Spin Transport in Heavily-Phosphorus Doped Si Nanowires with CoFeB/MgO Contacts

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Semiconductor spintronics aims to manipulate the spin degree of freedom of electrons in an attempt to search for next generation electronic devices beyond Silicon based complimentary metal oxide semicondutors (CMOS). One of the challenges for semicondcutor spintronics is to find a suitable spin transport channel with long spin relaxation time by which spin polarized electrons injected from a spin source travel in a subtantial distance witout spin dephasing to a spin drain. Silicon (Si), the mainstream semicondutor, is advantageous for semiconductor spintronics owing to weak spin-orbit coupling, long spin diffusion length, and compatibility with the CMOS process. The Si nanowire featured with the one-dimensional confinement, single crystallinity, and clean surfaces is expected to be an outstandping platform to study the role of the dimensionality and size effects in spin injection, transport and detection in semicodncutor. However, there is few report on spin tranport in Si nanowire to date. Here we show the electrical spin transport in heavily-phosphorus doped Si nanowires with an enhanced spin injection and detection efficiency using an MgO tunnel barrier. We also discuss the effect of nanowire geometry on the detected spin signals.

Heavily-phosphorus doped Si nanowires used in the spin transport experiments were synthesized using vapor-liquid-solid (VLS) mechanism with silane (SiH_4), phosphine (PH_3), and Au catalyst in a low pressure chemical vapor deposition (CVD) system. It is found that the Si nanowires are degenerate *n*-type semiconductor with low resistivity of ≈ 13 mΩ·cm at room temperature. We employed the lateral spin-valve geometry with ferromagnetic CoFeB/MgO contacts for the spin transport. The enhanced non-local spin signal (ΔR) as high as 4 kΩ and a clear memory effect were observed while sweeping the applied magnetic field at 1.8 K. It is noted that the curved base line of non-local spin signal is found, which is resulted from local magneteization of CoFeB/MgO contacts on a cylindrical shape of Si nanowire. The contribution of the geometry of Si nanowire to the observed spin signals will be discussed in detail.