280 nm reflectometry – helpful tool for in-situ control of AlN-based MOVPE-growth

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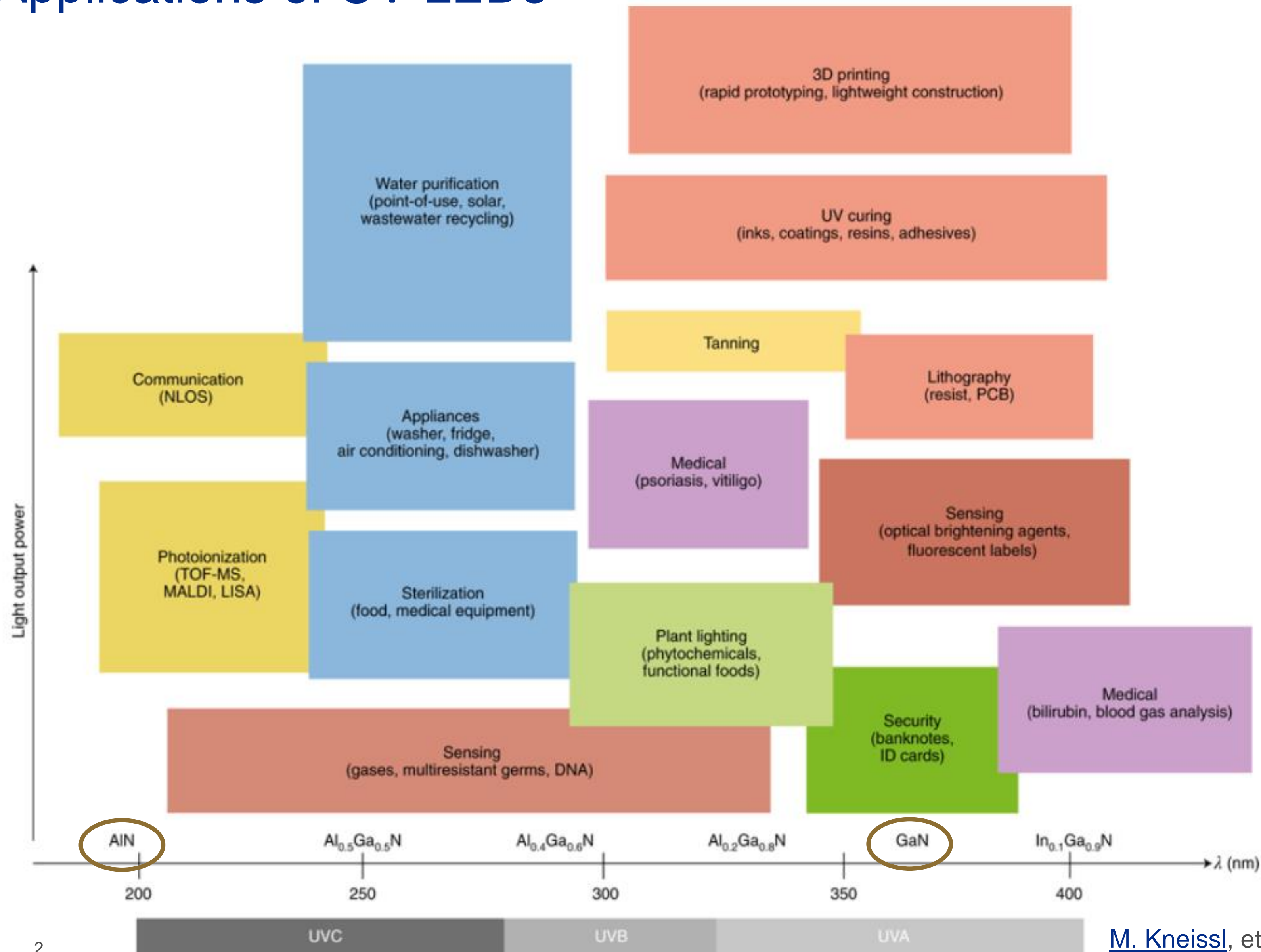
Applications of UV-LEDs



M. Kneissl, et al. *Nature Photonics* **13**, 233 (2019)

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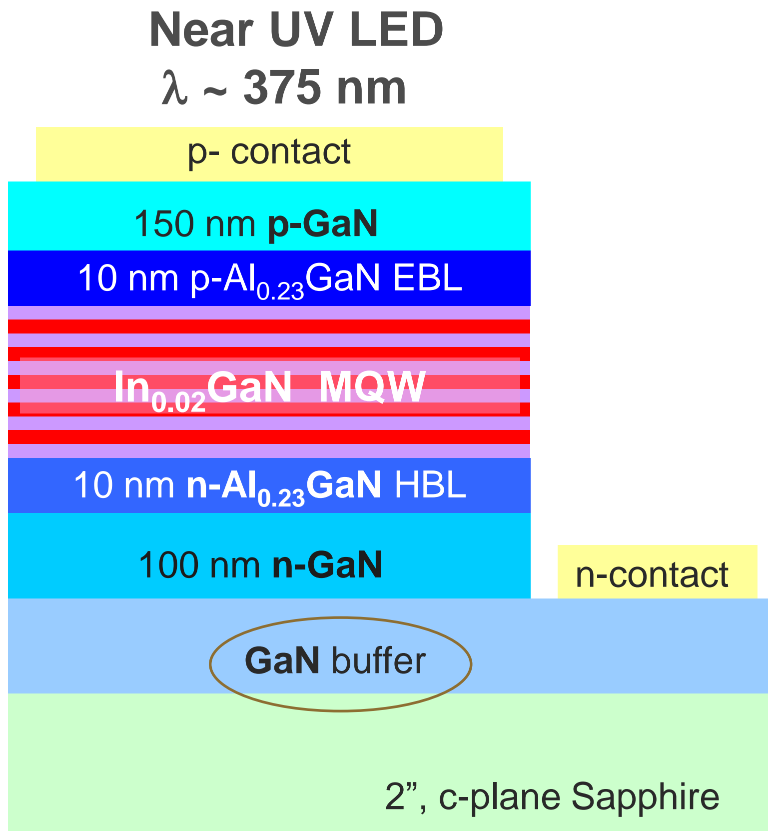
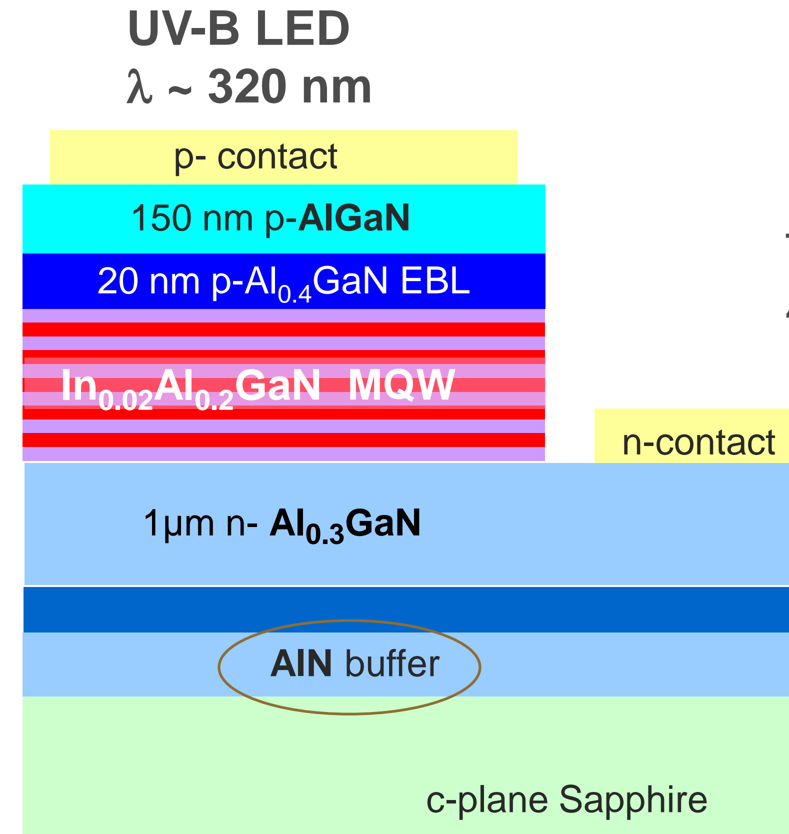
UV-LED Structures and in-situ reflectometry / pyrometry



Absorbs
405 nm light

Wafer surface
temperature



Transparent for
405 nm

Satellite
temperature

- Mainly tensile strain by AlGaN

- Allways compressive strain by $Al_xGa_{1-x}N$
  (x < 0.6 : non-pseudomorphic!)

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Growth of UV-LED structures and in-situ reflectometry / pyrometry

- In-situ control of MOVPE growth required for process development and reproducible results
- Reflectometry at 950, 633 and 405 nm as well as 950 nm pyrometry established for GaN based growth processes ➔ determination of growth rate, curvature and wafer surface temperature possible
- AlN based UV-LED structures transparent for these wavelengths ➔ need for light sources with shorter wavelengths

- **C**lose **C**oupled **S**hower Head Reactor, 6x 2 inch with LayTec Epicurve®TT (Std.: 950 / 633/ 405 nm)
- + In-situ reflectometry at 280 nm (Curvature measurement)

- AlN / sapphire templates with different threading dislocation density (TDD) were used in the same growth run ($1x10^9 cm^{-2}$, $6x10^9 cm^{-2}$)
- Deposition of AlGaN-based LED layer structure on c-plane sapphire

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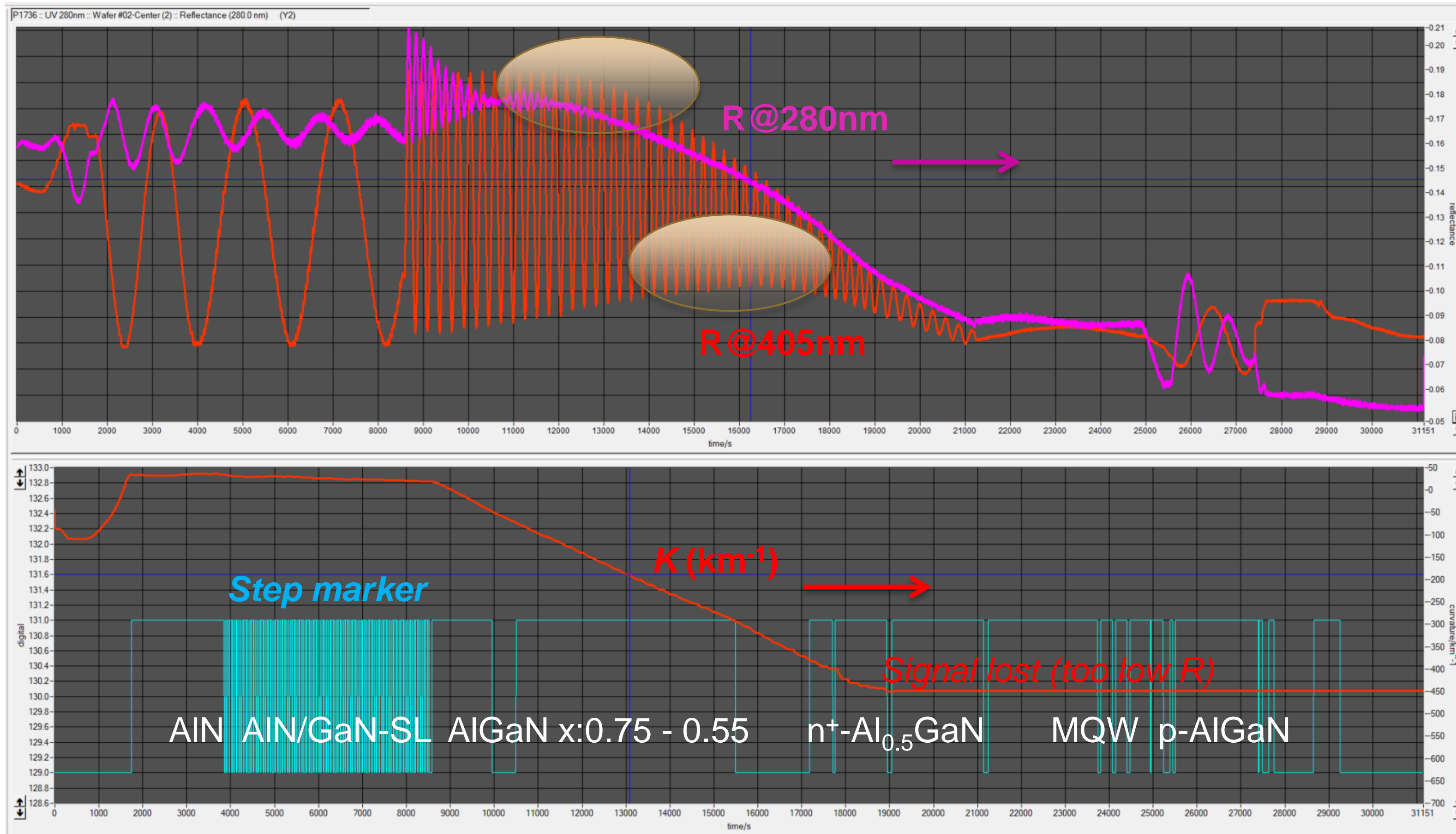
Reflectometry at 405 nm and 280 nm / Curvature during MOVPE of UVB-LED

TDD of AlN template: $1x10^9 cm^{-2}$



- Reflectivity drops ➔ non-pseudo-morphic growth causes roughening
- Higher sensitivity of R@280nm for surface roughening (average intensity) in comparison to R@405nm

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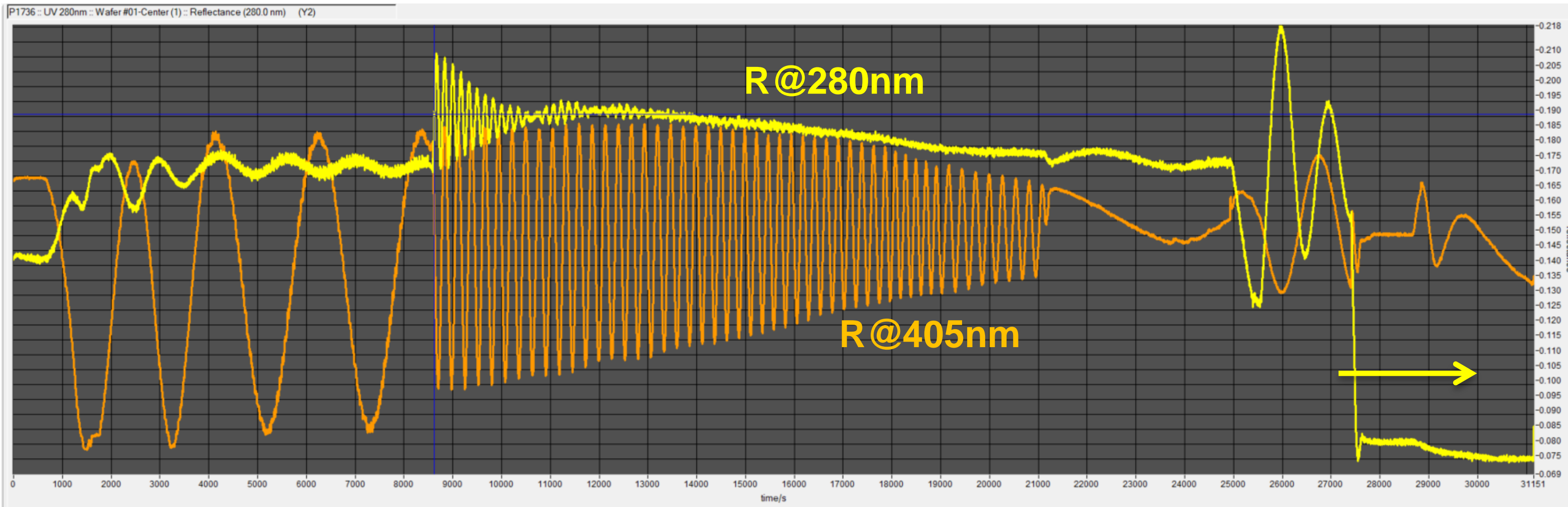
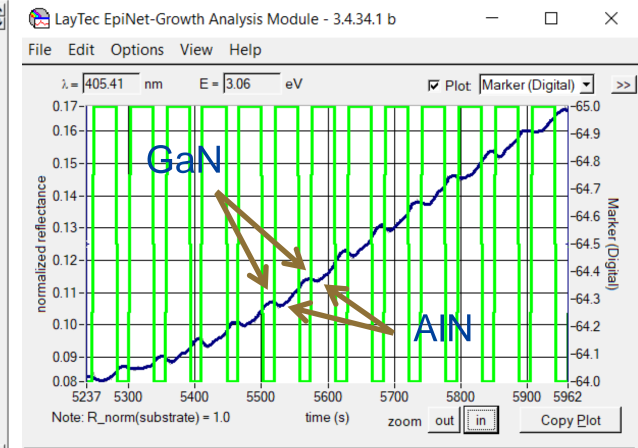
Reflectometry at 405 nm and 280 nm / Curvature during MOVPE of UVB-LED

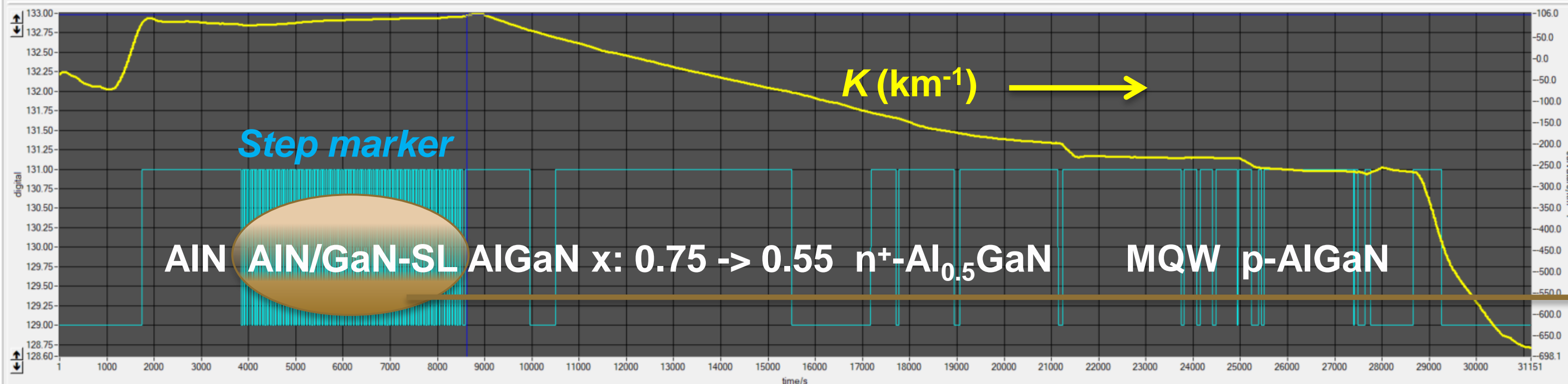
TDD of AlN template: $6 \times 10^9 cm^{-2}$

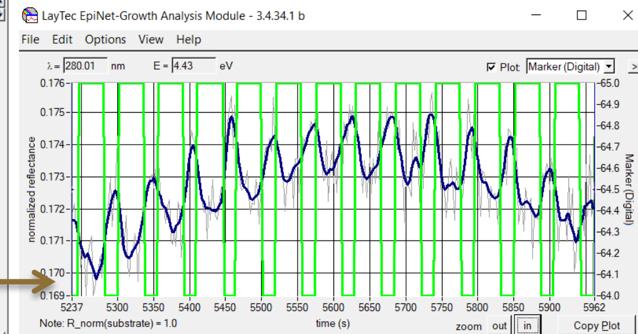
GaN / AlN super-lattice





@405 nm





@280 nm

- Higher sensitivity of R@280nm for composition changes eaven in thin layers (below 1 nm)

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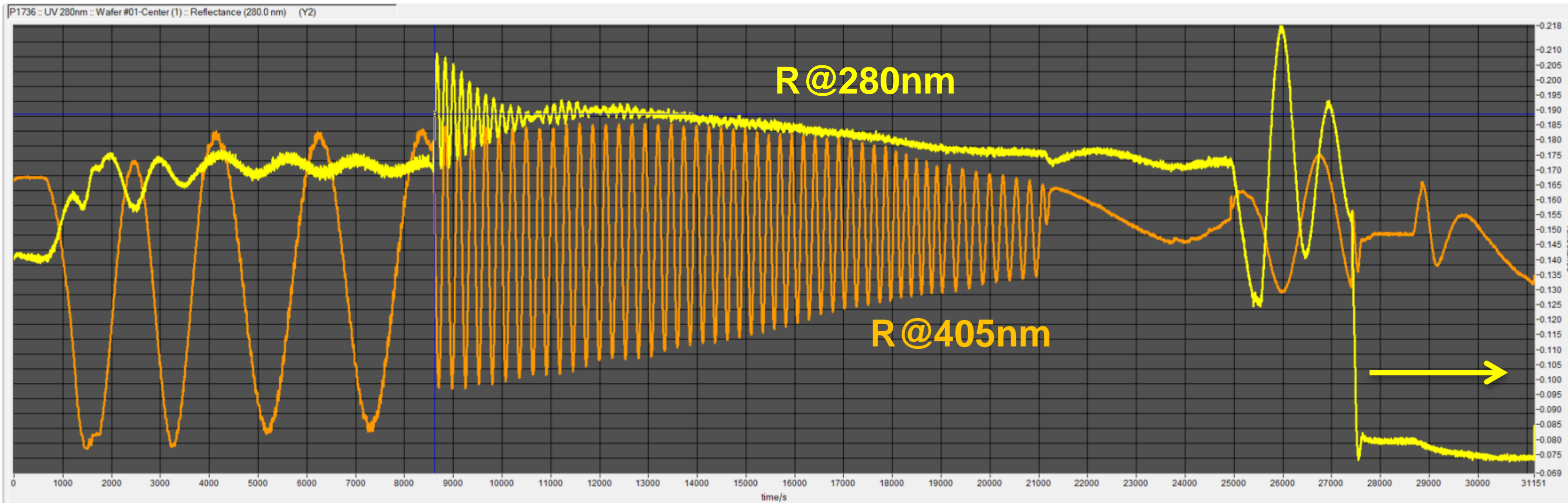
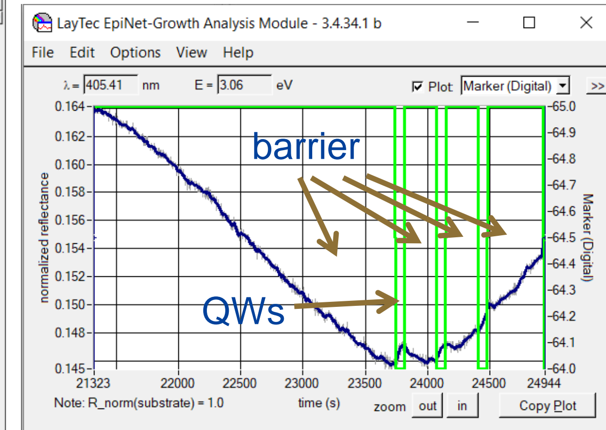
Reflectometry at 405 nm and 280 nm / Curvature during MOVPE of UVB-LED

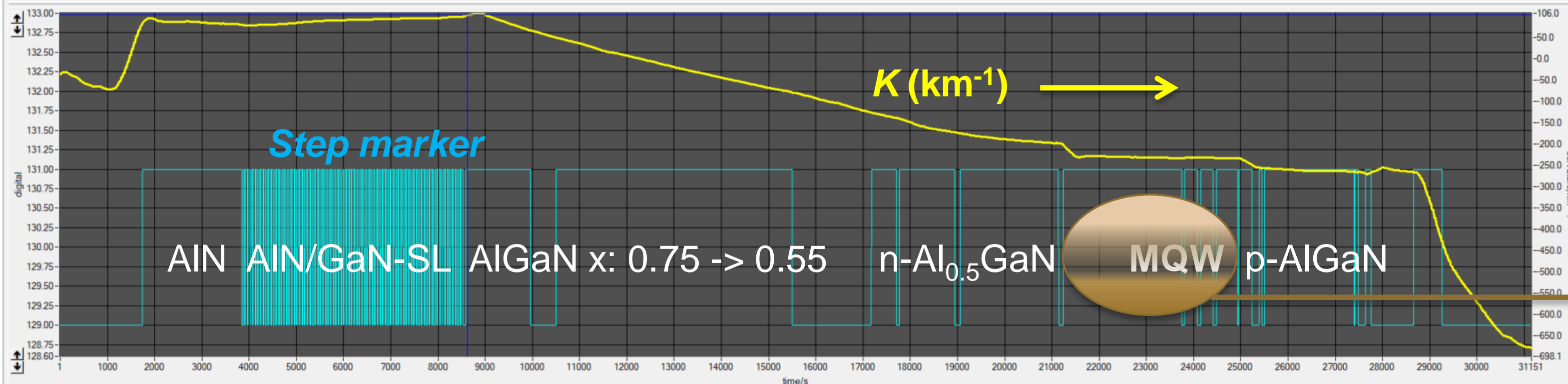
TDD of AlN template: $6x10^9 cm^{-2}$

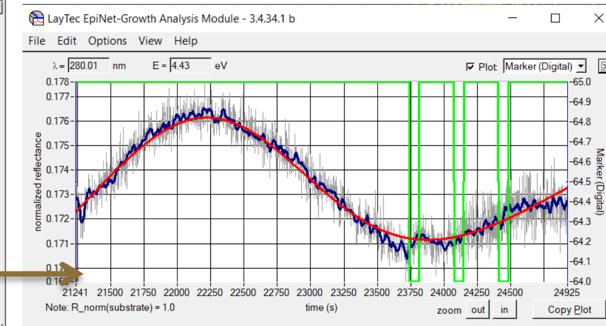
InAlGaN MQW





@405 nm





@280 nm

- Reflection of 280 nm wavelength enables determination of layer thickness below 50 nm

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Summary

- Reflectometry at 280 nm successfully realized in CCS reactor during MOVPE of AlGaN-based LED structures
- New sensor allows better control of surface roughening, composition changes and thickness determination of thin layers
- Surface temperature determination is still unsolved

Reason of different roughness behaviour in dependence of dislocation density of the AlN templates – see poster **P-D6**

11.15 Plenary Talk (D-2): **Dr. Thomas Zettler** “Metrology for MOCVD Processes - Latest Progress”, LayTec

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Thank you for listening

and LayTec for the helpful / constructive cooperation

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