Recent Progress in MOCVD Technology for Power Electronics Device Production

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Energy efficient power electronic (PE) devices drive today's high volume mass production MOCVD system developments. A considerable reduction of cost-per-epi-layer (CoO) within the next 3-5 years is foreseen with a clear objective that GaN and related materials get wider market acceptance and displace Silicon based devices in many electronic circuits and systems. Thus, inherent semiconductor capabilities such as high electron mobility, high breakdown field, low intrinsic concentration and high thermal conductivity can be utilized in the form of reduced energy consumption, size reduction and reduced cost of the overall circuit [1].

Central to the reduction of CoO are *uniformities* (on-wafer, wafer-to-wafer, run-to-run, system-to-system), system uptime, cost of consumables and *particle avoidance*. Uniformity improvements are typically addressed by "classical" reactor optimizations such as temperature and flow homogeneity, involving CFD-assisted iterative design of gas-inlets, wafer holders and heating systems. Further factors for the performance of PE devices are vertical breakthrough and buffer dispersion. The optimization of these aspects has experienced a journey from discrete $Al_xGa_{1-x}N$ staircase buffers to $AlN/Al_xGa_{1-x}N$ superlattices and carbon-doped buffer layers which also help in reducing the thermal expansion differential between the nitride device structure and its Silicon host wafer. Finally, particle avoidance is of utmost importance due to the large area of power devices and the requirement to transfer the device from the host wafer to the final package. In HVM reactors this is addressed by in-situ cleaning and wafer handling automation, both leading to a reduced necessity to open the reactor in between runs, thus keeping the reactor interior "sterile" from operator interaction and particle generating disturbances.

We will discuss these concepts by example of the latest generation of AIXTRON Planetary Reactors®. Considerations such as throughput, uniformities, particle reduction and effect on usable device yield as well as electrical performance of GaN-based power electronics transistors will be addressed. A further focus will be laid on wafer-bow control using in-situ measurement equipment to optimize strain reduction during growth and in the final structure.

References

[1] Ballestin-Fuertes J et al., Electronics 2021;10:677-702