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Spin-polarized reflection of electrons in a two-dimensional electron system

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We present a method to create spin-polarized beams of ballistic electrons by elastic scattering off a lithographic boundary in a mesoscopic geometry, and present experimental data corroborating the method. In the ballistic transport regime, the dominant scattering events involve the device boundaries. Whereas reflection of carriers from device boundaries is specular if spin-orbit interaction can be neglected, in the presence of strong spin-orbit interaction, spin-flip scattering results in different reflection angles for different spin polarizations. Reflection of a spin-unpolarized injected beam from a lithographic barrier gives rise to three reflection angles, hence three beams: two spin-polarized side beams and one unpolarized specular beam. The side beams can be captured through suitably positioned apertures in a mesoscopic geometry. Consequently, if the spin coherence length is longer than the mean free path, spin-orbit interaction together with the device geometry can be exploited for the preparation of spin-polarized carrier states. We present low-temperature experimental results verifying the realization of the method in a high-mobility, MBE-grown InSb/InAlSb heterostructure where spin-orbit interaction is strong. In our geometry, a small perpendicular magnetic field is utilized to sweep the triplet beam structure over an exit aperture, leading to steps in the magnetoresistance data. The data agree with Fermi contours calculated using realistic values of Rashba and Dresselhaus spin-orbit parameters. The multi-beam reflection process can be utilized to create spin-polarized carrier populations, without the use of ferromagnetic contacts (Appl. Phys. Lett., Jan. 05; NSF DMR-0094055, -0080054, -0209371).