ALLOS' low leakage, doping-free 600 V HEMT epiwafer technology is running in parallel on both Aixtron G5 and Veeco K465i at a customer

Dresden, Germany – 16th February 2017 – The latest generation of ALLOS Semiconductors' high crystal quality GaN-on-Si process achieves excellent isolation without doping. Applying this technology ALLOS recently concluded the development of customized epi structures with very low leakage for a power electronics customer. The epiwafer growth processes were established in this customer's Aixtron G5 and Veeco K465i reactors. Therefore, besides providing the desired epiwafer and device performance the project also allowed a unique performance and cost comparison of the two major reactor platforms used in the GaN-on-Si industry.

Since starting its business of enabling customers to master the challenges of GaN-on-Si technology in 2014 ALLOS has heavily invested in advancing its technology further and has achieved several development breakthroughs. Key elements of ALLOS' technology are very low leakage currents, superior crystal quality and its focus on manufacturability.

To have low leakage is seen as one of the prerequisites in the industry in order to enable mass-market adoption of GaN-on-Si for power electronic applications like power supplies and motor drives. ALLOS' technology fulfills the required low vertical leakage current of less than 0.1 µA/mm² at 600 V and at the same time is using growth conditions optimized to reach ALLOS' high crystal quality without using carbon or other dopants to isolate the GaN.

Carbon doping became popular in the GaN-on-Si industry in recent years as it can be easily employed to increase isolation. Unfortunately, commonly used techniques to increase carbon levels are resulting in degradations in crystal quality. ALLOS shares the increasing concerns of industry experts that insufficient crystal quality can have severe negative side-effects on crucial performance and quality characteristics. Consequently, ALLOS has worked on novel ways to accomplish very low leakage without compromising the crystal quality. The core of these innovations is growing extremely high quality epilayers without doping. This is based on ALLOS' patented and proprietary growth techniques and epi structures.

"Another concern many deciders are sharing with us is possible conflicts with incumbents who own strong IP around using carbon doping" says ALLOS' CMO Alexander Loesing and highlights "Avoiding such conflicts is another benefit of not using carbon."

In parallel ALLOS continues to implement its 'design for manufacturability' strategy. All features relevant for the epiwafer making process and for using these epiwafers for device

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production in existing silicon-based processing lines are taken into account and are optimized according to market requirements. Using this technology ALLOS' customers can produce cost-efficient GaN-on-Si epiwafers of up to 200 mm diameter which meet the SEMI-standard specification for thickness and bow, are very reliable in device making and show excellent electrical performance.

ALLOS' latest technology generation was recently transferred to and adapted for a power electronics customer. The project requirements included developing customized interlayer and superlattice based epi structures with up to 7 µm total thickness for 150 and 200 mm wafer diameter. Additional project objectives were specified device-level parameters and establishing the epi process in the Aixtron G5 and Veeco K465i reactors used for GaN-on-Si by the customer.

These two reactors types are the most widely used in the industry. In the project the same epi structures were successfully grown in both tools with very good and reproducible results. Overall the differences between the achieved results in the two reactors in terms of epiwafer characteristics and device performance were small and each reactor type showed merits and demerits.

Regardless of hardware and handling differences ALLOS achieved industry leading results in both reactor types. These include crystal quality XRD FWHM values of 330 arcsec for (002) and 420 arcsec for (102), threading dislocation densities of $2x10^8$ cm^{-2}, no meltback and no cracks on the entire wafer, tightly controlled bow of less than 30 µm for SEMI-standard thick wafers, mobility of 2000 cm^2/Vs and sheet resistance of 350 Ohm/sq. A sheet resistance uniformity of 1.5 to 3% (std. dev.) was achieved, depending on the platform. Furthermore, all device-level requirements were met, in particular low vertical leakage of < 0.1 µA/mm². Beside these technical parameters the economic factors like consumption, yield, reliability, maintenance and throughput for each epi process have also been analyzed.

"ALLOS' vast experience in installing its technology on many different reactor platforms and the robustness of our technology were essential in achieving the excellent results on the two hardware platforms in this project" says Dr. Atsushi Nishikawa, CTO of ALLOS and continues emphasizing "However, for the first time the same epiwafer structures were grown in two alternative reactor types in parallel and the epiwafers were processed and characterized under equal conditions in the same facility. Based on hundreds of runs this provides a unique performance and cost comparison of MOCVD reactors to the customer. It also gives them all the information they need for choosing their future production platform."

These strong results demonstrate that the choice of the right hardware is important but not paramount. In both reactors superb crystal quality and very low leakage without carbon doping were achieved, and in both reactors this was possible for interlayer and superlattice structures. "We often hear that there are demands to purchase new reactors to allow developers to achieve the desired epiwafer quality. Certainly, there are such cases but often

the truth is that you don't need to wait and the grass can already today become green regardless on which side of the river you are." adds Dr. Nishikawa.

"ALLOS remains neutral on reactor platform decisions and guided by our customers' requirements.", clarifies Alexander Loesing and adds "We are proud that we can deliver our technology in any MOCVD reactor the customer might already have, while being able to provide fact-based advice on reactor purchasing decisions in other cases."

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