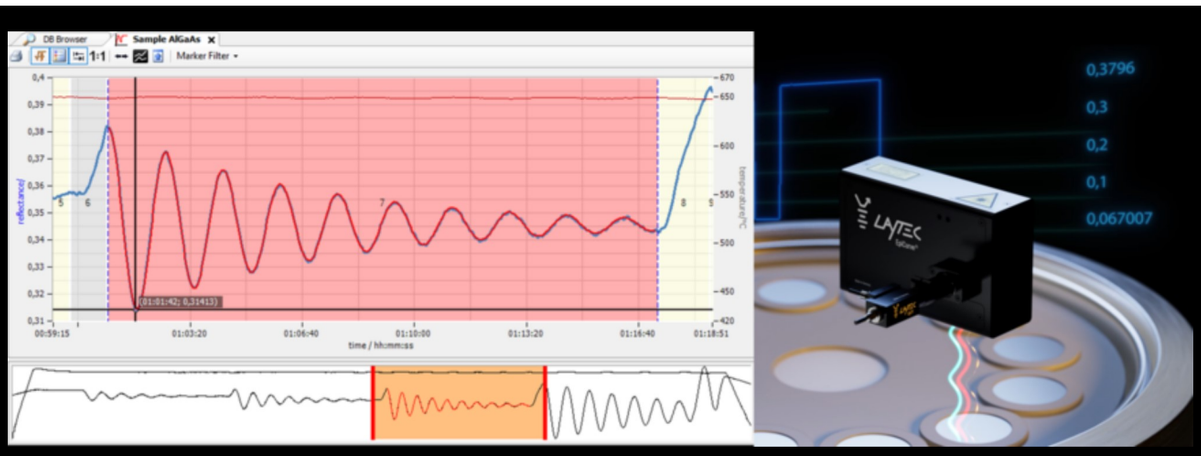
MEMBER OF THE NYNOMIC GROUP

Newsletter February 2024

Vol. #3 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!

Once again we are continuing with 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' 3rd volume, the "**Oscillation-based Growth Rate**" fit is introduced. In contrast to the previously introduced "NKR adv virtual layer fit" and the "NKR Fit on substrate/calibration-layer-corrected reflectance" algorithm, the "**Oscillation-based Growth Rate**" fit makes use of the known refractive index n and the extinction coefficient k to deduce the growth rate r during epitaxial growth from reflectance transients obtained by LayTec's **EpiTT** and **EpiCurve® TT**.

This fit is usually a convenient way to check whether a thick layer (multiple full oscillations within the respective growth step) grows in an "well-behaved" and expected manner, i.e. at a constant growth rate and with known n and k from EpiNet's database. It is also closely related to the **"Oscillation Period"** which is an even more simplistic but fast fit which merely determines the period time of one full oscillation as well as the number of such oscillations within the selected layer. Both fits rely on a purely (potentially damped) sinusoidal oscillation behavior.

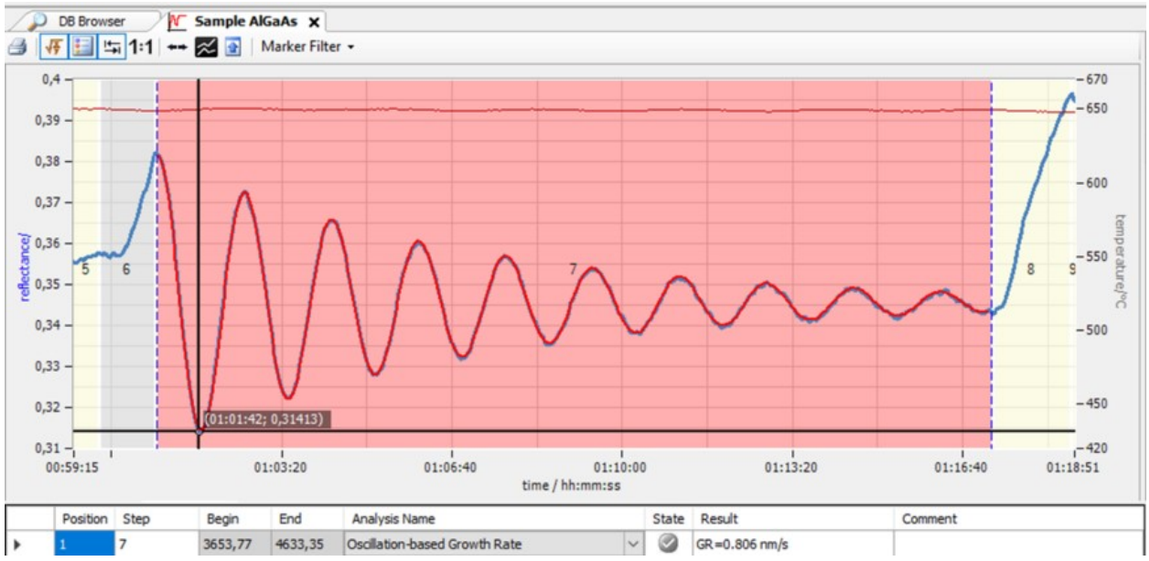


Fig. 1: Analysis screen of EpiNet® applying the "Oscillation-based Growth Rate" fit allowing deducing the growth rate and film thickness of thick layers based on pre-known refractive index n and extinction coefficient k. Here, the deposited material was AlGaAs and the respective values of n and k were taken from the EpiNet database. Note that the fit was exclusively applied to the process step marked in red.

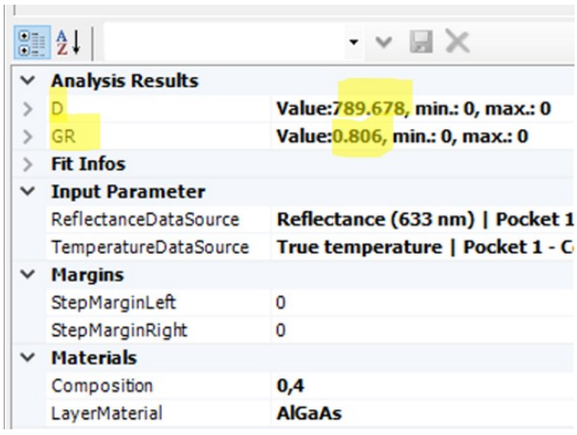


Fig. 2: Results window displaying the values for the thickness (D; in nm), and the growth rate (R; in nm/s). Additionally, the selected growing material is listed in the lower section.

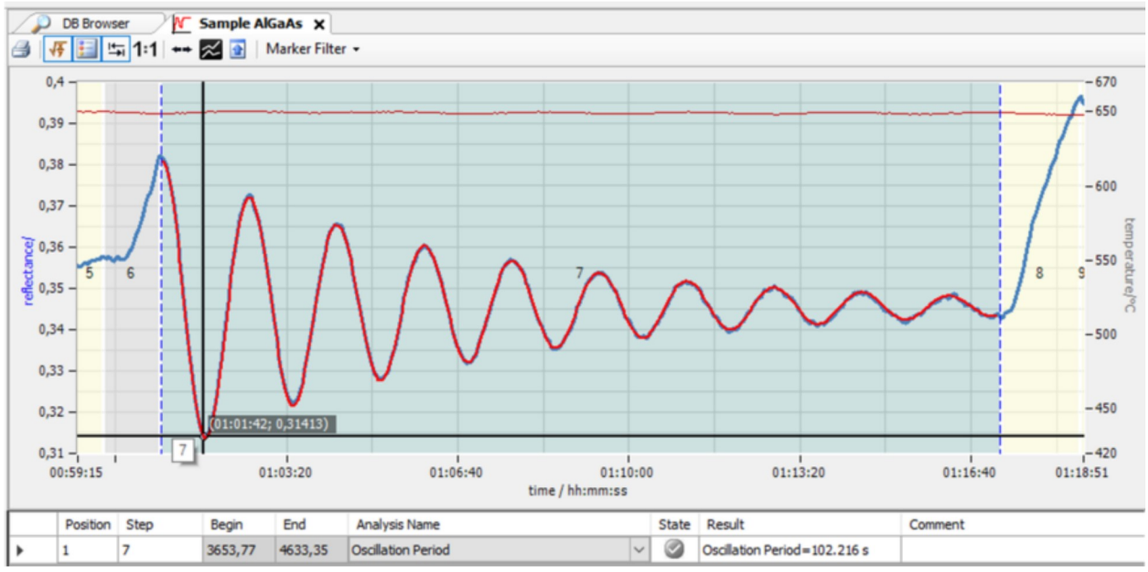
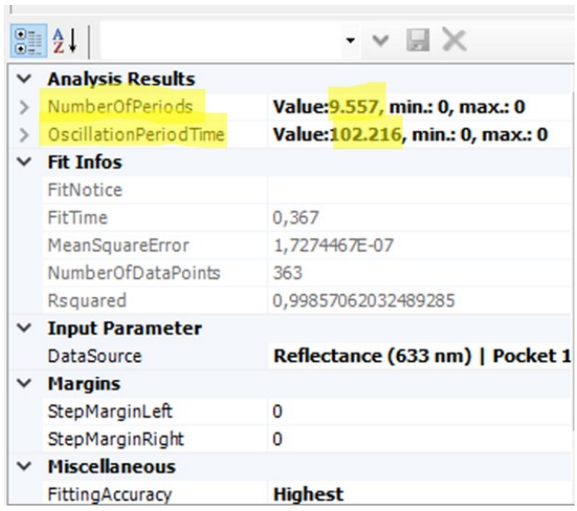


Fig. 3: Analysis screen of EpiNet® applying the "Oscillation Period" fit allowing for determining the oscillation period and the number of oscillations within the selected step based on a damped sinusoidal fit. Note that the fit was exclusively applied to the process step marked in red.

Fig. 4: Results window displaying the values for the oscillation period and the number of oscillations within the process step determined based on a damped sinusoidal fit.



Usage ideas and alternatives:

- The "Oscillation-based Growth Rate" fit is suitable for thick layers of known materials and a sinusoidal reflectance transient
- It is usually a good choice for quickly verifying whether reasonable results are obtained for a well-known growth process. Here, in particularly the appropriateness of the material parameters n and k are tested for consistence
- For detailed growth rate analyses or even unknown materials properties the NKR adv Virtual Layer Fit is usually a better alternative
- The most simplistic "Oscillation Period" fit is usually a suitable first step for approaching the analysis of new materials of unknown n and k in order to verify whether a "well-behaved" (i.e. damped sinusoidal) growth behavior is applicable for a given layer

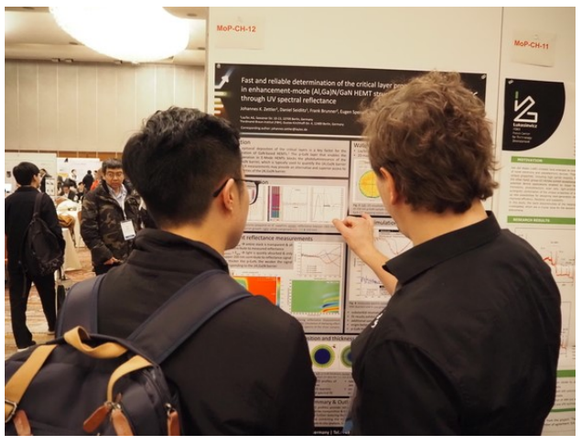
User instructions can be found in the manual and can be obtained via **info@laytec.de** Reference data is available in **EpiNet®**.

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!

Events 2024

We are looking back at some great events in 2023 and want to share some impressions here! This year you can meet us at the following exhibitions & conferences: **https://www.laytec.de/events**

We are looking forward to seeing you there!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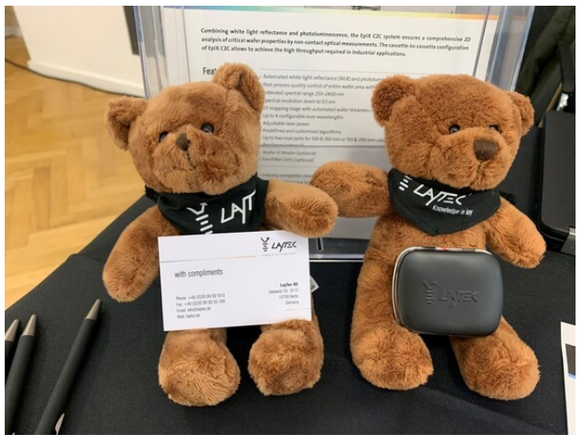
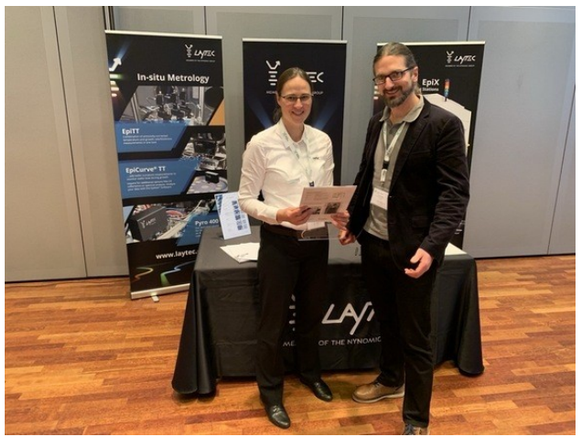

with compliments
LAYTEC


CERAMIC FORUM
CHINO


In-situ Metrology
EpiTT
EpiCurve® TT
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CS INTERNATIONAL CONFERENCE
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LAYTEC
InspiRe
In-situ monitoring of perovskite thin film formation
ILMetro
In-line metrology station for thin film deposition
PearL
Photoluminescence for thin film deposition
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We are very happy to announce our new sales & service partner for LayTec's metrology solutions – QES (Asia-Pacific) Sdn. Bhd!

QES will take over the distribution and service activities for LayTec related to the compound semiconductor market as well as non-MOCVD technologies like thin film photovoltaics, OLED, display production and further large area coating industries in Malaysia, Singapore, Vietnam, Indonesia, Thailand and Phillipines. Given the increasing demand in these industries, LayTec is glad to provide even faster and local support in the region.

QES, founded in 1991, specializes in manufacturing, distribution and provision of engineering services for inspection, test, measuring, analytical and automated handling equipment. QES Group of companies has since grown into a leading integrated solutions provider with manufacturing capability. Headquartered in Malaysia, QES has a strong direct presence through subsidiaries and affiliates in ASEAN countries and Singapore, Thailand, Indonesia, Philippines, Vietnam, Hong Kong (China) and Shanghai. QES's experiences and regional presence ideally complements LayTec's technological expertise for providing customised solutions to customers exactly where they are needed.

For more information, please contact SC Pang, **scpang@qesnet.com** or LayTec at **info@laytec.de**

Best practice for AbsoluT temperature calibration to reduce system-to-system variations

In the past years, the requirements for temperature monitoring and control during epitaxial processes for compound semiconductors increased significantly. Hence, the calibration of the in-situ monitoring systems becomes increasingly challenging. Unavoidable, small optical variations within different metrology systems (EpiTT/ EpiCurve® TT) and the calibration tools (AbsoluT) lead to minor, but significant deviations of the calibration between growth reactors. LayTec has therefore introduced a solution to improve the precision, reproducibility and accuracy of the temperature calibration that also reduces system-to-system variations. **Read more about this topic in the**

application note!

New research published by our partners and customers

From now on, we will present research papers published by our partners and customers in this section. In this work, they usually present research employing LayTec metrology systems on applications that go beyond their standard industrial use cases. Thereby, we hope to spread ideas within our integrated metrology community. Please also feel free to notify LayTec of any newly published work via info@laytec.de so that we can mention it here as well as on our LinkedIn channel. Enjoy Reading!

- Ta-Shun Chou and his colleagues from the Leibniz Institute for Crystal Growth (IKZ) published their work about “Homoepitaxial growth rate measurement and surface morphology monitoring of MOVPE-grown Si-doped (100) ß-Ga2O3 thin films using in-situ reflectance spectroscopy” in the Journal of Crystal Growth (vol. 603 (2023) 127003; **https://doi.org/10.1016/j.jcrysgro.2022.127003**) in which they applied autocorrelation analyses to in-situ reflectance monitoring data of gallium oxide homoepitaxy to analyze the growth behavior despite only small changes in reflectance intensity.

- Prof. Hideo Aida from Nagaoka University of Technology and his co-authors published their work on “Analysis of external surface and internal lattice curvatures of freestanding heteroepitaxial diamond grown on an Ir (001)/MgO (001) substrate” in Diamond & Related Materials (vol. 136 (2023) 110026; **https://doi.org/10.1016/j.diamond.2023.110026**) in which they applied an EpiCurve TT LP for an in-depth analysis of the dependence of curvature evolution during diamond hetero-epitaxy.

- The group of Prof. Takeuchi from Meijo University published their work on “In situ

cavity length control of GaN-based vertical-cavity surface-emitting lasers with in situ reflectivity spectra measurements" in the Japanese Journal of Applied Physics (vol. 62, 066504; **https://doi.org/10.35848/1347-4065/acdba9**) in which they used an EpiCurve TT VCSEL for controlling the cavity length in their VCSEL devices by combining spectral and transient based reflectance analyses.

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