

Above 2 A/mm drain current density of GaN HEMTs grown on Sapphire

F. Medjdoub¹, J.-F. Carlin², M. Gonschorek², E. Feltin², M.A. Py², N. Grandjean²,
and E. Kohn¹, *Member IEEE*

¹University of Ulm, Albert Einstein Allee 45, 89081 Ulm, Germany,

Email: farid.medjdoub@uni-ulm.de

²Institute of Quantum Electronics and Photonics, Ecole Polytechnique Fédérale de Lausanne (EPFL),
CH 1015 Lausanne, Switzerland

In this paper we discuss a result obtained from a GaN-based High Electron Mobility Transistor (HEMT) with AlInN barrier. This rather novel configuration promises high current densities up to 3 A/mm in a lattice matched configuration, the 2DEG being induced by the differences in spontaneous polarization [1,2]. Moreover, it offers a higher band offset between the GaN channel and the InAlN barrier as compared to AlGaIn. However, the materials system is difficult to grow due to the distinctly different growth conditions required for GaN and InAlN and the difficulty to incorporate In and Al in the same lattice without clustering. Indeed these properties have been seen in first promising investigations on Silicon substrate [3].

The studied structures were grown by Metal Organic Vapor Phase Epitaxy system on 2 inch diameter (0001) sapphire substrate [4]. They consist of 2 μm thick GaN buffer, 1 nm thick AlN spacer layer and 13 nm thick AlInN barrier layer with 81% Al composition (described in Fig. 1). Room temperature Hall effect measurements yielded a polarization-induced 2DEG sheet charge of $2.6 \times 10^{13} \text{ cm}^{-2}$ with a record electron mobility of $1170 \text{ cm}^2/\text{Vs}$ and a sheet resistivity of $211 \Omega/\square$ [5]. The devices are MESA isolated with Ar plasma etching. Then, a Ti/Al/Ni/Au ohmic contact stack is alloyed at 890°C in nitrogen atmosphere to provide contact resistances of $0.7 \Omega.\text{mm}$, as measured by linear TLM. The submicron gates ($L_g = 0.25 \mu\text{m}$) are defined with electron beam lithography. Ni/Au is deposited to produce the gate Schottky contacts. The HEMT devices are not yet passivated.

The output characteristics of a $0.25 \mu\text{m}$ gate length device with $25 \mu\text{m}$ gate width are shown in Fig. 2 and 3. The maximum drain current density at $+2\text{V } V_{\text{GS}}$ exceeds 2 A/mm in a reproducible way (2.33 A/mm for the presented device), which is to our knowledge beyond the highest drain current density of any AlGaIn/GaN HEMT structure, especially when fabricated on sapphire. The transconductance peaks at 265 mS/mm with 10V applied to the drain and -5V to the gate. The breakdown voltage is estimated to about 40V at pinch-off for a device with a drain source spacing of $2.5 \mu\text{m}$ and is thought to be linked to residual buffer layer leakage.

The improvement of the GaN buffer resistivity associated to the utilization of a Field Plate technology should strongly improve the three-terminal breakdown voltage of these structures. Small signal, pulsed and power measurements will be carried out on these devices.

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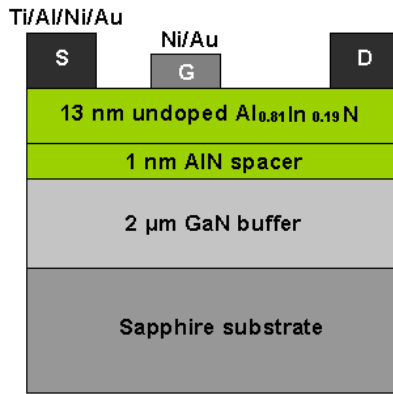


Figure 1: Schematic cross section of the AlInN/GaN HEMT devices

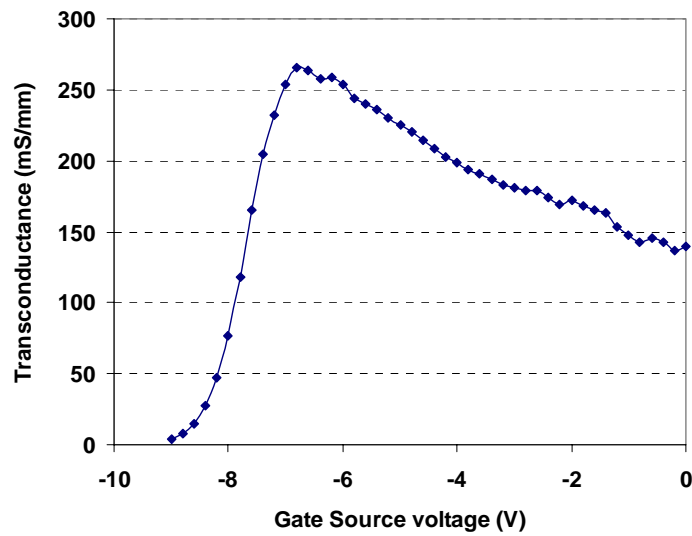


Figure 2: Transconductance of the $\text{Al}_{0.81}\text{In}_{0.19}\text{N}/\text{GaN}$ HEMT $25 \times 0.25 \mu\text{m}^2$ at a source-drain voltage of 10V.

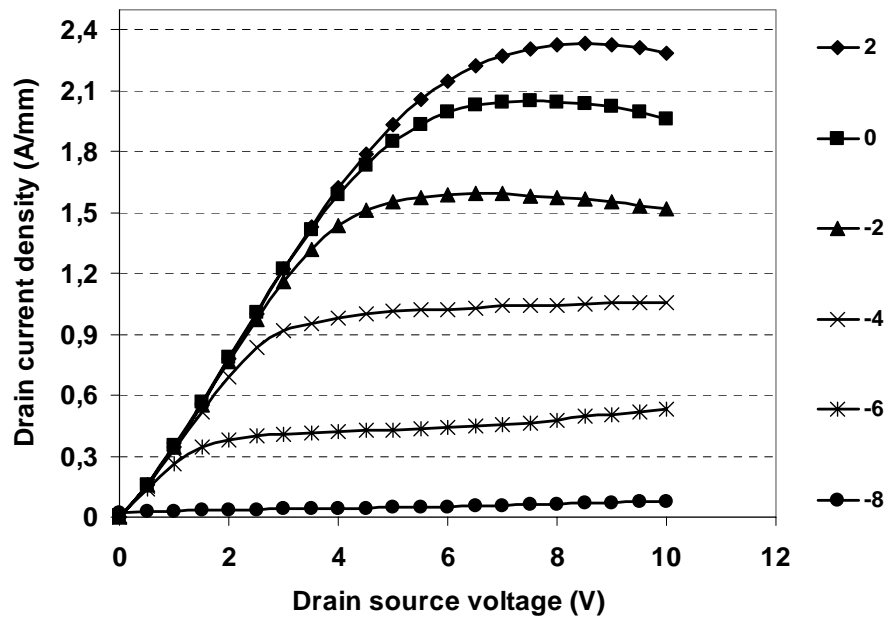


Figure 3: DC output characteristics of an $\text{Al}_{0.81}\text{In}_{0.19}\text{N}/\text{GaN}$ HEMT $25 \times 0.25 \mu\text{m}^2$. V_{GS} swept from -8V to 2V by step of 2V