Spin Polarization on a Plateau of a Half Conductance Quantum in a Quantum Point Contact

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Perfect spin filtering in a quantum point contact (QPC) with strong spin-orbit interaction was claimed based on the conductance quantization with the unit of a half conductance quantum ($G_q/2 = e^2/h$) [1]. As a more sound experimental proof, we measured transport through a QPC terminated with a quantum dot (QD) spin detector [2]. However, in this setup, the spin current through the QPC is inevitably blocked by the QD resulting in difficulties both in the elimination of back action from the QD and in the application of the spin current to spintronics. Here we report measurement of spin polarization in the vicinity of such a QPC with a single-lead quantum dot (SLQD) spin detector [3]. In the present setup, the spin current through the QPC is mostly introduced to the electrodes at a minimal back action from the QD and can be used, e.g., as flying spin qubits.

Figure 1(a) explains the principle to measure the spin polarization, which is attained through the comparison of tunneling rates for the process of $N = 0 \rightarrow 2$, and that of $1 \rightarrow 3$. This can be intuitively understood with considering the case in which the polarization is one. In the former process, the tunneling of the second electron is blocked by the Pauli principle while it is not in the latter. In Fig.1(b), the white regions are Ti/Au gates on a two-dimensional electron gas (the dark gray region) in an $In_{0.11}Ga_{0.89}As$ quantum well. Electron tunneling rate from the target QPC (t-QPC) to the QD can be measured as the signal in remote charge detection with the detector QPC (d-QPC) locked to a square-wave modulation of the plunger gate voltage.

A clear half-conductance quantization in t-QPC at 100 mK is demonstrated in the inset of Fig.2. The main panel of Fig.2 shows the signal amplitudes in $N = 0 \rightarrow 2$, and $1 \rightarrow 3$ regions when t-QPC is on the first half-quantized plateau as a function of the period of gate-swing. Apparent difference in the two regions manifests the spin polarization. We have estimated the polarization as $P = 0.70 \pm 0.11$ from rate-equation analysis.

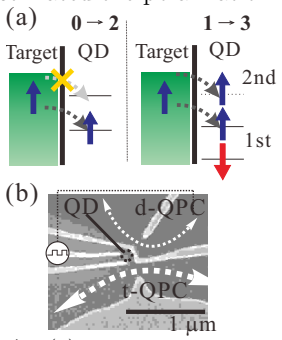

Fig.1. (a) Detection scheme of spin polarization by using two-electron tunneling processes to a side-coupled quantum dot and (b) the actual sample configuration.

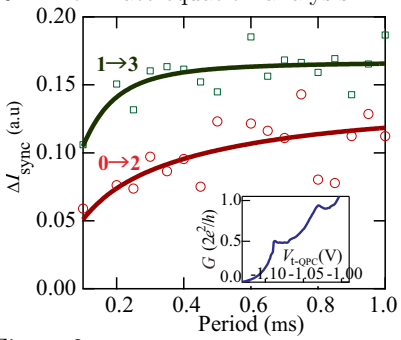

Figure 2. Tunneling signal amplitude in N = $0 \rightarrow 2$ and $1 \rightarrow 3$ regions as a function of th period of the gate voltage modulation. The soli lines are obtained by the fitting.

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[2] S-W. Kim, *et al.*, J. Phys. Soc. Jpn **81**, 053709 (2012).
[3] J. M. Elzerman, *et al.*, Appl. Phys. Lett. **84**, 4617 (2004).