

Supplemental Document “Correlating charge carrier profiles and elemental compositions in MBE-grown GaN/AlGaN stacks” by Stefan Schmult et al.

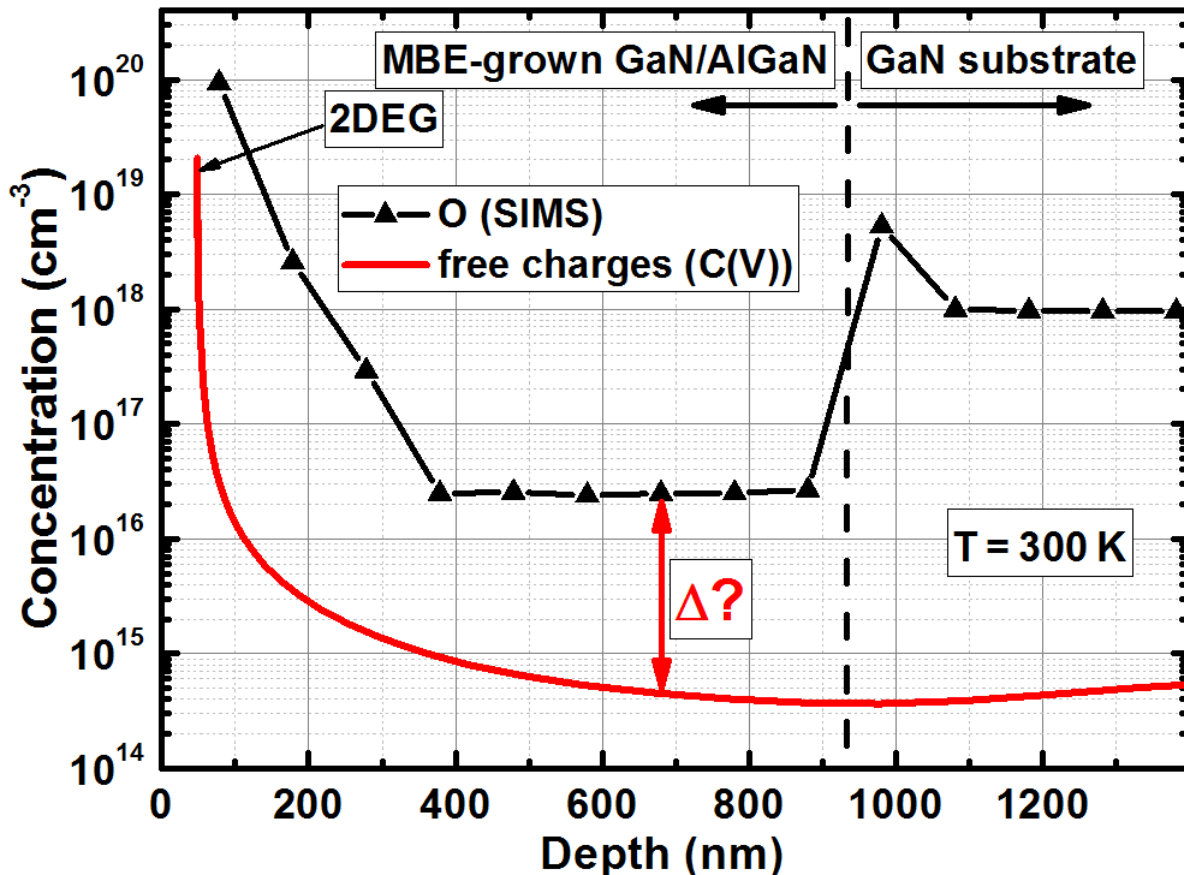


Fig. 1: Depth profiles of the oxygen and free charge carrier concentrations resulting from SIMS and vertical C(V) measurements, respectively (surface @ 0 nm). The GaN/AlGaN stack was grown on a heavily compensated (insulating) GaN substrate and hosts a 2DEG near the surface. Oxygen (a shallow donor) is the only detectable impurity by SIMS in the MBE GaN; its incorporation depends on the substrate temperature during growth [2]. The high-frequency C(V) measurement was performed in gate-source configuration, i.e. a gate metal layer serves as the top electrode and an ohmic contact to the 2DEG is used as the 2<sup>nd</sup> terminal. Therefore a defined bottom electrode is missing once the 2DEG is completely depleted, which likely results in the discrepancy  $\Delta$  between the oxygen and free carrier concentrations. The drop in the oxygen level verified by SIMS over the first 300 nm is a measurement artefact.

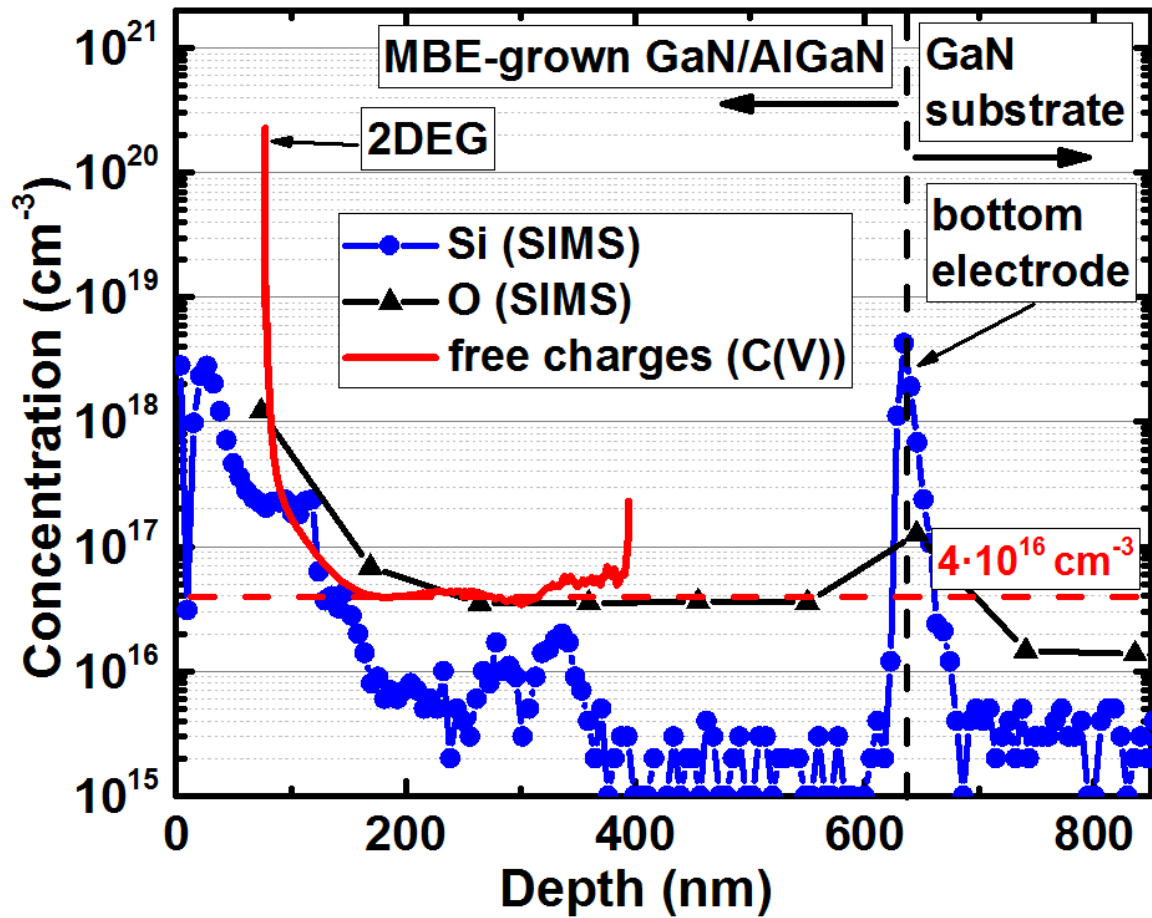


Fig. 2: Depth profiles of the oxygen, silicon and free charge carrier concentrations resulting from SIMS and vertical C(V) measurements, respectively (surface @ 0 nm). The GaN/AlGaN stack was grown on a uid GaN substrate and hosts a 2DEG near the surface. A parasitic channel is formed at the substrate/MBE interface, resulting from atmospheric silicon adhesion at the substrate surface. The annealed ohmic source metal stack makes contact to this parasitic channel and in consequence in this true vertical C(V) measurement performed in gate-source configuration this channel serves as a defined bottom electrode after the 2DEG is completely depleted. Using this defined parallel plate capacitor geometry, the concentrations of free carriers extracted from C(V) data and oxygen donors from SIMS agree well at a level of  $4 \cdot 10^{16} \text{ cm}^{-3}$ . The silicon level in the MBE GaN reflects the SIMS tool background for this specific run of  $1 \cdot 10^{15} \text{ cm}^{-3}$  and the drop in the silicon and oxygen levels over the first few hundred nanometers are again SIMS measurement artefacts.