QUANTIZATION OF ELECTRON ENERGY IN SHORT CHANNEL MOSFETS

O.G. Zhevnyak, Ya.O. Zhevnyak

Belarussian State University, Minsk
E-mail: Zhevnyakol@tut.by

As known there is an energy quantization in silicon inversion layers [1]. With co-authors we had showed this phenomenon may be influential for electron properties in MOSFET's current channel at definite conditions [2]. However these conditions are not deeply studied.

The purpose of present work is the investigation of gate and drain bias effect on structure of quantization energy levels in MOSFET's conduction layer (current channel). This effect is determined by changing of potential slope along the transistor's channel. On fig. 1 the general potential profiles into the MOSFET substrate are schematically presented.

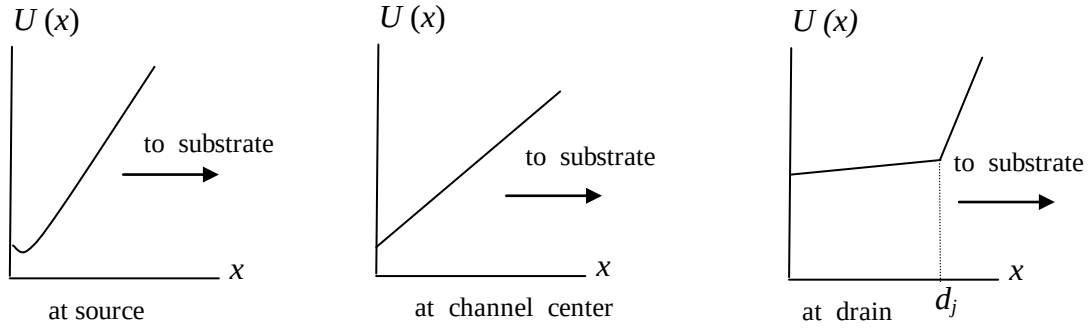

Fig. 1. Potential slope along the transistor's channel. d_j is the drain deepness into MOSFET substrate

Evidently the structure of quantization energy levels is not uniform along the channel.

In present work we have calculated the quantization energy levels by direct solution of Schrödinger equation

$$\psi'' + 2\frac{m}{\hbar^2}\left(E - U(x)\right)\psi = 0, \qquad (1)$$

where ψ – electron wave function, E – energy, $U(x)$ – potential profile into the substrate. Used bound conditions were $\psi(0) = \psi(\infty) = 0$. The potential profiles $U(x)$ at each channel section are obtained by using Monte Carlo simulation of electron transport in MOSFETs and solution of Poisson equation [3].

The solution of Schrödinger equation ψ we have found using infinite mathematical series as $\psi = \sum_k C_k x^k$. The roots x_i of equation $\psi(x_i) = 0$ give the values E_i in according to

$$E_i = Fx_i \ , \qquad (2)$$

where F – electric field in direction to substrate at considered section of channel. The values of x_i were numerically founded.

So the energy levels structures along the transistor's channel are calculated. We have considered MOSFETs at a wide range of gate and drain bias with channel length is less 0.4 μm. Gate oxide is equal 7 nm. We have considered drain deepness into MOSFET substrate equal 0.1 μm as well as 0.01 μm. The obtained data show that for studied conditions the quantization energy levels are appeared only for d_j = 0.01 μm. On fig. 2 the potential profiles obtained using Monte Carlo simulation are presented for last case. In other cases the energy quantization is not arisen as the distance between nearest energy levels is less than the temperature energy broadening.

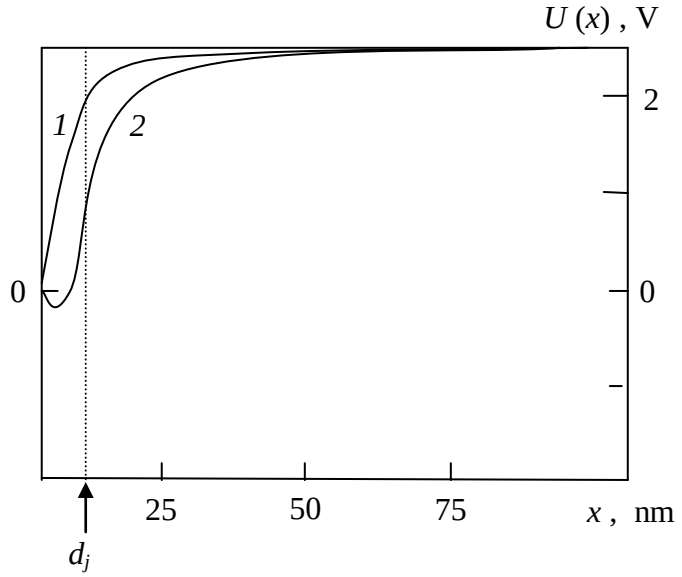

Fig. 2. Potential slope for MOSFET with d_j = 0.01 μm. V_G = 3 V, V_D = 1 V. *1* – at source region, *2* – at drain region

1. *Ando T., Fowler A. B.* and *Stern F. //* Rev. Mod. Phys. 1982. V. 54. P. 437–672.
2. *Borzdov V., Zhevnyak O., Komarov F., Galenchik V.* Monte Carlo simulation of integral electronics device structures. Minsk: BSU, Minsk, 2007. 175 p. (in Russian)
3. *Zhevnyak O.* // Proc. SPIE. 2008. Vol. 7025. P. 1M-1–8.