7×6 inch multi wafer Planetary Reactor® for the HBT and p-HEMT mass production

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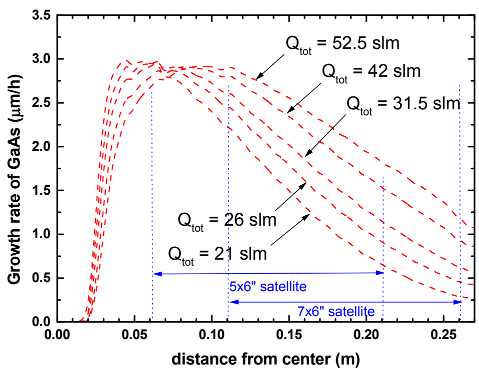
The AIXTRON Planetary Reactors® are proven to grow layers with outstanding uniformity along with highly efficient precursor utilization. We continued the development of the well proven 5x6" reactor and further expanded the capacity by 40% to a novel 7x6" configuration to meet the todays production requirements of the III-V compound semiconductor industry.
Computational modelling of the GaAs MOVPE process in the Planetary Reactor® reveals the dependence of layer thickness profiles on process parameters. In Fig. 1 the dependence of deposition uniformity on large 6" substrates in the 7x6" configuration upon total flow rate is shown. Predicting parametric dependencies for a wide variety of applications allowed us to speed-up uniformity tuning for various process conditions in this newly developed equipment.



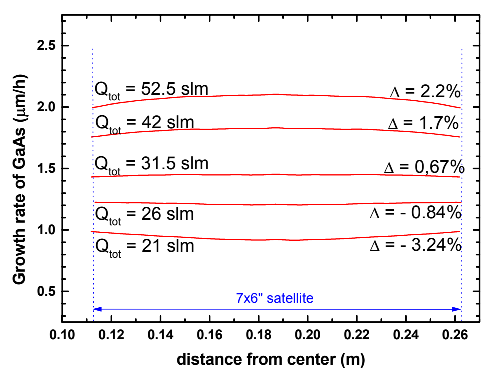


Fig. 1: Dependence of computed growth rate profiles on total flow rate in the AIX 2600 G3 7x6 inch configuration (left) on static substrates, (right) on rotated substrates.

Based on modeling results, taking into account the detailed heat transfer in the process environment we achieved an excellent temperature distribution of less than ±1°C determined by pyrometric temperature measurement (c.f. Fig.2).
The preceding computational modeling results could be approved by growth and doping experiments of GaAs, $Al_{0.3}Ga_{0.7}As$ and GaInP, which are prominent materials for HBT and HEMT structures. The layers showed very good thickness and doping uniformity confirmed by PL, XRD, Hall effect and sheet resistance measurements on wafer as well as wafer to wafer.

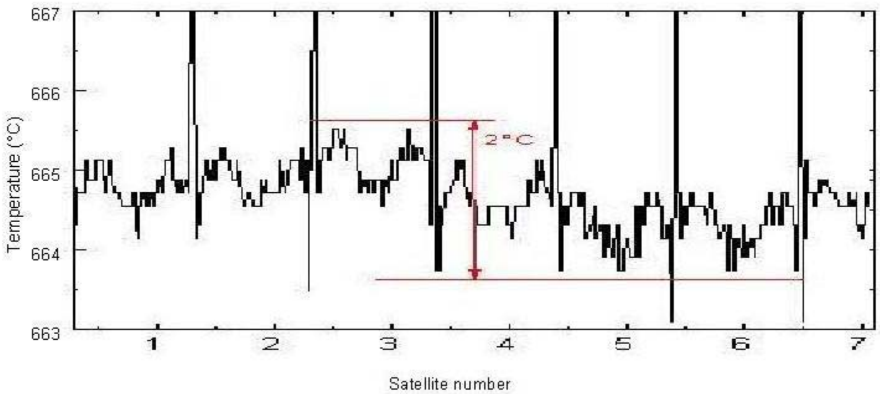
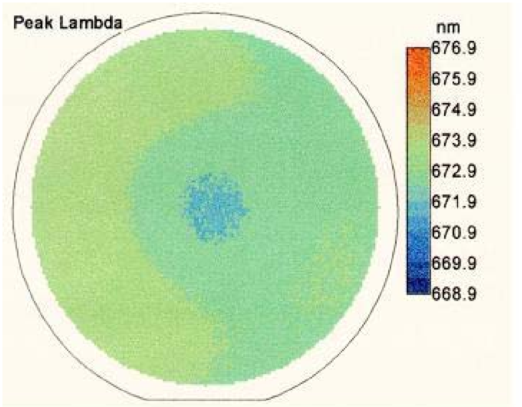


Fig.2 Wafer to wafer temperature distribution in an AIX 2600 G3 (7x6")
The temperature distribution on wafer as well as wafer to wafer is better than ±1°C.
The spikes are related to the higher temperature of the graphite between the satellites.

Fig. 3 shows Lehighton sheet resistance measurements on n- and p-type GaAs layers. The doping uniformity of GaAs resulted in standard deviations of 1.2% at a value of $8x10^{17}cm^{-3}$ for n-type and 1.2% at a value of $3x10^{19}cm^{-3}$ for p-type. The wafer to wafer homogeneity within one run was 0.4% and 1.4% for n- and p-type, respectively.

Fig. 3: On wafer doping homogeneity of 6" n-GaAs (left) und p-GaAs (right).

From PL and white light interference measurements we determined the wavelength and the composition of the grown AlGaAs and GaInP layers. The Al content in the AlGaAs layers was 31.7% with a standard deviation of 0.5% on wafer and 0.4% wafer to wafer. This results in a wavelength of 673nm with a standard deviation of 0.56nm over the wafer. The wafer to wafer deviation within one run was 0.4nm (c.f. Fig. 4). The thickness of the AlGaAs layers was 2µm with an standard deviation on wafer of 0.2% and wafer to wafer deviation of ±0.5%.



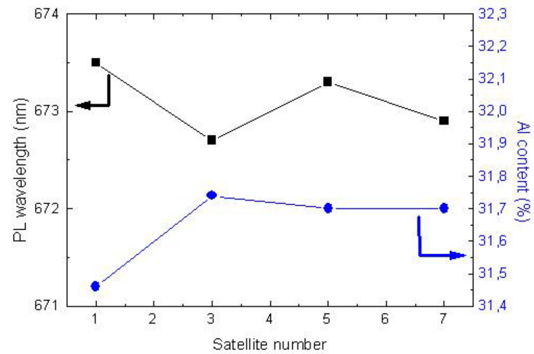
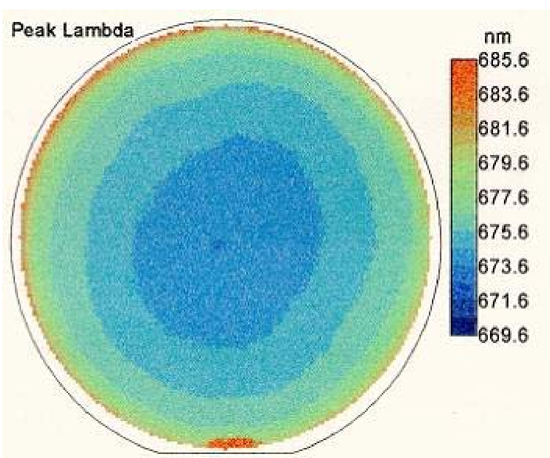


Fig. 4a: PL mapping of a 6” AlGaAs wafer with λ_{mean}=673nm and σ=0.6nm

Fig. 4b: wafer to wafer distribution of PL wavelength and Al content in a 7x6” Planetary Reactor® for AlGaAs

The growth of GaInP showed excellent layer homogeneity. We found a Ga content of 47.5% with a standard deviation of 0.75% on wafer and 0.3% wafer to wafer. The resulting wavelength was 676nm with a standard deviation of 1.8nm over the wafer. The wafer to wafer deviation within one run was 0.8nm (c.f. Fig. 5)



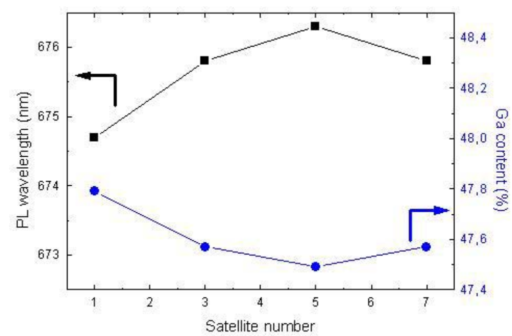


Fig. 5a: PL mapping of a 6” GaInP wafer with λ_{mean}=676nm and σ=1.8nm

Fig. 5b: wafer to wafer distribution of PL wavelength and Ga content in a 7x6” Planetary Reactor® for GaInP

The thickness of the GaInP layers was 1.3µm with a standard deviation on wafer of 0.5% and wafer to wafer deviation of ±0.1%.

In conclusion we present modeling results of the AIX 2600G3 MOCVD reactor in the 7x6” configuration for the growth of HEMT and HBT structures. We show the excellent homogeneity for the growth of GaAs, AlGaAs and GaInP layers on wafer as well as wafer to wafer which proves the qualification of the 7x6” configuration as a mass production tool for the III-V compound semiconductor industry.