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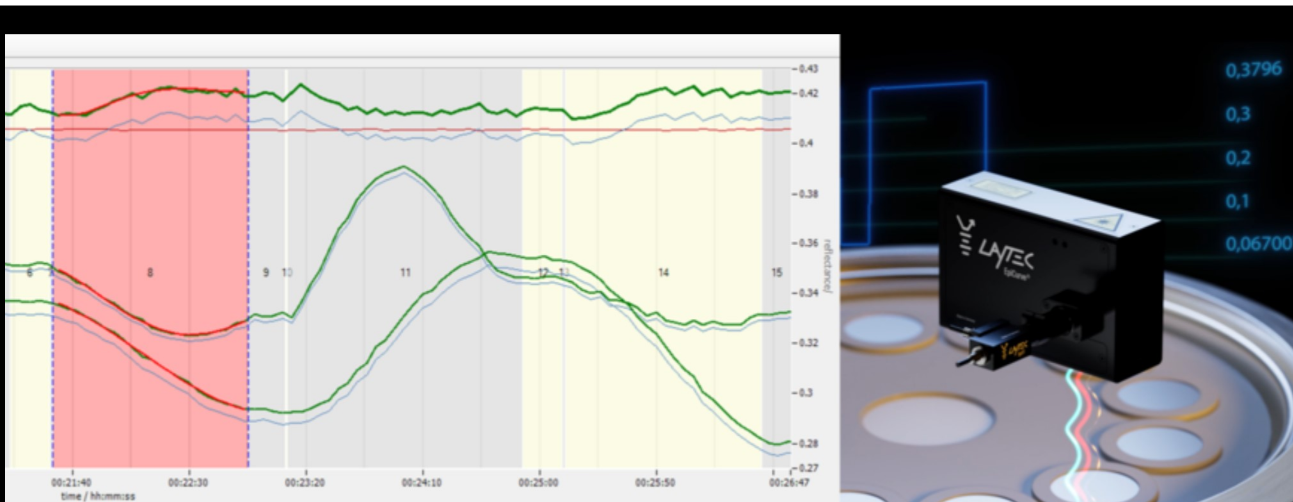
Vol. #4 of EpiNet®’s "Algorithm Deep-Dive" series

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

Welcome back to our new "Algorithm Deep-Dive" series! Here, we regularly introduce one of LayTec’s advanced in-situ algorithms featured in our EpiNet® software in this newsletter and 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’ 4th volume, the **“MultiWL Growth Rate Fit”** fit is introduced.



In contrast to the previously described fitting algorithms, the “MultiWL Growth Rate Fit” exploits the fact that in an **EpiTT** or **EpiCurve® TT** measurement, transients of several wavelengths (usually 405 nm, 633 nm, 950 nm) are measured simultaneously. Since the oscillations of all transients are caused by the same growing layer, they must exhibit the same growth rate. This additional requirement proves to be a powerful tool for increasing the robustness of a growth analysis and for obtaining very accurate determination of the growth rate for known materials as long as the applied model agrees well with the physical nature of the growing stack.

This fit is usually the most appropriate algorithm, if the material system is known (with known n and k from EpiNet’s database) and highest precision for the growth rate is desired. This is particularly helpful, if thin layers are to be analyzed. In this case only a small fraction of the oscillation can be recorded during deposition. Therefore, fitting the growth rate and/or thickness based on just one wavelength will be rather ambiguous. In contrast, if all available wavelengths are analyzed by the “MultiWL Growth Rate Fit” a robust analysis becomes possible even for very thin layers with significantly less signal than one full oscillation period.

Modifications of this algorithm ("MultiWL Composition Fit" and "MultiWL Growthrate Fit with Reflection Correction") also exist for particular use cases and will be subject of upcoming editions of our Algorithm Deep-Dive Series.

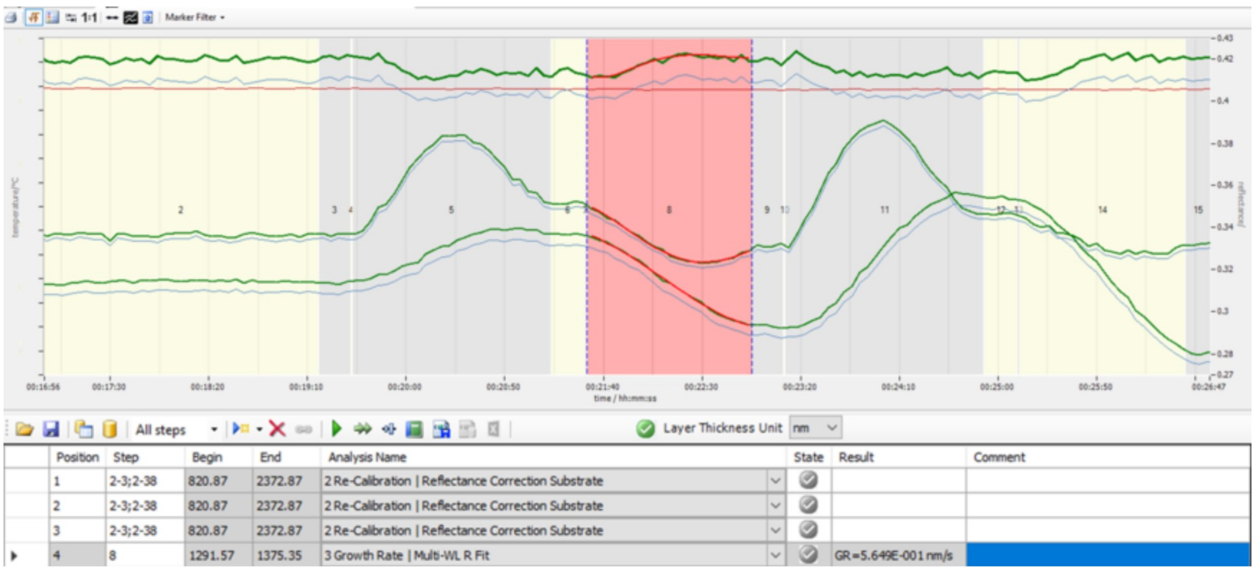


Fig. 1: Analysis screen of EpiNet® applying the "MultiWL Growth Rate" fit allowing for deducing the growth rate and film thickness by fitting all three (or two) wavelengths transients whilst requiring an identical growth rate for all of them based on pre-known refractive index n and extinction coefficient k. Here, the algorithm was applied to a thin InP layer grown within a quantum well structure growth run where the respective values of n and k were taken from the EpiNet® database. Note that in this example only a fraction of a full oscillation was measured for the InP deposition step.

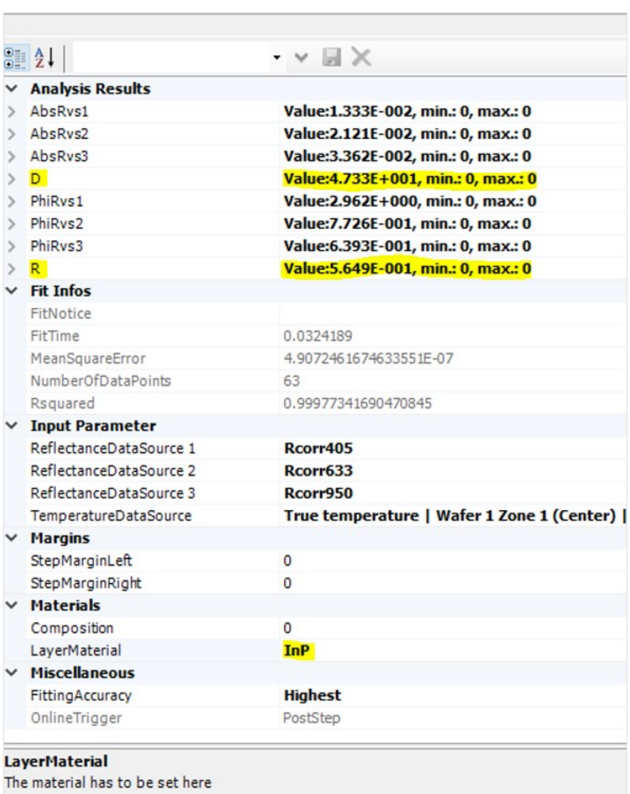


Fig. 2: Results window displaying the value (47.33 nm; 0.56 nm/s) for the thickness (D; in nm), and the growth rate (R; in nm/s). Additionally, the selected growing material is listed in the lower section.

Usage ideas and alternatives:

- Obviously, the algorithm requires two or three valid wavelengths transients in order to increase the robustness of the fit
- Particularly for very thin layers, the "MultiWL Growth Rate Fit" can enable a robust determination of the film thickness, whereas a fit based on just one wavelength might yield rather ambiguous thickness values
- Note that it is artificially restricted to three wavelengths and could be extended to more in the future

- In case of only two wavelengths one wavelength has to be selected twice
- For ternary materials, insert the composition in the corresponding field
- In case of uncertainty about the composition or the validity of available n, k values the NKR adv Virtual Layer Fit applied to one particular wavelength is usually a more suitable choice

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!

LayTec's TRIton for III-V Lab

We are very proud to announce that III-V Lab, a joint Lab between Nokia, Thales TRT and CEA Leti, has just ordered two TRItons, end point metrology products for plasma etch monitoring. This purchase order follows the recent successful collaboration between III-V Lab and LayTec on repeatable and reproducible plasma etch depth control during the manufacturing of InP lasers and detectors, as well as GaN transistors.

The two TRIton units will be installed on an Oxford Instrument Plasma Technology and SENTECH etch chamber. "We have already tested the TRIton monitoring efficiency during plasma etching on our ICP tools. The multi-wavelength metrology allowed us to get accurate real-time positioning during the etching process, even in the thinnest layers of a few nanometers. With the high resolution camera, one can easily identify the etching test-pads. The 3 wavelengths FPO profiles can be simulated and prepared for accurate plasma etch end-pointing anywhere in the heterostructures", say Jean Decobert, epitaxy team leader at III-V Lab, and Delphine Néel, processing research engineer at the III-V Lab technology platform.

TRIton is based on a combination of three wavelengths and offers unprecedented depth resolutions. Its performances enable extraction of key thin film parameters such as refractive index and absorption coefficient with a high precision, as well as real time etch rate extraction and thin film interface location. The cooperation has involved a broad range of cross functional expertise and skillsets, offering a unique framework to tackle all together many compound semiconductor technological challenges. We are going to deploy additional TRIton systems on further etch chambers in the near future. Stay tuned!

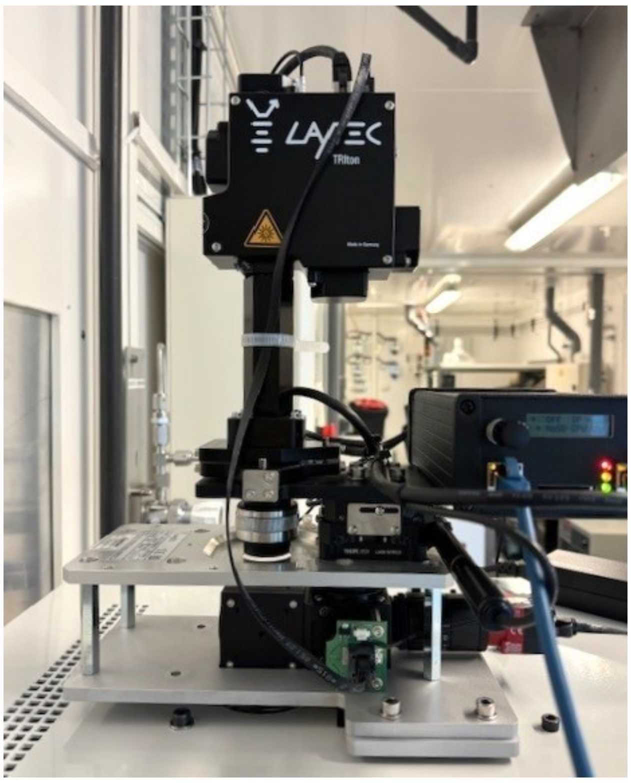


Fig.3: Picture of a TRIton installed on Oxford Instrument Plasma Technology ICP chamber.

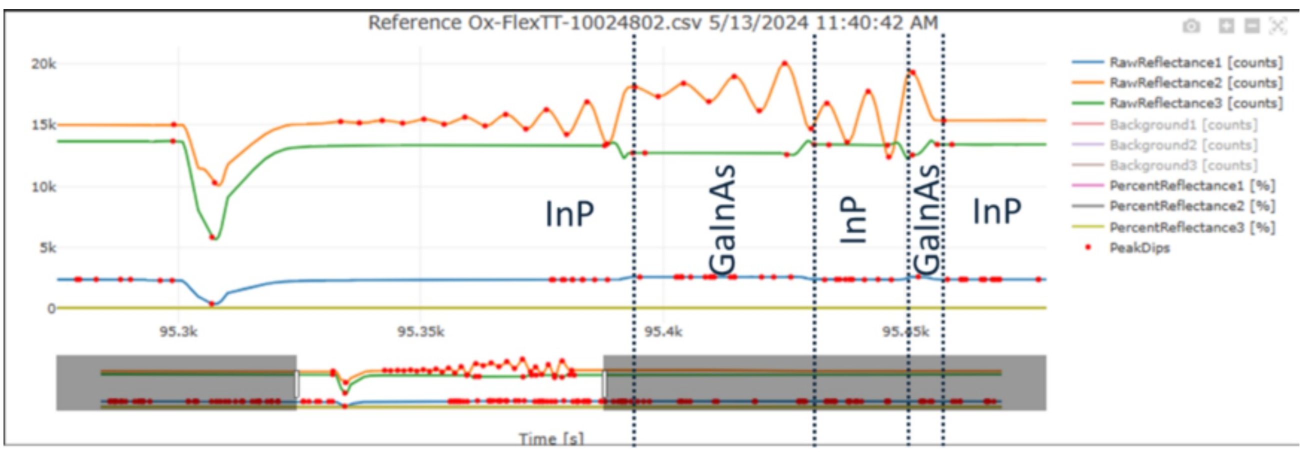


Fig.4: Snapshot of an etch transient recorded with a TRIton and its operating software EtchNet during plasma-etch monitoring of a InP based structure.

Full 2D characterization of HEMT device structure epi-wafers by LayTec's EpiX mapping station

For E-Mode GaN-on-Si HEMTs, as for many other device structures, in-situ reflectance measurements with our **EpiCurve® TT** give access to layer growth rates throughout the epitaxial growth process, i.e., for the entire stack. For very thin, ternary layers, however, the achievable accuracy for simultaneously determining thickness and composition is limited. Newer developments like the UV-reflectance addon or dedicated multi-wavelength and multi-layer analysis options reduce but do not eliminate this limitation.

For full and precise quantification of the barrier structure, it is helpful to additionally measure ex-situ wafer maps with **LayTec's EpiX WLR+PL wafer mapping station**. Typically, for GaN-on-Si HEMT-structures, 266 nm UV-photoluminescence (PL) is employed to determine the Al-composition in the AlGaN barrier. The downside is that this is only possible for D-Mode wafers, as otherwise the p-GaN top layer blocks the laser, and no PL signal is observed. For complex barrier designs (e.g., gradient or bilayer) PL fails to properly quantify the composition even for D-Mode wafers. With LayTec's EpiX, spectral UV-vis reflectance can be measured in addition to UV-PL providing simultaneous access to the thickness and composition of the barrier even for E-Mode device wafers. Prerequisite for the accurate quantification of the layer parameters from UV-reflectance are the low spectral noise, superior absolute accuracy and superior 2D measurement uniformity of the EpiX. The barrier properties are then determined by modelling and fitting the measured UV reflectance in the spectral region of the barrier bandgap (typically 270 – 350 nm). This works for D- and E-Mode wafers as well as for complex barrier designs. Typical p-GaN thicknesses also attenuate the amplitude of the barrier signature in UV-R, resulting in a higher noise of individual fits compared to D-mode wafers, but this can be significantly reduced by smart smoothing utilizing wafer symmetries.

In subsequent manufacturing steps this gained knowledge of the full wagfer is key for enabling yield-optimized high-precision end-pointing with LayTec's **TRIton in-situ metrology for plasma-etching**.

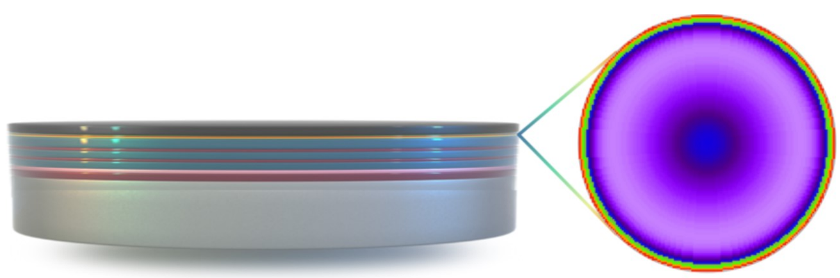


Fig 5: Graphical visualization of 2D uniformity mapping of epitaxial layer structure.

Fig 6: EpiX C2C white light reflectance and photoluminescence wafer mapping station.

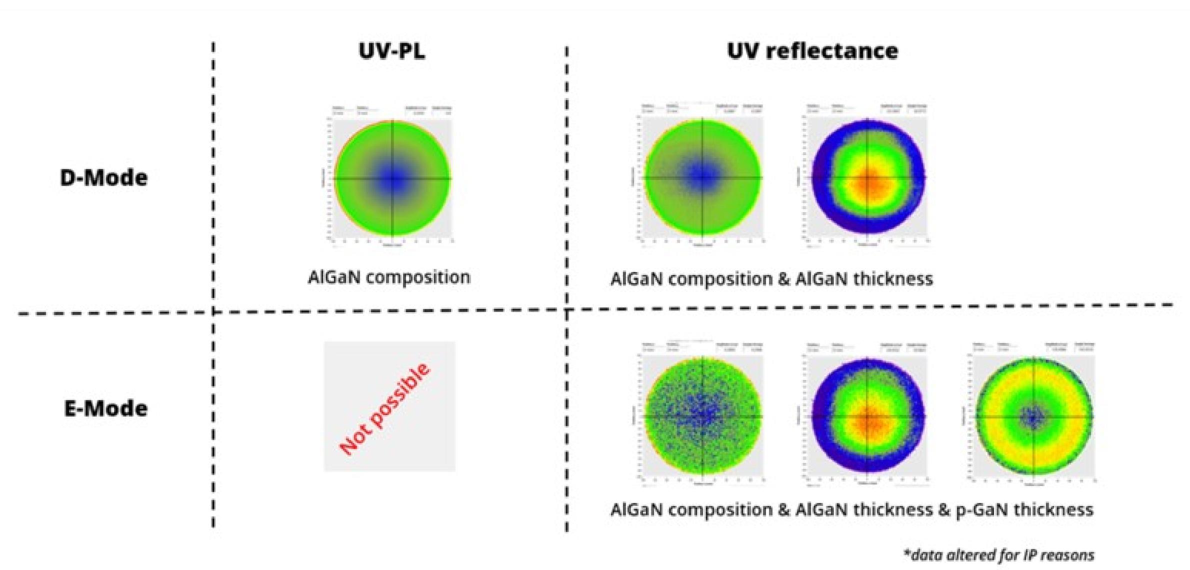


Fig 7: Comparison of obtained measurement results from UV-PL and UV-R mapping of GaN-on-Si HEMT structures.

To learn more about EpiX and our "Connected Metrology" approach, reach out to our team at **sales@laytec.de**!

Our website **Events** **Support**

LayTec AG
Seesener Str. 10-13, 10709 Berlin

Tel.: +49 (0)30 89 00 55-0
Fax: +49 (0)30 89 00 55-180
info@laytec.de
www.laytec.de