LAYTEC Knowledge is key

NEWSLETTER: April 21, 2016

EpiNet-SECS/GEM

A major European semiconductor manufacturer has qualified LayTec's EpiNet-SECS/GEM software package for MES integration in his power electronics production line! The software continuously transfers comprehensive wafer related in-situ metrology data to the fab's MES system throughout MOCVD runs: local wafer temperature, reflectance and wafer bow of up to 256 wafer zones. Furthermore, at the end of each epi run, the latest version of this software forwards to MES additional SPC information on growth rates, film compositions and surface roughness of pre-selected epi-steps.

Advanced process control with LayTec in-situ metrology

At Jenoptik Diode Lab (Germany), LayTec EpiTTs monitor MOCVD growth of edge emitting laser bars (Fig. 1). The tools are routinely used to calibrate growth rate and composition during calibration runs as well as to control production runs (Fig. 2). Specific key values, such as temperature or growth rate of specific layers on specific wafers, are extracted from the in-situ data and transferred into the MES (manufacturing execution system) for SPC (statistical process control). So, process stability can be monitored run-to-run and potential deviations can be detected immediately, paving the way for run-to-run control. The data in Fig. 2 (red circle) shows slight trends from run to run within one session. The deviations are based on conditioning effects of the reactor caused by an increasing coating. Jenoptik's experience proves that EpiTT is a valuable part of process control. Learn more at laytec.de/apc.

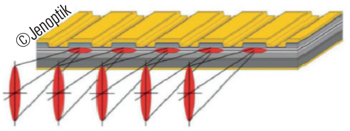


Fig. 1: Cross-sectional schematic of edge emitting laser bar.

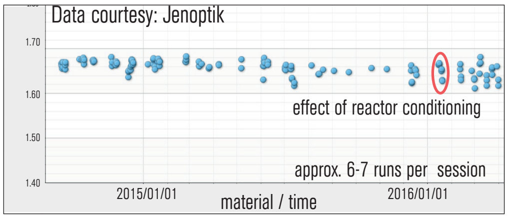


Fig. 2: In-situ growth rate data of one wafer and one specific layer, extracted from the MES system, showing all growth runs within 1.5 years as used for SPC in production.

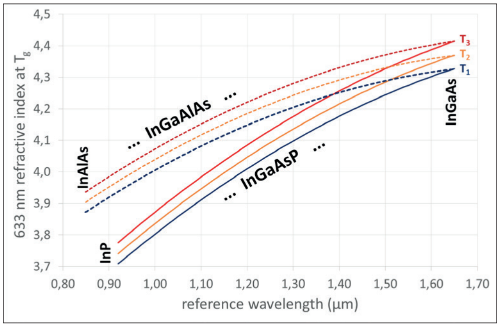
EpiTT Gen3: XRD referenced nk database for InP and related materials

InP based materials exhibit higher electron mobility and higher frequency response compared to GaAs. This makes InP HBTs a good candidate for next generation trans-impedance amplifiers in optical fiber communications and for 5G applications. Moreover, since InP HBT's base bandgap energy is much lower than that of GaAs HBTs, the InP based device's turn-on voltage and related power consumption are significantly lower. However, the high-yield MOCVD growth of device grade quaternary InGaAsP and InGaAlAs structures precisely lattice matched to InP is rather challenging, especially on larger wafers. The solution is in-situ process control based on accurate high temperature quaternary nk data.

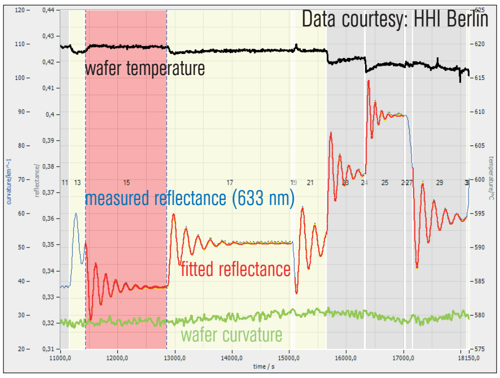
Together with Dr. Tony SpringThorpe's team at National Research Council of Canada and Christoph Hums and his co-workers at Fraunhofer HHI Berlin (Germany), LayTec has further improved the accuracy level of its nk database for these two quaternary material systems. Fig. 3 gives selected examples: Fig. 3a shows the 633 nm refractive index of InGaAsP and InGaAlAs in the full composition range at three relevant growth temperatures $T_1<T_2<T_3$. With n(x,T) and k(x,T) available for the full range of lattice matched quaternary compositions, precise and quantitative process control becomes straight forward. Fig. 3b demonstrates the smooth fit to in-situ reflectance of a device structure. In-situ wafer bow sensing (green line in Fig. 3b) by EpiCurve®TT validates the lattice matched growth.

For this highly precise nk database, growth rates and accurate lattice match were carefully matched to ex-situ XRD. Wafer temperatures were measured by EpiTT, which had been previously calibrated by AbsoluT. Find more at www.laytec.de/materials.

Fig. 3: Control of device related InGaAsP and InGaAlAs film growth on InP: When lattice matched growth is validated by in-situ wafer bow sensing, both quaternary material systems can be treated as an effective quasi-ternary mixture: $(InGaAs)_x(InP)_{1-x}$ and $(InGaAs)_x(AlGaAs)_{1-x}$, respectively.



a) The respective composition range (x=0…1) covers the reference (PL) wavelength range 0.92–1.65 µm for InGaAsP and 0.85–1.65 µm for InGaAlAs. The three lines for each material system give the 633 nm refractive index at three wafer temperatures.



b) The quaternary/ternary layers (steps 17–29) are lattice matched to InP (step 15) as can be seen from the unchanged wafer curvature (green line). Hence, the measured 633 nm reflectance data (blue line) of an InP/InGaAsP device structure can be exactly fitted (red line) yielding all compositions x and all growth rates. The −3 K reduction in wafer temperature due to the changed As/P ratio is a real effect.

You can meet us at the following workshops, conferences and trade fairs:

16–19 May 2016 | CS ManTech | Miami, FL, USA

12–16 June 2016 | ICCG-11 | Braunschweig, Germany

4–8 July 2016 | ICEM 2016 | Suntec, Singapore | Talk: In-situ Metrology for Advanced Device Fabrication in Semiconductor Epitaxy