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Quantum Computing in Silicon with Donor Electron Spins

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Extremely long electron and nuclear spin coherence times have recently been demonstrated in isotopically pure Si-28 [1-3] making silicon one of the most promising semiconductor materials for spin based quantum information. The two level spin state of single electrons bound to shallow phosphorus donors in silicon in particular provide well defined, reproducible qubits [4] and represent a promising system for a scalable quantum computer in silicon. An important challenge in these systems is the realisation of an architecture, where we can position donors within a crystalline environment with approx. 20-50nm separation, individually address each donor, manipulate the electron spins using ESR techniques and read-out their spin states. We have developed a unique fabrication strategy for a scalable quantum computer in silicon using scanning tunneling microscope hydrogen lithography to precisely position individual P donors in a Si crystal [5] aligned with nanoscale precision to local control gates [6] necessary to initialize, manipulate, and read-out the spin states [7]. During this talk I will focus on demonstrating electronic transport characteristics and single-shot spin read-out of precisely-positioned P donors in Si. Additionally I will report on our recent progress in performing single spin rotations by locally applying oscillating magnetic fields and initial characterization of transport devices with two and three single donors. The challenges of scaling up to practical 2D architectures will also be discussed.

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