Spin and charge transport through the Fe/MgO/GaAs heterostructure

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One of intensively investigated problems in modern spintronics is the problem of spin injection into semiconductor through the insulating tunnel barrier. It is well known that this method provides maximum efficiency of spin polarization of the injected electrons. The best known now insulator material for the tunnel barrier is MgO.

Here we present our theoretical results and the results of computer simulation of the tunneling current and spin polarization efficiency of Fe/MgO/GaAs junctions as a function of external voltage for different parameters characterising the semiconducting GaAs. The main mechanism of the current is related to the tunneling through the barrier changing its shape under bias voltage. We found that the resistance of strongly doped n- or p-type GaAs usually gives relatively small correction to the tunneling resistance for any parameters of semiconductor. However, our computer simulations show that the essential effect can be related to some special doping of GaAs in the border region near the MgO/GaAs interface. For example, a thin layer of nearly intrinsic semiconductor can be formed near the interface due to the deep levels of Fe impurity atoms in GaAs. It turns out that this changes dramatically the energy diagram of the junction making the tunneling characteristics similar to the case of tunneling to the energy gap.

Our theoretical results are in good agreement with the measurements of current-voltage characteristics of metal-insulator-semiconductor heterostructure with Fe nanodisks at the surface of GaAs semiconductor covered with thin MgO layer.

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