UV-vis reflectance mapping of nitride-based device structures

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LAYTEC
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Outline

Mapping within LayTec's metrology portfolio
Complementary products

Brief EpiX product intro
Have you visited our booth? It's there in 3D.

UV News from EpiX Labs
UV reflectance mapping

Thickness news from EpiX Labs
Wafer thickness measurements of SiC substates

Bow news from EpiX Labs
Flat and bowed wafers

Data news from EpiX Labs
EpiNet meets EpiX

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LayTec metrology within manufacturing chain, e.g. LED

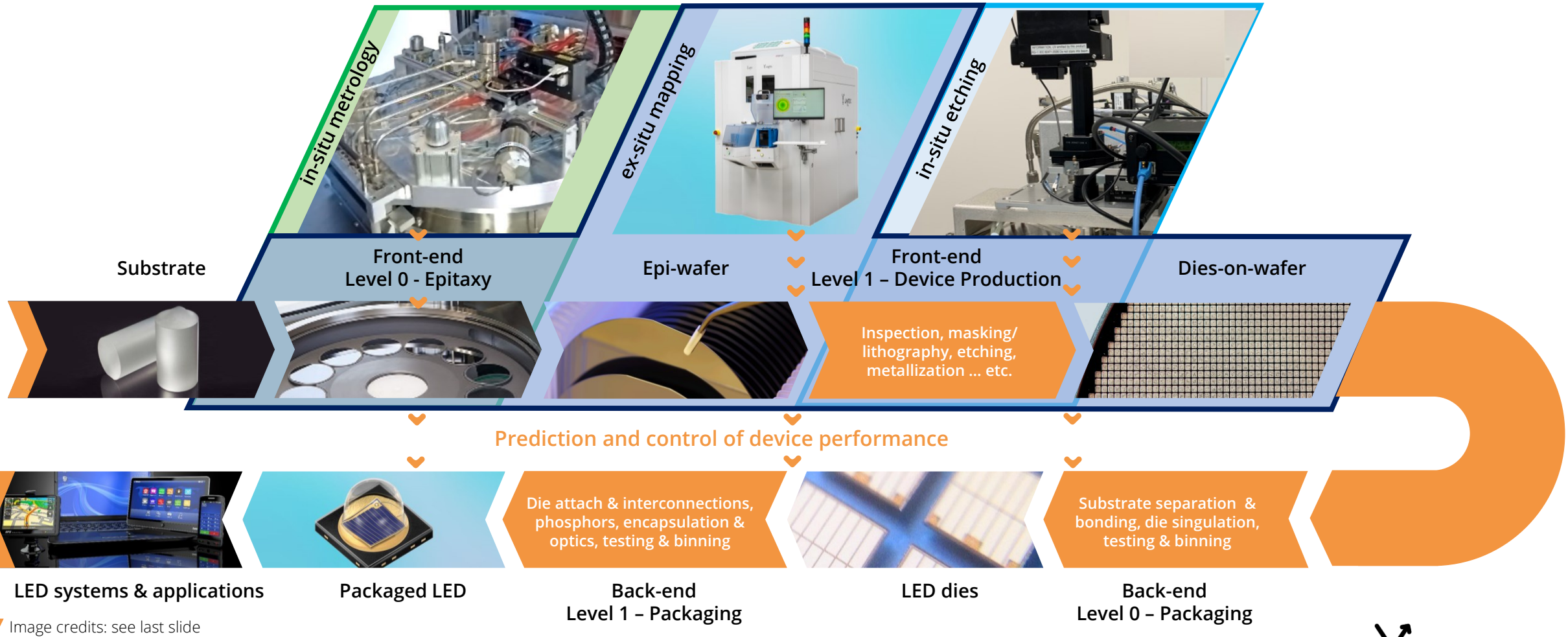

Image credits: see last slide

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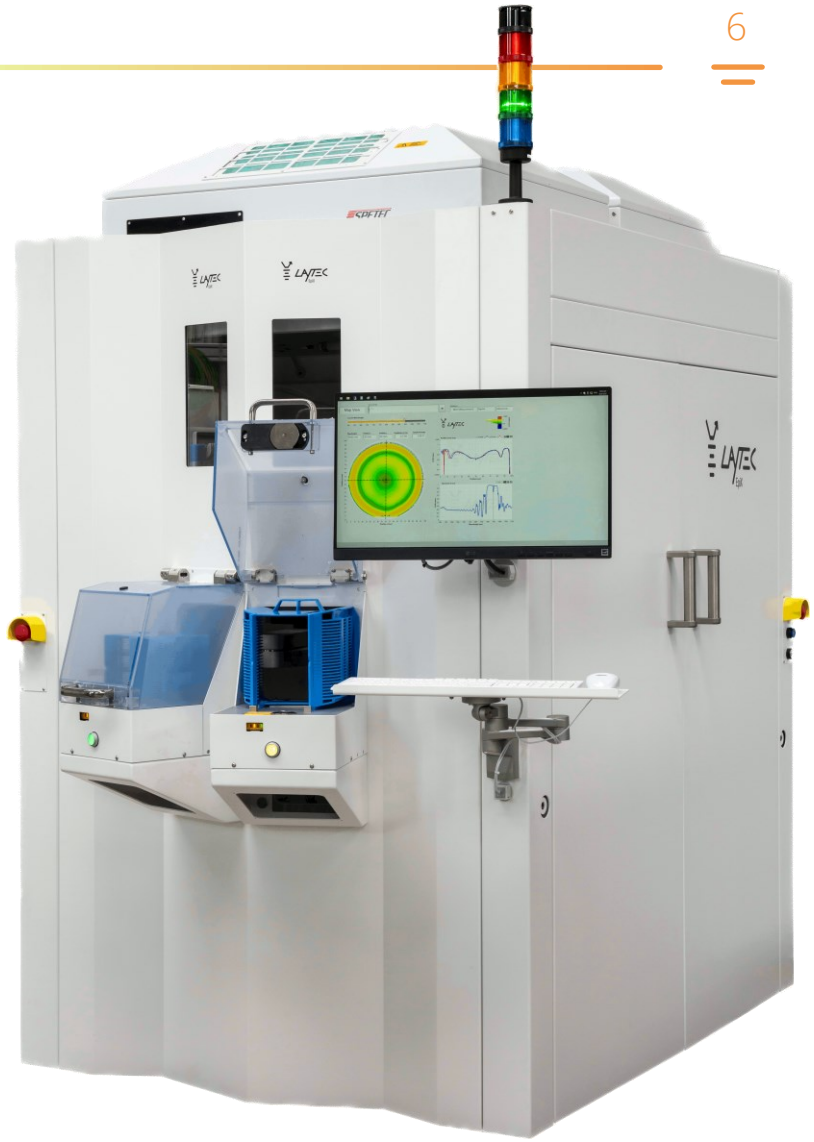
EpiX C2C – come visit the 3D version at booth 19

- White light reflectance and photoluminescence wafer mapping up to 200 mm
- 4-grating 300mm spectrograph with spectral resolution down to 0.1 nm
- spectral range 500 (250) – 2000 nm
- Cassette to cassette (C2C) extension to achieve high throughput required in industrial applications
- Industry-compatible clean room design with enclosed cassette ports and fan-filter-units
- post-process quality control of entire wafer area
- Smaller, manual edition also available



EpiX – measurement head & mapping stage

Measurement head containing optics for PL laser and white light

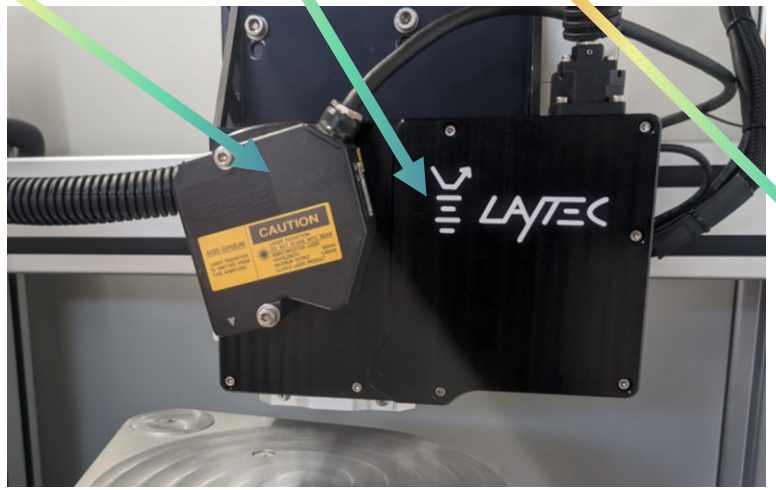
White light reflectance controller

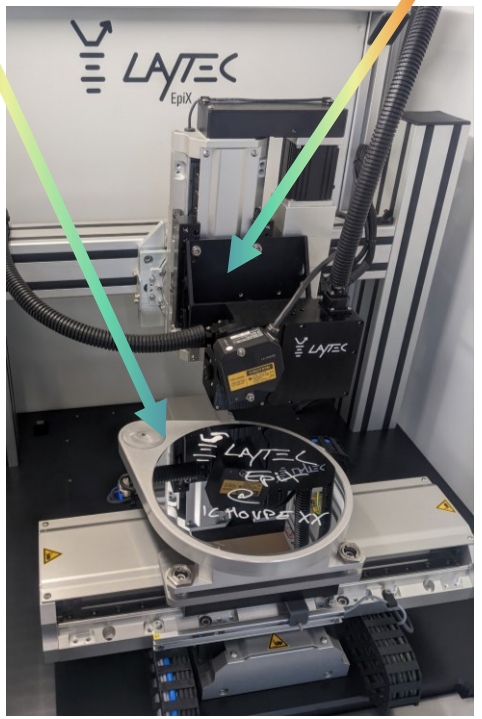
xy-wafer stage

z-adjustment unit for measurement head

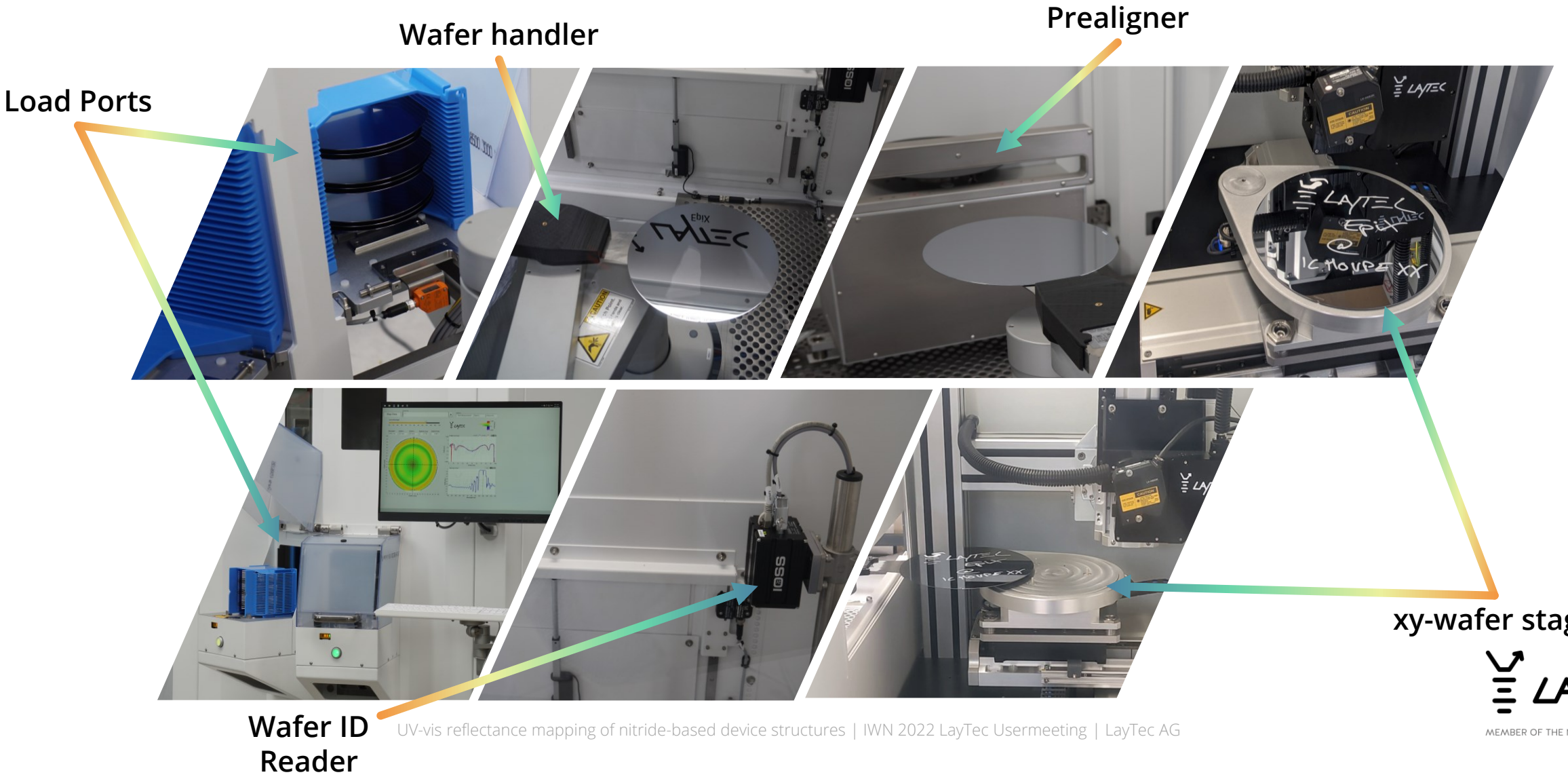
Sensor head for z-adjustment

PL laser controller with up to 4 wavelengths





Automated wafer loading

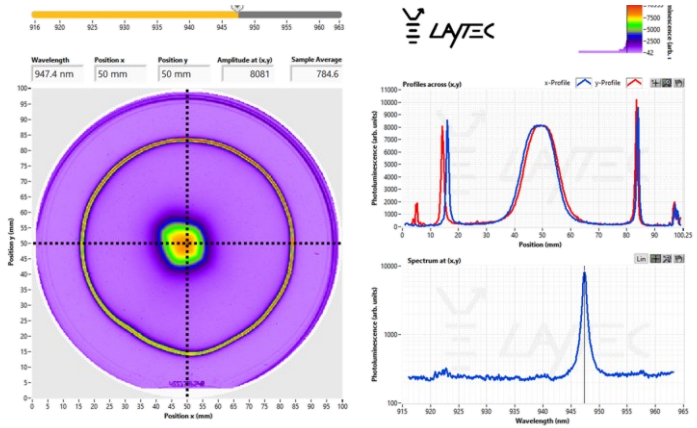


EpiX spectral analyses

- Starting point: auto-normalized data
- Spectral analysis manually triggered or in predefined recipes
- Output results, yield analysis, report generation

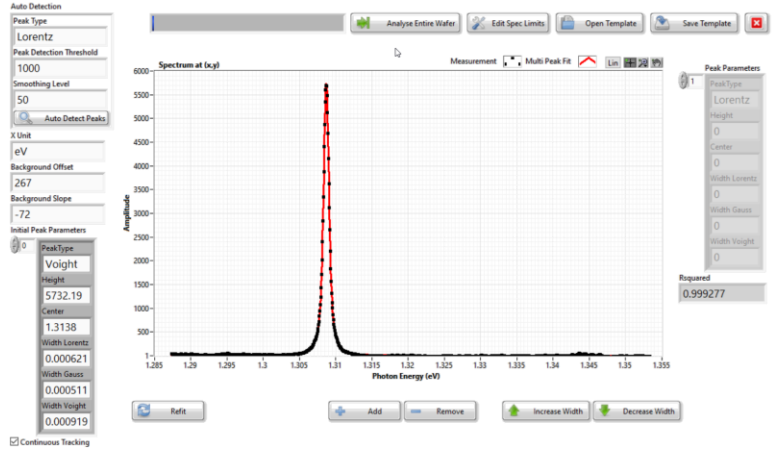
Normalized measurement data view

PL map



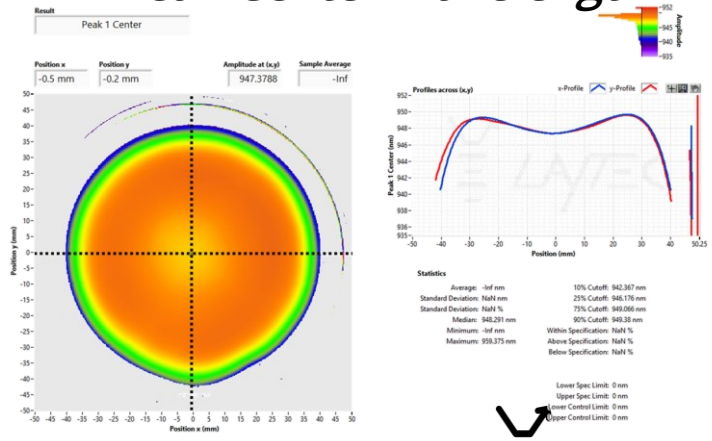
Spectral analysis

Peak fit



Result data view

Peak Center Wavelength



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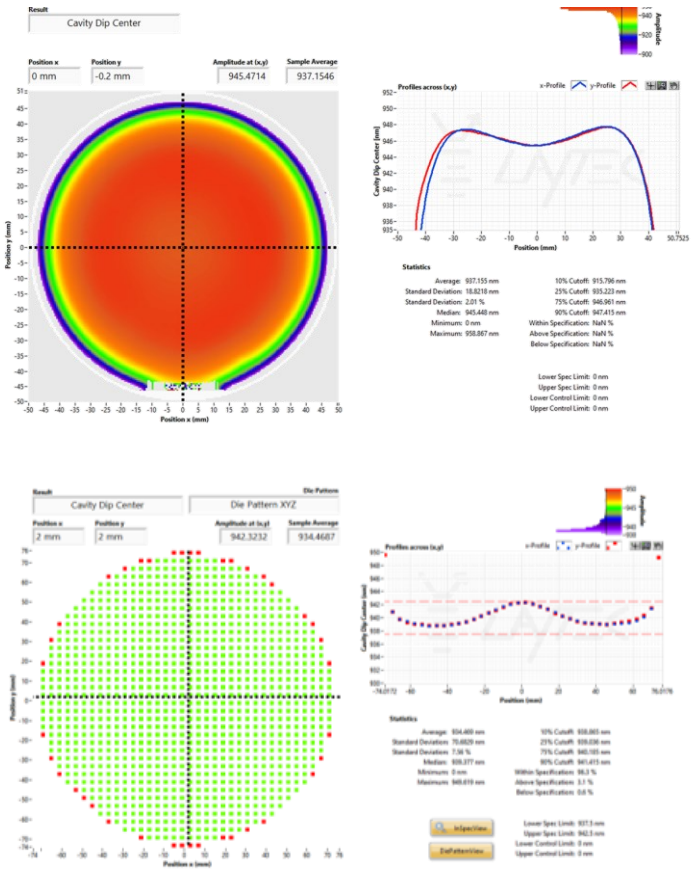
Analysis Features



Parameter	Value
Software modifiers	- Edge exclusion - Virtual rotation - Virtual die patterns
Predefined and customized algorithms	- VCSEL Analysis - Single film thickness - Analytic multi peak fit - Numeric multi peak analysis - Wafer thickness - Composition measurement - Integrated signal - Extrema tracking
Virtual die patterns	- Die pattern assignment - Import of customer die layout
Automated yield analysis & 2D pass / fail classification at	- Wafer level - Die level
Reports	- XML reports, PDF reports - ASCII exports

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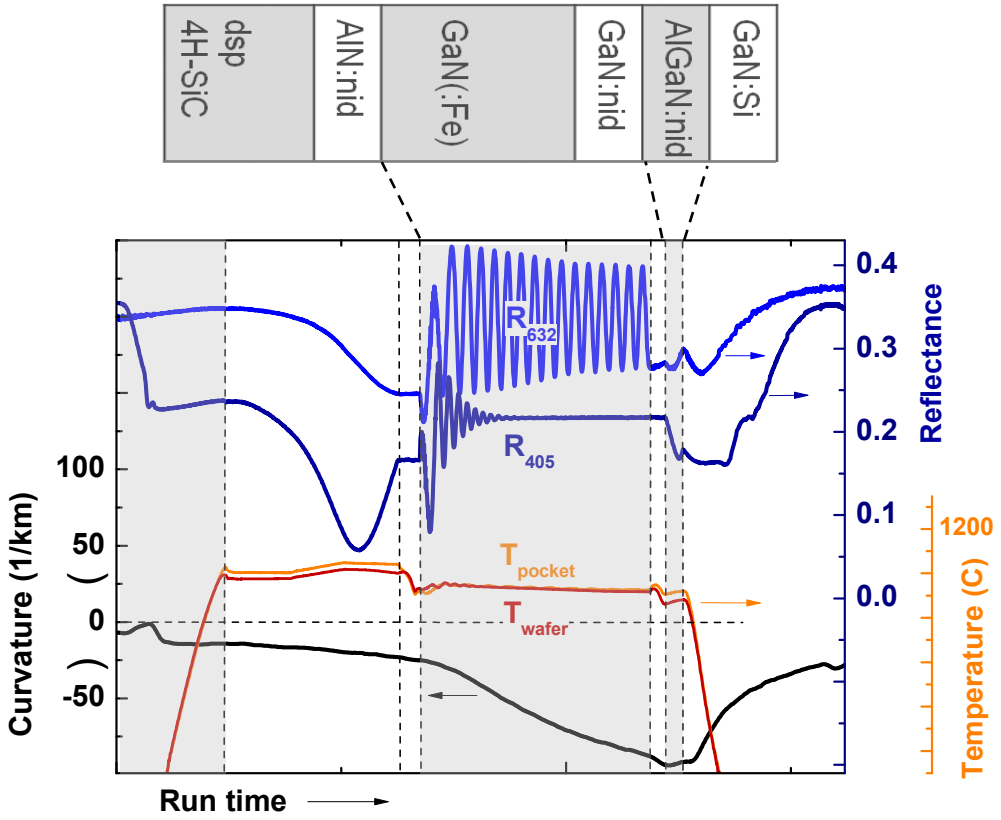
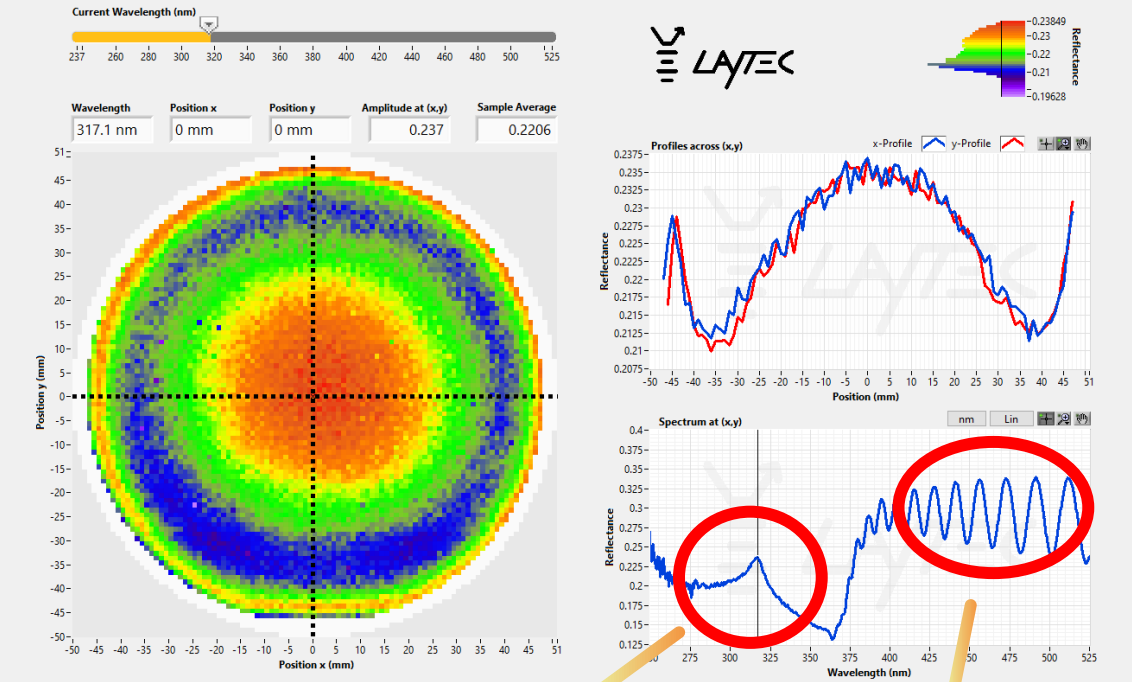
HFET on SiC: Full-stack analysis of in-situ data – work in progress



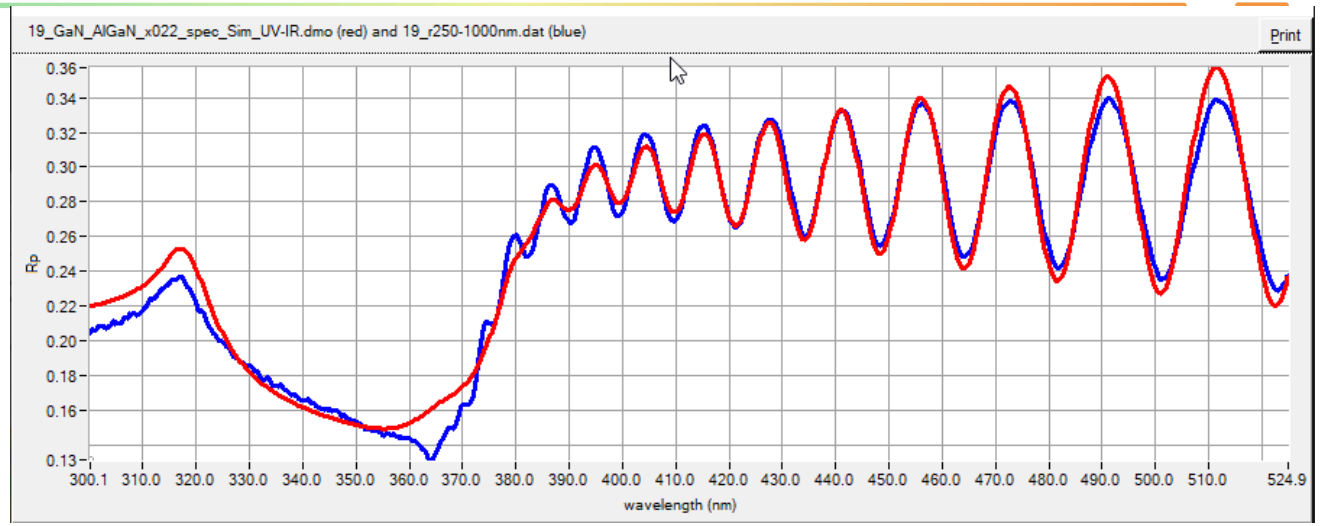
- Currently new analysis functions for AlN, GaN-3D/2D und i-GaN/etch in development to enable full stack analysis

Layer	sub-layer	WZ1_center
AlGaN barrier		22.2
i-GaN	i-GaN etch	-8 → 841nm
	i-GaN	849
Fe-GaN	Fe-GaN	904.8
GaN (3D-->2D)	GaN 3D + smoothing	396
AlN		35.8
	AlN HT	50.1 → 85.9nm
	AlN LT+LT_to_HT	
SiC-4H		
	total thickness (nm)	**2257.8**

HFET on SiC: Analysis of ex-situ data



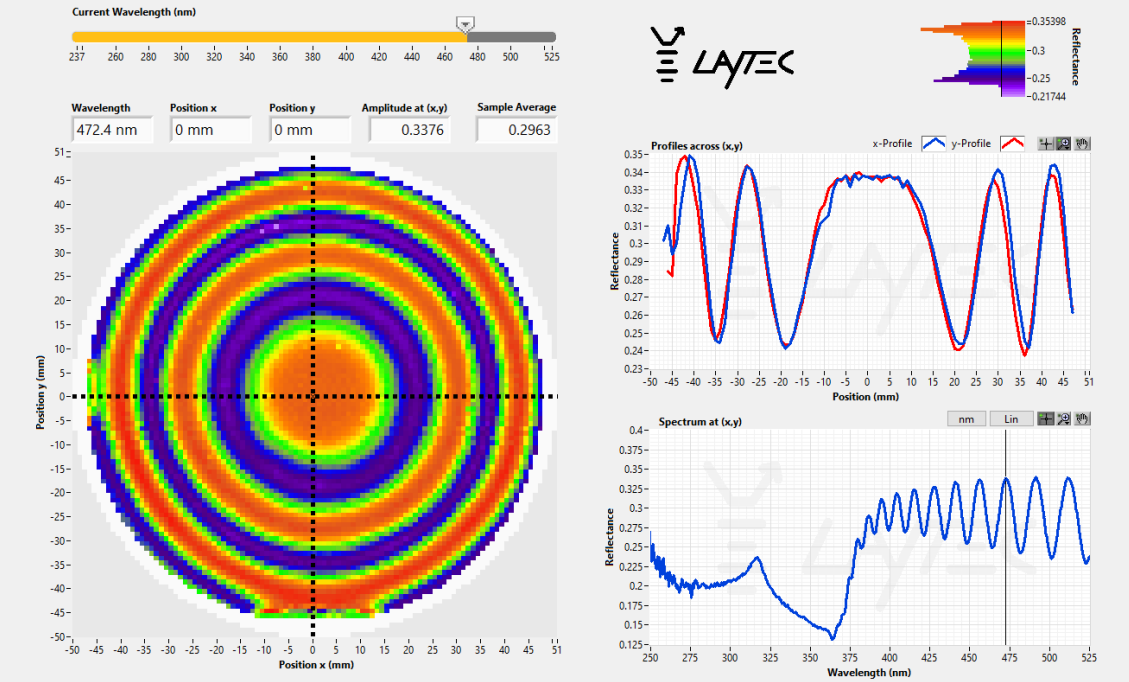
Normalized measurement data view



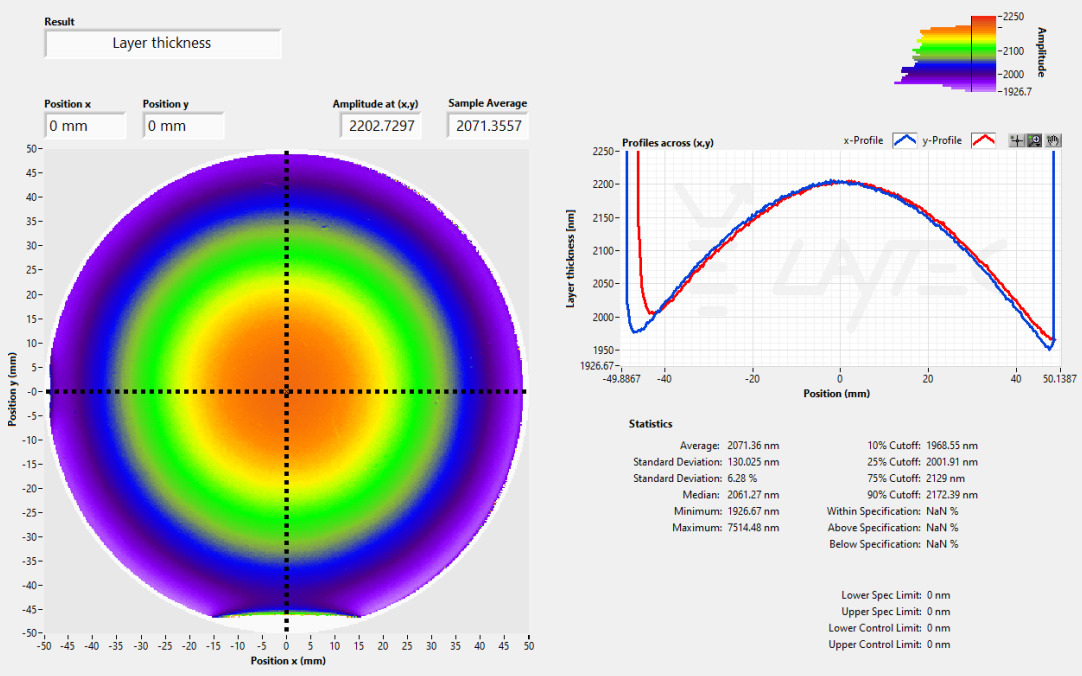
- Full stack analysis also here still work in progress
  - GaN + SiC band edge region highly sensitive to precise optical constants & modelling
- Analysis of dedicated spectral areas already provides valuable information

- AlGaN barrier composition
- Total thickness variation

HFET on SiC: Analysis of ex-situ data – Total Thickness Variation



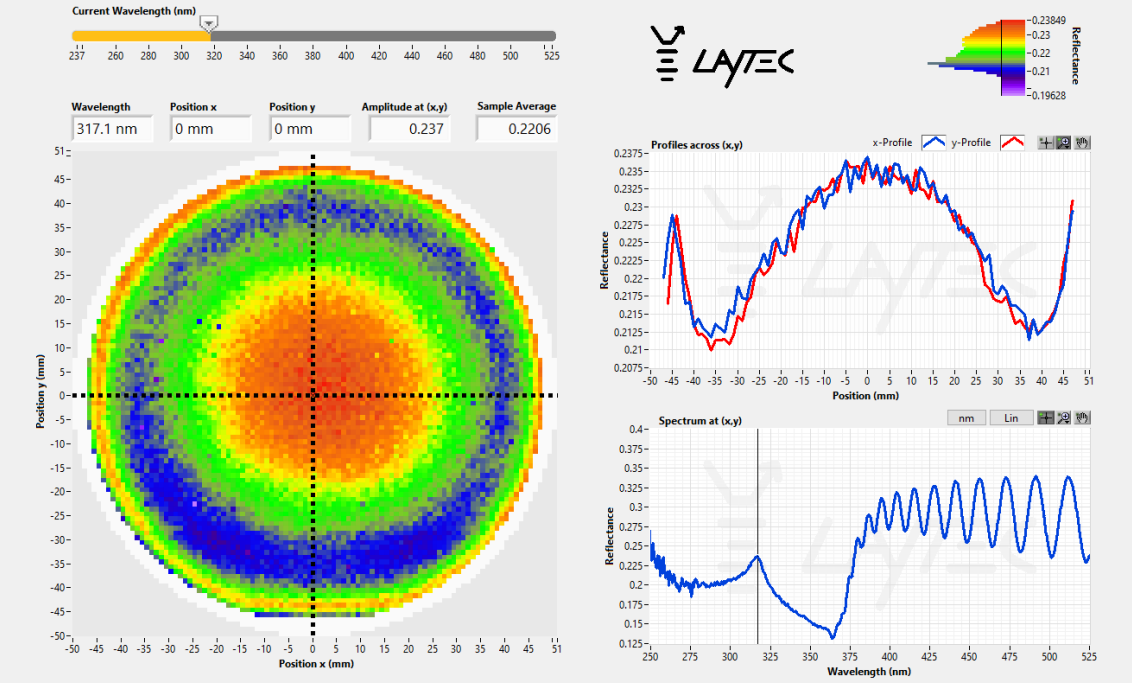
Normalized measurement data view

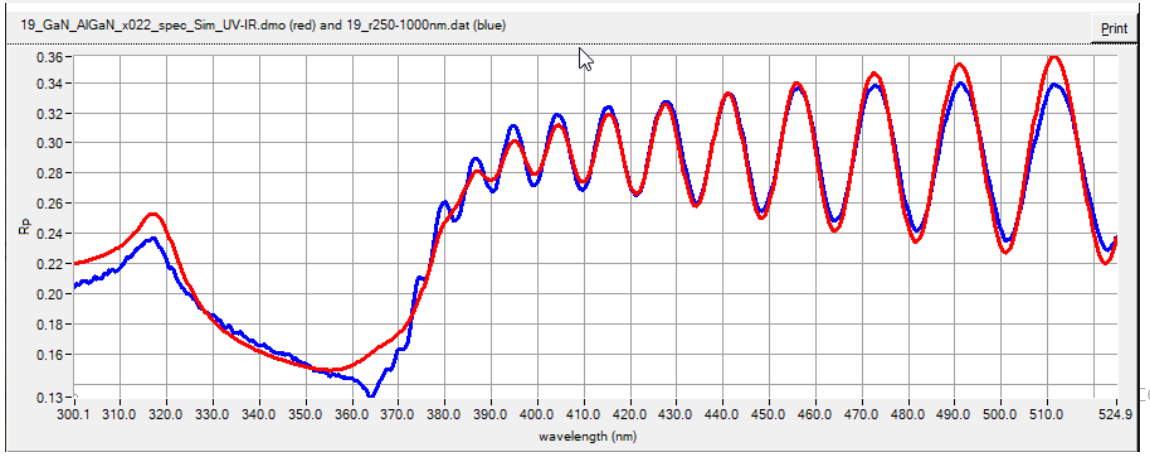


Result data view: TTV

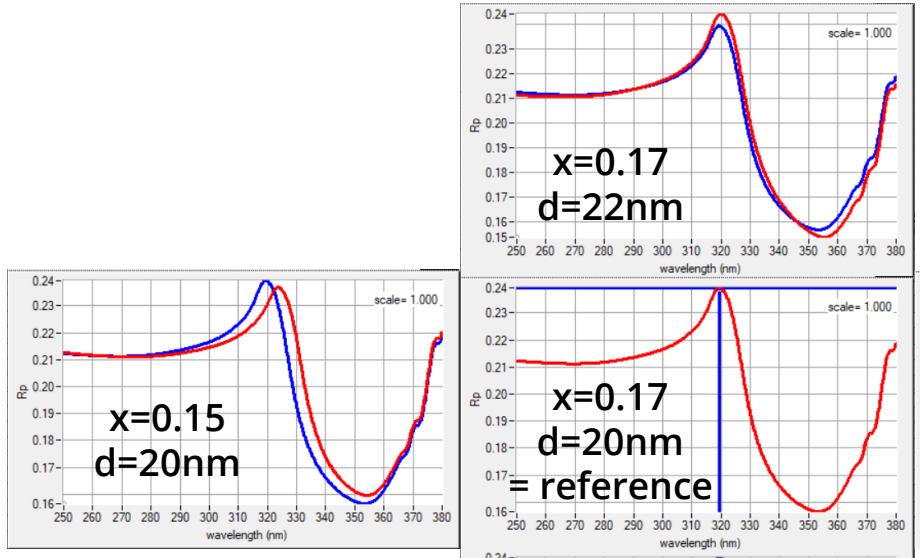
- Spherical profile, ~200 nm variation center to edge, slight deviation close to flats
- In good agreement to total thickness obtained from in-situ analysis

HFET on SiC: Analysis of ex-situ data – AlGaN barrier composition





- UV-peak λ-shifts with $Al_xGa_{1-x}N$ composition… (-2nm/%)
  … but not with d_{AlGaN} !
- AlGaN thickness only changes peak amplitude (0.1%/nm)



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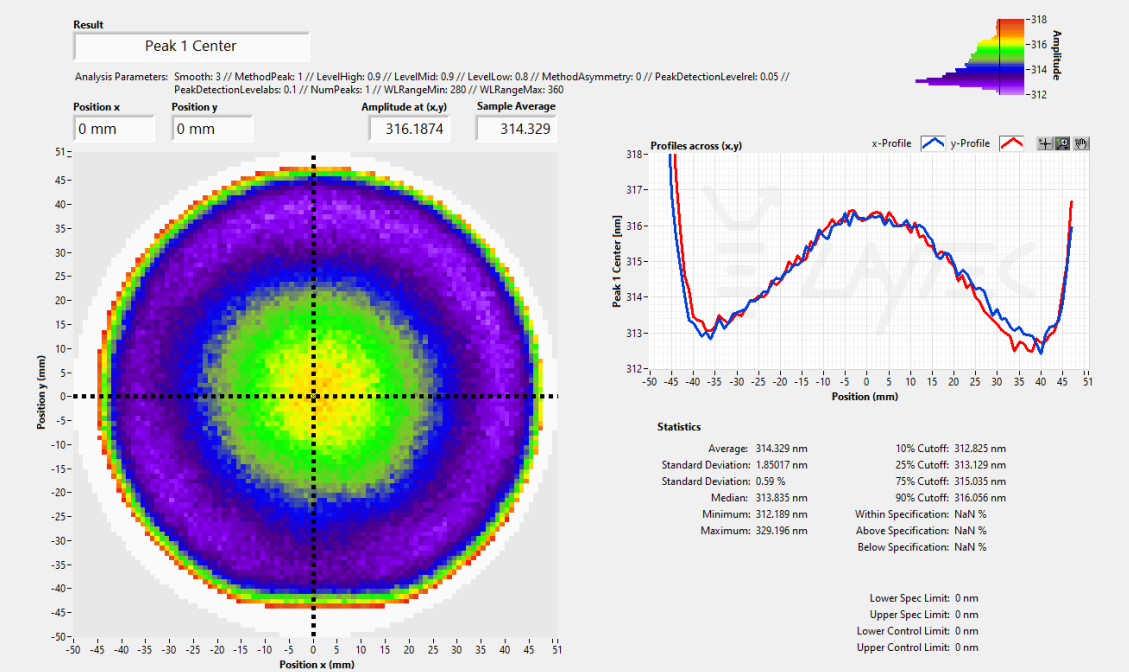
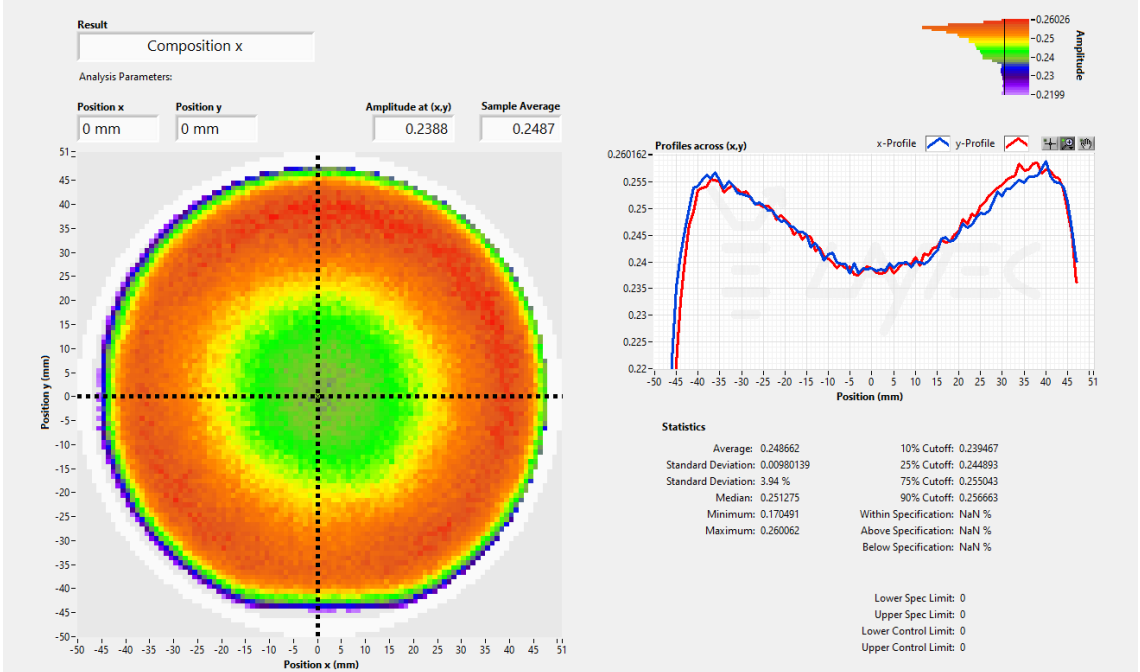
HFET on SiC: Analysis of ex-situ data – AlGaN barrier composition



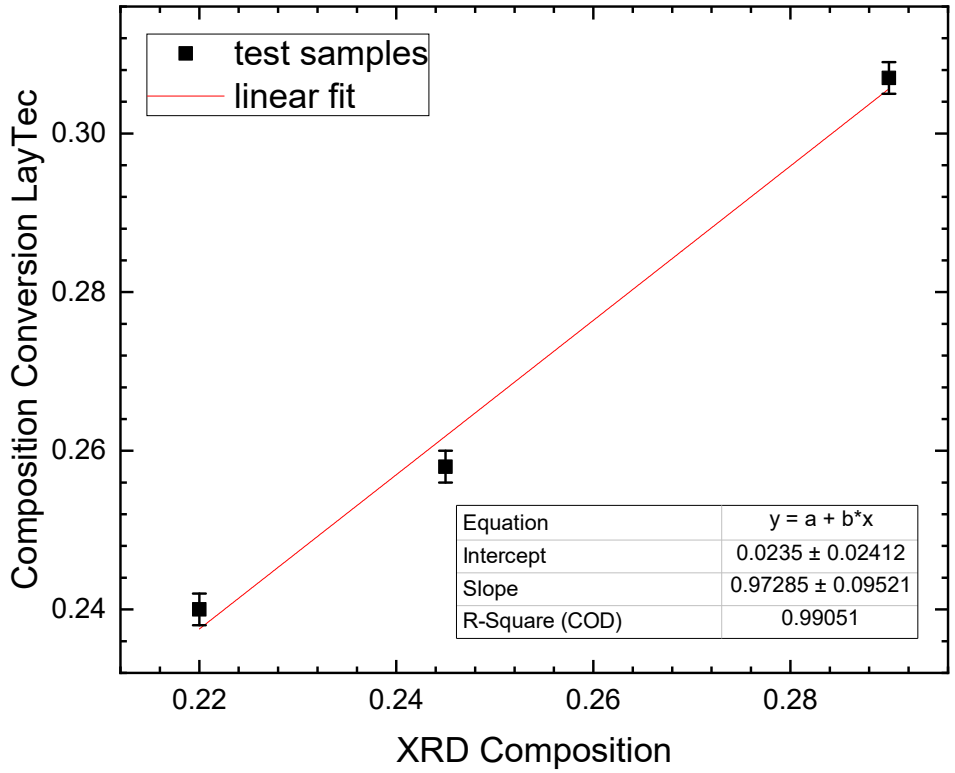
Result data view: Peak Center Wavelength



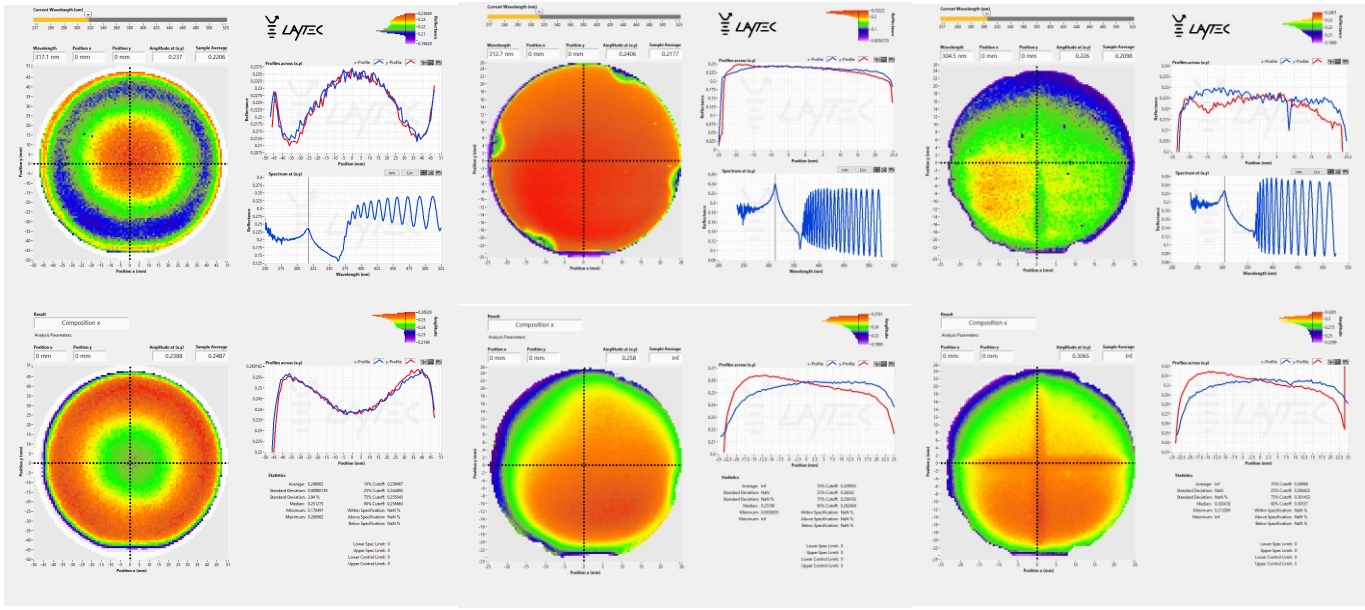
Result data view: AlGaN Composition

- M-shaped profile, ~1.5% nm variation center to edge, no influence of flat visible

HFET on SiC: Analysis of ex-situ data – AlGaN barrier composition



- Correlation XRD vs. EpiX composition of 3 HFET samples with different barrier compositions



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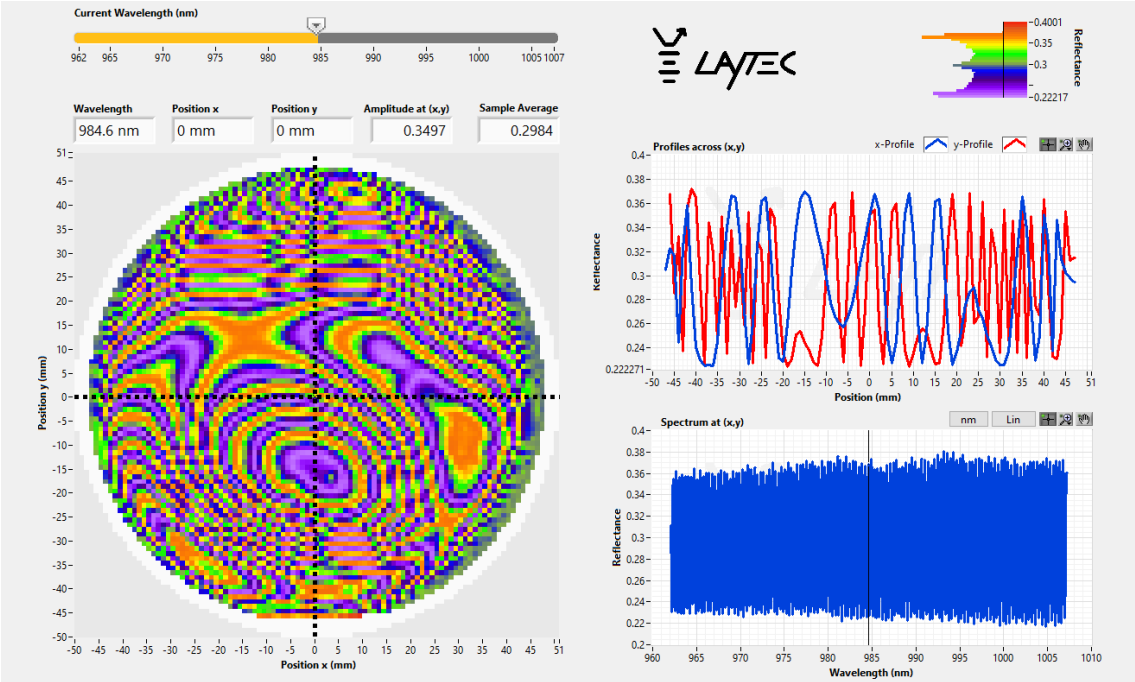
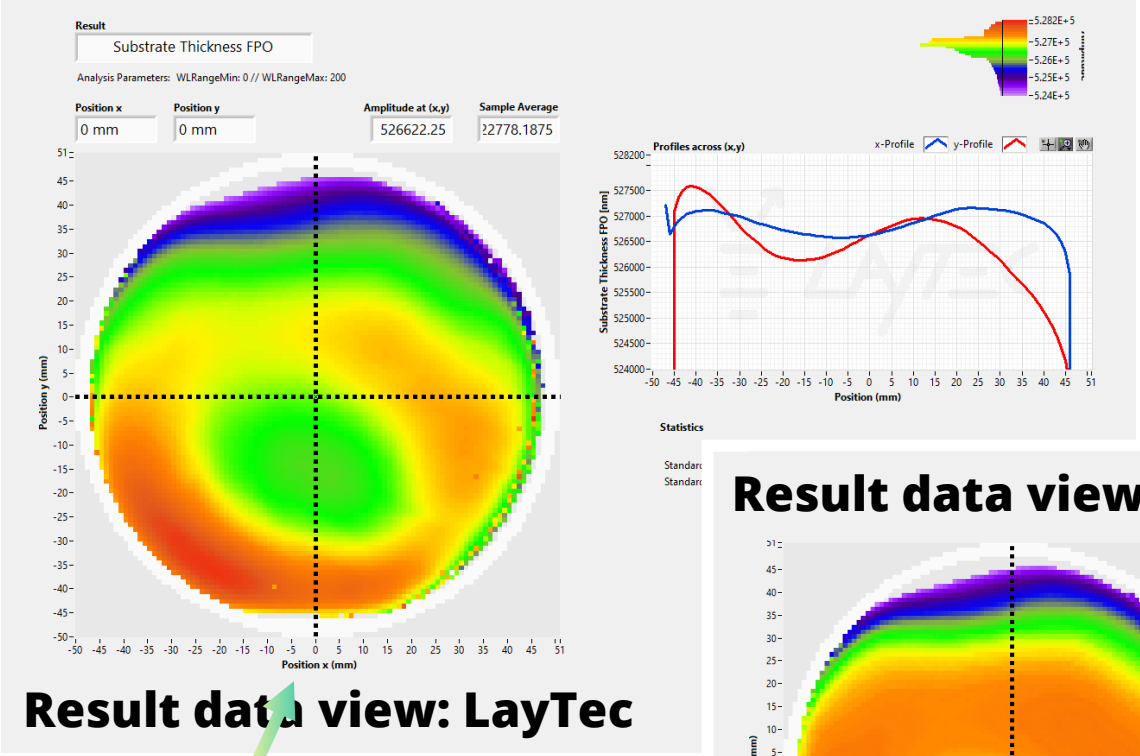
SiC wafer thickness / homogeneity mapping

- High spectral resolution white light reflectance mapping
- Works for double side polished, transparent substrates lik SiC, sapphire, glass, …
- nm scale accuracy*
  - *SiC: optical thickness variations mainly caused by n-variations
- Patent pending

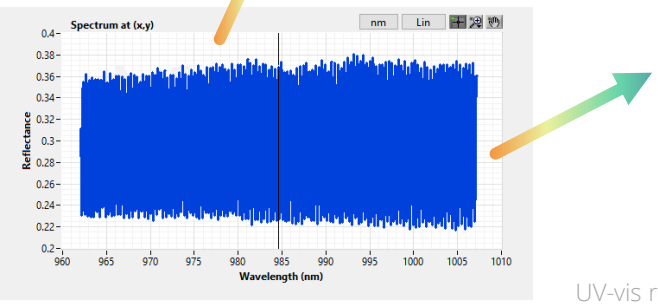


Normalized measurement data view

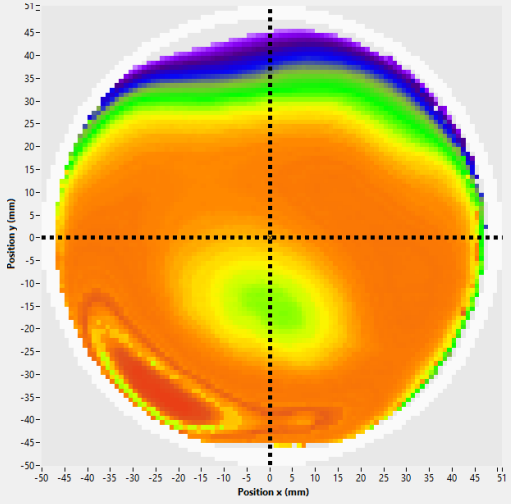
Significantly improving SiC wafer thickness mapping



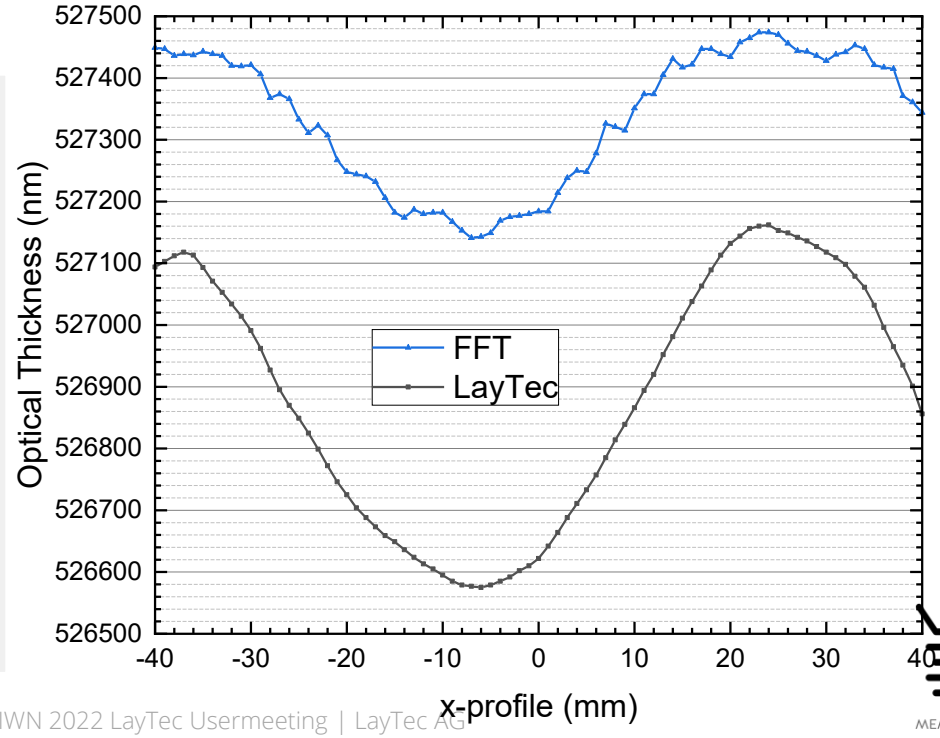
Result data view: LayTec



Result data view: FFT



- Accuracy of state-of-the-art FFT measurement limited
- Advanced measurement setup and analysis algorithms enable wafer thickness measurement on nm scale.
- Also useful for other applications (e.g., EPD for etching)



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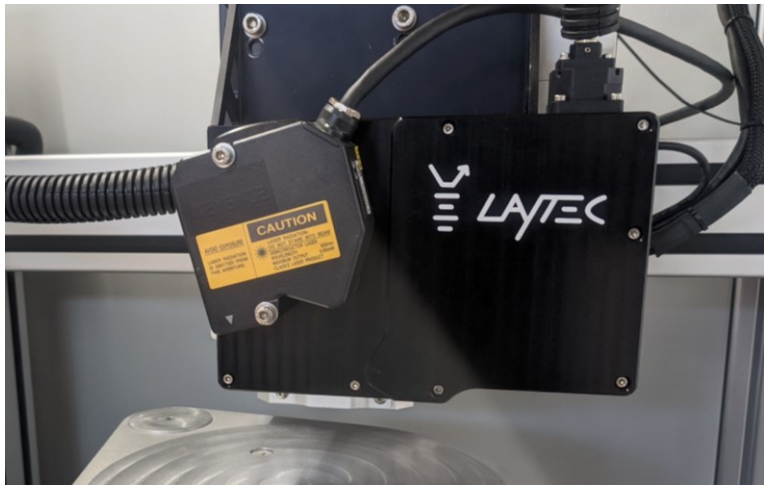
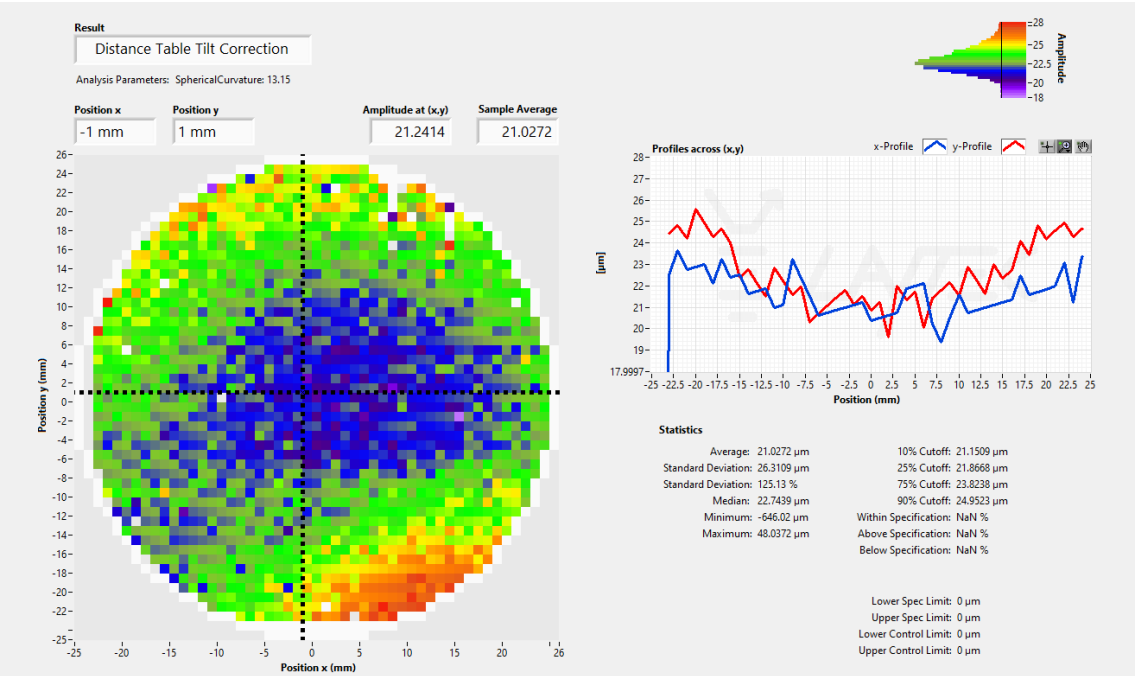
Bow mapping



- Wafer bow measurement capability is a frequent customer question required for strain engineering
- System already equipped with distance sensor for wafer thickness compensation
- Low hanging fruit: Use distance sensor for bow measurement
  - Distance measurement + plane correction + spherical fit / shape analysis

Bow mapping example 1 - 2“ Si 1000 Wafer

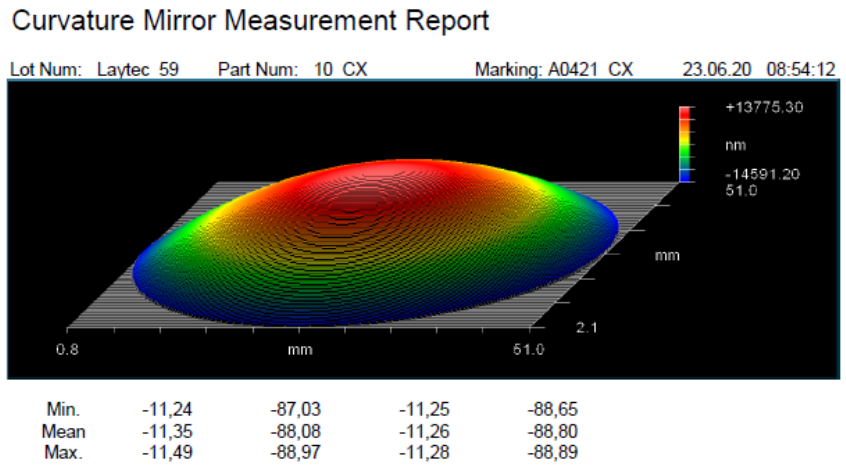
- Supposedly flat
- Measured variation over wafer < 6µm
- Current noise of bow measurement ≤ ±1 µm



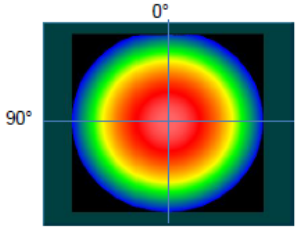
Result data view: Bow Profile

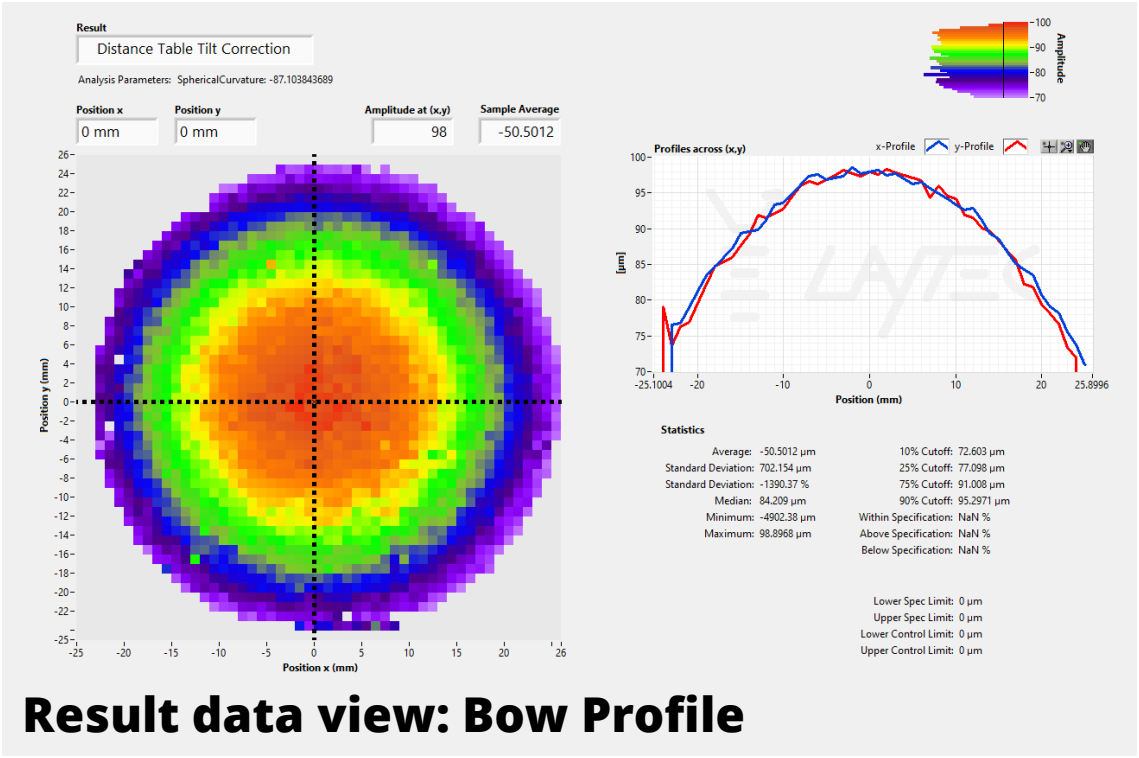
Bow mapping example 2 - 2“ CX EpiCurve Calibration Wafer

- Reference curvature value: - 88 ± 1 km^{-1}
- EpiX curvature value: -87.1 km^{-1}
- Excellent agreement between EpiX and reference data



Min.	-11,24	-87,03	-11,25	-88,65
Mean	-11,35	-88,08	-11,26	-88,80
Max.	-11,49	-88,97	-11,28	-88,89





Result data view: Bow Profile

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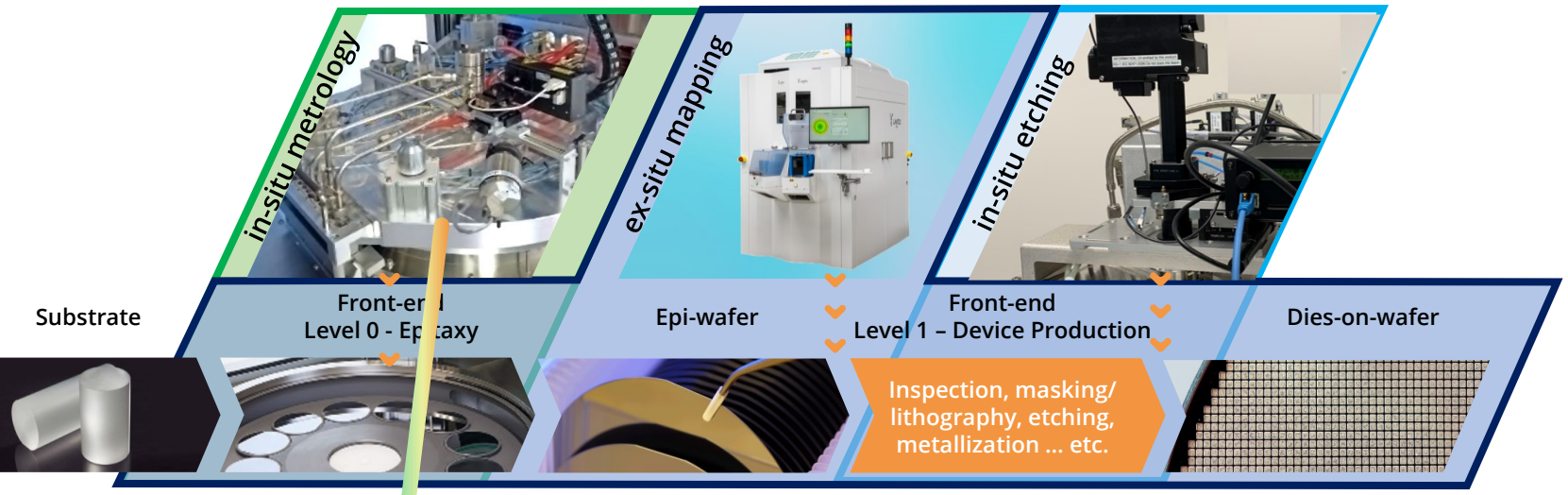
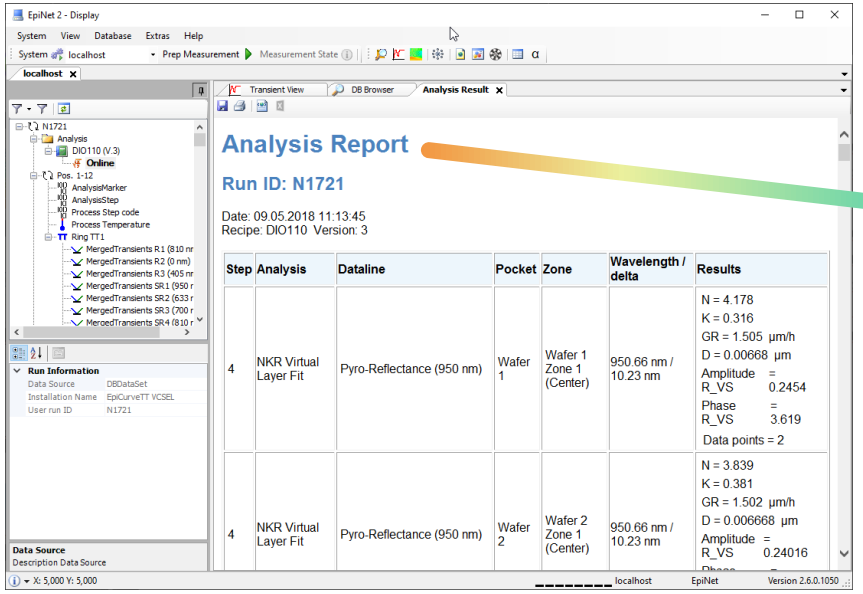
LayTec's tools start talking to each other…

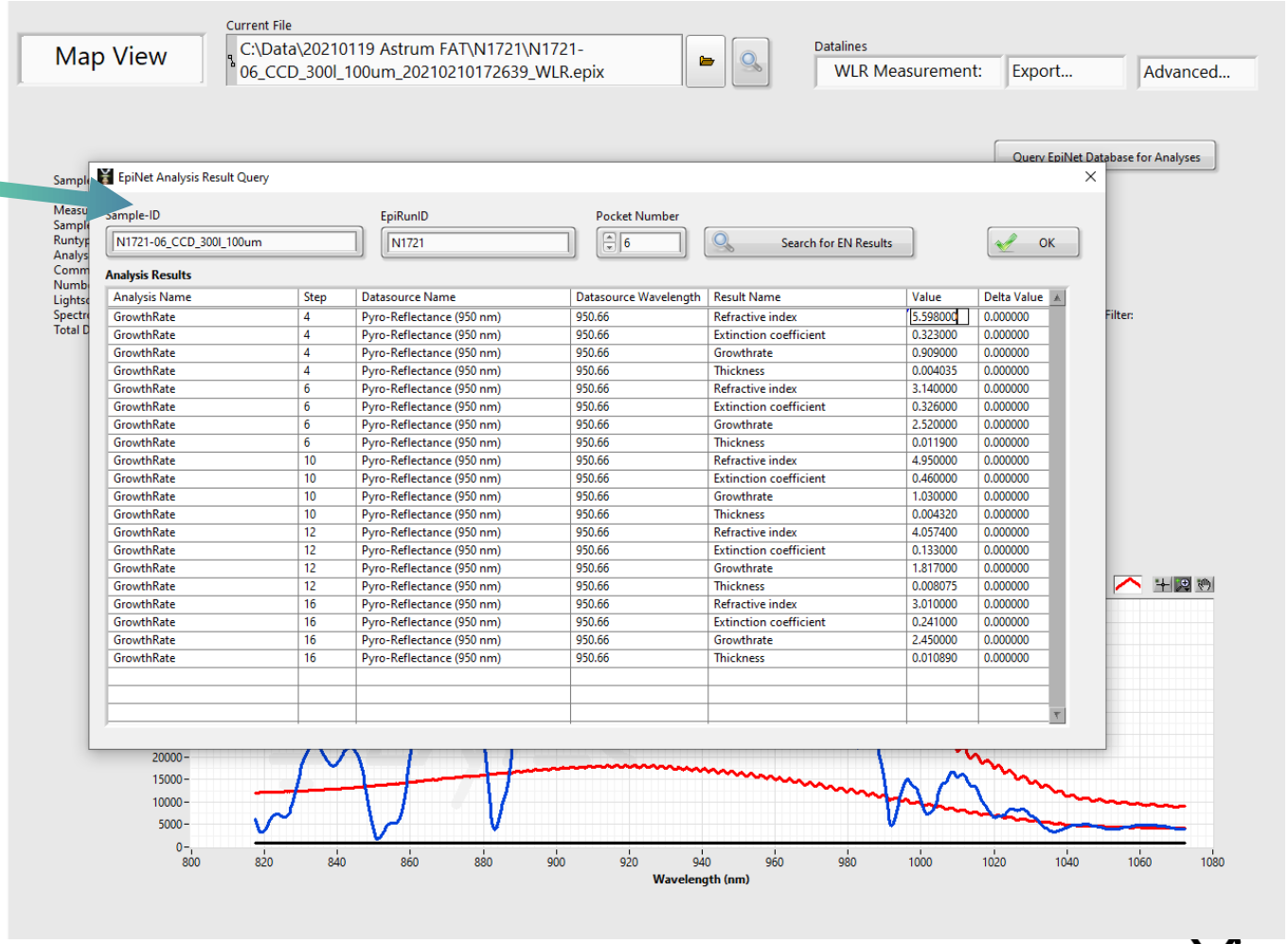


- EpiNet generates analysis results for each wafer (zone) for various layers
- EpiX can now access EpiNet database and read analyses results to use them as starting values in suitable spectral analyses

Layer	sub-layer	WZ1_center	
AlGaN barrier		22.2	
i-GaN	i-GaN etch	-8	→ 841nm
	i-GaN	849	
Fe-GaN	Fe-GaN		
GaN (3D-->2D)	GaN 3D + smoothing	396	
AlN			
	AlN HT	35.8	→ 85.9nm
	AlN LT+LT_to_HT	50.1	
SiC-4H			
	total thickness (nm)	2257.8	

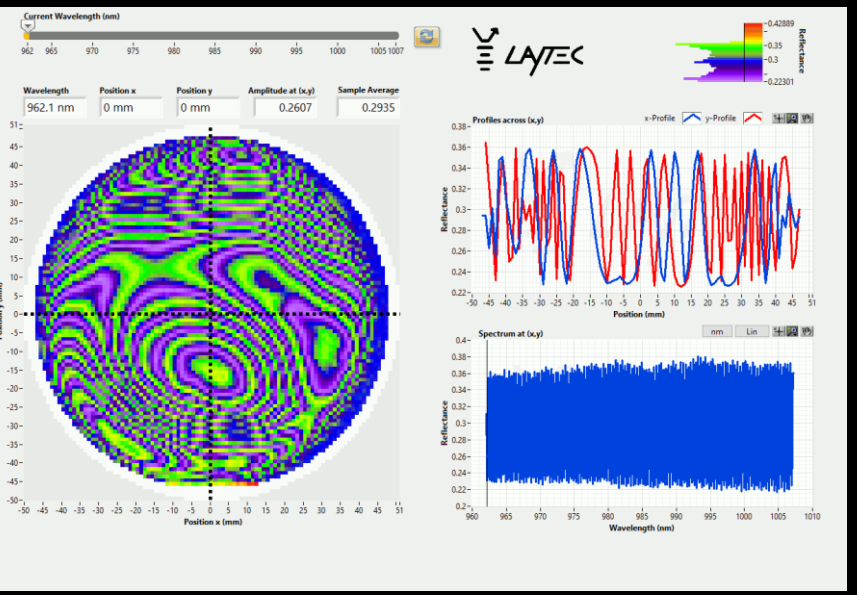
LayTec's tools start talking to each other…





- EpiX can now access EpiNet database and read analysis results to use them as starting values in suitable spectral analyses

LAYTEC EpiX @



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