Optimizing epitaxial layer uniformity by combining in-situ and ex-situ metrology

The combination of ex-situ wafer mapping and optical in-situ measurements during metal-organic vapor phase epitaxy (MOVPE) for laser devices constitutes a powerful method for obtaining maximum layer and die uniformity across the wafer for production of devices such as vertical-cavity surface-emitting lasers (VCSELs) or edge-emitting laser structures. This uniformity directly increases the yield in subsequent device processing with a strong cost impact. Ex-situ mapping measurements by means of white light reflectance (WLR) and photoluminescence (PL) are well-established methods to ensure sufficient uniformity prior to further processing in expensive dicing and packaging processes. Unfortunately, they do not directly disclose the root-cause of inhomogeneity that might be observed in these measurements. In contrast, in-situ measurements by means of emissivity-corrected pyrometry (ECP), reflectance and curvature directly reveal the effect of certain process parameter changes like heater or gas flow settings on the wafer temperature or layer composition. However, they never cover the entire wafer area and do not probe the layers under device operating conditions. Therefore, only a smart combination of both methods constitutes an efficient way for identifying the parameter mostly affecting the uniformity and tuning the process towards the most uniform layer properties across the wafer for cost-effective production.

Dr. André Maaßdorf et al. at the Ferdinand-Braun-Institute (FBH) established this approach by combining LayTec's EpiX mapping station (Fig. 1a), b)) and LayTec's in-situ measurement tool EpiCurve TT AR VCSEL+ (Fig. 1e)) for optimizing the gas flow profile and the susceptor configuration at their AIX 2800 G4 IC2 (12 x 4") epitaxial deposition system for AlInP/AlGaInP edge emitting diode lasers. The EpiCurve TT AR VCSEL+ combines curvature, three-wavelengths reflectance and emissivity-corrected pyrometry (ECP) of an EpiCurve TT with additional spectral reflectance capability. The EpiX-Mapper equipped with WLR and PL was deployed for wafer-mapping to deduce properties like layer thickness and emission wavelength. At the beginning of the optimization process a significant deviation in layer thickness (rel. deviations ≤ 8%) was observed (Fig. 1c). Moreover, in-situ ECP data obtained during deposition (Fig. 1d) revealed that the wafer temperature profile also exhibited a similar non-uniformity at the edges and further in the wafer center.

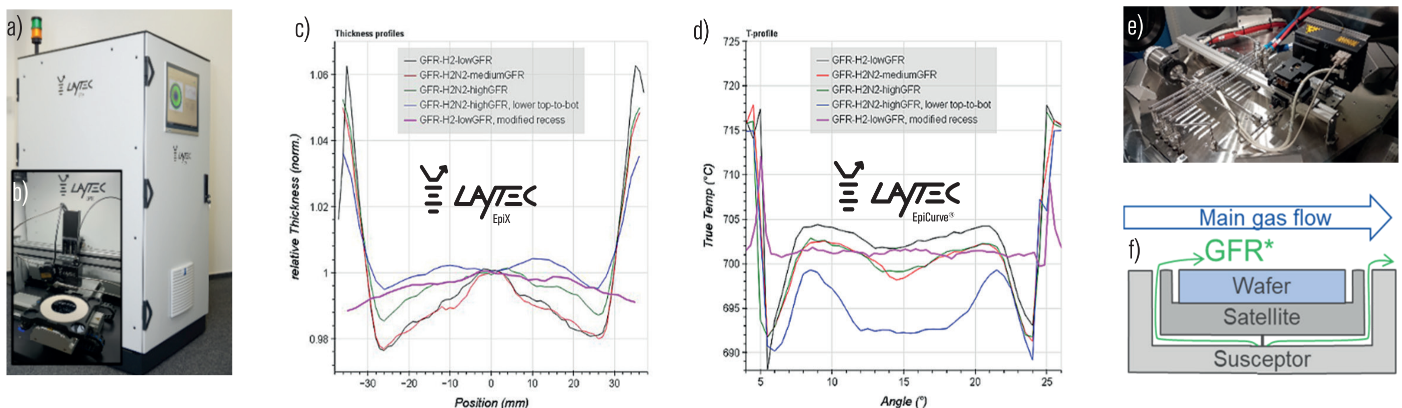

Fig. 1 a) EpiX mapping station for areal wafer inspection; b) xy-mapping stage of EpiX mapping station inside the cabinet shown in; c) Layer thickness wafer uniformity for various experimental configurations as measured with LayTec EpiX; d) Emissivity-corrected temperature wafer uniformity for the same configurations as measured in-situ by LayTec EpiCurveTT; e) EpiCurveTT mounted on the MOCVD reactor at FBH; f) Schematical sketch of the wafer susceptor configuration (GFR: Gas Foil Rotation)

Based on the results of the comparison of in-situ and ex-situ results, gradual modification of the gas foil rotation (GFR) and absolute gas flow, its distribution over the gas inlet as well as modification of recess of the wafer satellite led to an almost perfectly flat thickness profile (pink trace, Fig. 1c), d)).

These results clearly demonstrate the advantage of combining ex-situ wafer mapping to detect and eliminate wafer non-uniformities. Our upcoming application note will provide more details about this optimization process and will be available at www.laytec.de soon.

Save the date: LayTec is pleased to announce its 26th in-situ seminar on 11 July, 2022 in conjunction with **ICMOVPE XX** in Stuttgart, Germany. An official invitation and detailed information will follow soon.

Please note: LayTec announces the discontinuation of the software support for the NI PCIe 6025 data acquisition card. EpiNet 2.7 will be the last version that will be available for the usage with systems using this card. For further information please click **here.**

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