# Breaking the Mobility-Threshold Voltage Trade-Off in Normally-Off AlGaN/GaN MIS-HEMTs

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Surface and interface states play a critical role in determining the electrical performance and reliability of GaN-based transistors [1]. In particular, achieving normally-off operation in AlGaN/GaN MIS-HEMTs often requires barrier thinning or gate recessing, which can adversely affect carrier mobility and drain current. This trade-off between threshold voltage ($V_{TH}$) and channel transport remains an important challenge for high-performance GaN power devices [2]. In this work, we investigate an interface-engineering approach that combines shallow gate recess with oxygen ($O_2$) plasma treatment. Oxygen plasma treatment was initially developed to suppress current collapse [3,4] and was later shown to improve $Al_2O_3$/AlGaN interface quality and positively shift the $V_{TH}$ of GaN MIS-HEMTs [5].The shallow recess maintains a relatively thick AlGaN barrier and thereby preserves 2DEG transport [6], while $O_2$ plasma modification of the AlGaN surface enhances gate control and induces a positive shift in $V_{TH}$. The resulting MIS-HEMTs, employing a 9-nm recessed AlGaN barrier, exhibit a $V_{TH}$ of +1.4 V, a maximum drain current of 615 mA/mm, and a maximum transconductance of 136 mS/mm, together with a field-effect mobility of 1810 cm$^2$/V·s. The presentation will discuss the physical mechanisms responsible for the simultaneous enhancement of normally-off characteristics and carrier transport, with particular emphasis on the role of surface and interface electronic states. The results demonstrate the potential of interface engineering as a complementary approach to structural scaling for realizing high-performance normally-off GaN MIS-HEMTs.

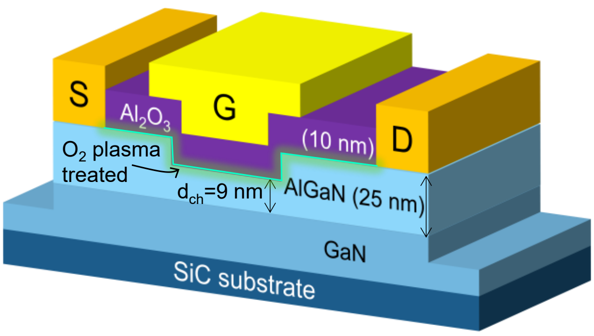


**Figure 1**. Schematic illustration of main GaN-based MIS-HEMT device studied in this work with shallow recess and $O_2$-plasma-treated AlGaN surface.

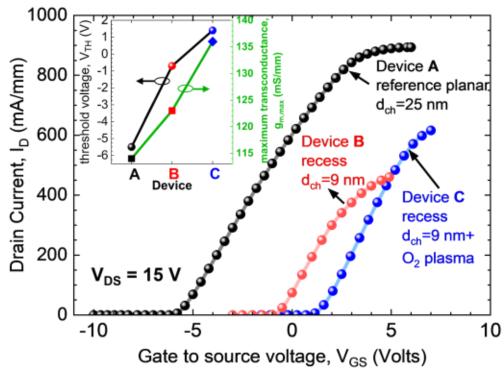


**Figure 2.** Transfer characteristics of studied devices: Device A – planar device, Device B – recessed gate device with $d_{ch}$ = 9 nm, Device C – recessed gate device with $d_{ch}$ = 9 nm and $O_2$ plasma treatment. Inset shows the corresponding threshold voltage $V_{TH}$ and maximum transconductance $g_{m,max}$, showing that shallow recess and $O_2$ plasma realized high $g_{m,max}$ and high $V_{TH}$ devices.

**Reference**

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