SECTION IV. ENGINEERING AND IT

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HOMOSTRUCTURAL FIELD TRANSISTORS ON GALLIUM ARSENIDE FOR SENSOR MICROSYSTEMS

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Homostructured GaAs field-effect transistors have already been used in high-speed LIC. In such transistors and logic circuits, high speed compared to field-effect transistors on mono-Si speed is achieved due to six times higher electron mobility in GaAs, increasing their average drift velocity in the active region of the device, due to the effect of flash drift and reduction to submicron the length of the shutter length. The latter two factors are interrelated as reducing the shutter size leads under all other general conditions to an increase in electric fields in the channel and a reduction in the travel time of the active region to picoseconds, when a flash drift prevents its saturation. In addition, reducing the size of the shutter system leads to a decrease in drain-source and shutter capacities. Modeling the operation of field-effect transistors, taking into account the speed of the flash and short-channel effects, requires consideration of the effects associated with the formation of bulk charge. In other words, in the general case, the Boltzmann equation must be supplemented by the well-known Poisson equation:

$$\vec{E} = \varphi a\rho/\varepsilon$$

and solve the problem of finding the complete distribution function φ (r, k, t) of electrons both in velocities and in spatial coordinates. Moreover, the effect of the flash of the electron drift velocity in the field-effect transistor is not local, as it depends on the electric field not only at a given point in space. Therefore, the problem of finding the function φ (r, k, t) and then the parameters of specific transistor structures is quite complex and analytically unsolvable.

Therefore, a number of authors have proposed a number of approximate for the calculation of stationary and non-stationary characteristics of field-effect transistors, which took into account the distribution of electrons in coordinate and velocity, bulk and surface charges, the phenomena of flash drift.

First of all, this is the most accurate calculation of the known method of Monte Carlo.

However, its application to calculate the multidimensional distribution function in the space of speed and coordinates and time requires a very large cost of machine time, even high-speed electronic computers such as "Elbrus". Therefore, complex so-called hydrodynamic problems are most often used, in the models of which for significant simplification of calculations already operate with average values, such as energy density, temperature, local concentration of charge carriers.

The hydrodynamic model already takes into account the spatial energy transfer of electrons and not the locality of the drift velocity and electric field in the submicron structures of the LIC. In Figure 1. the results of this calculation for mono-Si and GaAs are presented. If in the case of Si the average electron velocity depending on the coordinate in the local dependence approximation Vd (E) and in the approximate hydrodynamic model of energy transfer in space do not differ much (Fig. 1, a), then for GaAs this difference is very large (Fig. 1, b).

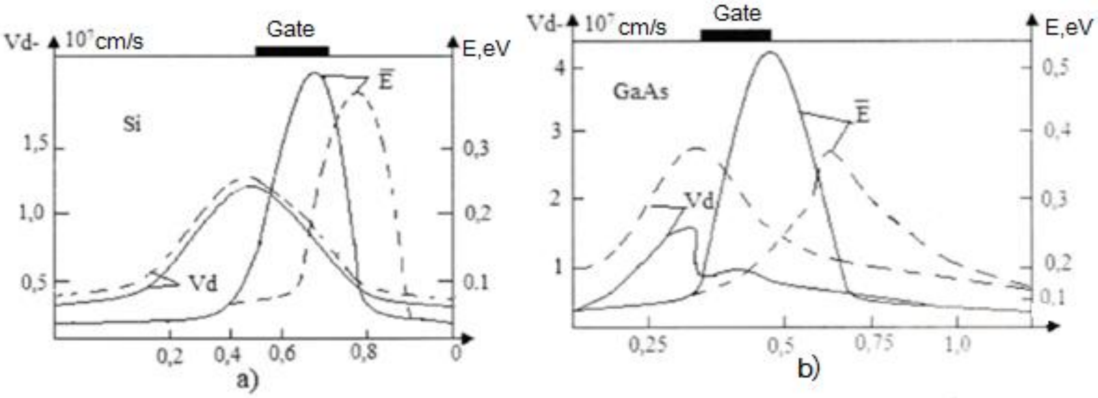


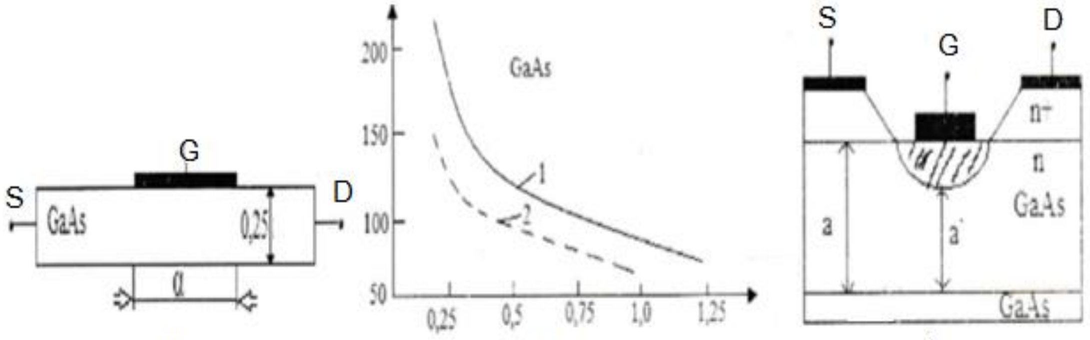
Fig. 1. **Calculated dependences of the forward energy and drift velocity on the coordinate for the field-effect transistor on Si. a) GaAs (Vc = 1.0V); b) with a submicron (0.25 μm) shutter according to the hydrodynamic model**.

Comparison of the calculated Volt Ampere Characteristics with experimental measurements for a field-effect transistor on GaAs with n + -ionically implanted submicron gates (d = 0.2-1 μm) showed a high value of the effective saturation rate $V_S = 2.3 \cdot 10^7$ cm/s with a high value flash speed in the channel. However, V_S does not depend on the channel length in the range of 0.2-1 μm, which in some ways contradicts the dynamic nature of the effect of the speed flash. Therefore, the researchers concluded that the strong electric field in which the electron velocity reaches a maximum, refers only to the region of 0.25 μm and does not depend on the length of the shutter.

Researcher R. Stendell performed a two-dimensional calculation of the electric field and electron current in a GaAs field-effect transistor on the basis of the Poisson phenomenological equations and continuity for the two-part GaAs model. The values of the relaxation times for the inter-valley transitions were determined by comparing the results of this calculation of the velocity flash after the inclusion of the electric field jump with the corresponding statistical calculations of Monte Carlo. Figure 2 shows the structure of the field-effect transistor and its slope, for which such a calculation was performed.

As we can see from the calculations, the effect of the flash drift speed significantly affects the steepness of the field-effect transistor at a gate length of up to 1 μm. The same researcher calculated the delay time and other characteristics of the field-effect transistor with a normally closed and normally open channel with a gate length of submicron size λ = 0.25 μm.

$(N_d(k) = N_0 e\varkappa\left\{-\left[\left(x - R_p\right)/2\,\Delta R_p\right]^2\right\})$ де $N_d=1\cdot10^{18}$cm^{-3}, $R_p=0$, and 0,02μm, $\Delta R_P=0{,}015$–0,028μm. The height of the Schottky barrier is exactly 0.8V.



a) b) c)

Figure 2. **The structure of the PT, for which a two-dimensional calculation of the electron drift velocity was performed**

a) $N_d = 10^{17}$ ***cm***$^{-3}$***, λ - gate length, distance, source-drain are equal to 3λ;***

b) calculations of the steepness of the PT taking into account the flash of drift speed (1) and without it (U_{BC} ***= 1B,*** $V_{SD} \approx 0$***);***

c) the structure of PTS.

Figure 2.c) shows a typical experimental structure of a Schottky field-effect transistor. The values of τ_{Di} P_D were calculated for a ring generator of inverters from a normally open to a normally closed state of a Schottky field-effect transistor.

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