

Spin injection into a high mobility 2DEG system

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Electrical generation and control of electron spins in semiconductors is the central theme in semiconductor spintronics and of big importance for device prospects. In particular spin injection into two-dimensional (2D) electron systems would allow for many new functionalities in future devices, with a Datta-Das spin field effect transistor [1] being a primary example. Building on successful realization of spin injection into bulk GaAs employing the diluted magnetic semiconductor (Ga,Mn)As as a ferromagnetic material [2] we extended our work into heterostructures containing 2D electron gases (2DEG). We investigate two types of systems: 2DEG confined in a InGaAs quantum well structure and high mobility 2DEG confined in an inverted AlGaAs/GaAs heterojunction.

Experiments were performed on lateral devices consisting of a 2D channel of 50 μm width with four ferromagnetic (FM) spin injecting/detecting contacts placed about 200 nm above the channel. FM contacts consist of a (Ga,Mn)As/GaAs Esaki diode structure, similar to the one used in experiments on bulk devices [2]. The doping profile and the layer layout of the used MBE-grown wafer were carefully designed in order to assure that: (i) a sufficiently large charge current flows from the Esaki diode down to the 2D system to generate spin accumulation; (ii) after etching away the layers forming a diode structure from the region between the contacts, a lateral transport occurs exclusively within the 2D layer. Magnetotransport measurements confirmed the formation of a high quality 2DEG in both investigated systems with mobility reaching $\mu=5\times 10^5$ cm^2/Vs for the inverted AlGaAs/GaAs heterojunction. We observe clear nonlocal spin-valve signals in both systems, with typical results for AlGaAs/GaAs structure shown in Fig.1. We discuss in details a peculiar bias dependence of the spin signal observed for the high mobility structure, with unusually high values of spin injection efficiency obtained for a certain range of negative bias values.

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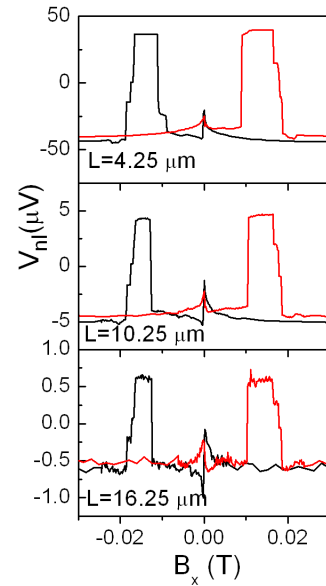


Fig. 1 Non-local spin valve signal (after removing the background) for three different values of injector-detector separation L observed for the AlGaAs/GaAs structure for an injection current of $I=-20\mu\text{A}$ at $T=4.2\text{K}$.

[1] S. Datta and B. Das, Appl. Phys. Lett. **56**, 665 (1990).

[2] M. Ciorga *et al.*, Phys. Rev. B **79**, 165321 (2009)