Deposition control during GaN MOVPE

D. Fahle[1], T. Krücken[2], M. Dauelsberg[2], R. Schreiner[2], H. Kalisch[1], M. Heuken[1,2] and A. Vescan[1]

[1] GaN Device Technology, RWTH Aachen University, 52074 Aachen, Germany
[2] AIXTRON SE, Kaiserstr. 98, 52134 Herzogenrath, Germany

Phone: +49 (0)241 8909-105 email: dirk.fahle@gan.rwth-aachen.de

For a horizontal metal-organic vapor phase epitaxy (MOVPE) system like a planetary reactor, a depletion profile for the growth rate (g_r) is developed with a characteristic maximum peak and an almost linear decline [1, 2]. This behavior is due to feeding-in group III precursors (metal-organics (MO), for example trimethyl gallium (TMGa)), together with ammonia (NH_3) in the center of the reactor for growth of GaN, see Fig 1. Group III material will deplete along its radial flow direction (caused by thermal decomposition, reducing down-stream the available supply from the gas phase) across the graphite susceptor. The rotation of the substrate in the linear region of the depletion curve averages the growth rate resulting in very homogeneous film deposition across the whole substrate. However, as illustrated in Fig. 1, parasitic deposits upstream the substrate cannot be avoided. These deposits can affect the subsequent epitaxial growth. This is especially valid for heteroepitaxy if a nucleation layer on a substrate like sapphire or silicon is grown. It is therefore desired to minimize the amount of parasitic deposits during growth or to even completely remove these deposits. Hydrogen chloride (HCl) addition to the GaN process has been proven to play a positive role in limiting parasitic gas phase reactions [3].

We report here that the HCl process can significantly reduce parasitic depositions on the reactor walls. In our experiments, we used a planetary hotwall system [2, 3] in a 2 inch wafer configuration. By this, the distance between substrate and injector was – compared to a 4 inch configuration – extended to gain a better insight into the impact of HCl on parasitic deposits (see Fig. 1).

HCl is injected at the lower level of the central gas injector and primarily provides for *in-situ* etch cleaning of the susceptor and inlay surfaces between injector and leading wafer edge. While HCl reacts with parasitic coatings on these surfaces to form gaseous byproducts it is consumed. Depending on the flow rate of HCl relative to that of TMGa, we observe that the etch clean effect extends over a certain distance from the injector towards the leading wafer edge displaying a visibly sharp, circular line of abrupt transition between the clean susceptor surface and still coated surface further outward. The distance of this abrupt transition to the injector was found to depend on the input flow rate of HCl for certain otherwise fixed conditions. This distance provides an indicator for the degree of coating reduction as shown in Fig. 2.

Further, we will report on the etch rate of HCl on GaN in the absence of NH_3 and TMGa and explain the etch mechanism in detail. We found that pulsed injection of HCl enhances the etch rate at temperatures below 830°C, see Fig. 3. By interrupting the HCl flow into the system, we obtained a film of liquid gallium on the GaN surface, which enhances the GaN decomposition rate and therefore the etch rate.

The addition of HCl during growth of GaN may offer a significant step forward towards stronger and improved control for the growth of the binary material, related ternary compounds as well as even more important for LED materials for blue, green and white emission. This will be investigated further.

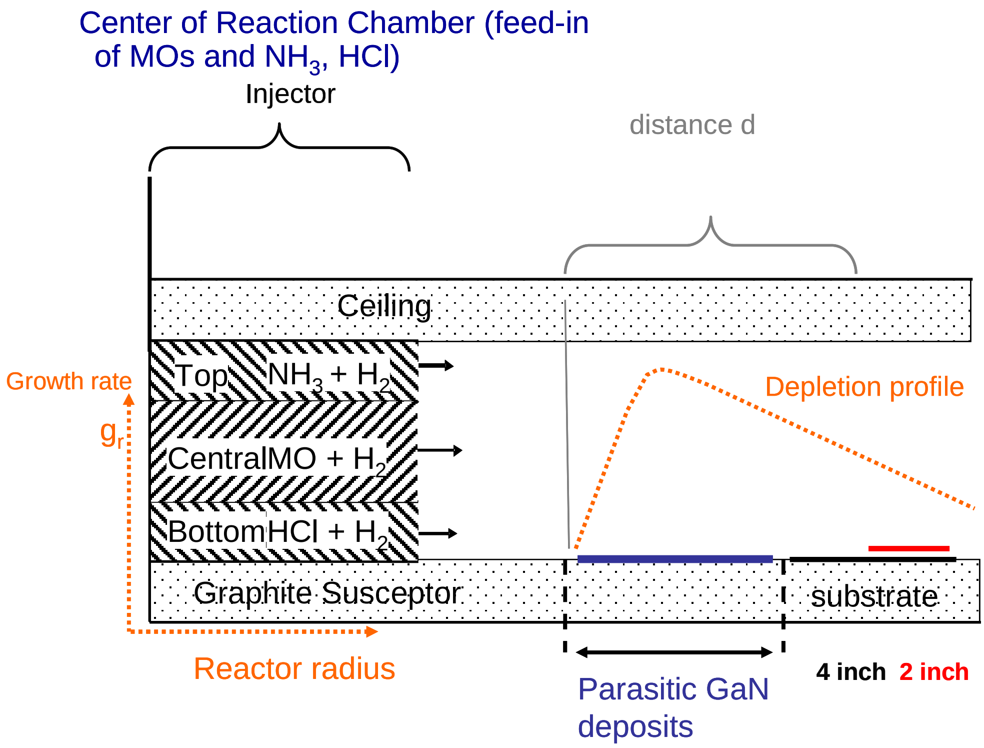

Fig 1. Experimental setup, the HCl is separated from the NH_3 by the central level of the injector. By introducing the HCl at the bottom level, it is introduced close to the area where the most parasitic deposits are formed. The typical depletion profile of the growth rate in a horizontal reactor is illustrated by the dotted line.

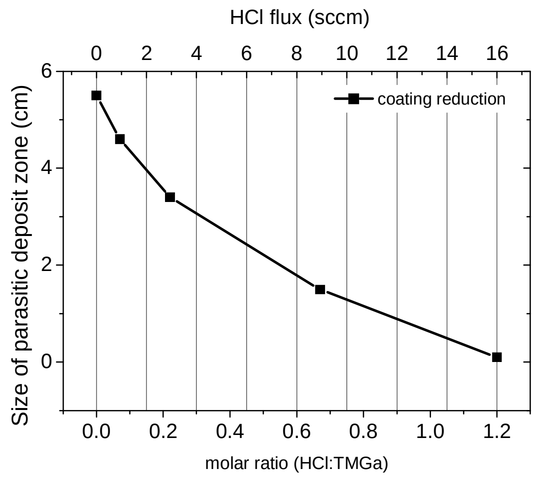

Fig 2. Reduced expansion of the parasitic deposits as a function of HCl flow. HCl is flown during growth of GaN and the distance between substrate and beginning of parasitic deposits measured.

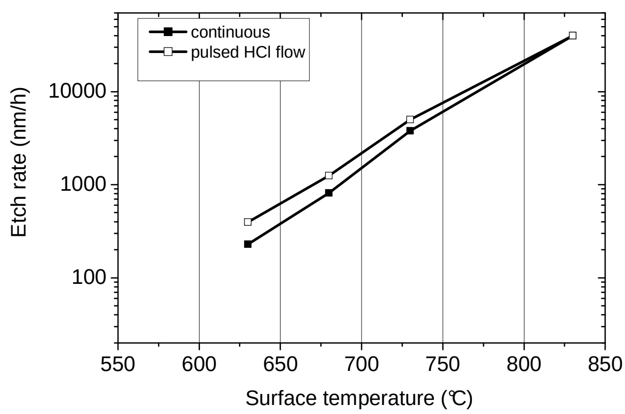

Fig. 3 Etch rates of HCl on GaN under hydrogen atmosphere (0.9 hPa). A comparison of a continuous flow of HCl and a pulsed flow is shown.

[1] C. Martin et al., J. Cryst. Growth 303 (1) 318-322 (2007)

[2] D. Fahle et al., Phys. Status Solidi C 8, No. 7–8, 2041–2043 (2011)

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