# A New KOH-Based UV Assisted Wet Etching Technique And its Application to AlGaN/GaN HFET Fabrication and Characterization

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The maturation of AlGaN/GaN heterostructures has prompted much activity toward the development of microwave power transistors because of the large ionization thresholds and excellent high-field transport properties in this system. However, the inherent chemical stability of group III nitrides has generally restricted the applicability of wet etching techniques to these materials —indeed, most nitride device processes rely on dry etching methods (see [1] for instance).

We have developed a simple well-controlled UV photo-assisted wet etching process which can be carried out near room temperature without making electrical contacts to the sample, and which does not appreciably degrade the GaN surface roughness from its original value: for example, AFM measurements indicate that the removal of ~1000 Å of GaN only degrades the RFM surface roughness by ≤ 10 Å. Etch rates of 20 Å/min have been achieved with a UV power density of only 1.2 mW/cm$^2$ at $\lambda = 365$ nm. The etch rates and the good resultant surface quality make the etch technique potentially attractive for gate recess etching. In addition, we have found that the etch exhibits a good selectivity with respect to C-doped GaN layers, thus enabling a uniform self-limiting mesa etching process to be employed.

We have used our process to implement submicrometer gate mesa-isolated AlGaN/GaN HFETs featuring excellent pinchoff properties, low gate leakage currents, and good device isolation in MBE-grown layers with a C-doped GaN buffer deposited on sapphire substrates (Fig. 1). The etching was used to characterize completed AlGaN/GaN HFETs by studying the evolution of transistor characteristics as a function of AlGaN barrier material removal from the extrinsic (GS, GD) regions of the channel (Fig. 2). Shallow barrier etches markedly reduce the gate diode leakage current without appreciably degrading the $I_D - V_{DS}$ characteristics (Fig. 3): these findings clearly demonstrate that surface states are available for parasitic conduction on the AlGaN/GaN surface, and that these states are associated with defective/contaminated material at the as-processed wafer surface. Such surface states could impact device performance if their charge state is modulated during device operation: surface states located in the AlGaN barrier or at its surface have previously been demonstrated to be related to poorer than expected large-signal microwave power performance due current compression [2].

Our presentation will describe the etching method and its characterization (time dependence of etch characteristics, AFM characterization of resulting surfaces) as well as the effect of AlGaN barrier etching on the performance of AlGaN/GaN HFETs.

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**References**

[1] S. J. Pearton et al., *J. Appl. Phys*. **86** (1), pp. 1-78, 1999.
[2] C. Nguyen et al., *Electronics Lett.* **35** (16), pp. 1380-1382, 1999.

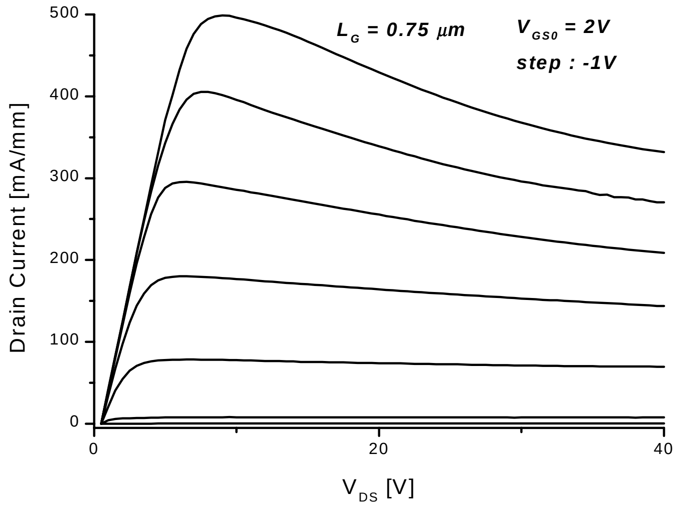


*Figure 1: DC characteristics of wet etch isolated transistors on MBE-grown AlGaN/GaN epitaxial layers.*

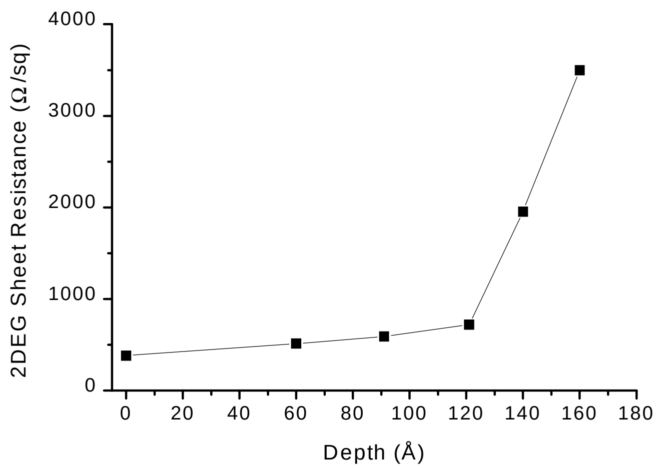


*Figure 2: 2DEG sheet resistance as a function of AlGaN barrier etch depth (180 Å initial thickness).*

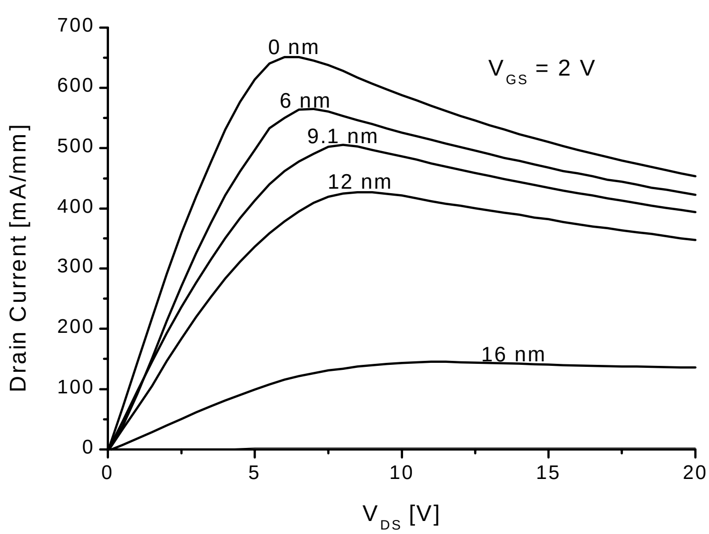


*Figure 3: Drain current dependence on top barrier etching. Shallow wet etches have almost no effect on $I_{DS}$ but reduce $I_G$ by more than an order of magnitude.*