**Development of a molecular single-electron transistor with a singleatom charge center**

V. Gaydamachenko1 , E. Morozova1 , S. Dagesyan1,2, E. Soldatov1,2, E. Beloglazkina1

*1. M.V. Lomonosov Moscow State University, Moscow, Russia, soldatov.es@physics.msu.ru*

*2. The Center for Quantum Technologies of M.V. Lomonosov Moscow State University, Moscow, Russia,* [soldatov.es@physics.msu.ru](mailto:soldatov.es@physics.msu.ru)

Single-electron transistor, parameters and characteristics of which are fundamentally improved with decreasing element sizes [1], is a promising element of extremely small, atomic-molecular scale. An atomic transistor consisting of a monatomic charge center inside a molecule connected to source and drain electrodes by aurofilic terminal groups of this molecule is the most promising, limiting version of such a transistor. However, the creation of a reliable technology for the manufacture of such nanoelements is not yet completed and is a very urgent task. In this paper, a version of such a molecular-atom nanotransistor has been developed and implemented.

To create a planar nanostructure of such a transistor on a silicon substrate coated with silicon dioxide, the bottom gate electrode was first formed in the lower layer of the element using a scanning electron microscope Supra40 with a Raith lithography attachment. The bottom gate was separated from top layer of transistor by a thin (20 nm) dielectric film that provided insulation leakage resistance of more than 1 TOhm at a voltage of 50 V. The structure of nanowires from thin (18 nm) gold films serving as a blank for the formation of transport and side control electrodes of a transistor was formed on this insulating layer by the methods of electron nanolithography. Further, the electrodes of the manufactured side gates were covered by a layer of alumina (Al2O3) 30 nm thick through the "windows" in the positive PMMA A2 resist mask. After removing the mask, a nanostructure was obtained in which the alumina film completely insulates the side gates, without affecting the nanowire. The leakage current measurements between the nanowire and the gate showed that the insulation resistance exceeds 1 TOhm. Then, the molecules of the aurophilic terpyridine derivative based on single rhodium atoms [2], having a length of 4.7 nm, were fixed on the surface of the nanowires during the "self-assembly". After that, by means of electromigration, a nanosized gap of 2-4 nm was formed [3] in a nanowire, during which one of the molecules fixed on the nanowire was built in the gap, thereby forming a tunnel system with charge center for electron tunneling through it. Measurements of electron transport through manufactured systems have shown the presence of a molecule in the gap and typical single-electron characteristics with a Coulomb blockade of about 250 mV.

Thus, molecular single-electron transistors with single molecules of aurophilic terpyridine derivative based on single rhodium atoms as an island with charge energy up to 250 meV are manufactured, which ensures their high operating temperature up to room temperature.

1. K.K. Likharev. “Single-electron devices and their applications”. Proc. IEEE, 87, pp. 606-632, 1999.

2. E.K. Beloglazkina, A.G. Majouga, E.A. Manzheliy et al. “Mononuclear ruthenium(II) and rhodium(III) complexes with S-[4-(2,2:6′,2″-terpyridin-4′-yl)phenoxy]butyl ethanethioate and 4′-[4-(1,2-dithiolane-3- yl)butylcarboxy)phenyl]-2,2′:6′,2″-terpyridine: Synthesis, electrochemistry, antibacterial activity and catalytical application”. Polyhedron, 85, рp. 800-8008, 2015.

3. S.A. Dagesyan, A.S. Stepanov, E.S. Soldatov et al. “Properties of Extremely Narrow Gaps Between Electrodes of a Molecular Transistor”. Journal of Superconductivity and Novel Magnetism, 28, pp. 787-790, 2015.