

First demonstration of RF GaN-based transistors using buffer-free heterostructures with low trapping effects

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Currently, 0.15 μm GaN technology are already commercialized and will enable reliable high power operation up to the Ka band. However, it is well-known that the buffer layers including many interfaces increase the thermal resistance, which severely limits the thermal dissipation. The resulting self-heating affects the power-added-efficiency as well as the device reliability. This phenomenon is even more pronounced for shorter gate length ≤ 150 nm as the electric field peak is increased. On the other hand, even though the buffer layers are used to manage the strain and keep the 2DEG away from defects / dislocations; theoretically, a thin nucleation layer with an outstanding quality would be enough to accommodate the growth of high quality GaN HEMTs avoiding the use of a complex stack. **This paper presents an assessment of a buffer-free AlGaIn/GaN heterostructure on top of a thin AlN nucleation layer grown by the company SweGaN using a hot-wall MOCVD. The total HEMT thickness from substrate to the top is less than 250 nm. Room-temperature Hall measurements showed high electron sheet concentrations of $1 \times 10^{13} \text{cm}^{-2}$ with an electron mobility about $2100 \text{cm}^2 \text{V}^{-1} \text{s}^{-1}$. The remarkable electron mobility reflects the high material quality with the absence of rough interfaces or defects. DC characteristics show a maximum current drain density in agreement with the carrier concentration with an excellent pinch-off. The breakdown voltage carried out before the passivation increases as expected with the Gate-Drain distance (GD) to reach almost 200 V with a GD=2.7 μm . Despite a non-optimized high ohmic contact resistances of $0.75 \Omega \cdot \text{mm}$, the extrinsic transconductance (Gm) reaches 280mS/mm at $V_{\text{DS}}=10\text{V}$ with resulting RF performances of $f_{\text{T}} = 57$ GHz and $f_{\text{max}}=176\text{GHz}$. The pulsed DC (1 μs pulse width / 1% duty cycle) characteristics showed a rather low current collapse reflecting limited trapping effects in this ultrathin heterostructure. These first results prove the high quality of this novel structure despite the absence of buffer layers and demonstrate its potential for future millimetre-wave applications.**

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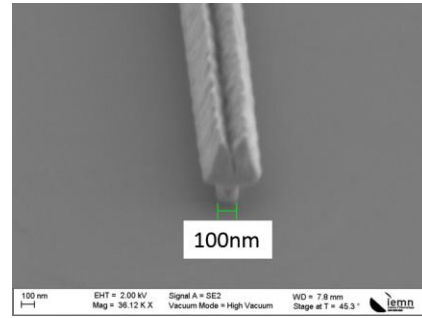
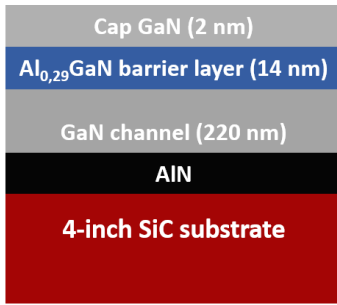


Fig. 1 : Schematic cross section of the AlGaN/GaN buffer-free and a MEB picture of the gate

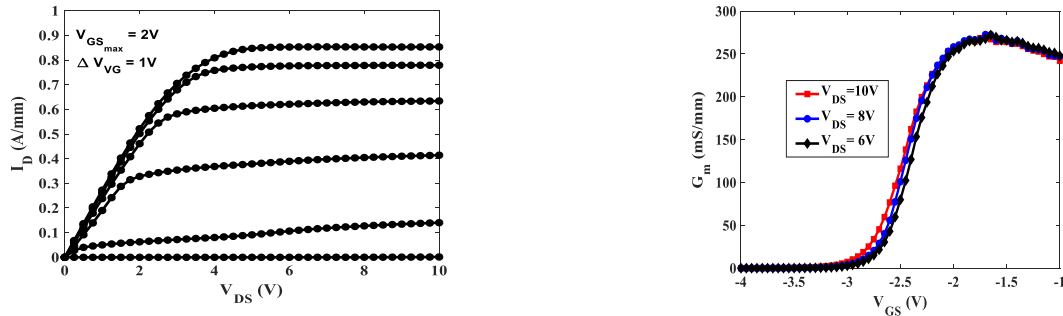


Fig. 2 : DC characteristics of the buffer-free HEMT

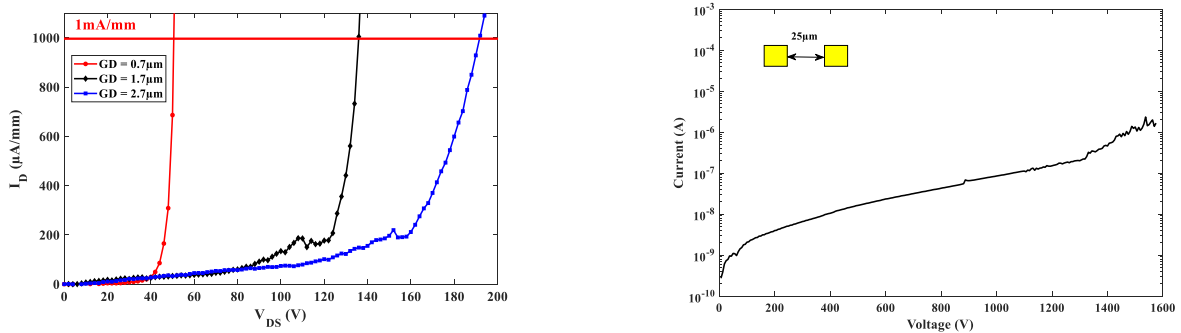


Fig. 3 : Three-terminal off-state transistor breakdown voltage for different Gate – Drain distance (left) and lateral buffer breakdown voltage between two isolated contacts separated by 25 μ m (right)

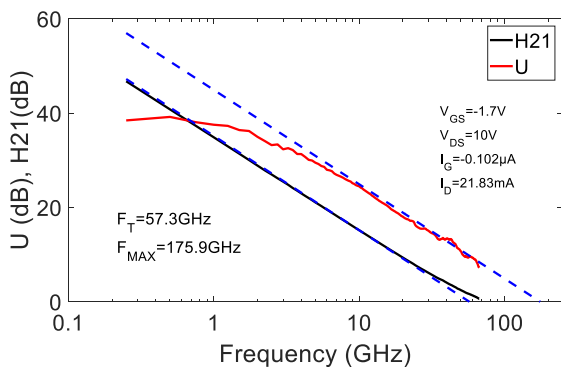


Fig. 4 : Small signal characteristic of 0.1x50 μ m² devices

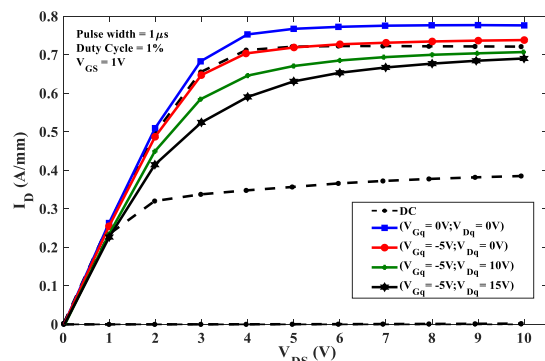


Fig. 5 : Pulsed DC for different quiescent points for 1 μ s/1% performed at open channel ($V_{GS} = +1$ V)