Hybrid nanostructures as local spin filters and detectors

G. Grabecki, J. Wróbel, and T. Dietl

Institute of Physics, Polish Academy of Sciences, Lotników 32/46, 02-668 Warsaw, Poland
ERATO Semiconductor Spintronics Project, Japan Science and Technology Agency

We review results of ballistic transport measurements carried out on nanostructures of $PbTe/Pb_{1-x}Eu_xTe$ quantum wells (QW). There are three main reasons making this system interesting in the context of spin-polarized transport. First, an extremely large static dielectric constant ($\varepsilon_0 \approx 1350$ at T = 4.2 K) leads to suppression of long-range Coulomb potentials of ionized defects. Therefore, electron scattering is both reduced and isotropic, which significantly relaxes conditions for observation of the conductance quantization [1, 2]. Second, because of narrow band gap and large spin-orbit interaction, the Zeeman splitting is comparable to the cyclotron splitting. This makes it possible to generate spin-polarized currents in a magnetic field below 1 T [3]. Finally, Schottky barrier effects are much suppressed for many superconducting metals deposited on PbTe, which enables observations of Andreev reflection-assisted conductance. It is well known that this effect may be used as a tool for electrical detection of spin polarization [4].

Nanostructures in the form of Hall bridges, quantum point contacts (QPCs), and quantum dots have been fabricated by electron beam lithography and wet chemical etching. The initial material consisted of 50 nm thick PbTe QW embedded between Bi-doped $Pb_{0.92}Eu_{0.08}Te$ barriers ($E_g \approx 0.6$ eV), grown coherently by MBE onto 2.5 μm $Pb_{0.92}Eu_{0.08}Te$ undoped buffer layer and BaF_2 substrate. Millikelvin magnetotransport measurements reveal a variety of conductance quantization phenomena. In particular, for appropriately large thickness of the quantum well we observe the expected theoretically orbital degeneracy of conductance *plateaux*. Furthermore, spin resolved half-integer conductance *plateaux* become visible in external magnetic fields as weak as 0.2 T. This indicates that QPCs of PbTe may be used as local spin filters tuned by *locally generated* magnetic fields (*e.g.* by means of micromagnets). We also performed differential conductance measurements as a function of the voltage bias *U,* on hybrid Indium/PbTe nanojunctions. For temperatures below the superconducting transition in In, we have observe a pronounced zero-bias maximum of the width ΔU consistent with Δ/e, where Δ is an energy gap in the superconducting In. The observed phenomenon points to a strong contribution of the Andreev reflection in our system. Both above findings indicate that PbTe hybrid nanostructures constitute a system suitable for *local* control of spin-polarized currents by *electrical* means.

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Name of the presenting author (invited): Grzegorz Grabecki
e-mail address: grabec@ifpan.edu.pl
url's: http://info.ifpan.edu.pl