X-Rays

Wilhem Conrad Röntgen
First Nobel Prize Physics 1901
Bragg’s Law

For constructive interference: \( n\lambda = 2d \sin \theta \)

Law of Reflection: \( \theta_{\text{in}} = \theta_{\text{out}} \)
Typical XRD Experiment
X-Ray Tube

SCHEMATIC CROSS SECTION OF AN X-RAY TUBE
Primary Optics (X-Ray Source)

Beam Dimensions: 1.2 mm x 20 mm
Detector

Xe-filled Proportional Detector

X-Rays

Detection Gas

Anode +

Cathode -

Voltage Source

Electrical Current Measuring Device
Detector Thin Film Setup

- Flat Crystal Monochromator
- Anti Scatter Slit
- Parallel Plate Collimator
- Optics 3 (= Diffracted beam path)
- Detector 3 (PW1711/96)

X-Ray beam
Angles in XRD

For Philips XRD: $\theta = \omega$.

For mechanical reasons, the X-ray tube is stationary. The detector and the sample are rotated to satisfy the Bragg condition.
Sample Alignment for Low Angle (XRR)

For constructive interference:  \( n\lambda = 2t \sin \theta \)
Task: Bring surface of sample to center point of system and make parallel to X-ray beam!
Sample Alignment – Dial Gauge

Little Hand shows 1, big hand shows 0.
Sample Alignment – Use X-ray Intensity

• The X-ray beam is 1.2 mm wide and ~ 20 mm tall.

• If your sample is larger than 20 mm you can use the following method to align the sample.
Sample Alignment – X-ray Intensity

$I = 0.5 \ I_0$

Detector

$I = 0.5 \ I_0$

Detector
Sample Alignment – Rocking Curve

This omega (or theta) scan is called a ‘rocking curve’!
Now we know the surface is parallel to the X-ray beams.
Typical XRR Measurement

Determination of these parameters is mostly done by simulation and fitting of measured data, especially for complex thin film multilayers.
Sample Alignment for High Angle (XRD)

Crystal planes are parallel to 0° plane!
Alignment of Crystal Planes

Measure a **rocking curve for θ (or ω)** and choose angle with max intensity. Now the sample is correctly aligned for XRD measurements!
Rocking Curve and Mosaicity

Due to disorder (mosaicity) in the sample the Bragg condition can be satisfied for a range of $\omega$ values.

Compared to a perfect crystal the rocking curve is therefore broadened.
When Finished

• Set X-ray power back to 30 kV / 20 mA
• Set z = 2 mm
• Click Move to Rest Position
• Close control window, shut down program
• Take sample out, clean sample stage from grease
• Close sliding doors (carefully).