# Effect of Silicon Nitride PECVD Growth on AlGaN/GaN HEMT Dispersion and Breakdown Characteristics

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Numerous researchers have studied the influence of silicon nitride passivation on AlGaN/GaN high electron mobility transistor large signal characteristics. Particular attention has been given to enhancing device breakdown characteristics by increasing the ammonia concentration during the PECVD $Si_3N_4$ deposition process.[1] Another important device parameter affecting large signal power performance is RF dispersion caused by surface states between the gate and drain.[2] Various passivation schemes have also been implemented to reduce RF dispersion, but lower dispersion typically results in lower breakdown. $SiO_2$ has been used as a passivation layer, resulting in lower drain current and degradation of RF performance.[3] The physical mechanism suggested for lower breakdown with lower dispersion is Si incorporating as a shallow donor at the AlGaN interface.

In this work, we have fabricated AlGaN/GaN HEMTs and examined the effect of modifications to the $Si_3N_4$ deposition process on device RF dispersion and breakdown. Figure 1 illustrates IV characteristics of the saturated drain current pulsed from four quiescent points. The bold curve is the DC sweep of Idss. Note that only the curve from Q-point (Vds = 0.5 V, Vgs = 0 V) nearly overlays the DC curve. The spread of the other curves indicates the presence of dispersion.

A baseline 300˚C $Si_3N_4$ deposition process using silane, ammonia, nitrogen and helium resulted in much better RF dispersion characteristics as shown in Figure 2. All of the pulsed sweeps are concentrated indicating reduced dispersion. At higher drain voltages the pulsed curves exhibit higher current due to lower self-heating, compared to the DC sweep. The breakdown dropped from greater than 50 volts to 25 volts after passivation. The potential cause for lower breakdown is a silicon-rich film. Therefore the ammonia flow was increased in the $Si_3N_4$ process. In addition, three films were deposited using 40, 60 and 80 watt plasma power settings applied to three samples. The resulting films had refractive indices of 1.9, and etch rates in BOE of 442, 329 and 312 Å/min, respectively. The baseiline $Si_3N_4$ etched at 420 Å/min. The devices deposited with the higher ammonia concentration $Si_3N_4$ all retained their high breakdown voltage of greater than 50 V.

The maximum pulsed current recovery was seen for the 60W process as shown in Figure 3. Three other Q-points shown in the previous figures were also tested, but the Idss recovery was lower than the 40 and 80W pulsed Idss curves of Figure 3.

These experimental results indicate that plasma power and nitrogen-to-silane ratio can be optimized to achieve lower RF dispersion and maintain device breakdown characteristics. Further studies are underway to optimize the nitride process and understand the physical mechanisms affecting these key device parameters.

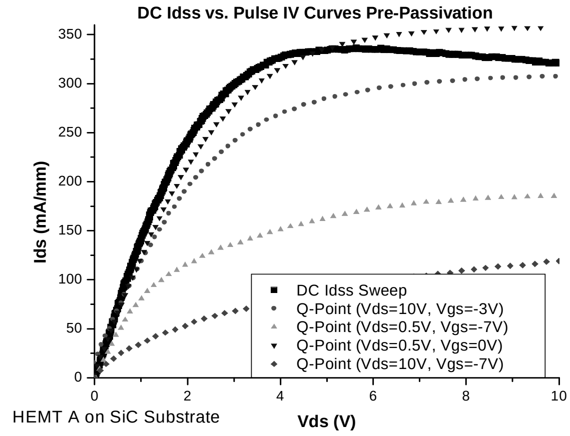


**Figure 1. DC Idss sweep versus pulsed sweeps from four quiescent points for a non-passivated HEMT.**

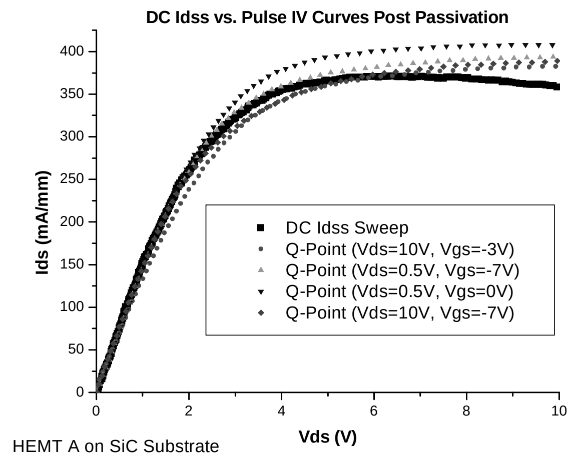


**Figure 2. DC Idss sweep versus pulsed sweeps from four quiescent points for a $Si_3N_4$ passivated HEMT.**

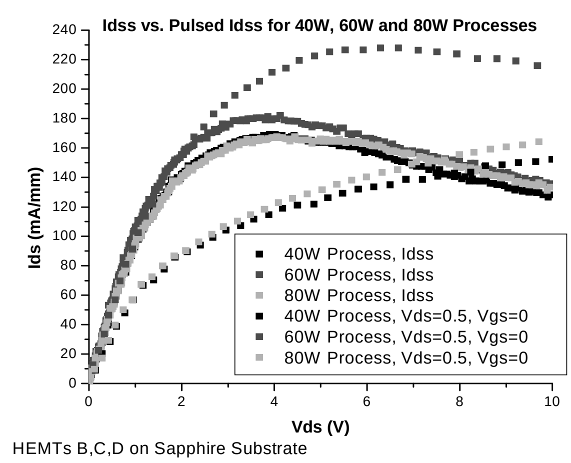


**Figure 3. Comparison of Idss versus pulsed Idss for 40, 60, and 80W PECVD $Si_3N_4$ deposition processes.**

## REFERENCES

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