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Robust few-electron quantum dot devices in nuclear spin engineered Si/SiGe

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Spins in gate-defined quantum dots are currently discussed as one of the most promising scalable qubit architecture. Since the identification of the hyperfine interaction as a dominant spin qubit decoherence mechanism, Si/SiGe heterostructures have been receiving steadily increasing attention for realizing devices almost free of nuclear spin carrying isotopes. Building Si/SiGe heterostructures from material enriched in nuclear spin-free isotopes brings new perspectives of reaching a regime of further improved decoherence times compared to Si/SiGe of natural isotope composition. In such isotopically engineered heterostructures, the decoherence is predicted to no longer be governed by the hyperfine interaction with the nuclear spin bath, but solely by dipolar interactions. In the first part of my presentation I will review the development of two-dimensional electron systems in 28Si for spin qubit applications in my group and discuss few electron double quantum dot devices based on these heterostructures. Being able to avoid hyperfine-induced decoherence then brings a second major limitation for the realization of robust spin qubits into focus. Indeed, the manipulation of such qubits relies on Coulomb interactions, enabling electronic noise to cause decoherence. Charge traps in the heterostructure may contribute to decoherence through a fluctuation of charges or through dipolar interactions of the spin degree of freedom of the trap and the qubit. In the second part of my talk I will present our recent study of charge noise in modulation-doped Si/SiGe heterostructures and discuss device and heterostructure designs which efficiently suppress charge noise.