Spin current polarization at room temperature in a nanowire resonant tunneling diode

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The operation of the magnetic resonant tunneling structures (RTS) as a spin filter has been demonstrated experimentally by Slobodskyy et. al [1]. In this type of nanostructures, the spin splitting of the quasi-bound state energy levels in the magnetic quantum well causes that the resonant tunneling conditions for spin up and spin down electrons are satisfied for different bias voltages, which leads to the spin polarization of the current. The spin filter effect in the magnetic RTS investigated to date is limited to very low temperatures and requires a strong magnetic field. These restrictions cause that recently more interest is focused on the application of the ferromagnetic RTS, especially these based on dilute magnetic semiconductors with the high Curie temperature, e.g. GaMnAs and GaMnN. Although the recent experiments reported that GaMnN exhibits the ferromagnetic properties at room temperature [2], the theoretical calculations show that the RTS based on GaMnN allows to achieve only 20 % spin polarization of the current at room temperature [3].

In the present report, we study the resonant tunneling structure embedded in a nanowire with ferromagnetic lead and quantum well made from DMS, e.g. GaMnN. The parallel and antiparallel magnetization of the lead and the quantum well is considered. Using the adiabatic approximation, we have shown that the resonant tunneling between the spin splitted subbands in the ferromagnetic lead and the quasi bound state in the quantum well leads to the full spin polarization of the current at low temperature for both the parallel and antiparallel magnetization of the magnetic layers. Calculations at room temperature show that for parallel magnetization the spin current polarization vanishes. On the other hand, the application of the nanostructure with the antiparallel magnetization of the magnetic regions reduces the spin current polarization to 70 % at room temperature. According to the best of our knowledge, this is the highest value of the spin polarization predicted at room temperature for the magnetic RTD.

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