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The shape of the relief of the insulating potential, created by ultrathin layers of the oxide

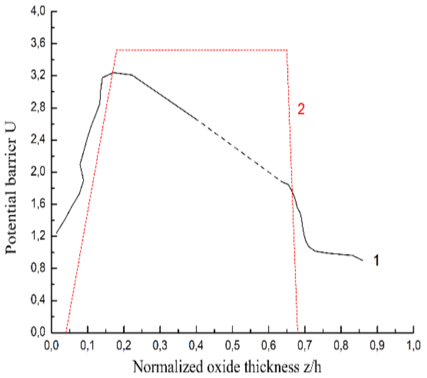
E.I. Goldman, I.A. Shusharin, G.V. Chucheva
Fryazino Branch of the Kotelnikov Institute of Radioengineering and Electronics of Russian Academy of Science, Fryazino, Russia, E-mail: gvc@ms.ire.mssi.ru

The insulating potential, created by ultra-thin (less than 5nm) oxide films has a more complex shape, than a rectangular one. Transition layers between plates and the oxide occupy at least 35% of the volume and largely determine properties of the insulator. Since there are no theoretical foundations that allow using the effective mass method to describe the wave function of an electron in a disordered material, the coordinate dependence of the potential in the insulating gap should be a certain function leading to the calculation results that coincide with experiment. This relief should be constructed from the experimental tunnel *I–V* characteristics of poly-n^+ Si-SiO_2-Si structures. This problem of inverting measurement data was solved earlier [1]. In this work, we will slightly change the previously developed apparatus and apply it to samples of poly-n^+ Si-SiO_2-Si structures, similar to those studied in [1], but with a pronounced asymmetry of tunneling *I–V* characteristics [2].

The inversion of the experimental dependence of the tunneling current on the voltage was obtained in [1]

$$\left[\frac{z_2(V)}{h}\right]^{3/2}-\left[\frac{z_1(V)}{h}\right]^{3/2}=\frac{2\bar{V}^{(1/2)}}{\pi}\int_V^{V_m}\left(V'-V\right)^{-(1/2)}\frac{d\ln\left[I\left(V'\right)/I_0\right]}{dV'}dV'$$

Where $z_{1,2}$ are coordinates of 1st and 2nd turning points, h is the thickness of the oxide, I_0 is the normalization constant, $\bar{V}=\left(9\hbar^2/32mh^2q\right)$, m is the mass of the tunneling electron, q is the elementary charge, V_m is the barrier removal voltage. From two branches of the dependence $I(V)$, depletion and enrichment Si, parametrically through functions $z_1(V)$, $z_2(V)$, successive approximations to the sought relief $U(z)$ were constructed. Calculations based on the trapezoidal potential with parameters providing the function $I(V)$ that is as close as possible to the experiment were used as a zero approximation (see curve 2 in Fig.). All actions were carried out for each of the 10 m values; the one at which the successive approximations converge in a single curve $U(z)$ in the best way was selected. The result for the relief (curve 1 in Fig.) corresponds to the 6th approximation and m=1.2m_0, where m_0 is the mass of a free electron. The barrier is much thinner than the insulating layer, its maximum is shifted towards the contact with the polycrystalline material, the potential drop towards the contact with Si is much more shallow than in the direction of poly n^+-Si, and the effective mass of the tunneling electron is greater than the value for a free particle.



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2. E.I. Goldman, S.A. Levashov, and G.V. Chucheva. “Features of the Characteristics of Field-Resistant Silicon–Ultrathin Oxide–Polysilicon Structures”. Semiconductors, **53**, pp. 465–468, 2019. https://doi.org/10.1134/S1063782619040109.