

Patterned Sapphire Substrates

Fast and easy growth analysis on PSS

Patterned Sapphire Substrates (PSS) are becoming indispensable in GaN LED production. LEDs grown on PSS typically have larger light output and better crystal quality. To take MOCVD processes on PSS under tight in-situ control, some additional efforts are needed. Every kind of patterned substrate, e.g. cone, dome (Fig. 1) or spherical pattern, requires individual calibration of the reflectance signal before the process. This document describes an easy automated way to meet this challenge.

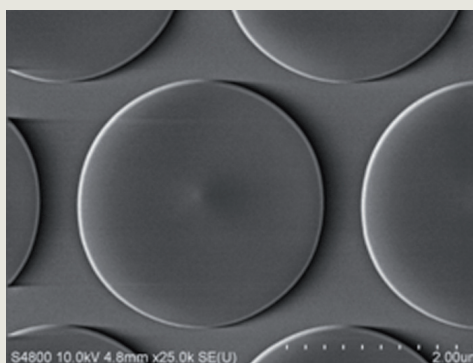
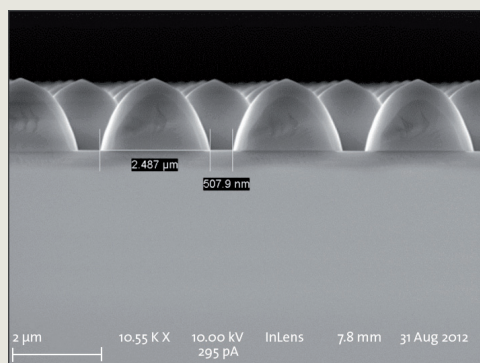


Fig. 1: REM images of PSS with domes (left) and cones (right) as pattern.

LayTec's in-situ metrology software EpiNet can be individually customized for various kinds of patterned substrates. Our users can expand the substrate database of the software by themselves. LayTec's Calibration Manual explains how to measure PSS reflectance in different pockets in one single calibration run. If required, LayTec also offers related customer trainings.

Once the initial reflectance values of the PSS substrates are uploaded to the EpiNet substrate database, the operator has the option to choose the needed substrate type in the RunType's Material Spec window as shown in Fig. 2. As a result, all PSS wafers can be monitored with the same accuracy as standard sapphire substrates.

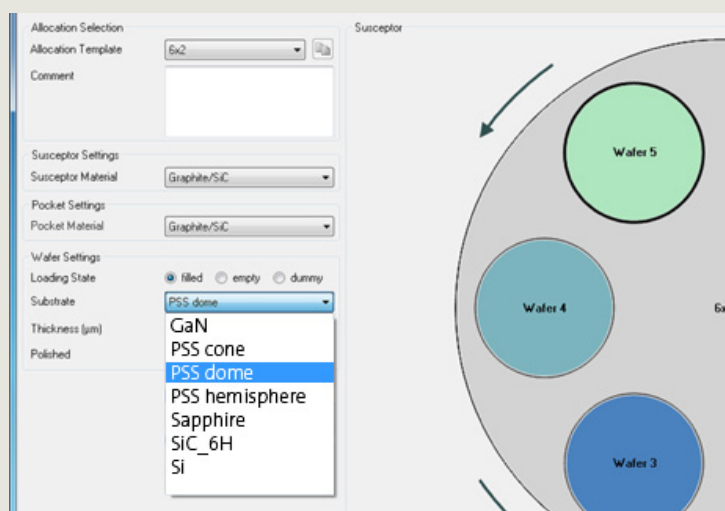


Fig. 2: Extract of a RunType's Material Spec window of LayTec's EpiNet software with customized database extended with additional PSS types.

Fig. 3 demonstrates a reflectance signal during GaN growth on PSS. The initial reflectance of the bare PSS substrates is typically lower than that of standard single-polished sapphire. In addition, the initial reflectance of the three wavelengths (405 / 633 / 950 nm) is very different because the interaction of light with the 3 dimensional nano-/micro-patterning (scattering, diffraction, interference) strongly depends on the wavelength. In the screenshot (Fig. 3), the increasing reflectance amplitude (after ~4000 s of the growth process) shows the coalescence process of GaN. After ~8050 s, the 405 nm reflectance stays stable at 15.5%, which is an indication of the GaN surface quality improvement. The 633 nm and 950 nm reflectance signals have well developed interference patterns.

Interestingly, some lateral non-uniformity of the PSS structures across the wafer obviously show up in these data.

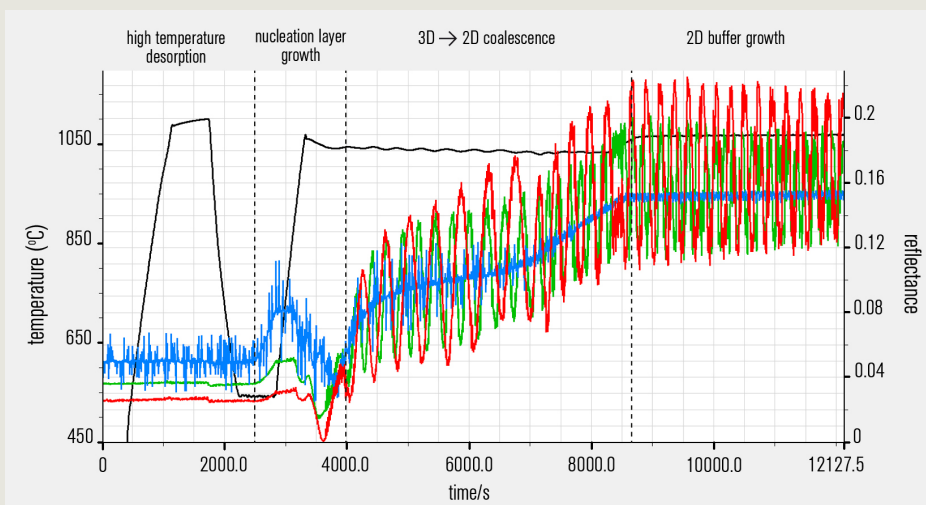


Fig. 3:
GaN growth on PSS measured by LayTec's EpiCurve®TT installed on AIXTRON Planetary® G3 reactor at FBH, Berlin, Germany.
Screenshot of EpiNet software: reflectance at 405 nm (blue), 633 nm (green), 950 nm (red); True Temperature (black).

The initial 405 nm reflectance on the bare PSS substrate (0... ~4000 s) is noisy, while 633 nm and 950 nm reflectance is rather smooth. The 405 nm wavelength is in resonance with some geometric parameters of the pattern's structure, which is non-uniform. As soon as the GaN buffer is thick enough, the 405 nm light does not reach the pattern anymore because of the absorption in the GaN. Hence, the 405 nm reflectance „noise“ reduces because the GaN surface is rather smooth. However, the interference patterns of the 633/950 nm reflectance look „noisy“ during 2 D buffer growth. Obviously, the initial non-uniformity of the PSS structure causes a certain non-uniformity in the GaN thickness.

LayTec's EpiNet software makes it easy to take LED growth processes on PSS under tight in-situ control. It quickly identifies even quality deviations and non-uniformities of the PSS substrates. Furthermore, the software also contains fitting of thin layers, wafer bow calculation and many further features indispensable for growth on PSS.

For further information please ask for EpiNet Flyer or contact: sales@laytec.de