CONTROLLING ELECTRON SPIN IN NON-MAGNETIC NANOSTRUCTURES

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Spin–related degrees of freedom are already applied in data storage technology, and semiconductor based spintronic devices have the potential to outperform conventional electronic and communication systems. It is essential, however, to develop methods for creation and detection of coherent carriers with polarized internal magnetic moments in non-magnetic matrix of conventional semiconductors. In this contribution I review the results of our recent theoretical and experimental works devoted to controlling the electron spins by spin-orbit interaction and by application of local magnetic fields in semiconductor devices of reduced dimensionality. First, I will focus on the influence of bulk inversion asymmetry on model spin field effect transistor and show that the conductance depends significantly on subband index and on the crystallographic orientation of the GaAs and InAs device channel.
Next, I will present the experimental data obtained for GaAs/GaAlAs quantum wires of length L=0.6, 10 and 15 micrometers. Results confirmed that the so-called "0.7 anomaly" is related to spontaneous spin polarization of one-dimensional electron gas and that this effect is very robust against the disorder. Furthermore, I will describe the new method of the g-factor determination for such quantum wires which is based on the splitting of the transmission vs width oscillations observed when the in-plane external magnetic field is applied.
Finally, I will consider theoretically the asymmetric redistribution of spins across the width of GaAs and GaN quantum wires, which may be induced by the external in-plane magnetic field gradient of 10^6 T/m. This study is motivated by our recent experimental work on the electronic spin separator based on the Stern-Gerlach effect. The analysis of results indicates that exchange interaction enhances strongly (up to 400 times) the effective magnetic field gradient at the center of 1D-channel. This causes the substantial spin polarization of electron liquid along the opposite wire edges for both materials, even if the bulk g-factors are assumed for GaAs and GaN.