Pyro 400 for real GaN surface temperature

LayTec has developed a new generation of pyrometers working at the wavelength of 400 nm: Pyro 400. The tool is the first real solution for direct surface temperature measurements of GaN layers. The temperature information provided by Pyro 400 is essential for further growth optimization and temperature control for future GaN LED and laser production.

Unlike conventional infrared pyrometry, which can only detect the temperature of the susceptor under the sapphire or SiC wafers, **Pyro 400** performs pyrometry on the actual GaN layer.

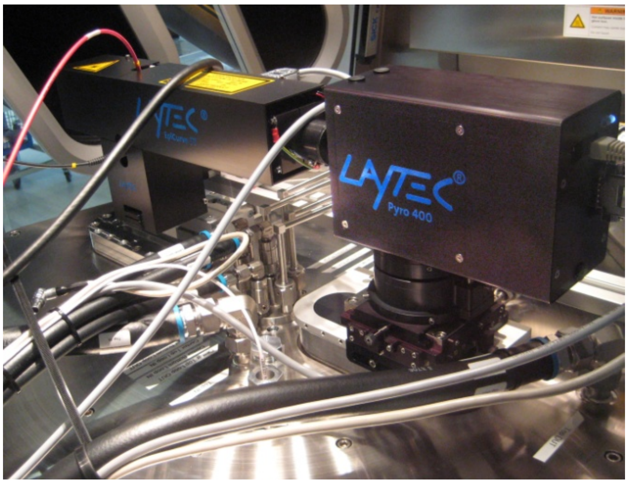

Fig. 1: Pyro 400 and **EpiCurve®TT** installed on Aixtron G4 Planetary® system for simultaneous temperature, reflectance and wafer bowing measurements.

At the wavelength of 400 nm GaN absorbs and thermally emits light, which enables pyrometry measurements of its surface temperature.

The **Pyro 400** system is specially designed for AIXTRON Planetary® MOCVD systems. If the second view-port is available, it can be combined with other in-situ monitoring systems such as **EpiCurve®TT** for simultaneous measurements of wafer bowing and reflectance at two wavelengths (**Fig. 1**). **Pyro 400** was recently approved in production lines by industrial customers and research institutions.

Fig. 2 shows typical linescan measurements: **Pyro 400** monitoring the wafer temperature profile during a full revolution of the susceptor. The data provides direct access to the GaN surface temperature distribution across each wafer in a planetry reactor. Together with the complementary reflectance and curvature data measured by **EpiCurve®TT**, the in-situ measurements give all information needed to optimize uniformity and LED performance. The data clearly shows that wafer bowing causes changes in temperature distribution and proves that the center of concave bowed wafers is hotter than the edges.

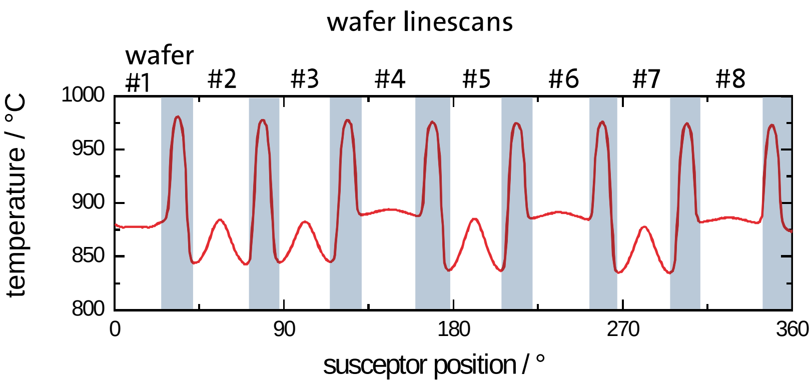

Fig. 2: Pyro 400 linescan measurement of 8x3“ configuration. Dummy wafers with a strong concave bowing (#2, 3, 5, 7) have a different temperature profile than GaN templates with just a slight concave bowing (#4, 6, 8). Blue background marks the gaps between wafers.

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Fig. 3 demonstrates screenshots taken during GaN based laser structure growth. On the left side of the screenshots there are colorplots of the whole structures grown on 11 wafers: 1st layer – GaN buffer, 2nd layer – GaN/AlGaN superlattice, 3rd layer – quantum wells. The blue curves in the right upper corners show the time-resolved temperature at a certain point on wafer #11, the curves in the lower graph on the right show the temperature distribution over the wafers (red) and susceptor (grey) at a certain point of time. The position and the time can be chosen with the cross cursor on the 3-dimensional colorplot (black crossing lines).

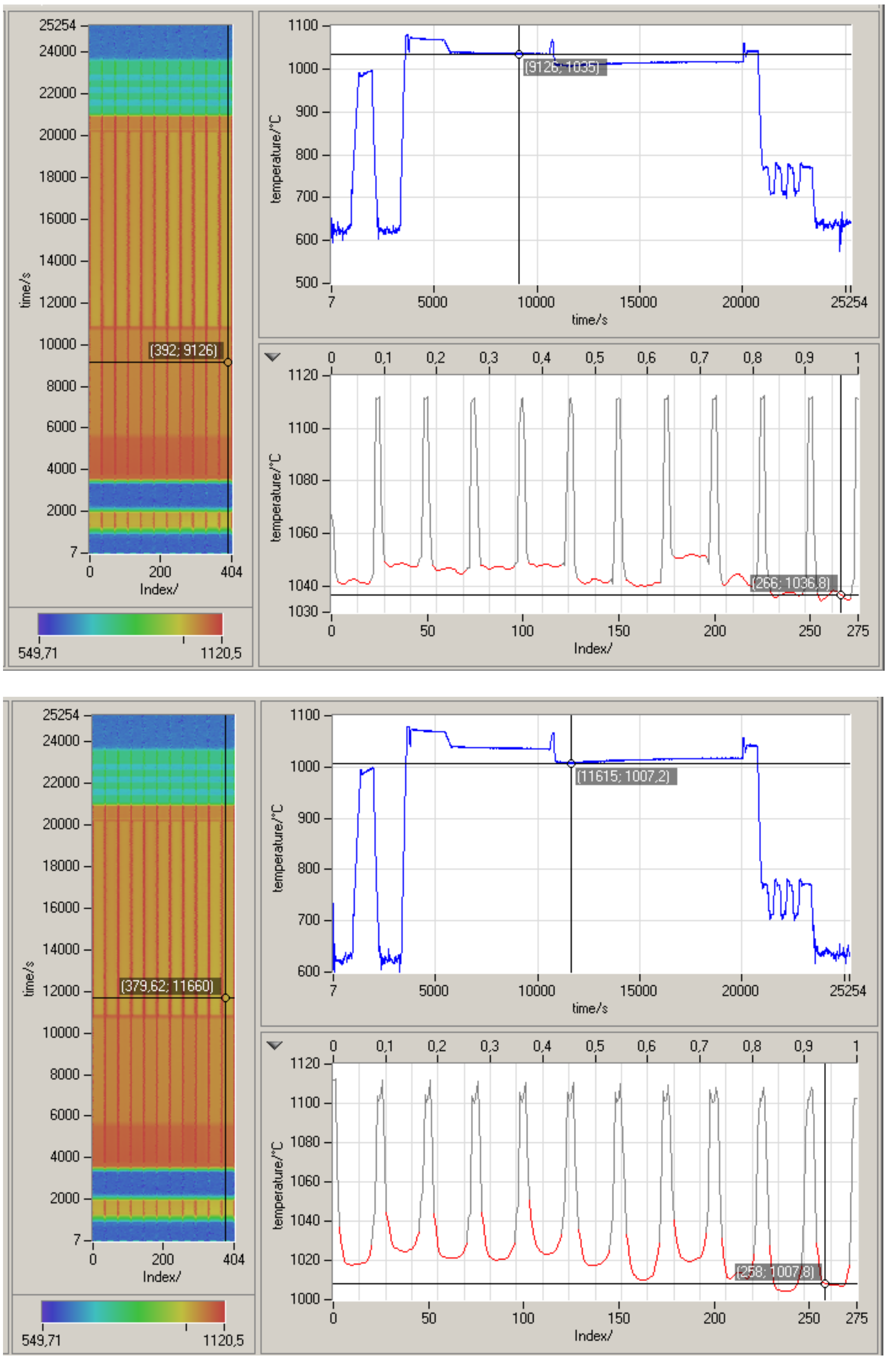

Fig. 3: temperature measurements with **Pyro 400** during GaN based laser structure growth on 11 wafers:

a) linescan of GaN buffer growth: the temperature in the center of the wafers is higher than at the edges (convex red curves)

b) linescan of AlGaN superlattice growth: the temperature in the center of the wafers is lower than at the edges (concave red curves)

According to the linescan in **Fig. 3a** taken during GaN buffer growth, the temperature in the center of the wafers is slightly higher than at the edges (convex red curves). This changes significantly when changing to different growth conditions for superlattice growth: the linescan of the AlGaN superlattice growth (**Fig. 3b**) shows that the temperature in the center of the wafers is lower than at the edges (concave red curves).

Pyro 400 is capable of measuring the slightest temperature deviations of the surface. **Fig. 4** shows temperature curves of quantum well growth on 5 wafers (marked with different colors). Temperature variations of 1-3 K between different pockets can be resolved clearly.

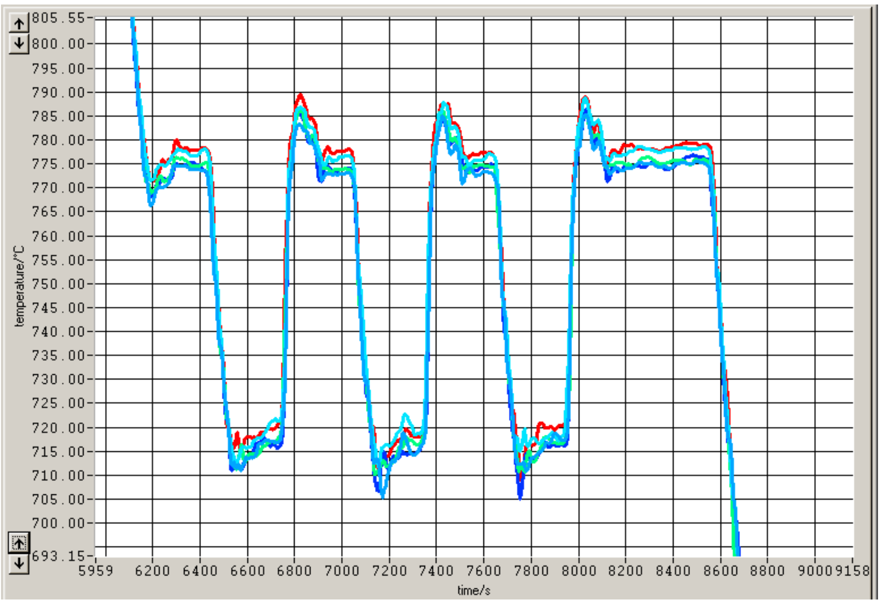

Fig. 4: time-resolved temperature measurements of quantum well growth on 5 wafers (each wafer is marked with a different color)

Using **Pyro 400** it was also proven that the real surface temperature of GaN is sensitive to changes of carrier gas, rotation speed, and reactor pressure. These GaN surface temperature effects cannot be detected by conventional infrared pyrometry.

Fig. 5 shows as an example how the real temperature of the layer surface changes, when the pressure is reduced from 400 mbar to 50 mbar. The measurements were conducted in an AIXTRON Planetary® MOCVD system with gas foil rotation. As the satellite rotation increases due to less pressure in the chamber, the flying height of the pocket increases, which cools the pockets by approx. 75 K (green curve). Yet the wafer surface temperature decreases even more by further 30 K (blue and red curves). These changes can be seen only with **Pyro 400**, whereas the process temperature measured by the light pipe (black curve) did not show any effects. Conventional infra-red pyrometry would only detect the effect on the pocket temperature (green curve).

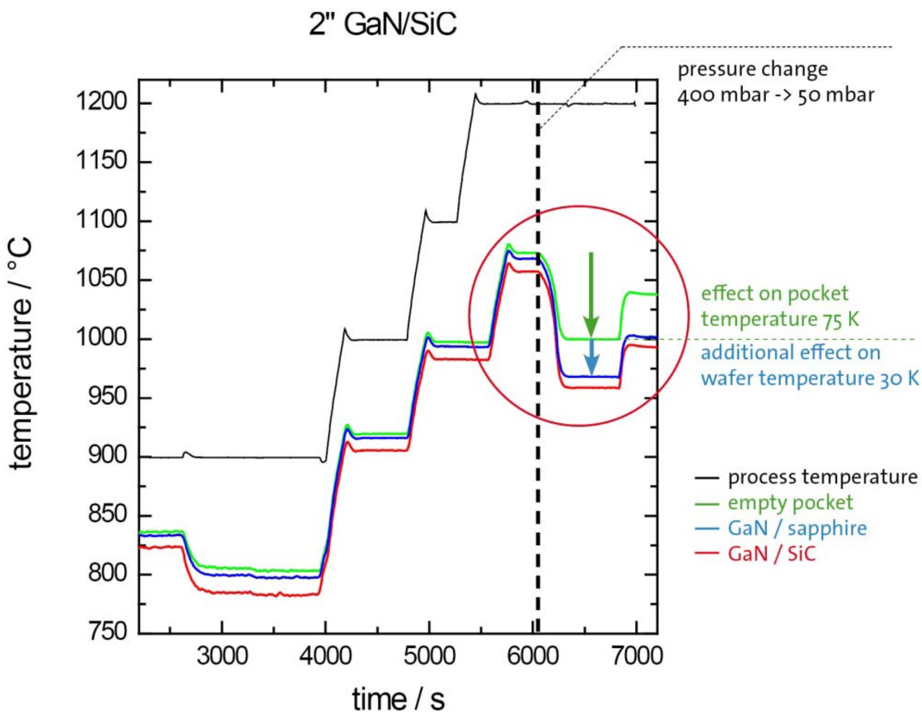

Fig. 5: Effect of pressure change on the temperature: while process temperature remains unchanged, **Pyro 400** (green, blue and red curves) "noticed" the changes in the pocket temperature (75 K) and wafer temperature (30 K). Black curve – process temperature measured by light pipe.

Additionally to these advantages, there are no emissivity oscillations during GaN buffer growth, which makes **Pyro 400** an ideal tool for temperature feed-back control application.

In summary, **Pyro 400** provides a new quality of temperature measurement with an unrivalled accuracy and will be of huge benefit in GaN based LED and laser production in the near future.