Jack of All Trades, Master of All:
The New D8 ADVANCE Plus with EIGER2 R 500K

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D8 ADVANCE Plus

The Perfect Balance of Simplicity and Sophistication

Effortless Equipment Setup

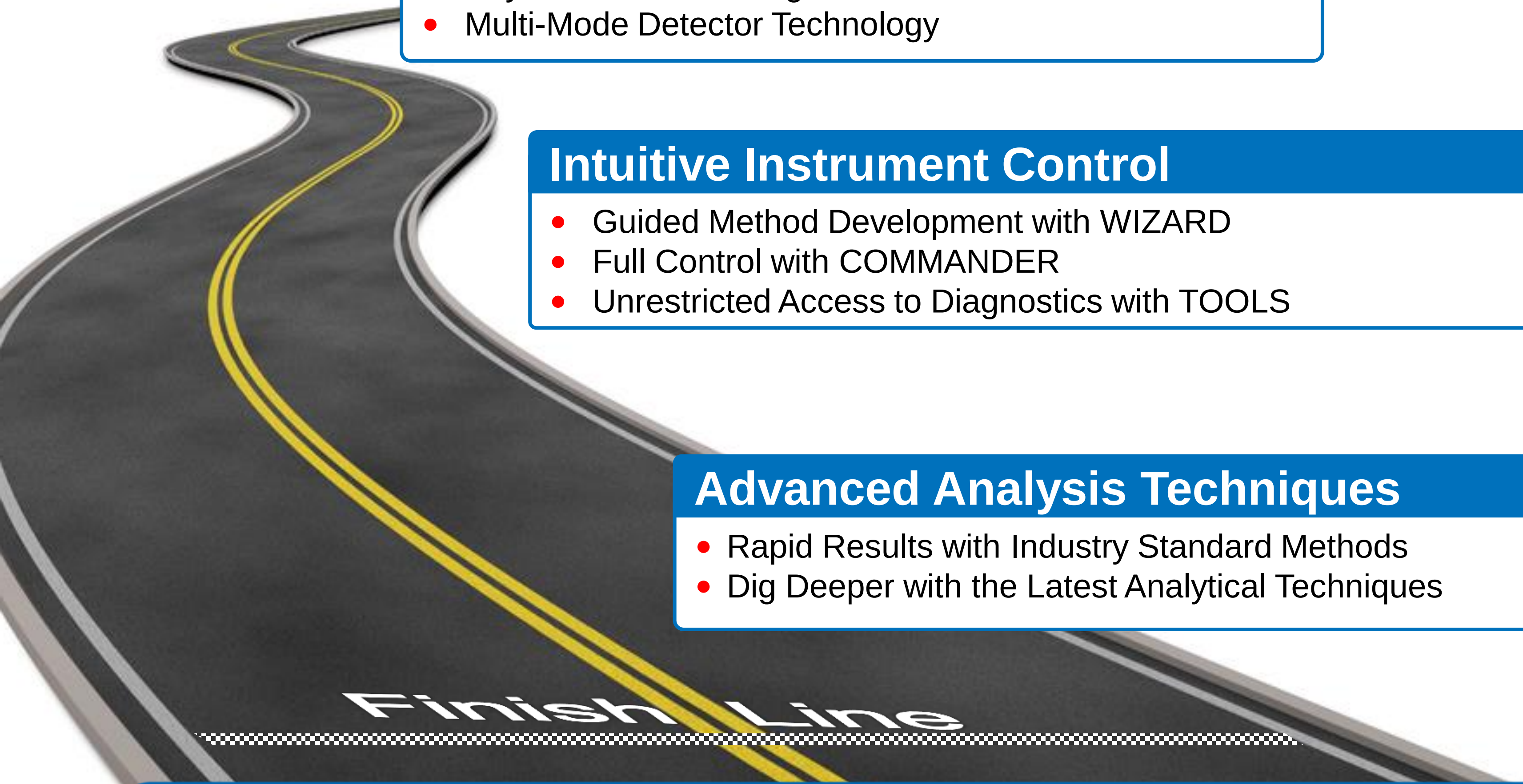
- No Touch Optics
- Bayonet-Mounted Stages
- Multi-Mode Detector Technology

Intuitive Instrument Control

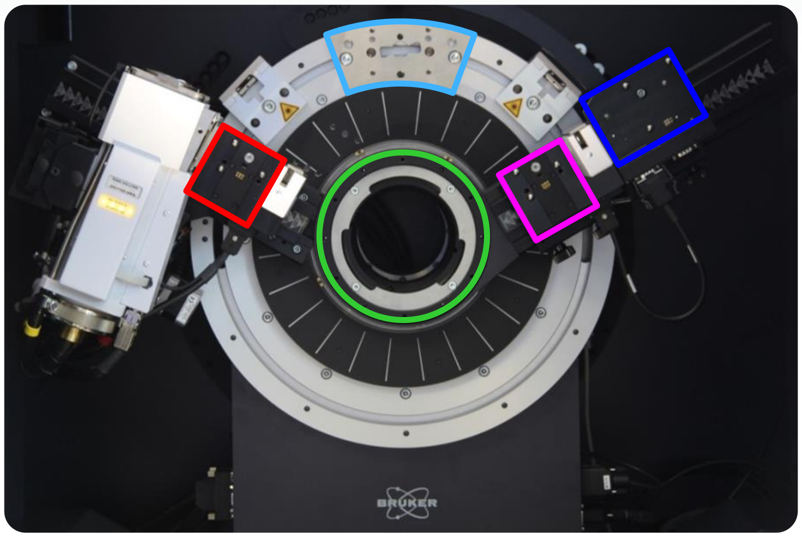
- Guided Method Development with WIZARD
- Full Control with COMMANDER
- Unrestricted Access to Diagnostics with TOOLS

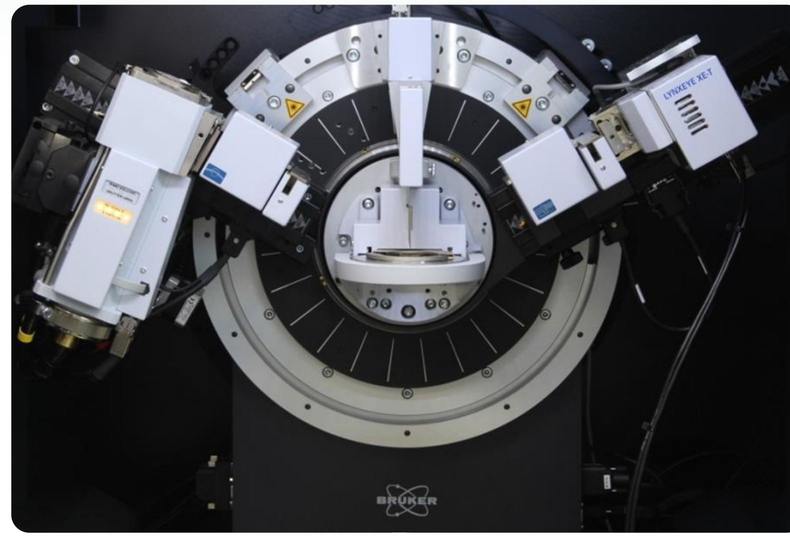
Advanced Analysis Techniques

- Rapid Results with Industry Standard Methods
- Dig Deeper with the Latest Analytical Techniques

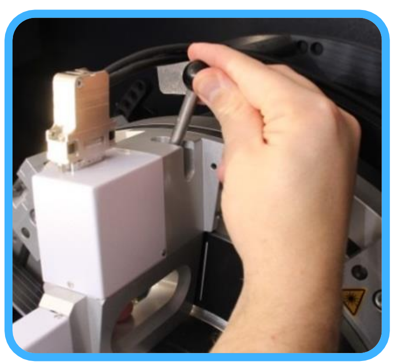


D8 ADVANCE Plus
Fundamentally Flexible





Primary Optic Bench



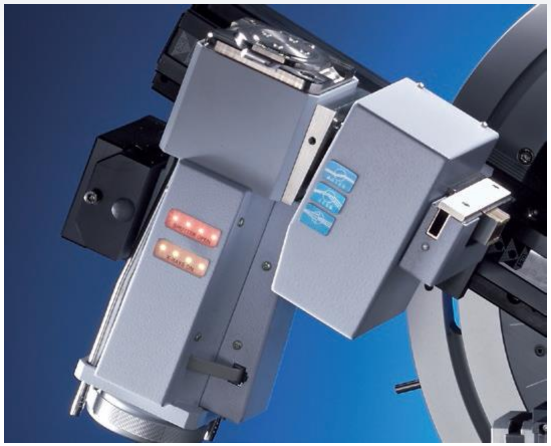
Goniometer Accessory Mount*

Sample Stage Bayonet

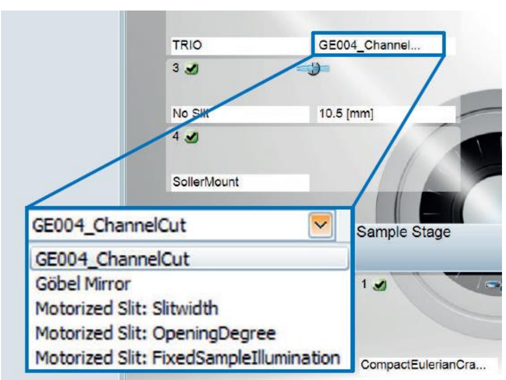
Secondary Optic Bench*

Universal Detector Mount

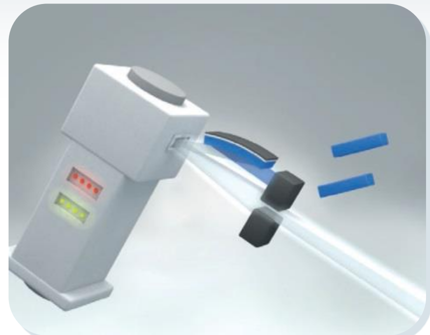
TRIO
Triple Beampath Primary Optics



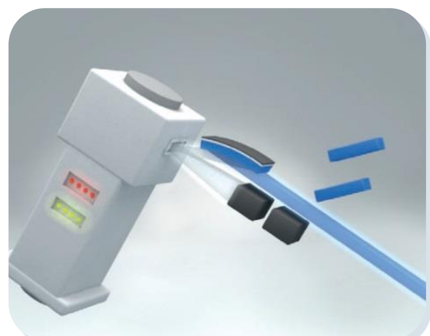
- Beampath selection by one click
  No further realignment required



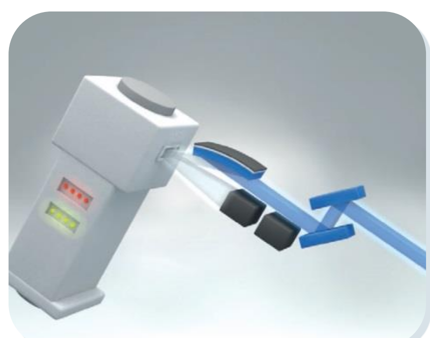
View in DIFFRAC.DAVINCI



1. Motorized divergence slit
- Bragg–Brentano geometry
- Powder XRD
- Bragg2D



2. Goebel mirror
- Parallel Beam geometry
- X-ray Reflectometry
- Grazing Incidence XRD
- Residual Stress
- Texture
- Microdiffraction



3. Goebel mirror + Ge(004) monochromator
- Highly parallel Kα1 geometry
- High Resolution XRD
- Reciprocal Space Mapping
- X-ray Reflectometry (Thick Layers)

POLYCAP
High Intensity Point Focus Beam

TWIST.TUBE

- Fast switching between line focus (for TRIO) and point focus (for POLYCAP)
- Automatic focus direction recognition

POLYCAP SNAP-LOCK optic

- Same optic for all wavelengths
- Parallel beam optic (divergence ~0.25° in both directions)
- Beam diameter: 4 mm

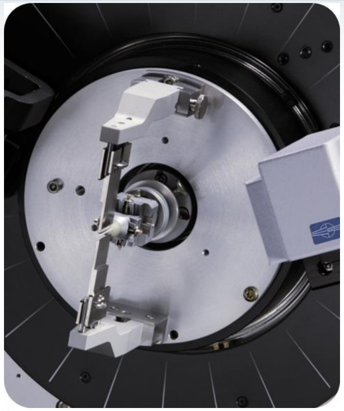
UBC Magnetic Collimators

- Tool-free and alignment-free exchange
- Excellent reproducibility with remounting
- Sizes available (mm): 0.1, 0.3, 0.5, 1.0, 2.0

Primary Applications: Microdiffraction, In-Plane GID

D8 ADVANCE Plus

Bayonet-Mounted Sample Stages



	Rotation Stage	CAPILLARY	COMPACT UMC	COMPACT CRADLE+	Non Ambient
Motorized Motion	Phi Rotation	Phi Rotation	XYZ	Phi, Chi, Z Manual X,Y	Various
Geometry	Reflection Transmission	Transmission	Reflection	Reflection	Various
Applications	• Powder Diffraction • GID • XRR	• Powder Diffraction • Structure Solution • PDF • SAXS	• Powder Diffraction • Well Plates • XY Mapping • GID • XRR	• Powder Diffraction • Pseudo-Gandolfi • HRXRD • XRR • IPGID	• Heating/ Cooling • Humidity • Reactive Gases • Tension • Electrochemical

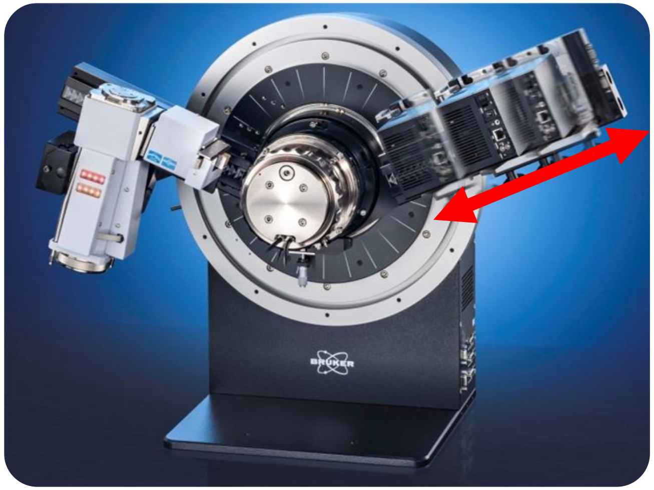
The New **EIGER2 R 500K**
Ergonomic Design for Dynamic Detection

Ergonomic 0°/90° rotation

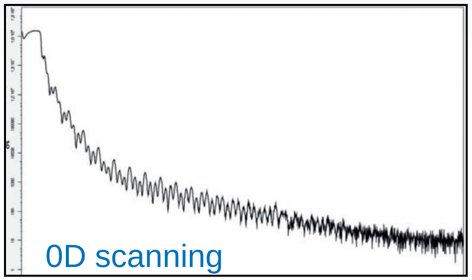
- Optimize for 2θ or γ coverage
- Tool-free switching
- Component recognition for rotation

Continuously Variable Sample-to-Detector Distance

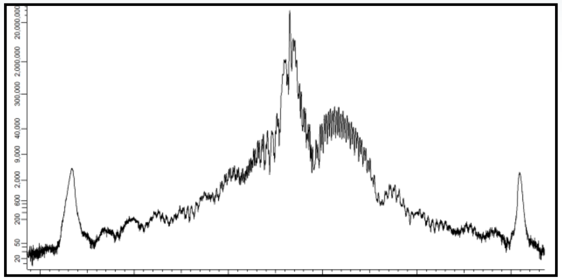
- 100 mm to 350 mm (D8 Advance)
- Balance coverage and resolution
- Tool-free distance adjustment
- No alignment or calibration

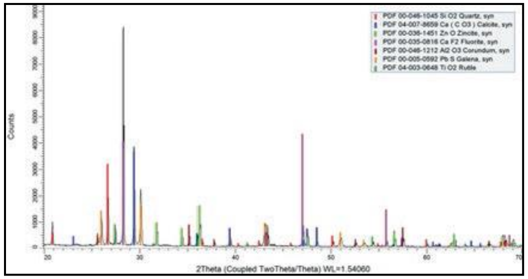


The New **EIGER2 R 500K**
A Multitude of Measurement Modes

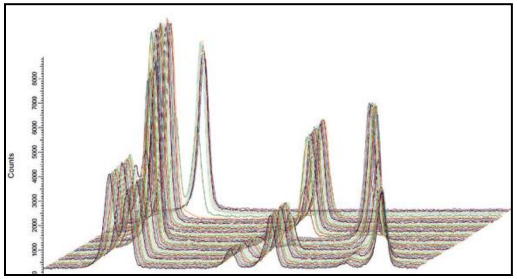


0D scanning

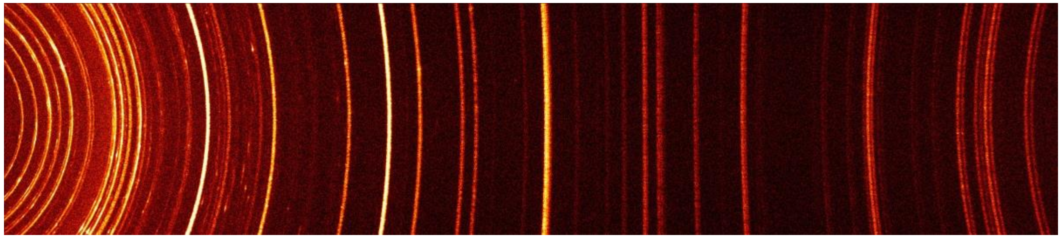




1D scanning



1D Snap-Shot

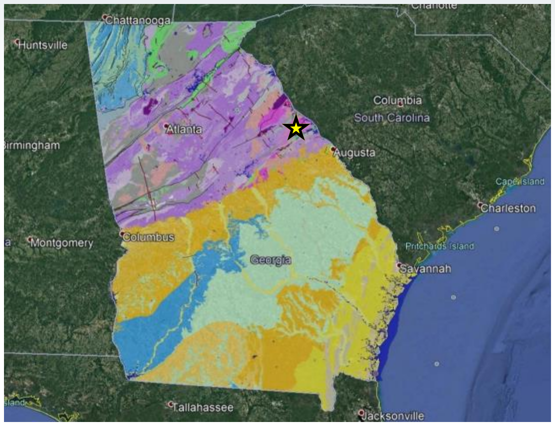


2D scanning

Mode	Type	EIGER2 R 500K
0D	Step Scan	✓
	Continuous Scan	✓
1D	Snap-Shot	✓
	Step Scan	✓
	Continuous Scan	✓
	Advanced Scan	✓
2D	Snap-Shot	✓
	Step Scan	✓
	Continuous Scan	✓
	Advanced Scan	✓

Phase ID of Geological Samples

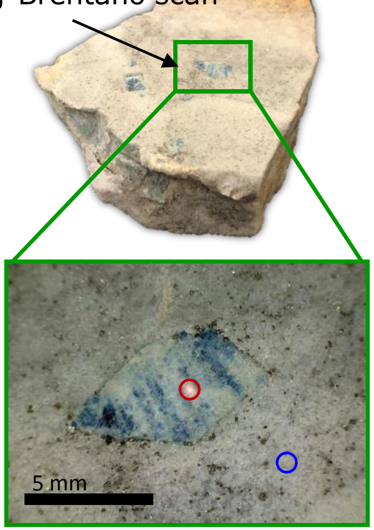
Bragg-Brentano Powder Diffraction

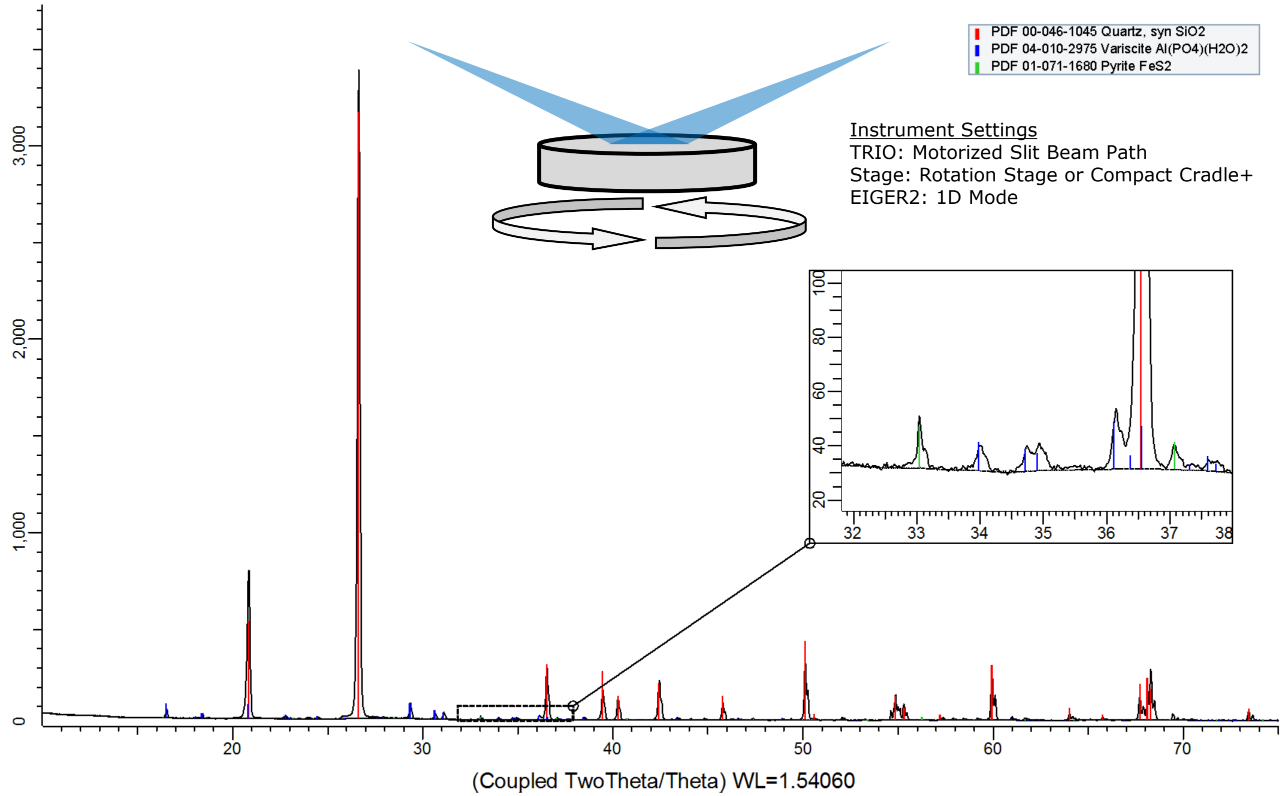


Graves Mountain is a NE/SW striking monadnock located in eastern Georgia, USA (Figure 1). Part of the Carolina Slate Belt, the low to medium grade metavolcanics of Graves Mountain were mined for kyanite to be used in high-alumina refractory products. In addition to kyanite, the locale is known to mineral collectors for its world-class twinned rutile crystals, iridescent hematite coatings on quartz, lazulite, pyrite, and pyrophyllite.

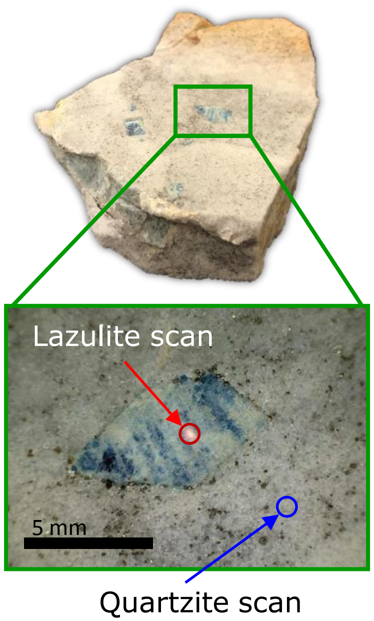
Reference: Hurst, Vernon J., 1959, The Geology and Mineralogy of Graves Mountain, Georgia: Atlanta, GA, Bulletin Number 68, Georgia Geological Survey, 33 p.

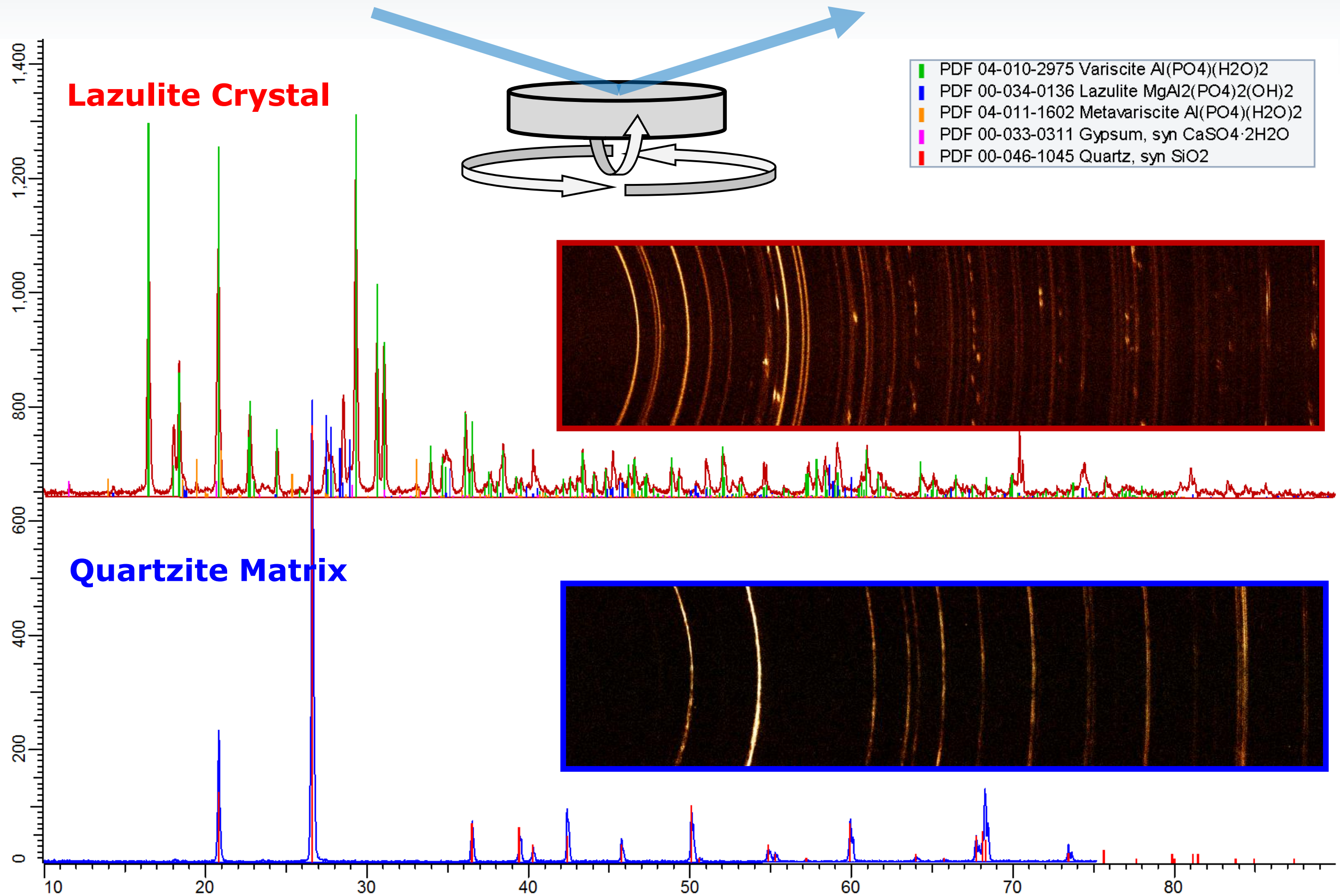
Region sampled by Bragg-Brentano scan





Phase ID of Geological Samples
Microdiffraction and Pseudo-Gandolfi

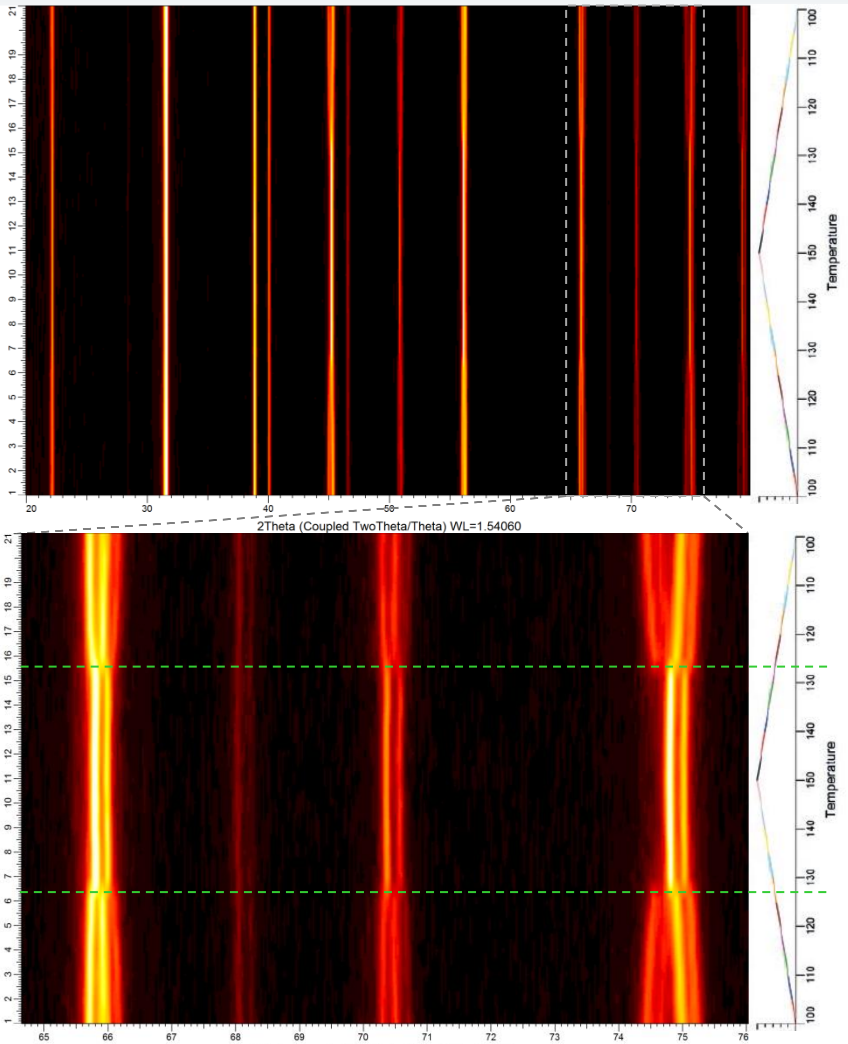


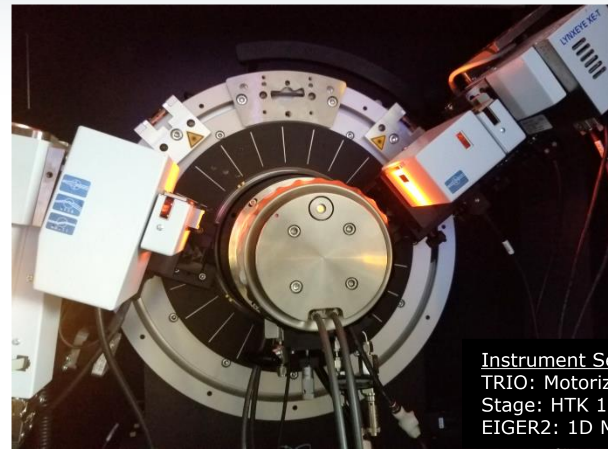


With Pseudo-Gandolfi technique it is possible to identify mineral phases without first crushing/grinding rock, many of which were invisible to a standard Bragg-Brentano scan.

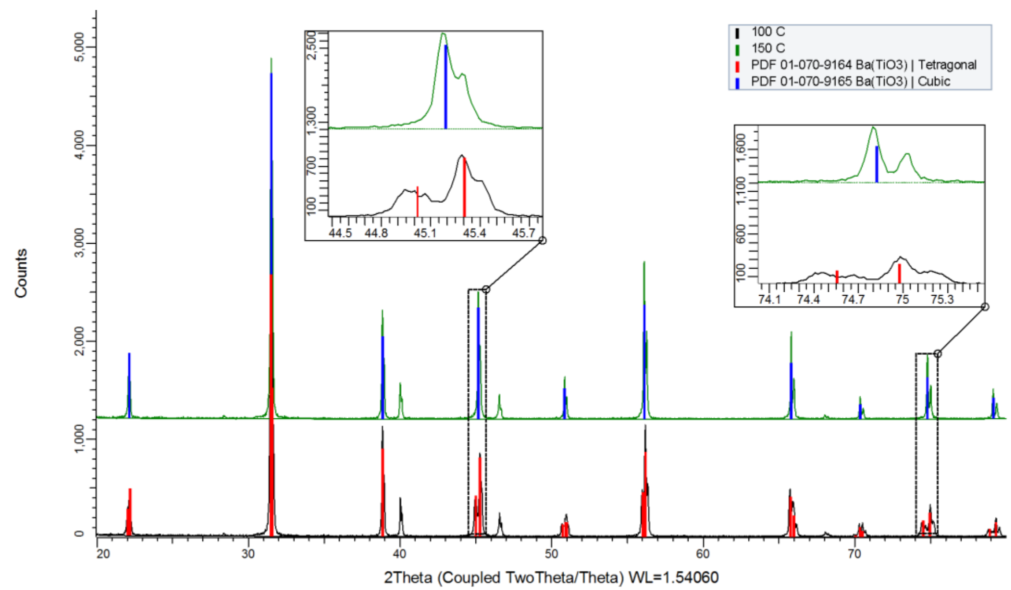
Non-Ambient Diffraction

Cubic to Tetragonal Transition of $BaTiO_3$ Powder



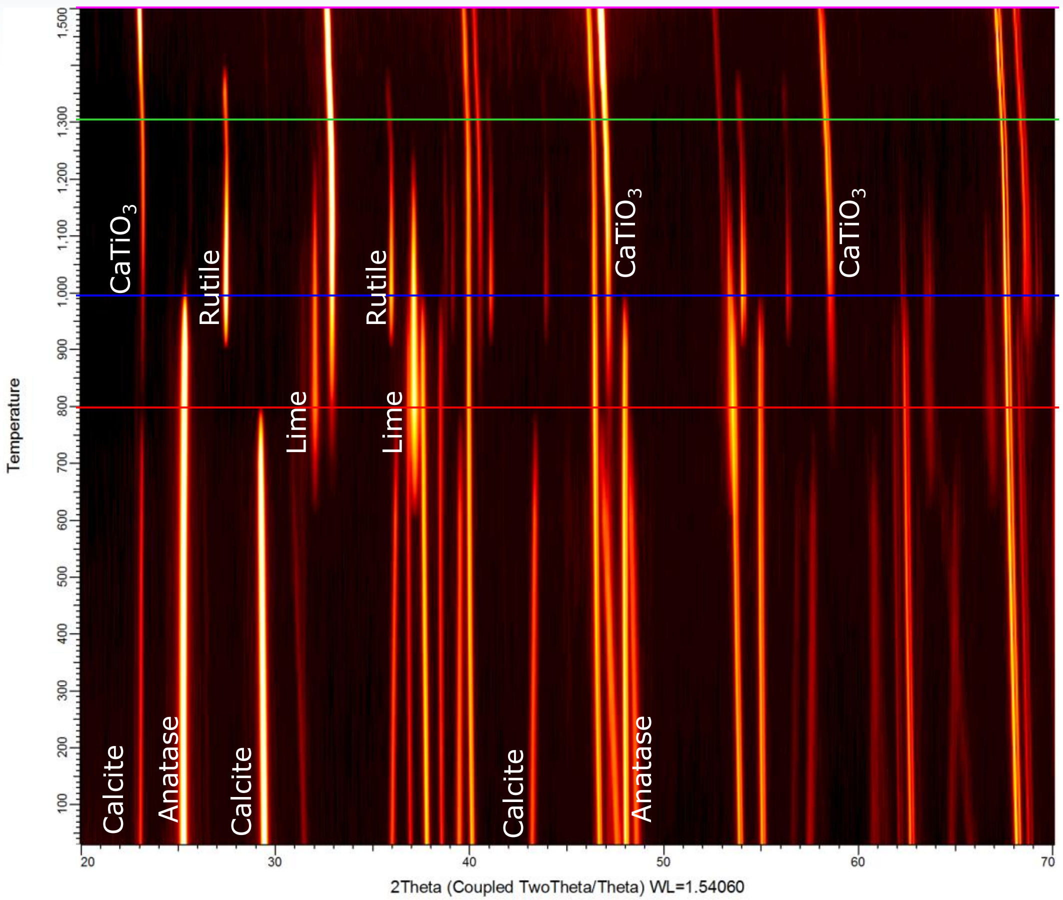


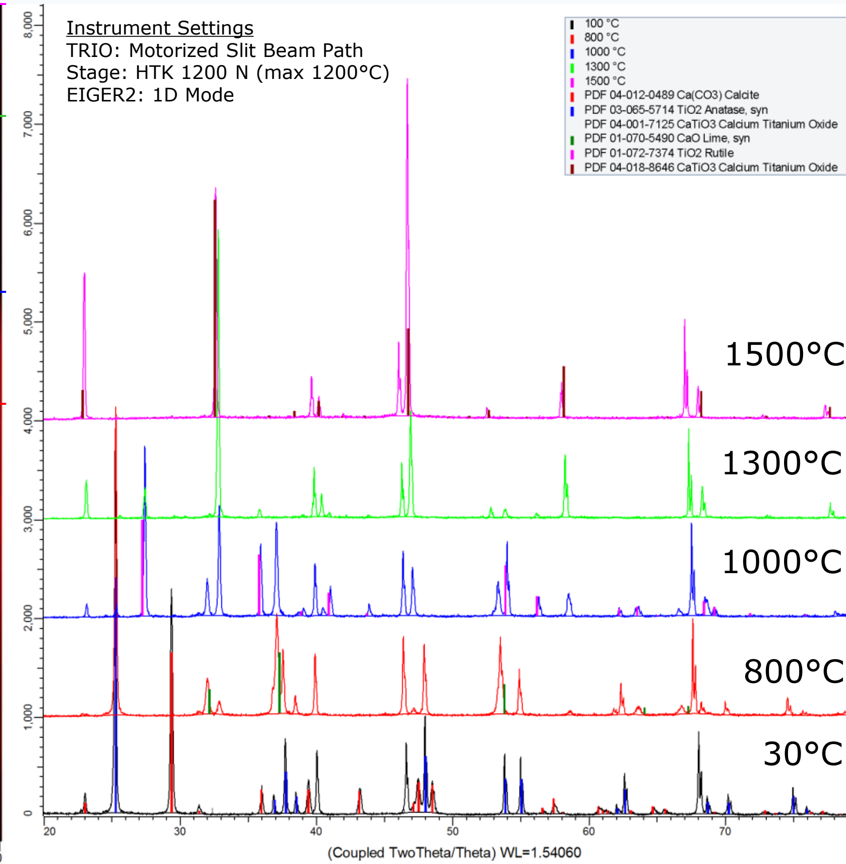
Instrument Settings
TRIO: Motorized Slit Beam Path
Stage: HTK 1200 N
EIGER2: 1D Mode



Non-Ambient Diffraction

Reaction of $CaCO_3$ and TiO_2 to form $CaTiO_3$



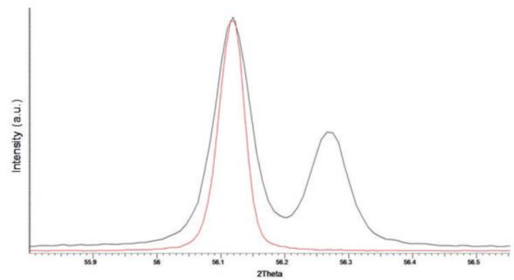


Powder Diffraction with Kα1 only

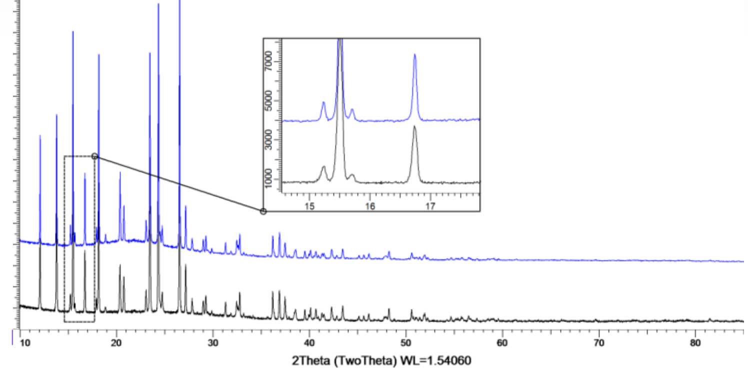
Structure of Paracetamol

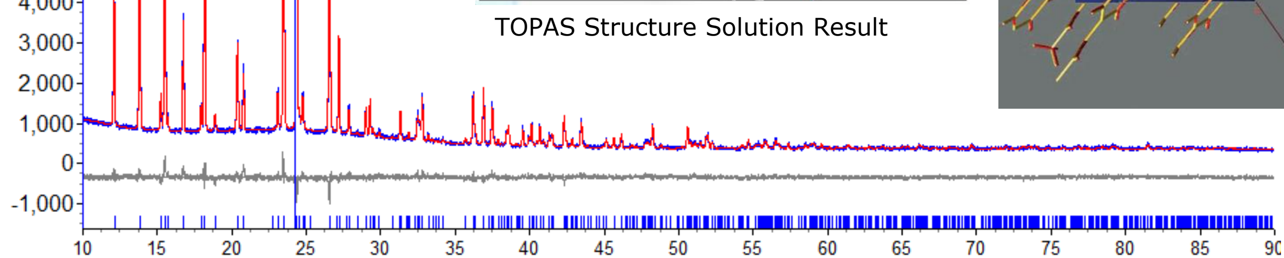
Instrument Settings
TRIO: Ge004 Monochromator Beam Path
Stage: Rotation Stage or Compact Cradle+
EIGER2: 1D Mode

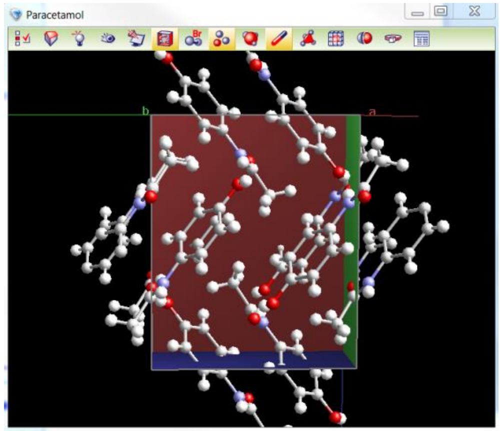
Resolution Comparison
Black: Goebel Mirror Beam Path (Kα1+Kα2)
Red: Ge004 Monochromator Beam Path (Kα1 only)



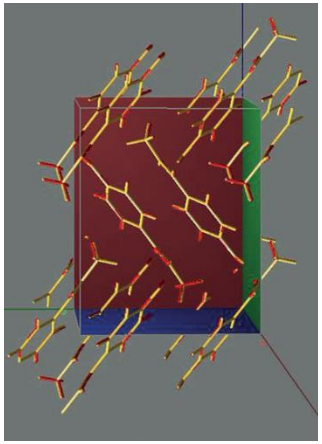
Comparison to Johansson monochromator
Black: TRIO Ge004 Monochromator Beam Path
Blue: Johansson Monochromator







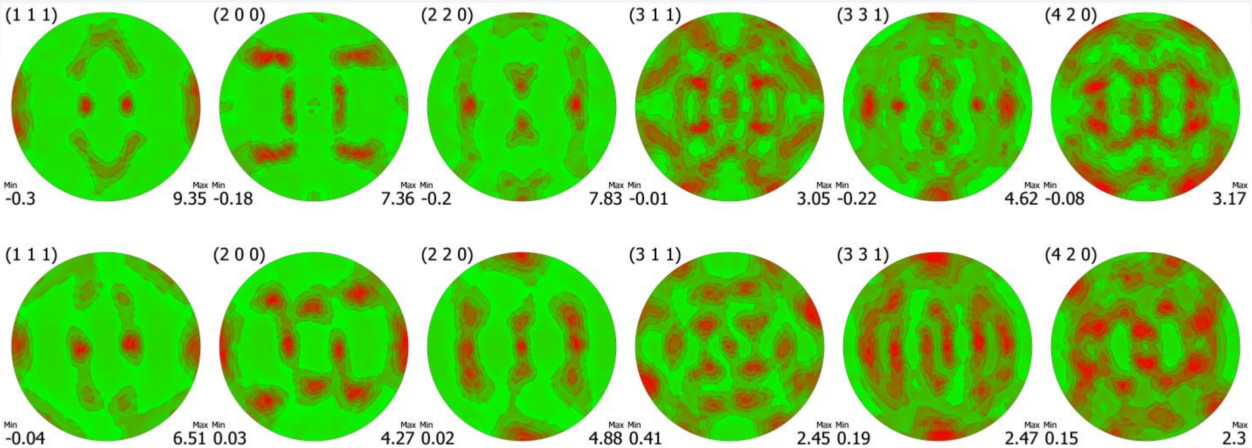
TOPAS Structure Solution Result

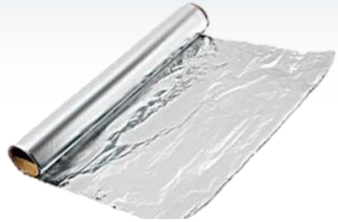


Perfect Agreement with Single Crystal Experiment
Single Crystal Data (Yellow)
Powder Diffraction Data (Red)

Pole Figures and Texture Analysis

Rolled Al Foil vs. Rolled and Drawn Al Can

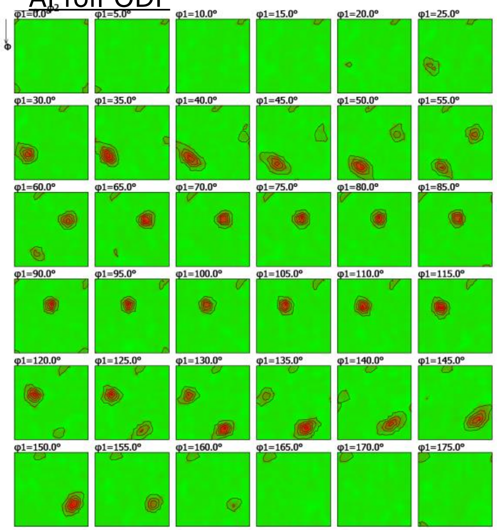




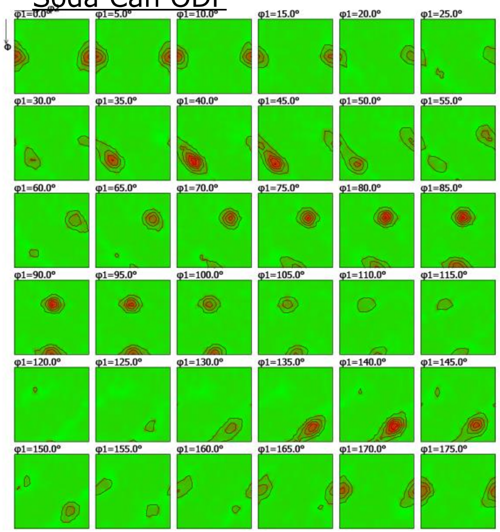
A pole figure maps the intensity of a single HKL reflection as a function of the angle of the diffraction vector relative to the surface normal.

The orientation distribution (ODF) of crystallites is usually plotted as intensity in a cubic volume, where each axis of the cube corresponds to one of the Euler angles.

Al foil ODF



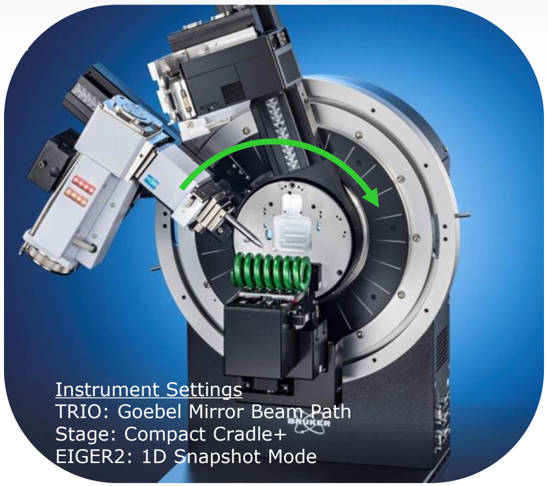
Soda Can ODF



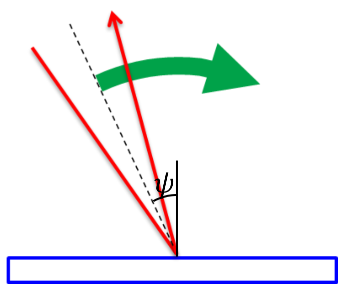
- Al Foil shows three distinct texture components in the ODF
- Soda can ODF shows the same three components, but with less broadening since it was not rolled as thin
- Soda can also shows a fourth component not present in the Al foil, due to the drawing process

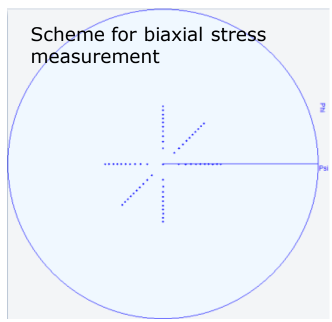
Residual Stress in 1D

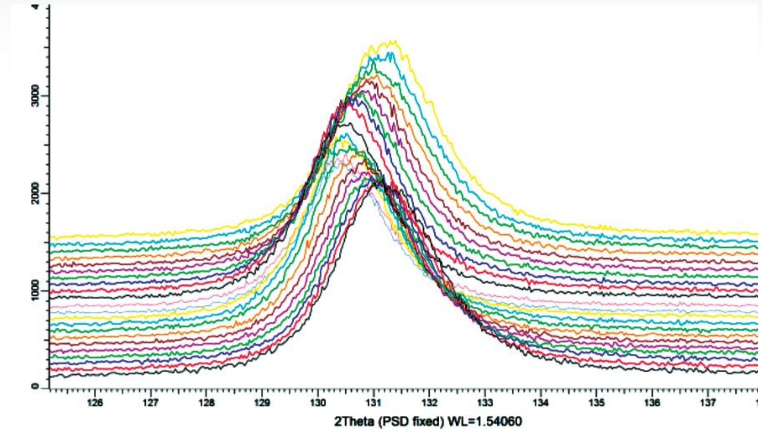
Polycrystalline Ta Coating Deposited at High Temp.

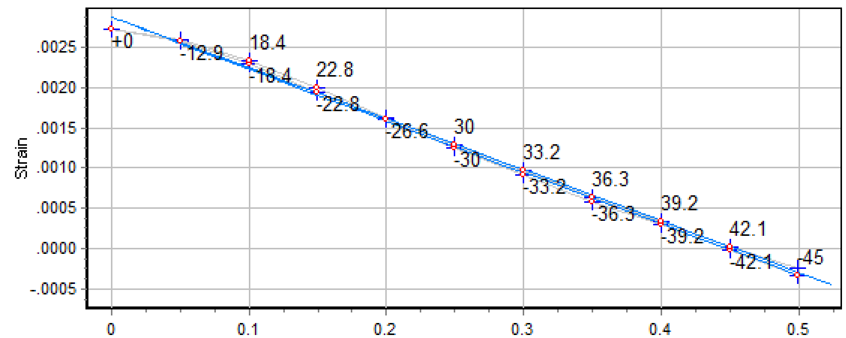


Sin²(ψ) Method (1D)









The classic $\sin^2(\psi)$ technique determines the stress of a material by the shift of a high-angle diffraction peak as a function of the tilt angle ψ of the diffraction vector away from the sample normal.

Iso-inclination mode: ψ tilt is in the diffraction plane

Side-inclination mode: ψ tilt is perpendicular to the diffraction plane

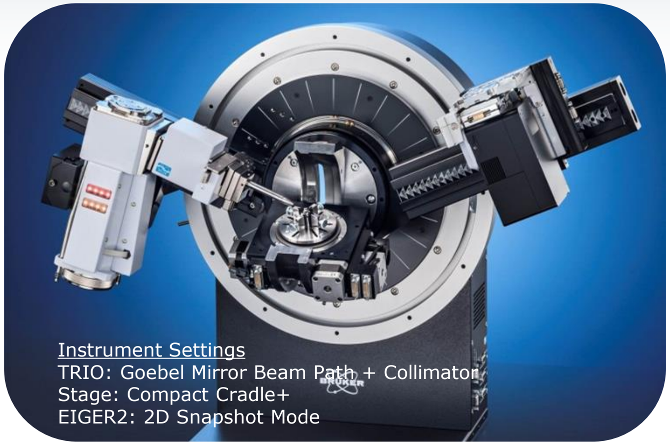
- Measured in iso-inclination mode using a line-focus beam and EIGER2 in 1D snapshot mode, resulting in extremely short measurement times (~10 s per scan)
- Suitable for large, flat samples
- This stress result represents an average value over a large surface area

Stress tensor (MPa)

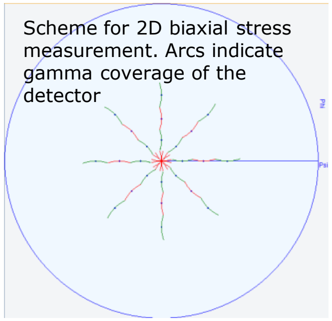
-1995.3 ± 23.8	65.5 ± 20.5	-3.8 ± 5.3
65.5 ± 20.5	-2008.6 ± 23.8	6.3 ± 5.3
-3.8 ± 5.3	6.3 ± 5.3	0.0 ± 0.0

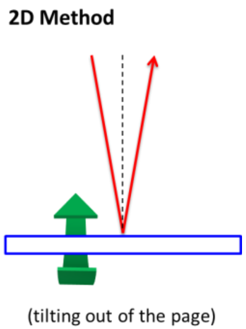
Residual Stress in 2D

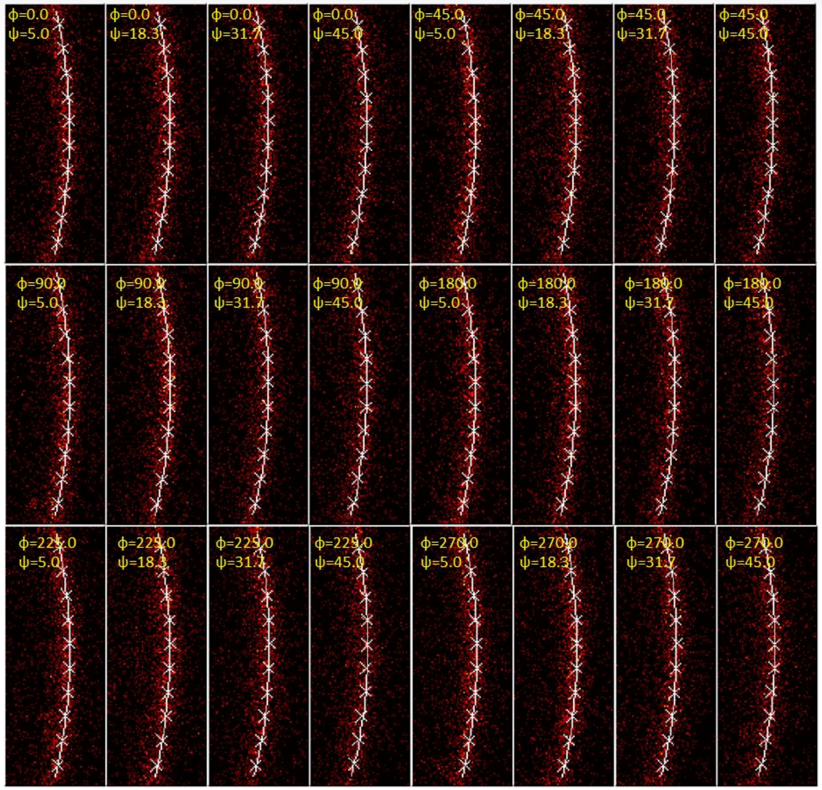
Polycrystalline Ta Coating Deposited at High Temp.



The 2D stress method extends the $\sin^2(\psi)$ technique by including the deformation of the Debye ring at several points, rather than just at the center







- Measured in side-inclination mode using a point-focus beam and EIGER2 in 2D snapshot mode
- Suitable for measuring small areas and features
- This stress result represents a local value
- Agreement between 1D and 2D methods suggests uniformity over the sample surface

Stress tensor (MPa)

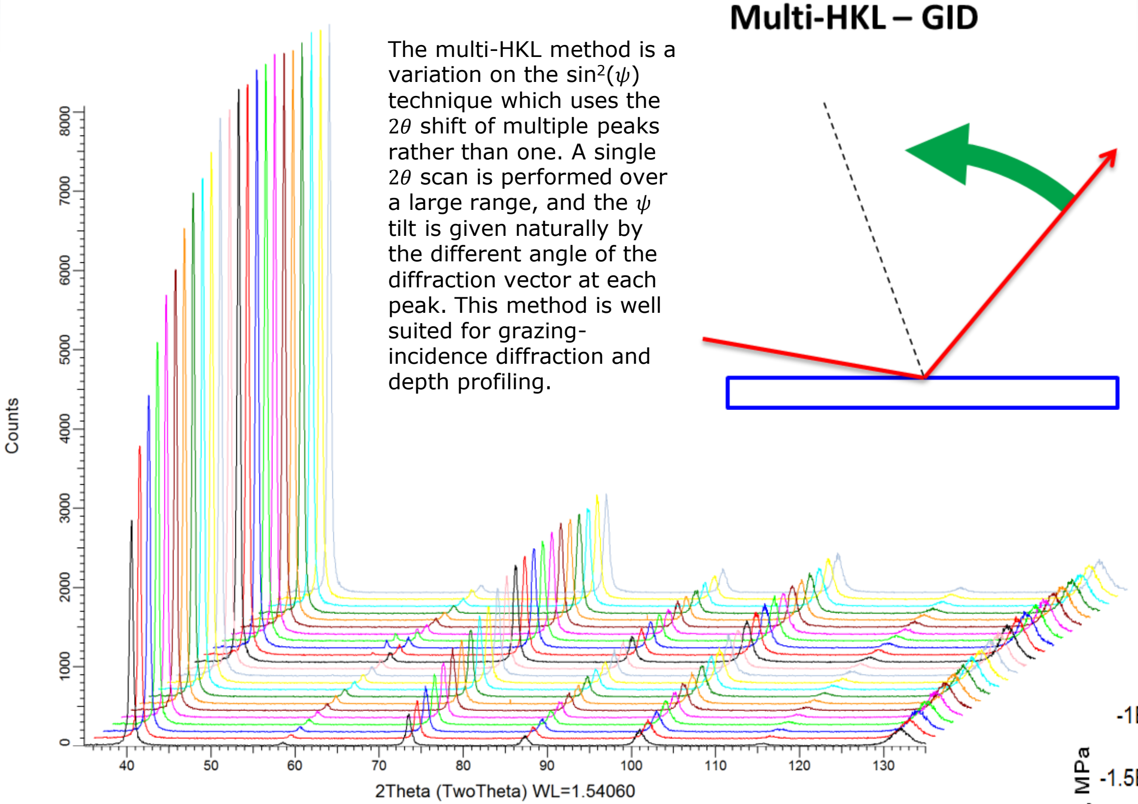
-2027.3 ± 19.2	10.3 ± 19.5	-1.6 ± 5.6
10.3 ± 19.5	-2027.7 ± 19.1	-0.1 ± 5.5
-1.6 ± 5.6	-0.1 ± 5.5	0.0 ± 0.0

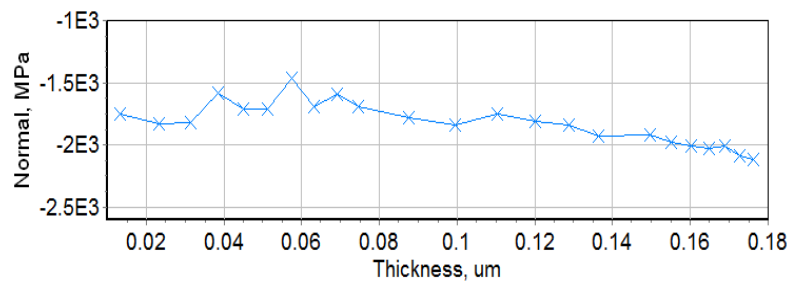
Residual Stress Depth Profile

Polycrystalline Ta Coating Deposited at High Temp.

Multi-HKL – GID

The multi-HKL method is a variation on the $\sin^2(\psi)$ technique which uses the 2θ shift of multiple peaks rather than one. A single 2θ scan is performed over a large range, and the ψ tilt is given naturally by the different angle of the diffraction vector at each peak. This method is well suited for grazing-incidence diffraction and depth profiling.

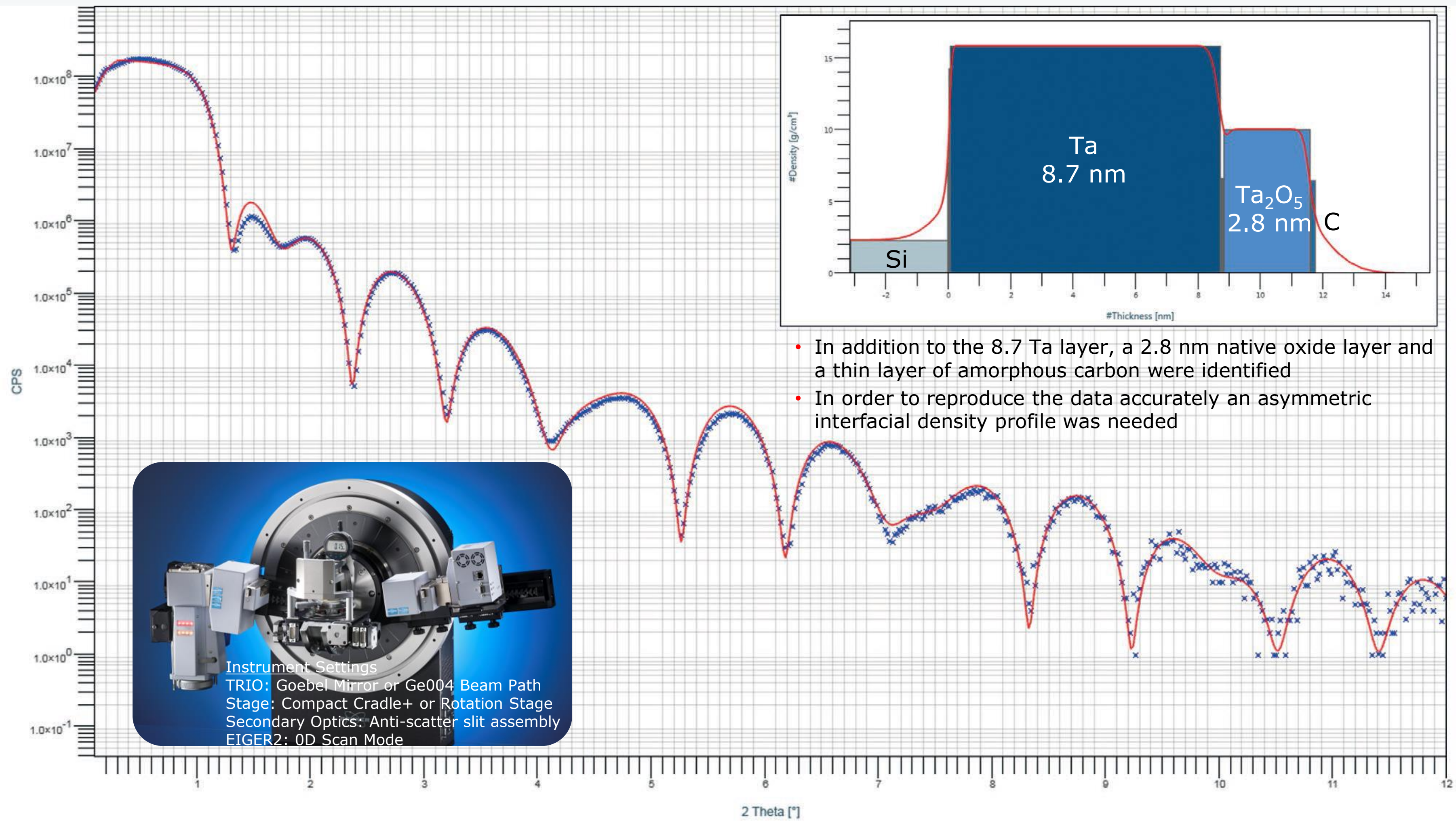




- Based on the GID depth profile the stress at the surface of the film is slightly lower than in the bulk
- The bulk value is in good agreement with the results of the 1D and 2D methods

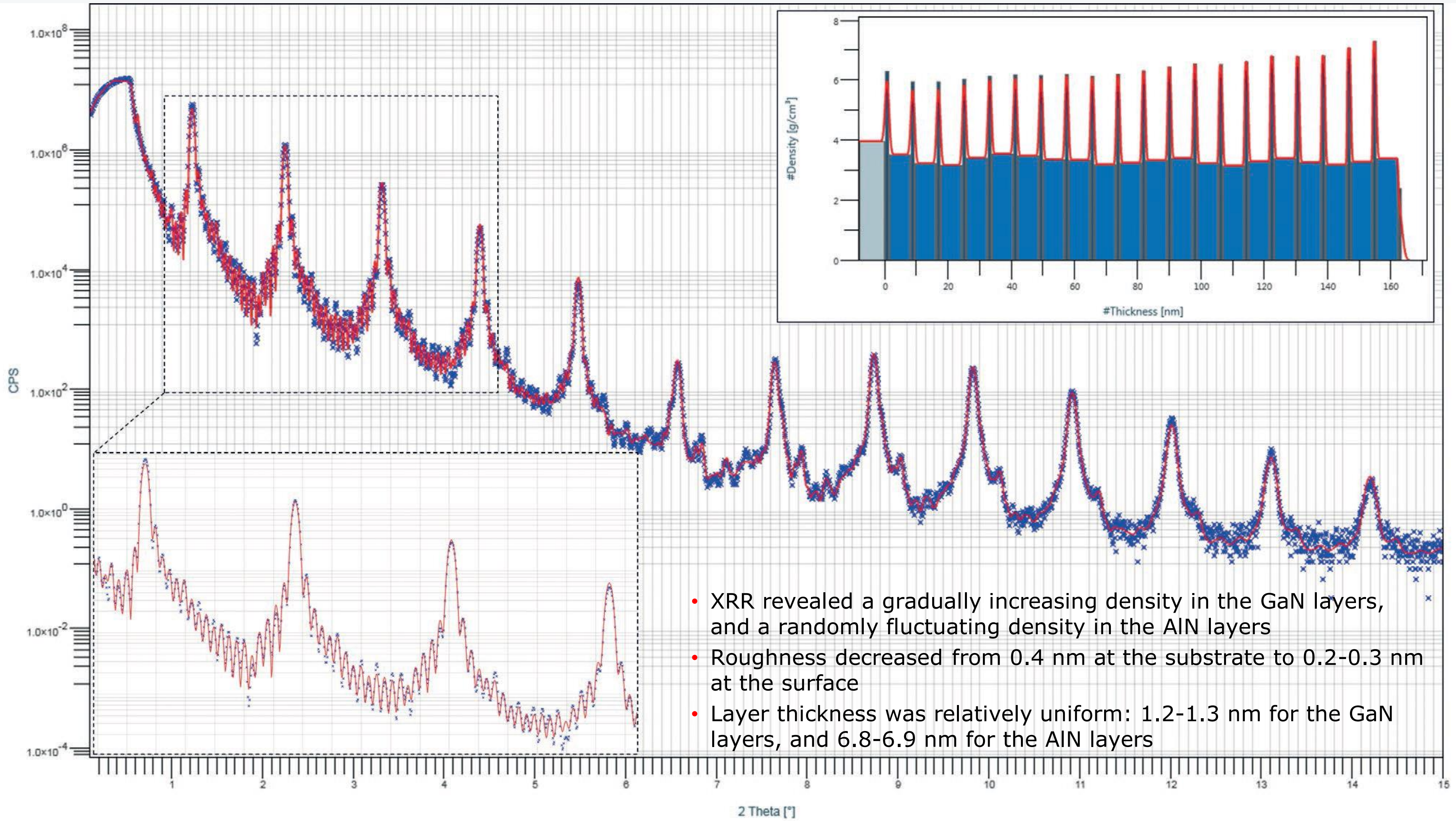
X-ray Reflectometry

Thin Ta Coating on Si



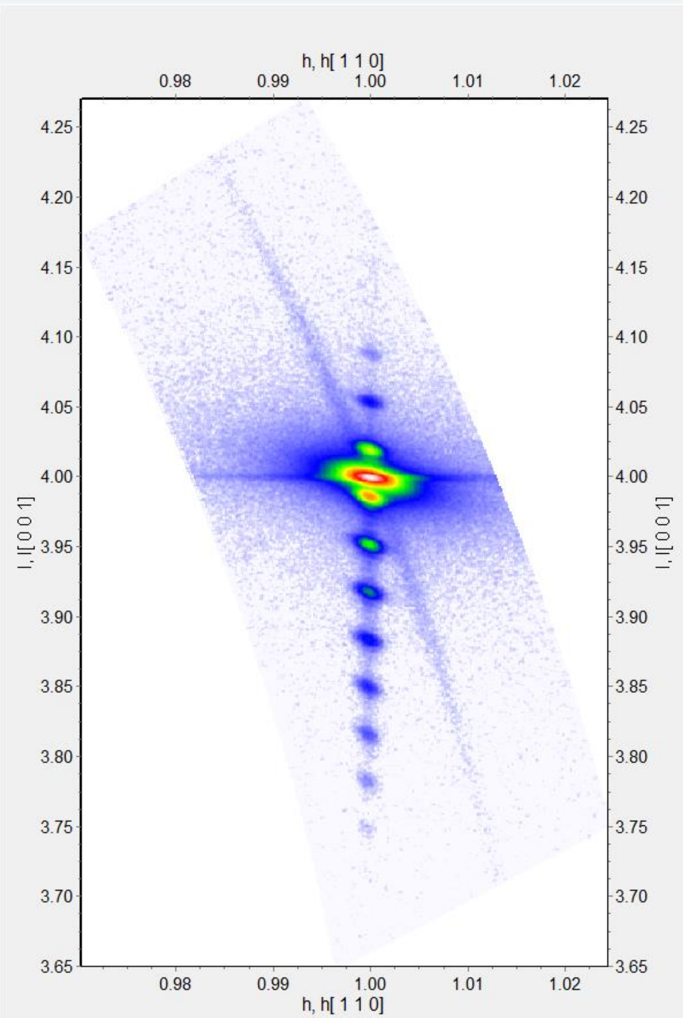
- In addition to the 8.7 Ta layer, a 2.8 nm native oxide layer and a thin layer of amorphous carbon were identified
- In order to reproduce the data accurately an asymmetric interfacial density profile was needed

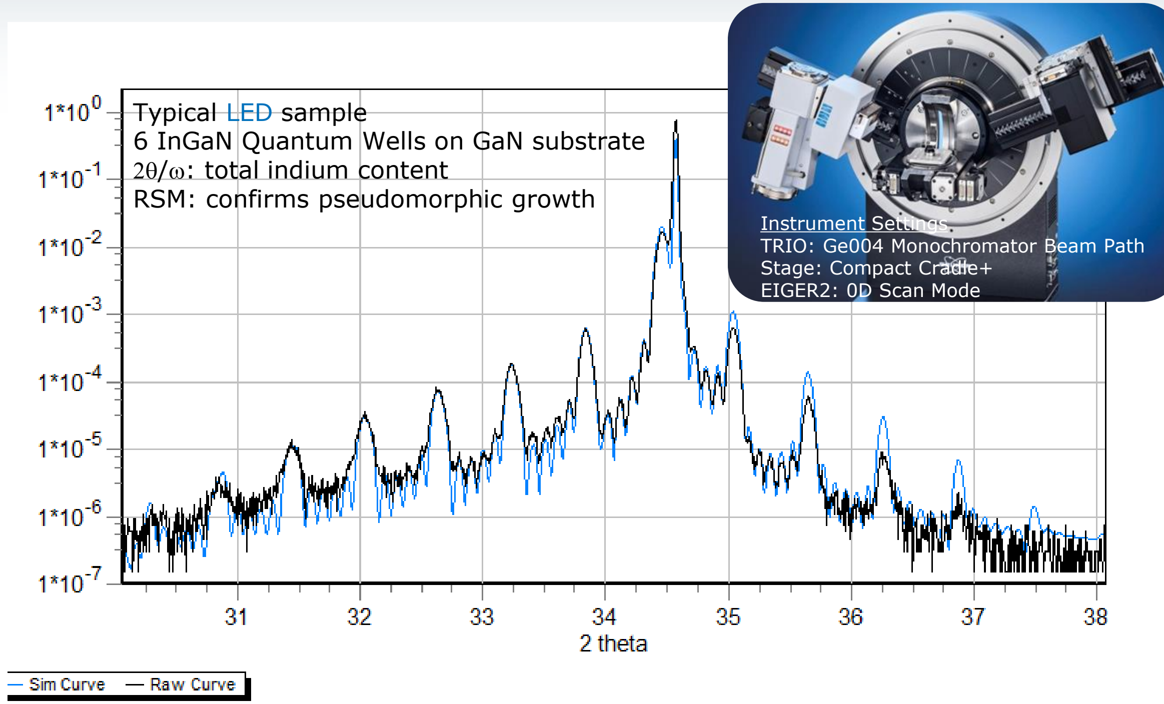
X-ray Reflectometry
GaN/AlN Superlattice on Si



- XRR revealed a gradually increasing density in the GaN layers, and a randomly fluctuating density in the AlN layers
- Roughness decreased from 0.4 nm at the substrate to 0.2-0.3 nm at the surface
- Layer thickness was relatively uniform: 1.2-1.3 nm for the GaN layers, and 6.8-6.9 nm for the AlN layers

High-Resolution X-ray Diffraction
Characterization of an LED multilayer structure

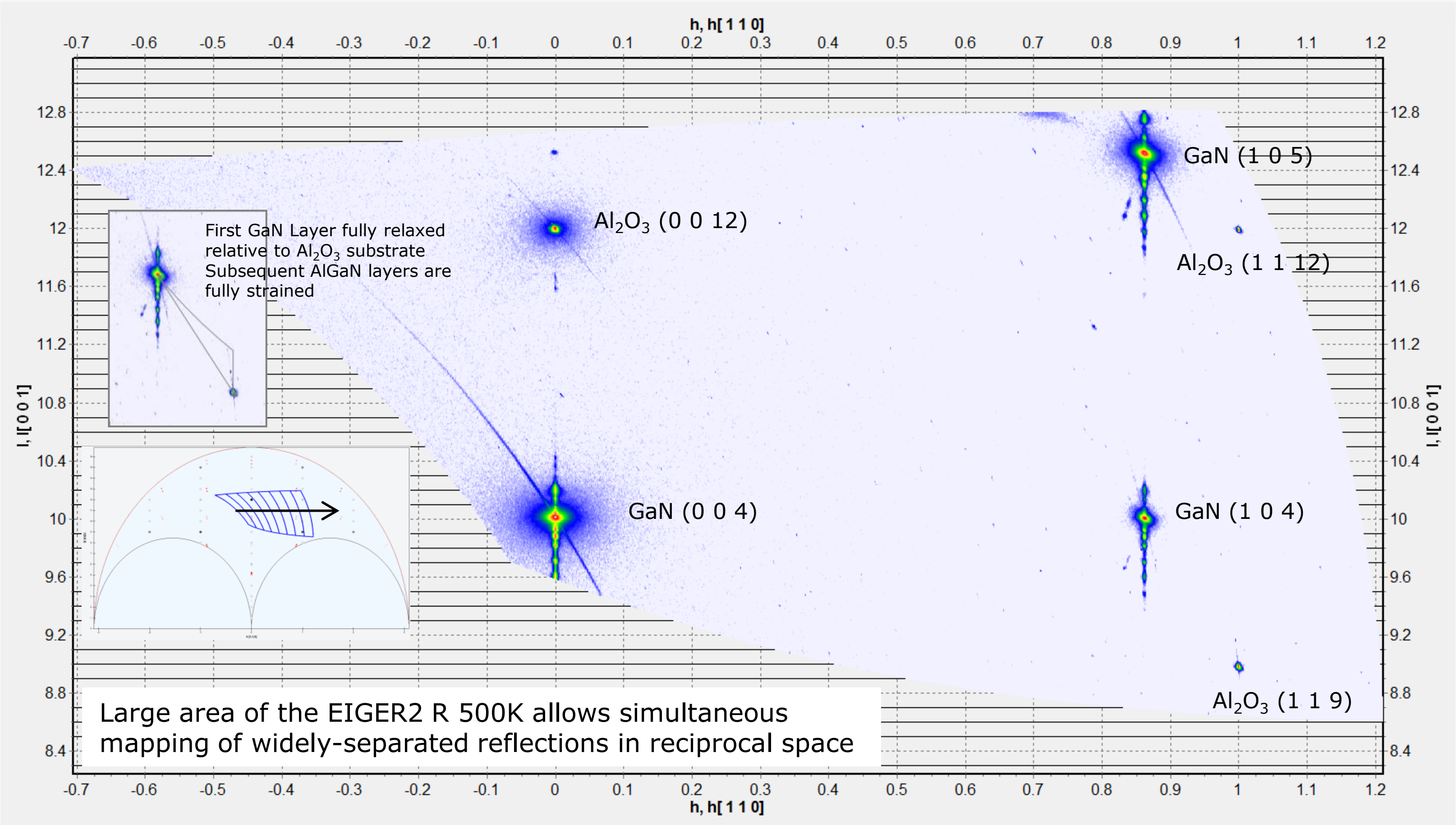




N	R	Material	Thickness (nm)	Conc In (%)	SL thick-ness (nm)
1	6	GaN	13.1425	0.0000	15.3383
2	6	Ga(1-x)In(x)N	2.1957	18.8660	
SUB	1	GaN	0.0000	0.0000	0.0000

Large-Area Reciprocal Space Mapping

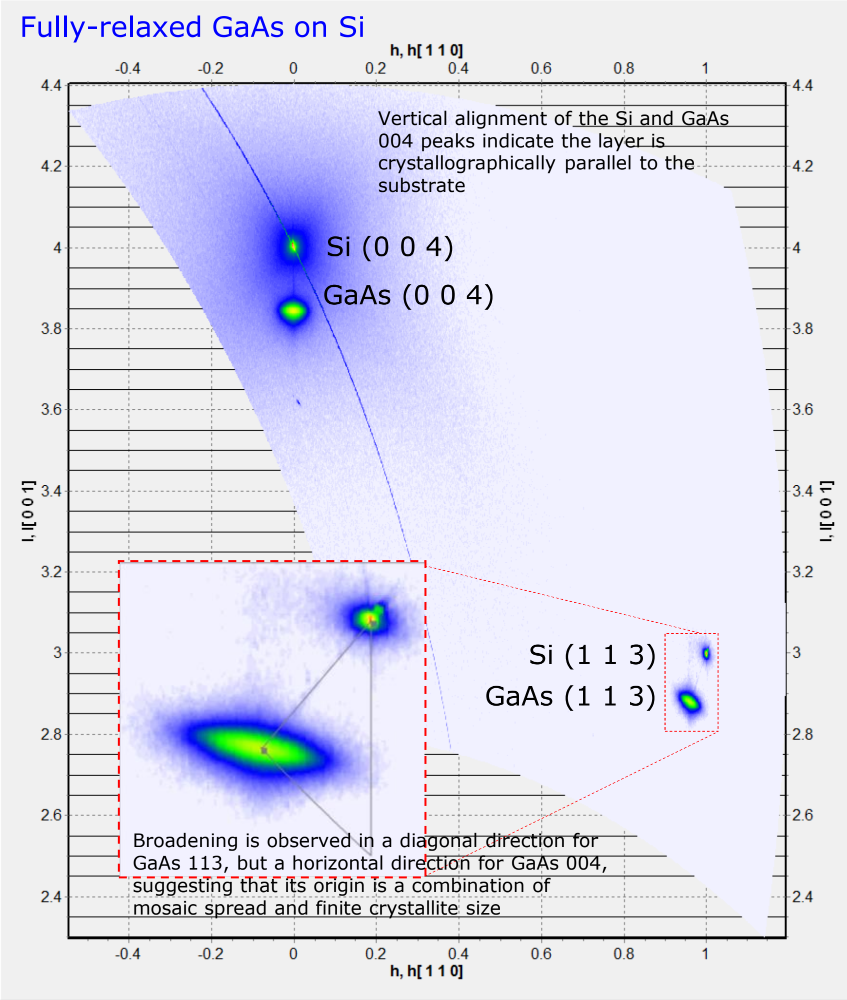
AlGaN LED on Sapphire

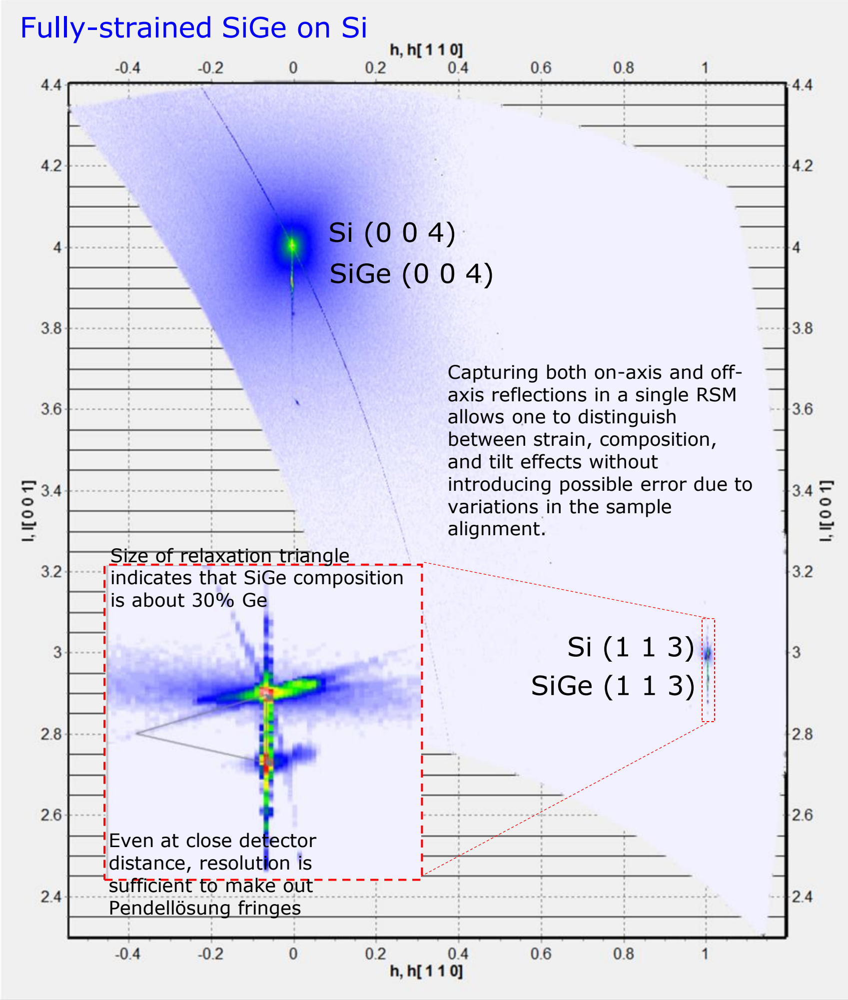


Instrument Settings
TRIO: Ge004 Monochromator Beam Path
Stage: Compact Cradle+
EIGER2: 1D Snapshot Mode

Large-Area Reciprocal Space Mapping

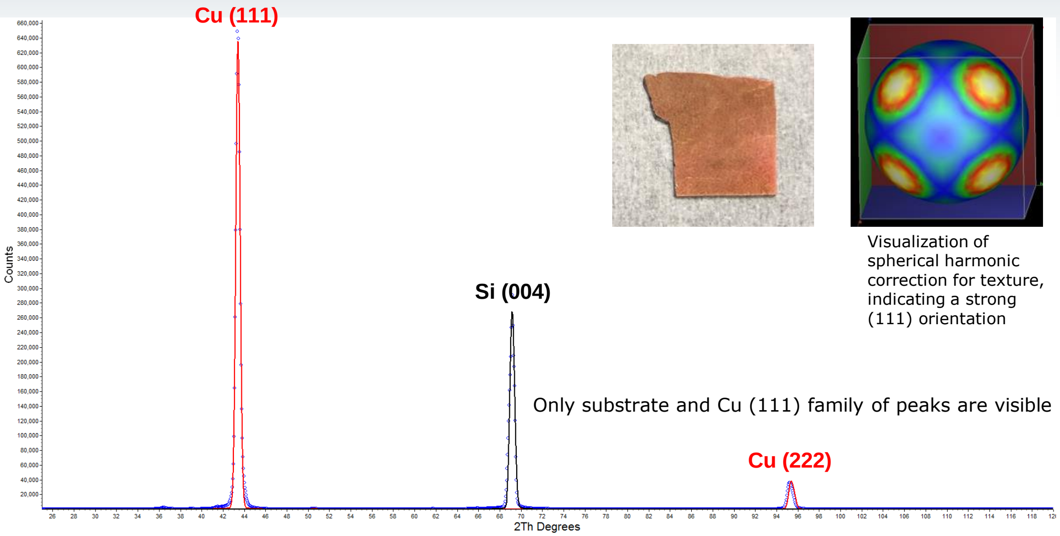
Single Layer Epitaxial Films



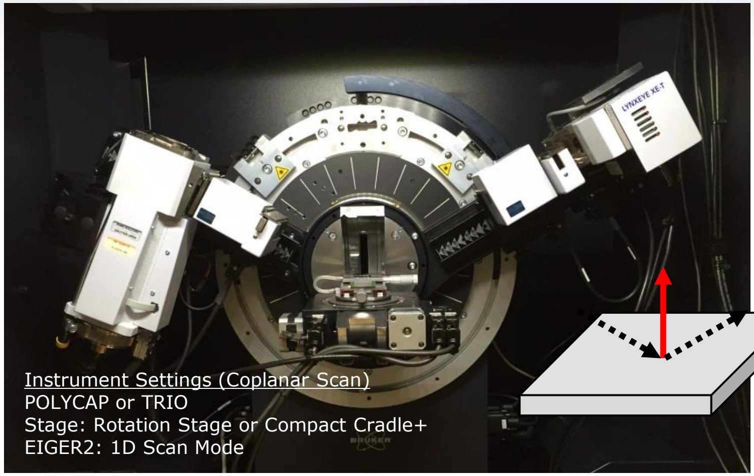


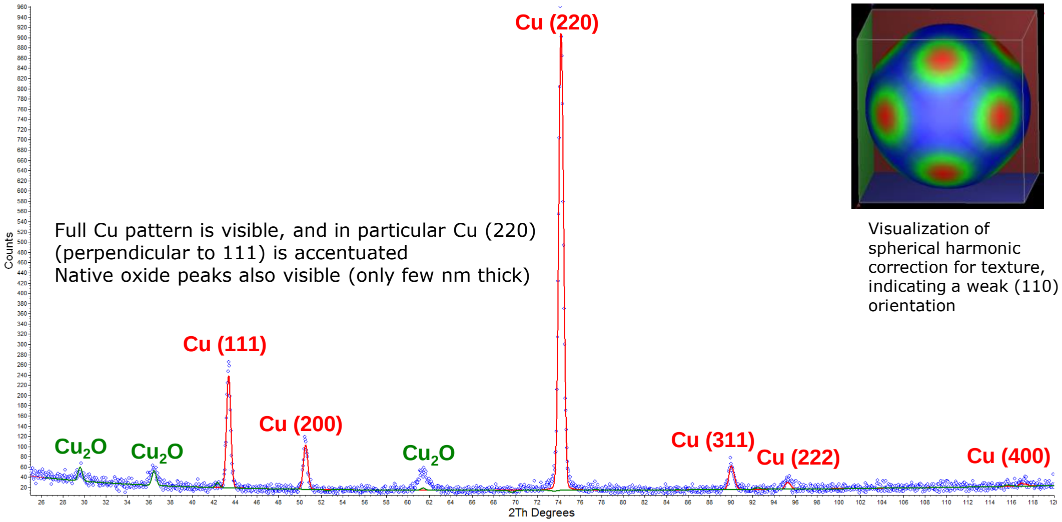
In-plane Grazing Incidence Diffraction

Fiber-Textured Cu Film on Si

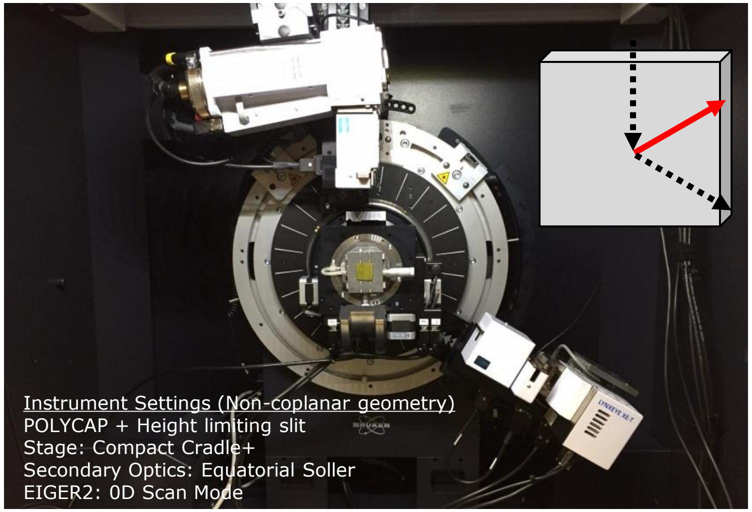


Visualization of spherical harmonic correction for texture, indicating a strong (111) orientation

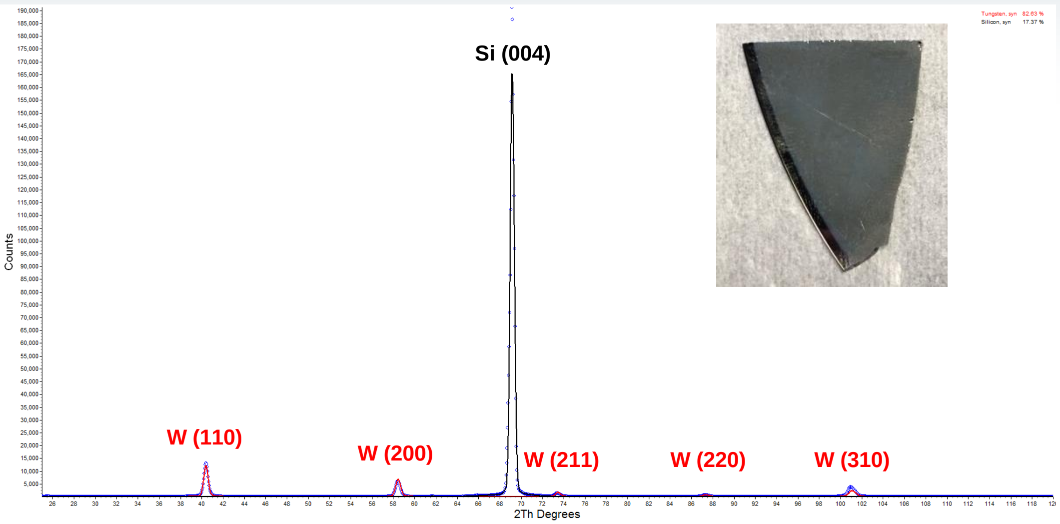


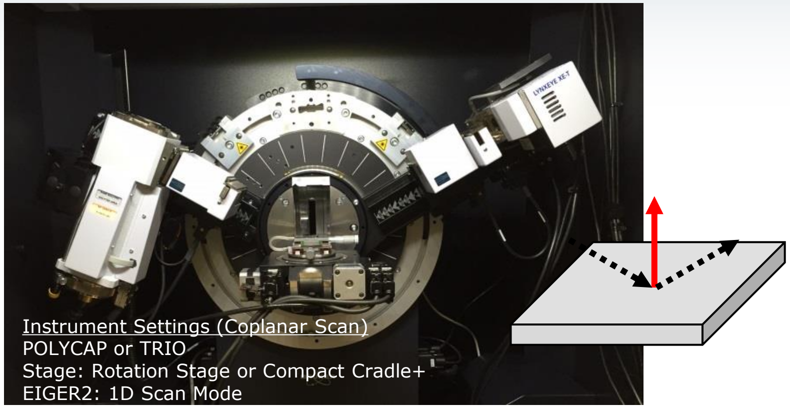


Visualization of spherical harmonic correction for texture, indicating a weak (110) orientation

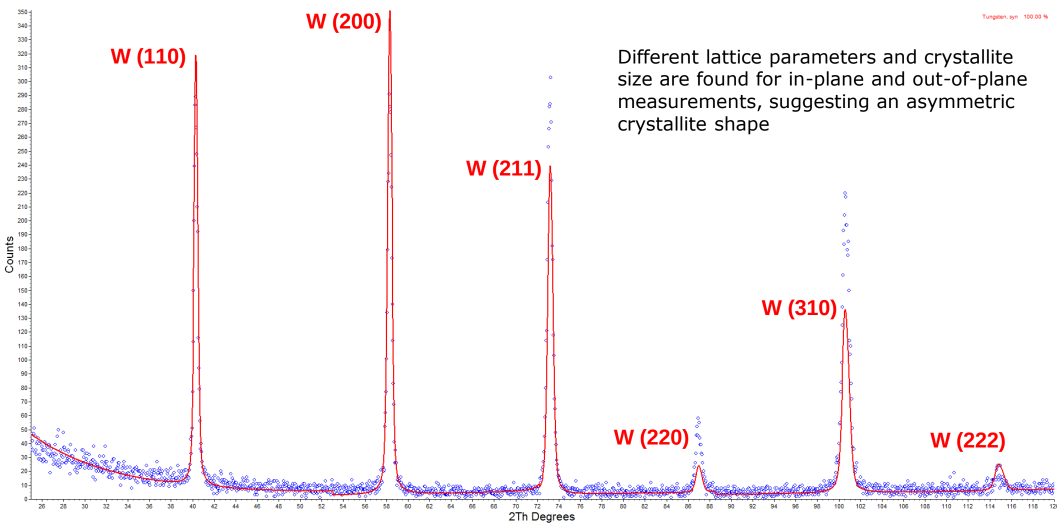


In-plane Grazing Incidence Diffraction
Polycrystalline W Film on Si

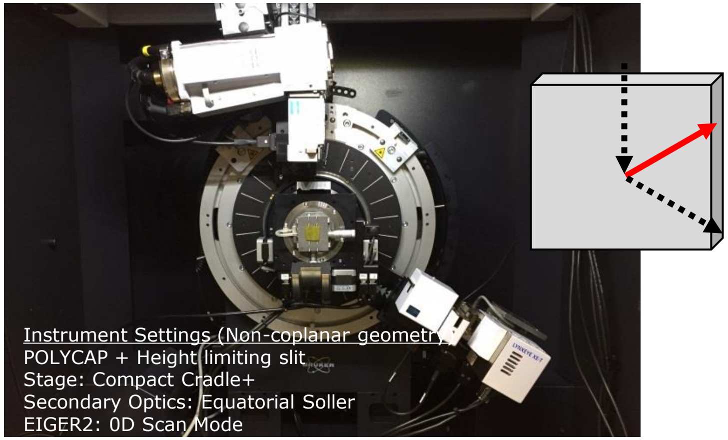




W Film	LP	Crys	Strain
Normal Scan	3.1565±0.0002	84.4±22.6	0.0008±0.0001

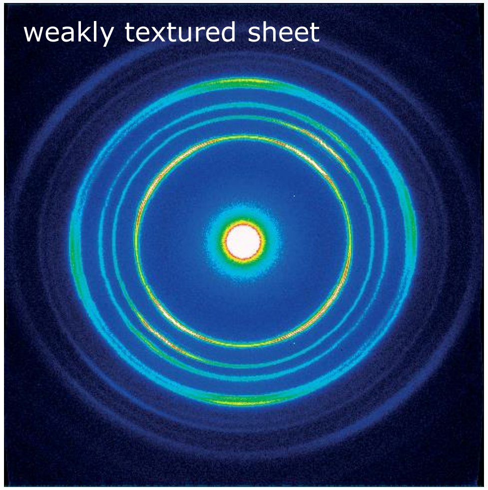


Different lattice parameters and crystallite size are found for in-plane and out-of-plane measurements, suggesting an asymmetric crystallite shape

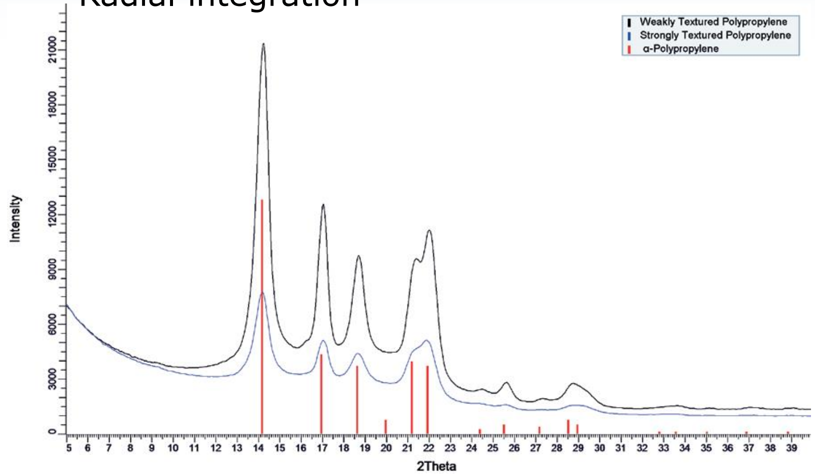


W Film	LP	Crys	Strain
IPGID Scan	3.1688±0.0003	53.1±16.8	0.0006±0.0002

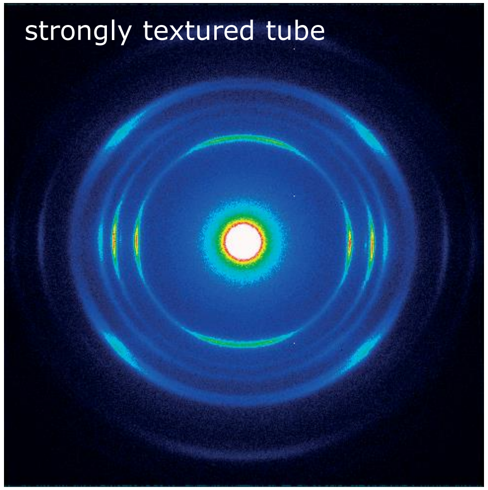
2D Transmission
Two Polypropylene Sheets



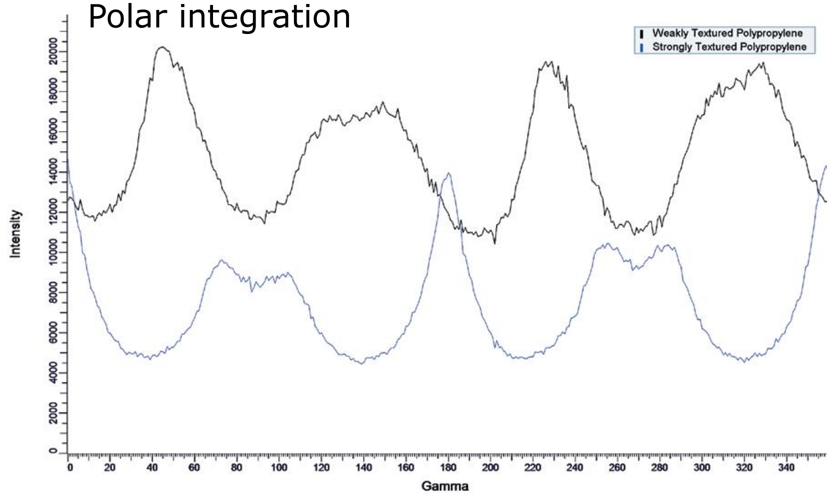
Radial integration



In addition to phase ID, radial integration contains information about microstrain and crystallite size



Polar integration

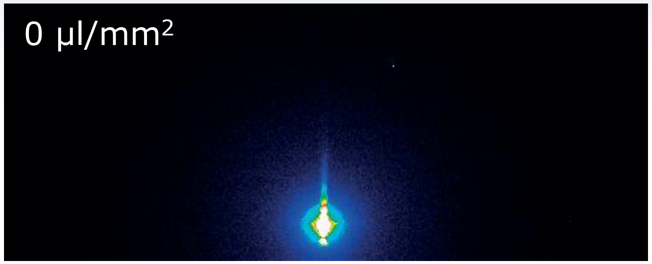


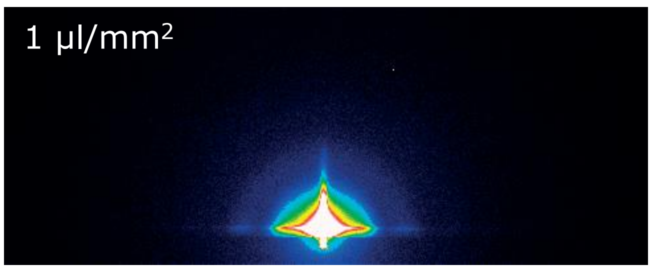
Polar integration gives information about the degree of orientation

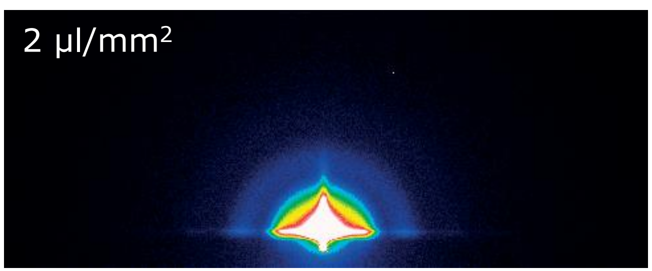
Instrument Settings
POLYCAP or TRIO Goebel Mirror + Collimator
Stage: Compact Cradle+
EIGER2: 2D Snapshot Mode

Grazing-Incidence Small-Angle X-ray Scattering

Ordering of Au Nanoparticles on a Surface

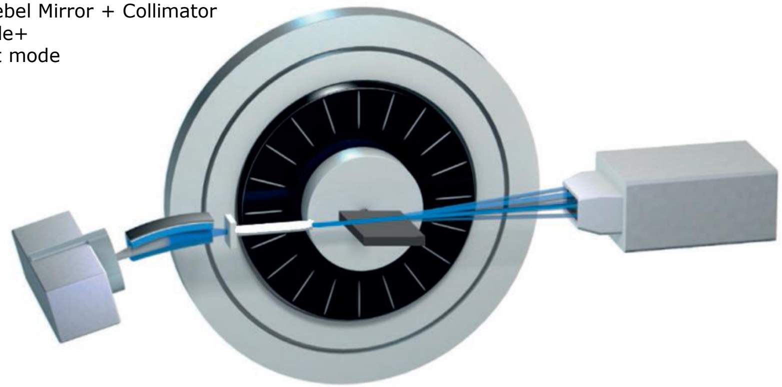


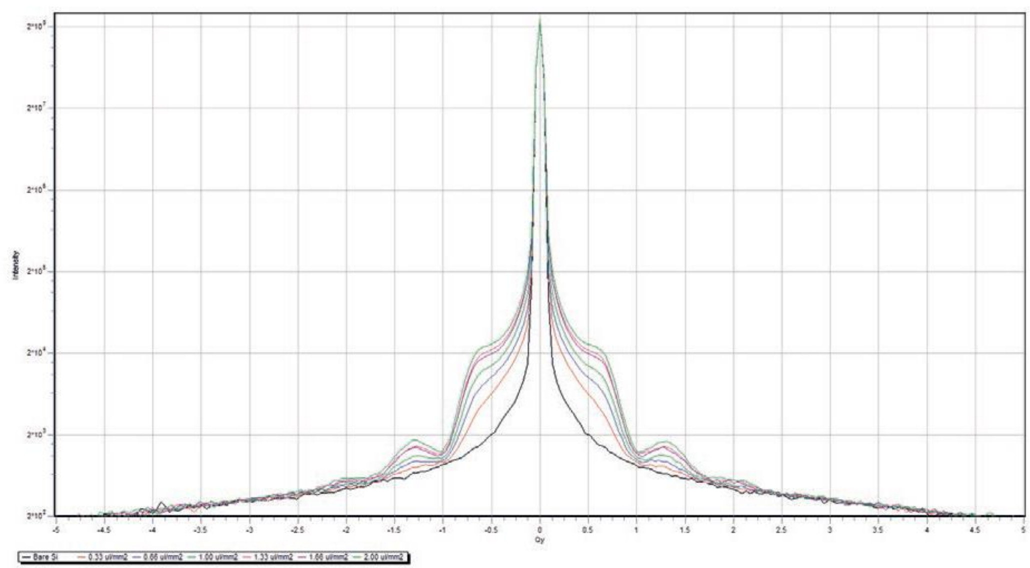




The isotropic scattering pattern indicates that the nanoparticles arrange in a 3D manner. As expected, higher order reflections become visible as the nanoparticle concentration is increased. First, second and third order reflections from the 10 nm Au nanoparticles are visible near the expected positions of Q = 0.62 nm^{-1}, Q = 1.26 nm^{-1} and Q = 1.89 nm^{-1} (Q=2nπ/d)

Instrument Settings
POLYCAP or TRIO Goebel Mirror + Collimator
Stage: Compact Cradle+
EIGER2: 2D Snapshot mode





D8 ADVANCE with TRIO and EIGER2 R 500K
Applications Summary

- Powder Diffraction in Bragg-Brentano or Parallel Beam
  - Phase ID
  - Quantification
  - Indexing
  - Rietveld Refinement
  - Structure Solution
  - Bragg 2D
  - Non-Ambient Diffraction
  - Microdiffraction
  - Transmission
- Residual Stress Analysis
  - 2D Method
  - Sin^2(Psi) Method
  - Multi-HKL method
- Texture Analysis
  - Pole Figures
  - Orientation Distribution Function
    - Component Fitting
    - Harmonic Fitting
  - Inverse Pole Figures
- High-resolution XRD
  - Rocking Curves
  - On-Axis Coupled Scans
  - Reciprocal Space Mapping
- Grazing Incidence Diffraction
  - Phase ID
  - Depth Profiling
  - GI-SAXS
- In-Plane Grazing Incidence Diffraction
  - 2D Materials and ultra-thin films
  - Surface oxides
  - In-plane lattice parameters and crystallite size
  - Epitaxial films relationship to substrate
- X-ray Reflectometry
  - Thickness, density, roughness of single and multi-layered films
  - Crystalline, amorphous, or liquid layers

BRUKER

Innovation with Integrity