GaN Power HEMT with Breakdown Voltage >800 V Grown by MBE

ZC Yang,[1,]* YQ Wang,[1] JG Zhuang[1], and Eason Liao[1]
[1] MASSPHOTON LIMITED, Hong Kong SAR
*zcy@massphoton.com

We report GaN power HEMT with breakdown voltage >800 V grown by MBE on sapphire. High breakdown voltage >800 V is obtained by using ultra-thin AlN buffer grown by MBE and one gate field plate structure technique. MBE technique enables dopant-free buffer layer and pseudomorphic growth of epilayers, which is beneficial to the high reliability of GaN power HEMT. One gate field plate technique helps reduce the total cost of fabrication and also contribute to the high reliability of GaN power HEMT. These merits shows the potential of the reported GaN power HEMT in the applications of high power electronics [1].

The schematic epitaxy structure of GaN power HEMT is shown in Fig. 1 (a). Plasma-assisted MBE was employed to fabricate the complete HEMT structure on a sapphire substrate. 1 μm AlN buffer layer [2], AlGaN layers with Al compositions of 70%, 50% and 20%, GaN channel layer, 1 nm AlN spacer, 24nm 30% AlGaN and 10 nm *in-situ* SiN were sequentially grown on the sapphire substrate. The schematic cross section of GaN power HEMT is shown in Fig. 1 (b). Source/drain ohmic contacts with typical contact resistance of 1.2 Ω·mm were obtained with Ti/Al/Ni/Au (20/120/30/50 nm) and rapid thermal annealing at 800 ℃ in N_2 for 30 s. One gate field plate structure (GS and GT) was formed with 120 nm gate recess in the 150nm thick ICP-CVD SiN layer with gate length of ~2 um and gate field plate metal of Ti/Al/Ti (30/500/30 nm) with field plate length of ~9 um. The gate drain spacing Lgd was ~22 um. Interconnection M1 to the ohmic contacts was formed by Ti/Al/Ti (30/1000/30 nm) through via holes V0.

The fabricated normally-on GaN HEMT exhibits an on-state current of ~160 mA/mm and a ON-resistance of 44 Ω·mm at drain bias Vds = 10 V and gate bias Vgs = 0 V, as shown in Fig. 2 (a). The device shows threshold voltage of ~-30 V and low gate leakage current below 1 μA/mm at drain bias of ~5 V, as shown in Fig. 2 (b). The insitu SiN grown by MBE suppresses the interfacial defects and thus enables the low gate leakage and device operation. The relatively high ON-resistance is due to the thin GaN channel and a back barrier of 8% AlGaN. Increasing the channel thickness and barrier composition and further optimization of the growth will lead to lower ON-resistance. Off-state characteristics is shown in Fig. 3. Off-state leakage less than 10 μA/mm was achieved at gate-drain voltage of 800 V, showing a breakdown voltage greater than 800 V. The relatively high breakdown voltage with one gate field plate structure shows the promise of the fabricated GaN HEMT in the applications of high power electronics with low cost.

References

[1] Zhibo Cheng et al., IEEE Transactions on Electron Devices, vol.71, no.12, pp.7689-7695, 2024.

[2] Junbo Wang et al., IEEE Transactions on Electron Devices, vol.71, no.11, pp.6609-6615, 2024.

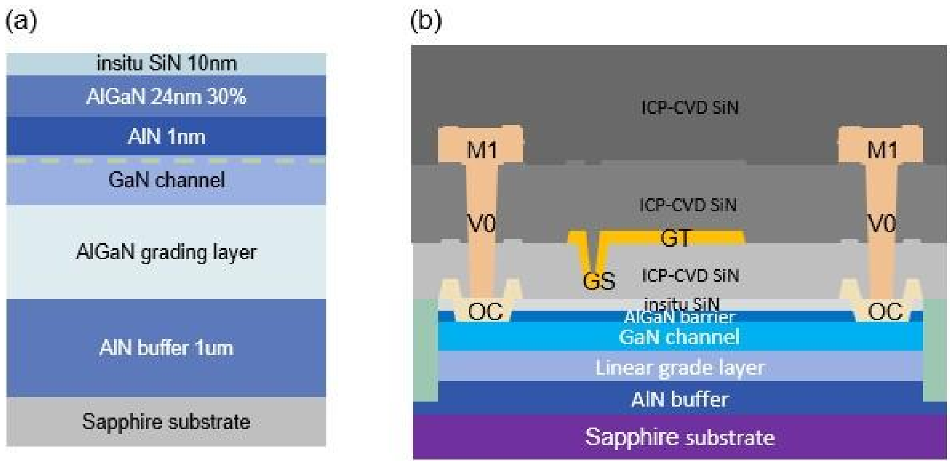

Fig. 1: Schematic (a) epitaxy structure grown by MBE and (b) cross section of GaN power HEMT

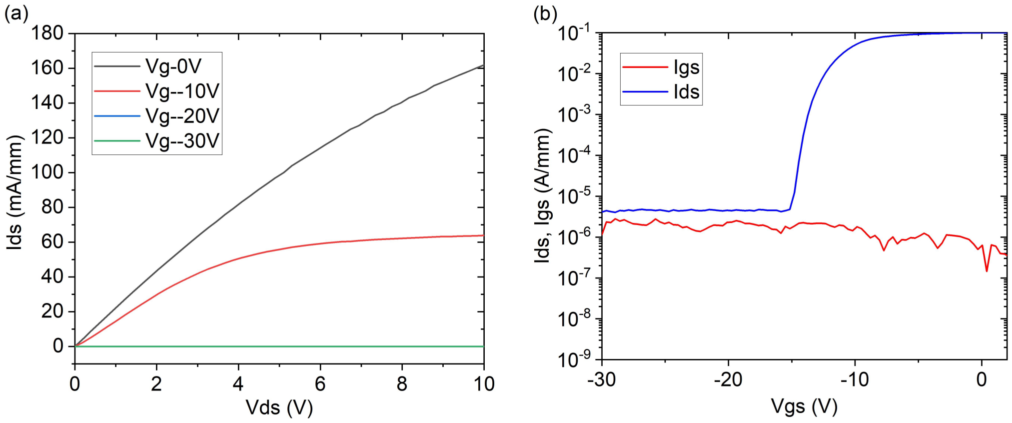

Fig. 2: (a) Output (a) and (b) transfer characteristics of GaN power HEMT grown by MBE

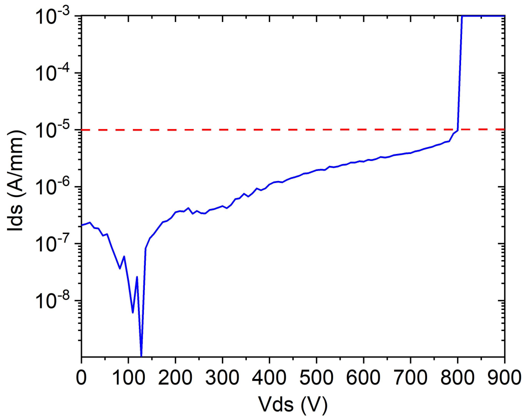

Fig. 3: Breakdown properties of GaN power HEMT grown by MBE