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Quasi-two-dimensional electron gas at the interface of two dielectrics: ferroelectric/antiferromagnet

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A high-mobility electron gas was first observed in 2004 [1] at the interface of $LaAlO_3$ (LAO) and $SrTiO_3$ (STO). After that, such heterointerfaces involving two insulating nonmagnetic oxides were comprehensively studied. In particular, it was found that the metallic phase (quasi-two-dimensional electron gas, q2DEG) is formed in the STO layers at the LAO/STO interface when the number of LAO layers is larger than three [2,3]. Such a system undergoes a transition to a superconducting state below 300 mK [4]. It has been shown that analogous to the ionic polar discontinuity, the quasi two dimensional electron gas (q2DEG [1]) may be created at an interface due to electric polarization discontinuity [2,3]. The creation of quasi-two-dimensional superconducting states at the interface and the ability to control such states by magnetic and electric fields is impossible without the use of new materials and without the development of new design interfaces. Unique properties of functional materials are achieved due to the effects associated with the complex composition of the interface structure. Such new materials include oxide heterointerfaces between two nonconducting oxides in which, owing to strong electronic correlations, unique transport properties are observed. We check the idea, that antiferromagnetic $LaMnO_3$ might be transferred to ferromagnetic state by increasing the concentration of free carriers by injection. This means that increasing the free change carriers might lead to the local ferromagnetic state and magneto-resistivity in a system with 2DEG. Therefore, there is an opportunity to switch both conductivity by an electric field (trigger effect), and the magnetic order (magnetoelectric effect) in the heterostructures similar to BTO/LMO.

We investigate the optical properties of q2DEG at the interface between ferroelectric oxide and insulating oxide in heterostructures, isostructural to $BaTiO_3/LaMnO_3$. The numerical simulations of the structural and electronic characteristics of the $BaTiO_3/LaMnO_3$ ferroelectric-antiferromagnet heterostructure have been performed. The temperature dependence of the electrical resistance has been studied for heterostructures formed by antiferromagnetic $LaMnO_3$ single crystals of different orientations with epitaxial films of ferroelectric $Ba_{0.8}Sr_{0.2}TiO_3$ (BSTO) deposited onto them. The measured electrical resistance is compared to that exhibited by $LaMnO_3$ (LMO) single crystals without the films. It is found that, in the samples with the film, for which the axis of polarization in the ferroelectric is directed along the perpendicular to the surface of the single crystal, the electrical resistance decreases significantly with temperature, exhibiting metallic behavior below 160 K [5]. The transition to the state with q2DEG at the interface is demonstrated. The effect of a magnetic field on heterostructure BSTO/LMO haves been investigated. It is sown that magnetic field change the resistivity properties of the interface BSTO/LMO very strong. The properties of the interfaces and the transfer to superconducting state are presented for the heterostrocture of ferroelectric/antiferromagnet with other compound.

The reported study was funded by Russian Scientific Foundation, research project No. 18-12-00260.

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