# Precision donor qubits in silicon

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Extremely long electron and nuclear spin coherence times have recently been demonstrated in isotopically pure Si-28 [1,2] 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 [3] 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. 20–50 nm 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 lithography to precisely position individual P donors in Si [4] aligned with nanoscale precision to local control gates [5] necessary to initialize, manipulate, and read-out the spin states [6]. During this talk I will focus on demonstrating single-shot spin read-out [8] and ESR control of precisely-positioned P donors in Si. I will also describe our approaches to scale up using rf reflectometry [9] and the investigation of 3D architectures for implementation of the surface code [10] and highlight that the device produced have the lowest noise characteristics of any silicon device to date [11].

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