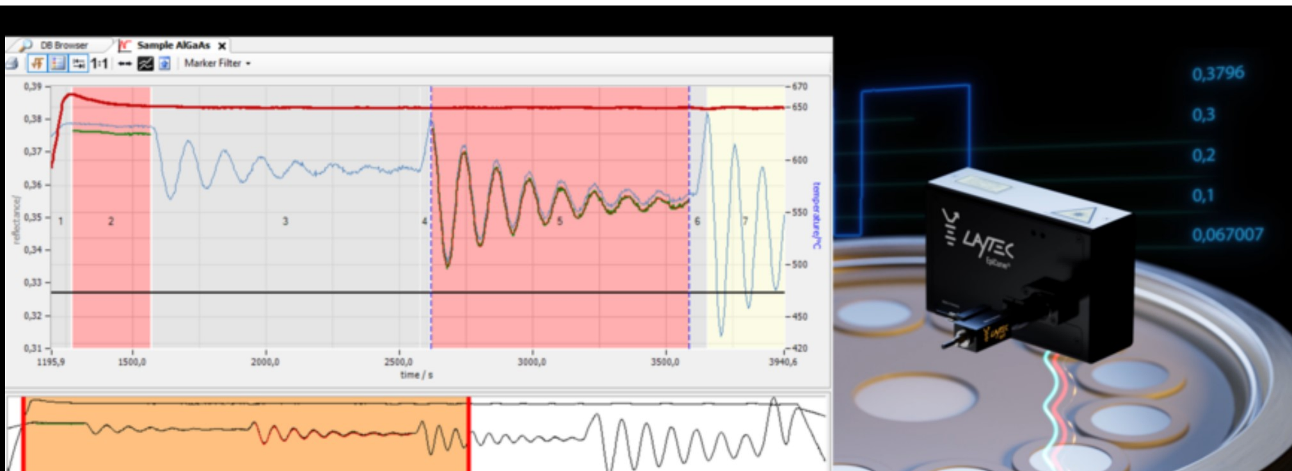
LAYTEC
MEMBER OF THE NYNOMIC GROUP

Newsletter November 2023

Vol. #2 of EpiNet®'s "Algorithm Deep-Dive" series

Getting the best out of your LayTec data: learn how to analyze your in-situ data most efficiently!

Recently we introduced our new "Algorithm Deep-Dive" series. Here, we regularly introduce one of LayTec's advanced in-situ algorithms featured in our EpiNet® software on **LinkedIn**. The series is meant to help you to fully exploit the possibilities of EpiNet® to the benefit of your epi process.



Today, in the series' second volume, the "**NKR Fit on substrate/calibration-layer-corrected reflectance**" is introduced.

Just as the previously introduced "NKR adv virtual layer fit" **the NKR Fit on substrate/ calibration-layer-corrected reflectance** algorithm allows for the simultaneous fitting of reflectance transients obtained by LayTec's **EpiTT** and **EpiCurve® TT** to deduce the refractive index n, the extinction coefficient k and the growth rate r during epitaxial growth of virtually all materials (e.g. AlGaAs).

Additionally, it conducts a reflectance correction by applying a correction factor for the reflectance calibration value Alpha using the knowledge of the optical properties from the underlying material. Accordingly, it can either relate to the substrate ("NKR Fit on substrate") or on a previously deposited layer of known material ("calibration-layer-corrected reflectance"). Note that the correction factor is fitted first, then the reflectance transient is corrected before the common NKR fit is executed.

Like the "NKR adv virtual layer fit" it can be applied to thick (>1 oscillation period visible) smooth layers of all (even unknown) materials. No optical properties of the fitted layer need to be known. However, in this fit additional knowledge about the underlying substrate and or layer can be used to ensure correct reflectance values as starting values for the fitting of the layer of interest.

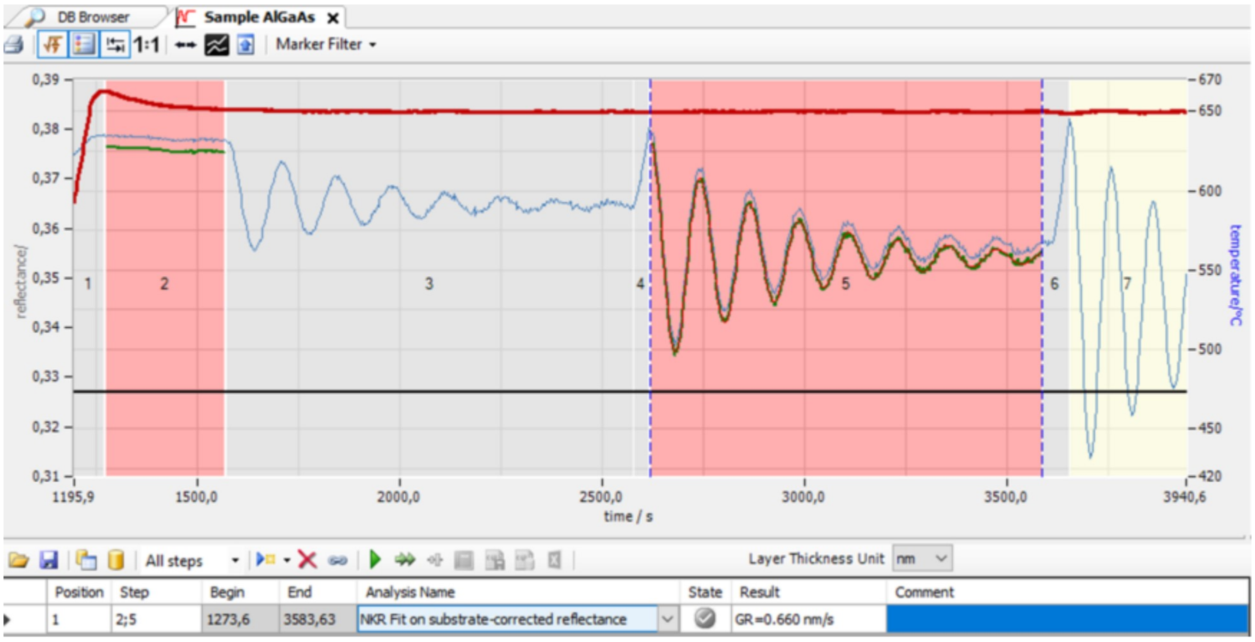


Fig. 1: Analysis screen of EpiNet® applying the „NKR on substrate-corrected reflectance" allowing for simultaneous fitting of the refractive index n, the extinction coefficient k and the growth rate r for analyzing materials like AlGaAs on top of a known substrate (here: GaAs). Note that the fit was exclusively applied to the process step marked in red.

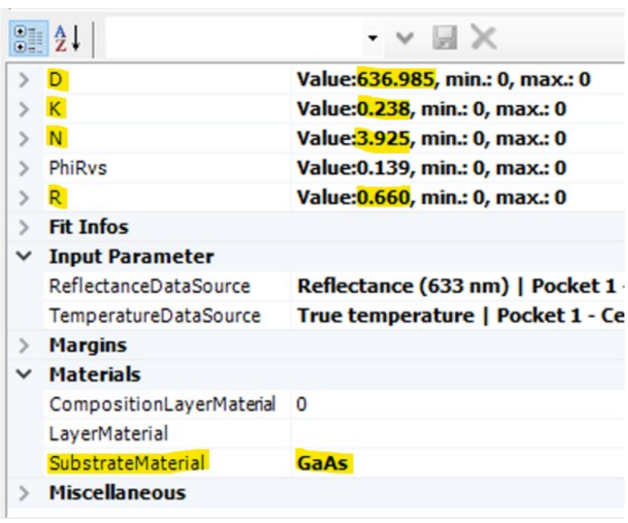


Fig. 2: Property grid displaying the values for the thickness (D; in nm), the extinction coefficient (K, dimensionless), the refractive index (N, dimensionless) and the growth rate (R; in nm/s). Additionally the known substrate material is selected in the lower section.

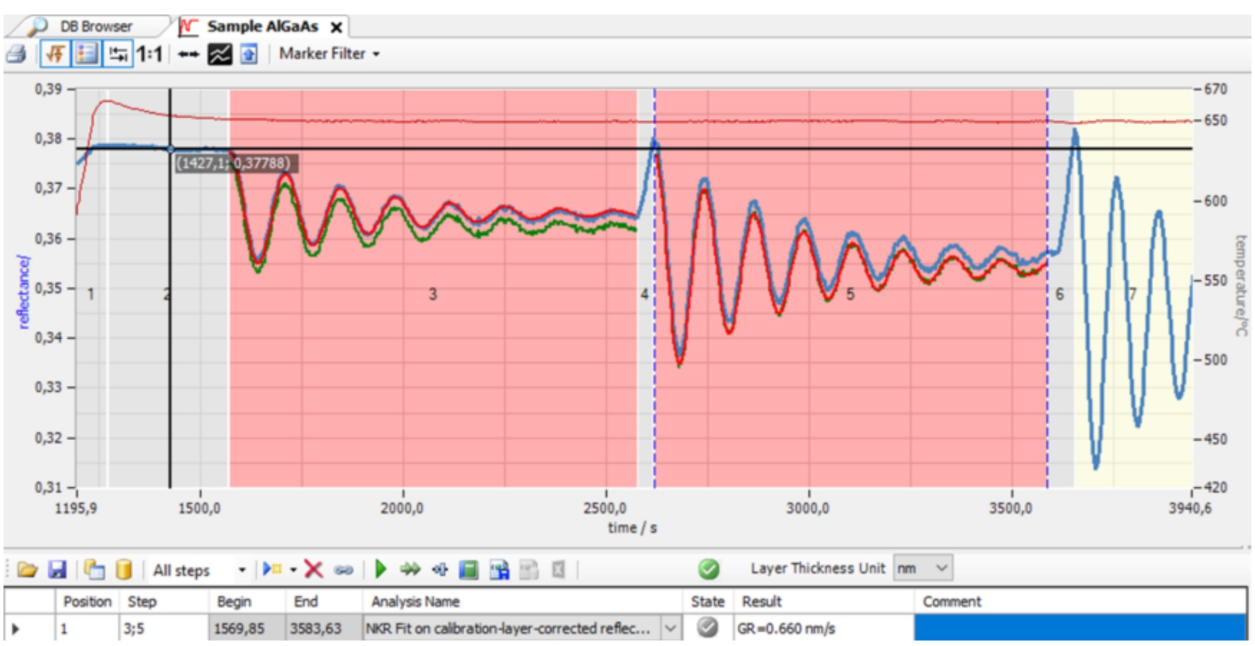


Fig. 3: Analysis screen of EpiNet® applying the "NKR on calibration-layer-corrected reflectance" allowing for simultaneous fitting of the refractive index n, the extinction coefficient k and the growth rate r for analyzing materials like AlGaAs on top of a known underlying layer (here: AlGaAs). Note that the fit was exclusively applied to the process step marked in red.

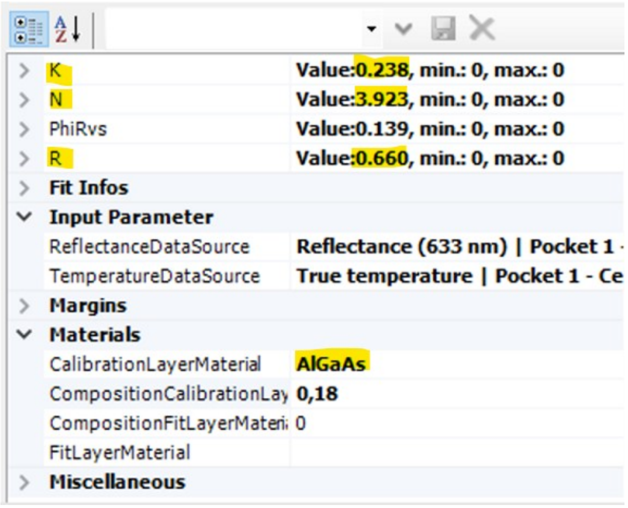


Fig. 4: Property grid displaying the values for the thickness (D; in nm), the extinction coefficient (K, dimensionless), the refractive index (N, dimensionless) and the growth rate (R; in nm/s). Additionally the known layer material and its composition is selected in the lower section.

Usage Ideas and Alternatives:

- Use cases are similar to the “NKR adv virtual layer fit” but this analysis is particularly helpful, if a slightly false reflectance calibration is suspected or to compensate changes in the optical path (e.g. increasing window deposition or deforming of the viewport)

Other than that the following items still apply:

- Use this analysis for thick smooth layers like e.g. contact layers, buffer layers, etc.
- By fixing the growth rate with thickness information about the layer from ex-situ measurements (e.g. XRD) it is possible to use this analysis to gain temperature dependent n and k data for unknown materials.
- For known materials, the multi-wavelength fits offer a faster and more precise analysis (to be covered in future volume of this series).

User Instructions can be found in the manual and can be obtained via **info@laytec.de**

Reference data is available in EpiNet®.

Please feel free to contact our support team via **info@laytec.de** for further introduction in a dedicated EpiNet® training or for receiving sample data for exploring the possibilities of the algorithm on your own. **Follow us on LinkedIn** and stay tuned for further "Algorithm Deep-Dives" in our upcoming posts!

First joint X Link® installation with all4-GP North America Inc.

What a start of our collaboration! Just shortly after welcoming **all4-GP North America Inc.** as our new North America Sales & Service partner for LayTec's metrology solutions for the photovoltaic industry in June, all4-GP North America Inc. and LayTec jointly installed another X Link® at a major US production site. Thanks to the team for doing an fantastic job on-site and to our customers for their trust in LayTec's XLink®.

We are looking forward to many further installations helping US PV manufacturers to ensure that their PV modules are well-encapsulated for a sustainable and durable energy generation! For more information, please contact Matthew Gansen via **matt.gansen@all4-gp.us** or LayTec at **info@laytec.de.**

We are very proud to announce our new Sales & Service partner for LayTec's metrology solutions for large area deposition processes – Shanghai DAYK M&E Equipment Co., Ltd (DAYK)

DAYK will take over the distribution and service activities for LayTec related to non-MOCVD technologies like thin film photovoltaics, OLED, display production and further large area coating industries in China and Taiwan. Given the increasing demand in these industries, LayTec is glad to provide even faster and local support in the region!

DAYK, founded in 2011, is a technology-driven provider for high precision measurement solutions in the semiconductor and related industries. Based in Shanghai, further branches are operated in Guangdong, Beijing and Fujian. DAYK's experience and regional presence ideally complements LayTec's technological expertise for providing customized solutions to customers exactly where they are needed.

For more information, please contact Justin Zheng, **jianping.zheng@dayk.com.cn** or LayTec at **info@laytec.de**

Impact of wafer curvature on the emission wavelength of UV LEDs (230nm)

Recently, we reported on the Interactive feed-back control for pocket temperature during epitaxial growth of 230nm UV-LED structures, which has been presented by LayTec's CTO Dr. Kolja Haberland at this years IWUMD conference in Metz, France. At the same conference, he also shared data of our partner Ferdinand-Braun-Institute in Berlin which directly reveals the impact of wafer curvature during epitaxial growth on the emission wavelength of nominally 230nm-emitting UV LEDs.

In Fig. 5 a) and b) the in-situ data of two UV LED runs with comparable growth recipes but different templates are shown as obtained with LayTec's EpiCurve®TT metrology system. The different templates directly impact the absolute curvature value (green trace; Fig. 5 c)) during multi-quantum-well growth and the evolution of the wafer curvature throughout the run. Particularly, for wafer A, this leads to a change of sign of the curvature, i.e. the wafer shape is inverted during growth.

As a consequence, the contact between the wafer and the heater pocket is significantly different for both wafers: Whilst wafer A exhibits a lower temperature at the wafer center compared to the edges, the opposite applies for wafer B. This directly affects the spatial distribution of the final emission wavelength on the wafers, as can be seen from Fig.5 d) and e): Wafer A exhibits the longest emission wavelengths in the wafer center, whilst they are found at the wafer edges for wafer B. This clearly shows, the importance of controlling wafer curvature during epitaxial growth is crucial for obtaining the desired device properties and a high wafer uniformity.

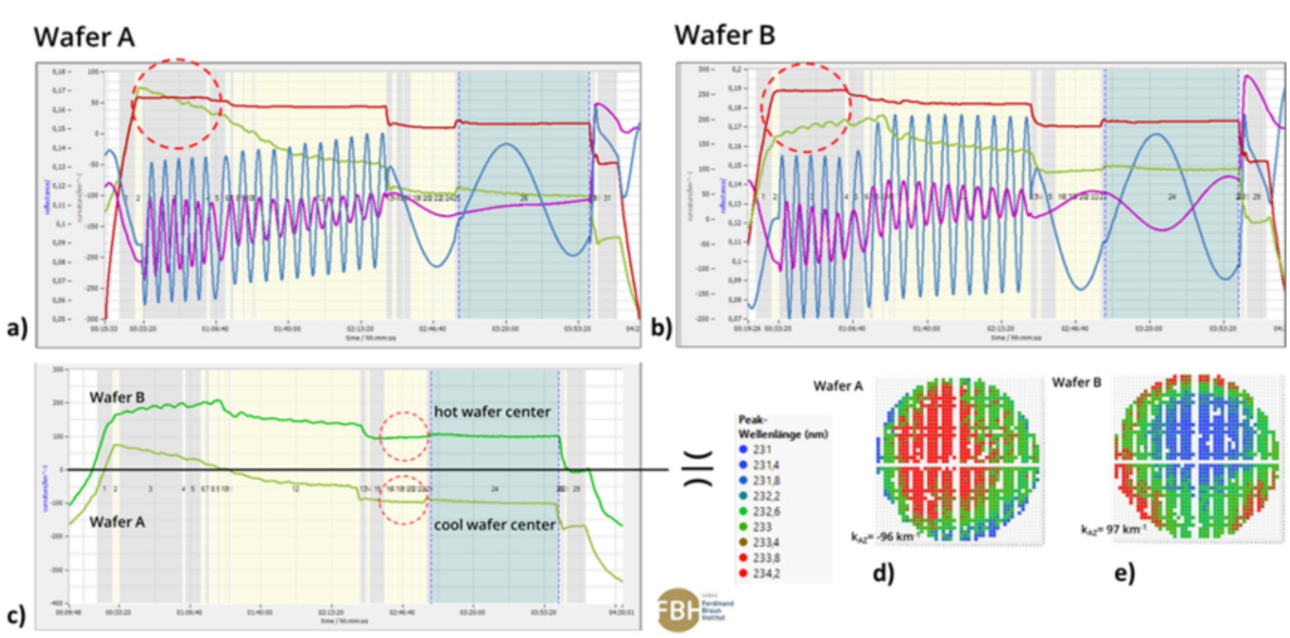


Fig. 5: a) and b) EpiCurve TT in-situ data of two epitaxial growth runs for nominally 230nm-emitting UV LEDs. In c) the curvature traces are directly compared. d) and e) compare the final distribution of the emission wavelengths of both wafers.

Contact us at **info@laytec.de** for further questions or requests!

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