Influence of Gatelength on the DC-Characteristics and f_T of Pseudomorphic Power-HEMTs

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Abstract -**Measurements and simulations of two pseudomorphic HEMTs designed for power applications are presented. The HEMTs are fabricated on the same wafer and do only differ in their gate lengths of 220 nm and 500 nm. Mixed hydrodynamic/drift-diffusion simulations are performed with a single consistent set of parameters. The important parameters g_m, g_{out} and f_T compare very well with the measured data. Therefore we are able to make accurate predictions of important circuit design parameters for a wide range of gate lengths relevant for modern GaAs MMICs.**

I. INTRODUCTION

Low cost, high performance power MMICs are required for many commercial system applications. Most of them are very cost driven with superior high frequency power capabilities in combination with high yield. Especially the reduction of gate length is a sensitive parameter of production cost which has to be balanced with the needed device performance. Rising the current gain cut-off frequency f_T also trades off with high output conductance. Accurate device simulation can be a substantial aid for the optimum device design for given requirements. But prerequisite is that the simulation is able to describe the device characteristics with a consistent set of parameters, i.e., not fitting the simulation to different devices individually. In this paper we present measurements and simulations with such a parameter set of two pseudomorphic HEMTs with gate length of 220 nm and 500 nm fabricated on the same wafer which compare very well.

II. SIMULATIONS AND MEASUREMENTS

In Fig. 1 the schematic cross section of the investigated HEMTs is shown. To simulate the influence of the gate length on the transport characteristics of the HEMT a hydrodynamic model is used in the channel and the upper barrier layer between gate and channel. Moreover source and drain contacts have to be on top of the cap layer only, i. e., not contacting the channel directly [1].

First the simulation of the HEMT with 220 nm was matched to the measurements by fitting parameters such as the effective distance from gate to channel d_{gch}, the active doping, the interface charge density between passivation and semiconductor, the low field mobility μ_0 and the saturation velocity v_{sat}. All parameters are found well within realistic ranges. In Fig. 2 simulations and measurements of the transfer characteristics of the two HEMTs are shown. Even though the parameters are fitted for the device with l_g=220 nm only, also the HEMT with l_g=500 nm is simulated very precisely. Also the measured and simulated transconductance g_m shown in Fig 3 compare very well. Both measurements and simulations show that V_T and $g_{m\,max}$ is shifted about 100 mV and $g_{m\,max}$ is raised about 50 mS/mm by reducing l_g from 220 nm to 500 nm. The maximum in g_m is reached at the same drain current.

C_{GS}+C_{GD} can be determined from simulations using the quasi static approximation

$$C_{GS} + C_{GD} = \left.\frac{\partial Q_G(V_{GS})}{\partial V_{GS}}\right|_{V_{DS}=const} \quad . \qquad (1)$$

Below pinch off both transistors show the same capacitance. In the active region they differ due to the difference in their gate contact area. Using the approximation

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$$f_T = \frac{g_m}{2\pi\left(C_{GS} + C_{GD}\right)} \quad (2)$$

f_T can be calculated. Fig. 4 shows the calculated $f_{T\,max}$ versus l_g and g_{out} at the bias point of $f_{T\,max}$ along with the measured data. It is shown that the simulated data are slightly higher than the measured ones. This is mainly due to a coplanar structure in which the HEMTs are embedded for RF measuremnts. The simulated f_T as well as g_{out} coincide very well with the measured data.

III. CONCLUSION

Measurements and simulations of two HEMTs which differ only in their gate length are presented. The simulated data obtained with one consistent set of parameters compare very well with the measurements. Also the calculated f_T shows the gate length dependence of the f_T very precisely. Therefore we are able to predict major device parameters important for circuit design with very high accuracy.

IV. REFERENCE

[1] H. Brech, T. Simlinger, T. Grave, and S. Selberherr, "Current Transport in Double Heterojunction HEMTs," in *ESSDERC'96 - 26th European Solid State Device Research Conference* (G. Baccarani and M. Rudan, eds.), (Gif-sur-Yvette Cedex, France), pp.873-876, Editions Frontiers, 1996.

V. FIGURES

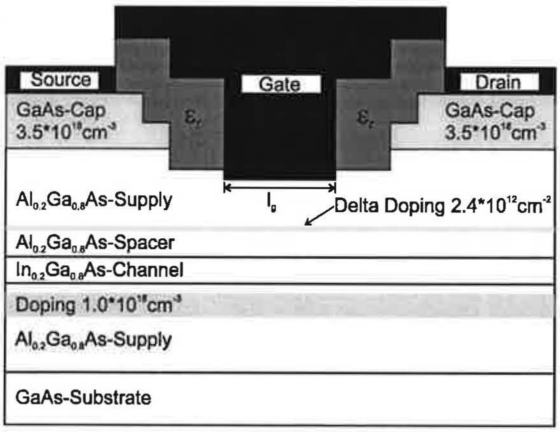

Fig. 1 Schematic cross section of the simulated HEMTs

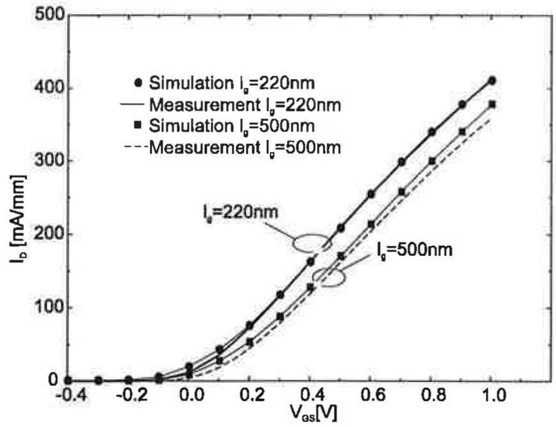

Fig. 2 Measured and simulated transfer characteristics of the two HEMTs

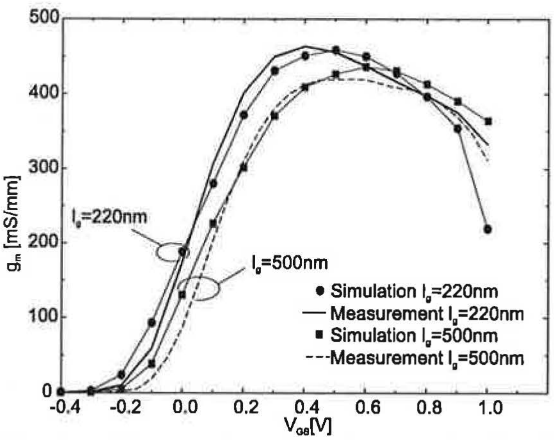

Fig. 3 Measured and simulated transconductance of the two HEMTs

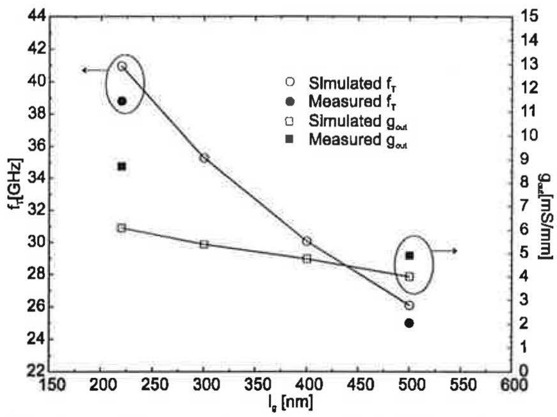

Fig. 4 Measured and simulated f_T and g_{out}