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Control and coherence of Loss-DiVincenzo qubits in Si/SiGe quantum dots

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Electron spins in Si/SiGe quantum dots are one of the most promising candidates for a quantum bit for their potential to scale up and their long dephasing time. We report for the first time the experimental realization of single electron spin rotations in a single quantum dot (QD) defined in a Si/SiGe 2D electron gas. The electron spin is read out in single-shot mode by a QD charge sensor. Spin rotations are achieved by applying microwave excitation to one of the gates, which oscillates the electron wave function back and forth in the gradient field produced by cobalt micro-magnets fabricated near the dot. By measuring the electron spin resonance frequency as a function of the external magnetic field, the electron g-factor of 1.994 ± 0.007 is determined. A dephasing time of T2*=850 ns, about 20 times longer than that in GaAs quantum dots, is extracted from the linewidth of the electron spin resonance peak. We observe spin Rabi oscillations with Rabi frequencies up to 5 MHz. Because the coherence time can be longer than the spin manipulation time, we are able to rotate the electron spin even when detuned in frequency, giving the typical chevron pattern when sweeping detuning and microwave burst time. We also realized Ramsey interference experiments, giving a free induction decay T2* = 800 ns. Looking closely, all these data exhibit interference patterns resulting from the contribution of two resonances separated by a frequency difference Δf =2-4 MHz. We tentatively interpret these two resonances as intra-valley spin resonance for two different valley states. Due to the valley-orbit mixing, the orbital wavefunction of each valley state is slightly different, which yields a different Zeeman splitting for each valley state. Finally, we perform Hahn-echo measurement and deduce, for the first time in Si/SiGe, a single spin T2=37μs.

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