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Silicon based quantum dot hybrid qubits[1]

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The charge and spin degrees of freedom of an electron constitute natural bases for constructing quantum two level systems, or qubits, in semiconductor quantum dots. The quantum dot charge qubit offers a simple architecture and high-speed operation, but generally suffers from fast dephasing due to strong coupling of the environment to the electron's charge. On the other hand, quantum dot spin qubits have demonstrated long coherence times, but their manipulation is often slower than desired for important future applications. This talk will present experimental progress of a 'hybrid' qubit, formed by three electrons in a Si/SiGe double quantum dot, which combines desirable characteristics (speed and coherence) in the past found separately in qubits based on either charge or spin degrees of freedom. Using resonant microwaves, we first discuss qubit operations near the 'sweet spot' for charge qubit operation. Along with fast (>GHz) manipulation rates for any rotation axis on the Bloch sphere, we implement two independent tomographic characterization schemes in the charge qubit regime: traditional quantum process tomography (QPT) and gate set tomography (GST). We also present resonant qubit operations of the hybrid qubit performed on the same device, DC pulsed gate operations of which were recently demonstrated. We demonstrate three-axis control and the implementation of dynamic decoupling pulse sequences. Performing QPT on the hybrid qubit, we show that AC gating yields π rotation process fidelities higher than 93% for X-axis and 96% for Z-axis rotations, which demonstrates efficient quantum control of semiconductor qubits using resonant microwaves. We discuss a path forward for achieving fidelities better than the threshold for quantum error correction using surface codes.

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