# Spin polarized current induced by the carbon nanotube double junction**.**

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Combination of nanotechnology based on carbon nanotubes (NTs) with spintronics is desirable for future technological innovation. Tsukagoshi et al. found the efficient spin injection from the cobalt electrode into the NTs (1). Nevertheless diffusion of the magnetic atoms from the electrode to the NT increases uncontrollable spin flip because of the large spin-orbit interaction of the ferromagnetic atoms. It indicates that the spin filter composed of atoms with small spin-orbit interaction is desirable. In this paper, a semi-conducting NT put between two metallic NTs is proposed as such a spin filter composed of only carbon atoms. The NTs are connected by the pentagon-heptagon pairs thus the sp2 network is kept as shown in Fig.1 (2). The Schottky barriers at the interfaces form a quantum well in the semi-conducting NT region, while the metallic NT regions function as leads (3). For the nanotube double junction (NTDJ) composed of the (8,0) zigzag nanotube sandwiched by the two (9,0) nanotubes, the zero bias conductance per spin is calculated by the method unifying the tight binding model, unrestricted Hartree-Fock approximation and the non-equilibrium Green's function (4). It is shown as a function of the gate voltage Vg for L=13 and 7 in Fig.2 and Fig.3, respectively. Here the negative gate voltage causing the hole doping is considered and L denotes the length of the (8,0) NT part in the unit of 3*a* with *a* being the bond length. It is found that the spin current occurs when the Coulomb interaction lifts the spin degeneracy of the resonant level in the semi-conducting NT region. An infinitesimal magnetic field is necessary only to determine which spin becomes firstly unoccupied. The conditions for the spin current are: [1] The Fermi level is set near the band gap edges by the gate voltage; [2] the length of the semi-conducting NT region, L, is larger than a threshold length. There are two threshold lengths, L1 and L2. In the present system, L1=4 and L2=6.
When L > L2, the down spin current flows firstly and the up spin current follows as the gate voltage becomes more negative as shown in Fig.2.That is to say, the polarization of the spin current can be controlled by the gate voltage. When L2 ≧ L > L1, however, the latter up spin current drastically diminishes as shown in Fig.3. Furthermore there is no spin current when L1≧ L. These results can be explain by the change of the Schottky barrier due to the gate voltage.

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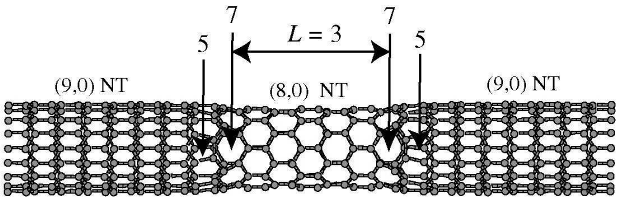

Figure 1: The atomic structures of the nanotube double junction (NTDJ), (9,0) NT - (8,0) NT - (9,0) NT, when L/(3*a*)=3 with *a* being the bond length.

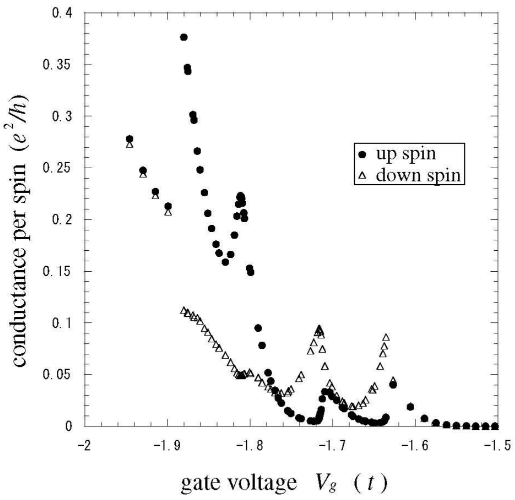

Figure 2: The conductance per spin as a function of the gate voltage Vg when L/(3*a*)=13.

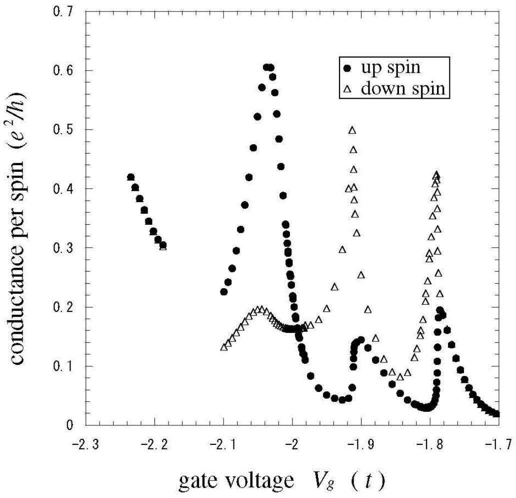

Figure 3: The conductance per spin as a function of the gate voltage Vg when L/(3*a*)=7.