EpiTT 405: InGaN MQW monitoring in GaN LED production

In respond to the growing interest of LED manufacturers world-wide, LayTec recently came up with a new EpiTT version for measurements at 405nm instead of 633nm. The TT performance and reflectance measurements at 950nm remain unchanged. 405nm is an ideal wavelength for InGaN growth monitoring as the following data shows.

Blue and white LEDs consist of thin InGaN layers which are active layers embedded in thick n- and p-type GaN layers. Standard reflectometers work at 633nm that is ideal for GaN growth monitoring, but in case of InGaN the growth can be monitored at 633nm only indirectly due to temperature effects, whereas the wavelength of 405nm makes it possible to monitor the growth directly and precisely. The advantage of 405 nm reflectance wavelength is mainly that the first grown GaN buffer layers are absorbing the light at 405nm (as the dark blue curve in Fig. 2 shows) causing no further Fabry-Perot oscillations, so that the growth of InGaN quantum wells on top of the GaN buffer can be studied in full detail and used for wafer-to-wafer and run-to-run comparison.

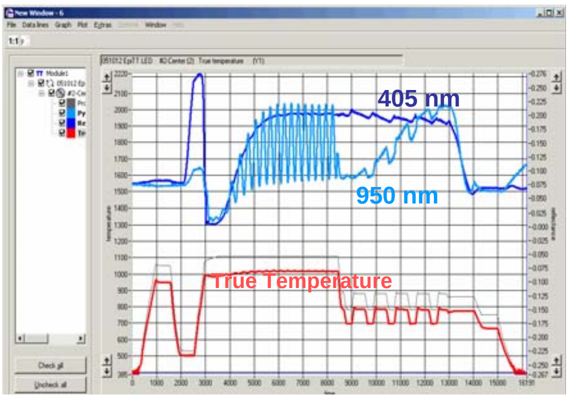

Fig.1: Growth of an InGaN/GaN LED structure in a planetary AIX 2600 G3 system with 11x2" configuration.

The new EpiTT 405 has already demonstrated its advantages in InGaN/GaN LED growth runs: differently from the 950nm reflectance, the 405nm data taken during buffer layer growth and MQW growth are not correlated anymore! Hence, small deviations in the GaN growth rate (wafer-to-wafer, run-to-run) do not limit the quantitative analysis of the 405nm data measured during the MQW growth. This is especially advantageous for the application in AIX planetary reactors with 24x2” wafer configuration, where no rotation symmetry of 3 wafers on one satellite is provided.

Measurements at 405nm allow studying effects of Indium variation as well as morphology effects. Fig. 1 shows reflectance traces for 950nm and 405nm and True Temperature transients for one wafer in a typical GaN LED-growth run. The 950nm data still can be used for GaN buffer growth rate analysis, while the 405nm signal is sensitive to InGaN quantum wells and does not depend on buffer thickness variations. Furthermore, the refractive index is less sensitive to temperature variations at 405nm than at 633nm, which means that the inherent temperature variations between quantum well and barrier deposition cause less temperature related changes in the refractive index.

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Analysis of the 405nm reflectance makes it possible to measure and – which is even more important – to distinguish signal process deviations in the InGaN growth rate and the InGaN composition. LayTec has carried out comprehensive tests to find the answer to the question: do InGaN composition and InGaN growth rate influence the 405nm reflectance differently, so that both parameters can be separated?

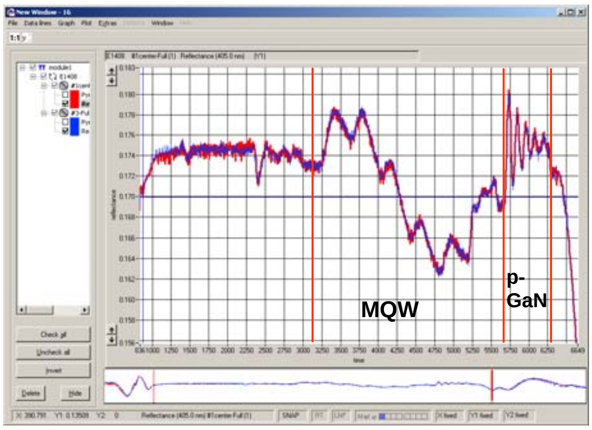

Fig. 2a: Wafer to wafer comparison in AIX planetary for ideal growth.

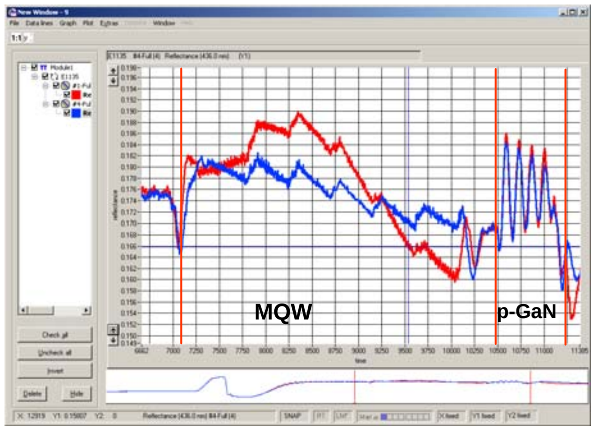

Fig. 2b: Effect of substrat miscut/roughness on InGaN MQW growth (blue: ideal growth; red: rough MQW on substrate with a wrong miscut).

Fig. 2 demonstrates 405nm reflectance data from two wafers in the same growth run: in Fig. 2a the two wafers show ideal homogeneous InGaN LED growth; Fig. 2b provides an example of a non-reproducible growth. In the second case the different InGaN QW quality shows up. However, after the MQW region the 405nm Fabry-Perot oscillations correspond again with the measurement of the p-GaN layer grown on a smooth surface.

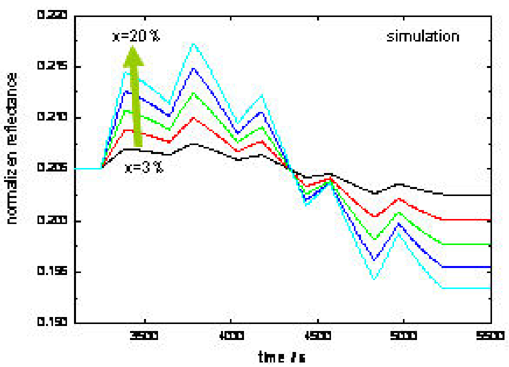

Fig. 3: Simulation effect of Indium content variation on the reflectance data at 405nm.

Variations of the Indium content, the InGaN growth rate as well as of the morphology of the GaN buffer and InGaN layers influence the 405 reflectance during MQW growth. With LayTec's software **AnalysR** all three effects can be simulated. A simulation of Indium content variations is shown in Fig. 3. Variations of the Indium content in the range of 1% already show up in the reflectance data by an initial increase in the amplitude of the signals.

EpiTT 405nm modules are now available as exchange parts for existing EpiTT LED systems. A solution for **EpiTTs** with halogen light sources (TSSEL) is under development.