Comparison between Measured and Simulated Device Characteristics of High Electron Mobility Transistors

R. Deutschmann†, C. Fischer‡, C. Sala‡, S. Selberherr‡

†SIEMENS AG, Corporate Research and Development, ZFE STKM 51,
Otto-Hahn Ring 6, W-8000 Munich 83, Germany

‡TU Vienna, Institute for Microelectronics,
Gusshausstr. 27-29, A-1040 Vienna, Austria

Abstract

Measurements of the C-V characteristics of pseudomorphic high electron mobility transistors (HEMT) and the comparison with simulations are presented. It is well known that the shape of the gate capacitance C_g versus gate voltage V_g relationship is strongly influenced by the properties of the quasi two-dimensional electron gas (Q2DEG) which forms the active region of the device, as well as by the onset of a so-called parasitic channel in the wide bandgap material. In order to study the influence of important technological parameters on the capacitance, the Schrödinger and Poisson equations were solved self-consistently in the structure, using the thickness of the doped layer d_A and the doping density N_D as the main fit parameters. The simulation results are compared with measurements performed on wafer on sub-μm gate-length transistors as well as on so-called fat FETs (L_g = 100 μm). In addition we present comparisons between measurements and the quasi-2D simulation program HELENA [1].

Summary

The self-consistent Schrödinger-Poisson-Solver (SPS) computes the charge-control law and the layer capacitances for arbitrary heterojunction MODFET structures as described in [2] and [3]. Only physical parameters like the effective electron masses, the dielectricity constants of the different materials and the conduction band-edge discontinuities (with $\Delta E_c = 0.66\ \Delta E_g$) forming the heterojunction were used as input parameters in addition to the structural layout concerning the thickness of the different layers and the doping densities. SPS considers up to three conduction band valleys (Γ, X, L), the local exchange-correlation potential and deep donor levels according to the model of Schubert and Ploog [4].

Measurements were performed on wafer by using a HP 4275 A impedance analyzer. The simulated and measured C-V characteristics were found to be in good agreement with each other. The evaluated fit parameters deviate substantially from nominal process targets. Nevertheless, the correctness of the simulation results was corroborated by results extracted from measurements of other HEMT electrical properties.
The consistency of the evaluated parameters could also be demonstrated by comparisons with the quasi-2D simulation program HELENA. Furthermore, simulation results obtained by HELENA led to very good correspondence when compared to DC-, AC- and noise measurements.

References

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