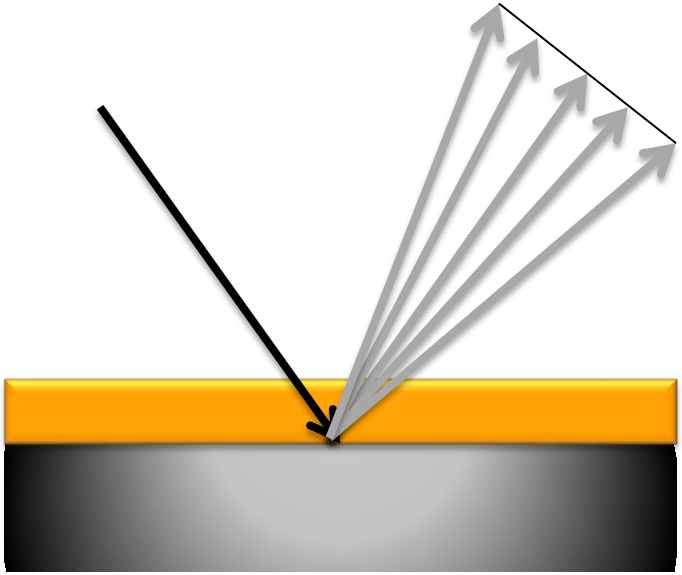
Phi-scan
- In plane orientation

Rocking curve
- Miscut
- Orientation

Polar plot
- Texture

HRXRD (High-resolution x-ray diffraction)

Increase the pathway through the sample

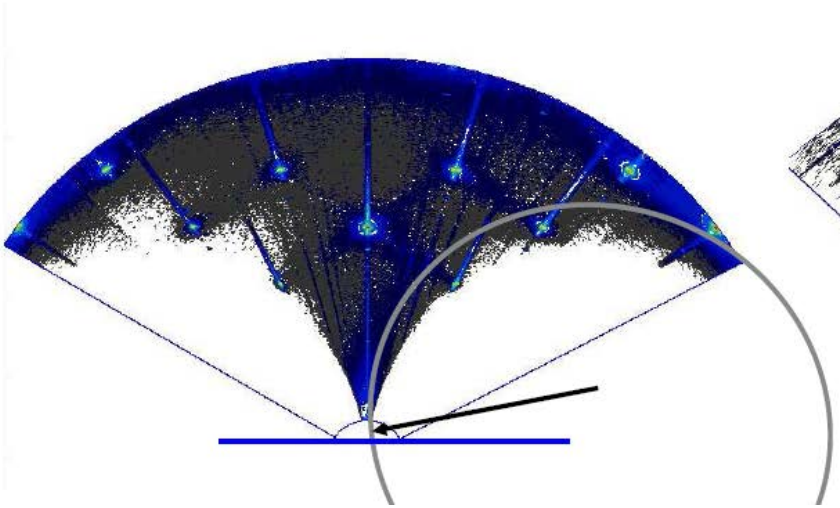


HRXRD (High-resolution x-ray diffraction)

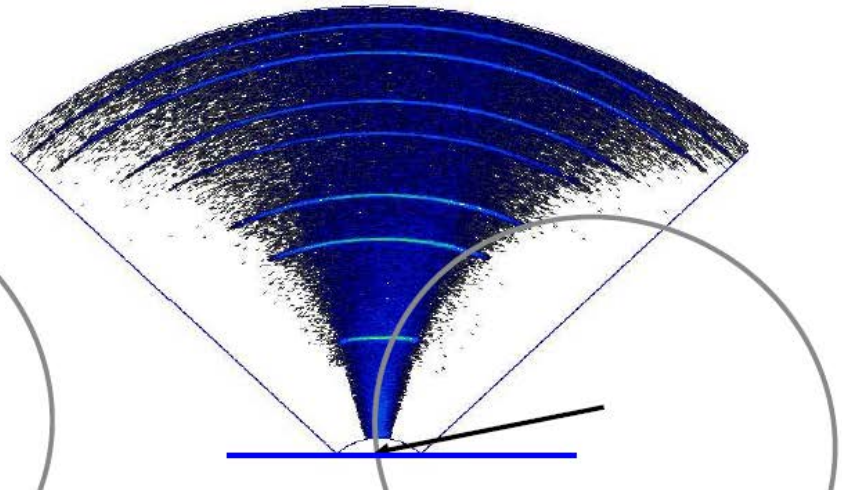
Map the reciprocal space to obtain information on:

- Orientation
- Strain
- Texture … and a lot more…

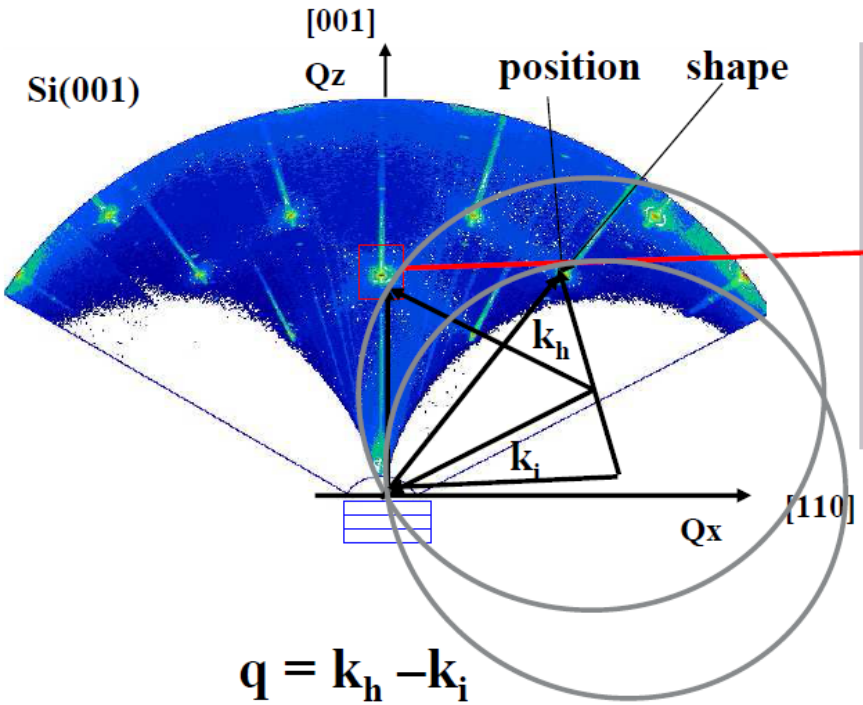
single crystal

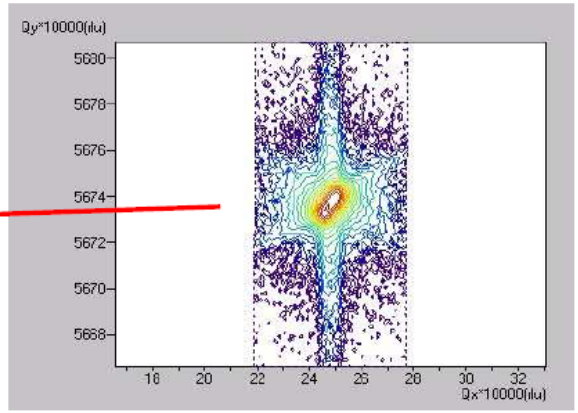


poly crystal



HRXRD (High-resolution x-ray diffraction)



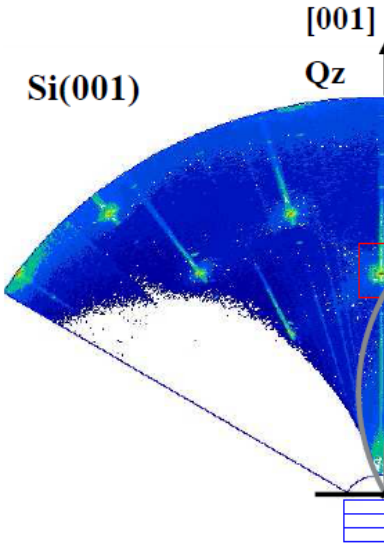


$$q = k_h - k_i$$

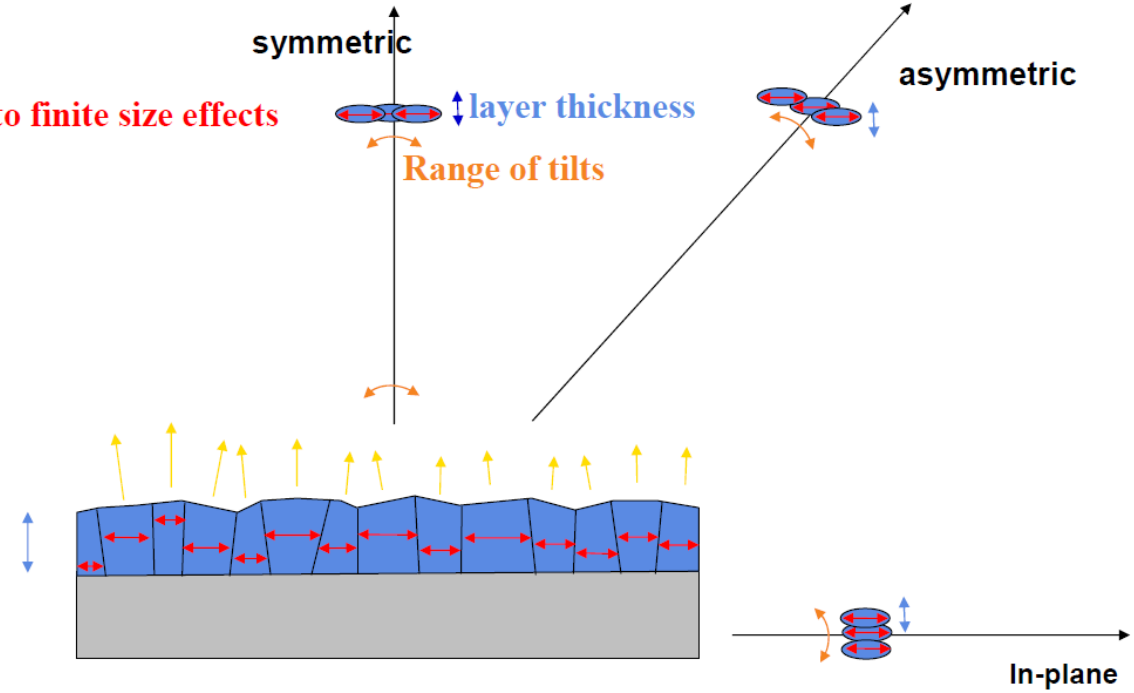
$$|q| = 2\pi/d$$

Courtesy P.Kidd. PANalytical Research , Sussex, GB

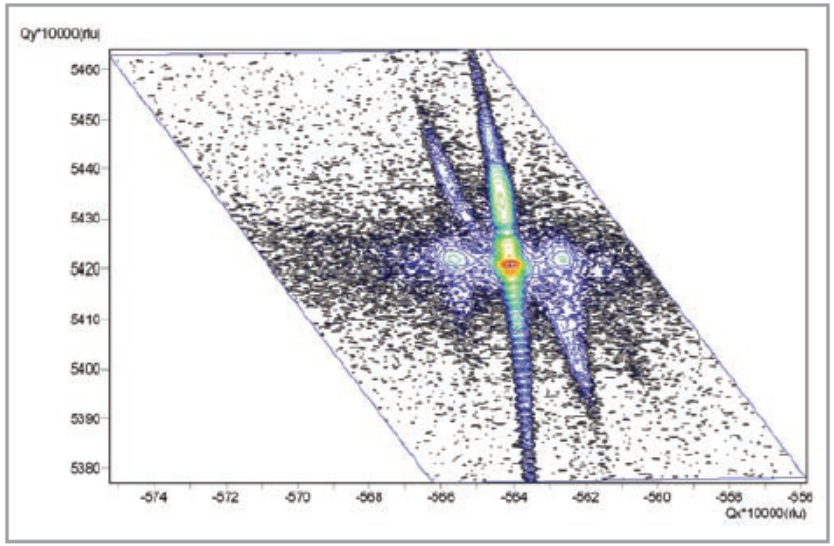
HRXRD (High-resolution x-ray diffraction)



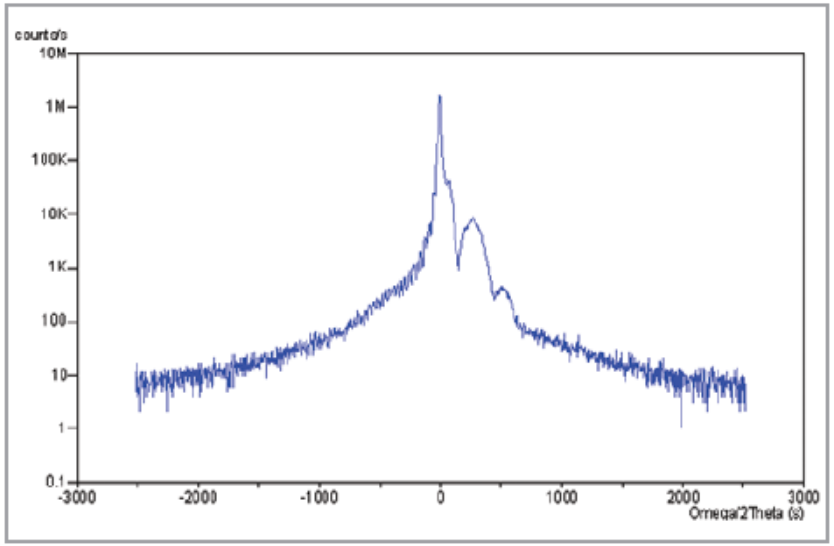
Spread due to finite size effects



HRXRD (High-resolution x-ray diffraction)



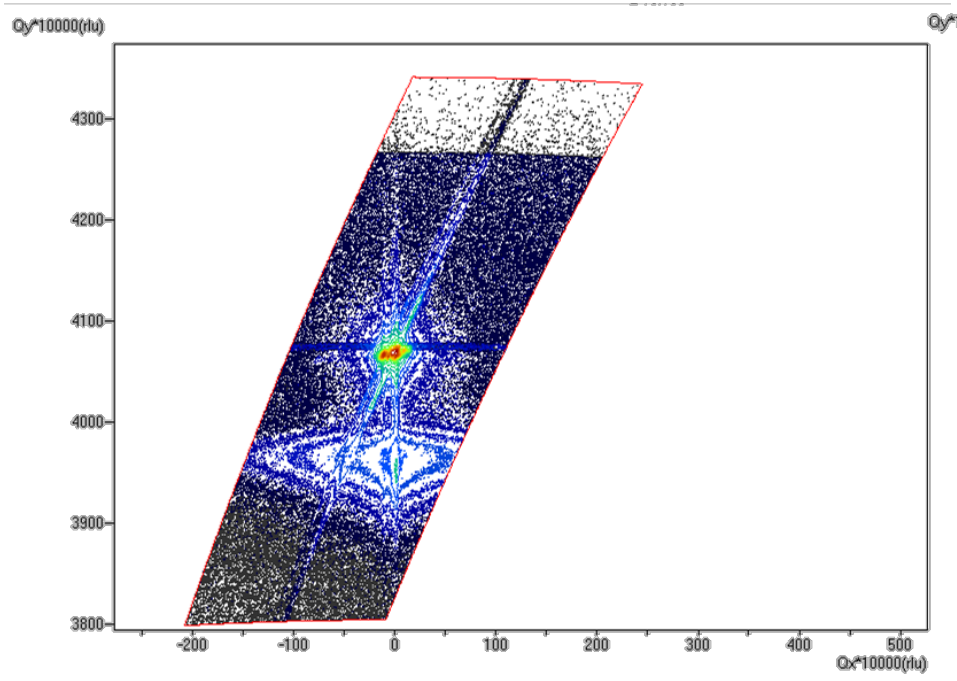
A reciprocal space map (RSM) of a GaAs based epitaxial solar cell structure

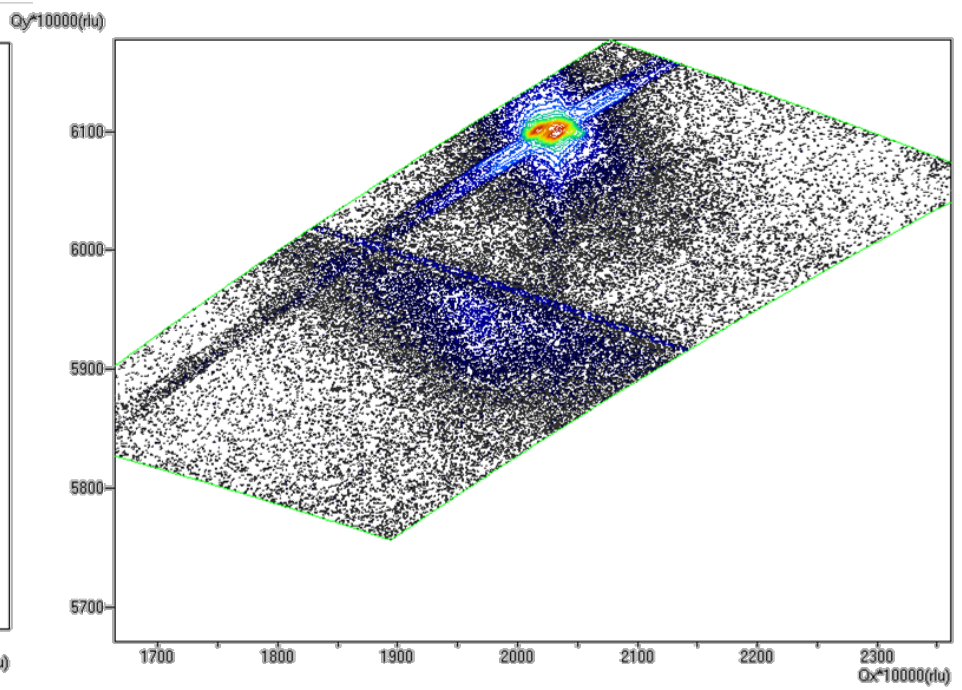


A rocking curve diagram (RC) of an epitaxial solar cell structure around the (004) reflection of the GaAs substrate

HRXRD (High-resolution x-ray diffraction)

Film of $NaNbO_3$ on $LaAlO_3$





XRR
- Film thickness
- Roughness
- Density

GIXRD
- Enhance material probed
- Phase
- Stress
- Depth profiling

HRXRD / RSM
- Texture
- Strain
- Orientation

Phi-scan
- In plane orientation

Rocking curve
- Miscut
- Orientation

Polar plot
- Texture