Cellular Monte Carlo Study of DC and RF Performance Enhancement Through Access Region Scaling

R. Soligo, D. Guerra, D. K. Ferry, S. Goodnick, and M. Saraniti
Center for Computational Nanoscience,Arizona State University, Tempe, AZ 85287, USA
e-mail: r.soligo@asu.edu

INTRODUCTION

The effects of access region (AR) scaling in a state of art InAlN/GaN HEMT [1] were investigated in terms of RF and DC analysis through our full band Cellular Monte Carlo simulator. Vertical scaling technology has long been adopted to improve HEMT high frequency performance and has been extensively studied [3]. However, in order to realize the theoretical frequency limit of the device, attention has recently been focused on horizontal scaling of devices [4]. The present work aims to supply numerical and physical guidelines to such design scaling.

DC PERFORMANCE

The DC performance was first analyzed by symmetrically scaling the source-gate and gate-drain AR, while keeping the gate length constant. Fig. 1 shows the $I_d - V_g$ characteristic for different scaling. In particular, the g_m of the device monotonically increases to four times its original value scaling down both the ARs. From Fig. 2 we see that an asymmetrical scaling of the gate-source AR, keeping the gate-drain lenghts at the original value of 630nm, gives a g_m improvement that is lower than the case of symmetrical scaling. On the other hand, scaling the gate-drain AR keeping the source-gate lenght to 630nm has no influence on the $I_d - V_g$ characteristic. However, it can be seen from Fig. 1 that the gate-drain scaling becomes relevant for shorter source-gate lenghts.

RF ANALYSIS

The influence of the AR scaling on the RF performance was analyzed extracting the f_T from the short-circuit current gain as shown in Fig. 3. The RF performance enhancement obtained with scaling was further investigated in terms of microscopic carrier dynamics. In Fig. 4 it can be seen that the AR scaling increases the average velocity of the electrons entering the gate from the source. The higher velocity is due to the increased electric field in the transport direction due to the shorter AR as shown in Fig. 5. The percentage contribution of the different electrons to the total transit time is displayed in Fig. 6. In particular, it can be seen that scaling the device reduces the bottleneck represented by the slow electrons that are entering the gate effective lenght, as been noted earlier by Guerra *et al.* [2].

CONCLUSION

In this work a state-of-art InAlN barrier GaN based HEMT was fully characterized for different symmetrical scaling of the AR length. The DC analysis showed a monotonic increase of the current and *gm* with a symmetrical scaling. Similarly, AR scaling was found to be an effective technique to enhance the RF performance of the device.

REFERENCES

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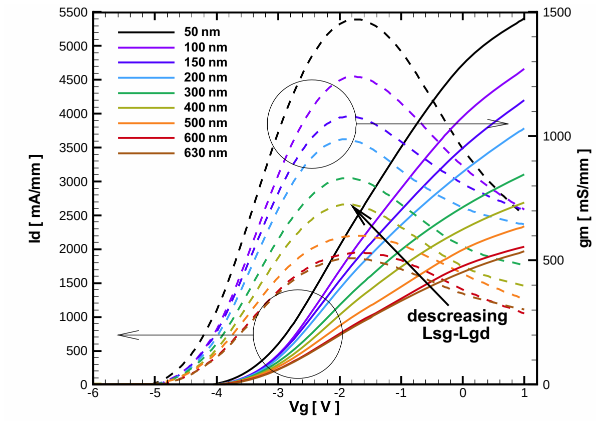

Fig. 1. Comparison of $I_d - V_g$ and g_m for different source-gate, gate-drain AR lengths corresponding to different colors in the legend.

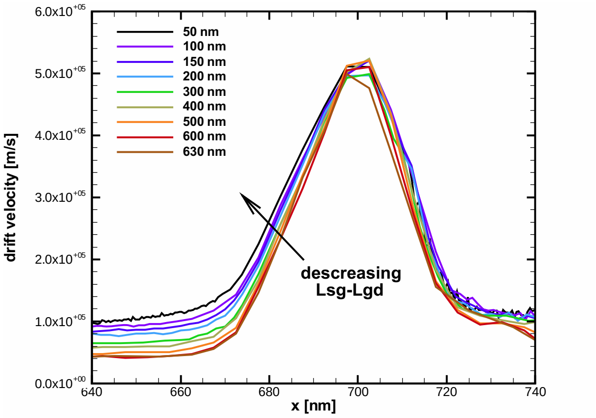

Fig. 4. Average electron velocity profile under the gate for different AR lenghts. Metallurgic gate from 670nm to 700nm.

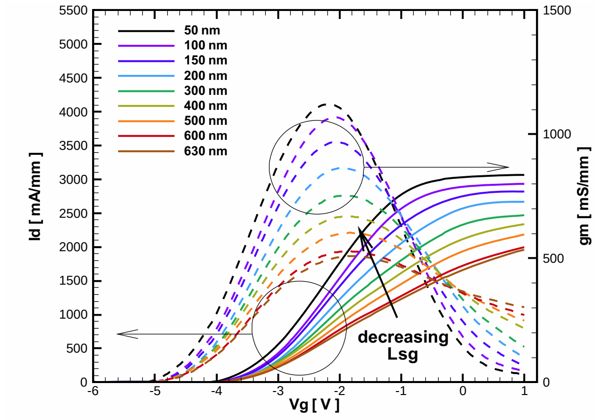

Fig. 2. Comparison of $I_d - V_g$ and g_m for different source-gate AR lengths corresponding to different colors in the legend.

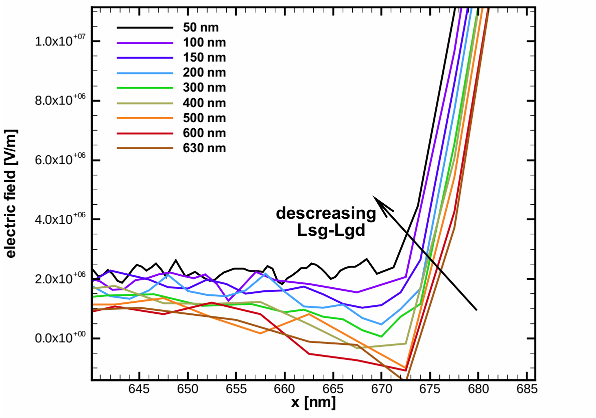

Fig. 5. Longitudinal electric field profile under the gate for different AR lenghts. Metallurgic gate from 670nm to 700nm.

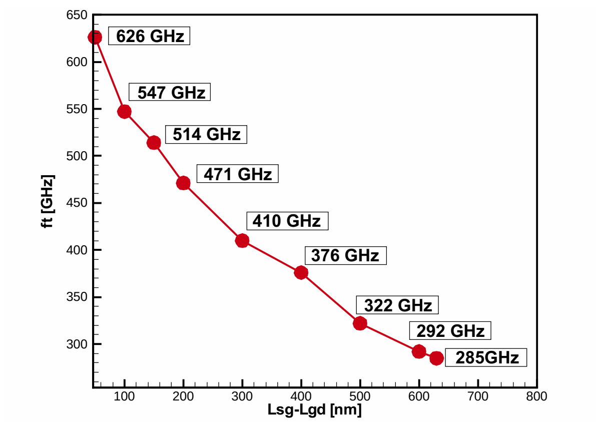

Fig. 3. f_t extracted from the short-circuit current gain for different AR (legend).

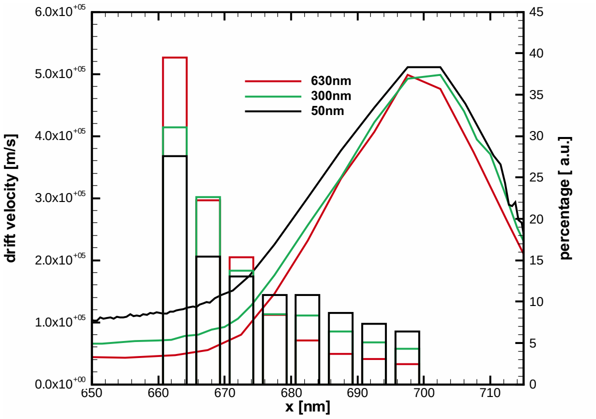

Fig. 6. Transit time percentage contribution due the different sections of Leff, with respect to the total transit time for different symmetrical AR lenghts.