All-electrical spin injection from a quantum point contact

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There is considerable interest in being able to control the spin dynamics because this could lead to the development of a range of spintronic devices that in principle are much faster and use less energy than their electronic counterparts. In order to develop successfully such concepts it is necessary to controllably generate, manipulate, and detect spin currents by electrical means and so minimize, or eliminate, the use of ferromagnetic contacts or external magnetic fields. Most research towards the implementation of this electrical approach has focused on using the spin-orbit interaction to induce spin polarized transport, as reported in various nanostructures including quantum point contacts[1, 2]. However, it is essential to develop a more general approach in which materials with a strong intrinsic spin-orbit coupling are no longer necessary, and consequently a longer spin dephasing (relaxation) time will be obtained, of crucial importance for quantum information processing.

In this work we demonstrate on-chip spin polarizing or filtering actions by driving the gate-defined quantum point contact, one of the simplest geometries for integrated quantum devices, away from the conventional Ohmic regime. We have utilized a technique of electron focusing [3, 4] to directly measure the degree of spin polarization of the current. The height of a focusing signal V_c quantifies the degree of spin polarization of the emitted current $P_e = (I_\downarrow - I_\uparrow)/(I_\downarrow + I_\uparrow)$ and the spin selectivity of the collector $P_c = (T_\downarrow - T_\uparrow)/(T_\downarrow + T_\uparrow)$, given by the following relation: $V_c \propto (1 + P_e P_c)$. Our results show that the focusing signal doubles in value only when both the emitter and collector point contacts were set to the 0.25 anomaly[4, 5], indicating that point contacts are fully spin polarized. In addition, the electrons retain their spin polarization as they bend around in the circular orbit. This illustrates that there is an appreciable spin coherence length and that the spin polarization can be transmitted over considerable lengths by purely electrical means. We furthermore demonstrate that an electrical configuration of gates and applied voltages can give rise to spin injection with a tunable spin polarization between 0 to 100%, which has implications for the development of spintronic devices and future quantum information processing.

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