Electrically controlled spin-transistor operation in helical magnetic field

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ABSTRACT

The realization of the functional spin transistor (spin-FET) still remains an experimental challenge of spintronics. This is due to the fundamental physical obstacles such as the low spin-injection efficiency from ferromagnet into semiconductor, spin relaxation, and the spread of the spin precession angles. All these effects lead to the low electrical signal in the up-to date realized spin-FET [1, 2]. An alternative spin-transistor design has been recently demonstrated by Betthausen et al. in Ref. [3]. In this approach, the spin of electron flowing through the nanostructure is subjected to the combined homogeneous and helical magnetic fields. The transistor action is driven by the diabatic Landau-Zener transitions induced by the appropriate tuning of the homogeneous magnetic field. Although this spin-FET [3] seems to be free of the above-mentioned physical obstacles, it requires the application of the external homogeneous magnetic field, which is difficult to be applied in the integrated circuit.

Motivated by this experiment [3], we propose the spin transistor design based on the helical magnetic field, in which the spin transistor action is generated by all-electric means without the external magnetic field [4]. For this purpose we use the Rashba spin-orbit interaction (SOI) induced by the lateral electric field between electrodes located on either side of the nanowire. In the proposed device, the transistor action is driven by the Landau-Zener transitions that lead to a backscattering of spin polarized electrons and switching the transistor into the high-resistance state (off state).

References

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