

## Efficiency optimized 18x3 inch Planetary Reactor<sup>®</sup> for AlGaInP based optoelectronic applications

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The Cost of Ownership (CoO) optimized AIX 2600 G3 Planetary Reactor<sup>®</sup> in the 12x4 inch and 49x2 inch configuration has set a new standard for mass production tools for LEDs. To close the gap between 2 inch and 4 inch systems the 18x3 inch configuration was developed using all the experience regarding precursor efficiency optimization, temperature management and gas injection from the 12x4 inch and 49x2 inch configurations.

In order to realize the productivity driven specifications of today's multiwafer systems the MOVPE deposition in a 18x3 inch configuration was analyzed taking into account the substantial physical and chemical processes by means of numerical simulation. Using this tool we optimized reactor geometry and hardware and determined the best process parameters for the particular hardware correlated to physical and chemical limits. Based on the experience from the 12x4 inch and 49x2 inch systems an efficient configuration requires a large, cold center with a large cold nozzle. Realizing these design criteria allows suppressing pre-reactions in the gas phase and avoids parasitic depositions on nozzle and reactor center which could cause particle generation and constitute a loss in efficiency. The temperature offset between entrance zone in front of the satellites and the wafer surface was kept below 15 K leading to a constant gas phase composition over the whole satellite. This is an essential requirement for a uniform composition of the grown layers. Fig. 1 show the 18x3 inch configuration with its large quartz center and short entrance zone as well as the large nozzle positioned close to the ceiling to achieve low nozzle temperatures.

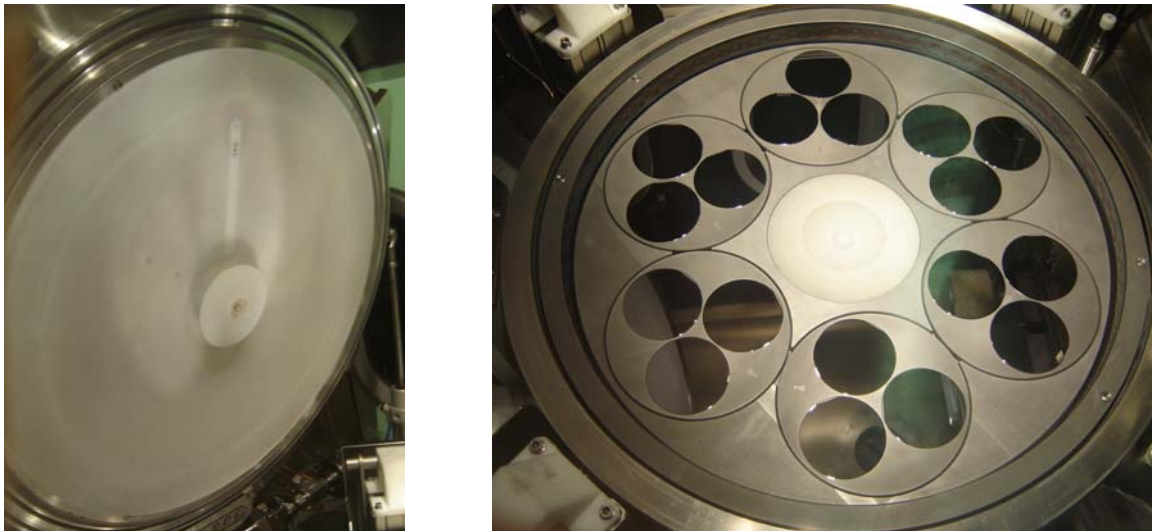


Fig. 1: 18x3 inch configuration: ceiling with large cold nozzle, susceptor with large cold quartz center.

In support of the process development we used the simulations to find the best flow regime for the AlGaAs and GaInP material system. (c.f. Fig. 1 for AlGaAs). One can easily see that the large nozzle and the cold center lead to a minimized loss of material in the entrance zone of the reactor, however the maximum of deposition is right before the satellite which is necessary for a uniform deposition on the rotated wafer. The plots include the depletion profiles for different total flows at fixed precursor flows and a fixed ratio between group III and group V inlet. A transition from a concave to a convex deposition profile on the rotated satellite can be observed, which guarantees the process tuning to uniform conditions. Comparable simulations for the GaInP material systems show a similar behavior.

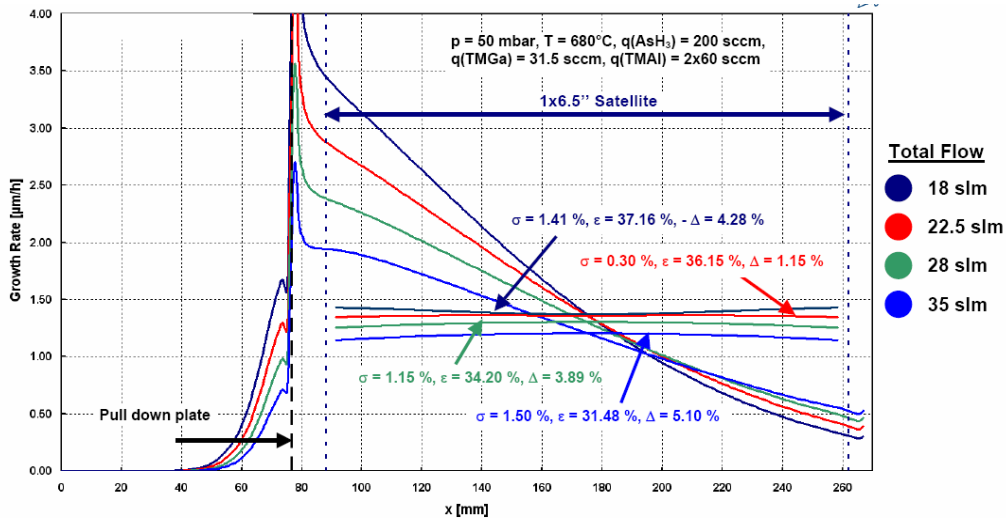


Fig. 2: Simulated depletion profiles for AlGaAs for different total flows in the reactor chamber. The horizontal lines indicate the thickness distribution over a rotated satellite.

To assess the suitability of the system for mass production of AlGaInP devices, the key processes for As/P based LEDs were developed including a AlGaAs/AlGaAs-DBR and a 10 period MQW with a Al<sub>70</sub>GaInP barrier and a Al<sub>20</sub>GaInP well. In Fig. 3 the wavelength distribution for DBR and MQW is shown. The DBR has an average stopband center wavelength of 594.6 nm with an standard deviation of 2.1 nm. The MQW has an average wavelength of 608 nm with an standard deviation of 0.8 nm. These achieved values proof the capability of the 18x3" configuration for today's requirements to an mass production system.

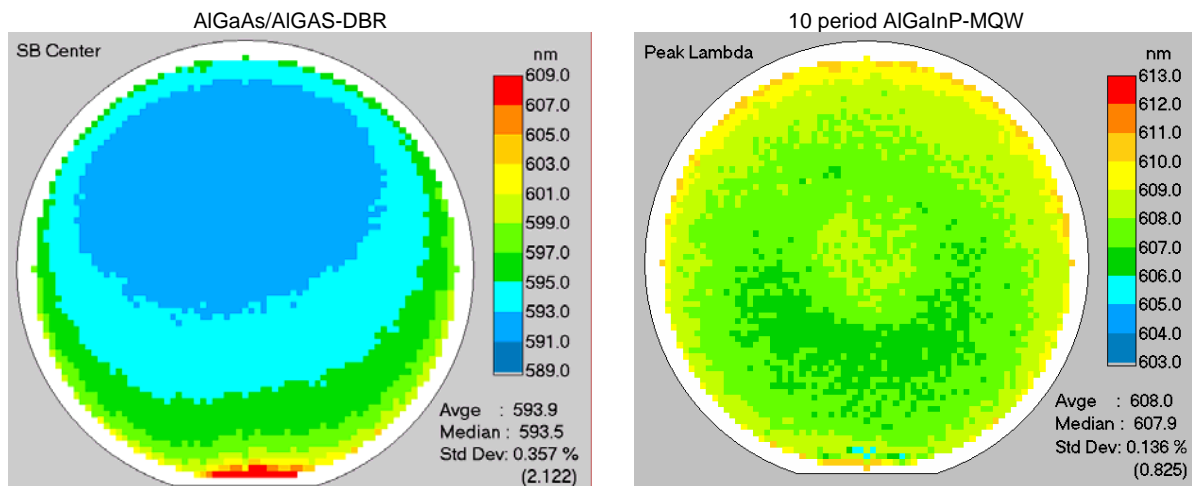


Fig. 3: Wavelength distribution of a 3 inch wafer for a AlGaAs/AlGaAs-DBR and a AlGaInP-MQW. The stopband of the DBR has an average wavelength of 594.6 nm ( $\sigma=2.1$  nm) and the MQW has an average wavelength of 608 nm ( $\sigma=0.8$  nm) (3mm edge exclusion).

The new AIX 2600G3 in the 18x3 inch configuration was developed with a special focus on the Cost of Ownership and therefore optimized on good precursor efficiency. The efficiencies for TMGa, TMAI and TMIIn calculated with vapour pressure data after Kayser et al. [1] are given for AlGaAs, AlInP and GaInP. For AlGaAs a efficiency for TMAI is 33% and for TMGa 38%. For AlGaInP the efficiency for TMAI, TMGa and TMIIn is 33%, 38% and 23%, respectively. These data are in good accordance to the earlier reported values for the 12x4" and 49x2" configurations which are well known for best precursor efficiency.

Additional information will be given regarding growth of AlInP, GaInP and AlGaInP as well as more detailed measurement results and their correlation to the data retrieved from simulations.

[1] O. Kayser et al., Chemitronics 3 (1988), 90 ff.