**Low-frequency spin qubit energy splitting noise in highly purified 28Si/SiGe**

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Electrostatically defined quantum dots in 28Si/SiGe heterostructures have been proven to allow the robust implementation of spin qubits as long as the device-intrinsic valley splitting energy is sufficiently large to operate the qubit. Here, we present the characterization of a gate-defined single spin qubit in a quantum dot layout with an integrated nanomagnet. The qubit is hosted in a molecular-beam epitaxy-grown 28Si/SiGe heterostructure presenting 60 ppm residual 29Si[1]. We find a robust valley splitting beyond 200 𝜇eV and a well separated orbital energy beyond 1 meV. In the operation window, we observe spin relaxation times 𝑇1 > 1 s. Using electron dipole spin resonance, the manipulation of the qubit yields 𝑇2\* ∼ 20 𝜇s and 𝑇2𝑒𝑐ℎ𝑜 ∼ 127 𝜇s[2]. We investigate the detuning noise spectrum of the qubit by extracting the resonance frequency from a series of Ramsey-type measurements and compare this noise to the noise spectrum of the adjacent sensor dot. We find charge noise together with the synthetic spin-orbit interaction due to the magnetic gradient to be the dominant qubit noise source at frequencies larger than 5 mHz. Given that the SiGe barrier has natural isotope composition, we also discuss the impact of the electron wavefunction overlap with the Si/SiGe interface on the qubit dephasing time.

##### [1] A. Hollmann et al., Phys. Rev. Applied 13, 034068 (2020) [2] T. Struck et al., npj Quantum Inf. 6, 40 (2020) [3] T. Struck et al., Sci. Rep. 11, 16203 (2021)

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Figure 1: Left: Measurement of the spin-up probability as a function of the evolution time te for a Ramsey-fringes pulse sequence. Each point corresponds to 500 single-shot measurements[3]. Right: Spin-up probability as a function of the evolution time te after a Hahn-echo gate sequence. The dotted line marks the fitted[2] T2echo.