



X-RAY METROLOGY FOR COMPOUND SEMICONDUCTORS

QCVelox-HR

Fully Automated HRXRD and XRR for
High-Throughput, High-Precision Metrology

QCVelox-HR



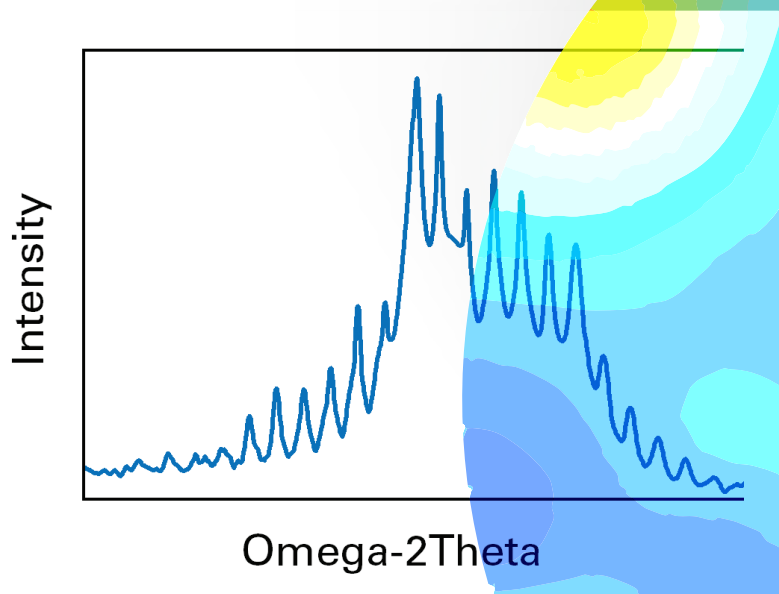
QCVelox-HR

High Resolution X-ray Diffractometer

QCVelox-HR is the highest productivity high-resolution X-ray diffraction (HRXRD) and X-ray reflectivity (XRR) metrology system for compound semiconductor manufacturing. The tool features full automation and factory integration software for high-throughput, precise production line measurement of complex epilayer structures. Once metrology data is collected, the powerful analysis software accurately and reliably gives epilayer process parameters, providing automatic data reporting and immediate feedback to control and monitor production lines. QCVelox-HR ensures precise epilayer thickness and composition control for high-performance compound semiconductor devices.

Only QCVelox-HR delivers:

- Industry-leading high-throughput X-ray metrology for compound semiconductor manufacturing
- Enhanced device performance and yield through fully automated epilayer quality control
- Reliable measurements and results reporting with a suite of powerful and dependable software



Industry-Leading High Throughput

X-Ray Metrology for Compound Semi Manufacturing

QCVelox-HR is a next-generation, high-throughput X-ray metrology system designed to deliver significantly higher throughput and high-precision measurements at a substantially lower cost per wafer. Bruker has incorporated numerous unique design features in this latest generation of equipment to achieve the fastest possible measurements with high precision. This innovation is backed by Bruker's extensive experience and expertise in providing cutting-edge, reliable equipment to the semiconductor industry.

Superior HRXRD and XRR Performance

QCVelox-HR utilizes HRXRD to provide extensive information on single-crystal substrates and epitaxial materials, including crystal quality, epilayer quality, composition, and thickness. This technique provides precise measurements of strain and crystal quality, which are crucial for optimizing the manufacturing process.

QCVelox-HR's XRR capability measures thickness, density, and surface roughness of thin film layers. A thorough understanding of these parameters is crucial for process control.

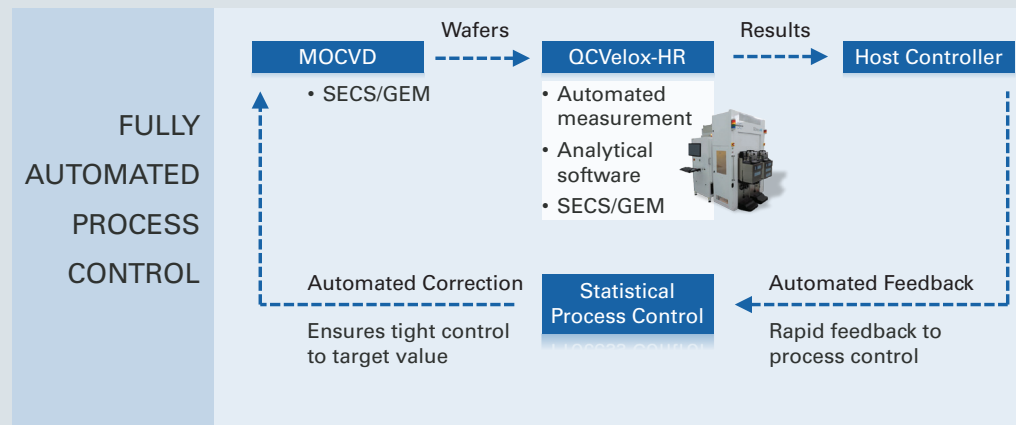
Seamless Automation

The system offers fully automated operation, including sample loading, alignment, measurement, analysis, and reporting. This fully automated process reduces the risk of human error and ensures consistent, repeatable results.

The system includes automated data analysis capabilities through RADS and REFS software, which streamline the process of interpreting measurement results. This advanced analysis along with automatic reporting enables faster decision-making and process optimization.



QCVelox-HR is equipped with robotic handlers and can be integrated with factory host systems, such as SECS/GEM. This integration enhances productivity and efficiency in a high-volume manufacturing environment.



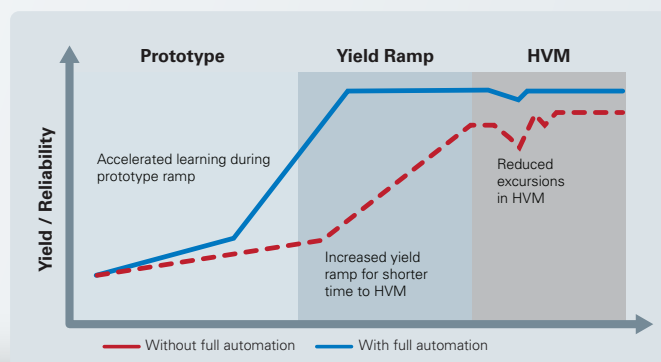
By providing rapid feedback on epilayer quality, QCVelox-HR allows for immediate adjustments to the manufacturing process, maintaining high quality standards and improving overall yield.

Enhanced Device Performance and Yield

Fully Automated Epilayer Quality Control

QCVelox-HR optimizes device performance and yield by providing fully automated advanced epilayer quality control throughout the product lifecycle, from R&D and process ramp to full production.

High throughput and precision enable higher sampling rates per wafer, allowing manufacturers to fully characterize critical structural parameters. This identifies process issues early, improving product quality and reducing waste. The system provides detailed information on properties, including composition, thickness, and uniformity of epitaxial layers and films, ensuring they meet specifications necessary for high-performance devices.



QCVelox-HR's fully automated, high-precision epilayer quality control enables manufacturers to:

- Shorten the R&D cycle
- Develop high-performance devices
- Reduce time to market
- Accelerate production ramp
- Fully optimize yield through control of key parameters
- Improve quality and reliability during mass production

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Automated X-ray Metrology Supplier

with thousands of semiconductor metrology tools installed worldwide

Reliable Measurements and Results

Industry-Leading Suite of Robust, Powerful, and Dependable Software

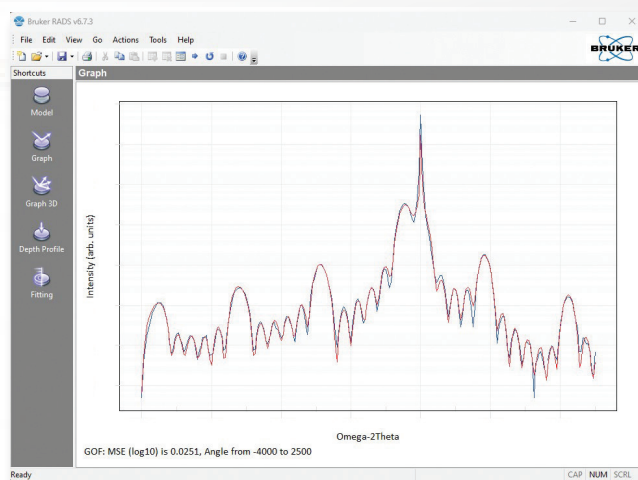
Leveraging extensive inline experience in fully automated fabs, Bruker has developed industry-leading software for automated analysis and reporting. Essential features are integrated, including batch fitting functionality for offline data analysis, automated wafer reports with pass/fail criteria, and optional reporting via SECS/GEM.

QCVelox-HR offers the following suite of Bruker software:

- RADS for analysis and reporting of composition, thickness, relaxation
- REFS for analysis and reporting of thickness, density, roughness
- PeakFitting for FWHM and multi-peak fitting for reporting of barrier composition in complex structures
- PeakSplit for automated 2D fitting of reciprocal space maps and offline relaxation and tilt analysis
- QuickGraph for offline data display and basic analysis

Rapid and Accurate HRXRD Measurement Analysis

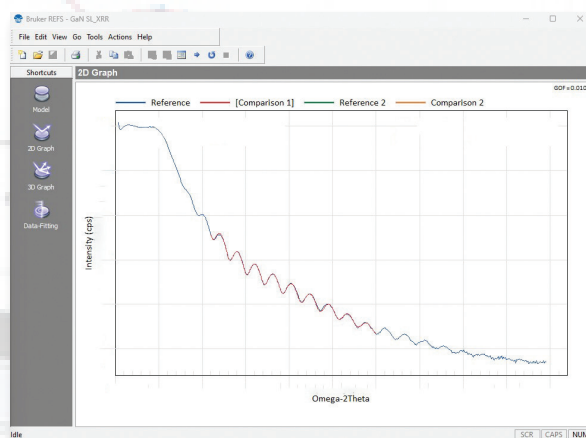
RADS simulation software features a patented genetic algorithm for automated analysis, ensuring high accuracy, repeatability, and speed. It offers auto-fit capabilities for individual barrier/well layers, mosaicity, and both symmetric and asymmetric planes. The software allows for easy creation of analytical models through an intuitive graphical interface, making model entry straightforward and efficient. RADS can be used automatically from the control software, enhancing its efficiency and ease of use.



RADS software user interface during analysis.

Detailed XRR Spectral Analysis

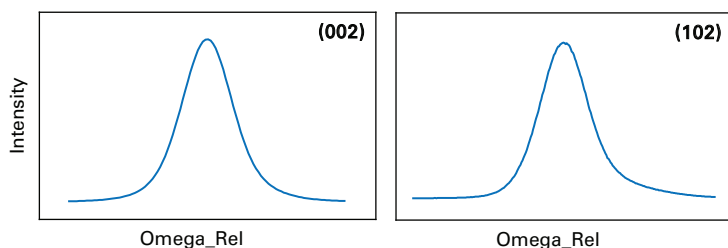
REFS simulation software can analyze single- and multiple-layer structures for thickness, roughness, and density. It features a patented genetic algorithm for determining optimal solutions and allows for model entry using an intuitive graphical interface. As with RADS, REFS can be used automatically from the control software.



REFS software user interface during analysis.

Comprehensive X-ray Metrology for Compound Semi

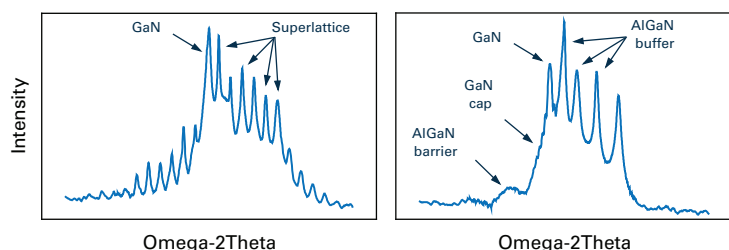
QCVelox-HR acquires the full set of measurements needed to accurately determine key epitaxial growth parameters for effective process control, yield, and performance enhancement. Full wafer mapping is available for all techniques within a single recipe.



Rocking curves to monitor twist and tilt of GaN layer.

Rocking Curves for Twist and Tilt

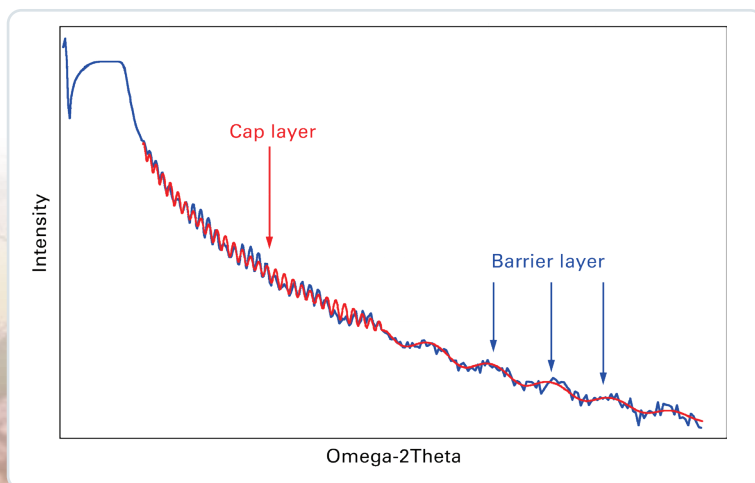
The full width at half maximum (FWHM) of the symmetric GaN (002) rocking curve and the skew symmetric GaN (102) rocking curve are used together to measure the twist and tilt mosaic of the GaN channel.



HRXRD to measure composition and thickness of buffer layers, barrier layer, and cap layer.

Omega-2Theta Scans for Composition and Thickness

Omega-2Theta scans in triple axis mode are used to determine AlGaIn buffer layer compositions, GaN cap thickness, and AlGaIn barrier layer thickness for step-graded buffer structures. For superlattice structures, this method is used to determine the period and composition of repeated bilayers.



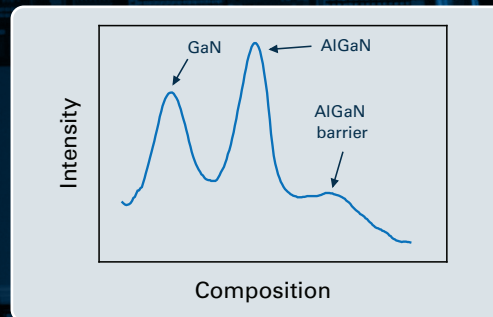
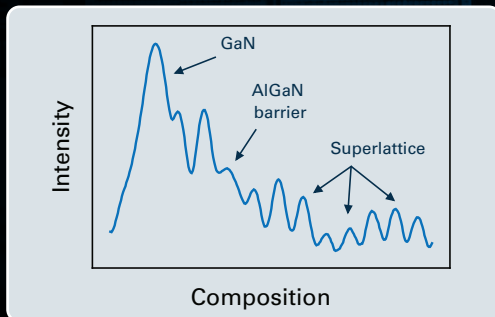
XRR to measure thickness of barrier and cap layers.

X-ray Reflectometry of Barrier and Cap Layers

XRR precisely measures the thickness, density, and surface roughness of the AlGaIn barrier and GaN cap layers, providing critical data for evaluating the film's quality. Bruker's multi-stage REFS modeling method provides precise characterization of these layers.

Accelerating Next-Gen GaN Power Device Manufacturing

Composition and relaxation of the AlGaIn barrier layer are crucial for strain engineering in GaN power devices, playing a key role in optimizing device performance and reliability. Accurate control of these parameters ensures the best possible functionality. However, peaks from the AlGaIn buffer layer can obscure the signal from their barrier layer, making precise measurements challenging. Bruker has developed innovative techniques to overcome this interference, ensuring accurate and reliable characterization of the barrier layer for step-graded buffer and superlattice structures.



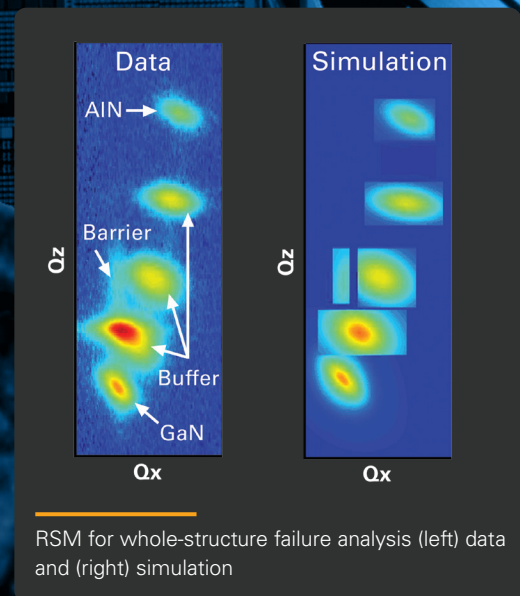
Composition scan of step-graded buffer (left) and superlattice structure (right).

Qz Scan for Composition of Barrier Layer

Bruker's composition scan addresses the challenge of buffer peaks masking the barrier layer peak by performing a direct line scan across the GaN layer in the L direction of reciprocal space. This method allows for accurate measurement of the AlGaIn barrier layer with minimal buffer layer interference and can be easily integrated into a recipe.

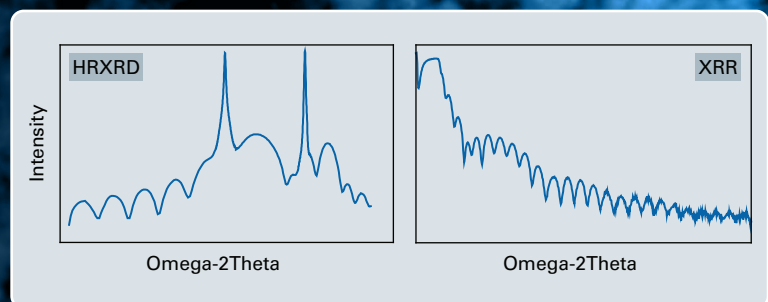
RSM for Whole Structure Analysis

Determining the composition and relaxation of barrier and buffer layers in semiconductor devices is complex but crucial for failure analysis and device reliability. Bruker's asymmetric RSM solution addresses this with precise measurements, fast data collection via a high-intensity 1D detector, and automated analysis using PeakSplit software.



Combining HRXRD and XRR for Comprehensive Analysis

QCVelox-HR accurately measures the epitaxial layers and automatically reports the parameters, providing fast feedback to production. HRXRD measures the crystal quality, strain, relaxation, and thickness of the epilayers, while XRR determines the thickness, density, and surface roughness of the epitaxial layers.



(left) HRXRD and (right) XRR of GaN on SiC.

QCVelox-HR Specifications

X-ray Beam	X-ray tube / generator	2.2 kW Cu LFF sealed tube
	Ge(004) resolution	<10" FWHM Si(004) rocking curve, Cu K α_1
	Ge(220) resolution	<30" FWHM Si(004) rocking curve, Cu K α_1
	Ge(111) resolution	<50" FWHM Si(004) rocking curve, Cu K α_1
Goniometer Stage	Omega range, resolution	<0° to >93°, <0.1"
	2Theta range, resolution	<0° to >150°, <0.1"
Sample Stage	X/Y range, resolution	>300 mm on both, <0.001 mm
	Z range, resolution	>10 mm, <0.0010 mm
	Phi range, resolution	Unlimited, <0.003°
	Chi range, resolution	-45° to 5°, 0.001°
Detector	Detector type	1D as standard
	Triple axis crystal	As standard
Automation and Facilities	Wafer handling	Wafer robot with open cassette up to 200 mm; EFEM 200 mm–300 mm FOUP, 150 mm–200 mm SMIF
	SECS/GEM	Yes
	Cleanliness specification	ISO Class 3
	Standards compliance	SEMI S2, S8, S14, S22, S23, F47
	Footprint (with EFEM)	1.35 m x 2.6 m

Service and Support

Bruker's combination of global service infrastructure, local applications expertise, and proactive support aims to maximize customer uptime and success over the tool's lifespan. Before install, applications engineers conduct demonstrations and feasibility studies. At the install, there is a dedicated field service engineering team on-site to oversee installation and testing. Once the tool is installed, operator and maintenance training covers recipe creation, automation, data analyses, and tool maintenance SOPs. Regular software and firmware updates ensure access to the latest performance enhancements. Remote support is offered, and annual planned maintenance visits are conducted by field service engineers. Onsite process development and optimization support is also available.

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