博士論文（要約）

Experimental investigation of spin qubits in Si/SiGe double quantum dot

（Si/SiGe２重量子ドットにおけるスピン量子ビットの実験的研究）

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Electron spins in semiconductor quantum dots (QDs) are one of the promising candidates for implementation of scalable solid state quantum computing. Various requirements for implementation of spin qubit: initialization, readout, one and two-qubit operations [1] have been realized in experiments using electrons conned in few-electron GaAs QDs [2-9], although they are plagued from relatively short phase coherence time (T_2^*) due to nuclei surrounding the conned electrons.

To overcome the short coherence time, an instant way is to remove nuclear spins in the host semiconductor material. Among a variety of nuclear spin free semiconductors (C, Si, Ge etc.), we choose Si material because of its compatibility to gate-defined QD structure and availability of high quality materials.

In this thesis, first we have established robust fabrication techniques of stable Si/SiGe QDs. By the optimization of heterostructure and gating technique, we have realized reduction of the charge noise of modulation-doped Si/SiGe devices and few-electron DQD. Eventually, we have realized dual-gated undoped Si/SiGe QPC and QDs to further reduce the charge noise level comparable to those of the best GaAs QPCs and QDs.

Next we have performed measurement of an undoped Si/SiGe DQD with a micromagnet.

The first part of DQD measurement is focused on microwave spectroscopy of a two-electron Si/SiGe DQD. Using Pauli spin blockade readout technique with two different state preparation techniques, we characterize spin-valley states in a two-electron Si DQD. The addressable resonance condition due to the micromagnet enables more precise analysis of the spin-valley states as compared to the previous work in many-electron Si MOS DQD [10].

In the second part of the DQD study, we present individual high-fidelity coherent operations of single spins in a two-electron Si/SiGe DQD. We have realized initialization and readout of individual spins in the DQD using the energy selective readout technique using reservoirs. A large stray magnetic field produced by the micromagnet enables nearly one or two order faster spin rotation as compared to the previous studies in Si QDs [11, 12]. We have also performed characterization of phase coherence time using Ramsey interference. The Ramsey measurement shows a phase coherence time $T_2^* \sim 2$ μs which is roughly two orders improved from those of GaAs DQDs [4,5].

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