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Addressable single-spin control in multiple quantum dots coupled in series

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Electron spin in semiconductor quantum dots (QDs) is promising building block of quantum computers for its controllability and potential scalability [1]. Recent experiments on GaAs QDs have demonstrated necessary ingredients of universal quantum gate operations: single-spin rotations by electron spin resonance (ESR) which is virtually free from the effect of nuclear spin fluctuation [2], and pulsed control of two-spin entanglement [3]. The scalability of this architecture, however, has remained to be demonstrated in the real world. In this talk, we will present our recent results on implementing single-spin-based qubits in triple, quadruple, and quintuple QDs based on a series coupled architecture defined by gate electrodes. Deterministic initialization of individual spin states and spin-state readout were performed by the pulse operation of detuning between two neighboring QDs. The spin state was coherently manipulated by ESR, where each spin in different QDs is addressed by the shift of the resonance frequency due to the inhomogeneous magnetic field induced by the micro magnet deposited on top of the QDs. Control of two-spin entanglement was also demonstrated. We will discuss key issues for implementing quantum algorithms based on three or more qubits, including the effect of a nuclear spin bath, single-shot readout fidelity, and tuning of multiple qubit devices. Our approaches to these issues will be also presented. This research is supported by Funding Program for World-Leading Innovative R&D on Science and Technology (FIRST) from JSPS, IARPA project "Multi-Qubit Coherent Operations" through Copenhagen University, and Grant-in-Aid for Scientific Research from JSPS.

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