The growth of AlGaN/GaN HEMT structures in large scale Planetary Reactors such as the AIX 2600G3 HT in 8x4 inch configuration

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Electronic devices for high performance and high temperature applications are becoming more and more important in today's markets. High frequency power transistors and circuits are increasingly needed for mobile communication, radar technology and automotive applications. They must fulfill stringent, technological requirements like RF and microwave performance as well as high temperature operation and ruggedness at higher voltage levels. The AlGaInN material base has high potential to meet these requirements.

Low cost of ownership, large throughput, high uptime and low maintenance costs are the key requirements of the semiconductor industry. AIXTRON has met these requirements by the adaptation of the well proven Planetary Reactor® concept for the high−volume production of nitride semiconductors. This development has culminated in the AIX 2600G3 HT system which is available in the 24x2 inch and 8x4 inch configurations (see fig. 1).

To prove the production capability of the AIX 2600G3 HT (8x4") for electronic applications, such as high electron mobility transistors (HEMT), $Al_{0.3}GaN$− and AlN layers were grown and characterized on 4" sapphire substrates. For this investigation, the main targets were uniformity of growth and electronic characteristics. The layer thickness variation of the AIN layer was measured to have a standard deviation of 5.6% for an edge exclusion of 2 mm (see fig. 2). The growth rate of the AIN−layer was 0.92 µm/h according to in−situ interferometry. This result demonstrates that a uniform transport of the reactive TMAI takes place over the 4" wafer surface leading to uniform growth.

With this material established, an AlN/GaN multi−layer sequence has been developed to serve as a buffer for thick Si−doped $Al_{0.3}GaN$−layers. These were grown with a growth rate of 1 µm/h on 2" and 4" wafers. In order to reduce the strain between AlGaN and sapphire and allow the upper layer to be crack free, an AIN/GaN multi−layer buffer was developed and optimized. The thickness variation for the whole layer structure was 2.1% (see fig. 3). The average Al content was 32.9% with a standard deviation of 0.89% across the wafer, measured at 9 positions using high resolution x−ray diffractrometry. The Al concentration in the layers could be easily controlled by the TMAl flow (see fig. 4).

To examine the doping concentration Hall measurements were carried out on the $Al_{0.3}GaN$:Si layers. The average carrier concentration of 5 measurement points on the 4" Wafer was 6×10^{18} cm^{-3} with a mobility of 52 cm^2/Vs.

With these results we investigated the growth of device related two dimensional electron gas (2DEG) structures on 4 inch sapphire. Room temperature Hall effect measurements yielded a free carrier sheet concentration of 4×10^{12} cm^{-2} with a mobility of 1200 cm^2/Vs.

These results render the AIX 2600G3 HT system in its 8x4 inch configuration fit for the mass production of today s novel semiconductor devices. Add−ons, like in−situ monitoring tools such as EpiTune ® II allow for the easy and straightforward process transfer from smaller systems. In addition, these tools give the confidence of direct observation of the growth process in today s highly demanding production environments.

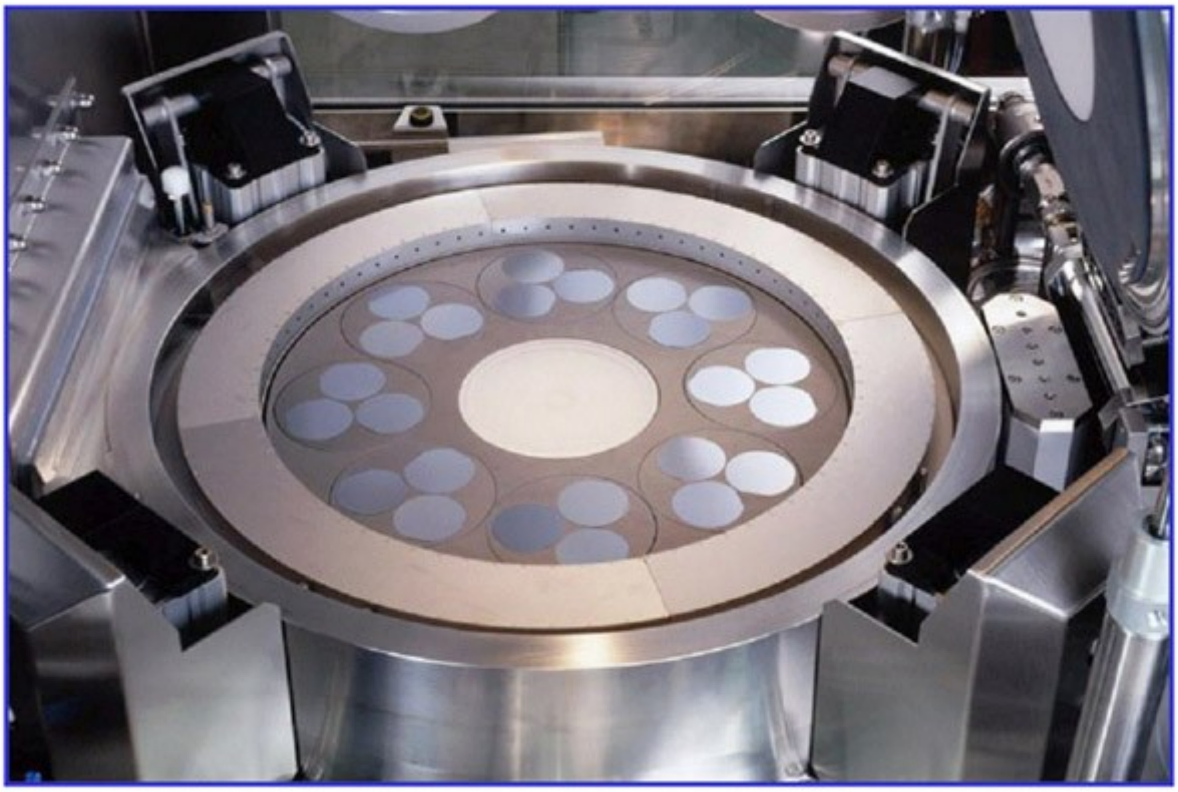

Fig. 1: Photo of the AIX 2600G3 HT.

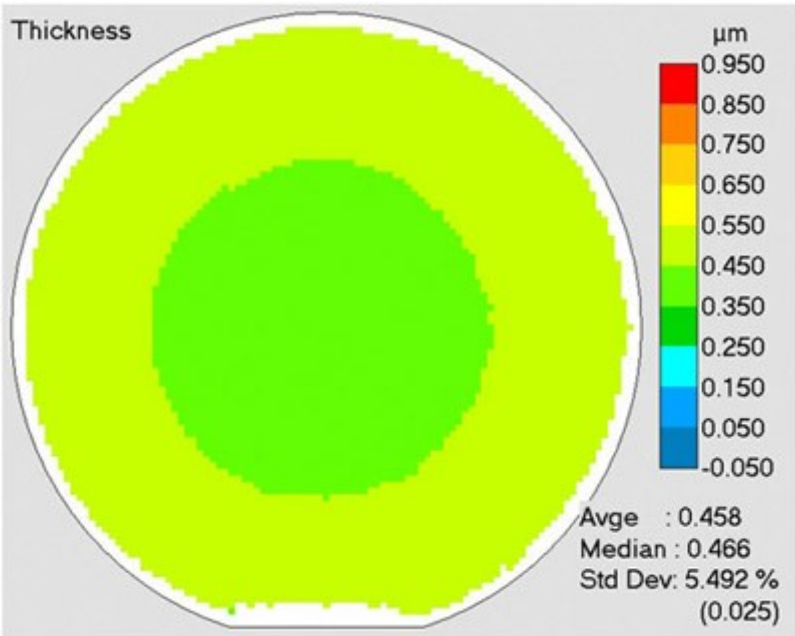

Fig. 2: Thickness mapping of AlN on 4 inch.

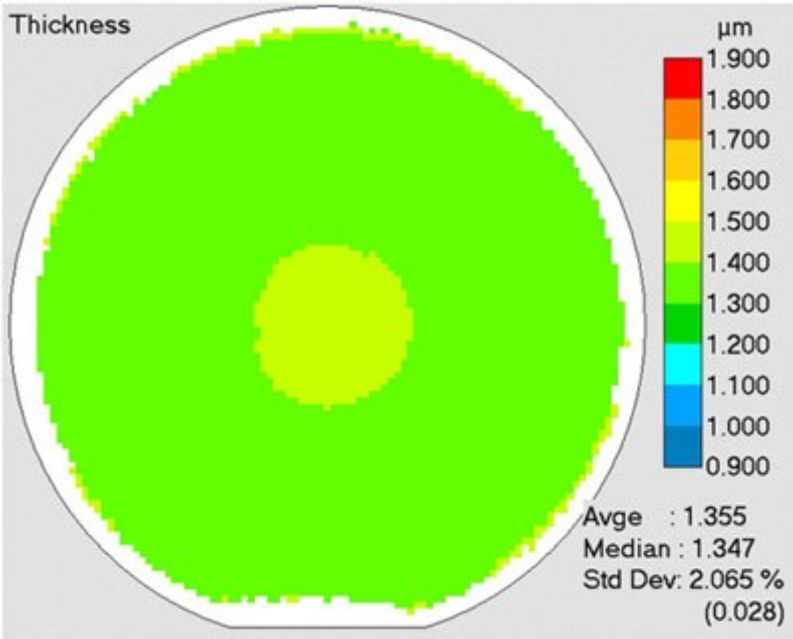

Fig. 3: Thickness mapping of $Al_{0.3}GaN$ on 4 inch.

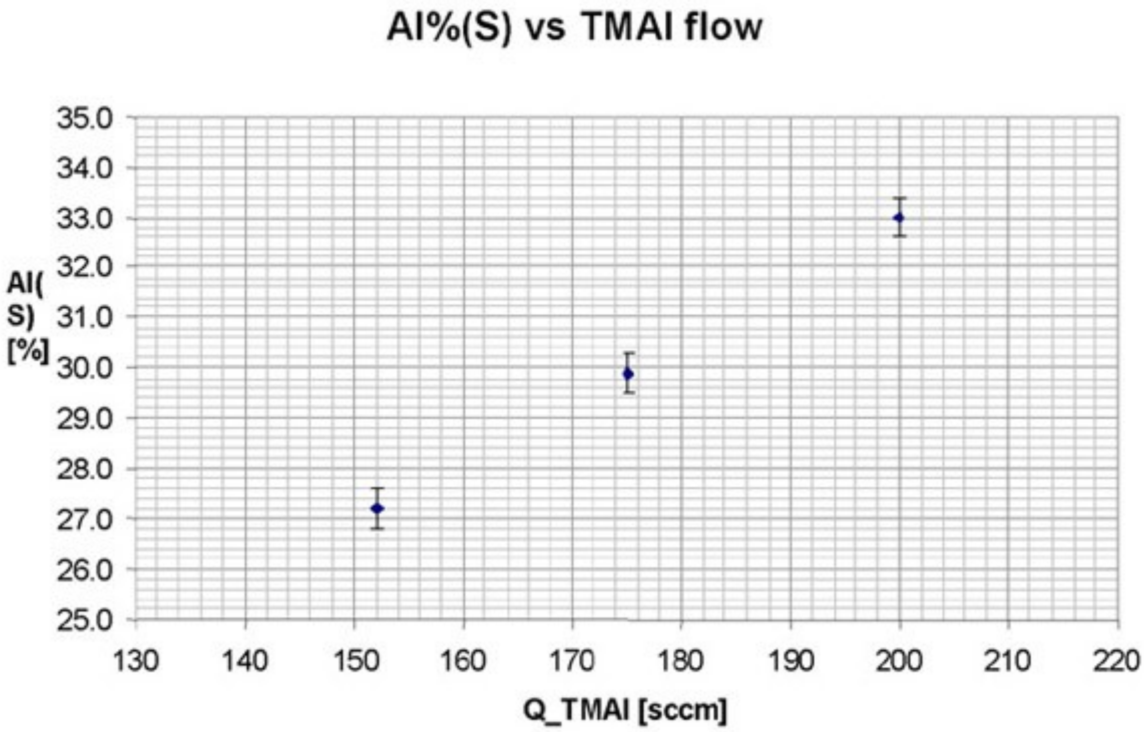

Fig. 4: Al incorporation dependency over TMAl flow.