Ballistic transport in spin field-effect transistors built on Si and InAs

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Spin field-effect transistor (SpinFET) proposed by Datta and Das [1] is composed of ferromagnetic metallic source and drain contacts which sandwich a semiconductor region. We investigate influence of a temperature to the properties of InAs channel devices. The tunneling magnetoresistance (TMR) oscillates between positive and negative values [2, 3] as it is sown in Figure 1. As the length of the semiconductor channel increases, the period of oscillations decreases proportionally to the length of the semiconductor channel. Temperature exerts significant influence on the device characteristics. For the channel length L=0.3μm oscillatory amplitude of the TMR dramatically decreases even for the T=10K and completely vanishes for the T=50K. Although for the channel length L=0.03μm TMR oscillate even for the T=150K. Therefore shorter channel are preferred for practical realizations of SpinFETs. As it is shown in Figure 2 the value of the steady current depends on the value of the band mismatch (δEc) between the ferromagnetic and semiconductor region even for the room temperature the values are different. This effect provides an additional option to tune the performance of the SpinFET. Finally we study properties of the SpinFET built on the silicon fin. Fins of [100] orientation shows stronger dependence on spin-orbit interaction treated in the Dresselhaus form [4].

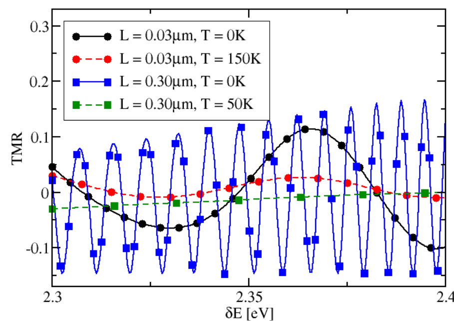

Fig. 1: TMR dependence on the value of δE, for E_F=2.47eV, eV=0.001eV, α_R=31.7meVnm.

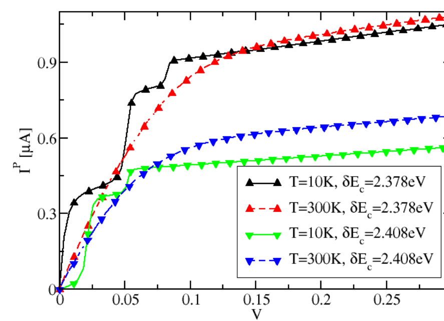

Fig. 2: Current dependence on the value of the drain-source voltage for L=0.03μm.

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