Calculation of Switching Characteristics in a 0.5 μm Gate GaAs MESFET Using 2D-Particle Simulation

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ABSTRACT-The oscillations proper to the submicron GaAs MESFET have been observed in the drain current during some schemes of switching operation using a particle simulator with an ensemble Monte Carlo technique for the first time.

ACCURACY OF THE PARTICLE SIMULATION-The number of particles employed in each initial step of the simulation is 30,000. In order to suppress the numerical noise and to achieve the better time resolution of the currents responses as well as the authors can, we have repeated the simulation ten times using different numbers in the Monte Carlo procedure. The current responses are obtained by averaging the data on the currents arithmetically. This procedure nearly corresponds to a simulation with 300,000 particles. The time period for solving the Poisson's equation is less than 0.005 psec which is used for achievement of better self-consistency between the distributions of carrier density and electric field. The time resolution of the current responses is 0.05 psec which is smaller than that in the previous work by a factor of about 4. Owing to the better statistical convergence and the better self-consistency, the numerical noise is greatly suppressed. In addition, we have confirmed that the source, drain and gate currents approximately obey a Kirchhoff current law.

CURRENT RESPONSES-Figures 1(a)-(d) show the current responses associated with some schemes of OFF→ON switching operation. The currents consist of rapidly varying parts(overshoot and undershoot) just after the switchings and slowly varying parts following them. The switching time is determined by the latter parts. It seems to be larger for V_D=1.0 V than that for V_D=0.4 V, because the number of electrons in the satellite valleys with a large effective mass increases with V_D. Owing to the more accurate simulation in the present work, we have found an oscillation of the drain currents around 1 psec in Fig. 1(b) for the first time. The relaxation time approximation presented by Stenzel et al.(1987) could not reproduce this oscillation. Such an oscillation is hardly observed in the source currents. It is enhanced in the faster switching operation(Fig. 1(d)), but is suppressed for small V_D (

Figs. 1(a) and 1(c)). We have confirmed from the time-resolved data on the distributions of carrier density, electric field, and velocity that the oscillations are caused by the forward and backward movements of electrons between the drain and gate. Figure 2 shows the time-resolved distributions of carrier density. We can see an oscillation of the carrier density under the drain edge of the gate which causes the oscillation of the drain current.

The present results on the oscillation may be useful for better modeling the switching characteristics by RTA.

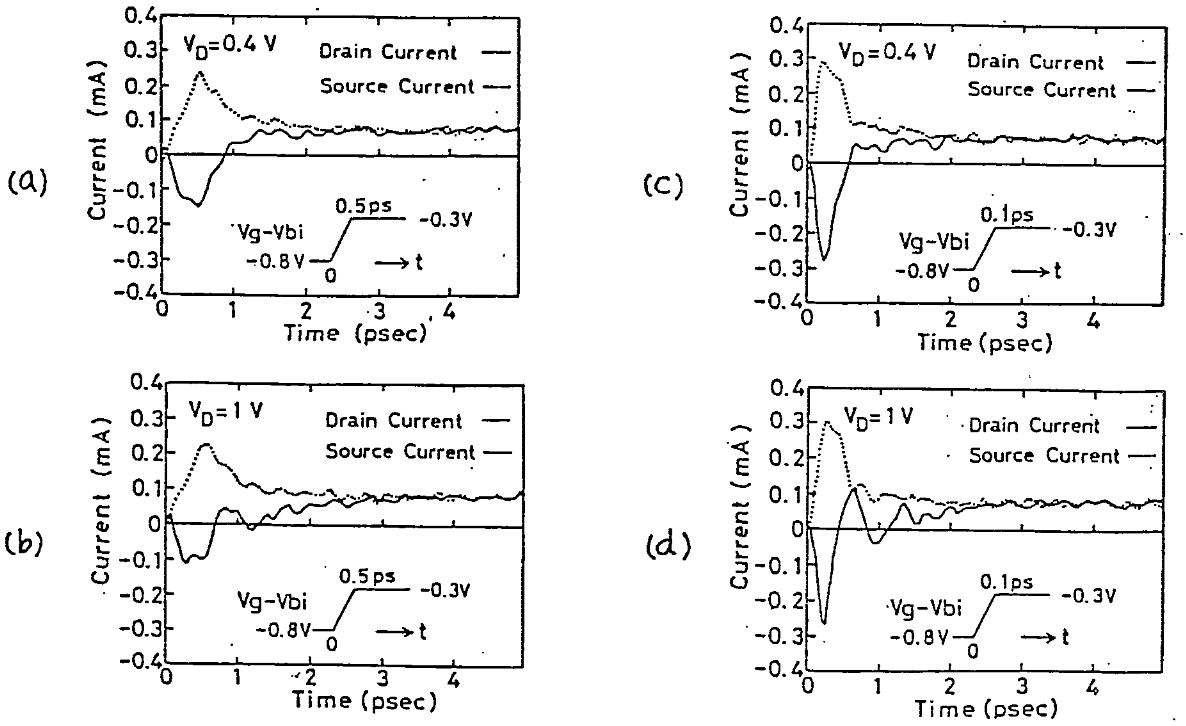

Fig. 1 Current responses for some schemes of OFF →ON switching operation.

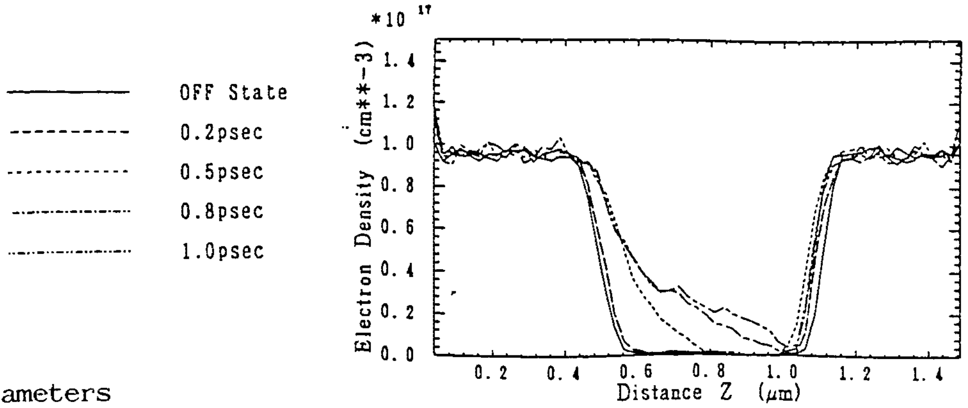

Fig. 2 Time-resolved distributions of carrier density along the bottom of the channel for V_D=1.0 V.

Table 1 Device parameters

lattice temperature: 300 K
doping density : 10^{17} cm^{-3}