Floating gate in a 2DEG island for electrostatically connecting distant quantum dots

T. Obata, M. Yamamoto, and S. Tarucha

Department of Applied Physics, University of Tokyo, Hongo, Bunkyo-ku, Tokyo 113-8656, Japan

Integration of multi-spin qubits has recently focused in the research frame of quantum computation with quantum dots (QDs). Manipulation of two individual single spins[1], control of spin singlet entanglement[2], and observation of long decoherence time and echo time by use of dynamical decoupling techniques[3] have been successively achieved . The next step is to scale up the quantum gates with more quantum dots. However, it is still challenging to address many quantum dots with sufficiently strong inter-dot couplings because it is crucial to accommodate gates and control lines to engineer larger scale QD systems. To solve these problems, it is theoretically proposed to use metallic materials as a floating gate for dipolar coupling between QDs, which can leave a larger space for making a complex electrical circuit[4]. We follow this concept to design the floating gate to connect two quantum dots 1μm apart. We prepare quantum dots defined in a 2DEG by Schottky gates and a floating gate defined in the same 2DEG by etching. We find that the floating gate in a 2DEG electro-statically couples the two quantum dots strong enough to control dipolar coupling between two spin qubits.

A scanning electron micrograph of our device is shown in Fig. 1. Two DQDs are separated by a 1μm long and 0.6μm wide 2DEG island. We find that two separated DQDs are capacitively coupled through the incompressive confined 2DEG island. We measure two sets of charge stability diagrams of the two DQDs as a function of two gate voltages for the two DQDs and find that when the number of electrons in one of the two DQDs is changed by one, the Coulomb peak positions for the other DQD is shifted, influenced by the change in the electrostatic potential of the first DQD. In addition, we observe that the inter-dot charge transition of one DQD also depends on the charge state of the other DQD. This is an indication that dipolar coupling between two qubits can be implemented by the floating gate. We also note that it is possible to turn on and off the coupling by a surface gate on the floating 2DEG[4]. We discuss these results and the possible extension of magnetic floating gates for the long range direct interaction of spin qubits[5].

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