NUCLEAR SPIN TRANSISTOR PREPARED BY ELECTRON BEAM LITHOGRAPHY

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Abstract

The hyperfine interaction between electron and nuclear spins is traditionally regarded only as one of effects contributing to the electron spin relaxation in solids. Under certain circumstances, however, the spin of electrons is effectively transferred to nuclei by the interaction (effect known as dynamic nuclear polarization). The polarized nuclei can act with strong hyperfine fields back on the electron spin system. This opens physics with interesting possibilities which will be illustrated on the example of an all electrical electro-nuclear transistor. The device is a hybrid ferromagnetic metal/semiconductor micro-structure (based on Fe/n-GaAs epitaxial layer system) which utilizes dynamically polarized nuclear spins to control electron spins in an n-GaAs channel. The operation principle of the device consists of two steps. In the first step a weak signal out-of-plane electron spin polarization is generated by the Spin Hall effect which is used for the dynamic polarization of GaAs nuclei. In the second step the non-local spin Hanle experiment is performed. Electrons are injected from an Fe injector with in-plane spin polarization and the non-local spin signal is detected on an adjacent Fe detector as function of external out-of-plane field. The precession of in-plane spins is controlled by the nuclear spin polarization via hyperfine interaction. The subtle signal out-of-plane nuclear spin polarization (0.01-0.1%) controls precession of the strong in-plane spin polarization (1-10%) of injected electrons. Hence, the device performs amplification of the original spin signal used for the polarization of nuclei. The device allows for a convenient electrical detection of very weak spin polarization.

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